Improving Handwritten Isolated Arabic characters Recognition with Particle Swarm Optimization Algorithm

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Abstract

This manuscript considers a new approach to Simplifying pattern recognition based on simulation of behavior of schools of fish and flocks of birds and called particles swarm optimization algorithm (PSOA). We present an overview of the proposed approaches to be optimized and tested on a number of handwritten characters in the experiments as well. Experimental results of the optimization algorithm are found to be very efficient and give higher recognition accuracy. It is noted that the PSOA in general generates an optimized comparison between the input samples and database samples which improves the final recognition rate. Experimental results show that the PSOA algorithm is convergence and more accurate in solution with low error recognition rate .The recognition rate of our proposed system is 87.856% and rate error recognition is 12.142%.

Key Words: Pattern recognition techniques, handwritten characters, Recognition, Feature extraction, particles swarm optimization, Algorithm.

تحسين تمييز الحروف العربية المعزولة المكتوبة يدويا باستخدام خوارزمية أمثلية حشد الجزيئة

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الملخص

هذا المخطوط يعتمد نموذجا جديدا لتبسيط التمييز معتمدا على طريقة محاكاة سلوكية مجموعات من الأسماك وأسراب الطيور تسمى خوارزمية أمثلية حشد الجزيئة .(PSOA). نقدم لمحة عامة عن النهج المقترح ليكون الأمثل واختبار عدد من الرموز المكتوبة بخط اليد في التجارب العملية أيضا .النتائج التجريبية تبين أداء أعلى درجة من هذه الخوارزمية تم التوصل الى أن مثل هذه الخوارزميات يمكن يولد المقارنة المثلى بين عينات من المدخلات وعينات من قاعدة البيانات مما يحسن من معدل التمييز النهائي .النتائج العملية تبين أن خوارزمية حشد الجزئية تعطي أكثر تقاربا، أكثر دقة في الحل مع انخفاض نسبة خطأ التمييز.وكانت نسبة التمييز في نظامنا المقترح هي 87.856% ونسبة الخطأ هي 12.142%.

الكلمات المفتاحية: تقنيات تمييز الأنماط، تمييز الرموز المكتوبة يدويا، استخراج المميزات ، خوارزمية أمثلية حشد الجزيئة.

Introduction

Pattern recognition is a science that helps develop "classifiers" that can recognize unknown instances of objects into different categories and classes. Pattern recognition techniques are used in wide variety areas such as commercial applications, engineering, business, medicine, etc. Common examples include character recognition, the scanning of a printed page; natural language recognition, analysis of images taken from airplanes or satellites, or analysis of medical images in order to scan for abnormalities. A particle swarm optimization algorithm (PSOA) is used to solve many of difficult problems in the field of pattern recognition .One of the main branches of pattern recognition is character recognition. Handwritten character recognition in different language (which includes Japanese, Hiragana, Katakana, Kanji, English, Arabic, alphanumeric and symbols) has emerged at the end of the 1960s [1]. A complex task due to the variations among the writers like style of writing, shape, stroke etc., is the problem of the handwritten characters recognition. Handwriting characters recognition, including of both isolated characters and continuous texts, have received intensive attention [2]. Character recognition is a form of pattern recognition process. In reality, it is very difficult to achieve very high accuracy. Even human too will make mistakes

when come to pattern recognition common ways used for characters recognition would be the use of artificial neural networks and feature extraction method[3] . This manuscript investigates the application of an efficient optimization method, known as Particle Swarm Optimization algorithm, to the field of pattern recognition. PSOAs solves optimization problems by simulating the social behavior of bird locks . PSOA algorithm starts with a random population initialization of particles in the search space Unlike other evolutionary optimization methods, particles in PSOA do not recombine genetic material directly between individuals during the search, but works under social behavior in swarms instead. Therefore, it finds the global best solution by simply adjusting the moving vector of each individual according to personal best and the global best position of particles in the entire swarm at each time step (generation) .

Review of the related work

On-line and off-line are famous two types of character recognition systems. Each system has its own algorithms and methods. The main difference between on-line system and off-line system is that in first system the recognition is done in the time of writing while in second system the recognition is done after the writing is completed For the past few years , intensive research has been done to solve the problem of Arabic character recognition. Mohamed S. El-Wakil , Alsadoun [4]. Many published researches have been implemented with the problem of Arabic character recognition for example isolated Arabic characters, Arabic words, Arabic texts.....etc Challenging problems are being encountered and solutions to these are targeted in various ways to improve accuracy and efficiency. This methods has been practiced by many like, T. S. El-Sheikh and S. G. El-Taweel , Al-Yousefi H. & Udpa S.S. [5]. Artificial Neural Networks (ANNs) are the common seed used as the classifiers “recognition or discrimination stage". Many researchers have been used to overcome the disadvantage of ANNs which is time consuming for computation and obtained good results for example, used error back propagation Neural Networks approach to accelerate the computation This methods has been practiced by many lik, Sherif K. & Mostafa M., Khorsheed M.S. [6], Souici

L, Farah N., Sari T. & Sellami M ,]Ayman J. Alnsour and Laheeb M. lzoubady [7], Velappa Ganapathy,and Kok Leong[14].Another method which is known as the Freeman chain this method stores the position the first pixel of the input character and the positions of successive pixels along the input character's border. This methods has been practiced by many like, Hung, Y., Liu, Y. K. and Zalik, B. [8], John,Jomy,K.V.,Pramod; Balakrishnan, Kannan [9]. Now a day's Evolutionary Algorithm (EA) have been successfully applied to find the solution of numerous problems from pattern recognition domain. It uses biological evolution viz. reproduction, mutation, recombination and selection. The commonly method now used Evolutionary Algorithms are Genetic Algorithm, Evolutionary Programming, Evolutionary Strategy, Genetic Programming, Particle Swarm Optimization, Artificial Immune, Ant Colony Optimization and Invasive Weed Optimization and Bee's Optimization [10-11].

