Implementation of Artificial Neural Network and Random Iteration Algorithm Uses in Medical Images

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Abstract

This research present a multiply connected neural network designed to estimate the fractal dimension (Df) using the Random Iteration Algorithm (IFSP). Fractal analysis is a powerful shape recognition tool and has been applied to many pattern recognition problems. Additionally, the one of the most adaptive Random Iteration Algorithm (IFSP) methods for estimating (Df). The architecture presented separates the calculation of (Df) into two sections, a data sampling section and a linear regression section. The data sampling section provides the ability to dyadic ally sample the data. The linear regression section simply calculates the slope of the best line through the sampling results. Instructional program was designed and built according to Knirk and Gustafson Design model, as one of the instructional design model in order to comprehension of the integrated ideas and concepts related to research .

Keywords: Neural Network, Random Algorithm, Medical Images

الخلاصة

يقوم هذا البحث بدراسة شبكة عصبية متعددة الارتباطات صممت لحساب البعد الكسوري باستخدام طريقة الدالة المكررة العشوائية .التحليل الكسوري هو اداة تعريف او تمييز بشكل فعال وله تطبيقات عديدة بمسائل التعريف النسقي بالاضافة الى ذلك ، طريقة الدالة المكررة العشوائية هي واحدة من الطرق الشائعة لحساب البعد الكسوري . تم فصل حساب البعد الكسوري الى قسمين قسم عينة البيانات وقسم التراجع الخطي . قسم البيانات العينية يجهز للقابلية لتجزئة البيانات العينية. قسم التراجع الخطي ببساطة يقوم بحساب المنحني لاحسن خط موجود في نتائج العينات .برنامج تعليمي تم تصميمه وبناءه نسبة الى نموذج تصميم (Knirk and Gustafson) كواحد من النماذج التعليمية المصممة حتى يتم استيعاب الأفكار المتكاملة و المعطيات المتعلقة بالبحث .

1- Introduction

The concept of fractal has given rise to a new system of geometry that has a significant impact, not only on mathematics but also on such diverse fields as biomedicine, Physics, chemistry, physiology, geology, meteorology, material science and fluid mechanics.
A distinctive feature of most fractals are "self-similarity" but it must be noted that not all fractals have self-similarity or at least not exactly satisfying this property, because self-similar object is one whose component parts resemble the whole [1] .

2- Image Metric Space

A metric is a function that measures the distance between two things. For example, the things can be two points on the real line, and the metric can be the absolute value of their difference. The reason for using the word "metric" rather than "difference" or "distance" is to make it more general. There are metrics that measure the distance between two images, the distance between two sets, etc. [2].

A metric space (X, d) is a space or a set of points, say X, together with real valued function d: $X \times X \rightarrow R$. which measures the distance between pairs of points (x and y) in X. suppose that the function d has the following properties:

$$\left.\begin{array}{ll} \text{a.} & d(x, y) > 0 \\ \text{b.} & d(x, y) = 0 \text{ if } x=y \\ \text{c.} & d(x, y) = d(y, x) \\ \text{d.} & d(x, z) \leq d(x, y) + d(y, z) \end{array}\right\} \quad \forall\ x, y \in X$$

Such a function d is called a metric on the space X. The set X may represent a set of points, or a set of images.

In order to discuss image compression, the image should be represented as a mathematical function, z = f(x,y). The graph of this function is generated by taking an image and plotting the grey level of each pixel at position (x,y) as a height (with white being the highest and black is the lowest height). Thus, when referring to an image, the function f(x,y) gives the grey level at each point (x,y) [3].

3- Random Iteration Algorithm

It is more powerful tool than deterministic algorithm, the IFS is the iterated function system with probabilities (IFSP)[4]. It is a sort of random iteration algorithm, IFS is constructed by associating a probability value to each of the affine transformations according to its "importance" relative to other affine transformations. An IFSP is an IFS W = {w1, w2, …, wn} with probabilities P = {p1, p, … , pn}, such that pi > 0 for all i = 1, 2, … ,n,

$$\sum_{i=1}^{n} p_i = 1 \qquad \text{……………………………….(1)}$$

It is possible to construct fractals using equal probabilities. However, to be efficient and to cover the space as quickly as possible, the best procedure is to set the value of each probability to be proportional to the volume of its corresponding transformation. The volume of a transformation is defined as the volume of the absolute value of the determinant of the deformation matrix. That is, the default probability should be [5]:

$$P_i = \frac{|\det A_i|}{\sum_{j=1}^{n} |\det A_j|} = \frac{|a_i d_i - b_i c_i|}{\sum_{j=1}^{n} |a_j d_j - b_j c_j|} \qquad \text{………………………………. (2)}$$

