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Editors

Florbela P. Fernandes
Research Centre in Digitalization and Intelligent Robotics (CeDRI)
Instituto Politécnico de Bragança

Pedro Morais
Applied Artificial Intelligence Laboratory (2Ai)
Instituto Politécnico do Cávado e do Ave

Pedro Pinto
Applied Digital Transformation Laboratory (ADiT-LAB)
Instituto Politécnico de Viana do Castelo

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Welcome

This document presents the proceedings of the 2nd Symposium of Applied Science for Young Researchers - SASYR. This scientific event welcomed works by junior researchers on any research topic covered by the following three research centres: ADiT-lab (from IPVC, Instituto Politécnico de Viana do Castelo), 2Ai (from IPCA, Instituto Politécnico do Cávado e do Ave) and CeDRI (from IPB, Instituto Politécnico de Bragança). The main objective of SASYR is to provide a friendly and relaxed environment for young researchers to present their work, discuss recent results and develop new ideas. In this way, this event offered an opportunity for the ADiT-lab, 2Ai, and CeDRI research communities to gather synergies and promote collaborations, thus improving the quality of their research. The SASYR 2022 took place in a hybrid environment at Escola Superior de Tecnologia e Gestão of Instituto Politécnico de Viana do Castelo on the 22nd of June, 2022.

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Vítor Carvalho, 2Ai, Instituto Politécnico do Cávado e do Ave

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Bang-bang temperature controller for a custom-made SMD reflow oven

Rafael Luis Yanase de Rezende[1] and João Paulo Coelho[1,2]

[1] Polytechnic Institute of Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.
[2] Research Center for Digitization and Intelligent Robotics (CeDRI). Polytechnic Institute of Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.
jpcoelho@ipb.pt

Abstract. This paper present the preliminary results regarding the application of a simple bang-bang control strategy to a custom-made SMD reflow oven. This device was built by retrofitting a recycled electric oven where both measurement and actuation chains are included. It will be shown that set-point tracking cannot be attained accurately through the use of a simple ban-bang controller and that severe temperature oscillations are observed.

Keywords: Bang-bang controller, reflow oven, SMD soldering

1 Introduction

The use of surface-mounted devices (SMD) in printed circuit boards (PCB) is not only required for companies that target mass-production appliances. Indeed, at the present, the use of those types of electronic components must be equated even at the prototyping level. This is true since many companies are offering only integrated circuits, or electronic components in general, arranged in SMD packages. However, the soldering process of SMD components is more complex than that of common through-hole devices. This is due to the fact that a simple soldering iron is generally not suited to solder SMD. Especially if they are lead-free. For soldering SMD components, usually, a reflow oven is required. This type of equipment is usually expensive since they are not mass-production appliances. For this reason, this paper addresses the retrofitting of an off-the-shelf electric oven and repurposes it to become an SMD reflow equipment.

Due to the fact that the soldering process requires a particular temperature profile, the oven must include a controller capable of following this temperature reference signal with minimum deviation [1]. There is a myriad of possible control strategies that can be employed to carry out this task. Proportional, integral and derivative (PID) control is a very popular methodology but, in this paper, an even simpler method will be evaluated on its ability to provide good set-point tracking. In particular, this work provides experimental results regarding the use of a simple bang-bang controller.

After this introduction, Section 2 will describe the overall mechatronic setup associated with the construction of the reflow oven. Section 3 will be devoted to analysing the open-loop step response and Section 4 will present the set-point accuracy results regarding the set-point tracking ability of a bang-bang controller. In the final section, the main conclusions are highlighted followed by future work directions.

2 The mechatronic structure of the reflow oven

The temperature profile of a typical industrial reflow electric oven is divided into different types; one is composed of different phases of heating (ramp-soak-spike) and the other is a ramp from the starting temperature until the peak temperature (ramp-to-peak) [2]. In order to follow such a temperature profile, closed-loop control must be implemented. In this context, the goal of the current work is to design and implement a temperature controller able to track the required temperature for soldering SMD components into PCBs.

Usually, the reflow process of SMD components requires temperatures that can reach 250 °C. Those temperatures are within the grasp of common domestic appliances and, for this reason, a common electric oven was retrofitted with suitable actuators and sensors. Figure 1 show the overall aspect of the solution under development. The left-hand side of this figure shows an additional heating element added at the top of the grill where the PCB will stand. Moreover, the same figure also shows a bracket built to hold the temperature sensor. The right-hand image illustrates both the electronic actuation and instrumentation chains.

Fig. 1: Top heating element and thermocouple bracket.

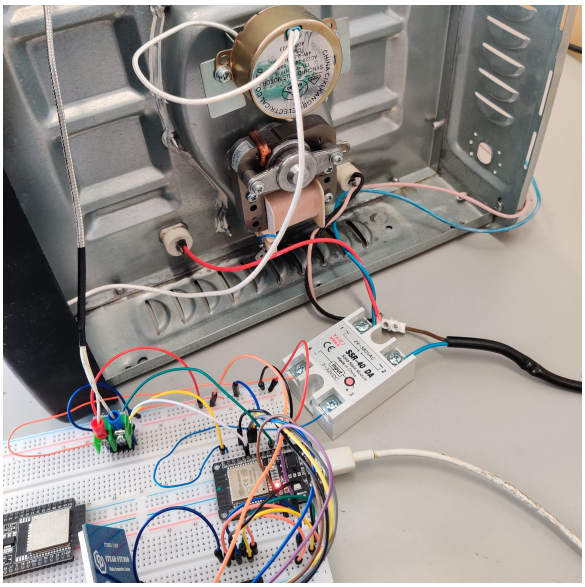

Fig. 2: Electronic instrumentation and actuation prototype.

The temperature inside the oven is measured via a K-type thermocouple [3] and its signal conditioning was handled by a MAX6675 integrated circuit that performs cold junction compensation and A/D conversion.

The power delivered to the heating elements is commanded by a 40A solid state relay excited by a pulse-width modulated control signal. This signal is provided by an ESP-WROOM-32 development board according to the control algorithm that runs inside.

The user can interact with the reflow oven through a graphical user interface displayed on a 1.8 inch TFT screen. The user can navigate among the provided menu by means of a rotary encoder.

3 The open-loop step response

In this section, the dynamic response of the oven to a step input signal will be evaluated. The signal was applied to the solid-state relay and the temperature delivered by the thermocouple was recorded with a sampling period of 200 ms. The obtained result is presented in Figure 3.

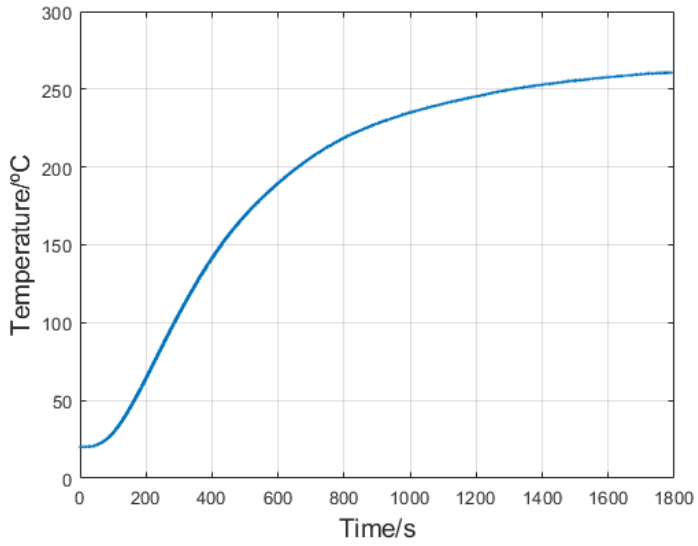

Fig. 3: Open-loop dynamic response of the reflow oven to a step input signal.

The analysis of this response suggests that the system dynamics can be approximated to a first-order transfer function with a pure time-delay with the form [4]:

$$H(s) = K\frac{e^{(-s\tau)}}{(as+1)} \tag{1}$$

where k denotes the system DC gain, τ the dead-time and a the time-constant.

The numeric values of each one of those three coefficients were obtained through a heuristic approach that started with a rough estimate of those variables from the step response and was empirically fine-tuned by trial and error. The obtained values that best fit the model to the measured data were found to be $K = 246$, $\tau = 108$ and $a = 433$. A comparison between the measured data and the simulated step-response using the above model is presented in Figure 4).

As can be seen, the overall dynamics are acceptably captured by the simple first-order model. However, the initial dynamics suggest that a higher-order model could be more suitable to fully explain the system's transient behaviour.

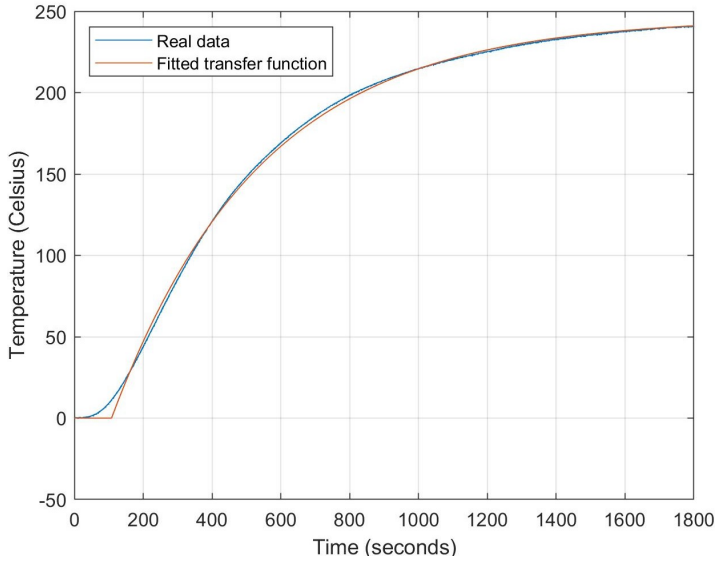

Fig. 4: Accuracy of the first-order model obtained by an iterative procedure.

4 Bang-bang controller and set-point accuracy

As initially stated, the aim of this paper is to evaluate the suitability of a simple bang-bang controller to provide enough closed-loop set-point accuracy to be successfully used as the control strategy of the reflow oven.

In the control theory context, a bang–bang controller describes a closed-loop feedback strategy where the control signal switches between two discrete states [5]. Usually, hysteresis is added in order to prevent stressing the actuators.

In the present context, a digital version of the bang-bang controller was implemented in the microcontroller. In short, the behaviour of this controller can be summarised as follows: if the measured temperature goes below a given region defined around the set-point, the power to the heating elements is delivered. On the other hand, if the measured temperature exceeds the upper bound of the defined region, the power is cut-off. In the current application, a $\pm$ 2.5 °C hysteresis band around the set-point is considered. Moreover, three different trials, with different set-point amplitudes, have been performed: one at the low temperature of 40 °C, the other at 80 °C and a final trial at 180 °C.

Regarding the former, Figure 5 show the closed-loop step response to a 40 °C. As can be seen, the oven reaches a maximum temperature of 72 °C and in the steady-state phase, the temperature fluctuates between 38 °C and 63 °C.

Figure 6 illustrate the result obtained for a 80 °C step input. In this case, the system reaches a maximum temperature of 109 °C and, when in steady-state, oscillates between 74 °C and 101 °C.

The last trial regards a set-point of 180 °C. The results are presented in Figure 7 and measurements show that the maximum temperature achieved by the system is near

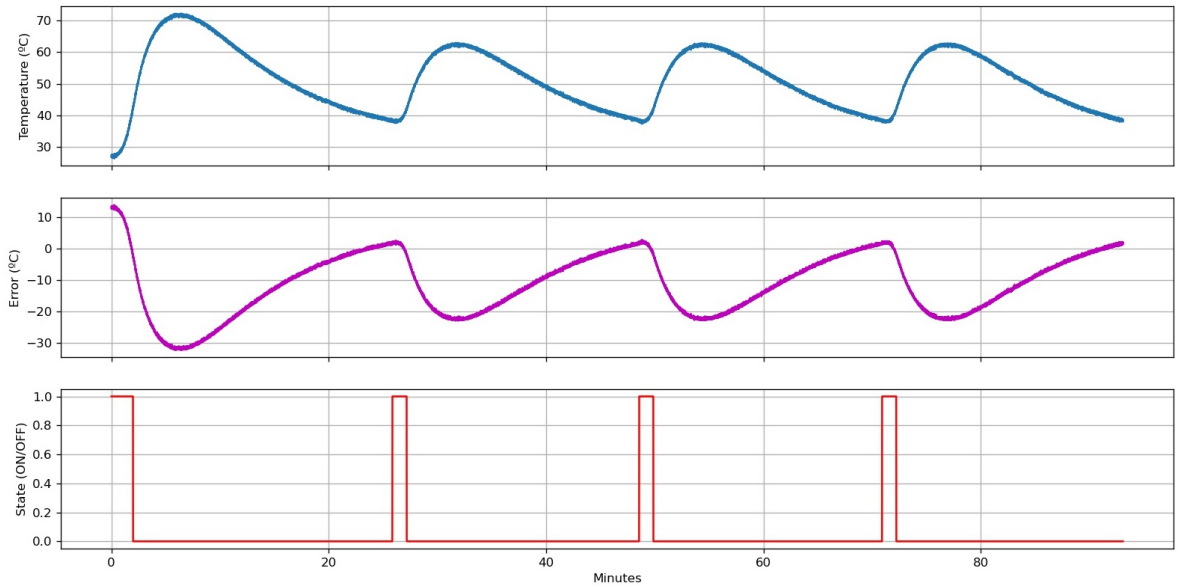

Fig. 5: Transient and steady state response at 40 °C.

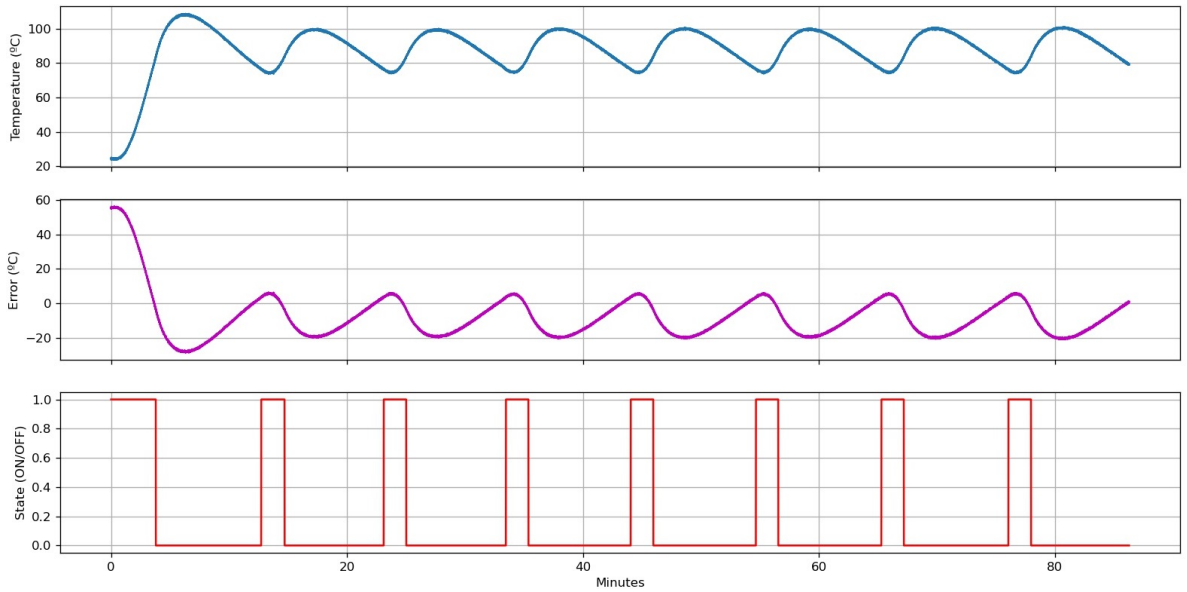

Fig. 6: Transient and steady state response at 80 °C.

189 °C. During steady-state, temperature oscillates between a maximum of 187 °C and a minimum of 172 °C.

As can be seen, the relative ripple due to the switching behaviour of the bang-bang controller diminishes with the increase of the set-point amplitude. For the trials that involve the lower temperature set-point, a ripple of 25 °C leads to a relative value of 62.5%. Applying the same idea to the other two trials lead to a value of 33.8% for the case where the set-point has an amplitude of 80 °C and just 8.3% for the

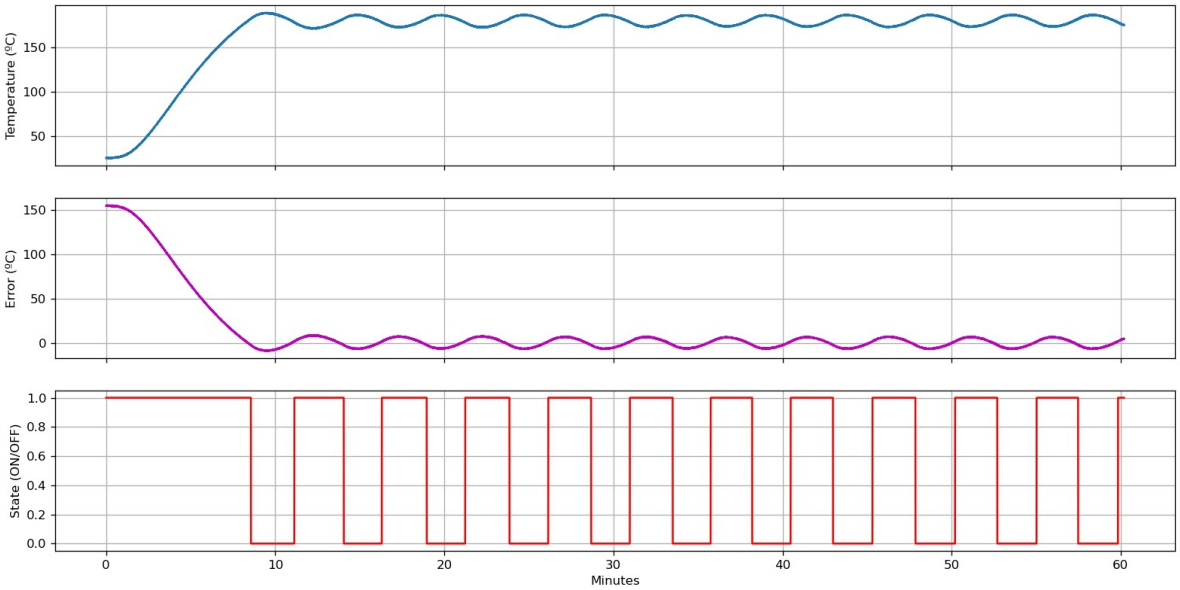

Fig. 7: Transient and steady state response at 180 °C.

higher temperature situation. Those results suggest that a bang-bang controller does not possess enough set-point accuracy to be used as the control strategy for the reflow oven. For this reason, other approaches must be explored such as the use of PID control.

5 Conclusion and further work

Being able to solder SMD devices into printed circuit boards requires the use of reflow ovens which can be expensive. For this reason, this paper deals with the preliminary results of retrofitting an off-the-shelf electric oven into an SMD reflow oven. Besides the economic motivation, the process of repurposing any machine is always an excellent way to apply many of the concepts tough during engineering courses.

Along with this paper, results regarding the open-loop step response were presented. It was shown that a simple first-order plus dead time transfer function can be used to capture the overall system dynamics.

Experiments with a feedback controller based on a bang-bang strategy were carried out. The obtained results point-out large ripple and poor set-point tracking for lower temperatures. Moreover, and even for higher temperatures, zero steady-state error is impossible to achieve using this method.

For this reason, more complex control systems must be implemented and evaluated regarding their set-point tracking performance. PID control is a good candidate and will be the next strategy to be evaluated. The design of PID controllers is more challenging and frequently relies on the system model to compute its gains. For this reason, obtaining a more accurate model for the reflow oven will also be investigated. In particular, using system identification techniques based on empirical data obtained from the system response. Optimisation algorithms, such as genetic algorithms, will be employed to derive the best parameters and structure for the model.

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Research on the usage of steganography in online services

Pedro Sousa[1], António Pinto[2], and Pedro Pinto[3]

[1] Instituto Politécnico de Viana do Castelo, IPVC, Portugal
pguilhermesousa@ipvc.pt
[2] CIICESI, ESTG, Politécnico do Porto, Portugal
CRACS & INESC TEC, Porto, Portugal
apinto@inesctec.pt
[3] Instituto Politécnico de Viana do Castelo, Viana do Castelo, Portugal
ISMAI and INESC TEC, Porto, Portugal
pedropinto@estg.ipvc.pt

Abstract. Instant Messaging and Media Upload services are frequently provided within a social network platform. Such allows social networks to obtain additional information about users. Information such as when a user communicates, for how long, with whom, and where the user was, among others, are all available to the service provider, even when the communications are encrypted end-to-end.
In this paper, the authors review the current viability of steganography along with existing online services as a way to achieve anonymous, confidential, and covert communication, where only the sender and the receiver will know about the existence of this data.

Keywords: Covert Communications · Steganography · Anonymous Communications · Online Services

1 Introduction

Instant Messaging and Media Upload services are commonly provided by social networks and other online services, where users are able to exchange messages and other types of data between them. These services enable real-time connection with friends and colleagues, even in times when social distance is necessary, such as during the COVID-19 pandemic [7]. However, when using these services, the users, their activities and messages are subject to being tracked, analyzed, scrutinized, and profiled. Privacy has gained momentum with the implementation of the General Data Protection Regulation (GDPR) [1] by the European Union, however, users of these services still may not be fully aware of the extent of information being collected and the purposes for which it is being processed. Cases of misuse of personal information by social network companies, such as what happened in the Cambridge Analytica scandal [3], also brought to light some unlawful uses of personal information that these platforms gather and process.

Currently, some of these services adopted end-to-end encryption [4] to enable confidential communications between users and, with this, regain some of the users' trust in their services. However, it may be possible to identify communicating parties by analysing their web traffic [9], even when the messages they exchange are encrypted. Authors in [15] argue that communications services should be designed to enable parties to communicate in a way that no one knows who said something. Extending this argument, it would be important to design a communication system between parties where the participants are the only ones who know the content of the messages, the existence

of the messages, and the identity of the involved parties, hiding this information even for the platforms and servers being used for these communications.

Cryptography techniques have been proposed to enable confidentiality, identity, non-repudiation, and authentication, among others [5]. On the other hand, the use of steganography as a process for hiding secret messages in pictures can be used to reinforce anonymity [13]. One of the most known and more used image steganography algorithms is the LSB (Least-Significant-Bit) [8]. Thus, the combination of cryptography and steganography in a communication system would enforce confidentiality and also would assure that only the sender and the receiver are aware that a secret message exchange exists. To share secret information within images, online services, such as image sharing services or social network platforms, that can be used without authentication may result in the anonymity of the involved users.

In the work herein, the authors evaluated existing social network platforms and other online services in order to assess the possibility of uploading images containing secret messages, embedded using multiple steganography programs. For this evaluation, the authors opted for using readily available, free-to-use, steganography programs. This assessment confirmed the viability of the initial idea.

This paper is structured as follows. Section 2 presents the related work. Section 3 provides an assessment on online services to be used in the current context. Section 4 presents the final conclusions and points toward future work.

2 Related Work

This related work focuses on proposals combining the use of steganography techniques and tools, to enable concealed communications between users, without requiring new server infrastructure and without enabling server access to the exchanged messages. These related works are discussed next.

Authors in [16] argued that steganography could be used for message exchange between users in a way that only the sender and receiver were able to decrypt the message and were the only ones aware that the message exchanges existed. They also consider its use in mobile phones, which leads them to do a performance comparison of existing steganography solutions. They concluded, at the time, that it was feasible but highly influenced, in terms of execution times, by image size.

In [2], the authors proposed a secure form of communication that used steganography to hide the information exchanged between users. Their solution also aimed at using existing online services like social networks and photo sharing services to identify and compare the processing operations performed by multiple online services. One of their conclusions is that these processing operations (compression, resizing, metadata, and file name changes) hamper the use of traditional image-based steganography, thus proposing the use of filename-based and tag-based steganography techniques. Despite supporting message exchanges between users without servers being aware of them, their proposal does not encrypt the hidden messages and presents significant size constraints as only 4 to 7 bytes of data can be stored in each filename.

Authors in [11] studied the possibility of using Facebook as a platform to upload and share images including hidden messages with steganography. One of their findings is the

fact that, due to image compression, for Facebook to save storage space and bandwidth, the steganography process is generally disrupted. They tested multiple steganography programs and, for the most part, had little success in obtaining the information after the image was uploaded. Partial positive results were only obtained with prepossessing work and multiple attempts.

In the work [17], authors researched ways to bypass steganography disruption due to modifications to the submitted images. Their solution works by firstly creating a compressed version of the image, then embedding the secret data into the compressed image, resulting in a version called Stego-image. Next, an intermediate image is created using adjustments based on the Stego-image and the original image. The resulting image can then be uploaded to the social network and their compression will not have an impact on the secret data extraction.

More recently, authors Lu, et al., in their work published in 2021 [12], presented another solution that makes it possible to use steganography algorithms that are resistant to JPEG compression. In this work, the original image is first run through an auto-encoder, which also inserts the secret message, in an attempt to create an intermediate image which, by the predictions of the program, will generate the target image after image compression.

From the analysis of the related works presented, it can be concluded that the topic, despite not being new, is still under active research. Also, none of these solutions allows user anonymity as they require their users to authenticate before using the service. To the best of our knowledge, there is no solution that allows anonymous, confidential, and covert instant messaging services between users that do not require users to authenticate themselves, or a dedicated server.

3 Assessment of Social Networks and Content Sharing Services

Steganography and online content-sharing services are a central part of the paper. In particular, assessments on current steganography applications and online content-sharing services were conducted.

Concerning the steganography applications, the following were selected in their latest versions and assessed for the current context: OpenPuff [14], OpenStego [18], StegHide [10] and StegoShare [6]. All these applications are available in free versions as well as open-source versions.

OpenPuff supports for multiple formats and it provides multiple layers of protection, including: encryption of the secret data; scrambling so it is more difficult to know where it begins/ends; whitening to mix the scrambled data with noise; and finally, the whitened data is encoded through a non-linear function. OpenStego allows for data to be encrypted and then hidden in cover files as well as watermarking files in order to identify ownership.

StegHide allows for data to be encrypted and hidden in images of JPEG and BMP formats, but also in some audio formats.

StegoShare also provides the ability to encrypt and hiding data in images.

Current online services are known to change images/photos characteristics after upload. These changes can be verified in compression, resolution, metadata, and file name,

and may impact steganography results. To assess this impact, two tests were designed. Both tests use the following selection of online services: Facebook, Twitter, LinkedIn, Hi5, Imgur, Flickr and ImgBox. The first test consisted of the generation of a set of *stego images* from a random image with a resolution of 3840x2160. Then, these *stego images* were uploaded to the selection of online services, and its resulting image size, resolution, and format were collected to check the changes introduced.

The first test was conducted in September 2021, and Table 1 presents the results obtained. These results show that Facebook converts images to JPEG format with a maximum resolution of 2048x1152 pixels using a high compression rate. In the case of Flickr, the results show that this service does not perform compression of the uploaded images, nor changes in their resolution. In ImgBox's case, the results show that the image resolutions are maintained, but the resulting file size indicates that a low compression algorithm is used.

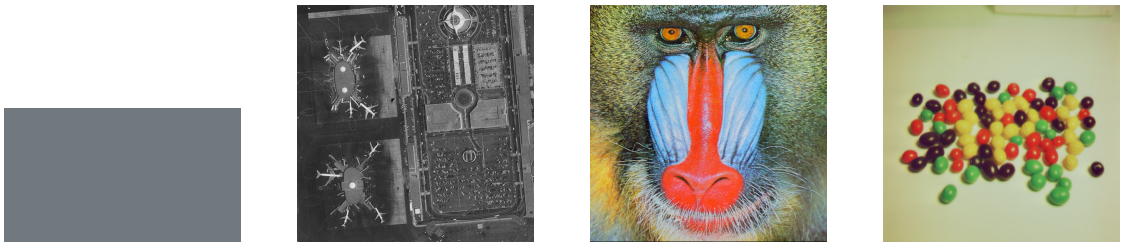
		Stego Images	Facebook	LinkedIn	Twitter	Hi5	Imgur	Flickr	ImgBox
OpenPuff	Size	6,72 MB	312 KB	186 KB	546 KB	2,2 MB	467 KB	6,72 MB	6,54 MB
	Res.	3840x2160	2048x1152	2048x1152	3840x2160	2048x1152	3840x2160	3840x2160	3840x2160
	Format	PNG	JPG	JPG	JPG	PNG	JPG	PNG	PNG
OpenStego	Size	7,8 MB	312 KB	186 KB	545 KB	2,06 MB	467 KB	7,8 MB	4,49 MB
	Res.	3840x2160	2048x1152	2048x1152	3840x2160	2048x1152	3840x2160	3840x2160	3840x2160
	Format	PNG	JPG	JPG	JPG	PNG	JPG	PNG	PNG
StegHide	Size	791 KB	277 KB	187 KB	770 KB	192 KB	749 KB	791 KB	877 KB
	Res.	3840x2160	1920x1080	2048x1152	3840x2160	2048x1152	3840x2160	3840x2160	3840x2160
	Format	JPG	JPG	JPG	JPG	JPG	JPG	JPG	JPG
StegoShare	Size	19,2 MB	339 KB	190 KB	647 KB	N/A	467 KB	19,2 MB	N/A
	Res.	3840x2160	2048x1152	2048x1152	3840x2160	N/A	3840x2160	3840x2160	N/A
	Format	PNG	JPG	JPG	JPG	N/A	JPG	PNG	N/A

Table 1: Results of the first test

The second test was designed to (1) understand if the compression algorithms used by the different services impacted the use of steganography; (2) to assess if the system would maintain its behaviour when using images with different characteristics, such as images with smaller resolutions or monochrome images; and (3) to assess if the system would work when hiding bigger text messages. Thus, this test consisted of 2 specific text messages of different lengths, encrypted with AES256, and hidden by a steganography application in 4 base test images of different colors and sizes. The first text message was "The quick brown fox jumps over the lazy dog" and the second is a random 256-character message. The adopted base test images for the second test are presented in Fig. 1 and consisted of a solid gray image with a resolution of 1920x1080 pixels, plus 3 other images from Volume 3 of the database of standard test images of the University of Southern California[4]. In particular, images "4.1.08 - Jellybeans" (256x256), "4.2.03 - Baboon" (512x512), and "5.3.02 - Airport" (1024x1024), were selected due to their different resolutions and the need to have both colored and grayscale images. All images were then converted to both PNG and JPEG formats due to the fact that

[4] `https://sipi.usc.edu/database/database.php?volume=misc`

some steganography programs only support one of the formats. To check the difference between the images before and after the upload to the online services, secure hashes (MD5 and SHA) were obtained and compared.



(a) Solid Color (b) Airport (c) Baboon (d) Jellybeans

Fig. 1: Adopted base images

The second test was conducted during the months of September and October of 2021, and a total of 224 images uploads were processed and analysed (7 online services, per 4 steganography applications, per 8 images - the selected 4 images with the first text message and the same 4 with the second one). Fig. 2 shows the percentage (%) of secret messages that were recovered after the respective image had been uploaded to and downloaded from, an online service. The results show that, when using Facebook, LinkedIn, and Twitter, no messages were recovered. The other services presented different results, having values of 0%, 75%, 87.5%, and 100% of success rates.

In detail, when using Facebook, Twitter, and LinkedIn services, the compression algorithm used does not appear to be the same, since the hash values of all images were different. Also, all images, regardless of resolution, file size, or format, were converted into JPG format, and the resulting file size is smaller. Images having a resolution of 3840x2160 pixels are reduced to 2048x1152 pixels on Facebook and LinkedIn. The metadata of the image is also changed.

When using Hi5, the image format is maintained regardless of its resolution. PNG and JPEG images maintain their format, even after the compression process. Images with high resolutions or images in JPEG format still undergo enough changes to disrupt steganography-based message retrieval. Hi5 appears to force a maximum file size of around 2 MB.

Considering Imgur, the results show that it reaches levels of 100% success rate when using images with a resolution of 1920x1080 or lower.

Images with higher resolutions, and in PNG format, are converted to JPEG and compressed in such a way that their size becomes far too small to retain the secret message. However, if the original image was already in JPEG format, the image file changes did not disrupt the steganography process.

Worthy of note, is the fact that the secure hash results of the retrieved images were different from the uploaded ones. After additional analysis, it was possible to conclude that Imgur striped metadata from all images, resulting in different hash values for the

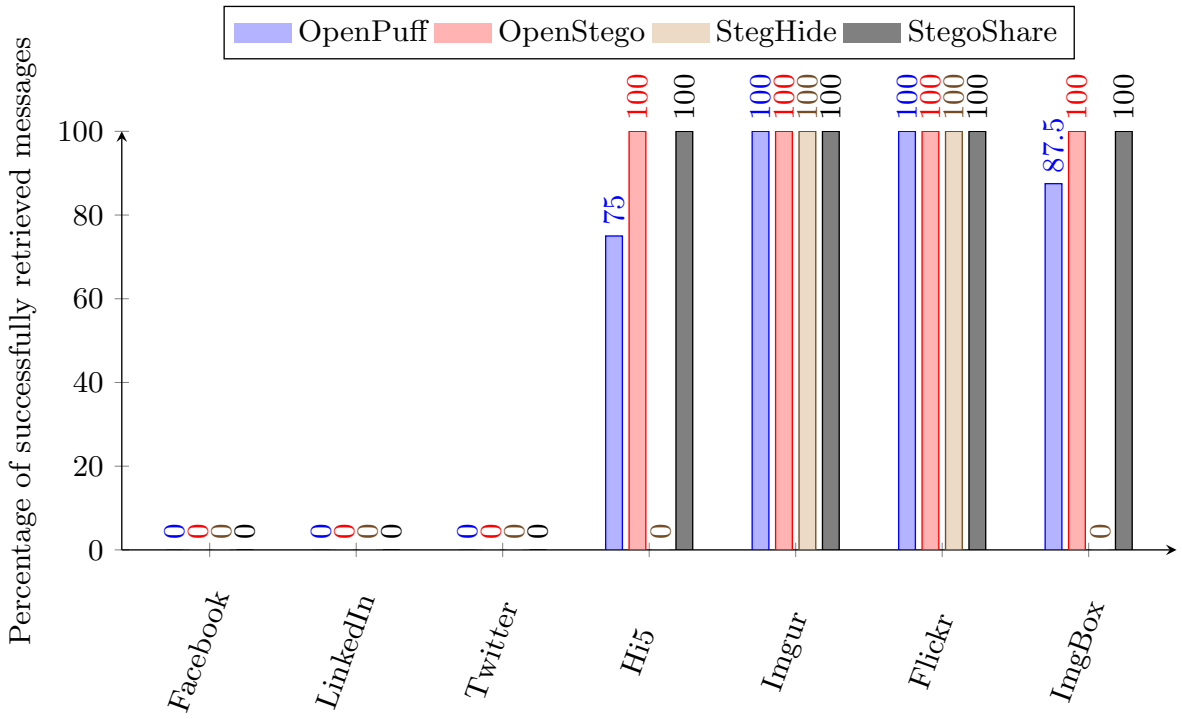


Fig. 2: Percentage of successfully retrieved messages

same images. These conclusions were drawn by extracting only the core data of the images and then comparing the secure hash values of these.

Considering Flickr, the results show that it reached the level of 100% success rate. These results are due to the fact that Flickr allows the user to download the original images, without any changes. Even image metadata and resolutions are preserved. The secure hash values of the downloaded images confirmed that no alterations were made to the uploaded images.

When using ImgBox, the results show that it was able to retrieve information when using all steganography programs, except when using StegHide. The reason for that is the same as the one found in the Hi5 section, because StegHide, in the context of our testing, can only work with JPEG images, which, in this case, undergo enough changes to disrupt steganography-based message retrieval.

