#7616 DEVELOPMENT OF LODGING DIRECTION DETERMINATION SYSTEM USING IMAGE PROCESSING

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ABSTRACT

In this study, image processing system was developed for application on rice plants to determine lodging condition, which was contributing factor to declining harvester efficiency by using combine harvester. Therefore, we developed a system for determination of the lodging direction by algorithm based on convolutional neural network (CNN). As for deep learning framework, Pytorch1.1.0 were used to train and test the judging direction. GoogLeNet was used as a pre-trained CNN model.

Lodging direction was defined as 3 classes in images (i.e. frontward, backward and the others). Charge Coupled Device Camera (CCD camera) was installed in head feeding type combine and image was captured in front of a divider (2-10 m). CCD camera's height and depression angle were set to 2.5 m and 39 degrees. Image size was 640 x 480 pixels, and the sampling rate was 30 Hz.

After acquisition of images, Region of Interest (ROI) were set to 250 x 250 pixels in images. These images were cropped in ROI. The images that are contained the lodging rice in more than half of ROI were selected manually. A total of 17,899 sample images were collected for training and validation. 4,997 images were used as training data and 12,902 images were used as validation data. As data augmentation, the training data was rotated 90°, 180° and 270°. Then, training and validation data were labeled manually. 19,988 images were used for training data set and 12,902 images were for validation, respectively.

The recall was applied for evaluation of the validation. As a result, the recall of frontward, backward, and others were 89.0%, 97.9%, and 81.5%, respectively. Main reason of the error was the situation where one image contains various lodging directions. However, total accuracy was 90.6%, so the result indicated that the developed system could be acceptable for determination lodging direction on combine harvester.

INTRODUCTION

According to the Japanese Census of Agriculture and Forestry in 2015, the number of growers with farmland area of 20 ha or more increased by 38.1 % to 3850 and it means that young workers will manage a lot of farmland (Static Agriculture Census, 2015).

To solve these problems, the Ministry of Agriculture, Forestry and Fishery of Japan has launched a plan to promote the development of robots for agricultural use. This also aims at increasing agricultural productivity and improving self-sufficiency in Japan. Currently, many different types of agricultural robots are under development in Japan, such as a robot wheel-type tractor (Kise et al., 2002, Yang et al., 2012), a robot crawler-type tractor (Takai et al., 2010), a robot rice transplant machine (Nagasaka et al., 2004) and a robot combine harvester (Iida et al., 2011). In all the research mentioned above, a real-time kinematic GPS receiver and an IMU/GPS compass are required. In addition, to ensure the safety and precision while combine harvesters operating autonomously, it is also important for combines to capable of identifying the surrounding environment quickly and accurately. For example, there is a research to distinguish what are harvested areas from what is unharvest areas using image processing (Yang et al., 2020). Especially, it is important to estimate lodging in harvesting. The lodging area takes more time and effort to harvest than the non-lodging area. The operator needs to adjust the cutting speed for lodging degree and direction. Therefore, the automation of process for adjusting the cutting speed is an important function for not only the development the of robotic combine harvester but also the reduction of agricultural workload, as well as proper positioning, which is independent of the operator's skill and experience.

From the above, lodging condition was focused on as data that can be get at harvesting by combine. Lodging is caused by excess of growth because of excess of fertilizer and causes to be deteriorated grain's quality, to generate disease and insect pest and to worsen with by efficiency at harvesting (Ibaraki, 1967; Saito, 1991). Acquisition and accumulation of lodging condition is result of cultivation management of the year and it can be used not only for sharing information but also for reference for fertilization after the next year.

Many research studies on prediction of lodging have been studied (Fukuda et al., 1988; Sato, 2002; Hama et al., 2016; Tanaka et al., 2016). As a method for determination of the lodging level, Morimoto et al. (2020) judged the level by support vector machine by using image processing with the CCD camera mounted on the combine. However, there is few reports on method to visualize lodging direction during harvest.

