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Improving Security of ID Card and Passport Using Cubic Spline Curve

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Abstract

In this paper, the proposes secure system to improving security of ID card and passports is by generating cubic spline co-occurrence code (CCO code) for each ID card. The authentication part, begins passing ID card through the checkpoint then the checkpoint will check the information of card or passport by also extracting features in order to generate the cubic spline co-occurrence code (CCO code), finally comparison is made between extracted CCO code at the checkpoint and CCO code that has been printed on ID card or passport (type of fraud like change personal picture or fraud it's information). Several tests were conducted to evaluate the performance of the proposed security system. Furthermore, the experiment results reveal that the proposed system can provide high-performance security systems as a result of use. This system can be used in many fields such as security of passport, ID card and certificate. Haralick features (Energy, Entropy, Variance, Contrast, Homogeneity) are very sensitive to any change in the information of ID card or passport, leading to detect any type of forgery.

Keywords: Cubic spline curve, GLCM, ID card, Feature extraction, Haralick.

تطوير حماية البطاقات الشخصية وجوازت السفر باستخدام منحني سبلاين

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الخلاصة

في هذا البحث، النظام الامني المقترح لتطوير لحماية الهويات الشخصية و جوا ازت السفر هو بتوليد مجموعة منحنيات من نوع مكعب سبلاين نطلق عليها CCO code لكل هوية شخصية او جواز سفر الجزء الثاني من النظام هو عملية فحص لمعرفة ما اذا كانت الهوية او جواز السفر مزورة ام لا. في البداية نقوم بتمرير البطاقة من خلال نقطة الفحص وتقوم هذه النقطة باستخلاص المعلومات من البطاقة او الجواز ثم تحول هذه المعلومات الى مجموعة منحنيات من نوع مكعب سبلاين CCO code بعد ذلك يقوم النظام بالمقارنة مابين ال **CCO code** المطبوع على الهوية والذي يمثل معلومات البطاقة الاصلية ومجموعة المنحنيات المولدة في نقطة الفحص فاذا كان الاثنان متطابقين فهذا يدل على ان البطاقة غير مزورة اما اذا لم يكونا متطابقان فهذا يعني ان البطاقة قد تم تزويرها(قد يكون التزوير بتغيير الصورة الشخصية او بتغيير المعلومات الشخصية الخ) . العديد من الاختبا ارت قد اجريت لمعرفة كفاءة النظام وقد اعطى النظام نتائج عالية من الامنية. هذا النظام ممكن تطبيقه في نظام حماية الهوية الشخصية وجوازات السفر وحماية الكتب الرسمية والوثائق . ان خصائص هارلك تكون حساسة جدا لاي نوع من انواع التغيير الذي يحدث في البطاقة المزورة.

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1- Introduction

In many countries in the world, national identification cards are typically issued to everyone, and in many places the law requires that the cards be carried in public at all times. From such ID cards a person's group affiliation can sometimes be extrapolated from characteristics such as family name, place of birth, place of residence or the person's face in a photograph. The proposed system improves the security of ID card and passport using Haralick features, gray level co-occurrence matrix, and cubic spline curve.

In 1973, Haralick [1] introduced statistical features. These features are generated by calculating the features for each one of the co-occurrence matrices obtained by using the directions 0°, 45°, 90°, and 135°, then averaging these four values. These features can be calculated by using (Entropy, Energy, Contrast, Variance, and Homogeneity) equations [2].

Texture analysis, which is based on the local spatial changes of intensity or color brightness, plays an important role in many applications (e.g., classification). The gray level co-occurrence matrix (GLCM) is a classic spatial and textural feature extraction method, which is widely used for texture analysis and pattern recognition [3].

The most common piecewise-polynomial approximation uses cubic spline interpolation between successive pair of nodes [4], the cubic spline method is such an algorithm given n data point, it constructs a smooth curve which passes through points [5].

2- Background

The curve can be defined as a results of plot of a function in space. A spline is a single curve that forms a set of piecewise continuous functions. Cubic spline is a spline of degree three in the interval $x_0 \le \ \le x_n$, which is made up of a set of piecewise polynomials s_i (x). the general form of cubic spline is expressed as:

$$R_i(x) = a_i + b_i(x - x_i) + c_i(x - x_i)^2 + d_i(x - x_i)^3 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

For i = 1, 2, ….. , n-1.

