Development of Counting Algorithm for Overlapped Agricultural Products

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ABSTRACT
Precision agriculture is a management philosophy that meets spatial variability found in agricultural landscapes. Precision agriculture techniques could be used to improve economic and environmental sustainability in crop production and management [1]. Performance evaluation is an important task in the management of agricultural product. The current manual based performance assessment is time-consuming, labor intensive and inaccurate [2]. To address this challenge, we propose a computer vision based system for automated, rapid and accurate assessment of performance.
In this paper an overview of previous research and systems to count the number of agricultural products and the yield estimate is conducted and their limitations are discussed. The computer vision techniques are presented to automate the process of counting. A new approach for counting of overlapped agricultural product is described.
The paper is concluded with results for counting of gerbera flowers by means of HSV (hue saturation and value) color space and erosion process which reduces the problem of overlapping and giving an accuracy of 89.86% under polyhouse conditions.

Keywords
Computer vision, counting algorithm, yield prediction.

1. INTRODUCTION
India is an agriculture based country and it is a very strong source of income for the livelihood of Indian farmers. Agricultural and horticultural products play a vital role in Indian economy as far as the foreign revenue is concerned. The revenue is based on the cataloguing of the product. Info age, for the collection and distribution of information processing the use and development in information and communication (ICT), has been tested and developed in many countries [3].
In post- harvesting stage production and cutting of good size and quality agricultural product, so that the farmer will get a good return in terms of money. Cutting of product is done manually so far which is not only laborious but the cumbersome and time consuming as well [4]. In addition, there are problems with the accuracy of manual count due to the higher amount of agricultural product and depletion of a continuous and repetitive work. Due to the large scale of production, even a 10% error in the estimate is a significant loss to the industry. If overestimated, money on pre-order for ships and trucks is lost and a large investment is potentially blocked due to excessive packing. If underestimated, collectors are insufficient, packers, packaging material and lack of time to sort boats may require a bulk sale of products at a much lower price. It is the need of hour to develop an automatic algorithm to ease the task and do it swiftly with more accuracy and precision. Having a robust automated counting technique facilitates rapid, consistent and convenient way to have products. This saves even more money spent on manual counting, as well as loss due to erroneous estimates.
In the present study we are going to propose a decision support system that could generate agriculture product yield information and serve as base for management & planning of marketing.

2. LITRATURE REVIEW
Jimenez et al. [5] studied on fruit detection using computer vision method. Fruit detection using range images and shape analysis provided better results. In range images each pixel was corresponds to the distance between the sensor and the point of the detected scene.

Annamalai et al. [6] developed an algorithm in which images were processed by HSI (hue saturation and intensity) color space for citrus fruit extraction. Citrus fruits were accurately detected and counted. Results showed that the model can forecast yield enhanced using cameras designed to cover the majority of the tree canopy. Accuracy was less due to three problems such as uneven illumination, partial occlusion, and color similarity.

Cointault and Gouton [7] proposed a feasible system for counting of wheat ears using color and texture analysis. For ear extraction kmeans algorithm was used because it was simple to implement and provide better texture stratification. For counting result improvement, each grayscale of the image was multiply by the contrast, which allows to increase the great intensities of ears and to decrease the weak intensities like soil, branches and leaves. Counting was done by three image processing methods in which first method was 1st order statistics, second was co-occurrence matrix and last was run length method. Run length gave optimum results among three and it was close to manual count.

Wijethunga et al. [8] presented automated counting algorithm for kiwi fruit. Field images were segmented using device independent L*a*b color space. 60% green kiwi fruits and 90% gold kiwi fruits were accurately detected and counted. Green and gold are the varieties of kiwi fruit. Overlapping of kiwi fruit causes false positive detection.

Harmsen et al. [9] presented a multi target tracking algorithm for flower counting in pot plant. Number of flowers in a pot plant determines the price at the time of selling. Flowers were recorded using limited number of 2D images captured by camera. RGB threshold was used for segmentation. To find shape and position of flower in the image adaptive motion model was used. It is an iterative process in which flower position was tracked at the regular instants of time. 94% of correct flowers were counted through this algorithm. In this experiment overlapped flowers were detected as single flower and single flower counted as multiple if it is divided by branches and leaves. If flower was occluded by foliage then it was not detected.

Moonrinta et al. [10] analyzed images captured by monocular camera for pineapple yield estimation. For feature extraction series of experiments were done using scale-invariant feature transform (SIFT), speeded up robust features (SURF) and Harris feature technique. Results concluded that SURF feature points and descriptors gave best tradeoff between time and stratification accuracy. Proposed algorithm still had a problem of merges and fragmentations.

