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WAVELET TRANSFORMATION DOMAIN FOR SUB IMAGE HIDING BASED ON THE DISCRETE WAVELET TRANSFORM DOMAIN

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ABSTRACT

The method in this paper depends on transmitting and receiving the sub image by hiding it inside envelope image (steganography process), using wavelet domain. This method depends on hiding sub-image inside the details information (high resolution) of the covered image after taking the discrete wavelet transformation applied on a covered image.

The proposed method for hiding and transmitting the sub image inside the cover image is done by shrinking its values in order to accommodate high resolution details of the discrete wavelet transform of the cover image, after this process is a accomplished, it must rearrange the shrieked sub image information by coding rows and columns positions for hiding inside the high resolution details of the wavelet domain of the cover image. Taking the inverse wavelet transform for the new cover image included with the hide information of the sub image information (transmitting steganography process). Here the restore operation of the cover image is ready for sending process at any transmission port.

The proposed method for receiving the cover image is done by taking the new covered image and applying wavelet transform again to get the details information that are included the coded information of the transmitted sub image. Then by encoding for the receiving high details information of the wavelet transform and re arrangement for both row and column as mentioned above but in inverse way, this will lead to the original shrinked sub image. Applying stretching process (d- shrinking) on a gated sub image, the sub image will get at the end of this step.

Finally, calculate the mean square error in tables to calculate error rate between different sub images that hided in the cover image and compute the error rate values when calculated according to restore the cover image and compare the result. Error rate is less than or equal to .003 when calculated using the cover image and the restore version of the cover image, when hiding different sub images inside it.

KEYWORDS: Discrete Wavelet Transforms (DWT), Inverse Discrete Wavelet Transforms (IDWT), Mallat Algorithm (Low and high Frequency Details), Image Steganography, Image Shrinking, Image De shrinking, Proposed Transmission Algorithm, Proposed Reception Algorithm, and Mat lab Instruction Sets.

أخفاء الصورة الفرعيه بأستخدام تقنيه التحويل المويجي اعتمادا على التحويل المويجي المنفصل

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المـــــوجز

الاسلوب المستخدم في البحث يعتمد علىأرسال و أستلام الصورة الفر عيه الموجودة داخل مظروف الصورة (عمليه أخفاء المعلومات) وذلك باستخدام تقنية المحول المويجي . هذة الطريقه تمكننا من أخفاء الصورة الفرعيه في داخل تفصيلات معلومات (دقه عاليه) الصورة المخبئه بعد أستخدام المحول المويجي على الصورة المغلفه.

الطريقه المقترحه لأرسال الصورة الفرعيه تتم عن طريق تصغير حجمها من أجل أستيعاب تفاصيل تحويل المويجات المنفصله ذات الدقه العاليه لغلاف الصورة . بعد أتمام هذة العمليه من الضروري أجراء اعادة ترتيب معلومات الصورة الفرعيه المنكمشه عن طريق الترميز لمواقع الصفوف و الاعمدة لآخفائها داخل مجال المويجات ذات التفاصيل عاليه الدقه لصورة الغلاف ،ومن ثم أخذ معكوس تحويل المويجات لصورة الغلاف الجديدة والتي تضم المعلومات المخبئه للصورة الفرعيه (أرسال عمليه أخفاء المعلومات) ،هنا عمليه الاستعادة لصورة الغلاف تكون جاهزة للارسال من خلال اي منفذ أرسال .

الطريقه المقترحه للأستلام صورة الغلاف تتم بأخذ صورة الغلاف الجديدة وأستعمال تقنية المحول المويجي مرة أخرى للحصول على المعلومات التفصيليه الموجودة في المعلومات المشفرة للصورة الفرعيه المرسله ، و بأجراء فك ترميز لمعلومات المحول المويجي ذات الدقه العالية المستلمه و أعادة الترتيب للصفوف و الاعمدة كما سبق و لكن بشكل عكسي ، والتي تؤدي الى الحصول على الصورة الفرعية الاصليه المنكمشة و بأجراء عمليه التمدد (عكس الانكماش) على المعلومات الحاصلة نتيجة فك الترميز يمكن الأن الحصول علي الصورة الفرعية نهايه هذة الخطوة .

أخيرا يمكننا حساب متوسط مربع الخطأ على شكل جداول لأجل حساب معدل الخطأ بين مختلف الصور الفرعيه و المخبئه في غلاف الصورة و حساب معدل قيم الخطأ عند حساب صورة الغلاف المستعادة و مقارنه النتائج . معدل الخطأ هنا سيكون اقل من ٠.٠٠٣ عند أخذ الصورة المغلفة (المظروف) واعادتها ضمن العديد من الصور الفرعية الواجب أخفائها.

1. INTRODUTION

1.1. Discrete Wavelet Transforms (DWT):

DWT is applied on a discrete time signal x (t) and then the coefficients after transform are categorized in two types, smooth (scaling) coefficients (approximated signal itself) and details coefficients. In which the energy of signal is partitioned in time and scale (2), and the equation of DWT as in the following:

$$g(t) = \sum_{k=0}^{\infty} c_{j0}(k)\phi_{j0k}(t) + \sum_{k=-\infty}^{\infty}\sum_{j=j0}^{\infty} d_j(k)\phi_{jk}(t) \quad (1)$$

The coefficient in this wavelet expansion is called DWT of the g(t). These wavelet coefficients completely describe the original signal and can be used in away similar to Fourier Series (FS) coefficients for analysis, description, approximation, and filtering. If the wavelet system is orthogonal, these coefficients can be calculated by inner products. The DWT is similar to a FS, but in many ways is much more flexible and informative. Unlike a FS it can be used directly no-periodic transient signals with excellent results (1).

1.2. Daubechies Wavelet Filter Coefficient:

A particular set of wavelet is specified by a particular set of number, called wavelet filter coefficients. Here will largely restrict to wavelet filter in a class includes members ranging from highly localized to highly smooth (2).

The most simple and localized member, often called Daub4, has only four coefficients, C_0, C_1, C_2, and C_3. These coefficients will be selected as the element of transformation matrix or multi resolution analysis matrix (MRA matrix) used to compute the wavelet coefficients for the image. Multi- resolution algorithm process less image data by selecting the relevant details that are necessary to perform a particular recognition task (11). The energy of the image is distributed after applying DWT in four bands related to Quadrature Mirror Filter form (QMF).

These four bands represent by low information that represent approximately the original image itself with scale version of it, and three bands represented the vertical, horizontal and diagonal edges. These three bands of details are represent the energy concentrated region, thus in order to obtain another details information (next vertical, horizontal and diagonal edges) it must be taken from the low information at the first scale and so on (apply DWT in the form of MRA), (4).

By considering wavelets as a class of function, which are well suited for the multi scale analysis of an image. Loosely said, a multi scale analysis consist of analyzing the image at several scales where low scales nothing but the main contours of the image, and the higher scale contain only the finer details of the image (1)(2)(11).

Consider the following transformation matrix acting on a column vector of data to its right in equation (10-a); the first row generates one component of the convolved with the filter coefficients C_0, C_1, C_2, and C_3.

