Tamil Character Recognition Using K-Nearest-Neighbouring Classifier based on Grey Wolf Optimization Algorithm

Vishal Gali

University of Georgia, Georgia
Ishgali139@gmail.com

Abstract: Optical character recognition (OCR) systems are well-known and very effective in the area of the majority of trendy language recognitions in present data. Not like other languages, the recognition of the Tamil language is highly difficult and therefore significant endeavors have been put in state-of-the-art. Nevertheless, in order to recognize the Tamil characters in an accurate manner, the techniques are not so far developed. Hence, this paper presents a new Tamil Handwritten Character recognition model using 2 important procedures such as recognition as well as pre-processing. The conversion of RGB to grayscale is performed by the pre-processing stage, morphological operations image complementation, binarization with thresholding, as well as linearization. Subsequent to the linearization, the pre-processed image is fed to the recognition through an optimally configured K-Nearest Neighbour. Moreover, the Grey Wolf Optimization (GWO) algorithm is exploited to fine-tune the weights. The developed model performance is evaluated over the conventional techniques regarding various metrics.

Keywords: Handwritten, Preprocessing, Recognition, Tamil, Thresholding

Nomenclature

Abbreviations	Descriptions
CNN	Convolutional Neural Network
OCR	Optical Character Recognition
HTCR	Handwritten Tamil Character Recognition
MMCNN	multi-scale CNN
SVM	Support Vector Machine

1. Introduction

In multi-script documents, script recognition is considered as the important role of OCR [1]. The script is represented as a writing model that consists of a graphical shape and definite symbols. Every feature of script definite attributes which are differing from each other. In an automatic manner, to understand the handwritten documents, the identification of the script is very important. Handwritten script identification received huge attention in the image processing field. The main reason for global digitization is various handwritten books as well as scriptures. The distinctive spatial relation is the foundation of script identification between the strokes of a specific script from each other [3].

Using imaging devices, a machine can transform the handwritten documents that are detained to their corresponding machine-readable as well as searchable documents format frequently indicated as recognition of offline handwritten text. In pattern identification, handwritten text identification is considered the most important active research domain. In diverse real-world applications, the recognition of offline handwritten document text is considered as a vital model, the applications namely bank cheque book processing, postal mail sorting as well as data entry applications. In document images, by recognizing the text contents, the document text identification effortless the automatic data entry applications and therefore it highly minimizes the manual attempt. In implementing a document identifier for any specific language script, the primary step is chosen of appropriate document image database [5]. Here, the initial task is making a novel document image database for the script if the database is not present. The benchmark databases are frequently necessities to implement, evaluate as

well as analyzing diverse handwritten document identification systems. In handwritten document recognition, numerous benchmark databases for research and advancements are present such as Latin, Malayalam, Tamil, and Arabic [2].

Tamil is considered as the ancient language that is mostly exploited in southern India, Malaysia as well as Srilanka. In the Tamil language, the specialty is each sound pronounced possesses a syllable. The characters' economy to point out a word is minimum in the Tamil language. Although numerous isolated research analyses are performed in Tamil Handwritten document recognition, the main problem is the lack of a document image database in the Tamil language.

The main objective of this research is to present a K-nearest neighbor model which is optimally configured for the Tamil characters recognition and also tunes the weight. Moreover, the GWO Algorithm is introduced. Here, the performance of the developed method shows better performance with the conventional techniques.

2. Literature Review

In 2019, Kavitha B.R. and Srimathi C [1], worked on the handwritten Tamil characters identification by exploiting CNN in offline mode. From conventional techniques, CNNs were different from the HTR to extract the features automatically. Moreover, by training mode, a CNN method was developed with Tamil characters in offline mode from scratch. In 2020, Suganya Athisayamani et al [2], worked on the B-spline curves recognition, which was exploited to identify the 12 vowels in palm leaf manuscripts. The benefits of the B-spline curve were forcefulness as well as uniqueness. In the Tamil language, each vowel has numerous curves of diverse angles. To identify vowel, the integration of curves was exploited. In 2017, Ritesh Sarkhel et al [3], presented a new multi-column MMCNN based model. For recognition with SVM, a deep quad-tree on the basis of a staggering prediction approach was augmented with the technique. To maximize recognition rate a multiple level tree network was exploited as it votes via softmax probabilities of all decahexadrants less quadrants than a single CNN. In 2019, K. Manjusha et al [4], modeled a handwritten character image database for Malayalam language script. The conventional handwritten document image databases were a significant obligation for advancement as well as objective assessment of diverse handwritten text recognition systems for any language script. For handwritten Malayalam recognition, substantial research efforts were stated in state-of-the-art. Yet, the Malayalam language was presented. In 2020, Ayan Kumar Bhunia et al [5], developed a new technique of word-level Indic script recognition by exploiting merely character-level data in the training phase. A multi-modal deep network was used in this paper that uses both the online as well as offline data modality as input. A new conditional multi-modal integration technique was presented to integrate information from the online as well as an offline modality that uses the original modality of data being subjected to the network as well as therefore it integrates adaptively.

