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Medical Images Compression using Wavelet Transform

ضغط الصور الطبية باستخدام التحويل المويجي

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Abstract

In this project the compression system based on factor called weighting factor, which can be throughout it, specification the numbers of bits for each band. In this method wavelet transform was applied upon the image, and division the result transform coefficients into frequency blocks and then determining the standard devotion of each blocks. This was done to show the importance of each block and then to specify the numbers of bits necessary according to its subjection significance

From result which apparent in the tables, the smallest compression ratio equal (2) as in image (tt_1) and the largest compression ratio equal (5), that mean in this project compression system design to compression the image between 2-5 times, but in high compression ratio appear blocks in the image. This indicate that the system utilized as the lossless compression system.

الخلاصة :

في المشروع الحالي ان منظومة الضغط المستخدمة اعتمدت على عامل يدعى عامل الوزن والذي يمكن من خلاله تحديد عدد البتات لكل حزمة، ويتم ذلك بواسطة اجراء التحويل المويجي على الصورة وتقسيم معاملات التحويل المويجي هذه الى قطاعات تردد تقيس الانحراف المعياري لكل قطاع لتحديد عدد البتات الضروية طبقا الى اهميته العيانية. من خلال النتائج الظاهرة في الجداول فان اقل نسبة ضغط حصلنا عليها هي (2) كما في الصورة (tt_1)، واكبر نسبة ضغط هي (5) كما في الصورة (tt_3)، ذلك يعني ان المنظومة الحالية صممت لضغط الصورة بين(2-5) مرات، وعند استخدام نسبة ضغط عالية تظهر قوالب بالصورة. وذلك يشير الى ان المنظومة كمنظومة ضغط بالفقدان.

Key word (Computer, Medical images, programs of wavelet transform)

Introduction

It is quite clear that image-processing techniques are always the first stage of computer vision. One of the major topics within the field of computer vision is, in fact, image analysis. Image analysis involves the examination of the image data to facilitate solving a vision problem. With the massive sizes of image and volumetric datasets, compression becomes increasingly important to support efficient storage, transmission and processing. Practical data sequences normally contain a substantial amount of redundancy. Redundancy in signals can appear in form of smoothness of the signal or in other words correlation between the neighboring signal values. A data sequence, which embeds redundancy, can be presented more compactly if the redundancy is removed by means of a suitable transform. An appropriate transform should match the statistical characteristic of the data. Applying the transform on the data results in less correlated transform coefficients, which can be encoded with fewer bits. A popular transform that has been used for years for compression of digital still images and image sequences, is the Discrete Cosine Transform (DCT) [Wihelm (2007); Niel (1992)] .

Theoretical Concepts:

Wavelet Transform: Wavelets are mathematical functions that satisfy a certain requirement, and are used to represent data or other functions. Recent wavelet-based image compression algorithms have been shown by exploiting the space-frequency localization of the wavelet decomposition. Smooth areas of the image are efficiently represented with a few low-frequency wavelet coefficients, while important edge features are represented with a few high-frequency coefficients, localized around the edge. [M. Orchared (2008)]

In Wavelet Transform, dilations and translations of a mother wavelet are used to perform a spatial/frequency analysis on the input data. For spatial analysis, contracted versions of the mother wavelets are used. These contracted versions can be compared with high frequency basis functions in the Fourier based transforms. The relatively small support of the contracted wavelets makes them ideal for extracting local information like positioning discontinuities, edges and spikes in the data sequence, which makes them suitable for spatial analysis. Dilated versions of the mother wavelet, on the other hand, have relatively large supports (the length of the dilated mother wavelet). The larger support extracts information about the frequency behavior of data. Varying the dilation and translation of the mother wavelet, therefore, produces a customizable time/frequency analysis of the input signal. The Wavelet Transform uses overlapping functions of variable size for analysis. The overlapping nature of the transform alleviates the blocking artifacts, as each input sample contributes to several samples of the output. The variable size of the basis functions, in addition, leads to superior energy compaction and good perceptual quality of the decompressed image.[Kristan (2000); Bahman (2002)]

