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Advancements in Modi Script Character Recognition: A Comprehensive Survey

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Abstract: *The ancient Modi script is more complex to decipher than other scripts. However, the "Review on Modi Script Character Recognition System" provides a thorough overview of methods for doing so. Optical Character Recognition (OCR), Convolutional Neural Networks (CNN), Artificial Neural Networks (ANN), Support Vector Machines (SVM), Chain Code, Zerike moment feature extraction, and deep learning are only a few of the methods explored in this paper's literature review section. The methods for recognizing characters written in the Modi script are evaluated for their efficacy and suitability in this context. This report provides a broad overview of recent developments to help researchers and practitioners create effective recognition systems for the Modi script.*

Keywords: Modi character, OCR, ML, Deep Learning, HCR

I. INTRODUCTION

In the seventeenth century, the cursive 'MODI' script was developed to record the Marathi language in Maharashtra, India. MODI is written from left to right in the 'Devanagari' style, unlike other ancient Indian languages. Its creation may have been attributed to either 'Hemandpant' or 'Hemadri' in the 12th century. This script is crucial for reading and comprehending priceless records from the "Shivakalin" and "Peshvekalin" eras, which it has helped preserve. Integrating image processing and pattern recognition in studying handwritten documents is vital for efficiency, given the centrality of documentation to human society. Automation and technological integration are becoming increasingly important in this age of rapid industrialization. Work is made more accessible by digitalization in the internet age, and the advent of deep learning, especially in the form of convolutional neural networks (CNNs), heralds a new era in neural network algorithms that will revolutionize machine learning and artificial intelligence.

India has diverse traditions, religions, and languages and is a bastion of cultural richness and historical heritage. The MODI script, woven into India's written history, has been a conduit for recording knowledge in various disciplines, from medicine and Buddhist philosophy to culinary traditions and astrology. Character recognition, though seemingly straightforward, poses significant challenges in developing software capable of accurately recognizing the ancient MODI script without degrading the quality of input documents. This literature review focuses on MODI handwritten character recognition, emphasizing the challenges posed by the script's unique difficulties with language and cultural heritage. As the subsequent sections delve into the methods and tools employed to overcome these challenges, the study explores achieving reliable MODI script character recognition.

The study aims to create a system mapping well-known MODI characters to their Devanagari equivalents, addressing the translational gap. With 57 distinct classes of MODI script characters, the proposed approach leverages Deep Neural Networks (DNNs), particularly Convolutional Neural Networks (CNNs), renowned for their effectiveness in character recognition. Unlike conventional methods, CNNs operate on raw pixel data, eliminating the need for explicit feature definition and promising superior performance in bridging the linguistic gap between Devanagari and the MODI script.

The MODI script, originating from the Indo-Aryan language family, is significant in Indian linguistic history as one of the oldest and most antiquated scripts. It was prevalent in languages spoken across southern Asia, particularly in western and southern India, until the mid-nineteenth century. Embraced widely by the Maratha Empire, encompassing states like Maharashtra, Gujarat, Karnataka, and central India, the MODI script, also known as "MODI lipi," stands as a cultural treasure in western India, notably Maharashtra, with historical significance beyond language and culture. Under

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Chhatrapati Shivaji Maharaj's rule, the script thrived, shedding light on diverse fields in documents from the Shivakalin and Peshvekalin periods. Its distinctive structural features and calligraphic flourishes set it apart from other Indian scripts. Recognizing MODI script characters, whether typed or handwritten, poses challenges due to their cursive nature, compounded by a scarcity of picture libraries for character recognition systems.

Figure 1: Modi Characters

Preserving the cultural and historical history of Western India is an additional benefit of maintaining MODI script documents. Accurate recognition and translation of MODI script are crucial for ensuring future generations can benefit from this wealth of information. In the current era of technological advancement, the recognition and analysis of MODI script characters have gained renewed importance. Researchers and technology enthusiasts leverage machine learning, deep learning, and image processing techniques to develop character recognition systems, unlocking past secrets and bridging the gap between ancient wisdom and modern technology. Several classical works delve into the historical background of the MODI script. Hemandpant, or Hemadri, a multifaceted personality, developed the MODI script in the 12th century, finding widespread use in western and some southern parts of India. While numerous ancient scripts existed over centuries, Marathi was primarily written in Modi until the 20th century, especially for administrative purposes in Maharashtra. The British later introduced the Balbodh variant of Devanagari.

