Off-Line Signature Identification Using Moment Algorithm

تمييز التوقيع في حالة عدم فتح الخط بأستخدام خوارزمية العزم

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Abstract

In this paper, an off-line signature identification system is presented depending on moment algorithm. The proposed system consists of three steps. First step is enrolment module with the following operations: Transformation from colored image to gray level image, thresholding , thinning. Second step performs features extraction of the original signature by using Moment algorithm . The last step implements signature identification by using matching ratio.

المستخلص

في هدا البحث تم تقديم نظام تمييز توقيع في حالة عدم فتح الخط بالاعتماد على خوارزمية العزم. يتألف النظام المقترح من ثلاثة خطوات. الخطوة الأولى هي وحدة التسجيل التي تتضمن العمليات التالية: التحول من الصورة الملونة الى صورة رمادية، تحديد المدخل، ثم التنحيف. الخطوة الثانية: أستخلاص الخواص من التوقيع الأصلي باستخدام خوارزمية العزم. الخطوة الأخيرة : تنفيذ كشف التوقيع بأستخدام نسبة المطابقة.

Keywords: Signature identification, Off-line signature , Moment, Transformation.

Introduction

Off- line signature identification has a significant use mainly in establishing the authenticity of bank checks and other official documents, based on the signatures they carry. For instance, thousands of checks are being processed in a day in most banks or insurance companies; hence there is a great need for the automation of this process[1].

Off- line signature is a behavioral biometric; it is not based on the physical properties, such as fingerprint or face, of the individual, but on behavioral ones.

Off- line (static) signature authentication takes as input the image of a signature and is useful in automatic verification of signatures found on bank checks and documents[2].

The Proposed System

The proposed system consists of the following three modules:

Module 1 : Enrollment module

Module 2 : Features extraction module

Module 3 : Authentication module

Enrollment module

The main operation of this module is responsible for the enrollment signature image of a known person. After the input image was finished (the signature image will be captured by using a traditional scanner), signature image will be saved into temporary folder. The signature image must be named by the account number of the person (ID) to be used as identifier[3].

During enrollment to the system a user must supplies a number of reference signatures. The importance notice that we must consider are:

1- This module will not be complete only if the features extraction module be completed to save the values in the data file (reference database file).
2- people usually scale their signatures to fit the area available for the signature, therefore signature size must be normalized according to two of the dimensions (width and height)[4].

Preprocessing

The enrollment module includes all the preprocessing operations required for making the features easy to extract during the features extraction module, and available for authentication module. After the preprocessing operations for each image, the result must be saved in a temporary folder. The operations of the preprocessing are shown in fig.(1)[5]:

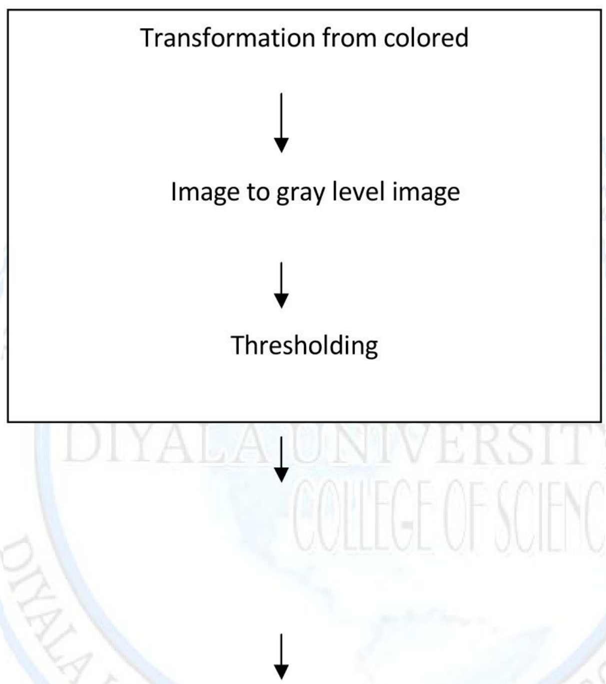

Fig.(1) The Block Diagram of Preprocessing Operation

a. Transformation Color Image to Gray Level Image

In this operation, the colored image of signature that entered by scanner to proposed system will transform to gray level image. Each colored input signature image will convert to a gray scale image by using the intensity relationship as described in eq.(1) [6]:

$$I = (R + G + B) / 3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where I is the intensity, and R, G and B are the corresponding red, green, and blue components. This relationship is performed on each pixel in the colored image. This intensity relationship will convert 24-bit/pixel images to 256 gray- level images. The conversion algorithm is shown as algorithm (1) at fig.(2):

```
Input   : Colored Image file

Output : Gray-level Image file



Begin

Step1 : Load the image from any file in to memory

Step2 : For i = 0 to image width

            For j = 0 to image height

              Begin

                  Get  red  color for  pixel  [ i , j  ]

                  Get green  color for pixel [ i , j ]
```

Fig.(2) Algorithm (1) Color to Gray Level Image Conversion

b. Thresholding

The thresholding is one of the most important approach to image segmentation. The aim of this stage is to isolate the all lines from signature itself. For this reason it must be segment the image in to two objects (background and lines) that identity each person. The result of this stage is a binary image (0,1) where 0's for background, and 1's for lines of a signature[7].

There is a way to extract the objects from background by selecting a threshold (T) that separates the modes. Then any point (x, y) for which f(x, y) > T is called an object point, otherwise, the point is called background point. Where f(x, y) is a gray level value at location (x, y) (The value of T is calculated by using the histogram of gray level image).

A threshold image g(x, y) is defined as eq.(2):

$$G(x, y) = \begin{cases} 1 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) <= T \end{cases} \quad \text{............ (2)}$$

Where f(x, y) is the gray level value.

c. Thinning

The main goal of thinning operation is to get rid of the difference existed the width of the pen (in order the signature of one person will be in one width even if he uses pens of different width). So, thinning operation will reduce these lines as much as possible to generate the exact shape for the main lines, and will reduce the calculations that are required for features extractions (by using the moments calculations)[8].

Thinning operation consists of successive passes of two basic steps applied to the contour points of the given region, where a contour point is any pixel with value 1 and having at least one 8-neighbor value 0 with reference to the 8- neighborhood definition shown in fig.(3).

9	**2**	**3**
8	**P1**	**4**
7	**6**	**5**

Fig. (3) The 8-neighbor of p1

Step 1 : Flags a contour point P for deletion if the following conditions are satisfied.

(a) $2 \leq N(p1) \leq 6$;

(b) $S(p1) = 1$;

(c) $p2 . p4 . p6 = 0$;

(d) $p4 . p6 . p8 = 0$;

Where N (p1) is the number of nonzero neighbors of (p1); that is,

$$N(p1) = p2 + p3 + p4 + p5 + \ldots\ldots + p8 + p9 \quad \ldots\ldots.(3)$$

And S(p1) is the number of 0-1 transition in the ordered sequence of p1, p2, p3,….,p8, p9 . For example N(p1)=4 and S(p1)=3 as shown in Fig. (4)[7]:

0	**0**	**1**
1	**P1**	**0**
1	**0**	**1**

Fig (4) The p1 value with their neighbors

Step 2: condition (a) and (b) remain the same but condition (c) and (d) are change to :

(c′) $p2 . p4 . p8 = 0$

(d′) $p2 . p6 . p8 = 0$

Thus one iteration thinning algorithm consists of:

- Applying step1 to flag border points for deletion.
- Deleting the flagged points.
- Applying step2 to flag the remaining border points for deletion.
- Deleting the flagged points

This basic procedure is applied iteratively until no further points are deleted, at that time the algorithm terminates, yielding the skeleton on the region.

Notice, if any condition of step1 or step2 are violated the value of point (p1) is not changed.

Condition (a) is violated when contour point p1 has only one or seven 8-neighbors valued 1. Condition (b) is violated when it is applied to points on a stroke 1 pixel thick, this condition prevents disconnection of segments of a skeleton during the thinning operation. Condition (c) and (d) are satisfied simultaneously by the minimum set of values : (p4=0 or p6=0) or (p2=0 and p8=0). Similarly, conditions (c′) and (d′) are satisfied simultaneously by the following minimum set of values : (p2=0 or p8=0) or (p4=0 and p6=0).

Creation Temporary Template

After all the preprocessing stages were completed then work on the signature image, the proposed system will create a temporary template as a temporary location to save the features that extracted from signature.

