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Hand Written Character Recognition Systems

Prashant Yawalkar[1], Dr. M. U. Kharat[2]
[1]Research Scholar, Associate Professor, MET's Department of Computer Engineering, MET's Institute of Engineering, BKC Nasik, India. prashant25yawalkar@gmail.com
[2]Professor and Head, Department of Computer Engineering, MET's Institute of Engineering, BKC Nasik, India mukharat@rediffmail.com

ABSTRACT

Handwriting has always been a primary tool of communication. New technologies have been developed in order to record this handwritten information. Special techniques describe nature of handwritten scripts and have implemented methods to convert it into electronic data. There has been a method of feature extraction for identification of single unit Devanagari character in the form of images known as OCR. Some algorithms to identify human written Devanagari scripts that make it flexible for feature extraction in character recognition technique are compared to get the best result. This overcomes a variety of limitations of OCR technique. The different algorithms like Genetic, Neural Network and thinning algorithm were used in history to solve the current concern arising in OCR. This paper focuses on making a survey of improvising the character recognition capability of feed-forward, back-propagation neural network, Genetic algorithm, Thinning and Hybrid approach with various parameters like noise, quality, accuracy etc. With these algorithms various case studies has been performed and results are analyzed for making subjective and objective studies in OCR.

Keywords Back-propagation, Character recognition, Genetic algorithm, Momentum Term, Neural Network, OCR, Thinning.

1. INTRODUCTION

If handwritten characters are neat and clean, they can be recognized by humans perfectly. But on the other hand, if the same task is assigned to machines then it becomes very difficult for them to do it [1]. There are numerous languages which use various scripts to write, one of those is Devanagari which is widely used for many major languages like Marathi, Hindi, Sanskrit, etc. Amongst them, Hindi and Marathi are most commonly used by many people. These two languages contain complicated curves and various shapes hence it becomes a complicated task to recognize. All these considerations formulate Optical Character recognition (OCR) in the company of Devanagari script especially tough [1]. Issam Bazzi, et al. had explained about speech recognition in OCR [58]. They proposed a system using trigram language model on character sequences and had open-vocabulary performance of 1.1% character recognition rate for English and 3.3% for Arabic, results which are close to the closed-vocabulary system performance. The final objective of designing a character recognition [104] system in the company of an exactness rate of

cent percent be pretty impossible for the reason that handwritten characters are non-uniform; they be able to written within a lot of different styles. Sriganesh Madhvanath along with Venu Govindaraju had presented an overview of features, methodologies, representations, and matching techniques employed by holistic approaches [67]. Hanhong Xue and Venu Govindaraju presented a performance model that viewed word recognition as a function of character recognition and statistically found the next of kin among a word recognizer with the lexicon [74]. Study on lexicon for text recognition was proposed by Jerod J. Weinman, et al. [127]. They had recognized text from images of signs in outdoor scenes which reduced character recognition error by 19%, the lexicon reduced word recognition error by 35% and sparse belief propagation reduced the lexicon words considered by 99.9% with a 12 times speedup and no loss in accuracy. Youssef Es Saady, et al introduce a system of Amazing handwriting recognition based on horizontal and vertical centerline of the character[93]. Alex Graves, et al. had presented a study for handwriting recognition [123]. Their path achieved word recognition verity of 79.7% on online information and 74.1% on offline information, valid enough for exceed a state-of-the-art HMM-based system.

Optical character recognition [6] can be termed as the motorized or else electronic conversion of scan imagery of handwritten, typewritten or printed wording interested in system-encoded content. To convert books and documents into electronics this process is used, so use as to manage a record-keeping system in an office, or to publish the text on a website. Using OCR we can change the text, look for a word or phrase, store it more neatly, display a replica free of scanning artifacts, as well as use methods like machine translation, text-to-speech and text mining to it. Techniques for word recognition based on Hidden Markov Models (HMM): lexicon driven and lexicon free proposed by A. Bharath and Sriganesh Madhvanath [37]. From the above both techniques first lexicon-driven technique is models each and every word in the lexicon as a sequence of symbol HMMs and second technique is the lexicon-free technique which use a novel Bag-of-Symbols representation of the handwritten word that is self-governing of symbol order along with allows speedy pruning of the lexicon. Huaigu Cao and Venu Govindaraju had implemented a system to process low quality handwritten documents [125]. Jonathan J. Hull, et al. had implemented different algorithms for character recognition [138]. In a study conducted Anne-Laure Bianne-Bernard et al., they studied on constructing an proficient word recognition system ensuing since the mixture of three handwriting recognizers [38]. Their outcome showed that relative information embed in the company of dynamic modeling much enhanced recognition. Similarly, Jose´ A. et al. proposed that their system outperforms the traditional Dynamic Time Warping between the original sequences, and the model-based approach which uses ordinary continuous HMMs [40], [107]. They stated that this increase in accuracy can be traded against a significant reduction of

the computational cost. Kamel Ait-Mohand, et al. presented two algorithms that extend existing HMM parameter adaptation algorithms (MAP and MLLR) by adapting the HMM structure [43]. Minako Sawaki and Norihiro Hagita, suggested a technique used for recognizing characters on graphical design [53]. Their experimental results for 50 newspaper headlines showed that this method achieved a high recognition rate of 97.7%, which is higher than the 17.0% of a conventional method which does not recognize graphical designs. A. El-Yacoubi, et al. described a hidden Markov model-based approach planned to recognize off-line unconstrained handwritten words designed for bulky vocabulary [59]. Kyung-Won Kang and Jin H. Kim had proposed a modeling scheme by which strokes as well as relationships are stochastically represented by utilizing the hierarchical characteristics of target characters. Alessandro L. Koerich, et al. had drawn the study to verify unconstrained handwritten characters [86]. Using their verification strategy, it was possible to achieve recognition rates of about 78% with 1% delay in the overall recognition process. At the 30% rejection level, the reliability achieved by the combination of the recognition and verification approaches was about 94%.

