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Plant Height Automation

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Abstract*: Plant height plays a crucial role in the growth and development of plants, and maintaining optimal plant height is essential for maximizing crop yields and quality. Automation technologies offer a promising solution to efficiently monitor and control plant height, particularly in hydroponic or soilless cultivation systems. This abstract presents a methodology for plant height automation that focuses on the supply of nutrient solution based on real-time height measurements. The methodology involves selecting and installing appropriate sensors, calibrating the sensors, defining height thresholds, connecting the sensors to an automation system, programming the system to trigger nutrient supply adjustments, and continuously monitoring and fine-tuning the process. By automating the nutrient supply based on plant height measurements, growers can create an optimized growth environment, promoting consistent plant growth and improving overall crop productivity. The abstract highlights the significance of plant height automation and provides a roadmap for implementing an effective automation system for precise nutrient management in plant cultivation*

Keywords: Plant Height, Raspberry pi3, Water Pump

I. INTRODUCTION

Image analysis is a powerful tool that is used in a variety of applications, including plant growth monitoring and research. In the context of plant height measurement, image analysis involves the use of cameras or drones to capture images of plants, followed by the processing of these images using specialized software. The software used for image analysis typically relies on computer vision algorithms to identify the plant canopy in the images and measure its height. This involves a series of steps, including image processing, feature extraction, and machine learning. The software may also need to take into account factors such as perspective distortion and lighting variations in order to provide accurate measurements. One advantage of image analysis is that it can provide more detailed information about plant growth beyond just plant height. For example, it can be used to measure leaf area, stem diameter, and plant volume.

This can be useful for researchers studying plant growth and development, as well as for farmers and growers looking to optimize crop yields. Another advantage of image analysis is that it can be done remotely, which is especially useful in large-scale applications. For example, drones can be used to capture images of crops in large fields, which can then be processed using image analysis software to monitor crop health and growth. This can be a more efficient and cost-effective approach than traditional manual methods. Overall, image analysis is a valuable tool for automating plant height measurement and monitoring plant growth. However, it requires specialized software and equipment, as well as a certain level of expertise to use effectively.

II. LITERATURE SURVEY

[1] “An image processing approach for measurement of chili plant height and width under field conditions” Chanchal Gupta V. K. Tewari Rajendra Machavaram Prateek Shrivastavastava Agricultural and Food Engineering Department, IIT Kharagpur, India July 2021. Plant height and width is an essential phenotypic parameter that can be used not only as an indicator of overall plant growth but also used to estimate the advanced parameters such as the design of agricultural machines, estimation of yield, and site-specific applications. Presently, chili plant height and width are mostly measured manually, which is laborious and time-consuming process. The goal of this study was to develop and evaluate a real-time phenotyping system using an image processing approach to measure chili plant height and width under field

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conditions. The image processing algorithm was level-opened and compiled in the open-source computer vision library (OpenCV) and Python language using PyCharm as an integrated development environment (IDE). The developed image processing algorithm was evaluated in both static and field conditions in two plots of chili plants. The developed system was able to capture a valid image of the chili plant under field conditions and accurately estimate the height and width of the plant with a RMSE in the ranges of 0.30-0.60 cm.

[2] "Plant Height Prediction for Maize Using UAV-Based Multispectral Imagery and Machine Learning Techniques" Lucas Prado Osco,José Marcato Junior, Ana Paula Marques Ramos, Danielle Elis Garcia Furuya, Dthenifer Cordeiro Santana,Department of Agronomy, Federal University of Mato Grosso do Sul (UFMS), Rodovia MS 306, km. 305 Caixa Postal 112, Chapadão do Sul, MS 79560000, Brazil October 2020. Under ideal conditions of nitrogen , maize can grow to its full potential, reaching maximum plant height (PH). As a rapid and nondestructive approach, the analysis of unmanned aerial vehicles (UAV)-based imagery may be of assistance to estimate N and height. The main objective of this study is to present an approach to predict leaf nitrogen concentration and PH with machine learning techniques and UAV-based multispectral imagery in maize plants.

[3]"Chlorophyll estimation in soybean leaves infield with smartphone digitalimaging and machine learning"Oveis Hassanijalilian, C. Igathinathane, Curt Doetkott, Sreekala Bajwa, John Nowatzki , SeyedAli Haji Esmaeili Department of Agricultural and Biosystems Engineering, North Dakota State University, 1221 Albrecht Boulevard, Fargo, ND 58102, USA, July 2020. Soybean leaf chlorophyll content is indicative of the plant growth and health issues. However, chlorophyll measurement using the standard chemical procedure is laborious, while the sensor-based electronic options, such as soil plant analysis development (SPAD) meter tend to be highly expensive and made only spot measurements. Therefore, a simpler and less expensive infield method of chlorophyll measurement in soybeans using smartphone camera with image processing and machine learning models was developed.

