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Wood Species Identification System

S. Mohan[1], K. Venkatachalapathy[2], S. Ezhil Priya[3]

[1]Assistant Professor, Department of Computer Science and Engg.
Annamalai University, Annamalainagar, Tamilnadu, India.
mohancseau@gmail.com

[2]Professor, Department of Computer Science and Engg.
Annamalai University, Annamalainagar, Tamilnadu, India.
omsumeetha@rediff.com

[3]P.G. Student, Department of Computer Science and Engg.
Annamalai University, Annamalainagar, Tamilnadu, India.
ezhilpriya.s@gmail.com

Abstract: ***The recognition of wood species is needed is many areas like construction industry, furniture manufacturing. Wood is traditionally classified by human experts. But human identification of wood type is not accurate and the manual identification is a time consuming process. So in this paper, an intelligent recognition for identification of wood species was developed. This paper uses image enhancement as a preprocessing techniques and uses a new method which divides the image into several blocks known as image blocking. Each block is extracted using gray image and edge detection techniques. In this paper, GLCM (gray-level co-occurrence matrix) is used as texture classification techniques. The GLCMs are generated to obtain three features: contrast, entropy and correlation. The classification technique used to classify the wood species is a correlation. Our experimental results showed that the proposed method can increase the recognition rate up to 95%, which is faster and better than the existing system which gives 85% recognition rate.***

Keywords: Image Enhancement, Preprocessing, Gray-level co-occurrence matrix, Correlation.

1. Introduction

There are more than 15,000 identified species of trees on the earth of which most of them are in tropical regions. With the high diversity of wood species, the classification of wood species became important. Wood Classification is also important for wood-based industry. Also, some of timber traders mix different types of wood to increase their profit, so identification of wood is very important.

Wood is traditionally classified by wood (human) experts. But it is impractical and cost-effective for a human to analyze and identify the wood species. Also human identification of wood type is not accurate and the manual identification is a time consuming process. Human experts are not abundant in the market to meet the demand in the industry. Hence automatic wood species recognition system is required and is capable of reducing the errors caused by the traditional wood identification system.

All the wood species have different texture, strength, density, hardness, odor, color. Texture is one of important characteristics used in identifying the objects in an image. Therefore, the classification wood species based on texture classification can be a reliable solution to solve this problem. In previous research [4], the system identifies the species of wood using the textural features present in its bark. The captured image undergoes preprocessing techniques. GLCM is used to retrieve the features of wood species. The features are energy, entropy, contrast, homogeneity, angular second moment. Classification is done using correlation technique.

The research conducted by the authors [6], have designed an automatic wood recognition system (using VSDP-Visual System Development Platform library) After capturing images, two procedures are used to enhance image quality using VSDP library, image sharpening and contrast enhancement. The feature extractor used is GLCM. Artificial Neural Network using the back propagation algorithm is used to classify the wood.

Wood identifications are necessary in the many areas like construction industry and furniture manufacturing. In the construction industry, choosing the right wood is very important mainly. In the construction industry, woods are mainly used for constructing the roof truss. If the wood materials are not strong enough and used for constructing the roof truss, part of the house may collapse after a period of time. In furniture manufacturing, the type of wood used must be chosen properly for manufacturing the chairs, table and cubboards. Verification of wood species is important to avoid unnecessary loss for manufacturing. Identification of wood species can also be used in other areas such as,

- Determining the type of wood fragments from a crime scene,
- Determining the material used in ancient architecture,
- Understanding the ecological information of an area to study the relationship between the species.

The primary objective of this paper is to explore the possibility of developing a system which is able to perform automated wood recognition using the concept of image processing.

This paper has to achieve the following goals:

- To use a low cost equipment to identify the wood species based on its microscopic features.
- To use a new method of image-based recognition system for wood type identification by dividing the wood image into several blocks.

This paper is organized as follows: in Section II, we presented the methodology of the proposed system. In section III, experimental results are discussed, followed by conclusion in Section IV.

2. Proposed Method

At the outset of the process, the input images for both testing and training are acquired using a high resolution digital camera. Before the wooden images are tested for its relevant species, it is mandatory for the system to be trained with all possible species available.

