Communications on Applied Electronics (CAE) - ISSN : 2394 - 4714
Foundation of Computer Science FCS, New York, USA
Volume 3 - No. 5, November 2015 - www.caeaccess.org

Adaptive Neuro Fuzzy Inference System based Tea Leaf Disease Recognition using Color Wavelet Features

Mustain Billah
Department of Information And Communication Technology
Mawlana Bhashani Science And Technology University
Tangail,Bangladesh

Mohammad Badrul Alam Miah
Department of Information And Communication Technology
Mawlana Bhashani Science And Technology University
Tangail,Bangladesh

Abu Hanifa
Department of Information And Communication Technology
Mawlana Bhashani Science And Technology University
Tangail,Bangladesh

Md. Ruhul Amin
Department of Information And Communication Technology
Mawlana Bhashani Science And Technology University
Santosh,Tangail,Bangladesh

ABSTRACT

Tea, a favourite bevarage in the world is made of tender new leaves of tea plant. So tea plantation is more concerned with tea leaf diseases. Infected leaves may be the source of disease for new leaves reducing the productivity of the plant. In order to reduce tea leaf disease, disease recognition is the initial step. Many techniques have been used for leaf recognition. In this paper, we have proposed a model for recognising tea leaf diseases, which uses color wavelet features and adaptive neuro fuzzy inference system (ANFIS). After processing the images, color wavelet features are extracted and provided to Adaptive Neuro Fuzzy Inference System (ANFIS) along with the disease types. This ANFIS based tea leaf disease recognition system using color wavelet features can recognise the disease of any new leaf image affected by disease accurately.

General Terms

Computer Science, Image Processing

Keywords

Image processing, ANFIS, Tea leaf disease, disease recognition

1. INTRODUCTION

The biggest challenge for tea growers nowadays, is to produce tea without pesticide residues. There is a growing demand for residue free tea, or at least low pesticide residue tea, in the highly industrialised countries and this property of tea is being well paid off. Tea plant diseases are usually caused by fungi, bacteria, alga and viruses. Also there are other diseases which are caused by adverse environmental conditions. There are numerous characteristics and behaviors of such plant diseases in which many of them are merely distinguishable. So the ability of tea leaf disease recognition in earlier stage is an important task. There is a risk of introducing new diseases into the state through infected plants even when they do not have obvious disease symptoms.

Technological advancement is gradually finding its applications in the field of agriculture.Some works have been done on recognition of rice diseases, citrus diseases, crop diseases, wheat leaf diseases, Betel vine plant diseases etc.The system proposed in[16] presents a SVM-based Multiple Classifier System (MCS) for pattern recognition of wheat leaf diseases. Based on the infected images of various rice plants the paper[13] describes a system for rice disease detection. Using an approach [5] that regularizes and extracts eigen feature from image and developing and decomposing scatter matrix cotton leaf diseases also identified. Design and implementation of an artificial vision system which extracts specific geometric and morphological features from plant leaves presents in paper [17]. The proposed system consists of an artificial vision system, a combination of image processing algorithms and feed forward neural network based classifier. A fuzzy surface selection technique for feature selection was used. Based on support vector machines a prediction approach for developing weather based prediction models of plant diseases is proposed in paper[7]. The performance of conventional multiple regression, artificial neural network (back propagation neural network, generalized regression neural network) and support vector machine (SVM) was compared. It was concluded that SVM based regression approach has led to a better description of the relationship between the environmental conditions and disease level which could be useful for disease management. Another paper [2] proposed Back propagation neural network for recognition of damaged leaves. It was proved that just a back propagation network and shape of leaf image is enough to specify the species of a leaf.