3. Proposed Handwritten Recognition model

3.1 System Model

In this research, a new Tamil handwritten recognition model is proposed by adopting 2 important procedures as pre-processing as well as recognition. Moreover, the handwritten document is produced manually which comprises numerals, consonants, and verbals. The architecture model of the developed model is illustrated in Fig 1. In the primary phase, the pre-processing is performed; the input image (Im) is fed to the RGB to grayscale conversion, morphological operations, image complementation, binarization with thresholding, as well as linearization. Generally, using the RGB to grayscale thresholding, the input image (Im) is in RGB format that is converted into a grayscale image (Im_{in}). In the binarization with thresholding stage, the grayscale image Im_{in} is transformed into a 2D-image (binary) as well as the global threshold value is calculated over it. Here, Otsu's technique is employed to calculate the image threshold. The threshold calculated (Im_{in}) is transformed to a binary image (white and black) (Im_{th}) as well as it is complemented (binary image inversion). Using morphological operations such as open and close, the pixels below 30 are evaded from the complemented image (Im^{Co}). The resultant image from the morphological operation is indicated as Im_{mo} . Then, Im_{mo} image is linearized that is gamma-accurate RGB values are linearized. At last, Im_{Lin} indicates the linearized image and it is fed to identification through an optimally configured KNN technique.

Fig. 1. Architecture model of Tamil handwritten character recognition

3.2 Pre-processing

To handle the handwritten document image, the pre-processing phase involves specific sub-processes as well as to create it extra suitable for the precise character recognition process.

a) RGB to Grayscale conversion

At first, (Im) in RGB format possesses its spectral module of red, green as well as blue [6]. As exhibited in eq. (1), the conversion of RGB is stated.

$$Im_{in} = \text{rgb2gray}(Im) \quad (1)$$

The (Im_{in}) obtained will range in amid white as well as black values (i.e. 0 to 255). Hence, it is referred to as merely gray shades as well as no other color.

b) Binarization with Thresholding

It is a technique of converting (Im_{in}) into a digital image that is black as well as white image. At first, the gathered image is smutty because of the smearing, text smudging, and aging [7]. The binarized image is signified as Im_b as well as it is obtained based on a threshold value.

Generally, the count of thresholding methods is being used to convert (Im_{in}) into a binary image. Amid them, Otsu's technique is highly efficient as well as it produces better binarization outcomes while background, as well as foreground intensities images, are separated.

Eq. (2) represents the formulation for Optimum threshold calculation, in that $H(Th)$ indicates given grayscale image histogram (Im_{in}) as well as for complete image, mean intensity is indicated as $m_f(Th)$ and $m_b(Th)$.

$$Th^{opt} = \arg \max H(Th) \cdot (1 - H(Th)) \cdot m_f(Th) - m_b(Th) \quad (2)$$

Moreover, the global thresholding is carried out by fixing the optimum threshold amid 0 as well as 1 of a grayscale image. Furthermore, this complete search for thresholding aids in changing intra-class variance that is variance occurs within the classes as well as its signified as a summation of weights of two classes stated in Eq. (3).

$$\sigma_w^2(Th) = \sigma_1^2(Th) \cdot \omega_1(Th) + \sigma_2^2(Th) \cdot \omega_2(Th) \quad (3)$$

$\omega_1(t)$ indicates separated 2 classes probability with a threshold Th as well as mean of class [10]. As per Eq. (4), the between-class variance is stated where, $\mu_1(Th)$ and $\omega_1(Th)$ represents class means as well as class probabilities, correspondingly.

$$\begin{aligned} \sigma_b^2(Th) &= \sigma^2 - \sigma_w^2(Th) \\ &= \omega_1(Th) \cdot \omega_2(Th) \cdot [\mu_1(Th) - \mu_2(Th)]^2 \end{aligned} \quad (4)$$

Generally, from the histogram $H(Im_{in})$, the class probability $\omega_i(Th)$ is calculated, which is stated in Eq. (5). By Eq. (6), the mean class is calculated, where, $x(Im_{in})$ indicates the value at the histogram bin center.

$$\omega_1(Th) = \frac{\sum_{x=0}^{Th-1} H(Im_{in})}{\sum_{x=0}^{Th-1} H(Im_{in})} \quad (5)$$

$$\mu_i(\text{Th}) = \frac{\left[\begin{array}{c} \text{Th}=1 \\ \sum H(\text{Im}_{in}).x(\text{Im}_{in}) \\ 0 \end{array} \right]}{\omega_i} \quad (6)$$

In between 2 values $\text{Th} = 0$ and 1 , thresholding operation is attained as:

A pixel turns out to be black if its gray level is $\text{Th} = 0$.