Table 2 summarizes the comparison of the tested online services with regard to file modifications, image characteristics modification, and the capability of retrieving the hidden text from the downloaded images. Considering Imgur, it can be concluded that it alters the image files but does not alter the image data, as proven by different hash values of the files, and equal hash values of the data section of the image. Imgur also enables the retrieval of the hidden text, unless the image resolution is above 1920x1080 pixels.

As a remark, Flickr and Imgur appear to be adequate to demonstrate the viability of the use of steganography.

Table 2: Online service comparison

	Facebook	Linkedin	Twitter	Hi5	ImgBox	Imgur	Flickr
Hash Not Changed?	N	N	N	N	N	N	Y
Image Not Changed?	N	N	N	N	N	P	Y
Text Retrievable?	N	N	N	P	P	P	Y

Image resolution should be 1920x1080 pixels or lower. The PNG format offers more space to hide information, but it is also more likely to suffer compression and format change. The smallest image size used, 256x256 pixels, was still able to hide a 256-character message.

In particular, Imgur allows images to be uploaded anonymously and these images are also not listed on their website, so only the users that have the URL or know the ID of the image can access it.

4 Conclusions and Future Work

The importance of actively protecting our digital presence online is clear and imperative. Our behaviour online is under current scrutiny and the users should have mechanisms to avoid such scrutiny, but still be able to use online services. The work presented herein researched how steganography interacts with online services.

Steganography can be used as a technique to enable covert communications, and existing online services were assessed in terms of their support for the use of steganography in their services. Despite most social networks disrupting steganography due to their focus on image compression, a selected list of online services can be used.

As future work, other online services could be analysed to create a list of similarly operating services for data sharing between users. Such a list would increase the levels of anonymity and resilience of a decentralized service focused on using steganography as the main protection.

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Monitoring System for Smart Buildings - Apolo Building Case

Rebeca B. Kalbermatter[1,2], Thadeu Brito[2,3], João Braun[2,3], Ana I. Pereira[2], and José Lima[2]

[1] Universidade Tecnológica Federal do Paraná, Brasil
rebecakalbermatter@alunos.utfpr.edu.br
[2] Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Bragança, Portugal
{brito,jbneto,apereira,jllima}@ipb.pt
[3] Faculdade de Engenharia, Universidade do Porto, Porto, Portugal

Abstract. The demand for better safety and comfort conditions in social centers served as an incentive to improve the automation of buildings, making them intelligent systems that could be integrated. However, alongside these innovations, there has also arisen a concern for the ecological risks surrounding the smart building. With these factors as a basis, this work aimed to monitor three main systems within each apartment in the Apolo Building (Bragança, Portugal), namely electricity consumption, water consumption, and waste disposal. These systems are integrated through a common database, where they are being stored. This study intends to create a platform for data analysis, making it accessible to the consumer, raising awareness of the expenses generated, and looking for short and long term efficiency measures.

Keywords: Internet of Things · Smart Buildings · WSN.

1 Introduction

Buildings were created to become the center of social spaces, for either economic or residential activities. With the advancement of life in society within these spaces, comfort and safety began to be prioritized [15].

In the 1960s, the first centralized control equipment appeared, which were used for air conditioning of the environments. In the 1970s, with the advance of microcontroller use, there was an expansion in the control processes, followed, in the 1980s by the advance in the need to improve the workplace's, telecommunications services and computer systems. These requirements would contribute to the emergence of three pillars of the intelligent building system: automation, telecommunications and computer systems [15].

However, there was great confusion in the use of the term *smart*, because it induced people to have unrealistic expectations about constructions. Due to the lack of economic capacity and poor familiarity of new technologies, these expectations have been frustrated, in a way, the therm gained a negative connotation [15].

In order to centralize and promote smart buildings, the Intelligent Building Institute (IBI) Organization defined an intelligent building by [20]:

> A building that provides a productive and cost-effective environment through optimization of its four basic elements - structure, systems, services and management - and the interrelationship between them. Intelligent buildings help bussiness owners, property managers and occupants to realize their goals in the areas of cost, comfort, convenience, safety, long-term flevibility and marketability.

Therefore, it was concluded that an intelligent building would not only be automated, but that it provides greater integration between the systems [11], being these related to infrastructure, automation of systems and control of them, management and maintenance.

Following the structuring of an intelligent building, integrating the systems highlighted here, the present work aims to collect, store and analyze the data of the Apolo Building, using as database the platform InfluxDB and the web application Grafana for better visualization of the data.

The rest of the paper is organized as follows: Section 2 presents related work, followed by Section 3 which presents the architecture of the developed system. Section 4 presents the developed work and its validation, with the results and future work presented in Section 5.

2 Related Work

Wireless Sensor Networks (WSN) is an infrastructure that contains sensing, computing and communication elements interconnected by a single network node that allows the measurement, collection and control of the systems involved [2]. According to [13], the WSN consists of two important parts, namely hardware and software. For the first, a typical sensor node is composed of a low-power embedded processor, memory, sensor with ADC units, radio transceiver, location finding system and power supply. The software is composed of operation system microcode, sensor drivers, communication processors, communication drivers and data-processing mini-applications. In [7], an energy management solution using WSN and web services with middleware technology. A web application developed in the project was used to illustrate the concept of monitoring the data collected by sensors, allowing on/off control of electrical applications. In [16], a software solution is presented to bridge the gap between raw hardware capability and a viable software system. The TinyOS application has a small physical size, developed "to support the concurrency intensive operations required by networked sensors with minimal hardware requirements".

Energy and water efficiency are major concerns in the construction of a smart building [12]. This concern must go from the project stage through construction and must be maintained during the use of the building. According to the Official Journal of the European Union [19], buildings had an aggregate of 40% of the total electricity consumption of the European Union, with consumption increasing each year. In order to this, the Directive 31/2010/UE[4] promoted energy efficiency measures by stimulating automation of buildings and monitoring of technical systems as an effective alternative. In this way, consumers gain access to information about their consumption, bringing more awareness about their behavior. In order to optimize the monitoring processes of constructed buildings, measurement can be done through passive Hall Effect sensors, which are able to measure the voltage or electric current in the wiring of the building through a clamp-shaped sensor.

[4] Directive 2010/31/UE of the European Parliament and of the Council of 19 May 2010 as amended by Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 and Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018.

With regard to water consumption, World Water Development Report [4] states that the immediate concern is not only with the availability of water, but also how it has been managed. Focused on efficiency measures, Teixeira [18] developed a system that allows certification and labeling of water efficiency. According to the study in his project, the building where the measures were applied there was a reduction of 63.9% of the water consumption.

Another important system considered in this work is the waste management system, which has evolved in the development of smart cities through Internet of Things (IoT). In [3], Cerchessi et al. developed a waste management optimization application by monitoring the capacity of waste bins. Through the use of *LoRaWAN* [17], measurement is done by ultrasonic sensors docked in the recycle bin. The data is collected and analyzed in real time, allowing for planning of the next waste collection. With this technique, an 18% reduction in collection time and a long-term optimization of waste policies was observed.

All this integration between objects and systems is possible through *Internet of Things*. The term, which originated the origin in 1999 with the researcher Kevin Ashton [1], was associated with the technology that integrated inanimate objects, allowing communication, transmission and executions of various functions. However, the fast evolution of technologies involved brought significant concern to the industry. In [10], highlights that the growing evolution and increasing complexity of IoT brings troubling issues involving equipment heterogeneity, exorbitant amount of data, security and privacy.

3 System Description

The data was collected by three main sensors, these being the YF-B2 sensor, for measuring water flow, the weight cell, for measuring of waste disposal, and finally, the IoTaWatt, for monitoring electricity consumption. The first two have a connection with an ESP32 microcontroller, which sends the data to the database via WiFi. The IoTaWatt, however, sends directly via WiFi to the InfluxDB database. The constructed of architecture can be visualized by the diagram in Fig. 1.

For comparison and better analysis purposes, the DHT11 sensor, responsible for measuring the local temperature and humidity, was also added to the system. The sensors DHT11, the weight cell, and the water flow are designed to communicate with the ESP32, which is responsible for collecting and sending the data.

The IoTaWatt [8] is a device with an integrated microcontroller capable of measuring up to 14 different circuits through the passive sensor. A wall transformer converts the local voltage to a reference voltage, allowing the unit to determine the voltage and frequency of the monitoring line. It has its own web application so that real-time monitoring can be done. Despite this ability, we configure the device to transmit the data to the database via WiFi.

The choice of microcontroller ESP32-WROOM-32D [6] was by the fact that it is an embedded system board that integrates WiFi and Bluetooth on the same board, with low power consumption and high performance.

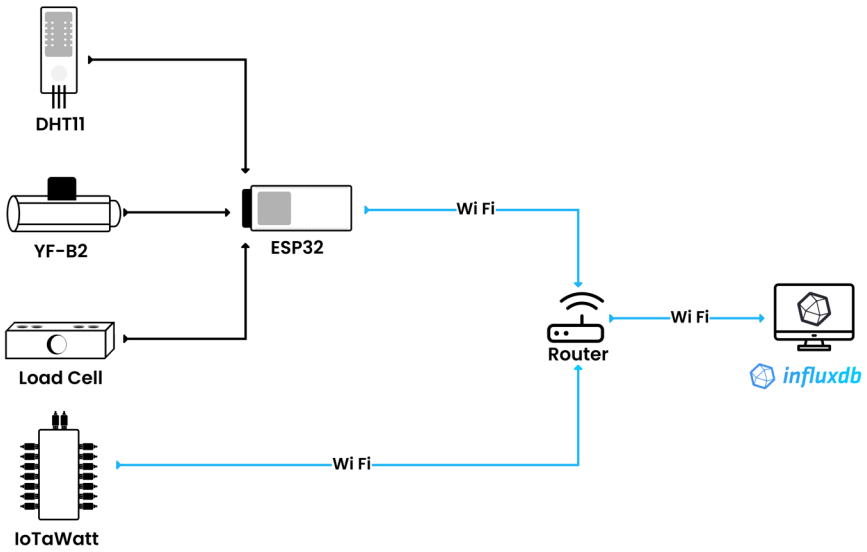

Fig. 1: System Architecture

The database chosen was InfluxDB [5], a platform developed by InfluxData that has a great popularity in systems involving Time Series Database (TSDB) [14]. This platform uses a language similar to Structured Query Language (SQL), with a high performance for times series. For a better view of the stored data, Grafana [9], a web application that allows the creation of monitoring panels by combining the data obtained in InfluxDB, will be used. The entire system was installed directly on the Windows operating system on the local computer of the building management.

4 Work Development

As mentioned, the measuring systems were developed to monitor the apartments in the Apolo Building. As the building is in the final phase of construction and with much of the structure already finished, an attempt was made to interfere as little as possible on the construction process.

The tests are being carried out in just one pilot apartment, where the IoTaWatt sensor, balance sensor and temperature and humidity sensor are already located. The water flow sensor depends on the installation of a professional, because it is the only one that makes necessary intervention in the structure of the building, it has not yet been possible to integrate it in the data collection. With this exception, it is possible to observe already in Fig. 2 the data being collected in the apartment, through the monitoring page created in Grafana.

For the waste weighing system, a 3D-printed prototype was developed that allows any waste drum to be used in the system. A button was attached to allow changes to the drum.

As the hardware part is still under development, it will not be presented at this time.

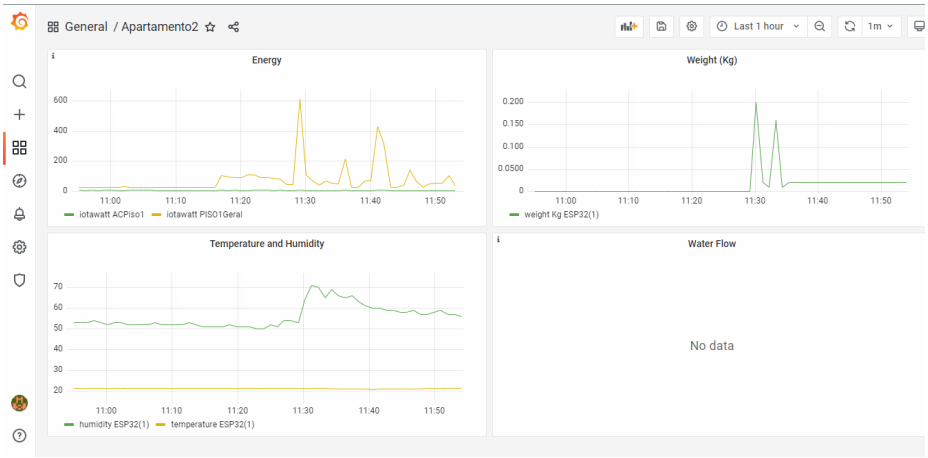

Fig. 2: Grafana Monitorization

5 Conclusions and Future Work

The integration of systems has become an important source of centralisation of information for the entire process developed in the building. Projects like this have great potential to have many doors open for future applications. As noted, using low-cost sensors and an open source database it is possible to create an integration with several input possibilities. This paper presented a monitoring proposal for buildings, so that, with the integration between systems, a diagnostic analysis of the data on consumption can be made.

The installation already allowed an advance in data acquisition and storage, so that, although it is not a real consumption, since the apartment does not have a resident, it allows us to develop and validate the proposed system. As the amount of collected data is still fairly small and the installation in all apartments is pending, we present the current results only to demonstrate the operation of the designed system. The objective of the work presented here is, through the data collected under the authorization of the resident, and the application of machine learning, to present possible exaggerated or peak-time expenses that could be avoided. The application of a linear regression will allow the identification of these expenses and predict the resident's consumption behavior, offering ecological solutions that allow economic and resource spending reduction. It is worth pointing out that the objective is not to act directly on the resident's behavior, but the data analytics allows to observe the behavior through the information presented to them. It is also expected that the data presented in Grafana will be better structured in order to make the application more objective. In the future, an application is also expected to be developed for the residents of the building, so that they might be aware of the building's consumption of resources.

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Artificial Intelligence to Identify Olive-Tree Cultivars

João Mendes[1], José Lima[1], Lino Costa[2], and Ana I. Pereira[1]

[1] Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, 5300-253 Bragança, Portugal {joao.cmendes, jllima, apereira}@ipb.pt
[2] ALGORITMI Center, University of Minho, 4710-057 Braga, Portugal
lac@dps.uminho.pt

Abstract. The exponential advance in artificial intelligence techniques makes it possible to apply them to previously thought to be impossible sectors. In this work, a different approach is presented to identify the different varieties of olive trees present in the olive groves of Portugal. Using its leaves and deep learning algorithms necessary for its classification, the proposed system can perform a reliable, low-cost, and real-time identification of the olive trees.

Keywords: Artificial intelligence · Olive · Classification.

1 Introduction

The production of olives, whether for olive oil or table olives, is a growing business, according to the Observatory of Economic Complexity (OEC), in 2020, approximately 1.23 billion dollars were handled in world trade, with Portugal being the third largest exporter with approximately 6.9% of the total amount [1].

In Portugal, olive growing is an activity of high economic, social and environmental importance. There are 361 483 hectares of olive groves in the country, in about 118 450 farms [12]. The olive tree is distributed from north to south of the country, with particular incidence in the interior regions, with Alentejo, Trás-os-Montes, Beira Interior and Ribatejo e Oeste being the main producing regions. In the last campaign (2021), provisional data from the National Statistics Institute point to a record harvest with an expected oil production of 2 25 million hectoliters [13]. This production is obtained through the various olive-tree cultivars present in our country, whether autochthonous or not. These blends of varieties are often beneficial as they each have unique chemical, physical and flavor characteristics [10,18] that are commonly used either to improve the season or date of harvest through the selection of varieties with different maturation periods, or to ensure a more harmonious composition of the oil from an organoleptic point of view.

In this way, and highlighting the notorious chemical and physical differences of the different olive-tree cultivars, it is extremely important for the olive oil producer to carry out a reliable and rapid identification of the varieties present in their olive groves. In this sense, a bibliographic research was carried out on the various identification techniques applied over time. Two terms, "Olive identification cultivars" or "Olive variety identification" were searched in two of the best-known databases (Web of Science (WOS) and Scopus). The research resulted in 914 and 534 documents in the WOS and Scopus databases, respectively, after their collection, the R software was used, combined with the bibliometrix tool [2], where trends and research techniques were analyzed as well as the main keyword groupings.

Through the results obtained, it was possible to perceive that most of the techniques applied for the identification of varieties consist of genetic analysis, techniques such as random amplified polymorphic DNA (RAPD), molecular markers, microsatellites, chemometrics and DNA Fingerprints [3–5, 7, 8, 20]. Techniques that have high reliability of responses, but are somewhat time-consuming processes that do not allow us to identify them on the spot, with the need to collect samples to analyze in the laboratory and with a relevant associated cost when one considers that in the same olive grove there can be dozens of different species. Other techniques related to identification through artificial vision have also been studied and implemented with encouraging hit rates [6, 17, 21]. On the other hand, these techniques always use the tree's fruit to proceed with its classification, thus being restricted to a specific time of the year to proceed with its identification.

Analyzing the problems that arise from the techniques presented above, the focus of this work is to ensure a form of identification on the spot, with minimal impact on the tree, and that can be carried out at any season of the year. In this way and analyzing what is being done in other cultures, the solution presented involves the use of artificial intelligence algorithms to identify the leaves of the tree. This is a solution that solves practically all the problems shown above, guarantees an instant classification without having to resort to specialized technicians, it is possible to do it every year, since the olive tree is a permanent leaf tree. It also guarantee that the impact for the tree and the cost associated with the process is null.

This implementation becomes easier taking into account the advances in the area of artificial intelligence algorithms, following the hardware developments. This type of algorithms has proven to be highly qualified for solving this type of tasks, being applied to various species such as pistachios [11], grapes [16, 19], apples [15] and other examples [9, 14].

In this way, the proposed approach is summarized by the use of artificial intelligence algorithms to identify the different autochthonous olive tree species.

This papers is organized as follows. After the introduction, section 2 presents the work methodology where the system architecture is approached and the focus of this article is highlighted. Finally, the third chapter concludes the article and points out future work.

2 Methodology

As the main objective of this work is the development of an artificial intelligence system capable of identifying the different varieties of olive-tree cultivars. For that, there is a set of steps to be taken and implemented, thus ensuring the correct functioning of the system. Figure 1 presents the system architecture.

As a common need for all artificial intelligence problems, the dataset is undoubtedly the most important element of these implementations. In this way, and since it is an innovative approach to the problem in question, it was necessary to proceed with the creation of a sufficiently large dataset of images to guarantee a good behavior of the classification algorithms. To this end, and with the help of partners specialized in the area, several visits were made to olive groves to collect the necessary material. It was

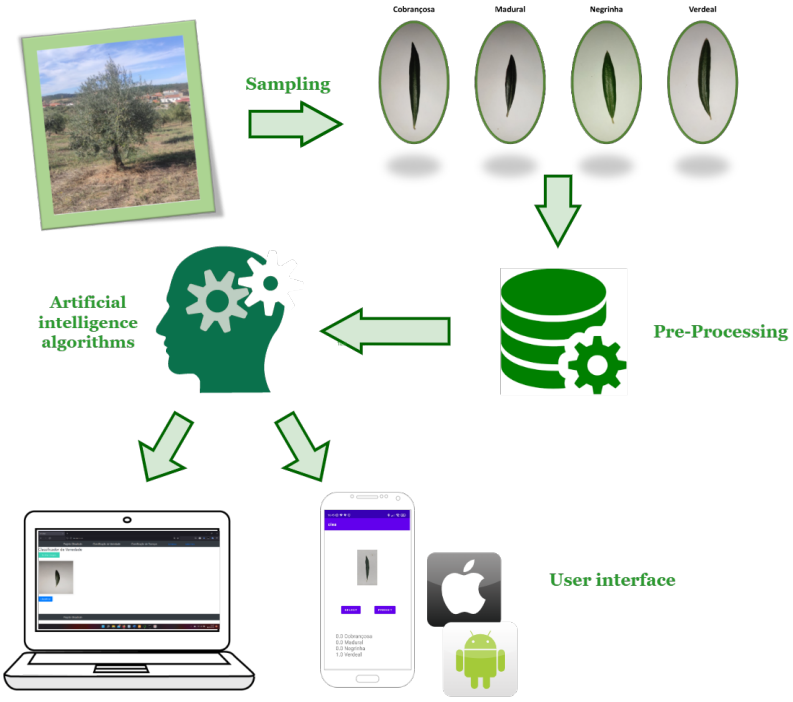

Fig. 1: System architecture.

stipulated at the outset to make collections in the different seasons of the year in order to accompany the growth and recession of the leaves, as well as other factors that have an impact on their development, such as water or nutrient stress, thus ensuring a correct identification regardless of the phase and conditions in which the tree is found.

After each sample collection, several processes need to be carried out, starting with the photographic capture of each sample on a white background to facilitate the algorithm training process, then there is a pre-processing of the images in order to reduce their size, optimizing the functioning of the algorithms. In this pre-processing, the photos were cut through autonomous processes, resized to a resolution of 299x299 pixels, and further normalized in its three layers (RGB). Once these processes are completed, it will be possible to implement the artificial intelligence algorithms. This implementation will consist of three steps: training the algorithm using the training set, classifying the test data, and analyzing it. After the implementation and the adjustments, the models will be made available on two platforms, the web version, and the mobile version, thus allowing their use by all interested stakeholders, whether they are consumers, producers, or just enthusiasts in the area.

3 Conclusion and future work

Constant hardware improvements are enabling a significant advance in the use of artificial intelligence methods for the most diverse purposes. As it was possible to prove with the cited references, there are already some works that propose similar approaches in different cultures, demonstrating the possibility of success of the presented study.

As the main future works of the study, it is possible to highlight the continuation of updating the dataset with more samples and the application of various machine and deep learning methods to enable the best possible results. It culminates in an easy-to-use application that aims to make it possible to identify on the spot, without additional costs for the user, the different varieties present in the national territory.

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Development of a Didactic Simulation Tool for Electromagnetism

Bianca Auwarter[1] and Ângela Ferreira[2]

[1] Instituto Politécnico de Bragança, Portugal
a37866@alunos.ipb.pt
[2] CeDRI, Instituto Politécnico de Bragança, Portugal
apf@ipb.pt

Abstract. The use of iterative simulations can present itself as a very important aid for problems involving electromagnetism, since a classical approach requires the use of concepts often not developed by students, such as vector calculus and geometry. Simulations also have the advantage of making use of images that can often be used together with the theoretical concepts. This work presents a tool developed by using an open source interface to finite element software that provides a visual iteration of the basic laws of electromagnetism, helping the student to better understand the abstract concepts present in classical problems. Currently the tool has been developed to demonstrate electrostatic problems and it is being expanded to incorporate magnetostatic problems as also eletrodinamics.

Keywords: Simulations · Electromagnetism · OneLab.

1 Introduction

The concepts present in electromagnetism, such as field, electric potential, force and vectors, cause concerns among students due to their abstract nature and mathematical demands. Research has shown that students remember images more easily than textual explanations [10], so the use of tools that can translate such obscure concepts into images has become plausible, for some researchers, the use of images is fundamental for a concretization of theoretical concepts already acquired [12].

The current teaching model was developed during the industrial revolution and aimed to train students to adapt to work in factories [1]. Nowadays we live in the "social media culture", the interpretation of images has become something common, young people are bombarded with more than ten thousand images a day [11]. In a society where everything is becoming digital, where seeing things through a screen has become the new normal, nothing more correct than an upgrade in the way of presenting concepts that, until now, due to lack of technology, were at the mercy of a good imagination.

Finite element tools aim to represent physical reality through a model, this method is a mathematical tool that makes use of the discretization of the study domains and divides them into small parcels, called finite elements. Software that makes use of the finite element method has become increasingly popular, currently presenting an impressive number of publications [17]. Despite the popularization of such tools, the license for such software can still present a high cost for academic use. Free software licenses are one of the solutions to these problems, and can present great competition, in performance issues, when compared to paid software [5], [14].

This work uses an open source software that makes use of the finite element method to propose an educational tool to help visualizing some concepts, through interactive simulations, in the electromagnetism discipline.

This work is organized as follows: the next section will present an overview of the finite element method. Section III introduces the tool itself, explaining in a general way its approach to some simulations already performed, specifically for Coulomb's law and finally section IV finalizes the paper with the main conclusions.

2 Finite Element Method (FEM)

Problems with simple configurations can be obtained an exact solution, through analytical methods, however, for problems where it is not possible to establish boundary conditions is used numerical methods, where approximate solutions are obtained, one of these methods is the finite element method.

In 1943 Richard Courant proposed a simple idea, which years later became known as the finite element method [3]. FEM was first applied to structural problems, only in 1968 it was applied to problems of electromagnetism [9].

The application of the finite element method usually involves four main steps, which are: discretization of the study region, approximation of the solution, where equations for the sub-regions are obtained, assembly of a system for all equations and finally the resolution of this system [17].

Domain discretization is the process of dividing a domain, which is bounded by a boundary, into subdomains called elements. The division of this domain is done by creating a mesh. The way that this domain discretization is done significantly affects the precision of the results [13], since in a finite element mesh a spatial discretization error appears, it is possible to reduce this error by making the mesh denser, however this presents a higher computational cost [19].

For straight lines or curves, which are the one-dimensional domains, short line elements are used, in order to approximate the original line. In the two-dimensional domain is usually used elements in the shape of triangles or rectangles. Usually, rectangle for rectangular regions and triangles for irregular regions. It is possible to use tetrahedrons, prisms or rectangular bricks for three-dimensional domains [21]. It is also possible to mix geometric shapes according to your domain.

A mesh is a set of elements, and an element is a set of nodes. The number of nodes present in the element is associated with the interpolation of the function within the element.

With the discretization already performed and with the points already identified, points that for continuous value problems will represent a variable, called nodal variable, the second step begins. In this step the nodal approximation and interpolation will be performed, that is, a polynomial will be defined for each element, from the nodal variable, keeping its magnitude continuous.

It is possible to obtain the polynomial equations in two different ways, the variational method and the weight-residual method, also known as Galerkin's method [17].

With the variational method the nodal variables need to be adjusted, by minimizing or maximizing some magnitude associated with the real problem, to obtain a good

approximation of the variable distribution. This method provides a system of algebraic equations where the resolution allows to obtain the nodal values. To maximize or minimize some variable it is necessary to set the partial derivative, of some magnitude related to the real problem, to zero [17].

It is possible to divide elements by order, for example: first dimensional elements can be defined as first or second order. First order elements, for a one-dimensional problem, are defined by two nodes, so it can be defined as a line segment, a linear function. Second-order elements are defined by three nodes, so it can be defined as a parabola, which is a quadratic function. For a two-dimensional problem of first and second order three and six nodes are required, respectively. So it can be concluded that the number of nodes of an element is associated with the order of the interpolation function within the element [2].

With the residual-weight method, the most direct way to obtain the equations, it is first necessary to find the residue, then the residue will be multiplied by a weighting function (W) and these will be integrated into the study domain and set equal to zero, as shown:

$$\int_{\Omega} W R \, d\Omega = 0 \tag{1}$$

Developing this integral will obtain the sum of two domain integrals and the difference of one boundary integral, this equation is known as the weak form of the problem. An important point is that the boundary integral is related to the boundary conditions of the problem. The integrals are performed over the whole calculation domain and not over each element and are associated to the nodes and not to the interpolation functions.

The boundary conditions can be of two types, being of Dirichlet condition or Neumann condition [20].

In the Dirichlet condition a value, usually zero is imposed on the nodes present at the edges of the problem, making it unnecessary to use the weighting functions on these nodes. In this boundary condition the normal vector and the case study vector will be perpendicular [17].

The Dirichlet condition can also be called the elimination method because this method eliminates the algebraic equation in which the condition is imported, thus reducing the size of the matrix system [17].

For the Neumann condition no value is imposed on the node of my domain, however it is imposed that the normal vector and the vector of the variation of the study unknown are parallel, i.e., the variation in the direction perpendicular to the contour will be equal to zero.

3 Onelab interface

Onelab is an interface to open source finite element code, its standard package consists of a mesh generator, called Gmsh, a finite element solver and an optimization library [15].

An open source is a software that has been made so that everyone can openly access, modify or distribute it at no cost [15]. Open source software is already available in

several areas, for example OpenFOAM [16], fluid dynamics, Aster Code [18], structural analysis, among others

OneLab was developed by C. Geuzaine, at the University of Liège in 2010, stands for Open Numerical Engineering LABoratory and allows the user to develop the most varied problems through a user-friendly interface [8]. To start using OneLab the user needs to construct the problem geometrically, that is, to transport the real problem to the virtual. To construct the "geo" part of the problem the user counts on an interface made up of several shortcuts that help in the moment of performing the design, the tool allows 2D and 3D designs.

The scripting language is used in this initial phase to develop the necessary designs, it is also possible to establish parameters that will act as a servant for the so-called "solver-clients". This makes OneLab based on a client-server model, structured in a way that it has a database, a graphical front-end and local and remote clients, connected through a TCP/IP protocol [6].

Once its geometric structure is defined and validated it is possible to use the Gmsh support, which is nothing more than a mesh generator, the software works with already stipulated patterns of mesh size and type, however these can be changed [7].

For the solution of the problems imposed to OneLab, it is used GetDP, a free finite element solver that uses mixed elements in the discretization of the problem [4].

For solving electromagnetic problems the software already has some libraries with the necessary mathematical principles, and it is also possible to find some examples of problems involving electrostatics, magnetostatics, and even electric motors in its collection.

3.1 OneLab Problem Development

In this study we developed some problems, involving electromagnetism, to test the functionality of OneLab in academic environments. It started with a more simplified approach in electrostatics, three point charges (Fig. 1), applying the Dirichlet limits,

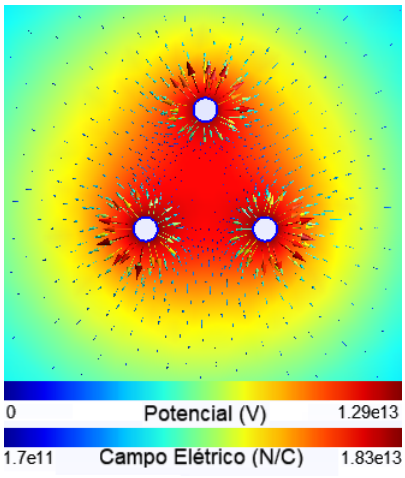

Fig. 1: Three positive point charges.

where the student could change the value of the charge and move them in the space under study, making use of a specific interface for this problem (Fig. 2).

This problem aims to make the concept of electric field and potential more visible to the student, allowing him to apply theoretical concepts in a practical example.

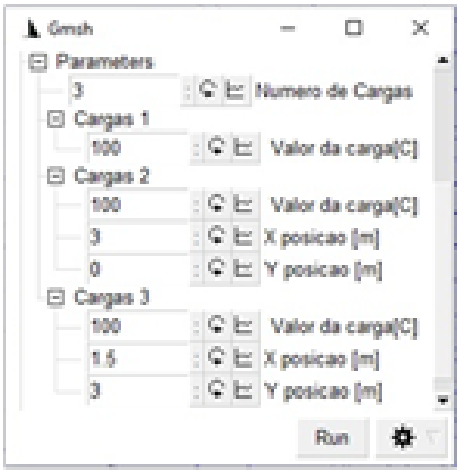

Fig. 2: Example of the user interface for Coulomb's law simulations.

Another didactic simulation presented is the line conductor, which allows the student to apply the right hand rule. In this problem the student can impose the current intensity that will pass through the wire, negative values being possible, thus testing the direction of the field.

The example of a capacitor (Fig. 3) was also developed, where the student can visualize in a practical way how this component works, making the concept of electric field and dielectric more visual.

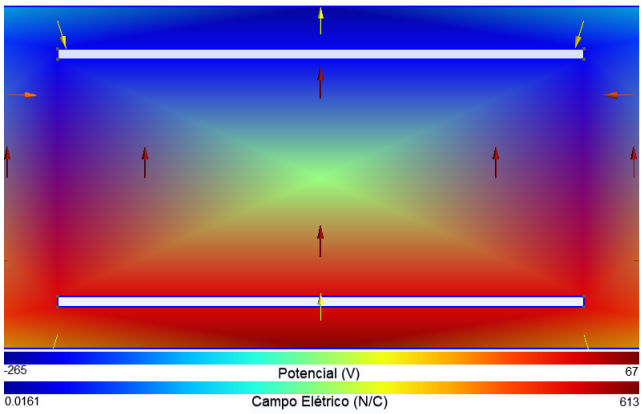

Fig. 3: Example of a Capacitor.

It is also possible to show concepts separately in the images, Fig. 4 shows the electric potential in the capacitor.

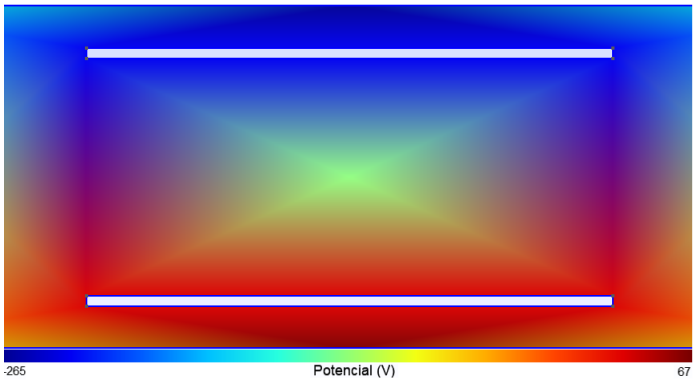

Fig. 4: Example of a Capacitor, Electric Potential.

Fig. 5 shows only the field. With this it is possible to explain different concepts to students, making use of the same example.

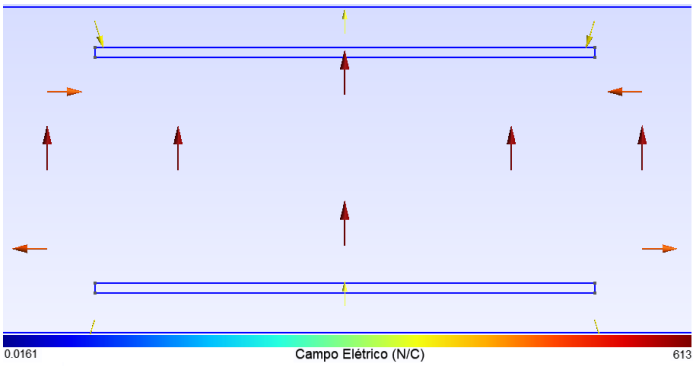

Fig. 5: Example of a Capacitor, field.

The software provides libraries that already include the mathematics for solving problems involving electrostatics and magnetostatics. With this, it was only necessary to develop extension codes so that there would be a connection between the libraries and the problems created in Onelab's graphical interface.

4 Conclusion

Simulation tools are becoming more and more present, which suggests making use of them to make the learning process more dynamic and current. In the age of technology, learning needs to keep up with development, and laboratory experiments are not always feasible due to their high financial and time costs. Tools that make use of finite elements

help in the issue of learning through simulations, and when these tools come with open source it becomes even more plausible in terms of costs for the academia.

With the development of more examples, the OneLab software appears as a great ally for the learning of electromagnetism in universities, because it allows to simplify, in a visual way, concepts that until then were considered abstract.

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Literature Review for Sample Size Analysis in Time Studies

Maria Isabel da Silva[1] and Clara Bento Vaz[2]

[1] Instituto Politécnico de Bragança, Portugal
a52500@alunos.ipb.pt
[2] Research Center in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Portugal
clvaz@ipb.pt

Abstract. An important method related to Lean strategies is Hoshin Kanri which combines operation and strategic management in order to solve both short and long-term problems in companies. Time studies are an effective way in order to apply this method. This paper regards to literature review in time studies of a process. In the literature review, two approaches of defining a sample size are presented: statistical analysis and conventional guide's method, both currently used in some companies. Future analysis of the data collected in a company's production line is devoted to verify whether or not the sample size is adequate, using both methods presented in this work.

Keywords: Hoshin Kanri · Lean Manufacturing · Sample size

1 Introduction

Many companies prioritize short-term over long-term problem solving inside industrial processes. This happens due to the apparent ease in dealing with daily problems in comparison with future ones [9]. However, "having a strategy suggests an ability to look up from the short term and the trivial, to view the long term and the essential, to address causes rather than symptoms, to see woods rather than trees" [4].

