

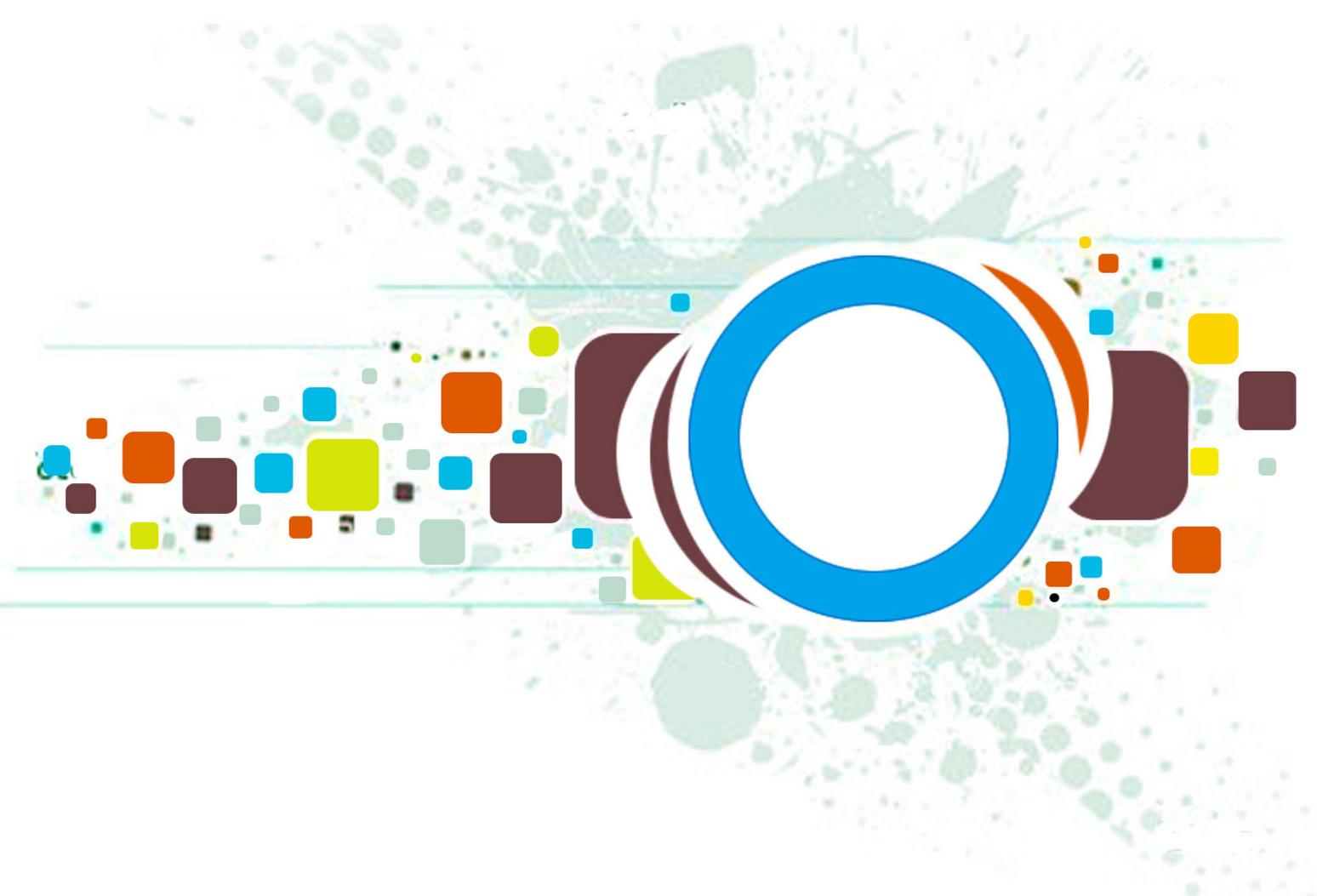
Volume 7 • Issue 5 • November 2013

Editor-in-Chief
Professor Hu, Yu-Chen

INTERNATIONAL JOURNAL OF
IMAGE PROCESSING (IJIP)