A pixel turns out to be white if its gray level is $\text{Th} = 1$.

In obtaining the textual information aforesaid technique aids even from lower quality images. At last, the grayscale image (Im_{in}) is transformed into a white as well as black image, as well as threshold calculated binary image is indicated as Im_{Th} .

c) Image Complementation

The ensuing (Im_{Th}) is complemented (inverse of binary or intensity image). “The image complement block estimates a binary or intensity image complement. The complemented image (Im^{Co}) is fed to binary morphological operation [8].

d) Binary Morphology

The input image evaluation is performed based on the shape is referred to as morphology that is Morphology = study of shape [9]. Moreover, the ensuing Im^{Co} is fed to morphological operations such as opening as well as closing.

Opening: “This operation is erosion ensuing by dilation” as well as indicated in Eq. (7). Moreover, it aids in eradicating the lesser object from the complemented binary image (Im^{Co}).

$$\text{Im}^{Co} \circ S = (\text{Im}^{Co} \ominus S) \oplus S \quad (7)$$

Closing: “This operation is dilation ensuing by erosion”. This helps in removing lesser holes as well as gaps from the complemented binary image Im^{Co} , and it is indicated in Eq. (8).

$$\text{Im}^{Co} \bullet S = (\text{Im}^{Co} \oplus S) \ominus S \quad (8)$$

Erosion is “Structure eradication of particular size as well as a shape which is stated as S ”. As per Eq. (9), the erosion (E) of the image Im^{Co} by structuring elements S is indicated.

$$E = \text{Im}^{Co} \ominus S \quad (9)$$

Filling of holes of a particular size as well as shape and size stated using S is expressed as Dilation. As per eq. (10), for the image (Im^{Co}), the dilation (D) by the structuring element S is stated.

$$D = \text{Im}^{Co} \oplus S \quad (10)$$

Hence, by applying morphological operations such as open and close, the pixels below 30 are eradicated. Subsequent to the binary morphology the ensuing image is indicated as Im_{mo} , that is furthermore subjected to the linearization procedure.

e) Linearization

In analyzing the image quality linearization is very important. It is a “process which transforms non-linear image data into linear image data, therefore it is made-up to regress non-linear tone curve is used to linear image data”. From linearization, the image ensuing is referred to Im_{Lin} .

4. Objective model

As aforesaid, the KNN technique is optimally configured through fine-tuning weights using the proposed optimization technique.

The stated objective model is signified in Eq. (17), whereas Acc indicates recognition accuracy of KNN.

$$\text{Ob} = \text{Max}(\text{Acc}) \quad (11)$$

4.1 K-Nearest Neighbour

k -NN is a kind of classification where the function is merely approximated locally and all computation is deferred until function evaluation [14].

As this technique lies on distance for classification if the features indicate diverse physical units or come in greatly diverse scales then normalizing the training data can enhance its accurateness noticeably

[11]. Both for classification and regression, a practical model can be to allocate weights to the neighbor's contributions, hence nearer neighbors give more to average than large distant ones.

The k -NN classifier can be represented as allocating the k nearest neighbors a weight $1/k$ and all others "0" weight. This can be generalized to weighted nearest neighbor classifiers.

$$\sum_{i=1}^n w_{ni} = 1 \quad (12)$$

4.2 Proposed GWO Algorithm

GWO is an optimization algorithm that uses a technique that is enthused using predatory nature of grey wolves in nature by mimicking their hunting behavior [12].

Numerous swarm intelligence methods are mimic the hunting and searching behaviors of few animals. Nevertheless, GWO imitates the internal leadership hierarchy of wolves, hence, in the searching procedure the best solution position can be comprehensively used by 3 solutions. However, for other swarm intelligence approaches, the optimal solution is explored only led by a single solution. Therefore GWO can highly minimize the premature and falling into the local optimum probability.

It is taken into consideration of 4 kinds of grey wolves known as α, β, δ and ω to understand the leadership hierarchy [13].

$$\bar{X}_g(t+1) = \bar{X}_0(t) - \bar{P} \cdot \bar{R} \quad (13)$$

$$\bar{R} = |\bar{Q} \cdot \bar{X}_0(t) - \bar{X}_g(t)| \quad (14)$$

$$\bar{P} = 2\bar{v} \cdot \bar{y}_1 - \bar{v} \quad (15)$$

$$\bar{Q} = 2 \cdot \bar{y}_2 \quad (16)$$

The values $\bar{y}_1$ and $\bar{y}_2$ possess arbitrary values in the [0,1]

$$\bar{v} = 2 - \left[\frac{2t}{\max_iter} \right] \quad (17)$$

$$\bar{X}_g(t+1) = \frac{\bar{X}_1 + \bar{X}_2 + \bar{X}_3}{3} \quad (18)$$

5. Result and Discussion

The developed Tamil Character recognition with an optimization technique was developed and discussed in this paper. Here, the outcomes of the proposed and conventional models obtained were shown. These samples consist of 169 folders with 1000's images. In these folders, there are 0 to 155 character images written in the Tamil language. The developed model was evaluated with conventional techniques such as the Genetic Algorithm (GA) and Artificial Bee Colony (ABC) algorithms.