For i = 1, 2, … .n

Process of encoding an arbitrary IFSP using random iteration method. It is the process of rendering a fractal from its IFSP. The steps of the algorithm can be given as follow [6]:

1. Initialize x = 0, y = 0 (Starting point).
2. Choose arbitrary k to be one of the numbers 1, 2,…, n, with probability P_k
3. Apply the transformation wk on the point (x, y) to obtain the point (x', y').
4. Plot the point (x', y').
5. Set x = x' and y = y'.
6. Goto step 2.

The process mentioned above are illustrated by the flowchart shown in Figure (1)

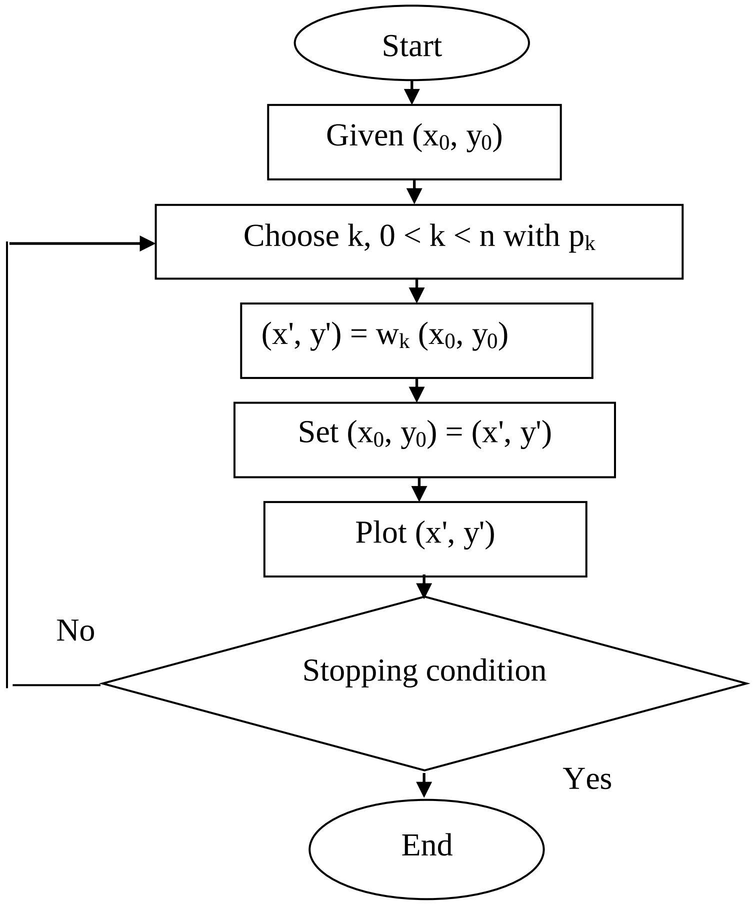

Figure (1) Flowchart of the image generation using random IFS

Linear regression is used to find the best fitting line as shown in fig(2)

