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# A SURVEY ON HANDWRITTEN CHARACTER RECOGNITION USING ARTIFICIAL NEURAL NETWORK

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*Abstract* -**To automatically recognize the handwritten Hindi character is a very tricky task. Because these characters are written in unlike sizes, dimension, orientation, thickness and format. The Hindi Language is one of the complex language which having compound characters. Compound characters are the combination of one or more characters to make complex characters. Thus the structure of these is complex in compare to separate characters. DEVANAGARI is the scripting language for many languages including Hindi, Sanskrit, Marathi, Nepali, Gujarati and so on. This paper discusses the survey on the recognition of handwritten Hindi compound characters by artificial neutral network and their variants.**

*Keywords:* **Segmentation, Classification, Character Recognition, Feature Extraction and Artificial Neural Network (ANN).**

## I. INTRODUCTION

The off-line handwritten character recognition becomes the key aspect in modern research. Because of the numerous application found in last few decades due to vast use of bank cheques, zip code, car plates, automatic sorting of postal mail and other office works [1], [2]. Recognition of Hindi handwritten character is the one of the major problem in today's world. Hindi characters are not recognized efficiently and precisely by computer machine system. Many researchers had done many algorithms to recognize these Hindi characters. Many kinds of software are available in the market for optical Hindi characters recognition [3]. None of the or standalone machine or process can find recognition with 100% accuracy. Hindi characters recognition is becoming more and more important in the today's modern world. It helps to solve more complex problems and ease jobs for humans. The problems of recognition of hand-printed characters are still an active area of research. With still need of increasing requirement for office automation, it is vital to provide practical and effective solutions [4-6]. It has been found that all sorts of structural, topological and statistical information about the numbers do not lend to help for handwritten character recognition process due to different types of writing styles [9].

There are numerous work has been done in the similar field some of them are explained below. Najmeh Samadiani et al. proposed the neural network based approach for recognition of printed English characters [5]. The author used SOM neural network for recognition task. By Junchuan Yang et al. [2] proposed feature extraction of alphanumeric character based on integrated neural network. This paper gives the idea of handwritten character recognition system, which uses a variety of pattern recognition; this method has improved the accuracy of handwritten number recognition system. The paper proposed by J.M. Alonso-Weber et al. [7] which takes the combination of pattern transformations and additive input noise annealing for character recognition which are handwritten. In this the test error is less than 0.43%, which is up to standard if we compared it to other complex neural architectures like Deep Neural or Convolution Neural Networks. Amitkumar Shinde et al. [27] proposed recognition of Marathi character by converting sign language to text. This system uses forty-six Marathi sign language alphabets and 500 words of sign language. The some work based on fuzzy model based handwritten number recognition proposed by O.V. Ramana Murthy et al. [15]. This method deals with number detection of both Hindi and English numerals. The recognition is carried out by the fuzzy logic sets by modifying exponential membership functions which are fitted to these logic sets are derived from the character features consisting of normalized distances obtained using the Box approach.

In the field of cursive handwritten character recognition the author Jin-Yong Ha et al. [10] proposed the idea of combining the network of hidden Markov model (HMM's) and the dynamic programming-based search is highly relevant to online handwriting character recognition.

The some other author namely Muhammad Imran Razzak et al. proposed the Urdu-like cursive scripts for optical character recognition. This paper proposed the survey of the optical character recognition literature with reference to the Urdu-like


cursive scripts. This method used for both offline and online character recognition process.

This paper presents the survey on the recognition of handwritten characters. The first step is to pre processed the handwritten character for recognition. For this the paper uses the first to convert the jpeg image into its equivalent binary complemented image. Then after this paper have to find out the feature extraction and then classify this feature based on the certain set of rules. And then recognise the handwritten character based on the artificial neural network (ANN).

The rest of the paper is described as follows. In Section 2, introduces the pre-processing which includes binarization, noise reduction and size normalisation of the image data set. Section 3 describes the segmentation method which includes explicit and implicit segmentation. Section 4 describes the feature extraction algorithm which includes six methods. Section 5 describes classification algorithm based on ANN which includes five methods.

## II. Pre-processing in DEVANAGARI Script

For Pre-processing of an image, we firstly need to acquire image which takes input characters of Devanagari script are scanned by the scanner in jpeg format of 300 dpi. Hence in image acquisition process the input is in handwritten character format and output is in digital format for pre-processing.