The data is a collection of images that has been cut into 500x500 pixels. Authenticated wood samples were obtained for testing and training the data. Before testing the images of wood, the wood images have to be trained. For training the wood sample, image enhancement is the first step. It is done to improve the quality of the image. The image enhancement techniques used are contrast enhancement and image sharpening. Next blocking method is applied that divides the images into several blocks. RGB image blocks are converted to gray image blocks. Edge detection is applied to gray blocks. The features are extracted from gray block and Edge detected block. For each wood image, the features are extracted and stored in a separate flat file. The extracted features of a wood image compare with the features extracted from the test image during the testing process. The testing process is made very easy by identifying the correlation value between the test and the train image.

3. Wood Species Identification

This paper can identify 10 Indian wood species, namely jack, rosewood, sandalwood, satin, Sal, mahogany, mulberry, oak, ironwood and teak.

3.1 Image Acquisition

The system has been set up to acquire the image of wood using a high resolution digital camera. The captured image size is 1280 x 1024 pixels. Then image has been cropped into 500 x 500 pixels. This paper can identify 10 Indian wood species. Each type consists of 100 images derived from wood samples. So totally there would be 1000 images. These 1000 images are used for training and testing is done by using five images of each type. Thus, for testing we would have 50 images.

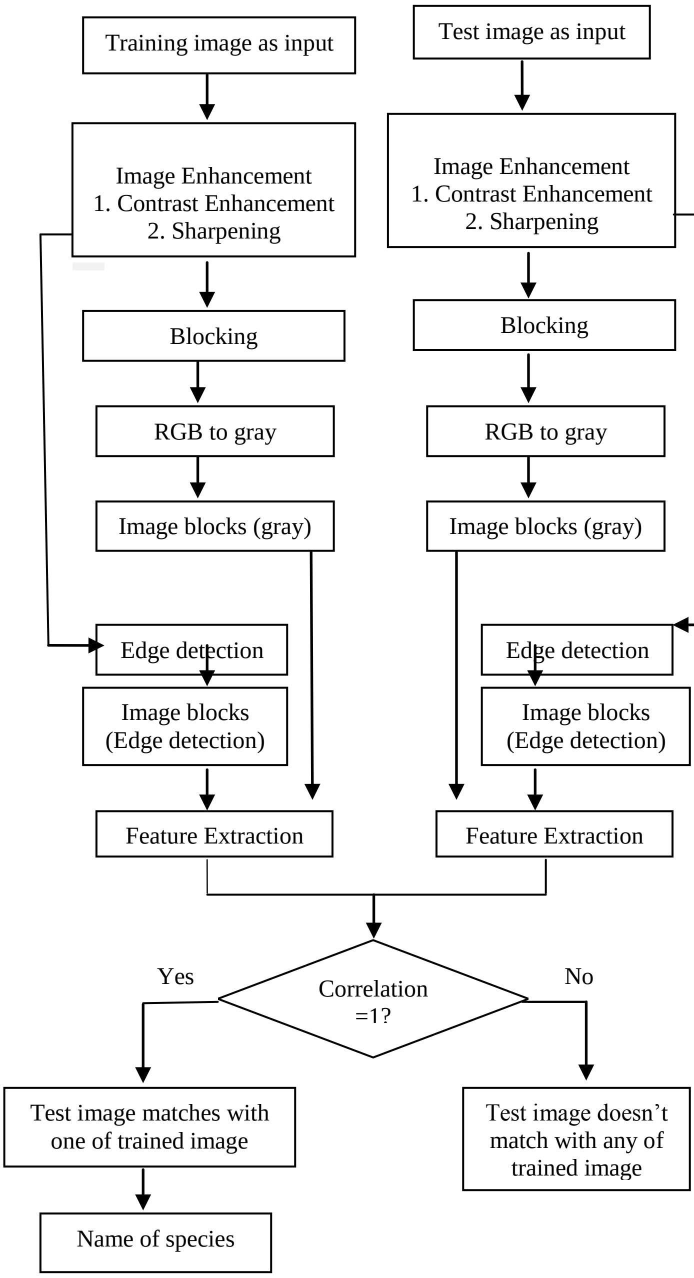

Figure 1: Proposed wood recognition System

3.2 Image Enhancement

It can be defined as conversion of image quality into better and more understandable level for feature extraction. Image enhancement is the improvement of digital image quality (e.g. for visual inspection or for machine analysis) without knowledge about the source of degradation.