In our manuscript that aims is to build isolated handwritten Arabic characters recognition system which conducted through three main steps. The first step is responsible for preparing the input images of characters, and normalizing the size of the images performing characters to make the input images in the form of matrices equal dimensions. The second step extracts the main features of the preprocessed images. The third step processes the main features to recognize the input characters. The method is used in our manuscript one of the Evolutionary Algorithms is Particle Swarm Optimization Algorithm (PSOA).

Overview of the Arabic characters

Arabic language it is one from many ancient languages . It is spoken by many people in the world and this language is written as texts ,words, characters than 1000 years ago . Arabic presents some specific characteristics. Table (1) shows the Basic Isolated Arabic Characters and their forms.

Table (1): Basic Isolated Arabic Characters and their forms

	Characters	Isolated character
1	Alef	ا
2	Baa	ب
3	Taa	ت
4	Thaa	ث
5	Jeem	ج
6	Haa	ح
7	Khaa	خ
8	Dal	د
9	Thal	ذ
10	Raa	ر
11	Zia	ز
12	Seen	س
13	Sheen	ش
14	Saad	ص
15	Dadd	ض
16	Tah	ط
17	Thah	ظ
18	Ayn	ع
19	Ghyn	غ
20	Faa	ف
21	Qaf	ق
22	Kaf	ك
23	Lam	ل
24	Meem	م
25	Noon	ن
26	Ha	ه
27	Waw	و
28	Yaa	ي

The properties of characters in the Arabic language are [12]:

- It is composed of 28 characters.
- Arabic characters are written from right to left in both printed and handwritten forms.
- The forms of characters replaced depend on their position in the words
- Characters can be assembled in several forms and a lot of them are Similar.
- Loops and cusps.
- Characters are connected even when typed or printed.
- Found two kinds of spaces between Arabic words and within an Arabic Word introduced by Characters that have no middle form . Characters that Have no middle shape MF.
- The characters are written following a line called "baseline", which is Down the main body of the characters which is about 2/3 down the main Body of the characters.

Particle Swarm Optimization

The Particle Swarm Optimization algorithm (PSOA) was originally designed by Kennedy and Eberhart in 1995. PSOA is a population based searching method which imitates the social behavior of birds or fish schooling. The population is called a "swarm" and the individuals are called "particles". Each particle moves in the swarm with a velocity that is adjusted according to its own flying experience and retains the best position. It ever encountered in memory. The best local and global positions ever encountered by all particles of the swarm are also communicated to all particles. Advantages of PSOA have no mutation calculation and overlapping. PSOA compared with the other Evolutionary Algorithms, it occupies the better optimization ability and it can be completed easily. The popular form of particle swarm optimizer is defined in the following equations and flow chart in Figure (1) [13]

$$v_{id}(t+1) = w * v_{id}(t) + c_1 r_1 \left(p_{id}(t) - x_{id}(t)\right) + c_2 r_2 \left(p_{gd}(t) - x_{id}(t)\right) \quad \text{... (1)}$$

$$(t+1) = x_{id}(t) + v_{id}(t+1) \quad \text{.....(2)}$$

Where

v_{id} :is the velocity of particle i along dimension d

x_{id} :is the position of particle i in d

c_1: is a weight applied to the cognitive learning portion

c_2: is a similar weight applied to the influence of the social learning portion.

r_1, r_2:are separately generated random number in the range of zero and one

w: is the inertia weight

The PSO algorithm consists of just six steps, which are repeated until some stopping condition is met [14]:

Step 1: Create an initial population of particles with random positions and velocity within the solution space.

Step 2: For each particle, calculate the value of the fitness function.

Step 3: Compare the fitness of each particle with each *Pbest*. If the current solution is better than its *Pbest*, then replace its *Pbest* by the current solution.

Step 4: Compare the fitness of all the particles with *Gbest*. If the fitness of any particles is better than *Gbest*, then replace *Gbest*.

Step 5: Update the velocity and position of all particles according to Eqs.(1) &(2).

Step 6: Repeat steps 2-5 until a criterion is met.

