Variable Rate Spraying System for Orchard Trees

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Abstract – *Automatic pesticide spraying requires precise calculation of canopy size of trees. It is challenging due to complicated growth structures and sizes of plants. In growing seasons, we found trees have different shapes and sizes. So we need to assess this changing things about tree like heights, widths, diameter and total canopy volume of tree. It is important to calculate canopy volume to advance spray application efficiency as well as reduce the atmospheric pollution. Because if canopy volume of tree changes then requirement of pesticide doses will changes. So each and every tree has different requirement of pesticide. Hence this literature review focuses on many techniques used by the researchers for calculate accurate canopy volume and also application of optimum amount of spray on targeted trees.*

Key Words: **Canopy volume, Variable rate spraying, Ultrasonic sensor, Target Detection.**

1. INTRODUCTION

Canopy volume is refers to the canopy cover which is visible by our eyes. Actually it is the space we have to find which is acquired by different organs of plant like leaves and branches of any plant. This canopy volume parameter is useful to define plant growth as well as productivity of plant. And hence they can be indicators for tree biomass and growth assessment, crop forecasting, water utilization assessment, health evaluation, and long-term fertility monitoring. Thus, there are large amount of agricultural applications insecticide treatments, watering to plants, fertilization, and crop training which depend largely on the structural and geometric characteristics of the above-ground organs of plants. So here need is to Develop automated equipped system with potential of finding canopy characteristics to bring down environmental contamination and production costs.

Some of the applications like Automatic pesticide sprayers require precise calculation of canopy size. Important factor about plant is it must have saved from attacks of insects and various diseases. Farmers mainly uses large amount of pesticide treatment or chemical application for higher production. But excessive use of chemicals causes Effect on fruits and soil productivity which pollute the environment. Thus it is harmful for human health. Spraying pesticide is also causes harm to human body through air because of this chemicals. Hence it is important to develop system which calculate parameters of tree like height, width and diameter of plant and find the canopy volume so we can decide how much amount of pesticide application requires to the specific plant which can give proper solution to our many problems.

2. Literature Review

Due to the irregular shapes and structure of trees canopy measuring is complicated .Various techniques have been investigated to achieve this goal. For example, orchard tree structure digital test system developed to estimate tree canopy size. In this paper Author has developed a system under ultrasonic technology. System includes a conveying platform, lower computer and upper computer. The sensor can calculate the distances between the tree canopy and the sensor using the slider moves vertically. They placed ultrasonic sensor at fixed at positions. Distances from different height series can be processed into Access database. The lower computer made up of a circuit board, motor driver and current voltage converter. The circuit board used to read sensor data, process the data, and send the result to the upper computer. Upper computer used to record data into Access database and show the results to the users at the same time. According to measured distances, the volume of the tree canopy can be obtained. A Hawthorn tree structure is calculated By using the orchard tree structure digital test system,. The result gives that probing accuracy is not less than 87%. The orchard tree structure digital test system is designed with high accuracy, reasonably, and is easy to use. The probing volume of tree canopy is greater than the actual volume, which could be corrected appropriately [1].

In some research, MATLAB software is used to analyze ultrasonic energy based on transmitted and echo waves. In this paper Author has developed a canopy density model for planar orchard target density detection testing system based on an ultrasonic sensor. In which Orthogonal regression central composite experiments were designed and conducted using man-made canopies of known density with three or four layers of leaves. The target density detection system consist of an oscilloscope, a DC power supply, a test bench, an ultrasonic sensor, a fixed mount, and a computer. The test bench consists of a wooden frame, fishing lines and wire fencing. The wire fencing was fixed to two sides of the wooden frame to attach fishing lines. Fishing line crossed the wire fencing grid in the same plane to constitute a layer, the spacing of fishing line was 5 cm. there were nine rows of two fishing lines in each layer. The leaves could be clamped on each row using clips. The leaves of the Chinese glossy privet were chosen for the experiment. It showed that the relative errors of model density values and actual values of five, four, three and two layers of leaves were acceptable [2].

