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A Review of Advances and Challenges in Modi Character Recognition

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Abstract: *This research paper reviews existing literature surveys on Modi character recognition, aiming to discern trends, methodologies, and challenges in this evolving field. The Modi script, an ancient writing system, presents unique challenges for character recognition due to its historical context and cursive nature. Our analysis encompasses diverse literature sources, exploring approaches such as deep learning, transfer learning, and thresholding techniques employed for Modi character recognition. By synthesizing insights from these surveys, we aim to provide a holistic overview of the current landscape, identify gaps in existing research, and offer valuable perspectives for future investigations in the preservation and digitization of the Modi script.*

Keywords: Modi Character, Modi Lipi, Deep learning, CNN

I. INTRODUCTION

One of the oldest and most antiquated scripts in the linguistic history of India is the Modi script, derived from the Indo-Aryan language family. Languages written in the Modi script were spoken across Southern Asia, with Western and Southern India considered particularly significant. Until the mid-nineteenth century, the Modi script was the standard for writing in the Modi language. This script found widespread use in the Maratha Empire states, including Maharashtra, Gujarat, Karnataka, and several regions in central India. Various classical works of literature delve into the historical background of the Modi script.

Hemandpant, also known as Hemadri, was a diplomat, administrator, architect, poet, theologian, and scholar who developed the Modi script in the 12th century. It primarily saw use in Western and some Southern parts of India. Numerous ancient scripts have existed for centuries, and until the 20th century, Marathi was predominantly written using the Modi script. During that time, the state of Maharashtra employed it for administrative purposes. The British later introduced the Balbodh variant of Devanagari.

The Modi script comprises 46 unique letters, with 36 consonants and 10 vowels. It incorporates features that facilitate smoother writing, reducing the need to lift the pen from the page and dip it in ink when transitioning from one character to the next. While some characters exhibit a "broken" form, others take on a more "circular" shape. Consequently, the Modi script is characterized by a kind of "cursive" Marathi writing style. Figure 1 illustrates the primary character set of the Modi script.

Figure 2: The basic characters of MODI.

Fig.1 Modi Character

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In the multifaceted landscape of India, where approximately 780 languages resonate, the historical and linguistic tapestry is enriched by the MODI script. Originating in the 12th century and persisting for about six centuries, MODI played a pivotal role in written communication, notably during the reign of 'Chatrapati Shivaji Maharaj' in Pune. The script's evolution and historical significance provide a unique lens to explore the intersection of linguistic diversity and cultural heritage. Against this backdrop, academic interest converges on handwritten character identification, aligning with the forefronts of Pattern Recognition, Image Processing, Natural Language Processing, and Document Analysis.

The amalgamation of technology and automation is undeniable in the contemporary landscape, characterized by swift mechanization and a relentless pace. The march toward digitalization, a hallmark of the computer age, transforms how information is processed, stored, and accessed. However, the challenge persists in translating the nuances of real-world information, such as the cursive MODI script, into the digital domain. MODI, an ancient language cultivated in the 12th century by Hemadpant, is primarily used for writing. The script's cursive nature adds a layer of complexity, making recognizing characters inscribed by various writers challenging. A pronounced shift toward handwritten character recognition has occurred in contemporary research, underscoring its pivotal role in disciplines like image processing, natural language processing, and pattern recognition. The MODI script is a venerable guardian of invaluable knowledge, spanning diverse disciplines and epochs in the rich tapestry of India's historical and cultural heritage. Rooted in history, this ancient script has preserved countless documents from eras such as "Shivakalin" and "Peshvekalin," acting as a bridge to our linguistic and cultural past. However, the intricate characters of MODI pose a unique challenge in deciphering and preserving this rich heritage. In response, this study embarks on a transformative journey in handwritten character recognition, explicitly focusing on MODI script identification

