A Review on Handwritten Pattern Recognition

Nagulu Hemanth[1], Gangisetti Praveen Sai[2], Gunji Lakshmi Gopinath Sai Kumar[3], Kusampudi Mohan Krishna[4], Inunganbi Sanasam[5], Venkata Vara Prasad Padyala[6]

[1,2,3,4]*Department of CSE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur 522502, AndhraPradesh, India*

[5,6]*Assoc. Professor, Department of CSE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Guntur 522502, AndhraPradesh, India*

Abstract: Recognition of handwritten documents and text is one of the most difficult tasks in the field of pattern recognition. It contains a large number of variables to recognize words, alphabets, digits and characters and some strokes in handwriting are mandatory. Our paper focuses on handwritten text which is manually written by humans. In this process we use artificial neural network, convocational network, machine learning and deep learning to process the handwritings. Basically handwritten recognition is of two types. One is manual and another one is online. The manual one is done by this human observation and the online one is done by artificial intelligence. This method is one of the most difficult ones because of the slant and uniqueness. In these patterns we look for specific strokes and patterns in which we can classify the words which affect the system requirements. By this paper we can help mini researchers who are trying to improve the technology in this sector so they can reduce the error rate and increase the efficiency of the model. The main difficulty in this process is to identify the letters which are written in cursive writing and block writing and also let us which overlap on each other and combine.

Keywords: ***Script, Cursive writing, Machine learning (ML), Deep learing(DL).***

1. INTRODUCTION

Handwritten text recognition is another name for handwriting recognition. It is the capacity of a computer to take understandable handwritten input from sources including paper documents, pictures, touch-screens, and other media. Data entry methods for handwriting recognition systems include a touch screen, electronic pen, scanner, pictures, and paper documents. The result is produced after it has been processed. as a digital record that may be viewed and changed at a later time. Different methods, including statistical, structural, neural network, and syntactic methodologies, have been used both online and offline.

Multiresolution process is the representation of pictures at many resolution levels. "In multi-resolution processes, pictures are divided into smaller regions each one by one. Wavelets serve as the multiresolution process's key components. Multiresolution theory, a powerful new technique to signal processing and analysis, was initially discovered to be based on wavelets in 1987. The representation and analysis of pictures at different resolutions are the focus of multiresolution theory. This method is utilized by the HCR system.

The biggest trouble with this technique is classifying the picture of any handwritten word, irrespective whether it is in block, cursive, or the other style of writing. The solution to this problem is a fully functional model that aids the user in converting handwritten format to digital format. As a result, this technology frequently serves as a machine-human interface.

The characters are stripped out of each word picture during the classification stage. Then after, it categorized each character on its own to recreate a word. In order to produce digital text, it must do a comparison between the properties extracted from the image of the handwritten characters and those in a library of other image models that have been suggested to identify or identify the handwritten characters.

This study reviews a number of handwriting recognition systems in depth for a number of contemporary issues, including document analysis, postal address interpretation, processing bank checks, signature verification, information technology, education systems, and research. Various papers have been studied for the analysis of the existing algorithms

and techniques for numerous pattern recognition applications. Further, we have identified their key findings and the challenges involved in them. This review looks at new processes and strategies that claim to speed it up recognition while decreasing processing time.

2. General Steps of Handwritten Pattern Recognition

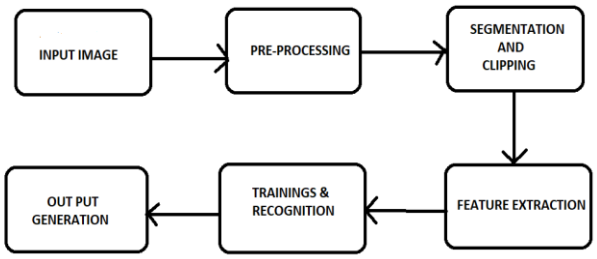

Fig 2.1 Work Flow

I. Data Collection (input image):

In order to find solutions to research problems, we must first collect and properly evaluate data from a variety of sources. Pattern recognition is a data analysis method that uses machine learning algorithms to automatically recognize patterns and regularities in data. This data can be anything from text and images to sounds or other definable qualities. Pattern recognition systems can recognize familiar patterns quickly and accurately.

