Sensor Orientation Selection and Adaptive Control of an Actuated Sensor Platform for Autonomous Vehicles

Abstract:
Perception of the environment is an essential capability for autonomous vehicles. Safe autonomous driving requires in particular a high sensor resolution and a large field of view. A high sensor resolution is required for
early detection of distant objects as well as for capturing important features in sufficient detail. A large field of view is essential for observing the vehicle's surrounding area that is relevant for the current driving task. In general there are two possibilities to satisfy these competing requirements: Attaching more than one sensor to the vehicle or using a sensor that can actively adjust its orientation, a so called active sensor. Utilizing an active sensor requires the selection of meaningful sensor orientations. This mechanism is called selective attention, according to its counterpart in the human perceptual system. Besides providing a high sensor resolution and a large field of view, selective attention in combination with an active sensor is a means to enhance information density in the sensory input data stream. This is a way to economize the autonomous vehicle's computational resources and achieve real time capability more easily compared to processing equally detailed data derived from several sensors that are fixed to the vehicle body. The selection of meaningful sensor orientations as well as the control of an actuated sensor platform are the two major subjects addressed in this thesis. The selection of appropriate sensor orientations depends on the given driving task: Obviously, turning left at an intersection requires a different sensing strategy than turning right, as the importance of oncoming traffic differs considerably for both tasks. Therefore the proposed method for selecting the next sensor orientation is based on three task dependent criteria: The importance of objects with respect to the current situation, the available information about these objects as well as sensor coverage of the vehicle's relevant surrounding area. The requirements for an active sensor comprise high positioning speed, good tracking behavior as well as attenuation of disturbing sensor motions. Individual control algorithms capable of adapting to varying operating conditions are developed for each requirement. The combination of these algorithms results in a flexible and powerful control architecture for actuated sensor platforms. The applicability of the proposed method for sensor orientation selection and the control of the actuated sensor platform are evaluated by three different means: through simulations, while processing real sensor data derived from intersection scenarios and during test drives including convoy driving and fully autonomous road-network navigation.