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Enhanced DWT based on TOP-HAT Transform for Hindi Character Recognition

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ABSTRACT: Character Recognition by machines is an innovative way by which the dependence on manpower is reduced. In this paper, a novel technique that combines both DWT and top-hat Transform is suggested for Hindi character recognition. The suggested approach is a three-step procedure. The suggested methodis verifiedonthe Devanagari Hindi characters database. In the first step of pre-processing, which is resizing of the image is performed. In the second step, features are extracted by using traditional discrete wavelet transformed (DWT). Features such as entropy, standard deviation, and energy are extracted and classified by employing a Support vector machine (SVM). Results show that classification accuracy is of 72% is obtained through the traditional DWT at the second level of decomposition. For further improvement of the performance of DWT in the third step, top-hat transform is integrated with DWT. For the enhanced DWT classification accuracy attained is 76%, that is an increment of 4 % is achieved as compared to the traditional DWT.

KEYWORDS: Hindicharacters, Top-Hat Transform, Discrete wavelet transform, Support vector machine (SVM)classifier.

I.INTRODUCTION

Texture analysis is a crucial area in the field of computer vision and related fields. The texture is one of the important characteristics used in the identification of interesting objects or regions within an image. Texture analysis has various applications in computer vision, image processing, medical image processing, object recognition, remote sensing, content-based image retrieval, and related fields, Jianguo Zhang, and TieniuTan[1]. The study of texture will preferably be invariant to the viewpoints. Texture analysis includes four major issues: a) extraction of textures, b) inequality of texture, c) classification of texture and d) texture shape. Texture classification relies on statistical texture analysis of the co-occurrence of grey level (GLCM) texture images.Harlick et al. [5] generalized matrices of co-, which define edge statistics of the second order.An alternative to generalized co-occurrence matrices is to look for pairs of edge pixels that fill those edge magnitude and direction conditions in full. While the image texture is not precisely defined, it is easily interpreted by humans and is thought to be a rich source of visual knowledge–about the existence and three-dimensional shape of physical objects [6]. To extract the texture information of an image; many techniques are in existence. They are co-occurrence matrix [5], Gabor filter [2], wavelet transform [3]. Approaches to texture analysis are usually categorized into 1. Structural [17], 2. Statistical [18], 3. model-based [19] and 4. Transform [6].

Discrete Wavelet Transform (DWT) is a method that describes the spatial and frequency information of an image, Sundararajan [7]. The DWT is a multiresolution technique that divides the image into low (L) and high (H) frequency band [8]. A. Ahmadian and A. Mostafa [3] have proposed Gabor wavelet is highly significant in representing the texture structure. The high-frequency band provides edge related information of an image and is popularly used in watermarking techniques [10]. The low-frequency band is used further decomposition. S. Nithya and Ramakrishnan [10] propose a Wavelet Domain Directional Binary Pattern using Majority Principle ($WDDBP_0$) which integrates the discrete wavelet transform. The image is decomposed i.e., divided into four sub-images. Those sub-imageslabelled LH1, HL1, and HH1 represent the finest scale wavelet coefficients i.e., detailed images while the sub-image LL1 corresponds to coarse coefficients i.e., approximation image [8]. Thus, features extracted from all the sub-images. Chang and Girod [11] introduced direction adaptive discrete wavelet transform that utilizes directional lifting for effective feature extraction. A. Ahmadian and Arivazhagan et al. [3,12] presented rotation invariant texture classification involving Gabor filters. The texture features are extracted by computing the mean and variance of filtered images. Swathi S Dhage [4] et. al prosed an iris pattern by using a combination of pre-processing using random transform and top-hat filtering, feature extraction using discrete wavelet transform (DWT) and discrete Cosine Transform (DCT).