[4] "Leaf segmentation in plant phenotyping: a collation study" Hanno Scharr, Massimo Minervini, Andrew P. French, Christian Klukas, David M. Kramer December 2019 Image-based plant phenotyping is a growing application area of computer vision in agriculture. A key task is the segmentation of all individual leaves in images. Here we focus on the most common rosette model plants, Arabidopsis and young tobacco. Although leaves do share appearance and shape characteristics, the presence of occlusions and variability in leaf shape and pose, as well as imaging conditions, render this problem challenging. The aim of this paper is to compare several leaf segmentation solutions on a unique and first-of-its-kind dataset containing images from typical phenotyping experiments.

[5] "Leveraging Image Analysis for High-Throughput Plant Phenotyping" Sruti Das Choudhury, Ashok Samaland Tala Awada, School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, United States 24 April 2019. The complex interaction between a genotype and its environment controls the biophysical properties of a plant, manifested in observable traits, i.e., plant's phenome, which influences resources acquisition, performance, and yield. High-throughput automated image-based plant phenotyping refers to the sensing and quantifying plant traits non-destructively by analyzing images captured at regular intervals and with precision. While phenomic research has drawn significant attention in the last decade, extracting meaningful and reliable numerical phenotypes from plant images especially by considering its individual components, e.g., leaves, stem, fruit, and flower, remains a critical bottleneck to the translation of advances of phenotyping technology into genetic insights due to various challenges including lighting variations, plant rotations, and self-occlusions.

[6] "Measurement and Calibration of Plant-Height from Fixed-Wing UAV Images" Xiongzhe Han, J. Alex Thomasson, G. Cody Bagnall, N. Ace Pugh, David W. Horne, William L. Rooney, Department of Biological and Agricultural Engineering, Texas A&M University, College Station, TX 77843, USA, November 2018. Continuing population growth will result in increasing global demand for food and fiber for the foreseeable future. During the growing season, variability in the height of crops provides important information on plant health, growth, and response to environmental effects. This paper indicates the feasibility of using structure from motion (SfM) on images collected from 120 m above ground level (AGL) with a fixed-wing unmanned aerial vehicle (UAV) to estimate sorghum plant height with reasonable accuracy on a relatively large farm field.

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III. OUTCOME OF LITERATURE SURVEY

- By referring nearly10 papers and journals related to the project, the outcome for the literature survey is as follows it can conclude that many surveys had been done on plant height detection
- The image processing method was found to accurately estimate the real-time plant height
- The image processing algorithm approach using OpenCV and Python language was strongly correlated with manual measurement values

IV. PROBLEM STATEMENT

The objective of plant height automation is to provide an efficient and accurate method for measuring plant height and monitoring plant growth.

V. METHODOLOGY

Proposed Model:

The proposed system totally consists of a capturing section and an output section. The block diagram from the proposed model, the capturing section consists of a camera, an optocoupler and a power supply connected to the Raspberry Pi3 directly. When the camera is focussed onto a certain plant, the camera detects the height, or the length of the plant placed at least 1m apart from the plant. Based on the plant's height the output section begins to work. In the output section, we have a relay, water pump and a laptop to show the output on to the screen. When the camera captures the height of the plant, the data gets stored and checks the data to give an output. the output here, refers to the flow of the water pump, the data that is collected measures the initial length of the plant and releases the water pump into the pot. In actuality, this data is being referred as the initial growth of the plant and refers the data for every length of the plant it grows. In certain environmental factors, the growth of the plant is stunted or rather remains the same height, during that situations the same amount of water will be served to plant until it detects a change in them.