Having this in mind it is important to act strategically and focus not only on daily challenges but also on the future ones. Thus, this approach generates added value to the costumers and engaged employees [9]. One of the tools to support a company in the designing of a strategic management is the Hoshin Kanri, which can combine both short and long term problem solving [15].

This methodology consists in two main elements, deployment and planning [13]. Thus, targets and priorities to be achieved in a specific deadlines are set. While demanding commitment to develop solutions by which these targets are reached, Hoshin Kanri builds a link between strategic and operational management [11] [13].

Problem identification is a key factor for the method, hence understanding the process is necessary [6] [16]. This understanding can be facilitated through labor standards, which can be set through the time studies of a process [2].

Several steps are needed to accomplish a reliable study of time [10] [2]. One of them includes deciding how many observations are necessary to measure the time of a given process in order to obtain more-similar-to-reality results. It can be determined by a statistical method or by a conventional guide [17].

In [17] [12] and [2], it is presented similar techniques to do work measurements through the study of time. Those techniques follow a number of steps that are basic principles to generate reliable measurements while estimating the approximated time in which an operator does his job inside a workplace.

However, before knowing the procedure of reliable work measurement, it is important to understand that analysing the job times is a vital task, once it works as input for many analysis inside a company, including strategic planning, estimating labor costs and designing incentive systems [12].

In a production line, standard time is the time that an operator uses to accomplish a task under typical conditions. In order to accomplish the standard time, a qualified worker working at a constant pace is needed. It is also important to consider the layout of the workplace and all the process parameters. A change in any of those factors can also modify the standard time, making it inaccurate [12] [2].

In [2] the steps to determine the standard time are, firstly defining which task inside the production line is going to be studied, secondly, the task needs to be divided into precise elements, that can be called measurement points - this division in small elements is necessary because, some of them may not be performed in every cycle and it can be identified whether or not the worker's proficiency is similar for all the steps [12]. Thirdly, it is necessary to define how many times the task will be measured. That means how many job cycles should be analyzed to bring up the more precise results. Finally, every parameter is decided, the time is recorded and the average (arithmetic mean) is calculated. That considering the adjustments for unusual factor - by eliminating some observations measured in which the operator did some unusual thing due to, for instance, a machine problem or interruptions of any kind [2].

The third step related to sample size will be the focus of this work and will be discussed in the next sections. Therefore, the present work aims to review the current literature for statistical analysis regarding to the sample size currently used in the time studies in a company's production line in which Hoshin Kanri methodology has been implemented.

2 Literature Review

A review of the existing literature concerning the theme of this paper started with the search for "Hoshin method" in Scopus platform, once it is important to give an overview about the importance of sample size in strategic management methodologies. There were about 158 results for the research mentioned above, in which 45 were about engineering and/or management from the past 5 years. The mental map used to start the research is represented by Fig.2. [6] gives an overview of the labor standard importance and [2] presents that it can be set through time studies.

Concerning strategic management, [9] and [4] give an overview of the current state of some companies and their industrial processes. With [9], [15] [11] and [13] it was

possible to understand the method of Hoshin Kanri. Mainly in [11] and [13] it is showed the link between operational and strategic management brought through Hoshin Kanri method. [4], [16] and [10] gave also a good base for Hoshin Kanri theories, introducing the labor standards and time studies.

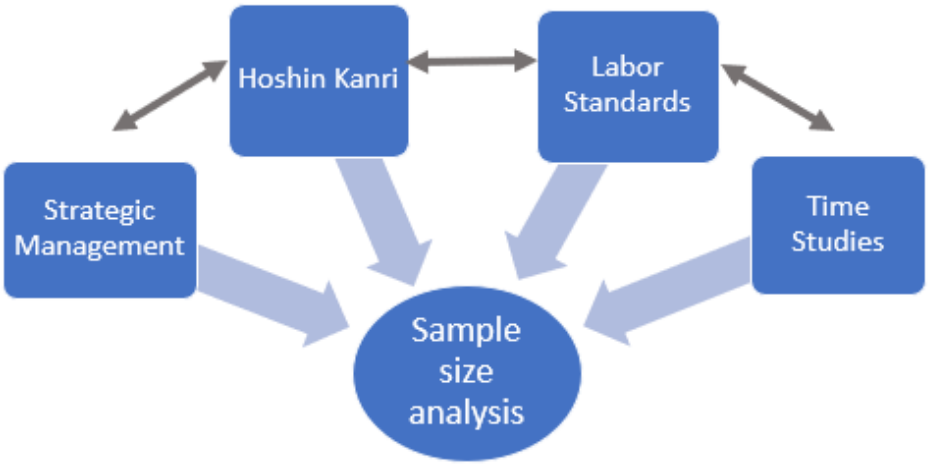

Fig. 1: Scheme of the mental map used for starting the literature review

Table 1 summarizes the time studies found in the literature. In [12] and [2], the concept of standard time was introduced, as well as in [2] the equation of sample size in time studies was presented. [12] and [2] also presented steps to measure the times, while [12] presents only 4 steps, [2] divides it in a more detailed manner, specifying that is necessary to make a division of the process into small elements. [10] focus on the third step, according to [2], that concerns sample size.

Although [1] and [10] give a good overview about statistical analysis of sample size, it is in [3] that it is presented some suggestion on values of accuracy and level of confidence. In [2] it is highlighted the influence of subjectivity in the measurements and the possible imprecision in final results.

Table 1: Summarized literatures on time studies

Reference	Description
[17]	Overview of time studies
[10]	Presentation of statistical and mention of convention approaches
[2] [12]	Overview of time studies and statistical approach
[1], [2],and [3]	Similar statistical approaches with case studies
[7] and [18]	Convention guides approaches

An important fact to mention is that almost all papers in time studies present similarities, once they mention an overview and also focus on the statistical approach of the sample size. It is important to state that [1], [2] and [3] present case studies regarding to statistical analysis, using it to estimate the sample size. Conventional guides was firstly mentioned in [10].

For the conventional guide method, not much was found. Although [7] and [18] present statistical method as well, they give further information about the conventional method, that is an interesting alternative used by some companies, as General Eletric [7] to estimate the sample size based on the minutes spent in the element for which the time is being measured.

3 Time studies

3.1 Statistical analysis

While measuring the times for operators in a production line, in which the jobs are repetitive, statistics techniques can be used to determine the required sample size or the number of observations equal to n, to provide reliable results, in a given level of confidence [1].

The sample size formula in time study work measurement is based on the normal distribution, considering the following parameters, according to [3] and [2]:

$\overline{x}$: mean of the observations.
s: standard deviation of average time from the preliminary observations.
z: number of standard normal deviate (or z-score) corresponding to the desired level of confidence selected.
p: desired precision or accuracy.

Hence, the number of observations is given by equation (1).

$$n = \left(\frac{z.s}{p.\overline{x}}\right)^2 \tag{1}$$

In order to illustrate the application of equation (1), a preliminary time study is conducted. In the first step it is necessary to define the number of observations required. Gathering more data through this first step makes possible to estimate new parameters and calculate a new sample size required for a particular confidence level [3]. However, some of the approaches can check if the precision resulting from a feasible sample is justifiable, since the sample size can be based on economic constraints.

Once it depends on human perception, the approaches mentioned above are susceptible to subjectivity, which is not incorporated into the model. That may cause an erroneous decision on sample size for not representing reality correctly [2]. The level of confidence and accuracy, for instance are parameters that depends on one's judgement. For the

first one, a low number could be not good enough to bring up good results and a 100% confidence could have big cost during the analysis [3]. Although any level of confidence could be chosen, most approaches use 95% and 99% [3]. In [12], it is stated that the accuracy level usually is ±5 %.

Also the standard deviation can generate imprecision, once it is rare that the value of s (standard deviation of the preliminary sample) described in the equation (2) is exactly equal to that of subsequent samples. [8].

$$s = \sqrt{\frac{\sum(x_i - \overline{x})^2}{(n-1)}} \tag{2}$$

Where:

s: standard deviation of average time from the preliminary observations.
x_i: value of each observation
$\overline{x}$: mean of the observation
n: sample size of the preliminary observation

If the sample size resulting on the equation (1) is less then what it was used in the beginning of the analysis, it means that the sample size must be increased. For example, considering a simple production line for an automotive company in which the operator A produces the product X in a specific cycle, going from the machine 1 to machine 2, and in turn, going to machine 3 and then returning to machine 1. This cycle is measured considering a preliminary sample size of 20, after that, one calculates the most adequate sample size by using the equation (1). Supposing that the n resulted was 30, the next step is to measure the cycle 30 times, changing to the new values of $\overline{x}$, x_i, preliminary sample size and consequently, n. This will happen many times until one gets an adequate value for the sample size [7]. Figure 3 illustrates the statistical method described.

By doing this method, one can find out that either a larger sample is needed or that the sample taken was adequate for the measurements [7]. However one disadvantage for this method is that, because of the number of iterations that may be done to reach the adequate sample size, the time spent for this sample size analysis could be high, and this may be costly for a company that will need an employee to perform these time consuming analyzes. Any how, in general, it is necessary to understand that the formula 1 gives approximated results and the more iterations are made, the more accurate the results can be, which is interesting, considering the importance of time studies into a company's performance parameters [14].

3.2 Conventional guide method

The statistical method is susceptible to several inaccuracies [2]. Besides, according to [7], the method is valid, only if it is confirmed that the observed variations are due to chance and are not made intentionally by the operator and it is also a laborious method, once

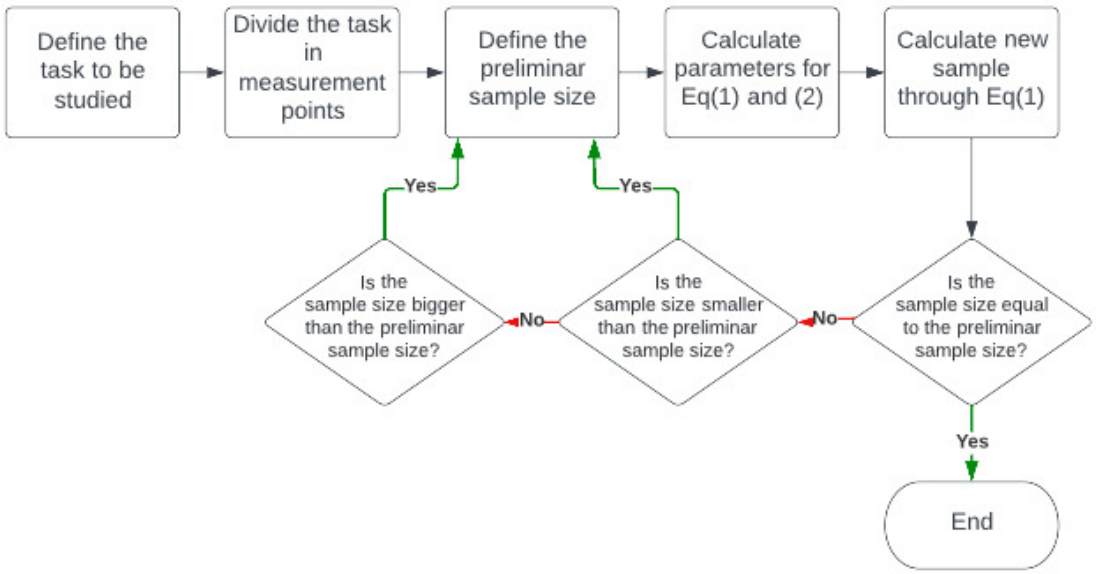

Fig. 2: Fluxogram ilustrating the statistical method

a given cycle is composed of several elements. Until an adequate number n is found, the sample size may vary for each element within a given cycle. This fact results in calculating the sample size for the element that, within the process, needs the largest sample size.

As a consequence of this fact, [7] presents a conventional guide for the number of observations, the sample size to be collected, based on the total number of minutes per cycle, which is summarized in the Table 2 [18]. In the case of adopting the conventional, it is important to make the observations continuously, once occasional elements, also called periodicals, may appear [7]. For this convention it is also important to ensure that periodical tasks are observed in a pattern several times.

Table 2: Number of recommended cycles for time study [7]

Minutes per cycle (min)	0.10	.25	0.50	0.75	1.0	2.0	5.0	10. 0	20.0	40.0
Number of cycles recommended	**200**	100	60	40	30	20	10	8	5	3

Therefore, for the company time studies, this method can also be adopted, once the total time in minutes taken for each activity of each operator inside the line in analysis is usually between 1 and 2 minutes, which imply a sample size of 20 measurements according to Table 2 [7].

Once this method is based on a previously-defined table, it may be susceptible to subjectivity and may also cause an erroneous decision on sample size. Additionally, the fact that sample size is not chosen by making iterations continuously, it maybe slightly imprecise when compared to the statistical method. However, it is used in many companies as General Electric [7], since it is not a time consuming method. On the 3 below, it is possible to see the illustration of the conventional method.

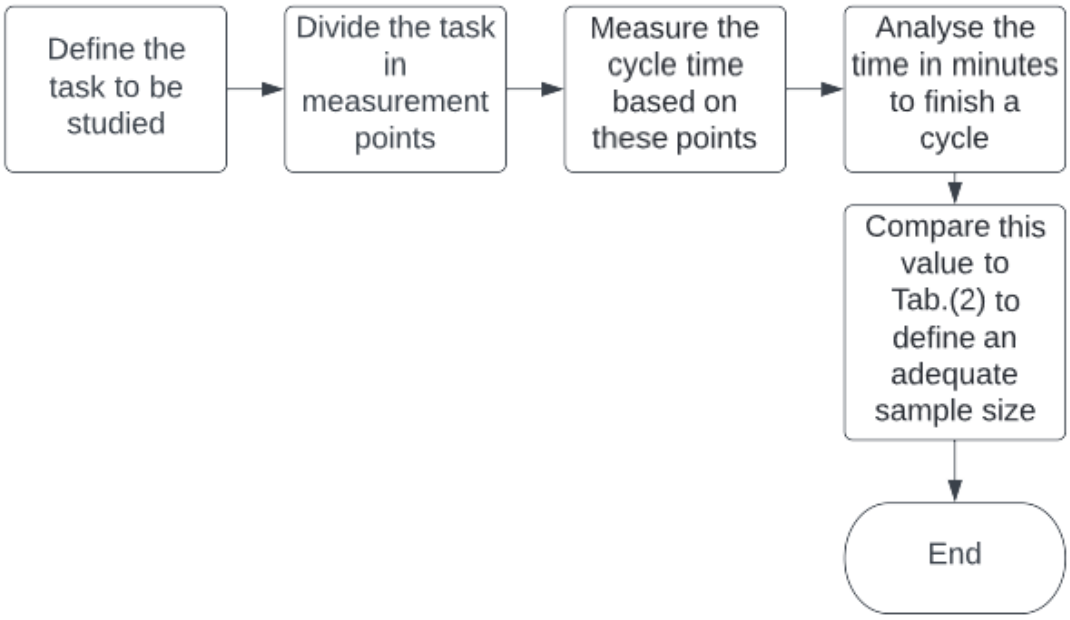

Fig. 3: Fluxogram ilustrating the conventional method

4 Conclusion

Visualizing the global need for time studies related to efficiency gains in processes, in the calculation of costs associated with products and in various performance parameters, it is important that the sample size to perform the time analyzes is as adequate as possible

Thus, with the present paper, it was possible to understand the similarities between the approaches used to estimate sample size for time studies in several areas. For the production lines, it could be verified that both conventional guide and statistical method could be applied for checking if the current sample size used for measurements inside a company is adequate.

For future works it is expected that an automatized spreadsheet will be created to estimate and verify those sample size, using both conventional guide and statistical

methods mentioned in this paper. The development of statistical data treatment will be made the times measured for future works, focusing on the statistical method mentioned.

Acknowledgment

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Functional Electrical Stimulation Driver for a Werable-based Bio-stimulation System

João Lucas Gonçalves[1], José Lima[1], and Paulo Leitão[1]

CeDRI, Instituto PolitÃ©cnico de BraganÃ§a, Portugal
{joaogoncalves, jllima, pleitao}@ipb.pt

Abstract. Electrical stimulation is widely used in clinical applications as an auxiliary treatment method for muscle injuries or illnesses provoked by muscle atrophy. In most cases, the regular stimulation systems do not provide the proper flexibility to fit the patient's needs or do not provide the freedom of movement due to their size. This paper presents an electrical stimulation driver based on a MOSFET-Transformer topology controlled by a microcontroller. The circuit is integrated into a wearable bio-stimulation system that uses dry electrodes and is controlled by a mobile application. The main system requirements are the stimulation flexibility as well as the driver size. The circuit must be able to generate stimulation pulses according to the patient necessity and be small enough to fit a piece of wearable equipment. The pulses are generated by a microcontroller, controlled by a mobile application, the application sets the pulse parameters such as width, amplitude, and frequency, and the driver performs the signal conditioning, amplifies, and generates the output waveform.

Keywords: Functional Electrical Stimulation · Wearable Biostimulation · Stimulation Circuit · Electrostimulator.

1 Introduction

Electrical Stimulation can be used to produce changes in muscle action and performance, specifically in clinical settings it can be used to improve muscle strength, decrease atrophy, and increase range of motion, among others [2].

However, most electrical stimulation equipment's are bulky and does not provide the necessary flexibility regarding the stimulation parameters [4] [5].

This work presents the development and experimental results of an electrical stimulation driver developed for a Wearable-based Bio-stimulation System. The main objective of this work is to develop a circuit capable of generating flexible parameters to fulfill muscle stimulation according to the patient necessity and be small enough to fit in a wearable device.

This work has been developed in the environment of the NanoStim Project, this project aims the development a system capable of identifying walking movements by acquiring electromyogram signals and processing those signals using a machine learning protocol to create a stimulation pattern dedicated for each patient according to their illness and condition. This way, the patient that suffers from a motion deficiency can fulfill the required treatment at home, avoiding the setbacks of locomotion to the physiotherapy clinic without compromising the treatment efficiency. The description of the remaining blocks of the project can be seen at [8].

The rest of the document is organized as follows: Section 3 presents the system requirements, Section 2 presents the current state of art of the technology, Section

4 describes the system development, Section 5 presents the experimental results and Section 6 presents the conclusions of the realized work.

2 State of the art

Functional electrical stimulation is the most common treatment technique used in motor function improvement, aside from conventional therapy and occupational therapy [4]. FES can be used to treat a great variety of diseases, conditions, and disorders in a non-invasive manner [7] [3].

To fulfill this *Cheng at al.* [4] proposes two alternatives of implementation. The first implementation is based on two integrated circuits timers 555, with operational amplifiers to generate the pulses, and a transformer to step up the output voltage, the pulse parameters are controlled by changing the discrete components. The second implementation consists of a transistors pair and resonant converters where the pulse amplitude is regulated by changing a resistance.

Following the same principle, *Velloso et al.* [9] proposes a solution composedof operational amplifiers for conditioning and feedback, followed by a pair of transistors and a step-up transformer. The system is controlled by a *LabView 7.1* application to control the pulse parameters.

Similarly, *Basumatary et al.* [1] propose a microcontroller based system that produces biphasic waveforms using n ESP32, waveform converter, current amplifier, and a step-up transformer.

3 System Requirements

Electrical Stimulation consists of the generation of muscle contractions by artificially inducing a series of short electrical pulses applied to the muscle using electrodes. To promote the muscle contractions, the circuit must generate biphasic pulses controlled in amplitude, time, and frequency [4] [6], in a way that those parameters can be fully controlled.

Usually, the regular stimulation systems provide pre-determined programs for stimulation, in most cases, those programs do not fit the patient condition [7]. The development of a flexible system makes it possible to create a specific treatment for each patient and make the due adaptations according to the patient progress.

4 Stimulation Circuit

The proposed Stimulation Circuit is composed by a MOSFET - Transformer topology, associated with a DC-DC step-up converter where the pulses are applied using dry electrodes. With that in mind, the driver must generate an biphasic pulse where the parameters are determined by the system commands. The circuit can be observed in Figure 1.

The stimulation driver is divided in two blocks, conditioning and amplification. The conditioning block is composed by a pair of MOSFETs, each MOSFET receive and switch one pulse from the microcontroller.

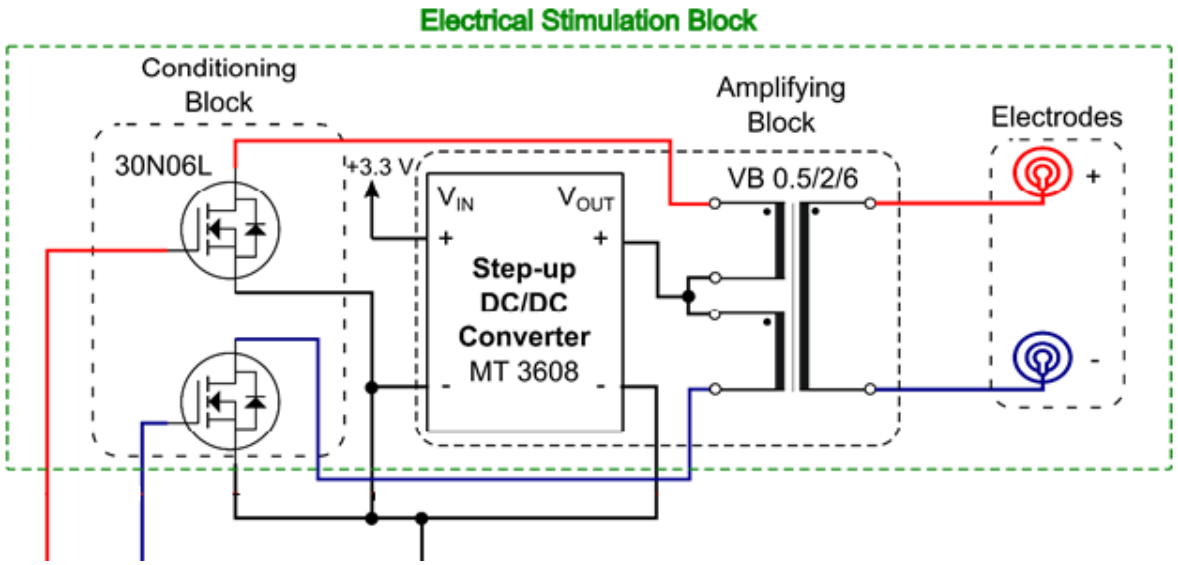

Fig. 1: Electrical Stimulation Circuit, divided in conditioning and amplification block.

The amplification block generates the biphasic waveform, and amplify the output signal. This block is composed by a DC-DC step-up converter with a 1:20 conversion rate, and a transformer VB 0.5/2/6 with a 6:230 conversion rate. The step-up was chosen due to its conversion rate and price, and the transformer due to its size (22/22.7/19mm) and disposition of the pins. The chosen transformer have four pins in the low voltage size, this make it possible to generate the biphasic waveform, and amplify the output signal simultaneously.

The pulses are generated by the microcontroller, modulated in amplitude by the conditioning block, and applied to the pins at the ends of the low voltage side of the transformer, while the step-up converter feeds the transformer with a constant voltage. This configuration makes it possible to generates the biphasic waveform, and reach the necessary amplitude to fulfill the muscle stimuli.

The complete NanoStim architecture is described by Sestrem et. al in [8]

5 Experimental Results

The application of the circuit consists in the command, generation and application of pulses modulated in amplitude, time and frequency. The pulses are generated by a ESP32 microcontroller, commanded by a mobile application connected via Bluetooth Low Energy (BLE) Protocol, and applied to the patient skin using dry electrodes.

The pulse amplitude is increased by changing the pulse width by applying a PWM, and the frequency is altered by changing the time between pulses. During the experimental tests, the pulse width was changed between 10μs and 250μs, once the stimulation voltage vary for each subject the pulse width was changed until the signal generates visible muscle contractions. Figure 2 illustrates an example of an output waveform acquired during a stimulation application.

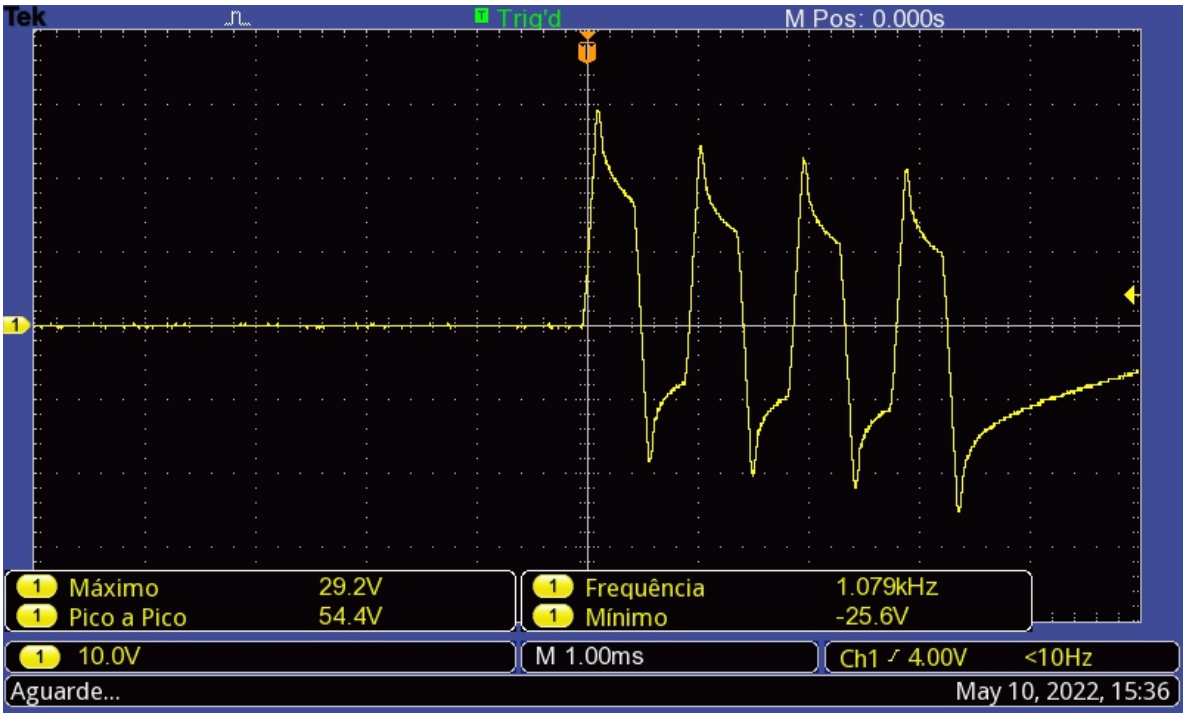

Fig. 2: Output signal acquired during a stimulation test using a 34mm Titanium based dry electrode.

This output signal is an example of an output signal obtained during a stimulation test performed on the forearm muscle. The pulses were applied using titanium-based dry electrodes, and visible muscle contractions were generated by applying an output voltage around 54V peak-to-peak.

6 Conclusions

The proposed stimulation driver based on a MOSFET-Transformer topology considers the use of dry electrodes and a flexible pulse generation applied by a microcontroller controlled by a mobile application. Preliminary tests were performed and show that the main objectives of the circuit were achieved, mainly in the production of flexible pulses according to the system command. Also in the generation of muscle contractions by the application of the pulses using dry electrodes concerning the patient comfort, in a way that the stimulation was performed without any signs of discomfort or pain.

During the tests, it was noticed that the position and condition of the skin were critical to obtaining a quality stimulation output, so the skin needs to be cleaned properly and the electrodes have to be fixed in the optimal position to recruit the right muscle fibers.

Future work is devoted to minimizing the circuit volume by changing the components to smaller ones that achieve a satisfying result. Developing a PCB prototype integrating the stimulation driver with the remaining NanoStim blocks is also considered a future work.

ACKNOWLEDGEMENTS

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Connection Validation for Titanium Based Thin Film Dry Electrodes

R. Conselheiro[1,2], P. Leitão[1], and C. Agulhari[2]

[1] Research Center in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
{raulconselheiro, pleitao}@ipb.pt
[2] Federal University of Technology - Paraná, Campus Cornélio Procópio, 86300-000, Brazil
raulkaizer@alunos.utfpre.edu.br, agulhari@utfpr.edu.br

Abstract. Titanium based dry electrodes were developed for muscle electrical stimulation and signal acquisition. To maintain the electrodes inexpensive, they were made through fusion deposition modeling and covered with thin film. As uncontrollable changes occurred during the printing process, the developed connectors ended with irregularities that compromised the electrical conductivity as the deposition of thin film could not overcome these irregularities. The linear architecture used for printing also results in electrodes with weak resistance against forces applied in perpendicular ways making the connector often detach from the electrode. This work presents the proposition of auxiliary structures for conductivity while using the connector previously developed just for support and stability.

Keywords: Thin film · Snap button · Dry electrode.

1 Introduction

When dealing with biosignals there are several options of sensors that may be selected according to the desired signal, position, condition of use, specific conditions of the patient, and so on. In the same way that these parameters may differ, there are lots of options for bioelectric electrodes. The terms wet and dry are used to separate them into two major groups, being considered wet electrodes the ones requiring some type of electrolyte between the electrode and the skin, or the ones with some type of conductive gel in its main body [**?**] (also known as semi-dry electrodes as the gel is highly viscous).

Allergic reactions due to the medium/long-term exposure to the conductive gel [**?**] are not an uncommon sight. Furthermore, as time passes, the electrolyte dehydrates, worsening the signal and prejudicing the electrodes, making them disposable after just a few sessions [**?**]. So, electrodes that dispense the use of conductive gel started to be developed creating the category of dry electrodes.

As a new type of technology, many different approaches have been taken in recent years regarding the composition and the electrode's features [**?**] [**?**]. Since they can be used for acquisition of various signals and electric stimulation of many muscles, they can be found in the most varied shapes and materials [**?**] [**?**]. These electrodes aim at being efficient, inexpensive, and hypoallergenic allowing its reuse after the proper cleaning. The comfort when maintaining the electrodes on skin for long periods is also one of their strong points as they do not need gel [**?**].

Nevertheless, if the transmission quality between the electrode and the necessary electronic systems is not reliable, there is no point in presenting all the described advantages as the acquired signal may be compromised during the transmission process. In the same way that the electrodes were improved, new connection methods are developed. Conductive glue was used by [**?**] to connect the wire to the metal pattern used as electrode. Conductive silver paste was used by [**?**] to glue the gold plated connector for lead wire. The usage of conductive cloth wrapped around the electrodes [**?**] or conductive tape [**?**] to fix the structure to the electrode's "body" were also find in literature but the analysis of these methods efficiency was not deep or the focus of the works.

Aiming to ease the connection, this work brings the design and tests of connectors for dry electrodes made of Polylactic Acid (PLA) through Fusion Deposition Modeling (FDM) and then, functionalized with titanium based thin film deposition. Aiming for a stable and reliable connection that can endure the routines of the electrodes such as treatment sessions and cleaning, an adaptation of the snap button technology was implemented and improved according to the electrode's unique features.

2 Performance Indices and Tests

The first connector design followed the shape and purpose of commercial snap buttons but instead of being spherical at the end, it was a simple cylindrical pin to verify if the thin film deposition would be able to cover the entire structure. As the electrodes were 3D printed, sometimes the final piece presented irregularities at the surface almost invisible to the naked eye; So, to measure the electrical resistance after the deposition was the easiest way to verify if the thin film would be able to compensate for these irregularities.

Another important factor was the printing geometry of the piece since it would not only influence the strength to weight ratio but the smoothness of the surface [**?**]. Even so, due to the electrodes' size and purpose, only linear architecture could be used. The adherence of substrates in linear geometry presents enough strength in horizontal orientation but as shown in Figure 1, this structure is weak when force is applied in vertical orientation since the adherence is not strong enough. This happens because when force is exercised perpendicular to the piece it works in the same way as removing layers of an onion, in other words, when pulling the pin (i.e. during the disconnection) the force applied is easily enough to detach the pin from the electrode's body.

Fig. 1: Broken pin after connector pressure test

Knowing the pin would easily come off of the electrode, the base of the pin was widened to better distribute the force and reduce the chances of rupture. The new model can be seen in Figure 2 where the structure on the side of the electrode is just a support to be used during the deposition process. The pin dimension for this model were obtained after the internal dimensions of the female snap connector were measured to ensure it would not fall off during experiments.

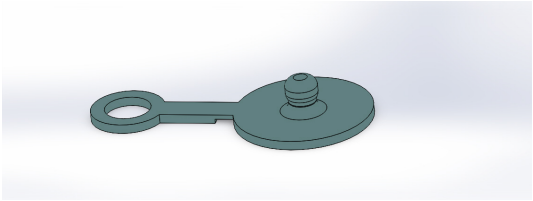

Fig. 2: Broken pin after connection tests

With the new electrodes in hand, tests consisting on continuously connecting and disconnecting the electrode to the female connector were carried to verify the pin's endurance. Another way of analyzing the snap button quality was to measure the electrical resistance between the base (that is supposed to stay in contact with the skin) and the top of the pin. As stated earlier, the irregularity of 3D printed surfaces makes it difficult for the thin film to cover the electrode evenly, so the electrical resistance at different points of the electrode is a good indicator of gaps on the cover.

Among the many possibilities of thin film, the one chosen to be subjected to the tests was copper as its electrical resistance was lower and this would ease the electrical resistance analysis. Also, the characteristics of copper are well known while the other thin films were the result of combined elements which made it difficult to know their chemical and physical characteristics with precision.

3 Results

Since the pin was designed with the internal dimensions of the female snap connector, the pressure applied together with the stiffness of PLA was enough to remove the parts of the thin film as illustrated in Figure 3.

In some cases, the diameter of the snap button ended bigger than in others due to changes in the printing environment to which the printer was subjected to. This resulted in excessive pressure which resulted in the male connector breaking during disconnection (see Figure 4 for reference) and if the pin broke inside the female connector the process of removal could worsen the conductivity of the female connector.

To prevent diameter variation from being an issue, another version of the snap button was designed with the necessary adaptations. The diameter was slightly decreased to reduce the pressure and prevent the pin from breaking and the height of the pin was increased to ease the disconnection process. Although intended to just ease the disconnection, the increase in height created the gap shown in Figure 5 between the female snap connector and the electrode. It clarified that the responsibility for transmitting

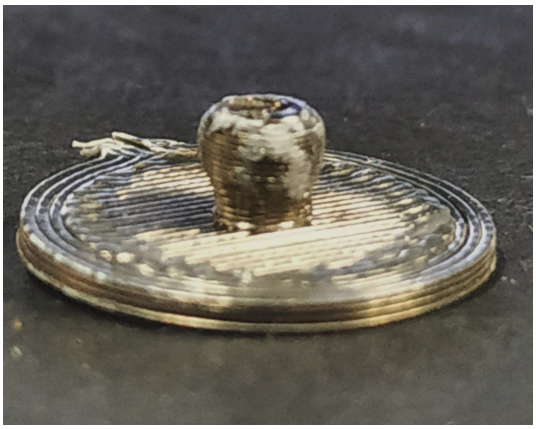

Fig. 3: Snap button with damaged thin film

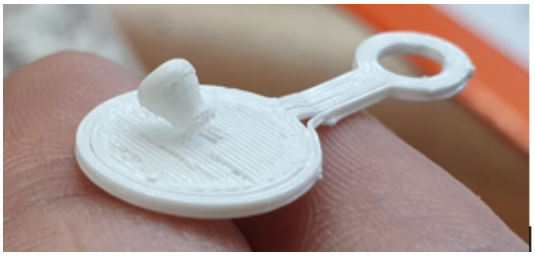

Fig. 4: Broken pin during disconnection

the signals was on the contact now severed by the gap, while the pin only worked as support to maintain the stability.

Fig. 5: Gap between electrode's "body" and female snap connector

To support the affirmation of the pin being just a support Table 1 shows the immense increase in electrical resistance for copper electrodes. Both experiments were made with electrodes recently produced with intact thin film and the same female connectors were used for all electrodes with cleaning sessions between the tests.

