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A Review in Tamil Palm Leaf Manuscript for Character Recognition

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ABSTRACT

More than two thousand years ago, the people of South Asia utilized palm leaf manuscripts for record-keeping and data transmission. These historical records contain value information for several age group peoples on a variety of themes, including culture, astronomy, mathematic, astrology and medicine. The valuable information is written in local languages these priceless records are damaged due to lack of maintained. Many researchers are dedicated to safeguarding the antique palm leaf scripts in order to preserve our priceless knowledge writings. However, as science and technology have advanced, images have become a vital means of transmitting information, and image processing has seen a surge in recent years. Numerous image processing techniques have been proposed for the efficient data retrieval, which includes image enhancement, segmentation, processing, restoration, compression and acquisition. Creating an effective image processing system to efficiently extract metadata from these manuscripts automatically is one of the goals. The world's oldest language is Tamil, and because writing styles vary greatly, it can be challenging from palm leaves to recognize ancient Tamil characters. Efficient feature extraction, selection, and character identification are necessary components of a system for identifying ancient Tamil characters. On this context, the study examines the literature on various techniques and strategies for locating, classifying, and extracting data from historical inscriptions inscribed on Tamil palm leaf manuscripts.

Keywords: *Tamil Palm Leaf, Image Enhancement, Image Segmentation, Data Retrieval, Ancient Tamil Character, and Character Recognition.*

1. INTRODUCTION

Tamil is a highly literary language and one of the eldest in the world. Numerous palm leaf scripts from antiquity include uncommon commentary on Sangam, Saiva, Vaishnava, and Jain writings, poetry of all kinds, exceptionally valuable medicinal works, food, jewelry, astronomy, astrology, vaastu, and Kaama shastra, dance, drama, medicine, Siddha, and so on. The aging of documents, low-quality palm leaf and the presence of an obstructing outline, background intensity change from shadows, smudging, vowing, uneven intensity, and random noise distribution all contribute to the degradation of historical documents. The handwritten text of the damaged palm leaf may exhibit a variety of variations in stroke brightness, stroke connectedness, and stroke breadth. Restoring the document's data is essential.

Handwritten character identification is one of the most challenging character recognition problems. Understanding the input as a order of characters from a set of characters is the aim of character recognition. Techniques for processing images provide many difficulties. These can be resolved by learning how to divide characters during the segmentation process, identify a limitless number of character fonts and sculpting styles in noisy images, and distinguish between characters that are similar in shape but pronounce themselves differently. Numerous scholars' endeavor to employ an array of methodologies in order to surmount the intricate character recognition challenges. The hardest thing to do is identify a character's sculpture in contrast to other character recognition from various sources and eras.

Fewer scholars have thoroughly examined character recognition from palm scripts, despite the fact that a great deal of research has been done in the arena of Tamil palm leaf handwritten character recognition. The literature suggested a few surveys. However, as far as we are aware, no poll has yet incorporated the most recent papers. The steps involved in character recognition from the palm leaf manuscripts are explained in this paper's section III. A detailed explanation of the multiple investigations carried out at every phase of the digitization process for palm leaves is provided in Section IV and Section V concludes the work.

2. STEPS INVOLVED IN TAMIL CHARACTER RECOGNITION SYSTEM

From the palm leaf script data extraction process is a big task for recognition of characters. On image processing techniques authors mainly focused on image acquisition, image enhancement and image segmentation method to capture clarity of the image, component of character images and algorithms for recognition. The system's primary goal is to identify Tamil characters found in palm leaf manuscripts. This is accomplished by grouping the characters into suitable types according to features that are taken from each individual. Figure.1. below illustrates the role of each step for the mechanism of palm leaf manuscript character recognition.

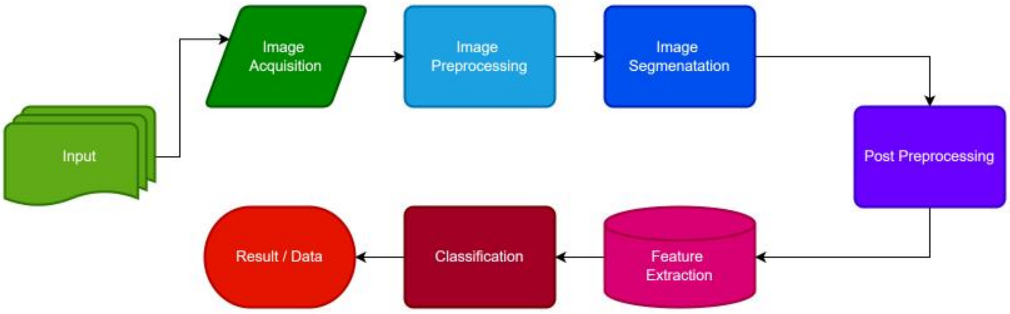

Figure1: Steps involved in Tamil character Recognition

2.1. Image Acquisition

The act of retrieving an image from a source—typically a hardware-based source—for processing is known as image processing. It is the initial stage of the workflow since processing cannot begin without an image. The acquired image has not undertaken any processing. During the image acquisition progression, a combination of sensors that are sensitive to the specific type of energy transforms incoming light energy from an object into an electrical signal. These tiny subsystems cooperate to give the most accurate representation of the object to your machine vision algorithm. Even if users have complete control over lighting, the cameras and sensor system mainly depend on the existing technology.

Perhaps the most crucial component of a machine vision system is illumination. The lighting should evenly illuminate every surface of the objects that are visible. Shadows and glare should be avoided while configuring the lighting system. Stability and spectral homogeneity are crucial. The methods with the highest contrasts greatly contribute to a machine vision system's increased efficiency. Making an image that the machine vision algorithm can use is the aim of the entire image acquisition process. The success of a machine vision system is primarily dependent on the quality of the imaging system. The dataset, which consists of these gathered images, serves as the foundation for other procedures depicted in figure 2.