Figure 2: Character Set of Modi Script

With 46 unique letters, comprising 36 consonants and 10 vowels, the Modi script facilitates seamless writing, minimizing the necessity to lift the writing instrument from the page and dip it in ink between characters. The script displays both "broken" and "circular" forms, resulting in a distinctive "cursive" Marathi writing style, as depicted in Figure 2, illustrating the fundamental character set of the MODI script.

Recognition of characters in the ancient Modi script significantly bridges historical linguistics and modern technology. As a script deeply embedded in India's cultural heritage, addressing the preservation and deciphering of Modi script characters presents distinctive challenges. This paper presents a comprehensive literature review that delves into various techniques and approaches for recognizing Modi script characters. From conventional methods such as Optical Character Recognition (OCR), Chain Code, and Zerike moment feature extraction to cutting-edge technologies like Convolutional Neural Networks (CNN) and Artificial Neural Networks (ANN), the survey encompasses a spectrum of methodologies. The introduction lays the groundwork for an in-depth exploration of the advancements and intricacies associated with Modi script character recognition, reflecting the fusion of ancient script preservation with contemporary technological innovation.

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II. LITERATURE REVIEW

Ancient Indian scripts exhibit a consistent writing style and character arrangement across 12 languages, comprising 22 Scheduled Languages and 99 Non-Scheduled Languages in India. Indo-Aryan languages, rooted in the Brahmi Script, predominantly utilize a horizontal left-to-right structure. Pattern Recognition relies on features such as Color, Texture, Size, Position, and Shape, which hold significance in the context of ancient Indian scripts within Offline Handwritten character datasets. Color features are particularly notable, involving spaces like RGB, LUV, HSV, and HMMD. Texture, encompassing groups of pixels, plays a vital role in pattern recognition, with spatial and spectral texture methods offering distinct approaches. Object Recognition, addressing shape, type, size, and location, introduces a new dimension to Computer Vision. The third feature, shape or size, is classified into region-based and contour-based methods. As emphasized by researchers, the MODI Script is pivotal across various platforms. The intersection of writing with technology creates opportunities for interdisciplinary research. Noteworthy progress has been observed in Pattern Recognition, Handwritten Character Recognition, and Transliteration using Machine Learning and Deep Learning over the past decades.

The literature survey highlights researchers' exploration of the Ancient MODI script, focusing on its properties and features. Achieving automation in Ancient Handwritten Character Recognition with 99% accuracy is critical. The MODI script finds applications in Pattern Recognition, Handwritten Character Recognition, and Machine Learning with transliteration mechanisms. Considering the extensive research output, this survey selectively encompasses work from 1855 to the recently published paper in 2023, capturing the evolution in Pattern Recognition and Handwritten Character Recognition within the MODI script domain.

2.1 Handwritten Character Recognition System

Creating a system for handwritten character recognition represents the primary objective of this study. The presented information avoids specifying the procedures and processes employed, but the title hints at a comprehensive examination of the strategies employed in identifying characters in handwritten form. Advancements in optical character recognition systems are driven by the ubiquity and significance of handwritten text, particularly across diverse languages and scripts. The applicability to character recognition underscores persistent efforts to enhance algorithms for recognizing handwritten content [1].

Over recent decades, addressing the various writing styles within Handwritten Optical Character Recognition (HOCR) datasets has become a crucial challenge. The distinctive identity of India, characterized by cultural and geographical diversity, has given rise to numerous scripts and languages. Notably, significant efforts have been devoted to developing HOCR systems that accommodate diverse handwriting styles in India. The complexity and structure of Indian characters contribute to the burgeoning research in character recognition systems. This study reviews prior research on handwritten character recognition in MODI [2].

The study delves into character segmentation in vintage handwritten MODI Script documents, a central theme of this work. Characters on a single line can be neatly separated using the Vertical Projection Profile (VPP) method when a zero-pixel column separates them. Adapting to the unique characteristics of this script, where characters in a single line are written without lifting the hand, the authors propose a novel approach to character isolation using dual thresholding criteria to minimize segmentation errors. The methodology, drawn from extensive background research, is straightforward and cost-effective, facilitating easy comprehension and swift implementation, yielding satisfactory outcomes [3].

