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Wavelet Energy and Shape Features for Plants Recognition

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Abstract

This work presents plants recognition system with rotation invariant based on plant leaf. Wavelet energy features are extracted for sub-images (blocks) in addition to three of leaf shape features: [area, perimeter, circularity ratio]. (8) species of leaves are used in different size and color, (15) samples for each leaf are used. Leaves images are rotated at angles: 90˚, 180˚, 270˚(counterclockwise,clockwise). Euclidean distance is used, the recognition rate was 98.2% with/without rotation.

Keywords: Shape Features, Leaf Shape, Sub-Images, Wavelet Transform, Wavelet Energy.

طاقة المويجة وخصائص الشكل لتمييز النباتات

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قسم علوم الحاسوب، كلية العلوم، الجامعة المستنصرية، بغداد، العراق.

الخلاصة

هذا العمل يقدم نظام تمييز النباتات بالاعتماد على ورقة النبات . خصائص طاقة المويجة استخرجت من تقسيم الصورة الى بلوكات بالإضافة الى استخراج ثلاثة من خصائص شكل الورقة (المساحة ، المحيط ، نسبة الاستدارة) . تم استخدام (8) انواع من النباتات بمختلف الاحجام والالوان ، (15) نموذج لكل نوع من الانواع الثمانية .

صور الاوراق دورت بزوايا (90 ، 180 ، 270) درجة مع عقرب الساعة وعكس عقرب الساعة ، تم استخدام مقياس اقليدس وكانت نسبة التمييز 98.2 % مع التدوير وبدونه .

1. Introduction

Images take essential role in human cognition. The human brain can easily recognize image, which is a collection of meaningful parts, each part has certain characteristics. Some useful features are used in image recognition. The process of discrimination has always been one of the most important challenges facing human generally and programmers particularly. Any programmer forward to build a recognition system look like humans especially in term of accuracy

Since ancient times, plants are vital to animals, many animals eat leaves of plants. plants play an effective role in human life, people also eat leaves, such as: "cabbage", "lettuce", and "spinach" plants, also we use the leaves of the tea plant to make tea , but the crucial role of plants is in medicine. Human eye can be used leaves, fruits and flowers to classify plants, but because the plants are grown seasonally flowers and fruits will not be available so leaves take vital role in recognition process. Leaf presents several significant information which will be beneficial in distinguishing leaf from other leaves. Leaves of plants can be recognized by their color, shape and size

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Any leaf has its own shape that can used to distinguish one leaf from another leaf ,inspite of leaves have different shapes and sizes but sometimes some plants are very similar in leaf shape so using only shape features does not give desired results, a simple plant leaf can take one of the following shapes: acicular, digitate, oval, linear, pinnate, cordate, palmate, deltoid, compound, lobed and spatulate. Most plants have similar colors, leaf color is also changed during autumn in some plants, changes in leaf color may affects the process of discrimination negatively.

In image processing, wavelets transform play important role to characterize images. It has ability to describe data in image based on hierarchical decomposition of the image information. Wavelets are mathematical functions that used to represent and analyze images, it is performed in diverse fields, especially in recognition system, therefore in this work two types of features will be extracted: wavelet energy features and shape features.

The organization of this paper is as following: section two discusses previous work. In section three the proposed method is explained. Section four contains the experimental results. Section five summarizes conclusion and future work.