II. Data preprocessing:

It is the method of converting raw data towards something that can be used by a machine learning model. In order to build a machine learning model, it is the first and most important step. Data preprocessing is a step in the data mining and data analysis process that takes raw data and transforms it into a format that can be understood and analyzed by computers and machine learning.

III. Feature extraction & Classification:

Feature extraction is the process of determining the features to be used for learning. This process includes transforming raw data into numerical features that can be processed while maintaining the information in the original data set is called feature extraction. Compared to using machine learning on the raw data directly, it delivers better outcomes. Classification is the task of assigning a class label to an input pattern. In Classification, we apply the model to the training and testing datasets to divide them into different categories.

IV. Output:

The output is generated after the classification method, and the classification's results are used to determine the performance of the developed algorithm.

3. LITERATURE WORK

Many articles and research papers based on from reputable sources, including IEEE, Science Direct, and Springer, were studied and evaluated. After examining the abstracts of more than 30 papers, we chose 20. 15 papers were ultimately chosen for examination.

Table 1. Summary of literature reviewed.

S.no	Author & title	Methodology	Data Sets	Results
[1]	"Holistic Urdu handwritten word recognition using support vector machine," Sagheer, Malik Waqas, et al.	Support Vector Machine (SVM)	CENPARMI Urdu Words Database.	A higher performance classifier (SVM) for cursive word identification is produced by a considerable recognition performance on the CENPARMI Urdu Database, and compound feature sets—which include structural and gradient features—are successfully recovered in this study.
[2]	Wu, Yi-Chao, et al. "Handwritten Chinese text recognition using separable multi-dimensional recurrent neural network."	Recurrent Neural Network with Separable Multi-Dimensional Long Short-Term Memory (MD LSTM-RNN).	CASIA-HWDB dataset.	When compared to the conventional method, separable (SMD LSTM-RNN) modules, which extract contextual information in different directions, use a lot less computation time and resources (MDLSTART). The suggested handwritten Chinese text recognition approach outperforms existing LSTM-based methods and is competitive with cutting-edge systems.

[3]	Cheekati, Bindu Madhuri, and Roje Spandana Rajeti. "Telugu handwritten character recognition using deep residual learning."	residual learning framework	IIITS-Telugu Handwriting Database; HP Labs database (Telugu) India	Deep Convolutional Neural Networks efficiently identify the key elements of a given image and look for patterns within them. As a result, it has been demonstrated that ResNet-50, part of the Deep CNN architecture, detects Telugu characters more accurately and with less training time.
[4]	Chowdhury, Rumman Rashid, et al. "Bangla handwritten character recognition using convolutional neural network with data augmentation."	Convolutional Neural Network	Bangla Lekha-Isolated dataset	The model can learn the features or attributes of the classes more efficiently by using more data with variation.
[5]	Naik, Vishal A., and Apurva A. Desai. "Online handwritten Gujarati character recognition using SVM, MLP, and K-NN."	Support Vector Machines (SVM) using linear, polynomial, and RBF kernels, as well as multi-layer perceptrons and k-Nearest Neighbors (KNN) with various values of k (MLP)	dataset of 3000 samples and tested by 100 different writers	obtained an SVM-RBF kernel's greatest accuracy of 91.63% and an MLP's lowest accuracy of 86.72%.
[6]	Ali, Amani Ali Ahmed, and M. Suresha. "Arabic handwritten character recognition using machine learning approaches."	SVM (Scalable Vector Machine), KNN (K-Nearest Neighbor), and CNN (Support Vector Machine).	n AHDB and IFN/ENIT data sets	It is highly likely that CNN will provide greater and better performance overall for this process of character recognition for Arabic handwritten text. Also, the proposed model, which depends on CNN, has gained a rate of accuracy relative to CNN with the layer of soft max.
[7]	Byron Leite Dantas Bezerra. HDSR-Flor: A Robust End-to-End System to Solve the Handwritten Digit String Recognition Problem in Real Complex Scenarios	Deep learning, Neural Network	Brazilian Bank Check, ORAND-CAR dataset, CAR-A dataset	The proposed optical model successfully identified sequences in pictures with high noise while disregarding unnecessary data surrounding the target text.
[8]	Dutta, Kusumika Krori, et al. "Kannada alphabet recognition using decision tree and random forest models."	Random Forest	Acquired from a set of 72 students of the Electrical and Electronics Department at M. S. Ramaiah Institute of Technology, Bangalore.	Comparing the random forest classifier and the decision tree model, the random forest classifier performs more accurately.
[9]	Reta, Betselot Yewulu, Dhara Rana, and Gayatri Viral Bhalerao. "Amharic handwritten character recognition using combined features and support vector machine."	HOG, LBP and geometrical features,LDA,multicl ass SVM using ECOC framework	Amharic handwritten characters data set and Chars74K benchmark numeric data set.	By altering gamma and order, respectively, gaussian and polynomial kernels produced low accuracy results in comparison to linear kernel. For the recognition of Amharic handwritten characters, linear kernel yielded good results.

