

# Handwriting Recognition System Based on OCR

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## Abstract

In this paper, a new handwriting recognition system is proposed. This system was designed to recognize the isolated arabic characters and a group of characters that are merged to give a word. In arabic language the character is written in a different shapes according to its position in the word, that means the shape of the letter when it is written in the beginning of the word is not like the shape of the same letter when it is written either in middle or in the center of the word. This connectivity is a challenge in handwriting recognition, so we always search for a good methodology to make this recognition more sufficient. In this system we proposed a system that take a character from the user which is inserted as an image, this image is converted to be digital and this image is segmented to recognize the edges of the image, then it will be divided into small squares which are have an intensity values according to its color, which is ranged between 0 and 255. The recognition process is done by using artificial neural network to apply a matching process to recognize what is the image, and either it is a character or a word. This system is applied over 60 characters and 400 words, and it gives a high accuracy and an excellent performance which is 99.44% for recognizing character and 98.53% for recognizing words.

**Keywords:** Handwriting Recognition, Arabic Language, Image Processing, Artificial Neural Network.

# 1 Introduction

Every day the requirements of life increase, in the past the students just learn one language in a school, but today they learn two or more languages. Whereas their parent haven't time to learn them all the requirements. This lead to find a solution in which a computer can be a teacher of them.

In the past years, the handwriting recognition faced with many problems in dealing with many languages such as:Arabic, Farsi, Chinese, and other [1]. But in the advanced grades the problems with handwriting recognition is solved, and become more accurate and dynamic.

Writing is the most way that using over the world to transmit the culters from generation to generation, by using different tools according to the available ones.

In the natural state, the human can recognize the character and its shapes by using his eyes, but in computer machine where it follows an algorithm which is trained to a machine by the human's code to get a recognition process. In the machine case, it may not able to distinguish the characters; the characters may be written by a different writers of the same language, and the same person may write the same character in a different ways [2].

The needs to make a handwriting recognition system is not restricted in a specific language. In many studies, the researchers proposed a recognition system to recognize many languages, such as: Arabic language [3, 4], English language [5, 2] , Japanese language[6], Indian language[19], and Chineese language [18]. There are two types of the Handwriting Recognition: On-line handwriting recognition, and Off-line handwriting recognition. In each type there are a positive and negative points. But in general the On-line recognition system is more difficult than the Off-line recognition system in the implementation process.

In comparing the On-line handwriting recognition and the Off-line handwriting recognition, we can see that the recognition rates is higher in Off-line handwriting recognition because it has lower temporal information[19].

In this study, the online recognition system is presented, where the writing process is done in a real-time then the character is directly converted into another format as a function of time. When the user writes on screen by using the mouse, the signal is traced into coordinates in function of time:  $x(t)$  and  $y(t)$  [1].

In computer machine, the written character is dealed as a binary image. Then this image will be processed and manipulated by the image processing techniques which are presented by the feature extraction process and the matching process.

There is a technique is used with the blank spaces in the entire document which is called text padding, in which the blank spaces is filled by extraction

blocks of normalized text, so a texture block is created with a predefined size [8].

Another approach in the image processing techniques is the feature extraction, in which the features of the image is extracted by using many techniques such as: fourier transformation, Support Vector Machine(SVM), and classifier technique [9].

This paper begins with the Introduction, then the Arabic language concept is presented, the related works of the handwriting recognition are introduced, the experiment of this study is explained and finally the conclusion and the future works are illustrated.

## 2 Arabic Language

Arabic language is the native language of the arab people (about 250 millions) who are lived in 22 countries, and the second language of some countries, in where they use it behind there language.

Arabic language is the language in which the Holy Quraan was revealed. The Holy Quraan is the muslims book, and the muslims people should use arabic language to read Quraan and in thier praying regardless of thier spoken language.

Arabic language belongs to the family of Semitic languages. This family contains many languages such as Amharic, Tigre, Syriac, etc. which are had a long history over thousands of years[10].

Arabic alphabet consists of 28 letters, in which there are many letters that haven't any familiar letters in English language such as the letter dadh, which is a special character in Arabic Language and it make the Arabic language from other languages distinctive, and according to this specific characteristic, the Arabic language is called "logat al-dadh" which is mean "al-dadh language". In Arabic language, the shapes in which the Arabic letters are written differs according to it's position in the word. That means, when the Arabic letter is written in the beginning of the word it should have a shape that is unlike the shape of the same letter when it is written in the end or in the middle of the word, and the letter may be written in isolated form according to the structure of the word.

