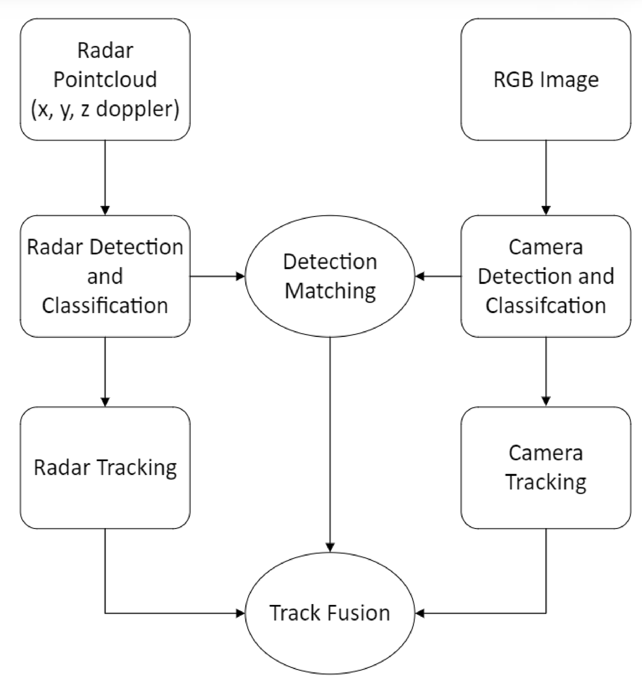
RADAR AND CAMERA FUSION

Centre for Mechatronics and Hybrid Technology
Mechanical Engineering McMaster University
Bao Ming Ding

EECOMOBILITY (ORF) & HEVPD&D CREATE

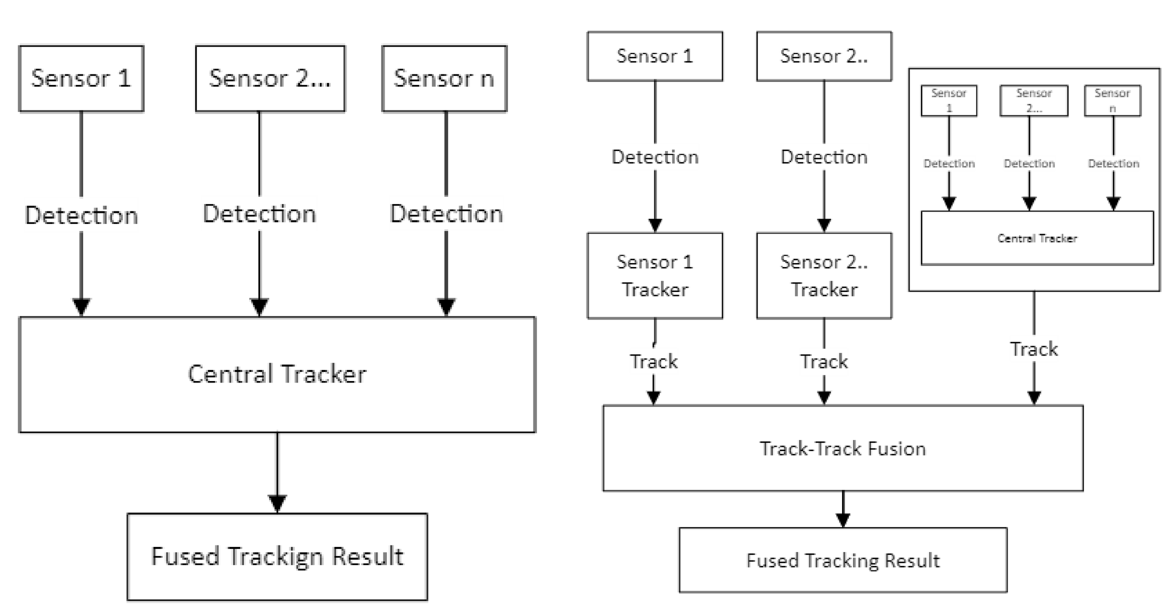
Sensor Fusion

Sensor fusion is the combination of information from multiple sensors to gain a better understanding of the environment or system being monitored.



