Urban Traffic Flow: Repairing and Synchronizing Traffic Lights in Paraná City

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Summary—

   The following work focuses on the problem of traffic flow in the city of Paraná. This problem is caused by lack of synchronization, lack of maintenance and the heavy traffic that the city of Paraná suffers on its main streets. The possible solution to the problem is to implement Artificial Intelligence in traffic lights. For the implementation of AI, the context and situation of the city's traffic lights must be studied. The large streets and avenues of the city are analyzed in order to study them and understand that the synchronization of traffic lights is one of the biggest problems that affect daily traffic in the city. After this, the AI proposal is presented as a solution for both automobile traffic and pedestrian circulation. Finally, the different strengths and weaknesses of the proposal are clarified. It is hoped that this project can generate a change in the thinking of those in charge of traffic in the city. This project also aims to allow people to reflect on their day-to-day actions when driving.

Keywords: traffic lights, traffic synchronization, AI.

Resumen—

   El siguiente trabajo hace foco en el problema del flujo de tráfico en la ciudad de Paraná. Este problema es causado por la falta de sincronización, falta de mantenimiento y el gran tráfico que sufre la ciudad de Paraná en sus calles principales. La posible solución al problema cuenta con implementar en los semáforos Inteligencia artificial. Para la implementación de la IA se debe estudiar el contexto y la situación de los semáforos de la ciudad. Se analizan las grandes calles y avenidas de la ciudad para poder estudiarlas y comprender que la sincronización de los semáforos es uno de los mayores problemas que afectan al tráfico diario de la ciudad. Luego de esto, se presenta la propuesta de la IA como solución tanto para el tráfico de los automóviles como para la circulación de los peatones. Por último se aclaran las diferentes fortalezas y debilidades que posee la propuesta. Se espera que este proyecto pueda generar un cambio en el pensamiento de las personas encargadas del tráfico en la ciudad. También este proyecto apunta a que las personas puedan reflexionar por su accionar del día a día cuando conducen.

Palabras clave: semáforos, tsincronización del tráfico, IA

I. INTRODUCTION

   Paraná is a big city (Fig. 1) and is the capital of the province of Entre Ríos, Argentina. The area of the city is 137 square kilometers and has a population of about 391.000 people according to the last census in the year 2022.
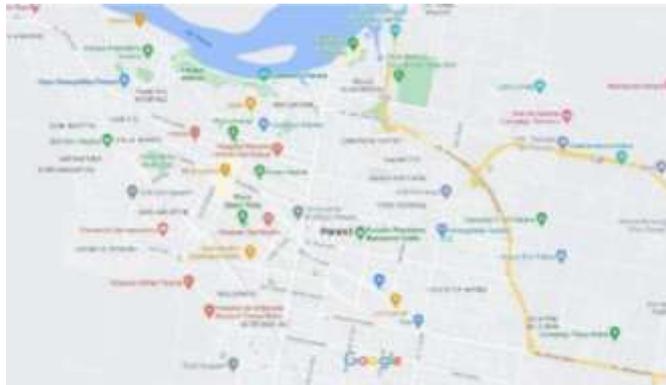
Fig. 1. Paraná city map.

   The fact that the city is big and has a large population also brings different problems such as the one analyzed in this project. In the city of Paraná there is a number of 137000 vehicles, which represents an approximate number of one vehicle every three people.

   In this project the focus is on the traffic lights that affect traffic of the streets in the centre of the city and the main streets that cross the city such as Francisco Ramirez Av. and Almafuerte Av. These are the busiest streets in the city and also the ones with the most complex problems. The objective of the project is based on improving the vehicular circulation in the city based on the repair of traffic lights out of operation and the synchronization of these to achieve-fluid traffic.

   In order to achieve this objective, this work is organized this way. First, there is a description of the city of Paraná. Next, the statement of the problem related to the urban traffic, and their causes and consequences. After this, is the approach to the possible solution to the problem, using AI in the traffic lights for the synchronization of them. In the next section, are the strengths and weaknesses of the possible solution to the problem. It is hoped that this project can generate a change in the thinking of those in charge of traffic in the city. This project also aims to allow people to reflect on their day-to-day actions when driving.

