

Video Image for Security System by Using Chaotic Oscillator for Segmentation

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Abstract

There are wide variety of mechanisms available for performing the authentication function. One of them is by using video film to monitor important places. In such systems the important task is recognizing human faces which need good segmentation and high feature extraction. In traditional technique the segmentation can be performed by region growing and shrinking, clustering method, and boundary detection which all take image pixel by pixel and compare each with neighbors to get the similarity. Chaotic oscillator depends on synchronization concept between points to determine the active points which construct similar region determining the object. Then RGB color space is used to determine skin color pixel. Skin color model aids the process of separating the face from the scene due to its skin color. After isolating the human face image which contains many features (eye, eyebrow, nose, etc...) they identify the person. Chaotic oscillator is used to extract the important features by removing any point that is not synchronized with its neighbors and gives new image which contains only the main face features and then compare this image with stored image in Database of authorized person and make decision on if (he/she) is an authenticated image or not.

Keywords: Chaotic Oscillator Segmentation; Face detection; Skin color segmentation

نظام المراقبة بالكاميرات الرقمية باستخدام مفهوم (Chaotic Oscillator)

الخلاصة

هنالك العديد من التقنيات المتاحة لإنجاز مهمة التحويل وأحدهم بواسطة استخدام الأفلام الفيديوية لمراقبة مكان مهم. في مثل هذه الأنظمة المهمة الأهم هو تمييز الوجوه البشرية التي تحتاج إلى تقنيات تقطيع جيدة وتقنيات استخلاص صفات عالية. إن عملية التقطيع في التقنيات التقليدية يمكن أن تتجزأ باستخدام نمو المناطق وتقلصها وطرق العنقدة واكتشاف الحدود والتي جميعها تأخذ نقاط الصورة نقطة بعد الأخرى وتقارنها مع جيرانها للبحث عن التشابه بين هذه النقاط بينما (Chaotic Oscillator) تعتمد على مفهوم التزامن أو التناغم بين النقاط لتحديد النقاط النشطة والتي تكون المنطقة المتشابهة التي تحدد الأشياء، إن هذه الأشياء ربما تكون وجه بشري لذلك استخدم فضاء اللون (RGB) للمساعدة في عملية فصل الوجه عن المشهد وفقا للون الجلد. بعد عزل صورة الوجه البشري والتي تحتوي على عدد من الصفات مثل (العين، الحاجب، الأنف،...) والتي تُعرف الشخص نستعمل ال (Chaotic Oscillator) لاستخلاص الصفات المهمة من خلال إزالة أي نقاط غير متناغمة أو متزامنة مع جيرانها للحصول على صورة جديدة تحتوي فقط على الصفات الأساسية للوجه ومن ثم مقارنتها مع صور الأشخاص المخولين المخزونة في قاعدة البيانات ومن ثم اتخاذ القرار كون الشخص مخول ام لا.

1. Introduction

The building of security system able to protect a specific location by using a static video cameras is not new, but the new is using a new technique in segmentation and feature extraction (Chaotic Oscillator Network). The segmentation method used implements a network of synchronized oscillators of the Terman-Wang type. This recently developed tool, which is based on temporal correlation theory, temporal (oscillatory) correlation offers an elegant way of representing multiple objects in neural networks, most of the neural network efforts on image segmentation centered around this theme. This theory attempts to explain scene recognition as it would be performed by a human brain [1]. This paper tries to detect authorized person by using the static cameras, the video film is split to a large number of frames, the processing of each frame data requires high speed and low storage capacity. This requirement is not available in traditional technique for segmentation and feature extracting which suffers from low efficiency so the chaotic idea is used to solve this problem depending on the synchronization of events to get the parallelism technique[2]. This paper will explain proposed video image for security system by using chaotic technique for segmentation.

2. Idea of System

The idea of the proposed algorithm depends on the protection of important location by using a number of static cameras put in different places leading to the location to be protected, all cameras are connected to computer system which works by capturing pictures from camera and analyzing them to identify persons by video images to determine which person is authorized then allowing him to enter without any alarm to the security staff and

unauthorized are prevented when reaching the protected location by alarm the security staff in addition to storing the pictures of unauthorized people in database and a report is generated from time to time about the people who try to attack the location. The security staff are told to prevent these people. The techniques used in the similar systems include taking specific shot from the video film to detect the human face and this face is cut by using traditional techniques for segmentation such as (region growing and shrinking, clustering technique, boundary detection) then features are extracted from the face and matched with the features of the authorized faces which are stored in database.

