

## **Early Detection of Disease-Viral Hepatitis Type-C Using Elman Artificial Neural Network**

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### **ABSTRACT**

The problem of founding important information in complex medical images which are needed in diagnosing of diseases with the complex data considered as one of the predication problem these days, so it is necessary to find aided means for diagnosing process. Artificial neural network (ANN) is one of them. This paper deals with the designing and implementation a classification ANN module for Lever Hepatitis(class-C) or type-C which doesn't have any vaccine these days. The different in diagnosing between hepatitis and other liver diseases is often difficult on purely clinical grounds in addition the damage to the liver causes changes in the pattern of the serum enzymes and in recent years this has led to develop disease testing and its vaccine. Elman neural networks (NN) have been applied for automated detection of various medical diseases. Like its application on blood sample tests extracted from on line microscope (like it used in this research).That feature selection is an important issue by removing features that do not encode important data information from the images used.This helps physicians to extract features which aided them in diagnosing process. Kernal principle component analysis (PCA) is used to represent blood images as eigen-features of training images in addition to extract mathematical module for classification of it. Finally a neural network (NN) is trained to perform the typical images and classify them (diagnosing process). The produced NN system produces used a matlab package in order to design and diagnose the proposed module. The object of this system used in our work is to diagnosing lever Hepatitis type-C in samples of blood images wherever difficulties in practical experiments by finding an optimal feature from specialists whom work in laboratories.

**Keywords:** HCV, Image Classification, Feature Selection, Kernal Principle Component (Kernal PCA), Artificial Neural Network.

## الكشف المبكر لمرض التهاب الكبد الفيروسي نوع ج - باستخدام شبكة ايلمان العصبية الاصطناعية

### الخلاصة

تعد مشكلة ايجاد المعلومات المهمة في الصور الطبية المعقدة والتي يحتاج اليها في تشخيص الامراض ذات البيانات المركبة والمعقدة واحدة من مشاكل التنبؤ بالامراض هذه الايام لذا فمن الضروري ايجاد الوسائل المساندة لعمليات تشخيص تلك الصور . تعتبر الشبكات العصبية الاصطناعية احداها. يتضمن هذا البحث تصميم وتطبيق نموذج لشبكة عصبية اصطناعية لمرض التهاب الكبد الفيروسي (صنف ج - ج ) اونوع ج - ج والذي لا يوجد له لقاح حتى اليوم. ان الاختلاف بين تشخيص التهاب الكبد والامراض الاخرى للكبد صعب جدا في اغلب التشخيصات السريرية اضافة الى ان الاذى الذي يصيب الكبد يغير في نمط انزيمات المصل مما قاد الى تطوير اختبار المرض ولقاحه في السنوات الاخيرة. طبقت شبكة ايلمان العصبية الاصطناعية في كشف الي لمختلف الامراض كاختبار عينات الدم المستخلصة من اجهزة المايكروسكوب ( كالمستخدمة في هذا البحث ) . ان اختيار الصيغ (الميزات) يعد من القضايا المهمة وذلك بازالة الصيغ التي لا تحتوي على بيانات المعلومات المهمة من الصور المستخدمة. ساعد هذا الاطباء في استخلاص الصيغ التي تدعمهم في عملية التشخيص. استخدم مبدأ تحليل كيرنال (PCA) لتمثيل صور الدم بصيغة (Eigen features) لصور التدريب بالاضافة الى استخلاص نموذج رياضي لتصنيف هذه الصور. اخيرا فان الشبكة العصبية الاصطناعية تدرب لاداء الصور المثالية وتصنيفها (عملية التشخيص) . استخدم نظام الشبكات العصبية الاصطناعية المنتج حقيقية Matlab لتصميم واختبار النموذج المقترح. الهدف من هذا النظام المستخدم في هذا العمل هو تشخيص مرض التهاب الكبد نوع-ج من خلال عينات لصور الدم والتي تشكل صعوبة في ايجاد صيغ مثالية لتشخيصها عمليا من قبل المختصين في المختبر .

### INTRODUCTION

It is useful to have a machine perform pattern classification for medical images .The problem with feature is not the lack of features but how founding feature, so the application of feature selection and grouping techniques are must for image classification problem (by reducing the size of the feature and deleting the irrelevant features).

With feature selection the small size and more relevant features set will increase classification accuracy and reduce the computation time.