II. PROBLEM DEFINITION AND ANALYSIS

A. Description of the Context

   Paraná is a city located on the left side of the province of Entre Ríos, which is distanced from other provinces due to the rivers that run along and across it. It is very close to the city of Santa Fé (Fig. 2), capital of the province of Santa Fe, and is connected by the "Túnel Subfluvial Raúl Uranga - Carlos Sylvestre Begnis". This connection allows all cars to travel from Entre Ríos to Santa Fe and the northern part of

the country, making the city of Paraná a very busy destination.
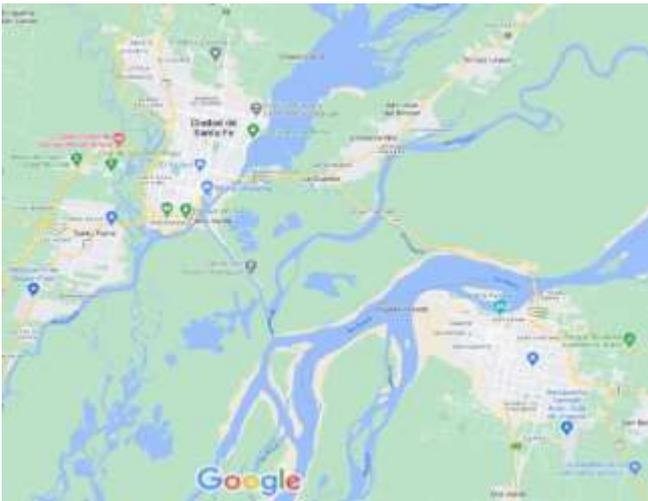
Fig. 2. Distance from Paraná to Santa Fe

The majority of streets that connect the city of Paraná lead to what is called the "Central Zone" (Fig. 3). This zone has an extensive area where people can find highly visited places such as the Sáenz Peña square (Fig. 4) and the Alvear square (Fig. 5).

Fig. 3. Paraná city centre zone map.
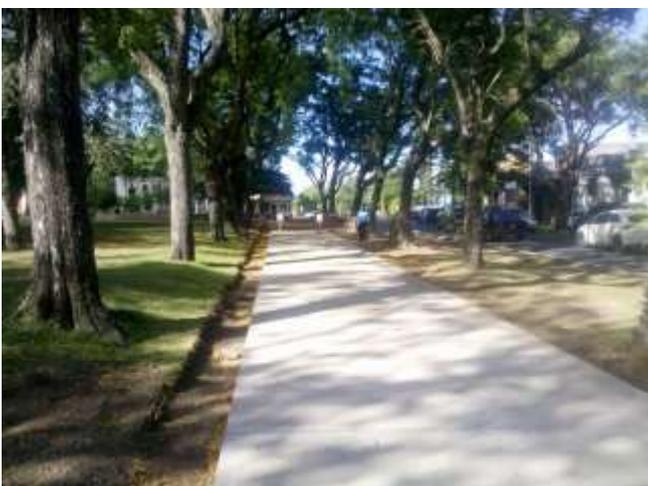
Fig. 4. Sáenz Peña square.

Fig. 5. Alvear square.

This central area of the city is very important for the present traffic analysis because it accumulates a large number of cars that transit it during the week. This fact is of great importance because the project aims at better traffic in the city and the best way to guarantee it is by analyzing the area of the city where more cars are concentrated.

Fig. 6. Círculo cinema.

In addition, in this area is located the Círculo cinema (Fig. 6), which is a relatively new cinema compared to the other cinemas in the city. As well as this, it is the cinema that most people visit, so in certain situations there are large numbers of people at the same time gathered to watch a film.

Fig. 7. San Martin hospital.

Relatively close to the cinema, the San Martin hospital (Fig. 7) is found, which is one of the most important public hospitals in the city. The hospital has all the branches of

medicine necessary for any emergency, and the fact that it is a public hospital makes it accessible and crowded.

Fig. 8. La Paz shopping mall.

Another place that is important to name is La Paz shopping (Fig. 8), which is currently the only shopping mall in the city. This mall is not very big, in terms of its extension, but the fact that it is the only mall in the city means that many people visit it.

Fig. 9. The pedestrian San Martin.

Finally, there is the San Martin pedestrian precinct (Fig. 9), this being the most visited place in Paraná. This can be seen every week, when people pass through this pedestrian precinct and visit all the stores that make it up.

Definitely, a particularity of Paraná city centre is the fact that almost everything is found there, like stores, banks, schools, hospitals, restaurants, and many other amenities. These facts make this area the busiest area of the city of Paraná.

