Handwritten Character Recognition using Machine Learning Approach - A Survey

Shivangkumar R Patel
L.J.I.E.T. PG Department
Ahmedabad, Gujarat - India
patelshivang82@gmail.com

Ms. Jasmine Jha
L.J.I.E.T. PG Department
Ahmedabad, Gujarat - India
jhajasmine@gmail.com

***Abstract*—Handwritten character recognition is a very popular due to its wide range of application. Processing application forms, digitizing ancient articles, postal address processing, bank cheque processing and many others are the growing fields in area of handwritten character processing. Handwritten character is attracting researchers since last 3 decades. Many approaches have been proposed for effective recognition. In this paper, we have shown the detail survey on handwritten character recognition using neural network as a machine learning approache.**

Keywords—handwritten character recognition; feature extraction; classification; machine learning; ann; svm

I. INTRODUCTION

First, Handwritten Character Recognition (HCR) is a classical application of pattern recognition. In 1981, Bezdek et. al. [1] gave the definition of pattern recognition, a process of identifying structure in data by comparisons to known structure; the known structure is developed through method of classification. In general terms, handwritten character recognition is the process to classify characters from the input handwritten texts, as per the predefined character classes. Applications of HCR span across the wide domain like, Identification of characters, Digitization of handwritten record, Application form reading and based on data entry, Translation system – recognizes the unknown language and translate it in a known language, Reading aids for the blind [2], [3], Bank cheque processing, Signature verification, Vehicle number plates [2], [3], Automatic pin code reading to postal mail [2], [3] etc.

In our daily life, we are doing character recognition all the time. While reading notes, sign-board or novel, our brain continuously does the HCR. We match it with our past experience and memory, and based on that we react or take an action or infer some new things. So, this is our natural character recognition.

First time character recognition was done by Tyuring, who tried to develop an aid for the visually handicapped [4]. The first time character recognizer came in 1940s. Before that, mostly all works were related to machine-printed text or a small set of handwritten symbols or texts [5].

Fig.1, show the types of character recognition system.

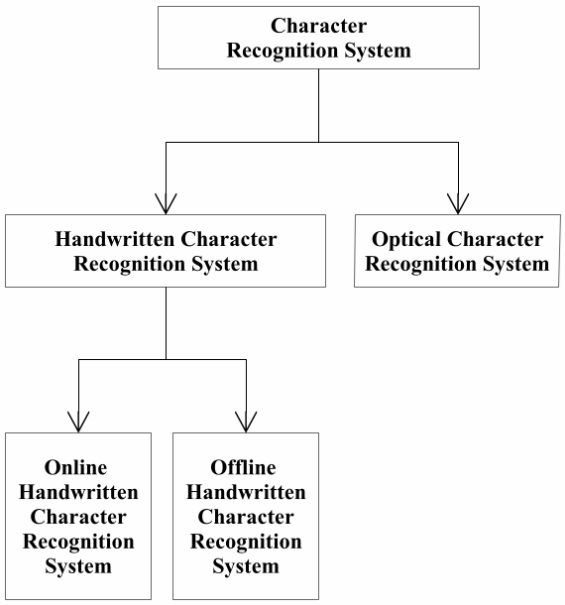

Fig. 1. Types of Character Recognition Systems

In 1980 to 1990, HCR rapidly got attention in research with online and offline approaches [6], [7]. After 1990, image processing and pattern recognition merged with each other with the use of Artificial Intelligence, and after that, very efficient and powerful computers and gadgets like scanners, cameras and other some special devices were developed. There is a large applications area that is covered with handwritten character recognition. Even after all these research, till this date not a single system exists that completely fulfills the goal of handwritten character recognition [8].

Offline handwritten character recognition system acquire static inputs. That means digitized text documents or scanned image copy of handwritten text [8]. Online handwritten character recognition system acquire live handwriting for recognition. Here a person writes on the digital device with the use of a special pen, and that data is used as live feed for system. Main difference between both systems is that online system contains one extra parameter that is time with data [8]. And it also contains the strokes, speed, pen-up and pen-down information as parameters [8]. State of the art, framework of

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handwritten character recognition system shown in the Fig.2. Basically all handwritten character recognition system contain image acquisition, preprocessing, segmentation, feature extraction and classification phases.