Fig. 2. Statistical analysis of the adopted as well as existing techniques regarding the accuracy

Fig 2 illustrates statistical evaluation of developed and other existing techniques. As the optimization technique is considered in this paper is stochastic in nature, it is very important to execute it 5 times, as well optimal value attained regarding the accuracy is examined. In the best-case performance scenario, the developed model possesses the maximum value which is superior to the GA and ABC algorithms correspondingly. Here, the proposed method 33% better than the conventional GA, 29% better than the conventional ABC algorithms. From, this analysis, it is evident that the proposed model shows highly effective to the conventional techniques and therefore it is examined to be better in Tamil Character Recognition.

6. Conclusion

In this research, a new Tamil Character recognition model was proposed by using two important procedures as pre-processing as well as recognition. Here, the pre-processing phase consists of five important stages such as the conversion of RGB to grayscale, image complementation, binarization with thresholding, linearization as well as morphological operations. After the completion of the linearization process, the pre-processed image was attained, which was fed to the recognition through optimally configured KNN. To fine-tune the weights, the GWO algorithm is exploited. The developed model performance is evaluated over the conventional algorithms regarding the positive as well as negative metrics.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

References

- [1] B. R. Kavitha C. Srimathi, "Benchmarking on offline Handwritten Tamil Character Recognition using convolutional neural networks", *Journal of King Saud University - Computer and Information Sciences* Available online 15 June 2019.
- [2] Suganya Athisayamani A. Robert Singh T. Athithan, "Recognition of Ancient Tamil Palm Leaf Vowel Characters in Historical Documents using B-spline Curve Recognition", *Procedia Computer Science* 4 June 2020.
- [3] Ritesh Sarkhel Nibaran Das Mita Nasipuri, "A multi-scale deep quad tree based feature extraction method for the recognition of isolated handwritten characters of popular indic scripts", *Pattern Recognition*, 26 May 2017.
- [4] K. Manjusha M. Anand Kumar K. P. Soman, "On developing handwritten character image database for Malayalam language script Engineering Science and Technology", *an International Journal* 5 February 2019.
- [5] Ayan Kumar Bhunia Subham Mukherjee Umapada Pal, "Indic handwritten script identification using offline-online multi-modal deep network", *Information Fusion*, 30 October 2019.
- [6] [35] Pushpajit Khaire, Praveen Kumar, Javed Imran, "Combining CNN streams of RGB-D and skeletal data for human activity recognition", *Pattern Recognition Letters*, vol. 115, pp. 107-116, 1 November 2018.
- [7] Xiaolin Li, Peng Wang, Xin-Jian Xu, Gaoxi Xiao, "Universal behavior of the linear threshold model on weighted networks", *Journal of Parallel and Distributed Computing*, vol. 123, pp. 223-229, January 2019.
- [8] Thomas H. Sharp, Frank G. A. Faas, Abraham J. Koster, Piet Gros, "Imaging complement by phase-plate cryo-electron tomography from initiation to pore formation", *Journal of Structural Biology*, vol. 197, no. 2, pp. 155-162, February 2017.
- [9] Cao Yuan, Yaqin Li, "Switching median and morphological filter for impulse noise removal from digital images", *Optik*, volume. 126, number. 18, page no. 1598-1601, September 2015.
- [10] Bency Jacob and Mr. S.B. Waykar, "Binarization and recognition of characters from historical degraded documents", *Recent Advances in Computer Science*.
- [11] Mashaan Alshammari John Stavarakakis Masahiro Takatsuka, "Refining a k-nearest neighbor graph for a computationally efficient spectral clustering", *Pattern Recognition* 6 February 2021.
- [12] Jun Deng Wei-Le Chen Chi-Min Shu, "Correction model for CO detection in the coal combustion loss process in mines based on GWO-SVM", *Journal of Loss Prevention in the Process Industries* 3 March 2021.
- Avinash Gopal, "Hybrid classifier: Brain Tumor Classification and Segmentation using Genetic-based Grey Wolf optimization", *Multimedia Research*, vol 3, no 2, April 2020.
- [13] Fatima-ezzahra Lagrari, "Image Steganography for Pixel Prediction using K-nearest Neighbor", *Multimedia Research*, vol 3, no 2, April 2020.