Another main aspect to analyze is the number of the avenues and main streets that cross the city (Fig. 10). The principal function of these main streets is the fact that they connect different areas of the city and allow cars to move quickly. This work focuses on the perimeter zone that these main arteries enclose.
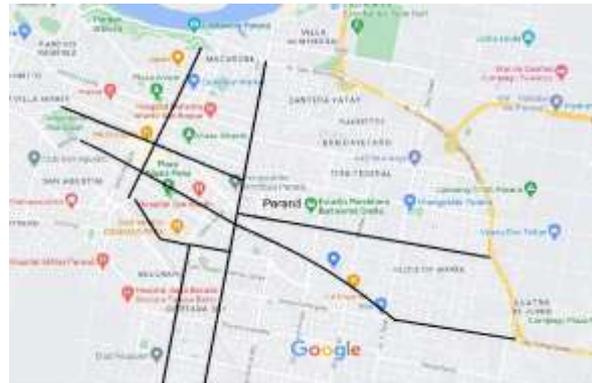
Fig. 10. Paraná city map, some avenues and main streets.

The avenues and main streets selected to analyze are Churruarín Ave., Almafuerte Ave., Francisco Ramirez Ave., de las Américas Ave., Bvd. Eduardo Racedo, 25 de Mayo St., Corrientes St. and Monte Caseros St. These streets were selected because they have the particularity that they extend for great distances and cross the center of the city, being really important transit routes for Paraná.

B. Problem Statement

In general, there are many aspects that actively affect traffic in the city of Paraná, such as the poor condition of the streets, the large number of cars per person, and other factors. However, in this project a specific focus will be made on traffic lights because they are the ones that have caused the most problems in relation to traffic in the city.

Traffic lights are a signaling device that allows the regulation of traffic on public roads and generally has three different lights for its signalling: red, yellow and green (as it is in Paraná). In Paraná there are two major problems in relation to traffic lights that occur mainly in the areas analyzed. These are the bad synchronization of the traffic lights and the traffic lights out of operation.

C. Description of Scenes that Help Picture the Problematic Situation

To understand what it means to have poor traffic lights synchronization, it will be explained what a good traffic synchronization looks like. In a good synchronization of traffic lights, they follow a concept known as "green wave". This concept refers to the fact that the traffic lights should turn on the green light as the cars circulate at a certain speed, allowing them to move freely without having delays, as shown in Fig. 11.

Fig. 11. "Green wave".

What happens in the center of the city and in its main avenues is that this "green wave" generally does not appear. The timing of the traffic lights in this area is not accurate. This bad synchronization is represented in the number of times in which the cars have to slow down because the traffic light has the red light on while at the next one the traffic light is green. That is when the green light goes on at the first traffic light, the next one will have the red light on, as shown in Fig. 12.

Fig. 12. Bad synchronization of traffic lights.

The other problem that is usually found on these streets is traffic lights out of order. The fact of having traffic lights out of operation is found more in the large avenues of the city than in the centre of the city, greatly affecting traffic.

Fig.13. Traffic lights out of operation.

Fig. 13 shows what a traffic light out of activity generally looks like. In the city of Paraná it is possible to identify out of operation traffic lights in two ways. The first one is the already shown image in which the traffic light does not have lights on. The other way, which is very common in Paraná, is seen when the yellow traffic light blinks constantly indicating careful driving due to traffic light failures, as shown in Fig. 14.

Fig. 14. Traffic lights out of order.

D.   Identification and analysis of causes or factors that give rise to the problem:

To address the aforementioned problems, it is important to analyze the causes or factors that influence them. As for the improper operation of traffic lights and the traffic lights out of order, there are three main causes that cause this event.

The first cause to name is the lack of maintenance of traffic lights in the city of Paraná. Traffic lights maintenance is an important task to ensure that they continue to function properly over time. This task has to be relatively frequent to prevent the lights from presenting both synchronization failures and more severe failures that cause the end of the lights' operation.

Fig. 15. Traffic light maintenance.

The second factor is the traffic lights that have obsolete or old materials in their components. Although this is not very frequent, today there are still traffic lights produced with old materials, such as lighting that is not based on LED devices. This fact is capable of causing traffic lights to burn.

Finally, there is a cause that mainly affects the flow of traffic, which is the bad configuration or synchronization of traffic lights when putting them into operation. These configuration failures are represented by a calculation error for the synchronization of the traffic lights.

E.   Identification and Description of the Consequences

The consequences that arise from this situation are several. However, they can be represented by two concepts, slow traffic and car accidents. Slow traffic is generated by a bad

flow of cars, which in this case is represented by the malfunction and synchronization of traffic lights. This can be seen in well known "traffic jams", which consist in a large accumulation of cars in a small area, as shown in Fig. 16.

Fig. 16. "Traffic jams".

The other great consequence that could arise in relation to the mentioned problems are car accidents. These car accidents are caused by human error due to the lack of correct signalling that a traffic light in good conditions should provide. Within this consequence, different events can occur. On the one hand, these accidents can only involve cars, and on the other hand, it can involve pedestrians and the results can be very serious.

Fig. 17. Car accident.

