Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 46 (2015) 1802 – 1808

Procedia Computer Science

International Conference on Information and Communication Technologies (ICICT 2014)

Image processing Based Detection of Fungal Diseases in Plants

Jagadeesh D. Pujari[a], Rajesh Yakkundimath[b,*] , Abdulmunaf S.Byadgi[c]

[a]*Department of Information Science and Engg. S.D.M.C.E.T, Dharwar-580008, INDIA*
[b]*Department of Computer Science and Engg. K.L.E.I.T, Hubli-580030, INDIA*
[c]*Department of Plant Pathology, University of Agriculutural Sciences, Dharwar-580005, INDIA*

Abstract

This paper presents a study on the image processing techniques used to identify and classify fungal disease symptoms affected on different agriculture/horticulture crops. Computers have been used to mechanization, automation, and to develop decision support system for taking strategic decision on the agricultural production and protection research. The plant disease diagnosis is limited by the human visual capabilities because most of the first symptoms are microscopic. As plant health monitoring is still carried out by humans due to the visual nature of the plant monitoring task, computer vision techniques seem to be well adapted. One of the areas considered here is the processing of images of disease affected agriculture/horticulture crops. The quantity and quality of plant products gets reduced by plant diseases. The goal is to detect, to identify, and to accurately quantify the first symptoms of diseases. Plant diseases are caused by bacteria, fungi, virus, nematodes, etc., of which fungi is the main disease causing organism. Focus has been done on the early detection of fungal disease based on the symptoms.

Peer-review under responsibility of organizing committee of the International Conference on Information and Communication Technologies (ICICT 2014)

Keywords: fungal disease; agriculture crops; horticulture crops; pattern recognition

1. Introduction

With evolution of computers, the very way we are living today is radically changed. Computers have made impact in all the spheres of life through their tremendous technological developments in terms of more powerful and

*Corresponding author. Tel.:+91-836-2232681; fax: +91-836-2330688
E-mail address: rajeshymath@gmail.com

Peer-review under responsibility of organizing committee of the International Conference on Information and Communication Technologies (ICICT 2014)
doi:10.1016/j.procs.2015.02.137

flexible computing devices. The potentials of computer and communication technologies are explored in science, engineering, medicine, commerce, law, agriculture, horticulture and the list becomes endless. The days are not far off, wherein robots control everything in this universe. The field of agriculture and horticulture is not an exception. Computer vision applications are slowly making their way in the fields of agriculture and horticulture. We see computers deployed in inspection of food products, packing of products, interpretation of grain and crop images in the agro-food industry, etc. The major advantage of using computers is that they are more accurate, precise and efficient as compared to human beings in the real world.

Significant progress in the area of computer vision and image processing (CVIP) has led to a good number of real world applications in industry, business, biological science, material science, medical science and the like. The development in certain disciplines of computer science like Artificial intelligence, Pattern recognition, Image processing, Neural networks, etc., promise the required technological support to tackle the various issues in computer vision. One of the applications considered in the present study is concerned with processing of images of agriculture and horticulture crops affected by fungal disease.

In the real world, farmers and agriculture experts visually carry out inspection of agriculture/horticulture crops such as cereals, commercial crops, fruits, vegetables and the like affected by different diseases for recognition and classification. This evaluation process is however, tedious, time consuming and moreover very much subjective. The decision-making capability of a human inspector also depends on his/her physical condition, such as fatigue and eyesight, mental state caused by biases, work pressure, working conditions such as improper lighting, climate, etc17. The development of a computer vision system to detect, recognize, and classify disease affected on agriculture/horticulture crops will avoid human interference and hence leads to précised unbiased decisions about disease infection and its further valuation. The development of an automated system also helps farmers avoid consulting divine experts. Applications of computer vision and image processing techniques certainly assist farmers in all the areas of agriculture/horticulture activities. A general literature survey in this connection is carried out. (Tuker and Chakraborty, 2008) have presented software which detects, characterizes and calculates percentage of leaf area diseased using digital image processing. (Camargo and Smith, 2009) have reported a machine vision system for the identification of the visual symptoms of plant diseases from colored images using SVM. (Di Cui, et al., 2010) have reported research outcomes from developing image processing methods for quantitatively detecting soybean rust severity from multi-spectral images. (Guru, et al., 2011) have presented a novel algorithm for extracting seedling diseases present on tobacco leaves using first order statistical texture features and Probabilistic Neural Network (PNN). (Rumpf, et al., 2010) have proposed automatic methods for an early detection and differentiation of sugar beet diseases based on SVM(SVM) and Spectral Vegetation Indices (SVIs). (Abunaser, et al., 2010) have developed an expert system for detection of plant diseases in early stages. (Sankaran, et al., 2010) have reviewed advanced techniques, namely, spectroscopic and imaging techniques and volatile organic compounds profiling-based technique for recognizing plant diseases. (Patil and Raj Kumar, 2011) have provided advances in various image processing methods to study plant diseases/traits for increasing throughput and reducing subjectiveness arising from human experts in detecting the plant diseases. (Al-Hiary, et al., 2011) have evaluated a software solution for automatic detection and classification of plant leaf diseases using Color Co-occurrence Matrix (CCM) and neural network classifier. (Barbedo, 2013) has presented a survey on methods that use digital image processing techniques according to detection, severity quantification, and classification of plant diseases from digital images in the visible spectrum.