The research likely investigates the processes of recognizing and converting handwritten Modi characters, addressing the challenges inherent in deciphering this ancient script. Given the historical significance of the Modi script in India, the paper may explore methods for accurately recognizing and converting handwritten Modi characters. Published in an international journal in 2015, the work contributes to the broader technical research and applications domain, bridging traditional scripts and contemporary recognition technologies. The early publication date highlights its initial contribution to the ongoing pursuit of effective methods for handling handwritten Modi characters [4].

Focusing on character recognition in the Indian Modi script, renowned for its historical significance and challenges for optical character recognition, this study contributes to information computing and signal processing advancements. Examining unique methods and strategies for character recognition in the Modi script, the research, presented at an

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international conference, showcases initiatives addressing the challenges of character recognition in this culturally diverse script [5].

In the context of rapidly evolving technologies, this study aims to contextualize the value of handwriting recognition. Technologies such as OCR (Optical Character Recognition) and Signature Verification are essential to handwriting recognition. This article categorizes and explains the components of these technologies, offering an overview of the field and a comprehensive bibliography. The adaptation of this method to different languages and cultures is also explored [6].

Figure 3: Modi Script Consonants, Vowel and Numerals

Today's extensive array of digital image processing techniques allows the application of feature extraction and classification in various scenarios. Artificial neural networks find everyday use in character recognition due to their exceptional noise tolerance, with the capability to yield accurate results. Feature extraction is the pivotal step in optical character recognition (OCR). This investigation explores OCR systems for several Indian scripts to identify the most compelling feature extraction methods using different classifiers.

Efficiency and a minimal error rate in character classification necessitate a distinct and discriminative difference between features. The absence of such a difference can hinder the development of OCR technology for Indian characters. This study offers valuable context to researchers and developers, aiding them in creating OCR technology for Indian scripts. Despite the challenges, implementing OCR for Indian scripts that consistently produces highly accurate results in all situations remains a significant hurdle [7].

To illuminate potential future directions for developing restoration software for Indic scripts, this paper provides a comprehensive overview of the current state of various scripts used from the medieval period to the present. It discusses the potential of digital recognition for handwritten and printed texts, emphasizing that although OCR has shown promise in improving accuracy for scripts like Devanagari, attempts for medieval and ancient scripts are limited. The multitude of languages and diverse writing systems further complicates the task, exacerbated by the scarcity of readily available digitalized language resources. The paper explores both the advantages and challenges of recognizing Indic scripts and acknowledges that, at present, only numbers and single letters can be reliably recognized. The study also presents the promise of statistical and soft computing techniques for decoding medieval scripts, providing the best OCR results for significant Indic scripts [8].

The paper introduces an estimate of the correlation coefficient for Modi numeral recognition, evaluating experimental results with various numerical pictures, divisions, and dataset sizes. Testing yielded a maximum identification rate of 85.21 percent on a 30,000-picture database, indicating the effectiveness of divisions. The work outlines the steps required to translate Modi characters into English using image processing methods, emphasizing the dormant status of numerous significant works composed in the Modi language [9].

This work seeks to enhance OCR system performance by employing the AMI approach for feature extraction. Four AMIs and a trained database are used in character experiments, revealing challenges with complex distortions but satisfactory classification for approximately affine distortions. The technique addresses problems with different handwriting styles by remaining consistent across transformations such as translation and scaling. Subsequent investigations will delve deeper into strategies like the box method to enhance success rates with varying character types [10].

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The paper discusses transliteration from the MDOI script into English using the proposed recognition model, briefly outlining the origins of the MODI script. The author details the Grayscale picture, Thresholding, Boundary detection, Cropping, Thinning, Scaling, and Template Matching stages of the MODI script's Conversion model [11].

Examining the history of ancient Indian scripts, such as MODI handwriting recognition, this paper highlights various image processing methods, including simple quadratic discriminant functions in neural networks and template matching. It underscores the significant opportunity for those studying Ancient MODI script character identification to create a unified, fully functional system for MODI script [12].