There are two purposes for entering signature image to the proposed system:

- The input image may be for enrollment purpose in database after features extraction.
- The input image may be for authentication. For this purpose, the features extracted from the image will not be saved into database of proposed system but will be saved into a temporary template.

Feature Extraction Using Moment Algorithm

The aim of the proposed system is to complete the authentication operation depending on the features extracted from the lines of the signature. In this stage (features extraction module), the proposed system will try to extract the features of the signature image (after preprocessing stage) by using moment method[7].

For a 2-D continuous function $f(x, y)$, the moment of order (p+q) is defined as described in eq.(4):

$$m_{pq} = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x^p y^q f(x,y)dxdy \quad \text{..........................(4)}$$

for p,q =0, 1, 2,…….

A uniqueness theorem states that if f(x,y) is piecewise continuous and has nonzero values only in a finite part of xy plane, moments of all orders exist and the moment sequence (m_{pq}) is uniquely determined by f(x,y). Conversely, (m_{pq}) uniquely determines f(x,y). The central moments can be expressed as:

$$\mu_{pq} = \int\int (x-\bar{x})^p (y-\bar{y})^q f(x.y)dxdy \quad \text{.........................(5)}$$

Where

$$\bar{x} = \frac{m_{10}}{m_{00}} and \qquad \bar{y} = \frac{m_{01}}{m_{00}} \quad \text{...(6)}$$

For digital image,

$$\mu_{pq} = \sum_x \sum_y (x-\bar{x})^p (y-\bar{y})^q f(x,y) \quad \text{..(7)}$$

The normalized central moments, denoted η $_{pq}$, are defined as:

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\gamma}} \quad \text{...(8)}$$

Where

$$\gamma = \frac{p+q}{2} + 1 \quad \text{..(9)}$$

for p+q = 2,3,......

A set of seven invariant moments can be derived from the second and third moments:

$$\phi_1 = \eta_{20} + \eta_{02} \quad \text{...(10)}$$

$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 \quad \text{..(11)}$$

$$\phi_3 = (\eta_{30} - \eta_{12}) + (3\eta_{21} - \eta_{0.3}) \quad \text{..(12)}$$

$$\phi_4 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{0.3})^2 \quad \text{....................................(13)}$$

$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} - \eta_{12})\left[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2\right] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})\left[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] \quad \text{.......(14)}$$

$$\phi_6 = (\eta_{20} - \eta_{20})\left[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] + 4\eta_{11}(\eta_{30} + \eta_{12})(3\eta_{21} + \eta_{03}) \quad \text{.......(15)}$$

$$\phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})\left[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2\right] + (3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})\left[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2\right] \quad \text{.....(16)}$$

This set of moments is invariant to translation, rotation, and scale change.

Feature Matching Percentage Calculation and Authentication Stage

First, call the template of the person from the referenced database depending on the ID (unique account no.). Second, execute the matching process between the saved template (in database) and the template that was created for authentication purpose (temporary template). The result of the matching will be as a ratio. If the ratio is equal or greater than 75% then the person is authorized otherwise the person is unauthorized[9].

To do the process of matching we suppose that, Ab[i] is any moment value of the template that created for comparison purpose (temporary template), and the Abdb[i] is any moment value from saved template (from database) values. Where A is any value from the moments values, i is the sequence of moments values i= 1,2,3……7, b is means template, and db is means the value from saved template (from database).

The matching ratio will be calculated from:

– The tolerance value (C) will calculate from:

$$C=Abdb[i] * q \quad ……(17)$$

Where q = tolerance ratio = 0.05

– The C value will be added and subtracted to / from the Abdb[i] for determining the permission range.

$$K1 = Abdb[i] - C \quad …..(18)$$

$$K2 = Abdb[i] + C \quad ……(19)$$

After getting the K1 and K2 the Ab [i] must be grater than or equal to K1, and smaller than or equal to K2. As shown below:

$$K1 \leq Ab[i] \leq K2 \quad …..(20)$$

If eq. (20) is satisfied, the two values (Ab[i] and Abdb[i]) will be taken into account when we calculate the total ratio of matching the two images of signature, and the total ratio will calculated as follow:

The matching percentage between Ab[i] and Abdb[i] will be calculated by:

There are seven moments values will be resulted from features extraction (F1,F2,…..F7). Any value from these values will take 1/7 from total ratio (1/7 □ 100 =14.285).