In the proposed approach, Statistical color wavelet features[19] have been encountered in this texture analysis scheme, for the discrimination of normal and abnormal leaves. The proposed detection scheme involves a novel feature extraction technique based on a discrete wavelet decomposition applied on RGB color spaces and statistical analysis of the wavelet coefficients associated with the color bands. The wavelet features are based on second-order textural information[14] estimated on the domain of the discrete wavelet decomposition of each color band of an image. In this paper, the textural characteristics[12, 15] estimated on the color discrete wavelet transform give valuable information about the set of features that produce the most discriminant subspaces for normal/abnormal leaves. The proposed scheme was tested on real data sets of tea leaf. Adaptive Neuro Fuzzy Inference System (ANFIS) has been used as the classification purpose. ANFIS captures the advantages of both neural network and fuzzy system. So it performs well in classification comparing to other techniques.

The rest of the paper is organized as follows: Section 2 gives a brief concept of color texture analysis.In section 3 theory of ANFIS is discussed. Experimental structure of our system is shown in section 4. Section 5 discusses the results of proposed experiment.

Communications on Applied Electronics (CAE) - ISSN : 2394 - 4714
Foundation of Computer Science FCS, New York, USA
Volume 3 - No. 5, November 2015 - www.caeaccess.org

2. COLOR TEXTURE ANALYSIS

Color texture analysis[12, 19] is based on the combined information from both color and texture fields of the image. Texture processing[18] was mainly focused on the use of gray-level image information. More research on this study led to the conclusion that the introduction of color information, especially by calculating grayscale texture features on the different color channels[3], significantly improves color texture classification. Other approaches that have taken into account the correlation of texture measures between the different color channels[4], have shown that color texture information can also be found in the way color channels are related to each other[10].However in this study we have considered only RGB color space.

3. THEORY OF ANFIS

Fuzzy sets were introduced by Zadeh (1965)[9], to represent and manipulate data and infor mation in which there are various alternative uncertainties. Ten years later, he introduced fuzzy logic[8] which is based on fuzzy set theory and represents an element into a certain degree of membership function usually taken as a real number between 0 and 1. Fuzzy sets can be considered as an extension of crisp set theory. The membership function, often given the designation of , is the essence of fuzzy sets. A membership function is a curve that defines how each point in the input space is mapped to a degree of membership usually taken as a real number in the interval [0,1].

In general, the steps involved in developing the fuzzy system are as follows:

- Specify the problem and analyse the purpose.
- Define linguistic variables to determine the fuzzy sets for antecedent(s) and consequent(s).
- Construct fuzzy rules.
- Identify and apply appropriate methods for fuzzification, fuzzy inference and defuzzification.
- Evaluate and tune the system.

Fuzzy inference system (FIS) is a process of mapping from a given input to an output using the theory of fuzzy sets. Characteristics of the adaptive neural fuzzy inference system close to the neural fuzzy system, significant results model of the nonlinear function. Adaptive Neuro-Fuzzy Inference System in the membership function parameters to focus on extracting information from the description of system performance. The ANFIS through the adjustment of system parameters of the specified error standard, and the data to focus on learning characteristics. Today, ANFIS has been used in classification and data analysisIt works similarly to that of neural networks. Using a given input/output data set, ANFIS constructs a fuzzy inference system (FIS) whose membership function parameters are tuned (adjusted) using either a backpropagation algorithm alone or in combination with a least squares type of method. This adjustment allows the fuzzy systems to learn from the data they are modeling. Assume that the fuzzy inference system has two inputs x and y and one output z. A first-order Sugeno fuzzy model has rules as the following:

Rule1:
If x is A1 and y is B1, then f1 = p1x + q1y + r1

Rule2:
If x is A2 and y is B2, then f2 = p2x + q2y + r2

Here,

$$output = \frac{w1.f1 + w2.f2}{w1 + w2} \quad (1)$$

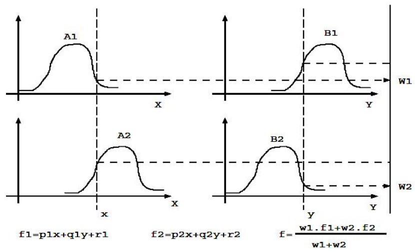

Fig. 1. Adaptive Neuro Fuzzy Inference System

Infact, ANFIS is the combination of both ANN fuzzy logic. ANN algorithms are also used for anfis training, learning.