Fig.2 Different Styles of Modi Script

Recognizing the pivotal role of documentation in human culture, our endeavour is fueled by the necessity to bridge the linguistic gap between Devanagari and MODI. With meticulous curation of 57 distinct classes of MODI script characters, we navigate through conventional feature extraction techniques, exploring moment invariants, affine moment invariants, chain code histograms, and intersection junctions. However, the groundbreaking shift to Deep Neural Networks (DNNs), particularly Convolutional Neural Networks (CNNs), takes centre stage in our pursuit of an exceptional recognition rate. As we delve into the nuances of handwritten document analysis, we acknowledge rapid industrialization and the need to integrate automation with technology seamlessly. The digital age demands a comprehensive understanding of transferring real-world knowledge to the digital realm, especially in handwritten character recognition. Deep learning emerges as a transformative force in this landscape, revitalizing neural network algorithms and ushering in significant advancements in artificial intelligence. In this context, our focus on MODI script recognition becomes a technological challenge and a cultural imperative, preserving the essence of an ancient script within the rapidly evolving realms of technology and automation.

This introduction sets the stage for exploring the complex world of MODI handwritten character recognition. The challenges presented by the ancient script are acknowledged, emphasizing the need for robust systems that can navigate

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the intricacies of linguistic and cultural heritage. Subsequent sections will unravel the methods and tools employed in our quest for reliable MODI script character recognition, offering insights into the technological innovations that promise to bridge the gap between historical scripts and cutting-edge recognition systems. This project embarks on the intricate journey of MODI handwritten character recognition, acknowledging the script's historical and linguistic significance. As we delve into the depths of this endeavor, we aspire to bridge the gap between ancient scripts and the cutting-edge advancements of the modern technological landscape. In doing so, we aim to contribute to the academic discourse and the preservation and understanding of cultural heritage embedded in the strokes and curves of the MODI script.

II. REVIEW OF VARIOUS RECOGNITION TECHNIQUES

2.1 Reviews of Modi Characters

Currently, the usage of the MODI script is dwindling, and only a limited number of individuals can comprehend it. Preserved among ancient historical MODI handwritten documents are invaluable information that holds cultural, historical, and administrative significance in the present day. This crucial information, relevant to the contemporary era, is preserved within thousands of handwritten MODI documents in both official and public sectors. The MODI-HHDoc Dataset comprises three thousand three hundred and fifty distinct examples of historical handwritten MODI document images. This dataset is a foundation for developing a system for digitizing, recognizing, transcribing, and transliterating information contained in the MODI script. The collection of this dataset is designed to ensure the system's adaptability to various approaches [1].

The number of individuals using the MODI script currently stands in the hundreds, with even fewer possessing the ability to comprehend it. Cultural, historical, and administrative information that remains relevant today is embedded in ancient historical MODI handwritten records. In both public and official sectors, thousands of old handwritten MODI documents contain essential information pertinent to the present day. The MODI-HHDoc Dataset consists of three thousand three hundred and fifty images of handwritten ancient MODI documents. This dataset can be employed to construct a system for digitizing, recognizing, transcribing, and translating old MODI documents, facilitating access to information written in the MODI script. The dataset was curated to ensure the system's versatility in accommodating diverse approaches [2].

The researchers conducted a comprehensive survey to examine and evaluate the current state of Modi script character identification. The primary focus of this survey is on character recognition within the Modi script, intending to encompass all pertinent methodologies, techniques, and advancements in the field. The authors are expected to explore various methodologies, including machine learning, deep learning, and image processing techniques. This study aims to survey prevailing practices in Modi script character recognition, shedding light on relevant trends, challenges, and potential directions for future research. Presented on the IEEE publication platform, this survey is positioned as a credible and indispensable resource for researchers, practitioners, and enthusiasts engaged in the dynamic field of Modi script character identification [3].