ISSN : 1985-2304

Publication Frequency: 6 Issues Per Year



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INTERNATIONAL JOURNAL OF IMAGE PROCESSING (IJIP)

VOLUME 7, ISSUE 5, 2013

**EDITED BY
DR. NABEEL TAHIR**

ISSN (Online): 1985-2304

International Journal of Image Processing (IJIP) is published both in traditional paper form and in Internet. This journal is published at the website <http://www.cscjournals.org>, maintained by Computer Science Journals (CSC Journals), Malaysia.

IJIP Journal is a part of CSC Publishers

Computer Science Journals

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INTERNATIONAL JOURNAL OF IMAGE PROCESSING (IJIP)

Book: Volume 7, Issue 5, November 2013

Publishing Date: 30-11-2013

ISSN (Online): 1985-2304

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IJIP Journal is a part of CSC Publishers

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Published in Malaysia

Typesetting: Camera-ready by author, data conversion by CSC Publishing Services – CSC Journals, Malaysia

CSC Publishers, 2013

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A Novel Machine Vision System for Identification of Yellow Rust in Wheat Plants

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Abstract

The crop of wheat is very often infected by a disease that leaves spots of brown, gray or off-white colors on the wheat plants. Scientifically, this disease is known as Yellow Rust. It's a kind of fungus that often kills young seedlings. The fungus spreads by air. Therefore, it is important to monitor the leaf at regular intervals so as to keep track on quality of growing wheat crop. In the presented paper, a novel machine vision system has been proposed that visual inspects the leaves of the plants and based on spots on leaves, it determines the nature of disease and its depth into the crop. The size of the fungus, color depth and location and locus of the fungus on leaves give an accurate determination of crop quality. In the presented work, the image of the crop leaves are taken by a good quality color camera and processed for getting a gray colored and segmented image depending upon the nature and size of the fungus. A criterion is set for acceptable and rejects crop quality based on the fungus level.

Keywords: Yellow Rust, Leaf Morphology, Perimeter, Segmentation, Leaf Area.

1. INTRODUCTION

Wheat crop in certain parts of Indian states of Punjab, Haryana, J & K and parts of Uttarakhand and bordering crop fields in Uttar Pradesh are affected by stripe rust or yellow rust of wheat caused by a fungal pathogen, *Puccinia striiformis* presently. The disease appears in the form of yellow stripes on wheat leaves. This disease appears if cold temperature with intermittent rains prevails during February and March. The affected leaves dry up, the grain shrivel and the yield is very low. e.g. in Rabi 2010-11, this disease led to huge losses in these states, the outburst of yellow rust in Districts of Kathua, Samba and Jammu on variety PBW 343 in the season (2008-09) was serious.

Wind is the main means of spread or dispersal for stripe rust. The spores are produced in huge numbers in pustules on the upper surface of leaves. Once the spores become airborne, the rust developing in any part of the wheat belt can spread rapidly to other areas; some spores can travel very far. In the presented paper, the visual inspection of yellow rust identification work is divided into following steps:

1. Image Acquisition
2. Thresholding
3. Segmentation
4. Feature Extraction
5. Result Comparison

2. IMAGE ACQUISITION

In the proposed thesis work, the crop plants images are acquired by using a CCD camera of approx. 3 M-Pixel resolution in 24-bits color resolution. The images are then transferred to PC and represented in MATLAB software. Here, it is to be noted that the proposed system is not to identify or visually inspect the each and every plant, but rather to identify at least one infected leaf

from the mass that may lead to infect the entire crop. Therefore, the objective is to identify the culprit one.

The key idea in the presented work is to develop a novel technique for detection of any disease/infection from the leaves in wheat plants that suffers at a higher rate than any other crop. After capturing the image, the leaves images are brought under image processing techniques to identify the growth and type of infections. Fig. 1 shows the image taken by CCD camera from the field in 24-bits color format.