The proposed algorithm will use chaotic oscillator for segmentation and feature extraction to get the best result.

3. Chaotic Idea

The chaotic ideas are derived from the existence of synchronous activities in different areas of brain. The brain is able to distinguish between objects and obtain the best results when information is collected in short time and with all direction of the object, this means of parallelism [2].

Chaotic Oscillator Network is used for segmentation and finding connected regions. This method is based on temporal correlation theory, which provides high speed for processing because it segments all objects with the same features in the same time (parallelism). To satisfy a computational mechanism for the oscillatory correlation theory, three key functions must be achieved:

- 1) The mechanism must be capable of synchronizing a locally coupled for assembly of oscillators.

- 2) It must be capable of desynchronizing different assemblies of oscillators that are activated by different objects.
- 3) Both synchrony and desynchrony must occur rapidly[3].

4. Chaotic Model

The model is a two dimensional network governed by the following equations[2]:

$$x'_{ij} = -ax_{ij} + G(\sum_{i+1, j+1} cx_{ij} + ey_{ij} + I_{ij} - \theta_x) + K \sum_{p=i-1} \sum_{q=j-1} H(|c_{pq} - c_{ij}| - \theta)(x_{pq} - x_{ij}) \dots(1)$$

$$y'_{ij} = -bx_{ij} + G(\sum_{i+1, j+1} dx_{ij} + fy_{ij} - \theta_y) + K \sum_{p=i-1} \sum_{q=j-1} H(|c_{pq} - c_{ij}| - \theta)(y_{pq} - y_{ij}) \dots(2)$$

$$G(v) = 1 / (1 + e^{-(v/t)}) \dots(3)$$

$$H(v) = \begin{cases} 1 & \text{if } v \leq 0 \\ 0 & \text{if } v \geq 0 \end{cases} \dots(4)$$

where (i, j) is a lattice point with $1 \leq i \leq N$ and $1 \leq j \leq M$; (p, q) is used as the index of the nearest neighbors of (i, j) ; x_{ij} and y_{ij} are dynamical variables of element (i, j) , c_{ij} is the pixel value of element (i, j) ; and k is the coupling strength. $H(v)$ is a Heaviside function and θ is a threshold value. Without the coupling terms, the equation is a Wilson-Cowan neural oscillator, where a and b are decay parameters (positive numbers) of x and y , respectively; c and f are self-excitatory parameters; e is the strength of coupling from the inhibitory unit y to excitatory unit x (it is a negative value to assure that the variable y acts as inhibitory). The corresponding coupling strength from x to y is given by d ; θ_x and θ_y are thresholds of unit x and y , respectively; $G(v) \in [0, 1]$ is a sigmoid function with T defining its steepness; and I is an external stimuli. If I is a constant, no chaos can appear since it

is a two-dimensional continuous flow . In order to get a chaotic oscillator, the external stimuli is defined as a periodic function: $I(t) = A\cos(t)$, where A is the amplitude of the driving signal. the interaction terms vanish when the oscillators are synchronized. Thus, the synchronous trajectory remains once the synchronization state is achieved[2]. For an input $I > 0$, the two nullclines intersect only on the middle branch of the cubic, and (1) gives rise to a stable periodic trajectory. In this case, the oscillator is called enabled and four bounding points for the periodic trajectory are $LC, LK, RK,$ and RC , whose x values are $LC_x = -2; LK_x = -1; RK_x = 1,$ and $RC_x = 2$. The periodic solution alternates between an *active phase* ($RK_x \leq x \leq RC_x$) and a *silent phase* ($LC_x \leq x \leq LK_x$). When the oscillator stays in the active phase, it is called active; otherwise, it is called silent. Within either phase, the oscillator exhibits near steady state behavior. Wang and Terman suggested that a major region must contain at least one oscillator, called a leader, which is located at the center of a large, homogeneous region. A noisy fragment does not contain such an oscillator[4]. Dynamical coupling structures generated by a set of neighborhoods associated with a specific oscillator. Based on the proximity and similarity principles, two grouping rules are proposed to explicitly consider the distinct cases of whether an oscillator is inside a homogeneous image region or near a boundary between different regions. The use of dynamical coupling makes our segmentation network robust to noise on an image, see Figure(1).

