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Bridging Heritage and Technology: A Review of Modi Script Character Recognition

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Abstract: *This paper provides a systematic review of advancements and challenges in Modi script character recognition, an ancient cursive script historically used in Maharashtra, India. The Modi script's unique features—its connected characters, cursive structure, and limited modern familiarity—pose significant challenges for Optical Character Recognition (OCR) and machine learning-based recognition methods. As there is a limited number of annotated datasets and variability in character styles, traditional image processing techniques, such as thresholding and edge detection, have seen limited success in this domain. However, recent advances in deep learning, especially Convolutional Neural Networks (CNNs) and hybrid models like CNN-SVM, have shown promising improvements in recognition accuracy and feature extraction, demonstrating their potential to handle the script's complexities. This review consolidates findings across various studies, focusing on the effectiveness and limitations of both conventional and modern methodologies. We highlight key trends, such as the shift toward transfer learning and hybrid models, which leverage multiple algorithmic strengths to overcome data scarcity and handwriting variability issues. Additionally, the review explores the potential of emerging techniques, including explainable AI, dataset augmentation, and cross-script recognition, to further enhance recognition outcomes. Our findings suggest that continued exploration of advanced methods, coupled with enhanced data resources, can play a pivotal role in the preservation and accessibility of Modi script texts. This paper contributes to the discourse on cultural heritage preservation through technology, offering valuable insights and future directions for researchers and technologists working on Modi character recognition and similar historical scripts.*

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

I. INTRODUCTION

The Modi script, originating from the Indo-Aryan language family, is one of the earliest and most archaic scripts in India's linguistic history. Languages utilizing the Modi script were prevalent throughout Southern Asia, with Western and Southern India regarded as particularly noteworthy regions. Until the mid-nineteenth century, the Modi script served as the standard for writing in the Modi language. This script was extensively utilized in the states of the Maratha Empire, encompassing Maharashtra, Gujarat, Karnataka, and several areas in central India. Numerous classical literary works explore the historical context of the Modi script.

Hemandpant, or Hemadri, was a diplomat, administrator, architect, poet, theologian, and scholar who created the Modi script in the 12th century. It was predominantly utilised in Western and certain Southern regions of India. For millennia, various old scripts have existed, and until the 20th century, Marathi was primarily inscribed in the Modi script. At that time, the state of Maharashtra utilised it for administrative functions. The British subsequently introduced the Balbodh variety of Devanagari.

The Modi script consists of 46 distinct characters, including 36 consonants and 10 vowels. It includes characteristics that enable more fluid writing, minimising the necessity to raise the pen from the page and immerse it in ink when moving between characters. Some characters display a "broken" form, while others assume a more "circular" shape.

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Thus, the Modi script is distinguished by a "cursive" style of Marathi writing. Figure 1 depicts the fundamental character set of the Modi script.

Figure: Modi Character

In India's diverse environment, where around 780 languages are spoken, the historical and linguistic fabric is enhanced by the MODI script. Emerging in the 12th century and enduring for over six centuries, MODI significantly influenced written communication, particularly during the rule of 'Chatrapati Shivaji Maharaj' in Pune. The growth of the script and its historical significance offer a distinct perspective to examine the convergence of linguistic diversity and cultural legacy. In this context, scholarly focus centers on handwritten character recognition, intersecting with the leading fields of Pattern Recognition, Image Processing, Natural Language Processing, and Document Analysis.

The integration of technology and automation in the modern landscape is indisputable, marked by rapid mechanization and an unyielding tempo. The progression towards digitalization, a defining characteristic of the computer era, alters the methods of information processing, storage, and retrieval. Nonetheless, the difficulty remains in converting the subtleties of real-world data, such as the cursive MODI script, into the digital realm. MODI, an archaic language developed in the 12th century by Hemadpant, is predominantly utilized for writing. The script's cursive form introduces a degree of complication, complicating the recognition of characters written by different authors. Contemporary research has experienced a significant shift towards handwritten character identification, highlighting its crucial importance in fields such as image processing, natural language processing, and pattern recognition.

The MODI script is a significant repository of essential knowledge, encompassing several fields and periods within India's historical and cultural history. This ancient script, steeped in history, has safeguarded several documents from periods like "Shivakalin" and "Peshvekalin," serving as a conduit to our linguistic and cultural heritage. The complex characters of MODI present a distinct challenge in interpreting and safeguarding this rich heritage. This study initiates a transformative exploration in handwritten character recognition, specifically concentrating on MODI script identification.