The matching percentage between (Ab[i] and Abdb[i]) is:

If Abdb[i] ≤ Ab[i] then the matching percentage will be:

$$M = \sum_{i=1}^{7} \left(\frac{Abdb[i]}{Ab[i]}\right) * 14.285 \quad .....(21)$$

Else

$$M = \sum_{i=1}^{7} \left(\frac{Ab[i]}{Abdb[i]}\right) * 14.285 \quad .....(22)$$

Where M is the total ratio.

The total ratio must be not less than 78% to accept the entered signature, otherwise the system will refuse the entered signature.

Results

The window of Signature Authentication system is shown in fig.(5).

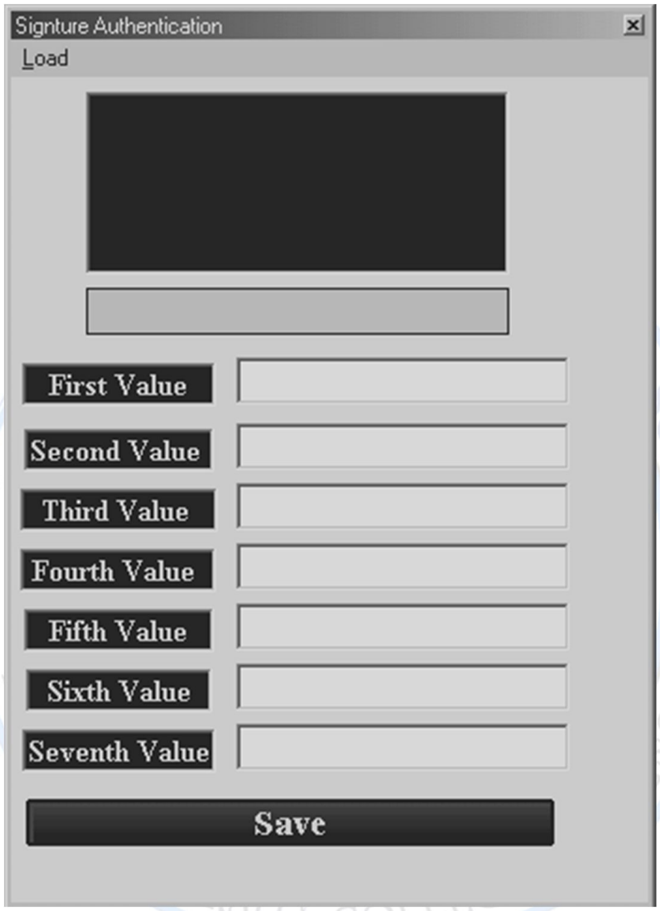

Fig.(5) The window of Signature Authentication

The "load" menu is shown in Fig.(6).

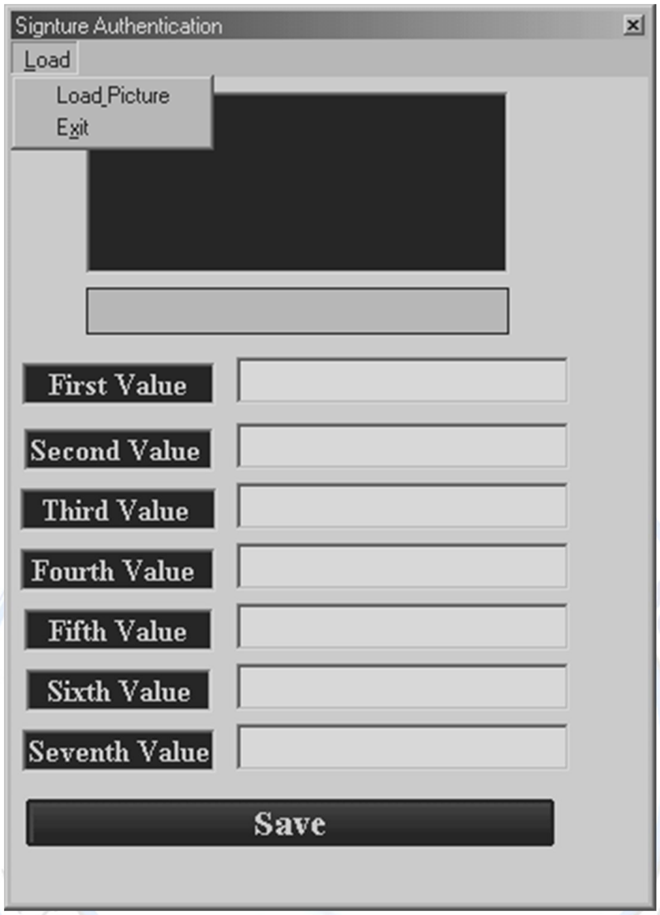

Fig. (6) The "Load" menu.