A wavelet expansion is similar in form to the well-known Fourier series expansion, but is defined by a two-parameter family of functions:

$$f(t) = \sum_k \sum_j a_{j,k} \psi_{j,k}(t)$$

where j and k are integers and the functions are the wavelet expansion functions. As indicated earlier, they usually form an orthogonal basis. The two-parameter expansion coefficients are called the discrete wavelet transform (DWT) coefficients of an preceding equation is known as the synthesis formula (i.e inverse transformation). The coefficients are given by:

$$a_{j,k} = \int f(t) \psi_{j,k}(t) dt$$

the wavelet basis functions are two-parameter family of function that are related to a function called the generating or mother wavelet by

$$\psi_{j,k} = 2^{j/2} \psi(2^j t - k)$$ (Daubechies, 1992).

Image Compressio:

Redundancy in signals can appear in form of smoothness of the signal or in other words correlation between the neighboring signal values. A data sequence, which embeds redundancy, can be presented more compactly if the redundancy is removed by means of a suitable transform. An appropriate transform should match the statistical characteristic of the data. Applying the transform on the data results in less correlated transform coefficients, which can be encoded with fewer bits. A popular transform that has been used for years for compression of digital still images and image sequences, is the Discrete Cosine Transform (DCT). [Pando (2004); Bach (2002); Rabi (2004)] The DCT transform uses cosine functions of different frequencies for analysis and decorrelation of data. In the case of still images, after transforming the image from spatial domain to transform domain, the transform domain coefficients are quantized (a lossy step) and subsequently entropy encoded. Another transform that has received a great amount of attention in the last decade, is the Wavelet Transform has been successfully applied in different fields, ranging from pure mathematics to applied science. Numerous studies, carried out on wavelet transform, have proven its advantages in image processing and data compression and have made encoding technique in recent data compression standards.]Ryan (1996); Henk (2001)]

WT: means wavelet transform>

Iwt: means inverse wavelet transform.