4. EXPERIMENTAL MODEL OF PPROPOSED SYSTEM

As stated earlier, our proposed system has mainly two stage. The detection stage (image preprocessing) and the recognition stage (ANFIS). Fig4 in following page shows a flow diagram of our model.

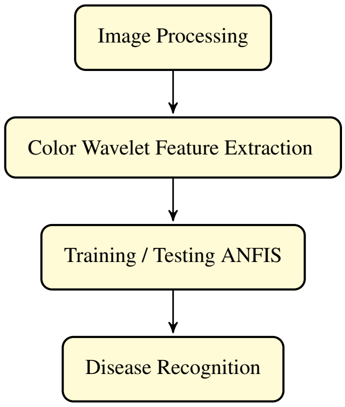

Fig. 2. Proposed System

4.1 Image Processing

It includes processes from image preprocessing to image normalizing. Tea leaf pictures are captured by digital camera. Fig 1 shows an affected tea leaf image.

Fig. 3. Tea leaf image affected by disease

Noises are removed from the images. Then images are normalized to a fixed size. For extracting gray level features, image must be converted to threshold image. But main concern in this study is about wavelet features.

4.2 Color Wavelet Feature Extraction

The proposed approach is based on the extraction of color textural features[11]. These features are estimated over the second-order statistical representation of the wavelet transform[1] of the color image. Since each feature represents a different property of the examined region, we consider as valuable information the covariance among the different statistical values between the color channels of the examined region. The extraction of the CWC vector[12] can be described in the following steps[6].

(1) The original color image is decomposed into three separate color bands.
(2) Each image is then transformed according to a threelevel 2-D discrete wavelet transform by using decomposition functions that follow the properties of the wavelet. The detail coefficients of the middle decomposition level are considered for further processing.
(3) The cooccurrence matrices, for each image of the previous step, are estimated into four directions, producing 36 matrices that are a second-order statistical representation of the original image.
(4) Four statistical measures (angular second moment, entropy, inverse difference moment, and correlation) are calculated for each matrix, resulting in a set of 144 components. Each of the measure carries different information about the texture.[19]
(5) Covariance values of pairs of the estimated features
(6) constitute the CWC feature vector to be used for the classification of the image regions.

4.3 Training ANFIS

In the training of ANFIS, it learns through adjusting its weights which is a supervised learning algorithm. Training ANFIS sufficiently in an iterative process, the weights are adjusted. For training Purpose MATLAB 2015a toolbox has been used. Some of the Collected features of tea leaf images have been reduced while other features are the inputs of ANFIS system. Three types of affected leafs of tea have been used as input to train. Each type has 15 samples that make 15 x 3 = 45 samples of pre-defined images of same pixel size. ANFIS can recognize any of 3 types of diseases.

5. RESULTS AND DISCUSSION

The correct diagnosis performance of ANFIS based tea leaf disease daignosis system is estimated by using sensitivity and specificity analysis and classification accuracy performance evaluation methods, respectively.

In this experimental study, 45 samples were used for training and another 30 samples for testing the system. Among the datasets about one third are affected leaf and rest are unaffected.

5.1 Sensitivity and Specificity analysis

Sensitivity (also called the true positive rate, or the recall in some fields) measures the proportion of positives that are correctly identified.

$$Sensitivity = \frac{TP}{TP + FN}(\%) \quad (2)$$

Specificity (also called the true negative rate) measures the proportion of negatives that are correctly identified.

$$Specificity = \frac{TN}{FP + TN}(\%) \quad (3)$$

The obtained values of sensitivity and specificity by using ANFIS based system for tea leaf disease diagnosis are given in Table 1.

Table 1. Values of sensitivity and specificity

Sensitivity	Specificity
97.23%	92.46%

5.2 Classification Accuracy Analysis

accuracy of a measurement system is the degree of closeness of measurements of a quantity to that quantity's true value.

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN}(\%) \quad (4)$$

The classification accuracy by using ANFIS based system for tea leaf disease diagnosis are given in Table 2.

