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Digital Image Processing Applications in Agriculture: A Survey

Janwale Asaram Pandurng
Department of Computer Science
Balbhim Art's, Commerce & Science College Beed
Beed (MS)- India

Santosh S. Lomte
Everest Educational Society's
College of Engineering & Technology,
Aurangabad (MS)- India

Abstract: Image processing has been proved to be effective tool for analysis in various fields and applications of an agriculture sector. Types of imaging techniques such as thermal imaging, fluorescence imaging, hyper spectral imaging, and photometric (RGB) feature-based imaging have contributed significantly.

Image processing along with availability of communication network can change the situation of getting the expert advice well within time and at affordable cost since image processing was the effective tool for analysis of parameters. This paper intends to focus on the survey of application of image processing in agriculture field such as imaging techniques for Crop Management, nutrient deficiencies detection, weed detection and fruit grading. The analysis of the parameters has proved to be accurate and less time consuming as compared to traditional methods.

Keywords: Image Processing, Remote sensing, Nutrient deficiencies, pest identification, Fruit grading, Crop management

I. INTRODUCTION

Image analysis is an effective tool for nondestructive analysis of agricultural objects, and has been widely used in agriculture. Improvement in digital image taking devices and software to operate on images has contributed in this. The main advantage of image analysis is its potential for nondestructive and objective analysis. There are the tools which can process not only visible images but also invisible images to human such as ultraviolet (UV), Near Infrared (NIR), Infrared (IR).

The application of image processing techniques to agriculture done by capturing images through the techniques of remote sensing, involving aircraft or satellites, which were then processed and analyzed using computers. With new technological advancements in image capture and data processing, imaging techniques have been developed to solve various problems in the fields of agriculture. Various types of imaging techniques such as thermal imaging, fluorescence imaging, hyper spectral imaging, and photometric (RGB) feature-based imaging have contributed significantly.

Image processing applications can be used in the following areas of agriculture:-

a) Crop Management: Using pest management detection of insect has been done, wireless sensor network is used for irrigation and weed detection is used for crop assessment using remote sensing.
b) Identification of Nutrient deficiencies and plant content: Nutrient deficiencies and various content of plants have been identified from leaves and skin of product using image processing algorithms.
c) Fruits quality inspection, sorting and grading: To improve and maintain the quality of fruits and vegetables and for Classification of agricultural products, image processing and machine learning is used.
d) Crop and land estimation and Object tracking: Geographic information System (GIS), color and texture segmentation algorithms are used.

II. CROP MANAGEMENT

Crop management includes activities to improve the growth, development and yield of agriculture crop. It includes activities like pest management, irrigation management, and weed detection. Image processing techniques can be used in management of crops.

Piyush Chaudhary et al. [1] proposed an algorithm for disease spot segmentation using image processing techniques in plant leaf. In this paper a comparison of the effect of CIELAB, HSI and YCbCr color space in the process of disease spot detection is done. Median filter is used for image smoothing. Finally threshold can be calculated by applying Otsu method on color component to detect the disease spot. An algorithm which is independent of background noise, plant type and disease spot color was developed and experiments were carried out on different "Monocot" and "Dicot" family plant leaves with both, noise free (white) and noisy background.

Phadikar, S. , Sil, J.[2] the paper describes a software prototype system for rice disease detection based on the infected images of various rice plants. Images of the infected rice plants are captured by digital camera and processed using image growing, image segmentation techniques to detect infected parts of the plants. Then the infected part of the leaf has been used for the classification purpose using neural network.

Yunseop Kim et al [3] this paper describes details of the design and instrumentation of variable rate irrigation, a wireless sensor network, and software for real-time in-field sensing and control of a site-specific precision linear-move irrigation system. Field conditions were site-specifically monitored by six in-field sensor stations distributed across the field based on a soil property map, and periodically sampled and wirelessly transmitted to a base station. An irrigation machine was converted to be electronically controlled by a programming logic controller that updates georeferenced location of sprinklers from a differential Global Positioning System (GPS) and wirelessly communicates with a computer at the base station. Communication signals from the sensor network and irrigation controller to the base station were successfully interfaced using low-cost Bluetooth wireless radio communication. Graphic user interface-based software developed in this paper offered stable remote access to field conditions and real-time control and monitoring of the variable-rate irrigation controller.

Kamal N. Agrawal1 et al [4] this paper proposed the weed detection technique using image processing system. A set of 16, including 11 shape and 5 texture-based parameters coupled with predictive discriminating analysis has been used to identify the weed leaves. Geometrical features were indexed successfully to eliminate the effect of object orientation. Linear discriminating analysis was found to be more effective in correct classification of weed leaves. The classification accuracy of 69% to 80% was observed.

III. IDENTIFICATION OF NUTRIENT DEFICIENCIES

Productivity and the quality of the cultivated crops heavily depend on the natural factors like nutrients, water, etc. There are number of diseases and deficiencies which can affect the productivity of the crops. So to identify the deficiencies present, there are number of traditional laboratory tests are present, which are time consuming processes. So, technology can support to improve the efficiency and decrease time complexity of the tests used for disease and deficiency identification.