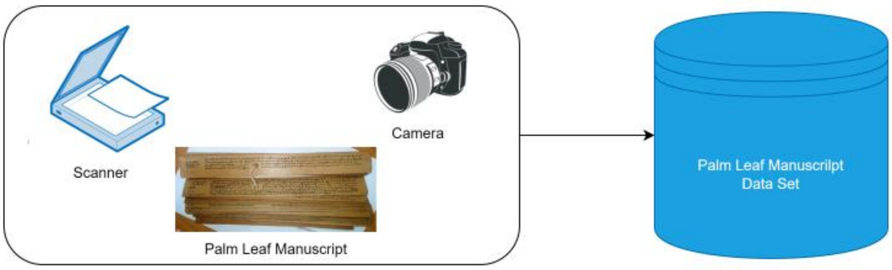

Figure2: Image Acquisition

2.2. Image Enhancement

The technique of altering digital images to make the results more appropriate for display or additional image analysis is acknowledged as image enhancement. There are numerous dissimilar approaches available for enhancing image quality. The techniques that are most frequently employed are contrast stretch, density slicing, edge enhancement, and spatial filtering. After the image has been adjusted for geometric and radiometric distortions, an attempt is made at image enhancement. Every band in a multispectral image receives a different application of image enhancement techniques. Because of their precision and vast range of digital operations, digital techniques have been proven to be more satisfying than photographic procedures for picture enhancement.

Using spatial domain techniques, one can directly manipulate an image's pixels. An image is converted from the spatial domain to the frequency domain using frequency domain techniques. Frequency domain techniques are used to translate an image from the spatial domain to the frequency domain. By using a Fourier Transform, pixels in the spatial domain are grouped and indirectly modified as part of the frequency domain method to improve the image.

Images can be made clearer by deblurring them. Image detail visibility is improved by contrast adjustment. The process of image brightening makes an image appear lighter. A few common types of smoothing filters are adaptive, Gaussian, and average smoothing. Smoothing filters help reduce and suppress image noise. Through the removal of blur, sharpening filters improve edges. Image capture, printing, and transmission processes can introduce noise. The intensity variance between adjacent pixels can be used in image processing to identify it. The use of linear or non-linear filters to smooth the image is one way that noise removal techniques help reduce the visibility of noise. The progression of transmuting an image so that the distribution of pixels at each gray level is roughly uniform is known as histogram equalization. These are methods for refining images and the intended result which is shown in the figure 3.

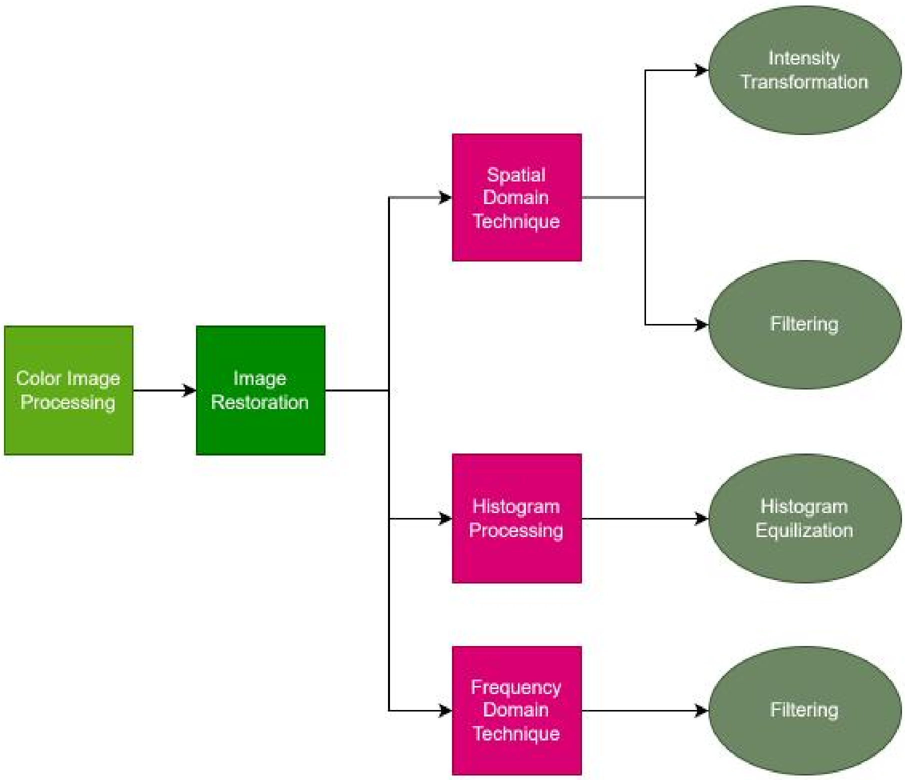

Figure3: Techniques in Image Enhancement for Palm Leaf

2.3. Image Segmentation

In order to reduce the complexity of a digital image and enable additional processing or analysis of individual image segments, the technique known as image segmentation divides the image into subgroups known as image segments. Segmentation is, technically speaking, the process of giving labels to individual pixels in an image in order to distinguish objects, people, or other significant elements.

The three steps involved in segmenting an image are line-level, word-level, and character-level segmentation. A skew-corrected image with text written as lines is given to Line Level Segmentation. Using line-level segmentation, the image is separated into lines. Word-level segmentation is applied to an image that has a single line with a string of words on it. The goal is to break up the image into words. An image with a single word made up of a string of characters is given to character-level segmentation. The goal is to separate the image into its component characters. For segmenting valid character thinning is done on string of characters. The resultant images will retain the portions of characters and it is shown in the figure 4.

