IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 5, April 2024

Advancements and Trends in CNN-Based Handwritten Text Recognition: A Comprehensive Survey

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Abstract: *Handwritten Text Recognition (HTR) is pivotal in transforming handwritten documents into digital format, enabling efficient search, storage, and information retrieval. In this project, we explore the application of Convolutional Neural Networks (CNNs) for HTR tasks. We comprehensively analyzed existing literature surveys to understand the current state-of-the-art techniques, methodologies, and challenges in HTR using CNNs. The survey encompassed various aspects including network architectures, dataset compositions, preprocessing techniques, and evaluation metrics. Our findings reveal the evolution of CNN-based HTR systems and highlight key trends in research, such as the integration of attention mechanisms and recurrent neural networks to enhance recognition accuracy and contextual understanding. Through this analysis, we provide insights into the advancements and future directions in CNN-based HTR methodologies.*

Keywords: Handwritten Characters, CNN, Literature Reviews.

I. INTRODUCTION

The field of handwritten text recognition has come a long way in the last 30 years; it helps transform human-readable handwriting into machine-readable text codes. Many scientific and commercial fields are interested in handwritten text recognition because it can automatically handle massive amounts of handwritten data. The fundamental issue with handwritten writing has always been that different depictions of the same character differ. Individual variances in writing style, as well as contextual variations in writing style, add another layer of complexity to the task of deciphering English handwritten characters. Also, the writer's mood and the setting in which they write may impact their style.

The intricacy of optical pattern recognition only becomes obvious when attempts are made to construct a computer system that might interpret handwriting. The best approach to developing systems that can recognise handwriting is supposedly using artificial neural networks. For more accurate handwriting recognition, neural networks are a great model for how the human brain functions. Automated systems can now read handwriting as well as, if not better than, humans. People utilise many writing styles, some very challenging to decipher. Reading handwriting may sometimes be challenging and time-consuming, especially when dealing with many papers from different people. The proposed system would be most effective with neural networks integrated because of their superior ability to decipher complex data and identify patterns that would be difficult to detect using traditional approaches. This project aims to develop a model that can recognize handwritten numbers and characters from an image using the Convolution Neural Network idea. We constructed a basic Convolutional Neural Network (CNN) system trained on the NIST dataset.

Handwritten Text Recognition (HTR) is a fundamental task in document analysis and understanding, facilitating the conversion of handwritten documents into digital format for various applications such as archival, search, and translation. Over the years, Convolutional Neural Networks (CNNs) have emerged as a powerful tool in image recognition and understanding, demonstrating remarkable success in tasks ranging from object detection to scene understanding. Leveraging the spatial hierarchy and local connectivity patterns present in handwritten text images, CNNs offer a promising avenue for automating the process of text recognition from scanned or digitized documents.

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The application of CNNs in HTR tasks has garnered significant attention from academia and industry, owing to their ability to learn hierarchical representations directly from raw pixel intensities, alleviating the need for handcrafted feature extraction. Using convolutional layers, pooling operations, and non-linear activation functions, CNNs can effectively capture intricate spatial patterns and structural dependencies inherent in handwritten text images, enabling accurate recognition even in the presence of variations in writing styles, sizes, and orientations.

This review research paper aims to provide a comprehensive overview of the state-of-the-art methodologies, techniques, and challenges in Handwritten Text Recognition using Convolutional Neural Networks. We survey a wide range of literature encompassing various aspects of CNN-based HTR, including network architectures, dataset compositions, preprocessing techniques, evaluation metrics, and benchmarking protocols. By synthesizing insights from existing studies, we aim to shed light on the evolution of CNN-based HTR systems, identify key trends and advancements, and delineate avenues for future research and development in this burgeoning field.

Through this review, we endeavor to provide researchers, practitioners, and enthusiasts with a comprehensive understanding of the current landscape of HTR using CNNs, offering valuable insights and perspectives to inspire further innovation and progress in the field.

