Development of Artificial Bee Colony Algorithm for Iris Segmentation

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Abstract. Iris segmentation is a crucial process in the iris recognition that it locates and captures the unique features inside the human iris image. However, iris image contains high noise rate and sometimes a genuine user is recognized as non-genuine by computer system. An algorithm from swarm-based intelligence is demanded for natural search images. Therefore, an experimental investigation was conducted to explore artificial bee colony (ABC) algorithm for iris segmentation. The ABC algorithm measures the performance of convergence in learning the authentic iris features. Based on the findings, the average fitness is always less than or equal to the best fitness, and the differences between the two goes on decreasing over time, which is until the algorithm completely converges. The parameters of ABC Algorithm are programmed with at best 100 times of calculation to collect the best iteration and best fitness. In fact, results showed that ABC uses the population for every iteration instead of a single iteration. Number of iterations directly affect the time of optimal search for ideal convergence, which meets the aim of this study. As a conclusion, if the mean and standard deviation is low in values, it is proven that the speed of searching the iris features is faster and more robust.

1. Introduction
Segmentation in iris recognition performs initial stage of detecting the most crucial part of the iris features [1]. In the initial phase, the iris shape is localised and other shape than iris is removed such as eye lids, eye brows and sclera. The almost round shape iris is normalized, which transformed into a rectangular shape for matching process. There are two types of iris segmentation that is circular and non-circular segmentation method. For circular segmentation, the iris is acquired in a round shape and the fundamental technique is the Integro-Differential Operator (IDO) and Hough Transform (HT) [2]. The circular type is suitable for ideal position and low in error rates. However, the non-circular iris segmentation [3] obtains the iris shape according to the original shape of the iris, which is almost round and in non-ideal condition. The non-circular iris segmentation involves partial segmentation [4], non-cooperative method [5], noise application and removal to images [6], active contours detection [7], hybrid segmentation method [8] and non-ideal segment with swarm intelligence algorithm. The non-ideal segment with swarm intelligence algorithm consists of ant colony optimization [9], particle swarm [10] and bee algorithm [11]. However, few studies on ABC algorithm is done for iris recognition [12],[11]. Thus, the purpose of this study is to investigate the performance of ABC algorithm in the iris segmentation.
1.1 Artificial Bee Colony Optimization (ABC) Algorithm

The Bee Algorithm offers behaviour position over other enhancement techniques as indicated by the way of the issue and it is an improvement calculation enlivened by the characteristic scavenging conduct of humble bees to locate the ideal arrangement. For the equation in Bees Algorithm, there are three phases which are initialization phase, employed bees’ phase and Onlooker Bees phase [11].

1.1.1 Initialization phase

The colony of artificial bees includes three groups of bees, employed bees, onlooker bees and scout bees. The food source vectors are initialized by scout bees. The initialization formula is shown in equation (1).

\[ x_{mi} = l_i + rand \times (u_i - l_i) \]  

where \( x_{mi} \) is a solution vector to be optimization problem, \( l_i \) and \( u_i \) is the lower and upper bound.

1.1.1.1 Employed Bees phase

Employed bees search for new food source with more nectar within the neighborhood of the food source \( x_{mi} \) in their memory. They evaluate the profitability (fitness) after they find a neighbor food source. Equation (2) shows how to determine the neighbor of food source.

\[ v_{mi} = x_{mi} + \varphi_{mi} (x_{mi} - x_{ni}) \]  

where \( x_{ki} \) is a random chosen food source, \( i \) is a random parameter index and \( \varphi_{mi} \) is a random number within the range \([-a, a]\). Thereafter, the fitness is calculated based on the equation (3) as provided.

\[ fit(x_m) = \begin{cases}  
\frac{1}{1 + abs(f_m(x_m))} & \text{if } f_m(x_m) \geq 0 \\
\frac{1}{1 + abs(f_m(x_m))} & \text{if } f_m(x_m) < 0 
\end{cases} \]  

Where \( f_m(x_m) \) is the objective function value of solution \( x_m \).

