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A New Design Based-Fusion of Features to Recognize Arabic Handwritten Characters

Amani Ali Ahmed Ali, Suresha M.

***Abstract:** Precise character recognition is a challenging task. The problem of reaching a conclusion in classification technique and feature set selection obviously fetches out in this manuscript with sufficient study. The proposed model processes the issue as well as handling the automatic selection issue of suitable features particularly for multi-font or style of Arabic script to get better character recognition. In this paper, introduced a model depended on fusion strategy for handwritten script recognition and identification of multi-font with SH Roqa, Naskh, Farsi, and Igaza. Experimentation has been performed on AHDB and AHCD data sets. The results of the experimental show an excellent performance with higher accuracy.*

***Index Terms:** Arabic handwritten script, Character recognition, Features fusion, Multi-font type.*

I. INTRODUCTION

The recognition systems of character in a freestyle and unconstraint handwritten document images have important attention, which convert the scanning document into digital format and editable text wherever is hold on within the pc for future use. Segmenting the lines of text into characters may be a terribly important step within the character recognition system of written scripts. Also, the segmentation of text line or the segmentation of word into character becomes thus complicated attributable to the free and joined nature of letter of the written pictures. Its many-sided varies of application as language based mostly learning, for blind reading aid, cheque process of the bank, and communication automation. Character recognition has two basic phases that are the segmentation and recognition, that the segmentation may be a basic innovate character recognition.

For languages like English, Latin and, Chinese have sufficient study research but in images of Arabic script are continuing active and not sufficient, therefore Arabic character segmentations is the most difficult because various styles of writing that make characters and the segmentation of text line so difficult, because of large number of letters with their various shape in various location and a huge character set with very high similarity of letters these all make the work of the segmentation of off-line scripts is not easy where a good system should be treating with different styles of handwriting, different font sizes and connected characters. The main phases within the segmentation of text handwriting images are segmented into characters, words, and line and finally, recognize the character. The noise of mages is removing within the stage of pre-processing; classify each character unambiguously by extracting the feature firstly and secondly distinguishing discrimination features in the phase of the feature extraction and use a classifier within the classification stage.

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II. RELATED WORK

In [1], review in detailed over recognition systems of script from multi-script type. In [2], a new segmentation technique is utilized for recognition of the text with three main subset domains analysis. To avoid detection failed authors used the Skeletonization method. They achieved a high accuracy with 98.9 and 97.4 on AHDB and IFN/ENIT datasets. [3] The features extraction of input images has been done and the functions of SVM used as a recognizer, for a letter recognition of Arabic script utilizing CNN. HACDB database has been used and achieved accuracy with 94.17%.

[4] Utilized the word document images thinning for the objective of fetch the stroke width of one pixel also to remove the ligatures of Arabic characters' shape and geometry are used in the segmentation procedure. The suggested segmentation approach deals with touching characters. [5] Explained the handwritten script recognition utilizing Artificial Neural Networks, Support Vector Machine and Template Matching. Among the way utilized, Artificial Neural Networks ended up giving more accurate outcomes. [6] Endeavored the handwritten recognition utilizing Deep Learning. Authors utilized CNN because of that the accuracy has been incremented also the computation time has been decreased. This study achieved 99.2% accuracy rate.

[7] Made an endeavor to identify a handwritten character by utilizing SVM classifier also MLP Neural Network. Various kernel-based SVM such as the classifiers of the quadratic kernel-based SVM, polynomial kernel, and linear kernel are utilized. Within the classifier model of SVM, there are training and testing phases. From every character, around 25 features have been extracted with the assistance of that SVM is trained. Among the three kernels utilized the linear kernel provides 94.8% accuracy rate. In [8] used the Hough Transform along with the method of Skeletonization for segmentation of the text and Gaussian mixture modelling framework method. The authors utilized the combination of Euclidean distance and Convex metrics to get the distance among neighboring overlapped components, classified as an intra-word or as an inter-word distance.

