

Degree thesis abstract data

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Thesis title

Automatic Weed Mowing and Recharging System of Electric Agricultural Robot
(電動農業ロボットの自動草刈および充電システム)

Thesis Abstract

An agricultural electric vehicle platform (EVP) equipped with a weed mower has been developed to solve agricultural issues such as labor shortages and environmental impact. Chapter 1 provides an overview of the background and relevant research on electric agricultural machinery. It also outlines the objectives of the study: to develop an electric vehicle platform (EVP) for agricultural use, equipped with a weed mower. The aim is to create an electric agricultural machine capable of continuous operation by combining autonomous driving and automatic recharging in the outdoor environment. In Chapter 2, we introduced the hardware of the EVP, including the system, sensors, and specifications. The parking and recharging system is introduced, including the electrode connectors for docking.

In Chapter 3, focusing on automatic weed mowing, we tested the robot's operation and continuity. It showed that it could operate for 100 min on a single full charge and mowed more than 15 a. Furthermore, we measured the path following accuracy on different routes by a global navigation satellite system with and without lifting up/down the mower. Those with right-angle turns and mower lifting demonstrated the highest path-tracking accuracy, achieving RMSEs of 1.9 cm in lateral deviation and 2.0° in heading deviation, although the operation time was longer due to the lifting and lowering motion. For paths without mower lifting, the soft U-turn path with a large turning radius achieved reasonable accuracy, resulting in RMSEs of 4.7 cm for lateral deviation and 5.8° for heading deviation.

Chapter 4 describes novel electrode connectors and an automatic vision-based parking system to enhance docking between an EVP and its charging station. To identify the AR marker and execute parking methods for docking, the turning control angle θ was calculated using ${}^c x_{AR}$ and ${}^c y_{AR}$ to control the EVP turning direction. This approach addressed the detection limitations of using AR orientation data. The results of the two-step parking method demonstrated a 65% increase in docking success. The turning angle errors in the second step of the two-step parking method were smaller, ranging from -1° to 0.5° . Overall, this vision-based automatic parking system achieved sufficient accuracy for reliable connector docking in outdoor environments.

In Chapter 5, we integrated the two systems and tested the automatic operation integration. The tested movement trajectory and the battery voltage change over time, which shows the electric power consumption, were recorded entirely. Optimized the turning method for the movement path, improving practical implementation when returning to the charging station. Overall, the automatic weed mowing and recharging system of the electric agricultural robot has been effectively developed and tested. Finally, in Chapter 6, the conclusions of this dissertation are summarized.