氏名	ARMAS ANDRADE TITO ROLANDO
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主査	准教授　アギレ　エルナン
	教授　田中　清
	教授　佐藤　敏郎
	教授　中村　正行
外部委員	准教授　佐藤　寛之（電気通信大学）

論　文　内　容　の　要　旨

２．要　旨（2,000字程度にまとめること。）

Cities are highly relevant since the last decades. They are common areas where people, meet, live and perform several activities. Mobility is the way to move or be moved freely and easily and includes infrastructure and services demand. For the managers and decision makers of the city, to guarantee an acceptable mobility level of service is a continuous challenge because the mobility and transportation system involve huge geographical areas, many variables, components and interactions among them and therefore shifts in a complex problem. Besides, developing a sustainable system where social, economic and environmental aspects are taken into account, imposes additional difficulties and constraints.

For a decision maker, dealing with all of those aspects variables and relationships is troublesome because the variable space turns vast and some objectives can be in conflict with each other.

This work focuses on a framework implementation that joins evolutionary computing, mobility and transportation simulators and data mining techniques. The aim is to provide a method and tools that allow the exploration of the potential solutions and also the trajectory of the evolution. The framework starts with mobility problem modeling according to a specific case of study. After that, evolutionary computing with single and multi-many objective optimization evolutionary algorithms is used to explore the tentative solutions according to the model. The outcome of optimization is analyzed in the variable and objective space to identify patterns, understand better the model, and extract some knowledge for the decision maker. The framework is iterative, where the knowledge extracted for the decision maker can be used as feedback to fine tune the model or to study more complex formulations of the problem.

In this work, Quito city's business center is used as real world case study which covers approximately 5x8 km2. This work implements a mobility model

for Quito, including mobility plans and the transportation network. Also, it studies traffic signal optimization formulating the problem from a single and multi-objective optimization perspective. Additionally, it studies level of service in public and private transportation using three-objective and bi-objective formulations of the problem.

As a first scenario, a 70 traffic signals optimization scenario is executed modelling the mobility of 20.000 agents that use private transportation. It is a large scenario not only due to the geographical area but also the variable space size which implies an expensive simulation computational time to evaluate each solution. A set of genetic operators is proposed to accelerate the convergence of the algorithm and promote a better solution's configuration for inducing continuous traffic flow among intersection neighbours. Several experiments perform single objective approach to minimize travel time.
A complete analysis is given in three type of spaces: the variable, the objective and the geographical. In the variable space, analysis verifies that the neighbourhood operators induce coordination between signals and find some patterns which are identified using clustering methods. The identified groups are geolocated, verifying that they are positioned in neighbourhoods as expected. Such clusters of coordinated signals favour the continuous traffic flows.
In the objective space, analysis verifies that the groups of coordinated signals no only benefit the reduction of travel time, but also decline emissions. Analyzing the difference in CO2 emissions between two solutions, one in the initial population and the other an optimized one, emissions reductions across the area of study when signals are optimized is found.

In another study, a bi-objective optimization approach to minimize travel time and fuel consumption simultaneously is conducted.
A set of experiments using the same mobility scenario but changing the emission model is performed. Mainly, the study examines the conflict between objectives, if any, when they are optimized simultaneously and how the settings of the signals relate to the trade-offs between them.
One of the challenges in this study is the computational time to evaluate the emissions and fuel consumption. That imposes an investigation to figure out a method to accelerate the evolution using small populations with relative small evaluations. In part, it is achieved by the implementation of deterministic varying mutation operator used in single-objective. Results show that the optimization of signals enabling different cycle times and coordinating them by adequately setting their offsets, lead to significant reductions in both fuel consumption and travel time. The small number of non-dominated solutions in the last generation show that both objective functions are correlated.

In this research, a different problem examines traffic density levels in urban transportation. The study contemplates the urban transportation system under various proportions of private and public transportation users. The purpose is to explain the conditions to achieve different levels of service and their relationships with the optimal configuration of the public transportation,

traffic density, travel time, fuel consumption and emissions. The level of service (LoS) refers to quality measures in a traffic stream. In this work, LoS is defined concerning to traffic density.

The scenario is based in Quito's business centre, modelling the mobility of 27.000 agents that use private and public transportation. In Quito, the massive passenger transportation is operated by private and public companies. Five main Bus Rapid Transit (BRT) corridors which are the most demanded and congested routes are considered for this mobility model. The levels of service are influenced by the proportions of the population that uses public and private transportation and translates to a bi-level optimization problem. For a given proportion, the model determines a proper configuration of public transportation system in terms of capacities of the buses and departure times between buses. A first scenario concerns with three-objective optimization, focus on minimizing travel time, fuel consumption and traffic density.

The Adaptive epsilon-Sampling and epsilon-Hood (AeSeH) algorithm is adopted to search the optimal solutions. A set of experiments and a trade-off analysis between objectives is conducted. The negative correlation between objectives verified a trade-off between travel time versus fuel consumption and travel time versus density. The results show that in general solutions with the best LoS, have low values of fuel consumption, but high travel times in opposite with solutions with worst levels of service that show best travel time but the worst fuel consumption. Sustainable public transportation implies a low environmental impact. In general, the results prove that best levels of service and low levels of fuel consumption can be achieved simultaneously. An analysis in Particulate Matter (PM) emission and its geo-location is conducted between two optimal solutions from the Pareto optimal set. The analysis pointed that a reduction in PM depends on BRT headways and technology (fuel type).

Another study concern to analyze the same scenario as a bi-objective optimization problem, focusing only on travel time and traffic density as optimization objectives. Comparable results show a confirmation that better LoS (low density) corresponds to a high proportion of public transportation users. Also, a new set of solutions with the same LoS is chosen to make a complete analysis of the variable, objective and geographical space. This complementary analysis revealed that even if the solutions share the same LoS with different configurations in capacities and headways, effects in pollution must be taken into consideration by the decision makers when they decide to improve the transportation system.

Finally, this work is summarized presenting the conclusions and future work.