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Zig-zag diagonal and ANN for English character recognition

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ABSTRACT

Pattern recognition is the most popular are in the modern world. Significant progress has made in English character and digits recognition technology. However, the performance of the existing system of English character and digits recognition can be increased. This study is suggested a novel method, zig-zag diagonal feature extraction method along with ANN to increase the recognition rate of the English character and digit recognition system. The proposed method of this method is tested on an official dataset of English characters (EMNIST) and English digits (MNIST), achieving a 99.8% accuracy and 94% accuracy, respectively.

Key words: ANN; backpropagation algorithm; feature extraction; OCR.

1. INTRODUCTION

A recent problem in pattern recognition is automatic word recognition, which can be recognized by an optical character recognition system (OCR) [1]. OCR system can convert the test of any images into a readable and editable format. With the help of OCR, scanned documents, PDF and images can be easily read and edit. The steps in OCR includes optical scanning, pre-processing, local segmentation [2]. In a character recognition system, feature extraction is a very useful step of the recognition system.

The goal of the feature extraction step is to extract the representing informative from the character that can help to understand or identify the pattern of the character - useful task helps to minimize the difficulty of the classifier. Zoning method is a prevalent and useful method, and it plays a very efficient performance to recognize the characters [3].

OCR is widely used as a tool for information extraction from printed paper such as identity card, statement of the bank, and computerized bill. Automatic character recognition has to turn into an useful research area of pattern recognition for several decade as its several requirements and needs [4]. Various types of modern and ancient scripts have been recognized such as, English [5], Chinese [6], Devanagari [3], Bangla [7] etc. under modern script, and Brahmi [8, 9], Ariyaka [10], Akharamuni [11] etc. under ancient category. However, the performance of the existing systems can be further increased by introducing new techniques.

English is a popular language of the world, and several types of techniques of feature extraction and classifiers are already applied to recognize the digits, characters, words, and text of English script. Widely applied feature extraction techniques are geometric, structural, chain code, and zoning methods. Similarly, ANN and SVM have been performed well to recognize the script.

Pradeep, et al. [12] used a hybrid technique of diagonal features and directional features to recognize the English characters and feedforward NN, radical basic function NN, the nearest neighbor, used to classify the extracted features. Similarly, Pradeep, et al. [13, 14] applied raster diagonal feature extraction technique along with ANN to recognize the English characters and achieved 99 % [14] and 97.84% [13] where 69 types of the feature used to identify the characters. The performance of this study is very well.

This study is focused on increasing the recognition rate of the English characters. Feature of English character is extracted by a new method (zigzag diagonal method), and ANN is used to classify those features. This study is also focusing on evaluating the recognition rate of the suggested method to the current promising techniques, which is used in English numeral recognition [15], and English character recognition [16].

Previous techniques belong to this study are discussed in section II. The suggested method to recognize the English character is explained in section III. Performance evaluation, including the discussion, is presented in section IV. In the last, closing comments are specified in section V.

2. LITERATURE

Feature extraction and classifier plays a significant role to develop the recognition system. So, this literature is considered the several methods of feature extraction and classifiers for the multiple recognition systems.

Structural, transformation-based, and statistical methods are mainly applied to extract the features of any character. Structural features focus on the shape of the character, such as line, points, curve, etc. Geometric also features part of the structural features [17], Transformation-based features

belong to Fourier Transform category [18], Zoning [3], projections [19] are the most common statistical features where zoning method is most popular method compare to other methods of this category.

Horizontal, vertical, and diagonal, these three types of method can be used to extract the feature based on the zoning method. Pradeep et al. [13, 14] mentioned that the diagonal feature extraction method has high performance compared to horizontal and vertical feature extraction method, and have notified that diagonal features have a strong correlation compared to horizontal and vertical features [20, 21]. Thus, diagonal feature extraction has a high accuracy compared to vertical and horizontal feature extraction. Two types of features can extract the diagonal method; (i) raster scan, and (ii) zig-zag scan.

As the conclusion of the comparison of feature extraction methods, The diagonal feature extraction method with zoning and binarization has a high performance in comparison to horizontal and vertical feature extraction with zoning and binarization [13, 14]. And the accuracy could be increased because this study used a raster scan method. Accuracy of horizontal, vertical and diagonal raster scan is 80.5%, 84.21%, and 98% respectively [14]. A similar study is also conducted in 2011, where the accuracy of horizontal, vertical, and diagonal raster scan is 92.69%, 93.68%, and 96.52 % respectively. Whereas, both studies conducted by the same authors on handwritten English characters recognition. Several features were 59 and ANN used to classify it.

