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Editors

Proceedings TEEM 2022:
Tenth International
Conference on Technological
Ecosystems for Enhancing
Multiculturality

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TEEM 2022 Preface

We celebrated the tenth edition of the Technological Ecosystems for Enhancing Multiculturality (TEEM) International Conference in the University of Salamanca, the institution in which it was born. Nine years ago, this academic conference project started. We had the goal to create a new interdisciplinary event in which the new advances in technology would be reflected in the resolution of the problems of Education and the Knowledge Society. We pursued the establishment of a new research community with a strong aim to help Ph.D. students to have opportunities to know and collaborate with consolidated researchers worldwide.

Looking back, we are very satisfied with the obtained results. We are a consolidated research community that has grown, many research projects were born in the previous editions, many collaborative papers in prestigious books and journals have been published, many international internships have occurred, but we are very proud because tens of new Ph.D. participated in the previous editions of TEEM Doctoral Consortium track and contribute to help the future Ph.D. to be part of the TEEM family.

This edition is a reunion event, fully face-to-face, after two editions in virtual and hybrid mode due to COVID-19. More than one hundred and ninety researchers shared their scientific advances in this tenth edition. Some of them were new, but most of them were regular participants in this conference, which reinforces the original idea of forming a solid scientific community.

It is also important to say that this TEEM tenth edition was within the European Campus of City-Universities (EC2U) Alliance (<https://ec2u.eu/>), co-funded by the Erasmus+ Programme of the European Union. The EC2U is a multi-cultural and multi-lingual Alliance consisting of seven long-standing, education- and research-led, locally and globally engaged universities from four diverse regions of the European Union: the University of Coimbra, the University of Iași, the University of Jena, the University of Pavia, the University of Poitiers (Coordinator), the University of Salamanca and the University of Turku.

TEEM 2022 has had 210 submissions from which 145 full papers were accepted; that is, there is a 30% rejection rate. These papers have involved 424 authors from 26 countries.

The TEEM 2022 was organized in 16 thematic tracks that covers research areas such as Educational Assessment and Orientation, Human–Computer Interaction, Computers in Education, Communication Media and Education, Medicine and Education, Learning Analytics, Engineering Education, Robotics in Education, Diversity in Education, Gamification and Games for Learning, Smart Learning and Laboratory-Based Education.

In addition to the regular sessions, the TEEM 2022 edition featured three prestigious guest speakers. Firstly, Gema Parreño Piqueras, Developer Advocate at Iterative, gave the inaugural keynote entitled “Alignment of language agents in video games.” Dr. Oriol Borrás Gené, Professor at Universidad Rey Juan Carlos (Spain), gave a keynote entitled

“3 years escaping from a room, learned lessons.” The closing lecture was given by Dr. Ricardo Colomo-Palacios, Full Professor at the Østfold University College (Norway), with the title “Academia-Industry collaboration: a view from IT.”

We would like to thank the members of the Steering Committee for their counsel and the International Scientific Committee for their accurate and timely reviewing. We would also like to thank the Track Chairs for their efforts in organizing the academic issues related to each track and the Organizing Committee for their huge effort in all the associated tasks that an international conference involves. We would like to do a special mention for the Editors-in-Chief of the linked journals that have offered special issues or slots in their regular issues for those selected and extended papers of TEEM 2022 conference that will have another in-depth review following the guidelines of each journal. Last, but not least, we would like to thank the participating organizations: University of Salamanca, Research Institute for Educational Sciences at the University of Salamanca, GRIAL Research Group and European Campus of City-Universities (EC2U) Alliance for their support.

Next year, we will continue with eleventh edition of TEEM Conference that will be held at Bragança, Portugal, organized by Instituto Politécnico de Bragança.

October 2022

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Robot Development for Educational Purposes: Advances on Real and Simulation Environments

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Abstract. Nowadays, Automated Guides Vehicles and Autonomous Mobile Robots are equipped with electromagnetic or optical automatic guiding devices and can navigate, interact, perform path planning and avoid obstacles. It is crucial to develop applications to support the teaching by real and/or simulated robots. In this paper the authors propose a simulation of an AGV system, that uses localization based on mounted cameras for positioning and control by a central system. Also, a real robot prototype is proposed. The mobile robot should reach the destination point precisely and kept inside the desired margins, avoiding collisions. The presented results show the developed system in operation.