5. Facial Recognition

Facial recognition technology identifies people by analyzing features of the face that are not easily altered, the upper outlines of the eye sockets, the areas

around the cheekbones, and the sides of the mouth. The technology is typically used to compare a live facial scan to a stored template, but it can also be used in comparing static images such as digitized passport photographs. Facial recognition can be used in both verification and identification systems [5]. The task of recognizing human faces is essentially a two-step process:

- (i) the detection of an automatic location of the human face.
- (ii) the automatic identification of the face based on the extracted features[6].

6. Face Detection

Face is the most distinctive and widely used key to a person's identity. Face detection is concerned with determining which part of an image contain the face. The problem of detecting the faces and facial parts in image sequences has become a popular area of research due to emerging applications in human-computer interface[7].

7. Facial Features

Facial features are extracted to compute a set of geometrical features (facial features such as nose width and length, mouth position and chin shape). With prior knowledge that face has bilateral symmetry, one can extract and compute facial features by horizontal and vertical edge dominance maps[8]. A set of landmark points is first identified from the front and side views of the human face, which are then used for feature measurement based on area, angle and distances between them. The combined set of features extracted from both the views is usually very effective to distinguish faces and provides more reliability over systems using features only from a single view because the side profile features provide additional

structural profile information of the face, not visible from the frontal images[9].

8. Texture Description

Texture refers to the visual patterns that may or may not have properties of homogeneity, which results from the presence of multiple colors or intensities in the image. It is a property of virtually any surface, and contains important structural information of surfaces and their relationship to the surrounding environment. The attributes and utilities of textures can be summarized as follows:

1. Textures are repetitive patterns, which characterize the surfaces of many classes of objects. Thus classification of object patterns becomes easy if the textures present in the image are identified and differentiated from each other.
2. Textures provide vital information about the arrangement of the fundamental elements of an image.
3. The attributes of a texture may be described in qualitative terms such as *coarseness*, *homogeneity*, *orientation* of image structure, and *spatial relationships* between image intensities or tones. Texture analysis is the quantification and use of such image properties which aid in texture discrimination [10].

9. Skin Color Detection

Color is a low-level cue for object detection that can be implemented in a computationally fast and effective way for locating objects. It also offers robustness against geometrical changes under a stable and uniform illumination field. The information about skin color can be exploited as a feature for facial image analysis. It can be utilized in two ways: as a classifier to label pixels as skin and nonskin candidates or as a verifier to determine whether a found area possibly

contains skin or not. In both cases, its role is to separate skin from nonskin background [10]. Using skin-color as a feature for tracking a face has several advantages. Color processing is much faster than processing other facial features. Under certain lighting conditions, color is orientation invariant[11]. Good skin color pixel classification should provide coverage of all different skin types (blackish, yellowish, brownish, whitish, etc.) and cater for as many different lighting conditions as possible [12]. Skin segmentation aims to locate skin regions in an unconstrained input image. It plays an important role in many computer vision tasks such as face detection, face tracking and hand segmentation for gesture analysis[13].

10. Proposed System

The proposed system uses a number of static cameras in many places leading to protected location. All these cameras are connected to computer system, each camera captures video imagery and passes it to proposed system and then the following steps will be performed as show in Figure (2).

Step1: Frame Splitting; The Audio Video Interleave (AVI) video sequence is split into sequence of frames that are created continuously as shown Figure (3). The number of frames may be large (30 frames per second) or more. This split aids one to get only the different images which represent different states of object moves to reduce time and storage space.

Step2: Detecting the Moving Objects; After the frames are split in step1, the frames without similarity are searched to get only different frames which represent new image with new background or new motion which gives information about

object track. This image will be saved with its background and its location in DB. This step is repeated with each new image as shown Figure(4).

Step3:Background Removing; In this step, initial background is saved for each location in front of each camera and after image is received from step2 image will be subtracted from corresponding background in DB to get person image $P(x,y)$, see Figure (5) which illustrates removing background by the following process:

$$P(x, y) = |F(x, y) - B(x, y)| \quad \dots (5)$$

If $P(x, y) < \text{threshold}$ then $P(x, y) = 0$.

Else $P(x, y) = F(x, y)$.

where $B(x, y)$ is the background image.

$F(x,y)$ is the object with background image.