Modi	Gujarati	Devanagari	
ઇ	ઈ	ई	e
ગ	ગ	ग	ga
ઘ	ઘ	घ	gha
ડ	ડ	ड	da
છ	છ	छ	cha
જ	જ	ज	ja
ઞ	ઞ	ञ	nya
ઢ	ઢ	ढ	dha
ત	ત	त	ta
શ	શ	श	sha
ષ	ષ	ष	ssa
ક્ષ	ક્ષ	क्ष	shya

Figure: Different Styles of Modi Script

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Acknowledging the essential function of documentation in human society, our initiative is driven by the need to reconcile the language disparity between Devanagari and MODI. Through the thorough curation of 57 distinct classes of MODI script characters, we examine traditional feature extraction strategies, including moment invariants, affine moment invariants, chain code histograms, and intersection junctions. Nonetheless, the transformative transition to Deep Neural Networks (DNNs), especially Convolutional Neural Networks (CNNs), is paramount in our quest for an outstanding recognition rate. In examining the intricacies of handwritten document analysis, we recognise the swift industrialisation and the necessity for seamless integration of automation with technology. The digital era necessitates a thorough comprehension of converting real-world knowledge into the digital domain, particularly in handwritten character recognition. Deep learning serves as a transformational influence in this domain, rejuvenating neural network techniques and facilitating substantial progress in artificial intelligence. In this context, our emphasis on MODI script identification presents both a technological challenge and a cultural necessity, safeguarding the integrity of an ancient script amidst the swiftly advancing domains of technology and automation.

This introduction establishes the foundation for examining the intricate domain of MODI handwritten character recognition. The difficulties posed by the ancient script are recognised, highlighting the necessity for strong institutions capable of addressing the complexities of linguistic and cultural legacy. The next sections will elucidate the methodologies and instruments utilised in our pursuit of dependable MODI script character recognition, providing insights into the technological advancements that aim to connect historical scripts with modern recognition systems. This project initiates the complex endeavor of MODI handwritten character recognition, recognizing the script's historical and linguistic importance. We aim to connect ancient texts with modern technology breakthroughs. Our objective is to enhance academic discourse and to save and comprehend the cultural history inherent in the strokes and curves of the MODI script.

II. REVIEW OF VARIOUS RECOGNITION TECHNIQUES

A. Reviews of Modi Characters Recognition

The utilisation of the MODI script is declining, with only a few personnel capable of understanding it. Ancient historical MODI handwritten documents include priceless information that possesses cultural, historical, and administrative relevance today. This vital knowledge, pertinent to the modern period, is included throughout thousands of handwritten MODI documents across both official and public sectors. The MODI-HHDoc Dataset consists of three thousand three hundred fifty unique instances of historical handwritten MODI document pictures. This dataset serves as a basis for creating a system to digitise, recognise, transcribe, and transliterate material in the MODI script. The compilation of this dataset aims to guarantee the system's flexibility to diverse methodologies [1].

The present number of individuals utilising the MODI script is in the hundreds, with an even smaller subset capable of understanding it. Ancient historical MODI handwritten documents include cultural, historical, and administrative information that remains pertinent today. Numerous antiquated handwritten MODI documents in both public and official sectors hold critical information relevant to contemporary times. The MODI-HHDoc Dataset comprises three thousand three hundred fifty photos of handwritten historical MODI papers. This dataset can be utilised to develop a system for digitising, recognising, transcribing, and interpreting antiquated MODI documents, hence enhancing access to information inscribed in the MODI script. The dataset was meticulously chosen to guarantee the system's adaptability to various methodologies [2].

The researchers performed an extensive survey to assess the present condition of Modi script character recognition. This survey primarily concentrates on character identification in the Modi script, aiming to include all relevant strategies, techniques, and breakthroughs in the domain. The writers are anticipated to investigate diverse strategies, encompassing machine learning, deep learning, and image processing techniques. This paper intends to examine current methodologies in Modi script character recognition, highlighting pertinent developments, problems, and prospective avenues for future research. This survey, published on the IEEE platform, serves as a reliable and essential resource for researchers, practitioners, and enthusiasts involved in the evolving domain of Modi script character recognition [3].

The published study explores an efficient method for character recognition in the Modi script, garnering significant interest from researchers. The fundamental purpose of the project is to improve the efficiency and accuracy of Modi script character recognition by the development and application of innovative methodologies, potentially using

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computer techniques like as machine learning and image processing. To enhance recognition outcomes, the essay thoroughly delineates the proposed technique, outlining its primary elements and methods. This work, published in the IJCA, validates and substantially enhances Modi script character recognition, offering important insights for scholars and practitioners [4].

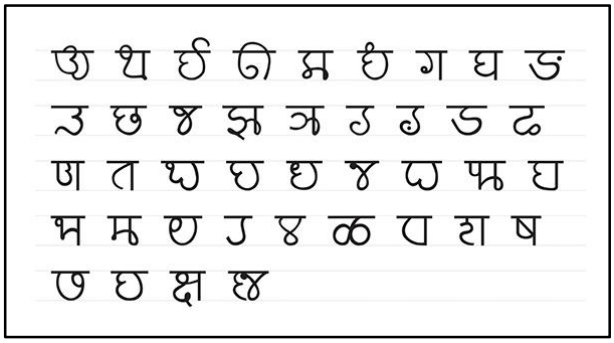

Figure: Handwritten Modi Script

The researchers performed a comprehensive evaluation of current methodologies for recognising Modi script characters. This review thoroughly analyses machine learning, image processing, and other computational techniques utilised by researchers prior to publication. The authors intend to deliver an exhaustive review for researchers, practitioners, and enthusiasts, encompassing the present status of Modi script character recognition, its historical background, developmental progress, and prospective directions. The credibility of this review is enhanced by its publishing in the IJCA, rendering it a significant resource for anyone engaged in Modi script character identification methodologies [5].

