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Smart traffic lights in sustainable urban logistics

Los semáforos inteligentes en la logística urbana sustentable

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Abstract

Due to the rapid growth of cities has the need for mobility of goods and people in less time. Primary roads are saturated by vehicles passing through them. The City of Veracruz, Mexico, this problem together with the topography and topology own territory has favored an elongated growth of the city, which journeys are getting longer. Transit through primary roads affected by poor automated control of road (traffic lights) which favors addition to huge losses in man hours (HH), further contamination by CO and CO2 due to timeouts motor for circulating. This research was conducted monitoring traffic volume on a road in the city reaching the proposed solution of an intelligent system of synchronized traffic lights. Any proposed solution will help to alleviate mobility problems currently affecting this city.

Intelligent traffic lights, Synchronized traffic lights, Monitoring

Resumen

Debido al rápido crecimiento de las ciudades tiene la necesidad de la movilidad de bienes y personas en menos tiempo. Las vías primarias están saturadas por el paso de vehículos. La Ciudad de Veracruz, México, esta problemática aunada a la topografía y topología propia del territorio ha favorecido un crecimiento alargado de la ciudad, en la cual los trayectos son cada vez más largos. El tránsito por las vías primarias se ve afectado por un deficiente control automatizado de la vialidad (semáforos) lo que favorece además de enormes pérdidas en horas hombre (HH), una mayor contaminación por CO y CO2 debido a los tiempos muertos del motor para circular. Esta investigación se llevó a cabo el seguimiento del volumen de tráfico en una carretera de la ciudad llegar a la solución propuesta de un sistema inteligente de semáforos sincronizados. La solución propuesta ayudará a aliviar los problemas de movilidad que actualmente afectan a esta ciudad.

Semáforos inteligentes, Semáforos sincronizados, Monitorización

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Introduction

The accelerated growth of modern cities is due to various factors, including commercial and industrial growth, migration from the countryside in search of satisfiers and comforts, etc. These cities have deficiencies in the planning of their growth that ends with a shortage of basic services or with an infrastructure that is inadequate for a demand requested by its inhabitants.

The area of analysis is the City of Veracruz, Ver., where the characteristic layout of the Greco-Roman models brought by the Spanish conquerors was maintained for many years as a perfect grid of a few blocks in both directions on the shores of the port, It is worth mentioning that it is one of the most important activities in the city, it began to be insufficient by the end of the 19th century and began its growth towards the southeast, bordering the coast and towards the south with the construction of the alameda that today bears the name Salvador Diaz Miron. Today the city has grown to the point of extending beyond the municipal territory, what we know as the City of Veracruz, is conurbated with three adjoining municipalities, Boca del Río, Alvarado and Medellín. With very specific urban settlements that demand great mobility from their inhabitants. The natural growth of the city has been sectorized by poor urban planning, or because the natural context of the area has dictated the parameters of extension and growth.

There are very well defined areas, to the south, bordering the beaches, there is the first level residential and commercial growth, to the west and south west are the residential settlements of medium interest and the industrial zones, to the north of the city the settlements of interest social and popular, leaving the center of the port and commercial traffic area related to this activity. This sectorization promotes the mobility of people from north to south and vice versa with journeys of 15, 20 and up to 25 km per day, from the residential areas in the north to the commercial areas in the center or south of the city or towards the west of the city to the industrial areas. The need for housing and the growth of subdivisions in the peripheries, It has not been accompanied by a study of the dimensions of the existing roadways or the creation of alternative routes that relieve traffic on the existing ones.

In addition, the layout of the roads has not been consistent with the growth of the city, for this reason we do not have roads that cross the city or peripherals that help decongest the interior roads. If we add to all this that the natural growth of the city with its respective need for mobility demands a greater number of transport options, which in this case is reduced to two, public transport by means of buses and public and private transport through cars. As background, smart traffic lights operating in the Netherlands are based on the premise that the red phase does not always need to last four seconds; Sometimes, depending on traffic conditions, it will be more effective to open the way in 3.2 seconds, for example, or in a little more time (López, 2016).

Due to recent advanced communication possibilities between traffic infrastructure, vehicles and drivers, optimization of traffic light control can be approached in a novel way. At the same time, this can introduce unexpected new dynamics into transport systems. Research has been conducted on how drivers and traffic light systems interact and influence each other when informed about driver and light behavior. Agent-based models have been developed to simulate transport systems with static and dynamic traffic lights and controllers using information about the behavior of traffic lights (Costalle et al., 2016). Proposals have been made for a new approach to dynamically manage signal cycles and phases at an isolated intersection.