The first and second derivative of these n-1 equations are fundamental of these process, and they are:

$$R_i^{'}(x) = 3(x - x_i)^2 + 2c_i(x - x_i) + b_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$R_i^{''}(x) = 6d_i(x - x_i) + 2c_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

For i = 1, 2, ….. , n-1.

From derivative cubic spline equation can obtain three matrixes to solve the equation A x = b. Solve equation A x = b, the four parameters of cubic spline curve (a, b, c, d) will be gotten [6,7].

$$A = \begin{bmatrix} 1 & 0 & 0 & \cdots & \cdots & 0 \\ h_0 & 2(h_0 + h_1) & h_1 & & & \vdots \\ 0 & h_1 & 2(h_1 + h_2) & h_2 & & 0 \\ \vdots & & \ddots & h_{n-2} & 2(h_{n-2} + h_{n-1}) & h_{n-1} \\ 0 & \cdots & \cdots & 0 & 0 & 1 \end{bmatrix},$$

and **b** and **x** are the vectors

$$\mathbf{b} = \begin{bmatrix} 0 \\ \frac{3}{h_1}(a_2 - a_1) - \frac{3}{h_0}(a_1 - a_0) \\ \vdots \\ \frac{3}{h_{n-1}}(a_n - a_{n-1}) - \frac{3}{h_{n-2}}(a_{n-1} - a_{n-2}) \\ 0 \end{bmatrix} \quad \text{and} \quad \mathbf{x} = \begin{bmatrix} c_0 \\ c_1 \\ \vdots \\ c_n \end{bmatrix}.$$

3 - Co-occurrence Matrix (GLCM)

A histogram represents only information about distribution of intensities, but not about the relative location of pixels with respect to each other in that texture. Statistical moments of the intensity histogram of an image or region are one of the simplest findings for describing texture. The Gray Level Cooccurrence Matrix (GLCM) method is a way of extracting second order statistical texture features. GLCM will help to provide valuable information about the relative location of the neighboring pixels in an image [8]. GLCM expresses the event rate of gray values of two pixels that are located in particular Distance (d) and direction with respect to each other in image. Usually the distance between two pixels are considered equal to 1 (d = 1) and the possible angle between two pixels with 0°, 45°, 90° and 135° degrees are expressed [1].

3.1- **Statistical Features:**

The mathematical definitions of these features are [9-13]:

1- **Entropy:** The entropy indicator measures the disorder or complexity of an image the entropy is large when image is not textually uniform.

Entropy $=\sum^{N}_{i=0} \sum^{M}_{j=0} (i, j) \log (i, j)$ …………………………………… (4)

where p(i,j) is probability of pixel.

2- **Energy:** This statistic measures the textual uniformity, it detects disorder in textures, the energy value is high when gray level distribution is constant or periodic form.

Energy $= \sum^{N}_{i=0} \sum^{M}_{j=0}[(i, j)]^2$ ……………………………………... (5)

where p(i,j) is probability of pixel.

3- **Contrast:** This statistic measures the difference between the highest and lowest values of contiguous set of pixel.

Contrast $= \sum^{N}_{i=0} \sum^{M}_{j=0}(i - j)^2 p(i, j)$ ………………………………... (6)

where p(i,j) is probability of pixel and i,j are location of pixel.

4 – **Variance:** This statistic measures heterogeneity.

Variance $= \sum^{N}_{i=0} \sum^{M}_{j=0}(1 - u)^2 p(i, j)$ ……………………………… (7)

where u is mean of p (i, j) and p(i,j) is probability of pixel.

5 – **Homogeneity:** This statistic measures homogeneity of image.

Homogeneity $= \sum^{N}_{i=0} \sum^{M}_{j=0} p(i, j)/(i - j)^2$ ……… ……. (8)

where p(i,j) is probability of pixel and i,j are location of pixel.

The values of Haralick features are real values.

4 -The **Proposed System**

The proposed system consists of two main parts: The curves configuration part and the authentication part. This is used to prevent fraud of ID card and passport (as shown in. figure 1) that describes the block diagram of generating CCO code. Secure system work is shown in the following steps:

Step1: Generate CCO code for ID card

1- Read ID card information and split ID card image into n blocks, where n = 1,2,3…… 2- Extract statistical feature for each block.

