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Development of Mobile Eggplant Grading Robot for Dynamic In-field Variability Sensing

— Manufacture of Robot and Performance Test —

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Abstract

A machine vision-based mobile eggplant grading robot was developed as a model to sense and log essential data needed for precision farming and traceability of agricultural crops. The robot consisted of battery railcar, trailer, grading mechanisms including manipulator, end-effector, machine vision and divider. Manually operated, the robot moved along crop ridges during the harvesting process with the grading mechanisms all mounted on the trailer. The robot sensed and logged the field spatial variability dynamically by grading manually harvested eggplant fruit of individual tree. This paper presents the details of manufactured robot and results of the performance test conducted. Test results showed that the robot was feasible for field spatial variability sensing in greenhouse.

[Keywords] eggplant, grading, machine vision, post harvesting, traceability, precision farming

I Introduction

Precision farming (PF) introduced in 1990s was another agriculture revolution brought about by the development in information technology (IT). Demand for effective crop field management has generated growing interest in the study of field spatial variability. Implementation of PF requires several fundamental principles of the electronics technologies such as Global Positioning Systems (GPS), Geographical Information Systems (GIS), yield monitors, Variable Rate Application (VRA), and remote sensing. Citrus, cotton, grain, peanuts, potatoes have attracted much attention from researchers for many years mainly because of mass production of these agricultural crops (Tumbo et al., 2002; Rains et al., 2005; Nathan and Jonathan, 2004;Vellidis et al, 2001; Persson et al., 2004). On the other hand, implementation of PF in small-medium scale farm has received little attention. In Japan, most of these small-medium scale farms produce horticultural crops such as vegetables, fruits and specialty crops. The current used PF equipments are impractical or unsuitable for small-medium scale farms as these equipments were designed and developed for large-scale farms. For instance, the current GPS system reading was lacks precision for location reading of individual trees. Individual tree-based sensing is desirable as such data enable farmers to address the special needs of individual tree within the field.

In-field spatial variability map is one of the important components for site-specific crop management. Such maps can be use to identify localized problems and are helpful in making decisions related site-specific management. Maps are generally constructed by correlating the in-field spatial variability to the location data. A dynamic sensing device is required to sense and record the in-field spatial variability. Crop apparent attributes are important information indicating soil fertility and surrounding conditions. Currently, there are plenty commercial fruit grading systems (Throop et al., 2005; Kurita et al., 2006; Shearer and Payne, 1990; Leemans and Destain, 2004; Blasco et al., 2007; Miller and Delwiche 1989; Laykin et al., 2002). Such grading robots generally operate in centralized grading facilities where neighboring growers ship in their crops for grading and payroll tallies. Although such

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static grading systems could grade the crops precisely, it is difficult to construct in-field spatial variability map. This is because the location data is unavailable and crops are graded regardless of origin. The static grading systems cannot correlate the crop apparent attributes to the location data. Therefore, an on-the-go grading robot that can grade the crop and log location information is required for constructing in-field spatial variability map.

Qiau J. et al., (2005) attempted to perform individual tree-based sensing for the sweet pepper using a mobile fruit-grading robot. The robot sensed the in-field spatial variability by acquiring 5 images of manually harvested sweet pepper. Fruit mass was measured using an electric scale. Quantity, mass and appearance of the fruits were interpreted as the spatial data of individual trees. However, the location data was manually recorded and post-processed. Data collected from the images were then integrated into the manually recorded location data to create the in-field spatial variability map in a matrix form. Real-time application of the prototype robot is constrained by lack of location data logging system. Nevertheless, the laboratory test conducted on the prototype demonstrated that individual tree-based sensing is feasible and is applicable to other horticultural crops.

The objective of this study is to develop a mobile fruit-grading robot for eggplant, equipped with dynamic location data logging system using odometry approach and integration of incremental motion information from wheel rotation. In order to position the spatial data, a rotary encoder attached to the wheel provided a location data by measuring traveled distance from a referenced point. This approach explored the advantages of eggplant cropping system trees are planted in rows with fixed spacing. With a coordinate system, the X-coordinate data was interpreted from a referenced point of each row while the Y-coordinate data was interpreted from the location of the furrow. Odometry approach was evaluated its feasibility in providing the location data. This paper reports the performance of a prototype robot on dynamic location data logger system.

II Material

1. Eggplant

Eggplant is one of the most consumed vegetables in Japan, with an annual yield of 372,400 t and an average of 3,350 kg/10 a. Intensive care including sufficient and consistent supply of fertilizer and water to the trees are required for quality eggplant production. Quality eggplant fruits are firm, heavy (in relation to size), free from defects and decay, and have glossy outlook. Fruits are harvested after attaining required size for marketing. In order to prevent any damage during fruit handling, the eggplant fruits are harvested manually with pruning scissors, leaving the calyx attached to the fruit. Since the eggplant fruits are perishable, the manual harvesting is unavoidable due to the current market demand for defect-free fruits. During harvesting, grower moves in between the crop ridges pulling a cart. Harvested eggplant fruits are then placed in the containers loaded on the cart. Filled containers are emptied into the truck for shipping. Such practice enables the grower to have knowledge on the crop yield per tree in the field. Observations made show that a grower can harvest an average of 2 medium-sized fruits at a time lasting approximately 15 seconds. This study concentrated on fruit size between 120-220 mm in length and acceptable to the market. Usually, three to five fruits with individual weight of between 65-130g were harvested from a healthy tree.

2. Training system of eggplant trees

Conventional training system of eggplant trees was investigated before the prototype was developed. The spacing varies with the cultivar, soil type and cropping system and can be generally categorized into two groups: (i) the “summer” eggplant, seasonal and grown from summer to early autumn on open field, (ii) the “autumn” eggplant, grown from autumn to end of spring in greenhouse. This study focused on the “Senryo” cultivar of “autumn” eggplant. Trees were planted in a single-rows of approximately 1.8-2.0 m width at the center of a ridge, with varying length depending on the size of the greenhouse For suitable yield, the ideal spacing between the trees is approximately 600 mm. Trees are pruned to maintain two branches from the main stalk, and are normally staked in U-shaped or V-shaped manner to support the tree from fruit load. Tree height is maintained at approximately 1.6 m and fruits position ranges from 0.6-1.5m from the ground. Figure 1 shows the training system of eggplant trees for the prototype.