It has an improved performance system called "off-the-shelf" it is flexible and can be implemented with the aim of avoiding complex and computationally expensive solutions. In these systems, traffic is monitored in real time with multiple fuzzy logic controllers. Implementing this device does not require powerful hardware and can be easily implemented in a low-cost device, thus paving the way for extensive use in practice (Collotta et al., 2015). It has an improved performance system called "off-the-shelf" it is flexible and can be implemented with the aim of avoiding complex and computationally expensive solutions. In these systems, traffic is monitored in real time with multiple fuzzy logic controllers. Implementing this device does not require powerful hardware and can be easily implemented in a low-cost device, thus paving the way for extensive use in practice (Collotta et al., 2015).

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To streamline vehicular traffic in the densely populated areas of Mexico City, Mexico developed a program based on the use of traffic lightsself-organizing at UNAM. These traffic lights do not depend on a central control but depend on the local conditions where an adaptive solution to the road traffic problem is found (Olivares, 2014).

In this article, a bibliographic review of the importance of an implementation of intelligent traffic lights in the routes of the main streets of the city is carried out. The methodology used to carry out a monitoring of the volume of vehicles (vehicle capacity) is described. The results section details what was obtained and the traffic light synchronization proposal.

Hypothesis

Carrying out an analysis of the delays that occur due to the bad synchronization of traffic lights in the city, you can save fuel use costs, less stress to get to the work zone and consequently less polluting emissions to the environment.

Problem Statement

The poor urban planning that has led to roads that are scarce for the volume of vehicular traffic generates several problems of great social, economic and environmental impact. Taking longer to travel the same distances involves investing more time in the simple activity of moving from one point to another, which reduces social coexistence in addition to translating into very high economic costs due to the loss of man hours (HH), which can be productive in other activities.

Downtime, where vehicle engines continue to run and release substances resulting from the combustion of diesel, gasoline, gas or any other hydrocarbon, translate into emissions of carbon monoxide CO and carbon dioxide CO2, among other pollutants, which they are expelled into the atmosphere without any benefit.

The Port of Veracruz in an elongated way without counting the construction of road axes, or primary roads with the capacity to relieve the vehicular load that little by little was loaded with the connection of secondary roads coming from the new housing centers, or from the need for mobility of people from one end of the city to the other using the same roads. You can talk about various solutions, an urban reordering, construction of road axes including starting with the "first floors", reorganizing public transport, using new technologies in engines that make them less polluting and thus reduce greenhouse gas emissions. greenhouse, in short, they are multiple and at the same time costly or difficult to implement.

Smart traffic lights

Part of the problem is the travel times, we could start by trying to make the transit of cars through these roads more fluid, and this can be obtained at a relatively low cost that consists of putting an automated traffic light system or commonly called " smart traffic lights. There are three main types of automated traffic lights, the first and the most economical, it consists of placing equipment that will be synchronized in such a way that when a vehicle starts with the first green light, it will always reach the green light at the next traffic light in the entire road going to the design speed, 40, 50 or 60 km/hr, this system also serves as a maximum speed controller.

Another system includes cameras and specialized sensors that measure the waiting queue and that, through software, change the stop light to continue, giving priority to the areas with the highest traffic loads.

The third system that also uses cameras is a central monitoring system, which in addition to having a traffic controller who will determine vehicle flow priorities, can act as an urban surveillance system.

The more complex or sophisticated the system, the more expensive it is to implement and operate. However, the system of synchronizing, through software or a very simple programming, the turning on of the green lights in such a way that it respects a specified speed, will save a lot of time.

Methodology

A vehicle survey (Figure 1) was carried out on one of the busiest arteries in the city of Veracruz, Salvador Díaz Mirón Avenue, in the section from Parque Zamora to Simón Bolívar Avenue (Figure 2). It was found that in a section of approximately two kilometers, there are fourteen intersections (Figure 3) with their respective traffic lights, which are not synchronized, generating waiting times that vary depending on the time of day and the day on which the measurement is taken reading.

