Adult Literacy using Information Technology

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***Abstract*—This paper reports on our project, "ALIT", Adult Literacy using Information Technology, consists of an adult computer literacy software package that aims at helping adult illiterates to learn how to basically read and write in Arabic. Our proposed software seeks to empower its users with substantial and effective educational gains. This is achieved by providing adequate tools such as voice communication with the user and interactive Arabic handwriting recognition using geometrical features and neural networks to automatically recognize (read) on-line handwritten Arabic words. Moreover, the proposed ALIT seeks to offer a variety of economic, social, and human-development benefit. The success of this program depends to a large extent on illiterates' willingness to choose, adapt, and use the IT based software effectively.**

***Index Terms*—Arabic language, illiteracy, Information Technology, neural networks, signal processing.**

I. INTRODUCTION

In its basic definition, literacy is a person's ability to read, write, speak, communicate, and use personal acquired skills to get involved in a society in order to improve his/her social and economic status [5]. During the past years, there has been a tremendous improvement in technology. Nevertheless, the number of illiterate people in the world is increasing continuously, particularly those rates of third world or underdeveloped countries [8]. Consequently, many worldwide agencies and governments are putting their best efforts to help eradicate illiteracy among adults [11]. These attempts are trying to integrate the different and various functional opportunities that information technology has to offer [5]. Some of these existing technologies are able to handle speech and handwriting recognition [5].

The purpose of this paper is to present a comprehensive study about the feasible and beneficial solutions that can contribute to the increase in the spread of adult literacy. Moreover, it seeks to identify our contribution in developing an adult literacy computer program. Throughout our research and development of a new design approach, we tried to combine the advantages of existing literacy programs and develop new procedures that would offer substantial benefits to the user.

Our project, "**ALIT**, **A**dult **L**iteracy using **I**nformation **T**echnology", an instructional literacy software, is a computer literacy program whose aim is to help illiterate adults learn how to read and write. The program guides its users into many subdivided parts and levels that are appropriately paced in order to guarantee a pleasant method of learning.

During the last four decades, significant research and work has been done in the field of pattern recognition, specifically character recognition. However, few researches have been dedicated to *cursive* character recognition, such as cursive Arabic characters [11]. In our project, we used neural networks with a standard back-propagation training algorithm, in order to implement the handwriting recognition process.

II. RECOGNITION APPROACH

Due to the complexity of the Arabic language, we were confronted with several options and methods concerning how to proceed with the recognition of Arabic characters. The factors that affected the way to recognize those characters can be summarized as follows.

First of all, the Arabic language is composed of 28 main characters, each written in four versions: beginning, median, termination, and separated types. In addition to that, there are several letters in the Arabic alphabet that contain one, two, or three points such as letters "ب", "ت", and "ث". We should choose a method that takes into account all the possible locations of the point(s) and recognizes the appropriate letter within an appropriate margin of error. For example, Figure 1 shows two handwritten letters "ب". Figure 1(a) is considered right, but Figure 1(b) is considered wrong because of the incorrect location of the point.

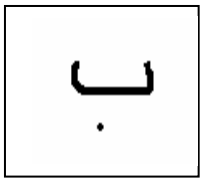
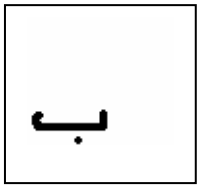


Figure 1 (a) A Correct "ب"

Figure1 (b) An Incorrect "ب"

Moreover, the fact that the user is an illiterate means that he/she doesn't control completely the movement of the pen, and thus, his/her handwriting. Therefore, we should provide a handwriting recognition tool that is able to recognize a letter of any size, not completely centered in the space assigned, and with some imperfections (a reasonable margin of error) [6]. Letters such as those shown in Figure 2 should be counted as correct.



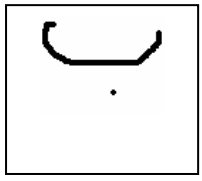


Figure 2 (a) and (b) Two Correct Versions of "ب"

Furthermore, Arabic characters are cursive and written from right to left. Thus, while teaching the user to write Arabic, we should be sure that he is writing from right to left and not the other way around. So, the handwriting recognition tool should keep tract of the direction in which the user is writing.

Figure 3. The Direction to for Writing Letter

There exist two methods of handwriting recognition: *off-line* and *on-line*. *Off-line* recognition presents major problems associated with the loss of dynamic information. Consequently, this makes it difficult to perform recognition without possible tracking of speed, direction, and sense of pen. In other words, we can't record the actual hand movement of the user [1-2]. This major problem is solved in *on-line* recognition, thus making it an easier and preferable method. Therefore, in addressing the problem of recognition of cursive Arabic characters, we use the method of *on-line* recognition for its advantageous characteristics [6].

III. NEURAL NETWORK

Character recognition is an area of pattern recognition. Using a multilayer neural network, with the back-propagation learning algorithm, our system can manage to recognize an Arabic character. First, we will be discussing the basic principles of pattern recognition with neural networks. And then, we will continue with the explanation of our system.