$P(x, y)$ is the object image.

Step4: Chaotic Oscillator For Segmentation; chaotic oscillator segmentation method uses the locally excitatory globally inhibitory oscillator networks (LEGION) algorithm for segmentation [4]. This means searching each pixel image to determine which pixel is active (its value is not zero due to Heaviside function that is used in section 4) with neighbors to isolate them from others called silent (their value is zero due to Heaviside function) that may happen when you take the pixel with two neighbors, one with row and other with column and then calculate $V1, V2$ with row and column respectively and determine the heaviside for $V1, V2$ by using equation in section (4). The heaviside is threshold to specify if the pixel is active or silent and puts "0" to silent pixel and "1" to active pixel in new image array and that is repeated for each pixel in original image to point all active pixels. This is dependent as image map to

determine each object in original image. Each pixel in image maps information about three pixels with the same characteristics which means synchronization between the pixels and desynchronization with other. Synchronization happens to three pixels in the same time it means parallelism. So chaotic satisfies the parallelism and synchronization.

The proposed system develops the use of chaotic oscillator network to be adapted with the video system, the model is described by the following:

$$X = ((a * P1) + I + \theta X) + Hx \quad \dots (6)$$

$$Y = (1/1 + (b * P1) + I + \theta y) + Hy \quad \dots (7)$$

$$V1 = V1 + ((P1 - P2) * T) * (P1 - P2) \dots (8)$$

$$V2 = V2 + ((P1 - P3) * T) * (P1 - P3) \dots (9)$$

where :

P1: the pixel value.

P2,P3: the pixel neighborhoods.

X ,Y :the dynamical variables of element (x,y).

$\theta X, \theta Y$: the thresholds of unit X,Y.

I: the external stimuli is defined as a periodic function $I(t) = A \cos(t)$.

A: the amplitude of the driving signal.

a: self-excitatory parameters.

b: The corresponding coupling strength from x to y.

T: defining its steepness.

H: the heaviside function.

The value of $H=1$ if $V \leq 0$ then in this case the oscillator jumps to the active phase. Otherwise, overall coupling is negative due to the global inhibition, which makes the oscillator stay in the silent phase. In this way, activation is propagated to other oscillators via local fixed connectivity until all the oscillators representing the same region are activated. Thus, the dynamics of our network preserves the property of locally excitatory globally inhibitory oscillator networks (LEGION). That is, it is the process of both synchronization through local excitation among neighboring oscillators and

desynchronization through global inhibition.

Here the (μ and σ) where μ and σ are two tolerance parameters for measuring homogeneity are not used in the algorithm because there implementation on the video system with standard environment which is not necessary to test and find the similarity and homogeneity see Figure (6).

The proposed algorithm illustrates by the following steps:

Algorithm 1 Chaotic Oscillator For Segmentation

Input: frames sequence, Objects

Output: segment region

1: Start

2: Do Until not EOF(image file).

3: get the pixel (i,j) and it's two neighbors.

4: separate the objects color space component to three channels (R,G,B).

5: calculate the value of V for each channels by

$$V1 = V1 + ((P1 - P2) * T) * (P1 - P2)$$

$$V2 = V2 + ((P1 - P3) * T) * (P1 - P3)$$

6: apply (V1) to threshold:

If $V1 \leq 0$ Then $Hx = 1$

Else

$Hx = 0.$

7: apply (V2) to threshold:

If $V2 \leq 0$ Then $Hy = 1$

Else

$Hy = 0.$

8: implement the following equation to find X,Y

$$X = ((a * P2) + I + \theta x) + Hx$$

$$Y = ((1 / 1 + (b * P1) + I + \theta y) + Hy)$$

9: go to the next frame(F_{i+1}).

10: if $i \leq$ the last frame (F_i) then go to step 2.

11: End.

Step5: Face Recognition; The next step in proposed system after determining the object by chaotic oscillator network is the face recognition. Face recognition requires both visual and geometric information processing, and there are three-steps:

- i. Face Detection.
 - a) RGB Color Space
 - b) Connectivity
- ii. Feature Extraction.
- iii. Face Identification.

i. Face detection

Face detection is the first step of face recognition and is concerned with determining which part of image contains face, it is achieved by color texture approach, where human faces have a distinct texture that can be used to separate them from different objects. The texture is computed by using the skin feature, the proposed system uses the skin color texture to determine human faces by using color space to represent pixel color. The face detection steps will be performed as shown in Figure (7).

a) RGB Color Space

It is one of the most commonly used color spaces, the RGB color space is separated to three channels.