Another different between Arabic and another languages is the written procedure, in which the Arabic word is written in a connected way (the characters are strung together to form a word) whereas the English word is written in separated way (each character is written separately to form a word) As shown in the below figure.

This connectivity may make a problem in the recognition The Arabic letters

are written from right to left unlike many languages that are written from left to right. For all the previous mentioned reasons, the Arabic language is a perceptive language. Figure 2 shows the alphabet letters with its shapes[11].

### 3 Related Works

There are many researches presented in Arabic handwriting recognition, the following explanations introduce some of them.

In 2004, the researchers present a handwriting recognition that is writer-independent and it is online system. This system depend in it's work on cluster generative statistical dynamic time warping. They present a character recognition experiments of frog on hand using CSDTW and online handwriting database. And they applied the system on a Linux Compaq iPAQ embedded device. The accuracy of thier system record a high result[5].

Sternby et al. used a novel algorithm to find an application that make a template matching scheme in the recognition system of Arabic script. This algorithm treat the diacritical marks dynamically. The template used in this system is robust to conditions, and the training data is scarce. In the experiments of the system, there is a reference system based on the promising state-of-the-art network technique of BLSTM is performed. In this system the actual shape matching is independent of the dictionary, this means that it can give a results with dictionaries and without it[12].

Another work in the same year, Assaleh et al. present a handwriting recognition for arabic alphabet which is online and based on video images. Thier work depend on the hand motion, which is give an information about this motion. After this analysis, they applied a discret cosine transform, Zonal coding and low pass filtering. Then it is classified by a classification technique, and it is enhanced to reach a multiresolutional classification. The result of this work shows a high accuracy with 99% recognition rate[13].

In 2010, Ishida et al. proposed an algorithm for a sequence classification which is named Hilbert warping algorithm. This algorithm worked with an image sequence which is taken by a camera. The proposed method depend on phase synchronization to align the input image sequence to be a reference sequences. The aligment process and the acumulative distance are caculated at the same time and then they are used for the classification process. In this handwriting recognition the proposed method gave a high recognition accuracy[14].

Another work in handwriting recognition system but with offline mode

was published by Kala et al. by using the genetic algorithm. In this system the authors have a collection of images which they were converted into graphs. Each graph presents one character and this graph was mixed to generate a styles as a children of the parent styles, then the matching process was applied between any graph and the system's graphs. This system was applied on English characters, and they used 69 characters as training data, where the number of inputs was 385 inputs. This system was correctly recognized 379 characters, so in this study the researchers reach a high accuracy (98,44%)[15].

In 2011, The recognition system of the signature was presented by Chaudhari et al.. In this paper the researchers present a handwriting recognition system by using three techniques of the feature extraction. They test their system on 560 signatures for 56 persons with 10 signatures for each person. Each signature processed by three techniques of feature extraction (Hus Moment, Zernike moment, and Krawtchouk moment). Then they applied a neural network training, and used a fuzzy hyperbox. Their system record a good result in using these features and it records a high accuracy rate[16].

## 4 Experiment and Methodology

Since the proposed study focus on the handwriting recognition for learning the children, it deals with a special group of people, so it was designed by using graphics and sounds to attract the child to use this program.

The methodology of the proposed system have many steps, start with write a character using a pen and a small pad. This character will be read as image, this image will be preprocessed and analyzed using many image processing methodologies to use in the OCR process. Every image will be divided into 25 squares, each square has a value.

The main problem that the proposed algorithm solved is that the Arabic words are written only by connected characters not by isolated characters, so there is need to find an end point to stop and take a segment of picture then recognize what this character is as shown below.

In proposed algorithm we used the Microsoft Agent, in which we can create this system with a voice animations for our applications and create an animated content. And we used the image processing techniques to extract a features of the character's images.