Likewise are the third, fifth, and other odd rows. If the even rows followed this pattern, offset by one, then the matrix would be circulate, that, an ordinary convolution that could be down by Fast Fourier Transform (FFT) method. Instead of convolution with C_0, C_1, C_2, and C_3, however, the even rows perform a different convolution with C_3, $-C_2$, C_1, and $-C_0$. The action of matrix the overall is thus to perform a tow related convolution, then to decimate each of them by half and interleave the remaining half (15) (13). It is useful to think of the filter C_0, C_1, C_2, and C_3 as being a smoothing filter, call it **h**, smoothing like a moving average of four point. Then because of the minus signs, the filter C_3, $-C_2$, C_1, and $-C_0$ call it **g**, is not a smoothing filter. (In signal processing contexts, **h** and **g** are called (QMF),(5).

For such a characterization to be useful, it may be possible to reconstruct the original data vector of length N from its N⁄2 smooth or s- components and its N⁄2 detail or D- components. Requiring the matrix in equation (10.b) to be orthogonal, so that it's inverse is just the transposed matrix. One can see immediately the matrix in equation (10.b) is inverse to matrix in equation (10.a) if and if these two equations hold:

$$C_0^2 + C_1^2 + C_2^2 + C_3^2 = 1 \qquad (2)$$

$$C_2C_0 + C_3C_1 = 0 \qquad (3)$$

If additionally it require the approximation of order two, then two addition relations are required:

$$C_3 - C_2 + C_1 - C_0 = 0 \qquad (4)$$

$$-C_2 + 2C_1 - 3C_0 = 0 \qquad (5)$$

Equation (2) and (3) are equation for 4- unknown C_0, C_1, C_2, and C_3 first recognized and solved by Daubechies, the unique solution (up to a left-right reversal) is:

$$C_0 = (1+\sqrt{3})/4\sqrt{2} \tag{6}$$

$$C_1 = (3+\sqrt{3})/4\sqrt{2} \tag{7}$$

$$C_2 = (3-\sqrt{3})/4\sqrt{2} \tag{8}$$

$$C3 = ((1-\sqrt{3}))/(4\sqrt{(2)}) \tag{9}$$

Where, the wavelet coefficient for convolution in DWT domain is as in equation (10.a) and the coefficient for convolution in the IDWT as in the equation (10.b).

$$\begin{pmatrix} c_0 & c_1 & c_2 & c_3 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 \\ c_3 & -c_2 & c_1 & -c_0 & 0 & 0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 \\ 0 & 0 & c_0 & c_1 & c_2 & c_3 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 \\ 0 & 0 & c_3 & -c_2 & c_1 & -c_0 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 \\ \vdots & \vdots & & & & \ddots & & & & & & & \\ 0 & 0 & 0 & 0 & \ldots\ldots & & & & & c_0 & c_1 & c_2 & c_3 \\ 0 & 0 & 0 & 0 & \ldots\ldots & & & & & c_3 & -c_2 & c_1 & -c_0 \\ c_2 & c_3 & 0 & 0 & \ldots\ldots & & & & & 0 & 0 & c_0 & c_1 \\ c_1 & -c_0 & 0 & 0 & \ldots\ldots & & & & & 0 & 0 & c_3 & -c_2 \end{pmatrix} \tag{10.a}$$

$$\begin{pmatrix} c_0 & c_3 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & 0 & c_2 & c_1 \\ c_1 & -c_2 & 0 & 0 & \cdots & 0 & 0 & 0 & 0 & 0 & 0 & c_3 & -c_0 \\ c_2 & c_1 & c_0 & c_3 & \cdots & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ c_3 & -c_0 & c_1 & -c_2 & \cdots & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \ddots & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & c_2 & c_1 & c_0 & c_3 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & c_3 & -c_0 & c_1 & -c_2 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & c_3 & -c_0 & c_1 & -c_2 \end{pmatrix} \tag{10.b}$$

1.3. Two dimension (2-DIM) DWT implementation using Mallat algorithm:

1.3.1. Algorithm:

Like the FFT, the DWT is a fast, linear operation that operates on a data vector whose length is integer power of two. Also like the FFT, the wavelet transform is invertible. The DWT consists of applying a wavelet coefficient matrix hierarchically. First to the full data vector of length N, then to the "smooth" vector of length N/2, then to the "smooth- smooth" vector of length N/4 and so on until only a trivial number of "smooth……. smooth" component (usually 2) remain the procedure is sometimes called a pyramidal algorithm(4)(5)(11), for obvious reasons. The output of the DWT consists of these remaining components and all the "details" components that were accumulated along the way, the diagram show in the **Figure (1).**

If the length of data were a higher power of two, there would be more stages of applying equation (10.a) (or any other wavelet coefficients) and permuting. The end point will always be a vector with to S's and the hierarchy D's. D's, d's etc. Notes that once d's are generated, they simply propagate through to all subsequence stages. A value d, of any level is termed a 'wavelet coefficient' of the original data vector, the final value $S_1\,S_2$ should strictly be called 'father- function coefficients' although the term "wavelet coefficients" is often used loosely for both d's and final S's the full procedure is a composition of orthogonal linear operation, the whole DWT is itself an orthogonal linear operation, to invert the DWT, one simply reverses the procedure, starting the smallest level of the hierarchy and working (in above diagram) from right to left, inverse discrete wavelet transforms (IDWT),(5)(7).

The inverse matrix (10.b) is of course used instead of the matrix (1.a). In two dimensions, the wavelet representation can be computed with a pyramidal algorithm similar to the one dimension algorithm described above. The two dimensional WT can be seen as a one dimensional wavelet transform along the X and Y axes, (11). It can be shown that a two dimensional WT can be computed with a separable extension of the one dimensional decomposition algorithm. At each step the decomposed image represented by L_1^J into a low resolution image L_1^{J+1} and three details imageD_1^{J+1}, D_2^{J+1} and D_3^{J+1}. The details images are obtained by applying the low pass and/or high pass filters (QMF) along rows and columns. Thus D_1^{J+1} represents vertical details information to the original image L_1^J, D_2^{J+1}represents horizontal details information to the imageL_1^J, D_3^{J+1} and represents the high frequencies to the to the original L_1^J. , a block diagram in **Figure 2 (a)** illustrates this algorithm (4)(6).

Firstly, convolve the rows of image L_1^J with one dimensional filter, retain every other row, convolving the columns of the resulting signals with another one dimensional filter and retain every other column. The one dimensional reconstruction algorithm described clearly in pyramidal algorithm can also be extended to two dimensions (IDWT). At each step the image L_1^J is reconstructed fromL_1^{J+1},D_1^{J+1}, $D_2^{J+1}$and D_3^{J+1}. this algorithm illustrated in **Figure 2 (b)**. Add a column of zero, convolve of the rows with a one dimensional filter, add arrow of zero between each row of the resulting image, and convolve the columns with another one dimensional filter (10). **Figure (3)** represents Mallat representation of the details image information through WT at depth three.