This study concentrates on character segmentation in historical handwritten Modi Script manuscripts. The Vertical Projection Profile (VPP) method, although efficient in segmenting adjacent characters on a single line, necessitates modification to accommodate the script's distinctive features. The authors present a novel approach for character separation employing dual thresholding criteria to minimise segmentation mistakes. This approach, derived from comprehensive background study, is straightforward, rapid, and economical, rendering it appropriate for researchers [6].

The literature review seeks to analyse MODI handwritten character identification, recognising the escalating difficulties presented by the distinctiveness of individual handwriting styles. By employing character recognition software, computers may convert handwritten writing into a legible format, thereby safeguarding significant records of earlier attempts to interpret Indian languages. The MODI script warrants considerable respect, resulting in the creation of language-specific identification algorithms. The variety and intricacy of Indian scripts persist in captivating scholars in Handwritten Optical Character Recognition (HOCR) datasets [7].

In recent decades, Handwritten Optical Character Recognition (HOCR) has faced a substantial challenge: addressing the diverse array of writing styles included in HOCR datasets. The many scripts and languages of India exemplify its unity in variety, necessitating the development of versatile HOCR systems. The complex composition of Indian characters has stimulated research into character recognition systems, emphasising efforts utilising MODI for handwritten character recognition [8].

The principal objective of this research is to establish a methodology for the recognition of handwritten characters, underscoring the significance of handwritten writing across diverse languages and scripts. The title implies the necessity of thoughtfully evaluating solutions for the recognition of handwritten characters, notwithstanding the absence of specified procedures or processes in the presented data. The study enhances optical character recognition systems, focussing on the prevalence and importance of handwritten text [9].

The researchers implement and validate various algorithms for the recognition of handwritten Modi characters, including Naive Bayes, Euclidean distance, and enhanced Minimum distance methods. The introduction of methods for extracting gradient, structural, and concavity features highlights the automation of feature vector binarization. The suggested system attains a notable identification rate of 83.19% by employing the GSC feature extraction technique and the Minimum Distance classifier with the minimisation function, verified on a dataset including 95,000 Modi

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handwritten characters over 55 classes. Despite difficulties in generating training data, especially for outdated Modi document recognition, the study illustrates the system's invariant property and utilises historical handwritten Modi manuscripts for annotated Modi character data. [10]

B. Deep Learning based MODI Script Character Recogntion

From the 17th century to the mid-20th century, the Maratha administration utilised the "MODI lipi" script as its official writing system. This script also recorded religious texts in Maharashtra, Western India. As a "MODI manuscript," it is culturally significant and defines the period in which it was composed. Unfortunately, understanding of this "lipi" is still restricted, despite its capacity to educate and motivate modern young. Discussions have emerged concerning the establishment of a MODI recognition system in the field of handwritten character recognition to enhance learning. Numerous pattern recognition applications, such as character recognition, utilise methods based on deep learning. Currently, recognition tasks are enhanced by the application of transfer learning techniques. The proposed approach utilises CNN and Vgg16 algorithms for the classification of MODI characters [11].

Certain languages provide greater difficulties for OCR than others; MODI serves as a prime example. The MODI script is particularly tough because to its largely cursive style and the limited number of visually related letters. Current literature suggests that the Modi script has not been evaluated using deep learning methodologies, including InceptionV3 and ResNet. The use of Residual within the InceptionV3 framework for offline deep learning in handwritten character recognition is advocated. The handwritten Modi Barakhadi dataset consists of samples from around 25 persons, analysing the 7721-item dataset. The Otsu binarization method facilitates character preparation for subsequent processing by isolating them. The utilisation of a real-world, multi-author database of handwritten characters evaluates the efficacy of each method in processing pre-processed data. The implementation of ResNet50 on processed images results in a recognition accuracy of 94.552% and a model precision of 0.86. InceptionV3's image recognition processing attains a testing accuracy of 93.923% and a model precision of 0.843% [12].

This study utilized Alexnet, a deep learning model, to effectively recognize characters in an old Indian handwriting system. The current experimental setting employed solely the individual characters from the outmoded MODI script to assess the performance of the deep learning method. A success rate of 89.72% was attained in an experimental setup utilizing the Alexnet model in MATLAB. This experiment utilized all fifty-eight characters of the handwritten MODI script, incorporating one hundred distinct graphic variations for each character in the final output. This presentation clarifies the existing status of the proposed research strategy and concludes that the experiments were successful. Thus, the straightforward yet effective execution of MATLAB programming illustrates the application of the deep learning model in the initial phase of the experimental research endeavor [13].