3- Convert the values of features to integer values by multiplying the equations of statistical features by block size.

4- Use the values from step 3 as points to draw set of curves (CCO code).

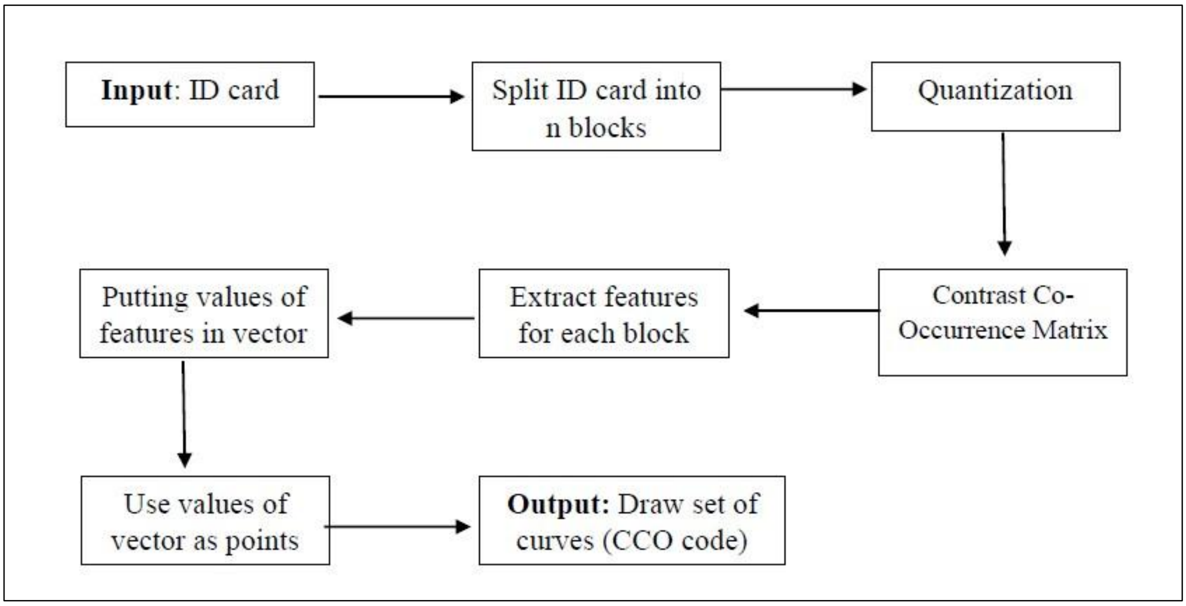

Figure 1- Diagram describing the process of generating CCO code for ID card

Algorithm1: Generate CCO code for ID card.

Input: ID card or passport.
Output: CCO code.

Process:

Step1: Read the information of ID card, then split the ID card into n of Blocks.
Step2: Perform a uniform color quantization (with quantization level *Q)*.

Step3: Construct a co-occurrence. Four directions are performed in this work
(□=0□,45□,90□ □and 135□). This produces 4 matrices of ($Q \times Q$) integer element per matrix.

Step4: Feature extraction for each normalized co-occurrence matrix
(Entropy, Energy, Contrast, Variance, and Homogeneity).
Step5: Put the result numbers in vector.

Step6: Use the numbers of vector as points.

Step7: Draw set of cubic spline curves between points. The set of curve is called CCO Code.

Step8: Print CCO code on ID card.

End

Step2: Check the ID card is fake or not.

Figure- 2 shows diagram of checking the ID card is fake or not. At check point the propose system do the following:

1- Read ID card information and split ID card into n blocks, where n similar to n in generated CCO code.
2- Extract statistical feature for each block.
3- Convert the values of features to integer values by multiplying the equations of statistical features by block size.
4- Use the values from 3 as points to draw set of curves (CCO code).
5- Compare between generated CCO code and CCO code printed on ID card, if similar means ID card is not fake otherwise it is fake.