1.1 Devanagari Script

Devanagari script and Roman script are different in a number of ways. It has two-dimensional compositions of symbols: foundation characters in the central strip as well as optional modifiers. Two characters possibly will be in shadow of every one. Whereas line segments [128] be the main features used for English, the majority of the characters inside Devanagari script are formed through curves, holes as well as strokes. In Devanagari language script, the formation of uppercase and lower-case characters is not available. But having more amount of symbols than that of English. Marathi is an Indo-Aryan language mostly spoken by about 71 million people, most of the Marathi peoples of western and central India [9]. It is the official language in Maharashtra state. Marathi is one of the Prakrit languages which developed from Sanskrit. Typically, the handwriting manner changes from person to person as well as signature also vary from person to person [124].Having a large character set with cursive also [70], curves as well as lines are in the particular shape formation, which may over lapping in a word. As per individual writing style a touching characters can touch each other at different position. Some of the regions of a Devanagari scripts as follows [10], [12].

ु ू ृ ॅ ॆ े ै ॊ ो ौ ं ः

Fig.2. Modifiers used in Devanagari

Poonam B. Kadam and Latika R. Desai proposed a robust system that automatically detected and extracted text in images from different sources, including video, newspapers, advertisements, stock certificates, photographs [105]. Similarly, Tapas Kanungo, et al., had used p-values related in the company of the expected models to choose the model that is nearer toward the real world [65].

Vowels: अ आ इ ई उ ऊ ऋ
ए ऐ ओ औ अं अः

Consonents: क ख ग घ ङ ष
च छ ज झ ञ स
ट ठ ड ढ ण ह
त थ द ध न क्ष
प फ ब भ म त्र
य र ल व श ज्ञ

Fig.3. Vowels and Consonants

1.1.1 Properties of the devanagari characters

1. End bar characters

अ ख घ च ज झ ञ त थ ध न प ब भ म य ल व श स

2. Non bar characters

इ उ ऊ ए छ ट ठ द ड ढ र ह

3. Middle bar characters

ऋ क फ

1.1.2 Structural analysis of touching characters

Based on the above discussion, the Devanagari characters can be ffect ized as follows [8]:
Category 1: Touching characters containing sidebars or no bar at right end
Category 2: Half character touching to full characters containing sidebars at right end.
Category 3: Pattern between two vertical bar of touching characters that may have middle bar character.

E. Kavallieratou, et al. presented a system which resulted that the databases gave promising accuracy results that vary from 72.8% to 98.8% depending on the difficulty of the database and the character category [95]. OCR is a field of study in computer vision, artificial intelligence and pattern analysis. Character recognition for various languages like Marathi, Hindi, etc. can be performed. For recognition of this, various algorithms are used. It is possible to recognize handwritten characters as well as printed characters and intelligent characters. Cheng-Yuan Liou and Hsin-Chang Yang suggested a structural-feature-to-structural-feature technique sampled by maximally fitting bent ellipses in local strokes [49]. This is transformed into an undirected graph to resolve the asymmetric difficulty. The same was referenced by Andrew W. Senior and Anthony J. Robinson [50]. Their results showed that the way of recurrent mistake propagation networks be able to useful effectively to the task of off-line recognition of cursive scripts. Recognition rate was achieved on an open-vocabulary task is 87%. Moreover, different techniques like feature extraction, pattern recognition, neural networks, Thinning, etc has been discussed for OCR [115], [134], [135]. Hybrid approaches like Neural-Zernike,

Neural-Gene and others are being used for improvement in accuracy.

Amlan Kundu et al. proposed different alternatives for handwriting recognition [54]. In order to identify a handwritten character, the image has to undergo some processing steps as described in Fig 4. The pre-processing stage helped to remove unwanted noise, performs binarization and slant angle correction.

After segmentation [118] by line, word and character, the features of the particular image were extracted. Classification of image and post processing are the further steps performed in character recognition. Xiaoqing Ding, et al. presented an effecttive method used for the offline recognition of unconditional handwritten Chinese texts [113]. Their experiments showed that their algorithm can achieve a recognition rate of 90.28% on a single unknown character and 99.01% if five characters are used for font recognition. Qiu-Feng Wang, et.al implemented a Chinese text recognition system where on experimental set of 1,015 handwritten pages, the projected approach achieved character-level correct rate of 90.75% and accurate rate of 91.39%, which were more superior by means of far to the top outcome reported in the literature [39]. Roongroj Nopsuwanchai, et al. introduced offline recognition for Thai language [111]. A pair of confusable characters was considered. With their system, the accuracies of recognizing these two characters at 77% and 81%, respectively, were obtained. However, after MMI training, the accuracies significantly rose to 87% and 90%, respectively.

1.2 Image Acquisition

Converting paper document in the form of digital image with the help of scanning process is called image acquisition. Jon Almaz et al. had proposed a system which addressed the problems of word spotting and word recognition on images [45]. Tijn van der Zant, et al., submitted a method where the results using their system as compared normalized word-image matching were more appropriate [120].

1.3 Preprocessing

The digital image obtained from scanning may contain some amount of noise depending upon the quality of scanner. Deduction of this noise from captured image is called preprocessing. Qixiang Ye and David Doermann had analyzed and compared technical challenges, methods, and the performance of text detection and recognition research in color images [46]. A detail explanation of noise and text recognition in noisy documents was proposed by Yefeng Zheng, et al. [79].

