Smart Roundabout (September 2018)

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***Abstract*—every single day to go from home to work, I have to drive on average through eleven roundabouts. It allows me to feel how much cumbersome is to stop brusquely because of the low visibility or the unpredictability of the traces of "some drivers". In addition to unnecessary braking, we also use too much fuel to speed up enough to go inside, in some cases with the same unnecessary violence. Both cases generate the majority of environmental pollution in cities. It also aims to avoid accidents arising from these acts. My objective is to avoid these situations, being the measures applicable immediately, simply and economically. Smart roundabout has a group of electromagnetic loops sensors capable of detecting speed and size, installed about thirty meters away. Also, has installed programmatic luminous speed signals that indicate the speed that the vehicles will have to circulate with to make the entrance as efficient as possible. The knowledge I have acquired during the degree allows me to choose the LabVIEW software to program the control and a simulator capable of showing the behavior.**

***Index Terms*—Control, Drivers, LabVIEW, Pollution, Program, Roundabout, Sensors, Simulator, Smart, Vehicles.**

I. INTRODUCTION

THIS article is about an innovative traffic control model of a roundabout. Explain how its inventor has developed a functional prototype and the improvements it brings compared to the existing ones.

II. MOTIVATION

The main motivation has been the challenge of innovating in something that had born a century ago. I really want to change that kind of road constructions, to apply Industry 4.0[1], to use interaction between infrastructure and people to increase safety on our roads. Before choosing the project I was searching for internet about some related topics and I saw that interior ministry of Spain published a public contract which consists in creating a platform for DGT 3.0 (Dirección General de Tráfico), and then I realized that all I want to apply to improve safety is sooner than I thought.

Finally, I chose Smart Roundabout as a project because the safety is what I want to devote to.

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III. METHODOLOGY

Brainstorming, research, physical data collection, the creation of the simulator, creation of the control and analysis of the functioning.

I started by thinking a good solution for the problems I found driving through roundabouts, after I was searching for the technology and companies which use them, I met with one of the engineers of Etra Bonal in his office. Once I knew how they solve their projects I began searching for a real example near my home, I drove through a roundabout few times to know most common speeds driving through.

After that, I started to program the simulator at the same time I was designing the simulator interface.

Finally, I developed the control and tested her capabilities.

IV. OBJECTIVES OF THE PROJECT

Amongst all the objectives, this project consists in to demonstrate that another kind of active safety could be applied on our roads just using current technology.

The main target is to create a satisfying control of vehicles applying Industry 4.0, and prove that we are spending too much energy and making pollution with no sense.

Now, I know the mobility is a very important issue because of overcrowding of vehicles. These cause traffic problems, noise and pollution. Then, I want to take action on this matter and demonstrate that we could decrease all of these problems.

Therefore, I have divided the principal big objective into small ones.

Thinking about which solution could be applied, related with current technology because I want to apply existing technology to create something that can be used as soon as possible. Cultural arrangement, everybody has to be ready to interact with this technology without problems, easily applicable, for the first reason and economics reasons we can't expend tons of money on it, the solution has to be economic and as simple as possible. At this time, I need a platform to construct the solution, this one should be known by me at least a little and I can choose among some software that I used during my degree, this software has to have code interface for the program the control and a user interface to show a simulation. Then the other objectives are to create the control and simulator.

The last objective is to get de capabilities of the control and the simulator, I need to confirm if the first design was enough to comply with the requirements.

In summary, the control must help drivers to go into the

roundabout with the minimum effort and the control needs to calculate the best way and communicate to the drivers.

A. *Hypothesis*

The control of the roundabout with four entrances and one single lane using four sensors and four indicators, one for each entrance can avoid the total braking of the vehicles.

V. Roundabout

It is necessary to begin talking about the birth of roundabouts, Eugène Hénard (1849-1923), a French architect who designed the first urban roundabouts in Paris and the first roundabout was built in 1976[2]. Now we meet with we find different types of roundabouts, all derived from the original, based on circulation in one direction.

A. *Innovation in roundabout*

From 1976 to now, engineers were innovating on roundabouts, currently we can watch on our roads these kind of roundabouts. Turbo roundabout aims to avoid accidents by lateral impact, then it needs to make restrictions in the lateral movements between roads, in many of these limited by continuous line.

Picture 1. Turbo roundabout

To put traffic lights inside of roundabouts sounds illogical, but the reason for introducing them is to dose the flow of vehicles with an external control. It is easy to saturate a roundabout of these dimensions if we do not apply the properly control of the entrances and exits.