Decision Level Fusion

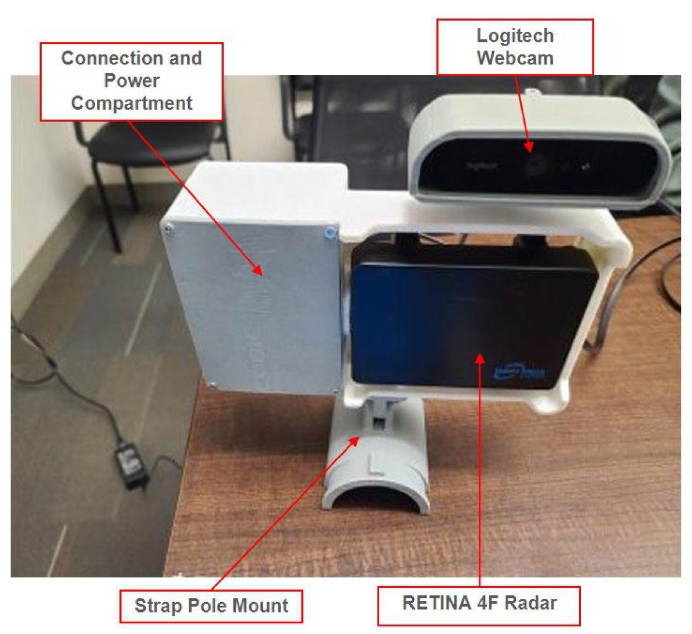
Decision-level fusion allows a plug-and-play capability to add additional sensor modules with relatively minimal change to the software architecture. Second, decision-level sensor fusion can be implemented in a distributed computing system which relaxes the primary processing device's computational and data bandwidth requirement.



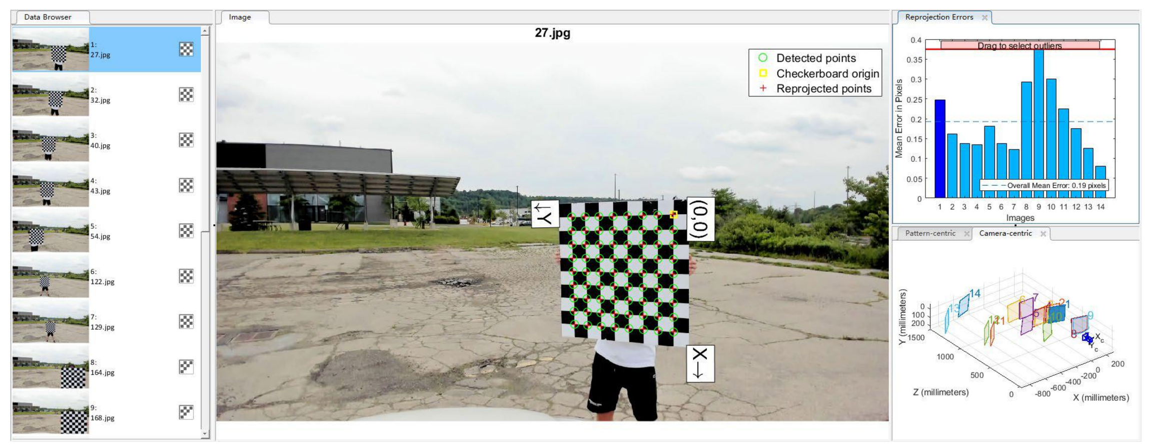
In object tracking scenarios, decision-level fusion can be subdivided into two sub-categories based on when fusion is applied: Central **Level Track Fusion** (CLTF) and **Track to Track Fusion** (T2TF).