The loaded signature image is shown in fig.(7).

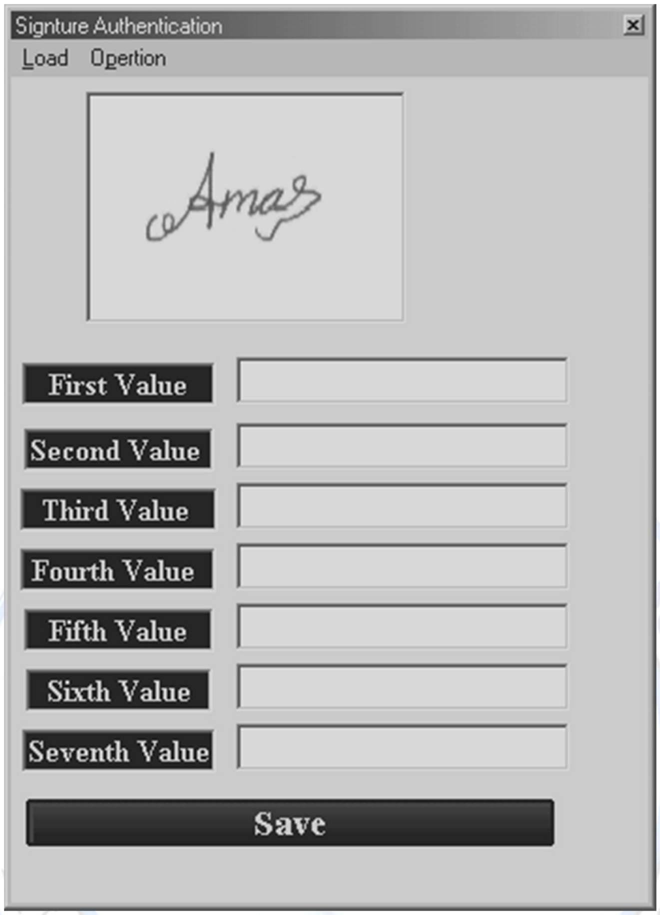

Fig.(7) Load signature image.

Thresholding operation is shown in fig.(8).

Fig.(8) Convert to gray level and thresholding operation

Thinning operation is shown in fig(9).

