ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

HANDWRITTEN ALPHANUMERIC CHARACTER RECOGNITION AND COMPARISON OF CLASSIFICATION TECHNIQUES

Neha[*1] & Deepti Ahlawat[2]
[*1&2]N.C.College of Engineering, Israna, Panipat, India, Haryana, India

DOI: 10.5281/zenodo.1147604

ABSTRACT
Several techniques have been proposed by many researchers for handwritten as well as printed character and numerals recognition. Recognition is the process of conversion of handwritten text into machine readable form. To achieve the best accuracy of any recognition system the selection of feature extraction and classification technique is important. The data about the character is collected by the features and accordingly classifiers classify the character uniquely. For handwritten characters there are drawbacks like it differs from one writer to another, even when same person writes same character a number of times there is difference in shape, size and position of character. Latest research in this area have used various types of method, classifiers and features to reduce complexity of recognizing handwritten text. In this paper, advantages and disadvantages of two different techniques of feature extraction and classification have been discussed.

KEYWORDS: HCR, Feature extraction methods, HOG, PCA, Image classification techniques, SVM, KNN, NN.

I. INTRODUCTION
Handwritten Character Recognition (HCR) is the capability of a computer to acquire and translate explicit handwritten input through many automated process systems. HCR can be isolated into three steps namely pre-processing, feature extraction and classification (recognition). HCR is the process of converting scanned images of handwritten text into computer processing text such as ASCII code. It is generally used to improve the speed of operations, reduce error or noise in the documents and decrease storage space needed for paper documents. It is a simple method for fast retrieval, easy search, save more compressed data. It is an active field of research in pattern recognition and image processing system. Feature derivation is an important job in character recognition system. Its main task is obtaining particular information from character in order to minimize variations within class pattern. HCR is a challenging issue because there is a divergence of identical characters due to the change of writing styles. The variance in writing styles makes the recognition task difficult,resulting in not good output of the recognition of character process. HCR has many applications in mail sorting, bank processing, document reading and postal code recognition. Off-line handwriting recognition is a challenging research area towards exploring the newer techniques that would improve recognition accuracy. Feature extraction stage is used to remove redundancy from data. There arethree types of features on whichfeature extraction methods for character recognition are based: a) statistical features b) structural and c) transformation based features. The most statistical features that have been used for character representation are: a) zoning- where the image is divided into several zones, b) projections and c) crossings and distances.

II. MOTIVATION
Organizations widely use documents to acquire information from customers. These documents are generally handwritten. Such documents can be forms, checks, etc. For their easier retrieval or collection ofinformation documents are transformed and stored in digital formats. Manually filling same data into computer is a common practice to handle that information. It would be tiresome and time consuming to handle such documents manually. Hence, the requirement of a special Handwritten Character Recognition Software arises which will automatically recognize texts from image of documents. The process of extracting data from the handwritten

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

documents and storing it in electronic formats has been made easy by Handwritten Character Recognition (HCR) Software.

Health care industries, Banking sectors and many such organizations where handwritten documents are used regularly, HCR finds its use. HCR systems also find applications in newly emerging areas where handwriting data entry is required, such as development of electronic libraries, multimedia database etc.

III. STRUCTURE OF HCR

Image acquisition

Image acquisition is an initial phase of character recognition system. It is the process of converting document into an electronic form. This has been done with the help of scanning process.Generally the image is used in black and white form with any format such as JPEG, BMT, and BMP etc., this image is forwarded to the subsequent blocks for further processing. Image acquisition is the creation of digital images. Digitization produces the digital image which is fed to the pre-processing phase.

Pre-processing

Pre-processing is next phase of text recognition system. It includes noise removal, binarization, error detection, skew detection/correction, edge detection and filtering. Pre-processing of document is required to detect and remove all unwanted bit pattern which reduce the recognition accuracy. After pre- processing of text, features have been extracted using various feature extraction techniques for recognition purpose.