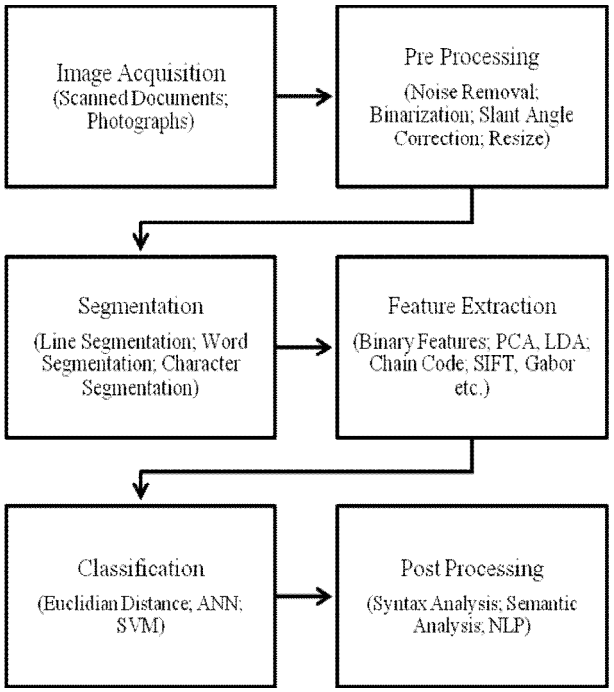

Fig 4 Basic Stages in Character Recognition

The technique presented was used for image enhancement to improve page segmentation accuracy of noisy documents. After noise identification and removal, the zone segmentation accuracy increased from 53% to 78% using the Docstrum algorithm. The key advantage of pre-processing a handwritten character was to systematize the information so as to make the recognition simple. Toru Wakahara and Kazumi Odaka put forward an adaptive or category-dependent normalization method that normalizes an input pattern against each reference pattern using global/local affine transformation (GAT/LAT) [55]. It was shown that GAT/LAT normalization on real, cursive input patterns against correct reference patterns substantially decreased the degree of handwriting fluctuation within the same category by about 20% and 40%. Besides noise reduction, normalization and segmentation [114] of image is also done to make the further recognition process effortless. In normalization, resizing of characters is done for stroke width, slant, slope, height of the characters. The normalization task will trim down each character image to one consisting of vertical letters of uniform height made up of one pixel-wide stroke [2], [112]. Zhenwen Dai and Jorg Lucke studied at removing corruptions like dirt, manual line strokes, spilled ink, etc from a single letter-size page based only on the information the page contains [44]. Shijian Lu, et al., presented a document retrieval technique that was capable of searching document images without optical character recognition (OCR) [119]. Their experimental results showed that the proposed word image annotation technique was fast, robust, and capable of retrieving imaged documents effectively.

1.3.1 Thinning

Kamaljeet Kaur and Mukesh Sharma have proposed that Thinning is process of reducing a ‘thick’ digital item to ‘thin’ skeleton [27].

To identify the geometrical feature of objects thinning is commonly used method. For example, using the thinned outcome the tree structure of the bronchus can be determined. For getting superior causes of cancer or brain tumor an image skeletonization can also use on medical images. Much more algorithm presented to find skeleton of an image. There is a way used for skeletonization of a binary image in which they use gradient and watershed to take out what can be an image in real plus performed the skeletonization more than the image to avoid high intensity values and implement the morphological dilation operator with thin parameter to get back the resultant image. This method was applied on some artificial images and results of applying this method on a variety of images will be shown. They have calculated the time and PSNR values and also compared the results with some existing algorithms. Maher Ahmed and Rabab Ward explained about thinning algorithm used for character recognition [75].

Thinning operation used to reduce binary valued image regions in image processing and which reduce lines that approximate the center skeletons of the regions. It is generally necessity of the lines has thinned outcome should be connected with each single image region, and then these can be used to infer shape and topology in the new image. Zhongkang Lu, et al. had been carried out this study [69]. A frequent use of thinning is in the preprocessing stage to facilitate higher stage study and recognition for such applications as OCR, diagram understanding, fingerprint analysis, and feature detection for computer dream [30].The outline of a binary image is an key demonstration for the shape examination and is of use for a lot of pattern recognition applications. The outline of an entity is a line connecting point's midway among the boundaries [29]. Thinning applied in a lot of fields such as automated industrial inspection, pattern recognition, biological form explanation and image coding etc. The most key objective of thinning is to obtain enhanced efficiency and to decrease transmission time. The skeleton refers to the "bone" of an image [30]. Primary reported plan of skeleton was specified by Blum [28], where a skeleton is distinct as a set of points at which the fire fronts of "grassfires" starting from the limit meet. Many thinning algorithms have been presented; all will around classified into two classes: one is sequential algorithm and other is parallel thinning.

They proposed a process for image thinning using gradient and morphological dilation operator is used to find the resulted image. The method was applied to some artificial images. By the result, their proposed method has helped to find what an image can be by filling it with gradient like in star and airplane image. So it is being used in satellite images to find what an image can be in real.

Fig.5. Preprocessed Images (a) Original (b) Segmented (c) Shirorekha eliminated (d) Thinned (e) Image Edging

The maximum value recognition of image is completed to allow easier subsequent finding of pertinent features as well as objects of curiosity [7] as shown in Fig 5

Converting binary shapes obtained from edge/boundary detection or thresholding to 1-pixel wide lines was performed. For example, the threshold version of hand written or printed alphanumeric can be thinned for better representation and further processing.

1.4 Segmentation

The most critical process is segmentation that decides the achievement of character recognition technique. In segmentation process it is used to rot an image of a sequence of characters into sub images of individual symbols by segmenting lines and words. R. Manmatha and Jamie L. Rothfeder implemented a study on segmentation of historical documents [85]. This approach was experienced on a various data sets and it was shown that, on 100 sample documents of handwritten document images, a total error rate of 17% was observed. Rakesh Kumar Mandal et al. proposed a recognition system using CSIM so as to improve its performance [142]. Anne-Laure Bianne-Bernard et al. had executed Grapheme Segmentation in their framework. Grapheme is either a character or a subpart of a character. Their concentrate basically concentrates on creating and recovering the pictures of grapheme [38].Vikas J Dongre and Vijay H Mankar had actualized a basic histogram based way to deal with portion Devanagari documents. Through their framework just about 100% effective division was accomplished in line and word segmentation [7].Richard G. Casey and Eric Lecolinet lists the scope of systems that was produced for segmentation [153]. They presented a strategy which filters the lexicon by lessening its size. The framework could accomplish 50% size lessening with under 2% blunder.

1.5 Feature Extraction

Features are in the sense of information which was extracted from the input image. This all information must be similar for similar images but it must be distinct for other images. These features play major role in pattern recognition. Thus the selection of feature extraction technique becomes an key aspect in achieving high recognition performance. Kwok-Wai Cheung, et al. had implemented techniques in character extraction [72]. They had performed testing of altogether 633 handwritten city name images and achieved an overall accuracy of around 92% for matching the first characters of the city names. Some feature extraction methods are projection, bordered transition, zoning etc. The projection method performs compression of data through a projection. Black pixel counts are taken along parallel lines through the image area to generate marginal distributions. Border transition technique assumes that all the characters are oriented vertically. Each character is partitioned into four equal quadrants. Zoning is a process that involves the division of the character into smaller fragment of areas. Prof. M.S.Kumbhar and Y.Y.Chandrachud had implemented a handwritten marathi character recognition system which involves the feature extraction technique of zoning [146].Piotr Dollar and C. Lawrence Zitnick showed that the results obtained real-time performance like orders of magnitude faster than many competing approaches like gPbowt-ucm (color only) algorithm, RGBD segmentation algorithm etc. [47]. Madhvanath, et al., conducted a study on contour representations of binary images of

handwritten words [60]. The lexicon was reduced using the features of word length, ascenders, and descenders. With their system, lexicon can be reduced in half with a less than 2% error rate. L. Anlo Safi and K.G.Srinivasagan presented an overview of feature extraction techniques for off-line recognition of Tamil characters [103].