FIGURE 1

3. THRESHOLDING

The acquired color image is now converted to gray scale color scheme. Local and global thresholding approaches may be utilized to produce a binary image from the gray scale image. In the present work, a median filter of 3x3 kernel is applied and then a thresholding algorithm based on Otsu method is applied (global thresholding) [6]. Fig. 2 is the image after converting the same into gray shade format. Median filter is applied to remove the salt and pepper noise which is normally present in the crop field images. Median filtering is similar to using an averaging filter, in that each output pixel is set to an average of the pixel values in the neighborhood of the corresponding input pixel. However, with median filtering, the value of an output pixel is determined by the median of the neighborhood pixels, rather than the mean. The median is much less sensitive than the mean to extreme values (called outliers). Median filtering is therefore better able to remove these outliers without reducing the sharpness of the image. The results after applying the median filter are shown in Fig. 3. When Otsu algorithm is applied over the filtered image, a binary image as shown in Fig. 4 is obtained.



FIGURE 2

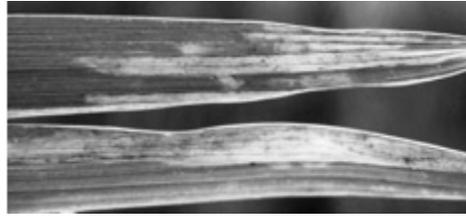


FIGURE 3



FIGURE 4

4. SEGMENTATION

The threshold image is now segmented based on bwlabel algorithm in MATLAB. Fig. 4 is taken as input image for segmentation. Below are the figures after segmentation using 8-connectivity of pixels and bwlabel function in MATLAB software.

Small leaf portions based on connected pixels basis can be left out as they do not contribute much in visual inspection of wheat plants. Another segmentation based on color is also employed in the presented work. Color based segmentation suggest the discoloring of the leaf due to any infection present in the crop.



FIGURE 5



FIGURE 6

5. LEAF CONTOUR EXTRACTION

In order to calculate the leaf area, the contour of the leaf is to be determined. The contour of the leaf is extracted using the sobel operator in matlab. Fig. 7 shows the result after applying the sobel operator on input image.



FIGURE 7

The Sobel method finds edges using the Sobel approximation to the derivative. It returns edges at those points where the gradient of intensities is maximum.

6. LEAF PERIMETER AND AREA COMPUTATION

Leaf parameters are computed using the matlab command `regionprops`. It calculates the leaf perimeter and area. The leaf perimeter is the no. of pixels on the leaf contour. The leaf area is computed by counting the number of pixels confined within the contour as extracted in leaf contour extraction section of this paper. Later on, the infected leaf area is computed from the segmented image.

7. FEATURE EXTRACTION

In the presented paper work, following observations are supposed to be monitored:

- I. Leaf Morphology
- II. Leaf Area, perimeter
- III. Completeness of the leaf
- IV. De-coloring of leaf due to fungus or decease

Leaf Morphology of the leaf suggests and compares the leaf under test with the standard or reference image of the leaf. Leaf morphology comparison between standard and leaf under test is approximate and not exact. However, the normalization of leaf under test with respect to size is must before comparison. Leaf Area and perimeter suggest the size of the leaf after normalization of the leaf size with respect to standard one. Completeness of the leaf with respect to its morphology suggests that if any part of the leaf is bitten by an animal, then, that part of the field may be infected by the animal's larva transferred on the leaf. That larva may penetrate into the crop and may infect the same and the nearby plants as well.

8. HISTOGRAM ANALYSIS

A RGB image is converted to gray scale image using the following formula:

$$\text{Gray Color Code} = (0.299 * R + 0.587 * G + 0.114 * B)$$

Where R -> Red, G-> Green and B-> Blue Color Value

Histogram of the input image is one of the complementing tool in identifying and confirming the presence of yellow rust in wheat plants. Any sharp rise of the yellowish color peak in the histogram indicates the presence of yellow rust in wheat crop/plant. The peak in histogram in yellow region can be fair estimate of the yellow rust infection into the plants.