The objectives of this research were 1) to collect sample image during harvest using combine harvester, 2) to develop rice lodging direction detection algorithm.

MATERIALS AND METHODS

Method of Sample Image Acquisition and Definition of Region of Interest

In this research, the tablet (FZ-M1, Panasonic) and the head feeding type combine harvester (HJ6123GZCAPLW, Iseki) were used and CCD camera on tablet's back collected images in front of a divider. Also, camera's height and depression angle were set to 2.5 m and 39 degrees in 2018 (Figure 1). Image size was 786,432 pixels and the sampling rate was 30 Hz. 171,877 images were collected.

Figure 2 shows data preparation. After acquisition of images, ROI (Region of Interest) were set to 250 x 250 in images (Figure 3) and cropped in ROI.

Then, the images that are contained the rice in more than half of ROI were selected. Finally, images visually determined to be lodging were selected as training and validating images. 4,997 images were selected as training images and 12,902 images were selected as validating images, respectively.

Figure 1. Position of CCD camera installation

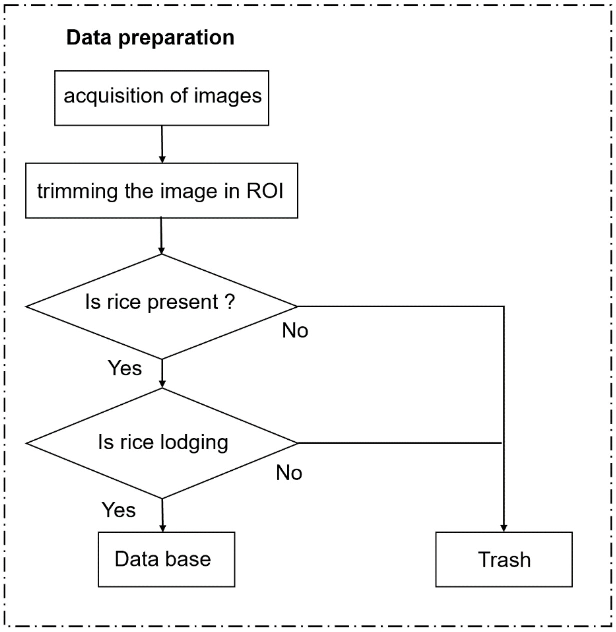

Figure 2. Steps of the data preparation

Figure 3. Region of interest

Development of Lodging Direction Algorithm

Figure 4 shows steps of the proposed algorithm. Firstly, as data augmentation, rotating the training images 90°, 180° and 270°. Lodging direction was defined as 3 classes (Figure 5) in an image (frontward, backward and the others), and labeled manually for training and validating images. As a result, 19,987 images were made as training set and 12,902 images were made as validation set, respectively. Pytorch0.3 were used to train and test the judging lodging direction. GoogLeNet was used as a deep learning model. Trained with the training set, and then validating the model on the validation set, respectively.

