

## Chapter 3

### Literature Review

---

Handwritten characters can be recognized either using online or offline system. In case of online system the character images are processed during their creation. In case of offline system, document is first generated, digitized and stored in computer and then processed. Some external factors like pressure put on the writing pad and speed of writing have a great impact on online system but have little impact on the offline system [170]. The online systems are better performers than the offline systems because of the presence of temporal information in case of online systems [149]. But in practical life, in order to carry out the digitization of manual documents, we need to use offline systems.

A lot of work has already been carried out in the field of handwritten recognition, using online and offline systems. But the accuracy is still confined to around 90% in case of offline systems due to a huge variation in shape, size, scale, handwriting styles, orientation and many other factors [50].

Segmentation of characters has been done in recognizing Amazigh writing, from a single line using vertical histogram [62]. Methods are also used to enclose the images into windows and cells in order to identify the images [6]. Morphological analysis has also been done in some work in order to segment units of text. The smallest unit of characters having certain linguistic meaning in it is called morpheme [133]. The method is inspired by other work that has already been done in the field of segmentation and contour tracing algorithms [138]. A contour is an enclosure around the character. Basu S et al has developed a segmentation method to extract out offline handwritten Bengali script. In this paper a hybrid model of image based dissection and recognition based segmentation is proposed [15]. Hong C et al have worked on segmentation and recognition of continuous handwriting Chinese text. This method performs basic segmentation and fine segmentation based on varying spacing thresholds and minimum variance criteria [80]. Kurniawan F et al have proposed a region based touched character segmentation method. In this approach Self Organizing Maps (SOM) has been used to identify the touching portions of the cursive words [95]. Kumar M et al have worked on

the segmentation of isolated and touching characters in offline handwritten Gurmukhi script recognition. In this method a technique called water reservoir based technique has been applied for the identification and segmentation of touching characters [93]. Nikolaou N et al have worked on segmentation of historical machine-printed documents using adaptive run length smoothing and skeleton segmentation paths [131]. Ramteke A S and Rane M E have worked on offline handwritten Devanagari script segmentation. This method uses connected component approach and vertical projection profile, which is the histogram of input image, where the zero valley peaks show the space between the words and characters [155]. Bozinovic R M and Srihari S N have worked on locating the reference lines as the lower-line, lower-baseline, upper-baseline and the upper-line [32].

The character images are actually patterns and proper identification of these patterns plays a significant role to identify a handwritten character. Identification of common features of identical characters plays a vital role in the identification of varying character patterns. A feature vector is extracted out of the handwritten character images and fed into a classifier. Some of the examples of pattern classifiers are nearest or k-nearest-neighbor classifier [70, 184], Bayes classifier [166], neural networks [105] and support vector machine [13, 104, 204]. A lot of work has also been done on the feature extraction methods. Many feature extraction methods based on statistical and structural features and global transformation techniques are discussed [195]. Common features present in the characters can be used to generalize the variations in patterns.

Multiscale Training Technique (MST) has been used in many places to solve the generalization problems [200, 158, 76]. The accuracy of MST is 85%. Results of MST depend largely on resolution of the character images. Image resolution and the training speed have to be optimized to achieve the highest percentage of accuracy. Work has already been carried out to identify the characters in Devnagri script by combining multiple feature extraction techniques like intersection, shadow feature, chain code histogram and straight line fitting [12]. Another approach towards feature extraction technique is to calculate only twelve directional feature inputs depending upon the gradients, where the features of the handwritten characters are the directions of the pixels with respect to their neighboring pixels [179]. Hybrid methods are also applied to recognize the handwritten characters. One such method is a prototype learning/matching

method that can be combined with Support Vector Machines (SVM) in pattern recognition [42]. K-nearest neighbor methods can be used to recognize the patterns [96]. In K-nearest neighbor methods the pattern is obtained by looking into k number of nearest patterns having the least Euclidean distance with that of the pattern.