In this research Artificial Neural Networks (ANN) are extremely useful work for this type of information from the input data [1]. Artificial neural networks are commonly referred to "Neural Network NN" that meant the simulation of the biological neural networks of the human brains which are made of number of simple highly interconnected processing elements to process information by their dynamic state to external inputs, thus they called "Computing Systems" [2].

The ANN has been studied in order to understand and limitate the human-like performance in solving problems with complexity, incomplete or unrelated data which

cannot be solved easy by human diagnosing. The capability of ANN to classify features refers to its ability to approximate function and how generalized them so that in medical images which have one of the greatest problems of medical diagnosis especially the subjectivity of the specialist. The experience of the professional greatly affects the final diagnosis. This is due to the fact that the result does not depend on a systematized solution, but on the interpretation of the patient's answer.

The solution to this kind of problems can be found in the area of Adaptive Pattern Recognition, where the solution rests on the easiness with which the systems adapts to the information available, in this case coming from the patient in addition medical image classification is not easy classify because that images are classified through microscope depending on human experts and the practical experiments which diverse due to the difference of conditions including the experimental and microscopes used. Further more the information of diseases cannot appear clearly through the gained images and this will lead the classification process to complexity stage.

For this problem it is very difficult to choose an optimal feature set manually practical experimentally. Most practical feature selection can be viewed as the combinations of different material and evaluate the result between high accuracy and small size in addition the computational cost always need consideration [3,4].

#### **VIRAL HEPATITIS OF HUMAN LIVER**

Viral Hepatitis (plural Hepatitis) is an inflammation of the liver characterized by the presence of inflammatory cells in the tissue of the organ. Hepatitis may occur with limited or no symptoms, but often leads to jaundice, anorexia (poor appetite) and malaise. Hepatitis is acute when it lasts less than six months and chronic when it persists longer. A group of viruses known as the Hepatitis viruses cause most cases of Hepatitis worldwide, but it can also be due to toxins (notably alcohol, certain medications, some industrial organic solvents and plants), other infections and autoimmune diseases [5].

A fairly common systemic disease, viral Hepatitis is marked by hepatocellular destruction, necrosis, and autolysis, leading to anorexia, jaundice, and hepatomegaly. In most patients, hepatic cells eventually regenerate with little or no residual damage. Advanced age and serious underlying disorders make complications more likely. The prognosis is poor if edema and end-stage liver disease develop.

There are six types of Hepatitis: Type A , B , C , D , E & G [6].

Viral Hepatitis type-C (HCV) known as delta Hepatitis which accounts for about 20% of all viral Hepatitis cases and is primarily transmitted through blood and body fluids or obtained during tattooing. Although Hepatitis-C viruses have been isolated, only a small percentage of patients have tested positive for them, perhaps reflecting the test's poor specificity. Usually, Hepatitis patients with HVC are often asymptomatic and undiagnosed. One third of adults will experience some mild & nonspecific symptoms(including fatigue ,weakness, jaundice, abdominal pain or dark urine).This type of Hepatitis is transmitted through transfused blood from asymptomatic donors and receiving tattoos. In Clinical tip Most patients with hepatitis C are asymptomatic. Hepatitis C virus is associated with a high rate of chronic liver disease (chronic hepatitis,

cirrhosis, and an increased risk of hepatocellular carcinoma), which develops in 50% to 80% of those infected. People who have chronic hepatitis C are considered infectious. Hepatitis C virus doesn't have any vaccine till now [7].

### **PATTERN RECOGNITION IN NEURAL NETWORKS**

Human beings do not analyze the different situations of real world as isolated facts, but they try to describe them in terms of patterns of related facts, sometimes these relations are implicit because they all refer to the same object. Some other time it is necessary to explicitly connect these characteristics in order to find relations.[8],since this skill is not only used for the perception of facts but also for knowledge ways of providing computers with this same pattern processing skill of human being has been sought for. In some application, pattern characteristics are best described by structural relationships, which is depending on sizes and location of information [9].

The using of NN allows to obtain suitable choice to trainable pattern classification because of their capability to generalize information as well as their tolerance to noise and their powerful in computational systems which consist of many simple processing elements connected together to perform tasks analogously to biological brains. So like other machine learning problem, the data will be divided to training set and testing data randomly. The training data will be used for feature selection, the testing data will be used for the evaluation of the accuracy of the finally selected feature set [10,11].