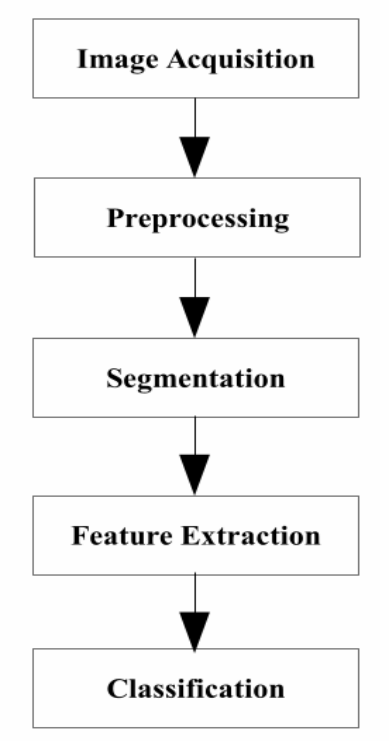


Fig. 2. Framework of Handwritten Character Recognition System

Rest of the paper is organized as follow. Section II, is literature review of various off-line handwritten characters recognition systems by various researchers. Section III, shows the comparison table of various systems. Last, Section IV concludes the survey.

II. LITERATURE SURVEY

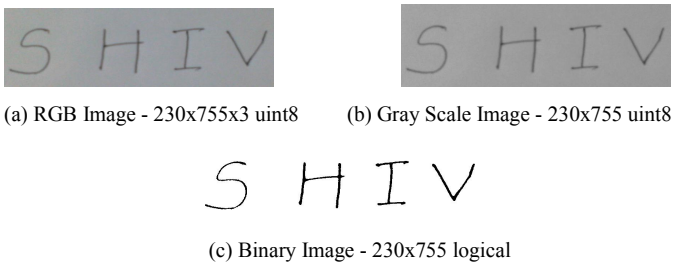
This Literature, review explore the every phase of handwritten character recognition system.

A. Image Acquisition

Image acquisition is the process of acquiring handwritten input data for character recognition system. Based on image or data acquisition, online and offline systems were developed. Bluche et al. used Rimes Dataset, which is in English [11]. For the numeric data, MNIST is a very popular dataset and used in [9]. Some other datasets are, Chars74K (English characters - natural images) [19], CEDAR (paid) [20], Semeion handwritten digit dataset [21], Pen-Based recognition of Handwritten digits dataset [21], etc. When there is no standard dataset available researchers use their own dataset for the recognition system [10].

B. Preprocessing

The Preprocessing is performed on acquired input data. It enhances the quality of input data and makes it more suitable for the next phase of recognition system. Gray scale conversion, binary conversion, noise removal, etc. are various techniques that are performed in this phase. Fig.3, show the basic preprocessing operations on the image.



(a) RGB Image - 230x755x3 uint8 (b) Gray Scale Image - 230x755 uint8

(c) Binary Image - 230x755 logical

Fig. 3. Preprocessed Images

Bluche et al. used gray scale conversion, binary conversion and then a noise removal technique is performed on the input data [11], [9]. While considering the results in [10] after the Gray scale and binary conversion, researcher used edges detection for segmentation. Otsu's algorithm widely used for gray scale image to binary image conversion.

C. Segmentation

Segmentation, is the process of splitting input text data image to line and then after individual character. It removes the unwanted part from the data image. There are two types of segmentation available, External and Internal. External segmentation is segmenting the paragraphs, lines and words. On the other side internal segmentation is segmenting of individual character from input text data [12], [13].

Various algorithms are available for segmentation. Histogram profiles and connected component analysis are some of the methods for line segmentation which are used in [14], [15]. Fig.4 and Fig.5 show the line and character looks like after histogram based segmentation.

Fig. 4. Segmented Line based on Histogram

(a) (b) (c) (d) (e)

Fig. 5. Segmented Characters based on Histogram

Spatial space detection for the words and Histogram method for the characters and other symbols which are used in [16], [17]. In [2], for character segmentation authors are using bounding box technique. After successful segmentation, resize operation is performed on all segmented image for uniform size.