Zig-zag scanning order performs better, and it is more efficient compared to the raster scanning order [20, 22]. The zig-zag scan is one of the most important for complex patterns, and it achieved good accuracy in Iris recognition [23]. Mitrpanont and Imprasert [24] believed that zig-zag method is a useful way to extract the features of those characters who have similar features and authors applied it to extract the features of handwritten Thai characters and increased accuracy was 2.13% from the other existing system. So, according to this analysis, it could be suggested that the zig-zag diagonal method along with zoning and binarization will perform well to extract the features of English character and digits and will help to increase the accuracy.

For the comparison between classifiers as the classification of the words and characters recognition for increase the accuracy, SVM and ANN have a high accuracy rate compared to other classifiers like HMM, K-nn, K-means classifier, Naïve Bayes, etc. [25-30]. Furthermore, Pradeep et al. [13, 14] used ANN for the classification of extracted features of English characters which are extracted by raster diagonal zoning method and El Kessab, et al. [15] also used ANN for the classification, and zoning, zigzag method separately used to extract the features of English digits. Thus, automatic English character and digits recognition will be introduced using the zig-zag diagonal zone method for feature extraction and artificial neural network for classification.

3. METHODOLOGY

Feature extraction and classification are the step of the system to recognize the English characters and digits. Feature extraction is a step where each character is converted into a feature vector by using feature extraction methods, which is used as an input to a classifier to identify the class [31]. The classifier can obtain the identity of the class and presented as the output of the system.

3.1 Feature extraction

A useful feature of the character will increase the accuracy of character recognition [32]. In this study, a hybrid method is introduced, that is the combination of the zoning method and zig-zag diagonal scan with the binary image to extract the feature of English character and digits.

Every character size is 27×18 pixels, which are divided into 9×9 zones, and the size of each zone is 3×2. So, 81 types of features have been used and are shown in Figure 1.

Features of each zone are used to extract the features by moving along the zig-zag diagonal scan of its respective 3×2 pixels and each zone has six values.

Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9
Z10	Z11	Z12	Z13	Z14	Z15	Z16	Z17	Z18
Z19	Z20	Z21	Z22	Z23	Z24	Z25	Z26	Z27
Z28	Z29	Z30	Z31	Z32	Z33	Z34	Z35	Z36
Z37	Z38	Z39	Z40	Z41	Z42	Z43	Z44	Z45
Z46	Z47	Z48	Z49	Z50	Z51	Z52	Z53	Z54
Z55	Z56	Z57	Z58	Z59	Z60	Z61	Z62	Z63
Z64	Z65	Z66	Z67	Z68	Z69	Z70	Z71	Z72
Z73	Z74	Z75	Z76	Z77	Z78	Z79	Z80	Z81

Figure 1: Character is divided into a zone

The value of each zone is scanned in a zig-zag manner and stored in a vector that is called a feature of the character which is shown by f_n. This procedure is sequentially repeated for all the zones.

$$f_n = [1\ 2\ 4\ 5\ 3\ 6] \quad [1]$$

Where, f represents the features, and n shows the number of zones (each image is separated), and [1 2 4 5 3 6] is the position of the pixels which is shown in Figure 2.

Values of f_n of all zone will be eugenically stored in a vector, and that vector will be called feature vector which is denoted by X_m

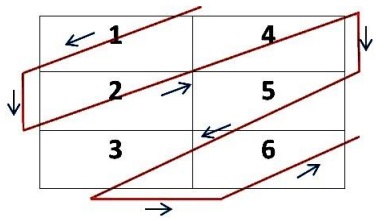

Figure 2: Position of the elements of a zone

$$X_m = [f_1, f_2, f_3, \ldots \ldots f_n] \quad [2]$$

Where X denotes the feature vector of a character and m indicates the number of samples for the training.

3.2 Classification

The classification step is used as a decision-making step of a recognition system, and it is used the extracted features as input from the previous step.

The feedforward NN (FFNN) is used to recognize the extracted features of English character and digits. The network is trained by back-propagation learning algorithm. This network takes extracted features as input and a target vector for the identification of the input vector during training. The weights of the network are continuously adjusting to reduce the errors in the training time. Along with the feature vector and target vector, several neurons in each layer, learning rate momentum, and the error value are also given as input to train the network.