Nuske et al. [11] estimated vineyard yield by detecting grape berries automatically and non-destructively using images captured from vehicles driving camera along vineyard rows. Green berries were detected against green background with the help of color and texture analysis. Yield prediction was done by computing the weight of berries which is equal to product of number of berries and mean weight of berry. Mean weight of berry have 10% variation from year to year.

Akin et al. [12] provided an algorithm that counts number of pomegranates on the tree using near camera images. Color and shape analysis gave the more robust outcomes and simplicity in implementation. In sunny days peels of pomegranate and leaves reflects more sunlight so that proposed algorithm has adaptive threshold value that was applied to the images according to the variable illumination condition. In binary image after thresholding, circles were fitted and their geometric centers were counted which were equal to the number of estimated fruits.

Dey et al. [13] demonstrated yield prediction of grapevine which also applicable for major types of crop. The series of images were exercised using a structure-from-motion module to regain a dense and colored 3D reformation of the scene. The recommend method implemented a combination of shape feature and color model for grapevine extraction. Experiments showed that green grapes (prior to ripening) having accuracy of 0.98 and accuracy of 0.96 for changing color grapes (during ripening).

Patel et al. [14] investigated the use of digital image analysis techniques for developing an automated counting system for all round shape fruits. For color extraction they use L*a*b color space instead of RGB color space and then applied fruit segmentation and edge detection on resultant images. A circular fitting algorithm was used on binary images for exact fruit detection and counting. The proposed method can precisely discriminate the occluded fruits with the counting efficiency of 98%. The algorithm had problem of overestimation and underestimation. When a single fruit was hidden by foliage and the separation distance was more than 9 (3 X 3) pixels then they were counted as different fruits. Sometimes group of fruits were counted as single fruit by the algorithm due to close connectivity.

Linker et al. [15] estimated the number of apples in color images acquired in field under natural condition. Color image was segmented using apple color and smoothness. Arcs were fitted in the segmented images and combined, then compared with reference circle which was a sample model of an apple. 85% of apples were accurately detected in the images. Color saturation and natural illumination causes incorrect detection of green apple.

Wang et al. [2] estimated yield for red and green apple using computer vision based system. Two cameras were used for image capturing by automated orchard support vehicle in night time to reduce illumination effects. HSV color model was used for extraction of useful information. Average diameter and eccentricity of each apple was calculated so that round shape region was recognized as an apple. Threshold for eccentricity was 0 to 0.6 for apple count and below this threshold value, region treated as noise. Two nearby apples touching each other were discriminate by calculating the distance of major axis of ellipse and then split into two parts. Occluded apples were counted as multiple apple so to minimize this problem center of apple to apple edge distance is calculated. If the distance was less than threshold value than an apple was counted as single object. The apple yield prediction errors for red apple were -3.2% of 480 trees and 1.2% for a green apple in 670 sample trees.

Sarkate et al. [3] described a computer vision based system for automating the precise yield prediction of gerbera flower from the polyhouse images. Flowers were extracted using HSV (Hue saturation and value) color model and histogram analysis. Then otsu thresholding was applied for image segmentation process. About 75 images were tested with this technique. System has 80.12% accuracy for pink color flower and 100% for yellow and red color flower. Overall accuracy was 86.58%. The counting results got contaminated majorly due to overlapping of flowers and illumination.

Diago et al. [16] used machine vision system to count the number of flowers for grapevine yield estimation. 90 images were processed for counting of flower using proposed algorithm. Images were captured in open field condition. Regression was analyzed by observation of three cultivators giving regression correlation above 80%.

Dorj et al. [17] developed a computer vision based algorithm to identify and count tangerine flower for yield prediction of tangerine. Important steps of algorithm were consists of image capturing, Gaussian filter in preprocessing step to remove noise from images, white color extraction and segmentation, and at last counting of tangerine flowers. Total 21 sample tree images were captured in May which was the most favorable blooming season for tangerine flower. For noise reduction different Gaussian filter 1x1, 2x2, 3x3 were processed and best result obtained at Gaussian filter 2x2. Images were captured in natural field conditions so that Gaussian filter also minimized the illumination effects.

Sengupta et al. [18] implemented an automatic detection and counting system for yield estimation. Green citrus identification in green background had a very difficult task and having a problem of occlusion. Firstly shape and texture classification combined with support vector machine (SVM) was used to detect as many citrus fruit as possible. Problem of wrong detection were solved by graph based connected component algorithm and Hough transform for line recognition. Over 81% of citrus fruit in a set of images captured from a citrus grove were correctly detected and counted. In the proposed algorithm partially occluded citrus fruit were impossible to detect due to the presence of shadow and cause poor discrimination between the background and citrus fruit.

