International Journal of Innovative Computing, Information and Control
Volume **5**, Number **9**, September **2009**

 ISSN 1349-4198
pp. **2499–2510**

AN ALGEBRAIC FRAMEWORK FOR TRAFFIC STATE ESTIMATION

Hassane Abouaïssa

Laboratory of Computer Sciences and Automatic Control, LGI2A
University of Artois
Technoparc Futura 62408, Béthune, France
hassane.abouaissa@univ-artois.fr

Received May 2008; revised September 2008

Abstract. *This paper addresses the traffic density estimation problem and its application for real-time freeway ramp-metering. The proposed approach rests on the use of algebraic methods for numerical differentiation. Its application is a novel attempt in the field of traffic flow modeling and control. Numerical simulations as well as an application for a real-time isolated ramp-metering illustrate the relevance of the approach and show convincing and encouraging results.*
Keywords: Traffic control, State estimation, Algebraic methods, Macroscopic models

1. **Introduction.** In many applications, the knowledge of the useful information for both the present and the future behavior of any system is given by the so-called state variables. The values of these crucial quantities are usually measured via a set of sensors or have to be estimated. Moreover, even if they can be measured, these variables are often corrupted by additive noises. State estimation is therefore of importance in order to make the control design mush easier by providing accurate state values. It's also a valuable tool for fault detection and plays an important rôle in providing a necessary prognostic information for the evolution of the studied system [1].

The classical means for the design of a state estimator are, for linear systems, the well-known Kalman filters and asymptotic observers [2], [3]. Nevertheless and as stated in [4], although they are widespread in most of engineering fields where they are playing a key rôle, several difficulties are still persistent with respect to the tuning (gain schedule), the numerical analysis (Riccati's equation where the precise statistics of the noise has to be quite accurately known), and the sensitivity to perturbations. The extension of these estimation methods to the case of nonlinear systems has been the topic of extensive research in the last 30 years and the question remains largely open (See e.g. [5] and the references therein, see also, [6], [7]).

The work presented in this paper focuses on the traffic state estimation for real-time freeway ramp metering. The main objective is to offer an alternative to existing methods by taking advantage of recent advances in numerical differentiation. Such method which is of algebraic flavor is a novel attempt in the field of traffic flow modeling and control.

The paper is structured as follows: Section 2 highlights the importance of the traffic state estimation and control. Section 3 details the principle of numerical differentiation. Section 4 shows the use of this new algebraic method in order to estimate the traffic density. Some numerical simulations, provided in Section 5 illustrates the relevance of the proposed approach and its application for real-time local ramp metering. Finally, in Section 6, some open problems and furthers works are discussed.