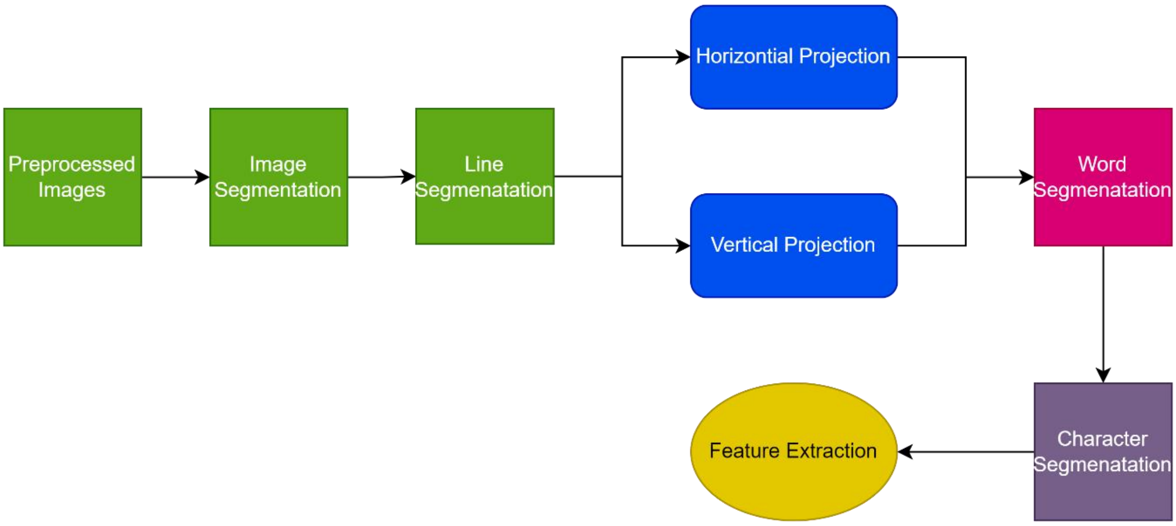

Figure 4. Techniques in Image Segmentation for Palm Leaf

3. LITERATURE SURVEY

The paper [1] presents a support vector machine-based method for identifying offline handwritten Tamil characters. The preprocessing techniques described include thresholding, skeletonization, line segmentation, and normalization. The feature extraction process involves dividing the normalized character frame into non-overlapping zones and calculating pixel densities for these zones. The SVM-based recognition process is explained, including the training and testing phases, and multiple binary SVMs being used for multiclass classification. The experimental results demonstrate the system's effectiveness, achieving an overall recognition accuracy of 82.04% for 34 different Tamil characters, with the highest accuracy at 98.9% and the lowest at 62.84%. Finally, the paper concludes by highlighting the potential for future improvements in feature extraction and the combination of multiple classifiers to enhance recognition accuracy. In [2] Tamil handwritten character recognition, data preprocessing is done by normalization, smoothing and resampling, this preprocessed data is used as local feature to extract at each point. After preprocessing to extract global features Fourier transform, discrete cosine transforms and wavelet transform is applied on the preprocessed data to capture the overall information. Both local and global feature is concatenated and its first derivate features are computed to train an SVM with RBF kernel. This method is applied on 155 classes (symbols) and the classification accuracy is 95.86.

In [3] this work, image acquisition is done with the system (Name of the system RATHCPM) to capture the image from palm leaf. The captured image is preprocessed by applying image cropping (boundary of the character needs to crop), image resizing (all cropped character is resized), image binarization (converting image to binary image to extract feature) and image Thicken (to get the skeleton structure of the character). To extract the features from the preprocessed image, stroke detection is a process by separating a character, to find the line (vertical, horizontal, zigzag and tail) a character hold in each block. Also to find the loop in a character (to find starting and end position of character) color filling algorithm is used in each block of the character image. From feature extraction, genetic algorithm is applied on the fitness value of the input character to display the best recognition result. To identify character, 66-bit chromosome is used by the system and this system is more complex and still face difficult in defining a standard structure. The study [4], presents a Feed Forward Back Propagation Neural Network (FFBNN) based character recognition system for Tamil palm leaf scripts. Optical character recognition is utilized to convert hand-written or typewritten images into machine editable text. The process involves segmenting the palm leaf script characters using sliding window and adaptive histogram calculation methods, assembling them, and storing them in a database. The character recognition is achieved through FFBNN, where the characters stored in the database are learned. The system was tested on ten sets of Tamil palm leaf scripts, showing an impressive accuracy of 90% in character recognition. The success of the proposed system was evaluated by erratic the number of hidden layers.

In this paper [5], they proposed a method to convert ancient Tamil handwritten scripts to text form. The system scans the palm leaf and stores the image in JPEG format. The preprocessing first step is image cropping to identify characters from the image. After cropping, to segment characters from each word, a graphemes extraction technique is applied. Third step is image resizing, to avoid different character size image is resized into 100 * 100. Fourth step is image thinning to extract nearest pixel, using Image Zoning techniques characters are stored as Boolean matrix to generate nodes in the graph. Using the breadth-first search algorithm, pattern matching is applied to convert the character into an equivalent Tamil character. This [6] research paper develops a method for classifying Tamil characters using Convolution neural networks (ConvNets) int 35 distinct classes. In image recognition tasks, where transformations have produced notable improvements in recognition accuracy, data augmentation is applied on the image. First complementary images is produced, normalized them to values between 0 and 1, and then used rotational deformations to improve spatial invariance, resulting in a dataset of huge images to increase the size of the dataset. Stochastic pooling and probabilistic weighting is used for pooling in ConvNet. A type of regularizer Local response normalization is applied to groups neurons in a local neighborhood that are uniformly big. Local contrast normalization is implemented as layer for correcting shading artifacts. For output, activation function used in this ConvNets is non-linear hyperbolic tangent.