The literature survey has revealed that there is fair amount of scope for plant disease identification in the area of agriculture and horticulture. There is a need for design of a machine vision system that automatically recognizes, classifies, and quantitatively detects plant disease symptoms. Many diseases exhibit general symptoms that are caused by different pathogens produced by leaves, fruits, stem/stalk, roots, etc. Plant diseases are caused by bacteria, fungi, virus, nematodes, etc., of which fungi are responsible for a large number of disease symptoms in plants 15. Disease fungi take their energy from the plants on which they live. They are responsible for a great deal of damage and are characterized by wilting, scabs, moldy coatings, rusts, blotches, and rotted tissue. This being the motivation, the visual symptoms based identification and classification of fungal diseases in agriculture/horticulture crops is proposed to assist the farmers technologically. The paper is organized into four sections. Section 2 gives proposed methodologies. Section 3 describes results and discussion. Section 4 gives conclusion of the work.

2. Proposed methods

In the proposed work, we have focused on early detection of fungal disease from visual symptoms. This useful work in the real world comprises of the tasks like image acquisition, pre-processing of images, feature selection, development of methodologies for identification of fungal disease symptoms affected on different agriculture/horticulture crops, and finally development of architecture for the Computer Vision System (CVS).

As a first step, images of fungal disease symptoms affected on different agriculture/horticulture crops are collected from department of plant pathology, University of Agricultural Sciences (UAS), Dharwar INDIA and University of Horticultural Sciences (UHS), Bagalkot, INDIA. Fig.1 summarizes some of the image processing methods proposed for fungal disease detection.

