ABSTRACT

The development of autonomous vehicles requires robust technologies to ensure directional stability during movement. A major challenge lies in maintaining straight-line motion despite sensor disturbances and cumulative drift. This study develops an orientation estimation system for autonomous vehicles using a 9 DOF IMU sensor, focusing on yaw measurement for lateral movement correction on a 2D path. A 3-state Kalman Filter is implemented to integrate yaw, yaw rate, and gyroscope bias data, aiming to improve dynamic orientation estimation. The system is tested on a JetRacer AI Kit prototype equipped with a BNO055 IMU sensor, utilizing adaptive steering control. Tests include obstacle-free paths of 540 cm and 1370 cm, as well as evaluations of responses to orientation disturbances of 20°. The results show that the Kalman Filter achieves a yaw rate noise reduction of 87.5% (from 1.6°/s to 0.2°/s) and effectively addresses angle wrapping and cumulative IMU drift. The steering system provides real-time correction with a fast response (0.7 s) for minor disturbances and smooth response (2.1 s) for major ones. Sensor accuracy reaches a gyroscope error of 1.80% and a magnetometer error of 0.16%. This study demonstrates that applying the Kalman Filter in IMU data processing significantly enhances the directional stability of autonomous vehicles.

Keywords: autonomous vehicle, IMU, Kalman Filter, orientation estimation, directional stability