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Analysis and Comparison of the Farima Model with other Evolutive Algorithms in Order to Predict Vehicular Traffic on Carrera 7 in Bogota City

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Abstract

In this article we find a review of models with evolutionary algorithms, and the implementation of the FARIMA model in the prediction of vehicular traffic in the section of the 7th avenue between streets 34 and 170, in Bogotá city, previously having made the sample and characterization of the system. At the end you can find the results of the simulations performed and the error in the application of the model.

INTRODUCTION

Bogotá is Colombia's capital city, it has an overcrowded traffic and it doesn't dispose of enough information about it. Nowadays, both private and governmental agencies provide Sistema de Transporte Inteligente (ITS) like sensory traffic systems to recollect and report information in real time about the principal highways to the user. Most of these efforts have been done with stationary sensors, with transport systems with exclusive roadways or in the mix traffic case it counts with mobile device applications in order to report the traffic in real time; which it only provides information instead of a solution to the problem.

In order to process this information, it is accurate the use of methods that employ artificial intelligence, in such way that it is able to realize an anticipation and a timely action, making control towards the traffic. Specifically, the evolutive algorithms, have been extensively researched as an alternative to the exact algorithms to approach the controlling problem and the vehicular traffic prediction. These evolutive algorithms incorporate Hill Climbing, Genetic Algorithms (GAs), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and SFARIMA model.

SAMPLE AND SYSTEM CHARACTERIZATION

In order to take a simple from the vehicular traffic issue in Bogotá, it has been chosen the section of Carrera 7 between 34nd and 170rd street; this segment is the most important eastern avenue from the city, because it allows driving from south to north, passing by cultural, business, mall zones, and educational institutes; additionally, it has intersections with important avenues that goes through the eastern and western side of the city. The information found in the traffic study and the technical feasibility study for Carrera Séptima (streets 34th and 170th) in Bogotá. [1]

Vehicular Volume

The vehicular volume is clearly described in the traffic study and the technical feasibility study for Carrera Séptima (streets 34th and 170th) in Bogotá done in the year 2010, on south-north direction is shown in figure 1.

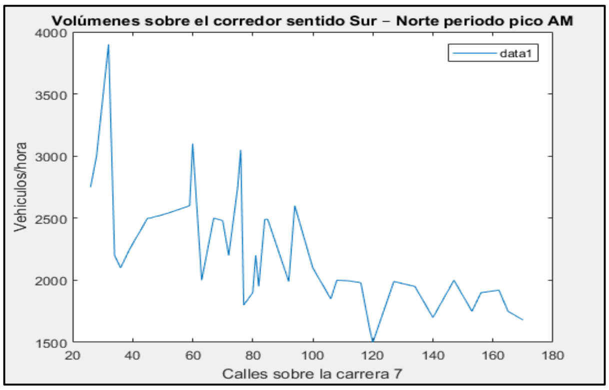

Figure 1. Volumes over the corridor direction S-N peak period AM. [1]

This corridor counts with a greater vehicular volume in the 26th to 45th street section, in Table 1 it is shown the main characteristics from the corridor.

Table 1. Traffic characteristics on carrera 7. [1]

INDICATOR	VALUE	UNITS
TCP routes	98	Routes in the most loaded section of the corridor
Buses peak hour	600	Bus/hour
Maximum travels volume TCP (street 31st - street 72nd)	16000	Passangers/hour/direction
Average speed TCP	26	Km/h
Maximum daily vehicles volume S-N direction (street 106th)	29456	Vehicules/day/direction
Maximum daily vehicles volume N-S direction (street 28th)	22190	Vehicules/day/direction
Maximum vehicle volume S-N direction (street 28th, Period 6:00-9:00 a.m.)	3900	Vehicules
Maximum vehicle volume N-S direction (street 106th, Period 6:00-9:00 a.m.)	7300	Vehicules