2. Previous Work

The approach in [1] by vijayashree T. and Gopal A. classified and authenticated the medicinal plants materials and herbs through image processing algorithm. The database is contained 50 leaves, six features are extracted from leaf, the method of principle component analysis (PCA) is used, the accuracy reached to 89.2%. Annu N. and Justin J. [2] proposed an approach to classify glaucoma images, their approach was very important because glaucoma was the second leading cause of blindness in the world ,their approach study that disease by using technique to extract energy signatures and probabilistic neural network(PNN) , the accuracy was 95%. Gurpreet K. and Gurpinder K.[3] used digital image processing for classification and recognition of plants based on leaf architecture , GLCM calculated and (10) leaf feature were extracted with Artificial Neural Network (ANN), 12 species of leaves were used, the accuracy of the system was 97.9%. Pande A. V. and Shandilya V.K. [4] presented approach for fruit and flower leaf identification and recognition. they used chain code method to extract features of the leaves such as length, width, shape and perimeter, douglas Peucker approximation algorithm is applied to the leaf, linear comparison technique was used to recognize leaves, the approach was accordant for the recognition of undamaged and damaged plant. Casanova D. and Joaci J. and Bruno O.M.[5] presented a method of plant classification using Gabor wavelet filters to extract texture features, an experiment using 20 species, they compare the results with texture Fourier descriptor and co-occurrence matrices and the better results proved the effectiveness of their method. Yahiaoui I., Mzoughi O. and Boujemaa N.[6] presented boundary-based approach for leaf identification, five of geometric parameters extracted as well as the directional fragment histogram(DFH), they obtained best classification rate. Neto J. C., Meyer G. E., Jones D. D., and Samal A. K.[7] presented an approach to recognize leaf based on elliptic Fourier and discriminate analyses, elliptic Fourier harmonic function was generated based on leaf boundary, PCA methods was used to select Fourier coefficient, that tool was very accurate in identification plants. Ehsanirad A. and Sharath Y.H.[8] used GLCM and PCA methods in order to classify plants based on its leaves, 13 kinds of plants used, the results showed that the accuracy for the GLCM method was 78% while the accuracy for the PCA method was 98%. Pallavi P. and Veena V.S.[9] used Zernike moments for leaf recognition, after resized the image of leaf some necessary image preprocessing operation was done, in addition to shape feature, texture feature(GLCM), color feature and vein feature were extracted, features gave as input to the neural network to get the best results. Valliammal, N. and Geethalakshmi, S.N.[10] proposed a hybrid method for enhancement plant leaf recognition, histogram equalization used for enhancement, adaptive threshold used in different region, (10) kinds of leaves were used, the experimental results showed that their method efficient when compared to other traditional methods. Lee K.B. and Hong K.S.[11] used leaf vein and shape features for leaf recognition, 21 leaf features were extracted for the leaf recognition, in that approach the result of experiments showed that the accuracy was 97.19%. Sandeep K.E.[12] proposed a method to identify the medicinal plants using the following leaf features: area of leaf, edge histogram and color histogram, in that approach (9) different leaf were used, that method was simple and efficient.

3. Methodology of research

This section presents techniques are used in this approach, Figure-1 illustrates the proposed recognition system.