II. LITERATURE REVIEWS

An increasing number of individuals can understand the MODI script, yet its use is on the decline. Information that is culturally important, historically noteworthy, and administratively relevant were all included in the saved archaic historical MODI manuscripts. Thousands of handwritten MODI papers maintained in official and public sectors provide information essential to the contemporary period. Among the 3,350 instances included in the MODI-HHDoc Dataset are photographs of old handwritten MODI documents. Using this dataset, one may create a system to digitize, recognize, transliterate, and extract information from old MODI documents written by hand. [1]

The MODI script is used by hundreds, yet few understand it. Handwritten MODI records include culturally, historically, and administratively valuable information. Many of the thousands of handwritten MODI documents provide vital information on current public and governmental affairs. The MODI-HHDoc Dataset comprises 3,350 handwritten mediaeval MODI documents. This dataset may be used to digitise, recognise, transcribe, and translate historic MODI documents to get MODI script information. The system needed data to handle multiple approaches. [2]

Researchers performed a comprehensive survey to assess Modi script character recognition. This paper covers all key methods, strategies, and advances for Modi script character identification. The authors may employ machine learning, deep learning, and image processing. This article provides a complete review of Modi script character recognition procedures and highlights key trends, challenges, and research opportunities. The survey is reliable and necessary for Modi script character recognition academics, practitioners, and enthusiasts, according to the IEEE publication platform.[3]

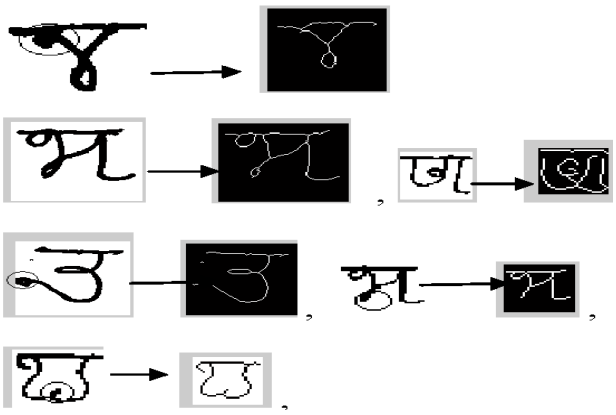

Fig.1 Handwritten script

The researchers develop an effective Modi script character identification method in their published work. This work aims to improve Modi script character recognition by developing and deploying novel methods, including machine

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learning and image processing. The article summarises the suggested technique, including its essential components and procedures, to enhance recognition results. IJCA publication validates the work, which sheds light on Modi script character identification for scholars and practitioners and significantly advances the field.4]

The researchers thoroughly evaluated Modi script character identification systems. This review will include all computational methods used by researchers up to the publishing date, including machine learning and image processing. The authors want to provide researchers, experts, and fans a complete history, present, and future of Modi script character identification. The International Journal of Computer-Aided Character Recognition (IJCA) may provide legitimacy to the review and provide a resource for Modi script character identification researchers.[5]

Character segmentation utilising old handwritten MODI Script papers is the subject of this study. According to the Vertical Projection Profile (VPP) method, a zero-pixel column ought to appropriately split two adjacent letters into individual ones on a single line. Updates to the VPP output are necessary as this script prints characters on a single line without raising a hand. In this study, the authors provide a novel approach to character segmentation error reduction by line separation utilising dual thresholding criteria. It was born out of the author's extensive research on the subject. Any researcher would benefit from the study's methodology since it is easy, quick, and inexpensive.[6]

The main objective of this study is to review the existing literature on MODI handwritten character recognition. Because every writer has a distinct style, character identification from handwriting has become more difficult in recent years. Computers may make previously illegible handwriting intelligible using character recognition software. Numerous historical efforts to understand Indian languages have left their mark on the written record. Here, the MODI script especially deserves more respect. To ensure the preservation of these priceless archives, several language-specific identification algorithms have been developed. The variety and complexity of writing styles seen in every Handwritten Optical Character Recognition (HOCR) dataset keeps academics interested in Indian scripts.[7]

How to handle the many different writing styles included in HOCR datasets has become a big problem in the field of Handwritten Optical Character Recognition (HOCR) in the last several decades. Indian culture and geography combine to form a singular identity as a place of unity in diversity; this, in turn, has resulted in a rich tapestry of spoken and written languages spoken and written throughout the nation. A lot of work has gone into creating HOCR systems in India that can handle different types of handwriting. There has been a dramatic increase in the study of character recognition systems due to the complexity and diversity of Indian characters. The studies that used MODI for handwritten character recognition are the primary topic of the previous research that is covered in this publication.[8]