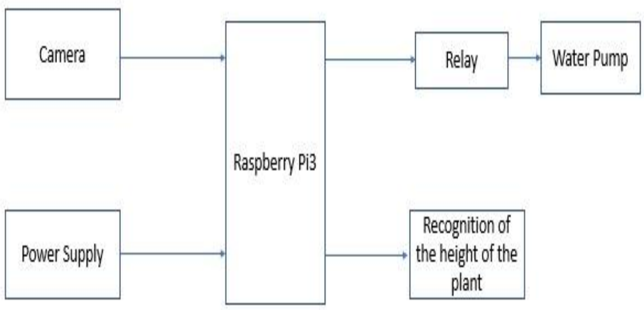

Fig 1: Block Diagram of Proposed Model

VI. HARDWARE AND SOFTWARE REQUIREMENTS

Raspberry pi

The Raspberry Pi is a series of small, single-board computers that were designed for educational and hobbyist purposes. The first Raspberry Pi was released in 2012 by the Raspberry Pi Foundation, a UK-based charity organization.The Raspberry Pi boards are small and affordable, with a credit card-sized form factor, and run on the Linux operating system. They have a variety of inputs and outputs, including HDMI and USB ports, GPIO pins, and a camera interface. The Raspberry Pi boards are highly customizable and can be used for a wide range of projects, from simple experiments to complex computing tasks.The Raspberry Pi 3 is a model of the Raspberry Pi series of single-board computers. It was released in February 2016 and is the successor to the Raspberry Pi 2.The Raspberry Pi 3 is powered by a quad-core ARM Cortex-A53 processor, running at 1.2GHz, which provides a significant improvement in performance compared to the Raspberry Pi 2. The Raspberry Pi 3 comes with 1GB of RAM, which is the same as the Raspberry Pi 2.The Raspberry Pi 3 has built-in Wi-Fi and Bluetooth connectivity, which allows for easy wireless communication with other devices.The Raspberry Pi 3 has a 10/100 Ethernet port, which allows for wired network connectivity.The Raspberry Pi

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3 has the same set of GPIO (General Purpose Input Output) pins as previous models, which can be used to interface with external sensors, actuators, and other electronic components. Operating system: The Raspberry Pi 3 supports various operating systems, including Raspbian, Ubuntu, and Windows 10 IoT Core. Power consumption: The Raspberry Pi 3 has a slightly higher power consumption compared to the Raspberry Pi 2, but it still remains relatively low and can be powered by a 5V micro-USB power supply. Projects: The Raspberry Pi 3 can be used for a wide range of projects, such as building a media centre, a retro gaming console, a home automation system, a weather station, or a robot.

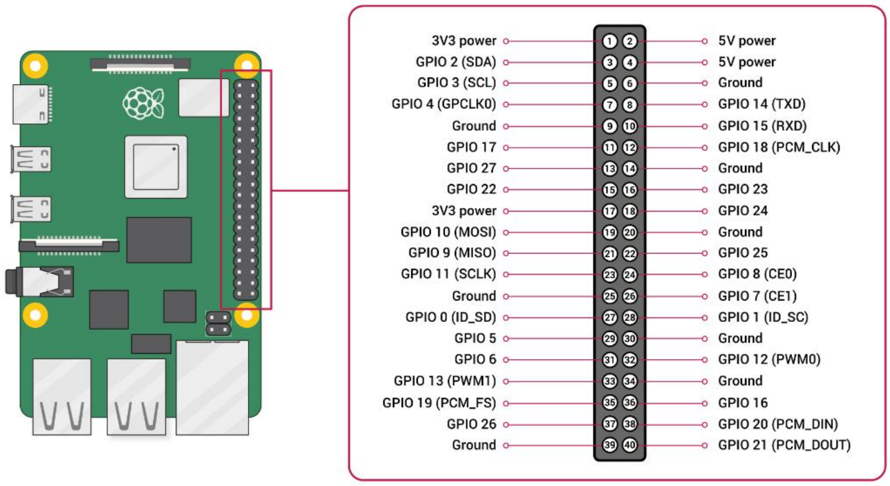

Fig 2: Raspberry Pi3

USB Camera

A USB camera is a type of digital camera that connects to a computer or other device via a USB (Universal Serial Bus) port. USB cameras are typically small and portable, and can be used for a variety of applications, such as video conferencing, video surveillance, and live streaming. USB cameras are designed to be easy to use and can be connected to a computer or other device without the need for any additional hardware or software. Most USB cameras are plug-and-play devices, which means they can be connected to a computer and will automatically be recognized and installed by the operating system. USB cameras come in a variety of shapes and sizes, with different resolutions and features. Some USB cameras are designed for high-quality video and image capture, while others are designed for low-light or infrared imaging. Some USB cameras also come with built-in microphones or other features such as autofocus or zoom. One advantage of USB cameras is that they are often less expensive than other types of digital cameras, making them a popular choice for applications where cost is a concern. They are also easy to set up and use, which makes them a good choice for non-technical users. USB cameras are a versatile and convenient option for a variety of imaging applications and are widely used in both consumer and professional settings.

Fig 3: USB Camera

Relay

A relay is an electrical switch that is operated by an electromagnet. It consists of a coil, an armature, and a set of contacts. When a current is passed through the coil, it creates a magnetic field that pulls the armature, causing the contacts to close or open. This allows the relay to control the flow of electrical current to a circuit or device. Relays are used in a variety of applications, such as in electrical power systems, automation, and control systems. They are often used to control large electrical loads or to switch high voltage circuits that may be dangerous for humans to handle directly. There are several types of relays, including electromagnetic relays, solid-state relays, and reed relays. Electromagnetic relays are the most common type of relay and use an electromagnet to operate the switch. Solid-state relays use semiconductor devices such as transistors to switch the current, while reed relays use magnetic fields to operate the switch. Relays are commonly used in combination with other electronic components, such as sensors and microcontrollers, to create complex control systems. For example, a microcontroller might use a relay to switch a high voltage motor on or off based on data from a sensor, relays are an essential component in many electrical and electronic systems, providing a safe and reliable way to switch and control electrical power.