1.6 Classification

Classification is carried out on the basis of features of the image. It is the process of assigning data to their corresponding class with respect to groups with homogenous characteristics. In this way, it divides the feature space into several classes based on the decision rule. Some classification techniques used for recognition of handwritten character are neural network, support vector machine, Genetic Algorithms, Fuzzy Logic etc.

1.7 Post Processing

Post processing [130] means grouping of symbols into string. The accuracy of optical character recognition can be increased if the output is constrained by a list of words that are allowed to occur in a document. The output stream may be plain text or file of characters [3].

2 RECOGNITION SYSTEMS

Basically, recognition of an input in image format has to be done but for doing so, input from two resources are taken which are online [78], [110] or pseudo-online [84] and offline [71], [109]. Online denotes any text file or from any documentary and offline means from handwritten or in the sense any hardcopy of document [68], [80]. These inputs will be converted into image format and subsequently some preprocessing techniques which use some algorithms are applied. In order to recognize a character, one of the conventional methods can be used like Neural Network, Genetic algorithm etc. Stress is given on efficiency improvement of the methodology. To obtain the best results, a hybrid approach like Neural-Gene, Neural Zernike can be considered. The implemented system can later be tested for the characters and numerals [73], [98], [122] and recognize them successfully. Kwok-Wai Cheung et al. concentrated how to incorporate deformable models into a Bayesian system as a bound together approach for modeling, matching, and a classifying shapes [48]. Using a model set with only 23 prototypes without any discriminative training, they achieved an accuracy of 94.7% with no rejection on a subset. Pak-Kwong Wong and Chorkin Chan proposed a disconnected written by hand Chinese acknowledgment system for characters taking into account multifeature and multilevel grouping [52]. They used a model set with only 23 prototypes without any discriminative training and achieved an accuracy of 94.7% with no rejection on a subset. Yuan Y. Tang, et.al suggested offline recognition of Chinese letters [51]. Experiments were conducted to recognize 5,401 daily-used Chinese characters. The recognition rate was about 90% for a unique candidate, and 98% for multichoice with 10 candidates. Daijin Kim and Sung-Yang Bang recommended approaches that integrated the statistical and structural information for handwritten numeral recognition [64]. Jinhai Cai and Zhi-Qiang Liu put forth an integration system for handwritten and numeral recognition [57]. They performed an experiment which used 50 clusters per class to achieve 97.90% recognition rate. Ke Liu, et al. had described the techniques for stroke extraction used in the recognition of handwritten Chinese characters [61]. Rejean Plamondon and Sargur N. Srihari described the nature of handwritten language, how it was transduced into electronic data, and the basic concepts behind written language recognition algorithms [63]. From observation there was an raise in the top choice word recognition rate between 80% to 95% with the use of language models. Yi-Kai Chen, et al. gave a study on numeral recognition [129]. Compared with the 98.00% accuracy of the benchmark HMMs, their new system achieved a 98.88% accuracy rate on handwritten digits. Yi-Kai Chen and Jhing-Fa Wang experimented touching handwritten numeral string where the experimental results on special database and some other images collected by them showed that their algorithm can get a correct rate of 96% with rejection rate of 7.8% [66]. Tal Steinherz, et al. gave an analysis of handwriting that improved loop investigation [121].

2.1 Character Recognition Using Neural Networks

As people can perceive characters and documents by their learning and experience thus character classification trouble is associated with heuristic logic. Henceforth for such matters neural networks which are pretty much heuristic in nature are to a great degree appropriate. For character recognition classification there are bunches of sorts of neural systems are accessible [132]. A neural network is a computing architecture. Neural network comprises of greatly equal interconnection of versatile "neural" processors. Due to its parallel nature, it can do calculations at a propelled rate than more than the established systems. It can without much of a stretch adjust changes in the information furthermore take in the properties of info sign [4]. Yield is bolstered with to each other node in the system however last decision relies on upon the mind boggling relations of all nodes. Theingi Htike and Yadana Thein had discussed a global search method for the Competitive Neural Trees (CNeT), which is utilized for training [91]. Michael S. Brown, et al., suggested a framework to restore the 2D content printed on documents in the presence of geometric distortion and non-uniform illumination has been presented [116]. Yusuf Perwej and Ashish Chaturvedi recognized handwritten English characters by using a multilayer perceptron with one hidden layer [145]. Vijay Patil and Sanjay Shimpi experimented English character recognition using neural network and their results indicated that the back propagation network provided good recognition accuracy of more than 70% of handwritten English characters [144]. Sameeksha Barve had proposed a study for neural network [147]. Here, the artificial neural network was trained using the Back Propagation algorithm.

Neural networks are a group of different models propelled by biological neural systems which are utilized to surmised capacities which can rely on upon enormous inputs and may unknown. Artificial neural networks [83], [136], [140] may displayed as systems of interrelated "neurons" which trade messages among each other [148]. The relations contain numeric weights which can be tuned in view of ability, building neural nets versatile to inputs and ready to able for learning. For example, a neural network characterized by an arrangement of information neurons which might be activated by means of the pixels of an information picture. In the wake of being weighted and changed by a capacity, the procedure

of initiations of these neurons is then passed on to different neurons which rehashed until conclusive yield neuron that figures out which activated character was read.