A. Pattern Recognition

The pattern recognition approach is the most used in practical application of character recognition. This method has two main steps, training the system for writing patterns, and then the recognition of a character takes place via pattern comparison or template matching. First parameter measurement takes place by extracting the required features via a filter bank analyzer or a linear predictive coding analysis, or even a discrete Fourier transform. Then the training procedure is provided by an algorithm. We used the back-propagation algorithm. This process, referred to as pattern classification, is then followed by the pattern-comparison stage, where the unknown input, the character being written, is directly compared to each possible pattern. The last step converts the unknown character to a recognized one [7].

B. Neural Networks

Neural Networks are the building blocks of artificial representations of the complex anatomy and physiology of real neural systems [9]. A neural network is basically a dense interconnection of simple, nonlinear, computational elements [10]. However, even with these simple computational elements, artificial neural networks (ANN) are able to perform sophisticated signal processing and pattern classification [9].

A simple computational element is made from N inputs, labeled x_1 to x_N, which are summed with weighs w_1 to w_N, thresholded, and then nonlinearly compressed to give the output $y = f\left(\sum_{i=0}^{N-1} w_i x_i - \Phi\right)$, with Φ as an internal threshold and f a nonlinear function such as a hard limiter or a sigmoid function.

1) Network Topologies

Two principal functions are the building blocks of ANN. The first one is pattern association and it is responsible for associating an output pattern in response to an input pattern. This input-to-output mapping is generally learned or estimated by the network and usually resides in a low-dimensional subspace. And the second important function is dimensionality reduction or feature extraction, where non-essential information is removed and more efficient features are created [9].

However the key issue in neural networks still relies on the network architecture. Network architectures can be divided into two principal types: recurrent and non-recurrent. The first one leads to a complex and dynamic behavior in the activation of the network because loops are integrated into the network; whereas the second one is simpler in structure because it is organized into different layers with unidirectional connections between adjacent layers. This structure is referred to as a feed forward architecture [9]. The first layer receives the signal after the feature extraction phase. Then the hidden layer is the computational layer and finally the output layer is the one which recognizes the character.

Many learning algorithms have been conceived for multilayer networks. One of the main ones is back-propagation, whose main purpose is to determine the weights of each element in a layer by applying a backward error propagation rule. The back propagation algorithm is a supervised learning algorithm. An input pattern is presented to the network and then an output pattern is computed. This output pattern is compared to a target output pattern resulting in an error value. The error value is propagated backwards through the network, and the values of the connections between the layers of units are adjusted in a way that the next time the output pattern is computed, it will be more similar to the target output pattern. This process is repeated until the output pattern and the target output pattern are almost equal. A typical learning process involves a lot of couples of input and target output patterns. Back-propagation networks are useful, among other tasks, for classification and generalization. [10] A good example of an implementation of these networks is character (handwriting) recognition, which we will be explained shortly.

In the future we will use Al-Alaoui algorithm for pattern recognition and classification which had been shown to improve classification by reducing the samples that are in error and by speeding up the convergence process [3-4]. The similarity between Al-Alaoui Algorithm and Boosting and Bagging was noted Andrew Webb [12].

C. Our System

The neural networks implemented for our project consist of a standard back-propagation training algorithm, with 32 inputs, one hidden layer with 32 neurons, and 29 outputs, each output corresponding to an Arabic character. All layers are fully connected with a log-sigmoid transfer function to calculate each output of each cell in the network. A schematic figure of the network is presented in Figure 4.

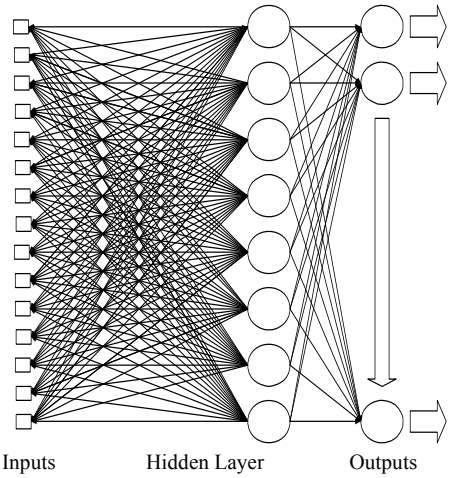


Figure 4. Schematic of Neural Network

The feature extraction takes place before the recognition algorithm. Basically, after the user moves the mouse to record a path, a smoothing algorithm takes place to pinpoint 17 base points and the angles that separate them on that path. . For example, the letter " ب" is represented as {101.25°, 78.75°, 56.25°, 33.75°, 11.25°, 0°, 0°, 0°, 0°, 0°, 348.75°, 326.25°, 303.75°, 281.25°, 258.75°, 45°}. These points are then computed into sines and cosines, which are then passed to the input layers of the networks. Then the recognition algorithm takes place and a character is recognized by the output layer.

IV. HANDWRITING RECOGNITION

First of all, we subdivide the board (which is the specified space to write on) into a grid and set the following standards (see Figure 5):

- A "down" movement is 0 degrees.
- A "right" movement is 90 degrees.
- An "up" movement is 180 degrees.
- A "left" movement is 270 degrees.

