Abstract

Robots can alleviate our lives by accomplishing tasks that are unpleasant or even dangerous for us. To employ them efficiently they should be autonomous, adaptive, and easy to instruct and use. Traditional white-box approaches to robot control are based on an engineer's understanding of the physical structure of a given problem from which he or she derives a possible solution which is implemented into the system. This is a powerful approach, yet also limited in several ways. The primary drawback is that such systems depend on predefined knowledge and therefore each additional behavior again requires the same expensive implementation cycle.

By contrast, humans and many other animals are not limited to innate behaviors but can acquire various skills during lifetime. In addition, for them detailed knowledge of the underlying (physical) process of a given task does not seem to be required. These features are attractive for artificial systems too.

In this thesis we therefore investigate the hypothesis that principles of human skill acquisition may lead to alternative methods for adaptive system control. In addition we postulate that an economical factor should be considered, i.e. tasks should be solved with little a priori knowledge and little processing, to arrive at efficient processing mechanisms. We investigate this for the task of autonomous driving which is a classical problem in system control with a wide range of applications. The precise task is to learn basic, anticipatory driving from a human supervisor.

After reviewing relevant aspects concerning human skill acquisition and introducing the notion of *internal models* and *chunking* we propose the application of the latter to the given task. We realize chunking with a database where human driving examples are attached to extracted descriptions of the visually perceived street trajectory. This is first realized in an indoor scenario using a robot, and later, in the course of the European DRIVSCO project, transferred to a real car. Furthermore, we investigate the learning of visual forward models which are part of internal models and their effect on control performance in the laboratory setup.

The main result of this interdisciplinary and application oriented work is a system which is able to produce action plans in response to visually perceived street trajectories, without requiring metric information for street following. The predicted actions concerning the robot setup were steer

and speed, and for the real car steer and acceleration where the predictive capactiy of the system for the latter was limited. Hence, the robot learned to drive autonomously from a human teacher and the car learned to predict the human's actions. The latter was successfully demonstrated during the international review meeting of the project. The outcome of this work is interesting for applications in robot control and especially intelligent driver assistance systems.