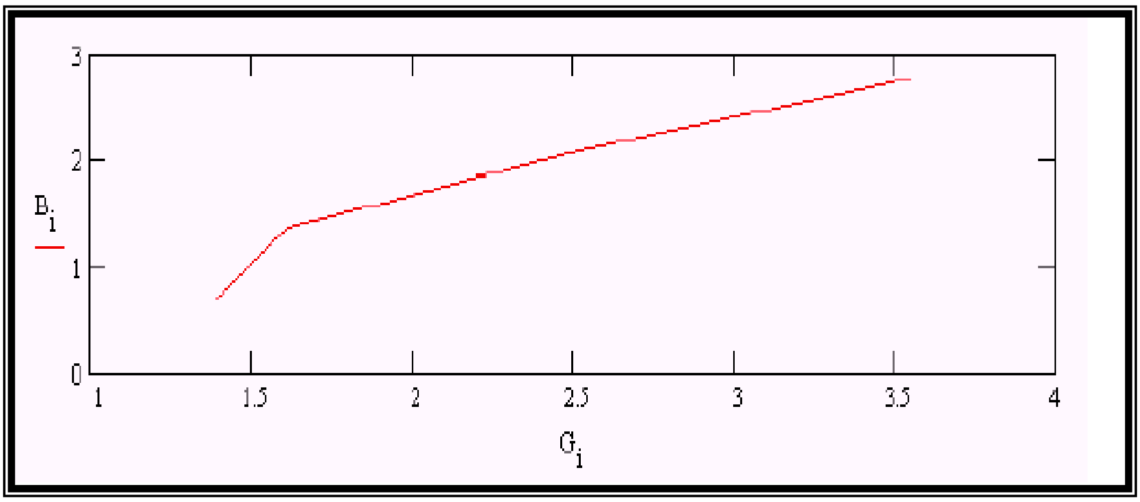

Fig (2) Log-log plot of data.

Df is the slope of this line. We used a grid size half the size of the previous grid. Other implementations use grid sizes of 3x3 pixels, then 5x5 pixels, then 7x7 pixels, and so on. Hence, the box counting method (BCM) (and most other digitally implemented methods) are only estimates of D_f (dB), where B_i number of box length and G_i maximum of box length [7].

4- Fractals in biomedicine

It is not surprising that the methods of fractal mathematics, which allow quantification of structure or pattern across many spatial or temporal scales, could be useful in many biomedical applications including:

- Biosignal analysis, pattern recognition.
- Radiological and ultrasonographic image analysis)[8].
- Cellular morphometry, nuclei (chromatin) organization, gene expression.
- Physiological and pathological states of brain and nervous system.
- Circulatory system, lungs and pulmonary system.
- Analysis of connective tissue, epithelial-stromal tissue interface, tissue-remodeling.
- Biological design, angiogenesis, evolutionary patterns, morphogenesis, spatio-temporal
- Tree structures, vessel branching.
- Structure, complexity and chaos in tumors.
- Membranes and cell organelles during growth and death (apoptosis, necrosis).
- Aging, immunological response, autoimmune and chronic diseases.
- Complexity, self-organization and chaos in metabolic and signaling pathways.
- Structure of biopolymers (proteins, nucleic acids).

5- Artificial Neural Network (ANN)

ANN is an information –processing system that certain performance characteristics in common with biological neural network One of the main advantages of the ANN is that they infer solutions from data without prior knowledge of the regularities in the data , they extract the regularities empirically [9] ,fig (3)shown the ANN

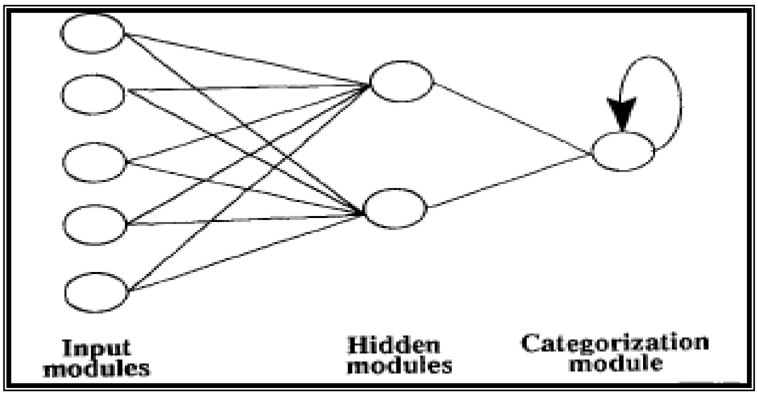

Fig (3) shown the ANN[10]

6- Learning Rule Using Maximum Entropy Estimation

We now present a brief review of maximum entropy estimation [11]. Given a finite set *S* of *n* elements, let *p* = {*p*0, *p*1, *p*2, …, *p*n}represent the probability distribution for *S*, where *pi* is the probability of occurrence of the *i*th element in *S*. We define the entropy *H* of *p* as:

$$H(p) = \sum_{i=0}^{n} pi \log(pi) \qquad \text{.......................... (3)}$$

Now, let f_k be a set of *c* functions on *S*, and *mk* be the set of values of the means of these functions. Maximum entropy estimation is simply the problem of finding a probability distribution *p* on *S* such that the distribution has the specified mean values *mk* and *H(p)* is maximized. *p* is a constrained maximization problem. In fact, using the gradient of the entropy, ∇H, we can solve it, where

$$\nabla H = \sum_{i=0}^{n} -(\log(po)+1), -(\log(p1)+1), .. -(\log(pn+1))^{T} \qquad \text{.......... (4)}$$

Now, we have the knowledge to build our gradient ascent learning algorithm [12].