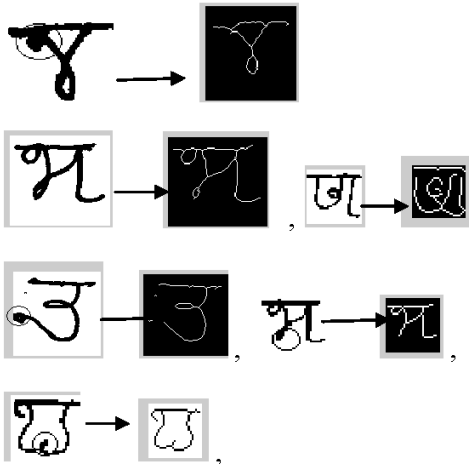

Fig.3 Handwritten Modi Script

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The published article delves into an effective technique for character recognition in the Modi script, receiving focused attention from the researchers. The research's primary objective is to enhance the efficiency and accuracy of Modi script character recognition by developing and applying novel methods, which may involve computational approaches like machine learning and image processing. In pursuit of improved recognition results, the article comprehensively summarizes the suggested strategy, detailing its main components and methodology. Published in the IJCA, this work establishes legitimacy and significantly contributes to Modi script character recognition, providing valuable insights for scholars and practitioners [4].

The researchers conducted a thorough review, analyzing existing Modi script character recognition approaches. This review comprehensively examines machine learning, image processing, and other computational methodologies researchers employ until publication. The authors aim to provide a comprehensive review for researchers, practitioners, and enthusiasts, covering the current state of Modi script character recognition, its historical context, development status, and future directions. The legitimacy of this review is bolstered by its publication in the IJCA, making it a valuable resource for those involved in Modi script character identification techniques [5].

This work focuses on character segmentation in vintage handwritten Modi Script documents. The Vertical Projection Profile (VPP) approach, while effective in dividing neighbouring characters on a single line, requires updating due to the script's unique characteristics. The authors propose an innovative method for character separation using dual thresholding criteria to reduce segmentation errors. This method, stemming from extensive background investigation, is simple, fast, and cost-effective, making it suitable for researchers [6].

The literature review aims to examine MODI handwritten character recognition, acknowledging the increasing challenges posed by the uniqueness of each writer's handwriting. Utilizing character recognition software, computers can transform handwritten text into a readable format, preserving valuable archives of historical efforts to decipher Indian languages. The MODI script, in particular, deserves significant respect, leading to the development of language-specific identification algorithms. The diversity and complexity of Indian scripts continue to intrigue researchers in Handwritten Optical Character Recognition (HOCR) datasets [7].

Recent decades have seen a significant challenge in Handwritten Optical Character Recognition (HOCR): coping with the wide variety of writing styles in HOCR datasets. India's diverse scripts and languages reflect its unity in diversity, prompting efforts to develop adaptable HOCR systems. The intricate structure of Indian characters has fueled research into character recognition systems, focusing on experiments using MODI for handwritten character recognition [8].

The primary goal of this research is to develop a method for recognizing handwritten characters, highlighting the importance of handwritten text in various languages and scripts. While specific methods or processes are not mentioned in the provided data, the title suggests carefully considering strategies for recognizing handwritten characters. The research improves optical character recognition systems, addressing the prevalence and significance of handwritten text [9].

The researchers apply and validate multiple algorithms for recognizing handwritten Modi characters, including Naive Bayes, Euclidean distance, and Minimum distance with improvement. Introducing methods for extracting gradient, structural, and concavity features emphasizes automation in feature vector binarization. The proposed system achieves a significant recognition rate of 83.19% using the GSC feature extraction technique and the Minimum distance classifier with the minimization function, validated on a dataset of 95,000 Modi handwritten characters from 55 classes. Despite challenges in creating training data, particularly for antiquated Modi document recognition, the study demonstrates the system's invariant property and leverages old handwritten Modi manuscripts for annotated Modi character data [10]

2.2 Deep Learning

From the 17th to the middle of the twentieth century, the Maratha administration employed the "MODI lipi" script as its official script. This script also documented religious works in Maharashtra, Western India. Culturally significant as a "MODI manuscript," it delineates the era in which it was written. Regrettably, awareness of this "lipi" remains limited despite its potential to educate and inspire contemporary youth. Discussions have arisen regarding creating a MODI recognition system within the domain of handwritten character recognition to facilitate learning. Various pattern recognition applications, including character recognition, leverage algorithms rooted in deep learning. Nowadays,

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recognition tasks are bolstered through the utilization of transfer learning algorithms. The suggested method involves the application of CNN and Vgg16 algorithms to classify MODI characters [11].

