Monitoring and Optimising of Public Transportation

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Abstract. The smart city topic became a very prominent concept in recent years, especially in the area of public transportation. This work aims to develop a modular GPS sensor based system which can be installed in any transportation vehicle. The module collects GPS location data of the vehicle, user flow and time and sends it through mobile data network to a database in a server. The sent data can be analysed through data mining strategies to decision support in terms of existing routes or add new routes through population flow analysis. The module will be powered by the vehicle via the car auxiliary power outlet. Some data will be available to the users through website and mobile App. In the website the public transportation institution can access to privileged information about it's bus fleet. In the website, the public transportation institution, can access to privileged information about it's bus fleet. In the mobile app, the user, can access the bus arrival time information, if the bus is on time or if it's late.

Keywords: GPS Monitoring · Data Analysis · Optimisation · Modular System.

1 Introduction

Public transport is one of the most used means of transport all over the world, but it aims at some problems that need to be solved, such as: delays, inefficient routes and little contact with its user, thus the need arises to study ways to solve these problems [8].

This project seeks to find a solution to the problems described above. It is composed by the development of a GPS location module, which will send the bus location to a database, as well as the date/time and the number of people getting in and out on the bus in each stop where a laser sensor is used to collect the passengers flow. These data will be later used to predict future passengers flow, reroute recommendations of existing routes and to monitor the bus in case of delays (accidents, weather, traffic, and others). In line with the European "Europe 2030" strategies, we are working to reduce CO2 emissions, increasing the transport is at the expense of our own transport [1].

The paper is organised as follows. The Section 2 presents the developed module to be applied on the bus. The data analysis and some optimisation approaches are presented on Section 3. The SmartMov system is presented on Section 4. Last section is devoted to the conclusions and future work.

2 SmartMov Modular System

The bus modular device aims to monitor the buses, as it will collect the real time location of each bus, the flow of each bus stop and send this data to a database. This data will be for later use in predictions of flow and real-time recommendations for the end user [4].

The device is organised according to the diagram in Fig. 1.

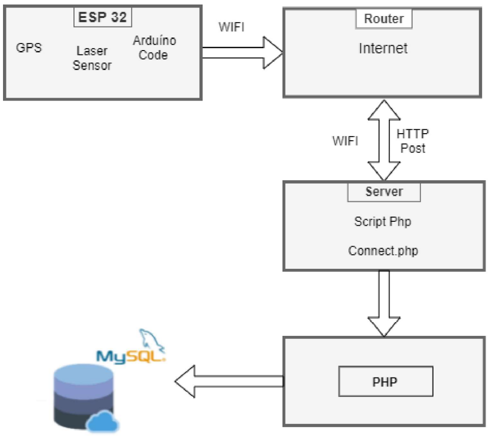

Fig. 1: Diagram of bus modular system.

The system is composed by a Esp32, laser sensor and a GPS where:

- ESP32 will be the controller of the device, it will be responsible for the data collection.
- The GPS will be responsible for locating the device, collecting the latitude and longitude, as well as collecting the date and time.
- The laser sensor will be the responsibility for the people flow value.

All the collected data will be sent using the ESP32. For that task, it will be used it's WIFI stack to connect the router, which will handle the internet access and server connection where the database is located. After being connected to the server, an HTTP post will be required every 25 seconds whereas the HTTP post is the request for the connection to the server. To publish data in the database a phpscript was developed that makes the connection between the ESP32 and all it´s components and the database. After all this steps we will have all the collected data published in the database [7].

A database is a simple repository of information related to all information of the bus routes and collected by the bus module system. In Fig. 2 we can see an example of the tables in the database.

Some information are manually inserted as for example the number of the bus, number of device active, drivers and bus stops. This database will get some information in real time given by the bus module system, named data obtained from GPS and laser sensor. So in real time the database will collect information related to bus position, time and users flows.

All these data will be stored in the database and will later be used for prediction of flow in each bus stop and future changes in the bus routes [6].

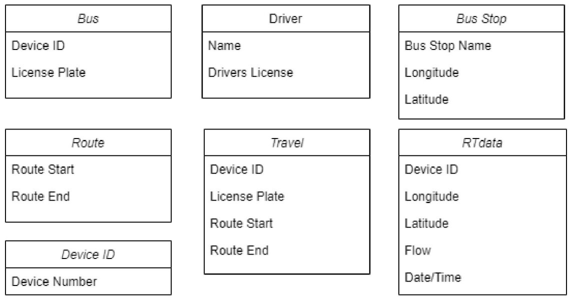

Fig. 2: Example of the database tables.

3 Data Analysis

In this work, the data collected was analysed by *K-means* since it is a classification method [5].

The data gather from the SmartMov Modular System will be collected and stored in a text file. This text file will be exported to Python. It was used the *K-means* method to classify the data associated to the departure time, arrive time, departure location, arrive location and users flow. Using Python, the first step is to run the data-set with a method called *Elbow* [3]. This method will return the ideal number of clusters for the considered data-set. The example in Fig. 4 presents the obtained results of an *Elbow* experiment.