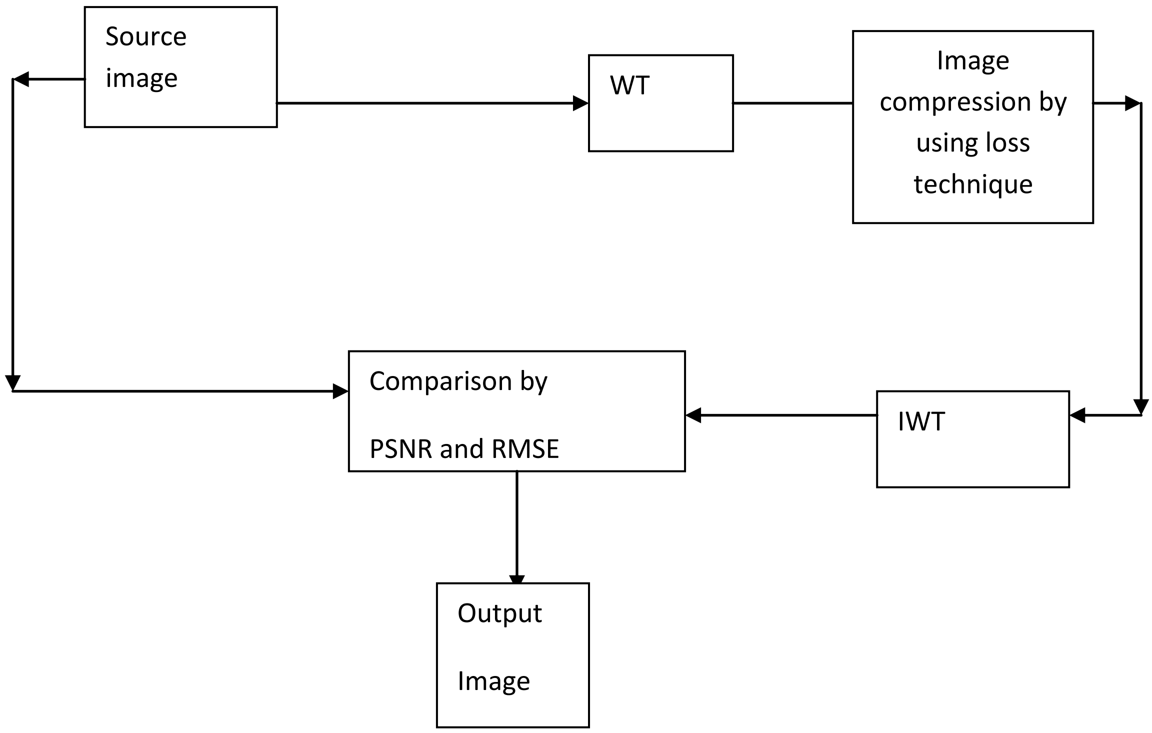


Fig-1- scheme clarify the procedure of achievement of the job

Material and method:

Wavelet based compression techniques have three steps in general:

1. Transform: data are first transformed into wavelet domain.

2. Thresholding: after transform the image to the wavelet, many of these coefficients may be modified so that the sequence of wavelet coefficients contains long strings of zero. There are different types of thresholding a tolerance is selected. Any wavelet whose value falls bellow the tolerance is set zero with the goal to introduce many zero with out losing a great amount.

3.Quantization: Quantization process converts a sequence of floating numbers to a sequence of integers. The simplest form is to round to the nearest integer.

4.Entropy Coding: the resulting symbols after quantization are further entropy coded to reduce the bit rate. [Donlad (2000); Jelena (2001) Ahmed (2000)]

Note:- The fidelity of the quality of the compression image depend upon the values of the (PSNR: peak signal to noise ratio) and (RMSE: root mean square error). The fidelity criteria can be obtained by the following equations:

After compression process the magnitude of error between the source image and the output image can be obtain by the following equation:

Error= $I_0(r,c)$- $I_r(r,c)$

Where I_0 represent the source image and I_r represent the output image.

$$Total\ Error = \sum_{r=0}^{N-1}\sum_{c=0}^{N-1} \mathrm{I}_0(\mathrm{r,c}) - \mathrm{Ir}(\mathrm{r,c})$$

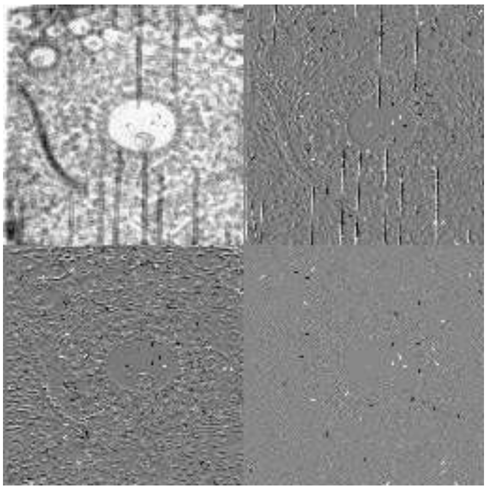
$$\text{RMSE}= \frac{1}{N^2}\sum_{r=0}^{N-1}\sum_{c=0}^{N-1} \mathrm{I}_0(\mathrm{r,c}) - \mathrm{Ir}(\mathrm{r,c})$$

$$\text{PSNR} = 10\log\frac{(255)^2}{MSE}$$

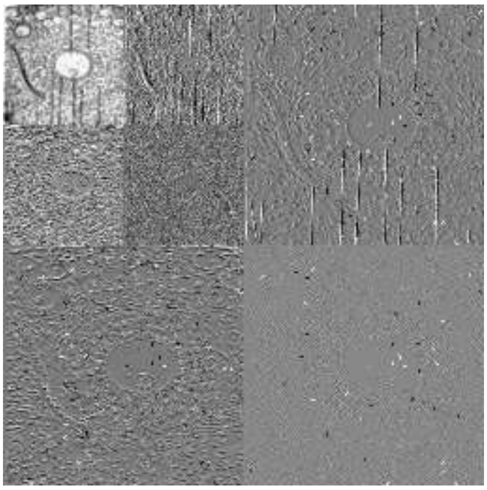
So that the procedure of this project must be consist of the following steps:-

A-Transform the medical images to wavelet transform by using first and second wavelet transforms. Here the (tissue, vessels) images will be utilize to transform it for the first and the second wavelet transform (F1g -1- show the tissue image).