A block diagram in **Figure 2 (a)** illustrates this algorithm by convolving the rows of image L_1^J with one dimensional filter, retain every other row, convolving the columns of the resulting signals with another one dimensional filter and retain every other column. The one dimensional reconstruction algorithm described clearly in pyramidal algorithm can also be extended to two dimensions (IDWT). At each step the image L_1^J is reconstructed fromL_1^{J+1},D_1^{J+1}, $D_2^{J+1}$and D_3^{J+1}. this algorithm illustrated in **Figure 2 (b).**

Secondly, add a column of zero, convolve of the rows with a one dimensional filter, add arrow of zero between each row of the resulting image, and convolve the columns with another one dimensional filter (10)(11). **Figure 3** represents Mallat representation of the details image information through WT at depth three.

1.3.2. Orthogonal Wavelet Energy Distribution:

In 2-dim DWT the energy of orthogonal WT is distribution in the details coefficient. Because at each scale of the WT there are approximated image and three details image, these three details represent the energy loot from original image in vertical, horizontal, and diagonal position (8). Thus, at each scale the details information (H, V, and D) are stolen from the image original then from smooth (approximated) information at that scale. Different algorithm for recognition is attempted by different researcher to design an algorithm using this distributed energy. All these algorithms are not leading to optimum recognition, because it depends on different local energy features(histogram feature) and it's difficult to find a standard features for different texture image(non-Gaussian and non-Stationary image)(4)(11).

1.4. Image Shrinking:

Region growing and shrinking methods segment the image into region by operating principally in the rc- based image space. Some of the techniques used are local, in which small areas of the image are processed at a time; others are global, with the entire image considered during processing. Methods that can combine local and global techniques, such us split and merge, are referred to as state space techniques and use graph structures to represent the regions and their boundaries (3)(9).

Various split and merge algorithm have been described, but they all are most effective when heuristics applicable to the domain under consideration can be applied. This will give a starting point for the initial split. In general, the split and merge technique proceeds as follows:

1- Define a homogeneity test. This involves defining a homogeneity measure, which may incorporate brightness, color, texture, or other application- specific information, and determining a criterion the region must meet to pass the homogeneity test.

2- Split the image into equally sized regions.

3- Calculate the homogeneity measure for region.

If the homogeneity test is passed for a region, then a merge is attempted with its neighbor(s). If the criterion is not met, the region is split. Continue this process until all regions pass the homogeneity test (3) (10).

There are many variations of algorithm. For example, starting out at the global level, it considers the entire image as our initial region, and then follows an algorithm similar to the preceding algorithm, but without any region merging (6).

Algorithms based on splitting only are called (multi- resolution algorithms splitting). This merge-only approach will be quite similar, with the differences apparent only in computation time. Parameter choice, such as the minimum block size all allowed for splitting, will heavily influence the computation burden as well as the resolution available in the result (9).

The user- defined homogeneity test is largely application dependent, but the general idea is to look for features that will be similar within an object and different from the surrounding objects. In the simplest case it might use gray level as our feature of interest. Homogeneity test required the gray-level variance within a region to be less than some threshold. Gray-level variance can define in two set of equations as shown in the next page.

$$i = \frac{1}{n-1}\sum_{(r.c)=region}[i(r.c) - i] \quad (10)$$

$$i = \frac{1}{n}\sum_{(r.c)=region} i(r.c) \quad (11)$$

2. THE PROPOSED APROACH OF IMAGE STEGANNOGRAPHY IN WAVELET DOMAIN

Image steganography in a simple meaning as explained previously is trying to hide active wanted image inside a cover image in a specific manner that doesn't change the viewing of cover image to everyone.

Now, apply image in a certain region of wavelet space of a cover image in a some studying protocol that doesn't effect on reconstructed output in the last previous section, the results of zero equalized HH algorithm proved that this region of wavelet space contain doesn't affect hardly on the reconstructed image therefore, try to hide the active wanted image in the HH resolution in wavelet space image. Making statistical study on the data point inside HH resolution, it find the band of data is very small and limited in a very narrow band, therefore the first problem that it must solve it is trying to make matching between the data point inside HH resolution and the data point of active wanted image.

2.1. Proposed algorithm of image steganography:

A block diagram of a generic image steganography system is illustrated in figure (4), Here, **Figure 4** represents the image steganography that takes two sides of work first, is transmission side second for reception, and this algorithm are explain on the next page in steps.

2.2. Proposed transmission algorithm:
Input: Active wanted image.
Output: The cover image.

Step 1: Start.
Step 2: Prepare cover image with size N*N result as shown in **Figure 7 (a).**
Step 3: Prepare active wanted image with size (N/2*N/2) at maximum as shown in **Figure 7 (b).**
Step 4: Take the two dimensional discrete wavelet transform (2D DWT) using specific wavelet filter (Daub 4) of the cover image shown in **Figure 7 (a).**
Step 5: Apply zero equalized algorithms on H.H region of the wavelet space as shown in **Figure 7 (c).**
Step 6: Apply proposed shrinking method as in **Figure 5** on active wanted data point shown in **Figure 7 (b)** into every narrow band to match the original data inside H.H region of the wavelet space shown in **Figure 7 (d).**
Step 7: Replace empty H.H region of the wavelet spaces by the image generated from the previous step in the **Figure 7 (d)**.
Step 8: Rearrangement the new form of HH region of the wavelet spaces using the proposed protocol of distribution explained in details in **Figures 6 (a) and (b)**, and shown in details in **Fgures 7 (d), (e)** and **(f)** respectively.
Step 9: Apply 2-D IDWT on the wavelet space of the same (LL, LH, HL) resolution and updated H.H resolution as shown in the **Figure 8 (a) and (b)** respectively.
Step 10: Transmit the resulted image.
Step 11: End.

2.3. Proposed reception algorithm:
Input: cover image.
Output: the original image.

Step 1: Start.
Step 2: Receive the work image of the proposed transmission algorithm in final step shown in **Figure 8 (b)**, which contains active wanted image inside it.
Step 3: Taking 2D-DWT of the working image using specific wavelet filter (Daub4) as shown in **Figures 8 (b)** and **(a).**
Step 4: Separate the image resulted in H.H region as single image as shown in **Figure 11 (b).**
Step 5: Appling the same protocol, which is used in the transmission algorithm but in a reverse direction in order to restore active wanted shrinked image as shown in **Figures 10 (a) and (b),** and in details steps of **Figures 11 (c),** and **(d)** respectively.
Step 6: apply D-Shrinking (stretching) algorithm as in **Figure 9** on image of previous step, which shown in **Figure 11 (d)** in order to restore the original active wanted image as it shown in **Figure 11 (e).**
Step 7: view the result active wanted image as shown in **Figure 11 (e).**
Step 8: End

3. DISCUSSION

3.1 Transmission region:

This section dedicated for applying the previous proposed algorithm of image steganography using wavelet domain on a test image of size (256*256) as a cover image and also four different images of size (128*128) as active wanted images. Implementation of the proposed method is take place in two regions (transmission and reception).

