

HYBRID NEURAL NETWORK ARCHITECTURE FOR AGE IDENTIFICATION OF ANCIENT KANNADA SCRIPTS

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ABSTRACT

Wide research has been carried out and is still taking place in the field of character recognition of handwritten English characters. Recognizing English characters is much simpler as there are only 26 letters and each letter is quite distinct from others compared to recognition of Indian language characters. Indian language characters have a base character along with vowels attached, forming single characters (raw characters). Origin of Kannada, a language of southern India, is as old as 5th century AD. The fonts have evolved over the centuries. The work involved is implemented in two phases. The first phase of the work incorporates an Artificial Neural Network for identifying the base character. The second phase consists of a Probabilistic Neural Network model designed for the identification of age pertaining to the base character. Characters dated from 3rd century BC to the present day are used for analysis and experimental results.

1. INTRODUCTION

Many researchers have been working on script recognition for more than three decades. Nevertheless, it remains to be one of the most challenging problems in pattern recognition. Kannada, as a separate language came into existence in 5th century AD, with its own letters [1]. Fig.1 shows the changes in the letters that have taken place during the course of time. The 18th century characters are almost of the same versions that are currently in use.

Brahmi script, appearing for the first time in Ashoka's* inscriptions is the mother of all the scripts of the 'Sanskritic' and 'Prakritic' inscriptions found in different parts of India [2]. Kannada language is derived from 'Brahmi' script dating back to 3rd century BC. Kannada letters, unlike English has vowels attached to form single characters. For instance in Fig.2, the first character is pronounced as 'coo' as in 'cool' and the second as 'key' which belong to the set of the third letter pronounced as 'cu' in 'cut'. The third letter is the base character.

The word '*Epigraphy*' is derived from two Greek words viz., *epi* meaning *on or upon* and *graphie* meaning *to write* and hence, epigraphy is a study of writings engraved on stone, metal etc.

Application of Artificial Neural Networks (ANN) for pattern recognition and character recognition has been more widely reported in literature in recent times. This has led to high expectation of what neural networks can do for different fields, especially fields where other approaches have not been successful [3]. Bayesian classifiers perform the classification

tasks more accurately. Probabilistic Neural Network (PNN), a Bayesian classifier is used in our work [4][5]. One of the advantages of using PNN is that no training is involved prior to classification.

𑀓	𑀔	𑀕	𑀖	𑀗	𑀘	3rd BC -2nd AD
𑀙	𑀚	𑀛	𑀜	𑀝	𑀞	2nd -5th
𑀟	𑀠	𑀡	𑀢	𑀣	𑀤	5th - 6th
𑀥	𑀦	𑀧	𑀨	𑀩	𑀪	6th - 8th
𑀫	𑀬	𑀭	𑀮	𑀯	𑀰	8th - 9th
𑀱	𑀲	𑀳	𑀴	𑀵	𑀶	9th - 11th
𑀷	𑀸	𑀹	𑀺	𑀻	𑀼	11th - 13th
𑀽	𑀾	𑀿	𑁀	𑁁	𑁂	13th - 15th
𑁃	𑁄	𑁅	𑁆	𑁇	𑁈	15th - 18th
𑁉	𑁊	𑁋	𑁌	𑁍	𑁎	18th onwards

Figure 1. Evolution of Kannada characters (Courtesy: Department of Epigraphy, Archaeological survey of India, Mysore)

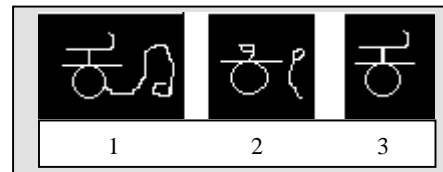


Figure 2. Sample of present day Kannada Characters

The paper is organized as follows: Section 2 elucidates the preprocessing necessary for the raw character images. Section 3 describes the Hybrid model incorporating the Artificial Neural Network and the Probabilistic Neural Network. Section 4 describes the Experimental results.

