Neuro-Snake Pattern Recognition And Classification Using Gradiant Vector Flow (Gvf And Hnn)

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Abstract

The most popular applications of Hopfield neural network algorithm (HNN) are pattern recognition and classification. But the HNN has some limitation like the local minima (oscillation) problem. In this paper a novel method of combining an active contour (snake) and an artificial neural network to behave together as pattern recognition and classification is presented. The approach used the technique of the gradient vector flow (GVF) that locate the boundary of target pattern (image) then pass it to a classifier built by Hopfield algorithm to classify it according to one of the storage pattern. The snakes can find the boundaries of objects so it is very accurate to take the shape of the object wanted, that will eliminate the noise from the original image and reduce the bit error rate of the Hopfield network to 0.215 and overcome the oscillation state in recognition of the entered pattern. MATLAB 7 program have been used for the simulation of the active contour and the pattern classification.

طريقة الثعبان العصبي للتميز والتصنيف باستخدام مجري المنحدر الاتجاهي

الخلاصة

اهم تطبيقات الشبكات العصبية وكمثال شبكة ال(Hopfield) هي تمييز الاشكال وتصنيفها (pattern recognition and classification). ولكن هناك بعض التحديدات المهمة في عمــل هذا النوع من المصنف وهي مشكلة التذبذب (oscillation) اي عدم القدرة على تمييز الاشــكال المتقاربة جدا . في هذا البحث تم ابتكار طريقة تجمع بين الناقلات الفعالة (active contour) او ماتسمى بال(snake) والشبكات العصبية الاصطناعية (ANN) لتعمــل كمييــز للاشــكال وتصنيفها. البحث يستخدم تقنية ناقلات التدفق التدريجي (GVF) في عمل المصنف حيث تقــوم بتحديد دقيق للاطار الخاص بالشكل (الصورة) ثم تمريره الى مصنف مبني على اســاس الــشبكة العصبية الاصطناعية (HNN)ليتم تصنيفه نسبة الى احد الاشكال المخزونة سلفا في المــصنف . الثعبان (snake) لها القدرة العالية للالتفاف على حدود الشكل المطلوب بدقة عالية لتاخــذ شــكل المقطع المطلوب مع حذف الاضافات الغير مطلوبة من الشكل (noise) وهذا سيساعد على تقليل نسبة الخطأ النقطي (bit error rate) الى دون 0.215 نسبة الى اكثر من 0.5 فــي المــصنف الاعتيادي وتجنب حالة التذبذب الموجودة في المصنف الخاص بالشبكات العــصبية الاصــطناعية تم استخدام برنامج mat lab 7 لعمل المحاكات للناقلات الفعالة (GVF) وعمليــة التــصنيف النهائية للاشكال.

Introduction:

Neural networks provide a different approach to solving problems as compared with more conventional algorithmic techniques, and have a wide range of potential applications [1].

The field of artificial neural Intelligent (AI) such as neural network, fuzzy theory, genetic algorithm, …etc, has rapidly developed in recent years. Each algorithm has their strength, but there are

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still have some limitation. In order to overcome these limitations, hybrid algorithms were developed by combining two or three AI approaches or with other solutions and then drew on the strength of each offset the weakness of the other.

Hopfield neural network (HNN) is widely used in image recognition and pattern classification. This algorithm still has some problems; the most important one in the field of classification is the local minima problem (oscillation).

Sank, or active contour are used extensively in computer vision and image processing application particularly to locate object boundaries.

This algorithm have a wide used for many application such as edge detection [2] and shape modeling [3] , segmentation tracking. Two important type of active contour which are first the parametric active contour [4] where the curve are drawn toward the edge by two deference forces which define the negative edge and an additional force (pressure), together generates the external force. The second method is the geometric active contour so this method combines from multiresolution method [5], pressure forces and distance potentials.

In this research we will combine one algorithm of artificial neural network (Hopfield) with snake active contour to produce a classifier with high quality of classification and small bit error rate[6,7].