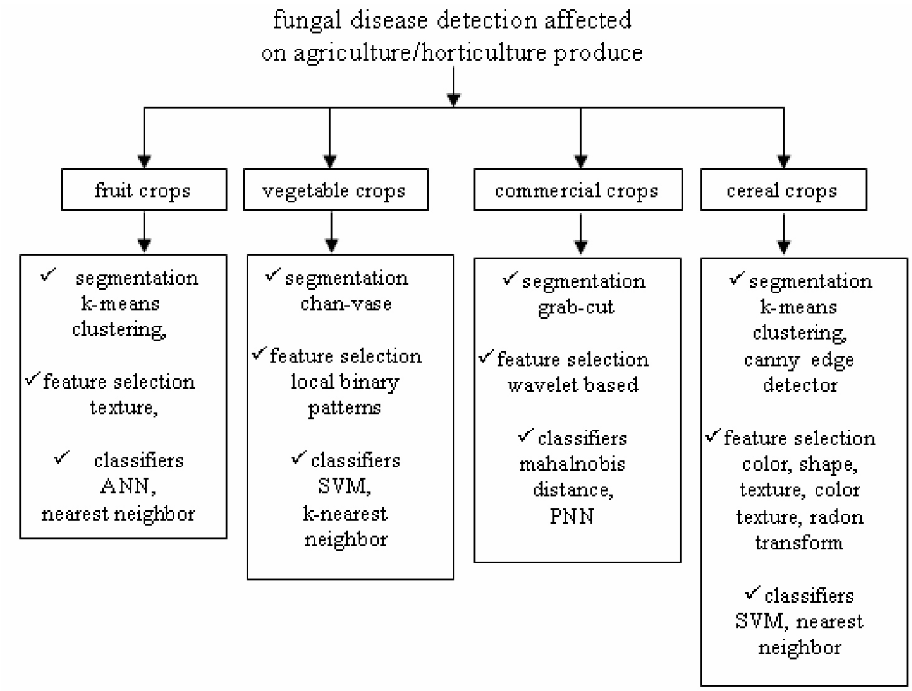

Fig. 1. Image processing methods used to detect fungal diseases

2.1. Identification of fungal disease affected on fruit crops

We have proposed statistical methods for quantitatively detecting and classifying fungal disease based on disease severity. Fungal disease symptoms, namely, anthracnose, powdery mildew, downey mildew affected on fruit crops are considered for the study. We have considered fungal disease symptoms affected on fruits like mango, pomegranate and grape. Images of fruits affected by different fungal disease symptoms are collected and categorized based on disease severity into partially affected, moderately affected, severely affected and normal. Statistical features using block-wise, Gray Level Co-occurrence Matrix (GLCM) and Gray Level Run length Matrix (GLRLM) are extracted from image samples. The Nearest Neighbor (NN) classifier using Euclidean distance is used to classify images into partially affected, moderately affected, severely affected and normal. The average classification accuracies are 91.37% and 86.715% using GLCM and GLRM features respectively. The average classification accuracy has increased to 94.085% using block-wise features [12].

The percentage of fungal disease based on disease severity is calculated. We have considered fruit crops like mango, grape, and pomegranate affected by anthracnose disease. To estimate the percentage of disease affected areas on the fruits' images, we have separated the disease affected areas from normal in the image using k-means clustering technique. The grading is performed based on percentage of disease severity and categorized into partially affected, moderately affected, severely affected and normal [11].

2.2. Identification of fungal disease affected on commercial crops

Methodologies are developed for identification of fungal disease symptoms affected on different parts of the commercial crops' plant. Plant's leaves, stem, fruits identification and finding out disease symptoms, plays a key role in successful cultivation of crops. Fungal disease symptoms, namely, anthracnose, powdery mildew, rot, alternaria leaf spot smut, wilt and gray mildew affected on leaves, stems and fruits of commercial crops' plant are considered for the study. Algorithms are developed to acquire and process color images of fungal disease affected on commercial crops like chili, cotton and sugarcane. The feature extraction is done using Discrete Wavelet Transform (DWT) and features are further reduced by using Principal Component Analysis (PCA). Reduced features are then used as inputs to classifiers and tests are performed to classify image samples. We have used Mahalanobis distance and Probabilistic Neural Network (PNN) classifiers for classification purpose. The average classification accuracy is found to be 83.17% for the test samples using Mahalanobis distance classifier. The average classification accuracy has increased to 86.48% using PNN classifier [14].

2.3. Identification of fungal disease affected on cereal crops

We have developed Radon Transform (RT) and Support Vector Machine (SVM) based detection and classification of visual symptoms affected by fungal disease. Fungal disease symptoms, namely, leaf blight, leaf spot, powdery mildew, leaf rust and smut affected on leaves of cereal crops are considered for the study. Algorithms are developed to acquire and process color images of fungal disease affected on cereal crops like wheat, maize and jowar. The developed methodology consists of two phases. In the first phase, Radon Transformation and projection algorithm are used to project patches (affected areas) on the surface of cereal crop and detect whether the cereal is disease affected or normal. In the second phase, fungal disease symptoms affected on cereal crops are classified using Support Vector Machine (SVM). The fungal disease affected areas are segmented from normal using k-means clustering technique. Color, shape, and color texture features are extracted from disease affected areas and then used as inputs to SVM classifier. The average classification accuracy of 80.83% has occurred with all the image types using color features. The average classification accuracy of 85% has occurred with all the image types using shape features. The average classification accuracy of 85.33% has occurred with all the image types using color texture features. The results reveal that color texture features using SVM classifier is more suitable for identification and classification of fungal disease symptoms affected on leaves of cereal crops.

The fungal disease affected areas are segmented from normal using k-means clustering technique. Color, shape, and color texture features are extracted from disease affected areas and then used as inputs to SVM classifier. The average classification accuracy of 80.83% has occurred with all the image types using color features. The average classification accuracy of 85% has occurred with all the image types using shape features. The average classification accuracy of 85.33% has occurred with all the image types using color texture features. The results reveal that color texture features using SVM classifier is more suitable for identification and classification of fungal disease symptoms affected on leaves of cereal crops[13, 15].