7- Instructional Design Model

The IDM quality of knowledge transferred from an instructor to a learner. IDM starts by analyzing the learning needs and goals and it is followed by the development (of a delivery system to meet learning goals). Testing and evaluation of learning materials and learning activities an organized productive frame and laws depended on educational theories. The model is constructed on the bases of the occurrence of a problem. There are several models for educational design. But all have common features, which are: -

- The analysis of a real problem which represents the educational demand.
- Definition of the aims and the strategy of every problem [13].

The flowchart model used in Fig below shows the five phases with their basic steps listed below them.

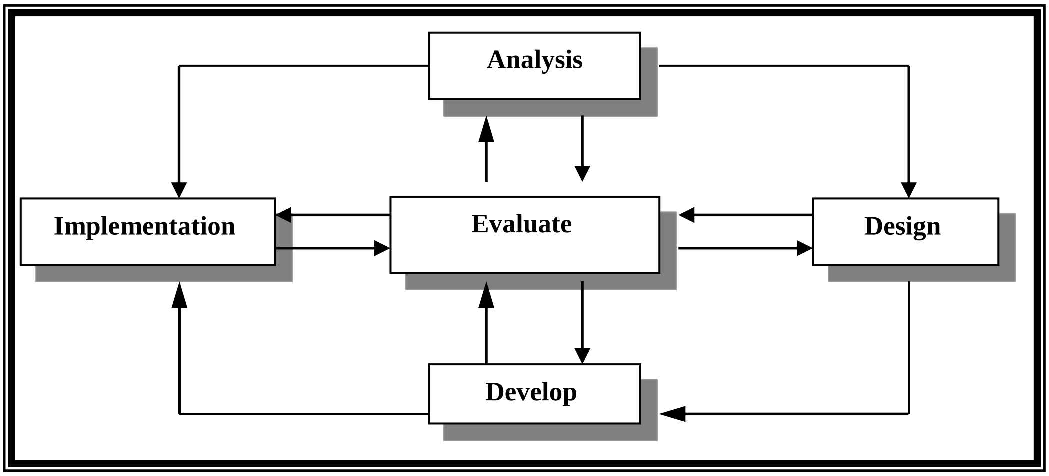

Fig (4) Flowchart model

8- Research procedure

The research use Matlab implementation the program to estimate the fractal dimension and neural network. The network consists of two independently trained stages. Both stages are in fact back propagation neural networks with one hidden layer. It is used to recognize blood cell images Fig (4) Multistage back propagation neural network