The algorithm used in characterrecognition be divided into three categories: image preprocessing, feature extraction, and classification. There isa different methodology used to recognize the Hindi characters out of those few methods are listed as- Support vector machine (SVM) algorithm, Neural networks, Naïve Bayes, Curvelet transform, and so on. P. Sujatha and D. Lalitha Bhaskari [13] have proposed the recognition of Telegu and Hindi characters. In that paper, theTelegucharacter recognition rate is 92.5 and the Hindi character recognition rate is 81.6, they proposed, CNN-KNN is proved to give better results than other methods. [14] Pooja Sharma has proposed an Indian script character Recognition,in the experiment the accuracy of the character recognition system depends on various factors such as training set and availability of sample data and test data. Prasanta PratimBairagi [15] has proposed that recognition of characters greatly depends upon the features used, the main emphasis is given towards the recognition of the individual consonants and vowels which can be later extended to recognize complex derived letters and words. Divakar Yadav et al [16] has suggested that major reasons for the poor recognition rate are error in character segmentation. They proposed a performance of approximately 90% correct recognition rate is achieved. Shalininpuri and Satya Prakash Singh [20] have discussed an efficient classification on handwritten mono-lingual datasets on Hindi, Sanskrit and Marathi languages using SVM. Their project includes projection profiles, Shiro Rekha-less characters, extract features, and classifies into pre-defined categories. ChayapornKaensar [21] has proposed to considered error rate, misclassified image rate, computing time along recognition rate. Based onthe above parameters SVM results better than K-Nearest Neighbour with recognition rate up to 96.93% for handwritten digit recognition.

In this paper, the proposed methods for Hindi characters recognition isthree-step procedure. In the first step of pre-processing, which is resizing of the image is performed. In the second step features are extracted by using traditional discrete wavelet transformed (DWT). Features such as entropy, standard deviation, and energy are extracted and classified by employing Support vector machine (SVM).

This paper organized as follows, section 2 represents a brief review, section 3 discusses the proposed methods in detail. The results are discussed in section 4, and section 5 defines the conclusion of project.

II.LITERATURE REVIEW

A. Discrete Wavelet Transform

The most common transformation technique adopted for compression of images is discrete wavelet transformations. The approach suggested for this paper is to achieve a high compression ratio in images by implementing wavelet transformation from Daubechies.

The wavelet transform has gained wide acceptance in signal processing and compression of images. Wavelet transforms a signal into a series of functions that form the basis. Those fundamental functions are called wavelets. The DWT was implemented as a highly effective and versatile tool for the decomposition of signals by sub bands. Today the 2D DWT is a crucial procedure in image processing. This is a study of multi-resolution, which decomposes images into wavelet coefficients which scaling function. In the Discrete Wavelet Transform, signal energy concentrates on specific wavelet coefficients. This feature is useful for compressing images. A timescale representation of the digital signal is obtained in DWT using digital filtering techniques.

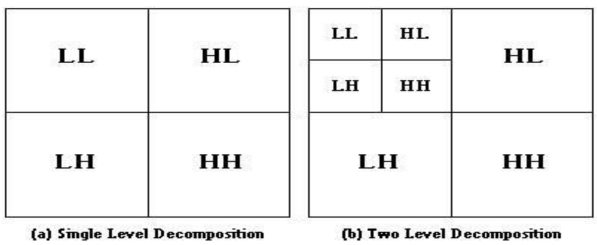

Fig.1. Discrete wavelet transform level decomposition

An introduction to some wavelet families are

- Haar
- Daubechies
- Biorthogonal
- Coiflets
- Symlets
- Morlet
- Mexican Hat
- Meyer
- Other Real Wavelets
- Complex Wavelets

B. Top Hat Transform

Top-hat transform is an operation in mathematical morphology and digital image processing that extracts small elements and information from the given images. There are two types of top-hat transform: the white top-hat transform is defined by any structuring factor as the difference between the input image and its opening; the black top-hat transform is doubly defined as the difference between the input and the closing image. Top-hat transforms are used for various image processing tasks, such as feature extraction, background equalization, image enhancement, and others (Wikipedia, 2020).

Mathematical definitions

Letf: $E \rightarrow R$

be a grayscale image, mapping points from a Euclidean space or discrete grid E (such as R^2 or Z^2) into the real line. Let b(x) be a grayscale structuring element. Then, the white top-hat transform offis given by:

$T_w(f) = f - f \circ b$,

Where $\circ$ denotes the opening operation. The black top-hat transform offis given by:

$T_b(f) = f \bullet b - f$,

Where $\bullet$ is the closing operation.

Syntax:

X = imtophat (I, SE),

I, original image,

SE, Structuring element (Wikipedia, 2020).