Creating a system that can identify handwritten characters is the main goal of this project. While the title implies that the tactics used to identify handwritten characters were carefully researched, the presented data does not specify particular methodologies or procedures. Due to the importance and prevalence of handwritten writing, especially in many languages and scripts, this study enhances optical character recognition systems. The ongoing efforts to improve algorithms for handwritten content identification are shown by their usage in character recognition.[9]

run a battery of tests to ensure that several algorithms can identify Modi characters written by hand, such as Naive Bayes with a maximisation function, Euclidean distance, and Minimum distance with an improvement and minimization function. Automation in feature vector binarization and techniques for extracting concavity, structural, and gradient features are also proposed. To validate the offered intelligent recognition approaches, the invariant Modi handwritten dataset is used. Combining concavity characteristics, a correlation coefficient, and maximum voting increases the recognition rate for handwritten Modi numerals. Meanwhile, GSC features do a good job of describing Modi's vowels. The correlation coefficient becomes more efficient as classes with distinct characteristics increase. Although it is challenging, a minimal distance classifier with a minimization algorithm can recognise both free-form cursive and stylish handwritten Modi characters. The GSC feature extraction approach can characterise the most baffling Modi aspects by effectively extracting geometrical, structural, and concavity information. Our best recognition rate of 83.19% was achieved by combining the GSC feature extraction method with the Minimum distance classifier and its reduction function. The identification rate is validated using 95,000 Modi handwritten characters from 55 classes. The proposed system has an invariant quality that has been shown. The enormous number of character symbols is a significant obstacle when producing training data for the ingenious but dated Modi document recognition system. one way to circumvent this is to construct an annotated Modi character dataset from the original handwritten Modi manuscripts. [10]

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2.1 MACHINE LEARNING AND DEEP LEARNING

The Maratha government adopted the "MODI lipi" script as their official writing system between the 17th and the middle of the 20th century. Also included in this script are religious texts from the Indian state of Maharashtra. Being a "MODI manuscript," it provides cultural significance by describing the period in which it was written. Not many people are aware of this "lipi," which is a shame since it has the potential to educate and motivate today's youth. with the field of handwritten character identification, there has been discussion of developing a MODI recognition system to aid with learning. Character recognition is only one of several pattern recognition applications that use deep learning methods. The use of transfer learning algorithms has recently improved recognition problems. To categorise MODI characters, the proposed approach uses CNN and Vgg16 algorithms.[11]

For optical character recognition (OCR), MODI is only one of several difficult languages. The MODI script is difficult to decipher since it is largely cursive and has few outwardly comparable letters; deep learning algorithms like InceptionV3 and RestNet have yet to be applied to the Modi script. For offline deep learning handwritten character recognition, it is recommended to use Residual in conjunction with the InceptionV3 framework. About twenty-five individuals had their handwriting samples included in the Modi Barakhadi collection. Examination of the dataset, including 7,721,001 items. Separate the characters using the Otsu binarization method toprepare them for further processing. Benchmark the performance of each approach on pre-processed data using a real-world, multi-author database of handwritten characters. A model precision of 0.86 and a recognition accuracy of 94.552 percent were produced by applying RestNet50 to processed pictures. Test results show that InceptionV3's processed-image recognition is 93.923 percent accurate, with a model precision of 0.843 percent.[12]

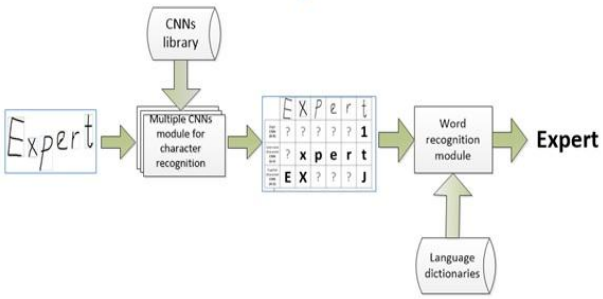

Fig.2 CNN Modules for handwritten character

The suggested experiment in this study employed the deep learning model Alexnet to correctly identify characters in a script that is thought to be from ancient India. to assess the efficacy of the deep learning technique in this particular experimental environment, we just used the specific characters from the old MODI script. Alexnet, a MATLAB model, was used to accomplish an experimental setup success rate of 89.72%. All fifty-eight letters of the handwritten MODI script were used in this experiment. The final output considered one hundred distinct visual versions for each character. The success of the trials is detailed in this presentation, which also describes the present status of the planned research approach. Consequently, the simple and effective implementation using MATLAB programming is shown via the use of the deep learning model in the first phase of the experimental research activity.in [13]