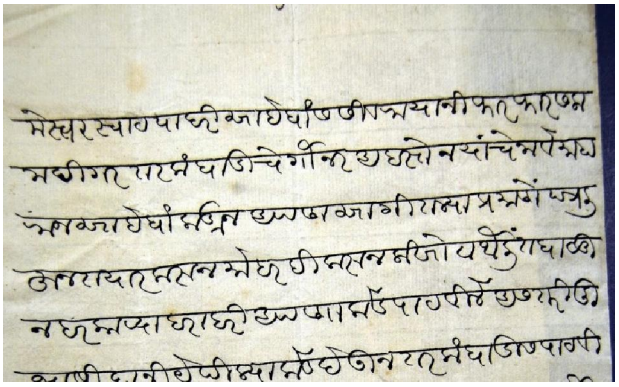

Figure 4: Modi Script Manuscript

In this literature, the process of implementing handwritten MODI OCR recognition is categorized into distinct steps. Pre-processing involves sub-steps such as skew angle detection, noise control, processing, morphological operations, and normalized segmentation, encompassing external and internal segmentation. Additionally, feature extraction, classification, recognition, and post-processing constitute integral phases. The groundbreaking MODI script, utilized in various cities across India and beyond, has been developed by scientists. Ongoing advancements, including typefaces and translators at CDAC (Centre for Development of Advanced Computing) and IIT Kanpur, as well as progress in MODI OCR, are noted [13].

A method for transcribing handwritten MODI scripts into standard English characters is proposed in this paper. The multi-step pre-processing procedures incorporate techniques such as Otsu's thresholding, trimming, noise reduction, scaling, the Stentiford thinning algorithm, and template matching. The researcher acknowledges study limitations, notably the small sample size used for final output development. An identified area for improvement is the scarcity of individuals experienced in MODI scripts, leading to prolonged translation times for MODI manuscripts into English and other languages [14].

This literature review centres on MODI handwritten character recognition, acknowledging the increasing difficulty posed by the uniqueness of each writer's style. Handwritten writing is transformed into a computer-readable format through character recognition, addressing the challenge of decoding Indian languages. The historical attempts to decipher Indian languages, documented in written records, underscore the significance of the MODI script in this context. Language-specific identification algorithms have been developed to preserve these valuable archives. The complexity and diversity of writing styles in each Handwritten Optical Character Recognition (HOCR) dataset continue to engage researchers in Indian scripts [15]

2.2 Modi Character Using Thresholding Technique

While acquiring images, various disruptions degrade their quality, encompassing low contrast, inadequate lighting, blurry backgrounds, and other issues. Employing the thresholding technique aims to enhance contrast, improve image prominence, and distinguish between foreground and background information. Several popular thresholding methods, such as Wolf, Sauvola, Otsu, Niblack, and Bradley, are widely used for numerous scripts. This study introduces a thresholding strategy tailored to binarise Modi characters effectively. Various local and global thresholding approaches are employed to achieve enhanced lighting, high contrast values, and more. The impacts of different thresholding

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strategies are assessed using two performance measures—peak signal-to-noise ratio and mean square error. Notably, the Otsu thresholding approach demonstrates favourable outcomes in binarizing Modi vowels in a more suitable form [16].

2.3 Segmentation Technique

An offline technique is employed for segmenting the old Modi script, utilizing the pixel density method to isolate characters from backgrounds. The process involves considering both local and global horizontal zoning. The segmentation outcomes for Modi characters demonstrate the feasibility and efficacy of this approach, although some segmentation errors persist. The suggested technique for character segmentation in Modi documents effectively divides various characters. Ligature estimation has proven instrumental in clustering segmentation, addressing challenges like badly damaged, touching, and closely spaced characters. Determining the overlapping area of character clusters is crucial for accurately dividing overlapping characters. Overcoming challenges related to character segmentation is essential to enhance the accuracy of Modi's character segmentation. The newly proposed algorithm effectively manages out-of-order characters. The presented findings encourage further research in this field [17].

The investigation results support the assertion that the proposed approach for analyzing MODI characters from digital photographs employs segmentation techniques, such as line segmentation, which accurately separates MODI characters. Once a character is segmented, it follows the shortest path in a graph representing the grey-level image to reach the methodology's data mapping and feature extraction stage. Given the study's cursive writing style of MODI alphabets, segmenting MODI characters along lines is the most logical. The analysis of MODI characters from digital images proves effective for the limited characters used in the MODI script, depending on the current stage of research methods. The paper defines an easy-to-follow process for extracting the MODI personality from digital images [18].

2.4 Deep Learning Approach

MODI, akin to the Devanagari script, was adopted by the Maratha empire during the 17th century to propagate Marathi culture and authority. The identification and translation of MODI script present challenges due to its waning popularity, the absence of a dependable script database, and the need for more suitable literature. This original research explores the application of a CNN architecture for recognizing MODI alphabetic and numeric characters. Classification employs a conventional machine learning classifier, yielding %a recognition accuracy of 92% for characters and 93.33% for numbers by comparing Random Forest and XGBoost [19].