This aid to use color texture to determine the skin color since the skin color texture at uniform daylight illumination is represented by the equation :

$$R > 95 \text{ AND } G > 40 \text{ AND } B > 20 \text{ AND } (\max(R, \max(G, B))) - (\min(R, \min(G, B))) > 15 \text{ AND } |R - G| > 15 \text{ AND } R > G \text{ AND } R > B [14]. \quad \dots(10)$$

The results show in Figure (8).

b)Connectivity

After detecting the skin color region and obtaining for good result, the proposed system considers the relationship between pixels to remove

noise, small region and obtain connected skin region by using mask of 3X3, checks the pixel and its neighbors. The loop contains 12 conditions (4-sides, 4-corners, and 4-diagonal neighbors) as shown in Figure (9), and considers an array of 2-D with the same size of image, each location of an array is counter to state of pixel and its neighbors, if true then add one to the counter, after that it tests each counter, if more than 9 then it considers this pixel as connected skin region see Figure (10).

After detecting the connectivity, find the largest connected skin region by finding the maximum high and width of the connected regions as show in Figure(11) and divide by 2 to determine the center of face as shown in Figure (12) which has the face skin location (skin image). Then by returning to the original image use the skin image to get face image, Figure (13).

ii. Feature Extraction

After the face detection procedure, the locations of the facial feature points are obtained. These locations are used as the initial information for finding the exact locations of facial features and face recognition. Six facial features are localized these are the left and right pairs of eyes, eyebrows, tip of the nose and the center of the mouth. It has been found from observations that under normal illumination conditions, the facial features, such as eyes, nose, mouth, etc. possess relatively is darker parts of the face. For feature extraction, another time chaotic oscillator method are used to extract features by implementing the equation in section (4) and applying the threshold:

result = 255 - cresult

If chaotic result > 255 Then P = RGB(0, 0, 0)

Else

If chaotic result < 10 Then P = RGB(0, 0, 0)

Else

P = RGB(255, 255, 255)

Different facial features are then extracted from the face profile, see Figure (14) and then these features are stored in DB to be compared later with the feature of the authorized people to ensure the people are authorized.

iii. Face Identification

In face recognition system, the large number of images available in the database make the search operation the most computationally expensive. Therefore, the recognition systems require efficient search algorithms. In most systems, face features of the authorized people are extracted from the original images, and stored in the face feature database. In recognition, the same features are extracted from the input face and the features of the input image are compared with the features of each model image in the database.

11. Experiment Results

The system was implemented using personal computer with the following specifications : Pentium IV, 2.7 GHz with 256 cache memory, 120 GB Hard Disc , 512 MB memory.

The computational performance and parallel processing are obtained by the use of chaotic oscillator algorithm for segmentation, The results of testing the performance of the chaotic oscillator segmentation are shown in Table (1) which shows the time required by chaotic oscillator algorithm compared with traditional segmentation methods.

12. Conclusions

This paper presents a monitoring system by using video cameras based on chaotic oscillator methods for segmentation. Some important conclusions will be presented as follows:

1. Chaotic oscillator method is used for segmentation of expected human

body. It provides large computational power and high performance because it processes the image with parallel and synchronization technique.

2. The use of chaotic oscillator reduces the time consumed because it is based on the temporal correlation theory (parallelism) which presents multiple objects in same time.
3. Chaotic oscillator method is used for removing noise and smoothing the images instead of many filters.
4. The use of connectivity as step of face detection remove noise and small regions of pixels.