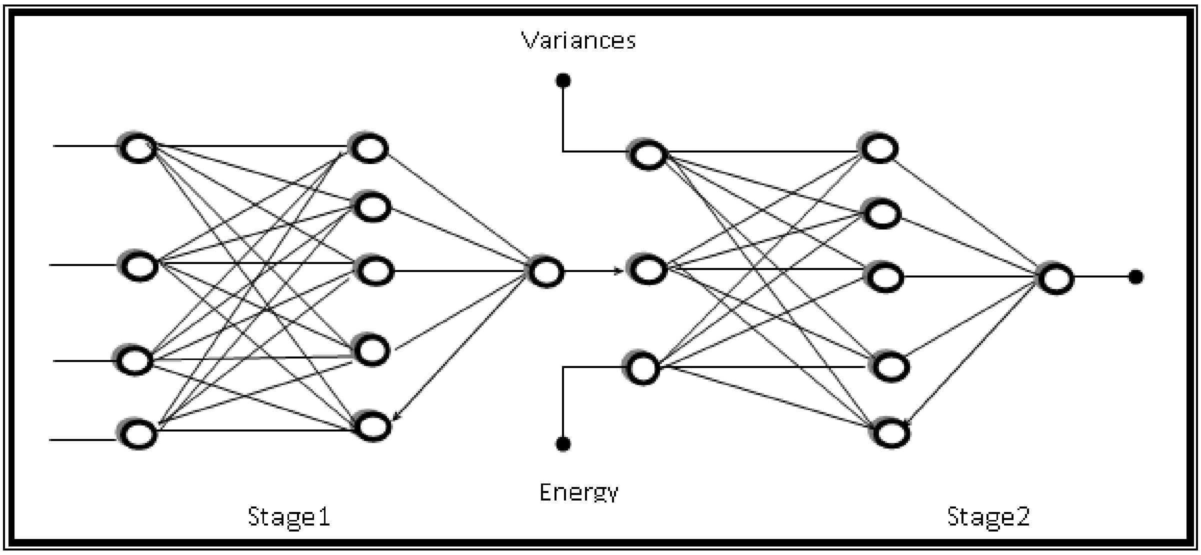

Fig (4) Multistage back propagation neural network for classifying images

The first stage, called the detail network, takes as its inputs all information bits of the region of interest. In their initial experiment by use a 16-bit region of interest. Thus, they had 16 input units. They state that they achieved best results with five hidden units in the hidden layer. Finally, one output unit is used representing the two classes of malignant and benign. The second stage takes three inputs, the output from the first stage and two calculated features. These features are both calculated from the region of interest extracted from the microscope. The first feature is the variance and is obtained by the following

$$v = \sqrt{\frac{1}{n^2}\sum_{i=0}^{n}\sum_{j=0}^{n} xi,j - \mu^2} \quad \text{..................... (5)}$$

Where *xi,j* are the inputs and are their average. This feature contains the same information as the standard deviation used in section, average is defined as:

$$\mu = \sqrt{\frac{1}{n^2}\sum_{i=0}^{n}\sum_{j=0}^{n} xi,j} \quad \text{........................ (6)}$$

Where *xi,j* is as before. The second feature is the energy and is defined by:

$$e = \sqrt{\frac{1}{n^2}\sum_{i=0}^{n}\sum_{j=0}^{n} xi,j} \quad \text{....................... (7)}$$

Where *Xi,j* is as before. These two features combined with the output from stage one form the inputs for stage two. As in stage one, stage two contains five hidden units. Its single output unit represents the final classification of the network: malignant or benign. Each stage is sequentially trained. Initially, the first stage is trained with the training data. Then, its output, along with the two calculated features, will be used as input to train the second stage. The training data consists of blood cell images of 16 x 16 pixels the data sampling section is designed to sample the data in a dyatic manner depending on the value of Ni. There are two types of nodes in this section: an input node, which segments the inputs (to 1 or 0); and a data processing node, which determines the sample rate. The neural activation function for the data processing nodes is:

$$Oj = [Ni * \sum nodes] + [(1 - Ni) * \max(nods)] \ldots\ldots\ldots \ldots\ldots\ldots\ldots \ldots\ldots (8)$$

Immediate left are treated as a single entity (via the maximum function). This is shown in the fig (4), [10].Given the activation function and its dependence on Ni a network becomes possible that provides parallel dyatic sampling .fig (5) shown the sample of medical image and histogram for these images