While surveying these concepts in a contribution by Mitrakshi B. Patil and Vaibhav Narawade, they presumed that in character recognition area the majority of the work was done on either segmentation or on only recognition of segmented characters [8]. Development of handwritten Devanagari OCR is a hard undertaking in pattern recognition area. Here, they have concentrated on a way that does the division of written by hand characters into word segmentation, line segmentation and character segmentation. Recognition procedure was finished with help of neural networks. The endeavor was to expands the execution as far as time and to discover nearer outcome. Sushama Shelke and Shaila Apte exhibited a novel strategy for recognizable proof of unconstrained handwritten Marathi compound characters[131]. S. Knerr, et al. worked on implementing the recognition of digits single layer training technology [141]. Their results gave roughly a 10% rejection rate for a 1% error rate in the recognition of handwritten digits without constraints on writing style. M. S. Kumbhar and Y. Y. Chandrachud recognize Handwritten Devanagari (Marathi) characters which basically centered around the use of Artificial Neural Network (ANN) [146]. For Arabic characters, Basem Alijla and Kathrein Kwaik implemented character recognition in Arabic [149]. Similarly, Khalaf Khatatneh, et al. had implemented Arabic Hand Written Optical Character Recognition [150]. Their proposed AHOCR strategy accomplished a remarkable test rightness of recognition ratedup to 97% for detached Arabic characters and 96% for Arabic content.

M. Egmont Petersena et al. reviewed lots of applications of neural networks of more than 200 in image processing and discussed the present as well as possible future responsibilities of neural networks; particularly feed-forward neural networks, Kohonen feature maps as well as Hop1eld neural networks [14]. The different applications are categorized into a novel bi-dimensional classification for image processing algorithms. One of the dimensions specifies the type of job made by the algorithm: preprocessing, data decrease characteristic taking out, segmentation, image understanding, object recognition and optimization. The additional dimension obtains the abstraction rank of the input data processed by the algorithm: structure-level, local feature-level, scene characterization, object-level, object-set-level and pixel-level. Each of the six types of tasks possesses specific constraints to a neural-based approach. These particular situations are discussed in detail. A composition is made of unresolved problems associated to the application of pattern recognition techniques in image processing and specifically to the application of neural networks. Lastly, they have presented a view into the future application of neural networks and relate them to novel developments. Xiang-Dong Zhou et al. had proved that their systems outperform not only a classical dynamic time warping-based approach but also a modern keyword spotting system, based on hidden Markov models [41]. Volkmar Frinken, et. Al suggested a word spotting method on neural networks. They pointed out that their work is a line-based approach and does not need any word segmentation. Moreover, it does not require bounding boxes around characters or words, which is often needed in the keyword spotting literature. Gaurav Kumar and Pradeep Kumar Bhatia have proposed a system which implemented the technique to recognize text in images [151]. Further, Reetika Verma and Mrs. Rupinder Kaur stated that Feed Forward Algorithm gave insight into the enter workings of a neural network and Back Propagation Algorithm compromised Training and Testing [152].

2.2 Character Recognition Using Fuzzy Algorithm

There have been fuzzy reasoning systems available in logic for a very long time. The popularity of the kind of fuzzy logic mentioned here is in part an anti-mathematical and anti-formal backlash. Some of the names of fuzzy logic systems studied by these people believe their anti-mathematical and anti-formal claim, however. For example, they refer to Godelian or Lukasiewicz logic systems, named for classical logicians such as Kurt Godel or Jan Lukasiewicz. In fact, the characterizations by fuzzy logic proponents of classical logic as inadequate to model vagueness are based upon a gross misrepresentation of classical logic as being binary: Classical logic only permits propositions having a value of truth or falsity. In fact, predicate logic (the classical logic of relational and functional systems, that includes first-order and second-order and higher-order reasoning systems) already deviated from that limited view in the time of the classic Greek philosophers. In the twentieth century, the mathematical logic community codified these notions by developing, from George Boole's Laws of Thought and Frege's theories of classes and Cantor's naive set theory, the notion of a Boolean algebra, which can be infinite, and can be densely ordered, thereby extending the set of possible truth values to continuum many, and then moved on to develop lattice theory, which generalizes Boolean algebra to provide truth value sets that are structured so as to accommodate modal and non-classical reasoning systems. (John von Neumann apparently was aware of this, and in some of his work, he referred to lattices as logics, presumably because they formed the structured sets of truth values he needed for reasoning about quantum systems and other non-propositional, or non-zeroth-order, systems.)

Fuzzy logic can be called as a form of lots of valued logic in which truth value of variables may be any real number between 0 and 1, considered to be "fuzzy". By contrast, in Boolean logic, the truth values of variables may only be 0 or 1, often called "crisp" values. Fuzzy logic has been employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. Furthermore, when linguistic variables are used, these degrees may be managed by specific (membership) functions. Adnan Shaout and Jeff Sterniak gave a detailed study on fuzzy logic [139]. They also proposed a recognition system based on fuzzy logic and presents results from testing on the MNIST character database.

Mohammed Zeki Khedher and Ghayda Al-Talib said that language of Arabia [108] is categorized in widespread use of dots or minor characters linked with main body or main characters [31]. More than half of the Arabian characters can only be differentiated by these secondary characters. Thus recognition of these characters has a significant importance in Arabic OCR. In printed text the problem is much easier than handwritten text due to the variety of shapes and the small sizes of these secondary characters. The utilization of fuzzy logic in recognition of these secondary characters was presented. Features of these characters like width, number of pixels, length and height-to-width ratio were used for finding the-

se characters. Membership functions for fuzzy logic treatment were obtained from handwritten data and are utilized in the fuzzy rules. The secondary characters may provide even further information for recognition of the characters.

Kandula Venkata Reddy et al. stated that now-a-days hand written letters detection has an important role [32]. This presented a view of future extraction technique for offline detection of segmented characters selective of a feature extraction technique. There are two methods for identifying hand written characters; which is active character detection (ACR) and contour algorithms. These two methods can be applied by using the fuzzy logic. They concluded that their system gave a useful technique for the reorganization of hand written characters to a large extent and the proposed technique was implemented on different unknown characters. By implementing these algorithms characters were recognized and fuzzy logic were used to reduce the time complexity. However there can be few mismatches if there is totally different style of hand written character due to dissimilar area.