3. PROPOSED ALGORITHM

Figure 1 gives the process flow chart, to be carried out for the simulation work.

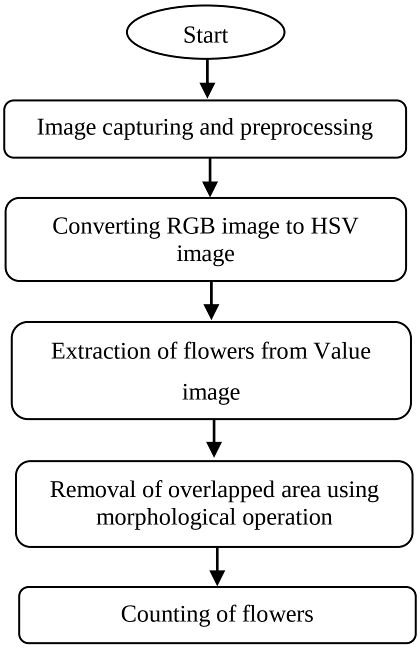

Fig 1: flowchart for counting of overlapped flowers

Images are captured in gerbera polyhouse by digital camera (Sony 12 Megapixels). The distance between the camera and the flower is upto 1 to 3 meters. In the experiment number of image was processed using Dual Core processor with 2 GHz frequency and 2 GB RAM. Original images were not used directly because they contain date and time display. They are cropped and resized into 400 X 533 pixels. For removal of noise Gaussian filter is used with kernel size of 2 X 2. Figure 2 shows the sample test image.

Fig 2: Sample test image

RGB images are converted into HSV color image. HSV color image has three components hue, saturation and value [19]. Value component of HSV image segmented the input image which is shown in figure 3.

Fig 3: Value image

Overlapped flowers are distinguished separately by means of morphological operation. Erosion is one of the most important morphological operations which is applied on value image so that the counting algorithm becomes more accurate. Erosion is the process of eliminating all the boundary elements from an extracted flower region, leaving the region smaller in area by pixels all around its perimeter. Erosion is useful for removing of connected flower regions to some extent and to remove too small area which acts as noise in counting of flowers. Figure 4 shows flower image before and after erosion process.

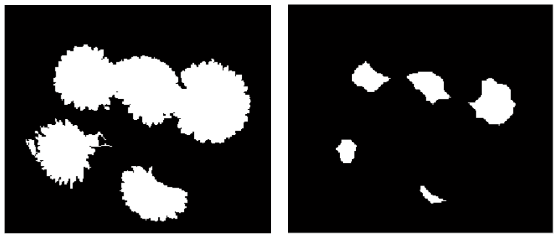

Fig 4: Erosion process

4. EXPERIMENTAL RESULTS

Numbers of images are processed using proposed algorithm. Here counting results for only 10 images are shown in table 1 and graph representation is shown in figure 5. Results showing that the overall accuracy of counting flower is 89.86%. Accuracy is the ratio of algorithmic count to manual count, multiplied by hundred.

Table 1. Manual and Simulated Results Comparison

Image No.	Manual Count	Proposed Algorithmic Count	Accuracy (%)
1.	5	5	100
2.	7	6	85.71
3.	6	5	83.33
4.	8	6	75
5.	5	5	100
6.	5	4	80
7.	6	6	100
8.	9	8	88.88
9.	7	6	85.71
10.	9	9	100

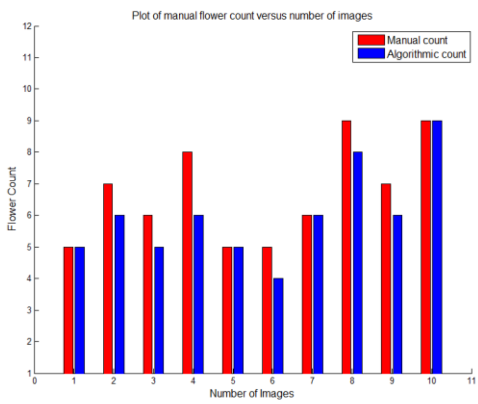

Fig 5: Graph showing manual count & algorithmic count

5. CONCLUSION

HSV color space transformation is a device dependent model and it provides a better segmentation. After segmentation based image, erosion process segregates connected region of flowers and then counting can be done. If the flowers are overlapped more than 30% then they are not separated by proposed algorithm. If we want to separate them then some flowers are eroded fully and missed during the counting process. Proposed algorithm does work well if the images are not suffered from illumination problem.