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III. PROPOSED METHODOLOGY

A. Proposed Model

Let $F=\{f_1, f_2,..., f_n\}$ be feature extraction techniques which used in the proposed model, $C=\{c^1,c^2,..,c^k\}$ is the k classifiers which used in the recognition process development. Given $W=\{w_1,w_2,...,w_m\}$ where m is scripts set of the character and the number of the scripts in a multi-type font, Arabic document images here w_i is the number of the characters in the ith script of Arabic, where $1 \le i \le m$. For all m script of Arabic apply the feature extraction strategies and obtain an individual feature set f. For all f_j which is a feature set train every k classifiers in the set C and obtain the recognition accuracy of the Arabic script. With offered C, f_j and W obtain accuracy after that select the classifier that is C_j^m which has the best rate of the accuracy utilized in W to identify Arabic scripts firstly and then recognized Arabic scripts using a feature set f_j. Evaluations of accuracy need testing set and training set to test and train the classifier C^k.

$$C_{F^+}^k = \max\{C_{F^+}^{k_1}, C_{F^+}^{k_2},...,C_{F^+}^k\} \quad (1)$$

Perform the experimentation also for all n number of the features with k number of the classifiers and obtain a selected list of the classifier $\{C_1^{k_1}(1..m), C_2^{k_2}(1..m),..., C_n^{k_p}(1..m)\}$ that for all n features is the highest accuracy.

The new model has k classifiers and n features for Arabic script recognition in an efficient way utilizing the features fusion. In level case of the feature fusion, using rule of features concatenation the extraction of feature from extraction strategy of n features are combined as $F^+=\{f_1, f_2,..., f_n\}$ that is an input into individual classifier and with highest accuracy of recognition classifier is selected like a method for Arabic script recognition. Eq. 1 is the selected classifier which depended on the feature fusion F^+ as mentioned in Figure 1.

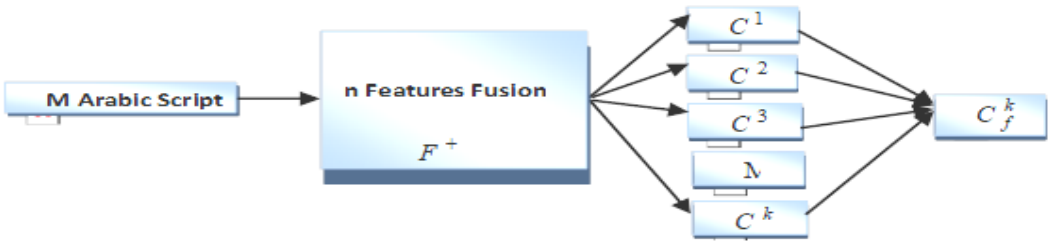

Fig. 1. Feature level fusion and classifier selection for script recognition and identification.

The recognition score threshold in the procedure of the fusion needs to be specified, where samples set with value smaller than the value of the threshold in the score of the recognition will be choose to train the next layer classifier. When specify θ must not be so huge which led to so much well samples recognition these are chosen to do classifier training of next layer that might make the next layer classifier incapable to concentrates on those bad recognized samples, which will decreasing the fusion performance of the classifier. Also θ must not either be so small which led to be the selected samples number might be so small that might too reason for issue of numerical unstable during the training of the following layer.

The whole samples number of the training is denoted by m, the number of the samples along with score of the recognition smaller than θ which through f classifier is recognized is indicated by m', the ration for a f classifier and specified recognition score θ is indicated by $R(\ )$ in Eq.2, the correctly number of the sample recognized through f along with recognition scores larger than θ denoted by M and the correct sample rate along with larger than θ in the recognition score is denoted by $CRR(\ )$ in Eq.3.

$$R(f,\theta) = \frac{m'}{m} \quad (2)$$

$$CRR(f,\theta) = \frac{M}{m-m'} \quad (3)$$

A. Feature Extraction

Gabor Filter Response: Filters of Gabor those have optimal resolution of joint in both domains of frequency and spatial and have properties selective of frequency and selective of orientation are filters of band-pass. The visual system of human is similar to Gabor filter orientation and Frequency performance. Therefore, to discriminate and perform six classes' texture authors exploited response of Gabor filter.