9. RESULTS

Table1 shows the area and perimeter of the segmented leaves using the `regionprops` function in MATLAB software. The yellow rust infected part in image is yellowish. We can find the percentage infected area of leaf due to yellow rust from the above table. And that will give the penetration of the disease into the plant. It is an important indicator to distinguish infection by morphological features. That is easy to get the differences by comparing the morphological

characteristics among different wheat diseases, such as area, diameter and other features. Further the identification or degree of penetration may be verified by histogram analysis. The amount of green tissue is an indication of health and the growth stage and condition of the plant. The use of digital images to quantify the greenish color shows that it is possible to obtain information about the amount of red, green, and blue light emitted for each pixel. The RGB values can be converted to hue, saturation and brightness (HSB) to simplify the interpretation of digital color-data.

10. CONCLUSION

Agricultural applications are an ideal target for the implementation of machine vision technologies. The ability to use image sensors remotely, requiring no contact with the subject or intervention by an operator provides a measure of robustness usually difficult to achieve in this area. RGB histogram analysis of a wheat plant image can be very strong tool in identifying the degree of penetration of the yellow rust into the crop. Ratio area calculation provides the measure of the disease and a quantitative analysis can be drawn for the yellow rust spread on the whole crop area. Using image processing techniques in monitoring the wheat crop, a fair idea of any kind of disease can be guessed in time if the image acquiring devices are installed to cover a wide area of the crop,

Sr. No.	Figures	Area (sq. Pixels)	Perimeter (Pixels Unit)
1		4471	392
2		4485	317
3		2997	339
4		2701	278

TABLE 1

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Color Image Watermarking Application for ERTU Cloud

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Abstract

Color image is one of the Egyptian Radio and Television Union (ERTU)'s content should be saved from any abuse from outside or inside the organization alike. The application of saving color image deploys the watermarking techniques based on Discrete Wavelet Transform (DWT). This application is implemented by software that suits the ERTU's cloud besides many tests to insure the originality of the photo and if there is any changes applied on. All that provides the essential objectives of the cloud to overcome the limitation of distance as well as provide reliable and trusted services to Authorized group.

Keywords: Cloud Computing, DWT, ERTU, Watermarking.

1. INTRODUCTION

Saving the contents of any cloud using watermarking demands high robustness against any attack. Maintaining these demands requires a good algorithm that can face the problems or attacks besides do the essential purpose which is saving it from any abuse. There is a contribution to protect contents by watermarks using Arabian letters where it has multipoint. From this advantage, it can be embedded 2 Byte instead of one Byte and there is no increase in the payload of the signal and it still maintains its imperceptibility [1]. The Digital Right Management (DRM) is one of aspect that studies how to control the cloud and the contents contained in. one of this contained type is multimedia where encryption, watermarking and distributing through wireless channel like mobile or through internet connection is important issue that many studies are deployed. Applying the management for this multimedia is discussed in [2]. Proposing a watermarking algorithm to embed the watermark into the original image by using complete complementary code method is introduced in [3]. A novel color hardcopy watermarking embedding is described. The proposed color embedding provides high transparency by modulating the watermark into the value and saturation color components of the document. After the color document is printed and distributed, the message is decoded by scanning the document

and applying the proposed post processing based on a Laplacian of Gaussian whitening filter [4]. An improved and more robust digital image watermarking algorithm based on traditional W-SVD algorithm is proposed. It is presented a novel HVS-based watermarking scheme. Firstly, to increase robustness of the scheme, the watermark is refined by a watermark strength regulation factor. Then a secret message is scrambled using Arnold transform and modified into a watermark template. Finally, the watermark template will be embedded in the low-frequency coefficients of the host image, after a 2-level DWT handling [5]. This paper is organized as follow: Defining the parameters and algorithm used in section 2. The numerical results are presented in section 3. Finally, in section 4, the conclusion of results is summarized.