### **RECOGNITION OF MEDICAL IMAGE SYSTEM**

The research line of NN applied to recognize patterns in our images taken from Al Yarmok Blood Center which is shown in fig (1).

The block diagram in fig (2) shows the main steps of this work. The computer imaging systems are comprised two primary component types, hardware and software. The hardware components can be divided into the image acquisition system & the display device. The software allows manipulation of the image and performs any desired processing on the image data which is in digital form .The images are obtained by microscope, analogue images generated from a computerize camera system using video camera and digitizer board. All images are compressed in group in size of (256\*256) pixel, so the analogue images are converted to digital shapes which are suitable to compute it with research program which is represented as two dimensional arrays of data with pixel value [12,13,14].

### **PREPROCESSING MODULES**

Processing of digital images involves procedures that usually expressed in algorithm form, so the process model involves a series of image enhancement and steps that can be classified in three phases: Noise removal, Segmentation and Normalization for each of preprocessing phase's steps [13].

**NOISE REMOVAL**

Generally the digitize images suffer from several types of noise. There are several sources of noise types. One of these sources is how the image acquired. If the image is acquired directly in digital format, the mechanism for gathering the data can introduce noise.

In this research Median filter is used to remove noise from blood images. Median filter is a nonlinear digital technique, often used to remove noise. This type of filters is used as a preprocessing step of this research, Median filter used as advantages to remove noise (no reduction in contrast across steps) doesn't shift boundaries as can happen with conventional smoothing, since the Median is less sensitive than the mean to extreme values, those extreme values are more effectively removed

In Median filter, the neighboring pixels are ranked according to brightness and the median value for the central pixel, the middle value becomes the output value for the pixel under evaluation [15,16].

**\*ALGORITHM OF MEDIAN FILTER**

Let  $x_{ij}$ , for  $(i,j) \rightarrow A \equiv [1, \dots, M] \times [1, \dots, N]$  is the gray level of a true M-by-N image(x) at pixel location  $(i,j)$

$S_{min}, S_{max}$  is the dynamic range of x, i.e  $S_{min} \leq x_{i,j} \leq S_{max}$  for all  $(i,j)$

$(y)$  is a noisy image .

In the classical noise model, the observed gray level at pixel location  $(i,j)$  is given by

$$r = p + q \quad \dots\dots\dots (1)$$

$(r)$  is defined as the noise level.

Let  $S_{i,j}^w$  be a window of size  $(w \times w)$  centered at location  $(i,j)$ , i.e.

$$S_{i,j}^w = \{ (k,i) : |k - i| \leq w \text{ and } (i,j) \leq w \} \quad \dots\dots\dots (2)$$

Let  $W_{max} \times W_{min}$  be the maximum window size .

The algorithm tries to identify the noise candidates  $y_{i,j}$ , and then replace each  $y_{i,j}$  by the median of the pixel in  $S_{i,j}^w$  .

For each pixel location  $(i,j)$ , do

- 1-Initialize Type equation here.  $w=3$ .
- 2-Compute,  $S_{i,j}^{min,w}$  ,  $S_{i,j}^{med,w}$  ,  $S_{i,j}^{max,w}$  , which are the minimum, medium and maximum of the pixel values in  $S_{i,j}^w$  respectively.

3-If  $S_{i,j}^{\min,w} < S_{i,j}^{\text{med},w} < S_{i,j}^{\max,w}$ , then go to step 5. Otherwise, set  $w=w+2$ .

4- If  $w \leq w_{\max}$  go to step 2. Otherwise,  $w$  replace  $y_{ij}$  by  $S_{i,j}^{\text{med},w_{\max}}$ .

5- If  $S_{i,j}^{\min,w} < y_{ij} < S_{i,j}^{\max,w}$ , then  $y_{ij}$  is not noise candidate. Else replace  $y_{ij}$  by  $S_{i,j}^{\text{med},w_{\max}}$ .

The noise candidates are replaced by the median  $S_{i,j}^{\text{med},w_{\max}}$ .

### CANNY EDGE DETECTION

The remaining pixels are left unaltered. Canny edge detection is used to detect edges in images used after noise removed by median filtering. Canny's aim is to detect the optimal edge detection algorithm.