The main problem which be solved by this paper was how the system can recognize the character and also the word. The system has two parts, the learning part in which there is no recognition process and it displays the right way to write any character or word. And the other and the most intersted and important part is the testing part in which the user write the character or

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Figure 1: Example of arabic word

no	shape	Final	Medial	Initial	no	shape	Final	Medial	Initial
1	ا	ا	ا	ا	21	ح	ح	ح	ح
2	ب	ب	ب	ب	22	خ	خ	خ	خ
3	ت	ت	ت	ت	23	د	د	د	د
4	ث	ث	ث	ث	24	ذ	ذ	ذ	ذ
5	ج	ج	ج	ج	25	ر	ر	ر	ر
6	چ	چ	چ	چ	26	ز	ز	ز	ز
7	ح	ح	ح	ح	27	س	س	س	س
8	خ	خ	خ	خ	28	ش	ش	ش	ش
9	د	د	د	د	29	ص	ص	ص	ص
10	ذ	ذ	ذ	ذ	30	ض	ض	ض	ض
11	ر	ر	ر	ر	31	ط	ط	ط	ط
12	ز	ز	ز	ز	32	ظ	ظ	ظ	ظ
13	س	س	س	س	33	ع	ع	ع	ع
14	ش	ش	ش	ش	34	غ	غ	غ	غ
15	ص	ص	ص	ص	35	ف	ف	ف	ف
16	ض	ض	ض	ض	36	ق	ق	ق	ق
17	ط	ط	ط	ط	37	ك	ك	ك	ك
18	ظ	ظ	ظ	ظ	38	گ	گ	گ	گ
19	ع	ع	ع	ع	39	م	م	م	م
20	غ	غ	غ	غ	40	ن	ن	ن	ن

Figure 2: Arabic alphabet shapes



Figure 3: Arabic character with 1 segment



Figure 4: Arabic character with 2 segment

the word on real time. In this model we used many processing algorithms to reduce the processing time to show the result in a short time.

#### 4.1 Data Set

The data set of this system has 60 individual arabic characters, and also 400 arabic words. In this system the training concept is presented because it is designed to be learning system, so the program shows to the user how to write the characters or words in the right form.

In the figure 5, the character data set is shown, and a sample of 400 words are also shown. The arabic letters are 26, but here we used 60 characters because

د	ؤ	ماهن
ا	ء	رحلة
أ	ئ	ربيع
ب	ر	خريف
ت	لا	شاه
ن	لأ	حروف
م	ي	كلمات
ع	أ	ارقام
ح	ة	بصل
ج	و	هاتف
د	ظ	ليرة
ع	ط	تغلب
غ	ذ	بجاجة
ف	ظبيعة	جمال
ق	وردة	خيل
ث	صيف	تلب
ص	تعليم	راسي
ض	أرب	زهرة
ش	أسد	سوف
س	تفاح	شروق

Figure 5: Sample of the data set

every letter has many shapes according to its position. See the following example. In addition, in the recognition system the user can add a new character



Figure 6: Example of the shapes of one arabic character

or word to this database, so this system has many functions to learn the right way to write any arabic character(s) and it is not limited to only recognition process.

## 4.2 Reading image

The proposed system is dealt with each character or word as an image. This image will be read when it is processed and matched with the tested image that present the character which will be recognized.

For each character and word there are 5 samples that were written by different persons so we have:

$60 \times 5 + 400 \times 5 = 2300$  samples in our data base.

Each image consists of many pixels, in which the pixel presents the smallest unit in the image. Figure 7 shows the structur of an image. Suppose that the size of this image is  $256 \times 256$  pixels.

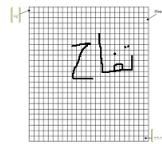


Figure 7: Structur of image

## 4.3 Feature selection

In this stage, many goals would be achieved to get a usable image such as, noise reduction, normalization, and compression the data of the image to be smaller in size.

The normalization process is applied in both size horizontaly and verticaly of the image. This normalization is done to get an optimal size which rise the recognition performance. The figure below shows an example of normalization of character.



Figure 8: Structur of image

An analog signal can be converted to digital signal by using two processes that is sampling and quantizing. Sampling didnt convert the analog signal to digital signal without using quantizing, they must works together to yields the digital signal[17]. Two precesses yields digital signal as shown in figure 9.

The amplitudes of the analog signal  $x(t)$  lie in the range  $(-V, V)$ . This range is partitioned into  $L$  subintervals, each of magnitude  $2V/L$ . Next, each sample amplitude is approximated by the midpoint value of the subinterval in which the sample falls. Each sample approximated to one of the  $L$  numbers. Thus,

the signal is digitized with quantized samples taking on any one of the  $L$  values. This is an  $L$ -ary digital signal. Now each sample can be represented by one of  $L$  distinct pulses[17].

Some features of the input image will be extracted. Any input image will be converted from analog to digital. An analog signal can be characterized as a signal its amplitude can take on any value over a continuous range, analog signal takes infinite number of values. on the other hand, digital signal takes a finite number of values[17].