D. Feature Extraction

Feature Extraction is the process of collecting different and very useful information of an object or a group of objects, so

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based on that collected information, we can classify new unknown objects by matching it. Feature is the robust representation of the raw data.

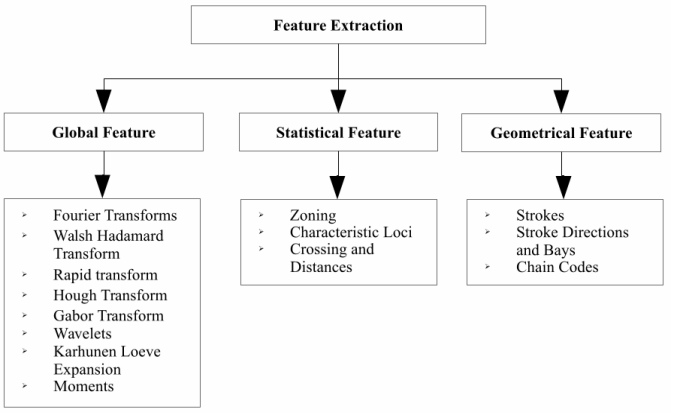

Fig. 6. Feature Extraction Techniques [22]

Fig.6, show various feature extraction methods. Zone based, statistical, structural, chain code histogram, sliding window, gradient feature, hybrid, etc. [3], [10], [14] are some of the most useful feature extraction techniques. In 1961, Freeman introduced chain code method called Freeman Chain Code. There are mainly two directions of chain code, 4-neighborhood and 8-neighborhood.

Xuewen Wang and Kai Ding et al. compare the Gabor feature and Chain code(the contour direction) feature, and results showed that Gabor feature is much better than chain code feature [18], [19]. Kai Ding and Cheng-Lin Liu et al. showed that Gradient feature and Gabor feature have some common properties : both are applicable on binary and gray scale images and is also immune to image noise [19], [20]. In addition, performance is almost similar but Gabor is more suitable for large scale texture data. Imani et al. used in [21], chain code histogram feature and distribution of foreground density across zones.

E. Classification

Classification or Recognition process is for decision making, like this new character fit in which class or looks like. It means, in the phase of classification characters are identified and assign labeling. Performance of the classification depends on good feature extraction and selection. Various classification techniques are available and they all are ultimately based on image processing and artificial intelligence.

In the Fig.7 show the various classification techniques [22]. Template matching, Statistical technique, Structural technique are the classical techniques which are mainly based on image processing. Neural networks, fuzzy logic and genetic techniques are based on soft computing. Jayashree et al. in [23], proposed hybrid method of soft computing. She used neuro-fuzzy with adaptive network, neuro-fuzzy is the hybridization of fuzzy logic and neural network.

After artificial intelligence involved with machine learning, almost all research areas are covered by it, and with the machine learning, very good results are achieved. In the field of handwritten character recognition, machine learning used various methods like artificial neural networks, support vector machine, naive bayes, nearest neighbor algorithms, decision trees, neuro-fuzzy, etc.

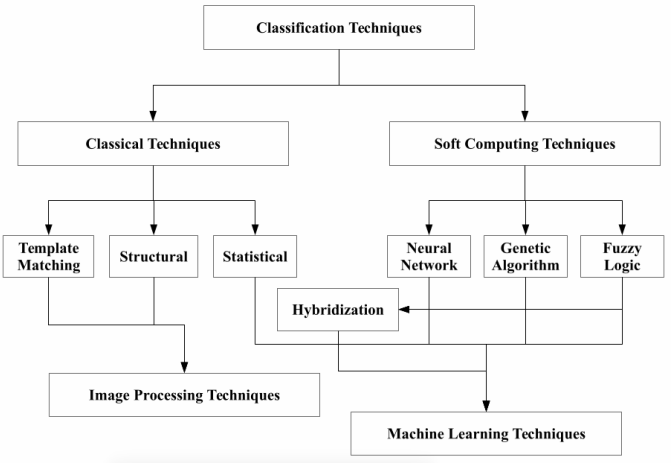

Fig. 7. Classification Techniques

Bluche et al. in [9], used HMM with the convolution neural networks, and made an explicit feature extraction system. Developed system was tested with Rimes dataset and found that character recognition rate was fast, but accuracy is low. Imani and Bingyu Chi et al. used Hidden Markovian Modeling, and results show that efficiency of the HMM classification are more dependent on feature extraction methods [21], [24].