The objective of creating a practical Character Identification System was to keep identification accuracy high without compromising the quality of the input documents. Utilising robust Convolutional Neural Network (CNN) methods, the Modi Script Character Recognizer System was developed and put into operation (MSCR). team has thoroughly evaluated all 48 letters that make up the MODI script, which includes vowels, consonants, and 10 numbers. In order to aid our system's training, we collected a large number of handwritten samples from various locations. This literature review explores the fascinating path to build MSR, a character recognition system, for the ancient MODI script by digging into the specifics of its development and performance. [14]

Deep learning can solve the problem of recognising handwritten characters in a scanned image. Making written Gujarati resources digital is of the utmost importance. Findings from this research point to the importance of developing a technology to scan handwritten text digitally. For this, can employ deep learning techniques, which make working with photos a breeze. [15]

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The developers of this software set out to solve a common problem: how to make it simple for everyone, anywhere to transpose handwritten notes into text. For those who have trouble reading digital text, there is also an in-built Text-to-Speech feature. Scaled up, it has the potential to benefit a great many more individuals. The results of using the handwriting recognition model have been promising. [16]

The Maratha dynasty promoted Marathi as a sign of strength and culture in the 17th century using MODI, a script that is akin to Devanagari. Identification and translation of MODI scripts may be difficult due to its shrinking user population, script databases that aren't dependable, and a lack of relevant literature. In this innovative research, the writers test the hypothesis that CNN architecture can recognise MODI numeric and alphabetic letters. After applying a conventional ML classifier to the data, compare Random Forest with XGBoost; the result is a letter recognition accuracy of 92% and a number recognition accuracy of 93.33%.[17]

Integrating deep learning methods results in an upgraded paradigm. In the first part of the article, the author discusses the difficulties of reading the old Modi script and how complex methods are required to solve these problems. Data preparation, model design, and training procedures are likely covered in great depth in the methodology section, which pertains to the application of deep learning. The results and discussions highlight the improved model's performance measures compared to more conventional approaches. Expect the conclusion to highlight their deep learning-based method's success, providing insights into real-world consequences and potential avenues for future study at the crossroads of historical texts and state-of-the-art technology. To better understand the recent advances in Modi script character identification, it is recommended that you read the whole work. [18]

The course will begin with an overview of the Modi script and the growing significance of automated recognition systems. To address these challenges, the authors may discuss the limitations of existing approaches and the potential benefits of machine learning. The technique section will likely detail the character recognition methods used. Accurate information about the data collection, preparation, and ML algorithms used should be provided. They could review the training process and any changes to boost the model's precision. The outcomes and talks show their recommended approach. Learn as much as you can about the model's accuracy, precision, and recall. Reviewing the model's performance, the authors may look at how it stacks up against previous research or industry norms. In the last section, they would review the findings, stress the importance of their work, and propose areas for further research. In addition to recommendations for extending the approach to other scripts or languages, keep an eye out for the real-world implications of the findings. For a more in-depth understanding of the specifics, methodology, and findings of this inquiry into Modi script character identification, it is recommended to read the whole paper. [19]

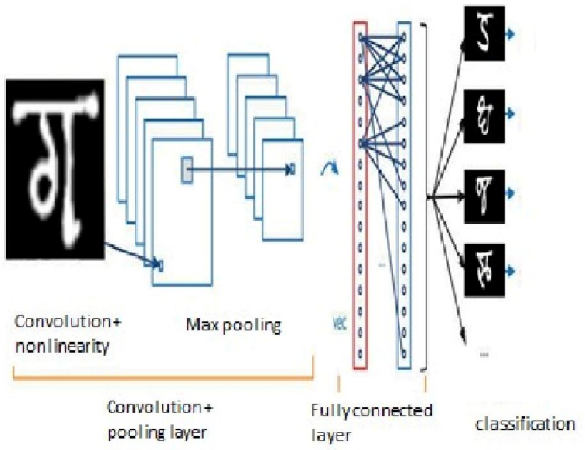

Fig.3. DNN Technique of Character Recognition

Since the introduction of digital computers, machine reading simulations have piqued the curiosity of computer science researchers. "character recognition" means to recognise printed or handwritten characters to extract machine-readable text from document pictures. Latin, English, and Chinese are foreign scripts that have proven useful for character identification. When working with scripts employed in Indian languages, the complicated character identification