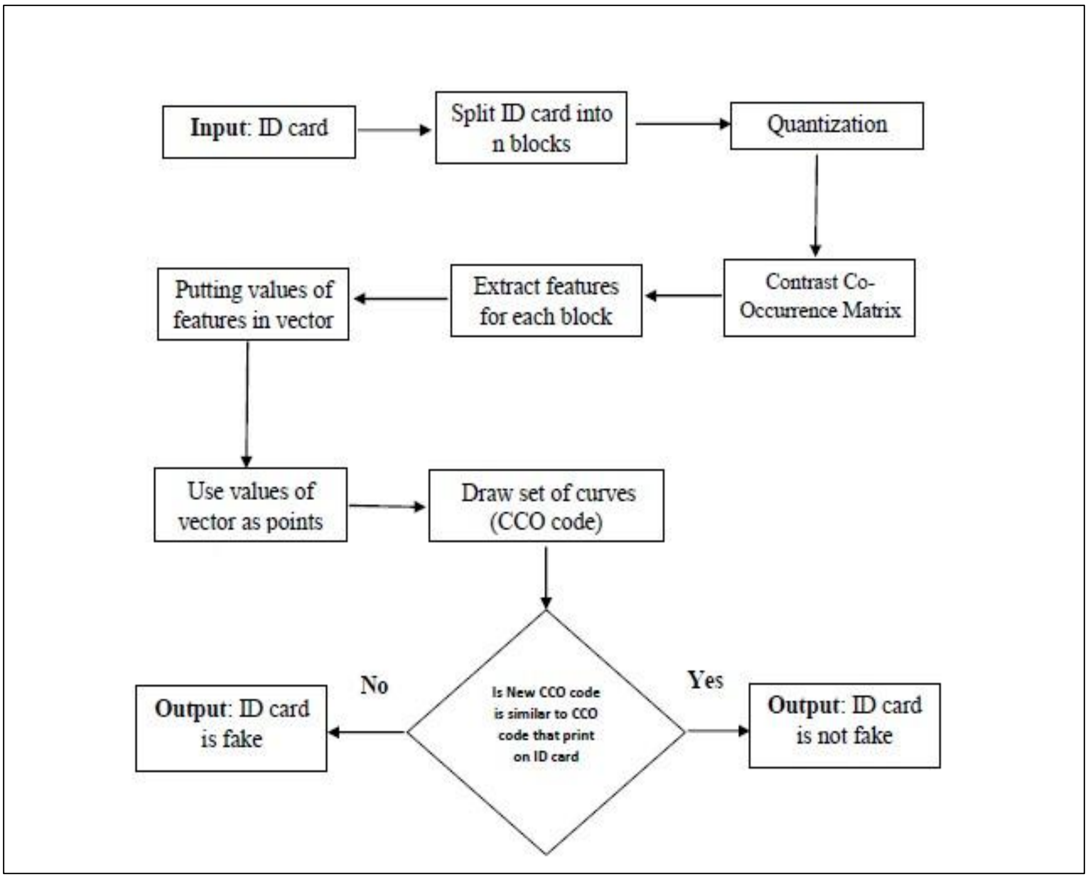

Figure 2- Diagram describing the process of checking if the ID card is fake or not.

Algorithm2: Check if ID card is fake or not.
Input: ID card or passport.
Output: ID card is fake or not. **Process**:
Step1: Read the information ID card, then split the ID card into n of Blocks.
Step2: Perform a uniform color quantization (with quantization level *Q).*
Step3: Construct a co-occurrence. Four directions are performed in this work (□=0□,45□,90□ □and 135□). This produces 4 matrices of ($Q\times Q$) integer element per matrix.
Step4: Feature extraction for each normalized co-occurrence matrix (Entropy, Energy, Contrast, Variance, and Homogeneity).
Step5: Put the result numbers in vector.
Step6: Use the numbers of vector as points.
Step7: Draw set of cubic spline curves between points. The set of curve is called CCO Code.
Step8: Compare between the generating CCO code and CCO code that printing on ID card. If the two CCO code are similar that means the ID card is not fake otherwise the ID card is fake.
End

5- Experimental Result

The proposed system was implemented using Visual C# 2015 and the tests were conducted on a HP PC with core i7 processor. To evaluate the performance of the proposed secure system several tests were conducted. First, in this test the ID card is split into 8 blocks, Table-1 shows the features of ID card before fraud by apply Eq. (4, 5, 6, 7, 8). In this table each row show features of one block, where Entropy represents complexity of block, Energy represents textual uniformity of block, Contrast represents the difference between the highest and lowest values of contiguous set of pixels, Variance represents heterogeneity of block, and Homogeneity represent homogeneity of block. .