Gray Scale Snake:

The original snake was developed by Kass Witkin and Terzopoulos in 1987 [8]. The name "snake" was named after its behavior on an image. While minimizing their energy, it slithers on the image[9].

A snake is expressed as a planar parametric curve in Eq.1 where these equations define the energy range of the snake where the parameter **s** is snake control points known as snaxels. The snake requires appropriate

parameters setting and initial locations of the snaxels according to the

subjective boundary to be close to the boundary[10].

$$v(s) = [x(s), y(s)] \quad s \in [0,1] \ \dots 1$$

where v(s) is the function of the tow dimension pixel point x(s) and y(s) .

The most known equation of the snake is contain three part. The first is internal energy which is further divided into two energy components: elasticity and bending forces these energy is control on the tension and the rigidity of the snake the second is the external energy where it is derived by the image and it attracts the snake to the target contour. Eq.2, Eq.3, and Eq.4 shows these faces[11].

$$E_{snake} = \int_0^1 E_{internal}ds + \int_0^1 E_{external}ds \ \dots(2)$$

$$E_{internal} = a.E_{elastic}(v(s)) + b.E_{bending}(v(s)) \quad \dots(3)$$

$$E_{external} = y.E_{image} \qquad \dots(4)$$

The parameters α and β in front of each term represent the weight functions. While the parameter y is define a weight to control the image force.

Gradient Vector Flow:

In 1997 Chenyang and Prince produced Gradient Vector Flow: A new external force for snakes . This method is deferent and modified from the traditional method to recognize the most wanted image from the gray scale .

A new external force to solve these problems is produce by Xu and Prince. The proposed energy force is derived from a vector fields as known as Gradient Vector Flow. Instead of using the gradient magnitude of an image as an external force, it uses spatial diffusion of the gradient of an edge map of an image [10].

The GVF snake involves a vector field derived by solving a vector diffusion equation that diffuses the gradient magnitude obtained form an image.

The development equation of the GVF is shown in Eq.5

$$e = \iint m\left(u_x{}^2 + u_y{}^2 + v_x{}^2 + v_y{}^2\right) + |\nabla k|^2 \dots$$
$$|v - \nabla k|^2 \, d_x d_y \qquad \dots 5$$

974

[12]Where V(x,y) is a function of u(x,y) and v(x,y) such that is defined to minimizes the energy functional where k(x,y) is the edge map of the image and μ is noise parameter.

The energy strength of Eq. (5) could be seen by drive the edge map *k* from the original pattern *h* where *h* is a function of two dimension map x and y to obtain the fallowing equation.

$$k(x, y) = -\sum_{0}^{i} E_{external}^{i}(x, y) \qquad …(6)$$

This additional force will help the contour to find his path in the gray scale to be very clear to the real shape or boundaries so that reducing the both number of snake and iterations[13].

Hopfield Neural Algorithms:

[14]ANN'soffer a computational approach that is quite different from conventional digital computation. Digital computers operate sequentially and can do arithmetic computation extremely fast. Biological neurons in the human brain are extremely slow devices and are capable of performing a tremendous amount of computation tasks necessary to do everyday complex tasks. One of the most common method is the two dimensional Hopfield model neural network can be summarized as follows. It consists of N^2 mutually interconnected neurons, whose current states are characterized by binary states.

Where V_{ij} is the value of the input pattern between (0.1 and -0.1) denoting the state of neuron *N*. A set of *M* patterns or images $V(m)$ where $m = 1, 2, ..., M$,[15].

Each matrix with $N \times N$ elements or pixels is stored in the network. The stored memory matrix element T_{ij} denotes the weight of the pattern which defines the interconnection strength between neurons. The general equation of the weight matrix and output value can be determined as fallow:

$$T_{ij} = \sum_{s=}^{M-1} x_{i}^{s} x_{j}^{s} \quad \text{When } i \neq j \qquad …(7)$$

Else T_{ij} will equal zero so the output value V can be obtained from:

$$V_{i}(t + 1) = f_{h}\left[\sum a\ T_{ij}V_{i}(t)\right] \qquad …(8)$$

Where f_{h} is the threshold function of the neuron and t is the time standard one important parameter must be known to ensure the work of the network is the energy function and can be find as shown[16]:

$$\mathit{D}E = \frac{-1}{2}\mathit{D}V_{i}\sum_{j} T_{ij}V_{j} = \frac{-1}{2}\mathit{D}V_{i}H_{i} \qquad …(9)$$

Neuro- Snake Classifications:

HNN Algorithm has been used because this algorithm is very powerful in recognition and classification. Although it has a common problem, is the local minima (Oscillation).

