Development of an Automatic Navigation System for Smart-GH Mobile Robot Using Odometry Method

Nuzula Afianah, S.Kom., M.Cs. (*Supervisor*)

Alfian Akbar Rizqi Maulana
Study Program of Mechatronics Engineering Technology
Engineering Department

ABSTRACT

The narrow environment of a greenhouse with varied floor surfaces such as soil, gravel, and paving poses a major challenge in implementing a mobile robot navigation system, particularly in maintaining positional accuracy and directional movement. This study aims to develop an automatic navigation system for the Smart-GH mobile robot using the odometry method as a reliable navigation solution in limited agricultural environments. The system was developed by integrating an external rotary encoder E40S6-360-3-T-24 equipped with a spring mechanism to consistently maintain contact between the encoder wheel and the track surface, along with a GY-25 sensor (MPU6050) for orientation estimation (yaw), in order to minimize error accumulation due to wheel slip. The robot employs a differential drive configuration with an ESP32 microcontroller, and applies PID control to correct heading error and cross-track error in real-time. Both control components work in an integrated manner to produce stable and accurate movement along the track. Testing on a straight path with a flat surface showed an average euclidean distance of 0.243 cm with a positional error percentage of 0.053%, MAE yaw of 0.362°, and MAE lateral of 0.0036 m. On turning maneuvers on a flat surface, the average positional error was 0.343 cm (L-shape) and 0.651 cm (U-shape). Testing in the greenhouse environment after applying a low-pass filter and stable count mechanism successfully reduced the average positional error from 8.216 cm to 2.597 cm (1.747%). Nevertheless, the GY-25 sensor still exhibits limitations with respect to external disturbances, such as mechanical vibrations, which may affect the stability of the robot's orientation estimation. Overall, the developed navigation system proved capable of operating reliably, evidenced by an average positional error of 0.053% on straight paths and 1.747% in the greenhouse environment after system optimization.

Keywords: *mobile robot, odometry, PID control, greenhouse, differential drive*