The aim of creating a realistic Character Identification System was to provide high recognition accuracy while preserving the quality of input documents. The Modi Script Character Recogniser System (MSCR), utilizing advanced Convolutional Neural Network (CNN) methodologies, has thoroughly analyzed all 48 characters of the MODI script, including vowels, consonants, and 10 numerals. The procurement of many handwritten samples from several regions has greatly enhanced the system's training. This literature review examines the complexities of MSR's development and efficacy, illuminating the intriguing process of implementing this character recognition system for the ancient MODI script [14].The training progress of the CNN algorithm reveals an accuracy of 73.93% and a loss of 0.9254, whilst the validation metrics demonstrate an accuracy of 76.46% and a loss of 0.8129. The duration of CNN instruction is documented as 9866 seconds.

Deep learning provides a method for recognizing handwritten letters in scanned photographs, especially for digitizing Gujarati materials. The results highlight the importance of creating technology for digitally scanning handwritten text through deep learning methodologies [15].

The developers of the application sought to simplify the transcribing of handwritten notes. The integrated Text-to-Speech functionality improves accessibility for those with reading impairments in digital formats. This program exhibits favorable results with its handwriting recognition model [16].

During the 17th century, the Maratha monarchy employed MODI, similar to the Devanagari script, to elevate Marathi as a cultural and potent emblem. This study investigates the identification and translation potential of MODI script, despite constraints such as a declining user base and inconsistent script databases. The authors attain recognition

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accuracies of 92% for letters and 93.33% for numbers using CNN architecture, contrasting Random Forest with XGBoost [17].

The research presents an innovative framework that uses deep learning techniques to interpret characters in the old Modi script. The methodology section meticulously outlines advanced techniques in deep learning, including data pre-processing, model design, and training procedures. The expected outcomes and discussions will highlight the performance indicators of the improved model, potentially contrasting it with conventional methods. The conclusion is anticipated to emphasize the efficacy of the deep learning-based methodology, offering insights into practical ramifications and prospective research avenues at the convergence of historical scripts and advanced technology [18].

The opening section of this paper elucidates the significance of the Modi script and the growing relevance of automatic recognition techniques. Addressing these difficulties necessitates an examination of the deficiencies in existing methodologies and the suggestion of machine-learning alternatives. The methodology section should delineate character recognition techniques, encompassing specifics on data collection, pre-processing, and the particular machine learning approaches utilized. The training technique and any modifications will be examined to improve model correctness. The results and discussions will illustrate the efficacy of the proposed technique, using criteria such as recall, precision, and accuracy, in comparison to previous research or industry benchmarks. The conclusion will encapsulate the findings, underscore the study's importance, and provide avenues for future research. In addition to suggesting analogous solutions for other scripts or languages, the practical implications will be examined. Readers are urged to explore the full article to have a comprehensive understanding of the investigation's specifics, methodologies, and findings [19].

Computer science researchers have been fascinated with machine reading simulations since the emergence of digital computers. "Character recognition" entails the extraction of machine-readable text from photographic documents through the identification of printed or handwritten characters. Although Latin, English, and Chinese scripts have been successfully utilized for recognition, Indian languages present distinct obstacles. This paper examines advanced feature extraction and classification techniques for MODI script recognition, analyzing their similarities and differences [20].

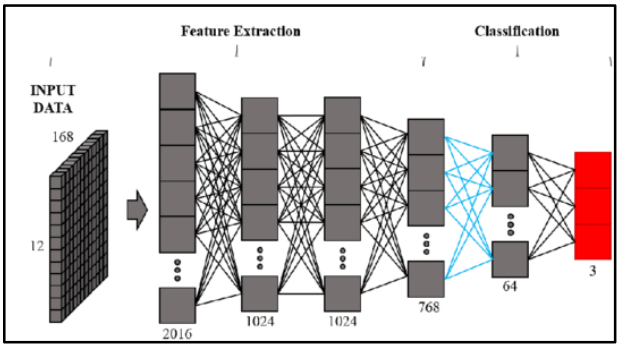

Figure: DNN Technique of Character Recognition

D. Transfer Learning

An introductory section contextualizes the script and The aim of creating a realistic Character Identification System was to provide high recognition accuracy while preserving the quality of input documents. The Modi Script Character Recogniser System (MSCR), utilizing advanced Convolutional Neural Network (CNN) methodologies, has thoroughly analyzed all 48 characters of the MODI script, including vowels, consonants, and 10 numerals. The procurement of many handwritten samples from several regions has greatly enhanced the system's training. This literature review examines the complexities of MSR's development and efficacy, illuminating the intriguing process of implementing this character recognition system for the ancient MODI script [21].