The paper [7] will result in an automated preprocessing method. The image is taken from GOML and then processed using preprocessing techniques including color to grayscale, denoising, applied wiener filter to remove blur in the image and image scaling to create a binarized image using weight encoding with Otsu method. It is assumed that the input image consists of two-pixel groups: the background and the foreground. PCA is utilized to highlights variance and highlights strong outlines in the dataset to learn condensed lexicon. The average mean value is then shifted to each block using the mean shift technique to smoothen the resolution. Using a trimmed median filter, random impulse noise and white Gaussian noise are eliminated in the final postprocessing stage. This paper [8] focuses on evaluating localized binarization techniques for manuscripts written in Tamil on palm leaves. The authors emphasize the need for preserving the textual content of these manuscripts through binarization, reducing storage volume and enabling character recognition and segmentation. The study evaluates the effectiveness of Niblack, Sauvola, NICK, and Bradley binarization algorithms in reducing the size of the digital images while preserving the textual content. The paper highlights the challenges of binarizing degraded document images and the complexity of character recognition, particularly in the context of Indian languages with compounded characters. The authors also discuss the significance of digitalizing palm-leaf manuscripts, the need for extensive memory space, and the limitations of compression techniques that follow a lossy mode of compression.

The paper [9] addresses the challenge of character recognition and information retrieval of earliest Tamil characters from holy place epigraphy. The research aims to develop a system for recognizing Brahmi, Vattezhuthu, and Grantha letters from holy place epigraphy and converting them into present Tamil digital text format. The proposed system overcomes the challenge of converting ancient characters by employing image zoning and multilevel perceptron neural networks for character recognition. The paper proposes a methodology involving image capturing by high quality camera and stored in JPEG format. In preprocessing image cropping, to segment each character grapheme extraction technique [18] is applied. To extract features from the image, thinning, binarization is applied on the image. Text conversion using Unicode Text, and database retrieval to identify each character in the datasets to achieve the desired results for Ancient Brahmi character recognition. Overall, the proposed system provides a valuable contribution to the preservation and understanding of ancient Tamil characters and their conversion into digital text format.

The task of recognizing ancient Tamil characters and retrieving information from temple epigraphy is discussed in the study [10]. The goal of the project is to generate a system that can translate modern Tamil digital text into Brahmi, Vattezhuthu, and Grantha letters from holy place epigraphy. By using picture zoning and multilevel perceptron neural networks for character recognition, the suggested approach gets beyond the difficulty of translating old scripts. In this study, a JPEG-formatted image capture system is proposed, utilizing a high-quality camera. Grapheme extraction approach [18] is used in preprocessing image cropping to segment each character. Thinning and binarization are applied to the image in order to extract features. Using Unicode Text for text conversion and database retrieval to determine each character's identity for vattezhuthu character recognition. This paper [11] presents a method to classify handwritten Tamil characters from degraded palm leaf scripts digitally by extracting features. It performs preprocessing steps like greyscaling, binarization and thinning. Features like perimeter, Euler number are extracted globally and directional features from uniform zones. Smart zoning is done by separating the image into quadrants and extracting zernike moments from critical regions which help increase character recognition efficiency. An SVM classifier is trained on the features to classify characters.

This paper [12] presents a framework for automated recognition of earliest Tamil characters taken from stone inscriptions using machine learning techniques. It discusses preprocessing steps like noise exclusion using median filter, binarization with global thresholding, segmentation for each row, line horizontal projection histogram, and for character bounding box method is used. To extract features shape and Hough transforms method are used. It then applies feature selection algorithms like Group Search Optimization and Firefly to reduce features before classification with Neural Networks, J48, Naive Bayes and KNN classifiers. Experimental results on ancient Tamil character datasets show improved accuracy, precision, recall and F-measure when combining feature selection and neural network classification compared to other techniques. This paper [13] presents a method for segmenting handwritten Tamil characters from palm leaf scripts using a histogram-based approach. It first preprocesses the images by converting them to grayscale, applying Otsu's thresholding for binarization, and performing skew detection and correction. It then segments the images into lines using vertical histogram projections and segments characters within each line using horizontal histogram projections. Experiments on 75 script lines containing 2098 characters achieved 87% accuracy in character segmentation.

This paper [14] proposes a procedure for separating Tamil letters from images of palm leaf script via image processing. The images are first preprocessed by converting to grayscale, filtering using median filter and thresholding using adaptive mean threshold. The characters are then segmented using contours. GLCM features like contrast, energy, homogeneity, correlation, dissimilarity and angular second moment are extracted from the segmented characters and stored. A comparison of these features is made between characters from palm leaf, stone inscription, handwritten and printed document images. The work aims to recognize the characters and classify them using these statistical features which can help preserve ancient Tamil literature digitally. They have presented [15] a novel TCR system in this paper that combines the ideas of convolutional neural networks and PCA. Originally, the datasets were gathered by the authors from the HP Labs website's offline IWFHR-10. Principal Component Analysis was employed to extract features, which were then classified using convolutional neural networks. The suggested model's output showed greater convergence. The authors reported research on CNN with PCA for Tamil character recognition; the distinction is in the enhancement of CNN structure.