Figure 1 Road monitoring

Figure 2 View of the experimental road for vehicular traffic measurements

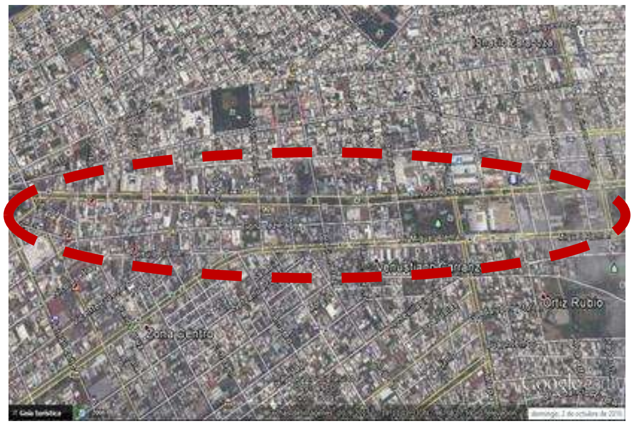

Figure 3 The experimental road, boulevard Salvador Díaz Mirón, where the section of analysis is found 14 intersections

Once the analysis of the traffic capacity was carried out, the data was analyzed and finally a proposal for the synchronization of the intelligent traffic lights in the experimental zone.

Results

In the analysis section, the results are a large accumulation of time for each stop in the interception lane, with a range that goes from 23 to 113 seconds.

At the intersection with Boulevard Simón Bolívar there is an estimated time of 113 seconds, which warrants taking up some other alternative solution, be it a bridge. In the case of the secondary streets of the experimental zone, there is a travel time of almost 10 minutes without counting areas of peak vehicular flow (Table 1).

Traffic lights	Intersection with Av. Salvador Diaz Miron	Time (sec.) Red	Green
one	Abasolo	36	50
two	Step and trunk	36	50
3	Virgilio Uribe	36	50
4	Jose Azueta	36	50
5	Turbide	36	50
6	Francisco J Mina	36	50
7	Alacio Perez	43	54
8	John Enriquez	43	54
9	Altamiran	43	54
10	Ignatius of the key	43	54
11	Molina Nuter	41	40
12	Orizaba	23	57
13	Red Cross	-------	-------
14	Simon Bolivar	113	36

Table 1 Travel time along Blvd Experimental on Av. Díaz Mirón

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Of the volumes of traffic measured, there is a total of 13,806 vehicles on a normal working day, with cars having the highest growth rate with 69%, in trucks (bus) there is 25%, while for cargo trucks and motorcycles 3% (Graph 1). From 00:00 to 06:00, the vehicular flow is low, increasing from 05:00 to 18:00; The hour of greatest vehicular influence is from 6:00 p.m. to 7:00 p.m. and a considerable decrease after 9:00 p.m. (Table 2).

Monday Friday	Car	buses	loads	motorcycles	Total
Hour	Vehicles / Hour				
00:00 - 01:00	46	0	1	0	47
01:00 - 02:00	19	0	0	0	19
02:00 - 03:00	20	0	1	0	21
03:00 - 04:00	21	0	0	1	22
04:00 - 05:00	55	0	1	1	57
05:00 - 06:00	153	189	12	5	359
06:00 - 07:00	389	204	20	6	619
07:00 - 08:00	486	214	28	14	742
08:00 - 09:00	483	229	37	16	765
09:00 - 10:00	443	204	35	14	696
10:00 - 11:00	404	177	33	11	625
11:00 - 12:00	501	190	43	20	754
12:00 - 13:00	599	203	55	30	887
13:00 - 14:00	686	219	30	30	965
14:00 - 15:00	612	201	25	27	865
15:00 - 16:00	578	197	23	26	824
16:00 - 17:00	576	180	21	25	802
17:00 - 18:00	682	210	19	30	941
18:00 - 19:00	797	232	18	36	1083
19:00 - 20:00	718	202	16	33	969
8:00 p.m. - 9:00 p.m.	680	195	20	14	900
21:00 - 22:00	334	188	9	20	542
22:00 - 23:00	167	0	2	6	175
23:00 - 24:00	125	0	2	1	127
Total Daily Traffic	9574	3434	441	357	13806

Table 2 Number of vehicles in a day taken in the experimental section

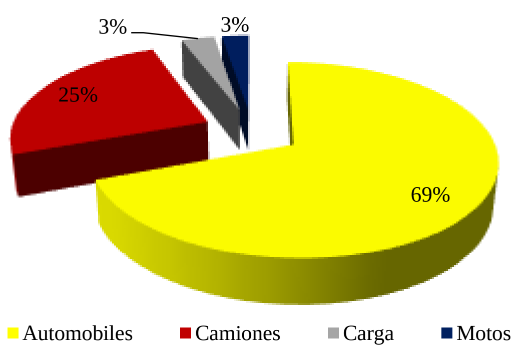


Figure 1 Vehicle influence in the experimental area

Two important results were obtained from the different gauging carried out: the daily average vehicular flow of 13,806 vehicles, and the average waiting time for each vehicle is two minutes and thirty seconds, 0.042 hours of waiting per vehicle, which would be covered in a time of 2 minutes with 50 seconds for the experimental analysis section, with a time saving percentage of approximately 70% (Table 3).