To overcome this problem a new method a new method adopted, a neuron-snake classifier. This classifier aimed to:

- Reduce the noise rate in the input pattern. That would increase the energy of the signal (pattern).
- Reduce the bit error rate in the HNN algorithm.

The input signal (patterns) passes through two steps, GVF and HNN.

The processes system has two stages as shown in Fig.(1):

- First, storage stage:

In this stage the patterns filtered using snake active contour. The snake takes the path near by the original pattern (shape) and saves it, this process named GVF. The input patterns to HNN passes through an activation function limited by (0.1,-0.1), this process named normalization, as shown in Fig(1). When all patterns passes and storage in HNN, it will be able to work as a classifier.

- Second, testing stage:

In this stage, unknown patterns interred to the GVF system, the GVF take off the noise from the interred pattern and normalized it then passes to the HNN (that have storage the patterns in the first stage) to recognize the patterns and classify it as in Eq. 10 below:

975

$$E_{NS} = E_{snake} + E_{neural} \qquad \dots(10)$$

$$E_{NS} = \int_0^1 E_{int\ ernal}\,ds + \int_0^1 E_{external}\,ds - \frac{1}{2}V\int_0^1 TVds$$

Examples and Results

MATLAB 7 simulator program has been used to build the whole system process. The patterns have been tested by the graphical user interface (GUI).

Two kinds of input data (patterns) have been used: two- dimensional matrix, and three- dimensional matrix. The number of bit in the two dimensional matrix x,y (64 x 64) and in the three dimensional matrix is x,y,z (256 x 256 x 64).

The dimension of the matrix has been chosen depends on the ideality in dimensions.

The parameters of the GVF system have been chosen randomly to reach the ideality as seen later.

The HNN contain 72 input output neurons as shown in Fig(2). Each neuron connected with all neurons except the neuron itself. The proposed network can storage four patterns and the dimension of the matrix of the patterns not exceed (72x64)[16].

$$M \le 0.15N$$

$$Ber = e^{-N/2P}$$

Where M is the number of pattern, N is the number of neuron, Ber is the bet error rate, P is the input pattern

Two examples of the two-dimensional matrix expressed below:

The letter (O) has been chosen as a first example. The inner area suppurated from the output area which is white by a black circle, the recognition attempt on the white area.

In the testing stage all parameters of GVF has been adjusted as in Fig.3

Fig.3 a,b,c,d,e shows the GVF process finding the input pattern boundaries. The crowded blue circles represent the target pattern and the other blue circle shows the snake path while finding the tested pattern.

The letter (I) has taken as a second example of the two dimensional pattern. This letter differs from the letter (O) that it can represent with only a black area. Fig.4 a,b,c,d,e shows the GVF process finding the input pattern boundaries.

A cross section area of the brain have taken as an example of three-dimensional matrix, because of the multiscale of gray color is available in that image. The eye has been selected to analyze the control of active cantor. Fig.5 a, b, c, d, e shows the GVF process finding the input pattern boundaries.

The snake path chosen randomly and after 80 iterations, the program could reach the boundary of the tested patterns.

It is noticeable that the time of recognition increases by increasing the matrix dimension.

The bit error rate calculations results for the same three examples above by applying them to the HNN directly was between 0.5 to 1 as in Fig.6 a, b, c and when applied to neuron-snake method decreases to 0.215 as in Fig.6 a1, b1, c1.

Conclusions

The criteria to measure the enhancement in HNN algorithm is the bit error rate.

The Bit error is decreases to 0.215 using the proposed method, while in the traditional way (using only HNN) were between 0.5 to 1.