Gabor filter considered as a linear filter with defined impulse response via a function of Gaussian multiplied by a function of harmonic, Gabor Filter Response denoted by GFR. Because Convolution theorem which is the multiplication property of convolution, the harmonic Fourier convolution function and the Gaussian Fourier transform function is the transform of Fourier of a Gabor filter's impulse response and it is given via Eq.4:

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$$g(x,y,\lambda,\theta,\psi,\sigma,\gamma)=\exp\left[\frac{-x'^2+\gamma^2y'^2}{2\sigma^2}\right]\cos\left[2\pi\frac{x'}{\lambda}+\psi\right] \quad (4)$$

Here $x^l = x\cos\theta + y\sin\theta$, $y^l = x\sin\theta + y\cos\theta$, λ performs the cosine wavelength factor, θ performs to parallel Gabor stripes function the normal orientation, Ψ performs the offset of stage, σ performs the envelope of Gaussian and γ performs the aspect ratio of spatial determining the Gabor support ellipticity function [9]. In this work utilized $\sigma=(2,4,6,8,10)$ for scale and $\theta=(0^0,45^0,90^0,135^0)$ for orientation and therefore gained 15 Gabor responses and for every response calculate the energy. Therefore, gain a 15 features vector.

Transition features: Another set of feature inspected in this manuscript which depending in both horizontal directions and vertical directions from background pixels to foreground pixels on the transition value extraction, from left side to right side and top side to bottom of image is skimmed for the objective of information extraction of transition the extraction action of those feature as in the following way:

Action1: 32 zones with 8×4 size spilt the Arabic handwritten contoured image.

Action2: For every zone the transitions number is calculated for every word image the 32 features are extracted.

Feature Set of Directional Chain Code Frequencies: The input image outline points' directional chain code frequencies are so beneficial for various applications like word and character recognition and segmentation. In our suggested model the images outline pixels' directional frequencies of chain code are extracted through the rule in the following: Arabic handwritten word covering by the minimum rectangle with bounding box is extracted for all input images in the beginning and adapted all images with a normal size of 32×32 pixels for eliminating the features to size and position, where this value chosen for normalized depend on many studies on geometric and experimentations. The maximum point of the top left to the point of flat maximum scanned the outline horizontally of the image via window map with size 8×4 over the image which includes 32 without blocks overlapped blocks also extracted chain code frequencies of eight directions for every block where eight directions showed in Figure 2 (a). Like extract a replacement with the set of feature with eight orders, have given to ease the features into four sets suit to four orders as shown in Figure 2 (b). In this figure displayed the four directions which through the zero and four directions the direction code of horizontal is specified, through the direction one and five the direction of principal diagonal is masked, through the direction two and six the direction code of vertical is displayed, and lastly through the three and seven directions the off direction code of diagonal is specified. So gained four values in all block indicating the appearances of those quantities also those four orders which utilized as feature set of direction of local contour, an unvarying block size is 32 with (8×4) which is treated in all image also four directions are computed which is in each block four features therefore 32×4=128 features are gained for all image for the objective of extracting those features.

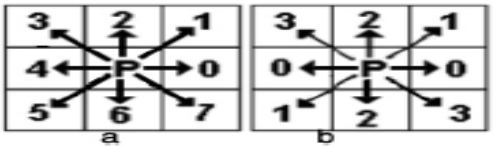

Fig. 2. Code pattern of eight direction chain (b): Code pattern of four direction chain.