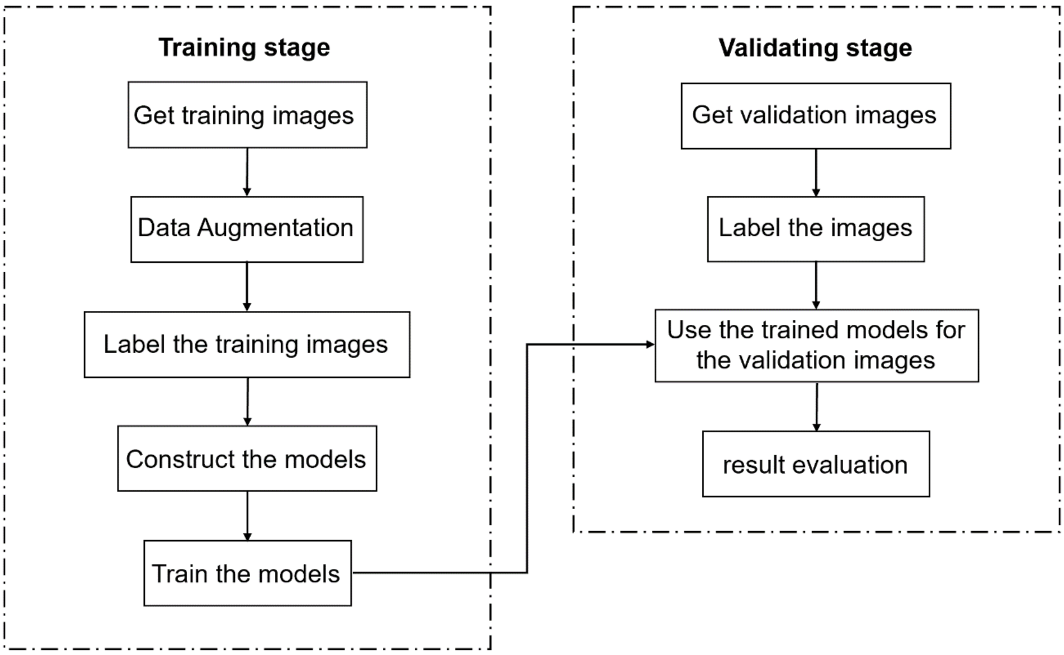

Figure 4. Steps of the proposed algorithm

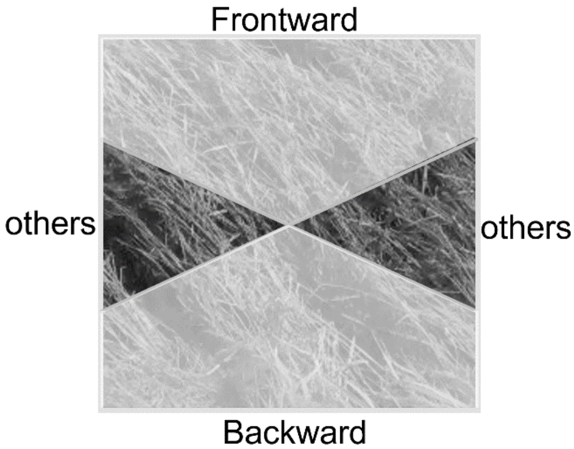

Figure 5. Definition of lodging direction

Model Training and Testing

Lodging direction was judged based on the liner Support Vector Machine leaned in advance. reproducibility defined as follows was calculated with each lodging direction.

$$Reproducibility = \frac{\text{The number of correct answers}}{\text{The number of the validating images}} \qquad \textbf{Equation 1.}$$

RESULTS AND DISCUSSION

Processing Result by Real-time Lodging Analysis System

Real-time lodging direction analysis system was applied, and the reproducibility was calculated. As the result, reproducibility of “frontward” was 97.9%, of “backward” was 81.5%, and of “others” was 89.0%, respectively (Table 1), and showed that the system was usable as a lodging analysis tool.

Table 1. Reproducibility of each lodging direction

		Prediction				
		Backward	Frontward	Others	Total	Reproducibility
Actual class	Backward	4,156	19	72	4,247	**97.9%**
	Frontward	310	5,673	385	6,368	**89.1%**
	Others	281	143	1,863	2,287	**81.5%**
	Total	4,747	5,835	2,320	12,902	**90.6%**

When there was a different direction of lodging in one image, it is considered to have been the cause of erroneous determination. Figure 6 is an image of “others”, but it was misjudged as “frontward”. Especially, it is considered that the high reproducibility of backward was a good tendency, because the head feeding type combine harvester may break when harvesting in “backward”. In addition, the number of the misjudgment of "backward" was more "others" than "Frontward". It is considered that the judgment on the borderline between “backward” and “others” was ambiguous, so we are

Figure 6. Image of “others”

trying to get more training data and to improve reproducibility.

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