B- Transform medical image to forward wavelet by using following algorithm:



First analysis levels by using wavelet transform Itr.



Second analysis levels by using wavelet transform Itr.2

Figure-1-

1.Load source file (SFIL) in Temp l.
2.Set I =1
3. ln put W = Image width: H= Image height and decomposition levels (Iter.)
4. Set W = W/2 : H= H/2.
5. SET Y=0.
6.Read two rows from Temp 1.
7.Input the first row into matrix A1, and the second row into matrix A2.
8.Set X=0.
9.Let K=2*x; j=k + I.
10. Input BI (x)= 0.25{AI(k)+AI(j)+A2(k)+A2(j)}.
BI(x + w)=0.25{AI(k)-AI(j)+A2(k)-A2(j)}
B2 (x) =0.25{ AI(k)+AI(j)-A(k)-A2(j)}.
B2(x+w)=0.25{AI(k)-A(j)-A2(k)+A2(j)}.
11.Set X=X+1.
12.If(X=W-1) write matrices B1, B2 into Temp2.
13.Y=Y+I
14.If(Y=H-1) copy Temp2 to Temp 1.
15. Set=I+1
16.IfI=Iter. Copy Temp 2 to output file (TFIL).
17.END.

Forward wavelet Transform

C-Inverse transforms upon the processed image to obtain the reconstructed image as the following algorithm.

The out put of forward Haar transform are scaling coefficients (LL) band and wavelet coefficients (LH, HL, HH) bands, each wavelet coefficient represent the amplitude of corresponding wavelet, these wavelet are the basis functions which the image analyzed to them, so the summation of these basis functions reproduce the original image.

1.Load source file (SFIL) in Templ.
2.Set I = l
3.l n put w = image width: H= Image height and decomposition levels (Iter.)
4. Set W = W/2 : H= H/2.
5. SET Y=0.
6.Read tow rows from Temp 1.
7.Input the first row into matrix A1, and the second row into matrix A2.
8.SetX=0.
9.Let K=2*x; j=K+I.
10. Input B1 (k)= 0.25{AI(x)+AI(j)+A2(k)+A2(j)}.
BI(k+1)=0.25{AI(x)-AI(J)+A2(K)-A2(j)}
B2 (k) =0.25{ AI(x)+AI(j)-A(K)-A2(j)}.
B2(k+1)=0.25{AI(x)-A(j)-A2(K)+A2(j)}.
11.Set X=X+1.
12.If(X
EMBED Equation.3
W-1) write matrices BI, B2 into Temp2.
13.Y=Y+I
14.If(Y=H-I) copy Temp2 to Temp1.
15. Set=I+I
16.If I=Iter. Copy Temp 2 to output file (TFIL).
17.END.

