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Development of an Unmanned Surface Vehicle Platform for Autonomous Navigation in Paddy Field

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1. Introduction

Paddy is planted in wide area in Japan. Relative to the high proportion of paddy planting area, the farmer labor force problem and the aging problem is restricting the development of paddy planting. Utilizing the paddy growth environment, to develop the unmanned surface vehicle is necessary to promote the automatic paddy management.

2. Materials and methods

The USV platform should be light enough to float on the water, and cannot destroy the paddy seedlings. In this study, a radio controlled air propeller vessel (RB-26, Hokuto Yanmar Co., Ltd., Ebetsu, Japan) was modified as the main body. For autonomous navigation and observation on the shore, the hardware system architecture of the USV platform was divided into two parts. One part was on the unmanned surface vehicle to execute navigation algorithm. The second part was on the shore of paddy field to monitor the USV running.

The target map was planned based on the actual paddy field. The mapping parameters included navigation coordinate of beginning point and end point, path spacing and the number of paths. And autonomous navigation also can be divided into two parts. One is line-following navigation. One is the turning control. From the navigation path, use the lateral error and the heading error as feedback control to do autonomous navigation.

3. Results and discussion

The experiment area was chosen in the experimental paddy field of Hokkaido University, Sapporo, Japan. The PC in the USV platform dynamically logged the lateral error and the heading error when running line-following navigation. The RMS of the lateral error was 0.13 m and the RMS of the heading error was 5.0 degree. For the purpose of observing the turning performance of this USV, the turning test with 4 different engine rotation speeds was done, 5000 rpm, 5500 rpm, 6000 rpm and 6500 rpm respectively. Under ideal situation, the trajectory of turning should be a circle. Nevertheless, the trajectory cannot be a circle, but an ellipse, that because of the influence of wind.

The map-based navigation is the combination of the line-following navigation method and turning control method. In autonomous map-based navigation, The RMS lateral error from the target path was observed to be less than 0.45 m, and the RMS heading error was 4.4 degree or less.

4. Conclusions

This research was to develop an agricultural unmanned surface vehicle platform with navigation sensors for autonomous navigation in the paddy field. Based on a navigation map, the USV platform will follow the target path using GPS compass.