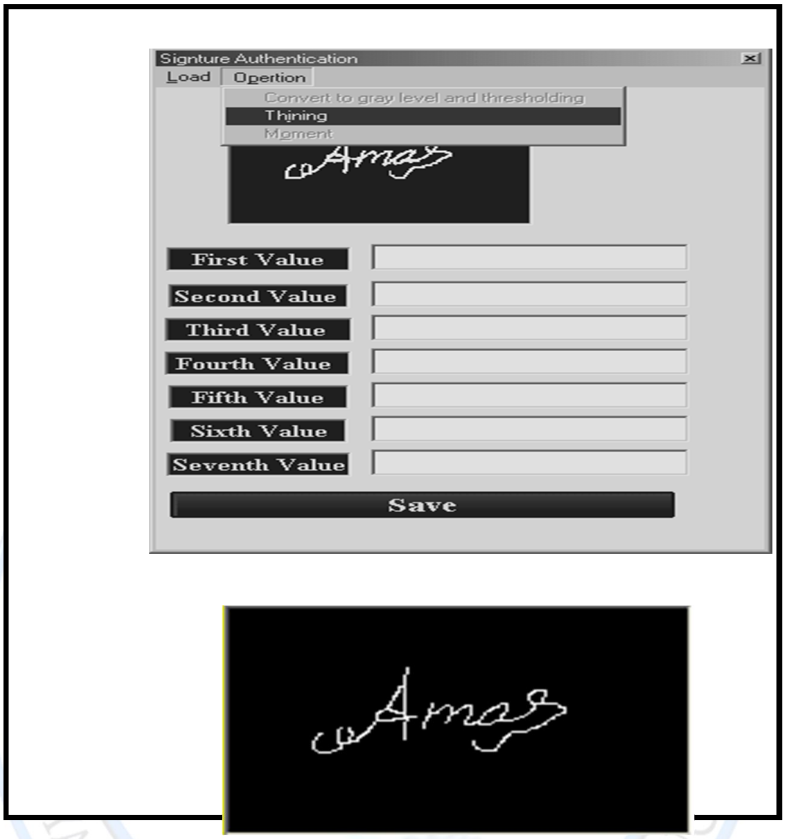

Fig.(9) Thinning Operation

The moment Operation (feature extraction) is shown in fig.(10).

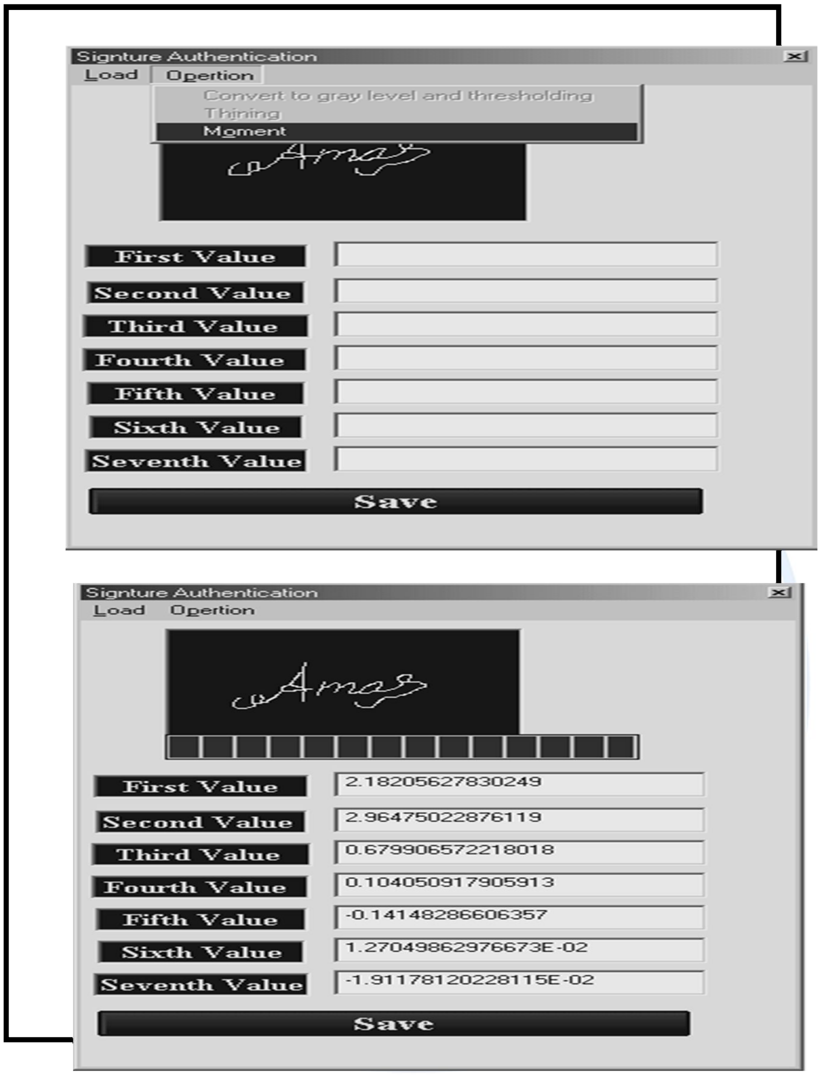

Fig.(10) The Moment Operation (feature extraction)

The matching ratio may be shown as fig.(11):

Fig.(11) Ratio of Matching Between Temporary Template and Database Template

Conclusions

The proposed System relays on the matching operation for granting the identification. The identification operation is called "one to one" search and depending on the available template and ID (unique account no.) for the person who needs to identify himself as authorized person. The ID must be unique as possible in the database.

The system is tested successfully for 100 signatures with matching ratios more than 90%. Therefore moment algorithm is successful method for identification.

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