Besides the works just stated above a thorough literature survey has been carried out on the work done so far in the field of online and offline handwriting recognition. Starting from fifties, the notable amount of work, found in the field of handwriting recognition, can be divided into seven decades. First three decades can be considered as the early stage of development and last three decades as well as the current decade can be considered as the recent stage of the period.

### **3.1 Early Developments**

The work in the field of handwriting recognition is in its seventh decade. Still lot of work has to be done in this field. To the best of our knowledge no such method has been developed in the field of offline handwritten recognition which can claim 100% accuracy on any type of script pattern. In the earlier three decades a lot of work has been carried out and lot many methods were developed during that period. A few of the methods also produced some fruitful results.

#### **3.1.1 Work during the Period 1951-1960**

During that period the work in the field of character recognition was started. Grimsdalc et al (1959) have carried out a notable amount of work in this area [69].

#### **3.1.2 Work during the Period 1961-1970**

A number of works has been carried out in this decade by different researchers. During this period Narasimhan (1964,1966) has carried out some work on labeling schema for the syntactic description of pictures and a syntax directed interpretation of different classes of pictures [128, 126]. Eden (1968) has suggested an analysis by synthesis method [61]. According to Eden, there exist a finite number of schematic features which form all the handwritten characters. Narsimhan (1969) has proposed a description and generation based recognition method [129].

### 3.1.3 Work during the Period 1971-1980

Narasimhan R and Reddy V S N (1971) have suggested a method which said that the current rules can be modified on the basis of experience and acquired knowledge [127]. Yoshida et al (1974) and Cox et al (1974) have extended the work carried out by Eden in sixties [210, 49]. Feng H F and Pavlidis T (1975) have suggested a feature extraction method for the syntactic pattern recognition by boundary approximation of the character using polygons on the basis of concavity [64]. Pavlidis T and Au F (1975) and Ali F and Pavlidis T (1977) have suggested a split and merge algorithm which is used for the polygonal approximation of characters for the numeral recognition [143, 2]. Sethi L K and Chatterjee B (1977) have used four basic primitives such as horizontal, vertical, right and left-slant to recognize Devanagri characters [169]. Rajasekaran S N S and Deekshatulu B L (1977) have worked on a two stage recognition system for Telugu alphabets [153]. A method has been used by Siromoney et al (1978) to recognize machine printed Tamil characters [183]. Adaptive threshold logic has been deployed by Marudarajan et al (1978) for printed Devanagri numeral recognition [120]. Some work has been done by Agui T and Nagahashi N (1979) to recognize hand printed Chinese characters [1].

## 3.2 Recent Developments

Works done during the last three decades as well as the current decade can be considered as the recent developments.

### 3.2.1 Work during the Period 1981-1990

Fuji et al (1981) have worked on a model for recognizing handwritten Kanji character [66]. Berthod (1982) has extended the work carried out by Eden in sixties [23]. Arakawa (1983) has carried out a research on online handwritten character recognition using Japanese characters [9]. Burr D J (1983) has designed a handwriting reader based on compensation of writing slant [38]. Yamashita Y et al (1983) have worked on the classification of hand printed Kanji characters by the structured segment matching method [208]. Maarse F J and Thomassen A J W M (1983) have worked on a method based on writing slant [109]. Brown M K and Ganapathy S (1983) have developed

preprocessing techniques for recognizing cursive type of handwritten scripts [35]. Yamamoto et al (1984) have worked on recognition of Chinese handwritten characters [207]. Cheng Y S and Leung C H (1985) have proposed a fuzzy set method for recognizing handwritten Chinese characters [46]. Sinha R M K and Mahabala (1985) have carried out a work on Devanagari script using syntactic method using an embedded picture language which was based on prototype context [181]. Xie X L and Suk M (1988) have worked on a model to recognize Chinese characters, based on features, reflecting structural information [206]. Young (1988) has worked on a model which recognizes the handwritten Chinese characters using neural networks [211]. Almuallim H and Yamaguchi S (1987) have worked on statistical and structural method for recognizing cursive Arabic characters [3]. Sinha (1987) has also suggested the significance of context in the recognition of Devanagari characters [182]. Bozinovic R and Srihari S N (1989) have proposed a method to recognize offline cursive script [31]. Lang K et al (1990) have worked on time-delay neural network architecture for isolated word recognition which is based on sliding window concept and it was used for speech applications [98].