Velocities

According to SITYMUR [2] from Universidad de Los Andes, the average travel speed at Carrera 7 is 26 Km/h. During the morning peak hours, from 6:00 a.m. to 9:00 a.m., the speed varies between 23 and 25 Km/h and during the afternoon peak hours the speed drops down to 20 Km/h. According to the Secretaría Distrital de Movilidad during August of 2010, it was detected a velocity in N-S direction of 17 Km/h between streets 162nd and 106th during a working week. Additionally, between streets 28th and 162nd in S-N direction it was distinguished an average speed of 24 Km/h during a working week. On the other hand, in the morning peak time stripe, from 6:00 a.m. to 9:00 a.m., between streets 106th and 162nd, it was reported an average velocity between 11 and 15 Km/h, being the particular vehicles the ones with greater speed.

Intersections

According to the selected section in Carrera 7 between streets 34nd and 72nd, a direct observation was made of the vehicular intersection, which is described in Table 2.

Table 2. Intersections in carrera 7 between streets 34nd and 72nd

INTERSECTION	EASTERN WESTERN FLOW	WESTERN EASTERN FLOW	ACCESS TO SOUTH NORTH LANE FROM WEST EAST	ACCESS TO NORTH SOUTH LANE FROM EAST WEST
STREET 34th	NO	YES	YES	NO
STREET 35th	NO	YES	YES	NO
STREET 39th	YES	NO	YES	YES
STREET 45th	NO	YES	YES	NO
STREET 46th	YES	NO	NO	YES
STREET 47th	YES	NO	NO	YES
STREET 50th	NO	NO	NO	NO
STREET 53rd	YES	YES	YES	NO
STREET 59th	YES	NO	NO	YES
STREET 60th	NO	NO	NO	NO
STREET 63rd	NO	NO	YES	NO
STREET 66th	YES	NO	NO	YES
STREET 70th	YES	NO	YES	NO
STREET 72nd	YES	YES	YES	NO

INTERSECTION	ABANDON-MENT SOUTH NORTH LANE TOWARDS EASTERN WESTERN LANE	ABANDON-MENT NORTH SOUTH LANE TOWARDS WESTERN LANE	EXCLUSI- VELY PEDESTRI-AN	DISTANCE FROM THE LAST INTERSEC-TION IN THE ANALYZED SECTION (MTS)
STREET 34th	NO	NO	NO	0
STREET 35th	NO	YES	NO	225
STREET 39th	NO	NO	NO	300
STREET 45th	NO	NO	NO	630
STREET 46th	NO	NO	NO	136
STREET 47th	NO	NO	NO	125
STREET 50th	NO	NO	YES	265
STREET 53rd	NO	NO	NO	385
STREET 59th	NO	NO	NO	540
STREET 60th	YES	NO	NO	119
STREET 63rd	NO	NO	NO	258
STREET 66th	NO	NO	NO	356
STREET 70th	NO	NO	NO	293
STREET 72nd	NO	NO	NO	266

Capacity on the Road

Due to the variation of vehicular volume according to the hour, it can be chosen to reduce the capacity throughout a factor of peak hours (FPH), which was calculated using poisson and binomial distributions. Table 3.

- Real capacity = C*FPH

Table 3. FPH, with random vehicle arrivals. [3]

TOTAL CALCULATED HOURLY VOLUME C	FPH	TOTAL CALCULATED HOURLY VOLUME C	FPH
100	0.68	1600	0.90
200	0.70	1800	0.92
300	0.72	2000	0.93
400	0.74	2200	0.95
600	0.78	2400	0.95
800	0.81	2600	0.96
1000	0.84	2800	0.97
1200	0.86	>=3000	0.97
1400	0.89		

Having average C 1850 veh/hour, doing extrapolation it obtains an FPH of 0.922, which will allow calculating the real capacity at carrera 7 in the study section.

EVOLUTIVE ALGORITHMS

With problems with non-linear solutions it is not enough with exact algorithms, it is necessary to migrate towards biological solutions that will have a feedback searching a constant update of the better solution, minimizing the error. On the artificial intelligence area, specifically on evolutive algorithms and in the pursuit of solutions to the established problem the following are described.