The oscillation state happens in the HNN when there are similarities between the storage patterns.

In this research an important problem were solved by eliminating the noise of the storage patterns (The snake surrounded the image). Then convert the pattern to a gray scale level using GVF before pass it in to neural network to be stored. Also that will increase the power of the pattern to be classified correctly in side the HNN.

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14a- ibid., Ch4, pp. 32.   **14b-** ibid., Ch4, pp. 33.
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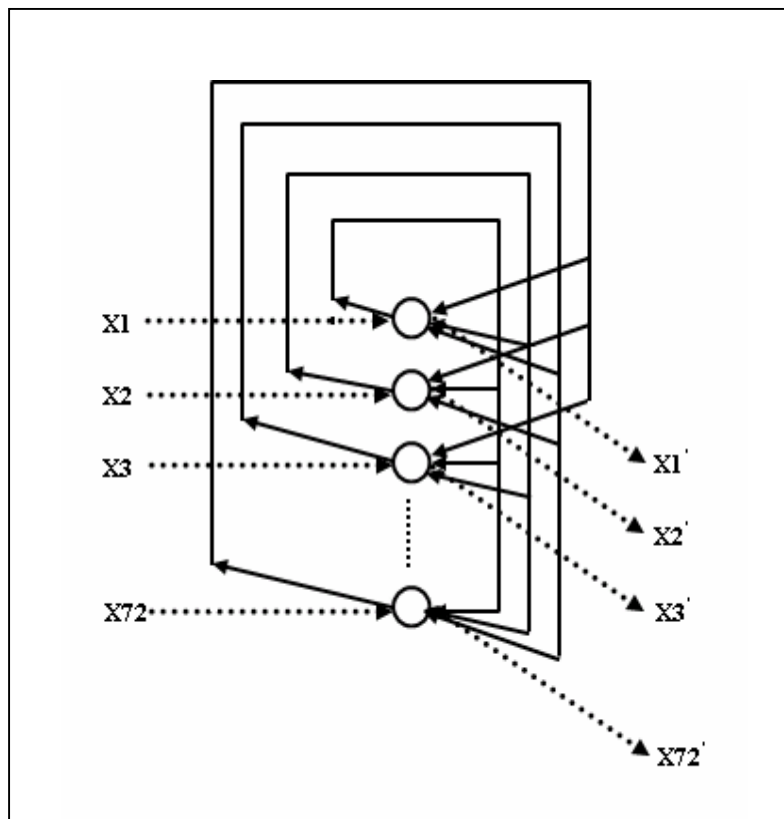
977
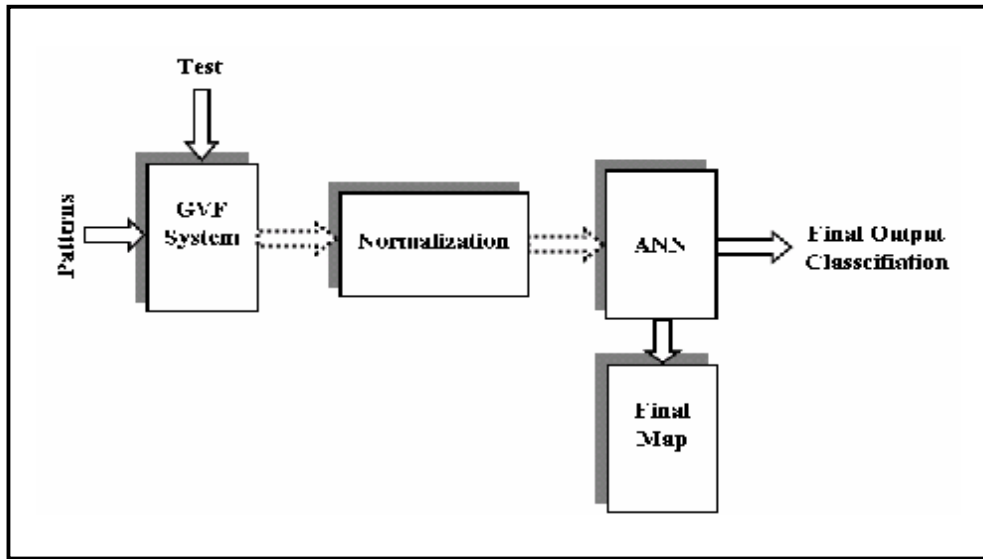
Figure(1) Neuro-Snake classifier
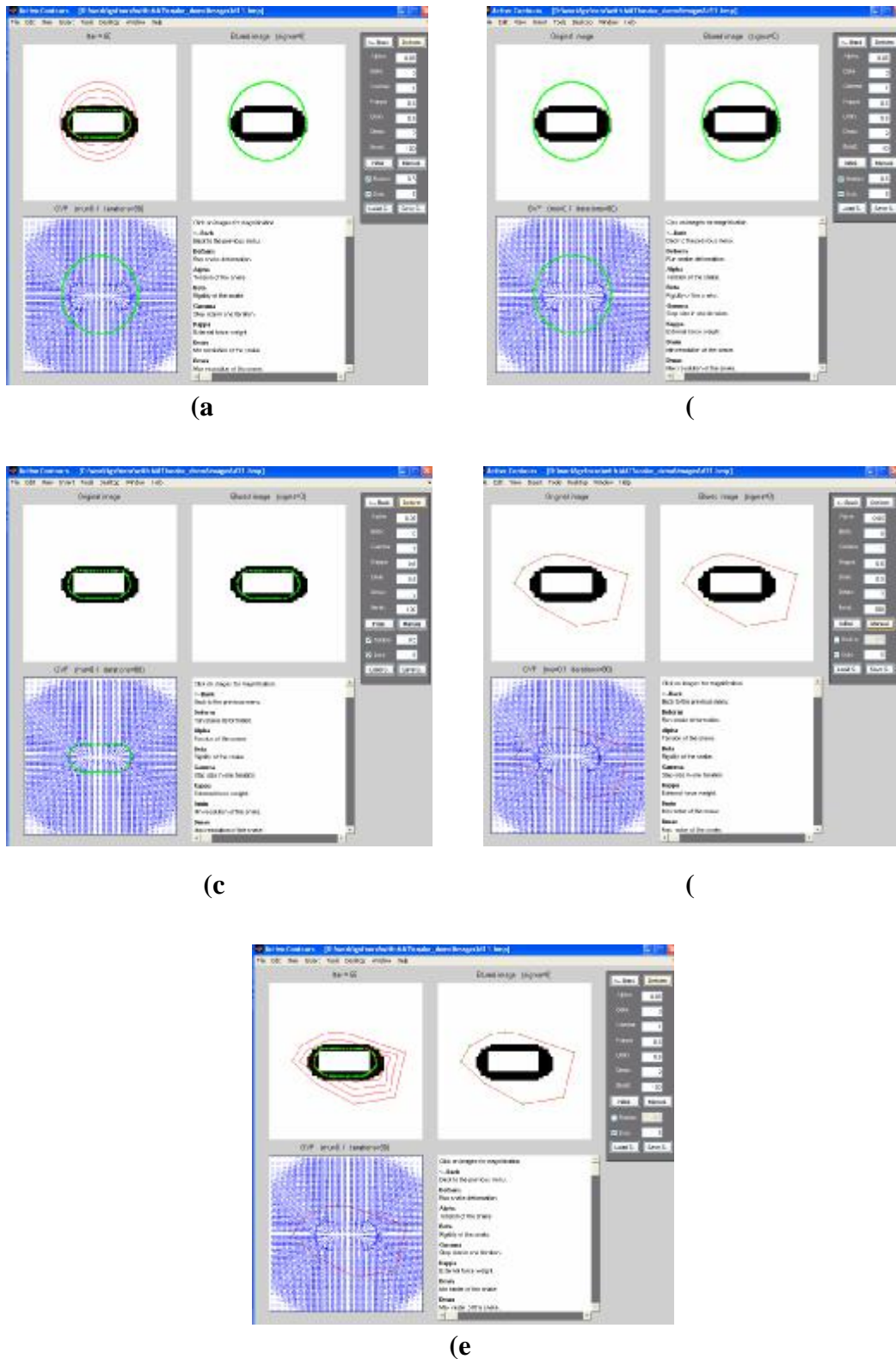