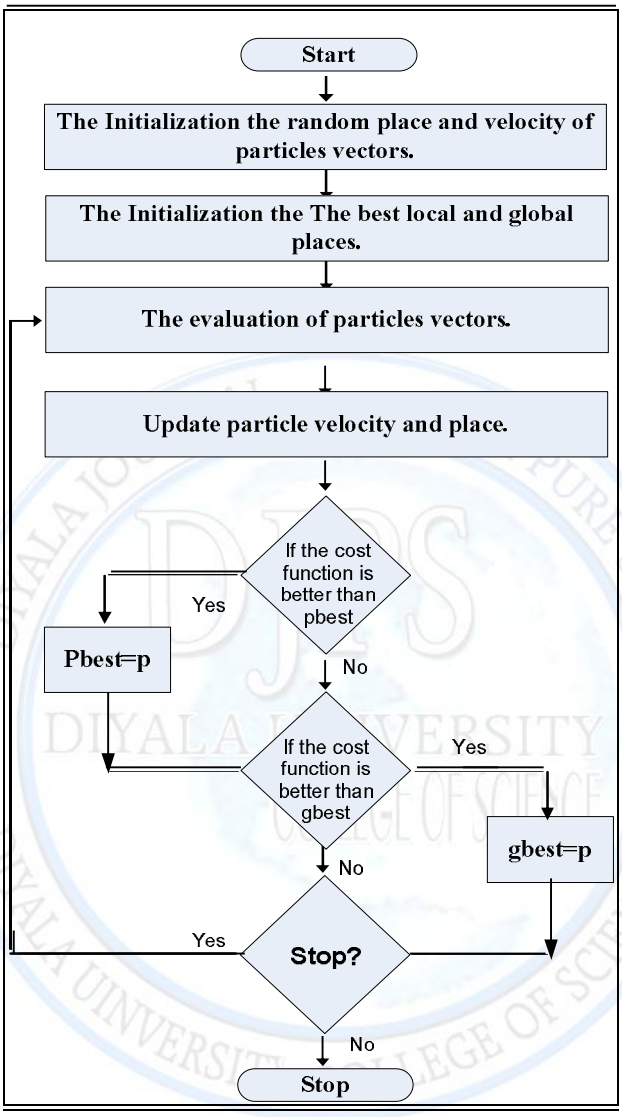


Figure (1): PSOA Flow Chart

Character Modeling

Handwritten Arabic Characters

Our proposed model used handwritten Arabic characters. A set of handwritten isolated Arabic characters is shown in Figure (2) for example.

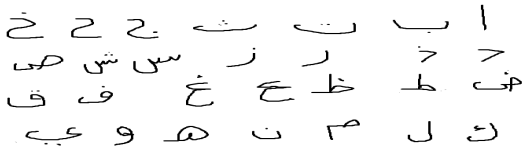


Figure (2): A Set of Handwritten isolated Arabic Characters

Normalization

There are lots of variations in handwritings of different persons. Therefore, process, so that all Characters normalization of characters is performed in equal dimensions of matrix. In this manuscript , characters are normalized into 28X28 pixel character ,first we take every character from 168 characters,28 characters saved as database and 140 samples each character with five shapes written by different persons. Our proposed algorithm read the characters as matrices in equal rows and columns .Below the steps of proposed algorithm explain the normalization of characters:-

Proposed algorithm of Normalization
Begin

Step1:Main program call subroutine of location
Step2:Delete matrix elements of any character from top until first location contain the value 1 stop deletion operation and save this row in the variable c1
Step3:Delete matrix elements of any character from down until first location contain the value 1 stop deletion operation and save this row in the variable c2
Step4:Make new matrix save the matrix dimension of it c1xc2
Step5:Rotate for new matrix by angle 90^0 ,repeat steps 2,3,4 and replace c1 by r1,c2 by r2 and saved this matrix
Step6:Rotate saved matrix by angle 270^0 until return the character to original shape but its dimension r2xc2
Step7:Saved the result matrix to use it in next processing mechanism zooming in main program
Step8:Make zero matrix its dimension 28x28 called w
Step9:Read the result file from cutting character called m
Step10:Apply the following a mechanism zooming equation to obtain new value for matrix its dimension 28x28
$W(i,j)=m(ceil(i*c2/28),ceil(j*r2/28))$
Step11:Saved the matrix w its shaped to be larger and fixed, with an area 28x28 in external file for use
End

The above algorithm applied to all characters, whether database or form characters to be recognized. Now, after the above steps we may have prepared characters saved as a database and shapes required to recognize by using the application of PSOA.

Feature extraction

Feature extraction is the important role in character recognition. It is extracts the well-defined characteristics, which classify the character in classification stage. The features are extracted by projection methods from original and skeleton image. We also extracted special points from thinned image. Features can be classified into two categories[15].

- Local features which are usually geometric (e.g. concave/convex parts, type of junctions: intersections/ T -junctions/endpoints, etc).
- Global features which is divided into two features the first is topological like (connectivity, number of connected components, number of holes) the second is statistical (Fourier transform, invariant moment).
- Diagonal feature extraction scheme for recognizing handwritten characters is proposed in the manuscript. Every character image of size 28X28 pixels is divided into 7 equal zones, each of size 4X4 pixels. The features extraction is done by moving each pixel along the diagonals of its respective 4X4 pixels. Which known a feature represents the smallest group that can be used for discrimination purposes and for a unique image within this stage, the features of the characters that are crucial for classifying them at recognition stage are extracted. This is an important stage as its effective functioning improves the recognition rate.

Database and Experiment

Database:

Database used Handwritten Arabic Characters in our experiments. Size of each character 28X28 pixels. database consist 28 character from ا to ي each character has different five shapes written by hand arrange in separate file for each character. The Training Dataset consists of 168 samples for characters (ا-ي) 28 saved as database, 140 characters with different shapes input samples .We use Matlab to extract the isolated handwritten character for each file. Some data samples are shown in Figure (3).