Image enhancement will

1. Improve the interpretability or perception of information in images for human viewers
2. Providing `better' input for other automated image processing techniques.

In this paper, contrast enhancement and sharpening is used as image enhancement techniques [10].

3.2.1 Contrast Enhancement

Contrast enhancements improve the perceptibility of objects in the scene by enhancing the brightness difference between objects and their backgrounds. It’s a useful method for processing scientific images such as X-Ray images or satellite images.

It is also useful to improve detail in photographs that are over or under-exposed. Contrast enhancement processes adjust the relative brightness and darkness of objects in the scene to improve their visibility.

3.2.2 Image Sharpening

Image sharpening refers to any enhancement technique that highlights edges and fine details in an image. Image sharpening is widely used in printing and photographic industries for increasing the local contrast and sharpening the images.

Human perception is highly sensitive to edges and fine details of an image, and since they are composed primarily of high frequency components, the visual quality of an image can be enormously degraded if the high frequencies are attenuated or completed removed. In contrast, enhancing the high-frequency components of an image leads to an improvement in the visual quality.

3.3 Blocking

When working with large images, normal image processing techniques can sometimes break down. The images can either be too large to load into memory, or else they can be loaded into memory but then be too large to process.

Blocking is the process of dividing the RGB image into several blocks (here four blocks) of equal size. The image blocking method is expected to reduce the number of features used and increase the recognition rate [1].

3.4 RGB to Gray

RGB to gray is the process of converting each block RGB image into gray image. This stage is done as needed at a later stage that requires the image of a gray scale.

The rgb2gray converts RGB values to grayscale values by forming a weighted sum of the R, G, and B components. Also rgb2gray convert RGB images to grayscale by eliminating the hue and saturation information while retaining the luminance.

3.5 Image Blocks(Gray)

Image blocks are the images converted from RGB images into gray image, which consists of the full image, top left block, the top right block, bottom left block and the bottom right block.

0	**0**	**1**	**1**
0	**0**	**1**	**1**
0	**2**	**2**	**2**
2	**2**	**3**	**3**

3.6 Edge Detection

Edge Detection reduces the amount of data and filters out useless information, while preserving the important structural properties in the image.

Edge detection is needed because important features can be extracted from the edges of an image [1].

Goal of edge detection:

- Produce a line drawing of a scene from an image of that scene.
- Important features can be extracted from the edges of an image (e.g., corners, lines, curves).
- These features are used by higher-level computer vision algorithms (e.g., recognition)

In this research, the edge detection used is Canny.

3.6.1 Canny Edge Detector

Canny operator is used, because it gives the expected results compared to other operators. Canny aim was to discover the optimal edge detection.

Canny algorithm runs in following steps:

1. Smoothing.
2. Finding Gradients.
3. Non-maximum Suppression.
4. Double Thresholding.
5. Edge tracking by Hysteresis.

3.7 Image Blocks (Edge detection)

Image blocks are the images converted from RGB images into gray image, which consists of the full image, top left block, the top right block, bottom left block and the bottom right block.

3.8 Feature Extraction

In this paper, the wood features are extracted using Gray Level Co-occurrence Matrix (GLCM). It is also referred to as Gray tone spatial dependence matrix [1].

There is a total of 14 features for GLCM. Among the 14 features, 3 features are used in this paper to recognize the wood species. The three features are Contrast, Entropy and Correlation.

3.9 GLCM

It is a tabulation of how often different combinations of gray levels occurs in an image. GLCM calculates how often pairs of pixel with specific values and in a specified value and in a specified spatial relationship occur in an image and creates a matrix and then extracting the statistical features from this matrix. Figure 2 shows a test image and the values are image grey levels (GLs).