4 Discussion and Conclusion

The necessity of reliable connections is of utmost importance since it is responsible for ensuring good signal acquisition quality and safe electrical transmission. There are

Table 1: Electrical resistance between the base of the electrode and cable end

Connection	Samples	$R_{th}(\Omega)$
Without gap	8	148
With gap	6	1.84K

many types of connection already existent and many proposed types still being studied, but the proposed electrodes require a new type specifically for them.

As the electrodes are 3D printed aiming to keep the price accessible, the best option is to also print the connector. For this reason, this work implements and tests a new type of connection simulating snap button but printed out of PLA together with the electrode and thin film covered. The necessary improvements were implemented in each new version and tested again until the conclusion of this work was achieved.

With the irregularity of FDM and the limitations of thin film deposition, the connector works just as a support to maintain the connection throughout the session. This being said, some type of disk or prominence must be included in future versions at the bottom of the pin. While maintaining the contact between the electrode and the female connector, if the diameter of this prominence is smaller than the diameter of the female connector and the electrode, the ease in disconnection aimed at when the increase in height was implemented remains.

Studies about other printing orientations aiming to increase the strength of the electrode remain as work to be done as well as other connection shapes that allow higher quality deposition making it possible to use only the pin for both support and transmission.

ACKNOWLEDGEMENTS

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Design and development of a mechatronic water saving system for conventional faucets

Ahmed Kchok[1] and João Paulo Coelho[1,2]

[1] Polytechnic Institute of Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.
[2] Research Center for Digitization and Intelligent Robotics (CeDRI). Polytechnic Institute of Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.
jpcoelho@ipb.pt

Abstract. In many places around the globe, such as North Africa and middle Asia, water is a very precious and scarce resource and must be used rationally. For example, preventing water from running through the taps when it is not being used is one of the actions that should be considered. Among several studies and efforts to save water use, it has been proposed to create a system for water usage mentoring [1]. Automatic water taps which are meant here are water taps on the sink and also water taps for ablution or showering. Other thoughts were about preventing leakage and detecting water overflows from containers based on the water level sensors invented as proposed by Coca, Teresa Mae, Perin, and Max Angelo [2]. While these remains to be enhanced, this article follows these ideas and describes the prototype that can be attached to conventional off-the-shelf faucets in order to prevent water waste. The system is conceived through the Solid-Works software by assembling the different parts of extracted sketches. The paper reports the possibility of using three batteries in serial while dropping down the current flow from the value of 2000 mAh to 300 mAh through a DC-DC buck converter. this was deployed as a result of the disability of one battery to satisfy the duration's condition. Using the Arduino Uno and the Buck converter the controlling signal and be insured through the H-bridge in order to switch between two outputs of the actuator for each stance.
Basically, the circuit is mounted on a breadboard and based on the main chips such as ATmega 328P and L296 in spite of the protection circuit as designed by Arduino. The electronic part will be incorporated into the system design conceived to fit the majority of single lever taps. the document later discloses the water wastage problem specific to the household's problem namely water taps, highlighting a shade of what predecessors had relevantly done to solve it. In addition, the paper provides the obtained results annexed with some explanatory diagrams and finally drawings of the conclusion. The signal delivered by the circuit was very satisfying with the 12 Volts actuator and was revealed effective and can be used in any application involving liquid levels. The actuator in return will be sufficiently able to carry and drag down the tap's lever with its 40 Newton force.

Keywords: infrared · Ultrasonic sensor · Single Lever Tap. ·

1 Introduction

Water is vital for all living things on the earth, so there must be an effort to save water. The suggested here-by system's working principle consists of two following functions: The water tap will open if there is an object(human) detected in front of the water tap. On the other hand, the ultrasonic sensor is set for water level detection as it will be located on the edge of the bucket. In this automatic faucet system, the Arduino mega2560 micro-controller is used as a data processor obtained from ultrasonic sensors and Passive Infrared Receiver (PIR) sensors. The two sensors are used interchangeably and the results are compared to determine the difference in response time. Based on the tests that have been done, it is found that the time needed for the ultrasonic sensor

to open or close the water tap is faster than the PIR sensor. When opening the tap the time needed by the two sensors is almost the same, which is only a 4ms difference. Whereas when closing the tap the time needed for the PIR sensor is much longer, which is more than 4s. This is because the process of returning the sensor to return to normal is not detecting the presence of humans in other words the sensor does not detect infrared rays and tends to require a longer time. As for the ultrasonic sensor because what is detected in the distance, then the object moves from the front of the tap then the distance detected will change immediately so that the tap will immediately close again.

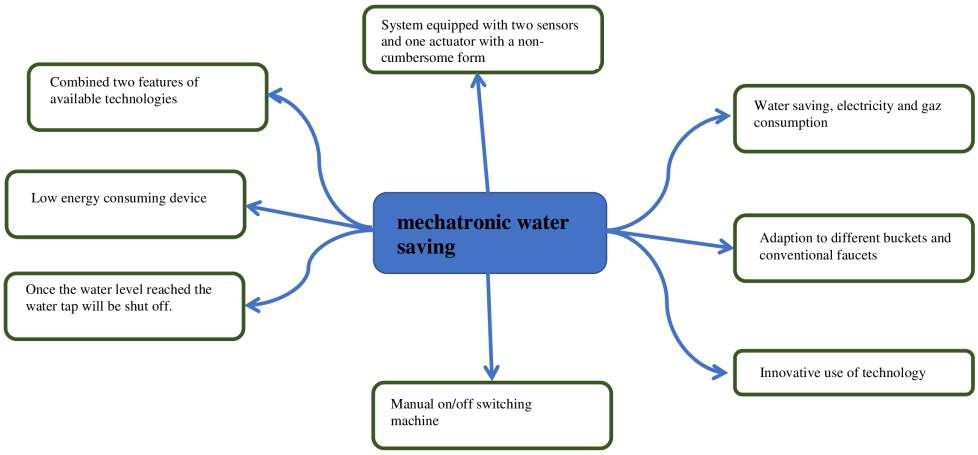


Fig. 1: Operational characteristics that the current solution must provide.

2 Related work

The author in [3] discussed a possible implementation of a camera to visualize, analyze and detect the washer's hand. the solution consists of the programming of the micro-controller through Python. An approach referring to the segmentation integrating color and motion. In addition to hand detection, his solution encloses another feature such as bottle detection that concerns water level detection. The bottle is detected, and the bounding box is computed. In that way, the machine will calculate the amount of the required water for the hand otherwise for fill the bottle/container. As a result, the accuracy obtained for the detection of hand is 85.7% and for the bottle is 77.8%. In [4] researchers have discussed a solution comprising of an infrared spreader and receiver

circuit, as well as a unit and a solenoid valve. The infrared sensor is used to detect hands. This investigation came as a response to the requirements of irrigating level managers in irrigation in farming. The working principle is the following: The pourings rate is determined through a Hall effect sensor. The Hall effect irrigates flood sensor is a used sense unit with a turbine rotor. the device is able to change its rotational speed in response to the irrigate flow rate. As a result, the project was a low-cost solution As well as simple for Mounting and accuracy above ground. The investigation paper in [5] is about a system that consists of a solenoid valve that will block/liberate the water flows thus the project aims to concrete a smart water meter monitor connected to an application through WIFI in order to send real-time data. this feature is ensured by the electronic chip ESP8266 equipped with WiFi. the card is related to an Arduino mega as an entry extension, In addition, The ATmega328P microcontroller put out instructions that are synchronized by the hardware, which then executes the desired operation. Users can use two extra functions: Set Timer and Set Plan. Users can use the Set Timer function to set a timer to turn on/off a water supply tap.

3 Materials and methods

Here are the steps which allowed us to define a possible approach to the prototype's creation. The mechanic conception was made through SolidWorks and three designs were proposed as steps leading to the final one as shown in Figure 2 and finally Figure 3.

The linear actuator gets changed to the miniature one. In order to find out the limitations of the actuator through the strength and intensity as discreet in Table 1.

As a result, the circuit combining sensors with Arduino Uno and the actuator using breadboard was established in Figure 10 the Arduino Uno will be replaced in the following circuit in figure 4 by Arduino Uno.

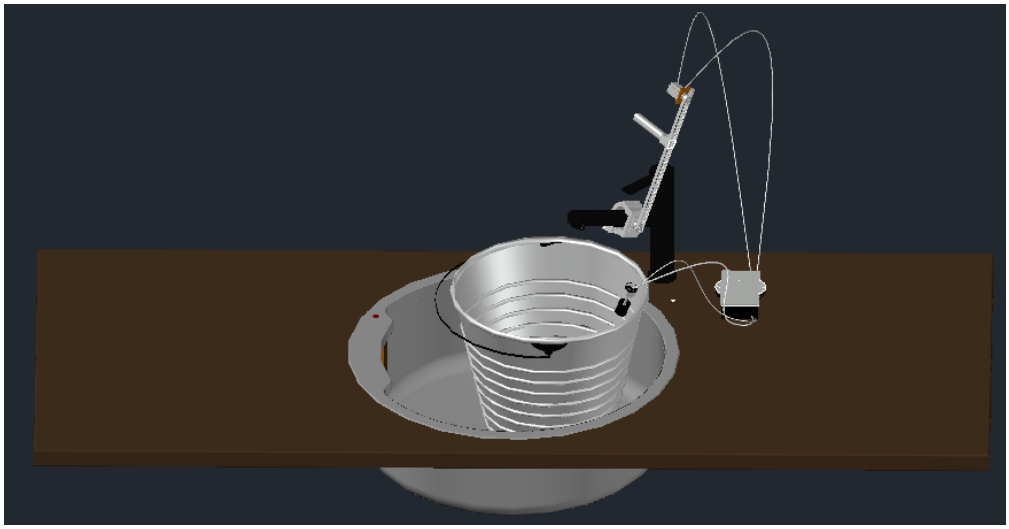


Fig. 2: First prototype

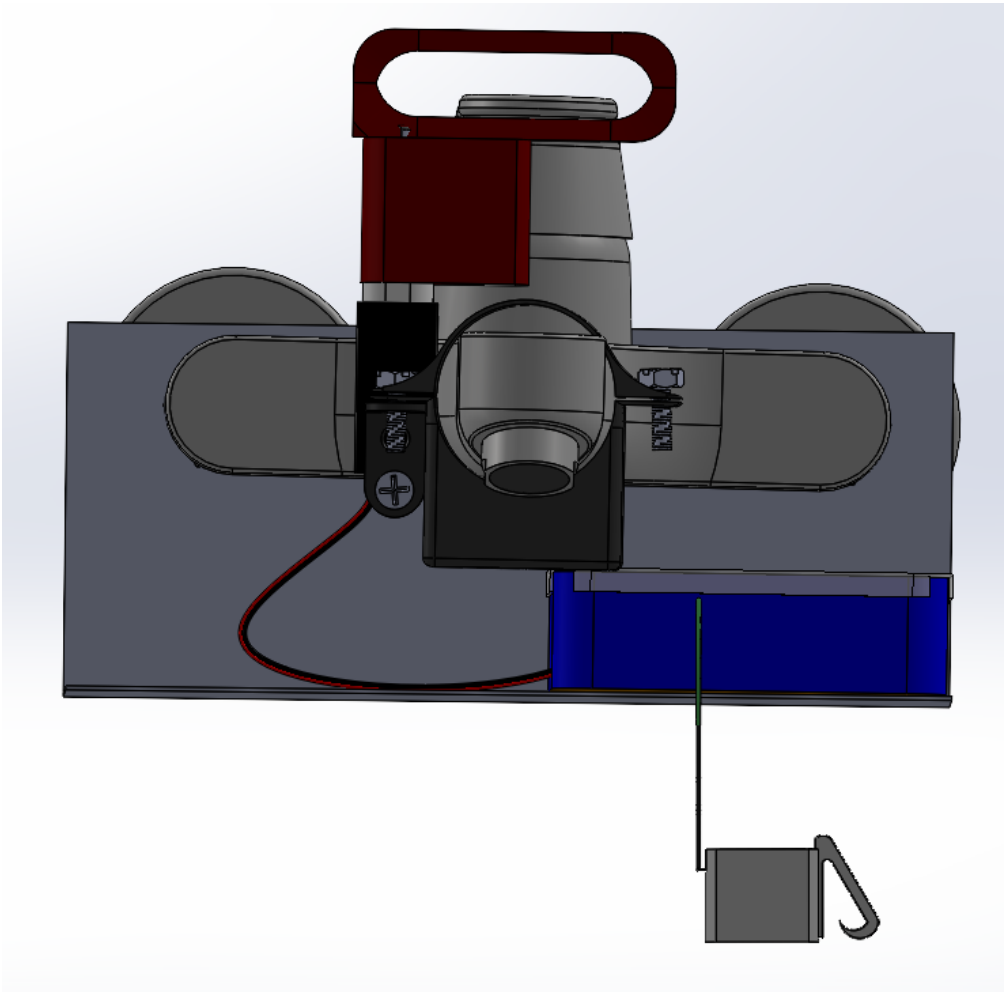


Fig. 3: Final prototype

3.1 Mechatronic solution

The Arduino Uno is a microcontroller board that may be programmed with the Arduino IDE (Figure 4). This board can take in data, process it, and then output the data. It includes 14 digital input/output pins, 6 analogical inputs, and 16 digital input/output pins. A reset button with an ICSP header has everything needed. Simply attach it to a power source to sustain the microcontroller. Use a USB cable to connect to your computer, or use an AC-to-DC converter to power it. For use, it will need an adaptor or a battery. It runs on a 5V DC power supply [6]. This board will be used in this project to control the water tap lever as well as receive data from the water proximity and water level sensor. The Arduino board then processes the data and sends it on. This electronic device shown in Fig. 5 emits infrared waves from one diode (emitter) to the other (receiver) in order to sense objects in the surroundings as well as other abilities such as detecting the motions and measuring the temperature. Based on alimentation

KG	0	0.771	0.94	1.402	2.180	2.342
I(A)	0.05	0.093	0.135	0.250	0.281	0.256

Table 1: variation of the intensity by the load

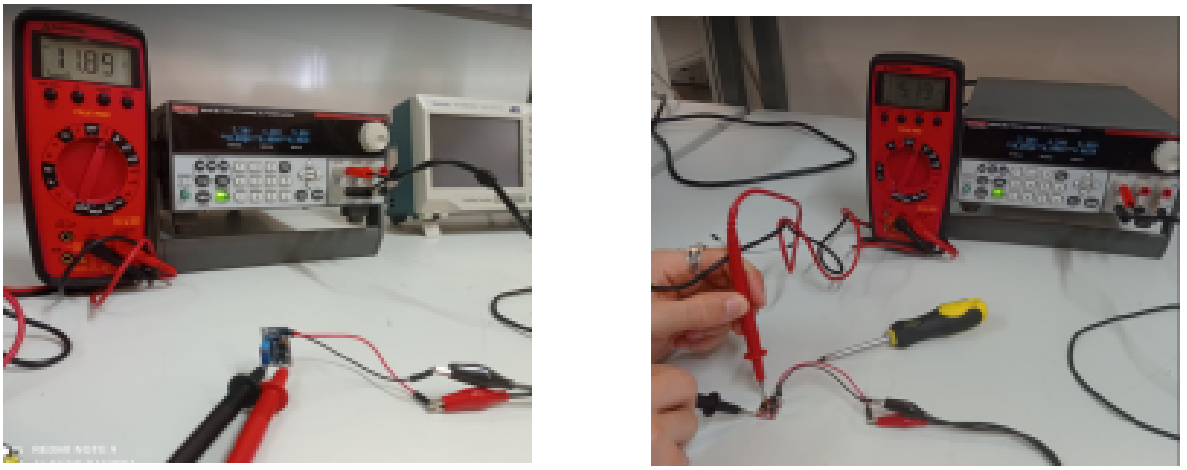
(VCC), ground (GND) and output (OUT) for feedback Pins, the asset of this sensor for the project is that it's used to detect human presence. As it is adjustable, this sensor operates in the following range: 2.8V at 15cm to 0.4V at 150Cc with a supply voltage between 4.5 and 5.5 VDC. Power by the Arduino card, the sensor will detect the human hand as an object when it will approximate the machine it will send feedback to the Arduino Uno card

3.2 Ultrasonic sensor

The ultrasonic sensor in Fig.6 works with the same principle as the infrared one and is able to detect liquid. that is why it will be better to be used for detecting liquid levels. by sending sound waves from the transmitter, which then bounce off of an object and then return to the receiver. You can determine how far away something is by the time it takes for the sound waves to get back to the sensor.

3.3 Mini linear actuator

This actuator in Figure 7 can move to push and pull a chosen mass that will be the lever in our case along its full stroke length. The speed of travel is determined by the gearing of the actuator and the load or force the actuator is working against at a given point in time. When power is removed, the actuator stops moving and holds its position, unless the applied load exceeds the back drive force which is 4kg or 40N, in which case the actuator will back-drive.



(a) Calibrating the B6289Y

(b) Calibrating the Q5KJ

Fig. 4: Calibrating the B6289Y and the Q5KJ

3.4 Results

For that, the transistor BS170 will provide a range of intensity between 50mA and 300mA. While using 8V from two batteries, the boost converters were instrumented in order to get 5V and 12V inputs respectively from Q5KJ and B6289Y, as shown in Figure 4a and Figure 4b. As a result, the circuit combining sensors with Arduino Uno and the actuator using breadboard was established in Figure 5. Now the question is how long will a 2000mAh battery lasts for a 600mAh current circuit this is solved by a very simple calculation: 2000/600=3.33 which is considered as 3h20 min approximately of continuous work. Taking into consideration this fact, one battery has not had enough capacity to keep the circuit charged for a long time. According to this 3 battery were set up in serial connected to the buck converter LM2596 to reduce the current then passing by the H-bridge L296 to alternate the output of the actuator as shown in the 6.

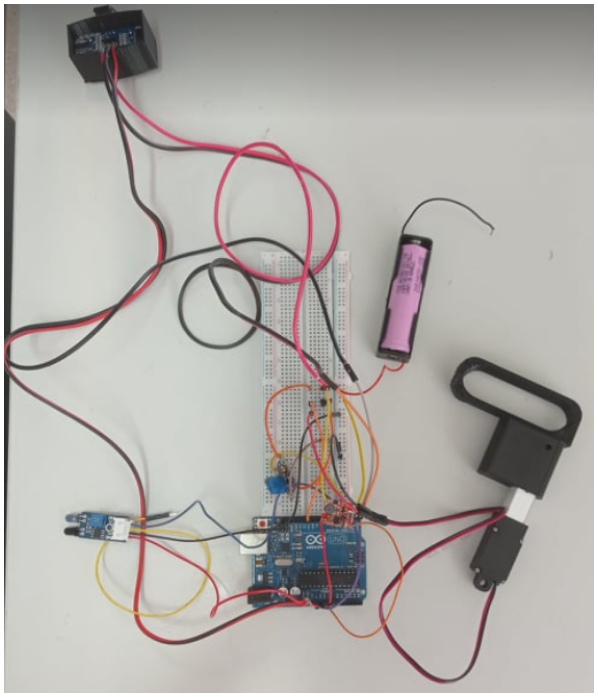


Fig. 5: electronic circuit

4 Conclusion and further work

The sole intention of this research work was to establish a flexible, economical, and easily configurable system that can solve our water loss problem. Existing tap and wash basins can be equipped with such a system to have economical use of water. The idea is based on a combination of two available functions noticed in two products already on the market which can be a siege of innovation using several possible approaches

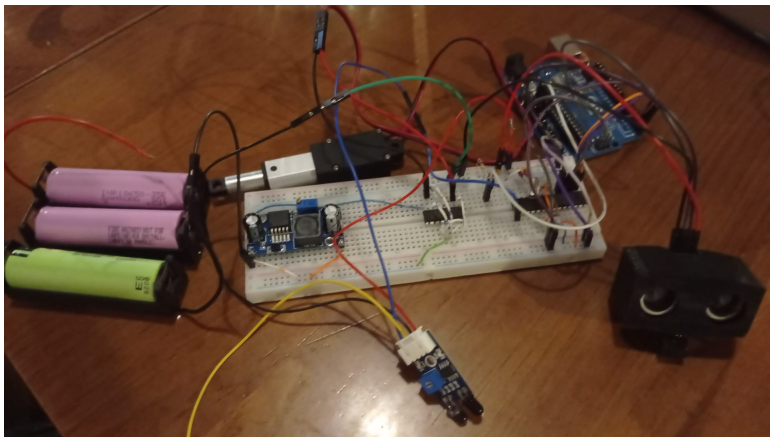


Fig. 6: Final prototype

and a broad variety of tools. The system can be improved by using a wireless sensor or adding a connection module to the HC-SR04. The ultrasonic sensor can be used in smaller dimensions and better shape more suitable for sticking to containers. For the same purpose, it is applicable to emerge the electronic part inside one Mold which will have a unified form as a device and reduce the bulk of the device. It is possible to make the level sensor programmable by the users as it can be quickly and practically adjustable to detect a defined level. It's also possible to reduce the space of the electronic layout as the ATmega can be directly added to the circuit programming it instead of the whole card. The machine's design can be reproduced in a more suitable way.

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Modelling of Conventional High Voltage Transmission Lines

Vicco Miguel Ferreira Martini[1,2] and Ângela Ferreira[2]

[1] Instituto Federal de Educação, Ciência e Tecnologia de São Paulo, Campus Votuporanga, Brasil
vicco.miguel@aluno.ifsp.edu.br
[2] CeDRI, Instituto Politécnico de Bragança, Portugal
m309234@alunos.ipb.pt

Abstract. This paper presents numerical results for generic three-phase transmission lines. The line parameters are calculated using formulations from the available bibliography and arranged in a systematic sequence on Octave with the aim to give as result three matrices 3x3 that present good accuracy at operational frequencies. Those formulations consider ground displacement currents, soil impedance correction using the method of Carson's infinity series and rigorous frequency dependence definitions with the Bessel functions to model the skin effect. Furthermore, it has been considered the external impedance, which is independent of frequency, and the capacitance between phases and phases and ground using the coefficient potentials matrix. The modeling ignores the shunt conductance and corona effect. The *RLC* parameters are calculated and analyzed using the classic procedure, based on an equivalent conductor applying the concept of Geometric Mean Radius (GMR), for several bundled conductors and the phase's equivalent height to the ground.

Keywords: Transmission Line · Parameters · Modelling.

1 Introduction

Electric power transmission systems are intended to transport energy from production sites to consumption points. Classically, production systems are located far from consumption points, due to the availability of the primary energy resource (e.g. hydroelectric plants). More recently, we are witnessing the penetration of distributed generation systems, which leads to greater complexity in the transmission and distribution of electricity.

The transport of energy between generation and consumption centers is done by transmission lines (TLs), which are typically overhead lines that operate at high voltage levels [1] usually operating at potentials of 132 – 500 KV, although even higher are used in parts of North America [9] and, along with this, as there is an increase in distances connected by transmission lines, there is also an increase in the significance of energy losses due to the growth of resistance due to the heating, for example, [2]. Therefore, the planning and operation of the electric power system are based on the correct parameterization and characterization of its elements in order to allow a reliable and safe operation [6]. Thus, it is completely possible, as presented in the present work, the elaboration of a computational routine that, from the input data, which are the geometric and constructive aspects of the line, calculates the electrical parameters of the transmission line to assist in the studies of the electrical power system.

The paper is divided so that section 2 shows the concepts of the Mathematical Modelling of a Transmission Line and put briefly how the parameters are classified. That section is subdivided into three main parts where subsection 2.1 shows the layout

characterization of the TL and how it needs to be interpreted. The 2.2 subsection will show the main concepts about the TL parameters that are modeled by the developed program passing through the concepts and equations of external, internal, and ground impedances as well as the concepts end equations about the shunt Capacitance. The 2.3 subsection shows how the conductor resistivity will be affected by the change in temperature.

In section 3, there is a short overview of the implemented computational tool and what kind of results the program will give to the user and shows what are the input data requested by the developed program.

2 Mathematical Modelling of a Transmission Line

In the mathematical modeling of components of an electrical system, the model consists of the representation of a phenomenon through equivalent circuits and/or mathematical equations [3], since an electrical transmission line can be modeled by four parameters that affect its functionality as part of the power system: resistance, inductance, capacitance, and conductance [12]. Such characteristics are further divided into longitudinal and transversal parameters. The longitudinal parameters are resistances and inductances. The transversal parameters are the conductances and the capacitances [8], so that, since the flow of electric current in the insulators of overhead lines is negligible, the conductance between conductors and the ground of an overhead line is normally neglected [12]. Finally, it is worth noting that the parameters of overhead transmission lines, as well as their electrical performance, depend almost exclusively on their geometry, that is, their physical characteristics [19], such as the height of the cables in relation to the ground, geometric characteristics of conductor bundles and soil conductivity [6].

2.1 Transmission Line Geometry

Before proceeding to the calculation and definition of electrical parameters, it is necessary to understand what data is needed for such a procedure. First, it is necessary to have the knowledge that overhead transmission lines are built having their conductors at finite heights above the ground, and are considered parallel to it [19]. Bearing this in mind, when suspended, the conductors take an approximate shape of a catenary, so that their height above the ground is variable and the vertical distance between a straight line connecting the two fixing points of the conductors on the towers and the straight line tangent to the curve is called arrow [16].

For calculation purposes, a correction is made for the height of the conductors, assuming the ground surface to be flat with the conductors suspended at the same height. The heights that must be considered at all stages of the electrical parameters calculations following this paper are calculated using the following expression [19]:

$$h_i = H_i - 0,7 f_i \tag{1}$$

once:

- H_i: conductor height above the ground at the point of its attachment to the structure

– f_i: the arrow of a conductor i

Still, on the geometric arrangement of the conductors, it is necessary to insert the horizontal position of the conductors referenced to a vertical axis of symmetry.

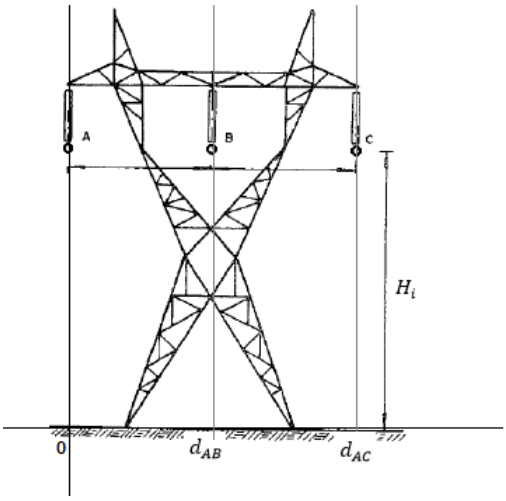

Fig. 1: Geometric layout of the phases in the tower. Adapted from [19]

Thus, the location of the phases in space is given by a two-dimension position, a horizontal position, and a vertical position taking the origin of the reference plane at one of the three phases.

Medium Geometric Ratio Finally, the last concepts on phase arrangement required are the geometric mean radius of the conductors (rmg) and the geometric mean radius of the conductor bundle (RMG). Normally the rmg is not calculated by the electrical parameter calculation programs once they are made available by the conductor manufacturers [15]. The same idea is extended to the case of a bundle n of conductors that make up a single phase, that is, the RMG is the geometric mean of the distances between the conductors that make up the bundle.

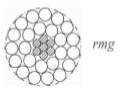

Fig. 2: conductor made of two layers of conductor material and a center with two layers of a steel core [15]

According to Acha *et al.* [9], for cases of transmission lines operating with 400 kV and above it is standard practice to have four bundle conductors per phase, whereas, for 230 kV lines, only three or two bundle conductors per phase are required. These arrangements are shown below Figures:

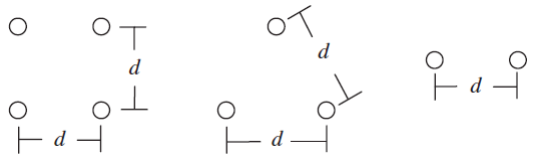

Fig. 3: Typical arrangements of bundle conductors [9]

and for each one, it is necessary to consider the below equations to RMG respectively

$$RMG = \sqrt[4]{rmg \cdot d^3} \cdot \sqrt[8]{2} \tag{2}$$

$$RMG = \sqrt[3]{rmg \cdot d^2} \tag{3}$$

$$RMG = \sqrt{rmg \cdot d} \tag{4}$$

2.2 Transmission Line Parameters

In the study of the performance of transmission lines, as well as in the development of new techniques to improve the transmission potential, it appears that the transport of electric energy is decisively influenced by the values of its electrical parameters and by the geometry and composition of the cables [5].A TL has four parameters that influence its behavior as a component of a power system, they are: resistance, inductance, capacitance and conductance [4]. Such characteristics are further divided into longitudinal and transversal parameters. For calculation purposes, the longitudinal impedance of a transmission line is divided into three components [4]: external impedance (Zext); internal impedance (Zint) and impedance due to current return through the ground (Zg).

External Impedance is due to the presence of various conductors that carry electric currents in the transmission line. As stated before, these currents generate magnetic fields that are linkage with the conductors of the circuit, inducing a voltage in it, therefore, the external impedance is due to the magnetic field present in the air, which surrounds the conductors [7]. It is worth remembering that the considered fluxes generate their own and mutual inductances, that is, the external flux of a conductor i will induce a voltage in itself and in the other conductors around it, so the longitudinal reactance is inductive and can be divided into self and mutual inductance [13].

Note that the external portion of the impedance is considered an ideal soil in such a way that we can apply the method of images [15]. Therefore, the magnetic flux that concatenates conductor i, for example, is generated by the currents that pass through itself, through its image, through conductor j, and through the image of conductor j. Thus, the external impedances of the above system can be given, as shown by Yamanaka [7] and Costa [5], by:

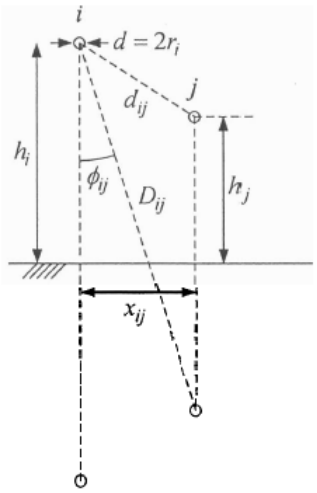

Fig. 4: Spatial arrangement of conductors and imaging method [15]

$$L_{ex_{ij}} = L_{ex_{ji}} = \frac{\mu_0}{2\pi} ln\left(\frac{D_{ij}}{d_{ij}}\right) \tag{5}$$

$$L_{ex_{ii}} \frac{\mu_0}{2\pi} ln\left(\frac{2_i}{r_i}\right) \tag{6}$$

where r_i is the radius of conductor i or, in the case of more than one conductor per phase, its geometric radius, D_ij is the distance between conductor i and the image of conductor j, d_ij is the distance between conductor i and conductor j and h_i is the height of phase i.

Internal Impedance or impedance due to the skin effect is present whenever a conductor is transporting an alternating current [4]. In alternating current, with increasing frequency, the non-uniformity of the linked flux occurs, intensifying the difference between the current densities in the different regions of the cross section [5]. That is, the closer to the surface of the conductor, the fewer lines of magnetic flux concatenate the current elements and, therefore, the opposition to the passage of the latter is more intense the closer to the center of the conductor.

The calculation of the internal resistance is more important than the calculation of the internal reactance, which represents a small portion of the total reactance [15] and in this paper was used the first order Bessel functions or modified Bessel functions [7].

The most current determination of these parameters is made for conductors with a steel core considering a circular aluminum crown around the steel core, with circular conductors being a particular case of these tubular conductors [15]. To calculate its value, it is necessary to have the data of the frequency (f) of the network, the DC resistance (R_{DC}), with the temperature already corrected for the operating temperature, the external radius of the cable (r_{ex}), as well as its internal radius (r_{in}) [18].

$$Z_{in} = R_{DC}\left(j \cdot \frac{1}{2} \cdot mr_{in} \cdot \left(1 - s^2\right) \cdot W\right) \tag{7}$$

Each one of those terms: s, mr_{in}, mr_{ex} are well defined at [15].

Note that for a line equipped with bundle conductors with n subconductors, the impedance value per phase will be, according to Silva [16]:

$$Z_{IN} = \frac{Z_{in}}{n} \tag{8}$$

Ground effect is due to the fact that the ground is not an ideal conductor and because there are interactions between the magnetic field of the phase and the ground. This phenomenon is called ground effect [5]. The impedance due to such an effect can be calculated by the Carson method and, like the internal impedance, it has a resistive component and a reactive component [13]. Carson's formulations were derived with some assumptions or limitations: (i) soil as isotropic and homogeneous linear medium with unitary relative magnetic permeability; (ii) propagation of waves at the speed of light and without attenuation in the axial direction to the conductor axis; (iii) low frequency condition (constant ground conductivity and negligible permittivity). These restrictions imply solutions with reasonable accuracy up to 1 MHz [10].

In that method have been considered conductors parallel to the ground, assuming the resistivity to be uniform and having infinite extension. It was demonstrated that the proper and mutual impedances of circuits with the ground return are equal to the impedances for a circuit involving perfect ground - in which an image conductor can be considered at the same depth as the height of the conductor above the ground plus a correction factor, applicable to both impedances [19]. As stated by Zanetta [15], mathematically there will be two correction parcels: a resistive Δr^c and an inductive Δx^c. Both corrections simply introduce the earth return effect and according to Costa [5], the ground impedance can be represented as a function of the correction terms, in a simplified way, as follows:

$$Z_g = \Delta r^c + j\Delta x^c \tag{9}$$

the corrections are functions of the angle ϕ_{ij} (shown in Fig.4).

The corrections Δr^c and Δx^c are shown in an infinite series shape with the aim of let the computational calculation easier and can be put as dependent on a α parameter as well demonstrated by Zanetta [15].

All the details about Δr^c and Δx^c, the angle ϕ_{ij} and about the α parameter are minutely described at references [15] and [19].

Shunt adimittance of a transmission line consists of a conductance and a capacitive reactance [12]. The potential difference between the conductors of a TL causes itself a charge as the plates of a capacitor when there is a potential difference between them, so it is this potential difference that is modeled by a capacitor. In addition to capacitance, there is also, in an overhead transmission line, a conductance between the conductors and the ground [7]. Conductance models so-called leakage losses. This loss includes the

losses due to the corona effect and the losses in the insulators [19]. However, since the flow of electric current in the insulators of the electric transmission lines is negligible, the conductance between the conductors and the ground is normally neglected [12]. Furthermore, the G values are much more variable with the level of pollution in the insulators than it's worth to be considered. [14].

Capacitive Reactance assumes the earth as a perfect conductor with zero potential, and in this way directly applies the method of images [15]. Knowing this, the formation of the capacitance matrix follows the same logic as the impedance matrix procedure, using the image method. The difference for the capacitance matrix is that the correction for the ground and skin effect is not necessary, having a simpler calculation in relation to the series impedance [18].

The capacitance matrix starts from the Maxwell potential coefficient matrix and in this case is directly applied the method of images [15].

$$P_{ii} = \frac{1}{2\pi\epsilon_0}\left(\frac{2h_i}{r_i}\right) \tag{10}$$

$$P_{ii} = \frac{1}{2\pi\epsilon_0}\left(\frac{D_{ii}}{d_{ij}}\right) \tag{11}$$

As sad by Zannetta, the capacitance matrix C is achieved by inverting P:

$$C = P^{-1} \tag{12}$$

It is concluded that the transverse admittance matrix of a transmission line is given by [7]:

$$[Y] = j\omega[C] \tag{13}$$

2.3 Changing Resistivity with Temperature

The resistivity of a conductor varies linearly over normal operating temperature [11] and at a temperature θ it is given by the expression:

$$\rho_\theta = \rho_{20}[1 + \beta(\theta - 20)] \tag{14}$$

- ρ_θ: it is conductor resistivity at a temperature θ in $[\Omega mm^2/km]$
- ρ_{20}: it is the resistivity of the conductor at 20°C in $[\Omega mm^2/km]$
- β: it is the temperature coefficient of resistivity

The resistivity at 20ºC of the conductor, as well as the temperature coefficient of resistivity, are known data, characteristic of each type of conductor [17].