Some languages pose more significant challenges for OCR than others; MODI is just one example. Its predominantly cursive nature and the presence of only a few visually similar characters render the MODI script particularly challenging. Existing literature indicates that the Modi script has yet to undergo testing using deep learning techniques such as InceptionV3 and RestNet. Utilizing Residual with the InceptionV3 framework for offline deep learning handwritten character recognition has been encouraged. The handwritten Modi Barakhadi dataset comprises samples from approximately 25 individuals, examining the 7721-item dataset. The Otsu binarization approach prepares the characters for further processing by segregating them. Employing a real-world, multi-author database of handwritten characters assesses how effectively each method processes pre-processed data. Application of RestNet50 to processed photos yields a recognition accuracy of 94.552% and a model precision of 0.86. InceptionV3's processed-image recognition achieves a testing accuracy of 93.923% with a model precision of 0.843% [12].

In this study, the proposed experiment effectively employed Alexnet, a deep learning model, for recognizing characters in an ancient Indian handwriting script. Only the individual characters from the obsolete MODI script were utilized to evaluate the deep learning method's performance in the current experimental setup. An experimental setup success rate of 89.72% was achieved using the Alexnet model in MATLAB. All fifty-eight characters of the handwritten MODI script were used for this experiment, factoring in one hundred different graphic iterations for every character in the final product. This presentation elucidates the current state of the planned research strategy and concludes that the experiments were fruitful. Consequently, the simple yet successful implementation using MATLAB programming demonstrates the application of the deep learning model in the preliminary stage of the experimental research activity [13].

The objective of developing a realistic Character Identification System was to maintain high recognition accuracy without compromising input document quality. The Modi Script Character Recognizer System, implemented using powerful Convolutional Neural Network (CNN) techniques (MSCR), has meticulously examined each of the 48 letters comprising the MODI script—vowels, consonants, and ten numerals. The acquisition of numerous handwritten samples from different locations has contributed significantly to the system's training. This literature study delves into the intricacies of MSR's development and performance, shedding light on the captivating journey to implement this character recognition system for the ancient MODI script [14].

The CNN algorithm's training progress indicates an accuracy of 73.93% and a loss of 0.9254, while validation metrics show an accuracy of 76.46% and a loss of 0.8129. The CNN training duration is reported as 9866 seconds.

Deep learning offers a solution to recognizing handwritten characters in scanned images, particularly in digitizing Gujarati resources. The findings underscore the significance of developing technology for digitally scanning handwritten text using deep learning techniques [15].

The creators of the application aimed to facilitate easy transcription of handwritten notes. The integrated Text-to-Speech feature enhances accessibility for individuals with difficulties reading digital text. With its handwriting recognition model, this application demonstrates positive outcomes [16].

In the 17th century, the Maratha kingdom utilized MODI, akin to the Devanagari script, to promote Marathi as a cultural and powerful symbol. Despite challenges like a dwindling user base and unreliable script databases, this study explores MODI script identification and translation possibilities. Utilizing CNN architecture, the authors achieve recognition accuracies of 92% for letters and 93.33% for numbers, comparing Random Forest with XGBoost [17].

The paper introduces an advanced paradigm integrating deep learning techniques to decipher characters in the historical Modi script. Emphasizing sophisticated methodologies, the methodology section intricately details deep learning applications, covering data pre-processing, model architecture, and training processes. Anticipated results and discussions will showcase the enhanced model's performance metrics, with potential comparisons to traditional methods. The conclusion is expected to underscore the effectiveness of the deep learning-based approach, providing insights into practical implications and future research directions at the intersection of historical scripts and cutting-edge technology [18].

The introductory section of this study explains the Modi script's significance and the increasing importance of automatic recognition methods. Overcoming these challenges involves discussing the shortcomings of current methods

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and proposing machine-learning solutions. The methodology section is expected to describe character recognition methods, including details on data gathering, pre-processing, and specific ML methods employed. To enhance model accuracy, the training procedure and any adjustments made will be investigated. Results and discussions will demonstrate the proposed strategy's effectiveness, including metrics like recall, precision, and accuracy, compared to other studies or industry standards. The conclusion will summarize the results, highlight the study's significance, and suggest directions for further research. Apart from recommending similar methods for other scripts or languages, practical consequences will be explored. Readers are encouraged to delve into the complete article to understand better the investigation's details, methods, and results [19].