2. PREPROCESSING OF CHARACTERS

Data used for analysis has been obtained from The Department of Epigraphy, Archaeological survey of India, Mysore. The data, scanned is as shown in Fig.1. Each letter of different centuries are converted to Bitmap images. These images are scaled

horizontally and vertically in proportion to fit a grid size of 10x14 pixels. This is followed by thresholding the image by a cutoff of 0.5 to convert gray scale images to monochrome images. These monochrome images are suitable for MATLAB implementation.

3. HYBRID MODEL

A Hybrid model incorporating the Artificial Neural Network (ANN) and Probabilistic Neural Network (PNN) is suggested in the paper. The work is mainly organized in two phases. The first phase involves recognition of present day version of the character. The second phase involves identification of the age of the character using Probabilistic Neural Network. Each base character has a characteristic Probabilistic Neural Network model, whose selection is decided by the ANN.

3.1 First Phase - Artificial Neural Network For Base Character Recognition

A Neural Network is a massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge and making it available for use [6]. During this phase, as shown in Fig.3, The ANN is trained by backpropagation algorithm to identify the present day base character corresponding to input character. The ANN thus, selects the PNN model assigned to the base character.

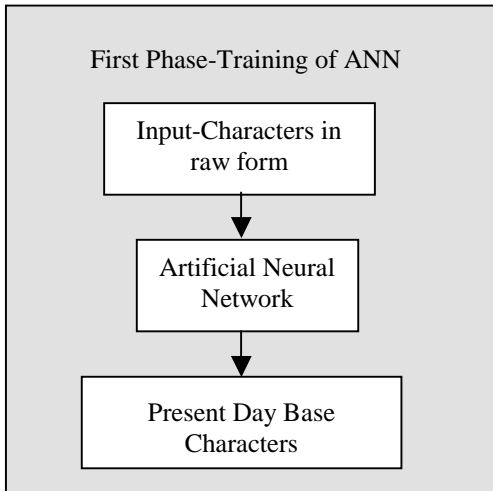


Figure 3. Block diagram illustrates recognition of base character.

3.2 Second Phase - Probabilistic Neural Network For Age Identification

PNN has an input layer, an exemplary layer, a summation layer and an output layer as shown in Fig.4. The activation function of a neuron in the case of the PNN is statistically derived from estimates of probability density functions (PDFs) based on training patterns [7]. PNN has prior data of known characters belonging to different centuries set as the interconnecting weights. The test character fed to the ANN is then fed to the PNN model selected in the first phase. The age of the character is the output of the PNN.

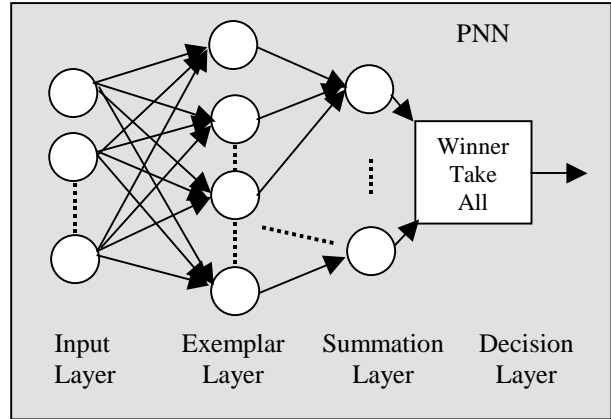


Figure 4. Model of a Probabilistic Neural Network. Test Character is fed to the input layer and the age of the character is obtained at the output.

The exemplar layer consists of the activation functions corresponding to each of the training sets. Estimator for the PDF is,

$$p(x | s_i) = \frac{1}{(2\pi)^{m/2} \sigma_i^m |s_i|} \sum_{j=1}^{n_i} \exp \left[\frac{-(x - x_j^{(i)})^T (x - x_j^{(i)})}{2\sigma_i^2} \right] \quad (1)$$

Where $p(x | S_i)$ is the probability of vector x occurring in Set S_i , the age of the character.