Figure (2) HNN for 72 neuron

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(a   (

(c   (

(e

**Figure (3) the GVF step to capture the pattern
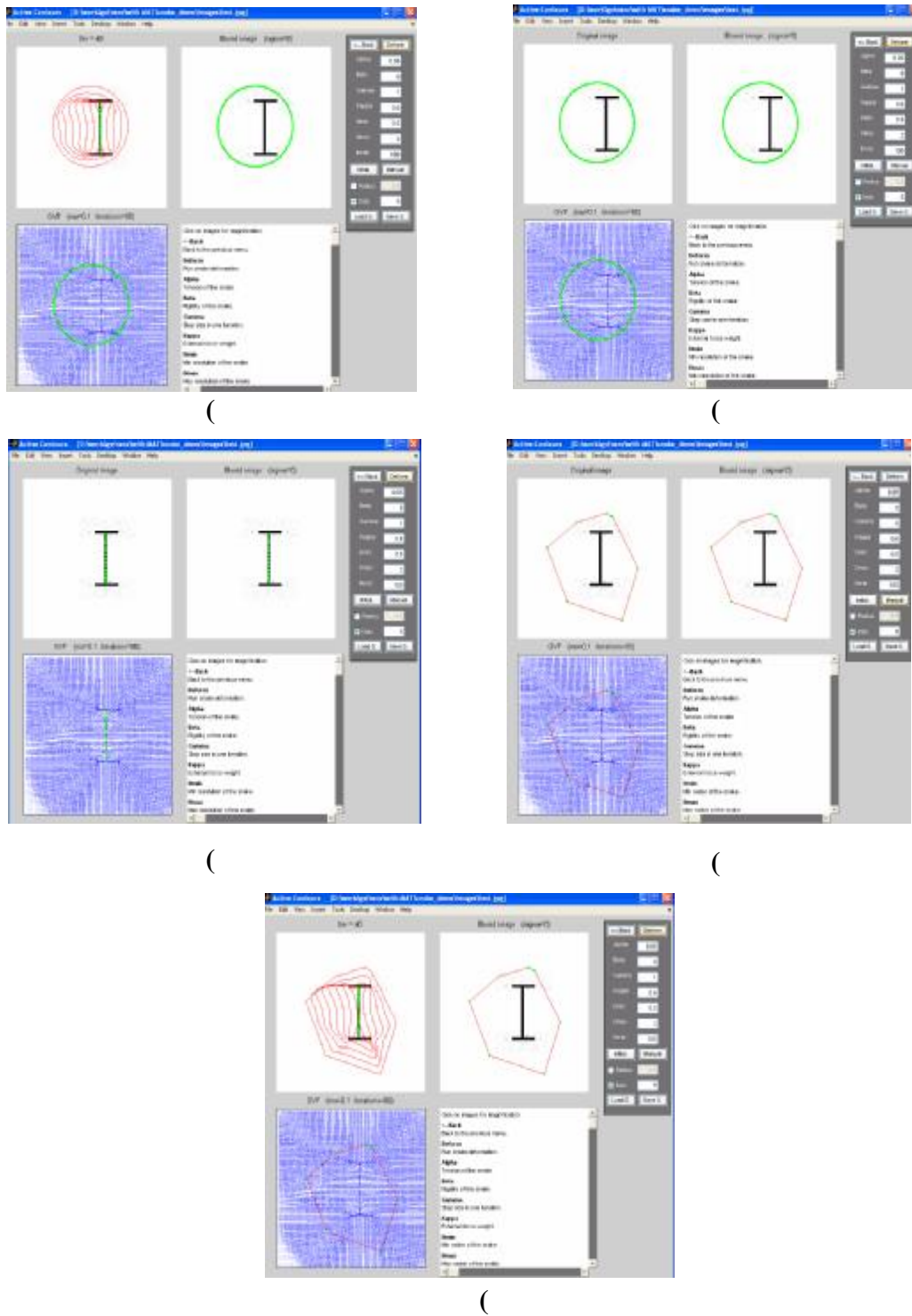(letter (O)) from the input image**