Researchers in computer science have been intrigued by machine reading simulations since the advent of digital computers. "Character recognition" involves extracting machine-readable text from document photographs by identifying printed or handwritten text. While Latin, English, and Chinese scripts have been effectively used for recognition, Indian languages pose unique challenges. This study investigates state-of-the-art feature extraction and classification methods for MODI script recognition, comparing and contrasting them [20].

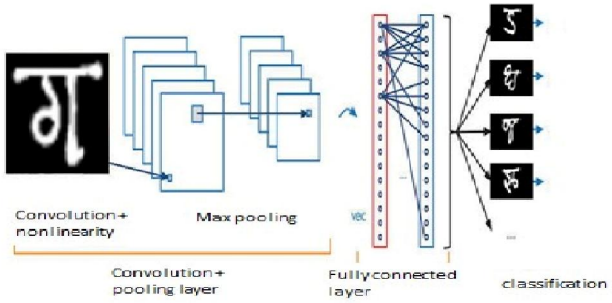

Fig.5. DNN Technique of Character Recognition

2.3 Transfer Learning

An introductory section contextualizes the script and underscores the escalating demand for optical character recognition (OCR) techniques to safeguard ancient documents. Sharma and Bhatia present a comprehensive Modi script OCR approach utilizing neural networks, covering data pretreatment and intricacies of the selected architecture; this constitutes the core of the research. The results and discussions furnish a comprehensive evaluation, comparing the method with current OCR solutions and incorporating parameters such as processing speed and accuracy. The conclusion emphasizes the significance of neural networks in Modi script optical character recognition (OCR), hinting at potential real-world applications and avenues for further study. The article unveils how modern machine-learning methods and historical scripts facilitate digitizing and preserving cultural items [23].

Deep learning-based algorithms have proven invaluable in various pattern recognition tasks, character identification included. The Convolutional Neural Network (CNN) emerges as a top-performing model successfully applied to character recognition. Whether for direct character recognition or feature extraction, CNN finds several applications in character identification. This paper employs a CNN autoencoder for character recognition in the MODI script, followed by classification using a Support Vector Machine (SVM). The on-the-fly data augmentation method enhances dataset generalizability and diversity. Until 1950, the ancient Indian script MODI was the exclusive script for writing Marathi. Libraries and temples worldwide house numerous MODI documents. Further research on character identification methods for the script is imperative to extract information from MODI manuscripts stored in different libraries. According to the proposed approach, state-of-the-art results in MODI character recognition are achieved using a CNN autoencoder as both a feature extractor and an SVM-based classifier [24].

This study adopts state-of-the-art methods to address the challenge of handwriting recognition in the obsolete MODI script, merging a Convolutional Neural Network (CNN) for feature extraction with a Support Vector Machine (SVM) for classification. By combining cutting-edge deep learning techniques with more traditional methods of script analysis, this work contributes to the advancement of Handwritten Character Recognition for the peculiar and challenging MODI script. Focusing on enhancing recognition accuracy in an old screenplay, the research employs CNN-based feature

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extraction, showcasing the meticulous application of state-of-the-art machine learning techniques for script analysis [25].

This project concentrates on handwritten text recognition utilizing a convolutional neural network (CNN) and a graphic user interface (GUI). The research suggests an easy-to-understand approach to automatic character recognition by combining CNN, which is successful in image-related tasks, with a user-friendly interface. Presenting a fully-fledged system prioritizing usability through a graphical user interface and employing state-of-the-art neural network algorithms for accurate recognition, this research substantially contributes to the field. Released in April 2021, it offers a state-of-the-art solution to issues impacting the field of handwriting character recognition over the past few years [26].