1 Introduction

Automated guided vehicle have become one of the best ways to do inter-logistics, automating processes that can be done by machines instead of humans, increasing savings, productivity and flexibility. In addition, they can position the goods ergonomically for assembly work or transport entire shelves or machinery [1]. Mobile robots in Industry can reduce human resources costs due to the ergonomic problems and valorize the economic area [4]. On the other hand, to implement robots, it is required to develop the engineering education so that employees are prepared to use the technology. As such, the importance of teaching tools is increasing, as it can be noticed by the expansion of Science, Technology, Engineering and Mathematics (STEM) methodology, that provide the development of several expertise, such as soft-/hard-skills, technological concepts and education through STEM methodology [13, 15, 16]. Sometimes, using real robots, is impossible or too expensive for schools and Universities, that way, simulation can be used to tackle this problem. Robotic simulators are an important tool that has being applied for several years [2, 11], but the increasing of computers processing power in the last years pushed up this approach. Digital factories

can benefit with this methodology too [5]. Simulation is a tool that can be used in different areas, such as flight education and training, [7] digital factories [5] and not only in engineering as clinical and medicine [8], healthcare [10] finance [9] just to mention some examples. So, teaching robotics is of huge importance, being a highly multidisciplinary area.

This paper presents a robot prototype, being also shown its simulation, that can be applied to teach robotics. Kinematics, based on the robot model, is implemented in the simulation, where the robot can be controlled. The real one should be included in a localisation system that can be done, for example, with image acquisition and processing [3], using fiducial markers [14].

2 Simtwo Simulation Environment

Simtwo¹ is a realistic simulator that can be used in education with the main objective of simulating mobile robots that use wheels or legs, but it can also simulate other types of robots like drones, industrial robots and others. It accomplishes this by decomposing the robots into rigid bodies and electric motors that can be applied as modules, being useful for new researchers. When using the program the first task is to create the robot model, this is done inside the program by using geometric solids *cuboid*, *cylinder*, *sphere*, some of this will be declared as servo motors or control center of the robots where the batteries and micro-controllers like Arduino would be located [12]. For the motors, they don't show up visually, but they are inside the joints of the wheels, and the accomplishment of this is done by following the following steps: 1) The creation of a robot file; 2) Establish the constants; 3) Start inserting the solids (these will be the rigid parts of the robots that do not represent the logic parts and may not make a mechanical movement); 4) The shells represent logical parts like Arduino, Raspberry pi. 5) Joints: the joints connect the solids and inside them resides the motors and here the characterization of how they are going to work, if they are active and are controlled and if they vary their speed or its constant.

Figure 1 shows the proposed robot inside the simulation environment.

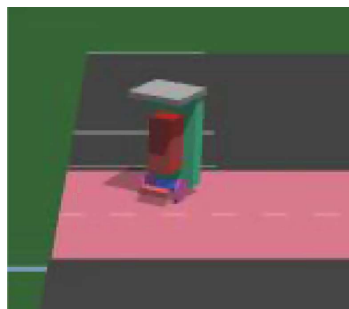


Fig. 1. Proposed Robot inside the simulation environment

¹ <https://github.com/P33a/SimTwo>.

After that it is required to create the world that the robot will move in this simulation, in this case it will be a simple road map, as shown in Fig. 2. The program that controls the robot is based on a Pascal script, that runs within the simulator, with a period of 40 ms. In this script, the global variables and functions can be used by the main block to control the actuators (motors) and read sensors.

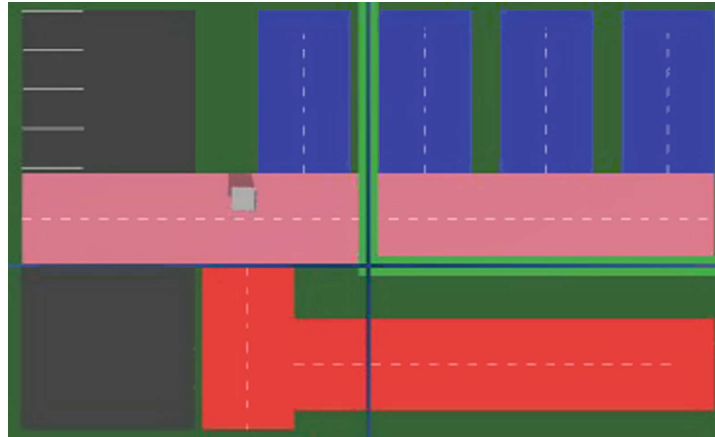


Fig. 2. Road Map

2.1 Robot Control Program

For the first experiment, the authors made a simple program that allows to control the robot, using script window of the program, allowing to see if the command for servo motors was correct and to insert the gains, that will allow the robot to turn. As a second step, it was simulated a complete autonomous robot. For this, the robot must know the difference between where is its localization in its world and where is the final destination point, so that it can orientate itself accordingly. To accomplish this, the computer retrieves the robot's current position and the destination, and it calculates the *theta*, using the Eq. 1.

