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Optimization of yield monitoring in harvest using a capacitive proximity sensor☆

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ABSTRACT

This study describes the process of applying the proximity sensor technology to measure grain flow during harvest in real fields. The results of the present study can eventually lead to the accurate prediction of harvest. In the experimental combine, the grains flowed through an elevating screw into the grain tank. The flow was monitored for the amount of grain via the attached proximity sensors. The results show a high correlation ($R^2 = 0.996$) between the signal detection time and the feed amount. The high correlation of the equation obtained in the present study proves the feasibility of the system and demonstrates its potential in terms of making a considerable contribution to precision in agriculture practice.

1. Introduction

Environmental pollution and safety problems in agricultural industry have become issues of primary importance in recent years. Economic growth and environmental preservation are both necessary; thus, eco-friendly agriculture and precision agriculture have become the topics of a great interest (Chung et al., 1999). Investigation of the grain yield in the field and identification of space conditions are crucial steps in the practice of precision agriculture (Chosa et al., 2004). Yield mapping as a data source on variability emphasizes the need to integrate data from all sources of spatial variability with the management/agronomic expertise of the farmer to develop an application strategy for field inputs (Stafford et al., 1996). Grain yield is used for evaluating of the information on the annual field management; it is also useful in planning for the next season. Recently, research on location information of grain yield in the field has become very popular. Shoji et al. (2009, 2010) used location-specific yield monitoring to examine and measure individual impacts of intermittent grain flow accelerated by auger blades. Nonlinear calibration was derived to relate each impulse detected by a sensor to the weight of the grain released at a single rotation of the auger blade, taking into account the rotational speed of the auger. The relative error of calibration was below 2% and the maximum relative error of validation amounted to 3.5%.

In this study, the grain yield was monitored in real time for precision agriculture. In combine, grains were flowed through elevating screws into the grain tank and monitored for the amount of the grain flow by the attached proximity sensors. The aim of this study was to develop an application of the proximity sensor technology through the grain yield monitoring in real outdoor fields, which can eventually lead to the accurate prediction of harvest using the relevant data.

2. Materials and method

2.1. Principle of operation system

Fig. 1 shows how grain flows through a combine harvester. Crops are cut in the cutting part at the start. From this, a mixture of straw and grain is sent to an intake of the threshing part; then, the mixture is separated into grain, straw, and tailings. Then, a

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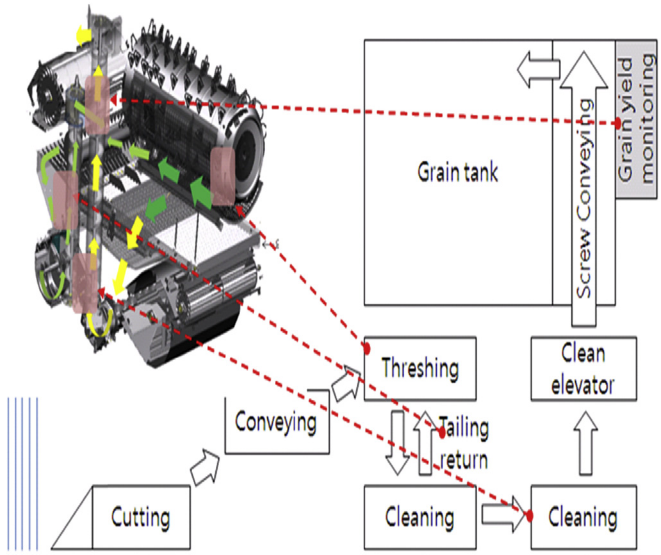

Fig. 1. Grain harvesting system.

conveyor recirculates a stream of the tailings that consists of mixed grain and straw along a path back to the intake. Before the crops enter the grain tank, the sensors attached at the level of the top of the screw monitor the amount of grain being conveyed in real time.

At the start, the grains from the hopper are conveyed through the rotating horizontal screw and are then passed over to the elevating screw. Before the grains are put in, the grain amount is signaled by a capacitive proximity sensor located on the top of the elevating screw.

The sensor signal is on real-time monitoring by the one-chip microprocessor (see Hidaka and Kurihara, 2007). The signal measured by the sensor is transferred to the PC using the RS232C serial port. A schematic diagram of the measurement setup is shown in Fig. 2.

Fig. 3 shows the relationships between the screw position and the sensor signal value according to the grain transport stage. The signal from the sensor was measured in voltage.