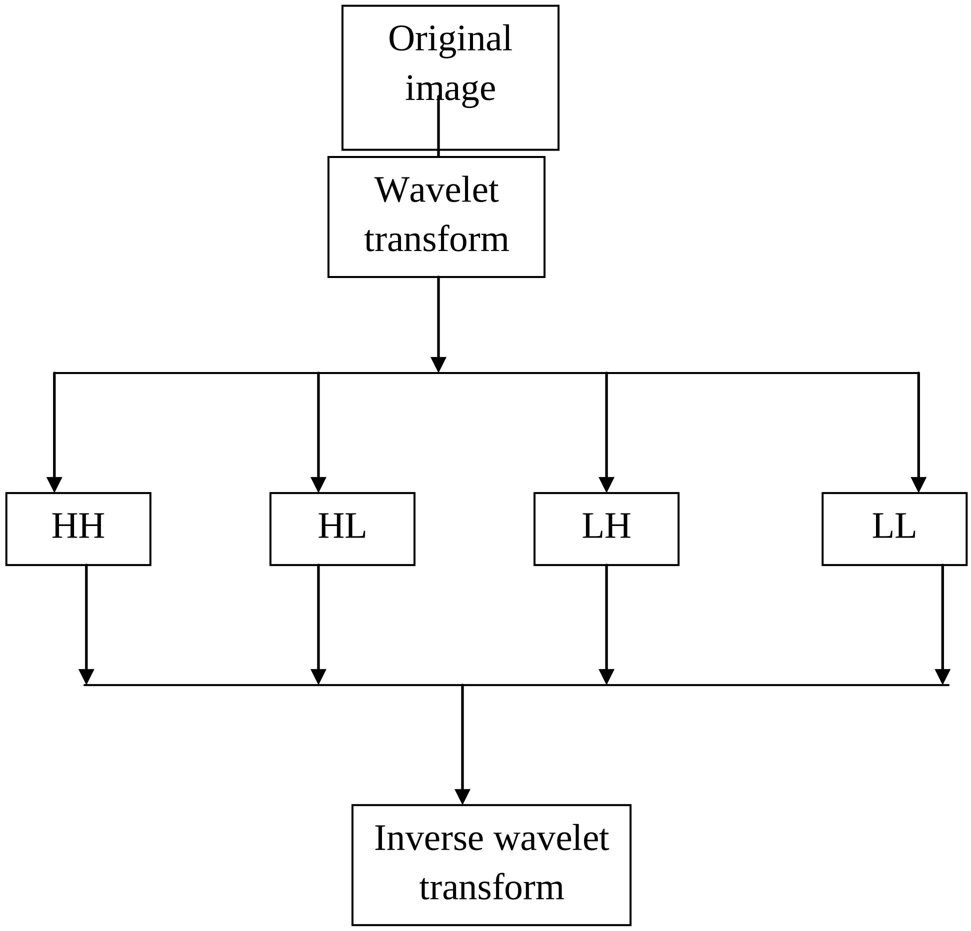


Fig -2-Inverse wavelet transform image
256x256

Tablet-1- The coefficients of compression image [tissue] by using the wavelet transform iter.1 where:-
Compression ratio: Comp. ratio

image	Comp. ratio	Inc. Fac.	PSNR	Iter.
Tt1	2	2	41.95	1
Tt2	3	2	31.87	1
Tt3	5	2	24.84	1
Tt4	5	2	23.06	1

Tablet-2- The coefficients of compression image (tissue) by using the wavelet transform Inc. Fac=3 where:

Image	Comp. ratio	Inc. Fac	PSNR
Tt6	2	3	42.27
Tt7	3	3	30.70

Tablet-3- The coefficients of compression image [tissue] by using the wavelet transform iter.2 where:-

Image	Comp. ratio	Inc. Fac	PSNR
Tt8	2	2	39.27
Tt9	3	2	32.53
Tt10	5	2	29.65

Table-4- The coefficients of compression image [veins] by using the wavelet transform iter.1 where:-

image	Comp. ratio	Inc. Fac	PSNR
T1	2	2	44.5
T2	3	2	37.44
T3	5	2	26.09

Conclusion and discussion

The results of the current research demonstrated in the following tablets, where these suggested methods are applied on gray level images,We used two images to test the efficiency of compression method. These images are (tissue, veins)

The System yields good results for compression ratios till 3:1. As the compression ratio increases, coarse quantization of the coefficients causes blocking effects in the decompressed image. When compression ratio reaches 5:1

So can be show from the results which in the above tables the following conclusion:-

1-When the values of the fidelity (PSNR) was high, that is meaning the compression image have best quality and vice versa for the values of the fidelity (RMSE).

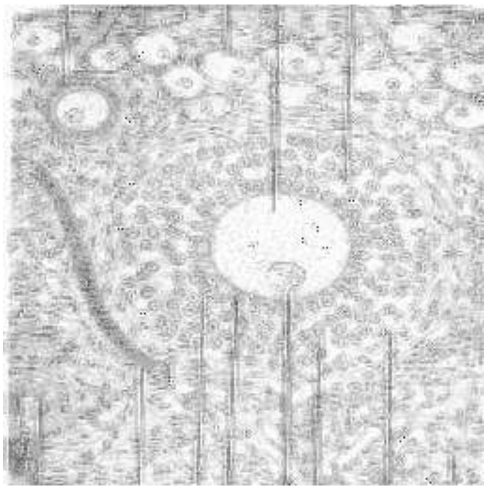
2-The values of the coefficients of the wavelet transform image viruses from one band level to another. To solve this problem, method have been design by using variable decreasing factor for each band from analyzing bands called Inclusion factor (Inc. Fac.).

