

Chapter 67

Adapting to the Traffic Swarm: Swarm Behaviour for Autonomous Cars

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ABSTRACT

Swarm behavior can be applied to many aspects of autonomous driving: e.g. localization, perception, path planning or mapping. A reason for this is that from the information observed by swarm members, e.g. the relative position and speed of other cars, further information can be derived. In this chapter the processing pipeline of a “swarm behavior module” is described step by step from selecting and abstracting sensor data to generating a plan – a drivable trajectory – for an autonomous car. Such a swarm-based path planning can play an important role in a scenario where there is a mixture of human drivers and autonomous cars. Experienced human drivers flow with the traffic and adapt their driving to the environment. They do not follow the traffic rules as strictly as computers do, but they are often using common sense. Autonomous cars should not provoke dangerous situations by sticking absolutely to the traffic rules, they must adapt their behavior with respect to the other drivers around them and thus merge with the traffic swarm.

INTRODUCTION

Limitations of Map-Based Path Planning

Autonomous cars are going to play a major role in future traffic. Even today there are many prototypes which are able to navigate in a complicated urban environment (Rojo et al., 2007). See the autonomous car “MadeInGermany” in Figure 1.

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Figure 1. The autonomous car “MadeInGermany” used in the AutoNOMOS Project. Source: Rotter (2014).



Current state of the art path planning for autonomous driving is based mostly on maps (Czerwionka, 2014). Predefined paths through the environment are stored in those maps, as well as additional information such as speed limits or stop signs. In general, a path is planned along those predefined trajectories, using data from the cars sensors (e.g. GPS, lidar, radar, and cameras) for localization and environment recognition (Göhring, Wang, Schnürmacher, & Ganjineh, 2011). Although the environment can influence the planned path to enable reactive manoeuvres (Wang, 2012) or interaction with dynamic changes can be realized in a low level controller (Göhring, 2012), autonomous cars are bound to stick to the roads and rules defined by maps. There are many advantages to a map based approach. E.g. the car can plan ahead and find the shortest path through the road network. Also the current velocity could be adapted far-sighted to the known trajectory of the road ahead. On the other hand there are several disadvantages in map-based approaches.

One fundamental problem is, that maps may not always be available at all or not in the needed level of detail. Another problem is, that maps are previously known information, which is usually stored some time before the actual driving is performed. Nowadays traffic infrastructure is underlying frequent changes. Map data can be outdated very fast: Roads are closed down due to construction works and new roads are build. Furthermore there are streets where the number or direction of drivable lanes changes based on time, weather or volume of traffic. Figure 2 shows example scenarios. Those frequent changes are addressed by concepts of dynamic maps, which could be distributed to the car with C2X communication technology. But there are cases where it is difficult or even impossible to acquire the momentary data needed for a reliable dynamic map.

The following examples illustrate highly dynamic situations, which are commonly occurring in daily urban traffic and provide difficulties for current map-based path planning. In all of those situations new temporary traffic lanes and rules, which can deviate greatly from the stored data in the maps, are defined by the traffic participants.

- Traffic accidents or road damage may cause parts of lanes being not be accessible, so new driving trajectories are emerging.
- Changing weather conditions can greatly influence the driving behaviour. E.g. fog and heavy rain lead to reduced range of sight and therefore lower speed limits.

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