International Journal of Engineering & Technology, 7 (4.42) (2018) 157-160

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Clonal Selection Algorithm for Low Quality Fingerprint Image Verification

Siti 'Aisyah Sa'dan[1,2]*, Rajeswari Raju[1], Nursuriati Jamil[3]

[1]*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Cawangan Terengganu*
[2]*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Cawangan Pahang*
[3]*Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia*
**Corresponding author E-mail: sitiaisyah@uitm.edu.my*

Abstract

Fingerprint verification has drawn a lot of attention to its approach in biometric since it is one of the most important biometric technologies nowadays and is widely used in several different applications and areas. It is applied in the forensic science area in order to identify people who were involved in criminal scenes such as the victims and the suspects. A human's fingerprint is unique and usually has its own patterns and ridges, which differs them from other's fingerprints. However, there are some drawbacks that can cause low accuracy and low performance of the verification. This occurs when the fingerprint images used are of low-quality and the fingerprints may be slightly incomplete (partial). Clonal Selection Algorithm (CSA) is known to be good in pattern matching and optimization of problems. Hence, this paper discusses the finding of the implementation of CSA in fingerprint verification. There were two main processes involved, which are features extraction using minutiae-based method and also the implementation of the CSA algorithm. Study shows that the FNMR result is 33.33% and the FMR is 16.67%. Further studies can be carried out by using the same algorithm, but focusing more on the feature extraction methods to improve the extraction of fingerprints.

Keywords: *Biometrics; Clonal Selection Algorithm; CSA; Fingerprint Verification; Forensic Science*

1. Introduction

Biometrics refers to the authentication techniques that are done based on the physical characteristics of a person that can be automatically checked [1]. A biometric system can be divided into two categories, which are identification system or a verification (authentication) system [2]. Biometrics is also known to fall under the pattern recognition system [2]. There are several different categories of biometrics and they are DNA matching, facial recognition, iris recognition and also fingerprint recognition.

In the biometric systems, fingerprint verification is most commonly known as one of their popular ways in identifying a person [3]. A human's fingerprint usually has its own patterns and ridges, which makes them different from other people's fingerprints [4]. Fingerprint is hard to be altered or copied and it will remain the same for a lifetime. A fingerprint is exclusively unique in terms of its local ridge characteristics and their relationships [5]. It consists of a pattern of ridges, furrows, ridges and minutiae. In general, there are three main patterns of fingerprints and they are whorl, loop and arch patterns. The process of fingerprint verification must first be done with a feature extraction to transform the information from the images into numeric or binary forms. Some of the commonly used feature extraction methods are minutiae-based and correlation-based.

Fingerprint verification has drawn a lot of attention to its approach in biometric since it is one of the most important biometric technologies nowadays [6]. It is widely used in several different applications and areas, and one of them is in the forensic science area. It is used to verify and identify people who were involved in criminal scene such as the victims and also the suspects. Forensic science is the application of the natural and physical sciences that questions the legal or public concern [7]. It is one of the scientific knowledge and technical methods used to analyze and interpret traces of evidence in order to answer questions related to criminal, civil and administrative law [8]. Identifying people who are involved in criminal scenes is a very serious matter since it may help in solving the criminal case with justice [8].

Even though fingerprint verification is known to be the most commonly used technique in identifying a person, there are still some drawbacks that can affect the accuracy of the verification [3] and this happens when the images of the fingerprints used are of low-quality [1]. The quality of the images is crucial since it will determine the accuracy of the verification. Low-quality images will cause a low performance in the verification [4]. This is because some of the ridges of the fingerprints are unclear and not connected, causing the fingerprints to be incomplete with the proper information that they should have.

In solving pattern matching and optimization problems, CSA is known to be a good algorithm to be implemented and used [9]. It has been implemented in several domain areas such as engineering, pattern recognition and also scheduling problems. Since fingerprint verification involves doing a pattern matching process, CSA is found to be suitable to be implemented to it. Therefore, the objective of this study is to overcome the problems of low performance and accuracy of fingerprint verification by implementing CSA. This study can help in improving the fingerprint verification that is applied in forensic science and also can be added as a new knowledge to the pattern recognition and image processing area.