3- As in the preceding paragraph, values of the coefficients of the compression image after wavelet transform mutate from one band level to another. To solve this problem, method have been design by using variable factor called inclusion factor (Inc. Fac.) to obtain equiponderant compression in the image by utilizing variable values for this factor when transmission from approximated level to the coarse levels. This process can be achieve by multiplying the coefficients of the approximate level with small value of (Inc. Fact), and high value for the coarse levels.

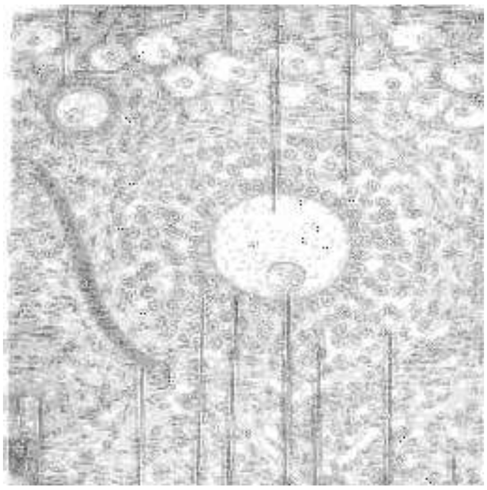
4-The compression image as show in the results from the tablets (1,3), the best quality image can be obtain in case two analytical level image of wavelet transform the values of the (PSNR) in case of the iter.1 Is less than of the values of the first iter.2 for the same compression ratio and the same Inc. Fac .The reason belong to that the first iteration may be not separate the large coefficients restricted it in the roughen levels, which have been less important in reproduced image, this was causing reduction the number of coefficients in the (LL) level which plays the important role in the quality of reproduced image (See Fig-3,5).

5. The features of the image play important role in the result obtained from the compression processes , where the values from the tablets (1,3) show that for the comp. ratio=2 and Inc.Fac=2, the RMSE=2.03 and PSNR=41.95 for the image tissue. Whereas the RMSE=1.5 and PSNR=44.5 for the image veins (See. Fig-3,6).

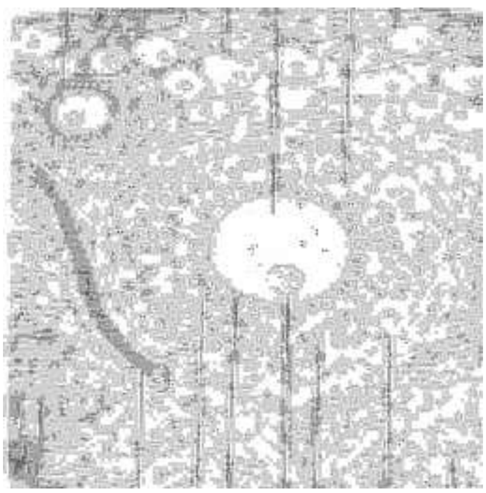
6. Tablet (2) show that the affection of the Inc. Fac. The values show for image (tt6) show that RMSE=2.67 and PSNR=39.59, Whereas for the image (tt7) the RMSE=7.42 and PSNR=30.70 for the same image (tissue) (See. Fig-4).