M. Hanmandlu et al. proposed that they have attempted to implement off-line recognition strategies for the isolated handwritten English characters (A to Z, a to z) [33]. The preprocessing of characters included bounding of characters for translation invariance and normalization of characters for size invariance. The difference in a character made by the rotation and deformation is the main concern. This difference has been considered by devising a fuzzy logic based method using normalized angle features. A fuzzy logic based method for the recognition of isolated handwritten characters was introduced. The normalized angle approach (applying fuzzy distance) gave the best result of 83%. However, some characters (such as 'E' and 'F', 'a', 'e', 'b') were at times wrongly recognized. This low detection rates were the result of not guaranteeing complete rotational invariance in the features, though a little part is being taken care of by the end and junction points and angle methods. Inclusion of total rotational invariance is needed to generate the prominent features. In cases of normalized angle method, it is possible to remove the rotational effect by getting the difference of normalized angles. The difference of normalized angles of adjacent branches definitely removes the rotational effect to a large extent. Use of more efficient thinning algorithms may be needed for generating better skeletons to enable extraction of more effective features. Investigation of many fuzzification functions is the only one way to get the correct fuzzy distance which in turn would help achieve improved recognition. It can be made possible to use fuzzy logic by treating the decimal equivalent of the same row of all samples of reference character as making a cluster such that variability exists in that cluster. Then fuzzy logic is easily amenable to get the membership functions for the elements of that cluster. This needs to be repeated for the rows and columns of reference characters. For an unknown input character, the membership functions for the rows and columns can be yielded. The fuzzy distance can then be easily calculated.

Hany Ferdinando proposed that to detect handwriting digit is not a difficult task for user, but for a computer, it could be very difficult. This project implemented the Fuzzy Logic system to find the handwriting digit. There were 3 constraints that needed to be taken into consideration, i.e. the real data were written with the same pen; the real data were scanned into image data and then converted to BW mode with other software which was not present in this project; program read image data file and not capturing with special device such as camera. Software was developed in Matlab. The designing of fuzzy logic used fuzzy logic editor. Before processing with Fuzzy algorithm, it needed to process the image and then obtain its features. Only simple image processing method will be used. Feature extraction was done with a vertical and two horizontal lines. The location of crossing point between these lines with the image data will be a feature. These pre-processed data will be an input for the fuzzy system. The fuzzy system has 7 inputs and 1 output along with 57 rules. The average result of detecting process is 80% after membership functions tuning. The average capability is 80% after tuning but it cannot be concluded that this is the efficient result as there are no specific rules to tune fuzzy system. Changing one parameter can give impact on the other parameters. The idea was to use some algorithm to optimize it. People can use Neural Network or Genetic Algorithm for optimizing.

2.3 Character Recognition Using Genetic Algorithm

In the field of artificial intelligence, a genetic algorithm (GA) is a search heuristic that mimics the process of natural selection. This heuristic is routinely used to generate useful solutions to optimization and search problems [5]. Genetic algorithms belong to a larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection and crossover.

Vedgupt Saraf and D.S. Rao stated that character detection is the mechanical or electronic transformation of scanned images of handwritten, typewritten or printed text into machine-encoded text [15]. In India, about 300 million people use Devanagari script for documentation use. There has been a great improvement in the research in relation with the recognition of printed as well as handwritten Devanagari text in the past some years. The problem that comes in Devanagari script character recognition using quadratic classifier gives less correctness and less efficiency. To give an answer of the above problem and also to achieve good efficiency, they used the genetic algorithm. It gave good results from the above methods. The idea of genetic algorithm arrived from the fact that it can be used as an outstanding means of combining different styles of writing a character and generating new styles. Closely looking at the ability of human mind in the recognition of handwriting, they have found that human has the ability to detect characters even though they might be looking that style for the very first time. This becomes possible because of their power to imagine parts of the known styles into the unknown character. The same power has been represented into machines. Nei Kato et al. proposed a precise system for handwritten Chinese and Japanese character recognition [56]. With this recognition system, the experimental result of the database had reached to 99.42%.

A generic algorithm is an optimization and search technique used in computer science to find normally correct solutions to problems. It is inspired by tasks in biological evolution like natural selection, inheritance, recombination, and mutation. Generic algorithms are normally realized in a computer model, in which a population of runner solutions to an optimization problem progress to better solutions. The evolution begins from a population of fully

random individuals and develops in generations. In each generation, the fitness of the whole population is calculated and multiple individuals are found from the present population depending on their fitness. These are changed, mutated or recombined to make a new population that becomes available in the next iteration of the algorithm. Usually, the solutions are shown in strings of 0s and 1s, by different encodings are also possible. So, evolutionary algorithms work on populations, in its place of resulting to one solution.

India is a multi-lingual and multi-script nation involves eleven unique scripts and very little work has been done towards disconnected handwriting recognition of Indian scripts. A genetic algorithm scheme towards the recognition of disconnected Devanagari handwritten characters and online Devanagari written by hand characters was exhibited. Testing was done on various people's specimens and got 98.78% acknowledgment precision [15]. This problem could have been understood with the nonappearance of genetic algorithms also. So as to see the significance of genetic algorithms, they have tried the information without the use of genetic algorithms and proved successful.

Priyanka Pradip Kulkarni et al. had proposed that there is a growing trend among worldwide researchers to recognize handwritten words of many languages and scripts [16]. Be that as it may, a large portion of the present work in these regions is constrained to English [143] and a couple of oriental dialects. The absence of effective answers for Indian scripts and dialects, for example, Sanskrit has hampered data extraction from a huge assortment of reports of social and chronicled significance. There are various feature extraction techniques such as Gradient feature extraction, Stroke method, and Fourier descriptor and chain code histogram. A proper feature extraction technique can increase the recognition ratio. A curve let transform and shape moment were investigated for Marathi and Sanskrit handwritten word identification system. Curve let transform supported the edges and curve discontinuities. After the curve let transform, several group of curve let coefficients were generated at different scale and angles. These coefficients were used with GLCM to compute features as contrast, correlation, homogeneity and energy of word image. Genetic algorithm was chosen for the optimization and finding the number of hidden nodes which is used as an input to neural network in classification step. After optimization, classification techniques were used for training and testing purpose. Most of the researchers used various classifiers for recognition of online handwritten word like Hidden Marko Model, K- Nearest Neighbor and Support Vector Machine. It was found that Neural Network gives better accuracy for recognition purpose.