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Table (1) The Segmentation by chaotic oscillator compared with traditional methods

Frame Sequence	Frame Type	Time Required	
		Traditional Methods	Chaotic Oscillator Method
1	GIF	6 Second	4 Second
2	Bitmap	8 Second	5 Second
3	JPEG	10 Second	7 Second

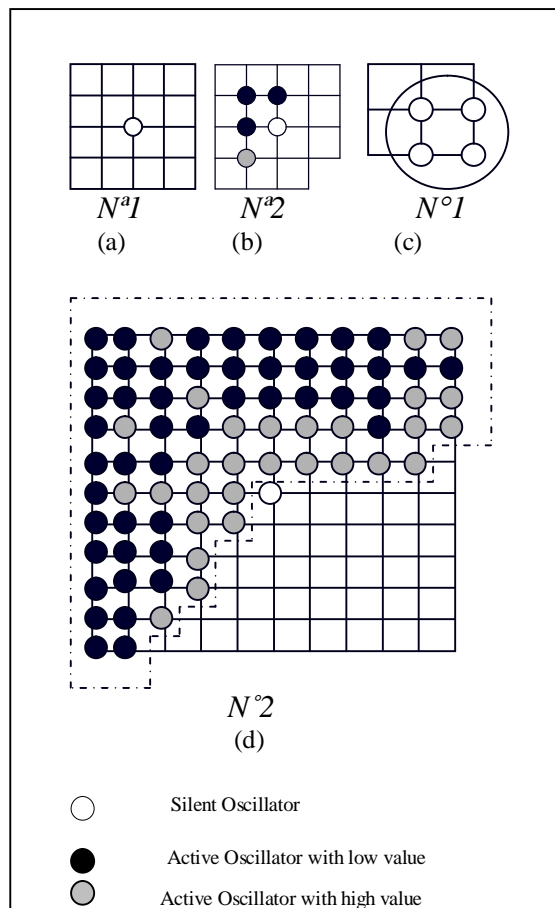


Figure (1) Examples of various neighborhoods. (a) The pixel neighborhood $N^1(i,j)$. (b) The region neighborhood $N^2(i,j)$. (c) The pixel neighborhood $N^1(i,j)$. (d) The region neighborhood $N^2(i,j)$.

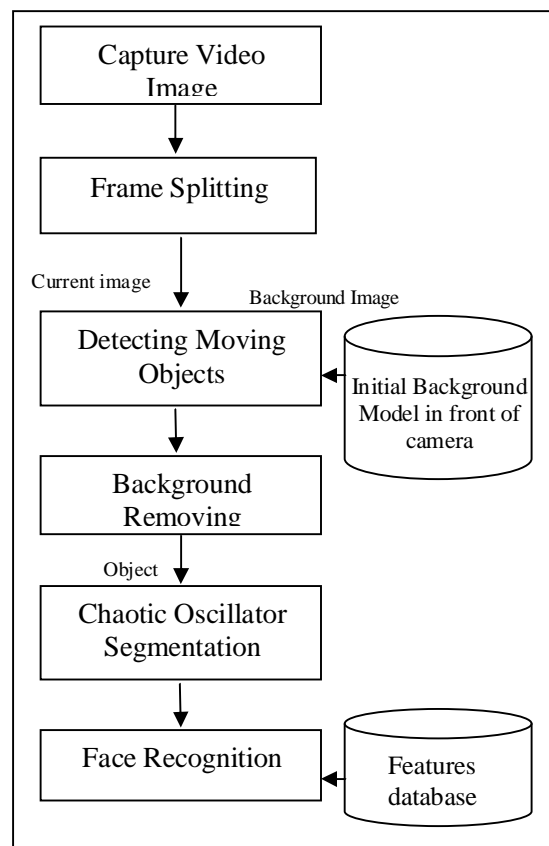


Figure (2) The system block diagram



Figure (3) Splitting of video sequence

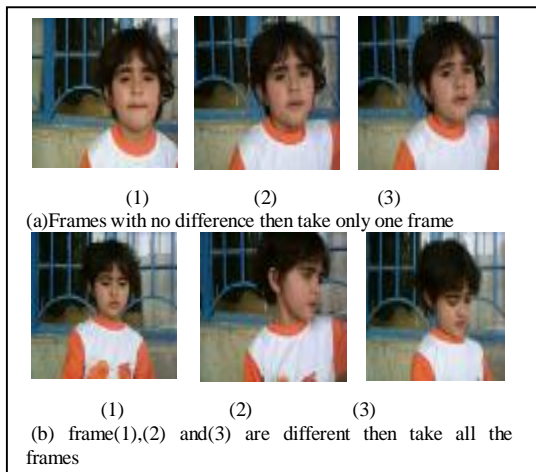
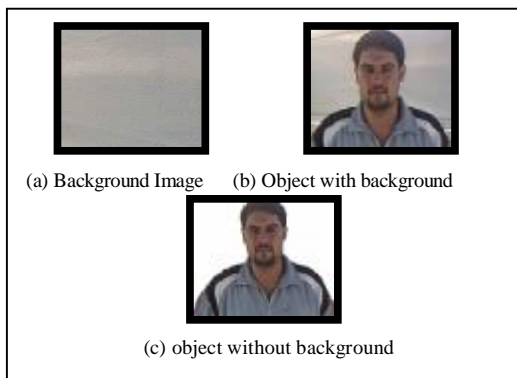