1.1.1.2 Onlooker Bees phase

Employed bees share their food source information with onlooker bees in the hive by dancing, and then onlooker bees choose the food sources by the probability. The probability is calculated by fitness values, \( fit(x_m) \) provided by employed bees. The probability value, \( p_m \) which is selected by an onlooker bee could be calculated by equation (4).

\[ p_m = \frac{f_m(x_m)}{\sum_{m=1}^{n} f_m(x_m)} \]  

After a food source \( x_m \) for an onlooker bee is probabilistically chosen, a neighborhood source \( v_{mi} \) is determined by using equation (4), and its fitness value is computed. Hence, more onlookers are recruited to richer sources and positive feedback behavior appears.

2. Proposed Method

The proposed algorithm starts by scout bees being placed randomly in the selection of sites due to its character of the food source vector. Then, the scout bees visited and evaluated the fitness of the sites called as “Elite Site” and bees that have the highest fitness are chosen as “selected bees” or “new bees” to track the iris feature in the region using neighbourhood search. Then, the algorithm conducts searches in the neighbourhood of the Elite Sites, assigning more bees to search near to the best e-sites. Searches in the neighbourhood of the best e sites are made more detailed by recruiting more bees to follow them than the other selected bees. Together with scouting, this differential recruitment is a key operation of the ABC Algorithm. The remaining bees in the population are assigned randomly around the search space scouting for new potential solutions. These steps are repeated until a stopping criterion is met. At the end of each of iteration, the colony has two parts, those that were the fittest representatives from a patch and those that have been sent out randomly. The algorithm performs a detection of iris features
and calculates the iteration and time of iteration for a combinatorial and functional optimization. Figure 1 shows the pseudocode of the proposed algorithm of iteration in bee algorithm.

```plaintext
// Initialization// Read problem, data, parameter values (B and NC) and stopping criteria
Do  //employed bees phase//
    Assign empty solution to each bee
    For (i=0; i<NC; i++)
        // forward step
        For (b=0; b<B; b++)
            For (s=0; s<f(NC); s++)
                // count moves
                (a) Measure possible moves
                (b) Select a move
                //backward step
                For (b=0;b<B; b++)
                    Measure the solution of bee, b
                    For (b=0;b=B; b++)
                        Decide loyalty for bee, b;
                        If (b=not obey; choose recruiter)
                    //onlooker bees phase//
                    Measure all solutions and find the best. Update best function and best criterion.
                //Bee parameter iteration//
                Max=100;
                nScoutBee=10;
                SelectSite=round(0.5*nScoutBee);
                nEliteSite=round(0.4*SelectSite);
                nSelectedSite Bee=round(0.5*nScoutBee);
                r=0.1*(VarMax-VarMin)
                rdamp=0.95
                //Iteration Process//
                For it=1 to Max
                    For i=1 to nEliteSite
                        Best newbee cost = inf
                        //Track iris image after the iteration process//
                        Calculate success rate and times
                        //Display graphs/
                        Display iteration and best fitness results
                End
```

Figure 1. Pseudocode of Artificial Bee Colony algorithm with iteration.

3. Results and Findings
The iris template image uses a public dataset for a standard performance. To avoid biasness, iris image is obtained from Center for Biometrics and Security Research in the Institute of Automation Chinese Academy of Sciences (CASIA) public eye database.

3.1 Results of Scout Bees and New Bees for Tracking Features in Iris Images
Figure 2 shows scout bees find the region selection to perform the iterations process, which involve movement of forward and backward. The scout bees need to achieve best solution for Elite Site to track the iris features. In order to get the highest iteration number and the highest fitness, the new bees are trooped to produce the best iteration number and the best fitness. The calculation is measured to test the success rate and number of times spent for the ABC algorithm to complete the segmentation process.