2.4. Identification of fungal disease affected on vegetable crops

The behavior of classifiers for identification and classification of fungal disease symptoms affected on vegetable crops are discussed. Fungal disease symptoms, namely, anthracnose, powdery mildew, rust, downey mildew, early blight, and late blight affected on specific type of vegetable crop are considered for recognition and classification. We have addressed how the disease analysis is done considering both sides of the leaves. The analysis of the fungal disease present on the leaves of vegetable crops is detected in the early stage before it damages the whole leaf and subsequently the plant. The Local Binary Patterns (LBP) extracted from disease affected leaves are used as input to the classifiers. An integrated classification system Neuro-kNN has been proposed, of which multilayer BPNN classifier is used for training purpose and k-Nearest Neighbor (k-NN) classifier for testing purpose. The recognition accuracy is observed using Artificial Neural network (ANN) and Neuro-kNN classifier methods. The average classification accuracy is found to be 84.11% for the test samples using ANN. The average classification accuracy has increased to 91.54% using Neuro-kNN classifier [16].

3. Results and Discussion

The comparisons of image processing techniques applied for identification and classification of fungal disease affected on different agriculture/horticulture crops are summarized in Table 1. The database is created to store the outputs of a feature extraction. The database is used to keep track of disorders of fugal disease symptoms affected on vegetable crops, fruit crops, cereal crops, and commercial crops that have been processed.

Table 1. Comparison of image processing methods for identification and classification of fungal disease symptoms

agriculture/horticulture produce	Fungal disease symptom	Affected part	Image processing methods	Classification accuracy
Fruits mango grape pomegranate	anthracnose	leaf, fruit, stem	thresholding, region growing, k-means clustering, watershed, back propagation neural network.	classification accuracies for normal and affected anthracnose fruit types are 84.65% and 76.6% respectively.
	anthracnose, powdery mildew, downey mildew	leaf, fruit, Stem	canny edge detector, median filter, gray-level co-occurence matrix, gray-level run length matrix, block-wise, nearest-neighbor	average classification accuracies are 91.37% and 86.715% using GLCM and GLRM features. The average classification accuracy has increased to 94.085% using block wise features.
Vegetables beans bengal gram soybean sunflower tomato	anthracnose, powdery mildew, rust, downey mildew, early blight, late blight	Leaf	Chan-vese, local binary patterns, k-nearest neighbor, neuro-kNN	recognition accuracy is found to be 84.11% for the test samples using ANN. The average classification accuracy has increased to 91.54% using neuro-kNN classifier.
Commercial Crops chili cotton sugarcane	anthracnose, powdery mildew, fruit rot, alternaria leaf spot, fusarium wilt, gray mildew, smut, red rot	leaf, stem, fruit	grab-cut, wavelet based, Mahalanobis distance, principal component analysis, probabilistic neural network	Classification accuracies of over 83.17% are obtained using Mahalanobis distance classier and 86.48% are obtained using PNN classifier.

				classification
	leaf blight, leaf spot, powdery mildew, leaf rust, smut	Leaf	imfilter, k-means clustering, RGB(Red, Green, Blue), HSI(Hue, Saturation, Intensity), boundry descriptors(shape), SVM	accuracies of over 80.83% are obtained using color features, 85% are obtained using shape features and 90.83% are obtained using all the feature sets.
Cereals jowar Wheat maize	leaf blight, leaf spot, powdery mildew, leaf rust, smut	Leaf	HSI, CCM, SVM	Classification accuracies of over 85.33% are obtained using HSI color features. The average classification accuracy has increased to 91.16% using HS color features.

4. Conclusion

The disease signature created helps to keep track of disorders of fungal disease symptoms of vegetable crops, fruit crops, cereal crops and commercial crops that have been processed. The task of fungal disease symptoms classification using image processing techniques was successfully implemented. Four different classes of agriculture/horticulture crops: fruit crops, vegetable crops, cereal crops and commercial crops affected by fungal disease were used for the considered work. Algorithms for feature extraction and classification based on image processing techniques were designed. The proposed work aims at development of methodology for identification and classification of fungal disease symptoms affected on horticulture and agriculture crops.

We wish to propose architecture to remotely monitor the crop for possible diseases and detect as early as possible to avoid further loss of crop using GSM, remote sensing or other modern means of telecommunication technologies resulting in intelligent farming. The work is complex and challenging in terms of high variability in outdoor conditions and general symptoms.

Acknowledgements

We would like to express my sincere thanks to Dr.Basavaraj.S.Anami, principal, KLE.Institute of Technology, Hubli, whose support, guidance and faith have always been an inspiration.