III. PROPOSED METHODOLOGY

In this paper, the steps involved in the process of Hindi characters recognition are pre-processing, feature extraction and classification. In pre-processing, which is resizing of the image and convert colour image (RGB) into grayscale image. The enhancement technique, top-hat transform is integrated with DWT. Using Daubechies wavelet as a decomposition filter, the grayscale images are decomposed by DWT up to a few stages during feature extraction. The method of decomposition is as follows: the grayscale image is segmented into four equivalent quarter-size sub-images, i.e., LL1, LH1, HL1 and HH2 at the first step of decomposition. The sub-image part LL1 is subsequently decomposed into four-quarter images of equal size, LL2, LH2, HL2 and HH2, to generate 2nd decomposition stage. Likewise, the coefficient of approximation (LL) of each level is again segmented into four sub-images of equal size in order to achieve the next higher degree of decomposition. In addition, three first-statistical properties, i.e. entropy, standard deviation and energy, are derived from each of these sub-images. In addition, these texture features vectors representing various sets of values are scaled in the range 0 to 1. The normalized vector function is then added to the input portion of the SVM classifier.

The proposed algorithm in this paper are follows:

1.Applying Top-Hat Transformation for image enhancement.

2.Appyling discrete wavelet transformation for top-hat transformed images.

3.Extract the features.

4. Apply SVM classification.

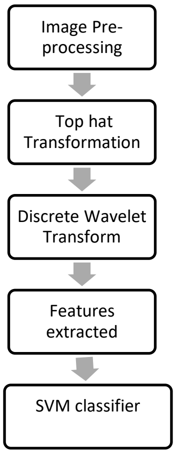

Fig. 2. Block diagram of machine learning algorithm

A. Image Pre-Processing:

The pre-processing of our technique is to re-size images without missing information at a resolution of 256x256. The data set considered consists of colour (RGB) images. Colour photographs have been converted into grey photographs with a resolution of 800x600. And this continues with the use of Visual Enhancing techniques. The initial dataset is made up of 50 images. Out of those fifty percent images are used for preparation, and fifty percent of the images are being checked.

B. Top Hat Transform:

The goal is to improve the image by adjusting its contrast using a particular contrast enhancement technique based on morphology. The product of image enhancement since Top-Hat Transformation has been implemented.

Fig.3. Top hat transform

C. Discrete Wavelet Transform:

DWT has a propensity to simultaneously accomplish spatial and frequency localization at any given moment. Turn a discreet wavelet, convert a discreet time signal into a discreet wavelet representation. DWT is used to divide the image to a pixel. The DWT returns a data vector of the same length as the entry. Wavelets are used to measure differences in

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intensity in the various orientations of the images. We decompose the input image to the second stage of decomposition.

D. Features Extracted:

In this paper, first order statistical moments of the grey level histogram of images, namely entropy (1), standard deviation (2) and energy (3)are used for feature extraction. The standard deviation refers to the measure of contrast in an image. Entropy is a measure of the quality of the image information, which is defined as the average variance of the source of information. Energy is a quantitative term for image processing. The goal behind the word ' steam' is to mitigate or optimize. It is used for standard object detection or segmentation tasks where it is proposed as an energy minimization problem.

$$\text{Entropy}= \sum_{i,j} p_{ij} log p_{ij}. \quad (1)$$

$$\text{Standard deviation, } \boldsymbol{\sigma} = \sqrt{\frac{\sum(x-\mu)^2}{N}}. \quad (2)$$

$$\text{Energy} = \sum_i \sum_j p_d^2(i,j). \quad (3)$$

E. SVM Classifier:

Support vector machineis a supervised machine learning algorithm which can be used for classification. It wasoriginally proposed as a binary classifier that works on the principle of constructing an optimal hyper plane to separate the two classes. This uses a method called the kernel trick toconvert the data and then, based on these transformations, determines an optimal boundary between potential outputs. The explanation for choosing this solver is that even large datasets require fewer memory and are recommended for standard classification tasks.

IV.RESULTS AND DISCUSSIONS

A. Hindi Characters Database

The Hindi character database in association with UCI machine learning repository, center for machine learning and intelligent systems; contains 50 samples. Each image sample has the resolution of 800x600 pixels. All the samples were correctly labelled. This database has five different classes, each class having 10 images. For testing and training, randomly select 25 images each

B. Results

In this paper, we used a set of 50 Hindi character images from the DevanagariHindi letters. Every image in that database is 800x600 pixels. we use the top-hat + DWT, where the training and testing images are decomposed to two levels by using db2 as a decomposition filter. When the original image is decomposed to first level of decomposition by applying db2 wavelets, four sub-bands LL1, LH1, HL1 and HH1 are obtained.Similarly, approximation (LL) coefficient of each level is again segmented into four sub-bands of equal size to obtain next higher level of decomposition. We select all the sub-bands from each decomposition level. Then statistical texture features like energy, entropy and standard deviation are extracted from the detail regions of DWT decomposed images, at different scale. Hence, the statistical features are derived from the second level decomposition of one image. Accordingly, for two levels of decomposition, total 12 features are extracted from each image. An SVM classifier is used to classify each texture feature to an appropriate class.