The computer's ability to understand handwritten text is becoming increasingly crucial, and handwritten character recognition technology has the potential to automate many tedious tasks. According to the research, convolutional neural networks (CNNs) outperform other methods in speed and accuracy. However, the structure necessary to provide state-of-the-art outcomes remains critical despite CNN's advancements in accuracy. The paper suggests improving accuracy by applying image-cleaning techniques to inputs and adding a spellchecker to the results. It also encourages exploring additional domains that could benefit from the suggested approach for automation [27].

This paper introduces something new in the fight against credit card theft. The introduction outlines the relevance of their study of current approaches, addressing the growing difficulties in this field. The methods section covers data pre-processing, model architecture, and training insights; the authors present a hybrid model integrating Convolutional Neural Networks (CNNs) and Support Vector Machines (SVMs). The results and comments showcase the model's performance indicators, potentially including a comparison to more conventional fraud detection methods. The conclusion summarizes the efficacy of their hybrid CNN-SVM model, providing suggestions for future research and possible applications in credit card security. To better grasp the innovative synergies used for improved fraud detection, it is recommended to read the complete paper [28].

At the outset, the article discusses the field's challenges and emphasizes the need for more sophisticated models, drawing attention to the unique value these models provide by combining CNNs and SVMs. It should explain everything in detail, from data pretreatment to the hybrid classifier's design and the training procedure. The discussion and results sections will likely present the hybrid model's performance metrics, contrasting it with more conventional approaches. The conclusion summarizes the model's efficacy, offers suggestions for future research on handwritten digit recognition, and suggests practical applications [29].

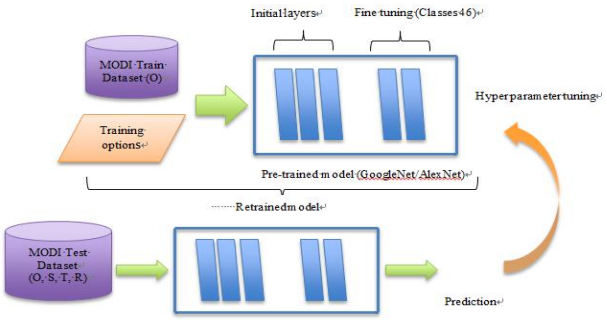

Fig.6 MODI Character Recognition Using GoogLeNet and AlexNet

The paper will likely commence with an introduction describing the unique challenges of the Modi script and emphasizing the use of Convolutional Neural Networks (CNNs) as a contemporary method for character recognition. The methodology section, delving into data preparation, CNN architecture, and training complexities, provides insights into CNN applications. The results and discussions section will highlight performance metrics, potentially comparing the CNN method with others. The conclusion will briefly underscore the effectiveness of their CNN-based model for Modi script character recognition, and the end section will hint at potential future research directions and practical implications for preserving historical scripts through advanced technologies. A more profound comprehension of integrating conventional scripts with modern neural network methods can be gained by delving into the complete paper [31].

The project's introduction will likely delve into the Modi script's unique characteristics and the inherent complexities in its digital processing. The methodology section will provide a comprehensive overview of the thresholding techniques

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employed, detailing their application in image processing and segmentation, with insights into experimental choices. Results and discussions will illuminate the effectiveness of these techniques through performance metrics and comparative analyses, offering a nuanced perspective on their applicability to the distinctive features of the Modi script. The conclusion will likely encapsulate key findings, emphasizing the significance of specific thresholding techniques and potentially hinting at future research directions in historical script digitization. Delving into the full paper promises a deeper comprehension of the meticulous evaluation of thresholding techniques for Modi script processing [32]

III. CONCLUSION

This review of literature surveys on Modi script character recognition sheds light on this field's dynamic and diverse research landscape. The challenges arising from the historical and cursive nature of the Modi script have catalyzed the development of innovative methodologies encompassing deep learning, transfer learning, and thresholding techniques. The synthesis of insights from various surveys enables us to discern emerging trends, identify areas of consensus, and highlight persistent challenges. This comprehensive understanding lays the foundation for future research endeavours, underscoring the importance of collaborative efforts to advance the accuracy and efficiency of Modi script character recognition. As technology evolves, the intersection of historical scripts and cutting-edge methodologies holds immense potential to enhance our comprehension of cultural heritage and facilitate its seamless integration into the digital realm.

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