Fig 4: Relay Module

Water Pump

A pump can be used with a Raspberry Pi to create a wide range of projects, such as automating watering systems for plants, creating home automation systems, or controlling water flow for hydroponic gardens. There are several types of pumps that can be used with a Raspberry Pi, including submersible pumps, centrifugal pumps, and peristaltic pumps. Submersible pumps are designed to be placed in water and are often used for applications such as aquariums or fountains. Centrifugal pumps use rotating impellers to move fluid and are commonly used in industrial applications. Peristaltic pumps use a series of rollers to squeeze fluid through a flexible tube and are often used in medical and scientific applications.

Fig 5 : Water Pump

Memory Card

Secure Digital, officially abbreviated as SD, is a proprietary non-volatile flash memory card format developed by the SD Association (SDA) for use in portable devices. The standard was introduced in August 1999 by joint efforts between SanDisk, Panasonic (Matsushita) and Toshiba as an improvement over Multimedia Cards (MMCs), and has become the industry standard. The three companies formed SD-3C, LLC, a company that licenses and enforces intellectual property rights associated with SD memory cards and SD host and ancillary products. The companies also formed the SD Association (SDA), a non-profit organization, in January 2000 to promote and create SD Card standards. SDA today has about 1,000 member companies. The SDA uses several trademarked logos owned and licensed by SD-3C to enforce compliance with its specifications and assure users of compatibility.

Fig 6: Memory card

Lithium-Ion (Li-ion) Battery

A lithium-ion or Li-ion battery is a type of rechargeable battery which uses the reversible reduction of lithium ions to store energy. It is the predominant battery type used in portable consumer electronics and electric vehicles. It also sees significant use for grid-scale energy storage and military and aerospace applications. Compared to other rechargeable battery technologies, Li-ion batteries have high energy densities, low self-discharge, and no memory effect (although a small memory effect reported in LFP cells has been traced to poorly made cells).

Fig 7: Lithium ion battery

6.1 Software Requirements

VNC Viewer

VNC (Virtual Network Computing) Viewer is a software application that allows remote access and control of another computer's desktop. It works by transmitting the screen image of a remote computer over a network to a viewer program running on another computer, which can then control the remote computer as if it were physically present. VNC Viewer is commonly used for remote technical support, remote access to work or personal computers, or for accessing virtual machines and servers. It supports various operating systems including Windows, Mac OS, and Linux.To use VNC Viewer, you must have a VNC server installed and running on the remote computer that you want to access. The VNC server software runs in the background of the remote computer, allowing VNC Viewer to connect to it and display the remote desktop on the local computer.Once you have established a connection between VNC Viewer and the remote computer, you can interact with the remote desktop using your mouse and keyboard, as if you were physically present at the remote computer. You can also transfer files between the local and remote computers and adjust settings such as screen resolution and color depth.

Fig 8: VNC Viewer

OpenCV

OpenCV (Open Source Computer Vision) is a free and open-source software library designed to help developers create computer vision applications. It provides a wide range of functions and algorithms for image and video processing, including object detection, facial recognition, motion detection, and more.OpenCV was initially developed by Intel and is now maintained by the OpenCV Foundation. It supports various programming languages, including C++, Python, Java, and MATLAB, and runs on multiple platforms such as Windows, Linux, macOS, and Android.

Fig 9: OpenCV

VII. EXPECTED OUTCOME

This paper is proposed to provide a nutrient solution based on the height of the plant. The camera that is present captures the plant that is placed at a distance and sends the data to the Raspberry Pi3. The captured plant is displayed on the VNC Viewer and measures its height. This data is kept as an initial height and is referred to for further growth of the plant. The two modules have their importance, the capturing section module monitors the plant height and conveys its readings, and helping us in the automation of the supply of nutrient solutions based on the height.

VIII. CONCLUSION

In conclusion, plant height automation utilizing sensors and an automation system provides an effective solution for precise nutrient management in plant cultivation. By monitoring real-time plant height measurements and adjusting the nutrient supply accordingly, growers can optimize growth conditions and enhance crop productivity. This automation reduces the need for manual intervention, saving time and labor costs. Implementing a systematic approach with calibrated sensors and defined height thresholds ensures accurate and reliable results. Continuous monitoring and fine-tuning of the system maintain its effectiveness over time. Customization to specific cultivation requirements and regular maintenance are essential for maximizing the benefits of plant height automation. Overall, this technology offers significant potential for improving agricultural practices, increasing yields, and advancing sustainable crop production.

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