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Utilizing Potential of Image Processing Techniques in Identifying Plant Phenotypic Characteristics: A Case Study

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SUMMARY

Image processing in identifying the plant phenotypic characteristics is emerging as an important technology to dissect phenotypic components in plants. These technologies allow the non-destructive screening of plants by means of image acquisition techniques. As plants are not static but living organisms with constantly increasing complexity in shape, architecture and appearance, it becomes difficult to analyse its characteristics using conventional methods. This instead can be done by the process of image acquisition and processing. These efficient image processing techniques can help in quantifying plant growth and performance based on plant phenotypic traits by considering its individual components, e.g., leaves, stem, fruit, and flower separately.

INTRODUCTION

Agriculture is the spine of human sustenance in this world. With the growing population now a days, we need more productivity from agriculture sector to meet the increasing demands. Advanced technologies like image processing have been proved to be an effective tool for analysis in various fields to get better results and providing efficient applications in the agriculture sector. With the advancements in agriculture field, huge amount of data is generated from various phenotyping systems. And the acquired data can be used to get the information regarding the parameters like canopy, yield, quality of product which are very important measures in agriculture. With the help of these parameters, smart decisions can be taken for better yield.

Importance of Plant Phenotyping

Plant phenotyping is an important tool to address and understand plant environment interaction and its translation into application in crop management practices, effects of bio-stimulants and microbial communities. Phenotyping with accurate measures has played an important role in the development of improved crop varieties around the world. The researches in this field are prominent because the data analysis of genome has increased the understanding of the field. And with the advancement and availability of inexpensive genotyping tools, crop functional phenotyping is experiencing the era where there is a produce of huge amount data, be it in the form of text, numbers, images, or videos. Having an in-depth data of such detailed information could help to identify suitable traits of plants that can be used for yield estimation. Image-based phenotyping can give vast information about many aspects to the farmer or the researcher. The first one is crop management, like pest and disease detection and irrigation methods. The second one is related to the analysis of physiological characteristics of crop, which helps in the identification of traits like nutrient deficiency and chlorophyl content. The third is, yield quality inspections and sorting using the images. This helps to reduce the use of human labour. Apart from the above areas, image processing can also be used in crop and land estimation using the Geographic Information System.

Image analysis in Plant Phenotyping

Non-destructive imaging of plants allows multiple measurements of plant growth and plant health over time without having to harvest plant material for analysis. These days there is a high usage of image processing in the field of plant phenotyping. There are many types of processing methods and technologies, like image enhancement, image restoration, image compression, or image analysis that are giving considerable results in the field of plant phenotyping. The image analysis particularly is very interesting because it permits to extraction of specific and precise information directly from an image. A processed image can be used for analysis of plant phenotypes, such as size, shape, color, growth, and leaf area. Which can be automatically extracted from image data to observe how such traits change over time. Since image processing is the effective

tool for the analysis of parameters, when it is combined with a communication network, it can be used to connect with the subject matter expert and get expert advice within time and at an affordable cost.

Case study

Experiments conducted by a research group presented methodologies like four-light photometric stereo that were able to extract 3D surface texture from plant at a high resolution. The RGB-D cameras such as the Microsoft Kinect was used for the experiments. This technology was used for the detection of meristem for weeding operation. Other methods were used to measure potato sizes in-the-field using 3D image.

Table1. Experiments conducted

S. No.	Purpose of experiment	Name of the experiment
1	Weed detection	2D weed detection and analysis in the field
		3D weed detection and analysis in the field
		Static four-source photometric stereo for plant analysis
		Two-source photometric stereo for plant analysis from a moving platform
2	Measurement of potato size	Measurement of the size distribution of potatoes as they are harvested in the field

Here the size of potato was calculated using 3D image and was compared with the original size. The system gave the accuracy of within 10% for extended periods and in a range of environmental conditions. The findings of Smith et al. (2018), are significantly important because it used the 3D images, removing the barrier like parallax, perspective, occlusion and changes in background light cause by using 2D images. The experiments also open up opportunities for measurement the size of fruits and vegetables like it is done for potatoes.

Table 2. Salient findings of the experiments

S. No.	Experiment	Findings
1	Weed detection	Different 2D and 3D weed analysis methods were implemented
		A highly functional user-interface was used to pull together the algorithms into one place
		Analysis and export data in a variety of parameters were modified to examine their effect on the resulting estimations
		Vegetation was detected and meristem of plants was localised
2	Measurement of potato size	Accuracy levels of within 10% both in the lab and in field
		The system is also able to operate with a relatively wide range of potato sizes (<45, 45–65, 65–80 and 80+ mm)
		It demonstrated key technologies and functionalities that would be used to implement the efficient potato harvester

CONCLUSION

The experiments successfully showcased how 2D and 3D image analysis can help to extract the plant phenotypic characteristics. However, there are areas on which the improvements can be done in the future for efficient results. Like if the cameras with depth of less than 1mm can be used, it can detect the small details in the leaf. Because of the potential to replicate the experiments easily in the field, the long-term potential benefits to agriculture are very great. And of its low cost, the technology of 2D and 3D Image processing is easy to access and can be widely applied. There is a great difference in the consistency of imaging techniques in environmentally controlled growth chambers and fields. This variation inconsistency should be kept in mind to

understand data collection fundamentals and experimental strategy and proper calibration of imaging-based systems and sensors to make the outcomes more precise and efficient.

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