Developing a Track Level Fusion Algorithm for Sensor Fusion of Autonomous Vehicles

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INTRODUCTION

- Sensor fusion involves combining data from multiple sensors.
  - The final model reduces information uncertainty.
  - A more accurate model of the environment around the vehicle is derived.
- Sensor fusion is very significant to modern technology.
  - Individual sensors can often be subject to inaccuracies or noise due to environmental conditions, manufacturing defects, etc.
  - It gives a more comprehensive view of the environment.
  - It has a wide variety of applications in many fields.

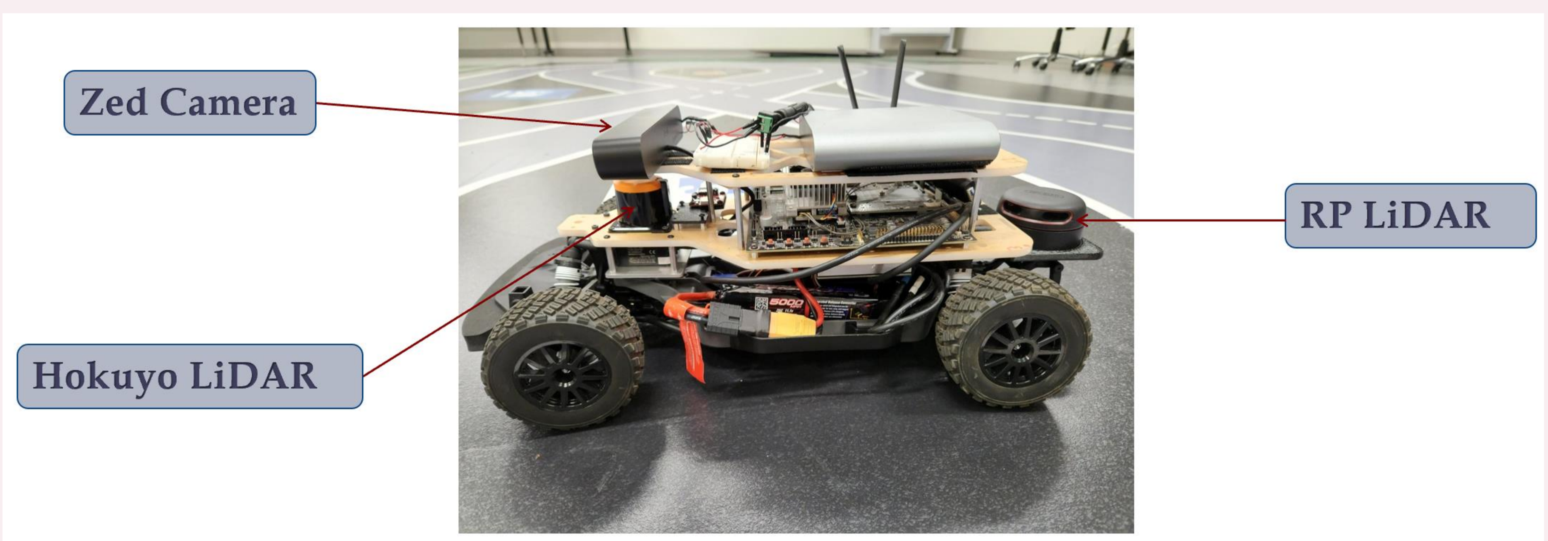

Figure 1: Three sensors used in the sensor fusion model

- Prior to fusion, sensor data goes through calibration, clustering and tracking, Fig 2.
  - Sensor data needs to be calibrated to filter out sensor noise and properly format the data before it can be processed.
  - The points then goes through a clustering algorithm where groups of points can be classified as objects (clusters).
  - Clusters pass through a tracking algorithm where we derive estimates on values like the velocity of the object.