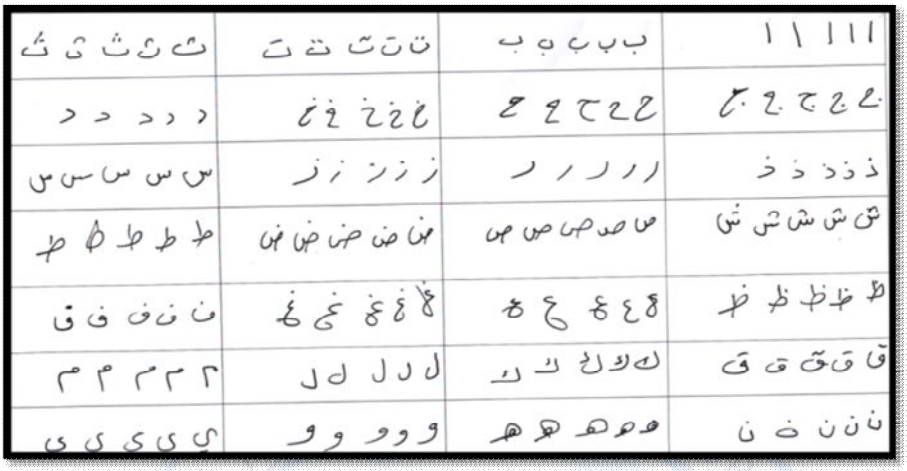


Figure (3): Sample of scanned handwritten dataset

Experiments

In order to check the working of the proposed model, we applied this algorithm in Matlab. Below the different images of the character (ق) Figure (4) and the basic steps as example of applied the proposed system are followed. In feature extraction of the image of the character (ق) the value of it.

Figure (4): Five image of character (ق)

The features extracted for character (ق) are:

[2.1018 2.1118 2.1168 2.0918 2.0868]

The results obtained for the feature extraction values of the five different shapes to the all input characters is presented in Figure (5) and it shows that the diagonal feature extraction provides higher recognition accuracy.

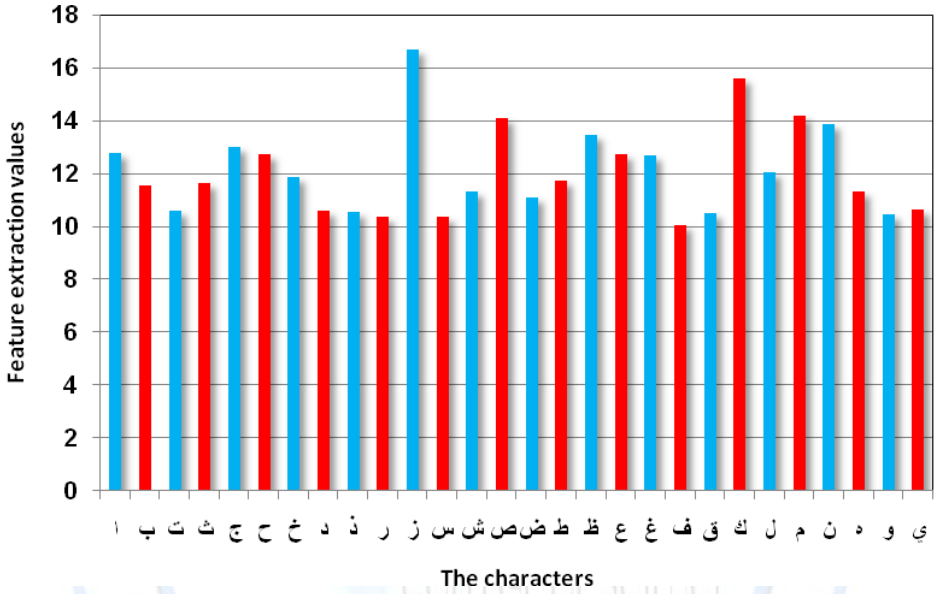


Figure (5): The variation of feature extraction values of five different Shapes of input characters.

The extracted feature are given to the proposed system, similarly the features of other characters from ا-ي are extracted and given for training.

Table (2): Feature extraction results for input characters.

	character	First value for shape1	second value for shape2	third value for shape3	Forth value for shape4	Fifth value for shape5	Sum of five value Shapes
1	ا	2.3852	2.4299	2.6509	2.6509	2.7164	12.7765
2	ب	2.3097	2.1597	2.4097	2.4097	2.4597	11.5486
3	ت	2.1144	2.1094	2.1244	2.1244	2.1194	10.5721
4	ث	2.3244	2.3094	2.3344	2.3344	2.3394	11.6219
5	ج	2.6016	2.4516	2.7016	2.7016	275016	13.0082
6	ح	2.5435	2.3935	2.6435	2.6435	2.6935	12.7175
7	خ	2.3684	2.2184	2.4684	2.4684	2.6184	11.8420
8	د	2.1190	2.1040	2.1290	2.1290	2.1340	10.5952
9	ذ	2.1061	2.0911	2.1161	2.1161	2.1211	10.5306
10	ر	2.0681	2.0531	2.0781	2.0781	2.0831	10.3405
11	ز	3.3418	3.2368	3.4418	3.4418	3.4468	16.7090
12	س	2.0713	2.0563	2.0813	2.0813	2.0863	103563
13	ش	2.2618	2.4118	2.1618	2.1618	2.1118	11.3088
14	ص	2.8177	2.6677	2.9177	2.9177	2.9677	14.0885
15	ض	2.2142	2.1992	2.2242	2.2242	2.2292	11.0711
16	ط	2.3417	2.3267	2.3517	2.3517	2.3567	11.7087
17	ظ	2.6873	2.6723	2.6973	2.6973	2.7023	13.4366
18	ع	2.5415	2.4365	2.6415	2.6415	2.6465	12.7074
19	غ	2.5348	2.5198	2.5448	2.5448	2.5498	12.6740
20	ف	2.0103	1.9953	2.0203	2.0203	2.0253	10.0517
21	ق	2.1018	2.1118	2.1168	2.0918	2.0868	10.5089
22	ك	3.1173	3.1023	3.1323	3.1323	3.1273	15.5867
23	ل	2.4699	2.7867	2.4405	2.4405	2.4157	12.0631
24	م	2.8392	2.6892	2.9392	2.9392	2.9892	14.1958
25	ن	2.7737	2.2587	2.7837	2.7837	2.7887	13.8683
26	ه	2.2659	2.2509	2.2759	2.2759	2.2809	11.3297
27	و	2.0903	2.0803	2.0753	2.1003	2.1053	10.4515
28	ي	2.1238	2.0238	1.9738	2.2238	2.2738	10.6190

