Combining Genetic Algorithms with Traffic Simulations for restructuring traffic networks subject to increases in population

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1 Introduction

Nowadays, population growth seems to have a direct impact on daily life due mainly to society progress. Traffic jams, pollution and parking problems are some of the most common problems in relation to traffic networks. In this paper, we present a methodology based on Optimization via Simulation (OvS) to select, from a group of nodes of a traffic network, the best alternative to increase the capacity of that network in the "Origin-Destiny Traffic Assignment Problem" (ODTAP), a subtype both of the "Facility Location Problem" (FLP) and the "Network Traffic Design Problem" (NTDP) [1-2]. Given a specific traffic network, which will suffer an increase in population, the main goal is to decide where to foment the installation of urban, industrial and/or commercial complexes so that it has a minimum effect over the total traffic system: considering the network already has a certain structure and a dynamic flow restricting possible configurations. To deal with the resolution of ODTAP, a Genetic Algorithm (GA) was used in conjunction with Traffic Simulations (TS), in an OvS based formalism.

The use of metaheuristics in OvS was useful to solve many problems in traffic systems. [3] apply OvS optimizing with "Particle Swarm Optimization" and simulating with the "SUMO-Simulated of Urban Mobility" tool [4] to programming changes in system of traffic lights. [5] use genetic algorithms in an OvS to solve the traffic lights synchronizing problem. And [6] applies OvS together with genetic algorithms for the redesign of pre-existing traffic networks.

2 Design and Implementation

In the OvS, the evaluation of the goodness of the solutions is done by the execution of a simulator, which functions as the generator of values of the objective function [7]. Both the optimizer (GA) and the simulator (TS) are independent from each other, interacting between them in a black box way. In our model, the values of the decision variables represent the increased capacity of the origin and destination nodes of the traffic net. They were coded into a binary chromosome. The objective function used is the average travel time on the network, which must be minimized. This function is evaluated using traffic simulations, which allow quantifying the dynamic effect of the variation of traffic flow on average travel times. The explicit constraints are of two types: two constraints in which capacity increases at the nodes of origin / destination must be equal to the population increase, and a set of constraints indicating the maximum variation of capacity of each node. Implicitly, we had another set of constraints defined by the network structure and patterns of pre-existing flow, which determine travel times between nodes to nodes. These restrictions are contained in the model to simulate. The OvS algorithm was implemented in "R" [8], using the traffic simulator "SUMO", the "genalg" package[9] and the "rSUMO" package for connections between the first two. It was tested with five different network topology and different levels of mutation rates, selection and crossover, using cross between two individuals in one point and without elitism.

3 Results and conclusions

The results of the experiments yielded promising results in this methodology; obtaining solutions close to optimal (estimated by sampling of simulations). While it is not too sensitive to initial solutions, this methodology responds better with bounded mutation rate. In Fig 1 y Fig 2 we can appreciate how, at the same time that the mutation rate increases, the quality of the solutions found gets better in average, until a certain mutation level is reached, in which the selection effect of the best solutions seems to be lost to generate the following solutions. Regarding this selection, we can see that as allowing more solutions can generate descendants, the mean travel time decrease.

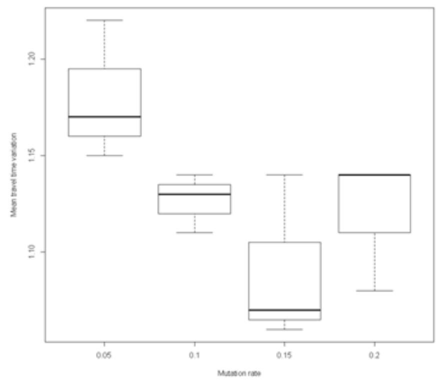

Figure 1: increase in the average travel time for four mutation rates.

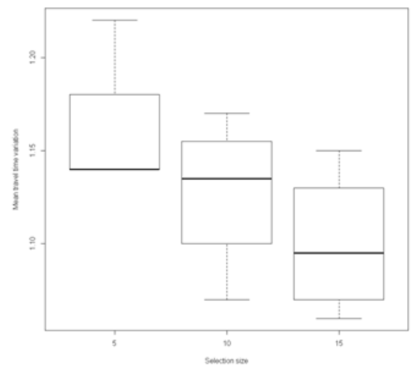

Figure 2: Increase in the average travel time for three selection sizes.

Once the samples analysed with the Kruskal-Wallis test, under the null hypothesis that GA parameters do not affect the quality of the found solutions, we can see that variations between different GA configurations are not from a random origin with a p-value = 0.001692.

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