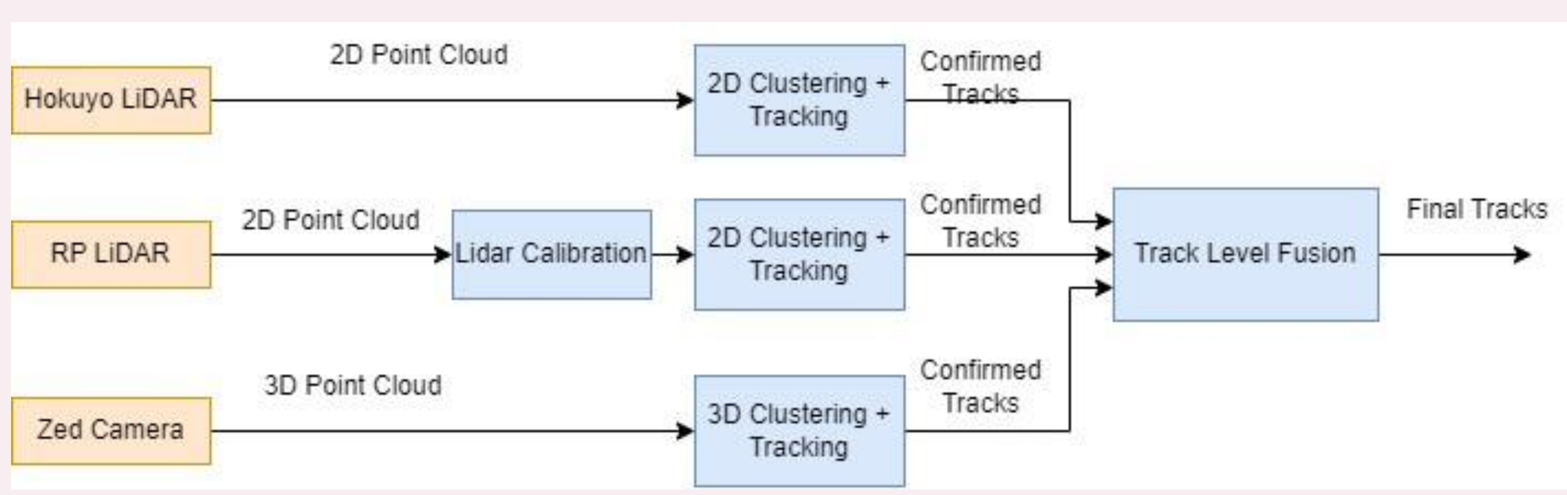

Figure 2: Flow chart of sensor fusion model and plan

OBJECTIVES

- Derive final tracks that represent the best estimate of the target tracks' final state based on all available information.
- Ensure the algorithm can handle noisy measurements, varying sensor frequencies and all sensor uncertainties.
- Ensure the final algorithm is efficient and optimizes computational resources.

METHODS

Track-to-Track Association

- The process of linking existing tracks from multiple sensors to each other based on their spatial and temporal characteristics.
- The goal is to correctly associate tracks that belong to the same target across different sensor measurements or time steps, Fig 3.
- This is done using Global Nearest Neighbor (GNN) Assignment.