Four filters used in Canny algorithm to detect horizontal, vertical & diagonal edges in each images. The edge detection operator returns a value for the first derivative in the horizontal direction ( $G_x$ ) and the vertical direction ( $G_y$ ), so the edge gradient ( $G$ ) and direction ( $q$ ) can be determined as [15]:

$$G = \sqrt{G_x^2 + G_y^2} \quad \dots (3)$$

$$q = \left[ \begin{array}{c} G_x^2 \\ G_y^2 \end{array} \right] \quad \dots (4)$$

### SEGMENTATION

The segmentation is so important that the overall system performance significantly affected by its function. Efficient segmentation algorithms are very computational intensive, while choosing simplest algorithm with the efficiency is not the correct choice, because it may produce significant error. These errors are rounded to be of more significance in the proceeding part of the system. The goal of segmentation is to change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is very importance step in most image processing applications and it has to be utilized for many different kinds of problems. Segmentation means that an image is either partially or completely divided into disjoint image region. Most of the time high level information of the specific problem domain is needed for an accurate segmentation [17].

Segmentation techniques are commonly divided into three groups:-

- 1-Thresholding
- 2-Edge based
- 3-Region based

In this research region based method is used because this method try's to find image regions directly by applying a certain homogeneity criterion on neighboring pixel of an

image which is suitable for images used in this research. Basically as in other techniques the segmentation in region method can be considered to consist of two tasks. Object recognition (desired patterns) and object delineation. Recognition is the task to roughly decide where an object is located [18].

In this type of segmentation method, it is only need a small numbers of seed point to represent the property wanted then grew the region can be classified the image as one of the pixel-based image segmentation with respect to its noise because of its selection of initial seed points. The grow regions appending to the neighboring pixel of seed point that have predefined properties similar to it and determines if the pixel should be added or not to the seed point then the iteration of region rule is stopped when there is no more pixels satisfy the criteria for inclusion in that region[9].

### \*BASIC FORMULATION OF REGION GROUPING

Let  $R$  represent the entire image region, it may view segmentation as process that partitions  $R$  into  $n$  sub regions,  $R_1, R_2, \dots, R_n$ , such that

- a)  $\bigcup_{i=1}^n R_i = R$
- b)  $R_i$  is connected region,  $i=1,2,3,\dots,n$
- c)  $R_i \cap R_j \neq \emptyset$  for all  $i \neq j$
- d)  $p(R_i) = \text{TRUE}$  for  $i=1,2,\dots,n$
- e)  $p(R_i \cup R_j) = \text{FALSE}$  for any adjacent regions  $R_i$  and  $R_j$

Here  $p(R_i)$  is a logical predicate defined over the points in set  $R_i$  and  $\emptyset$  is the null set conditions:

- a) Indicates that the segmentation must be complete, that is every pixel must be in a region.
- b) Requires that points in a region be connected in some pre defined sense.
- c) Indicate that the region must be disjoint.
- d) Deals with the properties that must be satisfied by the pixels in a segmented region for example  $p(R_i) = \text{TRUE}$  if pixel in  $R_i$  have the same gray level.
- e) Indicate that adjacent region  $R_i \& R_j$  are different in the sense of predicate [9].

### NORMALIZATION

The work in this research is based on the fact that all information about Hepatitis-C image can be recognized from image shape so the image must be normalized after segmentation to size of (256\*256) pixels. In this shape the restrict analysis for the pixel information is used.

The gray scale variation of image gives a good variation of information that help of spreading the histogram of the image across the entire spectrum, this is shown in equation (5) which depends on analyzing minimum and maximum value of image [19].

$$I_{\text{Prep}}(x,y) = \frac{I(X,Y) - \text{Min}(I)}{\text{Max}(I) - \text{Min}(I)} \dots\dots\dots (5)$$

$$I_{\text{Prep}} \in [0,1]$$

**EXTRACT FEATURES**

The selection of the adequate features plays an important role in the field of image segmentation, with these techniques it is possible to reduce the dimensionality of the problem with the objective to reduce its computational complexity. The small size and more relevant feature set will increase the classification accuracy and reduce the computation time. The output of feature selection algorithms are optimal, but such optimal feature set may perform badly in some practical problems. The reason is that the minimal feature sets depend heavily on the classification problem and the known data set [11].

The feature selection must be based on the separability of classes. Features that make possible greater separability of classes are more significant and must be chosen for implementation of image segmentation process. Kernel principal component ( Kernel PCA ) analysis is used to help the segmentation process by reducing segmented image (256\*256) pixel to (3 PCA) values.

