World Academy of Science, Engineering and Technology
International Journal of Electrical and Computer Engineering
Vol:18, No:10, 2024

Improved Distance Estimation in Dynamic Environments through Multi-Sensor Fusion with Extended Kalman Filter

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Abstract : The application of multi-sensor fusion for enhanced distance estimation accuracy in dynamic environments is crucial for advanced driver assistance systems (ADAS) and autonomous vehicles. Limitations of single sensors such as cameras or radar in adverse conditions motivate the use of combined camera and radar data to improve reliability, adaptability, and object recognition. A multi-sensor fusion approach using an extended Kalman filter (EKF) is proposed to combine sensor measurements with a dynamic system model, achieving robust and accurate distance estimation. The research utilizes the Mississippi State University Autonomous Vehicular Simulator (MAVS) to create a controlled environment for data collection. Data analysis is performed using MATLAB. Qualitative (visualization of fused data vs ground truth) and quantitative metrics (RMSE, MAE) are employed for performance assessment. Initial results with simulated data demonstrate accurate distance estimation compared to individual sensors. The optimal sensor measurement noise variance and plant noise variance parameters within the EKF are identified, and the algorithm is validated with real-world data from a Chevrolet Blazer. In summary, this research demonstrates that multi-sensor fusion with an EKF significantly improves distance estimation accuracy in dynamic environments. This is supported by comprehensive evaluation metrics, with validation transitioning from simulated to real-world data, paving the way for safer and more reliable autonomous vehicle control.

Keywords : sensor fusion, EKF, MATLAB, MAVS, autonomous vehicle, ADAS
Conference Title : ICCAR 2024 : International Conference on Control, Automation and Robotics
Conference Location : Houston, United States
Conference Dates : October 24-25, 2024