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Vehicular Traffic on Networks: Comparison among Solutions Modeling Vertex Flow

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ABSTRACT

Nowadays, the analysis of issues associated with road traffic within urban and suburban areas has taken a leading role in trying to implement efficient plans of transport regulations by taking advantage of the available infrastructure.

In fact, the occurrence frequency of slowdowns phenomena and strong congestions has greatly multiplied and caused a series of inconveniences and poor services for citizens such as the increased risk of accidents and air and noise pollution.

In order to solve the problem of urban mobility, it is possible to act with a rational management of infrastructure and a road artery-planning program using simulators able to identify critical points in the design phase and evaluate the correctness of the proposed interventions. For this reason, it is important to use mathematical models to predict the evolution of the traffic starting from the knowledge of quantities such as cars' densities at a given time instant.

These models are classified into *microscopic* and *macroscopic* ones. The former analyze the behavior of each single vehicle, while the latter consider situations that arise from the interaction of many particles derived based on concepts of the fluid dynamics.

The aim of the present research work is to review macroscopic fluid dynamic models dealing with traffic flow on road networks and to propose new solutions for the dynamics at intersections based on the integration of optimization criteria about the vehicular flow and rules for the distribution of traffic.

In detail, the Thesis analyzes, describes and highlights the following topics and results:

- physical variables that regulate road traffic and the relation that links them with each other, and some fluid dynamic macroscopic models for traffic on a single road (i.e. *LWR*, *Payne-Whitham*, *Aw-Rascle*, *Zhang*, *Third order* and *Multilane* models);
- vehicular traffic network based on the fluid dynamic model *LWR* and *conservation laws*, and characterized by some aspects to be solved like *initial conditions* on not infinite roads and *dynamics at intersections*. About the former aspect, the corresponding boundary value problems are presented and solved, while about the latter aspect the solution to Riemann Solver is given by considering also additional rules for traffic distribution that are well-defined in new appropriate models simulating the presence of traffic lights at intersections with variable or fixed cycles of red-green;
- numerical schemes used for the discretization of the conservation law and the solution of the dynamic at intersections. In detail, Godunov scheme, used for the determination of

density values for road sections in different time instants starting from the initial density value of each road on the analyzed road network, is considered;

- numerical results about an experimentation of some of the new models defined that are implemented within a road traffic simulator prototype by reproducing the behavior of vehicular densities on a road network with appropriate dynamics at intersections. These results are then compared in order to prove the correctness of each model, evaluate the performances and analyze some specific situations for optimization of car traffic.

Considerations and results obtained in this research work by simulation of traffic flows may be useful as support for authorities responsible for urban road network in order to make an appropriate urban planning by evaluating the needs of the country. In fact, it could be possible to avoid traffic congestion at certain areas or time slots, bring down the rate of air pollution or noise and minimize risks due to overcrowding of vehicles on roads.