Some researches has developed system to test the durability and measurement stability of an ultrasonic sensor under laboratory simulated, potential field spray application conditions and to determine the strategy for a variable-rate tree liner sprayer optimum sensor implementation shown. An outdoor-use, water proof ultrasound sensor was used in this research. To acquire data from sensors, a custom-designed data acquisition system was built with a peripheral interface controller. The PIC triggered the sensor and received analog signals from the sensor. By using the embedded A-D converter module of the PIC, the signal was converted to a discrete digital number. After the AD conversion, the digital information was sent to a laptop computer via serial communication. The operating pressure was carefully controlled by pressurized air. Spray nozzle operation was controlled by a solenoid valve coupled with an N-channel power MOSFET. The PIC in the data acquisition system triggered the valve via a data acquisition synchronize the logic signal and nozzle spraying. At the sampling rate of 10 Hz Sensor output data were collected for 5min, and three times for each sensor–nozzle configuration

Data collection was replicated and operating pressure. From the collected data, RMS errors of the sensor measurements were calculated, and the errors were used to identify the differences in the RMS errors on spray nozzle operating pressures [3].

In some researches, Electronic Control System is developed for Pesticide Application Proportional to them Canopy Width of Tree Crops which is based on ultrasonic sensors and proportional solenoid valves was mounted on an air-assisted sprayer [4]. The sprayer flow rate adjustment was based on the relationship between the actual tree width measured by the ultrasonic sensors and the maximum tree width of the orchard. The prototype was tested in olive, pear and apple orchards to assess the system performance in different crop geometries. The spray deposit distribution was measured in comparison with conventional air-assisted applications. Metal tracers were used so that spray deposits for each treatment could be measured on the same samples, reducing sampling variability. Liquid savings of 70%, 28% and 39% in comparison to a conventional application were recorded in the olive, pear and apple orchard respectively, which resulted in lower spray deposits on the canopy but a higher ratio between the total spray deposit and the liquid sprayer output (i.e. better application efficiency). A reduction of the maximum tree width parameter in the control algorithm in the apple orchard reduced spray savings but increased spray deposition, with spray savings mainly in the middle level of the outside canopy, compared to conventional air-assisted applications.

To developed characterized tree canopy structures under various laser sensor travel speed and detection distances by using Lidar-based interactive target detection system. The system consist of a sliding motion control system and a Lidar-based target detection unit. Laser scanning sensor used 2700 range for target detection unit used a to measure target object surface distances based on the time-of-flight principle. The control system controlled the laser sensor travel speed and travel distance by specifying a position and speed as a set point. To generate the reference (command) pulse trains using the embedded program was developed with MDK-ARM Keil IDE tools. The integrative touchscreen was configured in MODBUS communication protocol to offer effective user-machine interaction via custom designed graphical user interface (GUI). by using C++ and MATLAB programming languages A real-time data acquisition and data post-processing programs were developed based on respectively. For a wide range of parameters entire system was tested in the laboratory and operating conditions. At very low travel speed and high travel speed the system could detect and characterize tree canopy structure with acceptable accuracy [5].

In this paper, the author has developed system to evaluate the performance of an ultrasonic sensor under laboratory and field conditions. It is used to estimate distance measurements to apple tree canopies [6]. The aim behind this work is to analyse sensor performance to find the distance between greenery of plant and what are interference occurs in sensing operation. When ultrasonic sensor is analysed under laboratory condition, Results show that the average error in distance measurement with respect to the manual measurement is ±0.53 cm. despite of all possible sources of error, average error in distance measurement is relatively small.