$$\theta = \arctan \frac{Y_p - Y_r}{X_p - X_r} \quad (1)$$

This is the angle of the point, so the robot, subsequently, needs to calculate the difference between the angle of its orientation and the angle that was previously calculated. After that, it is capable of using the difference between angles that is stored in the variable named *ThetaNC* to multiply with the gain *KT* and then send it to the wheels, using a controller consistent with the robot Kinematics.

In the case of velocity, it needs to first calculate the distance between it and the point by using Pythagoras's theorem that, in this case, is demonstrated in the Eq. 2.

$$H = \sqrt{(Xp - Xr)^2 + (Yp - Yr)^2} \quad (2)$$

Moreover, the value that is returned from the operation is then multiplied again to get the speed (Eq. 3), and the parameters will be a gain of value 10 and the variable C , that is used as an electronic switch (0 or 1), that is commanded by a button that simulates an emergency stop button. Variable V is the linear velocity of the robot and ω is the angular speed.

$$V = H * 10 * C; \quad (3)$$

As for the two speed components (linear speed V and the angular speed ω) are combined it is possible to see them at Eqs. 4 (V_L velocity for left wheel) and 5 (V_R velocity for right wheel).

$$V_L = V + \omega \quad (4)$$

$$V_R = V - \omega \quad (5)$$

Two methods were created so the user can define the location of the point. The first one is to use *sheets* window (a Spreadsheet where user can interact) to insert the points manually and changes them when it reaches there, and the second is to write the points in the program in states. As an example, these would consist of the X and Y components of the points like demonstrated below.

$$Xp = 0.716$$

$$Yp = 0.1425$$

Simulation also is able to add more than one robot to the environment, without extra costs, in Fig. 3 it are shown two mobile robots in the map. The SimTwo simulator also handles the dynamics of the robots, as an example, Fig. 4 presents a collision occurrence during the simulation.

3 Simulation

Once the SimTwo simulation environment is prepared, the first test is to move the robot in a straight line, controlling its V and ω after giving it the coordinates of its destination, and this act is done in *sheet window*, being the end position monitored by using the *chart window*. The test point selected was $(-1; -1)$. As result, Fig. 5 shows the angle in Radians of the robot (θ) over time during the movement.

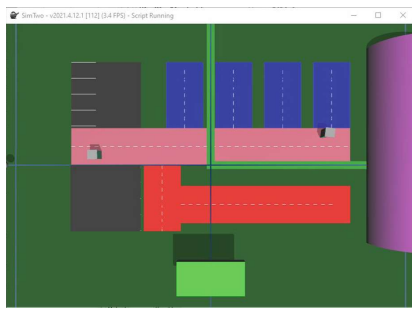


Fig. 3. Two Robots



Fig. 4. Collision

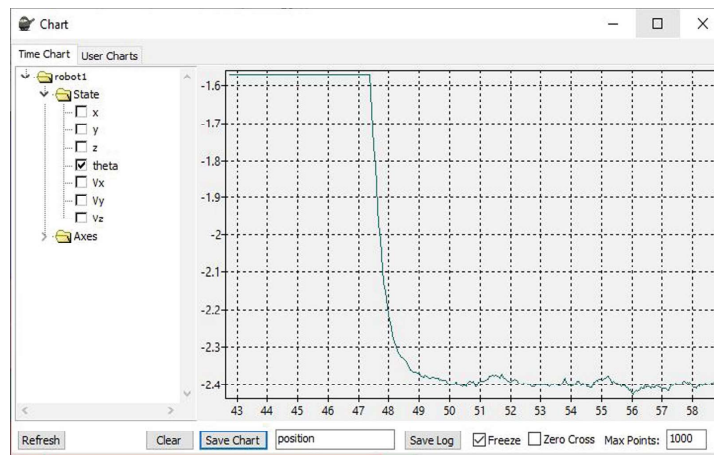


Fig. 5. Theta of the robot

What can be observed from this graph is that the robot does a higher course correction in the beginning, and after about two seconds, it only does a smaller course correction, because it only has to stay on track.