The result from the previous implementation is a single modified image of original cover image and the success of our proposed work is get the higher degree of similarity between the modified and the original cover image. Evaluation the degree of similarity using NMSE parameters, and all values of NMSE resulted from hiding (Butterfly, Brittney, Boy, and Man) in BARBARA image are listed in **Table 1** bellow:

3.2. Reception region:

The image stretching expand the band of data in histogram of the image to fit the full band (i.e. 0-255) of colors therefore the contract between colors of image are increased. Finally the resulted active wanted image must be similar to the original one. The success of this method must be offers high degree of similarity between the resulted active wanted image and the original one. All the results of NMSE values resulted from comparing between resulted and original version of active wanted image are listed in **Table 2** bellow:

4. CONCLUSION

In this method, the calculation of error is calculated by choosing different types of original cover images and also different types of active wanted images, and the calculation of NMSE is less than or equal to 0.03. This method adopts here active domain for hiding active wanted sub images, named wavelet domain. In this domain the reliability and the wide area (high frequency region) of the wavelet domain represent the main effect for hiding the shrinking sub image information inside the wavelet domain after rearrangement the shrinking sub image information. Wavelet transform domain is active domain, because the speed transformation with no error happened or loss in information after taking the inverse wavelet transform. The inverse transformation after hiding information on it, will lead to original hided sub image with no any loss or deform happened on the information of sub image. But it can see that the error rate is related for removing some high frequencies details of the wavelet transform and exchanging it with the sub image information only. Still wavelet domain is the best regard to other domains, related to the four band of it that can give wide area for study the information after taking the wavelet transformation.

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Table 1 NMSE of the BARBARA image, after hiding Butterfly, Brittney, Boy, and Man sub images.

Image name	Butterfly	Brittney	Boy	Man
NMSE of BARBARA image	0.0291	0.036	0.0126	0.0114

Table 2 NMSE of the restore BARBARA image, after hiding Butterfly, Brittney, Boy, and Man sub images.

Image name	Butterfly	Brittney	Boy	Man
NMSE of restore BARBARA image	0.0241	0.0121	0.0111	0.0220

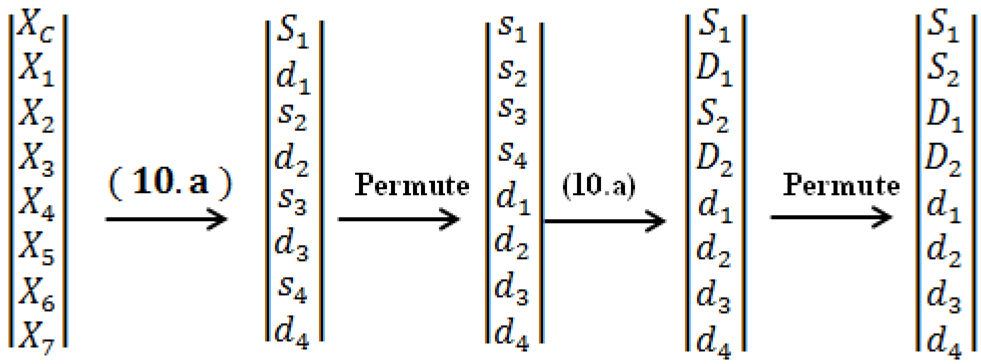


Figure 1 Represents the convolution steps of one dimension vector with discrete wavelet coefficients.

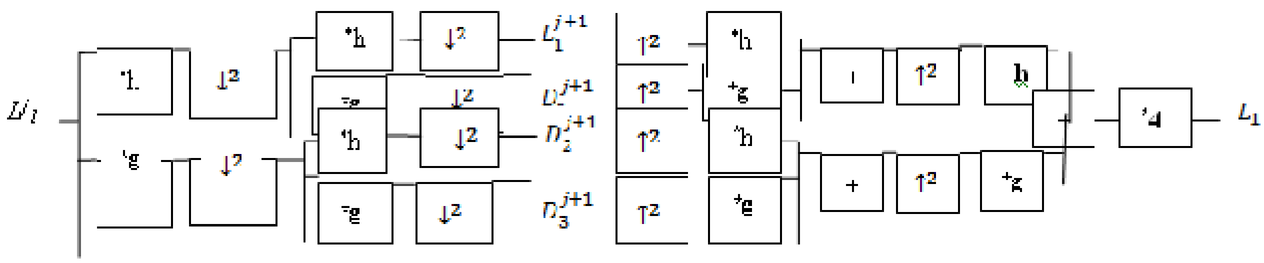


Figure 2 Represents in (a) the decomposition schemes of the discrete wavelet transform, (b) the reconstruction schemes of the inverse discrete wavelet transform. Note that * refer to convolution, ↓2 represents down sampling by two represents up sampling by two, and ↑2 represents up sampling by two.

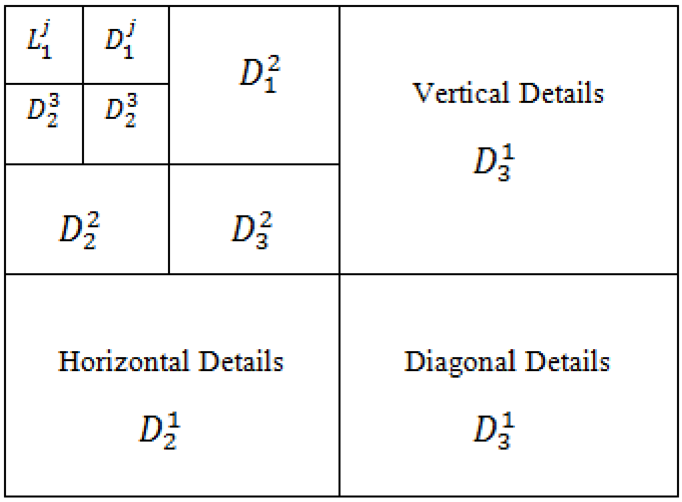


Figure 3 Mallet representation of the details image information through WT at depth three; where L refer to low or smooth information, while D refer to details information.