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The research presents an innovative framework that uses deep learning techniques to interpret characters in the old Modi script. The methodology section meticulously outlines advanced techniques in deep learning, including data pre-processing, model design, and training procedures. The expected outcomes and discussions will highlight the performance indicators of the improved model, potentially contrasting it with conventional methods. The conclusion is anticipated to emphasize the efficacy of the deep learning-based methodology, offering insights into practical ramifications and prospective research avenues at the convergence of historical scripts and advanced technology [26].

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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 [29].

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 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

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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 [30]

Summary of Systematic Review

This paper aims to consolidate and analyze the diverse methodologies applied in the recognition of this historical script. Modi script, an ancient cursive writing system predominantly used in Maharashtra, India, from the 17th to the mid-20th century, poses unique challenges for character recognition due to its distinct cursive structure and historical use. Unlike more contemporary scripts, Modi was developed for administrative documentation, resulting in stylized, connected characters that are challenging for OCR (Optical Character Recognition) technologies to decipher accurately. The summary of the Literature survey of MODI Script character recognition is presented in Table I.

Table: Systematic Review

Sr. No.	Author(s)	Title of the Project	Methodology	Key Findings	Published Year	Technical Aspect
1	Manisha Deshmukh, Satish Kolhe [1]	MODI-HHDoc: Historical MODI Script Handwritten Document Dataset	Dataset creation for MODI OCR using 3,350 images	Provides a basis for MODI script digitization and recognition efforts	2023	Dataset creation and preparation for MODI OCR
2	Aparna Shirkande, Alok Agarwal [2]	A Review of Various MODI Text Recognition Techniques	Literature review on MODI recognition techniques	Summarizes machine learning and deep learning approaches for MODI script recognition	2023	Review of recognition techniques
3	Sneha Deshmukh, Dr. Prashant Deshmukh [3]	A Comprehensive Survey on Modi Script Character Recognition	Survey on character recognition methods in MODI OCR	Highlights advancements and challenges in MODI character recognition	2023	Overview of character recognition methodologies
4	Abhay Verma, Dr. R. K. Gupta [4]	An Efficient Approach for Modi Script Character Recognition	Image processing and machine learning techniques	Introduces an efficient method for MODI character recognition	2022	Efficient recognition approach for MODI characters
5	Varsha R. Kurhade, Dr. R. S. Bichkar [5]	A Review on Modi Script Character Recognition Techniques	Comprehensive review of machine learning and OCR methods	Discusses various techniques, including deep learning, in MODI OCR	2020	Review of computational techniques for MODI OCR
6	Parag Tamhankar, Krishna Masalkar, Satish Kolhe [6]	Character Segmentation in Offline Handwritten Modi Documents	Vertical Projection Profile (VPP) with dual thresholding	Improves segmentation accuracy for MODI handwritten text	2020	Character segmentation techniques
7	Prathmesh Sainath Chidrawar, Vidya	Systematic Review on MODI Script Character Recognition	Literature review on MODI script OCR challenges	Emphasizes challenges due to varied handwriting styles in MODI	2023	Handwriting challenges in MODI OCR

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	Dhamdhere [7]			OCR		
8	Sahil Das, Krishna Wankhede, Anand Rituraj [8]	REVIEW ON MODI HANDWRITTEN CHARACTERS RECOGNITION	Review of MODI script OCR methods	Highlights machine learning-based solutions for MODI character recognition	2022	OCR challenges for MODI script
9	Prajjwal Bajpai, Mohd. Shahdil Shuaib [9]	HANDWRITTEN CHARACTER RECOGNITION SYSTEM	General character recognition techniques	Focuses on methods for recognizing handwritten text across languages	2020	Handwritten character recognition techniques
10	Manisha S. Deshmukh, Satish R. Kolhe [10]	Character Recognition of Ancient MODI Script Documents	Minimum Distance classifier with gradient and structural feature extraction	Achieves 83.19% accuracy in MODI character recognition	2023	Feature extraction and classification
11	Samrudhi Bhalerao, H. D. Gadade [11]	Modi Handwritten Characters Recognition Using Deep Learning	Deep learning using CNN	Utilizes CNN for MODI OCR, promoting cultural preservation	2023	CNN application in MODI script recognition
12	Chaitali Chandankhede, Rajneeshkaur Sachdeo [12]	Offline MODI Script Character Recognition Using Deep Learning	ResNet and InceptionV3 models for character recognition	High accuracy with ResNet (94.55%) and InceptionV3 (93.92%) for MODI script recognition	2023	Deep learning models for MODI OCR
13	Dr. Kirti Mahajan, Niket Tajne [13]	Ancient Indian Handwritten Script Character Recognition Using Deep Learning	AlexNet model for character recognition in MODI OCR	Achieves 89.72% success in recognizing MODI script characters	2021	AlexNet model for MODI character recognition
14	Jidnyasa Kondhare, et al. [14]	Recognition of Handwritten Modi Digits and Characters Using Deep Learning	CNN-based Modi Script Character Recogniser (MSCR)	Improves recognition accuracy by analyzing 48 MODI characters	2022	CNN-based recognition system for MODI
15	Bhargav Rajyagor, Rajnish Rakhlia [15]	Handwritten Character Recognition Using Deep Learning	CNN for digitizing handwritten text	Highlights CNN's efficiency in OCR for languages like Gujarati and MODI	2020	CNN for handwritten character recognition
16	Athira M. Nair, et al. [16]	Handwritten Character Recognition using Deep Learning in Android Phones	Text-to-speech integrated with handwriting recognition	Enhances accessibility for visually impaired users through integrated TTS	2021	TTS integration with handwriting recognition