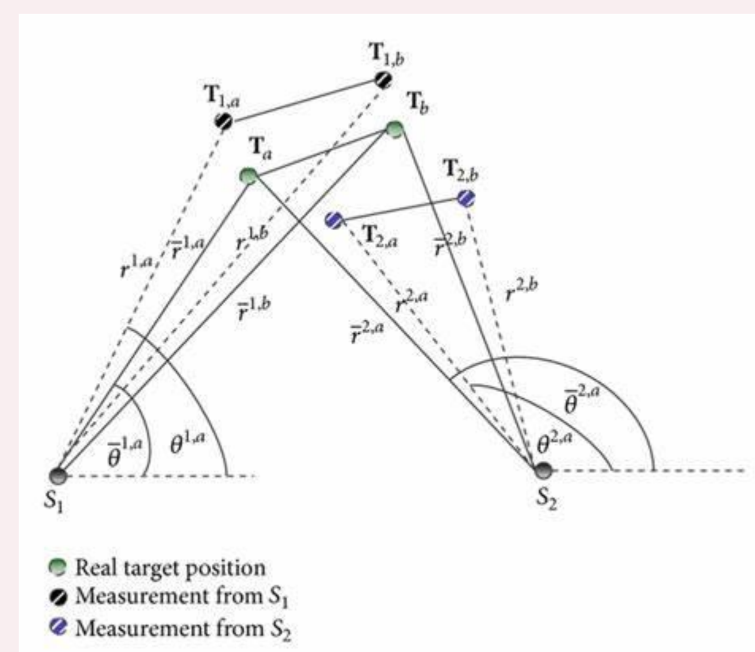

Figure 3: Sensor configuration showing GNN assignment, [1].

Track Level Fusion

- Fusion is performed using a Kalman Filter - optimal estimation algorithm.
  - This works by defining a state vector and covariance matrix as inputs to the algorithm
  - The Kalman filter makes a prediction on the state and error covariance of the tracks/objects, Fig 4.
  - This estimate is updated at each time step using the Kalman gain and the next measurements, Fig 4.
- The algorithm's predictions becomes more accurate as the model runs making it possible to rely on the model in the event of sensor malfunctioning.

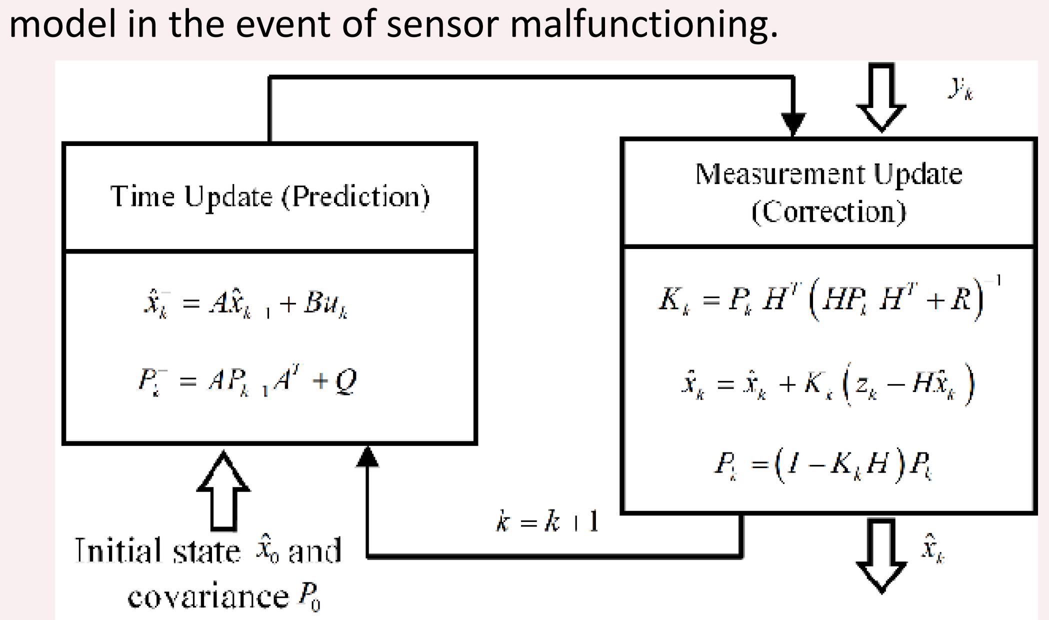

Figure 4: Kalman Filter process steps, [2].