In Fig. 6 it is observed a flat part in which the robot is turning in place orienting itself and then the robot moves in the correct direction.

After the robot gets close to the point, its velocity decreases, this is done to increase the safety of the robot and to prevent it from overshoot and hit something, having an proportional controller with saturation implemented. Another point that demonstrates the movement is the graph in Fig. 7, in the beginning, the axis rotates in the opposite direction.

Initially the robot above its center point while doing the robot does not move in the X and Y direction. After that occurrence, there is a spike in speed in both motors, but this varies a lot due the constant course correction. Subsequent to this, the circumstance that makes the average velocity decreases it's simply when it gets close to the point due to the program.

For the robot to get around a corner, the robot has two options: pivot on top of the center point or go around a point.

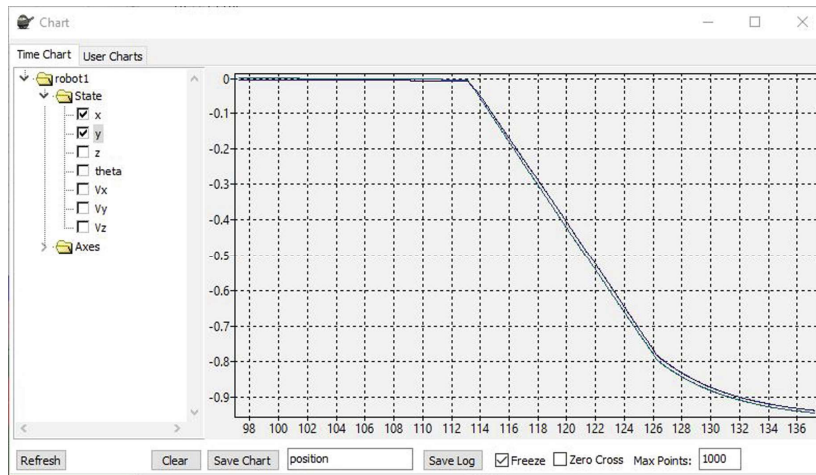


Fig. 6. X & Y of the robot

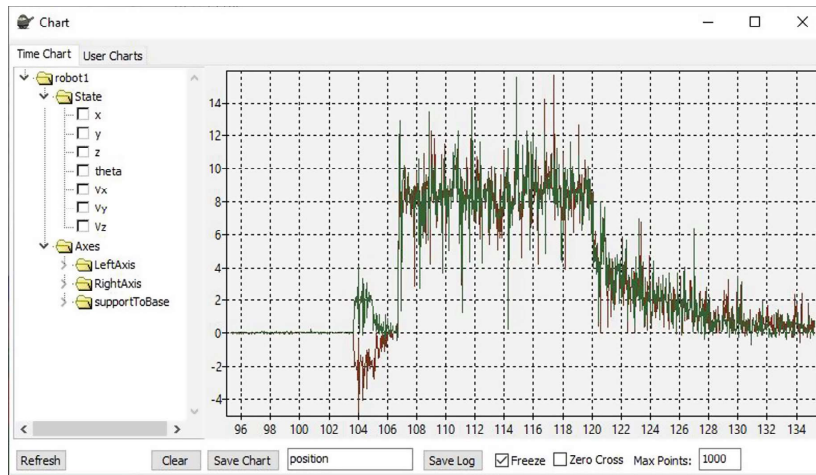


Fig. 7. V of the robot (X and Y axis)

The graph in the Fig. 8 displays that the difference in the axis velocity which lasts for quite some time, and that is because the robot was going in circles and due to this circumstance, the velocity of both axes are positive and only differ in value so that the robot turns.

In the latter part of the graph on Fig. 8 allows to see the time that it takes to make a 180° around a corner. In the same scenario, the graph in Fig. 9 displays the angle variation, and it shows a sawtooth wave and the particular reason for this circumstance is that the angle changes signal when it reaches 180° or π in radians proving that sawtooth wave which means that the robot is going in circles.

At the end sharp 180° turn is displayed, meaning that the slope of the wave has to do with how fast the robot does the corner.