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17	Maitreyi Ekbote, et al. [17]	Hybrid Deep Learning Approach to Handwritten MODI Recognition	CNN with Random Forest and XGBoost	Achieves 92% letter and 93.33% number recognition accuracy for MODI script	2022	Hybrid CNN-RF-XGBoost model for MODI recognition
18	Dr. Alok Jain, Dr. Poonam Sinha [18]	Enhanced Modi Script Character Recognition Using Deep Learning	Advanced deep learning framework with CNN	Enhances recognition accuracy for historical MODI documents	2023	Advanced CNN framework for historical MODI OCR
19	Aparna S. Gadge, Prof. C. S. Jadhav [19]	Recognition of Modi Script Characters Using Machine Learning	Machine learning for historical document recognition	Addresses MODI script OCR challenges with machine learning solutions	2020	Machine learning in historical document OCR
20	Jossy P. George [20]	Feature Extraction and Classification Techniques of MODI Script Character Recognition	Feature extraction and classification analysis	Focuses on advanced techniques for MODI OCR and analyzes feature extraction methods	2019	Feature extraction techniques for MODI script recognition
21	S. Chandure, V. Inamdar [21]	Handwritten Modi Character Recognition Using Transfer Learning	Transfer learning with discriminant feature analysis	Improved recognition through transfer learning techniques	2021	Transfer learning for MODI character recognition
22	Dr. R. K. Singh, Dr. Sanjay Kumar Singh [22]	Handwritten Modi Script Recognition Using Transfer Learning	Transfer learning for MODI OCR	Increases recognition accuracy for handwritten MODI script	2021	Transfer learning applications in OCR
23	Priyanka Sharma, Dr. S. S. Bhatia [23]	Modi Script OCR Using Neural Networks	Neural networks for character recognition	Uses neural networks for MODI OCR, enhancing character identification accuracy	2021	Neural networks in MODI OCR
24	Solley Joseph, Jossy George [24]	MODI Character Recognition Using CNN and SVM	CNN-based feature extraction with SVM classification	Effective character recognition using the CNN-SVM hybrid model	2020	Hybrid CNN-SVM approach for character recognition
25	Vishal Pawar, et al. [25]	MODI Script Character Recognition Using CNN and SVM	CNN and SVM classifier for MODI OCR	Achieves notable recognition accuracy for handwritten MODI characters	2022	CNN and SVM classifier integration

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26	Sandhya Anpat, et al. [26]	Handwriting Character Recognition Using CNN with GUI	CNN with a graphical user interface	Enhanced user interaction for MODI OCR application	2021	GUI integration with CNN model
27	Ajinkya Wani, et al. [27]	Handwritten Character Recognition Using CNN, KNN, and SVM	Comparative study of CNN, KNN, and SVM models	Examines accuracy and efficiency of various models for MODI character recognition	2021	Model comparison in handwritten recognition
28	Tesfahun Berhane, et al. [28]	Hybrid CNN-SVM for Handwritten Character Recognition	Hybrid model combining CNN and SVM	High accuracy in handwritten character recognition with CNN-SVM hybrid	2023	Hybrid CNN-SVM model for recognition
29	Savita Ahlawata, Amit Choudhary [29]	Hybrid CNN-SVM Classifier for Handwritten Digit Recognition	Hybrid CNN-SVM model	Effective for handwritten digit recognition, applicable to MODI script	2020	Hybrid model for handwritten digit recognition
30	Prof. Meenakshi Mukhopadhyay, et al. [30]	Modi Script Character Recognition Using Convolutional Neural Networks	CNN model for character recognition	Highlights benefits of CNN for MODI character OCR, emphasizing deep learning approaches	2022	CNN for MODI character recognition

IV. DISCUSSION

The discussion section of this review on Modi character recognition highlights the key insights and implications derived from examining various recognition methodologies and their application to the Modi script. This research underscores the challenges and innovations in applying OCR (Optical Character Recognition) techniques to historical and cursive scripts like Modi, which has unique characters and a culturally significant background.