2. FORMULATIONS OF PROBLEM

Watermarking image need to be measured and determined the qualities to decide how much it is effective. In the following, various metrics will be defined and explained to understand why it has been used in evaluation and the factors that must be considered.

The normal distribution is measure for probability of the data containing through the image and the distribution of it. It can be described as:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad (1)$$

The parameter μ in this formula is the mean or expectation of the distribution. The parameter σ is its standard deviation; its variance is therefore σ^2 . A random variable with a Gaussian distribution is said to be normally distributed and is called a normal deviation.

Spectrogram is a graph which indicates the frequencies of image versus time. It is used to get visual indication and comparison between the original and processed image. Distribution of the signal gives the distribution of the signal's amplitude and it becomes a good comparison tool between processed and original image. Histograms show the distribution of data values across a data range. It may be divided to many categories:

- a) Cartesian coordinates: shows the distribution of the elements in Y as a histogram with equally spaced bins between the minimum and maximum values in Y.
- b) Matrix input argument: when Y is a matrix, histogram creates a set of bins for each column, displaying each set in a separate color.
- c) Specifying number of bins: interpret their second argument in one of two ways as the locations on the axis or the number of bins. When the second argument is a vector x, it specifies the locations on the axis and distributes the elements in length(x) bins.
- d) Using data cursors: when the data cursor tool is used on a histogram plot, it customizes the data tips it displays in an appropriate way. Instead of providing x, y, and z-coordinates, the data tips display the following information: number of observations falling into the selected bin, the x value of the bin's center and the lower and upper x values for the bin

Scatter plots (also called scatter diagrams) are used to investigate the possible relationship between two variables that both relate to the same "event". A straight line of best fit (using the least squares method) is often included. The Scatter diagram helps to identify the existence of a measurable relationship between two items by measuring them in pairs and plotting them on a graph. Things to look for:

- a) If the points cluster in a band running from lower left to upper right, there is a positive correlation (if x increases, y increases).

b) If the points cluster in a band from upper left to lower right, there is a negative correlation (if x increases, y decreases).

c) Imagine drawing a straight line or curve through the data so that it "fits" as well as possible. The more the points cluster closely around the imaginary line of best fit, the stronger the relationship that exists between the two variables.

d) If it's hard to see where the draw a line, and if the points show no significant clustering, there is probably no correlation.

The DWT is performed using multilevel filter banks. The one level of decomposition can mathematically be expressed as follows [6]:

$$y_{high}(k) = \sum_n x(k)g(2k - n) \quad (2)$$

$$y_{low}(k) = \sum_n x(k)h(2k - n) \quad (3)$$

Where $y_{high}(k)$ and $y_{low}(k)$ are the outputs of the high pass and low pass filters, respectively, after subsampling by two. For images, the DWT is performed row by row and then, column by column. The image after wavelet decomposition is divided into four bands; a low frequency band LL, and three high frequency bands LH, HL and HH. Peak Signal to Noise Ratio (PSNR) is the measure for estimate of the quality of reconstructed image with the original one. It is given by computing the error between cover image with size $(N_1 \times N_2)$ pixel and watermarked image. Therefore, Mean Square Error (MSE) is obtained. Firstly then gets Root MSE (RMSE) and PSNR in (dB) is given by [7-8]:

$$PSNR = 20 \log_{10} \frac{\text{max pixel}}{\sqrt{\frac{1}{N_1 N_2 \sum_i \sum_j (h(i,j) - h'(i,j))^2}}} \quad (4)$$