RESULTS

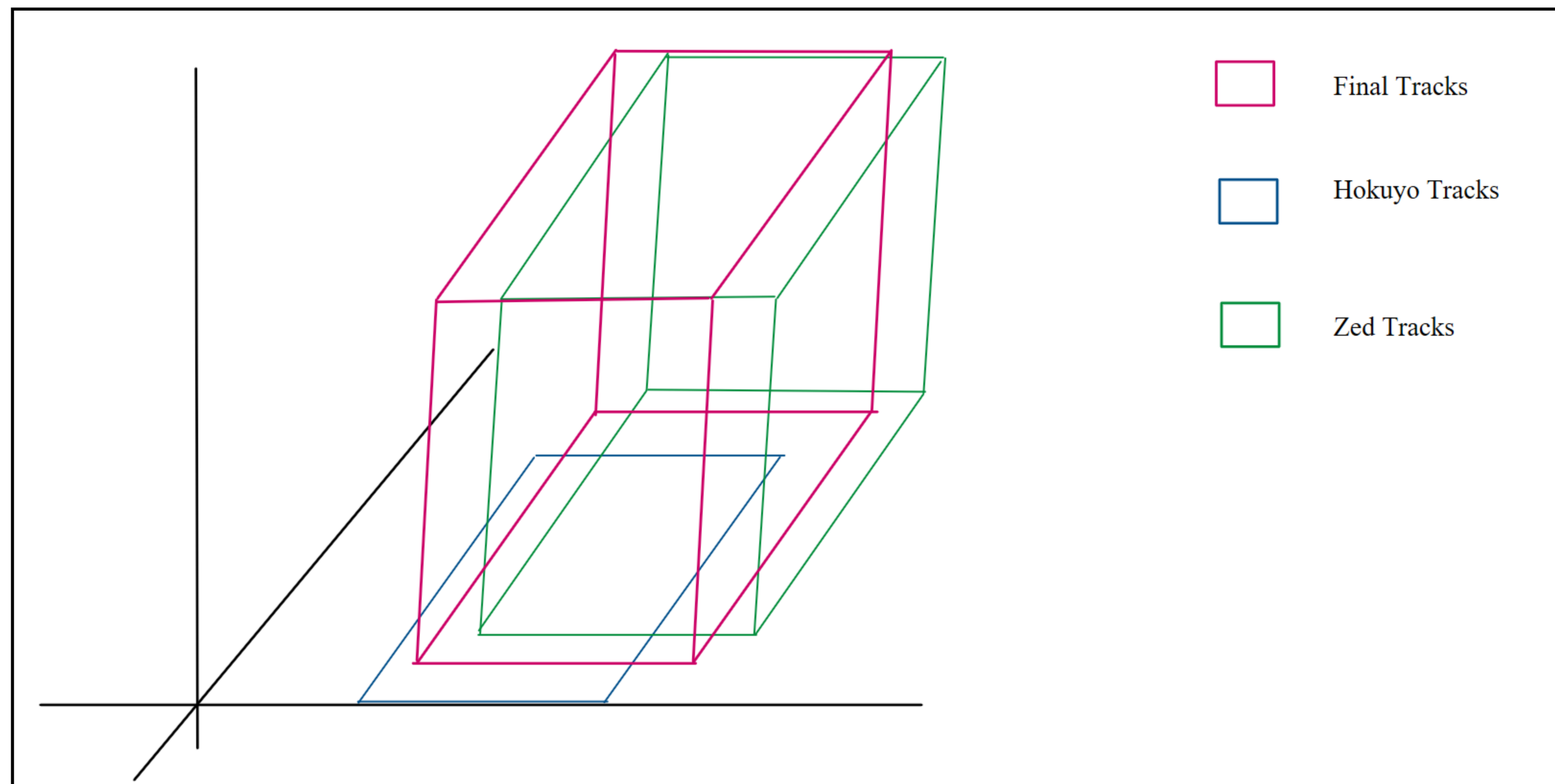

Figure 5: Final track example after track level fusion process

- The final tracks outputted from the model have a more accurate estimation of where the object is located and how fast it is moving, Fig 5.

FUTURE WORK

- The end goal of the sensor fusion model is object association and classification.
  - Object Association: Linking observations and tracks to form coherent representation of real-world objects, [3].
  - Object Classification: Assigning semantic labels or classifications to detected objects i.e., pedestrian, vehicle, etc., [3].
- Testing of the track level fusion algorithm in simulation and on the vehicle.
- Including the RP LiDAR tracks in the final track output.

REFERENCES AND ACKNOWLEDGEMENTS

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