The context [16] discusses a proposed method to classify characters segmented from Tamil palm leaf scripts using a hybrid Radial Basis Function (RBF) network with Genetic Algorithm (GA). The characters were segmented from historical Tamil palm leaf manuscripts, which can be difficult to read due to degradation over time and different styles of writing. The RBF network is used for classification, and GA is used to generate optimized weights for the RBF network. Nguyen-Widrow weight initialization is used to generate the initial weights for GA. This approach achieved 97.7% accuracy in classifying 130 characters from palm leaf manuscripts. [17] Images of palm leaves are preprocessed, first turning them into grayscale versions. These grayscale versions are then subjected to a filtering procedure to eliminate noise. Here, palm leaf scripts are a good source for the median filter. The Adaptive Mean thresholding method was then used to the filtered images to enable binarization. After that, contour-based convex hull bounding box segmentation was used to separate the characters from the threshold image output. Following segmentation, the characters are resized such that each character picture has the same dimensions. They are then saved as distinct class labels for the character dataset. An Adaptive Backpropagation Neural network with shannon, sigmoid activation function and Nguyen-Widrow weight initialization is used to classify the segmented characters.

The document [18] addresses the challenge of recognizing ancient characters due to their diverse formats and limited knowledge about them. It involves the pre-processing stage using Gabor filter, character segmentation using an overlapped method, and hybrid feature extraction with Multiclass SVM for character recognition (HFE-MCSVM). The assessment of the proposed HFE-MCSVM method is conducted in the Matlab simulation environment, demonstrating better performance compared to previous methods like Shape and Size aware Character Recognition and Conversion System (SSCR-CS). This article [19] discusses the challenges of line segmentation in Tamil language palm leaf manuscripts for optical character recognition. It compares common line segmentation methods used for other languages like Adaptive Partial Projection (APP) and A* Path Planning (A*PP) with a proposed method for Tamil texts. The proposed method segments lines into independent, touched, and overlapped categories depending on character interference. It uses connected component analysis and foreground/background segmentation to identify lines and obstacles. Performance is evaluated on Tamil palm leaf images and the proposed method achieves better results than APP and A*PP.

The document [20] discusses recognizing characters from Tamil palm-leaf manuscripts using convolutional neural networks (CNN). It creates a dataset of 15 classes of characters with 1000 samples each from scanned palm-leaf manuscript images. It then implements a CNN architecture based on the LeNet model with convolution, pooling, activation and fully connected layers to recognize the characters. The CNN approach recognizes the characters with 96.21% accuracy and predicts characters in 0.64 seconds, performing better than support vector machines, k-NN and feedforward neural networks. In this study [21] the proposed method makes use of convolutional neural network-based classifier training and efficient character detection. To quantify the statistical properties of the segmented characters, the Grey Level Co-occurrence Matrix feature extraction technique is utilized. There are 60 class variants in the dataset, and there are around 1000 distinct samples in each class. This study uses convolutional neural networks, a technology that yields 97.8% accuracy, to identify Tamil characters from old palm leaf scripts.

The [22] Tamil palm leaf segmented characters were classified in this work using the RBF network and CART. The first step involved preprocessing the scanned images of Tamil palm leaves into a grayscale image and then allowing the images to be filtered with a median filter to remove noise. The RBF network and CART algorithm were trained using the statistical features that were extracted from the segmented characters in the second phase using the GLCM feature extraction approach. Rather than using random initialization, the Nguyen-Widrow weight initialization technique was employed to build the weight for the RBF network. When RBF and the CART algorithm are compared using the Nguyen-Widrow method, RBF produces a promising result of 98.4% accuracy for character classification, whereas CART produced 98.8% accuracy. Contour-based convex hull bounding box segmentation was used to process and segment characters of Tamil palm leaf script [23]. Two versions of the segmented characters were created: the GLCM feature and Binary Coded Value. The suggested approach of the MABPN algorithm with Shannon activation function was used to train the features that were taken from the segmented characters. Nguyen widrow weight initialization was employed to initialize the weights instead of random weight initialization in the suggested technique since weight initialization is vital in Backpropagation Neural Networks. The models under evaluation are GLCM feature extracted values and Binary Coded Value models with a Shannon activation function employing Nguyen widrow weight initialization. Compared to binary coding, the suggested approach using GLCM characteristics as input produced a promising outcome.

Together with 12 vowels and 18 consonants, 216 consonant vowels, also referred to as composite characters (modified), are recognized in the proposed system [24]. steps in image preprocessing NTSC gray scale is used to transform RGB images into grayscale images. The median filter is used to eliminate noise. The grayscale image is transformed into a binary image. To identify the characters, it then uses a CNN architecture that includes convolution, pooling, activation, and fully linked layers. This CNN model achieves 93% training and test accuracy, outperforming ANN, support vector machines, component labeling techniques, clustering, and groupwise classification. The paper [25] examines the difficulties in reading handwritten characters and specifically concentrates on reading handwritten Tamil mantras. It highlights the intricacy of Tamil characters and the necessity of departing from customary hand-drawn elements. The study focuses on the automatic feature extraction and classification from individual Tamil characters using Convolutional Neural Networks (CNNs), a type of deep learning network. For increased efficiency, Principal Component Analysis (PCA) is used to detect the image's top eigenvectors. The proposed CNN's architecture and feature extraction method using PCA are described in the document. The final result is an accuracy of roughly 89.85% in identifying slogans with handwritten Tamil characters.

