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Author(s)	NGUYEN, TINH THANH
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学位論文内容の要旨

博士の専攻分野名称：博士（農学）　　氏　名：Nguyen Thanh Tinh

学位論文題名

Development of a smart sprayer system for rice fields in the Vietnamese Mekong Delta
（ベトナムメコンデルタ水田用スマート防除システムの開発）

There is a serious environmental pollution problem caused by the use of large amounts of plant protection products in rice cultivation in the Vietnamese Mekong Delta (VMD); therefore, a solution is needed to reduce the amount of pesticides while ensuring productivity and rice quality. The goal of this study is to develop a smart spraying machine which only sprays onto the crop's affected areas, thus reducing the amount of unnecessary spraying in areas. To achieve this goal a color camera was used to obtain images of the rice crops; and by developing an image processing program, weeds and rice diseases were identified. Finally, the program controls the individual nozzles to spray directly on areas of weeds or diseases.

1. Real-time detection of narrowleaf and broadleaf weeds

This study introduces an image processing method capable of real-time detection of two kinds of weeds (broadleaf and narrowleaf weed) in the rice field of the VMD. At the early stage of weed post-emergence (weeds have 2-3 leaves), the rice is in the period of 10-15 days after sowing. At that time, the weed's leaves have a smaller size than the rice plants and are less obstructed and overlapped by the rice leaves, so it is convenient for identification by image processing. Two image processing methods were applied and compared in this research: Faster region-based convolutional neural network (R-CNN) and bounding blob analysis. The input images were recorded using a red, green and blue (RGB) camera. The weeds detection accuracy and processing time were estimated for each method using the same image data source from Vietnam. Both methods were able to detect two kinds of weeds. In this experiment, the result show that the bounding blob analysis is simple but effective, with a shorter processing time and higher accuracy than the Faster R-CNN. The result from the bounding blob method obtained a 95.4% detection accuracy for the broad leaf weeds and 87.1% for the narrowleaf weeds; with the program processing is at 0.26s per frame.

2. Real-time detection of leaf blast and bacterial blight diseases

Two common diseases that cause serious effects on rice productivity were selected for identification, namely leaf blast and bacterial blight disease. The initial lesson of the diseases often appears on rice leaves, but with different in colors and shapes, so it is convenient for identification by image processing. The detection program is based on analyzing the average values of 3 channel colors (RGB and HIS color space) and the ratio of the two sides of the minimum rectangle bounding the lesions. Two classifier methods, the Gaussian Naïve Bayes and the K-Nearest Neighbor (KNN) were used to classify the diseases into various categories. The disease detection accuracy and processing time were estimated for each classifier method using the same diseases image data source from Vietnam. Both classifier methods were able to classify two kinds of diseases in an early stage of development with uncontrolled light conditions in the rice fields. The results show that the Gaussian Naïve Bayes is simple but effective, with a shorter processing time and higher detection accuracy than the KNN. The best detection accuracy results reached 90.0% for the rice disease on different growth stages and under uncontrolled lighting conditions by using the Gaussian Naïve Bayes classifier method which used both the R, G, B mean value and the ratio (min-rectangle bounding analysis); with the program processing at 0.24s per frame.

3. Development of a smart sprayer utilizing a commercialized sprayer

The real-time detection and spraying condition performance were put into practice on a Iseki sprayer machine (JK14, Iseki Co., Japan). A color camera (DFK33UX264, The Imaging Source, Germany) with a 6mm lens (SV-0614H, VS Technology Co., Japan) angle of view 70.7 degree can show a 1.6 m width area; corresponding to 4 spraying areas, each spraying area is 0.4 m wide. Each spraying area was sprayed by two independent nozzles. The two nozzles on each area were placed close to each other, each nozzle sprays a different chemical to treat different types of weeds or diseases. The nozzles were controlled via the Arduino Uno board and a relay. A multiple selection area detection software was developed in C++ using Visual Studio 2015 and OpenCV-3.4.1. The software interface shows to the user the number of the different kinds of object (weeds or diseases) detected and the number of sprays when the object crosses a detection line. Experimental results show that the system is accurate for identification and spraying a specific position when the sprayer moves at a speed of 0.65 m/s with stable light intensity conditions. The response time from the detection to the spray is 0.6 seconds.