Now, each image has two dimensions ( $x,y$ ), and has a size indicate these dimensions. Let the image has  $256 \times 256$  pixels, so  $x=y=256$ . The proposed algorithm starts with four steps: find start  $x$ , find start  $y$ , find end  $x$ , find end  $y$ .

For an image that has  $256 \times 256$  start  $x=0$ , start  $y=0$ , end  $x=255$ , end  $y=255$ . This image has two colors; white and black, each pixel in this image has an intensity which is presented by two values 0 or 255, in which 255 for the empty area and 0 for the written area.

To avoid the differences which are resulted by the different way in writing the character from one to another, the size may be written in large size and in another time may be written in small size. So, the solution for this problem was the scaling of the image of the character.

The written area would be divided into 25 squares ( $5 \times 5$ ) and take the intensity for each square. This intensity has a number of black pixel. These values matched with the predefined values to recognize the entire object (character or word). Figure 10 shows an example of a  $5 \times 5$  matrix of a written area.

#### 4.4 Character Recognition

To learn the system how to recognize the characters, the character image should be converted into text format. This conversion need a technique which is identified as Optical Character Recognition (OCR). So, OCR is a technique that used to convert the image into text to be meaningful to the computer.

There are many factors affected on the OCR accuracy such as: the original file, layout of page, analysing of the edge of each character, and the matching process[17]. The matching process was applied between the intensity values and program by understanding the number values for each pixel. This matching process is done by using the artificial neural network which make the recognition process faster.

## 5 Word Recognition

A word recognition process starts with reading the word as one image, this image will be analyzed to get a normalized image, this image will be segmented to determine the edges of the word, then the intensity values of each pixel of this image, and finally the matching process will be applied to identify what is the word.

## 6 Results

After applying all the experiment's steps, there are three clusters for the data set or the samples which are related to the number of segments. Therefore, we have three neural networks, for each network there are input samples, a hidden neurons for training purposes, and output neurons which give the results, see figure 11.

All the NN were trained on the samples of the characters and the word, where the type of these networks is Supervised back-propagation network. These networks give a very good results in both stages, training stage and testing stage, with a very small error for all data set. See table 1, where NN1 for 1 segment character, NN2 for two segments character, and NN3 for three segments character.

Table 1: Testing results

	<b>NN 1</b>	<b>NN 2</b>	<b>NN3</b>
Build time	5.10s	7.54s	0.65s
Training Set	320	370	76
Testing Set	320	370	76
Correctly Classified(character)	99.54%	99.23%	99.55%
Correctly Classified(word)	98.45%	98.32%	98.83%

Figure 12 shows the performance for one network of our NNs.

The performance of the recognizing process remain high wherever the size of the data set. In this system, the data set is large because it has characters with different shapes and many whole words. The NNs showed a high performance and the recognition process took extremely 1 second for each testing sample.

## 7 Conclusion

The recognition process for arabic handwriting is not easy because of the connectivity criteria in this language. In this system we proposed a good solution for this problem by using image processing techniques, segmentation with three

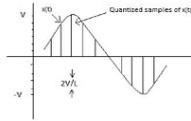


Figure 9: A/D converter

0	10	99	4	101
6	0	102	4	299
0	0	300	66	65
3	8	0	0	0
100	101	99	0	0

Figure 10: Intensity values for 5x5 matrix

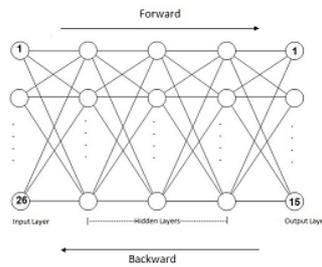


Figure 11: NN for 1 segment category

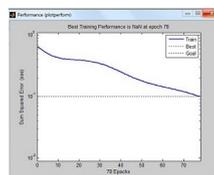


Figure 12: The performance of NN

categories according to the number of segments of each character, dividing each segment into small grids, and the neural networks for recognizing process to recognize what the character/word is.

The algorithms which are merged and used in this system made the arabic handwriting recognition system more efficient and faster for recognizing process and deny any effect of the arabic language shape. The performance of all NNs in this system is high, and the accuracy of recognising process is also high which is for all networks is 99.44% for character recognizing and 98.53% for word recognizing. Using segmentation and dividing processes minimize the size of the templates so, it didn't pull down the RAM and the recognition process was not slow because there was no overload on the capacity of our system.

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