Traffic lights	Condition	Wait time
abasolo	Red	00:15:35
step and trunk	Green	-
Virgilio Uribe	Red	0:24:10
joseph azueta	Green	-
Iturbide	Green	-
francis j mine	Green	-
alacio perez	Red	00:18:30
John Enriquez	Red	00:34:15
Altamirano	Red	00:39:03
Ignatius of the key	Red	00:29:22
nut mill	Green	-
Orizaba	Green	-
Red Cross	Green	-
Simon Bolivar	Red	00:10:22
total time		**2:50:37**

Table 3 Time proposal to synchronize traffic lights

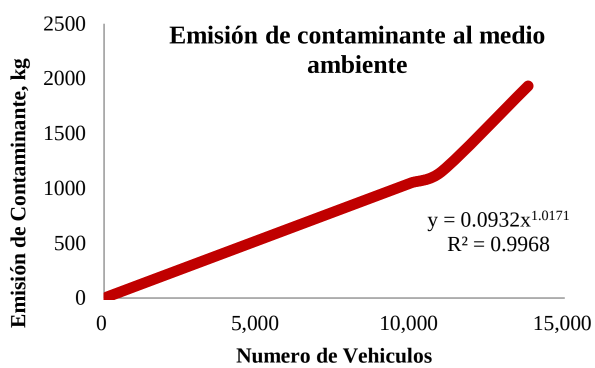
With these data we can calculate for a given number of vehicles the times lost in HH and the times of polluting gas emissions that could be reduced by simply synchronizing traffic lights and these results are shown in Table 4. For 100 vehicles taking into account Considering a waiting time of 0.04 hour, there is a CO_2 emission to the environment of 10.50 kg, in the opposite case of 11,000 vehicles per day, there is 1155 kg of CO_2 to the environment.

If we take into account the number of vehicles in the experimental zone of 13,806, we have a pollutant emission of 1,932.84 kg. Graph 2 shows the growth trend of contributions to the environment of pollutants, having a mathematical behavior of a potential type. This problem occurs in a section of the road, where it is important to pay attention to other important roads in the city of Veracruz, including the Mexican Army, Boulevard Simón Bolívar, Cuauhtémoc, Miguel Alemán, Rafael Cuervo, Ruiz Cortines, Juan Pablo Segundo. , among others, where there is no system of synchronized traffic lights and they are contributing large amounts of pollutants to the environment of the urban area. In the analysis of the HH for every 100 vehicles, there are losses of 294 pesos,

1	2	3	4	5	6	7
100	0.04	4.20	$70.00	$294.00	2.50	10.50
1000	0.04	42.00	$70.00	$2,940.00	2.50	105.00
2000	0.04	84.00	$70.00	$5,880.00	2.50	210.00
3000	0.04	126.00	$70.00	$8,820.00	2.50	315.00
4000	0.04	168.00	$70.00	$11,760.00	2.50	420.00
5000	0.04	210.00	$70.00	$14,700.00	2.50	525.00
6000	0.04	252.00	$70.00	$17,640.00	2.50	630.00
7000	0.04	294.00	$70.00	$20,580.00	2.50	735.00
8000	0.04	336.00	$70.00	$23,520.00	2.50	840.00
9000	0.04	378.00	$70.00	$26,460.00	2.50	945.00
10000	0.04	420.00	$70.00	$29,400.00	2.50	1050.00
11000	0.04	462.00	$70.00	$32,340.00	2.50	1155.00
13806	0.04	552.24	$71.00	$39,209.04	3.50	1932.84

Column 1: Number of vehicles
Column 2: Average wait time
Column 3: HH lost on hold per day
Column 4: Minimum daily wage
Column 5: Cost of waiting loss per day
Column 6: Average emission of pollutants in kg per hour of the vehicle.
Column 7: Emission of pollutants (kg) per day

Table 4 Analysis of pollutants to the environment by the number of vehicles



Graph 2 Potential growth of the emission of pollutants into the environment

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Conclusions

The implementation of smart traffic lights speeds up the movement of goods and people to commercial and work places, obtaining optimal transfer results. The impact of intelligent traffic light systems directly impacts the environment where around 13,806 vehicles circulate daily in the experimental area, emitting 1,932.84 kg of pollutants into the environment, which verifies the importance of carrying out a program for the proper functioning of intelligent traffic lights.

In areas where there is a high concentration of vehicles in the cities. Carrying out an analysis of the delays that occur due to the bad synchronization of traffic lights in the city, you can save fuel use costs, less stress to get to the work zone and consequently less polluting emissions to the environment.

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