3 Overview about the implemented tool

The program was completely developed in the Octave software and, as mentioned before, it works with the insertion of the data entered by the user to return the RLC parameters of the transmission line as a result. The arrays returned are of the type:

$$R = \begin{pmatrix} r_{11}\, r_{12}\, r_{13} \\ r_{11}\, r_{12}\, r_{13} \\ r_{11}\, r_{12}\, r_{13} \end{pmatrix} [\Omega/Km] \tag{15}$$

$$L = \begin{pmatrix} l_{11}\, l_{12}\, l_{13} \\ l_{11}\, l_{12}\, l_{13} \\ l_{11}\, l_{12}\, l_{13} \end{pmatrix} [H/Km] \tag{16}$$

$$C = \begin{pmatrix} c_{11}\, c_{12}\, c_{13} \\ c_{11}\, c_{12}\, c_{13} \\ c_{11}\, c_{12}\, c_{13} \end{pmatrix} [F/Km] \tag{17}$$

All these results are given per kilometer and the elements with indices $i \neq j$ are the so-called mutual ones, which are the parameters coupled between the phases, and the parameters with indices $i = j$ are the proper ones of each phase.

The input data are the geometric characteristics of the towers and conductor bundles, as well as the constructive characteristics of the cables. Details on the phase arrangement are the inner radius of the conductor, the outer radius of the conductor, DC resistance at 20^oC, temperature coefficient of the conductor material, the temperature at which the line will operate, the geometric mean radius, the number of conductors per phase, the frequency of operation of the network, the size of the arrow and, of course, the position in space of each of the phases. The latter is inserted as a vector, where the axis of the abscissa represents the vertical position of the phase referring to some arbitrary port in space and the axis of the ordinate represents the height of attachment of the phases to the tower.

4 Conclusion

This paper concentrates on the electrical parameters model of a general three-phase transmission line using the classical formulation and considering the frequency effect by using the Bessel equations. The developed model considers also the ground effect by implementing Carson's formulation and considering the interaction of the mutual and self electromagnetic fields between the three phases.

All those formulations were implemented on Octave and the output consists of three matrices for the parameters R, L, and C, each of them being of 3x3 dimension. The matrix for parameter R was implemented considering three contributions: operating temperature, skin effect, and the ground electric current return effect; L has also three contributions: skin effect, the ground return effect and the magnet flux linkage between phases; finally, C matrix models only one nature: the potential difference between phases and ground. Thus, the RL parameters are frequency dependent and all three parameters consider the geometric arrangement of three phases.

Future work will include the development of a friendly interface. In terms of modeling issues, the computational tool should also model the corona effect, the leakage losses in the insulators, and the consideration of atmospheric behavior.

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Development of a Data Monitoring System for a Cold Stamping Machine

Pedro Pecora[1] and Paulo Leitão[1]

Research Center in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal
{pedropecora,pleitao}@ipb.pt

Abstract. In this paper, through IoT-focused communication interfaces, an architecture is implemented to monitor the energy consumption of a cold stamping machine via dashboards. The dashboard contains information about electrical and physical parameters, namely current intensity, power, power factor, and acceleration. Alerts can be set to constantly monitor outliers in the measured data, sending an email to the responsible for the machine.

Keywords: Data visualization · Machine monitoring · Dashboard.

1 Introduction

The more an industry is connected to the Internet, the more its machines must be. Monitoring key parameters such as electrical consumption can be important for energy efficiency and machine health monitoring.

A huge amount of data is now made available on the shop floor via the advent of Industry 4.0 [8]. The increasing availability of the data may influence the way the data is viewed nowadays, being called the new oil [4]. Condition-based monitoring is a technique that relies on the abundance of data to evaluate the overall machine health [5], being used in many different fields, such as vibration monitoring, electrical monitoring, physical condition monitoring, and temperature monitoring [1]. Galar *et al.* [3] developed a vibration monitoring system to determine the overall health of a paper press, using 544 accelerometers installed into the bearings of the rollers that keep the paper sheet tensioned.

Energy monitoring is widely used in the industry to observe energy consumption, especially to avoid penalties for poor power-factor loads [2]. As for data monitoring and visualization, some research works have addressed real-time monitoring of the operating condition of industrial equipment using smart and digital technologies. For example, Mudaliar and Sivakumar [7], developed an IoT-based energy monitoring system using Raspberry Pi in a company that manufactures both high and low tension panels. The energy meters present in the industry read up to 60 electrical parameters, and the proposed monitoring system was developed using InfluxDB and Grafana, all hosted on a Raspberry Pi and made available to the user via Grafana's web server. [6] developed voltage and current nodes to create a real-time energy monitoring system implemented in a real industrial environment, measuring the 3 phases of a punching & shearing machine.

The paper is organized as follows: in addition to this introductory section, section 2, describes the case study and the adopted system architecture. Section 3 presents the

implementation of said system architecture, passing through the infrastructure created for the data collection. The data visualization and monitoring is presented in section 4. Section 5 is devoted to the conclusion and future works.

2 System Architecture and Case Study

This section describes the case study and system architecture developed with the idea of creating an environment for data monitoring.

2.1 Case Study

The case study of this work refers to a cold molding machine, called Zanni, installed in Catraport, a cold molding factory located in the industrial zone of Mós, Bragança, illustrated in 1. The machine has various dies to stamp metal parts with a force of up to 400 Tons in a range of 1 to 60 strikes per minute. Depending on the desired outcome, the process may vary the number of steps required to complete a piece.

Fig. 1: Metal cold stamping machine.

The whole cold stamping process begins with an aluminum coil being unwound, passing through a feeding system, that meticulously moves forward the sheet to be pressed by the Zanni. The leftover metal is then rewound, while the usable parts are ejected from the sides of the press.

Zanni is equipped with loggers to collect warnings and errors regarding sensors for the operational parameters, along with some security-related sensors, e.g. laser curtain. However, no physical or electrical data is gathered.

2.2 System Architecture

The system architecture can be seen in Fig. 2. This architecture brings the capability to digitalize a physical asset as a virtual model, feeding real-time data to perform condition monitoring and failure prediction.

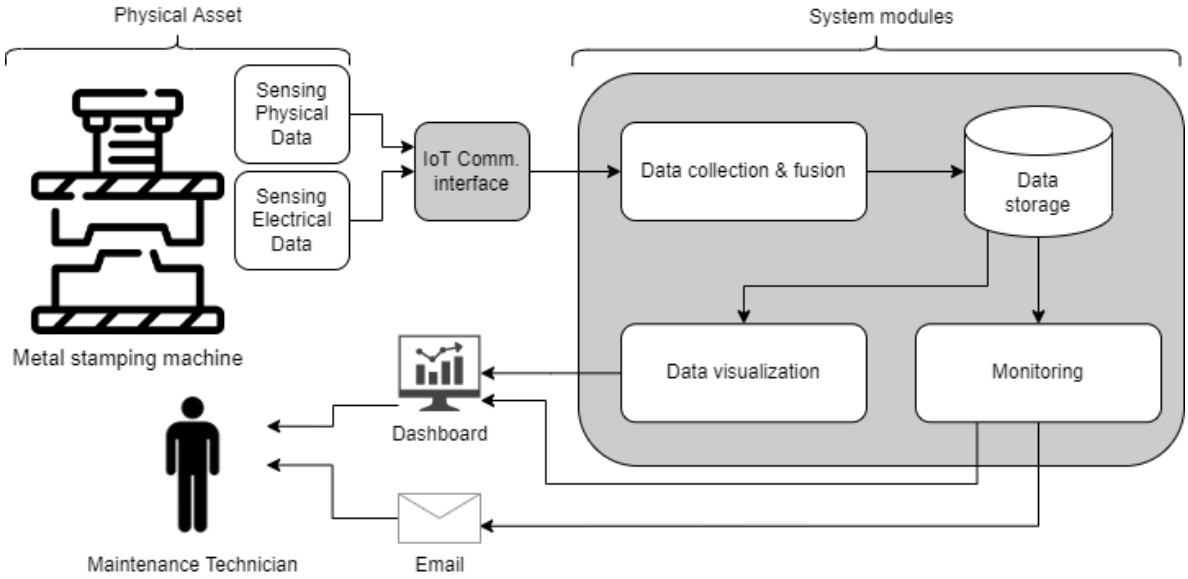

Fig. 2: Proposed system architecture

The *data collection & fusion* module is responsible for the aggregation of the data inputs into the data storage module. It serves as the middleman between the physical asset's data and the data storage. Since multiple data sources are considered, this module also includes data fusion functions, thinking about the data input frequency for each type of sensor used. Using an IoT communication interface, the data is then pushed into the *data storage* module.

As for the *data visualization* module, dashboards are created to give the maintenance technician an overview of the gathered data. Time series graphs, gauges, tables and icons, alongside some Key Performance Indicators (KPIs) can be used, to give more insight into the monitored data.

The *Monitoring* module consists of live monitoring of collected data and prediction of future values using linear regression or machine learning algorithms. The goal is to detect anomalies in the data within a reasonable time frame so that when the displayed values are analyzed, the maintenance team can be contacted if necessary. The recommendations given can be as simple as alerts on a dashboard and emails, or even more advanced predictions and trends in the data. In this work, the focus will be on the data collection, visualization, and monitoring modules of the architecture.

3 Implementation of the System Architecture

In this section, the devices used for data collection and data storage is described.

3.1 Data collection and storage

For the physical data, a combination of custom IoT nodes was made. The IoT node consists of an ESP8266 microcontroller, connected to an LSM303DLHC compass, the compass consists of a magnetometer and a ±16g, 16-bit output, 3-axis accelerometer, the latter is used for the collection of physical data. The data is read by the microcontroller with a frequency of 5Hz.

The electrical data collection comprises an IoTaWatt device, installed directly on Zanni's power box, that measures data regarding voltage, current intensity, power, and all the power-related data every 5 seconds. 3 displays the installed devices, on the left, is the physical data collection device, and on the right is the IoTaWatt device.

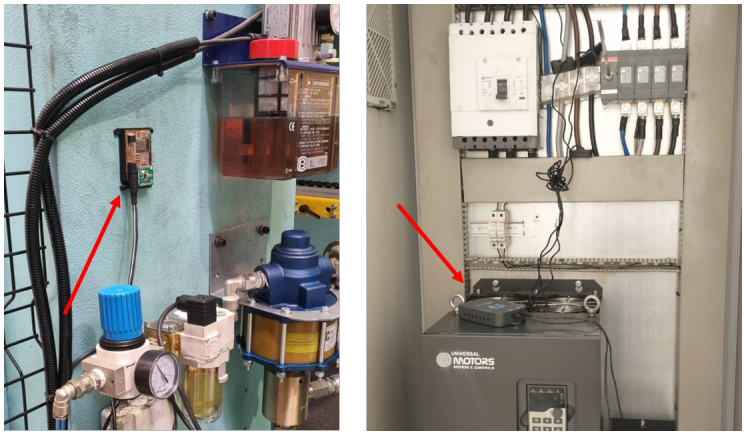

Fig. 3: Installed devices collecting data.

The collected data is then stored in a time series-driven database called InfluxDB (Influx) via the InfluxDB API. InfluxDB stores the data values along with their respective timestamps to create a timeline of the stored data. InfluxDB is the database engine chosen for this work since IoTaWatt has integration with Influx, allowing data to be stored effortlessly. Also, the database provides plenty of libraries for data to be uploaded from an ESP microcontroller. For a brief summary of the collected data, 1 describes all the measured data and their respective units. γ values range from 1 to 3, covering all measured phases.

4 Data Visualization and Monitoring

The data visualization is carried out using Grafana, where multiple dashboards can be created, alongside alerts for condition monitoring. Grafana is an open-source data

Table 1: Collected data short description.

Measured data	Description
Curr_phaseγ	Current intensity measured in the γ phase [A]
PF_phaseγ	Power factor measured in the γ phase
Power_phaseγ	Power measured in the γ phase [W]
Accel_X	Vibration in the X axis [m/s^2]
Accel_Y	Vibration in the Y axis [m/s^2]
Accel_Z	Vibration in the Z axis [m/s^2]

visualization tool that allows a better understanding of the data presented in a database, providing a variety of graphs and dashboards created within the tool.

For this work, Grafana is used to monitor all the measured data presented in 1. The created dashboard, 4, consists of three-time series graphs, each with all three phases of the measured electrical data, followed by KPIs such as maximum, mean, and minimum values gathered from a time window of 5 minutes, with the data being updated every 5 seconds. On the bottom right corner, the acceleration data on all three axes are displayed. An alert panel is presented in the top right corner, where alerts monitor outlier values, triggering if need be. Whenever an alert triggers, it becomes an entry in the alert panel and an email is sent to the maintenance technician.

To analyze historical data, the user can select multiple quick options of time span, e.g. this year so far, previous year, six months. Grafana also provides a direct input field for the desired date range, with a precision of up to seconds. Even if the user is analyzing the historical data, the KPIs will showcase the last 5 minutes available of data, not displaying the KPIs of the time filter. This feature was designed with the intent of giving the user a quick view of the live data while analyzing the historical one.

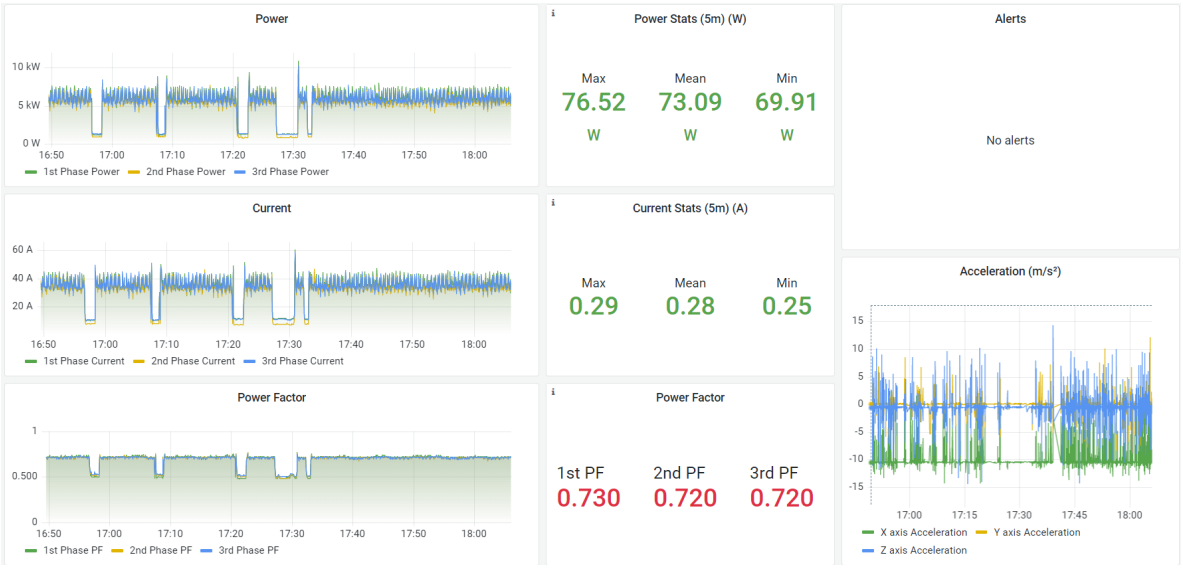

Fig. 4: Overview dashboard.

5 Conclusion and Future Works

The implemented dashboard can give the user a quick yet deep overview of the collected data. The custom data collection node works as intended, being viable even in an industrial setting. The proposed infrastructure has its flaws, since the installation is done in a real environment, the shop floor noise dampens the Wi-Fi signal quality.

For future works, some improvements can be made regarding the data, such as the implementation of control monitoring methods, and machine learning algorithms for failure prediction. A more robust Wi-Fi network to ensure no dead spots is also a viable case study.

Acknowledgements

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Manage users and spaces security constraints on a multi-agent system in a Adaptive Environment System

Pedro Filipe Oliveira[1], Paulo Novais[3], and Paulo Matos[2]

[1] CeDRI, Instituto Politécnico de Bragança, Portugal
poliveira@ipb.pt
[2] CeDRI, Instituto Politécnico de Bragança, Portugal
pmatos@ipb.pt
[3] Centro Algoritmi/Universidade do Minho, Departamento de Informática, Braga, Portugal
pjon@di.uminho.pt

Abstract. Nowadays managing user preferences and local actuators specifications is an actual problem on IoT adaptive systems. This paper proposes a multi-agent system to achieve a Smart Environment System, that manages the interaction between persons and physical spaces, where spaces smartly adapt to user preferences in a transparent way. With this work, we also propose a set of security customization to secure actuators and users present in managed spaces, that has been developed using a multi-agent system architecture with different features to achieve a solution to support all proposed objectives.

Keywords: adaptive-system, AmI, multi-agent, IoT, actuators, preferences, constraints

1 Introduction

The Artificial Intelligence field continues with an exponential growth rate, especially in the different sectors' applicability. Currently, multi-agent systems have been used to solve diverse situations, like in Ambient Intelligence.

Ambient Intelligence (AmI), is a ubiquitous, electronic, and intelligent environment, recognized by the interconnection of different technologies/systems, in order to carry out the different daily tasks in a transparent and autonomous way for the user [3].

Thus, multi-agent systems are made up of autonomous agents present in the environment and who have the ability to make decisions derived from the interpreted stimuli as well as the connection with other agents, to achieve common goals [15].

This work aims to propose an autonomous Smart Home model controlled by cognitive agents and to manage physical devices since agents allow communication with different controllers (Arduino, Raspberry).

The main expected contribution of this work is the possibility of applying MAS (Multi-agent system) to ubiquitous prototypes using the *Jason* framework and *ARGO* architecture applied to intelligent environments.

2 Materials and Methods

Figure 1 [9] [10] [11] [12] [13], shows the scenario of an environment where it intends to develop this work. Explaining this figure, it can be seen the user who through its different devices (smartphone, wearable, and other compatible) communicates with the system, and for that can be used different technologies, like Near Field Communication

(NFC) [14], Bluetooth Low Energy (BLE) [1] and Wi-Fi Direct [2]. Next, the system performs communication with the Cloud, to validate the information. And then the system will perform the management of the different components in the environment (climatization systems, security systems, other smart systems).

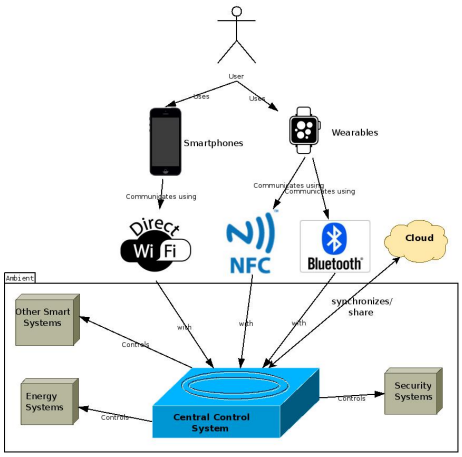

Fig. 1: Problem Statement

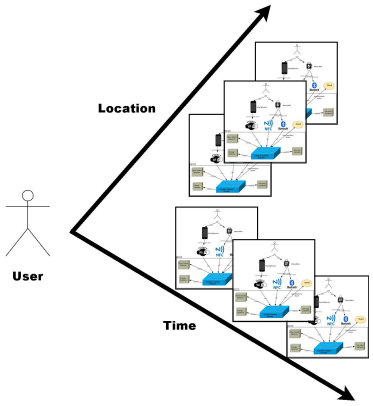

Fig. 2: Contextualization of Time/Environment Dimensions

To optimize the predictions of the solution proposed, an architecture for a multi-agent system was defined. The roles that each agent should represent, as well as the negotiation process to be taken, the different scenarios in which this negotiation should take place and the way it should be processed were specified.

Firstly, the entire physical structure must be prepared, where the local devices (Raspberry) are equipped with the network technologies previously identified so that they can detect the users present in the space.

For this purpose, a Raspberry is used per division, in this case, three on the ground floor (living room/kitchen, office, bedroom) and three on the first floor (one per room).

Regarding the actuators, these divisions have a hydraulic radiant floor heating system heated by a heat pump and a home automation system that controls the luminosity intensity in the different rooms.

This work proposes an autonomous Smart Home model, controlled through cognitive agents, which gets the final information to be applied by the actuators.

To do that, a house with six divisions was prototyped with different comfort features, namely temperature, luminosity, audio, and video.

This work resulted in the complete specification of an architecture that supports the solution found, to solve the presented problem. It will now be implemented, tested, and validated using real case studies, so as to gather statistical information to assess its effectiveness and performance in the context of the application.

In the final stage of this project, all sensor information transmission to the local system is demonstrated. Different sensors of presence, temperature, luminosity, humidity, etc. were inserted in this system. Some of these sensors include all these features, as is the case with some sensors that use ZigBee [4] [8] as communication technology as

shown in Figure 4. In this way, all the information collected by these sensors is passed through ZigBee to a receiver that is connected to a Raspberry representing the local system, as shown in Figure 3. Then all the information is stored in a database, and then can be used by the different agents present in the system.

It is well known that actually the problem of security, is of relevant importance, particularly with regard to intelligent environments, and all that can interact with user security. Also, this sector deals with configuration parameters for the welfare of the user, with regard to different valences. It should be noted the importance, to maintain the safety of these systems, since it is known that temperature and humidity values can impact into question the well-being and even the health of users. Thus, it is necessary to define all actuators, with regard to these security issues, especially with regard to maximum and minimum values.

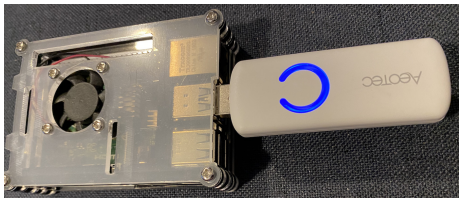

Fig. 3: Local System Raspberry and ZigBee receiver

Fig. 4: ZigBee Sensor

All these values are configured on local systems and then used by agents in the decision-making process. These values have a high priority and will function as restrictions, since in addition to being concerned with the safety of actuating equipment, but mainly concerned with the safety of users present in space.

Table 1 identifies the defined preference constraints, these constraints are necessary for a correct balance of spaces, whether private or public. A maximum value is defined for each preference, as well as the increment/decrement value that can be performed. Obviously, this table will be customized according to each location, and in the case of public places, we may have different restrictions, resulting from the specific environment of each space. This is the only way to guarantee the safety of the spaces and equipment present in the space. These validations will be guaranteed in the logical layer, depending on each negotiation agent's results, before the result is sent to the actuators.

3 Results

This section presents the technologies used in this project for the development of the entire multi-agent system applied to AmI.

At figure 5 is represented the different architecture layers, the agent that represents the local system receives its information, namely the security information (maximum values of temperature, gases, and others). Also for each user present at the local, there

Table 1: Preferences constraints

Preference/Constrain	Minimum Value	Maximum Value	Range	Units
Lighting	0	90	+- 10	%
Temperature	15	28	+- 2	ºC/ºF
Luminance	0	40	+- 2	Lux (lx)
Brightness	0	100	+- 2	Watts/cm2
Relative Humidity	20	80	+- 10	%
Sound	0	30	+- 2	dBm

will be an agent who represents him, he will receive information about the user preferences from the central system, which will be used for the negotiation process.

The negotiation process will then be made up of the local system agent and each of the user's agents present at the local. The negotiation result will then be passed on to the different actuators present in the local.

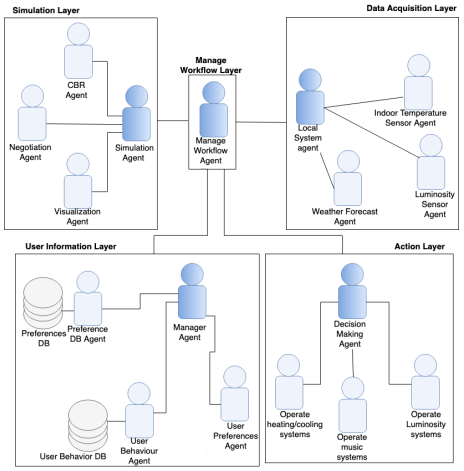

Fig. 5: Architecture of the multi-agent system [12] [6] [5] [7]

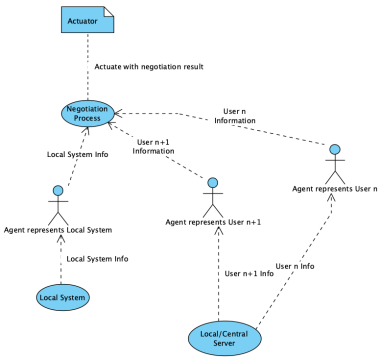

Fig. 6: AmI System - Use Case diagram

In the course of this project, the environments the focus will be mainly on are domestic/family, professional environments (workplaces), and public spaces, where a large number of people are usually present.

One of the rules used for conflict resolution was the hierarchy of preferences. Starting with family contexts, it was taken into account to maximize the preference value of adult elements (parents) over the children, in a ratio of 1 to 0.75. Another hierarchy is the preference value of the space if it exists, in this case, a proportion of 1.5 will be used. These cases may exist in spaces where there is some conditioning, such as kitchens/WC, or other spaces that have some type of conditioning.

The proportions described and used for the rules are detailed in Table 2.

In the professional context, the proportion values are also defined in a hierarchical way, and in this context, the professional hierarchy of space will be used, as well as the space preference value if it exists. The proportions described are detailed in Table 3.

Regarding public/social spaces, the predominant value will obviously be the space value with a proportion of 2, and each user will have a proportion of 0.15, as in these spaces it is natural that there is little variation in the values, derived by the high movement of people. The proportions described are detailed in Table 4. The formula used to achieve the optimum preference value for the different spaces is the following:

$$prefValue = \frac{\sum_{user=1}^{n} userPref \times userHierProportion + (spacePref \times spaceProportion)}{\sum_{user=1}^{n} userHierProportion + spaceProportion}$$

Type	Proportion
Adult	1
Child	0,75
Visitor	1
Space	1,5

Table 2: Type of users and proportions - Home space

Type	Proportion
Hierarchy_1	(100-1)
Hierarchy_2	(100-2)
Hierarchy_n	(100-n)
Space	150

Table 3: Type of users and proportions - Work space

Type	Proportion
User_1	0,15
User_2	0,15
User_n	0,15
Space	2

Table 4: Type of users and proportions - Public/Social space

4 Discussion and Conclusions

With this work, the specification of constraints for all specifications of proposed preferences for this work was achieved. In this way, the safety of users and actuators present in space is achieved.

Also, the total development of an architecture and respective cognitive model for a Smart Home was achieved, using a MAS with BDI (Belief-Desire-Intention) agents, developed using Jason and ARGO.

The main objective of this work was to verify the potential that this type of architecture has for the development of ubiquitous MAS using low-cost hardware, such as Raspberry.

The agent system modeling is fully developed. At this stage, the agent layer is developed and implemented and is now in a testing phase in the testing environment developed for this project.

For future work, the results of the testing phase will be analyzed and evaluated to improve this project and support other works in this field.

Figure 1 and 2 exemplify in a global way the architecture of the system where this work has been carried out.

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Development of technological support for electronic and robotics education in secondary education

Lorena Pereira de Carlos Jeranoski[1] and Paulo Leitão[1]

Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politecnico de Braganca, Campus de Santa Apolonia, 5300-253 Braganca, Portugal
lorenajeranoski@alunos.utfpr.edu.br, pleitao@ipb.pt

Abstract

Technological skills are increasingly needed in today's smart age. In this context, the inclusion of technological education in basic education becomes an important ally, aiming for the child to develop skills that will later be important for their experiences, such as protagonism, autonomy, logical thinking, creativity, and teamwork. This abstract aims to describe how a set of projects will be developed to create opportunities and democratize access to technological education for secondary school grades. The projects will be developed to use the open-source Arduino platform ®, and its components. Subsequently, they will be applied to students in curricular classes, in order to evaluate and qualify the learning and methods used.

Keywords: Technological education · Educational Robotics · Educational informatics.

1 Introduction

Currently, children have contact with the digital world very early, and for this reason, they appear to be fluent in technology, known as "digital natives". [5].

However, familiarity and naturalness when using the available technologies are not enough to acquire fluency, so it is necessary to know how to design, create and express yourself through these technologies [9]. In order to stimulate the necessary skills to acquire fluency, it is necessary that technology is approached as an ally of learning, bringing this interaction to the school environment. [8].

The main purpose of including a technological education is to develop skills that do not necessarily need to be applied to technology, such as: creating, developing solutions based on a real problem, using logic, having the ability to discern, resilience, protagonist, and creativity. [8].

The general concern is to allow the child to have a training that allows the resolution of real problems in the future, using tools that are available. Therefore, the student will be used to using these tools and, when the problem arises, will be able to use them in a natural and organic way. [8, 9].

In order to fulfill these objectives, aiming to combine technology with learning, a didactic material composed of electronic project scripts, including hardware and software, will later be prepared. All material will be built based on Jean Piaget's constructivist

theory, aiming at developing the student's ability to build their own knowledge. [3], increasing autonomy and protagonism.

These projects aim to establish concepts of electronics and computational thinking, and for this, the Arduino ®platform will be used. An open-source, affordable platform with extensive documentation [4], which enables the democratization of access to the material.

Subsequently, these materials will be applied within the classroom, in order to evaluate their effectiveness, as well as to point out improvements. Each project will have three versions, one for students at the beginning of secondary school, the second for more advanced students, and finally the educator's version.

Aiming for future improvement, to qualify and quantify the results of the materials, a survey will be carried out with the faculty and students who made use of the material in the classroom.

The next sections of the abstract will be organized as follows: Section 2 discusses the methods that will be used to make the material. Both didactic and technical methods, address the individual's way of teaching and learning, and the chosen prototyping platform. Finally, in Section 3 preliminary results will be presented.

2 Materials and Methods

In order to fulfill the main purpose of elaborating a didactic material of technological support for education in electronics and robotics for secondary education, research was necessary to understand how the individual learns, and what would be the most efficient teaching method to the proposed projects. In addition, a prototyping platform is needed for the Hardware and Software part of the projects.

With this in mind, the following subsections will first present the theory raised by Lev Vygotsky, which aims to try to explain how the development of learning in human beings takes place. This is followed by an explanation of the two teaching methods: Jean Piaget's constructivist theory and Project-Based Learning. Finally, the motivation to choose the Arduino®platform as the main material to compose Hardware and Software projects.

2.1 Way of Learning of the Individual

Human knowledge is strongly shaped by the environment in which it is inserted, and this process is influenced by the environment and by the individuals who live in that environment. This can be called social learning [10]. Social learning is of paramount importance for updating the individual's information. She is responsible for the constant change in the knowledge base. Vygotsky's thesis brings the perception that the cognitive development of the human being occurs with the interactions that he makes with the social environment, with the culture and with the other members of the culture.

Vygotsky defined two developmental levels of analysis of the relationship between "developmental process" and "learning ability" [10] and came to the following conclusions:

a) Actual Developmental Level (ADL): This level consists of all the tasks that the person can perform on his own, without the help of others. They are considered consolidated knowledge.

b) Proximal or Potential Development Level (PDL): At this level are the activities and functions that a person can do only with the help of others who are considered more capable. These are the roles in the process of maturing.

The distance between the two levels and the space between them is called the Zone of Proximal Development (ZPD). This can be developed with solutions to problems that are under the guidance of an individual who is best suited for that role. [10].

These definitions show us that to achieve the ADL it is necessary to develop the ZPD. For this, the projects were designed in a way to explore the consolidated knowledge, and from the challenge of the new project, create an environment susceptible to the development of ZPD, with the support of the educator. For this reason, support materials for educators will also be created, as mentioned above.

2.2 Teaching methods

One of the biggest perceived challenges for the progress of this work was the choice of the teaching method that will be used to guide the projects. Two pillars were chosen that will be followed throughout the work: Constructionism, which has the student as the protagonist in the process of knowledge construction [6], and project-based learning, an active teaching methodology [2].

Seymour Papert's constructionism is based on Piaget's constructivist theory, with which he shares the idea that learning involves building knowledge structures. Furthermore, for learning to be truly effective, students must learn based on the design of objects that are perceptible to the real world context, to real audiences, learning from their creative experimentation [7].

In order to increase individual development, constructionism proposes that teachers act as facilitators, training students to search for knowledge. This is done by replacing the purely expository class with a collaborative class in which, through the exposition of problems, students are invited to develop solutions for these [7].

The constructionist method provides the student with "active learning", which allows for making connections between different areas of knowledge. Project-Based Learning (PBL) is a constructionist approach that has the student as the main character, involving him in solving real problems. It is structured for students to elaborate and create projects aimed at solving these problems that are presented by the teacher or by themselves [1].

This environment for developing projects to solve a problem encourages effort, persistence and self-criticism on the part of students, in addition to attention, a sense of belonging and responsibility, self-confidence, time management and interpersonal communication. In this way, students can develop their own ideas and solutions, being able to apply them and learn by doing.

2.3 Arduino®Platform

One of the main concerns of this work was the accessibility and flexibility of use of the materials used in the projects. Therefore, the decision of the prototyping platform for the development was a crucial point in achieving this goal.

Among those available on the market, two development platforms were taken into account: Arduino ® and Raspberry Pi ®. As the projects are based on hardware control, that is, control of sensors and actuators and do not require massive data processing, the Arduino ®platform was chosen, due to the ease of use of the platform, which is programmed in C++ language. The Raspberry Pi ® platform is more suitable for projects that use data processing, in addition to using the Python programming language, which can be a difficult factor for beginners.

The Arduino ® platform is an open-source hardware and software platform, that is, all parts that integrate the platform can be used, modified, and distributed freely and freely. A great advantage is as it allows the collaboration of a large community. This feature allows it to be a low-cost platform, as copies can be sold without paying royalties.

The platform features several boards for beginner to advanced levels. At the beginner level, there are boards such as the Arduino UNO board, Arduino Leonardo, Arduino NANO, and Arduino Micro. Among them, for the elaborate projects, the Arduino UNO board was chosen, which is the most robust, easiest to access and most documented board of the entire Arduino ® family [4].

3 Preliminary results

From the research on teaching and learning methods, it was decided to structure a teaching material that could be used by students of different levels, allowing each one to use their consolidated knowledge and keep them motivated, as seen in Vygotsky's theory.

In this way, the final product of the projects will be the same for both students in early classes and for more advanced classes. However, they will have different ways of being approached. For more advanced classes, in-depth theories of electronics, programming, and design will be introduced. As well as challenges and problems that require a higher level of knowledge and logical reasoning. As for the initial classes, the projects will be approached in a playful and inviting way, in order to instigate interest in learning technology.

In addition to the materials for the students, there will also be support materials for the teacher, in order to offer all the necessary structure for the classes. The educator's material consists of videos of project assembly, including hardware and software, as well as its operation. In addition, it includes extra challenges that can be presented to students, depending on the progress of each project, at the discretion of the teacher. Questionnaires about the skills learned will also form part of this material.

Finally, to understand the impact and effectiveness of this material, it is intended to apply it in a secondary school, in moments created propitiously for this purpose. After each project is applied, teachers and students will be invited to answer qualitative and

quantitative questionnaires, in order to assess students' understanding of the topics covered. Socio-economic topics will also be addressed, in order to understand not only the student himself but the society around him, giving a systemic view of the context in which this student is inserted.

With these results, future improvements can be made, always aiming at the development of critical thinking, the necessary resilience in problem-solving, and also logical reasoning.

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Genetic algorithm applied in the structuring of maintenance routes in the energy generation sector electric

Gabriel Salles do Amaral[1], Ana Isabel Pereira[1,2], and Marjorie Maria Bellinello[3]

[1] Instituto Politécnico de Bragança, Bragança, Portugal
a52496@alunos.ipb.pt
[2] Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Bragança, Portugal
apereira@ipb.pt
[3] Universidade Tecnológica Federal do Paraná, UTFPR, Brasil
belinelli@utfpr.edu.br

Abstract. Hydropower plants play a fundamental role in the generation of Brazilian electricity, and it is essential to structure an assertive maintenance policy, to increase the reliability and availability of the industrial assets belonging to them. Within this context, one of the maintenance challenges is the planning of maintenance routes, since a hydroelectric plant has thousands of pieces of equipment, each one of them with its specificities. This work aims to develop a tool for structuring intelligent maintenance routes using technology 4.0 concepts, more specifically genetic algorithms, for assertive decision-making in relation to maintenance strategies.

