Set-Membership Estimation in Shared Situational Awareness for Automated Vehicles in Occluded Scenarios

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Motivation & Research goals

- The objective of this project is to model, formalize, and analyse a shared situational awareness framework for the ego-vehicle and extended vehicles, i.e., connected vehicles and infrastructure.
- Shared situational awareness is the ability to perceive and comprehend the traffic situation and to predict the intent of vehicles and road users in the surrounding of the ego-vehicle using local and connected sensors.
- This framework will allow to orchestrate the utilization of shared resources in complex and crowded environments and to define which kind of information each Connected and Autonomous Vehicle (CAV) and the infrastructure should share.
- Safety-critical application such as these require robust guarantees for the estimation of the road users.

Background

- Local CAV sensors typically provide a limited understanding of the environment due to limited sensor range, blind spots, and occlusions in the environment.
- Vehicle to vehicle (V2V) communication and vehicle to infrastructure (V2I) communication based on 5G or IEEE 802.11p standards, can help gather more information about the environment, and address the shortcomings of CAV sensors.
- CPM (Collaborative Perception Message) service supports sharing information between ITS-Ss (Intelligent Transportation System – Stations) [1].
- The main research areas are connectivity (enabled by V2I and V2V), cooperative driving, situational awareness, set-based estimation and traffic flow optimization.

Problem Formulation

- The problem considered in this research work is formulated around a scenario as shown in Figure 1.
- This scenario consist of two-lane road with a side-walk on each side of the road and a pedestrian crossing.

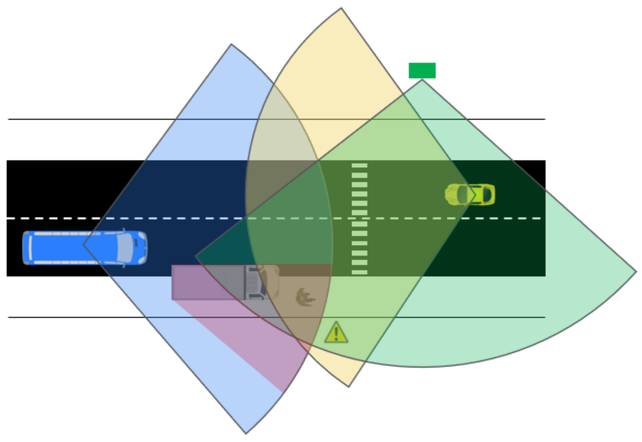

Figure 1 : The ego-vehicle with one local sensor, an additional V2V sensor and an additional V2I sensor.

- The ego-vehicle (blue bus) is traveling from left to right and is approaching the pedestrian crossing. The ego-vehicle is equipped with a sensor having a field of view represented by the blue-shaded circle segment.
- In this scenario, two additional sensors are included. One on the approaching CAV represented by yellow-shaded circle segment and other on the connected road-side sensor units represented by green-shaded circle segment.

References

1. Draft ETSI TS 103 324 V0.0.22 Collective Perception Service.
2. Vandana Narri, A. Alanwar, J. Mårtensson, C. Norén, L. Dal Col and K. H. Johansson, "Set-Membership Estimation in Shared Situational Awareness for Automated Vehicles in Occluded Scenarios," 2021 IEEE Intelligent Vehicles Symposium (IV).

Architecture of Share Situational Awareness

- The proposed architecture is presented in Figure 2. It consists of three parts: (i) Local and extended sensor network, (ii) Algorithms for shared situational awareness, and (iii) Decision-making.
- Measurement data from the sensors are collected and fused to perform state estimation.
- Based on these estimates, decisions are made, and actions are planned. In this paper, the focus is on (i) and (ii).