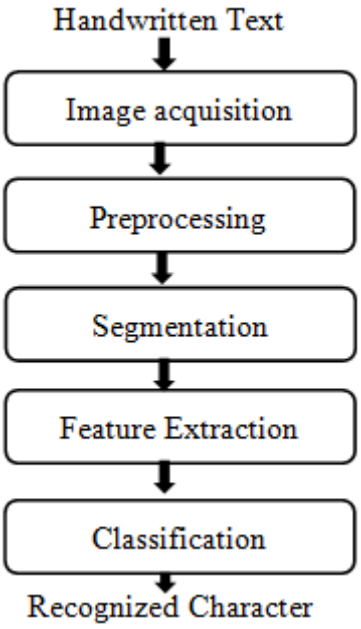


Figure 1: Handwritten Character Recognition Phases[1].

Segmentation

In this phase, an image of series of characters is decomposed into sub-images of individual character. To determine the boundaries of character, word and line segmentation, Segmentation is an important part of HCR system. In the process of segmentation, there may be presence of skewed characters and overlapping which causes difficulties. The following steps are performed for segmentation [2]:

i. Text is segmented into lines.
ii. Lines are segmented into words.
iii. Words are segmented into characters.

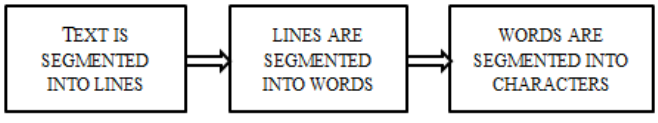


Figure 2: Segmentation steps [2].

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

There are two types of segmentation as follows:-

i. External segmentation- It is the segmentation, in which separation ofvarious writing units such as paragraph, sentences, or words can be done.
ii. Internal segmentation- In this type ofsegmentation, the image of continues characters is break-down into sub-images of individual characters.

Feature Extraction and Classification

Feature extraction technique plays the most vital part in recognition system. Feature extraction stage helps to remove redundancy from data. There are several feature extraction techniques like statistical and structural features. Classification stage is a decision making part of a recognition system and features extracted from the extraction techniques are used to identify characters.

IV. RELATED WORK

Recognition accuracy of the image depends on the sensitivity of the selected features and type of classifier used. Therefore, number of feature extraction and classification techniques can be found in the literature. The earliest Optical Character Recognition systems were not computers but the mechanical devices which were able to recognize characters are of very slow speed and low accuracy. In 1951, M. Sheppard invented a reading and robot GISMO that can be considered as the earliest work on modern OCR [3]. GISMO can read musical notations as well as words on a printed page one by one. However, it can only recognize 23 characters. The machine has the capability to copy a typewritten page. J. Rainbow, in 1954, devised a machine which can read uppercase typewritten English characters, one per minute. The early OCR systems were condemned due to errors and slow recognition speed. Hence during 60's and 70's, not much research efforts were put on the topic. The only developments were put on government agencies and large corporations like banks, newspapers and airlines etc.

Following are the papers perform on handwritten character recognition:

Kai-ping Feng, Fang Yuan (2013) extracted the gradient direction histogram (HOG) features of gestures, then, a Support Vector Machines is used for training of these feature vectors. At testing time, a decision is taken using the previously trained SVMs, and compared the same gesture recognition rate in different conditions. Experimental results show that the HOG feature extraction and multivariate SVM classification methods has a high recognition rate, and the system has a better robustness for the illumination [4].

J. Pradeep, E. Srinivasan and S. Himavathi (2012) implemented Neural Network based recognition system. They used three neural network (NN) topologies such as back propagation neural network, nearest neighbor network and radial basis function network for same training dataset. The performance of each network is compared and optimized the number of neurons in hidden layer which is not dependent on initial value. They concluded the combination of standard feature extraction technique with feed forward back propagation [5].