### 2.1 Binarization:

Binarization is the process which converts colored image or gray scale image into binary form (0 & 1) by thresholding [8] [26]. The method named thresholding is used to convert gray or colored image into binary image; some methods namely adaptive thresholding, global thresholding and local thresholding [28].

### 2.2 Noise Reduction:

In image the noise can be because of poor scanning or due to the writing instrument which is unwanted and should be removed for further process [2]. Some filtering methods are used for the noise reduction like Butterworth low pass filter, Median filter, Min-Max filter and so on [8].

### 2.3 Size Normalization:

Each character is normalized to fit within suitable window size like 30x30, 60x60 so that all charcters have same size of data [28].

## III. Segmentation

It is the process by which we can remove the Shriorekha from the Devnagri characters. Segmentation is very important for pre-processing of input data in which it extract only required characters of script [28]. The Segmentation is done in a following manner:

- First from the page, it identifies the line,
- Second it identifies word,
- Last, find the characters from the word.

The character segmentation is done by connection section labeling and projection analysis method. Mainly there are two types of Segmentation processes, Explicit Segmentation and Implicit Segmentation.

### 3.1 Explicit Segmentation:

The procedure for removing the some part of images into major components is done by explicit segmentation. Explicit segmentation can be segmented by using linguistic framework [29]. This process is computationally complex in compare to Implicit Segmentation but gives better results.

### 3.2 Implicit Segmentation:

Recognition and Segmentation of characters are done at the same time in this process. Segmentation is done for recognition assurance, including semantic syntactic or precision of the overall consequence [29].

## IV. Feature Extraction

For the handwritten characters images recognition the feature extraction technique is used in which characters are taken as unit and used for recognition purposes. Functional and mechanized pattern recognition system demands two basic functions. Creating attributes from an object which conveys the description task known as Feature Extraction [11] [26]. Successful application of machined pattern recognition system is character recognition [12]. Comparative analysis is presented for character geometry, neural networks and gray level difference method. Former two is widely used for character recognition, while the latter one is employed in recognizing texture. There may be two categories in which features may be classified which are namely Local Features extraction and Global Features extraction. Local Features deal with Geometric parts of the character images like number of end points, joints, branches, concave and convex parts while Global Features deal with Topological form of character images like projection profiles, connectivity, number of holes etc.

There are many methods of Feature Extractions:

- Zoning
- Crossing and Distances
- Gradient Local Auto Correlation
- Directional Features Extraction
- Histogram of Oriented Gradients
- Profiles and Projection Histograms

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### 4.1 Gradient Local Auto-Correlations (GLAC):

It can be described as a natural extension of SIFT of 1st order statistics i.e. histograms to 2nd order statistics i.e. auto-correlations. In GLAC, image gradients can be described in the form of their orientations and magnitudes. The formulation extends from Higher-order Local Auto Correlation (HLAC) of different pixel values to compare with gradients.

### 4.2 Directional Features Extraction:

Directional Features are used for both handwritten characters and machine printed characters recognition. In this features are extracted with the help of different gradient values with respect to their neighboring pixels. In this horizontal and vertical Sobel operator templates are used to feature extraction. The Sobel operator shows a result of zero vectors at an image point that resides in constant region intensity and shows a vector value at a point from darker to brighter values. 3×3 Sobel operator's windows are used to extract gradient features. It uses two templates, horizontal and vertical directions respectively for computing the gradient components.

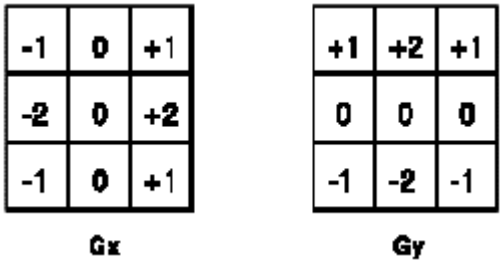


Fig. 1. Sobel Operator

The gradient vector of different direction is partitioned into two components synchronized with the two neighbors standard form directions by showing a number of standard directions. The components are assigned to the respective direction planes and on decomposing all the gradient vectors, a number of feature values can be extracted from each direction plane. The gradient is computed on each pixel value of the image that is normalized.

### 4.3 Histogram of Oriented Gradients (HOG):

The histogram of oriented gradients (HOG) is a feature extraction method used in image processing and computer vision for object detection [21]. This technique is used to count the number of occurrences of gradient orientation in localized portions of an image. The HOG method is similar to the edge orientation scale-invariant feature transform (SIFT), histograms (EOH) and shape contexts, but divers in that it is computed on a dense grid of evenly spaced cells and uses overlapping local contrast normalization for improved accuracy [23-24].