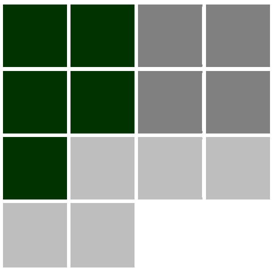

Figure 2: Test image and its gray values

GLCM texture considers the relation between two pixels at a time, called the reference and the neighbor pixel. In the illustration below, the neighbor pixel is chosen to be the one to the east (right) of each reference pixel. This can also be expressed as a (1, 0) relation: 1 pixel in the x direction, 0 pixels in the y direction.

The top left cell will be filled with the number of times the combination 0,0 occurs, i.e. how many times within the image area a pixel with gray level 0 (neighbor pixel) falls to the right of another pixel with gray level 0 (reference pixel).A different co-occurrence matrix exists for each spatial relationship (above, next to, diagonal). Fig.3 shows the matrix framework for the east (1, 0) spatial relationship.

2	2	1	0
0	2	0	0
0	0	3	1
0	0	0	1

Figure 3: GLCM values for the given image

3.10 Features

There is a total of 14 features for GLCM. Among the 14 features, 3 features are used in this paper to recognize the wood species. The three features are Contrast, Entropy and Correlation.

3.10.1. Contrast

It is a measure of the intensity contrast between a pixel and its neighbor over the whole image. Contrast is 0 for a constant image [7]. The formula is,

Species	Contrast	Entropy	Correlation
Sal	94.408	7.725	0.002
Rosewood	98.187	6.896	0.003
Mahogany	59.906	5.975	0.008
Mulberry	143.502	7.439	0.002
Sandal wood	148.908	8.259	0.001
Jack	121.731	7.406	0.002
Satin	410.734	8.720	0.001
Iron wood	217.071	7.876	0.002
Teak	368.734	8.413	0.001
Oak	325.189	8.585	0.001

$$Contrast = \sum_{i=1}^{G-1} \sum_{j=1}^{G-1} |i-j|^2 \, p(i,j) \qquad (1)$$

3.10.2 Entropy

Entropy is a measure of orderliness (how regular (orderly) the pixel values are within the window). It is a statistical measure of randomness that can be used to characterize the texture of the image. Entropy is usually classified as a first degree measure, but should properly be a "zeroth" degree [1]. The formula is,

$$Entropy = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i,j) * \log P(i,j) \qquad (2)$$

3.10.3 Correlation

It is the measure of how a pixel is correlated to its neighbor over the entire image. Range of values for correlation is 1 to -1 [1].

$$Correlation = \sum_{i=1}^{G-1} \sum_{j=1}^{G-1} \frac{\{i-\mu_i\} \times \{j-\mu_j\} \times P(i,j)}{\sigma_i \times \sigma_j} \qquad (3)$$

3.11 Classification using Correlation

The classification is done using Pearson's correlation coefficient [7]. In statistics, the Pearson product-moment correlation coefficient (r) is a common measure of the correlation between two variables X and Y. Pearson's correlation coefficient reflects the degree of relationship between the two variables [12]. It ranges from +1 to -1. The formula used to find the correlation value is,

$$R = \frac{\sum(x-Avg(x))*(y-Avg(y))}{\sqrt{\sum(x-Avg(x)^2 * \sum(y-Avg(y))}} \qquad (4)$$

Where R is a Correlation factor, x represents features of trained wood image and Y represents features of testing image. If both images are identical, then R will be 1.

4. Results and Discussions

This research can identify 10 types of Indian wood species. In this research three features are used to recognize the wood that provides the accuracy of more than 95%. The feature extraction values of gray and edge detected blocks are shown in Table 1 and Table 2.

The trained images results are stored in the database. The tested images vales are compared with the values of trained images. If trained images value matches the test image values, then the name of wood species will be displayed.

For testing, we have used five images of each type and so there are a total of 100 images were used for testing. Table 3 shows the correlation value of wood species. Figure 4 shows the graphical representation of wood species and its correlation values.

Figure 5 shows that the correlation value of testing image matches with the Jack, the tested image is identified as Jack wood.