R.Ramanathan, S.Ponmathavan, N.ValliappanL.Thaneshwaran, Arun.S.Nair and Dr. K.P.Soman (2009) proposed a technique for recognition of English and Tamil optical character using Gabor filter and support vector machine. The method works for 6 English fonts and 12 Tamil fonts. With the increase in iterations, there is increase in accuracy and after a few iterations, good accuracy is reached. When compared to other existing systems, this approach proves to be more efficient and reliable for Optical Character Recognition. Further algorithm optimization and development of engine is under progress [6].

Andreas Starzacher, Bernhard Rinner (2008) evaluate k-nearest neighbor (KNN), linear and quadratic discriminant analysis for embedded, online feature fusion which raises high limitations on computing resources and timing. These algorithms are implemented on multisensor data fusion (MSDF) architecture and are applied to traffic monitoring, i.e., distinguishing vehicles using distributed image, acoustic and laser sensors. The results obtained are very appropriate for further use, especially of LDA and QDA for embedded online fusion at feature-level [7].

Cha-Sup Jeong and Dong-SeokJeong (1999) presented a method for the recognition of handwritten digits. This recognition method is based oncontour information and Fourier descriptors. Theproposed method is divided into three steps: pre-processing, feature extraction and classification. First inpre-processing step, we extract the contours of the inputdigit image and separate the outer and inner contour from the image. Second, we extract

features from theouter contour and use them to build standard models. Inthe last step, by comparing the featuresof input digits with those of models we recognise the digit [8].

V. FEATURE EXTRACTION AND CLASSIFICATION

We have two main steps to follow for recognition of any character from an image,one is feature extraction and another one is classification of character.

A. Feature Extraction

In this stage of character recognition, the essential characteristics of the image are captured and it is the most important stage. Using this stage redundancy of the data can be easily removed. There are two important problems that must be sorted, which are feature extraction and feature selection. Programmers can manually determine the properties they feel are important. Some example properties might be Aspect Ratio, Percent of pixels above horizontal half point, Percent of pixels to right of vertical half point , Number of strokes , Average distance from image centre, Is reflected y axis , Is reflected x axis. Researchers have used several methods of feature extraction for handwritten characters [9].

For feature extraction method we use two methods:
HOG:Histogram Of Gradient (HOG) feature descriptor [10] is one of successful features for object detection and recognition. The main idea behind the HOG descriptors is thatby the distribution of local gradients magnitude and orientation, local object appearance and shape within an image can be characterized. The HOG descriptor can be calculated by dividing the original image into smaller connected zones, called cells and for each cell collecting a 1-D histogram of edge orientations or gradient directions for the pixels inside the cell. The combination of these histograms represents the descriptor. The local histograms can be contrast-normalized by calculating a measure of the intensity across a larger region of the image, called a block and then using this value to normalize all cells within the block for improving the accuracy. In illumination or shadowing,this normalization results is more invariant to changes. In this study, we set the cell size to 8×8 in which it is split and extracted 9 dimensional HOG from each cell.

PCA:Principal component analysis (PCA) is a mathematical procedure which uses the transformation to convert a set of observations of possibly correlated features into a set of values of uncorrelated features called principal components. PCA is a well-established method for the extraction of representative features for character recognition and help to reduce the dimension of the data. This technique is beneficial when a large number of variables do not include effective interpretation of the relationships between different features. By reducing the number of variables, one can interpret from less features rather than a large number of features. The number of principal components is less than or equal to the number of original variables. PCA can provide a lower dimensional representation to introduce the underlying structures of the complex data sets by selecting top j eigen vectors with larger eigen values for subspace approximation. Let us consider that there are P features for handwritten character recognition system. In the next step, the symmetric matrix S of covariance between these features is calculated. Now, the eigen vectors U_i(i=1,2,…,P) and the corresponding eigen values Δ_i(i= 1,2,…,P) are calculated. From these P eigen vectors only j eigen vectors are chosen corresponding to the larger eigen values (also called as principal components). An eigen vector corresponding to higher eigen value describes more characteristic features of a character. Using these j eigen vectors, feature extraction is done by using PCA.