[10]	Rani, N. Shobha, et al. "Deep learning network architecture based on Kannada handwritten character recognition."	deep learning network architecture,VGG19 NET	Devanagari character set	For the problem of very big classes of 188, the application of a lot of training information has shown satisfactory accuracy of about 73.51% with validation.
[11]	Medhavi Bhardwaj and Ayushi Pandey"Handwriting Recognition Using CNN"	Convolutional Neural Network	IAM Handwriting Dataset, IAM Dataset	Based on CNN data, this study assesses how well pre-processing and data segmentation techniques function. Our algorithm produces accurate predictions up to 69.16 percent and outgoing forecasts up to 81.16% while effectively detecting handwriting.
[12]	Pande, Shilpa Mangesh, and Bineet Kumar Jha. "Character Recognition System for Devanagari Script Using Machine Learning Approach."	Decision Tree classifier, Nearest Centroid classifier, K Nearest Neighbors classifier, Extra Trees classifiers and Random Forest classifier.	dataset of handwritten characters is taken which is preprocessed	With accuracy rates of 78% and 77%, respectively, the Extra Trees and Random Forest classifiers outperform other classifiers.
[13]	Hari Krishnan, A., Sourabh Sethi, and Rashi Pandey. "Handwritten Digit Recognition with Feed-Forward Multi-Layer Perceptron and Convolutional Neural Network Architectures."	feed-forward network with Multi-Layer Perceptron (MLP) and Convolutional Neural Networks (CNN)	MNIST dataset, a database consisting of 60000 training images and 10000 test images of handwritten digits.	For the categorization of images containing handwritten digits, CNN performs better than feed-forward MLP architecture in terms of accuracy and percentage error, even with fewer iterations. Yet, compared to CNN, MLP requires a much less training time.
[14]	Mukherjee, Partha Sarathi, et al. "A hybrid model for end to end online handwriting recognition."	Hybrid layered architecture consisting of three networks CNN	Devanagari and Bangla online unconstrained handwritten words.	In the first level of the proposed model, feeding the CNN hand-crafted features rather than raw data results in improved performance.
[15]	Kour, George, and Raid Saabne. "Fast classification of handwritten on-line Arabic characters."	A sub-linear time character classification	ADAB database	The classification repose time would be negatively impacted because to the k-d tree's sensitivity to high dimensional data when indexing without employing the dimensionality reduction technique. The dimensionality reduction and indexing stages were skipped, which cut the system's training time by around 7 seconds.