### **3.2.2 Work during the Period 1991-2000**

Principal Component Analysis (PCA) is a very well known method used for feature extraction. PCA linearly transforms a high dimensional input vector into a low dimensional vector by calculating the Eigen vectors of the covariance matrix of the inputs, whose components are uncorrelated. Turk M and Pentland A (1991) have proposed a feature extraction method which used Eigen faces for Recognition [198]. Tian Q et al (1991) have carried out a survey on the recognition of Omni font printed characters [194]. Jacobs R A et al (1991) have introduced a concept of modular neural architecture which has several expert networks and a gating network. In class modular concept a single task is decomposed into multiple subtasks and each subtask is allocated to an expert network [83]. Matan et al (1992) have developed a segmentation scheme on the basis of vertical cut which analyzes vertical projection of the image in order to segment the ZIP codes [121]. Lam L et al (1992) have carried out a comprehensive survey on thinning methodologies which is a space domain technique [97]. Thinning extracts out the shape information of the characters. Fujisawa H and Nakano Y (1992)

have worked on a model which segments and recognize the characters by analyzing the shapes of the strokes of the touching patterns [67]. Suen C et al (1992) have worked on the recognition of unconstrained handwritten numerals where structural features such as endpoints, fork points, holes, length, shape, or curvature of the individual strokes that occur as part of the character are considered [189]. Cheriet M and Suen C Y (1993) have worked on some preprocessing techniques because it is necessary to carry out some document analysis operations prior to recognizing text in scanned documents [47]. Some of the preprocessing techniques are putting thresholds, converting a gray-scale image into a binary black-white image, noise removal, extraction of the foreground textual matter by removing like textured background, salt and pepper noise and interfering strokes, line segmentation, the separation of individual lines of text, word segmentation, the isolation of textual words, and character segmentation, the isolation of individual characters. Martin G L et al (1993) have worked on integrated segmentation and recognition method to segment and recognize text which used exhaustive scans or learned saccadic jumps [119]. This method is a back-propagation learning neural network which exhaustively scans a character field. This method has been trained to recognize the position of the input window that it was centered over a single character or between characters. If the input window is centered on the character, the network classifies the character. This method produces high accuracy, generates too many candidate segments to enhance the accuracy. Bullock D et al (1993) have developed an ANN model to recognize cursive type of handwritten script [36]. Boccignone G et al (1993) have developed a method to recover dynamic information in static handwritten text [29]. Cardot H et al (1994) have developed a static signature verification system based on cooperative neural network architecture [40]. While scanning the text some noise like disjoint lines, bumps and gaps in lines etc. are found. Serra (1994) has given an overview of morphological filtering where some noise removal techniques are discussed [168]. Bellagarda E J et al (1994) have proposed a fast statistical mixture algorithm for the recognition of online handwritten text [21]. Bimbo A D et al (1994) have proposed an OCR which recognizes poor quality images by deformation of elastic templates [26]. Chen M Y et al (1994) have proposed a method which recognizes offline handwritten words using a Hidden Markov Model Type Stochastic Network [44]. Trier D and Jain A K (1995) have worked on a