References

1. Abu-Naser SS, Kashkash KA, Fayyad M. Developing an Expert System for Plant Disease Diagnosis. *Journal of Artificial Intelligence*; 2010, vol.3, no.4, pp.269-276.
2. Al-Hiary H, Bani-Ahmad S, Reyalat M, Braik M, and ALRahamneh. Fast and Accurate Detection and Classification of Plant Diseases. *International Journal of Computer Applications*; 2013, vol.17, no.1, pp.31-38.
3. Barbedo JCA. Digital Image Processing Techniques for Detecting, Quantifying and Classifying Plant Diseases. *Springer Plus*; 2013, vol.2, no.660, pp.1-12.
4. Bauer SD, Korc F, Forstner W. The Potential of Automatic Methods of Classification to Identify Leaf Diseases from Multispectral Images. *Precision Agriculture*; 2011, vol.12, pp. 361-377.
5. Camargo A and Smith JS, Image Pattern Classification for the Identification of Disease Causing Agents in Plants. *Computers and Electronics in Agriculture*; 2009, vol. 66, no.2, pp.121–125.
6. Chen. YR, Chao K, Moon SK. Machine Vision Technology for Agricultural Applications. *Computers and Electronics in Agriculture*; 2002, vol. 36, no.2-3, pp.173-191.
7. Di Cui, Zhang Q, Li M, Hartman GL, Zhao Y. Image Processing Methods for Quantatively Detecting Soybean Rust from Multispectral Images; *Biosystems Engineering*; 2010, vol.107, no.3, pp.186-193.

8. Guru DS, Mallikarjuna PB, Manjunath S. Segmentation and Classification of Tobacco Seedling Diseases. *COMPUTE '11 Proc.Fourth Annual Int.conf.ACM*; 2011, Bangalore, India.
9. Huang KY. Application of Artificial Neural Network for Detecting Phalaenopsis Seedling Diseases using Color and Texture Features, *Computers and Electronics in Agriculture*, 2007, vol.57,no.7, pp. 3–11.
10. Patil JK., Raj Kumar. Advances in Image Processing for Detection of Plant Diseases. *Journal of Advanced Bioinformatics Applications and Research*; 2011, vol.2, no.2, pp.135-141.
11. Pujari JD, Yakkundimath R, Byadgi AS. Grading and Classification of anthracnose fungal disease in fruits. *International Journal of Advanced Science and Technology*; 2013, vol.52, no.3, pp.121-132.
12. Pujari JD, Yakkundimath R, Byadgi AS. Statistical Methods for Quantitatively Detecting Fungal Disease from Fruits' Images. *International Journal of Intelligent systems and Applications in Engineering*; 2013, vol.1, no.4, pp.60-67.
13. Pujari JD, Yakkundimath R, Byadgi AS. Detection and Classification with Radon Transform and Support Vector Machine affected on Cereals. *International Journal of Computer Vision and Robotics*; 2014, vol.4, no.4, pp.261-280.
14. Pujari JD, Yakkundimath R, Byadgi AS. Automatic Fungal Disease Detection based on Wavelet Feature Extraction and PCA Analysis in Commercial Crops*;International Journal of Image, Graphics and Signal Processing*, 2014, vol. 1, no.12, pp. 24-31.
15. Pujari JD, Yakkundimath R, Byadgi AS. Classification of Fungal Disease Symptoms affected on Cereals using Color Texture Features. *International Journal of Signal Processing, Image Processing and Pattern Recognition*; 2013, vol.6, no.6, pp.321-330.
16. Pujari JD, Yakkundimath R, Byadgi AS. Neuro-kNN classification system for detecting fungal disease affected on vegetables using local binary patterns. *Agricultural Engineering International; CIGR*, in press.
17. Pujari JD, Yakkundimath R, Byadgi AS. Recognition and Classification of Normal and Affected Agriculture Produce Using Reduced Color and Texture Features. *International Journal of Computer Applications*, 2014, vol.93, n.11, 2014, pp: 17-24.
18. Pydipati R, Burks TF, Lee WS. Identification of Citrus Disease Using Color Texture Features and Discriminate Analysis. *Computers and Electronics in Agriculture*; 2006, vol. 52, no.1-2, pp.49-59.
19. Rumpf T, Mahlein AK, Steiner U, Oerke EC, Dehne HW, Plumer L. Early Detection and Classification of Plant Diseases with Support Vector Machines Based on Hyperspectral Reflectance. *Computers and Electronics in Agriculture*; 2010, vol.74, no.1, pp.91-99.
20. Sankaran S, Mishra A, Ehsani R., Davis C. A Review of Advanced Techniques for Detecting Plant Diseases. *Computers and Electronics in Agriculture*; 2010, vol.72, pp.1-13.
21. Tuker CC , Chakraborty K. Quantitative Assessment of Lesion Characteristics and Disease Severity Using Digital Image Processing. *Journal of Phypathology*; 2008, vol.145,no.7, pp.273 – 278.