The main algorithm of PCA is:-

$$\sum_{i=1}^N X_i = 0 \dots\dots (6)$$

It operates by diagonalizing covariance matrix.

$$\frac{1}{N} \sum_{i=1}^N X_i X_i^T \dots\dots (7)$$

In other words it gives an eigen decomposition of the covariance matrix

$$I_v = C_v \dots\dots (8)$$

Which can be rewritten as

$$I_x^T v = X_i^T C_v \quad \forall i \in [1, N] \dots\dots (9)$$

In PCA  $d \geq N$  dimensions if N points are used.

$X_i$ , if it can map to N-dimensional space with the Kronecker delta  $f(X_i)$

$$f(X_i) = d_{ig} \dots\dots (10)$$

Where  $f: R^d \rightarrow R^N$  &  $d_{ig}$  is the kroneker delta ( $f$  creates Elemanly independent vectors).

In PCA  $f(X_i)$  are not independent in  $R^N$  so

$$K = k(x, y) = (f(x), f(y)) \quad \dots\dots\dots (11)$$

Where k is the Gramian matrix in high-dimensional space .

$$v_1 = \arg \max \text{var}\{v^T x\} = \arg \max E\{(v^T x)^2\} \quad \dots\dots\dots (12)$$

Where  $\|v\|=1$ . We just need to compute inner products in the high-dimensional space[20].

**NETWORK ARCHITECTURE (CLASSIFICATION STEP)**

The final classification step of this research used neural networks to suggest it. NN used to map the templates features into final diagnose category. Taking into account the number of features can be significantly reduced.

Elman neural network is one of feedback neural network that have a fixed parameters and mapping with small topologies [21].

Elman's neural net are divided into four layers which are input layer, hidden layer, connecting layer and output layer as shown in figure (3).

The architecture of Elman neural net allows to enable network to distinguish separate input patterns from the same input sequence and the addition of the interior (connection) layer increases the capability of processing dynamic information of the network itself.

The Elman neural net have the adapt to time-varying characteristic because it have the function of mapping dynamicity and giving a simplify training [22].

The topology structure of Elman neural network shows that there are input (n),output(m) and (r) neurons in hidden layer and connecting layer , the weight between connecting layer and hidden layers are ( $w_{1,1}$ ) and the weight from hidden layer to output layer is ( $w_{2,1}$ ),  $u(k-1)$  represents the inputs of neural network ,  $x(k)$  represents the outputs of the hidden layer ,  $x_c(k)$  represents the outputs of connecting layer and  $y(k)$  represents the outputs of neural network,(f) represents the transfer function of hidden layer [23].

**\*ALGORITHM OF ELMAN NEURAL NETWORK**

The algorithm of Elman Neural Net can be represented as following: [23].

$$X(k) = f(w_2 x_c(k) + w_1(u(k-1))) \quad \dots\dots\dots (13)$$

$$X_c(k) = x(k-1) \quad \dots\dots\dots (14)$$

$$y(k) = g(w_3 x(k)) \quad \dots\dots\dots (15)$$

Where:

$g$  is the transfer function of the output layer and it is usually a linear function

$S$  type function is commonly used and can be defined as:

$$f(x) = (1 + e^{-x}) \dots\dots\dots (16)$$

$E$  is the error and  $t_k$  is the output vectors of the object

$$E = \frac{1}{2} \sum_{k=1}^m (t_k - y_k)^2 \dots\dots\dots (17)$$

**TRAINING PROCEDURE**

To evaluate the performance of any neural network recognition system, the accuracy of the system can be calculated as:

$$Accuracy\% = \frac{\text{Number of correctly classified patterns}}{\text{Total number of patterns}} \dots\dots\dots (18)$$

In this research Elman neural network is used for training and testing classification process where 100 images are used for training and 100 images used for testing, so in Elman neural net and its efficiency it can be evaluate the performance of microscope in testing images in more details. Median filter is also used to remove noise from each images then Canny detection is used to detect their edges while region growing used to segment image and reduce segmentation by (PCA) from(256\*256) to 3 Kernal (PCA) values as shown in table (1).

Elman neural network gives an following error values:

\* Training data error = 0.058388

\* Testing data error = 0.079287

The classifying results of training and testing images gave total classification accuracy about 100% for training and 96.69% for testing images.

