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Recognition of Handwritten Currency Symbols using Fuzzy Inference System

Arshia Gupta[1], Haneet Kour[2], Jatinder Manhas[3], Vinod Sharma[4]
[1, 2, 4]*Department of Computer Science and IT, University of Jammu, India*
[3]*Department of Computer Science and IT, Bhaderwah Campus, University of Jammu, India*

Abstract: ***In recent years, soft computing techniques have played an important role in the field of Handwritten Recognition. These techniques have been applied by different researchers to recognize handwritten scripts, alphabets, characters and so on. But no system has been proposed for the recognition of handwritten currency symbols. In this study, an automated intelligent system has been presented to recognize the handwritten currency symbols efficiently using Fuzzy Inference System (FIS). The experimental study has been conducted on the real dataset of the handwritten currency symbols of five topmost Asian richest countries. FIS has been implemented with subtractive clustering (SC) and fuzzy c-means (FCM) methods. The experimental result predicted that FIS with Subtractive Clustering achieved accuracy of 96.4% whereas FCM based FIS predicted 84% accuracy; hence SC-FIS outperformed FCM-FIS.***

Keywords: GLCM, FIS, Handwritten Recognization, Subtractive Clustering, Fuzzy C-Means.

I. INTRODUCTION

Even after an immense research, handwritten recognition is still a challenging task. These challenges occur due to enormous variations in handwriting. But handwriting is still a basic method in documenting our thoughts for the communication purpose. In the digitized era, it is more convenient to have digital document for communicating, storing and information retrieving. Now-a-days, it has been a trend to convert handwritten documents to digital one. It is more convenient via efficient handwritten recognition system instead of spending an ample amount time and money in operating the data entry tasks [**1**].

As the previous research in the field has focused on the recognition of digits, characters and different language scripts; still there are no such attempts to recognize Handwritten Currency Symbols. The need and necessity of currency symbol cannot be neglected as it represents the exact worth of money. If currency symbols get changed, the value of money also changes like **₹100 != $100.** Not only the exact worth of money is represented but also helps in determining the nation's economic health and hence the well-being of all the people residing in it **[2]**.

The main objective of this paper is to present an intelligent automated Handwritten Currency Symbol Recognition System based on Fuzzy Inference system (FIS). For the current study, handwritten currency symbols of five topmost Asian richest countries have been considered. FIS has been implemented with Subtractive Clustering and Fuzzy C-Means (FCM) as well.

II. LITERATURE REVIEW

The main aim of proposed research is to recognize handwritten currency symbols using Fuzzy Inference System. FIS have been applied by various researchers in pattern recognition. It has been found to be efficient for handwritten recognition such as scripts, alphabets, digits and so on

Novák et al. [**3**] presented three models to recognize characters printed on hot and cold metal ingots. These models were created with the help of neural networks, fuzzy logic, and fuzzy-valued functions. According to the results of the experiments, the fuzzy-valued function had the highest character recognition rate of 87.7%.

Shelke and Apte [**4**] introduced a model based on fuzzy based multi-stage classification for the recognition of handwritten devanagari script. This model classified 24 classes using fuzzy inference system. The presented system predicted recognition accuracy of 96.95%.

Popko and Weinstein [**5**] implemented structural approach to recognize handwritten digits by combining fuzzy logic with convolutional neural network. The presented model was validated on MNIST dataset. The proposed algorithm was shown to be flexible, with a high recognition rate of 99.23 percent.

For off-line word recognition, *Alvarez et al.* [**6**] suggested a fuzzy classification model. This method worked by segmenting single characters from given words and then marking each pixel as either vertical or horizontal strokes.

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The related positions between the vertical and horizontal strokes were then obtained using dynamic zoning. The extracted features were then used to point a character in standard grammar as a string, which was then validated using a Deterministic Finite Automaton. Finally, a Fuzzy Lattice Reasoning classifier was used to classify the data. The experiment was conducted on the IAM dataset, and the presented model estimated an accuracy of 90.80%.

For handwritten compound character recognition in Bangla script, *Pramanik and Bag* [**7**] implemented a shape decomposition-based method. Binarization and granular noise cleaning were used to preprocess the input image, which was then followed by segmentation area detection. Following that, group forming and shape decomposition were performed. Finally, features were extracted using a chain code histogram feature collection, and classification was performed using a multi-layer perceptron (MLP).