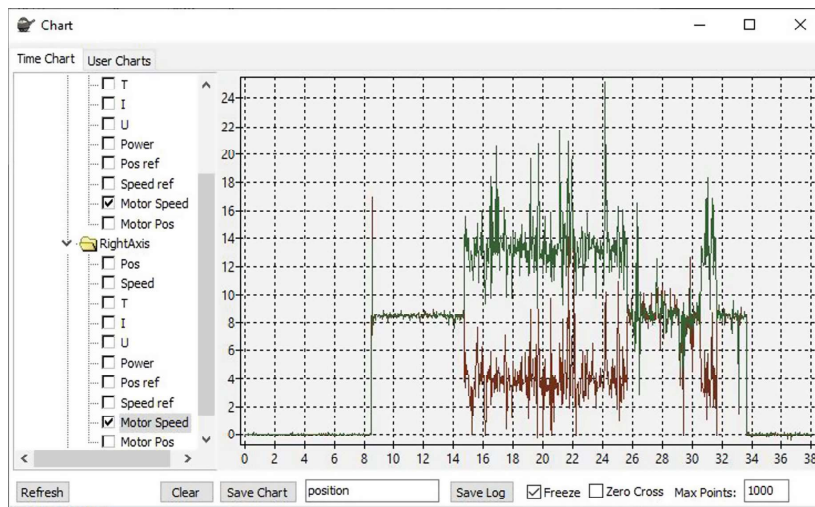


Fig. 8. V of the axis for Left and Right wheels

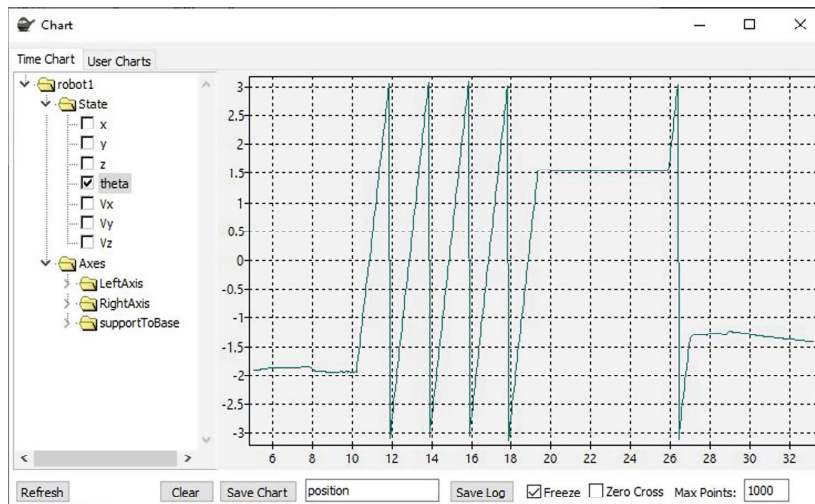


Fig. 9. Theta in a circular movement around the robot center

4 Robot Modelling

To create a robot model the authors started by printing the CAD files that were designed along with the wheels, as seen in the Fig. 10a, it was all 3D printed after being designed in SolidWorks. For the wheels they were created with chamfer so they did not require support when printing and a center valley (Fig. 10b) that can be used to place rubber to give more traction to the wells.

The assembling process required the use of a hot glue gun to attach the part that will hold the battery, and the motor was fixed using zip ties, and the final product can be seen in Fig. 10.