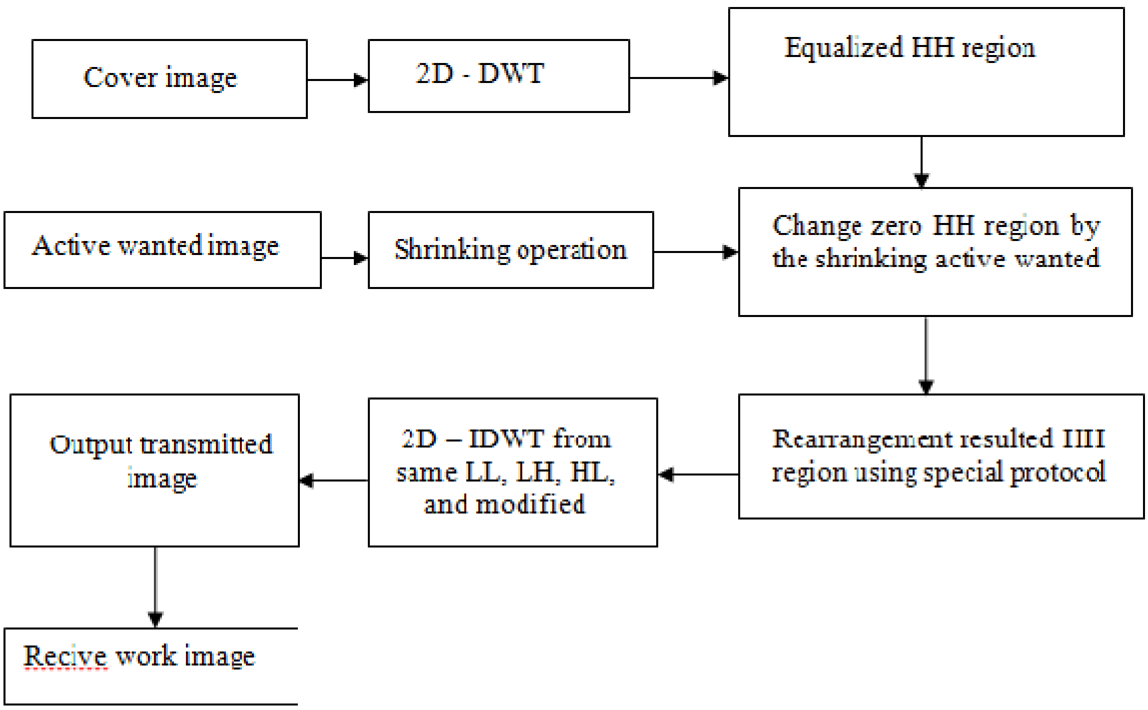


Figure 4 Overview of image steganography system (sub image inside image).

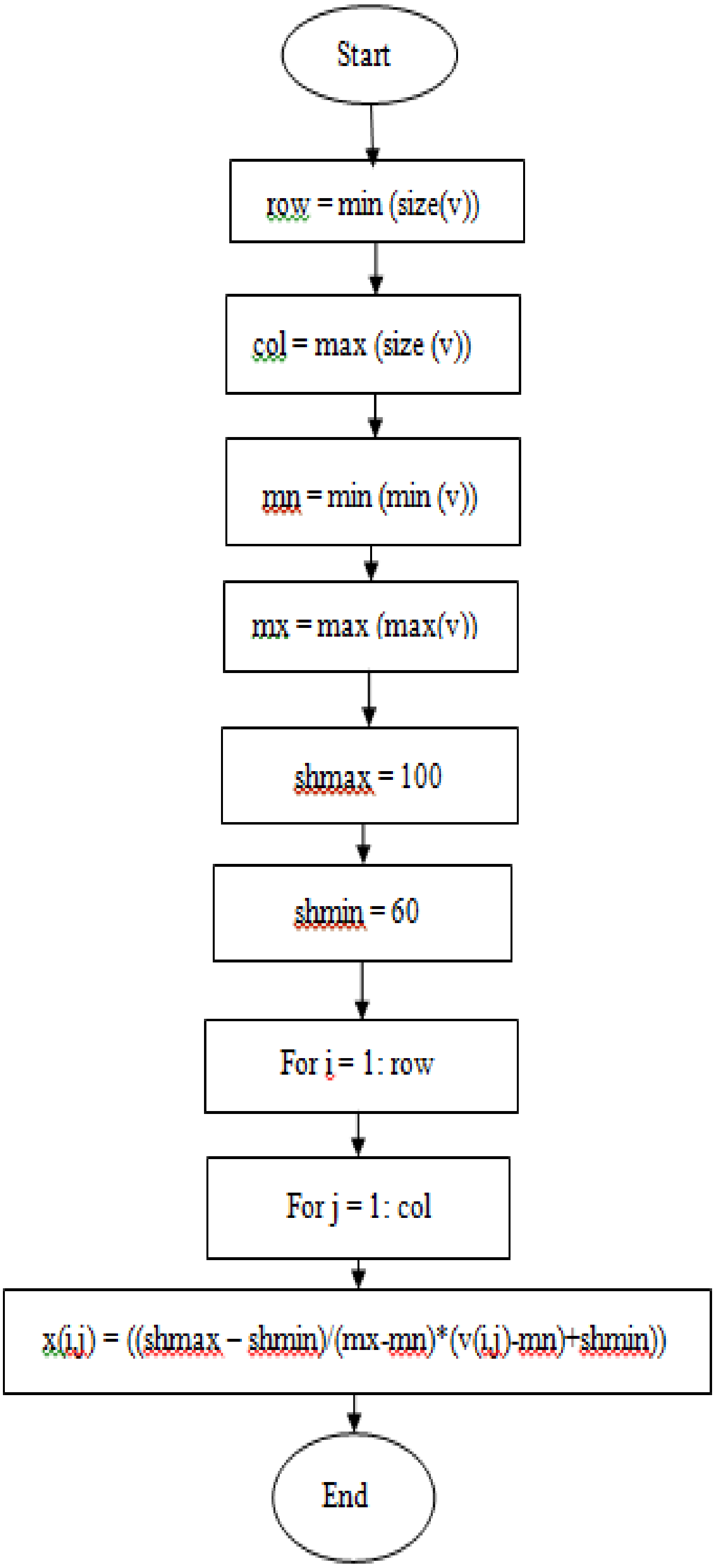


Figure 5 Proposed algorithm of shrinking method on action sub image (v), using mat lab instructions. Where, v is the original matrix size of sub image equivalent to 128 *128

.

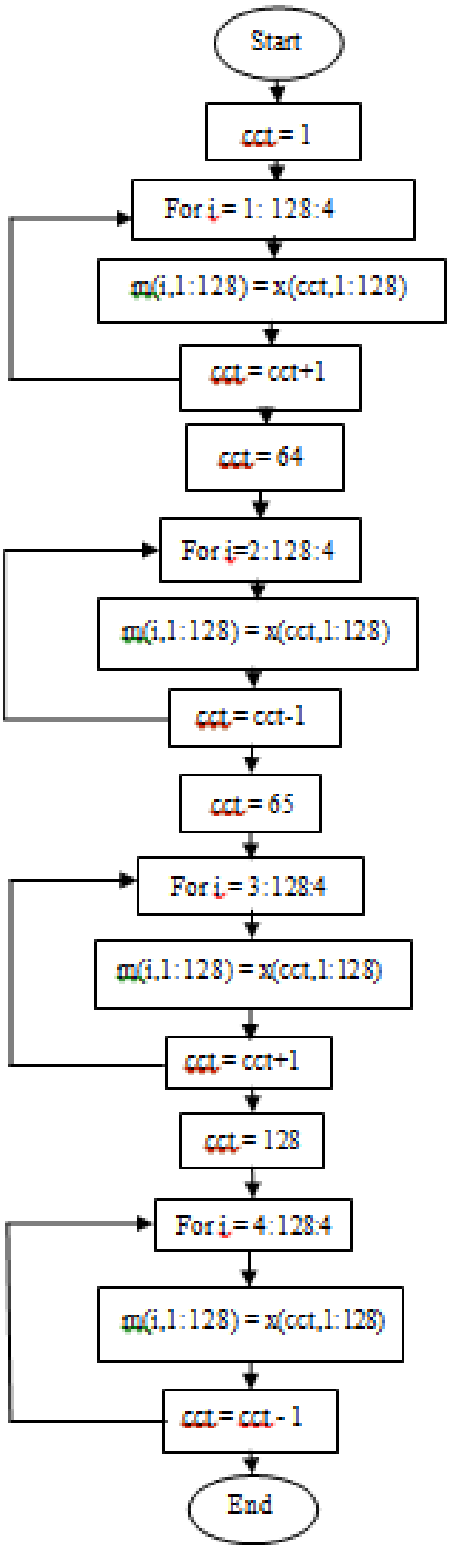


Figure 6(a) Proposed transmission algorithm for distributing H.H data of sub image x in row direction after shrinking in figure (5), using mat lab instructions.