Handwritten character recognition (HCR) is a some portion of offline character recognition. Written by hand characters have vast assortment of style changing starting with one individual then onto the next. Because of this extensive variety of variability; it is hard to be perceived by a machine. In spite of the fact that the exploration in Optical Character Recognition (OCR) has been continuing for most recent couple of decades, the objective of this area is still out of span. The greater part of the specialists have attempted to take care of the problems taking into account the image processing and pattern recognition techniques. OCR (Optical Character Recognition) is a dynamic field of examination in Pattern Recognition. OCR approachs can be arranged in light of two criteria; information procurement process which can be online or off-line and kind of the text which is printed text or written by hand content [17]. Devanagari is the most admired Indian script, used by more than 500 million people, which forms the basis for several Indian languages including Hindi, Sanskrit, Kashmiri, Mara thi and so on. English character recognition is extensively studied by many researchers and various commercial systems are available for it. But in case of Indian languages, the research work is very limited due to the complex structure of the language. Typically, HCR can be partitioned into three stages in particular pre-processing, feature extraction, segmentation and classification. Pre-processing stage is to deliver a perfect character image; it can be utilized straightforwardly and effectively by the component extraction stage to expel excess from information. Segmentation stage is to build the productivity for next stage. An classification stage is to perceive characters or words. Highlight extraction in HCR is an essential field of image processing and object recognition [18]. In a work contribution, the authors have concluded that research work standard datasets for Marathi and Sanskrit word is not publically available [16]. Words are written from different people of different age. The technique discussed above is curvelet transform and shape moment involves the extraction of the shape feature. Feature extraction for compound word is difficult. But curvelet transform supports the edges and curve discontinuities. Hence, curvelet transform proved to be useful in Marathi and Sanskrit word recognition system. This work exhibited neural network based classification framework for the recognition of offline handwritten Marathi and Sanskrit words. Among all the methods it was found that neural network gave better accuracy for recognition purpose. However, the accuracy of this proposed scheme was enhanced by increasing the number of training samples or applying the scheme at different resolutions. This recognition system can further be extended for the recognition of other words, sentence and documents.

2.4 Character Recognition Using Hybrid Approach

Different classification strategies have their own superiorities and shortcomings. Consequently numerous a times different classifiers are consolidated together to take care of a given classification problem. Diverse classifiers that are prepared on the same information may contrast in their worldwide exhibitions, as well as may show solid local differences. Every classifier may have its own particular area in the component space where it plays out the best. A few classifiers, for example, neural networks show diverse results with various introductions because of the haphazardness intrinsic in the preparation method. Rather than selecting the best system and disposing of the others, one can join different systems, consequently exploiting every one of the endeavors to gain from the information. In summary, there might be distinctive capabilities, diverse preparing sets, diverse grouping strategies or diverse instructional sessions, all subsequent in an arrangement of classifiers, whose yields might be consolidated, with the trust of enhancing the general classification accuracy [4]. On the off chance that this arrangement of classifiers is settled, then the topic concentrates on the blend capacity. It is additionally conceivable to utilize an altered combiner and advance the arrangement of info classifiers. A run of the mill mix plan comprises of an arrangement of individual classifiers and a combiner which combines the

results of the individual classifiers to settle on a definite choice. The scope of this system is to focus on designing a hybrid approach [94] for recognition of hand written Devanagari compound characters. An efficient recognition algorithm based on feature extraction and using a thinning neural network is proposed in this research proposal. Sara L. Su, et al. described a hybrid way for automatically constructing hinted TrueType fonts from on-line handwriting data [96].

Prof. Mukund R. Joshi and Miss. Vrushali V. Sabale had suggested that English character has been widely considered in last half century and advanced to a level, adequate to deliver innovation driven applications [19]. Be that as it may, same is not the situation for Indian languages which are confused as far as structure and calculations. The problem that rose in Devanagari character recognition provided less correctness and efficiency so they have used neural network and genetic algorithm to overcome that problem. Devanagari being the national dialect of India, talked by more than 500 million individuals, was given extraordinary consideration so that record recovery and investigation of rich old and present day Indian writing can be viably done. Devanagari scripts include Marathi, Nepali, Hindi and Sanskrit languages. They stated that for researchers working in the Devanagari character recognition area, it has now been widely accepted that a single classification algorithm cannot yield better performance rate, so they have not only implemented neural network but also genetic algorithm. Though, various techniques were well experimented by many researchers, an attempt was being made to enhance the existing results by using features like glcm, histogram and color domino. Seok Oh, et al. and Debananda Padhi proposed a novel hybrid genetic algorithm for feature selection [82], [99]. Sam S. Tsai, et al. has proposed a hybrid approach for character recognition [88]. The experimental results show that while text-based or image feature-based systems only achieved a recall of ~72%, the proposed hybrid system achieved a recall of ~91%. Ranpreet Kaur and Baljit Singh presented a hybrid neural approach [87]. Utilizing this proposed system, it was conceivable to perceive/characterize around 512 out of 562 letters and effectiveness of 91.1% was accomplished. Moreover, they had put forth a statement that there were many new procedures required for the expanding needs in recently emerging areas and with these methodologies there were many techniques for the character recognition of handprint Devanagari, Bengali, Tamil [102], Arabic [89], [90], Chinese [76], [77] etc. But very few researches are in printed material. So they proposed the character recognition for Devanagari newsprint scripts. The problem of perceiving penmanship, recorded with a digitizer, as a period succession of pen directions is known as on-line character recognition. Be that as it may, it can't be connected to documents printed or composed on papers. Off-line character recognition is known as Optical Character Recognition (OCR). This is a sub-field of pattern recognition in which images of characters from a text image are recognized and as a result of recognition respective character codes are returned. They concluded that they had proposed neural network and genetic algorithm based approach to the recognition of printed Devanagari text. As seen from the result, the overall performance of the system shoewed that though neural network architecture is complex but accuracy can be further increased by increasing the number of samples for training the network. Genetic algorithm helps to increase the efficiency. The blunders in perceiving printed Devanagari characters were principally because of inaccurate character segmentation of touching or broken characters. In India colossal volumes of historical documents and books (imprinted in Devanagari script) stayed to be digitized for better access, sharing, indexing, and so on. This will be useful for other examination groups in India in the regions of sociologies, financial matters, and etymology. Brakenseik, et al. had proposed offline recognition using hybrid approach [100].