This paper is organized as follows. The second section discusses the related works that have been done on fingerprint verification and recognition using different techniques and approaches. The third section describes the research method that is proposed in order to develop this study. The fourth section discusses the result of the fingerprint verification using CSA and the fifth section is the conclusion to the study.

2. Related Works

2.1. Fingerprint Verification

Fingerprint verification or mostly known as fingerprint recognition has been around since the late 1960s and it has evolved since then under different areas such as forensic science and security [10]. The scopes of the previous research differ from one to another. Some of the approaches focused on Image enhancement techniques before applying the recognition process, while some focused on the feature extraction process.

The studies of fingerprint recognitions actively done in various aspects. [1] discussed on the improvement of feature extraction which focused on the minutiae-based method with a different orientation value in the feature extraction. Low-quality fingerprint images retrieval and recognition has been used with Scale Invariant Feature Transform (SIFT) and Local Sensitive Hash (LSH) as in [11]. Meanwhile, [12] has discussed the subsurface fingerprint imaging using Full-Field Optical Coherent Tomography (FF-OCT). Standardize fingerprints model also has been proposed by [14] and also, some other studies on the fingerprint minutiae points extraction based on the Neural Network-based. These features can be used in verification systems [15].

2.2. Clonal Selection Algorithm (CSA)

The previous researches of CSA can mostly be seen applied in three different domain areas. They are pattern recognition or matching, optimization of problems and also scheduling. The previous works on the implementation of CSA are discussed as in [9],[13].

[9] proposed an implementation of CSA in pattern recognition, which is the shape recognition. They used three different types of shapes to be recognized. They have done two experiments and the static mutation rate and clonal rate were both used in the two experiments. In the first experiment, the clonal rate was set to 10% of population size while the mutation rate was set to 5% [9]. The result ranged from 77-79, which is quite low because only half of the shapes were recognized. The second experiment is done by changing the threshold value, thus increasing the result with a range of 80-96 which recognized 8 out of 10 of the shapes that were tested.

Meanwhile, [9] implemented CSA in the Construction Site Utilization Planning Optimization. This area falls under the optimization of engineering problems. The purpose is to do a decision making in identifying the most optimal layout for the temporary facilities designed in order to support the construction process [13]. The result showed that there is an improvement in the objective function when CSA is implemented to the process.

In 2015, [11] proposed an approach in a scheduling problem for urban bus vehicle. They have used CSA to quickly generate satisfactory solutions to the large-scale of the bus scheduling problems. The result showed that the CSA helped in making the process effective and can find the satisfactory solutions quickly.

3. Methodology

3.1. Data Collection and Data Preparation

Fingerprint recognition is based on images, therefore a dataset of fingerprint images to be trained and tested were collected. The images were obtained from an online database called "Fingerprint Verification Competition 2004" database. Data collection is the most crucial aspect in developing the study since it is the main source in ensuring the study meets its objectives [14]. The data that have been collected consist of 80 images of fingerprint from 10 different persons, and for each set of finger, it consists of 8 fingerprints that were scanned with different intensities, pressures and angles. For this study, the selected fingerprints to be verified came from only one finger set of one person, considered to be 'Person A' since each minutiae points of the fingers consist of about 50 points each, which already made it quite a huge number to be trained and tested using CSA. The Person A's data were divided into training images and testing images. Meanwhile, the rest of the data are notified as Non-person A.

3.2. System Design and Implementation

The steps involved in designing the system consist of two two steps, which are designing process for the preprocessing of fingerprint feature extraction and also designing the CSA architecture. The process starts with the pre-processing which is the feature extraction of the fingerprint. The result will be the minutiae points of the fingerprints and they are stored in a text file that acts as a database. From here, the CSA is applied in order to achieve the highest affinity value of the training sets that will be set as the threshold to be compared to the testing sets.

a) The steps involved in feature extraction are as follows:-

- *Thinning*: It performs a morphological operation (erosion) to form a skeletonized version of the binary image of the fingerprint.
- *Minutiae Extraction*: It is done by scanning the local neighbors of each ridge pixel using a 3x3 window and the Crossing Number (CN) concept is used as proposed by [17]. The 3x3 window is used to determine the bifurcation and ridge points which then will be used as the parameter and it gives a more precise removal of the unwanted noise. If the center cell has a value-1 and only one neighbor of value-1, then it is a ridge point. If the central cell has a value of 1 with three neighbors of value 1's, then it is a bifurcation point. The CN is used to differentiate between the preliminary ridge ending and the bifurcation points of the fingerprints.