Hill Climbing

Hill Climbing **[4]** is a local searching method to solve optimization problems. It starts with a randomly generated solution and it uses an iterative process for improves. In every iteration, the current best solution is selected to generate the next candidate solution (similar to the progeny in Gas), that it is maintained only if it can get a result with a better value depending on the objective. Hill Climbing has been implemented on some commercial timing programs for traffic signals such as PASSER V-03 (traffic control optimization program design by Texas Transportation Institute.) and TRANSYT-7F (TRANSYT 15 is the actual version of TRANSYT – the software is internationally known for the modeling and the signs optimization from all the traffic network, from the large signaling networks. **[5]** A very important issue with Hill Climbing is that it might get caught in some local optimal solutions. It has been proposed a variety of strategies in order to improve its capacity for global examination, like the introduction of a list and the implementation of aleatory restarts. Nevertheless, it is needed the additional investigations to evaluate the effectiveness of these strategies in the improvement of the traffic signals timing plans.

Genetic Algorithms (GAs)

The Genetic Algorithms has been very popular for the traffic signals synchronization and optimization, an example is the “Park et al” investigation [6]. They propose a GAs approach for the optimization of traffic signals under oversaturated conditions. The GAs approach has two main components: a GAs’ optimizer and a mesoscopic simulator. The GAs optimizer generates an initial set that has a variety of viable solutions. Every solution (also called GAs chromosome) represents a traffic signals synchronization plan with cycle lengths, divisions, displacement, and phases sequences. The aptitude values of these solutions are evaluated using the mesoscopic simulator. About the aptitude values, the GAs’ optimizer does the selection, the junction and the mutation operations about the set and searches the best signals synchronization plan. A key case in applying GAs for the traffic signals optimization is encode or decode cycle lengths, divisions, and compensations. If the traffic network increases, it is possible that the GAs might require a considerable amount of calculation time and the solution might deteriorate. Like the Hill Climbing method, the GAs optimization is implemented both PASSER-V 03 and in TRANSYT-7F.

Particle Swarm Optimization (PSO)

Recently, PSO [7] has also adopted for the traffic signals optimization [8]. Similar like GAs, the PSO generates a swarm (set) of initial solutions. Every solution is known as a particle and it has its own ubication, instead of applying crossing operations and mutation only to the selected chromosomes like in GAs, the PSO updates every particle location on every iterative step, as the iterative process advances, every particle will have a lot of different ubications. The PSO realized a tracing of the best ubications of every particle and the best ubication of all the particles in the whole swarm. When the criteria are accomplished, the best ubication of all the particles in the swarm generates as the final solution.

Ant Colony Optimization (ACO)

This algorithm was introduced by “Putha et al” [9] for the coordination of oversaturated traffic signals. In this study, the ACO was compared with GAs based on a network of 20 intersections without considering the turning movements. It was informed comparable results of both methods. The authors pointed that the structure of the algorithm of ACO makes it particularly adequate to substantially cut the calculation time.

Fractionally autoregressive integrated mobile average (FARIMA)

The models of long term or with memory such as FARIMA, are consider an extension of the short-term model ARIMA. On the long-term models, it is presented the propriety of a correlation that tends to zero decreasing exponentially, additional to these different studies concluded that by adding an appropriate redshift factor to the FARIMA model we can reduce the mean squared error by obtaining a better relationship point by point which it turns it into an appropriate model to predict future traffic despite of carrying with a greater consumption of resources.

According to the expose for the previous models it is suggested the FARIMA model as the most adequate for the traffic prediction at the study place described. [10]

METHODOLOGY

The long-term memory models are described from the equation (1).

$$\lim_{n\to\infty} \sum_{i=-n}^{n} |pi| = \infty \qquad (1)$$

Where p (k) corresponds to the correlation function.