Table (2) shows the classification results of training and testing images used in diagnostic system of research for different iteration.

The Elman neural network used provides both fast training and powerful mapping. Using Matlab package (R 2009 a) [23].

This neural network has 3 input nodes, 3 hidden nodes and 1 output node as shown in figure (4).

The combination of any two images with different Hapetitis & same arrangement features led the diagnosing step goes away of its goal, this situation referred to the behavior of NN on its arrangement. The NN arrangement on any two objects each of them equal in general features decrease the recognizing in training images, in addition the error rate doesn't decrease to its suitable rate .To avoid this problem which occur in the beginning of the computing program used in this work increasing the number of training

Hepatitis-C images are used As we mentioned earlier the research has been used 100 images for training.

## **CONCLUSIONS**

The contribution of this paper is that to extend techniques to provide a more robust method for feature extraction of medical image recognition. The use of neural network allows adjusting the weighting between the input prior knowledge of the neural network and the image track information based on the image quality and the reliability of the training set. The calculation of feature extraction may be considered as important information which placed as a heart of the system. In other words, if the system is successful in representing the input image with well defined features, the most difficult part of this system is how the recognition and classification problems may be solved in it. This paper has presented the application of Canny's technique, Median filter then region grouping, Elman neural network in order to get better classification of data in noisy data, it is found that the classification technique which is used gives the highest accuracy rate so Elman neural network shows the possibility of reducing input data to learning step by extracting features depending on region grouping. This technique can helps many research in image classification especially that not diagnosis easy from human like medical images which are increasingly being used in health care and medical research. There is consequently widespread interest in accurately relating information in the different images for diagnosis.

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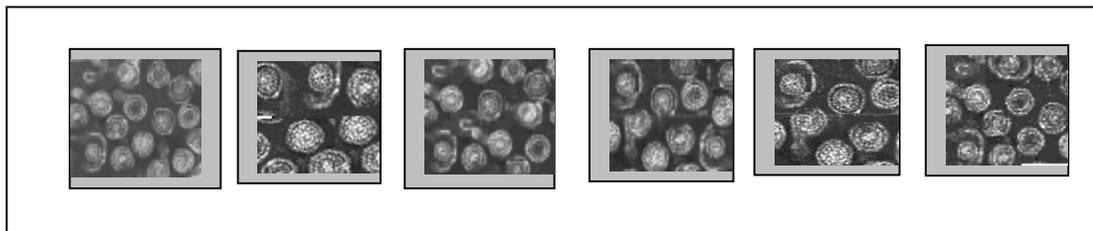