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approach presents an exceptionally formidable challenge. Devanagari, an abbreviation for the ancient Indian MODI script, was the initial alphabet used to write Marathi. The historical significance of the script outweighs its lack of formal usage. It isn't easy to apply MODI character detection on texts that require word-stopping signals, have comparable character forms, and have a wide variety of writing styles. Innovations in machine learning have been crucial to the success of character recognition systems. Examine and contrast the most recent feature extraction and classification approaches to MODI script recognition. [20]

2.2 Transfer Learning

This article details the process of building a supervised Transfer Learning (TL) classification system and compiling an image dataset of MODI handwritten characters. The network takes weights from an existing Alexnet model and uses them to retrain a Deep Convolutional Neural Network (DCNN). This network pulls features from every level it can reach in its role as a feature extractor. In order to train the classifier models, Support Vector Machines (SVMs) with activation characteristics are used. improve your knowledge of feature analysis and the accuracy of recognition by using these models. Deep feature discriminating attributes are chosen based on both subjective and objective criteria. Handwritten MODI characters achieved a recognition accuracy of 92.32% and handwritten Devnagari characters a recognition accuracy of 97.25%.[21]

First, there will be an introduction explaining the purpose of the study and the specific challenges of detecting handwritten Modi script. In order to prove that their work is unique, the writers should use Transfer Learning, a powerful method for improving performance in related jobs by transferring information learnt from one. Extensive insights into the detailed use of Transfer Learning to improve the recognition model are provided in the methodology section, which covers a wide range of topics including data preparation, model creation, and knowledge transfer from pre-trained models. Discussions and outcomes will likely focus on the performance metrics of the recognition model, comparing it to more traditional methods to emphasise its efficacy.[22]

This method covers data preprocessing and the subtleties of the chosen architecture. Regarding processing speed and accuracy, among other metrics, the findings and comments provide a thorough assessment of the approach compared to existing OCR systems. Highlighting the importance of neural networks in the optical character recognition (OCR) of the Modi script, the conclusion offers indications of possible real-world applications and directions for further research. The paper delves into how historical scripts and current machine-learning techniques work together to digitize and archive cultural artifacts. [23]

2.3 CNN

Deep learning algorithms have been successful in various pattern identification tasks, including character recognition. Convolutional Neural Networks are excellent character recognition deep learning models. CNN can extract features and recognise characters. This study examines MODI script character identification using a CNN autoencoder. A Support Vector Machine (SVM) classifies data using gathered features. On-demand data augmentation increases data diversity and generalizability. Marathi was only written in MODI till 1950. Library and temple collections worldwide have MODI documents. To get MODI manuscript data from libraries, script character recognition research is needed. The recommended technique uses a CNN autoencoder for feature extraction and an SVM for the classifier to achieve state-of-the-art MODI character recognition results. [24]

This study uses cutting-edge technology to recognise MODI script handwriting using a Convolutional Neural Network (CNN) for feature extraction and a Support Vector Machine (SVM) for the classifier. This work integrates cutting-edge deep learning algorithms with traditional script analysis approaches to improve Handwritten Character Recognition for the uncommon and difficult MODI script. The research uses convolutional neural network (CNN)-based feature extraction to improve identification accuracy in an old screenplay using cutting-edge machine learning methods. [25]

This study uses a CNN and GUI to identify handwritten text. A simple solution for automatic character identification uses convolutional neural networks (CNNs), which are successful in image-related tasks, and an intuitive user interface. This study significantly advances the area by introducing a fully functional system that uses state-of-the-art neural network algorithms for precise identification and prioritizes usability via a graphical user interface. When it comes out

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in April of 2021, it will be the most cutting-edge answer to the problems that have recently plagued the area of handwritten character recognition. [26]

The capacity of computers to decipher handwriting will soon be of paramount importance. Handwritten character recognition technology has the potential to automate several mundane tasks. Convolutional neural networks (CNNs) are superior to the other two approaches in speed and accuracy, as shown in the study. No matter how much progress CNN has made in accuracy, the framework required to provide state-of-the-art results remains the same. Enhance precision by including a spellchecker in the final product and using image-cleaning procedures on inputs. Learning about other areas that might benefit from the proposed method for automation. [27]