The FARIMA model has the parameter d, which measures the intensity degree from the long-term memory. **[11]**

In the (Eq.2) it is described the FARIMA model (p,d,q), where index p points out the order, the autoregression, d indicates the differentiation order, q is the order of the mobile average, and mean u.

$$\Phi(L)(1-L)^d(R_t-\mu) = \Theta(L)_{\varepsilon_t}, \ {}^{\varepsilon_t}\sim iid(0, {}^{\sigma_\varepsilon^2}) \quad (2)$$

Being L the delay operator (Eq.3).

$$\Phi(L) = 1 - \Phi_1 L - \cdots - \Phi_p L^p \qquad (3)$$

The FARIMA model allows the differentiator parameter d to take real values non-integers, R corresponds to the stochastic process that is stationary and invertible each time that every root give (L) and (L) (Eq.2) are found outside form the unitary circle.

In the case that d=0 the model has a short-term memory and it is known as the ARMA model. [12]

5. Results

The function is specifies: function [Z] = FARIMA(N,F,O,d,stdx)

Defining the function entries thereby: [13]

N = Length of the time series.

F= p which indicates the order of autoregression.

O = q which gives the order of the mobile average.

d = differentiation order.

stdx = parameter that forces the standard deviation of the time series.

Having this the function FARIMA is defined in MATLAB® the following way.

F(B)[(1-B)^d]Z=O(B)er
F(B)Z=[(1-B)^-d]O(B)er

Where B is the delay operator,

F(B)= 1+ B F1 + B^2 F2 ... + B^p Fp --> AR
O(B)= 1+ B O1 + B^2 O2 ... + B^q Oq --> MA

er = White noise, that can be specified as an entrance.

Z = Departures, time series simulated with the FARIMA model.

Consider that F(B) and O(N) are defined within the function "ARMAX" of MATLAB® from the 1994 versions. [14]

The use of the model to predict the vehicular traffic on Carrera 7, at certain points it is shown a close relationship between the real data and the anticipated ones, as it can be demonstrated in Figure 2

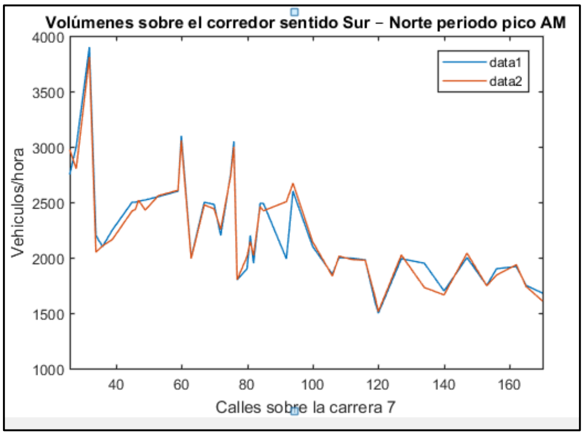

Figure 2. Application of the FARIMA model for volume prediction over the corridor direction S-N peak period AM (Red graph).

To analyse the predictions certainty it is calculated the cuadratic error described by the (eq.4).

$$\hat{\sigma}_t^2(h) = E(X_{t+h} - \hat{X}_t(h))^2 \qquad (4)$$

Table 4. Error percentage FARIMA model.

NUMBER OF POINTS COMPARED: 43	
COINCIDENCE OF POINTS	ERROR %
35	15.68

DATA ANALYSIS

After a careful review of the prediction models with evolutive algorithms, the FARIMA model has as an advantage that with the use of parameter d it obtains a model with long persistence; nevertheless, the adjustment of the model entails to a greater consumption of machine resources with relationship to other models.

In the case of traffic on carrera séptima, between streets 34th and 170th, on the morning Schedule, the model is appropriate to predict future traffic, observing the favorable percentage of coincidence points between the medium traffic and the estimated.

Additionally, it is found that it is not necessary for this particular case, control the mean quadratic error with some additional redshift value, nevertheless, the implementation of itself can decrease the error percentage within the values.

CONCLUSION

This document realized a brief relate of different models with evolutive algorithms and the FARIMA model was selected, by implementing and explaining in detail for the vehicular traffic prediction on Carrera 7 in the city of Bogotá. Obtaining a minimum error percentage in the prediction, and for this particular case it wasn't necessary to alter the model with some redshift factor, as it was observed in other applications consulted.

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