Publicly Available Summary for Classified Thesis

This thesis presents an in-depth investigation into the integration of modern commercial millimeter-wave (mmWave) radar sensors into the perceptive sensor suite of a mobile robotics platform. Potential use cases for mmWave radar in mobile robotics were explored, including object detection in adverse conditions such as rain, snow, and fog, where traditional sensors like lidar and cameras may be less effective. Software integration of the selected sensors was performed using dockerized Robot Operating System (ROS) environments to ensure future portability and reproducibility across various platforms. The challenges faced during this process, such as compatibility issues between ROS versions and varying CPU architectures, were addressed through the development of custom solutions and detailed documentation.

Physical integration of the sensors into a mobile robotics platform was achieved through the design and fabrication of custom mounting hardware. The placement and orientation of the sensors on the platform were optimized based on manufacturer recommendations to ensure optimal performance. Sensor calibration, a critical aspect of multi-sensor integration, was explored in depth. Both intrinsic and extrinsic calibration methodologies were investigated to formalize the spatial relationships between the mmWave radar sensors and the existing sensor suite, which included lidar, camera, and inertial measurement units (IMUs). Real-world experimentation was conducted using the platform equipped with the integrated mmWave radar sensors in various off-road environments. Data collection scenarios were designed to validate the performance of the radars in challenging environments. Preliminary results indicate reliable performance of the mmWave radar sensors in these challenging environments when compared to the performance of lidar and machine vision systems.

The thesis concludes by highlighting the progress made in the integration of mmWave radar sensors into the perceptive suite of a mobile robotics platform, providing a solid foundation for future research and development. The data collected during the study can be further analyzed using machine learning techniques to gain additional insights and improve the performance of autonomous systems in off-road environments. Potential for novel context-aware mobile robotics applications is significant and requires researchers to expand existing environment modelling beyond frame-to-frame Cartesian point clouds into larger dimensional information spaces.