HOG is a window based descriptor computed local gradient detection of interest point. The window is centred upon the point and divided into a regular square grid ($N \times N$). Within each cell of the grid a histogram is computed representing the allocation of edge orientations within selected cell. The edge orientations are computed as $\arctan(\frac{\delta I}{\delta y}/\frac{\delta I}{\delta x})$ and quantized into $q$ bins. The histogram counts are added to form a $q$-S vector for each cell, which are again added to form a $qn^2 - S$vector for the window.

#### 4.3.1 Constructing the Gradient Field

In order to encode the relative location of pixels and spatial orientation of sketches or Canny/Sobel edges of images, the author uses a dense gradient field interpolated from the thin set of edge pixels. The author begin with a mask of edge pixels $N(x, y) = \{0, 1\}$, derived either from the Sobel edge map of a photograph or from the mask of sketched strokes. A sparse orientation field is computed to find the gradient of these edge pixels:

$$\theta[x,y] \rightarrow \arctan\left(\frac{\frac{\delta N}{\delta y}}{\frac{\delta N}{\delta x}}\right), \forall_{x,y} N(x,y) = 1 \qquad (1)$$

We get a dense field $\theta_\Omega$over image coordinates $\Omega \in S^2$ constrained such that$\theta(p) = \theta(p), \forall_{p\in\Omega} N(p) = 1$. The dense field can be smoothening, foe this we introduce a Laplace constraint by seeking the Θ that minimizes:

$$argmin \iint (\nabla\theta - V)^2 \;\; s.t. \theta|_{\delta\Omega} = \theta|_{\delta\Omega} \qquad (2)$$

that corresponds to the solution of the following Poisson equation with Dirichlet boundary condition.

$$\Delta\boldsymbol{\theta} = \text{divv over } \Omega \text{ s.t. } \theta|_{\delta\Omega} = \theta|_{\delta\Omega} \qquad (3)$$

where div is the divergence operator and **v** is the guidance field derived from the original image. A discrete solution was presented by forming a set of linear equations for non-edge pixel that are fed into a scrubby linear solver to obtain the complete field.

### 4.4 Statistical Features:

The statistical features provide low complexity and high speed. In this method zoning, crossing and distances and projections on characters take place.

#### 4.4.1 Zoning:

In this the character in the frame is divided into different overlapping and non overlapping zones and then in each zone the density of each pixel is calculated. In zoning the control box that is a small rectangle is partitioned. Handwritten characters are normalized to fixed pixel size and each feature

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is labelled in accordance to the different zones of the control box.
Methodology for Zoning: - Using loop breaks the box into equal parts. In each zone find the density of each pixel. For further work store these features into a matrix.

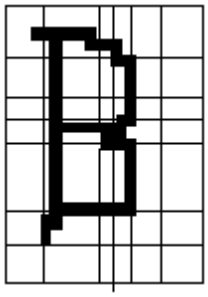

Fig. 2. Zoning [30]

### 4.4.2 Profiles and Projection Histograms

Two-dimensional handwritten character image can be converted into the one dimensional vector by making projections of the character images shown in fig 3. To make projection histograms Number of pixels in horizontal direction and vertical direction of a character image is counted. Distance between the boundary of the character image and bounding box in terms of pixels is profiles of image [30].

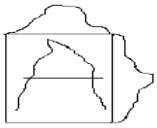

Fig. 3. Projection Histogram [30]

### 4.4.3 Crossings and Distances

The number of variations from background to foreground pixels of the images along with horizontal direction is horizontal crossing and the number of transitions from background with respect to foreground pixels throughout the image along vertical direction is vertical crossing. Horizontal distances are the distances between the first pixel from the left and last pixel from right boundaries of the image. Vertical distances are the distances which are between the first pixel from the bottom and top boundaries of the image. Fig 4 given below shows the crossings and distances in an image [30].

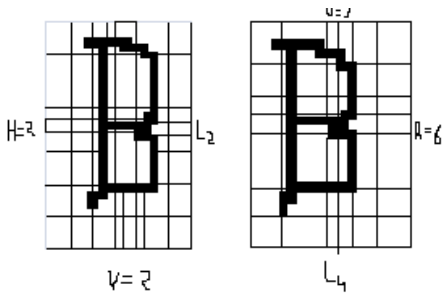

Fig. 4. Crossings in an Image [30]

## V. Classification

There are many classification algorithm has done by many scholars listed below.