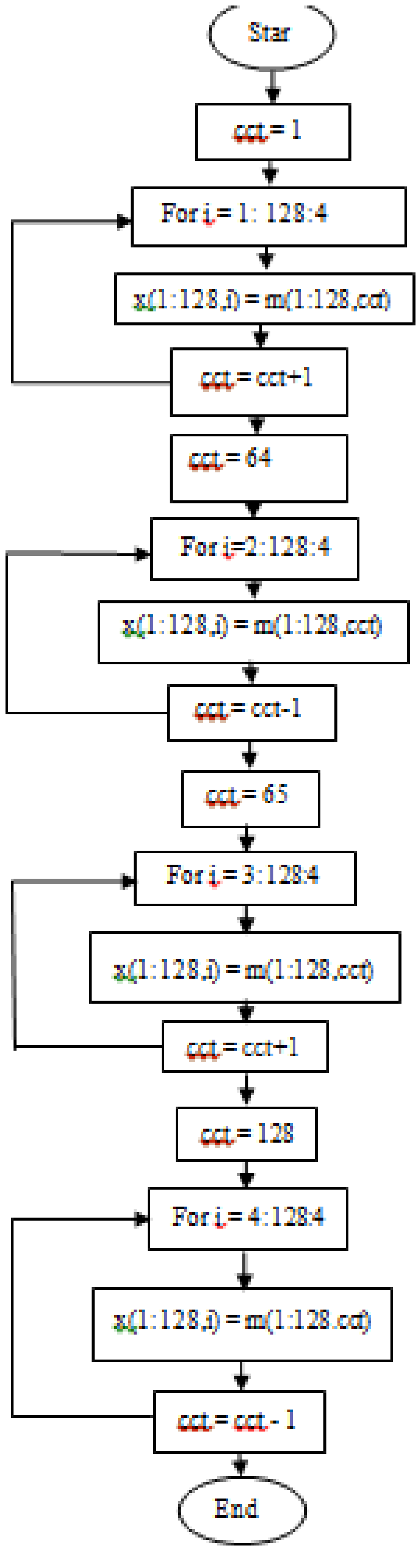


Figure 6(b) Proposed transmission algorithm for distributing H.H data of sub image m in column direction after distributed in raw wise direction, using mat lab instructions.

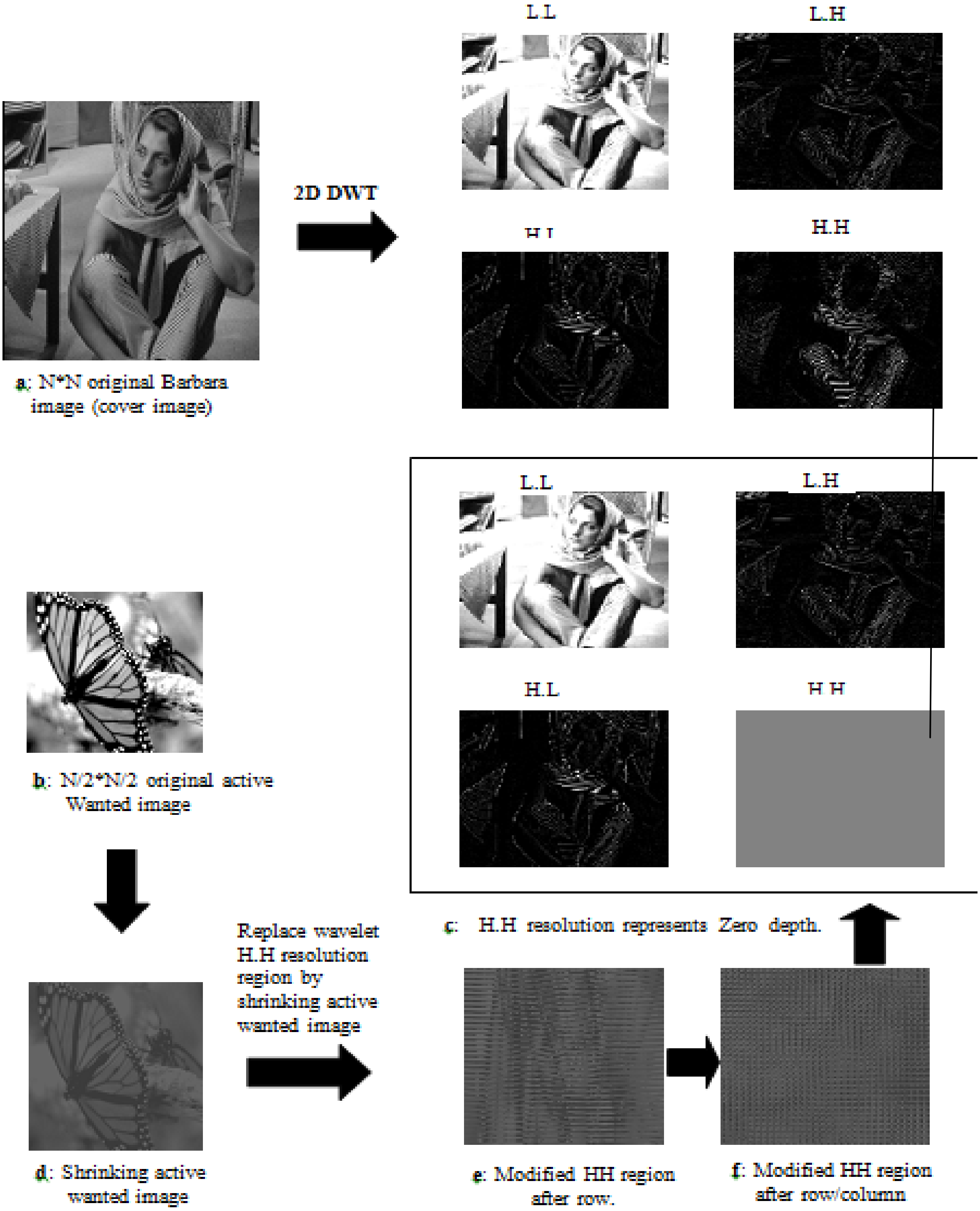
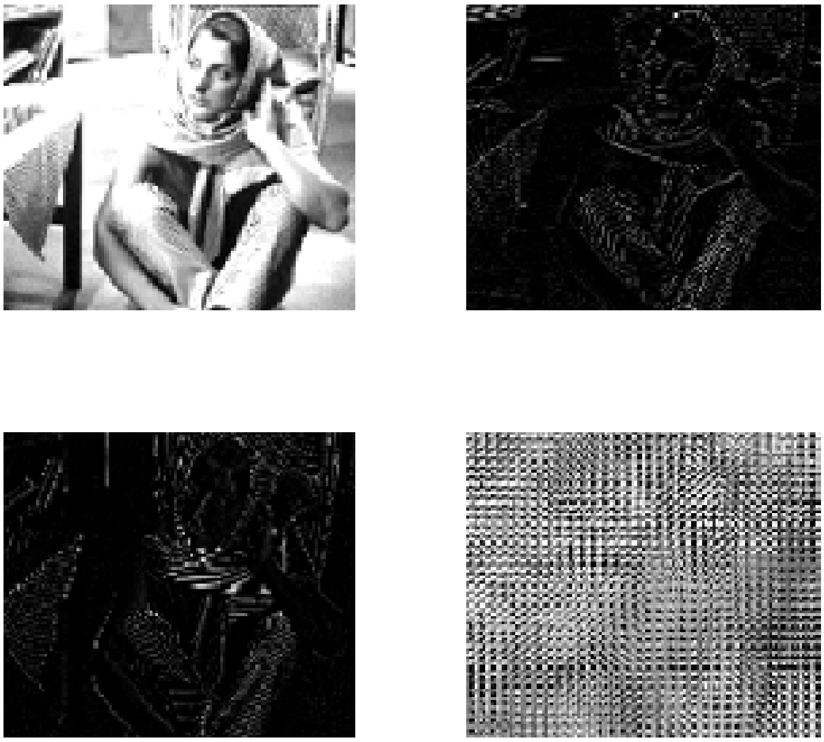