The study [26] highlights the growing need for character recognition software across a range of languages, with a focus on Tamil, which is among the oldest languages still in use. With a training accuracy of roughly 97%, the research suggested a unique architecture for the CNN model that was trained using a sizable dataset of handwritten Tamil characters. The study also covers the difficulties in recognizing handwritten characters, the peculiarities of Tamil, and the importance of digitizing Tamil characters for a range of uses. The difficulties and complexities of handwritten Tamil character recognition are also covered in the paper, with a focus on the need for better datasets and fewer ambiguities for recognition that is more accurate. On the palm leaf images [27], a first step in the separation of the foreground characters and background image is applied by filtering and deleting undesired character segments using noise reduction techniques. The difficulty of minor character breaks is mitigated by the thickening procedure. The character image's aspect ratio can be used to classify the character as single or multi-touching. There are more categories for single touching, like horizontal and vertical touching. They also clearly show the character stroke. The initial step in character segmentation is the identification of touching characters, which are divided into three categories: horizontal, vertical, and multi-touching characters. The second procedure involves dividing a single touching character into two linked characters. Finally, horizontal and vertical touching characters are subject to a proposed algorithm called the HorVer method in order to divide them into independent characters.

The document [28] discusses a novel method for recognizing ancient Tamil palm leaf vowel characters in historical documents using B-spline curve recognition. The recognition of palm leaf manuscript characters is a challenging problem due to poor raw text characteristics, and the proposed method aims to solve this problem by utilizing B-spline curves to recognize the twelve vowels in the palm leaf manuscripts. The advantage of B-spline curves lies in their uniqueness and robustness, enabling them to recognize characters written by different narrators with better accuracy. The method involves a set of preprocessing steps, including background subtraction, image denoising, and character separation, followed by the approximation of B-spline curves and the recognition of characters based on the combination of curves. The method's performance is evaluated using a data set containing more than 2000 scanned palm leaf manuscripts obtained from Aagama Academy. The document [29] discusses a proposed approach for enhancing offline Tamil handwritten character recognition using an optimal Newton Algorithm based Deep Convolution Extreme Learning Model (DCELM-NM). The paper proposes four principal stages: Data pre-processing, Segmentation, Feature extraction, and Classification, to address discontinuities, slanting, and variations in style and size challenges in tamil characters. The approach utilizes the Tsallis entropy approach-based atom search (TEAS) optimization algorithm segmentation method and the Deep Convolutional Extreme Learning Machine - Newton Metaheuristic (DCELM-NM) approach for feature extraction and classification.

The research paper [30] presents a detailed investigation into the development and performance evaluation of a handwritten Tamil character recognition system using deep learning and CNN, shedding light on the challenges and methodologies. The proposed system uses CNN with four Convolution Layers (Conv2D), four Max pooling layers, two Dense Layers, and a Flatten layer. The dataset consisted of 40,000 image samples, and the model was trained using an Adam optimizer with a learning rate of 0.01. The system can recognize 121 classes out of 247 Tamil characters and can also recognize words formed from combinations of these characters. The paper emphasizes [31] the technical challenges of recognizing Tamil characters from stone inscriptions due to their intricate nature, and the proposed system's focus on overcoming these challenges using deep neural networks. The pre-processing stage involves binarization, denoising, character segmentation, and size normalization to prepare the stone images for further processing. Feature extraction using Zernike moments is employed to extract the basic components of the Tamil characters, followed by classification using a backpropagation deep neural network. The optimization of neural networks using the simplex method during backpropagation with an improved dataset is also detailed, underscoring the systematic approach to addressing the recognized challenges.

The document [32] presents a novel approach to recognizing Tamil manuscript character images based on human structural perception of characters. The paper introduces a zoning strategy to address the deficiencies in uniform zoning approaches and proposes a hybridized zoning method, which substantially improves the recognition rate for character images with structural variation. The study also formulates a Tamil Palm-Leaf Character dataset and demonstrates a significant improvement in the symbol recognition rate. The document highlights the challenges and constraints involved in recognizing manuscript characters, emphasizing the marginal structural variations and the need for effective feature extraction methods to address these challenges. In this paper[33], the characters in Tamil palm leaf scripts are recognized through feature recognition using Enhanced Speeded Up Robust Feature with Bag of Grapheme (ESURF-BoG). The goal of this technique is to identify the input character's strongest critical points from various orientations. These key point features were developed as a model named Bag of Grapheme (BoG) with code word creation for training images. Thus, for the testing image, unsupervised key point features were extracted and pattern matching was carried out. The characters are recognized by the suggested architecture from a sizable data set of optical palm leaf manuscripts.

In this paper [34], the features of the characters taken from the palm leaf are trained using a recurrent neural network (RNN). In order to train the bidirectional long short-term memory (BLSTM) network and segment the character from the image, this method first includes a preprocessing step to remove noise. The characters are trained and tested using a feature vector that has nine zones for character strokes. To train the features of the characters, a large collection of characters is used. The paper focuses [35] on the application of Convolutional Neural Networks (CNN) for recognizing handwritten Tamil characters in offline mode, aiming to set a benchmark for offline Handwritten Tamil Character Recognition (HTCR) using deep learning techniques. The study made use of a standalone handwritten Tamil character collection (156 unique characters) created by HP Labs India. The authors distinguish between online and offline Handwritten Character Recognition (HCR) methods, explaining the difficulties of offline HCR due to dissimilarities in writing patterns.