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**Figure (4) the GVF step to capture the pattern
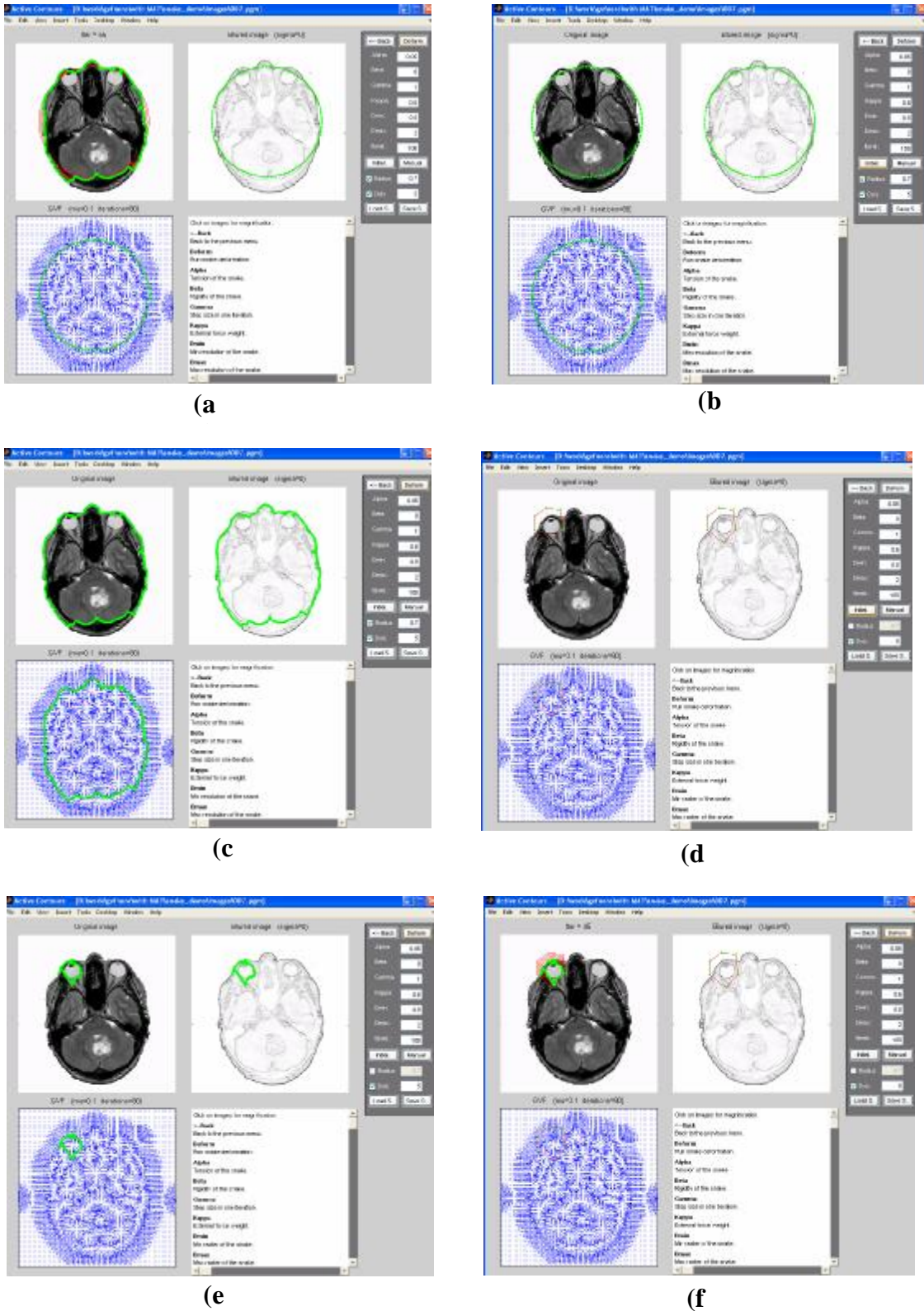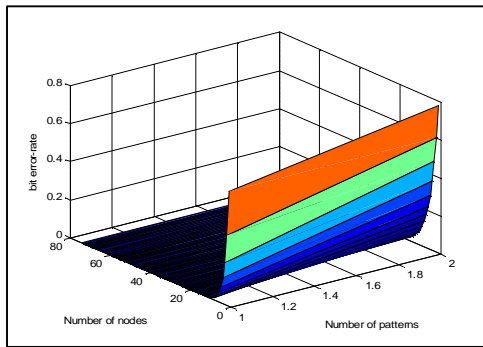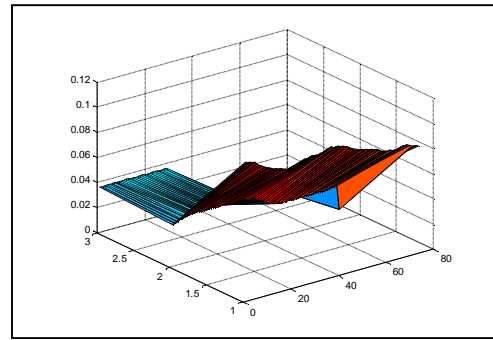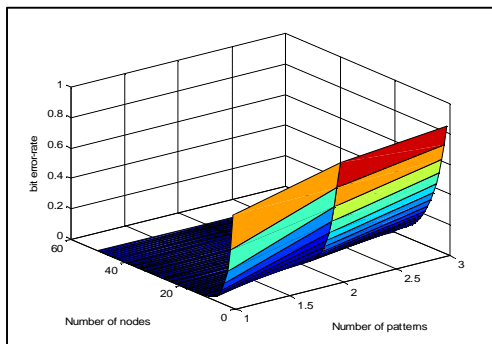(letter (I)) from the input image**