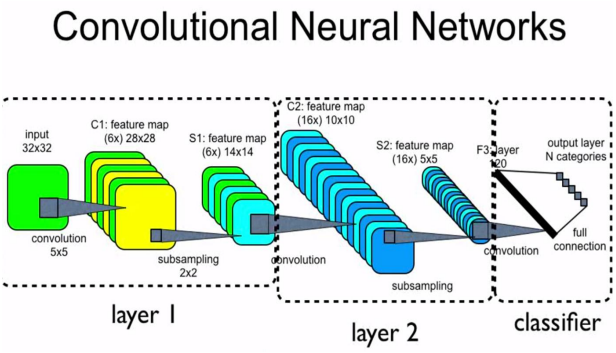

Fig.4 CNN Architecture

A fresh approach to combating the issue of credit card fraud. Addressing the increasing challenges in this subject, the paper's introduction explains why their analysis is relevant to current techniques. The authors provide a hybrid model that combines Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs), as detailed in the techniques section, which deals with data preparation, model construction, and training insights. The model's success indicators are included in the results and comments. These indicators may include a comparison to more traditional techniques of fraud detection. The conclusion provides a brief overview of the findings, highlighting the efficacy of their hybrid CNN-SVM model, and makes recommendations for further study and potential credit card security applications. It is suggested that you read the whole study to get a better understanding of the novel synergies used for enhanced fraud detection.[28]

Beginning with a discussion of the field's challenges and the need for more advanced models, the essay will highlight the distinct benefits of these models by integrating CNNs and SVMs (SVMs). Read the methodology section to learn about the joint operation of CNNs and SVMs. It should include everything from data pretreatment to the design of the hybrid classifier and the training method. In the discussion and results sections, you can expect to see performance metrics for the hybrid model compared to more traditional methods. The conclusion will give a brief overview of the model's effectiveness, recommendations for further research on handwritten digit recognition, and real-world examples of its use. If you want to know what innovative methods were employed to improve recognition results, read the whole article. [29]

The article will probably begin with an introductory section that discusses the difficulties of medical imaging, the importance of accurate detection methods, and the novelty of their Hybrid CNN-SVM Threshold Segmentation Approach. Data preparation, model design, training details, threshold segmentation, and the integration of Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs) are all described in great depth in the methods section. In the results and discussions sections, you can expect to see performance metrics, comparisons to other methods, and possible obstacles listed. In the conclusion, you can expect a brief summary of their approach's effectiveness, along with some suggestions for future medical imaging research and practical applications. You can learn more about their novel approaches to precise tumour identification and classification by reading the complete article. [30]

The paper will probably begin with an introduction that describes the script's special problems and stresses using Convolutional Neural Networks (CNNs) as a contemporary method for character recognition. With its in-depth analysis of data preparation, CNN architecture, and training complexities, the methodology section provides essential insights

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into CNN applications. The results and discussions section would highlight performance metrics, maybe comparing the CNN method to others; the conclusion section would briefly highlight the effectiveness of their CNN-based model for Modi script character recognition; the end section would hint at potential future research directions and practical implications related to the preservation of historical scripts through advanced technologies. Delving into the complete paper guarantees a more profound comprehension of integrating conventional scripts with modern neural network methods. [31]

The project's introduction likely delves into the unique characteristics of the Modi script and the inherent complexities in its digital processing. The methodology section will provide a comprehensive overview of the thresholding techniques employed, detailing their application in image processing and segmentation, with insights into experimental choices. Through performance measurements and comparative evaluations, these strategies would be shown to work for Modi script and discussed. The result will likely highlight thresholding strategies and suggest further historical script digitalization study. Reading the complete study will help you understand the careful examination of Modi script thresholding strategies. [32]

Handwritten character recognition converts handwritten characters into machine-readable format for processing. You may use photos, documents, or other character-based sources. Recognising complicated compound handwritten characters with intricate patterns is difficult. Convolutional neural networks (CNNs) have made great progress in HCR by learning discriminating characteristics from huge amounts of raw data. This article identifies test dataset characters using CNNs. CNN's character recognition accuracy and training on an image dataset are the main focus of this work. CNNs compare and contrast characters' characteristics and forms to identify them. The NIST dataset was used to evaluate our CNN implementation for handwritten character accuracy. A training batch of 1000 NIST pictures yields 92.91% accuracy on 200 images. [33]