Results and Discussions

Experiments were carried out on a database of handwritten isolated Arabic characters obtained as described in section 4.1.The input characters were grouped into 28 subsets. During each iteration, one subset was saved in different locations as, ا in location 1, character ب in location 2 until character ي in location 28. The input character was chosen as test set and the following proposed equation (3) were applied and combined to form training set.

$$F(A,B) = (f_1 + f_2)/M \ldots\ldots\ldots (3)$$

A: matrix of any character of database

B: matrix of require recognize character

$$f_1 = \sum_{i=1}^{28}\sum_{j=1}^{28}\begin{cases}1 & if\ A(i,j) = 1\\ 0 & otherwise\end{cases}$$

$$f_2 = \sum_{i=1}^{28}\sum_{j=1}^{28}\begin{cases}1 & if\ B(i,j) = 1\\ 0 & otherwise\end{cases}$$

$$M = \sum_{i=1}^{28}\sum_{j=1}^{28}\begin{cases}1 & if\ A(i,j) = B(i,j) = 1\\ 0 & otherwise\end{cases}$$

After compute the value of (F) from the equation (3), for all saved characters and (input character from ا to ي), choose small value from 28 characters by ordering from large to small and the location of the matrix. Now, simplify handwritten characters Recognition using a PSOA. Figure (6) illustrated

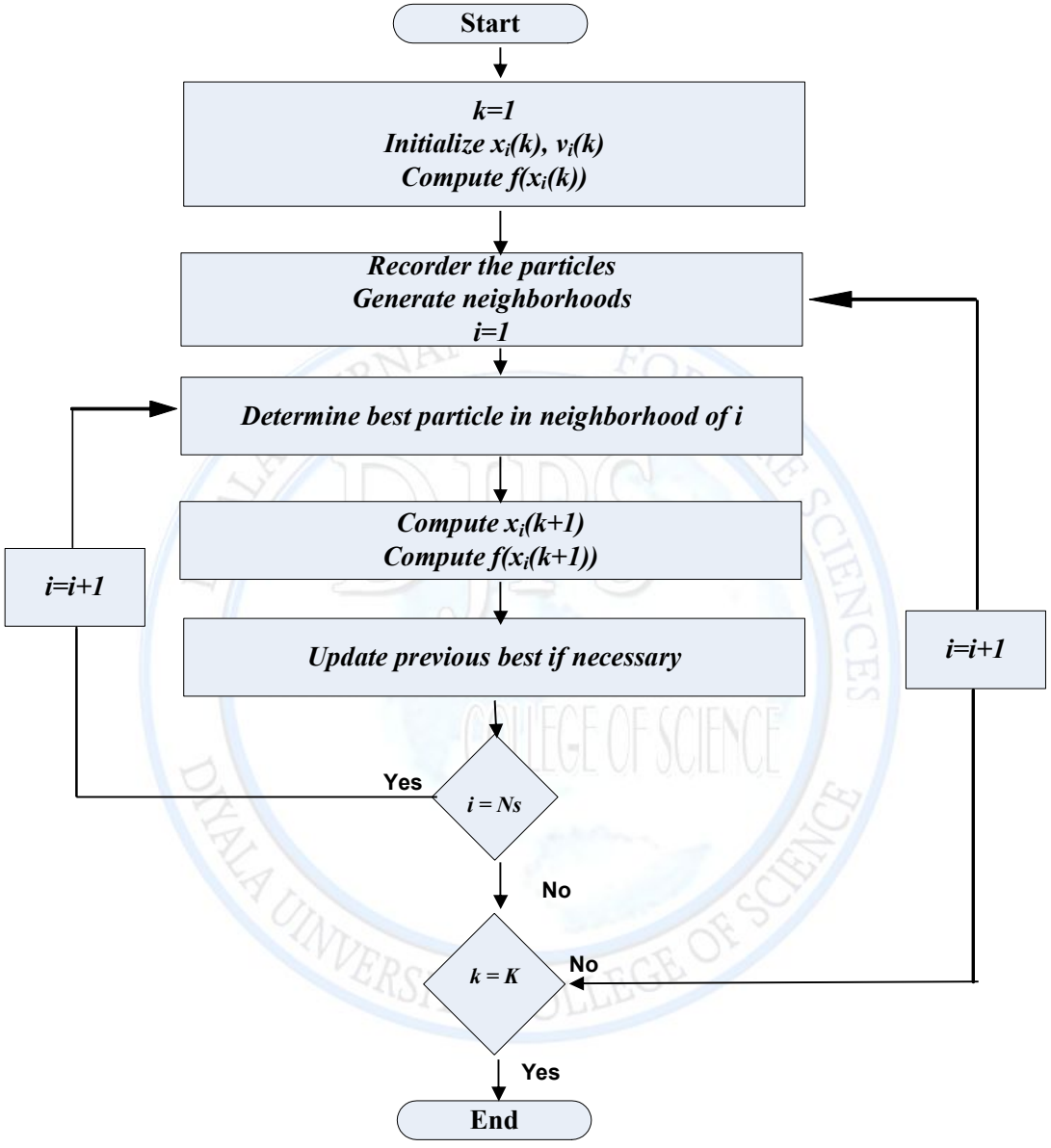


Figure (6): Proposed recognition flowchart of Handwritten isolated Arabic Characters.