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(a

(b

(c

(d

(e

(f

**Figure (5) the GVF step to capture the pattern cross
section of the brain from the input image**

981

(a)

(a

(b
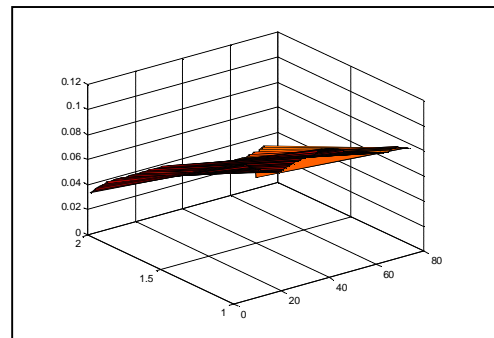
(b
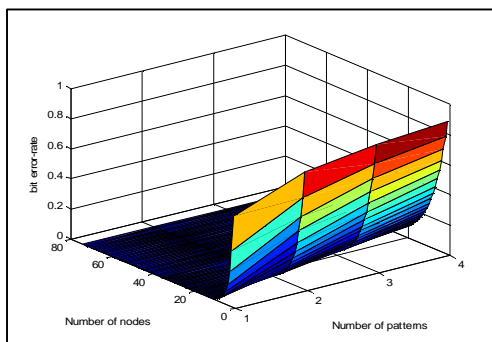
(c)

(c

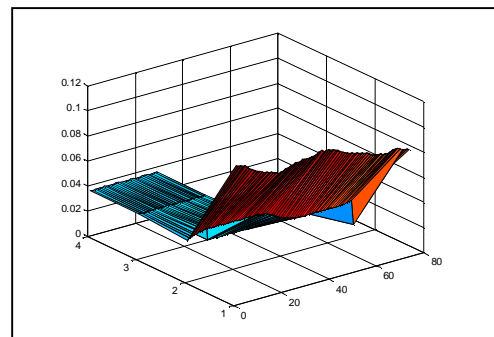**Figure (6)Bit error rate for**
a1, b1, c1   -the Neoro-Snake
classifier

982