The program was designed to facilitate the transformation of handwritten notes into typed text, offering a built-in Text-to-Speech feature for those with difficulties reading digital text. The potential benefits of this application extend to a broader user base. Encouraging results from the handwriting recognition model have been obtained [20].

The challenge of recognizing handwritten characters from scanned images can be surmounted through deep learning, emphasizing the necessity to digitize handwritten Gujarati materials. Establishing a system for automatically digitizing handwritten characters is deemed crucial, and deep learning methods are proposed for their efficiency in handling images [21].

In this research, three distinct deep-learning models' performances are compared. According to the experiment findings, AlexNet emerges as the best model for learning alphabets, surpassing GoogLeNet, which requires 200 seconds per epoch by a factor of 1.5. Due to its substantial input data requirements, the Simple-CNN model lags behind more sophisticated architectures like GoogLeNet and AlexNet. Researchers aim to enhance accuracy and speed by increasing the dataset size and refining the basic CNN design [22].

A practical Character Identification System has been developed to maintain high recognition accuracy without compromising input document quality. The MODI Script Character Recognizer System (MSCR) utilizes robust Convolutional Neural Network (CNN) methods. A comprehensive collection of handwritten samples has improved the system's training. The study by Jidnyasa Kondhare et al. (2022) explores the nuances of MSR's creation and performance, shedding light on the path to realizing this character recognition system for the old MODI script [23].

The study concludes that the experimental effort appropriately utilized the capabilities of the Deep learning model called Alexnet to recognize characters in an old Indian handwritten script. Using the Alexnet model in MATLAB resulted in an 89.72 percent success rate for the experimental setup, which included all 58 characters in the handwritten MODI script. The final output was based on 100 image variations for each character, demonstrating the success of the

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experiments. Using the deep learning model in the preliminary stage of experimental research activity showcases its easy yet effective implementation using MATLAB programming [24].

The MODI language poses a challenge for OCR, given its complexity as a primarily cursive script with visually distinct characters. According to available literature, deep learning techniques like InceptionV3 and RestNet on the MODI script remain unexplored. This study advocates using Residual and InceptionV3 frameworks for offline handwritten character recognition through deep learning approaches. The recognition accuracy for RestNet50 is 94.552 percent, with a model precision of 0.86, while InceptionV3 achieves a testing accuracy of 93.923 percent, with a model precision of 0.843 percent [25].

2.5 CNN, KNN, SVM, ANN Techniques

Identifying handwritten text poses a significant challenge in image processing and pattern recognition. Its applications span various domains, such as enhancing readability for the visually impaired, processing bank checks, and digitizing handwriting. Employing a multilayer Feed-forward neural network, this study aims to recognize English alphabet handwriting without the preliminary feature extraction step. The character set comprises 26 different alphabets, and the neural network undergoes training using fifty distinct character data sets. Subsequently, the trained network is utilized for classification and recognition, with each character resized to 30x20 pixels before training. The proposed method achieves higher recognition rates for handwritten characters than feature extraction-based systems [26].

In the evolving landscape, the reliance of computers on the ability to read handwritten text is imminent. Handwritten character recognition technology can automate numerous time-consuming tasks. Research indicates that, among three algorithms, CNN proves the most effective, yielding significant results in speed and accuracy. Despite CNN's strides in accuracy, a requisite framework is needed to produce cutting-edge results. To enhance precision, incorporate a spellchecker, and explore automation possibilities in other fields, employing image-cleaning techniques on inputs is suggested [27].

This research adopts a cutting-edge approach by integrating a Convolutional Neural Network (CNN) for feature extraction and a Support Vector Machine (SVM) as the classifier to detect handwritten letters in the archaic MODI script. This innovative methodology combines state-of-the-art deep learning with conventional script analysis approaches, contributing to the development of Handwritten Character Recognition for the challenging MODI script. The paper's incorporation of CNN-based feature extraction demonstrates a commitment to improving recognition accuracy in this ancient script [28].