[1] describes the development of a comprehensive handwritten Urdu word recognition system and the significant enhancement of its performance on the CENPARMI Urdu Database. A higher performance classifier for cursive word identification is adapted as a result of a holistic approach to word recognition. This work successfully extracts structural and gradient characteristics from compound feature sets. Using compound feature sets containing gradient features and structural features and training the classifier with all samples from the Training and Validation sets yields the best recognition results.

In [2], we developed a method for recognising handwritten Chinese text that is separable, allows information to be extracted in several directions, and uses less time and resources than conventional modules. The findings of the experiment demonstrate that the given data set performs methods substantially better than earlier methods and can even compete with cutting-edge systems. From the dataset of Chinese texts provided, we may draw the conclusion that

Chinese text can be recognised and faults can be demonstrated clearly.

We can discuss in [3] how several methods, including pre-processing, loss functions, and learning rates, are used to train networks to increase model accuracy. The strategies stated above will maintainably increase model correctness. We can enhance semantic segmentation and object detection thanks to the pre-trained models. Telugu characters written by hand can be recognised using convolutional neural networks. With the provided photographs, we can use this method to detect patterns. Telugu characters may now be recognised more precisely and with less training time thanks to this training. We draw the conclusion that the experiment's findings clearly demonstrate the ability to distinguish both old Telugu manuscripts and handwritten Telugu characters.

This study looks on the options and approaches for categorising handwritten characters in Bangla in [4]. The research demonstrates that the CNN strategy is more effective than other machine learning techniques. The adaptability of the system is illustrated by the suggested model's strong performance on additional datasets. More data with variation was also found to help the model acquire the properties or attributes of the classes more quickly. The web interface also allows for simple interaction with the model and real-time validation. While the system performs admirably in classifying individual letters of the Bangla alphabet, there is no way to detect a sequence of characters.

The approach has been presented for the online handwritten Guajarati character recognition employing some hybrid characteristics in [5], which describes pattern recognition. We have contrasted various classifier parameter values from the training set. 100 users participate in the entire process. 0.063 seconds of average execution time per stroke allowed for high accuracy. Low accuracy will be caused by repetitive characters and unclear characters. Two-layered classifiers can be utilised to improve this recognition of perplexing and similar characters.

4.APPLICATIONS OF PATTERN RECOGNITON

I. Postal Address Interpretation: The assignment of a delivery point encoding, such as a ZIP+4 code, to letter mail items is known as postal address interpretation. Images of the destination address on the mail piece faces are used to establish the encoding; addresses that are handwritten, have poor machine printing quality, are incomplete, or are wrong are excluded.

II. Bank Check Processing: Bank check processing using handwritten recognition involves the use of technology to read and interpret the handwriting on checks. This technology involves Optical Character Recognition (OCR) software, which uses a combination of image processing and machine learning algorithms to identify and extract relevant information from the check.

III. Signature verification: Signature verification for handwritten recognition involves using algorithms to compare and analyze the features of a person's signature to determine if it is authentic or not.

IV. Information Technology: Handwritten recognition technology involves the use of information technology to automatically recognize and interpret handwritten text or symbols.

5. CONCLUSION

Pattern recognition can be implemented utilising a variety of techniques, including pre-processing, loss functions, and learning rates, which are used to train networks for increased model accuracy. The strategies stated above will maintainably increase model correctness. We can enhance semantic segmentation and object detection thanks to the pre-trained models. Telugu characters written by hand can be recognised using convolutional neural networks. With the provided photographs, we can use this method to detect patterns. Telugu characters may now be recognised more precisely and with less training time thanks to this training. It is possible to detect historical Telugu manuscripts and handwritten Telugu characters. a method for recognising handwritten Chinese language that uses detachable modules, allows information to be extracted in different directions, and uses less time and resources than typical modules. The dataset outperforms earlier approaches greatly and is competitive with cutting-edge systems. The online recognition of handwritten Gujarati characters is possible using some hybrid features. For identical characters and characters that are unclear, two-layered classifiers can be employed, although the accuracy will be low. In order to recognise cursive words, higher performance classifiers like SVM are used. It is possible to properly extract the features that involve structural and gradient