And when ultrasonic sensor analysed under field, the average error is ±5.11. As we going to increase distance between sensor and plant then effect of interference occurs that may change the value and error may increase. When we put the sensor 30cm away from plant, it gives average error of ±17.46 cm. when we put the sensor 60cm away from plant, it gives average error of ±9.29 cm. thus as we increase distance between sensor and plant, interference get reduced. Hence we get large difference in testing within laboratory condition and field condition. Result shows that field condition is suitable for estimating distances [6].

In this paper the hyperspectral–hyperspatial fusion technique used to collects and processes information from across electromagnetic spectrum. The main aim of this method is to obtain spectrum for each pixel in the image of scene for finding any object or detect the object. The simulated citrus orchard trees are used for biological parameter extraction. The goal of this parameter extraction and optimization is to find values which reduces difference between measured values and results obtained by evaluation. Accurate measurement of water stress is obtained fusing thermal hyperspatial and hyperspectral imagery. For a better assessment of biophysical parameters in field areas, unmixing-based fusion technique on a hyperspectral airborne and hyperspatial dataset is used. They first tested the unmixing-based fusion method on simulated datasets to evaluate the proposed method. The fusion method was applied on a real test case, in which hyperspectral and hyperspatial thermal images were combined in order to better and more accurately detect water stress in commercial citrus orchards [7].

In this paper the performance of ultrasonic sensor is evaluated for target detection which is helpful for variable rate spraying technology. In growing seasons, the shape of plants are changed and getting irregular shapes. Due to this if canopy volume of tree changes then requirement of pesticide doses will changes. So each and every tree has different requirement of pesticide as per their respective canopy volume. As crop width changes, it may change volume. So it is need to estimate this values time to time. Thus A multi-nozzle air-blast sprayer was fitted with three ultrasonic sensors and three electro-valves, is used to adjust the flow rate from the nozzles in real time. The variations of crop width measured by the ultrasonic sensors will define the total flow rate sprayed by the nozzles. As compared to the conventional application, the pesticide liquid is 58% less was used. As per detailed analysis the pesticide liquid is uniformly sprayed to each and every part of tree like leaves and branches. Also reaches to inner part of crop. Thus, important fact that the reduction in spray volume could be followed by an equivalent reduction of plant protection products [8].

In this paper an orchard air-carrier sprayer is used evaluate the performance of a control system. By using the ultrasonic technology the target detection has been obtained so we can get the information about target thing. In the sprayer control system three-nozzle manifolds on each side of the sprayer were controlled by an on-board computer for precise pesticide spraying. Field tests were conducted to investigate the spray volume savings achieved through use of the control system. For peach and apple trees, the relationships between spray volume savings and orchard target architecture were analysed. Spray liquids savings ranged from 28 to 52%. As per the predicted and observed reductions in amount of spray liquid applied in apple and peach orchards, the performance of an orchard target-sensing and sprayer control system is evaluated. For a simple target presence/absence scheme of sprayer control, spray savings could be accurately estimated from the physical measurements of the target orchard section. Target crop architecture is important for spray dose application due to use of control system. Thus it increases the liquid volume saving compared to conventional application [9].

In this article an original algorithm created to detect and count trees in orchards using very high resolution images. The algorithm is based on an adaptation of the "template matching" image processing approach, in which the template is based on a "geometrical optical" model created from a series of parameters, such as illumination angles, maximum and ambient radiance, and tree size specifications. For four images from different regions of the world and different crop types, the algorithm is tested. These images all have < 1 meter spatial resolution and were downloaded from the Google Earth application. Results shows that the algorithm is very efficient at detecting and counting trees as long as their spectral and spatial properties are relatively constant. The overall accuracy was clearly above 90% for walnut, mango and orange trees. Due to openness of the apple trees or spaces between branches, gives poorer results which is under 75% [10].

3. CONCLUSION

As per this survey, concluded that ultrasonic technology is more reliable because of more accuracy and lower cost. It gives less relative error between measured value and actual value of canopy volume. Hence, liquid pesticide saving is more in comparison to the conventional application because of precise calculation of tree canopy volume.

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