3.5.

Thesis research review of Michal KUTIL

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The research work presented by Michal Kutil concerns the modeling and optimization of traffic flow in urban areas. This is an important research field since it addresses an actual and critical problem of traffic in large cities. The classical techniques using discrete events models are not appropriate since they give very huge reachable space states and the duration of the simulation is to much long. Modeling with Continuous Systems leads to approximate models, which are not suitable for this kind of systems. Michal Kutil gives in this thesis a set of coherent techniques leading to the same objective: the design of the traffic in large cities. There is a real need of such techniques for this kind of systems.

The second chapter presents a model of the traffic based on queuing network theory. This model is extended taking into account the number of vehicles in the queue and the mean waiting time of the vehicles. The author has proven that his model verifies the basic little's law. This model has been used for the computation of the control law for a simple intersection composed of two queues. Two well known methods of determining the control have been proposed. The first one is based on the linearization of the state equations and on a quadratic optimization. The second one the non linear model is kept and a predictive control is calculated. The advantage of the two controllers are discussed and compared with the simulation using real traffic data.

The third chapter concerns the general light controlled intersection model. This part is more familiar with my work since the used modeling tool is Continuous Petri Net. The main advantage of this model is to give a reduced state space for large systems. The basic idea, exploited here in a clever way is to replace the discrete number of vehicles by a real number. This gives a satisfactory approximation. The proposed modeling is correct since it represents the flows of vehicles. A main problem in this modeling and generally in Petri nets is the problem of conflicts which introduces indeterminism. Conflicts resolution must be introduced; the author has chosen the sharing proportionally with maximal speeds. It is a complex problem due the saturation of these speeds and on the places feedings whish are dynamically variable. A complete solution is given thanks to linear programming. The same problem is studied in reference [davi 04], it would be interesting to compare your approach with this one, which solves the general problem. In my opinion, a vey important contribution is the confrontation of the theoretical results with the reality. It was shown that the continuous modeling is much powerful than the corresponding discrete model, and

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the simulation has been compared with the real data from traffic in Prague. This is a strong point of this research. At last, in this chapter, I have one question concerning the traffic lights. They correspond to Boolean conditions, a light can be red, or green or yellow, and cannot be modeled with continuous Petri nets. Don't you think that Hybrid Petri nets constitute an appropriate answer?

The TORSCHE Scheduling Toolbox for Matlab is given in chapter 4. It covers a set of scheduling problems in computer science and manufacturing systems. It has been used successfully outside of this thesis (reconfiguration in embedded avionics application, textbook for courses in scheduling). This toolbox is available on the net.

In Chapter 5, The TORSHE is used for the traffic flow optimization. The offset and split of intersections were determined. The offset respects the green wave strategy and the split allows minimizing the time spent on the road. And once again these results were confronted to the real data of the light controlled intersections in an urban traffic region in Prague.

In conclusion the main contributions of the work are:

- Formalization of the traffic intersection model using the queuing theory
- Continuous Petri modeling compared with discrete modeling and
- Optimization algorithms of controlled intersections in traffic urban region.

In his thesis, Michal Kutil has provided on one hand, methodological original results linked with fundamental science domains, and on the other hand he has confronted these results with real traffic of Prague. His research work is of great actuality and several perspectives are given. The main one I see is to combine continuous and discrete behaviors in order to obtain a more powerful model. The work has been published in good journals (3) and conferences (10).

For all these reasons, the author of the thesis proved to have an ability to perform research and to achieve scientific results. I do recommend the thesis for presentation with the aim of receiving the degree of PhD.

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