Ghazanfar et al. [**8**] proposed a numeral recognition scheme for English, Arabic, Persian, and Devanagari numerals in order to form fuzzy sets of the features extracted using modified structural features. Each image had its geometrical primitives extracted. The results of the feature extraction process were fed into Neural Network and Nave Bayes classifiers. The fuzzy set-based decision mechanism was used to improve the recognition process by processing incorrectly recognized numerals. As per experimental results, the usage of fuzzy set-based decision process for both classifiers improved identification.

Nanehkar et al. [**9**] set out to recognize handwritten Farsi digits written in a variety of styles. To determine the best approach for recognizing handwritten Farsi digits, the authors compared standard methods such as K-nearest neighbor, artificial neural network (ANN), and support vector machine (SVM) classifiers with deep neural network (DNN). The experimental results predicted that SVM achieved 99.3% accuracy rate, whereas DNN got accuracy of 99.45% results.

III. METHODOLOGY

This study presents an automated handwritten currency symbol recognition system based on Fuzzy Inference System approach. The experimental study has been carried out on Matlab platform. The primary dataset of handwritten currency symbols has been collected offline. In the current study, the currency symbols of the five top most Asian richest countries [**10**] have been considered, as shown in table 1. This dataset consists of 200 images of each handwritten currency symbol, thus having 1000 images in total. Figure 1 presents one sample of currency symbols (considered in this study) written by anonymous person. The collected dataset has been divided into two sets in the ratio 80:20 i.e Train Set and Test Set. Thus Train Set has 800 images and Test Set has 200 images of handwritten currency symbols. The overall methodology of the current study is presented in figure 2.

Table 1: Top five Asian Richest Countries

COUNTRY	Currency Symbol	CurrencyName
China	¥	Yuan
India	₹	Rupee
South Korea	₩	Won
Indonesia	Rp	Indonesian rupiah
Turkey	₺	Turkish Lira

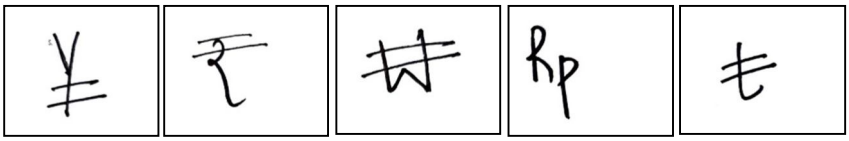

Fig. 1. Handwritten Currency Symbols

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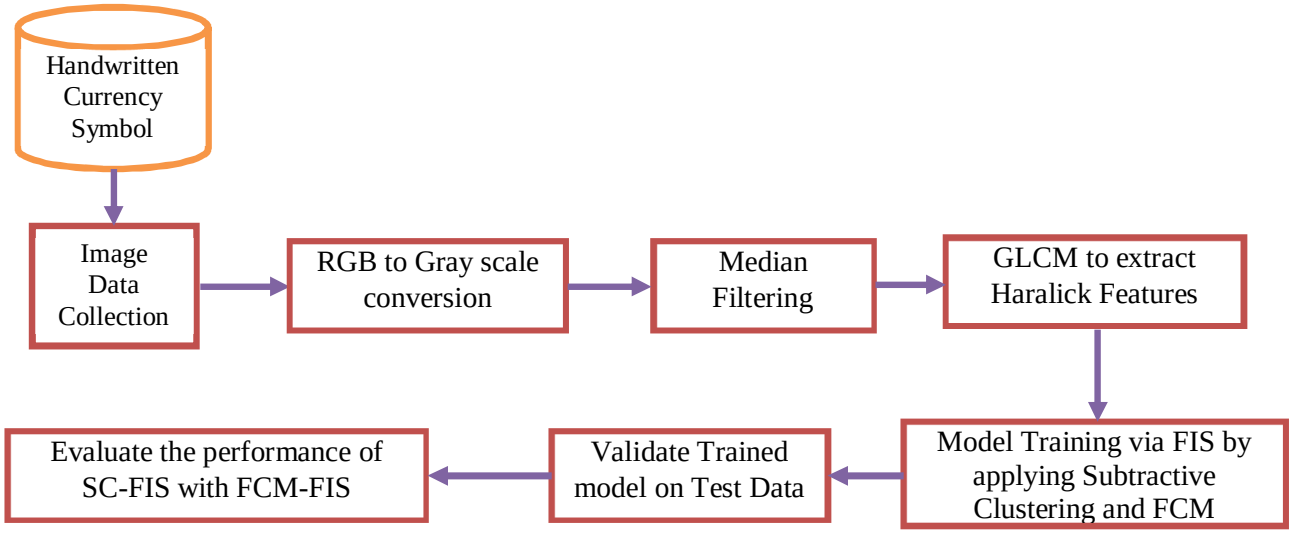