In our proposed model the particles are the entry data characters that exchange information and move to reach the highest value of objective function is considered in the velocity update equation. Further, we definitions of optimality, via objective function,

minimizing rate error recognition, and provide explicit solutions to it by choosing the largest vales of the entry handwritten Arabic Feature extraction. Figures (7,8,9,10,11) explain the application of the PSOA for some handwritten isolated Arabic characters such as (د, ش, ض, ق, ل) from 168 Training Dataset characters with five different shapes, and the result of applying PSOA.

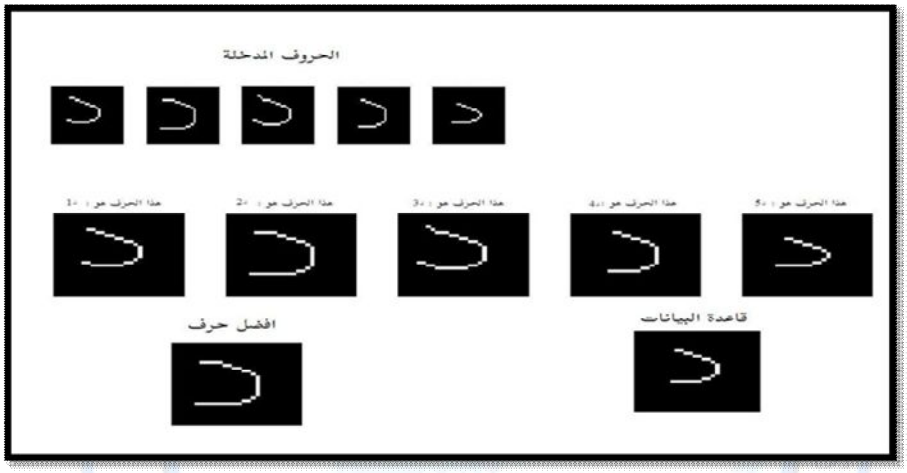


Figure (7): The application of proposed PSOA on the five shapes of input character " د "

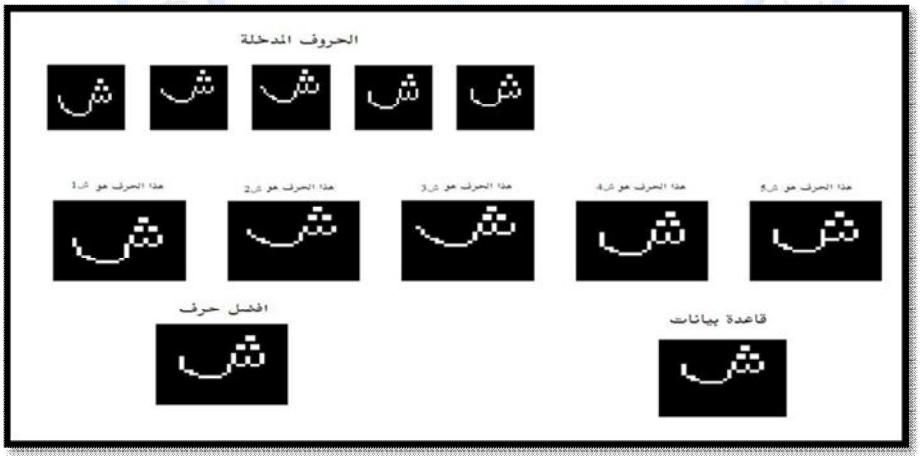


Figure (8): The application of proposed PSOA on the five shapes of input character"ش"

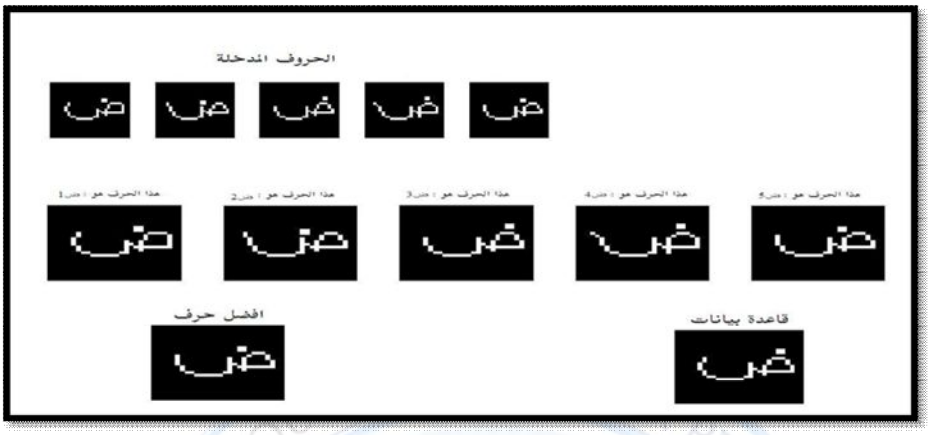


Figure (9): The application of proposed PSOA on the five shapes of input character "ض"