Figure 7 Represents the proposed transmission algorithm of the stego-image in steps.



a: Final wavelet resolution of transmitted image with modified HH region according to the process of rearrangement on shrinking active wanted image.

b: Final transmitted image

Figure 8 Represents the final covered image after taking 2D IDWT.

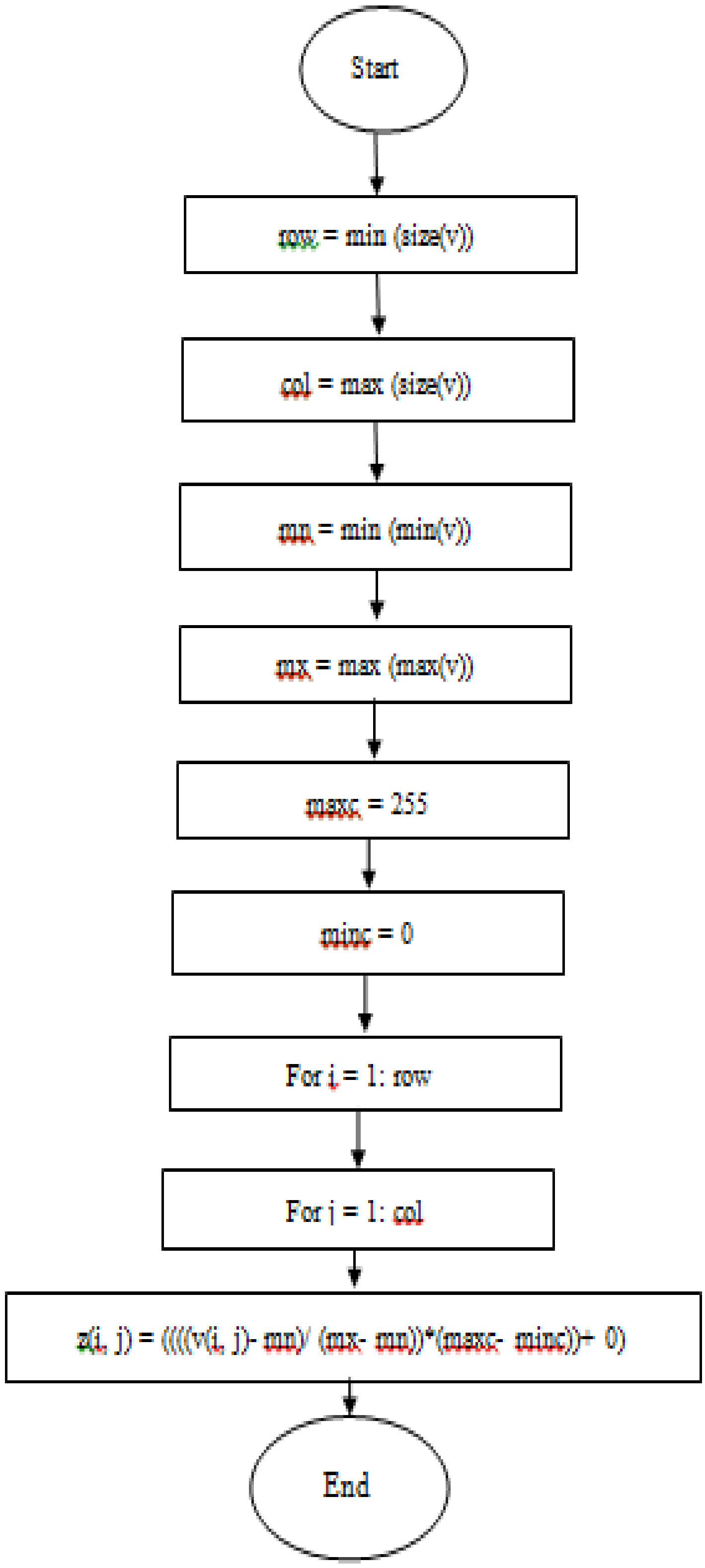


Figure 9 Proposed algorithm of the D-shrinking method (stretching process method) for wanted image v after invert arrangement in figures (10.a), and (10.b), using mat lab instructions.

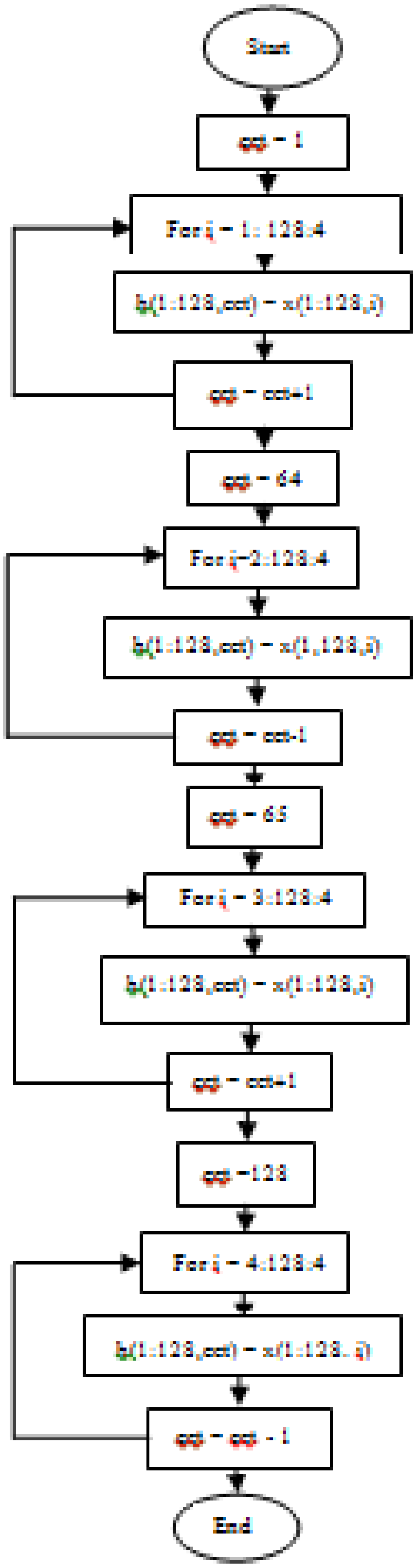


Figure10(a) Proposed reverse protocol for re- distributed H.H data x, using key to original shrink sub-image at raw direction, using mat lab instructions