Keywords: Genetic algorithms · Industry 4.0 · Maintenance policies · Maintenance routes.

1 Introduction

The current economic scenario and global competitiveness force companies to invest more in resources to strengthen their production processes and support systems to maintain stability and create competitive advantages in organizations. In this scenario, managing the maintenance of assets used in production processes becomes one of the main levers to improve the results of organizations, playing an important role in supporting business and operation strategies [9].

Maintenance management in modern production systems is not just about restoring physical assets to their operational state after a failure. As a business support process, it encompasses the planning, organization, implementation, and control of all maintenance activities, aiming at the application of preventive actions, and avoiding the occurrence of failures, thus increasing the useful life of the assets.

In Brazil, one of the sectors that play an essential role in the economy and maintenance of modern life is the Hydro Power Plants (HPP). This type of energy represents more than 60% of the Brazilian energy matrix [6].

A physical complex for electric power generation includes mechanical, electrical, and electronic assets added to a complex civil structure. These assets suffer from varied operating conditions, in addition to an extremely aggressive environment for construction materials, which can cause failures and interrupt energy generation [5, 8].

Thus, it is necessary to structure an adequate maintenance policy for the industrial assets used in the hydroelectric sector. In modeling the decision process in the era of industry 4.0, some techniques can be explored such as machine learning, neural network,

multi-objective decision methods, Genetic algorithm, and Bayesian networks, among others. The aggregation of these tools in the industrial decision-making process enables the optimization of decision-making processes in industrial maintenance, aiming for a robust and effective decision-making [2].

This work aims to structure a tool that points out assertive maintenance routes for equipment that encompass a Francis-type Hydro Generator Unit through the application of decision-making modeling with a genetic algorithm. This prioritization of routes and, consequently, of components leads to an adequate structure of an adequate maintenance policy, aiming to confer reliability in the electric power generation system with personal safety for employees and the environment.

The paper is organized as follows: Section 2 explains the concepts of the algorithm chosen for the solution, Section 3 presents the approach used to achieve the objectives of the work, Section 4 presents the preliminary achieved results of the developed algorithm and finally, Section 5 concludes the paper and suggests possible topics for future work.

2 Genetic Algorithm

The Genetic algorithm is a search tool based on the principles of natural selection and biological evolution, with the relative simplicity of implementation and effectiveness in performing global searches in adverse environments, being developed in the mid-1970s by J. Holland [3].

From a biological perspective, the ability of an organism to survive in an environment is determined by it is deoxyribonucleic acid (DNA), which is a combination of the DNA of its parents, inheriting some of their characteristics and others that arise due to the recombination of these DNAs. The set of these traits can contribute to the increase in the probability of adaptation of this offspring and, consequently, survival. Such characteristics will be passed on to the next generation and so on, improving, over time, the survival capacity of this species [1].

The Genetic Algorithm has three genetic operators: selection, crossover, and mutation. Whose main objective is to change the characteristics of individuals in the population, whether to diversify future generations or maintain characteristics of past generations [3].

In the selection, the parents of the next generation are chosen, in which their chances of being selected increase according to their value obtained in the fitness function. The crossover, in turn, aims to exchange information between the different candidate solutions. In which the random recombination of parental characteristics occurs to form a new individual [4].

Finally, the mutation occurs to increase the diversity of the newly generated population. It involves the random selection of genes within the chromosomes, assigning values within the selected range. This step allows new individuals to enter the population, restricting premature convergence or restoring desired traits that may have been removed from the population too soon [4].

3 Proposed Approach

For this research, the collected data used is from hydropower plants located in Brazil. A sample of the data is described in Table 1 where it is presented the Machine ID (ID), the subsystem that the activity will be carried out (Sub.), the number of days without performing maintenance (Exec. date), the activity to be performed (Activity description), the classification of the machine (Class.), the expected duration of the activity (E.D.), the time in which there was no energy generation, that is, the energy generating unit is stopped to perform maintenance activities. (D.T.).

The column "Freq." represents the periodicity necessary for the maintenance of this machinery in days, the service execution priority (Clus.), and, finally, the number of technicians needed to perform the tasks (N. Tech.).

Table 1: Sample of data used in this study.

ID	**Sub.**	**Exec. date**	**Activity description**	**Class.**	**E.D.**	**D.T.**	**Freq.**	**Clus.**	**N. Tech.**
1	Turbine Rotor	4711	External turbine inspection	20	4	0	720	8	2
2	Motor	6960	Pump motor lubrication	20	2	0	5000	9	2
3	Panel	6254	Inspection of the control panel for maintenance of the turbine shaft exhaust	30	2	2	17520	3	2
4	Generator Rotor	5532	Brush inspection and maintenance	20	6	7	4320	9	4
5	Guide Bearing	4302	Replacement of generator guide bearing thermometry	20	48	48	2160	7	3

The development of GA was inspired by the Knapsack Problem, which is a classic optimization problem. This involves a reservoir (backpack) with a fixed capacity and a number of items as contents, each with a weight and an associated value. The objective is to maximize the value of selected items without exceeding the backpack's capacity. The GA system was implemented in Python with the pyeasyga library [7].

4 Preliminary Results

To test the approach, it was considered that the plant's generation process was stopped, that is, there was a total stop with a duration of 10 hours and with 3 technicians available to carry out the maintenance tasks. For the GA parameters, the following values in Table 2 were tested and compared, where it is presented the population size of individuals (Pop. size), the number of generations (Gen.), the probability of crossover and mutation respectively (Crossover prob. and Mutation prob.), the running time of the algorithm (Time), the best value obtained by the fitness function (Score) and the best solution presented by the genetic algorithm (Best Solution).

Table 2: Comparison between GA parameters

Pop. size	Gen.	Crossover prob.	Mutation prob.	Time	Score	Best Solution
100	30	0.8	0.05	5.927	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
100	30	0.8	0.1	5.826	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
100	30	0.9	0.05	6.277	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
100	30	0.9	0.1	6.065	6.854	[1, 0, 0, 0, 0, 0, 1, 0, 1, 1]
100	60	0.8	0.05	14.872	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
100	60	0.8	0.1	13.764	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
100	60	0.9	0.05	14.089	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
100	60	0.9	0.1	14.565	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
200	30	0.8	0.05	13.789	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
200	30	0.8	0.1	13.775	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
200	30	0.9	0.05	13.975	6.854	[1, 0, 0, 0, 0, 0, 1, 0, 1, 1]
200	30	0.9	0.1	15.027	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
200	60	0.8	0.05	24.658	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
200	60	0.8	0.1	24.062	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]
200	60	0.9	0.05	23.884	6.854	[1, 0, 0, 0, 0, 0, 1, 0, 1, 1]
200	60	0.9	0.1	30.051	7.093	[1, 1, 0, 0, 0, 0, 1, 0, 0, 1]

Therefore, for the simulation performed in this work, the best combination of parameters was:

- Population size = 100;
- Generations = 30;
- Crossover probability = 0.8;
- Mutation probability = 0.1;
- Elitism = True;
- Maximise Fitness Function = True.

The activities selected for each technician by the genetic algorithm are represented in Table 3.

Table 3: The activities selected for each technician by the Genetic Algorithm.

Technician	ID	Subsystem	Activity description	E.D.
Technician 1	1	Turbine Rotor	External turbine inspection	4
Technician 1	2	Motor	Pump motor lubrification	2
Technician 1	7	Bearing	Inspection of thrust bearing limit switches	2
Technician 1	10	Speed Regulator	Inspection of the turbine aeration system	2
Technician 2	1	Turbine Rotor	External turbine inspection	4
Technician 2	2	Motor	Pump motor lubrification	2
Technician 2	7	Bearing	Inspection of thrust bearing limit switches	2
Technician 2	10	Speed Regulator	Inspection of the turbine aeration system	2

Where it is pointed out who is the technician (Technician), the Machine ID (ID) and its respective subsystem (Subsystem), the activity in question to be carried out (Activity description), and its estimated duration (E.D.).

5 Conclusions and Future Work

In complex installations such as hydro power plants, maintenance tasks must be planned assertively, so that the plant can achieve its main function, which is energy generation, because it has a large amount of equipment, each with its characteristics and specificities, it becomes a challenge to carry out this planning.

To solve this problem, in this work, a genetic algorithm was developed for the structuring of intelligent maintenance routes using data from a hydropower plant located in Brazil.

The result obtained for this data sample was excellent with a 5.826 seconds of the algorithm running time and a 7.093 score obtained by the fitness function, reinforcing the power of genetic algorithms for problem-solving.

In addition, a table with the tasks to be performed by each technician during the routes is presented.

In future works, larger data samples can be used, in addition to exploring other algorithms, such as Random Forest, and performing an accuracy comparison with the genetic algorithm.

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Modeling an Aggregate Production Planning

Fernando Zanella[1] and Clara Bento Vaz[2]

[1] Instituto Politécnico de Bragança, IPB, Portugal
a52494@alunos.ipb.pt
[2] Research Center in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Portugal
clvaz@ipb.pt

Abstract. This paper aims to present and discuss the benefits that small- and medium-sized companies can get when using mathematical programming to help in the decision-making process regarding aggregate production planning. The aggregate plan is concerned with determining the quantity of a good or a family of goods to be produced and also scheduling its production for the medium-range period, in which the main objective is to meet forecast demand while minimizing costs. To exemplify an aggregate production planning problem, a simplified model of a real company, considering four months, was proposed. Future developments should improve the model to consider other data such as inventory management and costs; raw material storage and logistics; employee costs, contracting and subcontracting and overtime.

Keywords: Aggregate Production Planning · Integer Programming · Mathematical Model.

1 Introduction

Production planning is an essential and complex activity inside a company that requires simultaneous cooperation between everyone responsible for the decision-making process. Usually, production planning can be separated into three different types: short-range plans; medium-range plans, and long-range plans [2].

Short-range plans are highly influenced by job assignments, ordering, job scheduling, and dispatching. Medium-range plans are elaborated to always be aligned with the long-range plans and strategy adopted by the company. Sales and operations planning (S&OP), budgeting, and inventory are some of the pillars that must be considered in every intermediate-range plan. Finally, a long-range plan is most of the time related to new infrastructure, research and development, new products, and facility location and/or capacity.

Lachtermarcher [5] stated that when it comes to solving problems involving short-, medium-, and long-term production planning, it is possible to develop a linear programming (LP) mathematical model and use it to find the optimal solution. Furthermore, it is possible to simulate different production scenarios and amplify the analysis horizon. The objective of this work is to present and develop an integer programming mathematical model for aggregate production planning, which is included in the medium-range plans.

Thus, the paper is organized as follows: the next section describes what an aggregate production plan is, and how integer programming can be used to develop it; the following section presents a simplified case study of a real problem of a given company, where an integer programming model is proposed; section 4 discusses the outputs of the proposed model; Finally, section 5 presents the conclusions and further work.

2 Literature Review

2.1 Aggregate Production Planning

The act of elaborating a strategic plan of operations among all possible horizons, to find the balance between resources and forecasted demand, is known as Sales and Operations Planning (S&OP) [2]. This planning has to consider every aspect possible of the production system, from the supply chain itself to the final customer [2].

One of the most important output information of S&OP is the capability to determine the feasible plans among all possibilities, considering any constraints, concerning the firm itself or the supply chain. The output of S&OP, which is included in the medium-range plan, is called an aggregate plan. As stated by Heizer et. al [2], the aggregate plan is concerned with determining the quantity of a good or a family of goods to be produced and also scheduling its production for the medium-range period. Most of the time, its main objective is to meet forecast demand while minimizing costs.

For an S&OP to be effective and generate a good aggregate plan, it has to have the following four features: a logical way to measure sales and output; a forecast of demand for the period considered; a defined method to determine the costs involved; a model that combines demand, costs, and production capacity so it is possible to develop a schedule [3].

Every aggregate plan must be capable of absorbing demand fluctuations, both caused by internal and external phenomena. In the first case, these phenomena are related to machinery defects, strikes, and product nonconformities, among others. On the other hand, everything that is out of the company's control is classified as an external phenomenon, such as supplier delays, unexpected worldwide events that affect the supply chain, etc. [3].

When it comes to aggregate planning strategies, considering a qualitative perspective, the decision-maker must know how the company wants to absorb any kind of demand variability. Therefore, several questions must be answered, such as: Is the company expanding its inventory capacity? Can the workforce size be variable? Are part-timers, outsourcing, and overtime an option? Should prices or market campaigns be used to influence the demand? [2].

In this context, the act of developing an aggregate plan involves both manipulating and determining a large set of controllable variables such as inventory levels, workforce size, production rates, subcontracting, part-time workers, outsourcing, etc. [3]. This can be solved by graphical techniques or mathematical approaches [2].

The first is a trial-and-error analysis that is easy to use but does not guarantee to find an optimal solution because it is mostly done by plotting one or more graphs, relating forecast demand, production capacity for regular time, costs, and any policy that may apply, for then using basic math to come to conclusions. The second method is more precise since it is purely mathematical based, being able to achieve an optimal solution.

2.2 Mathematical Based Decision Support Systems for Aggregate Production Planning

The currently available computational resources make it possible to develop various decision support systems based on the mathematical approach. These systems, usu-

ally based on quantitative models, are flexible and can be used both in academia and companies [6].

In the commercial environment, there are already a lot of computational systems used to plan and determine the production sequence. These programs are referred to as Advanced Planning and Scheduling (APS), and they use a vast variety of techniques to determine production planning, material acquisition, and delivery logistics. Nonetheless, these programs are not worth it for medium and small companies. The reason behind it relies on two main factors: (i) big companies are well organized and most of the time already have the required data in a management information system (MIS) that can be integrated with an APS system; (ii) the cost involved to customize, implement and train people to use an APS system is relatively high [1].

One feasible solution for small and medium companies is to develop their particular mathematical model to support the decision-making process regarding aggregate production planning. Among the large number of techniques that can be applied to solve such a problem, one very common is integer or linear programming. These models can be solved in almost any mathematical software, and therefore it is very accessible for the vast majority of companies [6].

2.3 Integer Programming: a Brief Introduction

Integer programming is a method that uses a set of mathematical linear functions to describe a certain problem and then solve it to obtain an optimal result expressed in integer numbers. It is important to state that the word programming, in this context, does not mean strictly computer programming, although computers are commonly used to solve this type of mathematical model [4].

When defining an integer or linear programming mathematical model, there are always four groups of elements: (i) objective function: a mathematical function that represents the goal; (ii) decision variables: the main entities that influence the goal, that is, variables on which the objective function depends; (iii) constraint functions: a set of equations that limit the solutions within the domain by representing real-world limitations to the decision variables; (iv) nonnegativity constraints: a set of constraints that prevent the decision variables to be negative. Fig. 1 summarizes the concepts presented so far.

3 Modeling an Aggregate Production Planning Using Integer Programming

3.1 Definition of the hypothetical scenario

To exemplify and apply the content discussed so far, it is proposed to model a simplified aggregate production planning of a real company, considering four months, which is approximately 65 working days. During this period, the firm is going to manufacture five different products using three different machines two shifts a day, as summarized in Table 1.

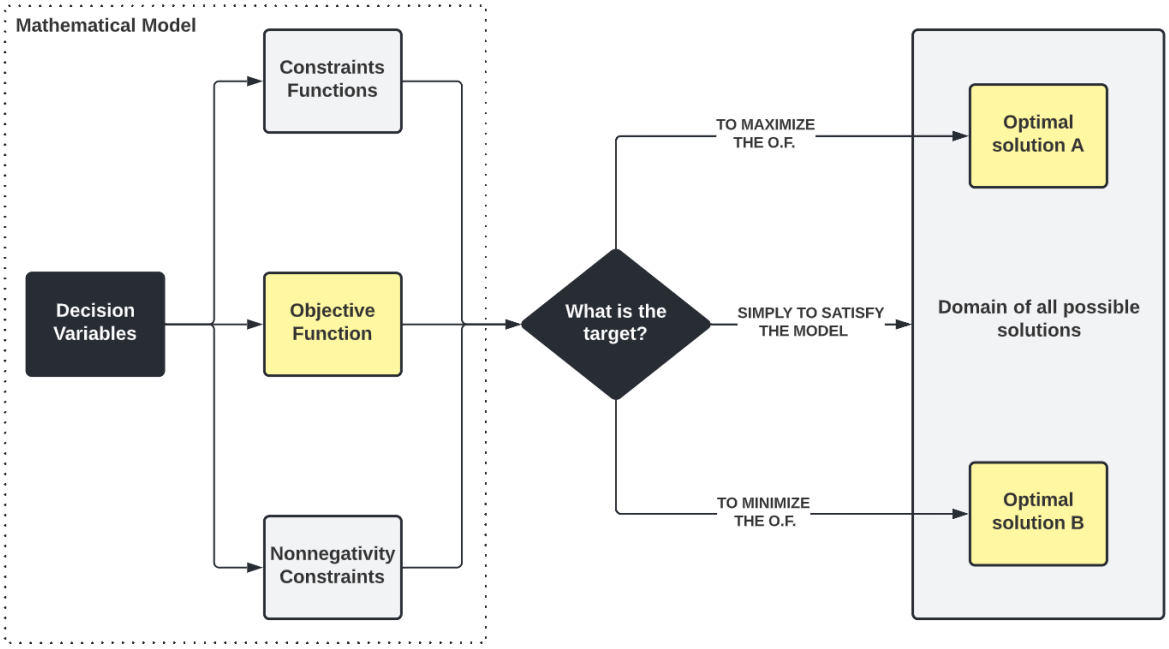

Fig. 1: Flowchart representing an integer or linear programming process.

Table 1: Company's simplified scenario

Working days	**Shifts/day**	**Nº of Products**	**Nº of Machines**
65	2	5	3

Table 2: Production distribution between products and machines

Product	**Machine 01**	**Machine 02**	**Machine 03**
Model 01	10 units/shift	Not produced	18 units/shift
Model 02	15 units/shift	Not produced	21 units/shift
Model 03	20 units/shift	Not produced	18 units/shift
Model 04	Not produced	28 units/shift	33 units/shift
Model 05	Not produced	19 units/shift	21 units/shift

Each one of the three machines is capable of processing a different set of products. Also, each product is manufactured at a different rate, depending on the machine, as shown in Table 2.

The demand for each product for the period is defined and known. There will be necessary to produce 1500 units of product 1; 1300 units of product 2; 700 units of product 3; 950 units of product 4; and 1500 units of product 5, totaling 5950 units. The company disposes of enough raw material to produce a maximum of 7500 products. Along with that, the company knows the profit margin for each product, which is summarized in Table 3.

Table 3: Demand and profit margin per product

Product	**Demand**	**Profit per unit**
Model 01	1500 units	€ 23,00
Model 02	1300 units	€ 22,00
Model 03	700 units	€ 21,00
Model 04	950 units	€ 19,00
Model 05	1500 units	€ 20,00

Since this is an oversimplified model, it does not consider any costs involving inventory management; raw material storage and logistics; employee, contracting and subcontracting; overtime; among others.

3.2 Integer Programming Model

Considering that one product can be manufactured in more than one machine, it is important to define X_{ij} as the quantity of product i processed in machine j. These quantities represent the decision variables of the linear programming model, thus, they have to be an integer number. Furthermore, it is important to notice that there are no X_{12}, X_{22}, X_{32}, X_{41}, and X_{51}, because some machines are not capable of manufacturing certain products (see Table 2).

As in this example, most of the time, when integer programming is used to develop aggregate production planning, the major objective is to maximize profit [2]. Thus, in such a case, the objective function is going to represent the profit itself.

The profit equation must consider every possible aspect: the more accurate the objective function is, the better the model. In a simplified way, the profit is a function of the quantity of goods that are produced times its margin, i.e., the difference between the selling price and the production cost. For the company under consideration, the profit equation can be written as follows in (1).

$$\begin{aligned} P = C_1(X_{11} + X_{13}) + C_2(X_{21} + X_{23}) + C_3(X_{31} + X_{33}) \\ + C_4(X_{42} + X_{43}) + C_5(X_{52} + X_{53}) \end{aligned} \tag{1}$$

Where P is the total profit, given in euros and the C_i is the profit for the product

i, expressed in euros/unit, accordingly to Table 3. In this context, the profit will be maximum by determining the optimal quantities X_{ij} to be produced.

The constraint functions are what limit the solution within the domain. In the model that is being presented here, there are three constraints: the available raw material; the usage of all machines during the four months; the minimum demand for every product.

As it is known, the company has enough raw material only to produce 7500 units of all products combined. In terms of the mathematical model, this can be written as follows:

$$X_{11} + X_{13} + X_{21} + X_{23} + X_{31} + X_{33} + X_{42} + X_{43} + X_{52} + X_{53} \leq M_{max} \tag{2}$$

Where M_{max} is the maximum quantity of goods that can be produced with the available raw material.

As previously mentioned, the second constraint is related to the limited machinery usage during the four months. As stated in Table 2, each machine produces a certain product at a certain rate. For example, both machines 1 and 3 can manufacture product 2, but their production rate is 15 units/shift and 21 units/shift, respectively. Because of this, it is needed to establish one constraint for each of the three machines, as stated below.

$$\frac{X_{11}}{T_{11}} + \frac{X_{21}}{T_{21}} + \frac{X_{31}}{T_{31}} \leq T_1 \tag{3}$$

$$\frac{X_{42}}{T_{42}} + \frac{X_{52}}{T_{52}} \leq T_2 \tag{4}$$

$$\frac{X_{13}}{T_{13}} + \frac{X_{23}}{T_{23}} + \frac{X_{33}}{T_{33}} + \frac{X_{43}}{T_{43}} + \frac{X_{53}}{T_{53}} \leq T_3 \tag{5}$$

Where T_j is the amount of work shifts that machine j can operate at its full capacity, during the 65 working days; T_{ij} is the average quantity of products i manufactured per shift when processed in the machine j, given in units/shift. Each constraint (3), (4) and (5) is measured in number of shifts, since each one is the sum of X_{ij}/T_{ij}, for every product i and machine j.

The third set of constraints is the minimum quantity of each product that has to be produced, i.e., the individual demand, which can be filled by the quantities produced in every machine. Therefore, it can be defined as follows.

$$X_{11} + X_{13} \geq D_1 \tag{6}$$

$$X_{21} + X_{23} \geq D_2 \tag{7}$$

$$X_{31} + X_{33} \geq D_3 \tag{8}$$

$$X_{42} + X_{43} \geq D_4 \tag{9}$$

$$X_{52} + X_{53} \geq D_5 \tag{10}$$

Where D_i is the product's i demand in the considered period, given in units, accordingly to Table 3.

The last mathematical definition that is required to complete the model is the non-negativity constraint - a premise of linear programming - which defines that it is not possible to produce a negative quantity of any product. This can be determined as follows in (11).

$$X_{ij} \in Z | X_{ij} \geq 0 \tag{11}$$

This assumption means that the quantity of product i manufactured in machine j, X_{ij} is greater or equal to zero and, as stated before, must be an integer because products cannot be produced partially, since the company is characterized by a discrete process.

The summary of the aggregate planning model proposed is presented in 3.2. It gathers all the information about the integer programming model discussed.

$$\text{Maximize } P = \sum_{i=1}^{5} \sum_{j=1}^{3} C_i X_{ij}$$

$$\text{s.t.} \quad \sum_{i=1}^{5} \sum_{j=1}^{3} X_{ij} \leq M_{max}$$

$$\frac{X_{11}}{T_{11}} + \frac{X_{21}}{T_{21}} + \frac{X_{31}}{T_{31}} \leq T_1$$

$$\frac{X_{42}}{T_{42}} + \frac{X_{52}}{T_{52}} \leq T_2$$

$$\frac{X_{13}}{T_{13}} + \frac{X_{23}}{T_{23}} + \frac{X_{33}}{T_{33}} + \frac{X_{43}}{T_{43}} + \frac{X_{53}}{T_{53}} \leq T_3$$

$$X_{11} + X_{13} \geq D_1$$

$$X_{21} + X_{23} \geq D_2$$

$$X_{31} + X_{33} \geq D_3$$

$$X_{42} + X_{43} \geq D_4$$

$$X_{52} + X_{53} \geq D_5$$

$$X_{12} = X_{22} = X_{32} = X_{41} = X_{51} = 0$$

$$X_{ij} \in Z | X_{ij} \geq 0$$

4 Results and Discussion

First of all, it is important to state that this model is oversimplified. In reality, much more variables must be taken into consideration, such as inventory management; raw material storage and logistics; employee costs; among others.

When involving up to 8000 variables, an integer programming problem can be solved through Excel using the Solver add-on. Therefore, since the model described in section 3 is relatively simple, it was imported into Excel and the add-on Solver was used. Thus, the results are shown in the Figure 2.

Aggregate Planning					
	Product 1	Product 2	Product 3	Product 4	Product 5
Machine 01:	0	843	1476	-	-
Machine 02:	-	-	-	950	1825
Machine 03:	1948	457	0	0	0
Sum:	1948	1300	1476	950	1825
Demand:	1500	1300	700	950	1500
Surplus:	448	0	776	0	325

Fig. 2: Results of the integer programming model

As can be seen, the maximum profit possible is € 158.950,00, which corresponds to € 37.735.50 a month. All machines are considered to operate almost at their maximum, once their usage is very close to 100%. The only goods that have been manufactured in surplus are products 1, 3, and 5, with 448, 776, and 325 surplus units, respectively. This was made to maximize the usage of every machine because the demand can be satisfied in less than 65 working days; therefore, those surplus items are going to be stored. The fact that only products 1, 3, and 5 are being produced in surplus is because the model identified that in such a way, the profit function is maximized.

5 Conclusion

It can be concluded that the model satisfies the optimization premise, since, after supplying the demand, the model seeks solutions in which the surplus products are more profitable, and then maximizes their production to ensure that no machine is idle. Furthermore, as each machine produces the same product at a different rate, it can be seen from the results that the model allocated most of the production of a given product to the most efficient machine, as it is expected.

Face all that has been presented in this paper, one can assure that integer programming consists of a powerful tool in developing aggregate production planning. No matter the size of the company, the possibility of predicting a vast number of scenarios is fundamental for any firm that wants to prosper and grow [2].

Along with that, it is clear that any small- or medium-sized company is capable of creating and operating its aggregate production planning using integer programming. Although the model shown in this paper is very simple, the importance of good management has been evidenced one more time.

Future developments should improve the objective function and the constraints functions to consider inventory management and costs; raw material storage and logistics; employee costs, contracting and subcontracting; overtime; among others. This will make the model more realistic, and, therefore, the results more reliable.

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Smart system for monitoring and controlling energy consumption by residence production and load

Paloma Greiciana de Souza Dias[1,3], Thadeu Brito[2], Luis Cláudio Gambôa Lopes[3], and José Lima[2]

[1] Instituto Politécnico de Bragança, Portugal
a52486@alunos.ipb.pt
[2] Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Bragança, Portugal
jllima, brito@ipb.pt
[3] Centro Federal de Educação Tecnológica de Minas Gerais (CEFET-MG), Leopoldina, Minas Gerais, Brasil
lcgamboa@cefetmg.br

Abstract. Monitoring and controlling the energy consumption of electrical appliances brings significant benefits to both consumers and the energy utility. This work presents a system for monitoring and controlling energy consumption by residence loads connected to smart plugs. The user will have a tool to view consumption information and remotely turn loads on and off, as well as control the power level at which certain appliances will operate. In addition, it is intended to give the system the ability to make decisions regarding the operation of electrical devices based on the electrical energy available. This decision-making can occur either through priorities established by the user or, possibly, through Machine Learning applied to the system, based on the consumption pattern. Solutions like these can even be applied in situations where the user produces his own energy and would like to use the surplus produced to meet certain loads.

Keywords: Monitoring and control Energy · Internet of Things · Priority of loads · ML.

1 Introduction

Currently, technological growth, coupled with the development of the Internet of Things (IoT), has fostered the evolution of smart systems [4, 10]. In this scenario, terms such as Smart City, and Smart Home, among others, are increasingly common. Within this theme, the Smart Plug technology can be highlighted, a device that, connected to residential electrical appliances, allows the monitoring of the energy consumption of these types of equipment as well as its remote control, including turning on and off [7]. The adoption of this technology interferes with the consumption pattern of its users. It can contribute to a more conscious use of energy [4].

Regarding the monitoring and control of plugs, several platforms can be used for such functions, such as applications on smartphones, through which the user can monitor their consumption and turn on/off the plug [1]. Thus, this work deals with a project under development that aims to monitor and control energy consumption in devices connected to smart plugs, allowing the user to visualize their consumption pattern and control their devices remotely from the activation and deactivation of the devices until the control of the consumed power. In addition, the smart monitoring and control system will have the ability to make decisions based on energy consumption priorities that the user can set. As an example, the consumer will be able to define the time when specific

devices must be turned on or off. Alongside this process, Machine Learning will also be implemented for the system's decision-making, contributing to the energy consumption by the devices with the highest priority given the available energy, whatever the source, and the user's consumption pattern.

Thus, this work is organized in parts, so that, in topic 2, the related works to the project theme are presented; in topic 3, the research proposal aims to reaffirm the objective to be achieved with the development of the project; in topic 3.1, the work development in this scenario is presented and, in topic 4, future works and the conclusion of the exposed ideas are presented.

2 Related Works

Currently, monitoring energy consumption is vital for taking measures that lead to a more conscious use of energy, the reduction of the exacerbated use of energy resources, and the consequent development of energy efficiency. The reality that involves energy management and introducing the concept of the IoT in the energy sector, the evolution of smart systems is remarkable, both on the generation and distribution side and on the demand side. As an example, in [2], Abdulrahman Al-Ali et al. published a paper on an Energy Management System (EMS) for smart homes, in which they used IoT and a data analytics platform. In this context, the microcontroller collected data regarding energy consumption and environmental conditions and sent it to a server. Then, the information was stored in a database and analyzed using Business Intelligence (BI) tools so that it could later be organized in a visually understandable way. Tables and graphs define this format, and reports are presented to energy consumers through a mobile platform. The system also gave the user the ability to control home devices remotely. Basically, through the mobile application, the consumer could turn on/off devices, which were connected to relays commanded by the microcontroller.

In [5], Syed Zain Rahat Hussain et al. developed a load monitoring and control system using LoRa technology and a SCADA server. The project consisted of a load energy consumption measurement system, whose data were processed and sent to a gateway via LoRa. The information was sent to a SCADA server managed by the power utility from the gateway and using the MQTT communication protocol. This server had a data visualization interface and functions such as alarms, and report development, among others. The information was analyzed in real-time and the SCADA system allowed ON/OFF control of the loads.

In addition to this topic, in [10], Kaike Alves Silva developed a system for monitoring energy consumption by electrical loads. For this, specific loads were used from which electrical quantities were measured, such as active, reactive, and apparent power, effective current and voltage, and the power factor. The ESP32 microcontroller was used for data processing due to its wide applicability and relevant resources, such as Wi-Fi communication and connection to the Arduino IDE. From there, the information was sent to the InfluxDB database, a type of TSBD (*Time Series Database*) and open-source database, commonly used in applications that deal with real-time data. Grafana was used as a tool to visualize the measured quantities, which provides the user with a real-time view of the measurement system and histories and alerts.

Within the reality that involves energy management using priorities for the use of electrical appliances, in [9], Mohammad Shakeri et al. developed a work that proposes the use of smart plugs connected to a residential energy management system (HEMS), which, in turn, communicates with the utility through a smart meter. Smart plugs can store consumption parameters of electrical appliances and send this information to the HEMS controller. It controls electrical devices based on established consumption priorities, defined by the user when the devices are controllable. In addition, HEMS also receives signals from the utility company to change or reduce the operating time of certain electrical appliances according to energy demand and price.

3 Research Proposal

The objective of this work is to develop a system for monitoring and controlling the consumption of electric energy through smart plugs, giving the user the possibility to visualize information related to their consumption pattern and to define which loads will work, in addition to the power level at which certain loads will act. In addition, it is intended to insert priority strategies for the operation of loads and also to use analysis methods such as Machine Learning to define, in a more elaborate way, the behavior of the system. Such strategies will also be useful to shape the functioning of systems that aim to take advantage of surplus energy production, redirecting it to specific loads instead of supplying it to the utility. Next, what was developed in the project will be presented, and the functions that will still be implemented.

3.1 Work development

The data read by the plugs is processed by ESP32, a microcontroller that contains features like built-in WiFi and Bluetooth, as well as two processors and other features that make it widely used in many wireless applications [8]. ESP32 sends data over WiFi to an Message Queuing Telemetry Transport Protocol (MQTT) broker. This is a communication protocol intended for Machine-to-Machine (M2M) communication, and its use involves publishing and transmitting data using a broker [11]. Figure 1 presents the structure of the system under development.

The code that runs on ESP32 is developed in the Arduino IDE. In addition, through MQTT, the Node-RED control tool is used, an open-source platform designed from Node-Js, through which it is possible to create flows that perform functions such as connecting to web services and sending data for other platforms, for example, [6]. Then, the consumption data is sent to the InfluxDB database and presented by the Grafana platform. In this way, users can view the consumption of appliances connected to smart plugs through their monitoring and control devices.

4 Future work and conclusions

Still considering Figure 1, it is intended to develop in the system the ability of the user to control the smart plugs, either turning the electrical devices on or off or control the power level at which they will work, and the ability to determine the priority

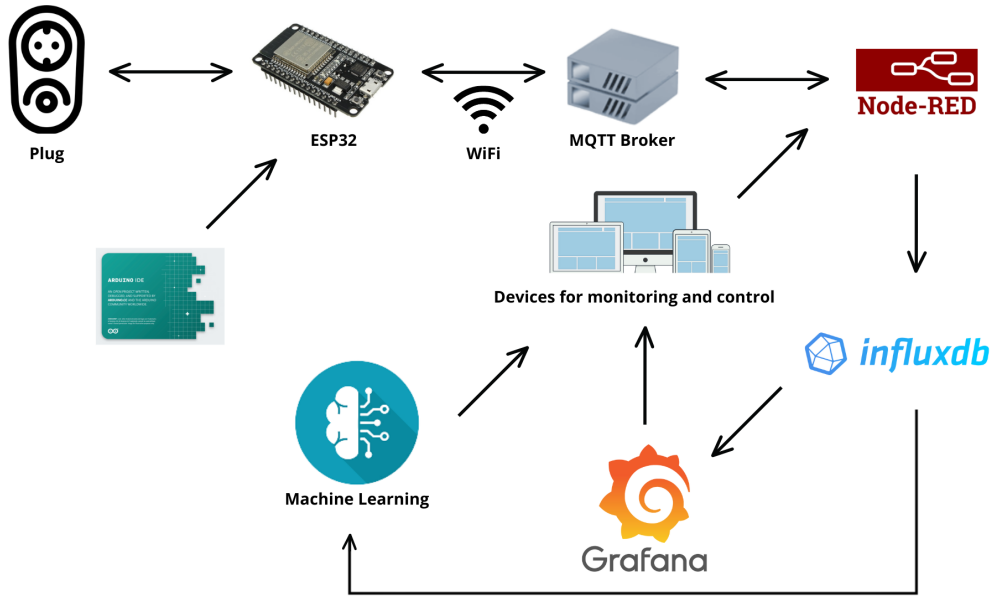

Fig. 1: Representation of the energy consumption monitoring and control system.

operation of their gadgets. In addition, the objective is to apply Machine Learning so that the system itself can analyze consumption behavior and make coherent decisions about which devices will work or not and under what conditions. As an example, in a scenario where the user generates his own energy and would like to use the surplus energy produced without sending it to a battery bank or to the grid, the consumer can manually establish a priority list of certain loads that will consume surplus energy and the power at which they will run, based on your needs. As defined by the user, a command is sent to the smart plug connected to the devices in question. When the smart plug executes the command established by the consumer, this information will be stored in a database, in InfluxDB itself. In this same context, decision making can also be done using Machine Learning. Based on the user's consumption history at a given time, excess energy will automatically be directed to specific loads. Likewise, when smart plugs execute the commands sent, this information will be stored in a database.