### 5.1 Support Vector Machine (SVM)

SVM is used for regression and classification analysis of pattern recognition of hand written character images and is used for analyzing the data [13-14]. SVM is a non-probabilistic binary linear classifier. Using kernel trick, SVM can perform non-linear classification. In SVM there are two types of learning supervised learning and unsupervised learning. Selections of penalty parameter and kernel function decide the performance of SVM. In this paper the main focus is on the FFNN. The SVM is flexible and versatile to use and it reduces the memory requirement in training period. But if the total features are greater than total samples then the performance of SVM will be poor.

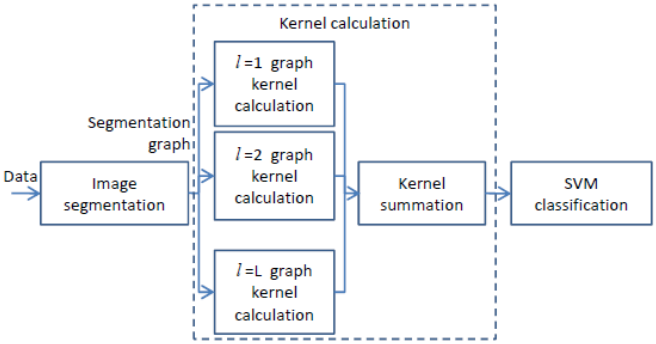


Fig. 5. SVM 'Kernel' Classification [14]

An SVM resolve to classify the hyper plane with maximum margin between the two classes in the featured space, by moving the input feature data onto a higher dimensional feature space, that are connected to the input space nonlinearly[14]. There are many authors who used the character classification of Radial Basis function kernels :

$$K(x, y) = exp(-\|xy\|\text{^}2/22) \quad (4)$$

A binary classification of handwritten character can be used in SVM elementary form. Then given training data of handwritten character with feature vectors $X_i$ is assigned to class $Y_i \epsilon \{-1, +1\}$ for $i = 1,2,3, \ldots \ldots \ldots, n$, the SVM solve.

$$minimize = \frac{1}{2}\|\omega\|^2 c \sum_{i=1}^{n} \varepsilon_i \, , such\ that\ y_i(k(\omega, x_i) + b) \geq 1; \varepsilon_i \geq 0 \quad (5)$$

Where $\omega$ is a vector and $\varepsilon$ is a 1- dimensional vector in the same feature space.
One popular technique for selecting features in SVM is RELIEF [16, 17]. RELIEF method assigns a weight to a

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particular feature detected that is based on the differences between feature values of nearest neighborhood pairs. Cao et al. [18] further developed this algorithm by learning feature weights in kernel spaces. This routine is often done as a data processing step, independent to the classifier construction. De la Torre and Vinyals [19] learned a subspace-parameterized Taylor series kernel growth that effectively down weighed irrelevant pixels for taxonomy with SVMs [20]. Recently, there are several papers that learn kernel matrices for classification [16–18].
A popular approach is to define parameterized connections to kernel matrices and optimize kernel parameters with an ideal kernel. Another popular approach is to learn a kernel which generates that property. In this technique, the kernel is learned independently of the SVM parameters.

### 5.2 Feed Forward Artificial Neural Network (FFANN)

It is an algorithm which is inspired from biological neurons. A feed forward neural network is organized in layers and consists of processing units like a simple neuron. In this all the units in current layer are connected with all the units in previous layer. Each connection consists of different weights or strength. In FFNN nodes refer to the units of a neural network. In FFNN the data enters from input and after this passing to the network. In this there is no feedback in layers. So it is called as a feed forward neural network classifier.

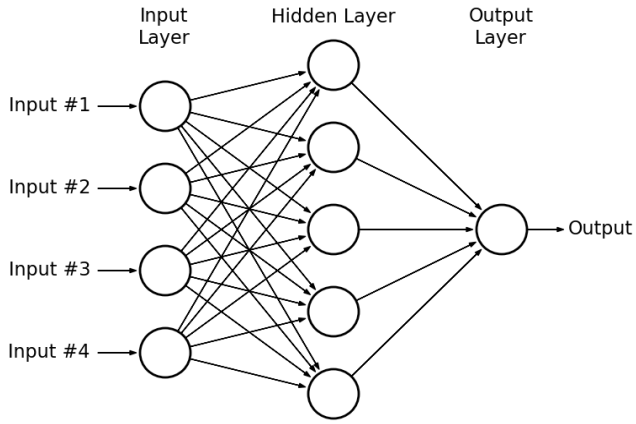


Fig. 6. Architecture of multilayer feed-forward neural networks

The architecture of feed-forward neural network (FFNN) with multiple layers is shown in fig 7. Multi layer perceptron (MLPs) is most commonly used feed-forward neural networks. The fig. 7 of FFNN is shown in which there are three layers namely input layer, hidden layer and output layer. In this every layer is connected to each previous layer [12]. The neurons at input layer w buffer the signals $x_{i,}$ *= (1, 2, 3, 4,5...., n)* . The input layer, connections $\Delta\omega_{ij}$ derives its output $y_j$ like a summing function *f*, as shown in figure 8.