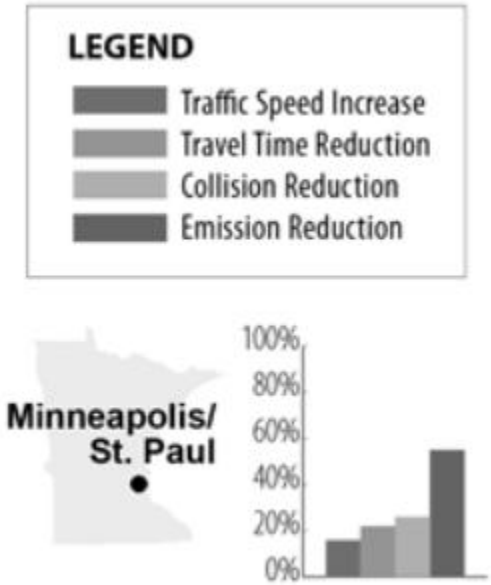
Picture 2. Saturated roundabout.

I have observed that some traffic jams are caused by the imprecision of the drivers when entering and the way it is circulated. Of the first twenty web pages that we found when searching for the word “roundabout” in Google, sixteen talks about how we have to circulate through, this is a symptom that is a notorious problem.

VI. Ramp meter

Finally, a control that we can’t see now in Spain but is very common in USA. Ramp Meter is a system that detects traffic jams and activate semaphores to dose the traffic of the other roads. We can arrive to this control, and look how for each green line only cross one or two cars with a frequency of 5 to 6 seconds. Graphic 1 shows how ramp metering works. U.S. Department of Transportation website[3] show some interesting data about the benefits.

They insure that Minneapolis identified a net annual savings of 1.160 tons of emissions and reducing CO emissions by 1.195 tons per year. We can see an example on the same website.



Graphic 1. Ramp meter benefits

This confirms that this kind of control can make our roads more efficient.

VII. Common technology

Ramp meter uses induction loop, is a type of sensor very common in Spain, used to count vehicles on roads with large number of drivers. The DGT controllers program the control to reduce the speed/kilometers before arriving at an area in which there is a large amount of vehicles, where there may be traffic jam. Therefore, they relate that there may be retentions and be liable to cause accidents. It is also used by companies with motorway contracts with the state in which they do not install tools, but they do charge from the state for vehicles traveling on that.

Is an electromagnetic detection system which uses a moving magnet or an alternating current to induce an electric current in a nearby wire [4]. When metallic pieces of the vehicles

cross the influence zone, provoke alterations, this means that the inductance (L) changes, therefore, generates a variation of frequency (W).

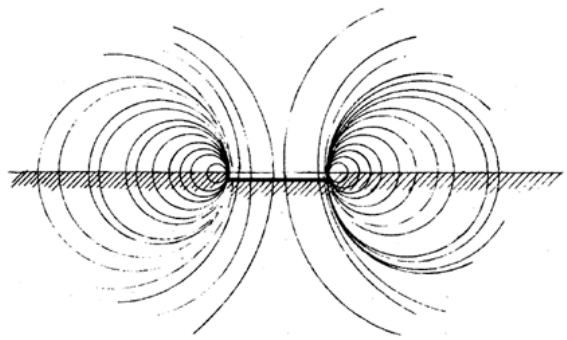
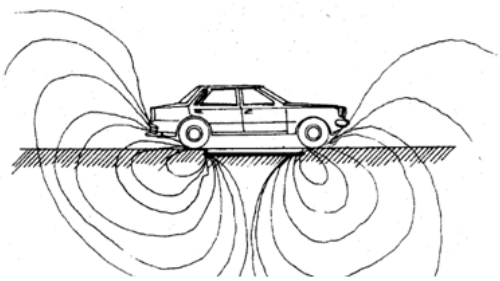


Fig. 1. Representation of induced electromagnetic camp



The operation of the oscillator is independent for each loops, there being no coupling between the frequencies of both loops, since the sampling is done in an alternative. The device has the peculiarity of allowing the programming of detection response sensitivity, the oscillator work with different frequencies, this avoid the coupling between the different detectors that are installed nearby, and the programming of different periods during the detector remains in response, in the presence of vehicles.

VIII. Some Common Mistakes

We can believe that this sensor only is used as a counter, but has more capabilities. Two consecutive loops are used finding the speed from the time the vehicle passes through each of them and the space between the loops. Is particularly useful in these cases, first, for its operating speed, and second, because the separation between loops is what the installer wants to have without any type of couplings between.

IX. Concept

Before starting the simulator programming, I had to specify what I wanted to simulate, how I am going to acquire the data and how the control was going to be carried out. Before starting the simulator programming, I had to specify what I want to simulate, how I am going to acquire the data and how the control is going to be carried out. The idea is to indicate to the drivers how fast they should go for not to encounter any obstacle when entering the roundabout at a sufficient distance to make it possible. For this, it is necessary to know the dimensions and speeds of the vehicles that circulate through them to make calculations, to indicate correctly by light signals, but with the difference that they won't be of maximum speed, they will be of advised speed, the speed inside roundabout is fixed for all vehicles.

Tipo	Registrations 2017	%	LEDs
A (Cars)	301.797	61,63	3-4
B (Bikes)	159.372	32,54	1-2
C (Buses)	28.482	5,81	6-7

Table 1. This table refers to the percentage of each type of vehicle that can be found on the road, in this way our simulator can distinguish between three characteristic types and generate randomly but within a statistical probability the type of vehicle with the frequency that we would really meet.

