Quick Turn-based Headland-Turning Control Strategy for an Autonomous Rice Transplanter

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Abstract

Rice transplanters are mechanically designed to sharply enter the adjacent row by disengaging the power of the turning-side rear wheel; thus, a headland-turning method for an autonomous rice transplanter, designed to fit this condition is required. This study presents a practical autonomous operation strategy for effective headland turning of the rice transplanter, considering both path-tracking and path-planning aspects. The fundamental idea of the proposed strategy was to maintain the maximum steering angle during turning. The path-planning algorithm was designed to initially generate waypoints geometrically in the provided environment and adjust the planned path in real-time to compensate for the deviations caused by the dynamic behavior of the vehicle. The waypoint-switching logic was one of the major factors that influenced the operation performance. The waypoint switching from turning to straight is crucial because the vehicle’s trajectory should be stabilized before entering the working area to ensure uniform plant spacing. The stabilization region was defined as the entry path. The proposed solution for trajectory stabilization was to experimentally determine the appropriate lateral boundary offset (LBO) for waypoint switching. The developed algorithm was tested in a real paddy environment, using a commercial autonomous rice transplanter with a modified path-tracking algorithm. In the field test, the planned path comprised nine headland turns, and the test platform consecutively tracked the path at two different speeds. The average RMSE of the lateral deviations of the entry path were 11.5 cm and 13.5 cm, respectively, at 0.54 m/s and 0.87 m/s.

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