Fig. 2: Methodology of the current work

The collected images of handwritten currency symbols are in the RGB format. Before model training, pre-processing and feature extraction have been carried out. For pre-processing, the collected images have been converted to gray-scale format. After this, median filtering has been applied to deal with noisy images. For feature extraction, GLCM (gray level co-occurrence matrix) has been applied at angle of 0°, 45°, 90° and 135° in order to compute Haralick Features. Total 52 haralick features have been computed for each image. These extracted features have been fed to FIS (fuzzy inference system) for model training.

In the current study, FIS has been implemented with subtractive clustering [**11, 12**] as well as fuzzy c-means (FCM) [**13**] in order to evaluate the performances of these two FIS for handwritten recognition. Subtractive Clustering based fuzzy inference system (SC-FIS) has been applied to classify handwritten currency symbols by setting cluster of radius = 0.6, squash factor = 2.0, accept ratio = 0.8 and reject ratio = 0.7.FCM based fuzzy inference system (FCM-FIS) has been implemented with 'gauss' membership function for each feature.

IV. RESULT AND DISCUSSION

The main objective of the current research is to implement recognition system for handwritten currency symbols based on fuzzy inference system. For the current work, two FIS systems have been implemented and their performance has been evaluated on the basis of four performance metrics: accuracy, recall, precision and f-score. The Experimental Results of SC-FIS and FCM-FIS for handwritten currency symbol recognition have been presented in table 2. From these results, it has been found out that both FIS can be used effectively for the recognition of currency symbols taken in this study. SC-FIS achieved accuracy of 96.40% with precision of 96.44% and recall of 96%. FCM based FIS predicted accuracy of 84% with precision of 83.99% and recall of 83.94%. Also the former achieved f-score value of 0.9502 and the latter got f-score value of 0.83.

Table 2: Experimental Results of SC-FIS and FCM-FIS for handwritten currency symbol recognition

FIS	Accuracy	Precision	Recall	F1-Score
Subtractive Clustering	96.40%	96.44%	96%	0.9502
FCM	84%	83.99%	83.94%	0.83

Figure 3 presents the comparative analysis of SC-FIS and FCM-FIS for handwritten currency symbol. It has been analyzed that SC based FIS outperformed FCM-FIS approach as the accuracy achieved by the former is better than that of the latter. FCM-FIS predicted more false positive and false negative as it achieved less precision and less recall values than those of SC-FIS.

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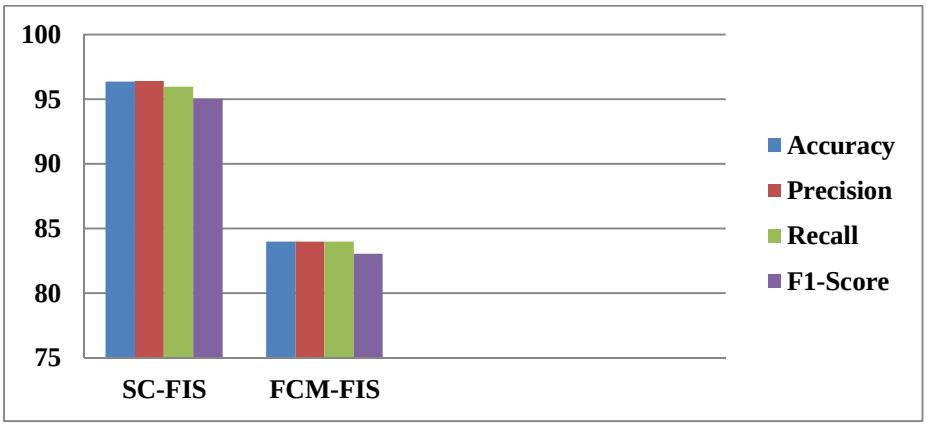

Fig.3: Comparative Analysis of FIS Techniques under study

V. CONCLUSION

It has been concluded that the fuzzy inference system is quite able to recognize the handwritten currency symbols efficiently. However, Subtractive Clustering came out to be the promising technique in recognizing currency symbols and achieved the better results than those of FCM approach. The current study is limited to only currency symbols of top most five Asian richest countries. In future, this work will be extended to include currency symbols of other countries.