The outputs of the feature extraction will be a set of minutiae points that consist of location *x* and *y* of both bifurcation and ridge points of the fingerprints that were used as inputs in the CSA process. The sample outputs are shown in Figure 1.

Fig. 1: Feature Extraction's Flow.

b) The next process is the CSA. The step by step process of the CSA is defined as follows:-

In CSA there are two main roles that were used throughout the process and they are *Antibodies* and *Antigens*. They both consist of randomly picked minutiae points of the training datasets that were obtained from the previous feature extraction phase.

Input: A set of minutiae points from one finger that consist of location x and location y of Bifurcation points, and also location x and location y of Ridge points.

1. Initialization: A population set of an antibody pool with a fixed size of 5 was initialized and randomly selected from the sets of minutiae points of one finger. From here, the pool is divided into two components, which are a set of memory antibody, ***M*** that represents the algorithm's solution and a re-

maining pool, ***r*** that were used to include the additional antibody that will be inserted to increase the diversity of the population.

2. This is a loop phase, where the number of generations, ***G*** was set to 2:-
a) Affinity evaluation: From the remaining sets of minutiae points of the previous step, one set of them were selected to act as antigen. Since it is in a looping process, the system would not choose the same set of minutiae points since they will be removed once they have been selected.
b) Antigen Exposure: Then, the affinity values were calculated for all the antibodies against the antigen. The affinity value refers to the resemblance of similarity between the antibodies with the selected antigen.
c) Selection: The highest affinity values of the antibodies were selected. Then they were sorted from highest to lowest.
d) Cloning: The cloning of the selected antibodies previously was done. The number of cloning depends on the affinity value. A higher affinity value will generate a higher number of copies and vice-versa.
e) Affinity Maturation (mutation): Mutate each of the cloned antibodies with a rate inversely proportional to their affinities: The higher the affinity rank, the smaller the mutation rate and vice versa.
f) Cloning Exposure: The clone is exposed to the antigen, and affinity measures are calculated once again.
g) Candidature: The antibodies with the highest affinity value in the clone were selected as candidates of the memory antibodies to be placed into ***M***. The ones that had a higher affinity than the antigen from the memory pool will replace that antigen.
h) Replacement: The set of minutiae points that still remained in ***r*** with the lowest affinity were replaced with the new random selected antibodies.
3. Cycle: Repeat step 2 until termination criterion is met which is ***2*** iterations.
4. Finish: Once the training iteration was completed, the memory ***M*** of the antigen pool was taken as the algorithm's solution to find the threshold value to be set.

4. A step before the final submission

For this study, the proposed evaluation methods used are the same as proposed by [3] which are False Non-Matching Ratio (FNMR) and False Matching Ratio (FMR). They are the standard performance measure for biometrics systems.

The FNMR determines the probability that the actual Person A is denied by the system. The equation is shown in (1). It happens when the matching score between the processed data with its template is less than the determined threshold.

$$FNMR = \frac{FalseNonMatches}{EnrolleAttempts} \tag{1}$$

The FMR determines the probability that the Non-person A is given an access and the equation is shown in (2). It happens when the matching score between the processed data with its template is greater than the determined threshold.

$$FMR = \frac{FalseMatches}{ImposterAttempts} \tag{2}$$

From the training process of CSA, the threshold value that was gained was set to **0.02**. First, the FNMR is done to test the verification of Person A. The FNMR result is 33.33%. Then, the FMR is done to test the verifivation of Non-Person A, while the FMR result to be 16.67%. Figure 2 shows the prototype interface for this study which is named.

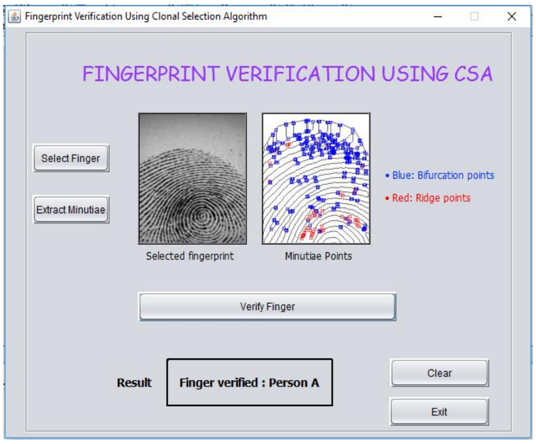

Fig. 2: Prototype of Fingerprint Verification Using CSA

The results of this study can be seen in Table 1 and it describes that the 2 datasets of Person A and Non-person A using the defined threshold value and their corresponding FNMR and FMR values.

