Smart Mobile Robot Design for Optimizing Melon Cultivation in a Greenhouse

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ABSTRACT

Melon cultivation in greenhouse environments requires an efficient operational system, particularly for environmental monitoring and pesticide spraying, as manual methods still present limitations in terms of time consumption, spray distribution accuracy, and occupational safety. This study aims to design, develop, and analyze the performance of a smart mobile robot as an automation solution to support the optimization of melon cultivation in a greenhouse, with a focus on structural strength, mobility performance, and spraying system effectiveness. This research employed an experimental method based on a design-and-build approach, encompassing literature review, design development, fabrication, system integration, testing, and result analysis. The robot was designed with dimensions of 450 mm × 600 mm, utilizing an aluminum hollow frame measuring 12.5 mm × 12.5 mm with a thickness of 1 mm, a differential drive configuration, and a spraying system based on a 12 V DC pump with an adjustable stick sprayer. Finite element simulation results indicated a maximum Von Mises stress of 6.91502 MPa, a maximum displacement of 0.120091 mm, and a safety factor greater than 15, confirming that the frame structure remained within safe operating conditions. Mobility performance testing under load variations from 13.9 kg to 18.9 kg produced a stable robot speed in the range of 0.34–0.35 m/s. The spraying system testing yielded an average flow rate of 1.832 L/min, an optimal spraying distance of 40 cm with a vertical reach of 170 cm, and a field capacity sufficient for spraying operations in small-scale greenhouses. The results demonstrate that the designed smart mobile robot is feasible as an automation solution to support melon cultivation activities in greenhouse environments.

Keywords: *Smart Mobile Robot, greenhouse, melon, design and build, spraying system, automation.*