The main challenges identified include the cursive and connected nature of the Modi script, the limited availability of annotated datasets, and the complexity of segmenting characters accurately due to their structural characteristics. Traditional methods, such as image processing techniques like thresholding and edge detection, often fall short in addressing these challenges. Thus, a notable trend has been the shift towards deep learning models, such as CNN, ResNet, and transfer learning approaches, which demonstrate a higher recognition rate and robustness in feature extraction and character classification.However, despite the advancements, certain limitations persist. For instance, deep learning models require large datasets for effective training, which is challenging due to the scarcity of Modi script resources. Additionally, issues like data imbalance and variability in handwriting styles impact model performance. Hybrid models, which combine machine learning with deep learning, such as CNN-SVM and transfer learning frameworks, show promise in overcoming some of these obstacles by leveraging the strengths of multiple approaches.

Future research directions could focus on enhancing dataset quality, utilizing synthetic data generation to augment training samples, and exploring advanced segmentation techniques tailored to cursive and historical scripts. Integrating explainable AI techniques to provide insights into model decision-making processes may also improve recognition transparency and accuracy. This research thus contributes to the broader discourse on cultural preservation and digital accessibility, aligning with ongoing technological advances in character recognition for ancient scripts.

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V. CONCLUSION

The review of Modi's character recognition highlights the substantial progress achieved in this domain, spurred by the need to digitize and preserve scripts of cultural significance. The unique structural features of the Modi script, such as its cursive and connected characters, have introduced notable challenges that traditional OCR techniques struggle to overcome. Researchers have thus explored various methodologies, finding deep learning models, particularly CNNs and hybrid frameworks, to be highly effective in enhancing feature extraction and recognition accuracy. These findings emphasize the critical role of combining advanced technology with a deep understanding of historical scripts to achieve accurate digitization. This comprehensive review of advancements and challenges offers essential insights and lays the groundwork for future studies focused on Modi's character recognition.

One of the most pressing areas for future research is dataset expansion and annotation. The limited availability of annotated Modi datasets has been a significant constraint, often limiting the potential of advanced recognition models. Future research should focus on sourcing additional historical Modi documents and employing synthetic data generation techniques to augment training samples. This expanded dataset will provide a more robust foundation for training deep learning models, improving recognition outcomes.Further exploration of hybrid and transfer learning models holds great promise for Modi's character recognition. Hybrid approaches, such as CNN-SVM combinations, have demonstrated notable success by leveraging the complementary strengths of multiple algorithms. Transfer learning, particularly fine-tuned for Modi script, could improve recognition accuracy while reducing the extensive data requirements typically needed for training deep learning models. These approaches could also accelerate the development of accurate Modi recognition systems.

As deep learning adoption grows in this field, explainable AI (XAI) has an essential role in enhancing model transparency. XAI techniques will make it easier for linguists and historians to interpret the recognition decisions made by AI models, fostering greater trust in automated Modi character recognition systems. This transparency is especially crucial for historical scripts, where the precision and interpretability of each recognized character carry significant cultural importance.Developing cross-script recognition models presents an exciting future direction. A model trained to recognize multiple ancient scripts, including Modi, would be invaluable for scholars working with historical multilingual documents. Such a model could facilitate comparative linguistic studies and aid in the preservation and understanding of a broader range of cultural texts, enriching research across different languages and historical scripts.

To make Modi script documents more accessible, future systems should prioritize user-friendly platforms that allow researchers and the public to search, index, and interpret these documents. Such platforms could serve as educational tools and resources, contributing to the broader goal of cultural preservation and accessibility. Additionally, advancements in character segmentation techniques are critical. Cursive and overlapping characters in Modi's texts present specific challenges that traditional segmentation techniques struggle to address. Developing segmentation methods tailored to historical and cursive scripts can improve character separation, further enhancing recognition accuracy and enabling more reliable digitization.Through these advancements, future research can make significant strides in digital preservation efforts, bridging historical content with modern technology. This will not only safeguard the rich cultural heritage of the Modi script but also ensure its accessibility to future generations, supporting both academic research and public interest in historical documents.

REFERENCES

[1] Manisha Deshmukh,Satish Kolhe, "MODI-HHDoc: Historical MODI Script Handwritten Document Dataset", Mendeley Data, V1, 2023

[2] Aparna Shirkande, Alok Agarwal, "A Review on Various MODI Text Recognition Techniques", Journal of Image Processing and Artificial Intelligence, 2023

[3] Sneha Deshmukh, Dr. Prashant R. Deshmukh, "A Comprehensive Survey on Modi Script Character Recognition", IEEE, 2023

[4] Abhay Verma, Dr. R. K. Gupta, "An Efficient Approach for Modi Script Character Recognition", IJCA, 2022

[5] Varsha R. Kurhade, Dr. R. S. Bichkar, "A Review on Modi Script Character Recognition Techniques", IJCA, 2020

[6] Parag Tamhankar, Krishna Masalkar, and Satish kolhe. A novel approach for character segmentation of offline handwritten Marathi documents written in Modi script. Procedia Computer Science, 2020

