American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-5, Issue-2, pp-248-253
www.ajer.org
Research Paper Open Access

The performance evaluation of an algorithm for fingerprint biometric recognition

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ABSTRACT: *In this article we have treated the performance of an algorithm designed to achieve the biometric identification through fingerprints. The paper consists in providing the design steps of this algorithm consisting of transformations that are currently being introduced in the system images. The algorithm used is in itself a database that holds a certain number of fingerprint images which are chosen to be included in the database in question. After the introduction of the database, the system is ready to perform the fingerprint identification. This process comprises a series of sub-processes that make up this algorithm. One of the performance parameters of the algorithm is the execution time needed to carry out the identification of various fingerprints. We have used 200 different traces of fingers and we have entered them in the database. Then, for each finger traces we have calculated the time of the execution of milliseconds needed to recognize the fingerprints. This execution time is set in relation to an arbitrary identification number ranging from 1 to 200 and so we have reflected the exponential regression trend-line together with the coefficient of determination. This coefficient has also led to the identification of the limits of this paper.*

Keywords: *algorithm, fingerprint, execution, biometric, regression*

I. INTRODUCTION

The personal identification consists in accompanying a particular individual with a corresponding identity. He plays an important role in our society, [1] where questions relating to the identity of an individual are performed millions of times a day by financial services organizations, health care, in electronic commerce, in telecommunications, government agencies, etc. With a more rapid development of information technology, people are becoming more and more connected with electronics. As a result, the ability to achieve accurate identification of individuals has become critical [2].

A diversity of varieties of systems requires personal and sustainable authentication schemes in order to confirm and identify the identity of persons seeking certain services. The aim of these schemes or systems is to ensure that services are accessible to legitimate users. Examples of these systems include secure access among different buildings, computer systems, mobile phones, ATM, etc [3]. In the lack of robust authentication systems, these systems are imminent. Consequently, the use of biometric parameters was born as a need to confront these threats.

II. METHODOLOGY

The methodology used in this study consists of two aspects. The first is the fingerprint identification algorithm and the second is the performance of this algorithm discussed in terms of execution time of the algorithm in conjunction with different fingerprints that are part of the database.

When a trace finger is added to the database of the application, the algorithm is executed 2 times: the first time for image input and a second time for the image rotated at an suitable angle (22.5 / 2 grade) so that the process becomes as varied in rotation. The rotation of the image is realized through using Matlab program using "`imrotate`" function. [4]

When an image of the fingerprint is added to the database, there is only one core point. On the other hand, when an input image is selected to perform the compliance of the fingerprint, then it will activate a series of fingerprint core and align points shall be carried out for each of them. Finally, it will be taken into consideration only the candidate with the smallest distance.[5] For example, we have 3 images in the database, *img1*, *img2* and *img3* where, each of them is characterized only by a core point and therefore will have 3 points each of their core is associated with an image present in the database. If we select an image for fingerprint compliance (should be "ImgNew") we will find a number of core points (let it be their number N). For each of these N

points nucleus (candidates) we will find the fingerprint images closest that is present in the database. Finally, we will obtain N distances (as the number of candidates of the core points).[6]
With respect to the second aspect, it consists of taking 200 samples consisting of the execution of the user's fingerprint identification process in milliseconds. After defining these samples they will be placed in front of the identification number of each finger trace. The identification number of such traces placed arbitrarily from 1 to 200. So we have created a graph where the x-axis shows the number of identification and the y-axis gives the execution time in milliseconds. Furthermore, on this relationship we have built the exponential regression which expresses the trend of the relationship in question. Also we have shown the respective coefficient of determination [7].

III. THE RESULTS

The rating of pixel-wise orientation field estimation is accelerated more by re-using estimates of the sums. The sum of the elements of a block centered on pixel (I, J) can be used for the calculation of the amount of elements centered on pixel blocks-in (I, J + 1). [8]This can be obtained in the following manner:

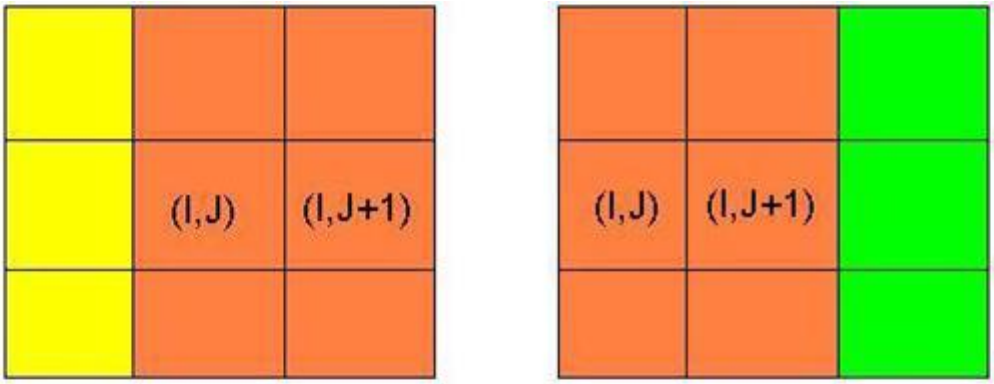

Fig. 1 – The explanation of the pixel-wise field estimation evaluation

Once the sum of values centered on pixel-in (I, J) is calculated (the amount of pixels and yellow pixels orange in the figure to the left), in order to score the sum of centered upon the pixel-in (I, J + 1), we simply learn from previous amount and add the yellow area green area (see figure right); in this way it is possible to maintain a series of calculations. [9] In other words:

$$\text{SUM (I, J) = yellow + orange} \quad (1)$$
$$\text{SUM (I, J+1) = SUM (I, J) – yellow + orange} \quad (2)$$

Now let's give the necessary steps for establishing the core point in the process of the fingerprint's identification. Initially, for an input image, we improve the fingerprint in order to have a better quality image. [10] In the figure below we have shown an image trace the finger at the entrance to the system.

Fig. 2 – The image of the fingerprint at the entrance of the system\

Below we have presented the enhanced fingerprint.

Fig.3 – The image of the enhanced fingerprint

After this operation, the image is segmented and separated from the background image of the fingerprint. This can be accomplished using a simple block-wise variance, background since usually it is characterized by a small variance. [11] The image originally is digitalized (using command imclose in Matlab), then eroded (using command imerode), so as to avoid holes in the image of the fingerprint and the unwanted effects outside its boundaries (between the fingerprint and background). [12] Image segmentation is repeated several times until the desired conditions are met. This is done so as to avoid adverse effects between the fingerprint and background.[13] Condition for which we are concerned is selected in this way:
The improved image is divided into blocks with specified size (typically 32x32 or 64x64). The whole image is filtered with a complex filter. Let be the maximum value of the image Cf_max the filtered current area of interest (which had previously been estimated by some initial parameters). For each block in the relative maximum we recalculate Cf_rel.[14] Finally, we consider a matrix logic F the elements of which (I, J) are equivalent to 1 if (I, J) is a block and this value is equal to or greater than the limit value (typically 0.65 * Cf_max in our simulations); F (I, J) is equal to 0 in all other cases (for example if F (I, J) is not a relative maximum block or a relative maximum block smaller than the limit value). If the number of non-zero elements of the matrix F is the logical limit value, then the image segmentation parameters re-calculated and the entire process is repeated once again.[15]

In the figure below we have presented the segmented image

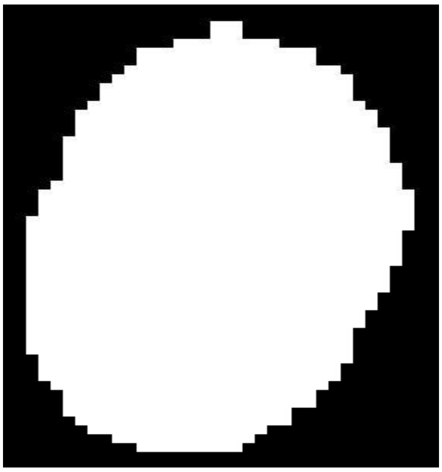

Fig.4 - The image is segmented, closed and eroded (erosion or binary close)

The next step consists of performing the calculation of the fast pixel-wise orientation field. The figure below illustrates this step in case of a finger traces involved in the system.

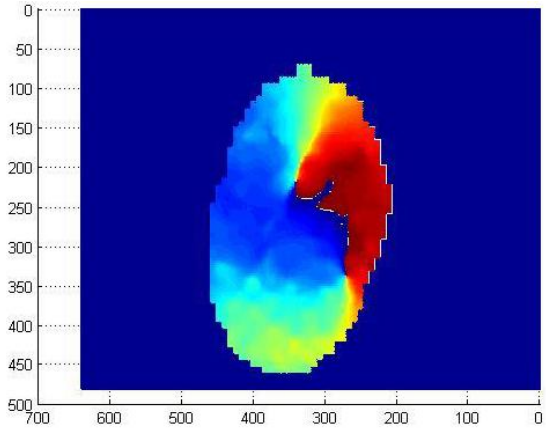

Fig.5 – The evaluation of pixel-wise orientation field in the area of interest

Further we use the field of orientation to provide a logical matrix where pixel-I (I, J) is set to 1 if the angle of orientation is less than or equal to π / 2.

Figure 6 – The logical matrix is at the local area of the little orientation that is less or equal to $\pi/2$.

Then we have calculated the output filter to improve the image of the fingerprint. In fact, it is not necessary that it be re-counted but we have used the recalculated the image in Figure 3.