Table 1- The values of features for each block in ID card before fraud

Block No.	Energy	Entropy	Contrast	Variance	Homogeneity
Block 1	0.036996	0.71793	0.08707	0.26283	0.2213
Block 2	0.008795	0.55345	0.07658	0.39673	0.10418
Block 3	0.016902	0.6402	0.08478	0.54992	0.14922
Block 4	0.017665	0.6193	0.06909	0.67971	0.15955
Block 5	0.003694	0.42377	0.06278	0.71987	0.05852
Block 6	0.003444	0.41384	0.06017	0.76473	0.762362
Block 7	0.003943	0.43401	0.06017	0.80617	0.0571
Block 8	0.00361	0.42076	0.06049	0.84312	0.059547

The values of features are float values Table- 4-1. The program will convert the float values to integer values Table- 4-2.

The proposed equations to convert the float values to integer values are:

- **For Energy:**

$New\ Value$ = Energy Value × $Width_B$ × $Height_B\ mod$ 500 . . . . (9)

Where $Width_B$ represent block width, ht_B represent block height and 500 represent the range of CCO code.

Example: First row the energy value = 0.036996 with Block size height = 31, width =409.

$New\ Value$ = Energy Value × $Width_B$ × $Height_B$ mod 500

= 0.036996 ∗ 409 ∗ 31 500

= 469

■ **For Entropy:**

$New\ Value$ = Entropy Value × $Width_B$ × $Heigh$ 500 . . . (10)

Example: First row the entropy value = 0.71793.

$New\ Value$ = Entropy Value × $Width_B$ × $Height_B$ mod 500

= 0.71793 ∗ 409 ∗ 31 500

= 103

■ **For Contrast:**

$New\ Value$ = Contrast Value × $Width_B$ × $Height_B$ mod 500 . . . . (11)

Example: First row the Contrast value = 0.08707.

$New\ Value$ = Contrast Value × $Width_B$ × $Height_B$ mod 500

= 0.08707 ∗ 409 ∗ 31 500

= 104

■ **For Variance:**

$New\ Value$ = Variance Value × $Width_B$ × $Height_B$ mod 500 . . (12)

Example: First row the Variance value = 0.26283.

$New\ Value$ = Variance Value × $Width_B$ × $Height_B$ mod 500

= 0.26283 ∗ 409 ∗ 31 500

= 332

■ **For Homogeneity:**

$New\ Value$ = Homogeneity Value × $Width_B$ × $Height_B$ mod 500 . ..(13)

Example: First row the Homogeneity value = 02213.

$New\ Value$ = Homogeneity Value × $Width_B$ × $Height_B$ mod 0.2213 ∗ 409 ∗ 31 500 = 306

Table 2- The values of features after convert to integer values

Block No.	Energy	Entropy	Contrast	Variance	Homogeneity
Block 1	469	103	104	332	306
Block 2	112	17	471	30	321
Block 3	214	117	75	472	392
Block 4	224	352	376	118	23
Block 5	47	373	296	127	242
Block 6	44	247	263	196	166
Block 7	50	3	263	221	224
Block 8	46	335	267	190	255

After that the result numbers in Table -2. are used as points to draw set of cubic spline curves (CCO code) then print (CCO code) on ID card Figure- 3.

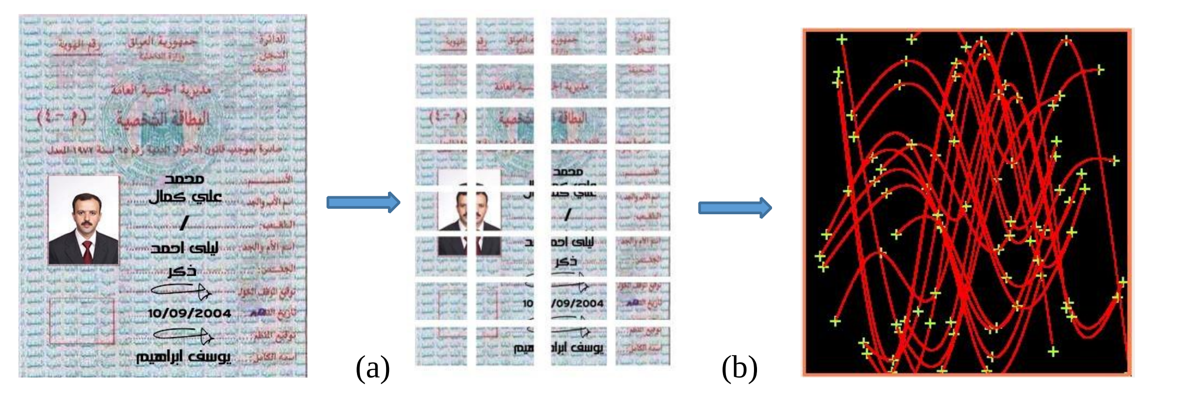

Figure 3- (a) Split ID card into n blocks. (b) Generate CCO code.