B. Classification

It is a very essential part in recognition of any written text. For this image classification we have used three algorithms:

1) **KNN:** K-nearest neighbor classification is a very simple and well- known technique that has been broadly studied. In the generative work of Cover et al. [11] the nearest neighbor decision rule is explained in detail. According to this work, for any number of classes, the error probability of the nearest neighbor rule has twice the Bayes probability of error as its supremum. Hence, it may be concluded that half of the total information needed is contained in the nearest neighborfor classification purpose (in an infinite sample set). The performance of KNN is determined by two factors [12]. First, it is critical to find an suitable k which is a non- trivial problem. In general, large k's are less affected by noise and having class boundaries to achieve smoother shapes. Adopting an optimal k from one

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

application to a different one is nearly infeasible. The second factor that influences the performance is the distance metric. There are a lot of approaches found in literature in order to enhance the performance of KNN algorithms, e.g., [13], [14], [15], [16].

KNN gives effective classification rates when applied to large data sets. For online fusion, KNN can only be applied to relatively small training sets due to the high computational effort in calculating the distances. Therefore, KNN is not ap- plicable for critical realtime systems if huge training samples are involved. Whenever new data x has to be classified, all distances between x and the training data have to be calculated. As distance metric we have implemented Minkowski distance L_m (see eq. (i)) which allows for flexible change of distance metrics (e.g., L_1 Manhattan and L_2 Euclidean distance) and Mahalanobis distance (eq. (ii)).

$$\mathrm{L_m}(p,q) = \left(\sum_{i=1}^{n}(|p_i - q_i)^m\right)^{\frac{1}{m}} \qquad (i)$$

$$\mathrm{M_k}(p,q) = \sqrt{(p_i - q_i)^T \sum_{k}^{-1}(p_i - q_i)} \qquad (ii)$$

In eq. (i) and (ii) n is the number of features, p, q are n-dimensional feature vectors and $\sum^{-1}$ the inverse covariance matrix of class k.

2) **SVM:** Support Vector Machine is a supervised type of machine learning algorithm in which a set of training examples is given, each belongs to one out of many categories, an SVM training algorithm builds a model that predicts the category of the new example. SVM has the higher ability to generalize the problem, which is the main goal in statistical learning.

Figure 3 is the simple model for representing support vector machine technique. The model consists of two different patterns and the goal of SVM is to separate these two patterns. The model consists of three different lines. The line having w.x–b=0 is known as margin of separation or marginal line. The lines w.x - b = 1 and w.x - b = -1 are the lines on the either side of the line of margin. These three lines together construct the hyper plane which separates the given patterns and the pattern that lies on the edges of the hyper plane is called support vectors. The perpendicular distance between the line of margin and the edges of hyper plane is known as margin. One of the objectives of SVM for accurate classification is to maximize this margin for better classification. The larger the value of margin or the perpendicular distance, the better is the classification process and hence reducing the occurrence of error.

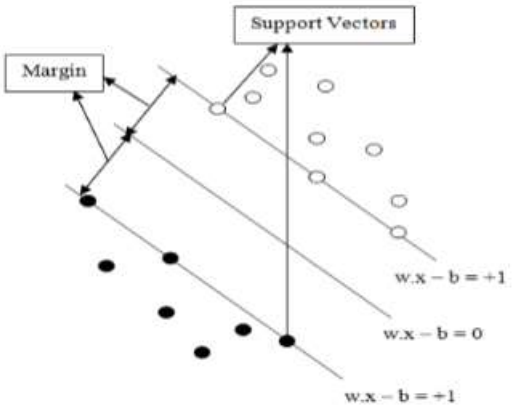


Figure 3: SVM Model [17].