Table1: Feature Extraction values of Gray Blocks

Table 2: Feature Extraction values of Edge Detected Blocks

Species	Contrast	Entropy	Correlation
Sal	33.978	4.707	0.015
Rosewood	152.364	5.633	0.003
Mahogany	165.660	5.593	0.002
Mulberry	384.210	4.853	0.001
Sandal wood	180.744	5.946	0.003
Jack	285.656	6.049	0.002
Satin	461.454	6.605	0.001
Iron wood	306.796	6.219	0.001
Teak	253.945	6.256	0.002
Oak	265.908	5.677	0.002

5.Conclusion

In this paper, an intelligent recognition system for the identification of wood species has been proposed. The system was designed to be cost-effective. The system shows high accuracy in recognizing wood when compared to manual identification. Image processing techniques have been used to improve accuracy. Contrast Enhancement and sharpening are used to improve the quality of the image. We have used GLCM as texture classification technique to extract the features of wood. For classifying the wood, Pearson's correlation coefficient technique has been used. The system shows accuracy of more than 95% in recognizing 10 Indian wood species.

Table 3: Correlation values of wood species

Wood Species	Correlation value
Sal	0.0147
Rosewood	0.0031
Mahogany	0.0024
Mulberry	0.0012
Sandal wood	0.0027
Jack	0.0052
Satin	0.0010
Iron wood	0.0013
Teak	0.0018
Oak	0.0007

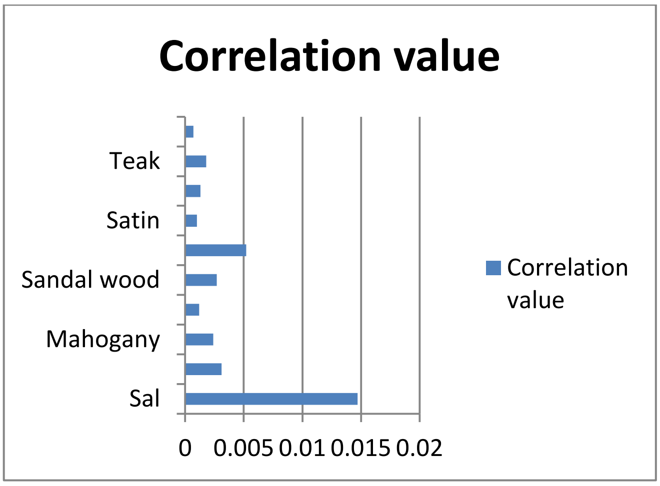

Figure 4: Graphical Representation of wood species and its correlation values

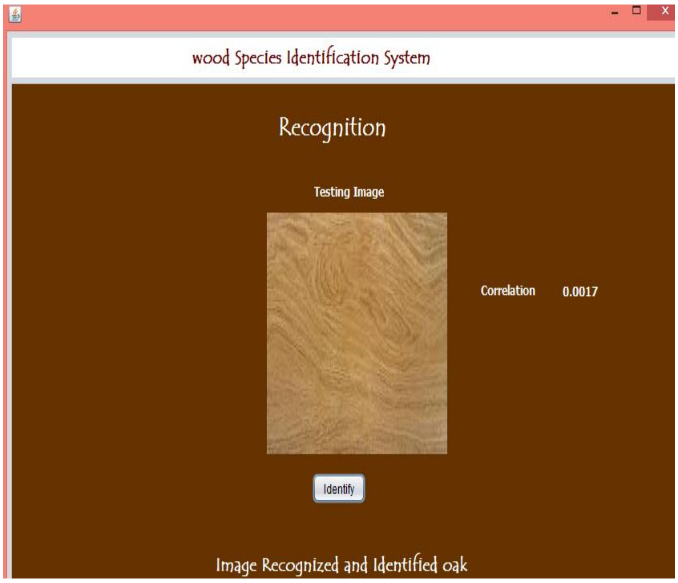

Figure 5: Recognition System that identifies the tested image as Jack wood.

Some suggestions for future work are,

a) There are still some combinations of blocks that have not been tested.

b) The system uses only three features, we can add features to increase the recognition rate.

c) The design of wood recognition system can be implemented onto an embedded platform that has a camera, processing board and LCD display.

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