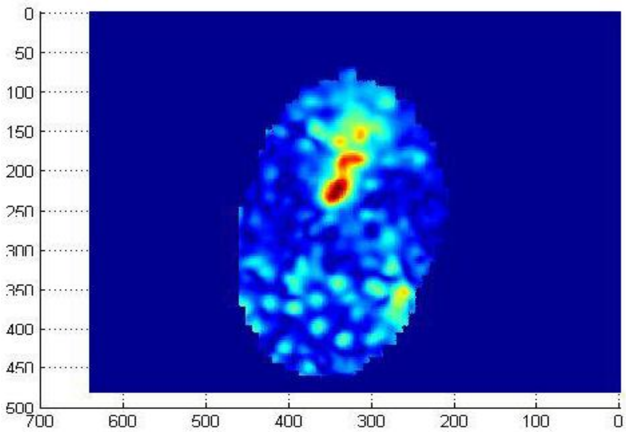

Fig.7 – The output of the complex filter of the enhanced image of the fingerprint

Then we have found the maximum value of the output complex filter where image pixels are placed at logical 1. [16]Finally all calculated points are subdivided into sub-groups of points that are close to each other. For each sub-group we will have a number of candidates and we consider only the sub-group with a number of candidates greater than or equal to 3. [17] For each of these sub-groups we have taken into account the group with the biggest coordinate. In this sub-group we have taken into account the core point with the biggest x-axis coordinate.

Fig.8– The image of the fingerprint and the corresponding core point

At this point we will give the results of simulation in Matlab of the performance of the algorithm used to achieve the identification of the fingerprint.[18]
Below we have shown the chart showing the dependency between the identification number of the ingerprint and time in milli-seconds of execution of identification process for each of the 200 fingerprints to consider.[19]

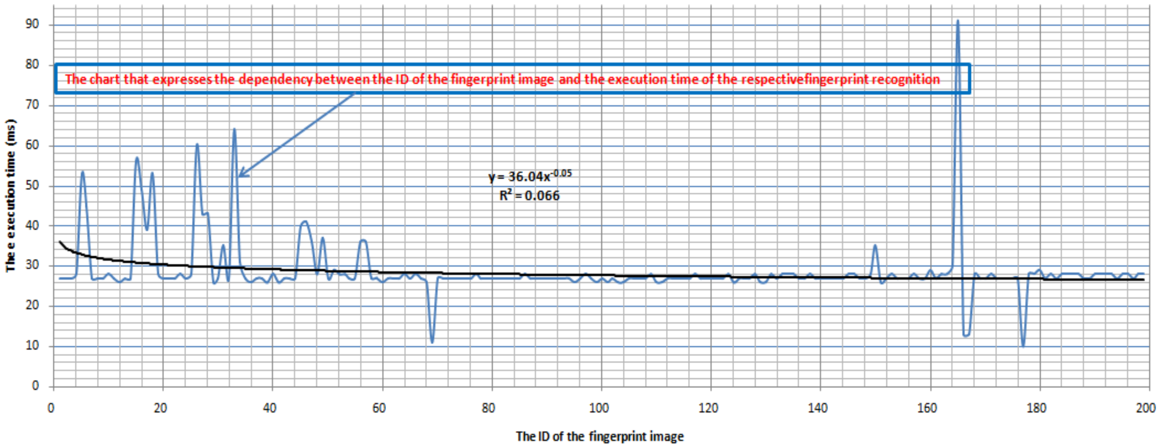

Fig.9 – The chart which expresses the dependency between the number of identification of the fingerprint and time in milli-seconds of execution of the identification for each of the 200 fingerprints

The trend-line is an exponential curve with the following equation:

$$y = 36.04 * x^{-0.5} \quad (3)$$

On the other hand, the coefficient of determination is $R^2 = 0.066$ which means that the dependency of the parameters from each other is in the range 6.6% and the rest remains to be studied and lies in the limitation status of this study.[20]

IV. CONCLUSIONS

In this article we gave the results of the performance of an algorithm designed for the identification of fingerprints. Initially, we have shown an introduction that discusses the problems of the present days on the threats that led to the development of biometric identification and authentication techniques.[21]
Secondly, we have treated the design methodology and performance analysis algorithm simulated in Matlab. This discussion consisted of two aspects: the description of the steps of the process of identification, the transformations incurred by the image of the input fingerprint and performance that perform the algorithm in terms of time of execution of identification of each image's track fingertips.[22]
Finally, we have interpreted the results of the simulations performed in Matlab to identify the finger trace from a database of 200 ones. Also, we have taken 200 samples to trace different user fingerprints together with relevant performance in the process of identifying each of them. This relationship has undergone exponential regression and the respective equation is filed for this regression. The coefficient of determination is 0.066 and it is indicates a 6.6% dependency on the parameters which highlights the limits of this article. [23]

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