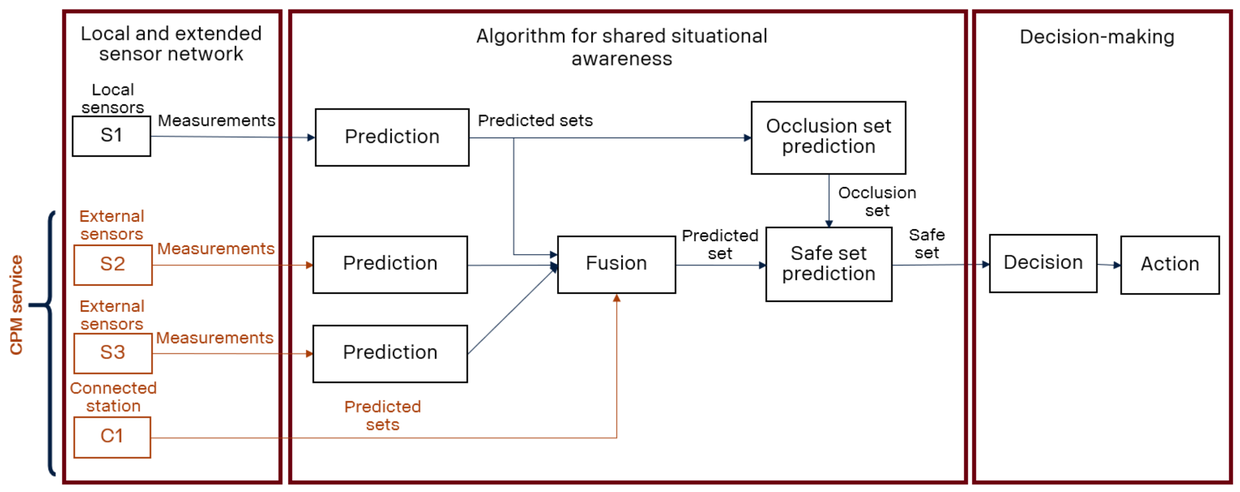

Figure 2 : Proposed architecture for set-based estimation for shared situational awareness.

Discussion

- In this work, set-based approach is considered, which models the noise and disturbance as unknown variables with known bounds.
- One of the most popular set-based approach is set-membership estimator, which is implemented in this project. And in this approach set of states are considered instead of a single state for estimations which will help in providing robust guarantees and safety margins.
- The set are mathematically represented using zonotopes as shown in Figure 3.

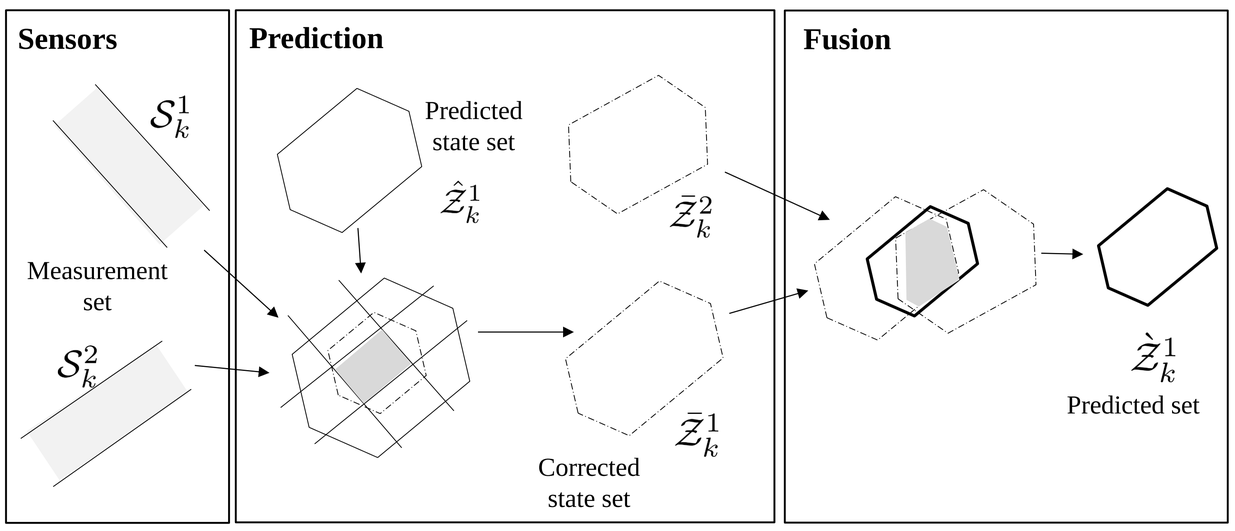

Figure 3 : Illustration of set-membership estimations for shared situational awareness [2].

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