Where $h(i,j)$ and $h'(i,j)$ are the intensity of the $(i,j)^{th}$ pixel before and after watermarking respectively. Correlation coefficient is used for similarity measurement. It gives an indication that how the original and watermarked image are identical. There is of course a threshold to decide the presence of the watermark. It can be calculated as:

$$C = \frac{\sum_{r=1}^H \sum_{c=1}^W (I_1(r,c) - \bar{I}_1)(I_2(r,c) - \bar{I}_2)}{\sqrt{\left[\sum_{r=1}^H \sum_{c=1}^W (I_1(r,c) - \bar{I}_1)^2 \right] \left[\sum_{r=1}^H \sum_{c=1}^W (I_2(r,c) - \bar{I}_2)^2 \right]}} \quad (5)$$

Where $I_1(r,c)$ is the value of the pixel at the point (r,c) in the original image. $I_2(r,c)$ is the value of the pixel at (r,c) in the encrypted image, \bar{I}_1 is the mean of the original image and \bar{I}_2 is the mean of the encrypted image that is calculated as follows:

$$\bar{I} = \frac{1}{W * H} \sum_{r=1}^H \sum_{c=1}^W I(r,c) \quad (6)$$

Similarity is a measure to detect the presence of watermark in the image. It calculates the intensity of the pixel for original and extracted watermark. If the image has not been watermarked, then it can be modeled as zero mean random variable. If there is a slight difference, then this image has been watermarked. So this metric gives an indication for presence or absence of watermark, the degree of similarity gives a picture for the amount of information that has been added besides the presence of attacks if any. It is also considered as a measure for the robustness of the

watermark against attack [9]. The layout of watermarking process is introduced in Fig. 1 and Fig. 2 shows the GUI of the software package.

3. NUMERICAL RESULTS

In this work, the targeted image is transformed using wavelet decomposition and the watermark image is inserted in the image. The watermark image is added to the original image by a factor. Then the reconstructed process is performed to get the original image containing the watermark image. The original images besides watermark used in this work are displayed in Fig. 3.

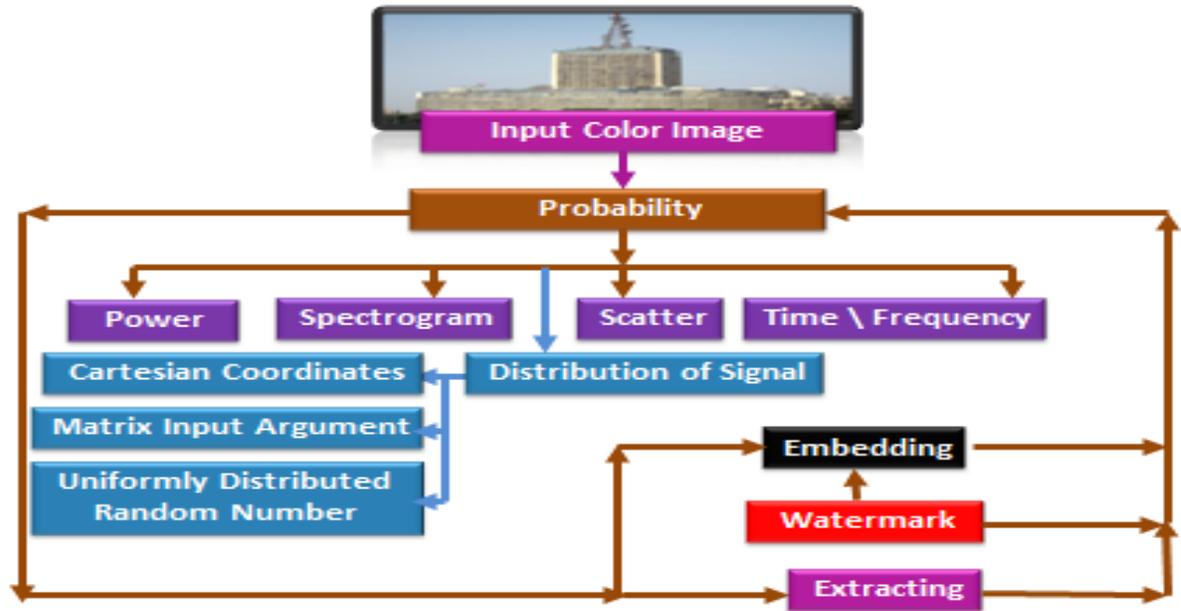


FIGURE 1: The Layout of Processing of the Watermarking.