The main objective of SVM is to maximize the margin of the hyper plane (i.e. the distance from the hyper plane to the nearest point of each patterns),so that it can precisely classify the given patterns i.e. larger the margin size more correctly it classifies the patterns.

The equation shown below is the hyper plane representation: Hyper plane, aX + bY = C (iii)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

The figure 4 shown below is the basic idea of the hyper plane explaining how it looks like when two different patterns are separated using a hyper plane, in a three dimensional space. Basically, this plane comprises of three lines that separates two different patterns in 3-D space, mainly marginal line and two other lines on either side of marginal lines where support vectors are located.

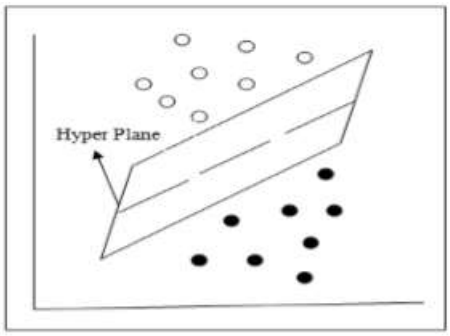


Figure 4: A Hyper Plane [17]

For non-linear separable patterns, the given pattern by mapping it into new space usually a higher dimension space so that in higher dimension space, the pattern becomes linearly separable. The given pattern can be mapped into higher dimension space using kernel function, Φ(x).

i.e.$x \rightarrow \Phi(x)$

Selecting different kernel function is an important aspect in the SVM-based classification, commonly used kernel functions are LINEAR, POLY, RBF, and SIGMOID. For e.g.: the equation for Poly Kernel function is given as:

$K(x, y) = <x, y>^p$ (iv)

Different Kernel functions create different mapping for creating non-linear separation surfaces. Another important parameter in SVM is the parameter C. It is also called a complexity parameter and is the sum of the distances of all points which are on the wrong side of the hyper plane. Basically, the complexity is the amount of error that can be ignored during the classification process. But the value of classification process cannot be either too high or too low. If the value of complexity parameter is too high then the performance of classification is low and vice versa.

The main principle of support vector machine is that given a set of independent and identically distributed training sample $\{(x_i , y_i)\}^N$ i=1, where $x \epsilon R^d$ and $y^i \epsilon \{-1,1\}$,denote the input and output of the classification. The goal is to find a hyper plane $w^T.x + b = 0$, which separate the two different samples accurately.

3) NN: Neural network also called as an artificial neural network. It is a biological model and it is based on the Biological Neural Networks structure and functions. Data or information that passes through the network affects Artificial Neural Network structure. Because a Neural Network learns from its surrounding and its past experiences sothat the same wrong condition occurs in future, it will already give appropriate solution for that [18]. Neural Network is useful in various ways.

A neural network is basically made of set of parallel and distributed processing units called nodes or neurons, these neurons are interconnected by means of unidirectional or bidirectional links by placing them in layers.The basic unit of neural network is neuron, it consist of N no of inputs to the network are represented by x(n) and each input are multiply by a connection weight which are represented by w(n).The product of input and weight aresimply summed and feed through a transfer function (activation function) to generate the result (output) as shown in figure 5.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

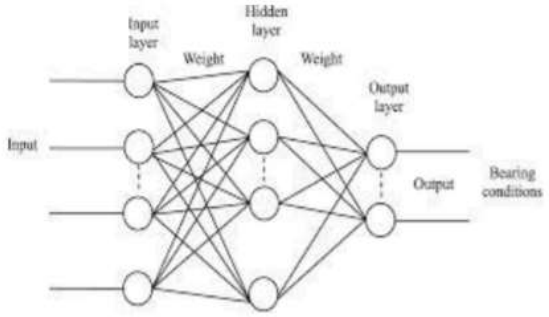
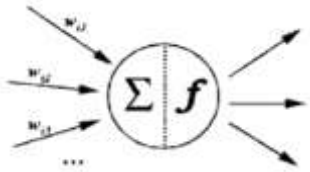