The paper discusses [36] a CNN-based optical character recognition system for recognizing characters in Tamil palm leaf manuscripts. Palm leaf manuscripts are scanned and preprocessed which includes a variety of filtering techniques, such as the median filter, Gaussian filter, and non-local means de-noising filter, are used to remove noise. The filtered image is further reduced to a binary image by applying adaptive thresholding method. Character Level Segmentation is an effort to isolate each character in a picture. All segmented and annotated patch images are combined to create a dataset of isolated characters. It consists of 8,500-character samples and 67-character classes, with 6,700 examples selected as a train set according to the character classes. The proposed system uses CNNs to recognize characters by employing convolutional, pooling, activation and fully connected layers. The model is tested on a new manuscript and characters are recognized with 87.33% accuracy showing CNNs are suitable for palm leaf manuscript character recognition. The document presents [37] a novel end-to-end deep learning-based model, ETEDL-THDR, for Tamil handwritten document recognition. The model aims to address the challenges associated with recognizing Tamil handwritten text due to variations in sizes, styles, and orientation angles of Tamil alphabets. The ETEDL-THDR model utilizes a series of processes including preprocessing using median filtering, segmentation at the word and line levels, feature extraction using the MobileNet model, character recognition using the BiGRU model, and hyperparameter optimization using the water strider optimization (WSO) algorithm. The model is designed to improve input image quality, perform segmentation activities, and identify Tamil characters using deep learning techniques.

In the research paper [38] the authors address the challenge of recognizing handwritten characters in the Tamil language. The paper highlights the difficulty in manually understanding handwritten Tamil characters due to variations in writing styles. To address this issue, the authors propose a CNN-VGG16-RF model, a combination of Convolutional Neural Network (CNN) and Random Forest (RF) classifier. The research also discusses the process of pre-processing, feature extraction, image normalization, and the utilization of the VGG-16 model with random forest classifier. The proposed model aims to accurately recognize Tamil characters from input images and was evaluated using the Tamil language dataset from the HP Tamil Lab website. The study addresses [39] the challenging task of recognizing Tamil characters in stone inscriptions, which are essential sources for understanding ancient history and cultural practices in Tamil Nadu. The authors propose a hybrid model, Self-Adaptive Lion Optimization Algorithm with Transfer Learning (SLOA-TL), which combines Lion Optimization Algorithm (LOA) for image pre-processing and Transfer Learning (TL) for character recognition. The LOA is used to optimize brightness and contrast, while TL, based on a Deep Convolution Neural Network, is employed for character classification. The study demonstrates that the proposed SLOA-TL model achieves better accuracy and speed compared to existing methods, making it an efficient design for recognizing Tamil characters in stone inscriptions and preserving traditional knowledge. Table-1 gives overall review and figure 5 shows the classification accuracy of all the papers mentioned above.

Paper and Dataset	Preprocessing Methods	Classifier	Output	Accuracy
[1]. Data samples are collected from different writers	Thresholding, skeletonization, line segmentation, character segmentation, Normalization	SVM	Recognizing offline handwritten Tamil characters	82.04%
[2]. IWFHR 2006 Tamil Dataset	Fourier Transform, Cosnie Transform	SVM with RBF Kernal	155 Class	95.86
[3]. Tamil alphabet	Image cropping, Binarization.	Genetic algorithm technique	recognizing Ancient Tamil handwritten characters	
[4]. Ten set of Tamil palm leaf manuscripts	Sliding window and adaptive histogram	Feed Forward Back Propagation Neural Network	Tamil character recognition	90%
[5]. Tamil Palm Leaf manuscript	Voronoi Image Zoning, Breadth First Search	BFS	Converting ancient Tamil handwritten scripts into text format	
[6]. IWFHR-10 Tamil character dataset from the HP Labs India, 500 samples of each 156 characters	Resizing	Convolutional neural networks	Classifying characters in Tamil	94.4%
[7]. Images collected from the GOML library	Weight Encoding with Otsu Method, Median Filter,	Proposed Novel Binarization Method	Extract the image from the degraded Tamil plam leaf image effectively for further processing.	PSNR = 46.2
[8]. Kamba Ramayana manuscript	Binarization,	Niblack, Sauvola, NICK and Bradley binarization algorithms	protecting the textual content helps in next level of character recognition	Bradley is much suitable
[9]. Different class of Brahmi characters from various writers of all the 237 Brahmi characters	Cropping, Resizing, Binarization, Image Zoning	MLP	Identification of Tamil Ancient Characters	84.57
[10]. Brahmi characters,	Cropping, Segmentation,	image zoning	Brahmi character and	Vattezhuthu = 89.75%,

Vattezhuthu character set	resizing, Thickening, Binarization	proposed algorithm	Vattezhuthu recognition	Brahmi= 91.57
[11]. Tamil palm manuscript samples	Grayscaling, binarization, thinning, Boundary Extraction	Quadratic SVM classifier	Identifying the handwritten Tamil characters in the manuscripts	95%
[12]. stone inscription (9 ancient characters with each character containing 35 samples)	Median Filter, Binarization, Segmentation. Shape and Hough transform	Group Search Optimization and Firefly algorithm, K-Nearest Neighbor (KNN), NN, J48 classifier	Feature selection to recognize the ancient Tamil script	
[13]. database generated by Collecting 15 Tamil palm manuscript samples	Otsu's algorithm, line segmentation and character segmentation using Histogram	simple histogram-based approach to segment Tamil palm script character	Number of lines recognized of 96 % and characters found correctly were 87%	87%
[14]. Palm leaf, Stone inscription, Handwritten, Document Image	Gray Scale conversion, Filtering, Adaptative Segmentation	GLCM Feature Extraction	Recognition of Tamil characters from palm leaf	Median Filter decreases the noise
[15]. IWFHR-10 dataset from the HP Labs website	PCA	CNN	To recognize the Tamil character	88%
[16]. 130 samples of Tamil palm leaf segmented characters were taken from Tamil Nadu Archaeological Department		Radial Basis Function (RBF) and Genetic Algorithm (GA)	To classify characters from Tamil palm leaf manuscript	97.7%
[17]. samples of Tamil palm leaf were taken from Tamil Nadu Archaeological Department	Filtering and thresholding, contour based bounding box segmentation	Adaptive Backpropagation Neural Network	Classification of Tamil Palm Leaf Script Characters	96%
[18]. Brahmi characters, Vattezhuthu character set	Gabor filter, overlapped character segmentation method	Hybrid Feature Extraction and Multiclass SVM based recognition method	Character recognition	proposed HFE-MCSVM shows better performance.
[19]. ICDAR 2013	Noise removal, morphology, binarization	Connected Component (CC) algorithm	Line Segmentation Challenges	proposed line segmentation method is successful in bringing out