The recognition rate of the first, second and third level DWT decomposition are56%, 72% and 36%.Out of three levels second level gives much performance so we considered second level DWT decomposition then we integrate the top hat enhancement technique to the original dataset followed with DWT decomposition, recognition rate raises up to 76%. The results are tabulated below

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Methods		Accuracy (%)
1.	DWT_Level_1	52
2.	DWT_Level_2	72
3.	DWT_Level_3	36
4.	Top-Hat + DWT	76

Table 1. Classification accuracies

Graph:

The images shown below are sample images with respective to their second level DWT decomposition and top-hat transform images. Three images each of the class in the database.

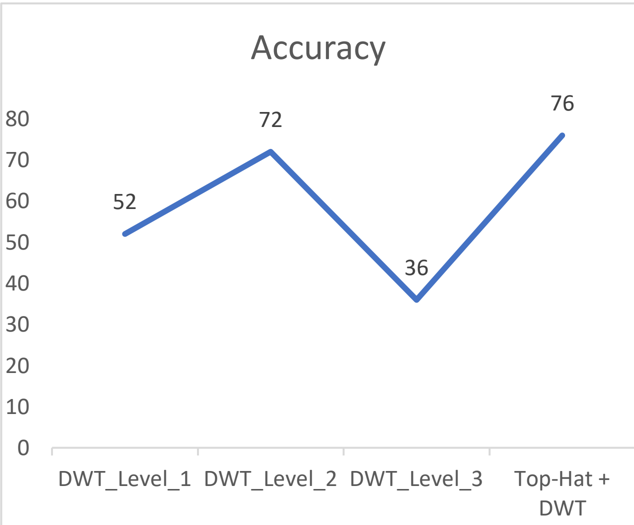

Fig. 4. Characteristics of enhancement methods.

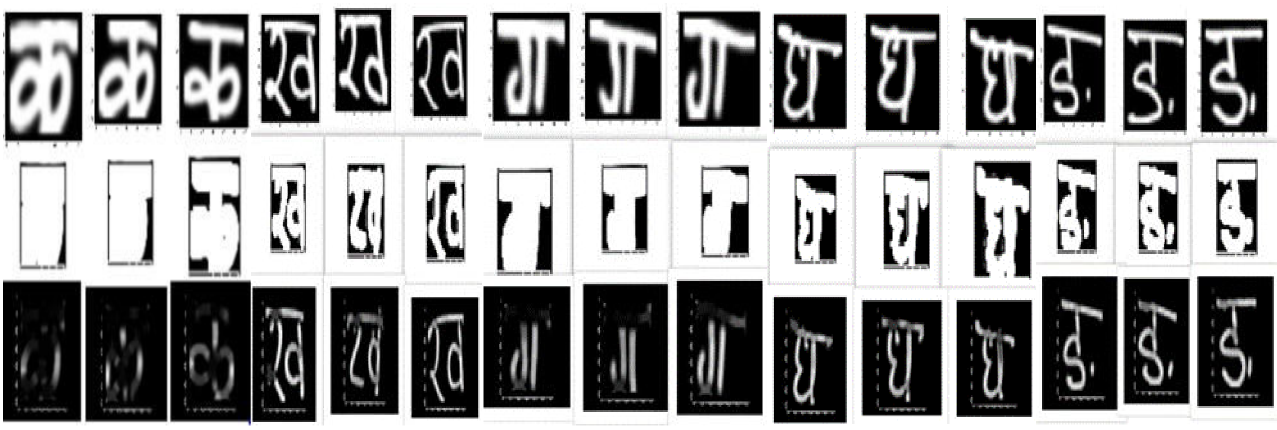

Fig. 5. Examples of original, 2nd level DWT and Top hat transform images in first, second and third row respectively.

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V. CONCLUSION

In this paper we implemented different image enhancement algorithms which are based on top hat filtering and discrete wavelet transform. A linear SVM classifier is use to test the efficiency of the proposed feature extraction strategies for different stages of image decomposition by DWT. The goal here is to increase the acceptance levels. Output findings show that the proposed DWT with the top hat transform is successful for the recognition of Hindi characters.

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