Figure 5:Basic Structure of Neural Network [19]

The basic of neuron model is often known as node or unit. It receives input from some other units, or may be from an external source. Each input has an associated weight w, which can be converted so as to model synaptic learning. The unit computes some function f of the weighted sum of its inputs. Its output, in turn, can serve as input to other units. The weighted sum is called the net input to unit i, often written as net_i. Weight from unit j to unit i is denoted as w_{ij}. The function f is the unit's activation function. In the simplest case, Figure 6, f is the identity function, and the unit's output is just its net input. This is called a linear unit.



$$y_i = f(net_i)$$

$$y_i = f(\sum_j w_{ij}\, y_i)$$

Figure 6: Simple Artificial Neuron Model [20].

VI. DISCUSSION

Table.1: Structure of HCR system

Phase	Description	Approaches
Acquisition	The process of acquiring image.	Digitization, binarization, compression
Pre-processing	To enhance quality of image.	Noise removal, Skew removal, thinning, morphological operations
Segmentation	To decompose image into its constituent characters.	Implicit Vs Explicit Segmentation
Feature Extraction	To extract features or characteristics from an image.	Geometrical feature such as loops, corner points Statistical features such as moments
Classification	To categorize or classify a character into its particular class.	Neural Network, Support Vector Machine, Nearest Neighborhood
Post- processing	To improve accuracy of OCR results.	Contextual approaches, multiple classifiers, dictionary based approaches

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Table.2: Advantages and Disadvantages of Classification Methods.

Classification Methods	Advantages	Disadvantages
Support Vector Machine (SVM)	• It gainsflexibility in the choice of the form of the threshold. • It contains anon-linear transformation. • It provides agood generalization capability. • The problemof over fitting is eliminated. Reduction in computational complexity. • Simple tomanage decision rule complexity and Error frequency.	• Resulttranspa rency is low. • Training istime consuming. • Structure ofalgorithm is difficult to understand. • Determinatio n of optimal parameters is not easy when there is nonlinearly separable training data.
k Nearest Neighbo r (kNN)	• Training is very fast. • Simple and easy to learn. • Robust to noisy training data. • Effective if training data is large	• Biased by value of k. • Computation Complexity • Memory limitation. • Being a supervised learning lazy algorithm i.e. runs slowly. • Easily fooled by irrelevant attributes.
Neural Network (NN)	• Ability to learn how to do tasks based on the data given for training or initial experience. • ANN can create its own organization or representation of the information it receives during learning time. • Computations may be carried out in parallel, and special	• Needs training to operate • The architecture of neural network is different from the architecture of microprocess ors therefore needs to be emulated. • Requires high processing

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

	hardware devices are being designed and manufactured which take advantage of this capability. • Partial destruction of a network leads to the corresponding degradation of performance. However, some network capabilities may be retained even with major network damage.	time for large neural networks.

VII. CONCLUSION

In this paper, we discussed different feature extraction and image classification methods for classifying blurry and noisy images. We also explained the structure of handwritten character recognition system. Table.1 briefly explained its phases, description and approaches. Finally in Table.2, wediscussed advantages and disadvantages of classification methods such as SVM, KNN, NN