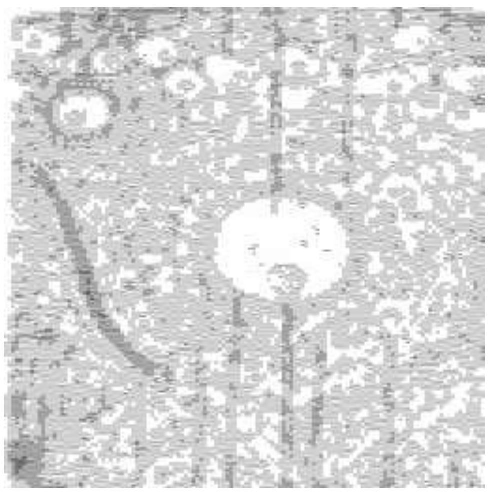
Tt1



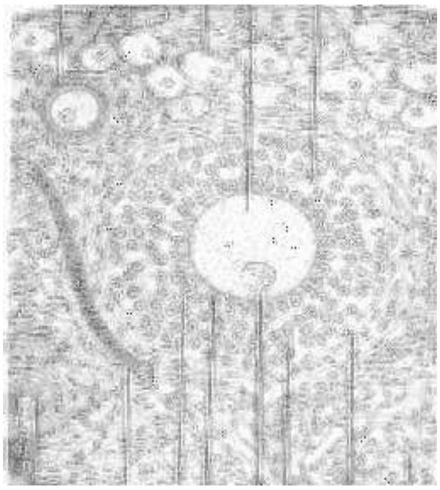
Tt2

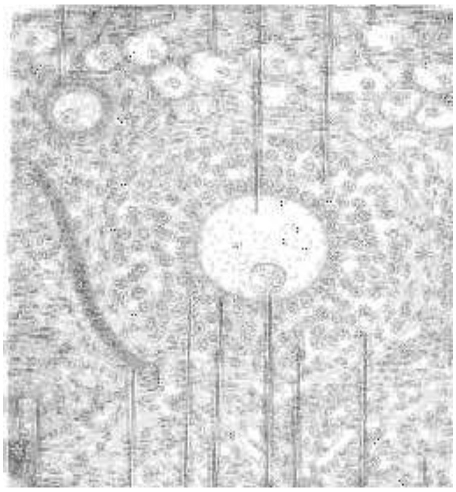


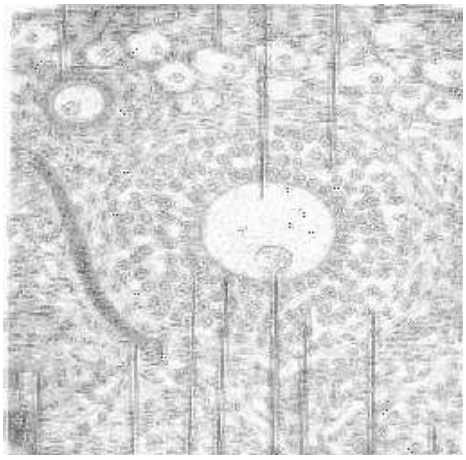
Tt3

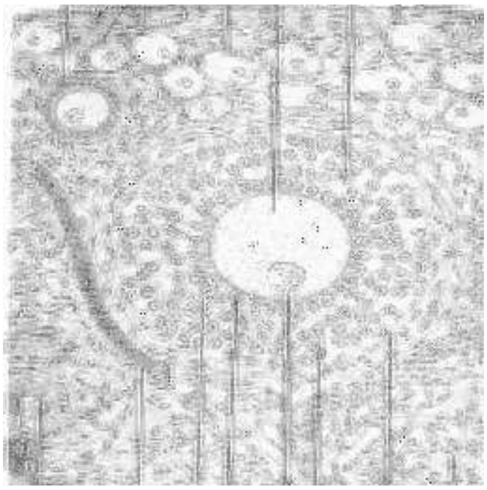


Tt4





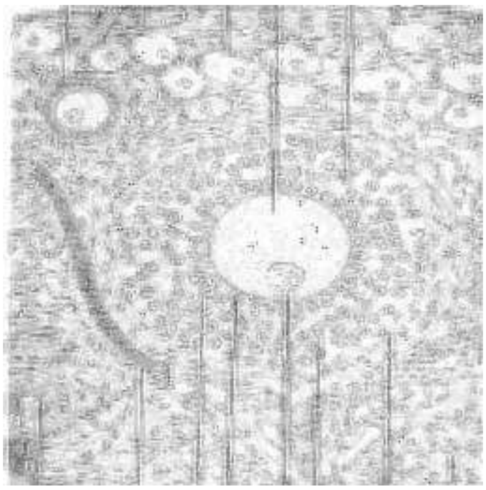


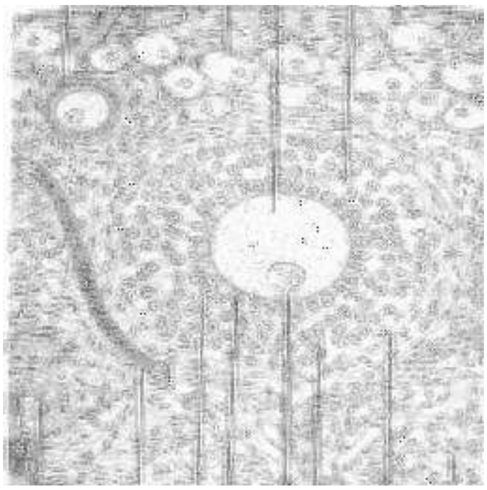