goal directed evaluation of binarization methods which is a space domain method required for compression [197]. This method applies a method called thresholding which reduces the storage requirements and increases the speed of processing by converting the colour or gray-scale images to binary by using a threshold value. Bramall P E and Higgins C A (1995) have proposed a method which recognizes cursive type of handwriting which is based on human reading Models [33]. Bauer F and Wirtz B (1995) have proposed a method based on parameter reduction and personalized parameter selection for automatic signature verification [17]. Lucas S and Amiri A (1995) have worked on a method which recognizes chain-coded handwritten character images with scanning n-tuple method [108]. Bengio Y et al (1995) have proposed an ANN and Hidden Markov Model Hybrid approach for online handwriting recognition [22]. Murase H and Nayar S (1995) have proposed visual learning and recognition of 3D Objects from appearances [125]. Anquetil E and Lorette E (1995) have proposed a method to recognize online cursive handwritten characters using Hidden Markov Models [7]. Bijhold J M (1995) has used color transformation for the extraction of handwritten documents [25]. Chen H et al (1997) have developed a piecewise linear modulation model for handwriting recognition [43]. Dehghan M (1997) has worked on a method which carried out signature verification using shape descriptors and multiple neural networks [55]. Anquetil E and Lorette G (1997) have proposed a perceptual model of handwriting drawing application for the handwriting segmentation problem [8]. Ohba K and Ikeuchi K, Detectability (1997) have proposed a method based on uniqueness and reliability of Eigen windows for stable verification of partially occluded objects [135]. Bouletreau V et al (1998) have proposed a method to recognize handwriting text and signature of an individual to analyze the special nature of writing, having application in forensic analysis [30]. Kim et al (1998) have worked on the architecture for handwritten text recognition systems where post processing stage of the handwriting recognition system was discussed [92]. In post processing stage, which is the final stage of the proposed handwritten recognition system, the printing of the recognized characters, in the text format, was carried out. Senior A and Robinson A (1998) have developed an offline cursive handwriting recognition system [167]. Coatea M et al (1998) have worked on automatic reading of cursive scripts using a reading model and perceptual concept [48]. Morita M et al (1999) have proposed a

method which used mathematical morphology and weighted least squares to correct handwriting baseline skew [123]. Nishimura N et al (1999) have worked on a method which carried out offline character recognition using HMM by multiple directional feature extraction and voting with bagging algorithm [132]. Lee S W and Kim S Y (1999) have proposed a new type of cascade neural network to train the spatial dependences in connected handwritten numerals, which was originally extended from the multilayer feed-forward neural network to improve the discrimination and generalization power [100]. Bazzi I et al (1999) have proposed an online omni font open vocabulary OCR system to recognize English and Arabic handwritten characters which is user dependent, having limited vocabulary and satisfactory for the restricted applications [18]. Saon G (1999) has proposed a random field based HMM to recognize cursive word [164]. Oh I S et al (1999) have carried out an analysis on class separation and combination of class-dependent features for handwriting recognition [134]. Steinherz T et al (1999) have carried out a survey on offline cursive word recognition [188]. Plamondon R and Srihari S N (2000) have carried out a comprehensive detailed survey on vast research carried out on online and offline handwriting recognition [146]. Said H et al (2000) have worked on the identification of a person based on the handwriting [163]. Mori M et al (2000) have described the synthetic generation of isolated characters and worked on generating new samples from handwritten numerals based on point correspondence [122].

### **3.2.3 Work during the Period 2001-2010**

Rahman R et al (2001) have proposed a multi expert framework for character recognition which is a novel application of Clifford networks [152]. Hamid A and Haraty R (2001) have proposed a Neuro-Heuristic approach to segment handwritten Arabic Text [74]. Handwriting patterns are actually two dimensional in nature. Park H S et al (2001) have developed a two dimensional HMM method to recognize offline handwritten characters [140]. Maergner V and Pechwitz M (2001) have described a system for machine printed Arabic OCR that was trained on synthetic data [110]. Marti U V et al (2001) have worked on a feature extraction method where writer identification was carried out using text line based features [118]. Marti U V and Bunke H (2001) have worked on the improvement of the performance of an HMM based cursive handwriting