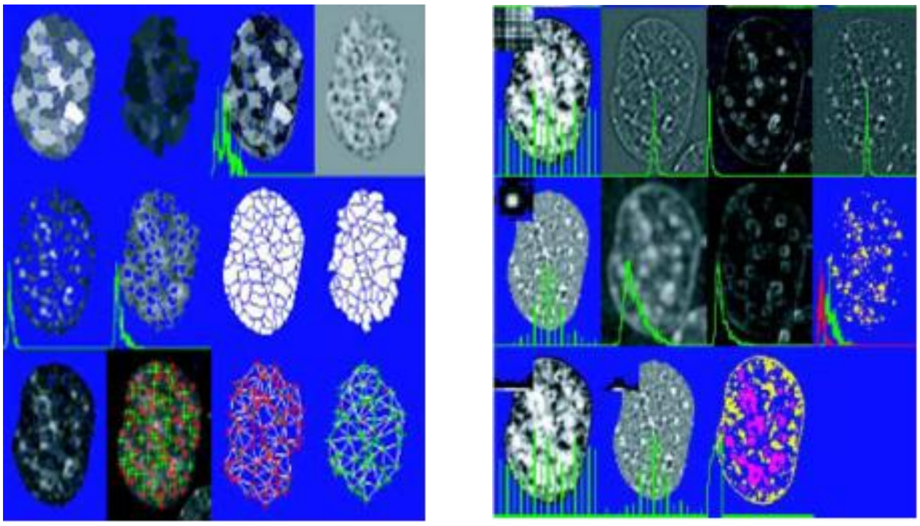

Fig (5) sample of image samples of images and histogram

In keeping with the all-neural network architecture, we also developed a neural network to compute the linear regression of the data generated by the sampling section and have the best of fractal dimension value by apply the equation (2) also designing and constructing an instructional computer program by using Knirk and Gustafson model to introduce the basic concepts for the fractal and neural according to is shown in fig(6).Twenty sub-images were selected from each microscope and where tagged, the Knirk and Gustafson Design Model is a three stage process which includes problem determination, design and development. The problem determination stage involves identifying the problem and setting instructional goals. The design stage includes developing objectives and specifying strategies. Finally, in the development stage, materials are developed. final evaluation is made on the basis of constructing special questionnaire for the learners to find out the opinions of 20-learners.

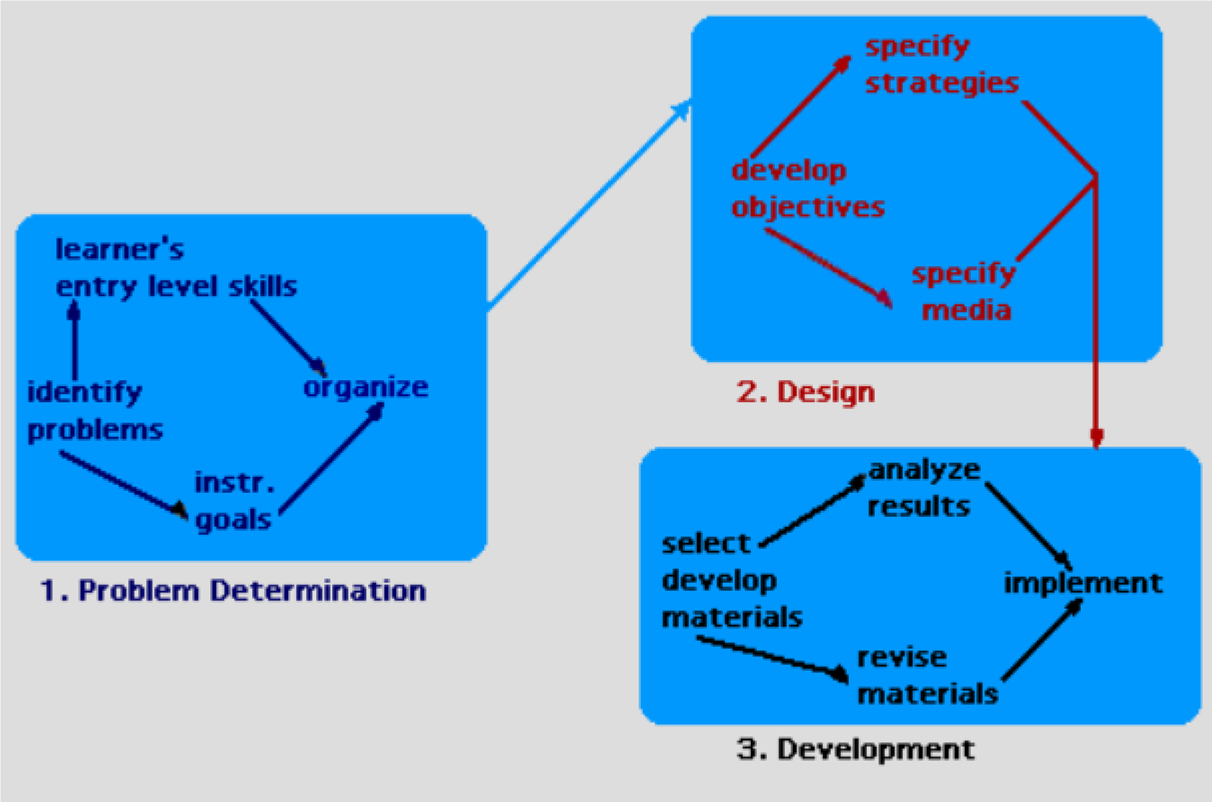

Fig (6) The Knirk and Gustafson Design Model [11].