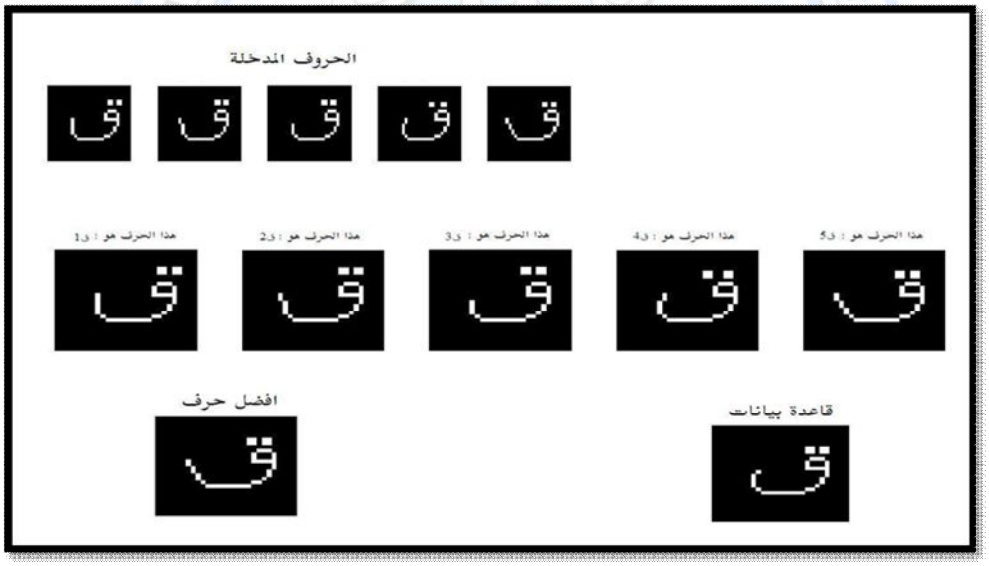


Figure (10):The application of proposed PSOA on the five shapes of input character"ق"

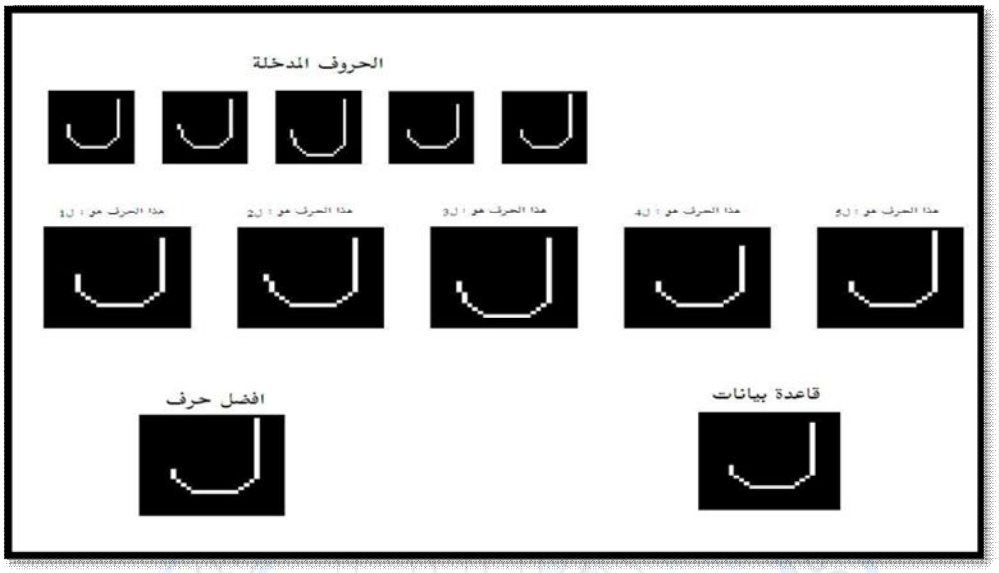


Figure (11):The application of proposed PSOA on the five shapes of input character "ل"

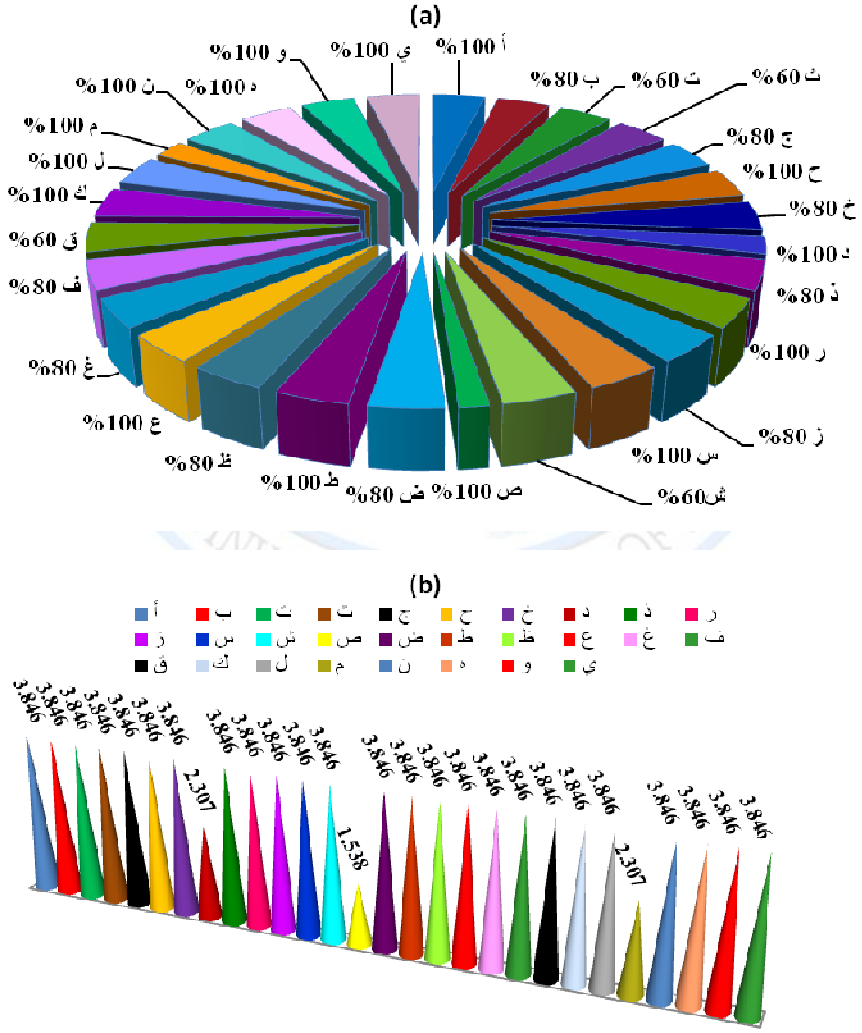
Take each character from above input characters (د, ش, ض, ق, ل), compute the matrix F(A,B) with characters of database and at the end of applied the PSOA appear Window contain the recognize characters and the value of F(A,B). The following Tables (3,4) present the results obtained testing our proposed model on handwritten Arabic database. Our experiment results illustrate in Figures (12 a,b and c), yield recognition rates for 168 handwritten isolatedArabic characters about 78.856%.We have achieved major improvements by applying PSOA with low Rate error recognition than other Evolutionary Algorithms such as Ant Colony Optimization(ACO) and Bee Optimization Algorithms (BOA).