recognition system, using a statistical language model [117]. Arica N and Fatos T Yarman-Vural (2002) have carried out a research to recognize optical characters for Cursive Handwriting [11]. Verma B (2002) has proposed a contour character extraction approach in conjunction with a neural confidence fusion technique for the segmentation and recognition of handwritten characters [201]. Marti U V and Bunke H (2002) have worked on the IAM-database which is an English sentence database for off-line handwriting recognition [116]. As a thumb rule the performance of an ANN increases with increase in training set but acquiring training data is a tedious and expensive process. Rowly H et al (2002) have worked on the effect of large training set sizes on online Japanese Kanji and English cursive recognizers [160]. Tomai C et al (2002) have worked on transcript mapping for recognizing historic handwritten document images [196]. Varga T and Bunke H (2003) have worked on the generation of synthetic training data for an HMM-based handwriting recognition system [199]. Helmers M and Bunke H (2003) have worked on generation and use of synthetic training data in cursive handwriting recognition [79]. Bunke H (2003) has reviewed the state of the art in offline Roman cursive handwriting recognition where the input was an image of a digit, a word or some text and the system produced an ASCII transcription [37]. Parkins A D and Nandi A K (2004) have proposed genetic programming techniques to recognize handwritten digits [141]. Kahraman F et al (2004) have carried out a comparison between the performance of SVM and ANN for handwritten character classification [89]. It is found that ANN consumes less storage and less computation time than SVM. Mansour M and Benkhadda M (2005) have proposed optimized segmentation techniques for Arabic handwritten numeral character recognition [114]. Vinciarelli A (2005) has worked on noisy text categorization which is a noise removal technique [203]. Marinai S et al (2005) have worked on a segmentation technique and used an ANN for Document Analysis and Recognition [115]. Basu S et al (2005) have worked on Multilayer Perceptron (MLP) which is used for 'Bangla' alphabet recognition [16]. The accuracy of the above model is 86.46% and 75.05% on samples of training and testing samples respectively. Islam M W et al (2005) have proposed a method to recognize handwritten Bangla Numeral using back-propagation algorithm with and without Momentum factor [82]. Rahman M S et al (2008) have proposed a method to Recognize Handwritten

Bengali Numerals for Postal Automation [151]. Majumdar A and Chaudhuri B B (2006) have proposed a zone based feature extraction algorithm where a MLP classifier has been used to recognize both printed and handwritten Bangla numerals [111]. Lorigo L and Govindaraju V (2006) have carried out a survey on offline Arabic handwriting recognition [106]. Zafar M et al (2006) have proposed a method to recognize online isolated handwritten characters by using back propagation neural networks with the help of sub-character primitive features [212]. Sharma N et al (2006) have suggested a method, which uses zoning and directional chain code features and considers a feature vector for the recognition of handwritten Kannada numerals which produces good accuracy, but comparatively high time complexity [172]. Hanmandlu M and Ramana Murthy O V (2007) have proposed a fuzzy model to recognize handwritten numerals [77]. Dinesh Acharya et al (2007) have used a feature extraction method to recognize handwritten Kannada characters where the features are 10-segment string, water reservoir, horizontal/vertical strokes, K-Mean clusters and end point with accuracy of 90.5% [59]. This method is not free from thinning. Muhammad Sarfraz<sup>1</sup> and Ali Taleb Ali Al-Awami (2007) have worked on Arabic character recognition using 'Particle Swarm Optimization' with selected and weighted moment invariants, moments are the features and obtained accuracy is 82% [124]. Shaw B et al (2008) have suggested a method based on continuous density HMM to recognize a word. This is a feature extraction method which uses the histogram of chain-code directions in the word image, scanned from left to right by using a sliding window, as the feature vector [175]. Velappa Ganapathy and Kok Leong Liew (2008) have worked on a method called Multiscale Neural Network Training Technique to recognize handwritten character and obtained an accuracy of 85% [200]. Jawad H A et al (2008) have worked on a component based segmentation technique to segment the words from handwritten Arabic text [85]. Araki N et al (2008) have proposed a statistical approach to recognize handwritten characters using Bayesian Filter [10]. Srivastava D K and Bhambhu L (2009) have used support vector machine for data classification [187].