6. ACKNOWLEDGMENTS

The authors are indebted to the department of electronics and communication, CTAE Udaipur for helping in carrying out the study and the experimental work in the laboratory.

7. REFERENCES

[1] Syal, A. Garg, D., and Sharma, S. 2013. A survey of computer vision methods for counting fruits and yield prediction. International Journal of Computer Science Engineering (IJCSE). 2. 346-350

[2] Wang, Q., Nuske, S., Bergerman, M. and Singh, S. 2012. Automated crop yield estimation for apple orchards. 13th International Symposium on Experimental Robotics (ISER 2012). 1-15.

[3] Sarkate, R. S., Kalyankar, N.V. and Khanale P.B. 2013. Application of computer vision and color image segmentation for yield prediction precision. IEEE International Conference on Information Systems and Computer Networks (ISCON). 9-13.

[4] Kohan, A., Borghaee, A.M., Yazdi, M., Minaei, S. and Sheykhdavudi, M.J. 2011. Robotic harvesting of rosa damascena using stereoscopic machine vision. World Applied Sciences Journal. 231-237.

[5] Jimenez, A.R., Ceres, R., and Pons, J.L. 2000. A survey of computer vision methods for locating fruit on trees. Transaction of the ASAE. 43. 3-23.

[6] Annamalai, P., Lee, W.S., and Burks, T.F. 2004. Color vision system for estimating citrus yield in real time. ASAE/CSAE Annual International Meeting, Ottawa, Canada. 1-9.

[7] Cointault, F. and Gouton, P. 2007. Texture or color analysis in agronomic images for wheat ear counting. Third International IEEE Conference on Signal-Image Technologies and Internet-Based System. 696-701.

[8] Wijethunga, P., Samarasinghe, S., Kulasiri, D. and Woodhead, I. 2008. Digital image analysis based automated kiwifruit counting technique. 23 International Conference on Image and Vision Computing New Zealand. 1-6.

[9] Harmsen, S. R. and Koenderink, N. J. J. P. 2009. Multi-target Tracking for Flower Counting using Adaptive Motion Models. Computers and Electronics in Agriculture. 65. 7-18.

[10] Moonrinta, J., Chaivivatrakul, S. and Dailey, M. N. 2010. Fruit detection, tracking, and 3D reconstruction for crop mapping and yield estimation. IEEE 11th International Conference on Control Automation Robotics & Vision (ICARCV). 1181-1186.

[11] Nuske, S., Achar, S., Bates, T., Narasimhan, S. and Singh, S. 2011. Yield estimation in vineyards by visual grape detection. International Conference on Intelligent Robots and Systems. 2352-2358.

[12] Akin, C., Kirci, M., Gunes, E. O. and Cakir, Y. 2012. Detection of the Pomegranate Fruits on Tree Using Image Processing. IEEE International Conference on Agro-Geoinformatics (Agro-Geoinformatics).

[13] Dey, D., Mummer, L. and Sukthankar, R. 2012. Classification of Plant Structures from Uncalibrated Image Sequences. Proceedings of IEEE workshop on application of computer vision (WACV). 329-336

[14] Patel, H. N., Jain, R. K. and Joshi M. V. 2012.Automatic segmentation and yield measurement of fruit using shape analysis. International Journal of Computer Applications. 45. 19-24.

[15] Linker, R., Cohen, O. and Naor, A. 2012. Determination of the number of green apples in RGB images recorded in orchards. Computers and Electronics in Agriculture. 81. 45–57.

[16] Diago, M. P., Sanz-Garcia, A., Millan, B., Blasco, J. and Tardaguila, J. 2014. Assessment of Flower Number per Inflorescence in Grapevine by Image Analysis under Field Conditions. Journal of the Science of Food and Agriculture. 94. 1981-1987.

[17] Dorj, U. O., Lee, M. and Senthilkumar, S. 2013. A novel technique for Tangerine yield estimation via flower detection. 2nd International Conference on Information Science and Technology. 7. 405-412.

[18] Sengupta, S. and Lee, W. S. 2014. Identification and Determination of the Number of Green Citrus Fruit under Different Ambient Light Conditions. Journal of Agricultural Engineering Research. 117. 51-61.

[19] Sural, S., Gang, Q. and Pramanik, S. 2002. Segmentation and histogram generation using the HSV color space for image retrieval. International Conference on Image Processing. 2. II-589-II-592.