Chapter XIII

Exploring the Potential of Multiagent Learning for Autonomous Intersection Control

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ABSTRACT

The problem of advanced intersection control is being discovered as a promising application field for multiagent technology. In this context, drivers interact autonomously with a coordination facility that controls the traffic flow through an intersection, with the aim of avoiding collisions and minimizing delays. This is particularly interesting in the case of autonomous vehicles that are controlled entirely by agents, a scenario that will become possible in the near future. In this chapter, the authors seize the opportunities of multiagent learning offered by such a scenario, by introducing a coordination mechanism where teams of agents coordinate their velocities when approaching the intersection in a decentralized way. They show that this approach enables the agents to improve the intersection efficiency, by reducing the average travel time and so contributing to alleviate traffic congestions.

INTRODUCTION

Traffic congestion is a costly problem in all developed countries. Many human-centered instruments and solutions (e.g. message signs, temporary lane closings, speed limit changes), are deployed in highways
and roads in order to speed up the traffic flow. Nevertheless, in line with the recent advances of computerized infrastructures, the problem of road traffic management is being discovered as a promising application field for multiagent technology (Klügl, 2005). Multiagent systems (MAS) are the ideal candidates for the implementation of road traffic management systems, due to the intrinsically distributed nature of traffic-related problems.

In this context, the problem of advanced intersection control, where drivers interact autonomously with a coordination facility that controls the traffic flow through an intersection so as to avoid collisions while minimizing delays, is receiving more and more attention.

In (Dresner, 2004) is introduced a reservation-based system in which vehicles request an intersection manager to reserve the necessary time slots during which they may pass through the intersection. This work opens many possibilities for multiagent learning, with the goal of improving the efficiency of intersections.

In this chapter, we present a coordination mechanism based on Probability Collectives (PC) (Wolpert, 2004). With such an approach, teams of agents coordinate their velocities during their approximation to the intersection in a decentralized way, with the aim of reducing the average travel time by making better, non-conflicting, reservations.

RESERVATION-BASED INTERSECTION CONTROL

In the chapter by Dresner et al. in this book, a reservation-based system for intersection control is proposed. In such system, an intersection manager is responsible for managing the vehicles that want to pass through the intersection, by assigning the necessary time slots, while the driver agents are responsible for controlling the vehicles to which they are assigned.

A driver agent, when approaching the intersection, “calls ahead” the intersection manager and requests a reservation of space and time in the intersection, providing all the necessary information to simulate the vehicle journey through the intersection (vehicle ID, vehicle size, arrival time, arrival velocity, type of turn, arrival lane, arrival road segment,...).

If the request is confirmed by the intersection manager, the driver agent stores the reservation details and tries to meet them. Otherwise, it slows down and makes another request at a later time.

The reservation system offers many opportunities for improving the efficiency of intersection, by incorporating learning mechanisms in the agents (Dresner, 2006). For example, since the intersection manager serves the requests in a “first-come-first-served” fashion, it is possible to relax this constraint and allow the intersection manager to respond to the requests at a later time. In this way the intersection manager can evaluate more competing requests at the same time and make a more well-informed decision.

While the learning opportunities for the intersection manager are of the form of single agent learning, the very multiagent learning opportunities reside in the driver agents. In the current implementation, driver agents must estimate the arrival time at the intersection, the arrival velocity, the arrival lane... without communication nor coordination with the other driver agents; each agent makes its request on the basis of its actual velocity, and, if the request is rejected, the driver slows down and tries again. On the other hand, by letting the agents form teams and coordinate their actions, we provide them with more information that they use to make decisions.
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