VIII. REFERENCES

[1] Sukhpreet Kaur, Simpel Rani, "A survey on feature extraction and classification techniques for character recognition of Indian scripts", *International Journal of Engineering Sciences*, pp. 122-131, June 2016.
[2] N. K. Garge, Dr. L. Kaur and Dr. M. Jindal, "Recognition of Off- line Handwritten Hindi Text using SVM", *International Journal of Image Processing (IJIP)*, Vol. 7, 2013.
[3] Satti, D.A., Offline Urdu Nastaliq OCR for Printed Text using Analytical Approach. MS thesis report Quaid-i-Azam University: Islamabad, Pakistan. pp. 141, 2013.
[4] Kai-ping Feng, Fang Yuan, "Static hand gesture recognition based on HOG characters and support vector machines*" Instrumentation and Measurement, Sensor Network and Automation*, pp. 936-938, Dec. 2013.
[5] J. Pradeep, E. Srinivasan and S. Himavathi,"Neural Network Based Recognition System Integrating Feature Extraction and Classification for English Handwritten", *International Journal of Engineering (IJE)*, Vol. 25, pp.99-106, May 2012.
[6] R.Ramanathan, S.Ponmathavan, N.Valliappan, L.Thaneshwaran, Arun.S.Nair and Dr. K.P.Soman, "Optical Character recognition for English and Tamil using Support vector machine" *International Conference on Advances in Computing, Control and Telecommunication technologies,* pp.610-612, Dec. 2009.
[7] Andreas Starzacher, Bernhard Rinner, "Evaluating KNN, LDA and QDA classification for embedded online feature fusion" *Intelligent Sensors, Sensor Networks and Information Processing,* pp. 85-90, Dec. 2008.
[8] Cha-Sup Jeong and Dong-Seok Jeong, "Handwritten digits recognition using Fourier descriptors and contour information" *IEEE TENCON*,Vol.2, pp.1283-1286, Dec. 1999.
[9] T. Wakabayashi, U. Pal, F. Kimura and Y. Miyake, "F-ratio Based Weighted Feature Extraction for Similar Shape Character Recognition", *ICDAR*, pp. 196-200, 2009.
[10] Dalal N. and Triggs B, "Histograms of Oriented Gradients for Human Detection," in Proceedings of *IEEE Computer Society Conference on Computer Vision and Pattern Recognition* , San Diego, pp. 886-893, 2005.
[11] T.M. Cover and P.E. Hart, Nearest neighbor pattern classification, *IEEE* Transactions on Information Theory, pp 021–027, 1967.
[12] M. Latourrette, Toward an ecplanatory similarity measure for nearest- neighbor classification, pp.238–245, London, UK, 2000.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

[13] T. Hastie and R. Tibshirani, Discriminant adaptive nearest neighbor classification, Pattern Analysis and Machine Intelligence, pp. 607– 616, 1996.
[14] C. Domeniconi, J. Peng, and D. Gunopulos, Locally adaptive metric nearest-neighbor classification, Pattern Analysis and Machine Intelli- gence, pp. 1281–1285, 2002.
[15] K.Q. Weinberger, J. Blitzer, and L.K. Saul, Distance metric learning for large margin nearest neighbor classification, pp. 1473–1480, Cambridge, Massachusetts, 2006.
[16] Y. Song, J. Huang, D. Zhou, H. Zha, and C. Lee Giles, IKNN: informative k-nearest neighbor pattern classification, pp. 248–264, Warsaw, Poland, 2007.
[17] Burges, C. J. C., A Tutorial on Support Vector Machines for Pattern Recognition, Data Mining and Knowledge Discovery, pp. 121–167, 1998.
[18] D.Prashanth Kumar et al, *International Journal of Computer Science and Information Technologies(IJCSIT)*, Vol. 5 (6), pp. 7041-704, 2014.
[19] ShrutiB.Hiregoudar, Manjunath.K, K.S.Patil, "A Survey: Research Summary On Neural Networks", *International Journal of Research in Engineering and Technology (IJRET)*, Vol. 03,pp.385-389, May-2014.
[20] K Ishthaq Ahamed, Dr. Shaheda Akthar, "Survey on Artificial Neural Network Learning Technique Algorithms" *International Research Journal of Engineering and Technology (IRJET)*, Vol.03,pp.36-39, Feb-2016

CITE AN ARTICLE

N., & Ahlawat, D. (n.d.). HANDWRITTEN ALPHANUMERIC CHARACTER RECOGNITION AND COMPARISON OF CLASSIFICATION TECHNIQUES. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *7*(1), 419-428.