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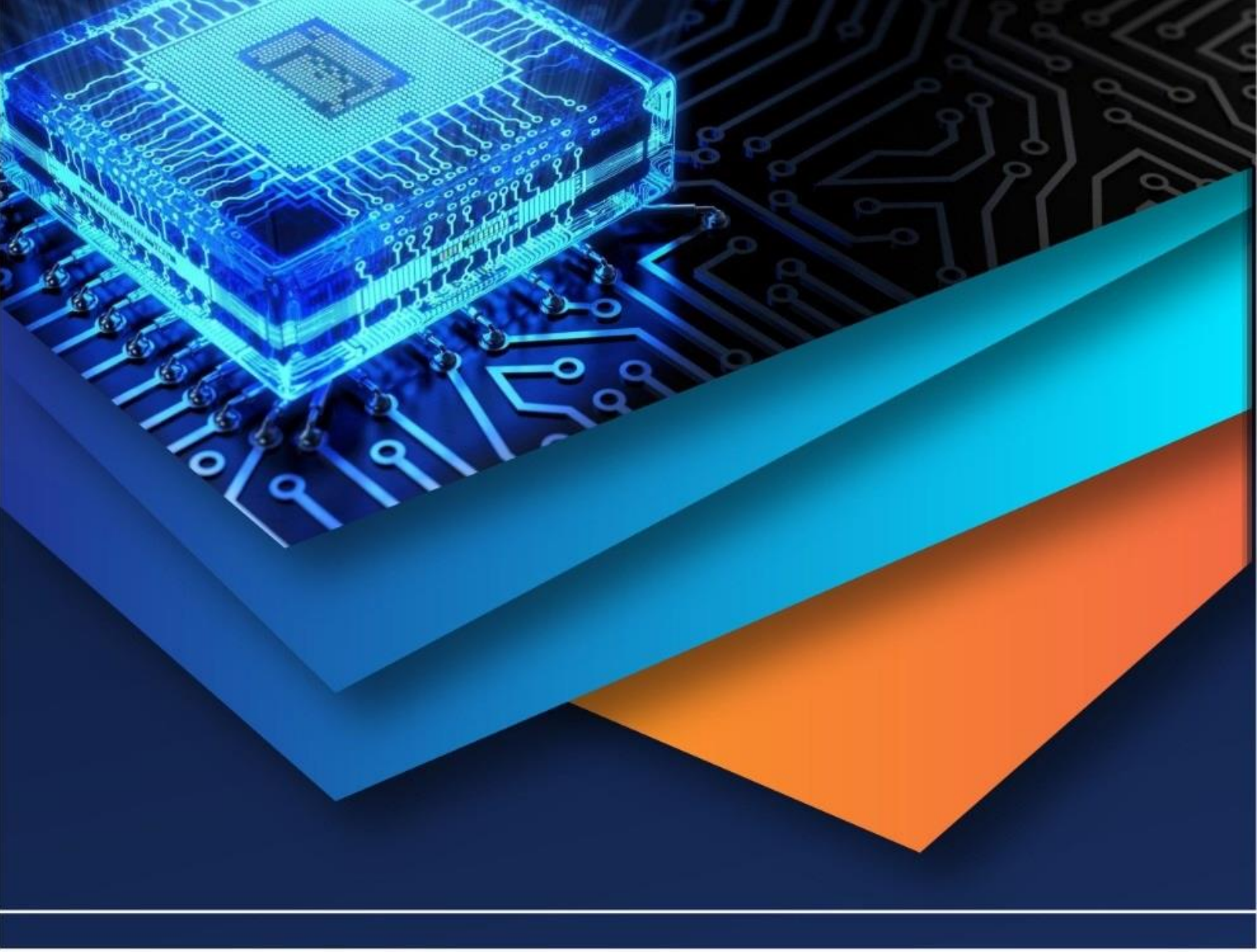

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