Hardware Setup

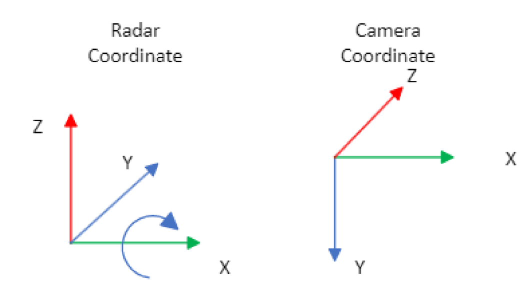
The fusion device is comprised of a RETINA-4FN mmWave radar capturing at 20Hz and a Logitech BRIO webcam capable of 1920x1080 video capturing with a variable refresh rate of 0-30 Hz and 90° azimuth FoV.



Synchronization and calibration of multiple sensors must be resolved before conducting sensor fusion. The data should be time-synchronized across all sensors. In other words, sensors must capture simultaneously. Unsynchronized data or frame jumps can significantly affect the system's performance, leading to missed or false positive detections.



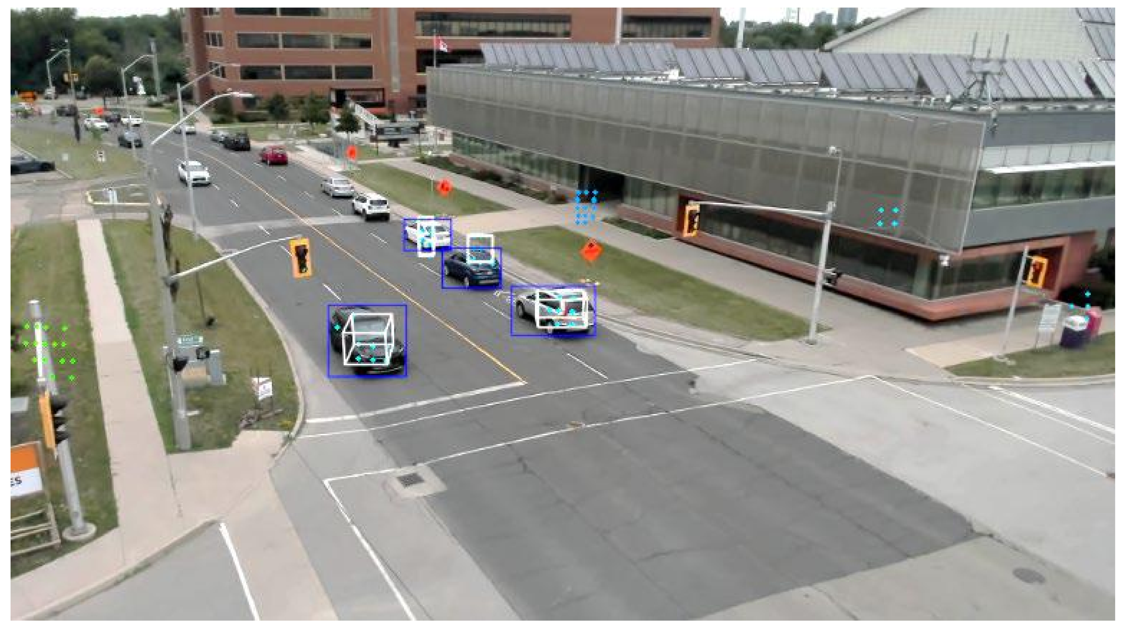
The camera sensor calibration is done by taking a series of images of the checkboard at 1280 x 720 resolution as the input to the camera calibrator app in the MATLAB Computer Vision ToolBox



Radar extrinsic calibration, using calibrated camera matrix, radar point clouds can be projected onto the camera. The radar calibration matrix can then be obtained by manually matching the corresponding radar object to its camera counter part