Table 2. Classification Accuracy of different models

Used method	Authors Name	Accuracy
Neural network Ensemble	Karmokar	91%
ANFIS	Used in this study	95.7%

From the table above, it is clear that proposed system has higher accuracy than other methods.

6. CONCLUSION

In this paper, a novel methodology for tea leaf disease diagnosis has been presented. For extraction of color tea leaf image features, covariances of the second-order statistical measures are calculated over the wavelet frame transformation of different color bands. Adaptive Neuro Fuzzy Inference System based tea leaf disease diagnosis system obtains very promising results. Decisions ca be taken that, color wavelet analysis performs better than other feature extraction methodologies. Again, ANFIS proves to have more classification accuracy for disaese recognition. In future we will work on ANFIS based lung cancer detection system using color wavelet features.

7. REFERENCES

[1] Tinku Acharya, Lina J. Karam, and Francescomaria Marino. *Compression of color images based on a 2-dimensional discrete wavelet transform yielding a perceptually lossless image*. Google Patents. US Patent 6,154,493.

[2] MS Prasad Babu and B. Srinivasa Rao. Leaves recognition using back propagation neural network-advice for pest and disease control on crops.

[3] Andrea Baraldi and Flavio Parmiggiani. An investigation of the textural characteristics associated with gray level cooccurrence matrix statistical parameters. 33(2):293–304.

[4] Piotr Dollr, Zhuowen Tu, Pietro Perona, and Serge Belongie. Integral channel features. In *BMVC*, volume 2, page 5.

[5] Ajay A. Gurjar and Viraj A. Gulhane. Disease detection on cotton leaves by eigenfeature regularization and extraction.

[6] Stavros Karkanis, Dimitris K. Iakovidis, Dimitris E. Maroulis, Dimitris Karras, M. Tzivras, and others. Computer-aided tumor detection in endoscopic video using color wavelet features. 7(3):141–152.

[7] Rakesh Kaundal, Amar S. Kapoor, and Gajendra PS Raghava. Machine learning techniques in disease forecasting: a case study on rice blast prediction. 7(1):485.

[8] George Klir and Bo Yuan. *Fuzzy sets and fuzzy logic*, volume 4. Prentice Hall New Jersey.

[9] George J. Klir and Bo Yuan. *Fuzzy sets, fuzzy logic, and fuzzy systems: selected papers by Lotfi A. Zadeh*. World Scientific Publishing Co., Inc.

[10] Topi Menp and Matti Pietikinen. Classification with color and texture: jointly or separately? 37(8):1629–1640.

[11] Christoph Palm. Color texture classification by integrative co-occurrence matrices. 37(5):965–976.

[12] George Paschos. Perceptually uniform color spaces for color texture analysis: an empirical evaluation. 10(6):932–937.

[13] Santanu Phadik and Jaya Sil. Rice disease identification using pattern recognition techniques. In *Computer and Information Technology, 2008. ICCIT 2008. 11th International Conference on*, pages 420–423. IEEE.

[14] Abdulkadir Sengur. Wavelet transform and adaptive neuro-fuzzy inference system for color texture classification. 34(3):2120–2128.

[15] Alina Surmacka Szczesniak. Classification of textural characteristics. 28(4):385–389.

[16] Yuan Tian, Chunjiang Zhao, Shenglian Lu, and Xinyu Guo. SVM-based multiple classifier system for recognition of wheat leaf diseases. In *World Automation Congress (WAC), 2012*, pages 189–193. IEEE.

[17] Panagiotis Tzionas, Stelios E. Papadakis, and Dimitris Manolakis. Plant leaves classification based on morphological features and a fuzzy surface selection technique. In *Fifth International Conference on Technology and Automation, Thessaloniki, Greece*, pages 365–370.

[18] Gert Van de Wouwer, Paul Scheunders, Stefan Livens, and Dirk Van Dyck. Wavelet correlation signatures for color texture characterization. 32(3):443–451.

[19] Gert Van de Wouwer, Paul Scheunders, and Dirk Van Dyck. Statistical texture characterization from discrete wavelet representations. 8(4):592–598.