Table 1: Results of Verification Based On Threshold

Data Sets	*Threshold*	*FNMR(%)*	*FMR(%)*
Person A	0.02	33.33	0.00
Non-person A	0.02	0.00	16.67

5. Conclusion

In conclusion, the aim of this study is to develop a prototype of fingerprint verification by using CSA and to evaluate whether this algorithm is suitable to be implemented in this domain since it is known to be good in pattern matching and optimization of problems. The accuracy of verification was measured using the standard biometrics performance measure, FMR and FNMR. For future works, the fingerprint verification using CSA may be enhanced with a focus on the process of extraction of minutiae points. Besides that, instead of trying to verify only one person, i.e. Person A, the number of persons may be added so that more data can be trained and tested, and the result of verification may be more accurate.

Acknowledgement

This study is supported by University Teknologi MARA.

References

[1] Patel, H., and Sharma, V.: 'Fingerprint Recognition by Minutiae Matching', International Journal of Engineering Trends and Technology (IJETT), 2013, 4, (2136-2140)
[2] Vatsa, M., Singh, R., Gupta, P., and Kaushik, A.K.: 'Biometric Technologies' (2005. 2005).
[3] Ravi, J., Raja, K.B., and Venugopal, K.R.: 'Fingerprint Recognition Using Minutia Score Matching', CoRR, 2010, abs/1001.4, (2), pp. 35-42.
[4] Prasad, D.R.S., Al-Ani, M.S., and Nejres, S.M.: 'An Efficient Approach for Fingerprint', 2016, (April 2015).
[5] Hong, L., Wan, Y., and Jain, A.: 'Fingerprint image enhancement: algorithm and performance evaluation', IEEE Transactions on Pattern Analysis and Machine Intelligence, 1998, 20, pp. 777-789.
[6] Naja, M.I., and Rajesh, R.: 'Fingerprint image enhancement: algorithm and performance evaluation', International Journal of Innovative Research in Computer and Communication Engineering, 2015, 3, (1).
[7] Houck, M.M., Initiative, F.S., and Rood, E.: 'Biometrics and Forensic Science What's the Difference?', n.d.
[8] Meuwly, D., and Veldhuis, R.: 'Forensic biometrics: From two communities to one discipline', 2012, pp. 1-12.

[9] Isa, N., Sabri, N.M., Jazahanim, K.S., and Taylor, N.K.: 'Application of the Clonal Selection Algorithm in Artificial Immune Systems for Shape Recognition', 2010, pp. 223-228.
[10] U. S. D. o. Justice. (3 May). U.S. Marshals Service. Available: https://www.usmarshals.gov/usmsforkids/fingerprint_history.htm.
[11] Zhong, Y., and Peng, X.: 'SIFT-Based Low-Quality Fingerprint LSH Retrieval and Recognition Method', International Journal of Signal Processing, Image Processing and Pattern Recognition, 2015, 8, (8), pp. 263-272.
[12] Raja K. B., Auksorius E., Raghavendra R., Boccara A. C., and Busch. C.: 'Robust Verification With Subsurface Fingerprint Recognition Using Full Field Optical Coherence Tomography', Computer Vision and Pattern Recognition Workshops (CVPRW), 2017 IEEE Conference on, 2017
[13] Wang, X., Deshpande, A.S., Dadi, G.B., and Salman, B.: 'Application of Clonal Selection Algorithm in Construction Site Utilization Planning Optimization', Procedia Engineering, 2016, 145, pp. 267-273.
[14] Thai, L.H., and Tam, H.N.: 'Fingerprint recognition using standardized fingerprint model', 2010, 7, (3).
[15] Alijla B. O., Saad M., and Issawi S. F.: 'Neural Network-based Minutiae Extraction for Fingerprint Verification System', Information Technology (ICIT), 2017 8th International Conference, 2017.