

# OPTIMAL CONTROL BASED HEURISTIC FOR CONGESTION REDUCTION IN TRAFFIC NETWORKS

F.J. MAYORANO, A.J. RUBIALES and P.A. LOTITO

PLADEMA, UNCPBA - CONICET, 7000 Tandil, Argentina  
 {fmayoran, arubiale, plotito}@exa.unicen.edu.ar

**Abstract**— The principal purpose of this work is to test the TUC strategy in a simple case using a micro-simulator designed ad hoc, previous to its real implementation.

Using concepts of traffic engineering we describe a well known dynamic linear model of traffic flow in a urban traffic network that is controlled using the traffic-light times. This simplified model allows to obtain a Riccati feedback matrix and compute traffic-light times that will improve the congestion levels.

We present some numerical experiments made with the model on an academic example and we validated them with a microscopic simulator that we have created based on Car Following theory and discrete event models.

**Keywords**— Optimal Control, LQ-Control, Urban traffic models

## I. INTRODUCTION

The reduction of urban traffic congestion is nowadays obtaining more and more attention. The traffic demand increases continuously and it cannot be followed by the improvement of the offer because it would imply the enlargement of the road infrastructure. The only way to cope with it is to improve the efficiency of the urban network.

Many research lines are currently active inside Traffic Engineering, some of them to determine the average distribution of the traffic on some time interval and how to manage it. The classical notions of Wardrop equilibrium and social optimum help to analyze and optimize medium or long term planning problems. This can help to reduce the congestion on average, but when there is some fluctuations around the mean traffic it is important to be able to reduce the possible negative impact. A practical way to reduce congestion is through an adaptive traffic light setting strategy.

When there is a technology capable of coordinating traffic lights, with green times calculated through sophisticated mathematical algorithms, a moderate reduction of travel times (or congestion) can be experienced as it is stated by the references Diakaki *et al.*

(2002), Dinopoulou *et al.* (2006). We have also verified this reduction at least in numerical examples made on microscopic simulators.

Our aim is to apply this methodology in the real case of the medium-sized city of Tandil, Argentina. This city is making up an Urban Traffic Control System which in its final stage will consist of a set of dynamic observers implemented through video-cameras in some junctions linked to a central computer that will compute the optimal green times and send them back to the linked junctions.

The methodology presented here is fundamentally based on the work of M. Papageorgiou and his coworkers and students (see Diakaki *et al.* (2002), Dinopoulou *et al.* (2006) and the references therein). It is called Traffic-responsive Urban Control (TUC) and is derived from a discrete time controlled model of the evolution of vehicle queues in each junction where the control of the system is made through the green times.

More precisely, we consider the macroscopic traffic model proposed by Gazis and Potts (1963) known as “store and forward” which is a linear model. The control variables are the traffic-light times at each intersection and the observed variables are the queue lengths on each arc. The desired objective is to minimize the total waiting time, so we consider as control objective the reduction of the number of cars actually present on the network during the analyzed period.

The TUC strategy can be described as follows. Thanks to the linearity of the system and the quadratic form of the objective function LQ methodology can be used to obtain a feedback matrix. Nevertheless, the restrictions imposed by traffic-light duration cannot be considered as LQ theory could not afford them, so the solution must be modified. This is done by a projection of the computed solution on the feasible solution set with an efficient algorithm that allows almost real time computation.

In the next sections we present the model (section II) and the control design and its projections over the feasible control set (section III). In the section IV we describe a micro simulator based on discrete event system theory, designed and developed to test the strategy. In section IV we present numerical results and tests and finally, we present the conclusion.