III. THE WAY FORWARD

A. *Problem approach*

Basically, this project aims to develop a change that allows to solve traffic problems to a large extent in the city of Paraná. The solution proposed here begins with the location and remodelling of traffic lights at each intersection in the area already analyzed.

This proposal seeks to continue the steps of the developed countries, such as Austria, England and Germany, through the implementation of new technologies in road traffic. Within the remodelling, the focus is on changing obsolete materials that the traffic lights themselves have for newer and more appropriate materials, in order to maintain the traffic lights for longer.

In addition, the main aspect of the proposal of this project emphasizes the development of technologies characteristic of the developed world, especially, from the implementation of artificial intelligence (AI) in the city's traffic lights. In order to make this possible, it is proposed to implement high-resolution cameras along with sensors under the asphalt that will be capable of sending sufficient information to an electronic device integrated within the traffic lights to regulate traffic.
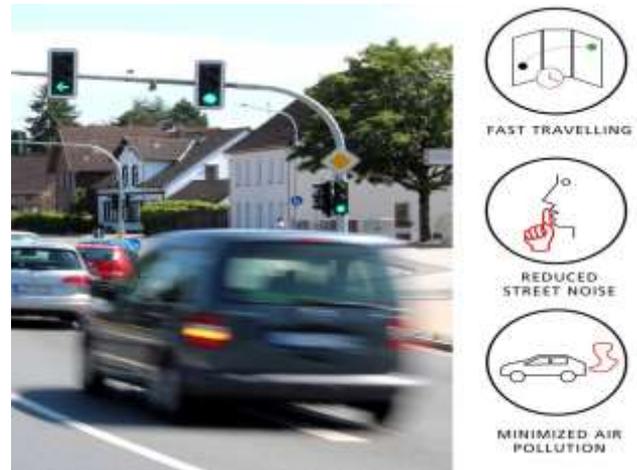

Fig 18. Traffic lights with AI.

The high-resolution cameras will be equipped with radar sensors, and together they will be able to more accurately capture the real traffic situation, allowing them to precisely determine the exact number of vehicles waiting at intersections and detect their average speed. Besides, it is possible to incorporate sensors under the asphalt that can complement the information on the circulation of vehicles. All this information will be directed to the device integrated with AI inside the traffic lights. It will use different learning algorithms to be able to record and calculate the optimal periods of operation at the traffic lights using the information obtained.

To fully understand how it works, it is possible to see the analysis of its operation in the different situations that may arise on public roads. Situations that may arise:

- Heavy traffic
- Average traffic
- Low traffic

Heavy traffic: in situations where traffic is heavy and many cars show up at corners waiting to cross, high-resolution cameras and radars collect information about the position and number of cars and pedestrians at the moment. This information reaches the AI, which is responsible for developing a plan to dissolve the traffic as soon as possible.

Fig. 19. AI at work.

Average traffic: at times when traffic is neither heavy nor low, high-resolution cameras and radars do the same job, but AI's job is simplified. In this situation, the AI should maintain traffic or speed it up by giving priority to the lane with the greatest accumulation of cars. In this way, traffic is accelerated where it is most necessary, reducing waiting time.

Low traffic: in situations where there is almost no traffic is where AI really shines. In comparison to this situation developed with common traffic lights, there would no longer be a long wait if there are no cars circulating in the other lane. Therefore, when the cameras and radars locate the first car to appear, the traffic light will immediately allow passage to reduce waiting times.

Regarding the synchronization context, it is expected to obtain significant changes in terms of traffic flow compared to the situation currently experienced in the city. In this way, it could be possible to both solve the problem of traffic circulation and also bring new technologies to test and implement in Paraná.

B. Strengths and Weaknesses of the Proposal

The main advantage that can be attributed to the proposal is faster traffic on the most important streets of the city. This same advantage also has consequences that are beneficial for the city, such us reducing noise pollution and reducing CO_2 emissions because cars slow down less frequently.

On the negative side, this engineering development is expensive compared to a conventional remodelling of traffic lights in a city like Paraná. Furthermore, this technology would be implemented in the most important streets of the city, which would ensure fast traffic on the but would not guarantee the same result on other streets.

IV. CONCLUSION

In conclusion, this project seeks to solve major road problems that constantly affect the people of Paraná. Emphasizing the city's traffic lights, the analysis is carried out and the different causes or factors that must be combated to achieve the proposal.

To address these problems, different solutions are presented based on the new technologies that are being developed in Europe. These solutions contemplate including AI at city intersections, adding radars, cameras and devices capable of reorganizing traffic so that it is much more fluid. Through this proposal it is expected to put an end to this major problem in the city and achieve a great change regarding traffic.

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