Shubhangi D C and Hiremath P S (2009) have worked on the recognition of handwritten English characters and digits using multiclass SVM classifier and structural micro features [177]. Jou C and Lee H C (2009) have carried out a research to recognize

handwritten numerals which is based on simplified structural classification and fuzzy memberships [88]. Rajashekararadhya S V and Ranjan P V (2009) have worked on the recognition of handwritten numeral/mixed numerals of South-Indian scripts which is a zone- based feature extraction method [154]. Bhattacharya U and Chaudhuri B B (2009) have proposed a method to recognize handwritten numerals for mixed Indian scripts [24]. Yanhua M and Chuanjun L (2009) have proposed an algorithm to recognize Chinese characters which was based on minimum distance classifier [209]. This algorithm uses two classes of feature extraction which are structure and statistics. The statistic feature decides the primary class and the structure feature recognized the Chinese characters. Keyarsalan M et al (2009) have worked on 'Font-Based' recognition of Persian characters using simplified fuzzy 'ARTMAP' ANN which is improved by fuzzy sets and 'Particle Swarm Optimization' and the accuracy obtained is 91.24% [90]. This is an offline method and used Persian characters. Pal A and Singh D (2010) have proposed an ANN model to recognize English characters [136]. In this work, MLP having one hidden layer has been used. The best case accuracy of this model is 94%. Pradeep J et al (2010) have worked on a model using diagonal feature extraction based handwritten character recognition system using neural networks. For classification ANN has been used [148]. Sharma D and Gupta D (2010) have used vertical, horizontal and diagonal profiles extracting out 54 features from each character where a feed forward, back propagation neural network with two hidden layers have been used for the classification [171]. Papavassiliou V et al (2010) have carried out handwritten document image segmentation into text lines and words [139]. Manivannan N and Neil M A A (2010) have worked on Optical Correlated neural network architecture to recognize patterns [113].

### **3.2.4 Work during the Current Decade**

Pradeep J et al (2011) have worked on a diagonal based feature extraction for handwritten alphabet recognition system using ANNs [147]. Kumar M et al (2011) have proposed a method using SVM classifier to recognize handwritten Gurumukhi characters where to extract the features of character, diagonal features extraction technique has been used [94]. Perwej Y and Chaturvedi A (2011) have worked on an ANN model to recognize English alphabets [144]. In this model binary pixels of the alphabets are used

to train the ANN. The accuracy of this model is 82.5%. Renata F. P. Neves et al (2011) have proposed a SVM based offline handwritten Digit Recognizer [157]. Som T and Saha S (2011) have used fuzzy membership function to recognize handwritten characters [185]. Dhandra B V et al (2011) have worked on a script independent approach to recognize Telugu and Devnagari handwritten numerals with probabilistic neural networks [58]. Pirlo G and Impedovo D (2011) have worked on Fuzzy-Zoning-Based Classification to recognize Handwritten Characters [145]. Shrivastava S and Singh M P (2011) have worked on the performance evaluation of feed-forward neural network with soft computing techniques to recognize handwritten English alphabets [176]. Siddharth K et al (2011) have proposed a zone based feature extraction method to recognize the numerals where the densities of object pixels in each zone have been calculated. The image is divided into  $4 \times 4$  zones and to enhance accuracy, the zones are further divided into  $6 \times 6$  zones and can be extended to a dimension of  $8 \times 8$  zones where 116 features have been extracted. Nearest neighbor classifier has been used to classify and recognize the numerals [178]. Huiqin L et al (2011) have proposed a distribution based algorithm based on image segmentation and distribution of pixels [81]. Dash T and Nayak T (2012) have worked on Non-Correlated character recognition using ANN which is an offline method and do not possess any linear relationships among the characters [53]. The accuracy obtained in this method is 78%. Jane A P and Pund M A (2012) have worked on the recognition of similar shaped handwritten Marathi characters using ANN which uses few standard individual characters. Handwritten characters have been recognized using many other approaches like template matching, HMM, QDF etc. Template matching is a good approach for the standard fonts but a poor performer for the handwritten characters and huge data set. Developing a HMM to recognize handwritten characters has been found complex [84].