				the very existence of lines
[20]. 15 variety of classes and each class contains around 1000 different samples palm leaf were taken from Tamil Nadu Archaeological Department		CNN	Recognizing Ancient Characters from Tamil Palm Leaf Manuscripts	96%
[21]. 1000 palm leaf were taken from Tamil Nadu Archaeological Department		CNN	Recognizing Ancient Characters from Tamil Palm Leaf Manuscripts	97%
[22]. 2460 palm leaf were taken from Tamil Nadu Archaeological Department	Gray Scale conversion, Median Filtering, Adaptative Segmentation, GLCM Feature Extraction	RBF and CART	Character classification in the handwritten Tamil palm-leaf manuscript	RBF 98.4% & CART 98.8%
[23]. palm leaf script, which was taken from the U. V. Swaminatha Iyer Library, Chennai.	Contour-based convex hull bounding box segmentation, Binary Coded Value and the Gray-Level Co-occurrence Matrix	Modified Adaptive Backpropagation Network	Classification of Ancient Handwritten Tamil Characters	MABPN-BCV 94.1%, MABPN-GLCM 96.23%
[24]. 1000 palm leaf were taken from Tamil Nadu Archaeological Department	Median Filter	CNN	216 characters are recognized	93%
[25]. IWFHR-10 datasets	Principal Component Analysis (PCA)	CNN	Tamil character recognition	89.85
[26]. 156 Tamil characters with nearly 350 samples for each character	Binarization	CNN	Tamil character recognition	97%
[27].	Filtering, Thickening,	HorVer Segmentation method	Tamil touching character segmentation	91%
[28]. 35 samples for each 12 ancient characters	Adaptative Filtering Method	B-spline Curves	Tamil Palm Leaf 12 Vowel Characters	
[29]. Datasets of Isolated Tamil handwritten character established by HP lab India	Thresholding binarization, adaptive filter, Cropping, Segmentation using TEAS	Deep convolution extreme learning-based Newton Metaheuristic (DCELM-NM)	Recognition of Tamil characters	98%

		approach		
[30]. 121 characters out of 247 for which the dataset is collected from students as well as from Kaggle website		VGG 16	Recognize words given on the combinations of these 121 characters	94.52%
[31]. Prehistoric Stone Image	Binarization, Denoising, character segmentation and size normalization. Zernike moments	Back Propagation deep Neural Network	Tamil Character Recognition	85%
[32]. palm-leaf manuscripts from 'Agathiyar Vaithiyam'	Zoning,	SVM classifier	Recognizing manuscript character images	90%
[33]. Palm leaf manuscript provided by Agamaa Academy	SURF, Bag of Grapheme, Histogram	Enhanced Speeded Up Robust Feature with Bag of Grapheme (ESURF-BoG)	Tamil Palm Leaf Character Recognition	
[34]. palm-leaf manuscripts	Local binary filter, bidirectional long short-term memory (BLSTM) network	recurrent neural network (RNN)	Character Recognition	94.33%
[35]. a standalone dataset of handwritten Tamil characters created by HP Labs India	Linear interpolation and a constant thickening factor	CNN	Handwritten Tamil Character Recognition	95.16%
[36]. a standalone dataset of handwritten Tamil characters created by HP Labs India	Binarization, thinning, Character Segmentation	CNN	Character Recognition	87.33%
[37]. collected own dataset from schools in and around Puducherry and Tamil Nadu	Median filtering, MobileNet approach	A bidirectional gated recurrent unit (BiGRU) model	Handwriting recognition	98.48
[38]. Tamil vowels such as 12 letters	Image binarization, normalization, and noise reduction	CNN-VGG16-RF model	character recognition for Tamil language	94.4
[39]. Stone Inscriptions	Optional histogram clipping, Binarization, Median Filter, Gaussian Blur, non-localized mean	Self-Adaptive Lion Optimization Algorithm with Transfer Learning (SLOA-TL)	Ancient Tamil Character Recognition in Stone Inscriptions	97.81%

Table1: Overall Comparison of survey paper.

Figure 5: Classification Accuracy

4. CONCLUSION

In order to extract the text of the inscriptions from Tamil palm leaf manuscripts, a number of investigations are carried out utilizing both online and offline approaches. Different strategies have been put forth to handle content retrieval and character recognition at different stages of image recognition. An analysis of the performance of several preprocessing, segmentation, feature extraction, and classification algorithms provide an overview of each method's efficiency factor. To identify every Tamil character with any degree of accuracy, there isn't a standard method. The most difficult problems at work are recognizing characters because of their similarities, semi-forms, slants, curves, or loops. Deteriorated or damaged inscriptions and poor image quality are the causes of poor recognition. There has been minimal progress in character identification of ancient scripts due to several technical challenges and a lack of a shared dataset. Successful content retrieval outcomes have recently been achieved using a deep learning model. These are just a handful of the basic issues that can be resolved in the future by enhancing character recognition.

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