Chapter XI
Learning Agents for Collaborative Driving

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ABSTRACT

This chapter studies the use of agent technology in the domain of vehicle control. More specifically, it illustrates how agents can address the problem of collaborative driving. First, the authors briefly survey the related work in the field of intelligent vehicle control and inter-vehicle cooperation that is part of Intelligent Transportation Systems (ITS) research. Next, they detail how these technologies are especially adapted to the integration, for decision-making, of autonomous agents. In particular, they describe an agent-based cooperative architecture that aims at controlling and coordinating vehicles. In this context, the authors show how reinforcement learning can be used for the design of collaborative driving agents, and they explain why this learning approach is well-suited for the resolution of this problem.

INTRODUCTION

Modern automotive transportation technologies have faced, in recent years, numerous issues resulting from the increase of vehicular traffic and having important consequences on passenger safety, on the environment and on the efficiency of the traffic flow.
In response, both manufacturers and public institutions have focused on such issues through research and development efforts, and have come up with many solutions. Among them, as mentioned in the introductory chapters, the field of Intelligent Transportation Systems (ITS) has gathered particular interest in the past twenty years. This chapter concerns a specific domain of ITS, which aims at designing fully autonomous vehicle controllers.

Many terms have been used to describe this field and its related technologies, such as Collaborative Driving Systems (CDS), Advanced Vehicle Control and Safety Systems (AVCSS) and Automated Vehicle Control Systems (AVCS). According to Bishop (2005), these systems could be defined as Intelligent Vehicle (IV) technology. Bishop characterized IV systems by their use of sensors to perceive their environment and by the fact that they are designed to give assistance to the driver in the operation of the vehicle. This definition of Intelligent Vehicles describes both Autonomous Vehicle Control and Collaborative Driving systems that we consider in this chapter.

Of course, the agent abstraction can be directly adapted to the definition of IV, as agents have the ability to sense their environment and make autonomous decisions to take the right actions. In the past, work related to the problem of autonomous vehicle control has already considered using intelligent agents. What we propose in this chapter is to show how agent technology can be used to design intelligent and collaborative driving systems. More precisely, we will detail the design of an agent architecture for autonomous and collaborative driving based on the use of reinforcement learning techniques. We intend to show that reinforcement learning can be an efficient technique for learning both low-level vehicle control and high-level vehicle coordination as it enables the design of a controller that can efficiently manage the complexity of the application, i.e. the number of possible vehicle states and the number of coordination situations.

The next section of this chapter surveys the field of autonomous vehicle control and collaborative driving. It also details what has been done in this field in relation to agent technology. The third section briefly explains agent learning techniques while the fourth and final section describes how reinforcement learning can be used to build agents that can drive and coordinate themselves with others autonomously.

**SURVEY OF COLLABORATIVE DRIVING SYSTEMS BASED ON AGENT TECHNOLOGY**

This section first surveys what has been done in the field of autonomous vehicle control and collaborative driving systems. Then, it describes how the software agent abstraction and machine learning algorithms have already been used in the design of such systems.

**Autonomous Vehicle Control and Collaborative Driving Systems**

In response to the problems related to the increase of vehicular traffic, most industrialized countries have decided in recent years to adopt a road-map detailing the future of their investments in Intelligent Transportation Systems (ITS) research. Starting in the early ’90s, this resulted in the fact that many research projects, often in the form of partnerships between academia and industry, began addressing the design of autonomous vehicle control systems. Research has rapidly led to the development of various applications, as detailed in Table 1.
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