$$y_i = f\left(\sum_{i=1}^{n} \omega_{ij} x_i\right) \quad (6)$$

Where *f* may be threshold function or a sigmoid, hyperbolic tangent or it may be a radial basis function.

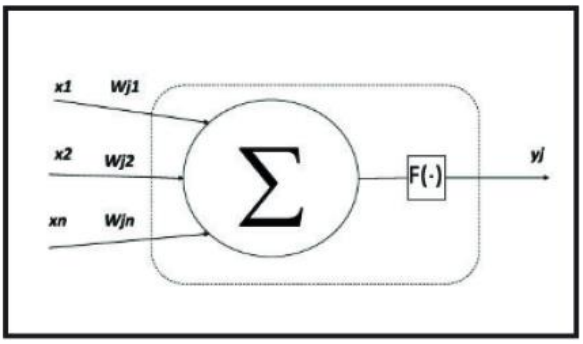


Fig. 7. Details of process in perception

The back propagation algorithm is gradient descent algorithm, is generally used MLP as a training algorithm. It results in change$\Delta\omega_{ij}$ , also known as weight of connection between the neurons I and j as follow:

$$\Delta\omega_{ij} = \eta\delta_j x_i \quad (7)$$

### 5.3 Taxicab Metric:

The simplest measure is to find absolute difference between the two patterns. Taxicab distance between two points is the summation of the absolute differences of their coordinates. Let's say "A" is the template feature image which is compared with test feature image "B". Assume that size of image is *m x n*. Taxicab distance measure between two images A and B is given as follow:

$$M_d = \sum_{i=1}^{M}\sum_{j=1}^{N} |A(i,j) - B(i,j)| \quad (8)$$

Taxicab metric is also known as rectilinear distance, namely Manhattan distance, $L_1$ distance, city block distance etc [31].

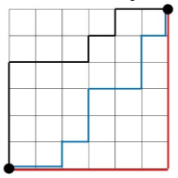

Fig. 8. Different ways to measure Manhattan distance [31]

### 5.4 Euclidian distance:

This technique is broadly used distance measure, which is also known as $L_2$ norm or nearest neighbour classifier. The Euclidean distance is the distance between two points which can be measured using ruler.

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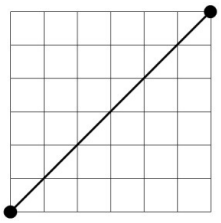

Fig. 9. Euclidean distance between two points [31]

This distance between two vectors of same size N is given by:

$$ED = \sqrt{\sum_{i=1}^{N}(A_i - B_i)^2} \qquad (9)$$

In same way, the Euclidean distance for two dimensional images can be given by:

$$ED = \sqrt{\sum_{i=1}^{M}\sum_{j=1}^{N}\big(A(i,j) - B(i,j)\big)^2} \qquad (10)$$

**5.5 Chess Board Distance:**

Chess board distance between two vectors is the greatest distance of their differences along any coordinate direction. It is also known as $L_{metric}$. Chess board distance between two vectors M and N with n coordinates.

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| 3 | 2 | 1 | 1 | 1 | 2 | 3 |
| 3 | 2 | 1 | | 1 | 2 | 3 |
| 3 | 2 | 1 | 1 | 1 | 2 | 3 |
| 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| 3 | 3 | 3 | 3 | 3 | 3 | 3 |

Fig. 10. Chess Board Distance [31]

## VI. Conclusion

In the last many decades the different algorithms have been proposed for handwritten character recognition. The precision of recognition algorithm is directly depends on parameter setting and selection of artificial neural network algorithm. For the character recognition task, HMM, different neural network algorithms and their combinations are used as the powerful tool. For the high reliability in segmentation, character recognition, and classification; we have to be used in an integrated manner to obtain more accurate results for complex problems. This paper is focused on the core method used in the field of character recognition. The following key challenges are supplementary to be carried out by scholars by increasing number of holes and strokes and mixed words.

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