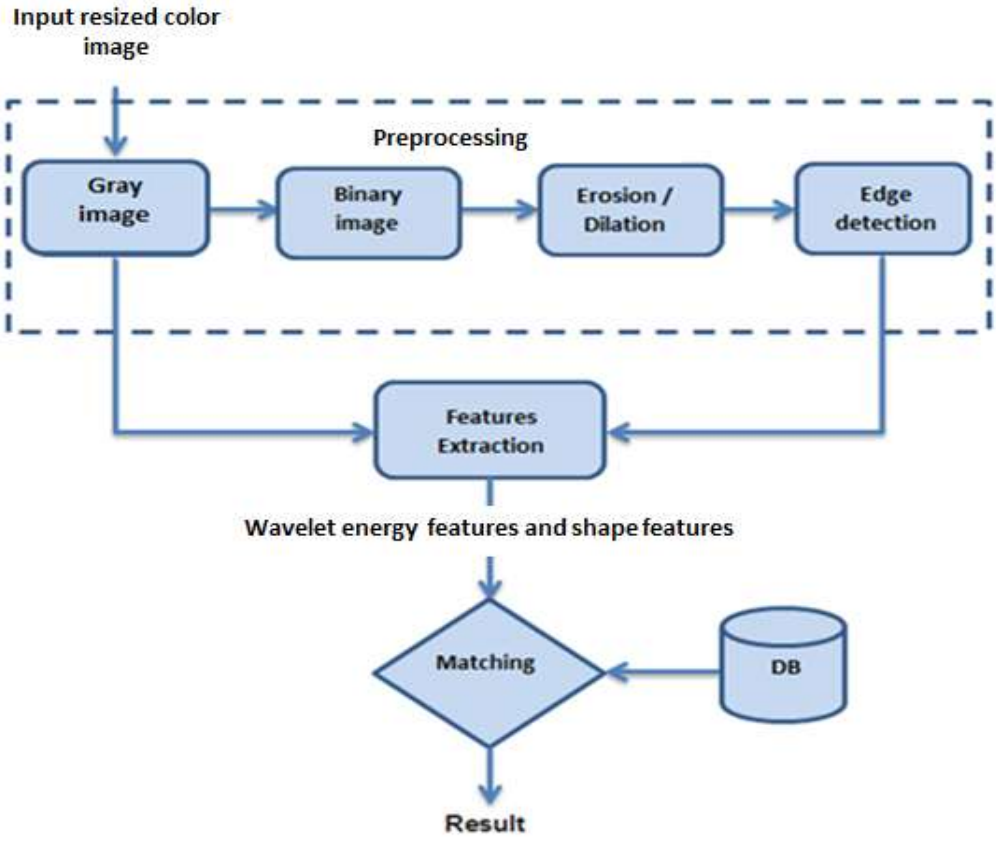

Figure 1-Block diagram of the proposed system

Image preprocessing operations are performed on leaf image. All images are resized into one size 128×128 because leaves of the same type may have different size as well as the different plants have different leaves size, see Figure-2, then image is converted into grayscale image using the following equation:

$$Gry = \frac{R_{xy} + G_{xy} + B_{xy}}{3} \quad \ldots\ldots\ldots (1)$$

Then image is converted to black/white image using thresholding method[13] in order to make image easy to process. Figure-2 illustrates that same type of plant had different size of leaves.

Figure 2-Different size for leaves of the same type.

Noise is eliminated by using the erosion and dilation technique, edge is detected using prewitt. Then features of leaf are extracted based on shape of leaf which carrying a significant information in addition to wavelet energy features to form a feature vector that used in recognition process.

Figure-3 below illustrates preprocessing steps for the oak leaf image which has green color then is converted to gray and to binary, holes are appeared in binary image so erosion/dilation processes are performed to eliminate holes, at the end edge of image is detected.