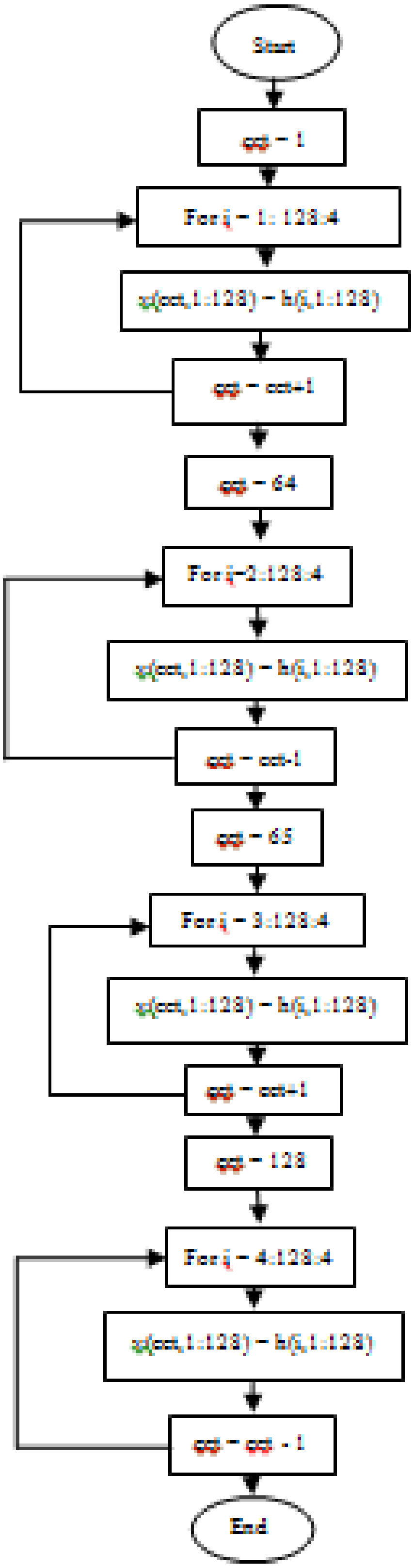


Figure 10(b) Represent proposed reverse protocol for re- distributed H.H data h, at raw/column directions to original shrink sub-image v.

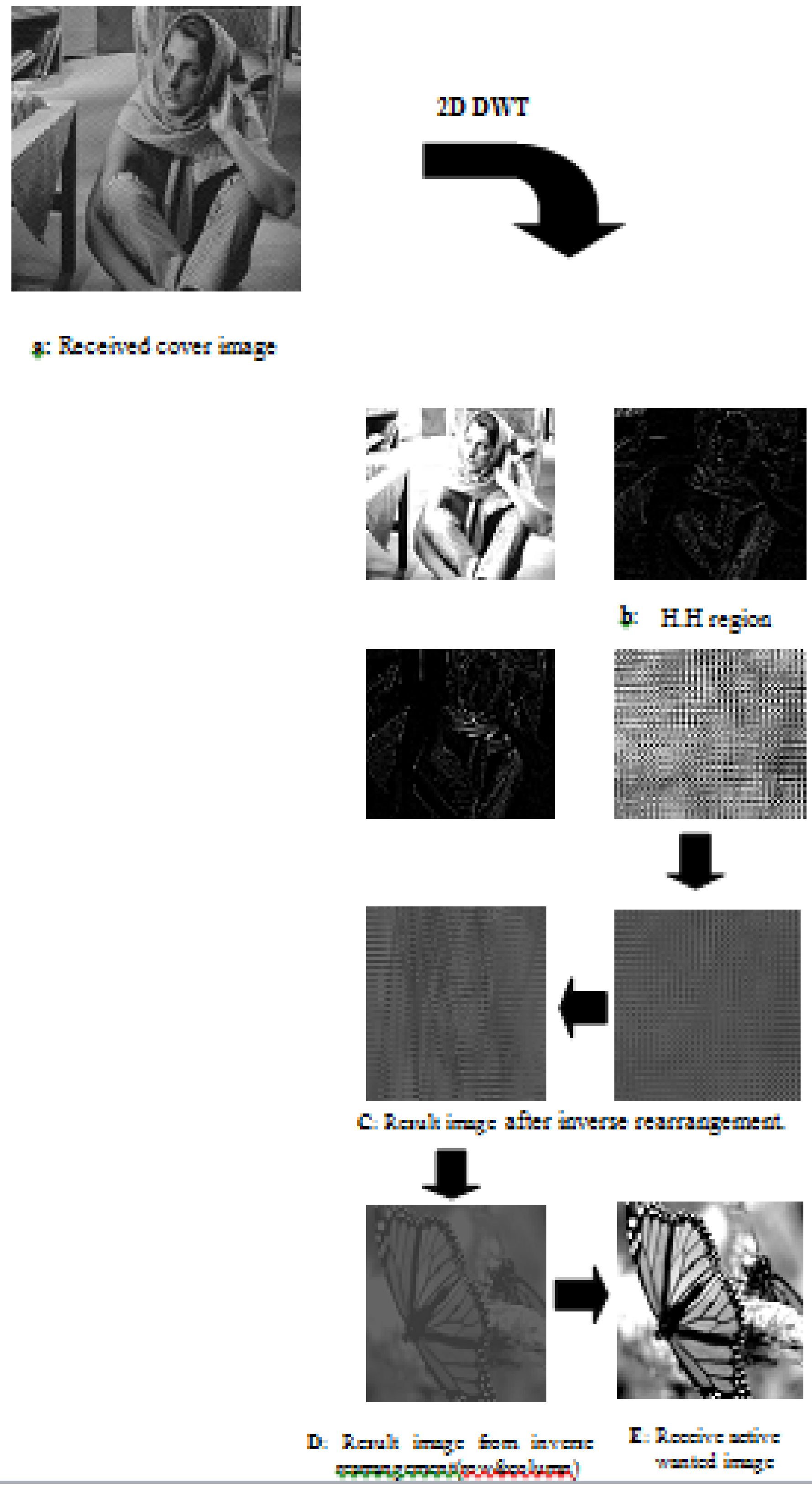


Figure 11 Represent the proposed reception algorithm in steps for getting active wanted image.