3.2 Graph of Best Fitness versus Iteration
Figure 3 shows the graph of Best Fitness versus Number of Iterations. As increased in best fitness, the number of iterations of scout bee’s iteration is decreased. The reason is the high number of iterations brings higher learning activity in scout bee with its nearby neighbourhood. When the scout bees familiar
with its surrounding then it is easier for the scout bees to track the iris feature. The graph shows the ABC Algorithm gradually decrease to converged as increase in number of iterations.

Figure 2. Iris segmentation using Artificial Bee Colony algorithm (Scout Bee).

Figure 3. Graph of best fitness versus no. of iteration.

3.3 Results of values obtained in Table for Best Fitness versus Iteration

Table 1 shows the result of success rate and times for an iris images to complete the segmentation process using ABC Algorithm with parameters obtained from figure 2, which is executed on MATLAB programming software application.

| Parameter | No. of Iteration | No. of Scout Bees |
|-----------|------------------|-------------------|
| 10        | 20               | 30                | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| Tmin      | 100              | 9.3E-07           | 3.14E-08 | 3.17E-08 | 8.09E-10 | 6.59E-09 | 6.76E-09 | 3.48E-09 | 3.02E-09 | 1.69E-09 | 1.59E-09 |
| VibMax    | 200              | 1.97E-11          | 1.28E-12 | 1.29E-12 | 8.63E-13 | 6.26E-13 | 6.23E-14 | 1.12E-13 | 1.37E-13 | 7.94E-14 | 5.42E-14 |
| nSelectedSite | 300            | 2.94E-16          | 1.09E-16 | 1.09E-17 | 2.99E-17 | 5.32E-18 | 1.12E-17 | 4.34E-18 | 2.95E-18 | 1.09E-18 | 1.17E-18 |
| nFiltsIn | 400              | 6.81E-21          | 4.91E-21 | 5.06E-22 | 7.27E-22 | 9.13E-23 | 1.14E-22 | 1.66E-22 | 5.03E-23 | 2.03E-23 | 4.67E-23 |
| nSelectedSite | 500            | 9.24E-25          | 6.39E-26 | 8.92E-27 | 4.99E-27 | 1.07E-26 | 3.53E-27 | 2.47E-27 | 2.63E-27 | 2.21E-27 | 2.21E-27 |
| nSelectedSite | 600            | 4.07E-29          | 1.99E-30 | 2.01E-30 | 8.28E-31 | 6.74E-31 | 4.14E-31 | 2.71E-31 | 1.07E-31 | 9.12E-32 | 4.08E-32 |
| R         | 700              | 1.15E-33          | 1.48E-34 | 5.24E-35 | 3.16E-35 | 1.48E-35 | 6.64E-36 | 7.80E-36 | 1.40E-36 | 3.28E-36 | 2.45E-36 |
| N upheld | 800              | 1.99E-38          | 3.09E-40 | 5.33E-40 | 9.28E-40 | 4.80E-40 | 1.02E-40 | 7.79E-41 | 7.79E-41 | 1.04E-40 | 4.98E-41 |
| 900      | 6.97E-41         | 1.83E-43          | 6.21E-44 | 2.41E-44 | 1.34E-44 | 5.33E-45 | 3.12E-45 | 4.54E-45 | 3.65E-45 | 7.31E-46 |
| 1000     | 8.63E-47         | 1.93E-48          | 3.59E-48 | 1.69E-48 | 3.80E-49 | 3.80E-49 | 4.38E-49 | 9.07E-50 | 1.19E-40 | 4.61E-50 |
4. Conclusion
Artificial Bee Colony (ABC) algorithm is one of a swarm intelligences based on the honey bees movement to find food. In ABC algorithm, the artificial bees are categorized as employed, onlooker and scout that helped each other to find a solution for optimization problem. The purpose of the study was to determine the performance of ABC algorithm to produce faster detection and more information obtained during iris segmentation. This study has shown that 70 scout bees and 600 iterations indicate produced average fitness for ABC algorithm to converge.

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