X. Simulator

The simulator had an enormous weight in the project, it had to be totally modular and compatible with the control that I will apply later.

A. Interface

The user interface of the simulator had to be similar to the selected model, but at the same time be able to simulate another type of configuration. The interface consists of a central rotary and four incoming lanes and four projections, in addition to a single lane ring that surrounds the roundabout.

The vehicles are distinguished in three types, making reference to data of new registrations in December, 2017 in Spain, I extrapolated the type of circulation that we can see in our roads, therefore, classifying this data of vehicles such as motorcycles, buses and cars.

The physical characteristics of the simulator were selected through real tests of circulation and data collection.

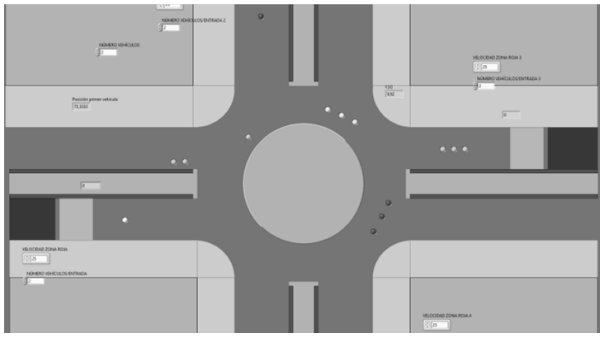
Diameter roundabout (m)	Total diameter (m)	Rail width (m)	Maximum external speed (km/h)	Number of departures
5,8	21,2	4,80	45	4

Table 2. These are some of the data chosen for the realization of the simulator.

I chose LabVIEW as development software because it has a great capacity, it is oriented to the visualization of data and indicators, and this allows programming in a simple and visual way. Although its license price is very high, the development time is much lower than you would need to perform the same simulator on another platform. This implies that to program needs less hours of an engineer, in this way we can see that the price is not very different compare with another open platform.

The way the vehicles are represented in the interface is by means of colored LEDs, a short succession of illuminated LEDs means that a motorcycle is circulating, a slightly longer length is assigned to the cars and finally the longest they represent buses.

The sizes were chosen from among the most common currently used, this approach allows to create a more realistic simulation.



It is designed to be able to visualize possible incorrect operations in a very precise and simple way. The lanes are differentiated by each entrance, although it a single lane. I also programmed useful elements to visualize data in real time and configuration elements, for example, we can visualize the real time, configure the number of vehicles we want to simulate and know the live position of the first vehicle, we can also see the simulation of the signals of traffic.

XI. Control

The control works by obtaining data at thirty-two meters from the roundabout, this allows, knowing the size and speed of the vehicle that circulates above the sensor, to be able to calculate at what time it will be circulating through each of the entries, thanks to this, a vehicle that has just entered a roundabout, where there are already other vehicles, has information about the spaces that will be or may be occupied. After determining which will be the space you can access, the control calculate the variation that must be made and only thirteen meters after the sensor, indicate the speed at which it should circulate.

XII. Conclusions

LabVIEW has proven to be up to the demands made during programming both in the design of the interface and in the control. My experience in solving innovative concepts has grown considerably along with my motivation to continue creating projects of this style.

After making tests of great duration and adjustments in the control, causing that they circulate until a total of 500 vehicles, I consider that the control is satisfactory, in spite of producing a 13% of partial unsatisfactory couplings of which 2% are fatal.

Partial unsatisfactory couplings are those that their the introduction will be satisfactory controlled by a human, while the fatal ones are those that the control points directly to a vehicle, large vehicles are that cause these types of variations impossible to circumvent. These tests have been carried out with a specific configuration of spacing between vehicles and concrete generation speed, with 2,160 vehicles per hour.

Compared with the Ramp Meter that caused the total stopping of the vehicle, I consider that, taking into account that the vehicles controlled by my application reduces on average 55% of its speed, the energy saving is 45% greater than Ramp Meter.

As the first large innovation project that I do on my own, I find that the greatest amount of development is found in the developing and testing of the prototype

A. *Future improvements*

As I have seen during the simulation tests, I distinguish improvements to be made in a short period of time and in the long term.

1) *Short term*

Immediate improvements that I can apply is the way in which the detection of vehicles is done, in this project, I base myself in ideal conditions and an improvement in realism will allow to be more robust in variations derived from the acceleration. In addition, the limitation of only obtaining data from vehicles at thirty-two meters from the roundabout doesn't prevents intermediate variations, this would be solved by creating an image recognition of vehicles, determining their size, speed and position in real time, without making approximations.

2) *Long term*

The long-term improvements are related to the communication between autonomous vehicles and infrastructure, where these vehicles receive accurate traffic information and can be coordinated, avoiding jams and accidents in a perfect way.

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