$x_j^{(i)}$ = j^{th} exemplar pattern or training pattern belonging to class S_i , century.

n_i = is the cardinality of the set of patterns in class S_i .

σ_i = Smoothing parameter.

The summation layer consists of one summation unit corresponding to each class. Each unit is used to compute the sum in (1) from the outputs of the previous layer. The output layer is the decision layer (Winner-take-all) [7][8] that selects the maximum posterior probability $p_r(S_i | x)$, from the outputs of the previous summation layer for each i . Posterior probability $p_r(S_i | x)$ that the vector x is from Class S_i is given by Bayes' rule ,

$$p_r(s_i | x) = \frac{p(x | s_i) p_r(s_i)}{p(x)} \quad (2)$$

where $p_r(x | S_i)$, $i=1,2,\dots,k$ is the priori PDF of the pattern in classes to be separated. $p_r(s_i)$, priori probabilities of the classes are equal (assumed equally likely). $P(X)$ is assumed to be constant. The decision rule is to select class S_i of the Age of the character for which $p_r(S_i | x)$ is maximum. The hybrid model can be visualized with the help of block diagram shown in Fig 5.

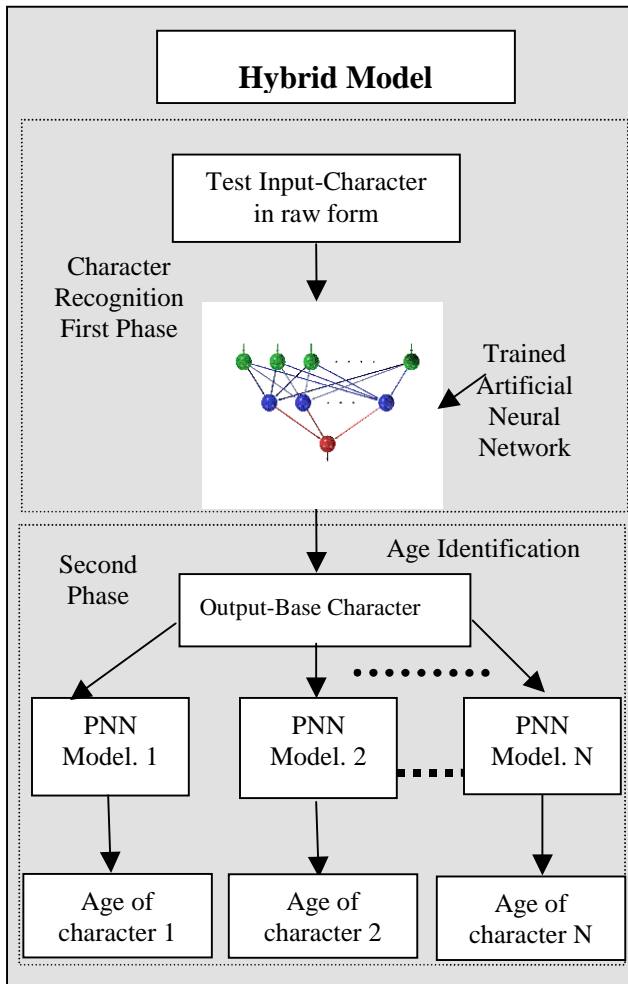


Figure 5. Program flow depicting the Hybrid model

4. EXPERIMENTAL RESULTS

4.1 Base Character Recognition by ANN

The neural network is trained for a set of 30 base characters. A typical set of results for nine different versions of nine different characters evolved over a period of 18 centuries as shown in Fig. 6 is presented. The characters used in the analysis range from 3rd century B.C to 18th century AD. Three similar sets of data were used to train the ANN.

4.2 Age identification by PNN

The PNN was tested with different sets of data. Some misclassifications were found in some of the characters of first 3 centuries in 1,2,7, 8 and 9 rows of Fig.6. The PNN also recognized images corrupted by random noise generated in Matlab with sufficient accuracy. Some of these images are shown in Fig. 7.