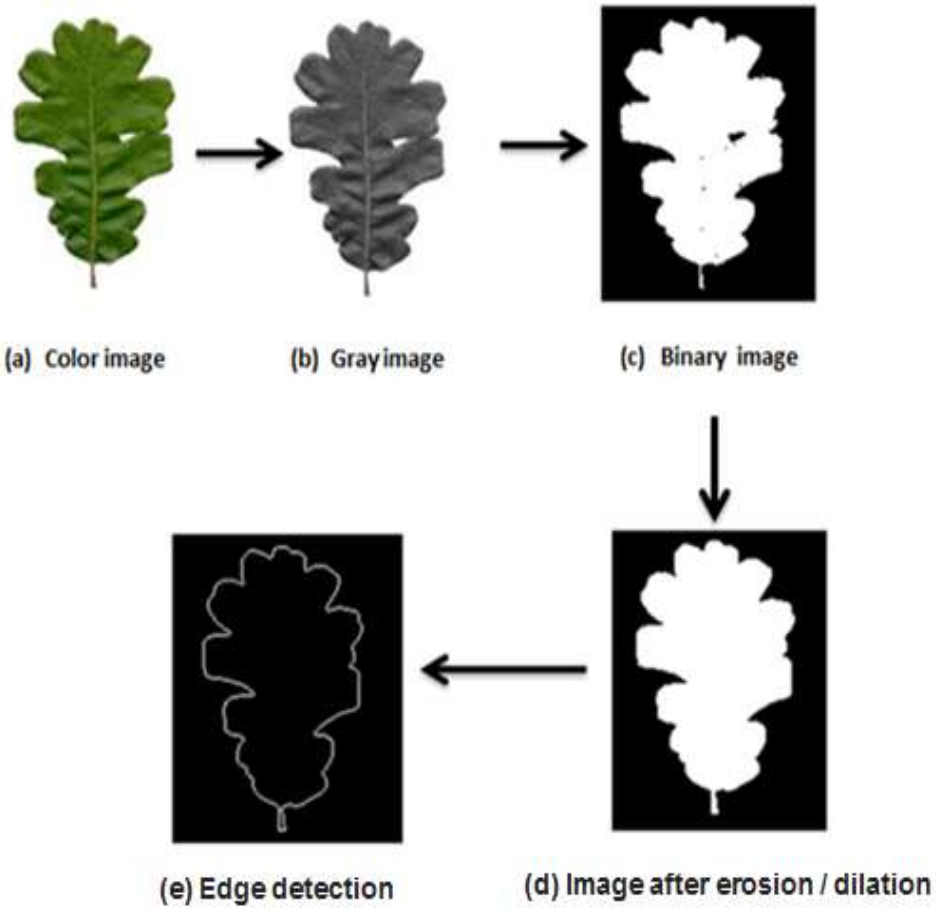

Figure 3- Preprocessing for input leaf image.

Features Extraction

Features extraction is a process of extracting relevant features from input image that can be used in recognition process. The basic purpose of extracting properties is remove repetition from data and reduce representation of data, This work based on:

A- Leaf Shape features

Shape of leaf can be consider the best property to identify a leaf, it differs from one leaf to another leaf. Color is differ from plant leaf to another plant leaf, in plant leaf sometimes: leaf of the same plant type may has different colors, see Figure-4(a), in one color for example the green leaf has several gradations of green color, see Figure-4(b), in the same leaf the right part of the leaf is differ from the left part in size or shape, see Figure-4(c), two leaves of the same type may similar in shape, but one may contain holes whereas the other does not, see Figure-4(d), therefore, depending on leaf color reduces the accuracy of the results.