This paper [5] introduced software "Nitrate app". The software has revolutionized the method to find nitrogen content in Maize leaves. Approach was to turn the manual process to a software application using image processing .Image of the Maize leaf is captured and preprocessed to remove the noise of source image. The color and texture characters of maize leave are extracted. Color characteristics analyzed using the RGB and the HSV model. A relationship between extracted features and nitrogen content was developed.

In this study [6] they applied a new technique based upon a commercially available hand-held scanner which overcomes the problems. They proposed algorithm to determine chlorophyll content, which non-linearly maps the normalized value of G, with respect to R and B, using a Logarithmic sigmoid transfer functions as follows:

CHOL=logsig[[G-(R/3)-(B/3)]/255]

Where: Correlation between Ch and Lab Ch was higher, Chol: Chlorophyll estimation by Opt leaf , G: Green Color: Red Color: Blue Color

In this study [7] developed classifiers based on different combinations of spectral bands and vegetation indices from original, segmented and reflectance images in order to determine the levels of leaf nitrogen and chlorophyll in the bean, and to defined the best time and best variables. A remote-sensing system was used, consisting of a helium balloon and two small-format digital cameras.

IV. FRUITS QUALITY INSPECTION, SORTING AND GRADING

K-mean clustering for strawberry grading into different categories on the basis of shape, size and color was proposed. [8]. The hardware includes camera, photo sensors with single chip microcomputer. Captured image was converted to G-R so that background can be separated after threshold. K-mean clustering was used to grade the strawberries. Shape was graded into long-taper, square, taper and rotundity using R-G channel and segmentation. This was used to find out contour helpful in indentifying the major axis of direction. Similarly horizontal line with threshold value was identified for size. Strawberry color feature was extracted by the dominant color method on a* channel in La*b* color space. System was also proposed for multi-feature gradation system. Size detection observed has average error of 3.55, color detection success rate was 88.8% and overall grading has 94%.

Fruits and vegetables classification using features and classifiers with fusion was proposed. [9] Images were the collected as a data over the period for distribution in supermarkets. 8bit color images were classified on the basis of statistical, structural and spectral basis. Image descriptors like global color histogram, Unser's descriptors, color coherence vector, border/interior, appearance descriptor, supervised learning techniques were considered. For background subtraction k-mean was utilized. Classification was done using diverse machine learning techniques such as Support Vector Machine (SVM), Linear Discriminate Analysis (LDA), Classification Trees, K-Nearest Neighbors (K-NN), and Ensembles of Trees and LDA and fusion. Multi-class classification provides custom-tailored solutions to problems and performed better. Model was helpful in classifying the species of produce and variety.

Morphological process based image analysis of shape in real time for inspecting and sorting processed mandarin segment was developed. [10] Images in RGB format illuminated with constant source were captured. These images were segmented in background and objects of interest. A morphological operation allows identifying the objects in complete, broken formats. The shape analysis was done by perimeter and area calculation. Once the contour was obtained, FFT was applied to discriminate low and high frequency details which were helpful in size determinations. Standard Bayesian discriminate analysis was used for classification. Mechanical system limits the speed of sorting. Model provided real time classification with enough accuracy.

V. CROP AND LAND ESTIMATION AND OBJECT TRACKING

In this study [11] to improve the performance of crop models for regional crop yield estimates, a particle filter (PF) was introduced to develop a data assimilation strategy using the Crop Environment Resource Synthesis (CERES)—Wheat model. Two experiments involving winter wheat yield estimations were conducted at a field plot and on a regional scale to test the feasibility of the PF-based data assimilation strategy and to analyze the effects of the PF parameters and spatiotemporal scales of assimilating observations on the performance of the crop model data assimilation. The significant improvements in the yield estimation suggest that PF-based crop model data assimilation is feasible. Winter wheat yields from the field plots were forecasted with a determination coefficient ( ) of 0.87, a root-mean-square error (RMSE) of 251 kg/ha, and a relative error (RE) of 2.95%. An acceptable yield at the county scale was estimated with a of 0.998, a RMSE of 9734 t, and a RE of 4.29%.

In this study [12] Tobacco crop area and yield forecasts are important in stabilizing tobacco prices at the auction floors. Tobacco yield estimation in Zimbabwe is currently based on statistical surveys and ground-based field reports. These methods are costly, time consuming, and are prone to large errors. Remote sensing can provide timely information on crop spectral characteristics which can be used to estimate crop yields. The challenges of the different tobacco land sizes have been overcome by identifying suitable satellite platform, with sufficient spectral resolution to separate the tobacco crop from the adjacent competing crops and noncrop vegetative surfaces. The identified suitable index correlated with tobacco in season dry mass and yield. The suitable vegetative indices can be employed in establishing tobacco cropped area and then applied the long-term area yield relationship from government and nongovernmental statistical departments to estimate yield from remote sensing derived cropped area.

VI. CONCLUSION

Image processing technique has been proved as effective machine vision system for agriculture sector. Imaging techniques with different spectrum such as Infrared, hyper spectral imaging, Remote sensing were useful in determining the vegetation indices, canopy measurement, land mapping etc with greater accuracies. Weed classification which affects the yield can be correctly classified with the image processing algorithms. The accuracy of classification varies from 85%- 96% depending on the algorithms and limitations of image acquisition. Thus this approach helps to save the environment as well as the cost. Thus we can conclude that image processing was the non destructive and effective tool that can be applied for the agriculture sector with great accuracy for analysis of agronomic parameters.

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