Figure (1) Samples of images tested in the diagnostic

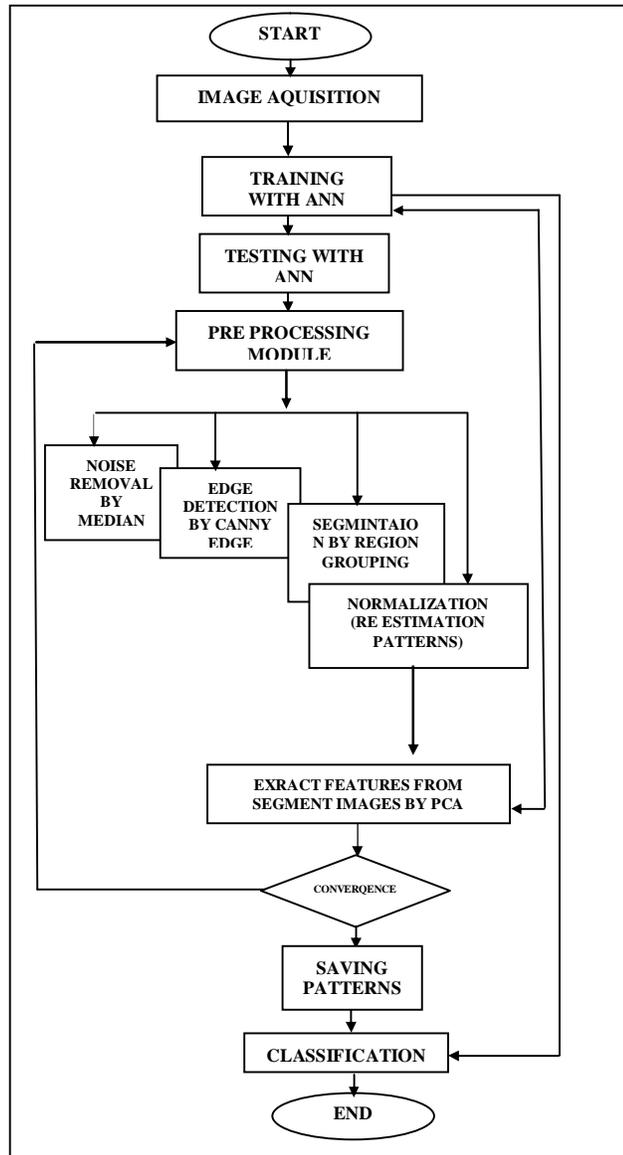


Figure (2) The main flow chart steps of the diagnostic system.

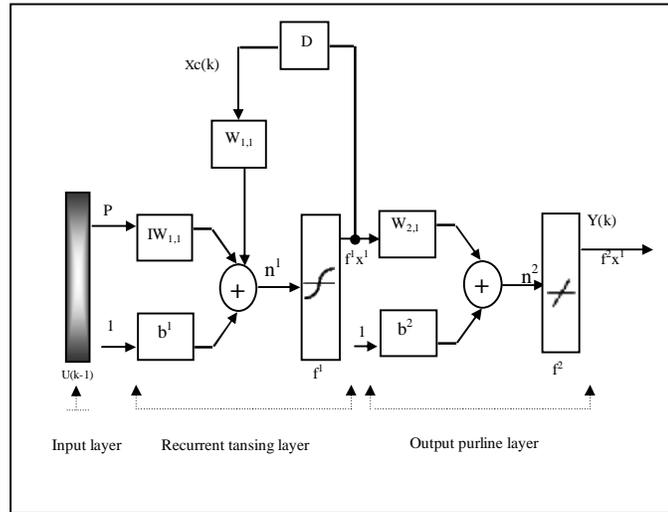


Figure (3) The main architecture of Elman neural network .

Table (1) The Kernel PCA values for research images.

No	Image	3-Kernal		
1		-0.0520	-0.0363	0.0412
2		-0.0356	-0.0522	0.0669
3		-0.0492	-0.156	0.0512

Table (2) the classification of training and testing images Used in diagnostic system.

Measure of training images	Mean value	Measure of testing images	Mean value
Sensitivity	96.79	Sensitivity	94.32
Specificity	99.01	Specificity	95.83
Total accuracy	100%	Total accuracy	96.69%
		Not classified	0.1

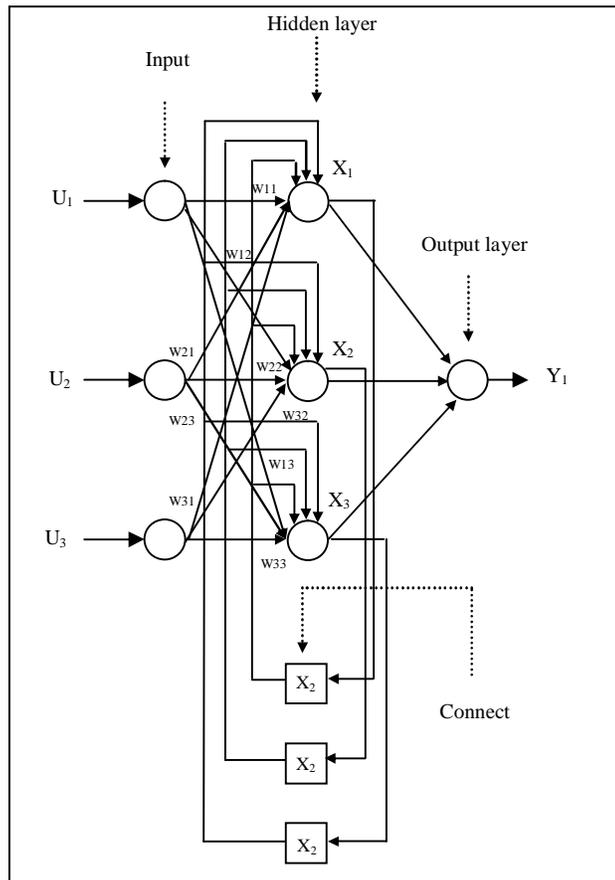


Figure (4) the main architecture of neural net used.