9-Experimental Results

We utilize the fractal dimension of the perimeter surface of cell sections as a new observable to characterize cells of different types. We propose that it is possible to distinguish from healthy cells with the aid of this new approach. Their goal was to achieve the upper bound of the reported accuracy of the method of visual inspection of fine needle aspirates. We computed 30 features from each image. These features are: area, radius, perimeter, symmetry, number and size of concavities, fractal dimension (of the boundary), compactness, smoothness (local variation of radial segments), and texture (variance of gray levels inside the boundary). For each of these ten features, the calculated mean value, extreme value, and standard error, totaling 30. Experimental results show that:

1- The multi-stage network resulted in a sensitivity of 100%. Unfortunately, the authors forgot to mention their achieved specificity. It is meaningless to mention one without the other. One could easily build a network that has 100% sensitivity. Simply, make the network always classify inputs as malignant, fig (7) show the value of fractal dimension for images uses in research.

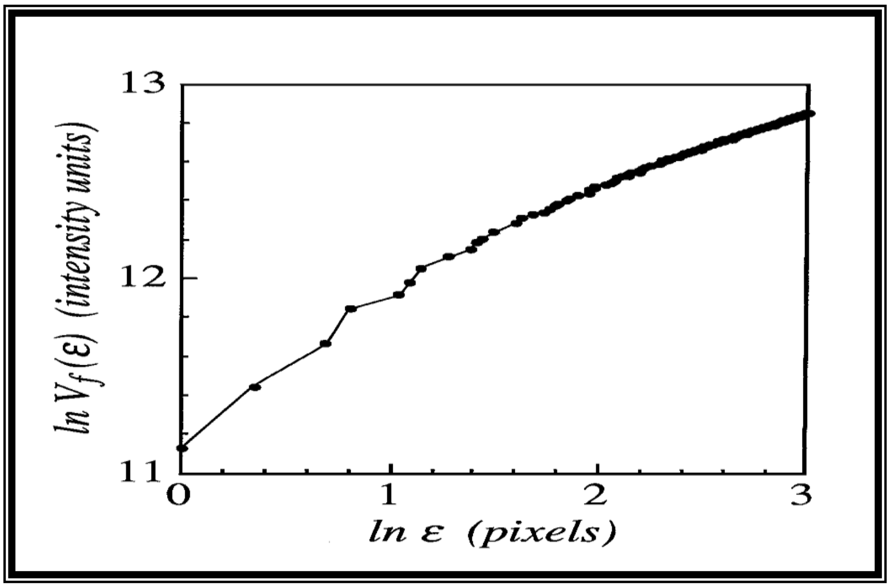

Fig (7) show the value of fractal dimension

2- We compare between the single-stage and multi-stage networks close, clearly the multi-stage network is an improvement over the single-stage network. Claims that using calculated features from a microscope image, instead of using the actual information bits of the image, as presented a multi-stage network that takes advantage of both the calculated features and the information bits, both approaches remain inconclusive in their experimental results 100% accuracy and 100% sensitivity respectively. These cases formed the training set used to train the system. As opposed to the other papers discussed earlier in this survey, one was built for each subset of one, two, three and four features (from the thirty calculated features). The remaining combinations that performed well on the testing set were then retrained using 10-fold cross-validation in order to estimate its real-world performance. One neural network diagnosis tool achieves 80% predicted accuracy and 100% observed accuracy.

3- The designed instructional program helps in saving time and efforts of the learner when studying the subject of fractal geometry and neural network application in medical images.

10- Conclusion

From discussing the results we conclude the following :

1- Multiply connected neural network designed to estimate the fractal dimension (*D*f) using the Random Iteration Algorithm (IFSP).

2- The architecture presented is composed of two sections, a data sampling section and a linear regression section. The data sampling section employs two types of nodes: an input node, which segments the inputs (to 1 or 0); and a data processing node, which determines the data sample rate. The data processing nodes use a neural activation function that, depending on the value of Ni. The linear regression section computes the slope of the line through the results generated by the data sampling section.

3- The architecture presented scales well and can demodified to process 1-D or 2-D data. While the neural network presented does generate an estimation of *Df* using the (IFSP), Several of the activation functions are not biologically plausible.

4- Instructional program tend to achieve the principals of teaching and learning through translating them into reality, so that by these principals, it buildup the skill of knowledge through providing experience to learn the fractal and neural network application**.**

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