Second, when the ID card is fraud by counterfeiter by changing name, personal picture, father name, birth day and so on, that's lead to change the extracted features values. In this test will change the personal name. See Table-3 shows features values after fraud.

Table 3- The feature values after change personal name

Block No.	Energy	Entropy	Contrast	Variance	Homogeneity
Block 1	0.036996	0.71793	0.08707	0.26283	0.2213
Block 2	0.008795	0.55345	0.07658	0.39673	0.10418
Block 3	0.016902	0.6402	0.08478	0.54992	0.14922
Block 4	0.017665	0.6193	0.06909	0.67971	0.15955
Block 5	0.003689	0.423592	0.062623	0.78124	0.0586008
Block 6	0.003577	0.419647	0.06073	0.62574	0.058837
Block 7	0.003943	0.43401	0.06017	0.80617	0.0571
Block 8	0.00361	0.42076	0.06049	0.84312	0.059547

Convert the float values to integer values using the Equations 9, 10, 11, 12, and 13. See Table- 4. For example:

Table 4- Show features values after convert to integer for ID card after change personal name.

Block No.	Energy	Entropy	Contrast	Variance	Homogeneity
Block 1	469	103	104	332	306
Block 2	112	17	471	30	321
Block 3	214	117	75	472	392
Block 4	224	352	376	118	23
Block 5	47	371	294	405	243
Block 6	45	321	270	434	246
Block 7	50	3	263	221	224
Block 8	46	335	267	190	255

After that the result numbers in Table- 4 are used as points to draw cubic spline curves Figure- 4.

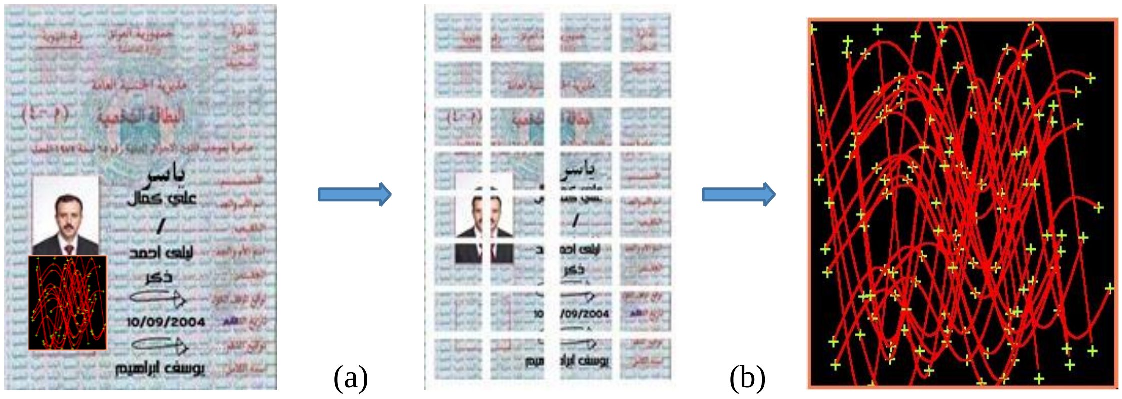

Figure 4- (a) Split ID card into n of blocks. (b) Generate CCO code.

Compare between generated CCO code and CCO code that printing on ID card, note two code are not similar that means the ID card is fake.

6- Conclusion

a) The proposed secure system improves the security of ID card and passport, Co-occurrence matrix is used with cubic spline curve.

b) The Haralick (Energy, Entropy, Variance, Contrast, Homogeneity) features are very sensitive to any change in the information of ID card or passport.

c) Change in the information of ID card or passport leads to changing in the value of features, and that leads to generate different CCO codes.

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