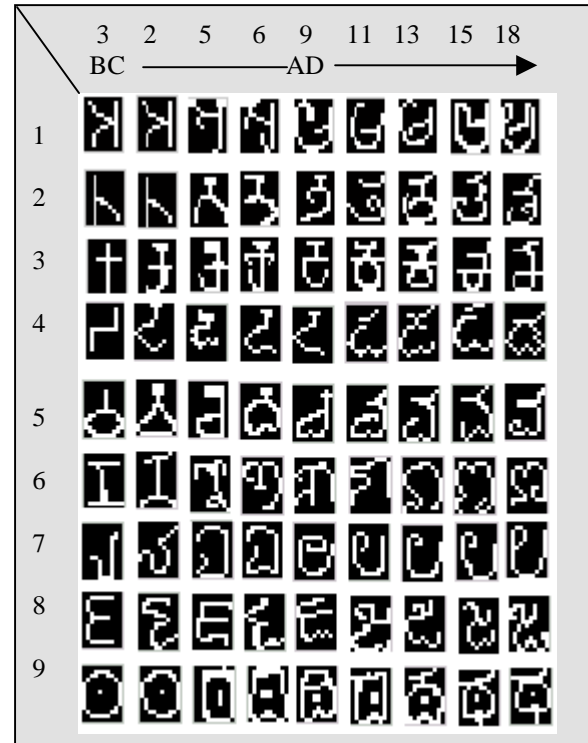


Figure 6. Set of Characters ranging from 3rd century BC to 18th Century AD.

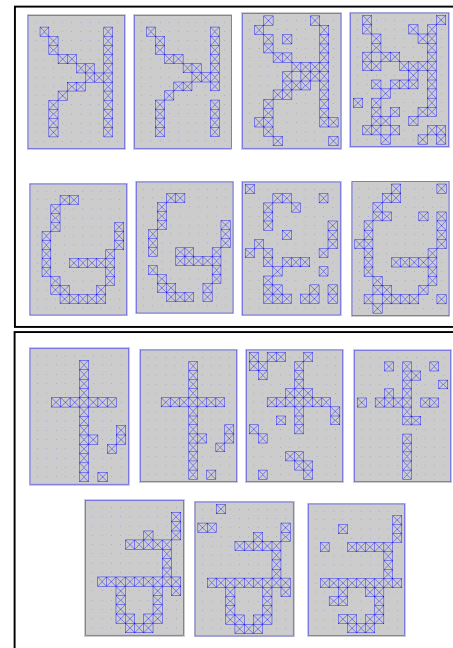


Figure 7. Images accurately classified by PNN.

The first row of characters in Fig. 7 belong to the same century with the first letter as the original character and the other three noisy versions of it. The first row corresponds to 1st character in Fig. 6 belonging to 3rd Century BC. It is pronounced as 'a' in 'China'. Similarly, the 2nd row corresponds to the same letter of 11th century AD. The 3rd row of characters correspond to 3rd

Century BC, 3rd character in Fig. 6, pronounced as 'cu' in 'cut'. Similarly, the 4th row corresponds to the same letter of 15th Century AD.

One of the age misclassifications of PNN is shown in Fig. 8. The 3 characters are the 9th row letters in Fig. 6 corresponding to 3rd BC, 2nd and 5th AD respectively. The base character, pronounced as 'Tha', belonging to 3rd Century BC, was correctly identified by the ANN and misclassified by the PNN as belonging to 2nd century AD.

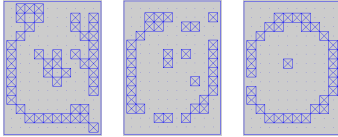


Figure 8. Characters misclassified by PNN.

5. CONCLUSIONS AND FUTURE SCOPE

The hybrid model developed is comprehensive and is implemented for 30 characters of different centuries ranging from 3rd century BC to present day. However, some characters of certain centuries are not discovered (denoted by – in figure 1) and hence could not be used for analysis. The classification and age identification of different characters by the hybrid model were satisfactory. This model can be easily extended to most of the other Indian languages. Script translation from ancient centuries to the present day of the ancient scripts can be developed using this model.

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