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 3, November 2024

[7] Prathmesh Sainath Chidrawar & Vidya Dhamdhere ,A Systematic Review on MODI Script Character Recognition, Conference paper, (LNNS,volume 727) ,2023
[8] Sahil Das, Krishna Wankhede, Anand Rituraj, "REVIEW ON MODI HANDWRITTEN CHARACTERS RECOGNITION", International Research Journal of Modernization in Engineering Technology and Science, 2022
[9] Prajjwal Bajpai, Mohd. Shahdil Shuaib, "HANDWRITTEN CHARACTER RECOGNITION SYSTEM", International Research Journal of Engineering and Technology (IRJET), 2020
[10] Manisha S. Deshmukh, Satish R. Kolhe, "Character Recognition of the Unconstrained and Invariant Dataset of the Handwritten Ancient Modi Script Documents", SSRN-id4330133, 2023
[11] Samrudhi Bhalerao; H. D. Gadade, "Modi Handwritten Characters Recognition Using Deep Learning Algorithm", International Conference on Machine Learning, Computer Systems and Security (MLCSS), 2023
[12] Chaitali Chandankhede & Rajneeshkaur Sachdeo, "Offline MODI script character recognition using deep learning techniques", Multimedia Tools and Applications volume 82, 2023
[13] Dr. Kirti Mahajan, Niket Tajne, "An Ancient Indian Handwritten Script Character Recognition by Using Deep Learning Algorithm", 1st international conference on emerging Scientific Applications in the Field of Engineering and Technology, 2021
[14] Jidnyasa Kondhare, Prof.V.A.Yaduvanshi, Ruchira Patil Radhika Kaldate, "Recognition Of Handwritten Modi Digits And Characters By Using Deep Learning Algorithm", Journal of Emerging Technologies and Innovative Research (JETIR), 2022
[15] Bhargav Rajyagor, Rajnish Rakhlia, "Handwritten Character Recognition using Deep Learning", International Journal of Recent Technology and Engineering (IJRTE), 2020
[16] Athira M Nair, Chrissie Aldo, Blessil Bose, Alex Joseph, Praseetha V.M, Sr. Elizabeth M J, "Handwritten Character Recognition using Deep Learning in Android Phones", International Research Journal of Engineering and Technology (IRJET), 2021
[17] Maitreyi Ekbote, Aishwarya Jadhav, Dayanand Ambawade, "Implementing a Hybrid Deep Learning Approach to Achieve Classic Handwritten Alphanumeric MODI Recognition", International Journal of Engineering and Advanced Technology Volume-12 Issue-1, October 2022
[18] Dr. Alok Jain, Dr. Poonam Sinha, "Enhanced Modi Script Character Recognition using Deep Learning", IJCSMC, 2023
[19] Aparna S. Gadge, Prof. C. S. Jadhav, "Recognition of Modi Script Characters using Machine Learning", IJRASET, 2020
[20] Jossy P. George"Feature Extraction and Classification Techniques of MODI Script Character Recognition", Semanticscholar, Corpus ID: 260481222, 2019
[21] S. Chandure and V. Inamdar, "Handwritten Modi character recognition using transfer learning with discriminant feature analysis," IETE Journal of Research, 2021.
[22] Dr. R. K. Singh, Dr. Sanjay Kumar Singh, "Handwritten Modi Script Recognition using Transfer Learning", IJRASET, 2021
[23] Priyanka Sharma, Dr. S. S. Bhatia, "Modi Script OCR using Neural Networks", IJCST, 2021
[24] Solley Joseph and Jossy George. "Handwritten character recognition of MODI script using convolutional neural network based feature extraction method and support vector machine classifier."IEEE 5th International Conference on Signal and Image Processing (ICSIP), 2020
[25] Vishal Pawar, Deepak Wadkar, Shivkumar Kashid, Premraj Prakare, Vinayak More, Prof. S.A. Babar, "Handwritten Character Recognition of MODI Script using Convolutional Neural Network Based Feature Extraction Method and Support Vector Machine Classifier", International Research Journal of Engineering and Technology (IRJET), 2022
[26] Sandhya Anpat, Sayali Khetri, Shreejal Dhule, Dr. J.E. Nalavade, "Handwriting Character Recognition using CNN with GUI", International Research Journal of Engineering and Technology (IRJET) 2021
[27] Ajinkya Wani, Unmay Pawar, Yash Gatagat, Dr. Meenakshi Thalor, "Handwritten Character Recognition Using CNN, KNN and SVM", International Journal of Technology Engineering Arts Mathematics Science, 2021

IJARSCT
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International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 3, November 2024

[28] Tesfahun Berhane, Tamiru Melese, Assaye Walelign, and Abdu Mohammed, Hindawi," A Hybrid Convolutional Neural Network and Support Vector Machine-Based Credit Card Fraud Detection Model ", Mathematical Problems in Engineering Volume 2023
[29] Savita Ahlawata, Amit Choudhary, "Hybrid CNN-SVM Classifier for Handwritten Digit Recognition ", Procedia Computer Science, 2020
[30] Prof. Meenakshi Mukhopadhyay et al., "Modi Script Character Recognition Using Convolutional Neural Networks", IJIRSET, 2022