Figure (4) Detecting the Moving Objects



Figure(5) Remove background

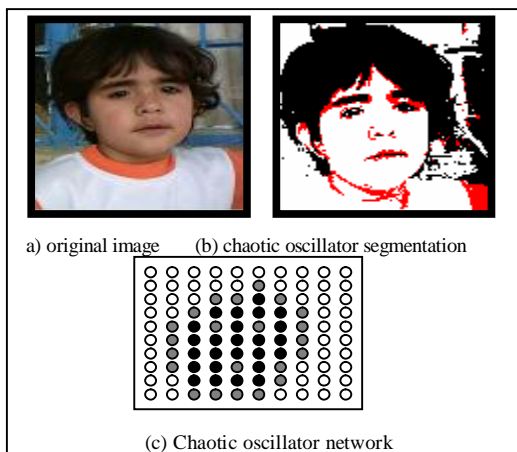


Figure (6) Chaotic Oscillator

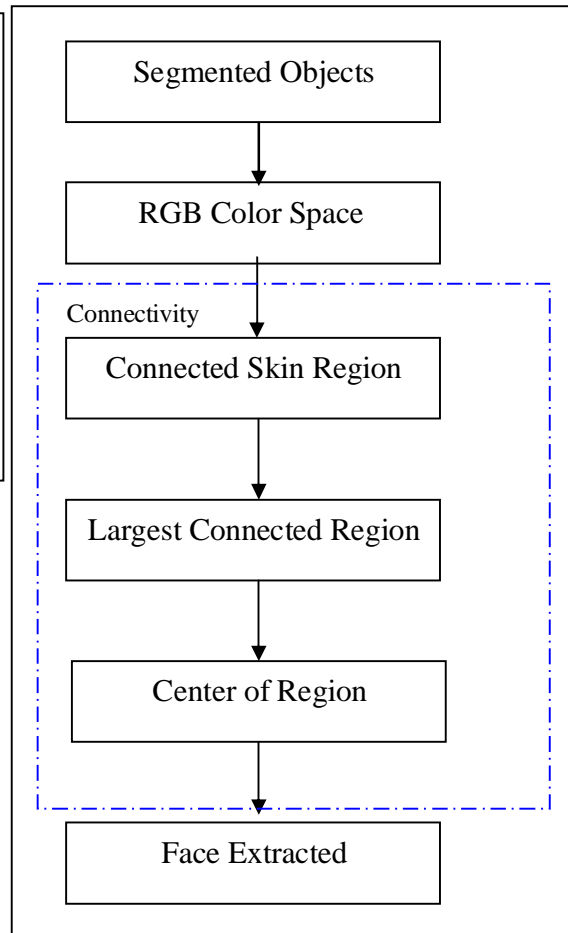


Figure (7) Face detection block diagram



Figure (8) Skin color in RGB color space

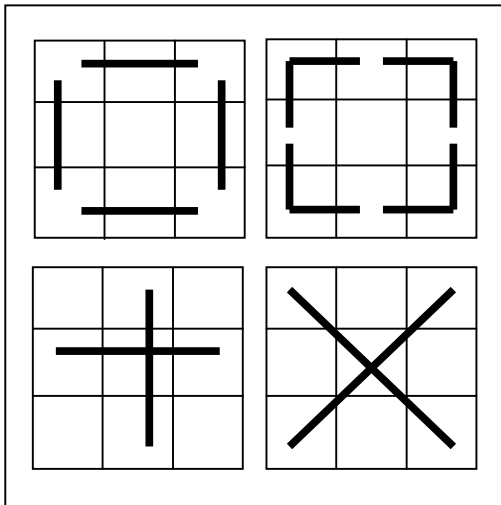


Figure (9) The type of connectivity



Figure (13) Face image



(14) Chaotic feature extraction



Figure (10) The connected regions



Figure (11) The largest connected region



Figure (12) Skin image