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Performance analysis of discrete wavelet transform based first-order statistical texture features for hardwood species classification

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Abstract

A simple and efficient discrete wavelet transform (DWT) based first-order statistical (FOS) texture descriptor is proposed in this paper to accurately classify the microscopic images of hardwood species. Primarily, DWT decomposes each image up to 8 levels using selected Daubechies (db1- db10) wavelet as a decomposition filter. Subsequently, four FOS features, namely, mean, standard deviation, skewness and kurtosis are employed to obtain substantial signatures of these images at different levels. The db3 based FOS texture features has achieved 96.80% classification accuracy compared to 93.20% classification accuracy obtained by local binary pattern features using linear support vector machine (SVM) classifier.

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Keywords: Discrete wavelet transform; linear support vector machine; hardwood species; first-order statistics

1. Introduction

Hardwood species have great demand in construction, shipping, musical instruments, ammunitions (like rifle butts), railway sleepers, decorative items, furniture, etc. They emanate from angiosperm trees and are identified by their broad leaves. Hardwood species are both evergreen and deciduous and possess complex cellular structure which differs noticeably amongst the same species. Key elements that are worthwhile in identification of the

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hardwood species are vessels, fibers, parenchyma and rays [1]. Surfaces of any wood can be acquired from three geometrical planes such as cross-sectional (transverse), radial and tangential. These planes speak about the surface uncovered during the process of marking. Microscopic images of cross-sectional surfaces contain ample information necessary to discriminate the hardwood species. Reasons which necessitate identification of wood species are: to protect illicit import and export of endangered wood species, to prevent wood traders from receiving undue profit margin by carrying out amalgamation of wood species, and to assist custom officials in the assessment of tariff and enforcement of trade regulations [2].

The wood species of any standing tree can be easily identified either by its leaves or fragrance or fruitlets or all. When these parts of a tree are axed from its trunk it becomes difficult to recognize timber and tree, thus necessitating the use of wood species identification techniques. These techniques are broadly classified in two categories; viz., traditional and machine vision. Traditional techniques of wood identification are based on analysis of macroscopic structures, hardness, color and scent of wood samples. Hardwood species identification, based on analysis of microstructures of image samples is the prevailing technique. The features of unidentified samples of hardwood species are matched against features of known hardwood species samples [3]. Traditional methods of wood identification are not only time consuming, but may also be erroneous as the identification accuracy is highly dependent on the competency of the officials involved in the identification process. Machine vision technology has been introduced with an aim to overcome shortcomings associated with the traditional methods of wood identification. It involves application of image processing techniques for identification and classification of image samples of hardwood species [4-12].

Initial wood identification technique employed use of gray level co-occurrence matrix (GLCM) to extract texture features of images of wood species and multilayer perceptron as classifier [4]. An in-house “Visual System Development Platform (VSDP)” to classify 20 tropical wood species of Malaysia was proposed by Khalid et al. [5]. They extracted texture features of each images using GLCM and used multilayer perceptron backpropagation neural network (ML-BP-NN) for classification. Bremananth et al. [6] proposed GLCM based texture features present in their barks classified with Pearson correlation technique for categorization of different Indian wood species. This technique helped to achieve high rates of classification accuracy. Combination of basic gray level aura matrix (BGLAM) and statistical properties of pore distribution (SPPD) techniques to identify 52 species of wood was proposed by Khalid et al. [7]. Moreover, Khairuddin et al. [8] suggested use of k-means clustering (18 clusters were selected based on minimum variance), followed by local discriminant analysis (LDA), kernel discriminant analysis (KDA)/generalized singular value decomposition (GSVD), with k-nearest neighborhood (KNN) as a classifier. A method for recognition of 24 wood species using the Gabor entropy feature along with mean and standard deviation classified by nearest neighbor classifier was proposed by Wang et al. [9].

Martins et al. [10] developed a database of microscopic images of hardwood and softwood species. In their investigation, features of image samples of hardwood and softwood species were extracted by means of GLCM, local binary pattern (LBP) and statistical methods with 24, 59 and 6 features, respectively. The LBP features classified with SVM achieved the best classification accuracy of 86%. Yadav et al. [11-12] proposed two different texture feature extraction techniques for classification of microscopic images of 25 different hardwood species using MLP-BP-NN classifier. The first technique integrated GLCM with Gabor wavelet to obtain texture features and yielded an accuracy of 92.60% [11], whereas the second technique, using Coiflet DWT based texture features provided classification accuracy of 92.20% [12].

The assessment of above work suggests that several texture feature extraction and classification techniques are used to improve the classification accuracy of hardwood species. It is obvious that the quality of the texture features extracted from the images of hardwood species have significant impact on the classification accuracy of the classifier. This research work proposes use of a DWT based FOS texture feature technique for improving the classification accuracy of hardwood species. Linear SVM classifier is used for evaluating the performance of proposed texture feature technique.

The present work is organized as follows: Section-2 presents the proposed DWT based FOS texture features for classification of hardwood species, Section-3 briefly describes DWT, FOS and linear SVM classifier, Section-4 details the performance evaluation of the DWT based FOS texture features, and Section-5 concludes the work.