Character identification, within the realm of pattern recognition tasks utilizing deep learning-based algorithms, has proven beneficial. This study applies the Convolutional Neural Network (CNN), a top-performing model, to character recognition. Using a CNN autoencoder for feature extraction in the MODI script is explored, and a Support Vector Machine (SVM) is applied to the retrieved features for categorization. On-the-fly data augmentation enhances dataset variability and generalizability. Since Marathi was primarily written in the MODI script until 1950, extracting information from MODI manuscripts in libraries requires further development of character identification methods. The suggested method utilizes a CNN autoencoder as a feature extractor and an SVM-based classifier, achieving state-of-the-art results in MODI character recognition [29].

This study employs a Convolutional Neural Network (CNN) and a Graphical User Interface (GUI) for handwritten text recognition. Combining a user-friendly interface with CNN offers a practical method for automatic character recognition. The research contributes significantly by presenting a fully-fledged system that utilizes cutting-edge neural network techniques for precise recognition and emphasizes usability through a graphical user interface. Dated April 2021, the contribution to the field of Handwriting Character Recognition stands out for its contemporary approach to recent challenges [30].

Exploring the recognition of handwritten characters in the MODI Lipi script, this study utilizes Convolutional Neural Network (CNN) and Data Augmentation Techniques. Using CNN reflects a cutting-edge approach for image-based tasks, and Data Augmentation Techniques enhance the model's performance and robustness. The research showcases an advanced methodology employing neural network technology and data augmentation to overcome obstacles the ancient MODI Lipi script poses. The publishing date of June 2022 underscores its contemporary relevance in the domain of Handwritten Character Recognition [31].

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This method detects forgeries in handwritten signatures by leveraging the signature's geometric features, an artificial neural network, and a neural network simulation tool. The signature's outline guides the extraction spots, and the features are trained using an artificial neural network. The Neural Simulation Toolkit then compares the original signature's retrieved features to examine relative signatures of other systems, validating the signature's authenticity based on trait matching [32].

The size of the DATABASE used to train the ANN in the proposed system was increased to demonstrate the effectiveness of using an artificial neural (backpropagation) network for character recognition by devising a means of recognizing patterns based on firing rules analogous to those of human neurons, a bridge between humans and computers can be established. Utilizing more efficient methods for training the ANN allows for dealing with more enormous databases with less time burden [33].

2.6 Transfer Learning with Discriminant Feature Analysis

The study presents the development of a classification framework for MODI handwritten characters using supervised Transfer Learning (TL). The image dataset for MODI characters is generated, and weights from a pre-trained Deep Convolutional Neural Network (DCNN) Alexnet are transferred for retraining the network. Features are extracted from various network layers, employing it as a feature extractor. Support Vector Machines (SVMs) are trained using activation characteristics to build the classifier models. The analysis of recognition accuracy and feature exploration is conducted using these models. Discriminant deep features are selected based on both subjective and objective metrics. A recognition accuracy of 92.32 percent is achieved for handwritten MODI characters, and for handwritten Devnagari characters, an accuracy of 97.25 percent is attained [34].

2.7 Chain Code Approach

Introducing a method for offline recognition of handwritten Modi Numerals, this study analyzes the chain code of handwritten Modi numerals through a feature extraction technique and employs a non-overlapping blocking strategy for feature extraction. The evaluation of Modi numeral recognition involves the utilization of a correlation coefficient to assess relationships. To gauge the reliability of the experimental outcomes, two approaches are employed: the non-overlapping division of numerical images and variation in sample size. The experiment achieved its highest identification rate, reaching 85.21 percent, when utilizing a database of 30,000 photos. Optimal recognition accuracy is observed with 55 grids [35].

2.8 Zerike Moment Feature Extraction

This paper shares the research findings into several existing Feature Extraction algorithms for recognizing Modi characters. Different methods of detecting Modi characters were examined and compared. Boundary descriptors were utilized to analyze Modi characters and extract meaningful characteristics. The incorporation of these distinguishing features enables the identification of Modi character. A vast number of Modi records detailing the history of the Maratha Empire awaited deciphering. Proficiency in reading and writing in the Modi script is limited. Understanding Modi character contributes to a deeper grasp of history [36].

An offline approach to character recognition in the Devanagari script for the Marathi language is proposed in this research. The KVKPR2013 database was designed with a specific focus on compound words. The method initiates with a structural pre-classification of characters using Zernike moments. Classification and recognition, achieved through SVM and k-NN, exhibit a noteworthy 0.37 percentage point improvement over previous approaches. The method, rigorously tested on a sizable dataset, addresses a gap in recognizing Devanagari Compound Characters. Future efforts will concentrate on improving categorization, with a plan to incorporate next-generation patterns and neural networks [37].