In short, it emphasizes the importance of working on the use of available electrical energy to meet the user's needs without compromising their comfort and consciousness.

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Building of Smart Plugs to Energy Efficiency in the Residence Load Management

William Rodrigues Silva[1], Thadeu Brito[2], Luis Claudio Gambôa[3], and José Lima[2]

[1] Instituto Politécnico de Bragança, IPB, Portugal
a52488@ipb.pt
[2] Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Portugal
jllima@ipb.pt, brito@ipb.pt
[3] Centro Federal de Educação Tecnológica de Minas Gerais, CEFET-MG, Campus Leopoldina, Brasil
lcgamboa@cefetmg.br

Abstract. It is known that electrical energy consumption is higher during the day than at night.This is a challenge to balance the consumption levels because when the consumption is high at night, it does not have energy production to supply and the tariff usage is cheaper. Aspiring to avoid the users consuming too much electrical energy and work on this usage control during the night, the present work aims to develop smart plug modules that could self-manage power in residence utilizing the minimum of grid energy. In this sense, the modules may use the overproduction of energy coming from generator systems (such as photovoltaic panels), eliminating the necessity of battery usage. Sometimes, the power supply could provide different values of current, consequently, the use of this electric energy needs to adapt according to the production. Therefore, the final objective is to build an intelligent electrical management system that works on energy efficiency.

Keywords: Smart Plugs · Energy Efficiency · Renewable Sources.

1 Introduction

With the population growth and the technological development that has been seen in the last years [4, 10], turns increasingly intense and necessary electrical energy usage. However, many sources used for electricity generation own limitations in nature or/and are big carbon gas emitters. Furthermore, in 2015 a work made by the Brazilian Association of Energy Conservation Service Companies (ABESCO), a non-profit company focused to promote actions and projects aiming the development of the energetic industry, demonstrated that companies also are affected by energy waste. The report shows that approximately 10% of the energy generated in Brazil, a country predominantly supplied by hydroelectric, is wasted. This percentage represents 12.64 billion reais which 2.79 billion are from the commercials end-users, 5.51 billion residential end-users, and others from industries and less impactful end-users.

In case of Portugal, one of the biggest issues related in the last years is the energy poverty that has been verified through the high percentage of people exposed to the cold weather at their homes: 18,9% of the population meanwhile the European average is 7,5% related to the European Union Statistics on Income and Living Conditions (EU-SILC) [2] turning the cold weather one of the most critical living conditions. Another research about this topic has been realized by OpenEXP, a global network of independent experts that aims the implementation of the sustainable development goals [7],

that 24,9% of the deaths in the winter was because of the bad home conditions and puts Portugal in the 25th place of the poorest countries energetically with 36,7% in the scale of the European Energy Poverty Index Tool (EDEPI) [6].

Furthermore, with the increase of the Internet of Things (IoT) in so many applications aiming smart and efficient systems, is introduced in the industry the smart plugs, that are plugged with a supervisory and control of energy supply apparatus set by the user through an app or via Web.

2 Related Works

The smart plugs present in the industry cannot disconnect a load automatically, for example, [9]. They have only an on-off control and don't have a sophisticated supervisory system away as the user could determine the priorities of each load and a custom supervisory system.

Some research about smart plugs can be found in IEEE Xplore, for example, like [8], that proposes the elaboration of a smart plug that communicates through Wi-Fi connection, uses of ESP32 microcontroller as an information center, a relay as an actuator, voltage and current sensor to get the measures and all the control and supervision are made by a WebApp. This system can measure the instantaneous voltage, current, power, energy consumption, and electricity bills. It had a virtual button to turn on or turn off the plug via the app as an action.

In [1], a similar proposal has been applied, which is used the wireless protocol Zigbee. This work has developed smart plugs and a condition monitoring circuity, with the function of a group of all the information and communication with the plugs. This circuit is composed of sensors that aim to control the temperature of a refrigerator and the illuminance through two temperature sensors, one for the room and another for the fridge, and a luminosity sensor. Therefore, through an algorithm flowchart defined by the code, the system can handle the load actuation automatically.

From the point of view of self-consumption, the energy oversupply from photovoltaic panels usually comes back to the grid, and, in some countries, does not have a regulation of this energy aiming to utilize the maximum of the generated power. Concessionaires can apply taxes that could vary depending on the company [5] or, in the case of self-generation, which is disconnected from the grid, it is necessary high invest in batteries.

3 Research proposal

Trying to use the supply energy coming from the photovoltaic panels, it is interesting develop an smart plug capable to redirect this surplus energy to a load that needs to work constantly during this period and, when this surplus energy over, it can switch automatically to the conventional one. The plugs also could make decisions based on the tariffs during the day turning the bills more cheaper.

The main idea of this work for now is to develop the hardware part of the plugs whose power can be controlled remotely using IoT technologies by decision-making made by the user in a supervisory system. Then, considering the voltage is constant, the current

intensity is the variable to be controlled using a TRIAC (Triode of Alternating Current). Arduino UNO R3 could control this component, that is, the microcontroller could set the values of current that an electrical device can use. The measures will be sent to the microcontroller for each plug connected with an ESP32 node, grouping many plugs, which will send, via Wi-Fi, to a monitoring center made with another ESP32 to receive the data and manipulate it to show on a screen to the user all the status of the system and customize the levels of power. The focus now is on the development of the hardware of the plug and the software using the Arduino board that controls each plug as marked in the red square in Figure 1.

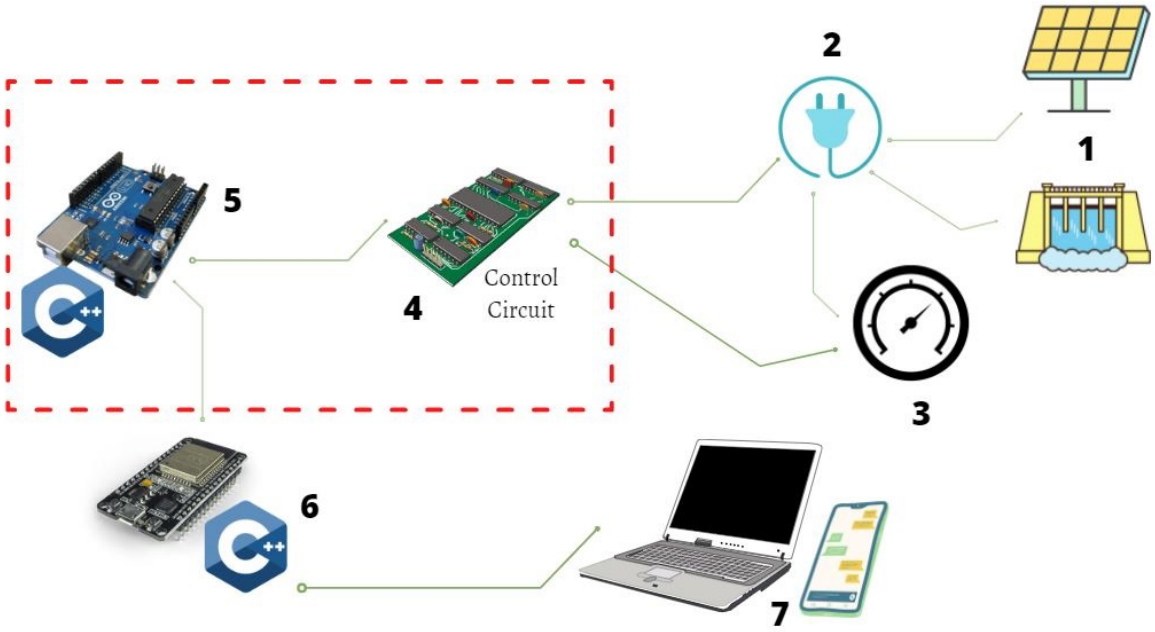

Fig. 1: Schema of the components that compose the smart plug operation.

The part ① is the generation coming from the renewable source or from the conventional power grid. The part ② represents the alternate energy available to be used or manipulated by the control circuit represented by ④. It will be necessary collect all the measures represented by ③ to build a complete supervisory system. The parts ④ and ⑤ will be inserted in a same protoboard which is the start step of the work. The supervising system that will be increase later is represented by the ESP32 of ⑥ and all the data and server represented in ⑦ that could be shown on a smartphone or laptop screen.

The control circuit was started with a basic dimmer lamp based on [3] replacing the control of TRIAC with the digital output of Arduino, increasing with an optocoupler that offers better isolation. After that, was growing an LDR (Light Dependent Resistor) to get information about the luminosity and control a load according to this data feeding with the 5V DC voltage and getting by the analog input of Arduino the luminosity.

Hereupon, it was designed as a circuit that only turns on or off the load through a relay. Last, it developed a circuit that works like a fading switch and is helpful in some applications like a chicken coop greenhouse. For example, a smooth luminosity control is necessary to offer comfort to the animals. These circuits grouped on an only board offer the user multiple possibilities of application in the same device.

One of the principal challenges of this work is dealing with the processing time and avoiding undesirable delays as long as it has an interaction between an analog variable and a digital one, causing an improper operation. As a solution for this issue, an appropriate way to get a fast response is the use of interruptions in the Arduino code.

4 Conclusion and future works

This work shows a purpose to control the power offering security for the user and an economical way to use the electrical energy through the joining of electronic components, offering different ways to control the power depending on the kind of load and programmatic skills to activate the TRIAC and, in the meantime, solving delaying problems that a digital converter can face interacting with an analog system.

For future works, it could be increased a machine learning system to get a considerable volume of data like the weather conditions and the user lifestyle to control some load getting more smarter management as a similar application that can be related in [9].

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Dynamic Extraction of Holiday Data for Use in a Predictive Model for Workplace Accidents

Danilo Magone Duarte Martins[1], Felipe G. Silva[1], Inês Sena[1], Laires A. Lima[1], Florbela P. Fernandes[1], Maria F. Pacheco[1], Clara Vaz[1], José Lima[1], and Ana I. Pereira[1]

Research Center in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal {m309041}@alunos.ipb.pt,{gimenez, ines.sena, laires.lima, fflor, jllima, pacheco, clvaz, apereira}@ipb.pt

Abstract. Workplace accidents are a concern for companies nowadays and can occur due to internal and external factors of the company. Thereby, several strategies are developed to predict and minimize the hazards in this environment. Companies resort to intelligent solutions, such as predictive analytics, aiming to increase productivity while ensuring safety in the work environment. In terms of accident prediction analysis, different input data are needed to ensure the accuracy of a predictive model. Therefore, this study aims to automatic collect and pre-process data from holidays for subsequent implementation in an accident-oriented predictive model to demonstrate its relevance in predicting accidents in the workplace.

Keywords: Data Extraction · Web Service · Data mining · ElementTree

1 Introduction

Accidents in the workplace have been extensively studied by developing theories that try to explain, prevent and reduce them. The most used approaches are the accidents research and the implementation of preventive actions. However, digital technology solutions, such as predictive analytics, have started to be studied and implemented, contributing to the improvement of safety in the workplace [3]. Several areas, such as energy and construction, use accident prediction through predictive models with different input parameters referring to the accident and workplace [1,10]. In addition to factors relating to the company and employees, external factors influence the occurrence of accidents as they are part of the employees' daily routine, and can directly affect their performance [2,7]. Some authors have developed occupational accident prediction models considering weather data as predictors [9,11].

Recent literature has demonstrated the relationship between psychological aspects and occupational accidents. Studies mention that employees who endure high pressure for productivity are more likely to develop high levels of anger, sleep disturbances, health problems, and an increased risk of accidents and/or injuries [12]. Other studies reinforce the link between occupational stress and workplace accidents [8]. A model that intends to predict accidents can be directly influenced by factors extrinsic to the workplace.

In this context, this work aims to develop a Python script that can automatically and dynamically collect, from a Web Service, dates (and respective days of the week) of Portuguese national and municipal holidays between 2018 and 2022, considering that some holidays alter their date periodically, such as Easter. In addition, it is not easy

to find a single calendar that gathers information about the municipal holidays of the various Portuguese cities, which usually do not occur on the same date and weekly day.

By obtaining these holidays' data, we intend to prepare a dataset and use it to study the impact that national and municipal holidays have on the retail sector and, consequently, on employees. It is mandatory to find input parameters for the accident prediction model¸ because several factors influence the occurrence of accidents. After an extensive review, none studies were found involving this type of data nor on the influence that holidays have on stores in the retail sector. In other words, holiday data can be explored in conjunction with accident information to increase the performance of predictive models and minimize risk. The data needed to feed a predictive system can be collected from different sources: sensors, forms, databases (online and offline), and directly from the internet, among others. One of the options for obtaining data collected directly from the internet is Web Services, which are applications without a graphical interface designed to receive and respond to requests from other applications. This communication with other applications is done using the HTTP protocol, and the XML specification for the data [15].

HTTP request libraries are easy to find in modern programming languages [14]; some of the most used Python HTTP request libraries are httplib2, urllib2, and requests [4]. The response of HTTP requests is divided into three parts: the status code, in a set of headers, and the entity-body. The entity-body is the most crucial part as it is where the web service client will get the information it needs when parsing an XML document [14]. Works such as those by [5,6,13] use the ElementTree library to analyze XML documents with the tree style strategy because, with this library, it is possible to parse an entire XML document with just one line of code.

This paper is organized into four sections. The Section 1 describes the study's structure, the motivation in the development, and a brief literature review on the relevance of holiday data in accident prediction and the usual procedure used to extract this type of data. The procedure adopted to collect the data is described in Section 2. In Section 3 the results obtained are analyzed and discussed. Finally, the study is concluded, and future work is presented in Section 4.

2 Methodology

Fig. 1 shows the steps used to obtain the dataset that contains Portuguese national and municipal holidays. As it is possible to observe, six steps were taken into account to obtain the desired data. A description of each step follows.

- Data Collection (Step 1) – To find or identify possible sources for the desired data, among web pages, databases, and Web Services, for example.

- Literature Review (Step 2) – After choosing the selected data source, there will be a literature review about the existing methods to extract the data and about the pre-processing methods.

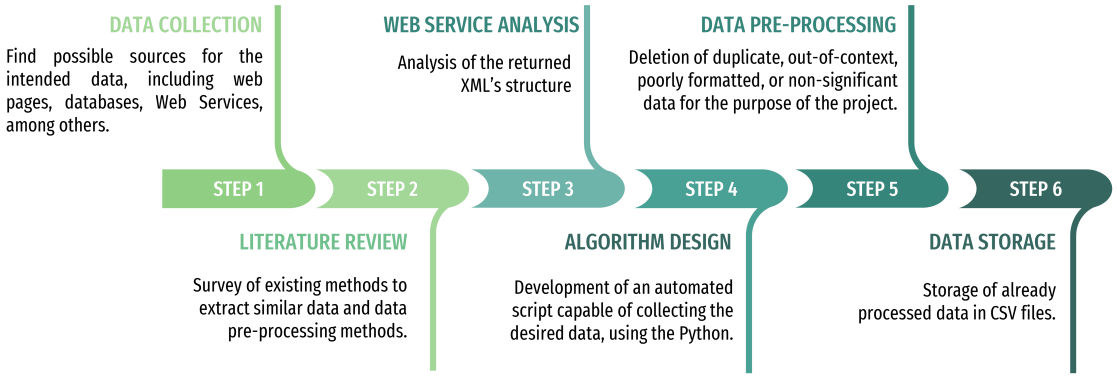

Fig. 1: Methodology used.

– Web Service Analysis (Step 3) – The structures of the XMLs returned from the Web Service were analyzed to prepare the algorithm's elaboration.

– Algorithm Design (Step 4) – Taking into account all the collected information, the algorithm will be designed through the development of an automated script capable of managing the desired data, using the Python programming language to create a client that receives documents XML from a Web Service.

– Data Pre-processing (Step 5) – After extracting the data through the algorithm developed in the previous task, pre-processing methods will be used to exclude duplicate, out-of-context, poorly formatted, or non-significant data for the project, as well as generating the day of the week when the holidays occurred, since the day can have some influence on accidents.

– Data Storage (Step 6) – The processed data will be stored in CSV files and used for further studies.

3 Results and Discussion

After searching for possible sources for the intended data, two Web Services were selected to return XML documents with information about municipal and national holidays. This choice is justified since this source had well-standardized data, facilitating the collection.

For Web Service, the year of interest must be a requesting data. In the case of municipal holidays, the ID number of the municipality is required, following a pattern provided by another service of the same Web Service. It was decided to collect data on all cities available in the Web Service and only then filter them according to the need. This approach was chosen since it is easier to autonomously filter the data once it is stored in a data frame of the Pandas library. This strategy could be problematic in large amounts of data, but this is not the case.

Before creating the script, the XML structures provided by the Web Services were analysed. Fig. 2 illustrates the hierarchy found for extracting data referring to municipal holidays.

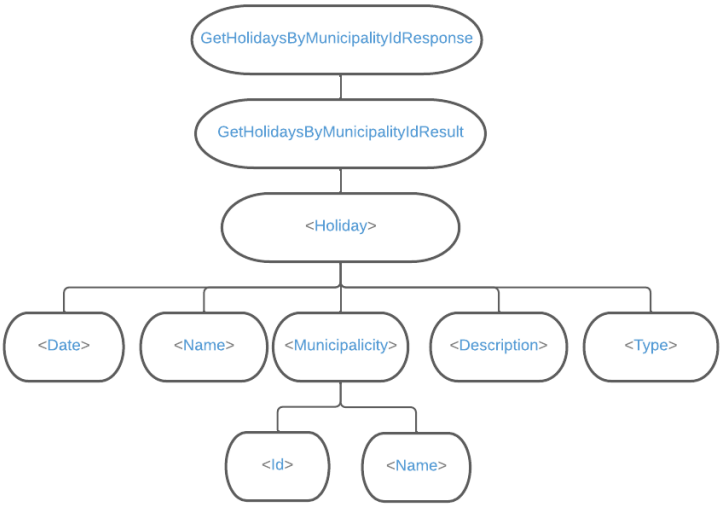

Fig. 2: XML Structure of Municipal Holidays

Fig. 3 presents the hierarchy found for collecting data on national holidays.

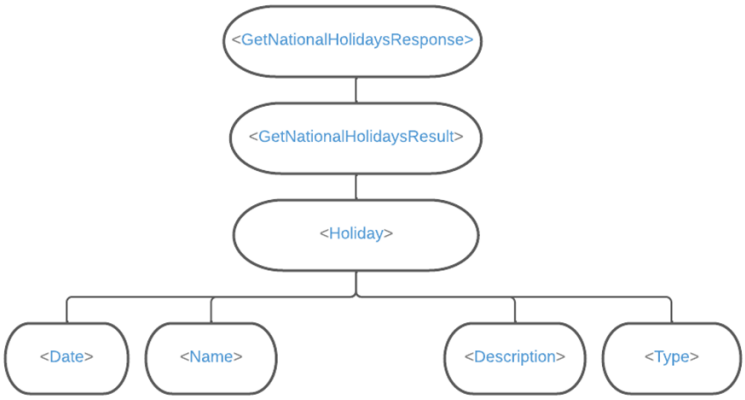

Fig. 3: National Holidays XML Structure.

The codes created make GET method requests for each year and municipality to the service in question, and the answer to these requests is stored in a variable of string type that has its content increased after each request made to the Web Service. This approach was chosen to facilitate the pre-processing data procedure.

With the content of all requests in a single variable, a pre-processing of the resulting XML is performed, that is, a single XML with the data of all the XMLs returned. The pre-processing consists of removing the root element, meaning, the tag at the top of the hierarchies shown in Figures 2 and 3 to allow the subsequent interpretation of the file by the libraries used.

Finally, the "fromString" function is used since string variables from the ElementTree library are used to obtain an Element object from the XML documents, one node from the tree. The node can be iterated to get access to the child nodes. The nodes have a "text" attribute with which it is possible to extract the text associated with each node and then obtain the desired data. Once the dates of each holiday are collected, the script get the corresponding day of the week using the weekday method of Python's datetime package.

The collected data are placed in data frames of the Pandas library in order to use the methods of this library to create *.csv* files as the final result of the scripts. In the next step of the research yet to be carried out, this library will also contribute to facilitate the filtering of the data.

The extracted dataset referring to municipal holidays contains about 914 data, showing the municipality's name, the holiday's representative date, and the day of the week that they occurred in each year selected, as can be seen in the sample presented in Table 1.

Table 1: Sample of the holidays data extracted in relation to municipal holidays

Municipality	**Date**	**Weekday**
Alcobaça	2018-08-20 00:00:00	Monday
Alvaiázare	2018-06-13 00:00:00	Tuesday
Ansião	2018-05-10 00:00:00	Thursday
...		
Elvas	2019-01-14 00:00:00	Monday
Fronteira	2019-04-06 00:00:00	Saturday
...		
Constância	2020-04-13 00:00:00	Monday
Coruche	2020-08-17 00:00:00	Monday
...		
Castro Daire	2021-06-29 00:00:00	Tuesday
Cinfães	2021-06-24 00:00:00	Thursday
...		
Calheta	2022-10-25 00:00:00	Tuesday
Velas	2022-04-23 00:00:00	Saturday

The dataset of national holidays extracted comprises 69 data, divided into the name of the holiday, the dates, and the day of the week that they occurred in each year selected, as shown in the sample shown in Table 2.

As shown in the tables, the data collected for each type of holiday were stored together, regardless of the year, to facilitate later use.

Table 2: Sample of the data extracted about national holidays.

Holiday	Date	Weekday
Ano Novo	2018-01-01 00:00:00	Monday
Carnaval	2018-02-13 00:00:00	Tuesday
Sexta-Feira Santa	2018-03-30 00:00:00	Friday
...		
Páscoa	2019-04-21 00:00:00	Sunday
Dia da Liberdade	2019-04-25 00:00:00	Thursday
...		
Restauração da Independência	2020-12-01 00:00:00	Tuesday
Imaculada Conceição	2020-12-08 00:00:00	Tuesday
...		
Dia de Camões, de Portugal e das Comunidades Portuguesas	2021-06-10 00:00:00	Thursday
Assunção de Nossa Senhora	2021-08-15 00:00:00	Sunday
...		
Dia da Liberdade	2022-04-25 00:00:00	Monday
Dia do Trabalhador	2022-05-01 00:00:00	Sunday

4 Conclusion and Future Work

The literature review made exposed that studies concerning the influence of holidays in workplace accidents occurrence are scarce. In this context, this research aimed to collect data to do such correlation. In this work scripts were created that can make requests to Web Services and interpret their response, and to store the collected information in *.csv* files.

To do so, extensive computational resources were not needed due to the use of the existing Python modules. The approach used may not be the most suitable for Web Services that can return extensive data, considering that the filtering was done only after data collection. However, the large computational cost involved in this process is not as significant for smaller applications as presented in this work.

After being processed and filtered by cities of interest, the obtained dataset will be used to study the impact that holidays may have on the occurrence of accidents. A new dataset will be prepared with the accidents between 2018 and 2022, already collected from a retail company in Portugal and associated to the occurrence of the holidays, the time spent from the last one and the proximity of the accident. These elements referring to holidays will be correlated with the cause of the accident to understand the influence of which a holiday may have on the behavior of the store and employees.

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MechDesk - An ontology solution to troubleshot vehicles problems

Diogo Camelo[1], João Ascensão[1], Rui Alves[1], and Paulo Matos[1,2]

[1] Instituto Politécnico de Bragança, IPB, Portugal
[2] CeDRI, Instituto Politécnico de Bragança, IPB, Portugal
a36739@alunos.ipb.pt, a34505@alunos.ipb.pt, rui.alves@ipb.pt, pmatos@ipb.pt

Abstract. Semantic Web is extension of the existing World Wide Web, providing tools and technologies to support the transparent exchange of information and knowledge among organizations. Nowadays, multiple areas can be approached by ontologies, part of the W3C standards stack, and the semantic web world, as the subject of this project, mechanics. Mechanics have been accentuated in a visible way, where the reality of living without means of transportation is not feasible in peoples lives. The development of new methods to increase the knowledge of drivers and everyday people about automated vehicles is essential. Regarding cars, revisions, maintenance, inspections, among others, are necessary and "mandatory" subjects and due to this, it is possible to prevent future damage by prolonging the life of the car. In certain cases, this doesn't happen, either due to wear of parts or unforeseen events, and despite being a busy market, drivers are not always informed about the best cares to take or the problems that may arise. As such, the theme of this project is to make a relationship between mechanical details, issues, and solutions. For that purpose, the defined ontology was exposed via a mobile application, with it providing to the user, several details that he can or not relate, and trough them, provide a connection with a certain problem and solution. The semantic web ontology was developed in Protégé, exposed into Apache Jena Fuseki server, and was running in an Azure Virtual Machine, allowing it to be available into the OutSystems application.

Keywords: Semantic Web · Ontology · Vehicles Maintenance.

1 Introduction

The internet as it's known today, has come a long way in a short period, from its origin as an exclusive technology for military use, to its current status as one of the developed world's primary sources of information and communication.

The Semantic Web is a vision about an extension of the existing World Wide Web, providing software programs with machine – interpretable metadata of the published information and data. In other words, further data descriptors are added to otherwise existing content and data on the Web. With this, computers can make meaningful interpretations, like the way humans process information to achieve their goals [5].

As in several cases, a normal user to achieve a goal, p.e information about a problem, doesn't need to have technical knowledge neither from the domain of the problem, neither from the technologies being used. The world is evolving in a way that creates a new reality, where everyday people can interact with multiple systems that they know a minimum or nothing, since those systems can grab the minimum information the user provides and process it.

Having this, the areas that can involve semantic web are various, such as health and medicine with medical diagnosis, higher education with assessment fraud, industrial

environments or public spaces vehicle maintenance, business-level schedules with their management, chemistry, human resources management or maintenance [6].

The specific number of vehicles worldwide is a little hard to obtain, what with all the different bodies responsible for counting them, but the best estimate put the figure at around 1.32 billion cars, trucks, and buses in 2016. It continues to grow at an astonishing rate If the staggering rate from the previous years of growth continues, the total doubling every 20 years, then we can expect to see some 2.8 billion vehicles on the planet in 2036 [2].

Maintenance keeps the vehicle running smoothly and safely down the road for a much longer distance compared to never doing upkeep. Observing the number of vehicles nowadays and the predictions for further years, ways of maximizing a vehicle or a certain component life span are needed. In certain cases, the drivers are not aware of what they should do or where is the cause of a certain problem when an unforeseen occurs.

As main scientific contribution, the authors present at this paper an ontology-based system to diagnosis car problems and suggest solutions. The diagnostic is done based on the reported symptoms, that can be detected and characterized by any conventional driver, does not requiring any kind of expert, helping it to a better perception of the situation he encounters at hand.

The remainder of this report is organized as follows: chapter 2 presents the concepts and basics of the semantic web; chapter 3 presents the defined ontology; chapter 4 presents the architecture and implementation; chapter 5 presents the conclusions and future work.

2 Semantic Web

Semantic Web technologies aim to define and interconnect data in a way similar to that in which traditional web technologies define and interconnect web pages. In the case of the traditional Web, each web page can be considered a unit of information or entity and pages are explicitly linked using HTML links [1, 7].

The Semantic Web requires interoperability on the semantic level as well as semantic interoperability requires standards not only for the syntactic form of documents but also for the semantic content. To allow a computer to understand the information at semantic web level, machine-readable information is needed, being Extensible Markup Language (XML) and Resource Description Framework (RDF)/RDF Schema (RDFS) two core solutions [3].

3 Ontology

In this section the ontology developed will be discussed and every component of it will be exposed and explained. During the development of this solution, two web semantic approaches were explored: ontologies and graph databases, being the first approach chosen to be continued and aborded. This was heavily due to the fact of the reasoner provided by the ontologies. The software used to develop this ontology was the ProtÃ©gÃ© ontology editor.

3.1 Classes

The ontology developed is constituted by the following eight classes: Vehicle, VehicleBrand, VehicleFuel, VehicleType, MechanicalComponent, Detail, Issue and Solution.

Since the main objective of this ontology was to associate mechanical problems with causes and identify possible solutions to solve these problems, the classes Detail, Issue and Solution were created. The class Detail represents a detail related to a mechanical component (MC) that is a symptom of an issue like p.e. motor noises or instability. The class Issue represents an issue that a vehicle can have in a specific MC, p.e. malfunctions in the gearbox or discharged battery. The class Solution represents a solution for an issue that a vehicle can have in a specific MC, p.e. charge battery or replacing a specific component.

To identify different types of vehicles and their MCs the classes Vehicle, VehicleBrand, VehicleFuel, VehicleType and MechanicalComponent were created. The class Vehicle represents a vehicle model, the class VehicleBrand represets a vehicle brand, the class VehicleFuel represents a vehicle fuel type, the class VehicleType represents a vehicle type and the class MechanicalComponent represents a MC of a vehicle.

3.2 Data properties

A common data property that every class has is an identifier, used to identify the instances of these classes, and something to describe them, such as a name or a label. Adding to that, some specific properties were also defined depending on the class. Regarding the characteristics of the data properties of these classes, they are all functional. This is due to the fact that these data properties cannot have no more than one value for each individual.

3.3 Object Properties

Regarding the object properties of this ontology, they were defined to associate classes, relating them.

The HasMechanicalComponent is the association between the Vehicle (domain) and the MechanicalComponent (range), the VehicleHasBrand is the association between the Vehicle (domain) and the VehicleBrand (range), the VehicleHasFuel is the association between the Vehicle (domain) and the VehicleFuel (range), the VehicleHasType is the association between the Vehicle (domain) and the VehicleType (range), the MechanicalComponentHasDetail is the association between the MechanicalComponent (domain) and the Detail (range), the IsPartOf is the association between the MechanicalComponent (domain) and the Vehicle (range), the IssueHasDetail is the association between the Issue (domain) and the Detail (range), the HasSolution is the association between the Issue (domain) and the Solution (range), the AssociatedWithIssue is the association between the Detail (domain) and the Issue (range), the AssociatedWithMechanicalComponent is the association between the Detail (domain) and the MechanicalComponent (range) and the HasIssue is the association between the Solution (domain) and the Issue (range).

These object properties represent the association of the classes of this ontology and some of them are the inverse of other object properties. In Table 1, the corresponding inverse object properties for each object property are presented.

Table 1: Object properties - Inverse Of.

Object property	Inverse Of
HasMechanicalComponent	IsPartOf
VehicleHasBrand	(-)
VehicleHasFuel	(-)
VehicleHasType	(-)
MechanicalComponentHasDetail	AssociatedWithMechanicalComponent
IsPartOf	HasMechanicalComponent
IssueHasDetail	AssociatedWithIssue
HasSolution	HasIssue
AssociatedWithIssue	IssueHasDetail
AssociatedWithMechanicalComponent	MechanicalComponentHasDetail

In Table 2, the characteristics of the object properties mentioned previously can be observed.

Table 2: Object properties - Characteristics.

Object property	Functional	Inverse functional	Transitive	Symmetric	Asymmetric	Reflexive	Irreflexive
HasMechanicalComponent	No	No	No	No	Yes	No	Yes
VehicleHasBrand	Yes	No	No	No	Yes	No	Yes
VehicleHasFuel	Yes	No	No	No	Yes	No	Yes
VehicleHasType	Yes	No	No	No	Yes	No	Yes
MechanicalComponentHasDetail	No	No	No	No	Yes	No	Yes
IsPartOf	No	No	No	No	Yes	No	Yes
IssueHasDetail	No	No	No	No	Yes	No	Yes
HasSolution	No	No	No	No	Yes	No	Yes
AssociatedWithIssue	No	No	No	No	Yes	No	Yes
AssociatedWithMechanicalComponent	No	No	No	No	Yes	No	Yes
HasIssue	No	No	No	No	Yes	No	Yes

3.4 SPARQL Queries

To demonstrate that the ontology fulfils her purpose, two SPARQL queries can be observed in Fig 1 and 2. The first query, given details/symptoms of a specific vehicle, gets all the issues associated with the given details/symptoms and the details/symptoms that also are associated with the issues found. The second query gets all details/symptoms of a specific vehicle.

```
PREFIX my: <http://www.semanticweb.org/Group2/ontologies/2021/11/Mechanical_Components_Problems#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT ?RelatedDetailId ?RelatedDetailName ?PossibleIssueId ?PossibleIssueName
WHERE {
  ?PossibleIssue my:IssueHasDetail ?RelatedDetail .
  ?PossibleIssue my:IssueId ?PossibleIssueIdPrev .
  ?PossibleIssue my:IssueName ?PossibleIssueName .
  ?RelatedDetail my:DetailId ?RelatedDetailIdPrev .
  ?RelatedDetail my:DetailsName ?RelatedDetailName .
  { SELECT ?PossibleIssue { ?PossibleIssue my:IssueHasDetail ?Detail {?Detail my:DetailId 1} UNION {?Detail my:DetailId 2}
} }
  BIND (xsd:string(?PossibleIssueIdPrev) AS ?PossibleIssueId) .
  BIND (xsd:string(?RelatedDetailIdPrev) AS ?RelatedDetailId) .
}
```

QUERY RESULTS

Table | Raw Response

Showing 1 to 5 of 5 entries

Search: Show 50 entries

	RelatedDetailId	RelatedDetailName	PossibleIssueId	PossibleIssueName
1	"1"	"Car is not starting"	"3"	"Discharged battery"
2	"1"	"Car is not starting"	"2"	"Dirty or misplaced spark plug"
3	"2"	"Excessive rotations"	"1"	"Car overheating"
4	"4"	"Heat"	"1"	"Car overheating"
5	"7"	"Little water in the radiator"	"1"	"Car overheating"

Showing 1 to 5 of 5 entries

Fig. 1: Return all the issues related to the details provided.

```
PREFIX my: <http://www.semanticweb.org/Group2/ontologies/2021/11/Mechanical_Components_Problems#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>

SELECT DISTINCT ?DetailId ?DetailsName
WHERE {
    ?Vehicle my:VehicleHasBrand ?VehicleBrand .
    {?Vehicle my:VehicleId 1} .
    ?Vehicle my:HasMechanicalComponent ?Mechanical_Component .
    ?Mechanical_Component my:MechanicalComponentHasDetail ?Detail .
    ?Detail my:DetailId ?DetailIdPrev .
    ?Detail my:DetailsName ?DetailsName .
    BIND (xsd:string(?DetailIdPrev) AS ?DetailId)
}
```

QUERY RESULTS

Table | Raw Response

Showing 1 to 19 of 19 entries

Search: Show 50 entries

	DetailId	DetailsName
1	"1"	"Car is not starting"
2	"11"	"Noise in the gearbox"
3	"13"	"Noisy transmission"
4	"14"	"Problem in shifting gears"
5	"18"	"The gear lever jumps from position"

Fig. 2: Return all the details for the vehicle provided.

4 Architecture and implementation

As referred, the main contribution of the project is the ontology. To make use of it, several ways to expose it into the user are possible, where in this case, a mobile application makes an everyday driver, with or without mechanical knowledge, provide information (Details) related to the vehicle or the occurrence. Based on these Details, and through the defined queries, the ontology makes a match with Issues and Solutions. In Fig. 3, it's possible to analyze the overview of the built architecture, consisting of 3 elements:

- An ontology that is responsible for having all data to be processed, being this data described in the previous chapter.
- An Apache Jena Fuseki Server, that is holding the ontology model and is responsible to make the ontology data accessible worldwide.
- A mobile application, developed in OutSystems, that making use of the developed ontology, provides the user with information about vehicles, to help him find a solution or solutions, plus the price to fix it, for a certain problem that it has.

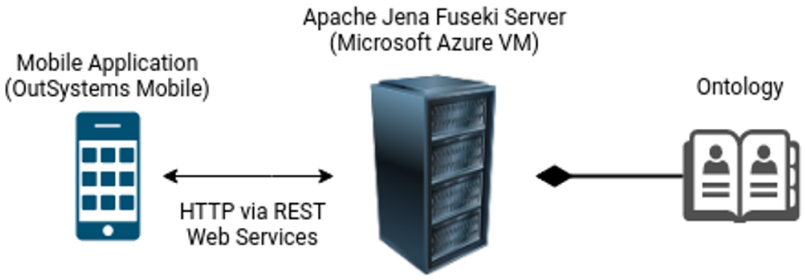

Fig. 3: Architecture Overview.

