Overview of Distributed Decision-Making for Urban Traffic Control

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Many current urban traffic control (UTC) strategies make use of *vehicle actuated* signal switching to improve throughput of single intersections. While this method significantly outperforms fixed signal control, the conflicting preferences of particular intersections present a major challenge in case of coordinated control of a larger traffic network. A traditional way of coping with this problem is the use of centralised control strategies where a single macro-controller limits the autonomy of intersection controllers.

A more scalable and flexible scheme is based on distributed control, where intersections are represented by intelligent agents that mutually cooperate in order to reach an optimum traffic state. A first attempt for real-world deployment of agent-based decision-making application was probably the distributed decision support system installed in Barcelona [1]. While it provided support for traffic management at urban motorways and at several critical approaches to the city, it was not used for traffic control in the inner city.

Control strategy can be also devised by playing a *distributed stochastic game* between agents [2]. This technique makes use of reinforcement learning to find an globally optimal policy which maps observed states to control actions. At least for a simple simulation scenario it gives very promising results.

Most of the presented systems use agents as impersonation for an intersection or even a group of intersections. Some approaches, however, use even finer granularity and place agents at individual signal groups at an intersection [3]. These agents then negotiate optimum signal plan setting for the intersection, given the constrains from other signal group agents at the intersection and constraints imposed by neighbouring intersections.

The most advanced example of an agent coordination strategy based on *distributed evolutionary game* models different variants of traffic control policies and offers them to a traffic manager [4].

While all the methods presented above address one very important issue of urban traffic control, namely the uncertainty between causes and actions that is present in the system, the communication between agents is closely related to the physical construction of the underlying intersection controllers. A different approach is proposed by the Bayesian Agents [5] where every agent describes the whole intersection (traffic model, control aims, control actions) in form of probability density functions. In such a way, agent cooperate by exchanging their "wishes" as pdfs and the task of devising an optimum control strategy can be represented by the merging operation.

References

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