Feed-forward backpropagation NN along with two hidden layers is performed as the classifiers. The log-sigmoid activation function is used for the hidden layer, and the competitive layer is the output layer to recognize the English character. Length of the feature vector (Xm.) is used to represent the amount of input neurons. The most optimized network is taken and presented at the training time of the network. Parameters of the neural network to recognize the English characters and digits are presented in Table 1.

Table 1: Parameters to train the network

Parameters	Values
Input nodes	486
Number of hidden layers	2
Hidden nodes	20, 20
Training algorithm	Levenberg-Marquardt backpropagation
Perform function	MSE
Training goal	0.01
Training epochs	50
Validation checks	10
Learning rate	0.1

4. RESULT

The proposed method is a hybrid of binarization, zoning method, and zig-zag diagonal scan, so the accuracy of the hybrid method is compared to these three methods (binarization, zoning method, and zig-zag diagonal scan). So, for the performance evaluation with Binarization method, the proposed method is applied to an official dataset of English alphabet dataset (EMNIST) [33]. Binarization and ANN used for the feature extraction and classification of English character [16]. Similarly, official dataset of the English digits (MNIST) [34] is used to compare the result with the zoning method and zig-zag diagonal scan because El Kessab, et al. [15] used MNIST dataset to recognize English digits and also use zoning method and zig-zag diagonal scan method to extract the features of English numbers.

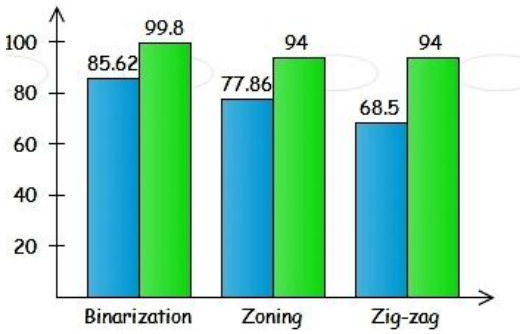

Figure 3: Comparison with base paper

So, for the performance comparison, two types of official datasets are used in this study; namely EMNIST [33] (English alphabet) and MNIST [34] (English digits datasets). Three hundred samples of each character for all 26 class means, 7800 samples are used to recognize the English characters. Similarly, 300 samples are used to identify the English numbers, and ten types of the class mean, 3000 samples are used to recognize the English numbers. One hundred samples of each class of English characters and digits are applied to test the accuracy of the advised technique.

Binarization technique was applied for the features extraction of English characters and achieved 85.62% accuracy [16]. Zone method was used to extract the feature of Latin digits and achieved 77.86% accuracy, and MNIST official dataset was used in this study [15]. The zig-zag scan was also used to extract the feature of Latin digits and achieved 68.5% accuracy, and again the MNIST official dataset was used in this study.

The proposed method achieved 99.8% accuracy, and 94% accuracy to recognize English characters (EMNIST) and English digits (MNIST) respectively (Figure 3).

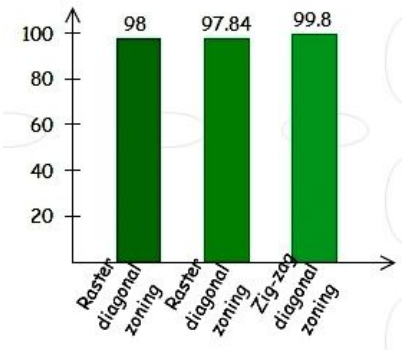

Figure 4: Comparison between raster diagonal and zigzag method

Pradeep et al. [13] used a method which was a combination of binarization, zoning, and raster scan. That study achieved 97.84% accuracy to recognize the English characters. However, no official dataset was used in this study. Raster scan was also used with binarization and zone method to extract the feature of English character [14]. Archived accuracy by this was 98% while, a total number of 54 features used in that study. The proposed method has been applied to the EMNIST dataset, which is the official dataset for English characters and achieved 99.80% accuracy (Figure 4). After the whole comparison, the proposed solution shows better performance compared to previous studies and show that the zig-zag scan is performed better compare to raster scan.

5. CONCLUSION

This study is introduced a hybrid method (zig-zag diagonal zoning method) for the feature extraction of handwritten English alphabets and numbers, and ANN used to classify the extracted features. This technique mainly focusses on improving the performance of raster diagonal zoning method. EMNIST and MNIST official datasets are used to train and test the system. Twenty-six classes of English characters and ten classes of English digits is considered. The proposed method achieved 99.8% accuracy, and 94% accuracy to recognize English characters (EMNIST) and English digits (MNIST), respectively. Accuracy of the suggested system is compared to the other studies and found out the proposed method is better to other studies.

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