4.1 Apache Jena Fuseki Server

Apache Jena Fuseki is a SPARQL server developed in Java. This technology made use of the ontology developed in ProtÃ©gÃ©, storing it in a server, being possible to access it through a REST API [4]. The first phase of the development was having the Jena Fuseki Server running at Microsoft Azure, following the upload of the owl file from ProtÃ©gÃ©. The last step was the setup of the reasoner since by default, Fuseki doesn't come with one.

4.2 OutSystems Mobile Application

OutSystems, a low-code platform, it's possible to accelerate the delivery and production of a project, since its implementation was intended to that. Since the main goal of the project is a user to find the cause and solution for its status, a portable and practical application was needed, being it better if developed in mobile. Nowadays, and specially while driving, a portable cellphone is the standard device that is present. Every data related with the ontology that is present in this mobile application, it's coming directly through a REST API, making full use of the previous components.

The main view, Figure 4 left, allows a user to search by car brands and associated models. The user in terms to proceed, must select both fields. After that selection, the user will be redirected to a new view, where, a list of all details is shown, as visible in Figure 4 right. These details are associated with the vehicle chosen previously and the user can select one or multiple details or search by a specific name. After that, it can click in "continue" and advance to the issues view.

In this issues view, Figure 5 left, there are presented all issues/problems, associated with the details provided by the user. In this way, the user can observe related problems that he may have and start understanding where the problem could be. Inside each issue, there are all details associated with the details selected previously. It is possible to click an issue, where the user will be redirected to the solutions view.

The last view, Solutions, all solutions related with the issue that the user choose are shown, where a problem can have one or more ways to solve it. Inside each one of them, it is a price associated. This price can range from 0€, where nothing needs to be changed, until the full price of a new mechanical component. This is visible in Figure 5 right.

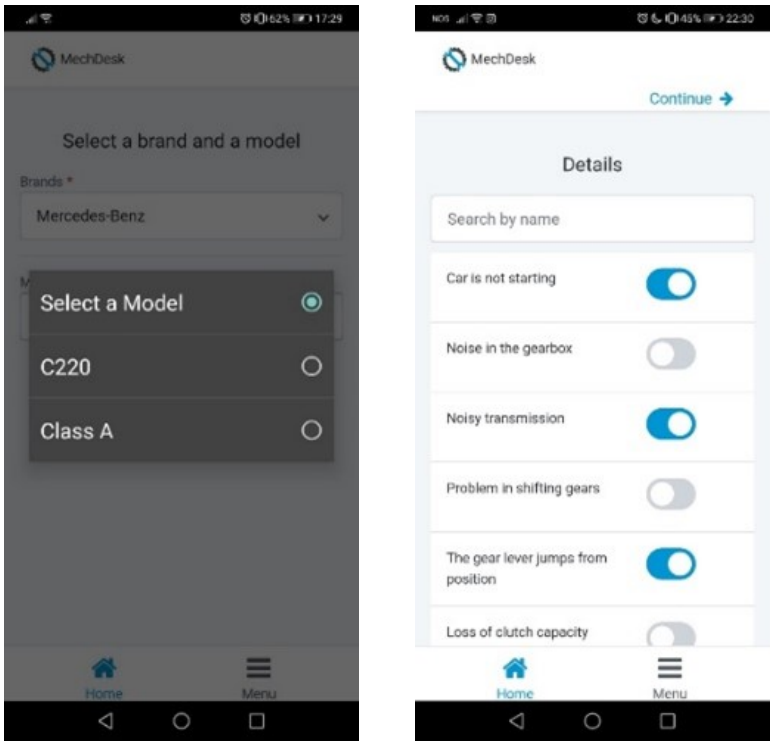

Fig. 4: Layout of the developed application (1).

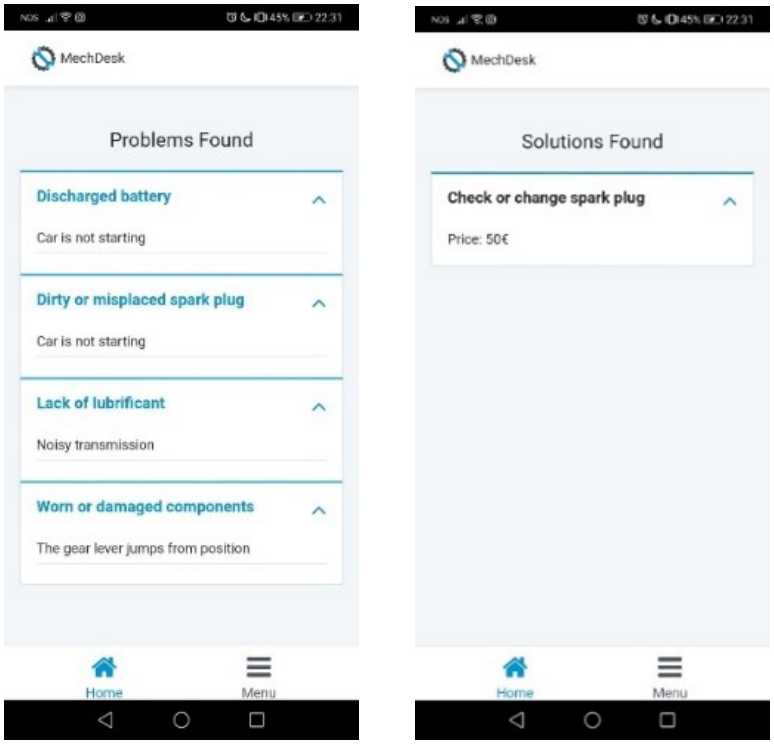

Fig. 5: Layout of the developed application (2).

5 Conclusions

This paper presents a resume about semantic web, as well as, the ontology, the queries, the architecture used and the mobile application. The software that was used to develop this project were Apache Jena Fuseki and OutSystems. With them, it was possible to upload the OWL, previously defined in ProtÃ©gÃ©, to the server, accessing it through the application. The reasoner was also added since, by default, it didn't come defined in the Apache Jena Fuseki. The SPARQL queries that were considered relevant for the application, demonstrating the application needs, were developed and shown. With this project, a relationship between car problems, causes and solutions was obtained, self-satisfying the primary goal of this project. Providing this kind of solution to users, becomes increasingly important, not only because the vehicle sector is growing increasingly, but also due to the driver's impartiality about the vehicle itself.

5.1 Future Work

For the future work, we have:

- Improve the ontology model, adding new concepts that were already identified and will allow to supply a better service.
- Improve the modulation with more realistic data.
- Improving the application to add features to the registered users.

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Volume Estimation of an Indoor Space with LiDAR Scanner

Jaqueline Bierende[1,2], João Braun[1], José Lima[1], and Ana I. Pereira[1]

[1] Research Centre in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Bragança, Portugal
{jbneto,jllima,apereira}@ipb.pt
[2] Universidade Tecnológica Federal do Paraná, Paraná, Brasil
jaqueline.bierende@hotmail.com

Abstract. Three-dimensional scanning is a task of great importance for our modern society and has brought great advance when it comes to precision of inventory. These sensors measure and map the material surface continuously, allowing real-time inventory monitoring. As this process is very complex, most technologies are expensive, and even low-cost ones are a good investment option for the average user. Therefore, this work presents the simulation of a low-cost Time-of-Flight based 3D scanning system, that after a voxelization process, performs the volume estimation of an object filled indoor space. The system consists of a 2D LIDAR scanner that performs a 180º degrees sweep through a stepper motor.

Keywords: LiDAR · Volume Estimation · Simulation.

1 Introduction

Accurate 3D shape reconstruction and volume estimation are important in many applications, for example, estimation of stockpiles and raw materials. LiDAR (Light Detection And Ranging) is a laser scanner, also known as laser rangefinders (LRFs), and is an attractive and efficient tool because the sensor remotely delimits the volume of interest by providing relative distance measurements from its point of origin.

For LIDAR scanners, the triangulation and time of flight (ToF) method are the two common approaches. Triangulation systems have a restricted range and depth variation, but they offer higher precision. ToF systems have a wide range and depth variation but lower precision [7], [6]. Time of flight is the most abundant type of LRF on the market due to relation cost/benefit. The accuracy of ToF-based systems is mainly determined by the sensor's ability to accurately measure the difference between the time of laser emission and reception of the reflected signal, which makes it possible to estimate the position of the object in space, as which is the case of the system developed in this work.

This accuracy during acquisition can be affected by interference from light, noise and the angle of incidence of the beam projected on the object being too oblique. Therefore, a controlled environment and a high quality circuit must be used to perform scans in more complex environments that in general, and these types of 3D scanning systems are very expensive [6]. For this reason, a low-cost 3D scanning system, that uses a 2D laser scanner with a ToF approach, was developed in this work. The objective and scope of this research work is for small environments, such as a deposit, where high performance was not required since there were not windows and it did not need a long reach.

In this work, the scanning is done in two dimensions (2D) with a scan range of 180° and a drive motor that results in several possible combinations between the scan plane and the axis of rotation to obtain a 3D map and calculate the volume of a room.

2 Related Work

The volume of a 3D surface can be calculated quickly using representations like height grids, voxels, or polygons. The authors in [4] created a point cloud by a laser range finder that is used to create the 3D surface and, from this, derive the height grid that is used to measure the volume of the payload.

Laser scanners have also been used successfully to measure the volume of solids. Zhang et al. [9] produced point clouds from laser measurements and evaluated two approaches for 3D surface construction and volume estimation.

In [3], Amaglo developed a volumetric computational method based on point cloud coordinates that was formulated in MATLAB software to estimate the volume of inventories using LiDAR data.

At the moment, voxel-based systems described in the literature are mainly used to estimate the volume of trees. For instance, papers [8] and [5] estimated trees volume by 3-D voxel-based modeling using portable scanning LiDAR data. In order to, from a fixed voxel size, create a solid model to characterize the contours of branches and trunks that describe the space occupied by the tree and thus, based on these occupied voxels, empty voxels not occupied within segments are identified for volume calculation.

3 System Architecture

The focus of this work is to simulate a scanning system composed by the modeling of a real low-cost 2D laser scanner and find the value of the volume occupied by objects in a deposit. The work can be defined in three steps for volume estimation:
1) Data collection: the simulation is performed in the SimTwo simulator and collected through the developed system.
2) Data processing: the data collected from the scans are converted to Cartesian coordinates, thus generating a single point cloud, and subsequently filtered to remove the walls.
3) Volume estimation: the cloud goes through the voxelization process so that it is possible to calculate the volume occupied by the object.

The constructed architecture can be visualized by the diagram in Fig. 1.

3.1 Data Collection

The simulation environment used is the SimTwo simulator, developed in *Object Pascal*. It is a free open source software where it is possible to model different types of robots, such as differential, omnidirectional, industrial, humanoid, and among others. The simulator was developed in 2008 and constantly receives updates available at [2]. The proposed system consist of a two-dimensional laser scanning subsystem driven

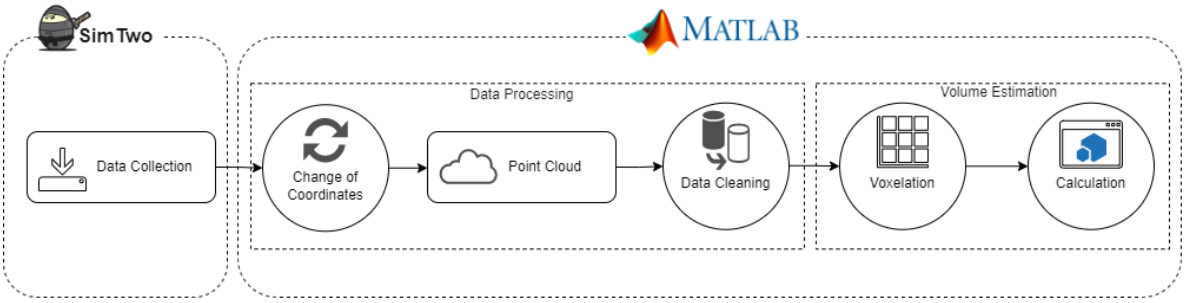

Fig. 1: System Architecture

by a stepper motor that collects, in real time, distance measurements alongside the orientation information of each light beam.

The Fig. 2 shows the operation of the system in the plane xyz. When the process starts, the laser rotates on its axis (α) and as soon as it completes 360°, the stepper motor increases the desired degree (φ). In this way, at the end, a text file is obtained that is exported to MATLAB.

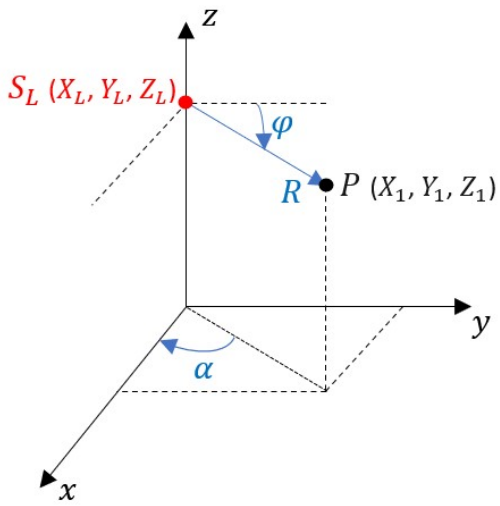

Fig. 2: LiDAR sensor coordinate system.

3.2 Data Processing

First, a CSV file is imported in the MATLAB environment. This file contains the distance from the sensor to the reflecting surface and the azimuth angle, so these points were collected in spherical coordinates and needed to be converted to the cartesian coordinate system.

After the conversion, the point cloud of the entire scene is generated. It passes through the process of wall, obtaining the point cloud from the interior of the deposit.

The point density and filtering algorithm play an important role in the volume estimation, which helps to provide a good estimate of the stock [3].

3.3 Volume Estimation

First squares of the same size were partitioned in the xy plane, with intention to unify all points in that region. Then, the average height of these points represents the height value for each grid, thus obtaining a cube. Each cube has an average height by which the volume calculation for that region is performed.

In the end, the total volume deducted in the Eq. 1 will be the sum of all voxel grids in the xyz plane.

$$V_{TOTAL} = \sum_{i=1}^{N} x'_i \cdot y'_i \cdot z'_i \tag{1}$$

Where N is the total number of cubes and in each voxel grid:

- x'_i represents the width of the grid.
- y'_i represents the length of the grid.
- z'_i represents the height and is calculated by sum the height of all points divided by the amount.

4 Preliminary Results

To test the approach, an environment with dimensions of $4x3x2m^3$ was simulated with a sensor located in the center at the top and inside a cube with dimensions of 0.25 x 0.5 x 0.5 m^3. The sensor's characteristics implemented in the software were taken from LiDAR Neato XV11 [1], where in a full rotation, it provides a measurement range of 360° with angular resolution of 1°. In this case, each laser sweep was limited to 180° angle α , totalling 180 beams per scan. The chosen servo motor increments 1° in angle φ per scan, which results in a system point cloud with 32400 points.

For each simulation it is necessary to choose a grid resolution that adapts to the density of points in the system, in this study a resolution of 0.027 m was used.

The result obtained by the software was a volume of 0.0623 m^3. Compared to the value of the real volume of the cube of 0.0625 m^3, it results in a percentage error of 4.32%.

The Fig. 3 shows the simulated system in the SimTwo environment and the Fig. 4, the point cloud obtained in the software MATLAB. By comparing both, it is possible to note that the point cloud represents the simulated system.

5 Conclusions

This work proposed a different approach for the volume estimation using low-cost LIDAR sensor, where the result is consistent with low error. The tests are valid till the fourth decimal digit, validating the proposed methodology.

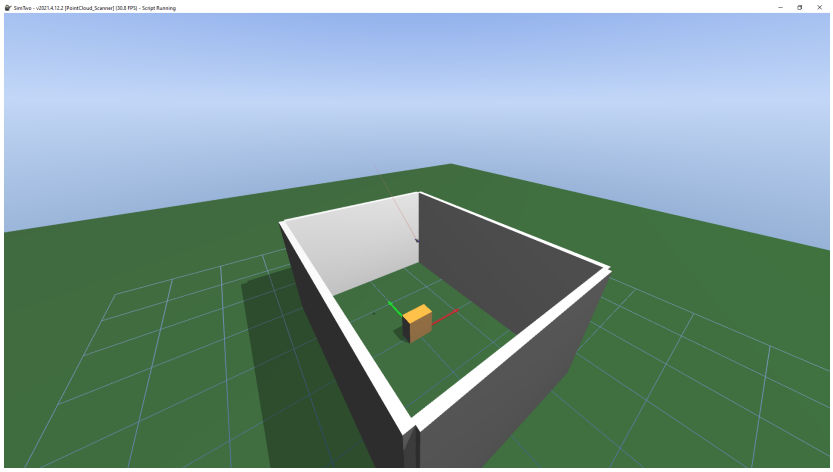

Fig. 3: Simulated case indoor scene with the 3D scanning system in SimTwo simulator.

Among some improvements that still have to be made in this project, there is the validation of the system for simulations with different objects and position.

As a future work, this procedure will be implemented in a real environment in a 3D scanning system aiming at the application for monitoring of the volume of wharehouse.

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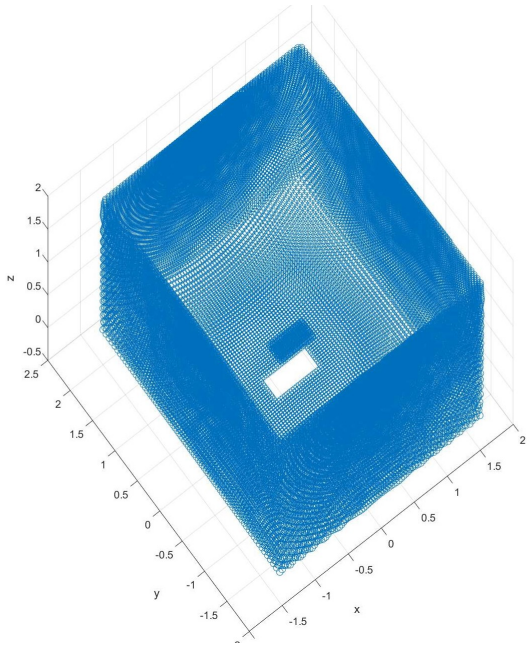

Fig. 4: Point cloud of the simulated scene.

Improving pedestrian's crosswalk accessibility through digital fencing

Facundo M. Bustos[1], José Gonçalves[1,2], and João Paulo Coelho[1,2]

[1] Polytechnic Institute of Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.
[2] Research Center for Digitization and Intelligent Robotics (CeDRI). Polytechnic Institute of Bragança, Campus de Santa Apolónia, 5300-253 Bragança, Portugal.
jpcoelho@ipb.pt

Abstract. One of the major challenges for visually impaired people is to walk safely in any urban landscape. Modern cities are using passive solutions, like audible signals, to promote the security of that pedestrians. However, these solutions may be insufficient to provide the relevant information about the traffic flow, and the length of the crosswalk among many other questions. Smart crosswalks can improve the access to such information by providing a way for the user to share data with them. This paper addresses this question by presenting the VALLPASS project that aims to develop a smart pedestrians crosswalk that, besides other design requirements, aims to promote accessibility by sharing local traffic data with the user. Besides that, pedestrian security will be tackled by defining a digital protecting fence based on the user location obtained from the RSSI values between two beacons and the user's smartphone. Details behind its operation and the overall functionality of a custom-made app will be provided.

Keywords: Pedestrians crosswalks accessibility· Digital fencing · Bluetooth

1 Introduction

According to the latest national censuses, in Portugal, there are about 890,000 people with vision difficulties, among which, around 27,000 are completely blind [1]. The lack, or significant deprivation of the sense of sight, translates into challenges that some people must overcome and that are normally not perceived by the rest of the population. Among the various domains of social life in which these difficulties can be felt, this article focuses on those that relate to mobility in typical urban environments. In this context, public transportation plays an important role in providing ways for visually impaired, or blind persons, to travel independently. However, to take the bus, train or just move around the city on foot, it is necessary to walk through streets where, usually, both people and vehicles coexist. The sharing of space between cars and people poses safety challenges that must be taken into account in order to avoid accidents that often end in fatalities. Security is even more critical on crosswalks since these are places where the probability of collision between vehicles and pedestrians is substantially higher. Knowing when and where it is safe to cross a given road is fundamental. Moreover, that information must be easily perceived by any pedestrian. In most cases, being able to see or hear greatly simplifies the process of crossing a road since, besides being able to easily grasp the traffic conditions, existent road signs, colour or graphic codes require visual perception.

At the present, in Portugal, there is a normative that promotes the inclusion of passive solutions to help visually impaired persons to walk safely [2]. In particular, the addition of floor tactile clues to facilitate the location of the crosswalk. Other accessible

pedestrian signals (APS), including audible signals and crosswalk tactile contrasts, are also conveniences that greatly help the visually impaired navigate in urban scenarios. However, even if this normative can be seen as a positive point toward the democratization of road access, passive solutions, such as the ones enumerated above, lacks vital information to help the user in unfamiliar environments. Indeed, it is worth noticing that memory and familiarity with the surrounding environment is a fundamental assets used for navigation. When in familiar places, visually impaired people generally know the layout and memorize the location of obstacles. For example, the number of lanes, the crosswalk extension or even the traffic pattern. However, when in unusual places or with high and complex traffic variability, prior knowledge is unavailable or inapplicable. Moreover, even audible clues that exist in some crosswalks may not be easily perceived due to several causes such as the traffic and surrounding noise. That is why efforts are carried out aiming at the integration of active accessibility strategies into crosswalks. In particular, the development of smart pedestrian crosswalks, aiming to increase traffic safety and improve accessibility is being targeted by both commercial companies and academia.

It is within this framework that the VALLPASS project, funded by the Portuguese program Norte2020 under the grant NORTE-01-0247-FEDER-113439, is being carried out since July of 2021 and with a predicted end date of June of 2023. This project aims to develop a pedestrian crosswalk that could be integrated into the smart cities paradigm. In addition, it intends to include active systems that could promote an increase in crosswalks safety targeting a broader pedestrian universe of users which includes visually impaired persons.

The aim of this paper is to describe the overall approach that will be taken in order to increase the smart pedestrian crosswalk accessibility to visually challenged pedestrians. Details regarding the solution envisaged will be provided in Section 3. Before that, an overview of related work is presented in Section 2. The closing section will be devoted to presenting the main conclusions of the paper and pointing out further work directions.

2 Related Work

This section will be devoted to describing the most common approaches found in the literature that deal with the problem of crosswalks accessibility improvement for visually impaired pedestrians. The solutions are found to fall into one of the following three categories: global positioning using GNSS/GPS, image processing and wearable sensors. Regarding the former, the use GNSS/GPS allows gathering both the global pedestrian location and where he or she is heading. This information, in conjunction with the map with the crosswalk locations, will be used to steer the person in the urban landscape. However, the use of GNSS/GPS as a guidance system must take into consideration the overall system precision which is around five meters under open sky [3]. Besides this error margin, satellite signals can be shadowed by bridges and buildings. Some of those drawbacks can be bypassed by using hybrid approaches that merge more than just one technology. For example, [4] from the University of Minnesota, designed a smartphone application that combines a digital map of the intersections and the user location obtained from GPS. For the cases where the GPS signal is weak, they placed

Bluetooth beacons to improve the information on the user's location. After arriving near the crosswalk, the application exchange messages with the traffic light controller, through Wi-Fi or LTE, asking how long the user have to wait until is safe to cross the road. This information will then be relayed to the user using audio messages. It is worth pointing out that this approach requires the location of Bluetooth beacons since, in general, they are not integrated into the conventional crosswalk signalling system. Moreover, it relies on the availability of an API to query the traffic system about its status which is not usually the case.

Another paper that explores the use of GPS for increasing the security of visually challenged persons was published by [5]. The authors have developed an application, named Virtual Guide Dog (VGD), which resorts to a GPS-based localization method to check when the user is near an intersection. If this is the case, the app will ask the pedestrian if he or she wants to cross the road and, if this is the case, the app will give orientations to steer the user. When the user is in position, the app connects via Bluetooth to the traffic light controller and acts as the physical process of pressing the crosswalk button. When it is safe to cross, the application indicates the user to start traversing. This solution suffers from the same issues as the previous by relying on third-party technology to operate.

Other researchers approached this question through computer vision and image processing [6–8]. In particular, using real-time video obtained from smartphone cameras or wearable devices, they are able to determine the crosswalk location and status giving information to the user if it is safe to cross. The problem with this kind of solution is that they need a fast image processing device and software that could be able to guide the user in real-time Moreover, at night the camera may not be able to correctly detect the crosswalk.

Kiyoung et al. [9] presented the Crossing Assistance System (CAS) where a location is performed through machine learning using the Received Signal Strength Indication (RSSI) from eight Bluetooth beacons located at a four-corner car intersection with four crosswalks (two beacons at each side of a crosswalk). In particular, a smartphone app takes the measured RSSI of each beacon and then the machine learning algorithm computes the user location. In this setup, the beacons send data every half second and the smartphone app is built in order to receive two RSSI signals per second provided by the eight beacons. According to the authors, the algorithm only requires three seconds to process the data and provide the user location. However, their work doesn't implement any guidance system but they mention it as a potential future work. In addition, Bluetooth beacons must be installed on third party systems which can be challenging.

Still, in the artificial vision area, [10, 11] put forward a real-time crosswalk detection algorithm in conjunction with adaptive extraction and consistency analysis in order to detect crosswalks at urban intersections. This algorithm ingests real-time video taken from custom made goggles that the user must wear [12]. The use of wearables always poses problems that span from the need to acquire a specific item that, due to its particular application and target audience, can be very expensive or even not within the person's sense of fashion and personal style.

The approaches described above require the integration with third-party technology, the installation of beacons or the purchase of specific hardware. In the following section, the integrated solution defined in the VALLPASS project will be explained and how it tackles the drawbacks of the above-mentioned solutions.

3 The VALLPASS accessibility approach

The VALLPASS project consortium is headed by the company VALLED and has as technological partners the research centres CeDRI and MORE. VALLED is a company based in Bragança, a city in the northeast part of Portugal, and focuses on the development of products related to street lighting, water pumping systems and solutions based on photovoltaic systems. On the other hand, CeDRI is a research centre that develops its activities within the areas of digitalization and intelligent robotics. Located also in Bragança, CeDRI is a multidisciplinary research unit fostered by the Polytechnic Institute of Bragança that promotes and applies technological solutions in the industry. The consortium is completed with the MORE collab centre, also from Bragança, which provides scientific, technological and innovation consulting services to companies in both the public and private sectors.

In short, the main objective of the VALLPASS project is to develop and build a smart pedestrian crosswalk solution able to improve the security of pedestrians and, at the same time, be compatible with the *smart cities* ecosystem.

Besides its ability to react to the environment adapting to both pedestrians and traffic, accessibility of visually impaired persons is also a major concern of the design requirements. In practice, visually handicapped persons may find the general location of crosswalks based on traffic noise or tactile cues. However, after getting its position, it is fundamental to "read" the traffic noise signature to know the moment when the street is secure to be crossed. This task is especially complex when the person is in unfamiliar environments where details regarding traffic flow patterns and crosswalk length among many other variables are unknown.

It is in this context that this work is being carried out. In particular, this paper addresses the architecture of a protection digital fencing system based on Bluetooth signals that will be integrated into the VALLPASS smart crosswalk solution. This digital fencing will be able to steer the pedestrian toward the crosswalk centre and provide acoustic, voice or vibration codes according to the actual degree of security for traversing the road. The main idea is presented in Figure 1.

In the situation illustrated in the figure, two VALLPASS units are installed sideways of a crosswalk. Each one of the VALLPASS elements includes a Class 1 Bluetooth beacon that provides an RF signature able to be detected to a distance of up to 100 m. Assuming that a given pedestrian has a smartphone with the VALLPASS mobility application installed, the RSSI of each Bluetooth beacon will be decoded by the software and the relative position of the pedestrian, regarding the crosswalk, is estimated.

It is worth noticing that, in practice, location by triangulation requires, at least, three points. However, in a typical crosswalk application, only two VALLPASS units will be available. Hence, there is an intrinsic uncertainty if the pedestrian is upstream or downstream of the crosswalk. However, this issue is not fundamentally a problem since

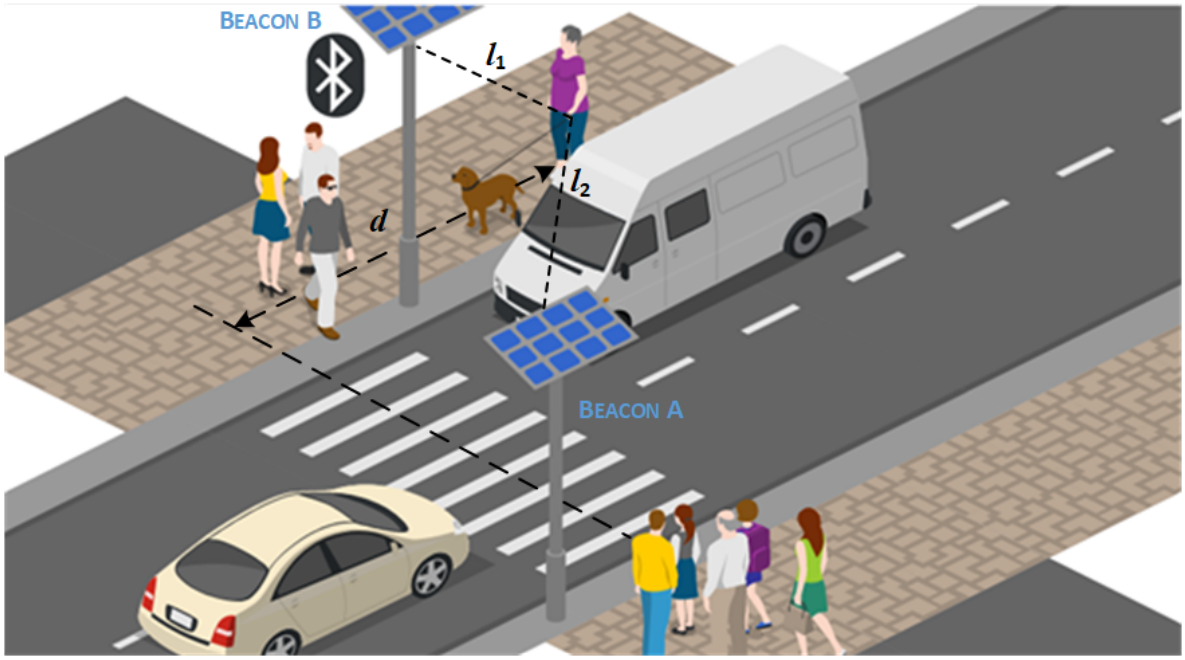

Fig. 1: User localization using two Bluetooth beacons embedded on the VALLPASS smart pedestrian crosswalk.

the location algorithm will be concerned with the relative peak power and disregard if the pedestrian is approaching the centre of the crosswalk from the left or from the right. Moreover, positioning is not the main objective of this system. Indeed, pedestrian positioning can be fine-tuned by himself with the help of the tactile cues embedded on the sidewalk. Being able to provide accurate information on the actual crosswalk and traffic status while providing decision support regarding the most secure time interval to cross the road is the key feature of the VALLPASS accessibility system.

In theory, the estimated distance D in meters between two Bluetooth devices using the RSSI value can be computed from:

$$D = 10^{\frac{P-RSSI}{10\eta}} \tag{1}$$

where $RSSI$ is a measure of signal strength expressed in dBm, P is the measured signal strength observed at a distance of one meter between the two devices and η is an attenuation constant that depends on environmental factors.

Using this approach, the distance l_1 between "Beacon B" of Figure 1 and the user smartphone can be estimated. In the same way, the distance l_2 between "Beacon A" and the user's handheld device can also be inferred. Once the distance between the pedestrian and each of the two beacons is found, the distance of the user to the centre of the crosswalk can be estimated.

Drawing a circle for each beacon with a radius equal to its distance to the user, two intersecting points can be obtained. Figure 2 present this concept.

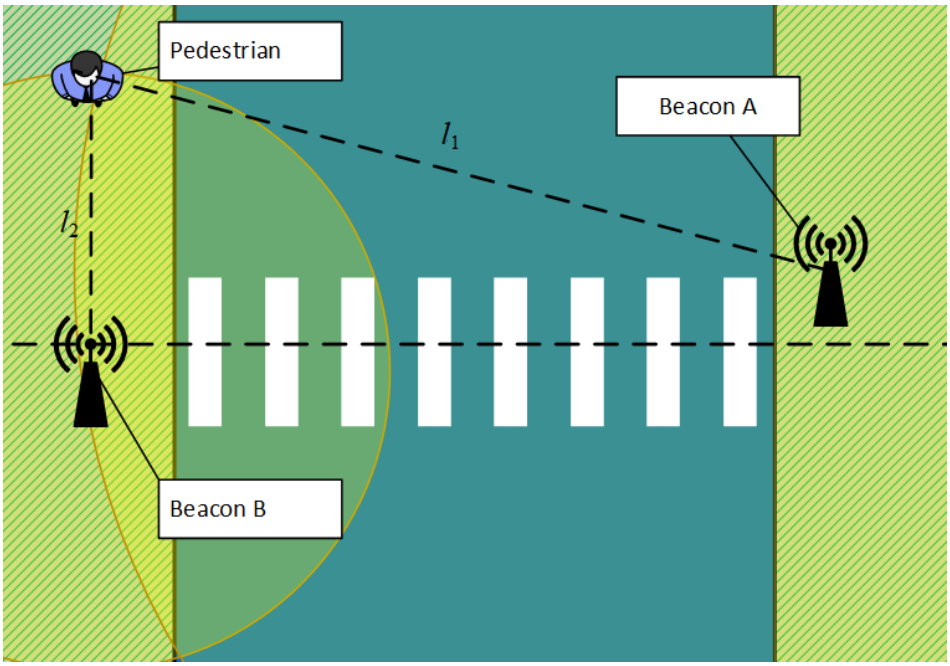

Fig. 2: Pedestrian localization from the distances estimation to each beacon.

Besides the RSSI, each VALLPASS element share with the application its ID and global position. This will be used to narrow down the location uncertainty. In practice, non-linearities and other problems due to RF signal reflections must be considered. Ongoing experimental results will soon reveal the best way to perform the data filtering and analysis.

Finally, and before the concluding remarks, a word about the smartphone app. Since the software is targeting visually impaired users, graphical information is irrelevant. As can be seen from Figure 3, the device will accept voice commands in order to, for example, raise or lower the sound volume, provide status information about the crosswalk, traffic information and so on.

Moreover, the use of the Braille alphabet encoded using the smartphone vibration actuator will be equated in order for the application to silently communicate with the user and vice-versa. This is not a new idea and has already been presented in the literature [13]. However, at least to the best of our knowledge, there is no commercial product available that explores this concept.

4 Conclusion

Modern societies are inclusive by definition and promoting life quality of all persons should not be a question of numbers. At the present, where societal digitalization is accelerating, efforts must be made to use that technology to further improve the urban mobility and accessibility of persons with disabilities. It is framed on this idea that the VALLPASS project seeks to develop a smart pedestrian crosswalk that has security

Fig. 3: Smartphone front-end for the VALLPASS accessibility portal.

as a major concern. One of the key concepts of this solution is the inclusion of active security measures targeting visually impaired persons.

This accessibility module will be based on the information exchanged between the user's smartphone or equivalent device and the VALLPASS units. A rough estimation of the user location, relative to a given set of VALLPASS units, will be obtained from the RSSI values of a Bluetooth beacon relative to the user device. The RSSI values will be used to compute the relative distance of the user to the crosswalk centre. After "locking" into a pair of VALLPASS units, the user will be able to query the system to get information on when to cross the road. This data exchange will be performed by a custom-made app that will execute voice commands. Communication between the user and the app through Haptic approaches using the smartphone touchscreen and vibration actuator will also be explored.

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