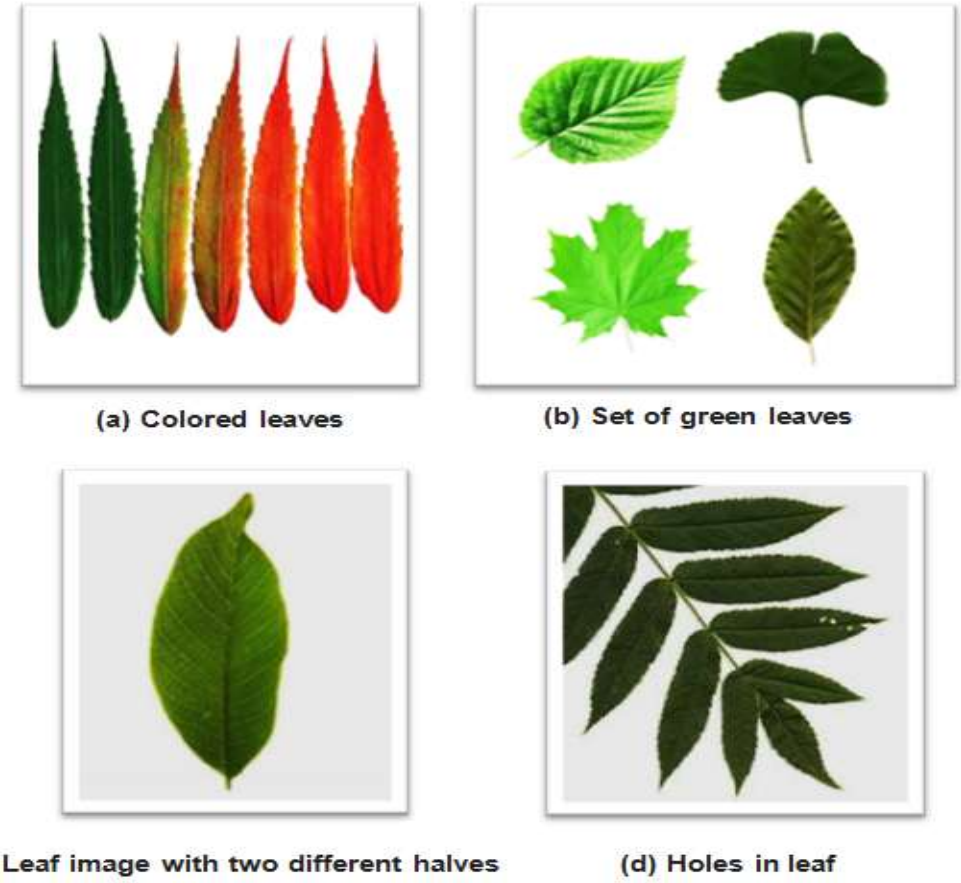

Figure 4-Variance cases of leaves.

In this work some shape features are extracted:

- **Perimeter** of the leaf can be found by counting number of pixels containing leaf margin.
- **Area** of leaf is number of white pixels in the binarized leaf image.
- **Circularity ratio** determines to what extent a shape looks like a circle, it is a ratio of the area of a shape to the area of a circle having the same perimeter [3]:

$$C = \frac{4\pi A}{P^2} \qquad \ldots\ldots(2)$$

Features vector contains: [wavelet energy, area, perimeter, circularity ratio] which are used in recognition process to recognize new leaf image.

B- Wavelet energy features

In this work, discrete meyer wavelet [14] is used, wavelet energy feature is used as a good characteristic for leaf image which is stable to some extent in rotation of the images. wavelet energy is extracted using the following algorithm:

Algorithm (extract wavelet energy features)

Input : Resized Color image .
Output: Wavelet energy .
Step1: Input the resized color image of leaf .
Step2: Convert the image to a grayscale image.
Step3: Divide the image into sub-images(four blocks).
Step4: For all blocks
Apply discrete meyer wavelet transform.
Compute wavelet energy.

Endfor.

Step5: End.

4. Experiments results

For implementation, Matlab7.0 2013a is used, the computer specifications are: window 7, intel processor with 2.4 GHz, RAM4.00 GB.

In this work, eight species of leaves are used: castanea, vitis, oak, populus nigra italica, fig, olive, clover and ginkgo biloba, which had different size and gradients of green color, (15) samples for each leaf image are collected, so (120) images are used, (64) leaves images are used for training, Figure-5 shows our leaves database. The images are collected using internet, all images are saved in JPEG format. For testing, (56) leaf images are used. 280 rotated leaves images at 90˚, 180˚, 270˚ angles (clockwise /counterclockwise) are used , so total data set are 336 leaves images. Minimum distance is computed using euclidean distance measure, the results are as follow in Table-1:

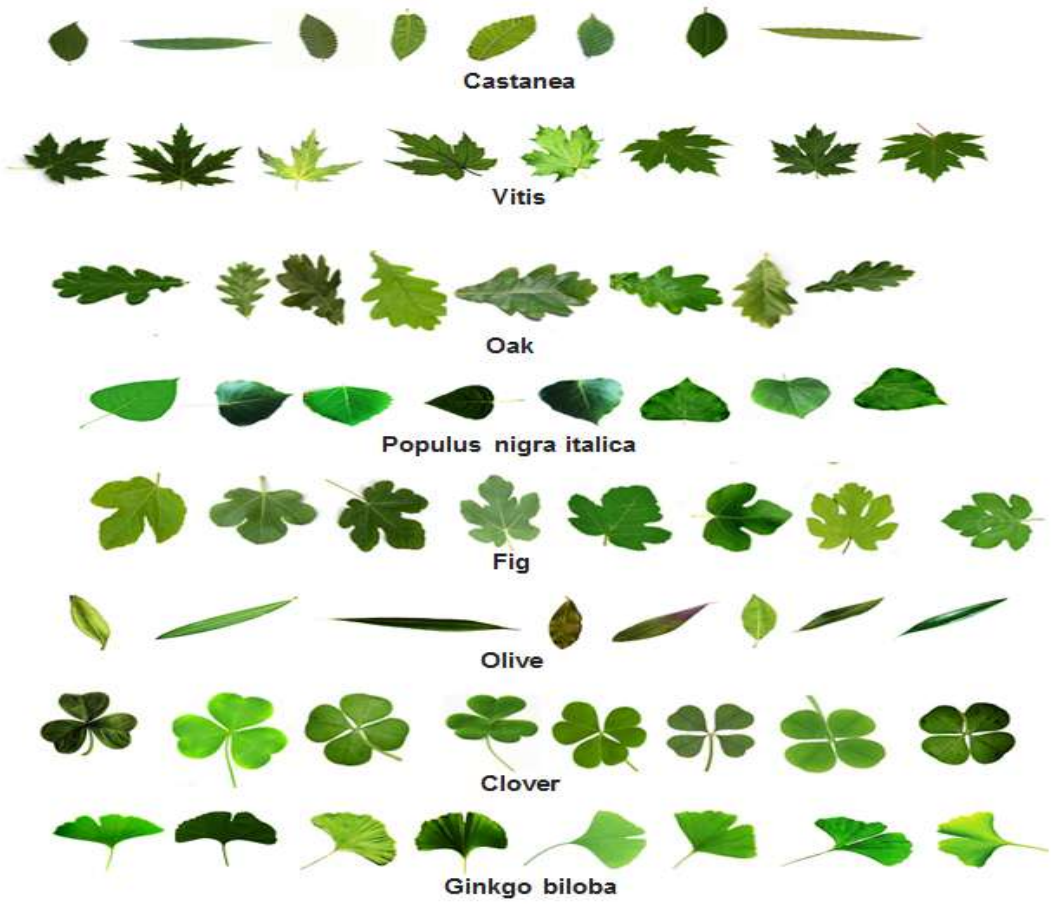

Figure 5-Leaves database.

Table 1-Recognition Rate (%)

No. of leaves images	R.R (%) without rotation	R.R (%) with rotation					
		Rotate 90˚ clockwise	Rotate 90˚ counter clockwise	Rotate 180˚ clockwise	Rotate 180˚ counter clockwise	Rotate 270˚ clockwise	Rotate 270˚ counter clockwise
56	98.2	98.2	98.2	98.2	98.2	98.2	98.2

Table-1 shows the recognition rate for tested images, the ratios above show clearly the excellent results. In oak, fig, castanea, populus nigra italica, olive, clover and ginkgo biloba species the recognition rate is 100% without rotation, in vitis plant there is one unrecognized sample of leaves

without rotation. When leaves images rotated at 90˚, 180˚ , 270 ˚ counter clockwise and 90˚, 180˚, 270˚ clockwise there was also one unrecognized sample in vitis plant, the recognition rate is still 100% in oak, fig, castanea, populus nigra italica, olive, clover and ginkgo biloba species, total recognition rate for the (8) species is 98.2%.

5. Conclusion and Future Work

The test results showed that the use of meyer wavelet energy and leaf shape features are efficient in recognizing leaves of plants regardless of the leaf color or size. Based on leaf shape features is excellent but in closed plants species the accuracy decreased , wavelet energy features have been extracted from each block in leaf image is more appropriate than general energy for the whole leaf image because it gave a good performance to our approach. This approach invariant to rotation, 56 images are rotated then tested and the recognition rate with/without rotation was 98.2%, this proves the effectiveness of this method. For future work more species of plants(very similar in their shape), large database and neural network can be used.

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