Tt6

Tt7

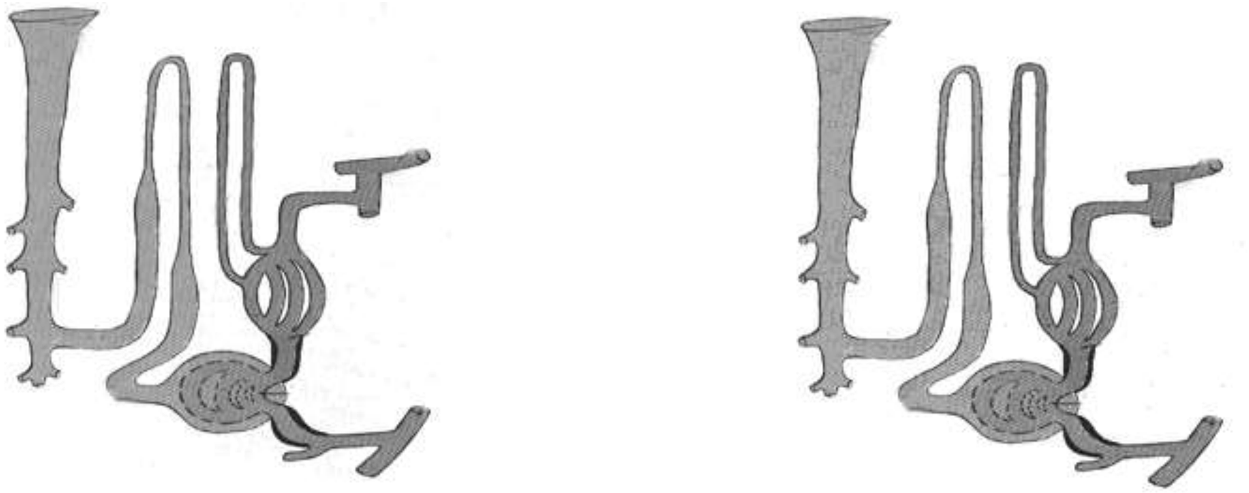
Fig-4- compression tissue image using wavelet transform itre.1 Inc. fac=3



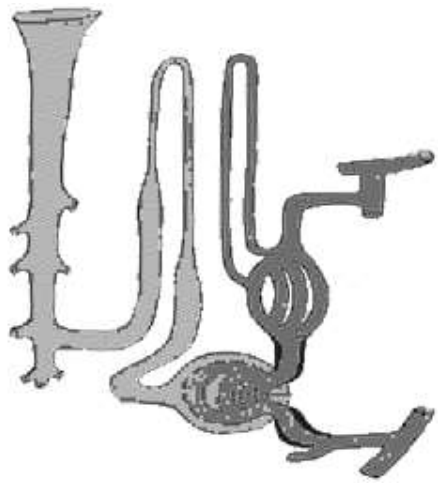


Tt8

Tt9



T1 T2



T3

Fig-6- compression veins image using wavelet transform itre.1

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