Radar Object Detection

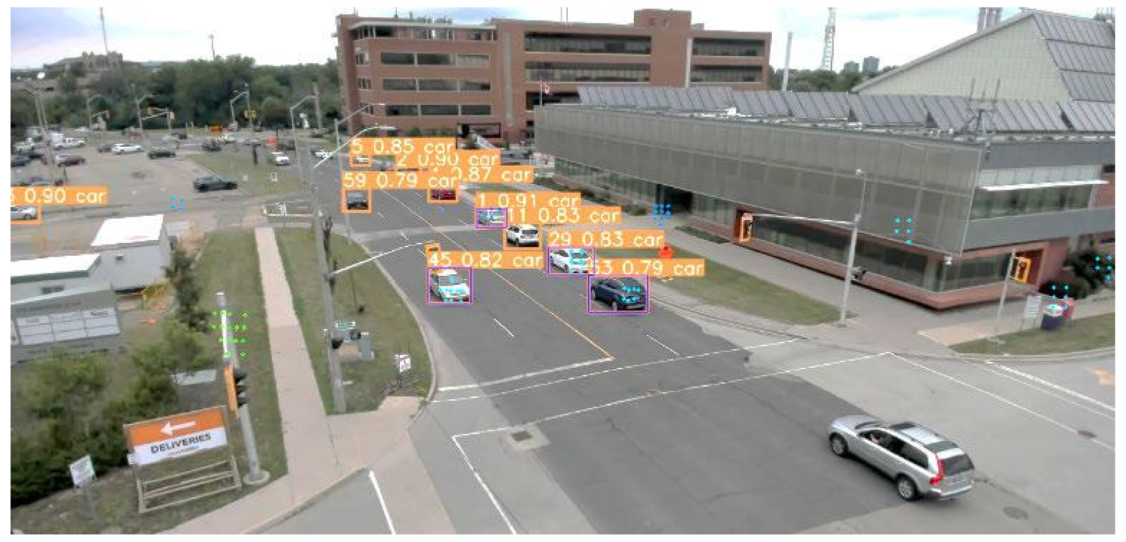
The **Density-Based Spatial Clustering of Applications with Noise (DBSCAN)** algorithm is an unsupervised learning algorithm which clusters data based on density. DBSCAN and its variants have been the mainstream method for clustering point clouds as they scale when dealing with a large number of data points while benefiting from a relatively short processing time.



Objects are detected in the radar point cloud output and projected on the camera plane