Table (3): Recognition results obtained from testing our proposed model on handwritten isolated Arabic characters

	character	Writer1	Writer2	Writer3	Writer4	Writer5	No. of successes shapes for testing	No. of failed shapes for testing	Recognition value of No. of successes shapes from 140 characters	Rate recognition
1	أ	1√	1√	1√	1√	1√	5	0	3.571	100%
2	ب	2√	2√	2√	2√	25×	4	1	2.857	80%
3	ت	3√	3√	3√	21×	2×	3	2	2.143	60%
4	ث	4√	4√	4√	25×	2×	3	2	2.143	60%
5	ج	5√	5√	5√	5√	7×	4	1	2.857	80%
6	ح	6√	6√	6√	6√	6√	5	0	3.571	100%
7	خ	7√	7√	7√	7√	19×	4	1	2.857	80%
8	د	8√	8√	8√	8√	8√	5	0	3.571	100%
9	ذ	9√	9√	9√	9√	27×	4	1	2.857	80%
10	ر	10√	10√	10√	10√	10√	5	0	3.571	100%
11	ز	11√	11√	11√	11√	13×	4	1	2.857	80%
12	س	12√	12√	12√	12√	12√	5	0	3.571	100%
13	ش	13√	13√	13√	12×	11×	3	2	2.143	60%
14	ص	14√	14√	14√	14√	14√	5	0	3.571	100%
15	ض	15√	15√	15√	15√	13×	4	1	2.857	80%
16	ط	16√	16√	16√	16√	16√	5	0	3.571	100%
17	ظ	17√	17√	17√	17√	13×	4	1	2.857	80%
18	ع	18√	18√	18√	18√	18√	5	0	3.571	100%
19	غ	19√	19√	19√	19√	7×	4	1	2.857	80%
20	ف	20√	20√	20√	20√	22×	4	1	2.857	80%
21	ق	21√	21√	21√	20×	22×	3	2	2.143	60%
22	ك	22√	22√	22√	22√	22√	5	0	3.571	100%
23	ل	23√	23√	23√	23√	23√	5	0	3.571	100%
24	م	24√	24√	24√	24√	24√	5	0	3.571	100%
25	ن	25√	25√	25√	25√	25√	5	0	3.571	100%
26	ه	26√	26√	26√	26√	26√	5	0	3.571	100%
27	و	27√	27√	27√	27√	27√	5	0	3.571	100%
28	ي	28√	28√	28√	28√	28√	5	0	3.571	100%
	The Average								87.856	87.856 %

Table (4): Final Recognition results obtained from testing our proposed system

No. of characters recognized	Rate recognition	Rate recognition from 28 characters	Rate recognition from 140 characters	Rate error recognition
15	100%	53.571	53.571	0
9	80%	32.142	25.000	6.428
4	60%	14.285	8.571	5.714
		100%	87.856	12.142



(c)

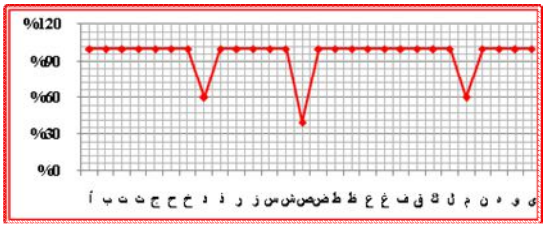


Figure (12): Experiment results from testing PSOA model on handwrittenisolated Arabic Isolated (a) recognition rates (b,c) recognitionValue of number of successes shapes from 140 characters.

Conclusions

In this present manuscript, a model of handwritten isolated Arabic characters recognition model using the concept of particle swarm optimization algorithm has been discussed. It is noted that the PSOA has been discussed . It is noted that the PSOA in general generates an optimized comparison between the input samples and database samples which improves the final recognition rate. The proposed model has been tested with a lot of handwritten isolated Arabic characters; high recognition rate has recorded of 87.856% Experimental results show that the PSOA algorithm is very good compared with other algorithms such as ACO and BOA، convergence and more accurate in solution.

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