B. Learning Classifier

Linear Classifier: It is a statistical classifier type denoted by LC utilizes a linear mixture features value for creating a class label. Mostly relying on circumstances, the linear classifier application where the classification speed is a significant problem. In feature vector the magnitude is large effort of LC as in the Eq. 5:

$$Y = f(w,x) = f\left(\sum_i w_i x_i\right) \quad (5)$$

Here a simple function denoted by f where the value is applied relying a confident threshold to the individual classes, weight vector denoted by w_i where a marked training set examples is learned, and the testing feature vector model is denoted by x_i .

Linear Discriminant Analysis: It is a linear classifier denoted by LDA also it finds an appropriate projection in a typical two issue of class that samples from various classes are fine separated and samples in a certain class minimally are scattered. Projection minimizes in every class the variance and maximizes among the two classes means the distance. In that time LDA project in the V direction the data points on line which maximizes Eq.6 or specifies a projection which maximizes the criteria function $J(V)$, here the means are μ_1 and μ_2, the two classes variance are σ_1^2 and σ_2^2. The data of training and projected compared with offered unknown sample utilizing NN classifier.

$$J(V)=\frac{|\mu_1-\mu_2|}{\sigma_1^2+\sigma_2^2} \quad (6)$$

Sequential Minimal Optimization: Sequential Minimal Optimization denoted by SMO solves quadratic programming which denoted by QP of support vector machine which denoted by SVM. The problem of QP is breaking by SMO into sub problem of QP, through solving a programming problem of quadratic a support vector machine of soft-margin is trained as mentioned in Eq. 7:

$$\max_{\varphi} \sum_{j=1}^{N}\varphi_j - \frac{1}{2}\sum_{j=1}^{N}\sum_{i=1}^{N} b_j b_i K(a_j,a_i) a_j a_i \quad (7)$$

Where $0 \le \varphi_j \le p,\ \ for\ j=1,2,3,...,N, \sum_{j=1}^{N} b_j\varphi_j$, here suppose a dataset $(a_1,b_1),(a_2,b_2),...,(a_N,b_N)$ where a vector of input which denoted by a_j and a label of binary which denoted by $b_j \in \{-1,+1\}$ with a classification problem of binary label, the function of kernel which provided through user denoted by $K(a_j,a_i)$, the multipliers of Lagrange denoted by variables φ_j and an hyper parameter of SVM denoted by

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p. In the beginning SMO the problem is breaking by this method into a sub-problems groups of smallest possible these analytically are solved. The issue of smallest possible includes φ_1 and φ_2 multipliers due to the constraint of linear equality including the multipliers of Lagrange, the constraints decreased to $0 \le \varphi_1, \varphi_2 \le p$ where $p = b_1\varphi_1 + b_2\varphi_2$ for any φ_1 and φ_2 multipliers, which p is the sum negative on the term rest inside equality constraint that in every iteration is fixed.

IV. EXPERIMENTATION

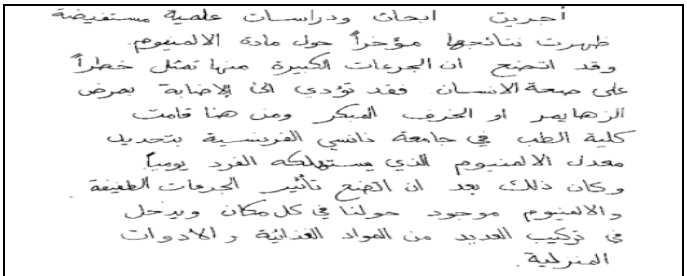
The proposed model is running on different databases of Arabic handwritten script, which are AHDB and AHCD databases. For the correction of the skew, the authors implemented the skew detection and correction algorithm in [10]. AHDB includes words and paragraphs of Arabic handwritten written through 100 various writers. The outcomes of experimental tabulated in Table 1 showed the accuracy of the characters recognition with percentage of 60/40 for training/testing over AHDB for the suggested model on four font type of Arabic script such as the type of the multi-font that appear in one document image combination of multi-type font and single font in documents images. AHCD dataset contains 16,800 characters those by 60 users are written. The outcomes of experimental tabulated in Table 1 showed the accuracy of the character recognition along with the percentage of 60/40 for training/testing over AHCD for the suggested model on four type of Arabic font as the type of the multi-font which appear in one document combination of multi-type font and single font in documents.

