Autonomous Rover Navigation for Mangrove Ecosystem Monitoring Using Sensor Fusion with STM32 and MATLAB/Simulink

B.Y.C. Fernando[1*], W.M.S.R. Weerasinghe[1], S. N. Ranathunge[2], D. Vakeeson[1], R.L.K. Lokuliyana[1]

[1]*Department of Mechanical Engineering, Faculty of Engineering Technology, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.*

[2]*Centre for Environmental Studies & Sustainable Development, The Open University of Sri Lanka, Nawala, Nugegoda, Sri Lanka.*

**bhagyafernando55@gmail.com*

Mangrove ecosystems face increasing threats from climate change, anthropogenic activity, and inadequate monitoring. Effective conservation and management require frequent, large-scale data collection across complex terrain characterized by dense root structures, tidal inundation, soft substrates, and GPS-denied environments under dense canopy cover. This study presents the design and implementation of a sensor integration framework for autonomous rover navigation in mangrove ecosystem monitoring. The navigation system integrates a BNO055 nine-axis Inertial Measurement Unit (IMU) with quadrature wheel encoders on an STM32 Nucleo U545RE-Q microcontroller, with firmware developed and deployed using the MATLAB/Simulink Embedded Coder Support Package for STM32. Sensor fusion is achieved through a dead-reckoning approach, in which real-time orientation estimates from the IMU (heading, roll, and pitch) are combined with rotational velocity measurements (RPM) from the wheel encoders to estimate the rover's relative position and heading in GPS-denied environments. Simulink models for both sensors were successfully developed, deployed, and validated, demonstrating reliable data acquisition within expected operating ranges: the encoder model produced stable RPM readings, and the IMU outputs remained within manufacturer-specified Euler angle ranges. These results demonstrate the feasibility of a low-power, embedded sensor fusion platform for autonomous navigation in challenging field environments such as mangrove ecosystems. The proposed framework provides a foundational sensor layer for future integration with LiDAR-based Simultaneous Localization and Mapping (SLAM) algorithms and a Robot Operating System (ROS), enabling fully autonomous environmental monitoring. This work contributes to a replicable embedded systems framework for developing cost-effective, GPS-independent, terrain-adaptive robotic platforms for next-generation mangrove ecosystem monitoring.

Keywords: *Autonomous navigation, Mangrove monitoring, Sensor fusion, IMU, SLAM, Embedded systems, Dead reckoning*