Dash T et al (2012) have applied the above technique with different ANN algorithms [52]. Dash T and Nayak (2012) T have developed an ANN having single output neuron which shows whether the tested character belongs to a particular cluster or not using 'C' language and obtained an average accuracy of 70.32% [51]. Jindal A et al (2012) have worked on diagonal features and SVM Classifier to recognize handwritten Gurumukhi Characters [86]. Patel D K et al (2012) have worked on recognition of

handwritten Characters using multi resolution technique and Euclidean distance metric [142]. Singh P and Budhiraja S (2012) have worked on the recognition of offline handwritten Gurmukhi numerals using wavelet transforms and obtained an average accuracy of 88.8% [180]. Amritha S et al (2012) have worked on code based online handwritten character recognition for Malayalam script using back propagation neural networks [5]. Hamad and Husam A Al (2012) have worked on over segmentation of handwriting Arabic scripts using an efficient heuristic technique [72]. Sharma O P et al (2012) have worked on an improved zone based hybrid feature extraction model to recognize handwritten alphabets using Euler number [173]. Hallur V C et al (2012) have carried out a survey on handwritten and printed Kannada numeral recognition [71]. Amrouch M et al (2012) have worked on a method which uses sliding window based on the Hough transform as feature extraction technique. Dividing the image in two windows and determining the dominant direction based on the Hough transform, directional feature vector sequence has been formed. This method is based on based on continuous HMMs and directional features with an average accuracy of 90.4% [6]. Zawaideh F H (2012) has worked on recognition of Arabic handwritten characters using modified Multi-Neural Network where an accuracy of 67.43% is acquired [213].

Sahu V L and Kubde B (2013) have worked on a method using isolated English alphabets. In this method Diagonal feature extraction scheme has been used for recognizing the offline handwritten characters. In addition, efficient features such as Eigen value and mean value are also used which improves the accuracy. The accuracy is very good but this method has been applied mainly for the isolated characters [162]. Garg M and Ahuja D (2013) have proposed a modified Hough transformation technique and four view projection profiles technique to extract the features of numerals [68]. Using the modified Hough transformation technique, maximum accuracy of about 93.12% and 72.5% has been achieved by SVM and MLP classifiers and an average accuracy of 90.1% has been obtained.

### **3.3 Conclusion**

It has been observed that different researchers have worked on different methods during the seven decades and have proposed different methods for preprocessing,

segmentation, recognition and post processing. Different methods like labeling schema for syntactic description of the pictures, syntax directed interpretation of different classes of pictures, description and generation based, synthesis method have been used during the decade of sixties. Rules modification on the basis of experience, split and merge algorithm, syntactic pattern recognition by boundary approximation using polygons on the basis of concavity and adaptive threshold methods have been applied during seventies. Work on writing slant, structured segment matching, fuzzy set, statistical, time delay and sliding window have been carried out during eighties. Works on vast areas in this field have been carried out in nineties. During this period the works that have been carried out are based on principal component analysis, modular concept, thinning method, segmentation by analyzing stroke shapes, preprocessing, back propagation, morphological filtering, OCR, HMM, binarization, chain coding, recognition methods using Eigen values, post processing, weighted least squares to correct baseline skew, multiple directional feature extraction and cascade neural network. First decade of the 21<sup>st</sup> century has evidenced different works on the methods based on multi expert framework for character recognition, neuro-heuristic approach, HMM, OCR, feature extraction, genetic processing, MLP etc. The work that has been carried out during the current decade is based on diagonal based feature extraction, SVM classifier, fuzzy, probabilistic neural network, zone based method, and distribution based method, sliding window and Eigen value. Different types of work have been carried out in different scripts like English, Devanagri, Bangla, Gurmukhi, Tamil, Telgu, Chinese, Japanese, Kanji and Arabic. This work is an effort to generalize and enhance the performances of the previously carried out work by proposing simple ANNs.