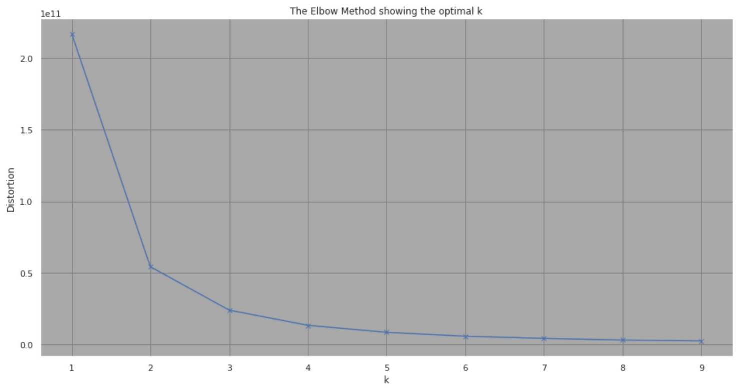

Fig. 3: ***Elbow method when N=4***

Once the results of the previous method are complete, the clustering algorithm *K-means* is launched. This algorithm will calculate the clusters with the number obtained in the *Elbow* method (in this case the N=4).

The goal of *K-means* is quite simple since it groups similar data points and discovers underlying patterns. This method looks for a fixed number of clusters in a data-set [2].

When analysing the output data of *K-means*, it is possible to start to identify patterns. With this information we can start to visualise which stops has a high flow of passengers and if this flow will affect the bus time arrival in the next stop. We can also spot if a stop has few to none passengers and the bus has to wait till the time to leave that stop.

After a full analysis of this patterns we can start to re-draw a possible new route for individual or collective buses, stretch or shorten the routes.

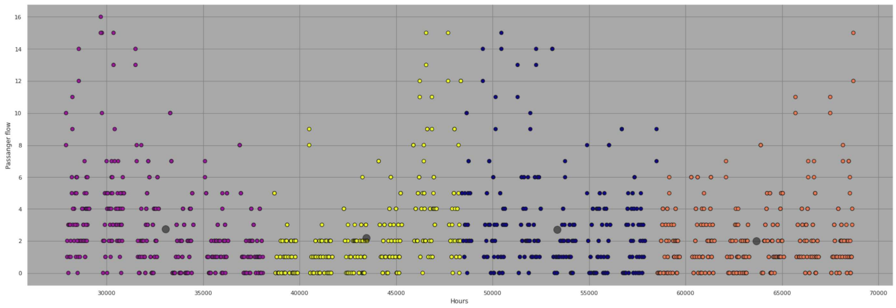

Fig. 4: ***K-means* when N=4**

4 SmartMov

SmartMov combine the technologies presented in Sections 2 and 3 in order to provide a monitoring and optimisation service for public transportation. With our cost effective FMS solution, companies can set up a professional tracking platform of their own and provide real-time tracking service and fleet management tracking service to their locals residents. SmartMov handles all technological issues, so companies focus strictly on their tracking business to realise rapid and ongoing ROI that includes increased revenue, reduce costs and ability to grow profit.

5 Conclusion and Future Work

This project presents an integrate system combined a bus module system with data analysis to improve the public transportation. The project proposes a new modular system, database and data analysis. The information will be available to the companies with the purpose of monitoring of its fleet and to the public with the purpose of visualising the bus arrival time.

As future work, it is proposed to install and validate the solution in a low density region where there are not any system to support the public transportation decisions.

References

1. Europeia, C.: Uma europa sustentável até 2030, `shorturl.at/zDIOS`
2. Garbade, M.J.: Understanding k-means clustering in machine learning, `https://towardsdatascience.com/understanding-k-means-clustering-in-machine-learning-6a6e67336aa1`

3. Gupta, A., Majumder, D.: Elbow method for optimal value of k in kmeans (2021), https://www.geeksforgeeks.org/elbow-method-for-optimal-value-of-k-in-kmeans/
4. Kodali, R.K., Valdas, A.: Mqtt based monitoring system for urban farmers using esp32 and raspberry pi. Second International Conference on Green Computing and Internet of Things (ICGCIoT) p. 395–398 (2018), https://doi.org/10.1109/ICGCIoT.2018.8752995
5. Na, S., Xumin, L., Yong, G.: Research on k-means clustering algorithm: An improved k-means clustering algorithm. In: 2010 Third International Symposium on Intelligent Information Technology and Security Informatics. pp. 63–67 (2010). https://doi.org/10.1109/IITSI.2010.74
6. Okwuibe, J., Haavisto, J., Harjula, E., Ahmad, I., Ylianttila, M.: Sdn enhanced resource orchestration of containerized edge applications for industrial iot. IEEE Access **8**, 229117–229131 (2020). https://doi.org/10.1109/ACCESS.2020.3045563, https://ieeexplore.ieee.org/document/9296769
7. Team, R.: Esp32/esp8266 insert data into mysql database using php and arduino ide, https://randomnerdtutorials.com/esp32-esp8266-mysql-database-php
8. Yu, B., Lam, W.H.K., Tam, M.L.: Bus arrival time prediction at bus stop with multiple routes. Transportation Research Part C: Emerging Technologies (2011)