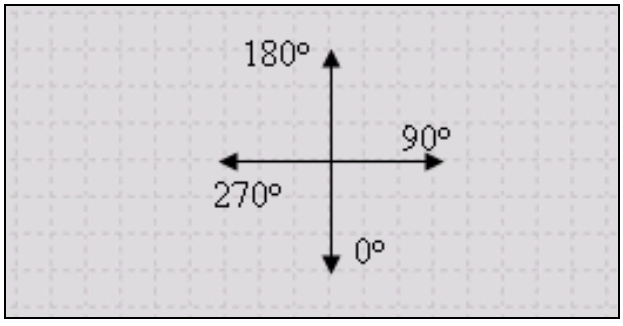


Figure 5. Movement in Degrees

The user draws the appropriate letter and the computer tracks all the movements of the hand made in the specified space. The path drawn is recorded as one vector.

Once the user is done, he/she clicks on the "Process" button and the computer stops recording. Anchor-points (sixteen of them) are placed along the path, extracting the general features of the letter. Then, based on the coordinates of these anchor-points, we calculate the cosine, sine and angles of every two successive points. Note that if the path is too small, the computer won't be able to process it. It should have enough space to place the sixteen anchor-points. We compare these results with the characteristics of the letters that we have in our database. If a neural network can recognize the gesture, then a pop-up message will appear telling you that you have correctly written the corresponding letter.

V. DESIGN OF THE ALIT SOFTWARE

The most important feature of our software is its ability to guide the illiterates and teach them the basics of the Arabic alphabet. One important feature is how to explain to the user the content of each button. Since he/ she can't read the written instructions, we have placed an icon with a microphone next to each button. Whenever the user wants to know the content of a specific button, he clicks on the icon and the computer will verbalize the instructions out loud.

First of all, once the program is launched, a Welcome page containing the name of the software (in Arabic) will appear. A previously recorded voice will read out loud simultaneously everything that is written on the screen.

Once the reading/ listening is finished, the program goes automatically to the tutorial. We should always keep in mind that the user is illiterate and it is highly probable that he has never used a computer before. This tutorial will help the user become familiar with the basic commands of a computer. It is composed of two parts. The first part will teach him/ her how to use and navigate throughout the program. More specifically, the user will learn how to "click" on a button and how to find out the content of a specific button. In the second part, the user will learn how to write on a touch-screen with a pen. He will have to reproduce the image displayed on the screen in the specified area. Once he accomplishes this task, the program will automatically go to the Main Page.

In the Main Page, the user can choose between five different levels of learning (each level containing five or six letters), or going back to the tutorial, or exiting the program.

After clicking on the desired level, the user goes to the Learn Page. As in the tutorial, he will have to reproduce the image displayed on the screen in the specified area. This is where the handwriting recognition takes place. The user can't go on to the next level before the computer recognizes the letter drawn. The user can erase as many times as he desires, go back and forward in the same level, or go back to Main.

At the end of each level, there is a quiz that tests what has been learned in this specific level. This page is similar to the Learn Page except that the letter to be written is not drawn on the screen but spoken out loud to the user.

VI. EXPERIMENT AND EVALUATION

In order to test the efficiency of our learning tool, we undertook a small experiment to measure how helpful and instructive ALIT is. We had difficulty finding willing Arab illiterates. So, we asked non-Arab people who are completely beginners in Arabic to test the software for us. Our experiment group was composed of 10 people, 4 females and 6 males: 4 French, 2 Swedish, and 4 Americans. Each tester carried out the first level of the program twice (testing a total of 100 characters). For each character, we recorded the number of times that they had to write the same letter before the program recognizes it.

The total number of 100 characters were obtained and divided into two sets, each set corresponding to a trial; and each trial is composed of five letters and a quiz grade. We used a notebook to administer the tests because our guests could not come to AUB and thus could not use the touch-screen. However, since all of them had already used computers and know how to manipulate a mouse, the obtained results are considered valid.

Table 1 regroups the results obtained by the 10 testers. The results show that on the first letter of the first trial each person repeated the same letter approximately 6.4 times (64/10) to writ it correctly. While on the second trial, the numbers dropped considerably , with an average of 3.1 per person. These results, showing that the numbers are cut by half in the second round, are encouraging.

VII. CONCLUSION

Through our design of the "**ALIT"** program, we seek to benefit the illiterate adults by enhancing and simplifying the instructional process, on basic and advanced skills. Our IT based solution to the world's illiteracy problem can also lead the way to addressing other societal issues on a larger scale. In other words, our **"ALIT"** program's primary objective is to set people on the right path to acquiring other literacy skills which would help them integrate their selves in the society as well as in the market.

TABLE 1.
RESULTS OF THE EXPERIMENT

	Trial 1	Trial 2
Letter " أ"	64	31
Letter " ب"	47	26
Letter " ت"	38	16
Letter " ث"	31	14
Letter " ل"	42	21

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