Many past information and bespoke characteristics have been the backbone of traditional handwriting recognition algorithms. It is not easy to train an optical character recognition (OCR) system using these requirements. In recent years, researchers in handwriting identification have made great strides by concentrating on deep-learning approaches. However, further research is essential, and improvements to identification accuracy are required due to the ever-increasing amounts of handwritten data and the availability of enormous computing power. The best method for handling handwriting identification challenges is convolutional neural networks (CNNs), which automatically extract different characteristics by analyzing the structure of handwritten letters and sentences. This proposed study investigates CNN-based handwritten digit identification using several design parameters such as stride size, receptive field, kernel size, padding, and dilution. Furthermore, our objective is to assess how well different SGD optimization techniques enhance the accuracy of digit identification from handwritten input. By using ensemble architecture, the recognition accuracy of a network is enhanced. Since ensemble topologies increase testing complexity and computational expense, we aim to achieve equal accuracy using a pure CNN architecture without ensemble architecture. Therefore, a convolutional neural network (CNN) design is suggested for achieving accuracy that surpasses ensemble topologies while simultaneously reducing operational complexity and expense. In addition, we detail the optimal set of learning parameters for CNN construction, which allowed us to break the previous absolute record for MNIST handwritten digit classification. After a battery of tests, the recognition accuracy for the MNIST dataset was 99.87%. [34]

New difficulties in feature selection for handwriting identification issues have emerged due to the data expansion, which has led to large-scale, high-dimensional data. An ideal feature selection algorithm that can improve the recognition accuracy of a handwriting recognition system while reducing training efforts and computational cost is required due to practical challenges such as the high degree of individual variation and ambiguity in handwriting styles. This work proposes a feature selection method based on evolutionary algorithms for handwritten digit recognition, focusing on the feature selection process. An effective feature set that includes the sample numbers' local and global properties is obtained by developing a hybrid feature set that combines statistical and geometrical features. The technique employs a genetic algorithm for feature selection and a k-nearest neighbor for fitness evaluation to find the unique features of the handwritten digit dataset. Results showed a 66% decrease in the original feature set without compromising identification accuracy in the studies conducted on the standard The Chars74K handwritten digit dataset. The findings of the experiment prove that the strategy is successful. [35]

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These days, computer vision applications rely heavily on Convolutional Neural Networks (CNN). This article presents the results of an offline study that employed a state-of-the-art CNN to recognise Tamil handwriting. While HTCR has always relied on human input to extract features, CNNs automate the process. An HP Labs India-developed collection of isolated handwritten Tamil characters was used. We trained a convolutional neural network (CNN) model using offline Tamil text and got excellent results on both the training and testing datasets. This was our first attempt at CNN development. This effort aims to use deep learning methods to establish a standard for offline HTCR. Compared to more conventional methods, this work's training accuracy of 95.16 percent is far superior. [36]

Optical Character Recognition (OCR) is a scanning technique that can accurately identify printed and handwritten letters, numbers, and symbols at high electrical speeds. The comprehension of visual information is now known as Intelligent Character Recognition (ICR). It is possible to transform scanned printed or handwritten characters into ASCII text using the OCR module's Intelligent Character Recognition (ICR) feature. When exchanging information digitally, the typical format is ASCII data. Letters, numbers, symbols, and whitespace are all given conventional numerical values by ASCII. Output Character Recognition (OCR) is the technical name for the process of converting two-dimensional textual information into machine-encoded text using an electronic equipment. You may use a scanner or even just take a photo of the text and the recognition algorithm will be able to tell the difference between machine-written and hand-written text. A Convolutional Neural Network model trained on the NIST dataset, which contains more than 100,000 pictures, is the subject of this articles' stated objective. In order to determine the likelihood of each class to which a picture belongs, the network learns from the characteristics retrieved from the pictures. With a loss of 2.53%, we have attained an accuracy of 90.54%. [37]

III. CONCLUSION

This research analyses Convolutional Neural Network-based handwritten text recognition. Synthesised multiple literature surveys to uncover CNN-based HTR methodology themes and trends. Our investigation shows that CNN architectures are crucial to HTR task excellence. We also stressed dataset curation, preprocessing, and assessment criteria in evaluating HTR systems. Advanced neural network topologies, preprocessing methodologies, and assessment frameworks will improve handwritten text recognition accuracy and efficiency. This study is useful for CNN-based HTR researchers and practitioners.

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IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 5, April 2024

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International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
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