Fig. 4 shows the grain feed rate signals based on the grain amount. Fig. 4[a] shows no signals owing to the amount of feed grain at the initial signal stage. Fig. 4[b] represents the state of a small amount of feed grain. This signal shows a rapid increase when it gets closer to the screw. Fig. 4[c] shows signals approaching the maximum value due to the large amount of feed grain present when transported.

2.2. Preliminary and field tests

Preliminary and field tests were carried out in this study. Fig. 5 shows the motor for rotation and crop input unit. In order to progress by unit, a test was performed using the grain threshing machine part. Driving the speed of the actual state, a hopper was used to progress input randomly into grain.

(1) Preliminary tests

For rotating the separate threshing unit, 1 hp at 1690 rpm AC motor was used. Special care was taken to uniformly put the grain onto the conveyor unit. Thereafter, a 40 kg batch of rice grain was

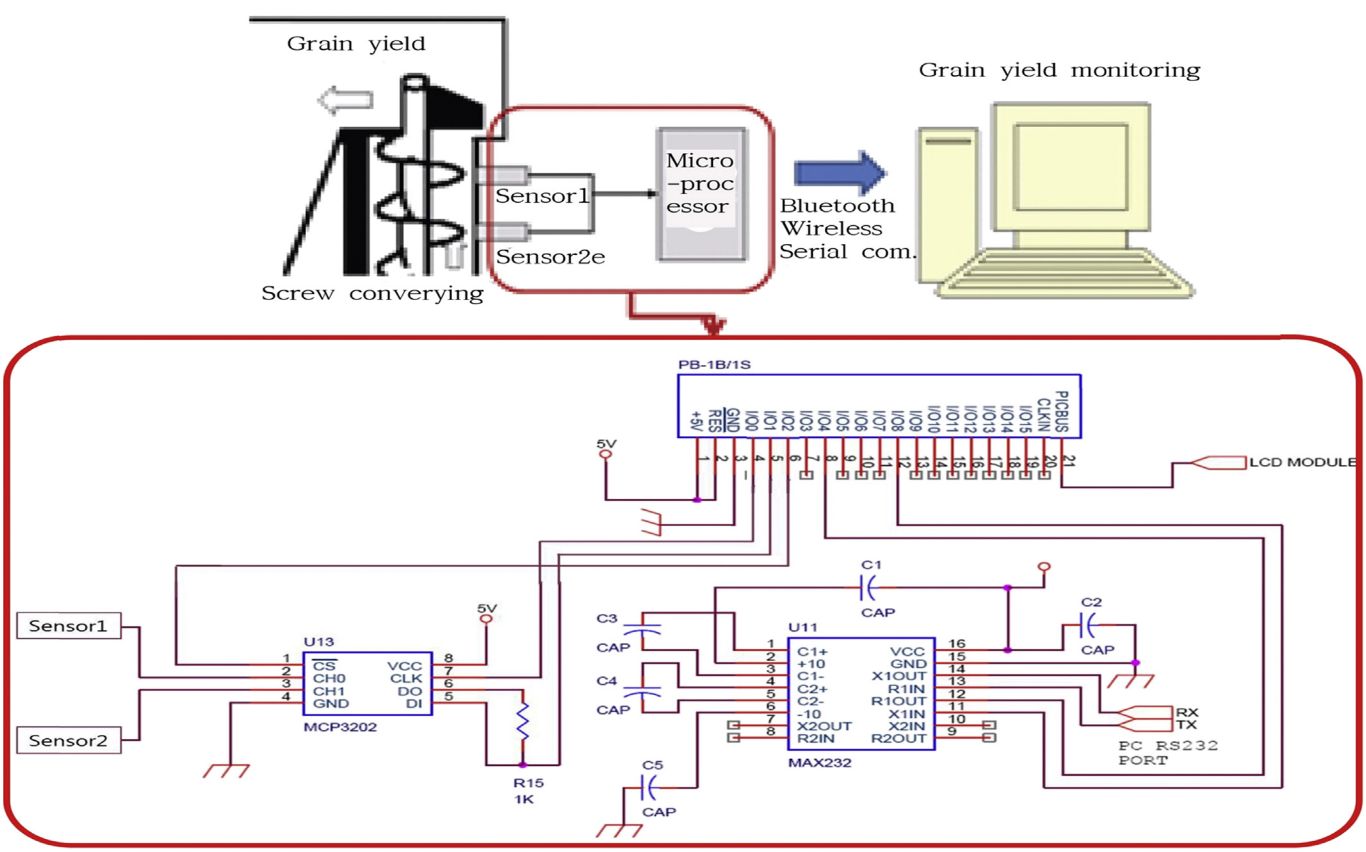

Fig. 2. Schematic diagram of the measurement setup.