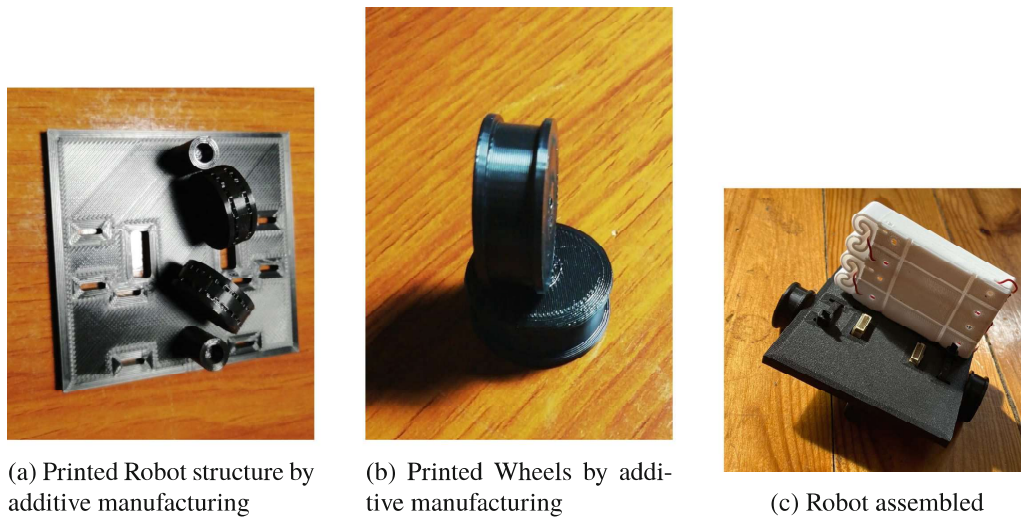


Fig. 10. Mechanical Robot components

4.1 Robot Architecture

The proposed robot architecture is a typical one, as presented in Fig. 11. A low level microcontroller (Arduino Nano) is used to send PWM signals to the driver that will actuate the motors. On the other hand, incremental encoders coupled to the motors shafts are used to acquire the speed for each wheel. The speed controller (PI controller) is implemented to follow the references received by the high level, by the computer. The robot is powered by two 18650 Li-ion batteries. These batteries supply the driver and a step down converter to 5V is used to supply the Arduino and encoders.

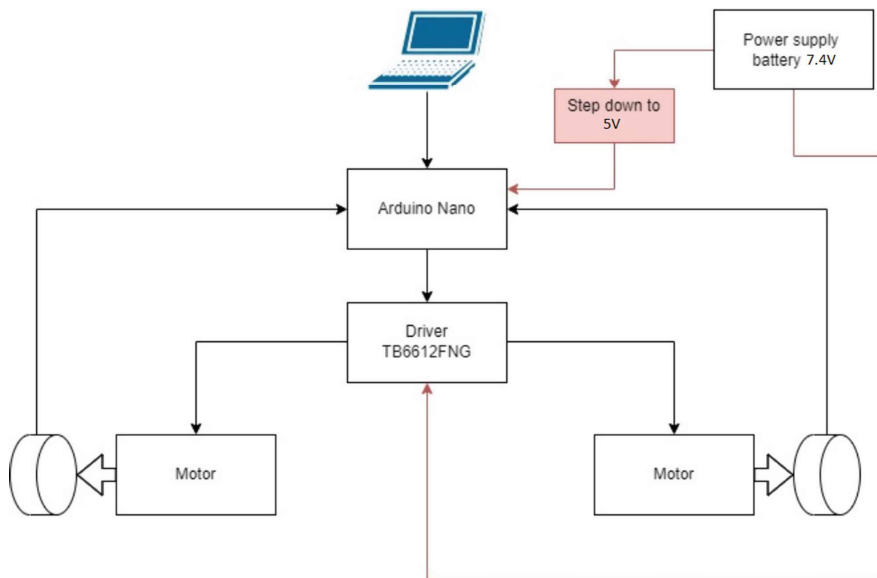


Fig. 11. Robot main architecture

5 Conclusions and Future Work

The project was aimed to create a model of an AGV that is cheap to produce and has a few sensors. This was achieved, and it also works as a testbed for the incoming students.

This paper showed that 3D printing in conjunction with Simtwo can contribute valuable knowledge to the user and create excellent teaching kits. Simtwo is an excellent platform that simulates an abundant number of systems that vary a lot between themselves. Moreover, combining Simtwo with 3D printing allows the students to test their ideas, perfect them, and see if they can be manufactured or assembled. Although 3D printing can help in construction, it still has its problems, but it is becoming more and more widespread, and this means that the students should start practicing with it all when they have the chance.

A project idea to prepare students of mechanical engineering and electronic engineering, is forming groups of two or three to create a two-year project in the university. The mechanical student, for example, would focus on a new manufacturing method by determining the material resistance of the parts made and how to improve it. In comparison, the electronics student will focus on gaining experience in expanding field both in terms of programming and designing a single robot or integrating it with a broader system. As future work, on the AGV system should focus on the two most important objectives: the camera system and the path planning. The first one will be how to set up a multiple camera system from the ceiling and that looks down at the hole space to interpret what is happening. The second one has to do with the system's artificial intelligence (AI) since all of the robots will take all the information from the servers. It will have to plan a path, select the necessary actions for every robot, and respond to a changing environment.

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