The suggested model obtains a high and good rate of the recognition for every type of Arabic font. The recognition outcomes of the characters of Arabic handwritten script visualize by mentioned in Table 1.

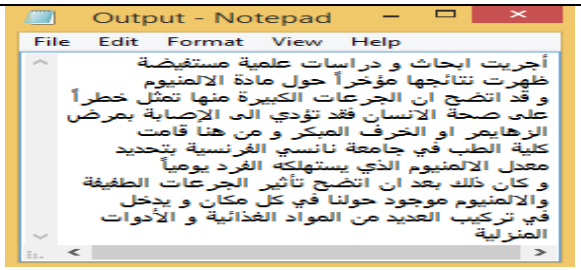
In Figure 3 displayed a few handwritten character recognition samples even with touching letters and overlapping letters in the document images of Arabic with every mentioned font type on AHDB and AHCD datasets also with other datasets for the objective of the validation.

Table 1. Arabic Script Recognition Accuracies

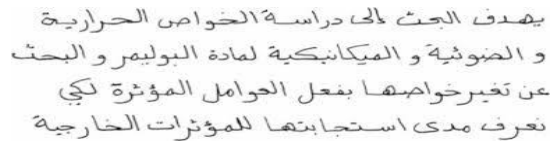
Font type	Dataset	
	AHDB	AHCD
Roqa	92.67	97.20
Naskh	97.12	98
Farsi	95.13	98.20
Igaza	99.24	99.55
Multi-font	97.30	98.95



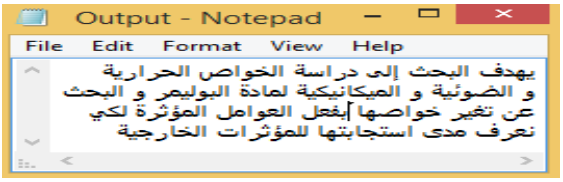
3.a Test Image1



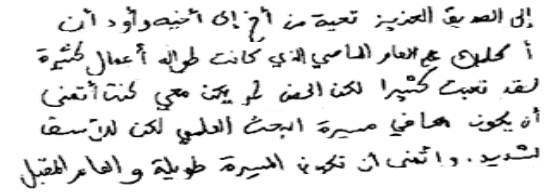
3.b Output Documents of Test Image1



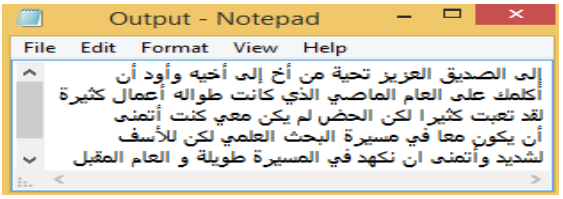
3.c Test Image2



3.d Output Documents of Test Image2



3.e Test Image3



3.f Output Documents of Test Image3

Fig. 3. Samples of Arabic handwritten characters recognition results

V. CONCLUSION

In this study, reliable characters' recognition of handwritten in Arabic script domain undertaken different types of the font as Naskh, SH Roqa, Igaza Farsi, and multi-fonts has been developed. The process of feature fusion range is concentrated. Proposed a selection method of features and classifiers automatically for the handwritten character recognition with Arabic, the proposed model is performed on appropriate utilization classifiers and extraction of features techniques. The proposed models verified the helpful for the advanced recognition issue of the patterns also made on the data given through base classifier better decision. Models are performed over common strategies of feature extraction; the fusion of appropriate features is proposed for improving the accuracy of character recognition.

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