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Non-Parametric Bayesian Filtering for Multiple Object Tracking

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Advanced driver assistance systems increase the comfort, efficiency, and safety of nowadays and future automobiles. Especially if these systems need to derive a safety critical decision like an emergency brake they require a reliable and precise environment recognition in order to keep the false triggering rate close to zero.

In this work, environment recognition means to recursively estimate both the time varying number of objects in a scene and their parameters like position and velocity—so called multiple object tracking. The thesis summarizes typical state of the art multiple object tracking approaches which classically consist of separate detection, observation association, and estimation stages. Often, the detection and association steps derive decisions which are hardly reversible during the tracking process. Additionally, the majority of current multiple object tracking systems insufficiently model the spatial extension of objects though high resolution sensors like laser scanner can observe it.

The scope of this work is to overcome these limitations by integrating dynamic as well as a priori knowledge into one Bayes filter, which is implemented by a reversible jump Markov chain Monte Carlo sampling approach. By that, it is possible to track spatially extended objects without dedicated detection and association steps. Instead, several models are combined in an integrated Bayesian estimation process. These models include how objects look like and move, where they are expected to appear and disappear, and how they interact with each other. By that, the approach contributes to the field of spatially extended object tracking and provides many connection points for further investigation.

The resulting multiple object tracking system rigorously utilizes the Bayesian framework to cope with the uncertainties occurring in different domains. This includes association ambiguities as well as observation and system process noises. Furthermore, a track management is included in a statistical fashion.

The work demonstrates three case studies of multiple spatially extended object tracking utilizing different sensors and algorithmic approaches. At first, a data fusion system combining a radar and a camera sensor using a classical multiple object tracking method is shown. Hereafter, a lidar based system is demonstrated which uses advanced occupancy grid methods in order to detect and track spatially extended objects. Finally, an implementation of the reversible jump Markov chain Monte Carlo sampling approach for a lidar based tracking of spatially extended objects is shown.