Handwritten characters in HOCR are identified from a digitized document image. Researchers worldwide have contributed to automatic handwritten character recognition. The success of a character recognition system hinges on the method's ability to identify shapes and extract relevant characteristics accurately. Feature extraction, the critical initial stage in defining a character's form, is accomplished through invariance features. With their orthogonality quality, Zernike moments describe the shape and identify rotation invariants. This paper showcases the automatic recognition of

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handwritten 'MODI' characters, demonstrating the superiority of Zernike moments over Hu's 7 moments with zoning. Considering MODI Script's historical significance until its replacement by Devanagari in the 19th century, this study adopts an offline approach [38].

The paper delves into the explored aspects in detail, potentially contributing to a pattern recognition system. Various features and their significance in image processing systems are examined. Due to patterns' diverse orientations and styles, multiple image preparation procedures are initially applied. Features serve as input into the recognition process. The paper discusses different techniques developed for feature extraction. Readers can use the information herein for an overview of feature extraction techniques, selecting the most suitable one based on their needs, such as image type and complexity (e.g., grey, color image) [39]

Table 1: Literature Review

No	Author	Title	Overview
1	Dr. Alok Jain, Dr. Poonam Sinha IJCSMC, 2023 [40]	Enhanced Modi Script Character Recognition using Deep Learning	The paper focuses on enhancing Modi script character recognition through advanced deep-learning techniques
2	Sneha Deshmukh, Dr Prashant R. Deshmukh IEEE Xplore, 2023 [41]	A Comprehensive Survey on Modi Script Character Recognition	This survey paper provides a comprehensive overview of various approaches and advancements in Modi script character recognition
3	Prof. Meenakshi Mukhopadhyay et al. IJIRSET, 2022 [42]	Modi Script Character Recognition Using Convolutional Neural Networks	The research employs Convolutional Neural Networks for accurate Modi script character recognition
4	Abhay Verma, Dr R. K. Gupta, IJCA, 2022 [43]	An Efficient Approach for Modi Script Character Recognition	The paper proposes an efficient approach to enhance the recognition accuracy of Modi script characters.
5	Dr. R. K. Singh, Dr. Sanjay Kumar Singh, IJRASET, 2021 [44]	Handwritten Modi Script Recognition using Transfer Learning	The research explores the application of transfer learning for improved recognition of handwritten Modi script
6	Priyanka Sharma, Dr. S. S. Bhatia, IJCST, 2021 [45]	Modi Script OCR using Neural Networks	This paper introduces an OCR system utilizing neural networks designed explicitly for the Modi script.
7	Aparna S. Gadge, Prof. C. S. Jadhav IJRASET, 2020 [46]	Recognition of Modi Script Characters using Machine Learning	The research focuses on Modi script character recognition through machine-learning techniques
8	Varsha R. Kurhade, Dr. R. S. Bichkar,IJCA, 2020 [47]	A Review on Modi Script Character Recognition Techniques	This paper comprehensively reviews various techniques employed for Modi script character recognition.
9	Rajendra Gharde, Dr Jayashri Vajpai, ICICCT, 2020 [48]	Efficient Modi Script Character Recognition System	The research proposes an efficient system for recognizing characters in the Modi script.
10	Yash R. Rathi, Prof. S. S. Sane, JCSIT, 2020 [49]	Modi Script Character Recognition Using Artificial Neural Networks	The paper explores the application of artificial neural networks for accurate recognition of Modi script characters

III. CONCLUSION

The literature review on Modi script character recognition systems presents various methodologies and approaches. The exploration encompasses OCR, CNN, ANN, SVM, Chain Code, Zeroth-order moment feature extraction, and deep learning techniques, illustrating the evolution of character recognition technologies applied to the intricacies of the Modi script. Each approach offers unique advantages, highlighting that the choice of technique depends on the specific

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requirements and challenges the ancient script poses. The survey underscores the importance of a nuanced understanding of Modi script characteristics and emphasizes the continual need for innovation in recognition methodologies to achieve higher accuracy and robustness. Advancements in technology can facilitate the integration of these varied approaches, paving the way for more sophisticated and effective Modi script character recognition systems preserving and unlocking the wealth of knowledge encoded in this historical script.

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