Rahman et al. in [25], proposed system for Bangla characters. He used Backpropagation neural network, and achieved 94.3% recognition accuracy. Amal Ramzi et al. in [8], used Backpropagation neural networks as a classifier. Ramzis proposed system for Arabic handwritten characters with combining online and offline features. The proposed system got 99.5% training accuracy but in testing, the maximum recognition rate achieved was 78.8%.

Rajashekararadhya et al. compared the NNC (Nearest Neighbor Classifier) with SVM (Support Vector Machine). Results showed that SVM is one step ahead of NNC [2]. Nasien et al. used SVM with FCC in [26]. Nasien used English handwritten NIST dataset. Accuracy of recognition is 86% for lowercase characters, 88.46% for uppercase characters, and 73.45% for (lowercase + uppercase) characters [26].

Nisha Sharma et al. in [27], proposed recognition system for hand printed English character, numerals and special symbols. Proposed system used multilayer perceptron neural network with Backpropagation and SVM classifier. System used hand printed English characters - uppercase, lowercase, numerals, and special symbols as a datasets. Recognition rate is 98% for numerals, 96.5% for special characters, 95.35% for uppercase and 92% for lowercase characters. Nisha Sharma et al. gave the reason behind choosing neural network and SVM is: “Neural network have been preferred to be used due to their high noise tolerance and SVM, for its high flexibility, scalability and speed”.

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In the next section, the various research works comparison in handwritten character recognition is shown.

III. COMPARISON TABLE

Comparison between various researchers proposed model show in the Table 1.

IV. DISCUSSION AND CONCLUSION

Handwritten Character Recognition is very useful in our daily lives, because it covers large area of useful applications. Various researchers proposed their work in this area and achieved good accuracy rate. Very few researchers focused and managed the time complexity. After many research works, we found that there is not even a single technique or system that can completely fulfill the requirements of Handwritten Character Recognition. So, off-line handwritten character recognition is still an open area of research for identifying various complexities and to resolve them.

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TABLE 1: COMPARISON TABLE

Paper	Feature Extraction	Language	Dataset	Classifier	Results and Comments
1.[2]	Simple & Efficient Zone based Hybrid Feature Extraction Algorithm	Kanada and Tamil Numerals	Numerical Data Own Created Datasets	NNC and SVM	Kanada (97.75% NNC + 98.2% SVM), Tamil (93.9% NNC + 94.9% SVM)
2.[3]	not specify	Alphanumerical + symbols	Not specify	RNN	good recognition
3.[9]	Grapheme segmentation and Sliding Window	English	Rimes Database	MLP	Very Fast But Low accuracy
4.[11]	DWT with Multi resolution technique	English Characters	Own Character Dataset	NN with Euclidian Distance matrix	good accuracy – up to 99.23%, But taking more time
5.[21]	Chain Code histogram Features, Distribution of foreground density across zones	Farsi	Own database 198 word classes	HMM	89.00%
6.[24]	Gradient feature	Chinese Alpha-Numeric	10,000 single character image and 4709 legal amount text line images extracted from real life Chinese bank checks	HMM	Average 97.13%
7.[25]	4x8 and 8x4 matrix for each character Segmentation of row and column	Bangla	Not specify	NN	very simple and 94.30%
8.[27]	Multi zoning, Geometrical feature distance and angle, topological feature end point transition, Directional feature chain code histogram	English characters and symbols	Own dataset	BPNN and SVM	BPNN: 98% for English numeral, 96.5% for special characters, 95.35% for uppercase English characters and 92% for lowercase English characters SVM: 92.167% for (uppercase and lowercase)characters
9.[28]	DCT Discrete cosine transformation	Arabic Numbers	ADBase database	DBN - Dynamic Bayesian Network	Average 85%, this result with corrupted data, slow recognition
10.[10]	7 FE methods and then ranking the feature vector and make new 3 feature vector	Numeric	MNIST	ANFIS & IBA ANFIS	99.52% and speed for recognition 24 digits/sec

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