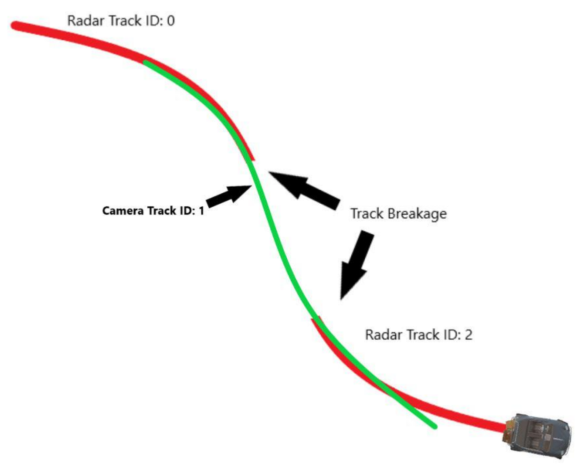
Camera Object Detection

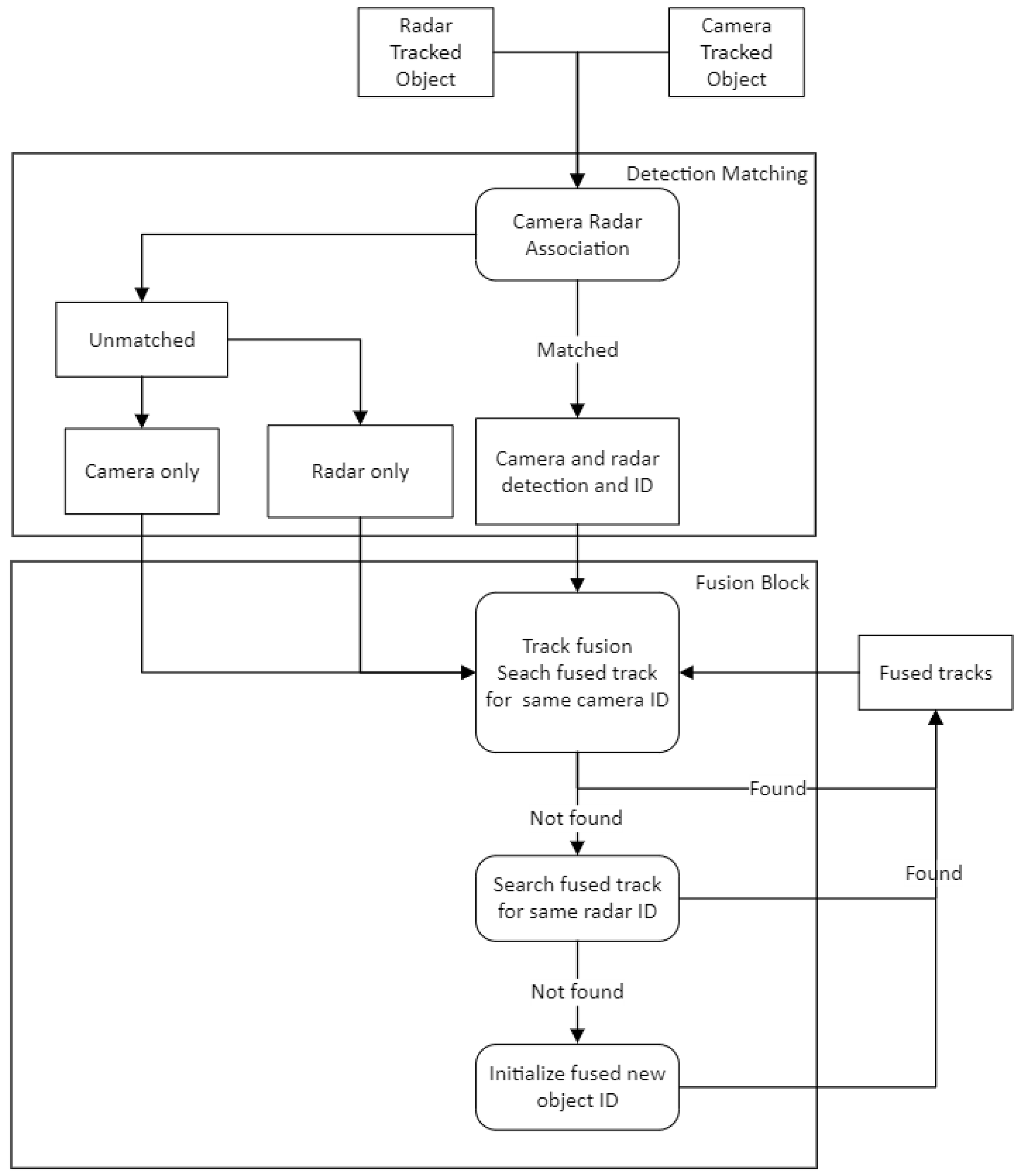
RGB image processing is a well-established field with much existing research and many efficient open-source algorithms to reference. This works utilizes **Yolov5** together with **StrongSort++** for camera object detection and tracking



Sensor Fusion Pipeline

Some applications utilize entrance and exit information to enforce illegal stopping or left turn. When the track ID switches, this effectively means that information on the vehicle travel trajectory is lost, which can lead to incorrect enforcement. In this regard, the fusion algorithm is proposed to assign radar and camera track to a fused track to fix broken trajectory in either sensor.





The **track fusion algorithm** runs on simple yet effective tracking techniques.
Single-point initialization is used to initialize the fused track ID. Then for every iteration, the input to the fusion block is the detected Object, the track fusion algorithm then uses the available tracking information from the sensor trackers to calculate the probability of correct matching.

McMaster University · University of Windsor · Western · CMHT Centre for Mechatronics and Hybrid Technologies · Ontario Research Fund

We acknowledge the support of the Ontario Research Fund: Research Excellence Program.

NSERC CRSNG

We acknowledge the support of the Natural Sciences and Engineering Council of Canada (NSERC), which invests annually over $1 billion in people, discovery and innovation.