In a study conducted by Ezzat Ahmad Zade et al., they have proposed handwritten character recognition systems using automated pattern recognition [21]. They expressed that it is one of the critical problems in the field of Information Technology. A method based on combining artificial neural networks and genetic algorithms to recognize handwritten of the Persian and Arabic offline characters were proposed. As the neural network searches for the optimal values of weights and biases of different layers, the researchers used an intelligent genetic optimization algorithm to find optimal values. 80% of samples obtained are used for training and 20% of samples are used for network testing. Because there are lot of common ground between Arabic and Persian alphabet, Persian handwritten character recognition method was also applicable to the detection of Arabic words [126]. The proposed method does not depend on a particular language and method, so it can be employed to recognize letters in different languages. It can also be used to identify letters typed in a variety of languages. MSE got aftereffects of the blend of artificial neural networks and genetic algorithms demonstrated that the proposed strategy is one of the best techniques to utilize in the field of pattern recognition. Azizah Suliman had implemented a hybrid approach of HMM and Fuzzy for recognition [92]. Satish Lagudu and CH. V. Sarma had proposed recognition of isolated handwritten characters and words using Hybrid Particle swarm Optimization and Back Propagation Algorithm [101]. The aim was to use the linear correlation algorithms in two dimensions for the purpose of Arabic numerals (Indian) so as to overcome the problems of documents that are stored in the form of image.

Transcribed character recognition alludes to the procedure of programmed character recognition through pictures of characters. So the text in pictures will be readable by machines. Since the number of text documents on the internet is countless and increasing, so it becomes difficult to automatically classify documents. One of the most important early phases of automatic text classification is character recognition. In some languages, character recognition of characters is curved, and character recognition has its own challenges [22]. Therefore, previously proposed methods to recognize letters in other languages are not applicable to letter recognition in Persian and Arabic languages. Very high degree of similarity of some Persian letters has made the recognition and classification process difficult and time-consuming. Since scripting letters are in the form of images with different sizes, so there are several obstacles on the processing of images. One of them is a variety of image formats with the existence of different resolution levels with no specific standard [23]. So to gain better recognition, images of handwritten letters have to be normalized [22]. Handwritten character recognition is far more difficult and time consuming task than typographical character recognition because there is no certain format or font type and handwriting differs from one to another [24]. Feature extraction has the ability to make good differ-

entiation between similar characters and this is a challenge itself, especially in Persian and Arabic language [25]. Images of handwritten letters often do not have good qualities and include an additional margin so text area detection is a challenge. As the process of training artificial neural networks is to find the optimal values for different layers of neural network weights and biases [26] and network needs to find optimal values for them, then the problem becomes an optimal search problem. So optimized intelligent search algorithms can be used instead of the standard algorithms of artificial neural networks. The motivation behind this study was to propose a technique in view of consolidating simulated neural networks and genetic algorithms for manually written character acknowledgment for Arabic and Persian dialects. Genetic algorithm was used to find the optimal values of weights and biases of different layers of neural networks. The presented method was applicable to all other languages. Ten letters of the Persian manuscript alphabet were chosen to evaluate the proposed method and by applying this method, system error (MSE) will be zero and after training, the system was tested and analyzed to check the accuracy of the proposed method. The second part was based on the previous works, in order to recognize letters and manuscripts in Persian and Arabic languages and other languages. In the third part, the researcher claimed how it is possible to extract character features. In the fourth part, there was a discussion about how to design an artificial neural network and using a genetic algorithm to find the optimal values of weights and biases of the different layers. The fifth section referred to results. Salvador Espan˜a-Boquera, et al. had acquainted new procedures with expel slant and inclination from written by hand message and to standardize the extent of content pictures with regulated learning strategies [106]. Dr. Yadana Thein and San Su Su Yee contributed an effective recognition approach for Myanmar Handwritten Characters [97] where by using Hybrid approach, over-all recognition accuracy of 95% was obtained.

The hybrid algorithm of Back Propagation [137] and Genetic algorithm were intended to train and test the system. The algorithm follows the steps:

i. Coding: In the first place the underlying qualities are to be in some sort of coding. Genuine number coding framework was adopted in this work. This system is of arrangement l-m-n.
ii. Weight extraction: To decide the wellness esteem for every chromosome they extricated weights from each of chromosome.
iii. Fitness: The wellness capacity was conceived for every problem to be illuminated.
iv. Reproduction: In this progression arrangement of mating pool was finished. Mating pool was shaped by barring that chromosome with slightest fitness esteem and supplanting it with a copy duplicate of the chromosome reporting the most elevated wellness esteem. The three unique administrators of genetic algorithm were connected to overhaul the populace in the propagation.
v. Convergence: A populace is said to be joined when 95% of people constituting the populace offer same wellness esteem. The last yields given by the calculation were the last weights to be balanced for the neural system. So in this hybrid approach they figured wellness capacity utilizing Genetic methodology rather than weights as in Back propagation algorithm.

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In order to enhance the exactness and rate while reducing the training requirements of a writer-dependent symbol recognizer, Joseph J. LaViola, and Robert C. Zeleznik had implemented this recognizer [117].

3. SUMMARY

Character Recognition for various Indian scripts like Devnagari, Tamil, Telugu, Bengali, and Kannada, Gurumukhi has been finished. Nonetheless, the vast majority of this exploration has been limited to the recognizable proof of segregated characters instead of the script. Systems utilizing a statistical method, syntactic and/or heuristic-based have been created. A considerable measure of exploration is still required for compound character, word, sentence and document recognition, its semantics and lexicon. Different techniques for treating the matter of Devnagari character recognition have been created surprisingly in the most recent two decades. Still a need to handle the difficulties in written by hand Devnagari compound character recognition with a specific end goal to give financially practical programming arrangements perseveres. This far reaching discourse ought to give knowledge into different ideas included, and upgrade further advances around there. Coordinating segmentation and classification may get more precision in complex case and high unwavering quality in character recognition system. An extensive degree for recognition of compound character for Devanagari script still exists. Expected result is a system created for acknowledgment of compound character in Devanagari script, utilizing different procedures like image zoning, neural network, fuzzy logic alongside hybrid approaches like fuzzy-neural, neural-genetic and so on. Another normal outcome is to upgrade grouping execution of character acknowledgment framework when contrasted with as of now accessible compound character recognition systems. Along these lines Recognition of character for Devanagari script in corrupted records is additionally anticipated.

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