features. This technique makes it possible to recognise Urdu words. When compared to other machine learning techniques, the CNN methodology is more effective. It is possible for the model to learn the features or properties of the classes more successfully by using a bigger amount of data with variance. Although the algorithm is doing a great job of categorising individual Bangla alphabet letters, it is not possible to detect a series of characters. For Identifying a string of letters or a group of words collectively can be viewed as a future scope because it calls for more sophisticated implementation techniques. Therefore, at the end, we can say that pattern recognition can be done in a variety of ways by utilising a variety of methodologies, and it can also be done simply and clearly using handwritten characters from different languages.

REFERENCE

[1] Sagheer, Malik Waqas, et al. "Holistic Urdu handwritten word recognition using support vector machine." 2010 20th international conference on pattern recognition. IEEE, 2010.

[2] Wu, Yi-Chao, et al. "Handwritten Chinese text recognition using separable multi-dimensional recurrent neural network." 2017 14th IAPR international conference on document analysis and recognition (ICDAR). Vol. 1. IEEE, 2017.

[3] Cheekati, Bindu Madhuri, and Roje Spandana Rajeti. "Telugu handwritten character recognition using deep residual learning." 2020 Fourth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC). IEEE, 2020.

[4] Chowdhury, Rumman Rashid, et al. "Bangla handwritten character recognition using convolutional neural network with data augmentation." 2019 Joint 8th international conference on informatics, electronics & vision (ICIEV) and 2019 3rd international conference on imaging, vision & pattern recognition (icIVPR). IEEE, 2019.

[5]Naik, Vishal A., and Apurva A. Desai. "Online handwritten Gujarati character recognition using SVM, MLP, and K-NN." 2017 8th International Conference on Computing, Communication and Networking Technologies (ICCCNT). IEEE, 2017.

[6]Ali, Amani Ali Ahmed, and M. Suresha. "Arabic handwritten character recognition using machine learning approaches." 2019 Fifth international conference on image information processing (ICIIP). IEEE, 2019.

[7]HDSR-Flor: A Robust End-to-End System to Solve the Handwritten Digit String Recognition Problem in Real Complex Scenarios

[8]Dutta, Kusumika Krori, et al. "Kannada alphabet recognition using decision tree and random forest models." 2020 3rd International Conference on Intelligent Sustainable Systems (ICISS). IEEE, 2020.

[9]Reta, Betselot Yewulu, Dhara Rana, and Gayatri Viral Bhalerao. "Amharic handwritten character recognition using combined features and support vector machine." 2018 2nd international conference on trends in electronics and informatics (ICOEI). IEEE, 2018.

[10]Rani, N. Shobha, et al. "Deep learning network architecture based on kannada handwritten character recognition." 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA). IEEE, 2020.

[11] M BHARDWAJ · 2022 — The report explores new strategies and various approaches that promise to reduce its processing time while providing the highest accuracy of its recognition.

[12]Pande, Shilpa Mangesh, and Bineet Kumar Jha. "Character Recognition System for Devanagari Script Using Machine Learning Approach." 2021 5th International Conference on Computing Methodologies and Communication (ICCMC). IEEE, 2021.

[13]Hari Krishnan, A., Sourabh Sethi, and Rashi Pandey. "Handwritten Digit Recognition with Feed-Forward Multi-Layer Perceptron and Convolutional Neural Network Architectures." 2020 2nd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA). IEEE, 2020.

[14] Mukherjee, Partha Sarathi, et al. "A hybrid model for end to end online handwriting recognition." 2017 14th IAPR International Conference on Document Analysis and Recognition (ICDAR). Vol. 1. IEEE, 2017.

[15] Kour, George, and Raid Saabne. "Fast classification of handwritten on-line Arabic characters." 2014 6th International Conference of Soft Computing and Pattern Recognition (SoCPaR). IEEE, 2014.