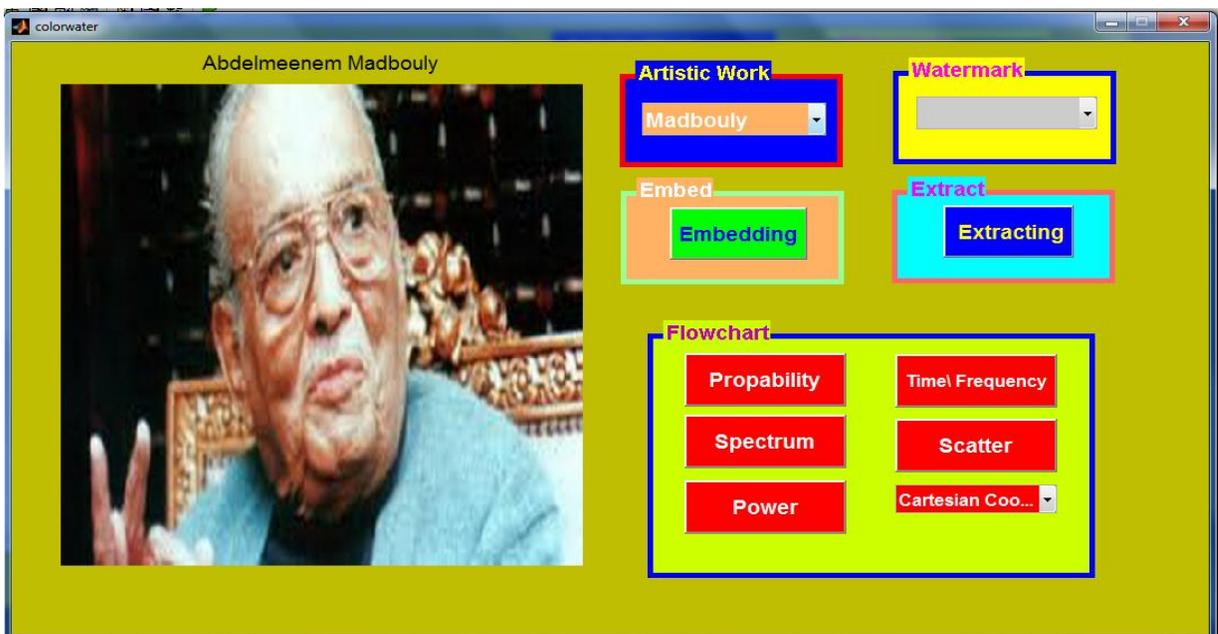


FIGURE 2: GUI for Color Image Watermarking Package for ERTU Cloud.

3.1. Embedding Process

In embedding process, a watermarking image is inserted into the content. Then, the new image is reconstructed to be like the original one containing the watermarking image. In Fig. 4, the original and watermarked images are showed where it is similar to the original. The normal distribution that displayed in Fig. 5 indicates the invisible change in watermarked image than original. Fig. 6 shows the spectrogram of each. The power of each image is monitored in Fig. 7 where it has almost unchanged in lower frequency and a small change in higher frequency. In Fig. 8 display the distribution of the images. It indicates a change in small value of data and almost no change in high value of the image. Fig. 9 represents the data contained in original and watermarked in time and frequency domain where it shows how much it is similar. From all above, this technique can suite the cloud for color image and save the content without any remarkable change in processed image. The scattering between the original and the watermarked is represented in Fig. 10 where it gives an indication how the correlation between them is high.

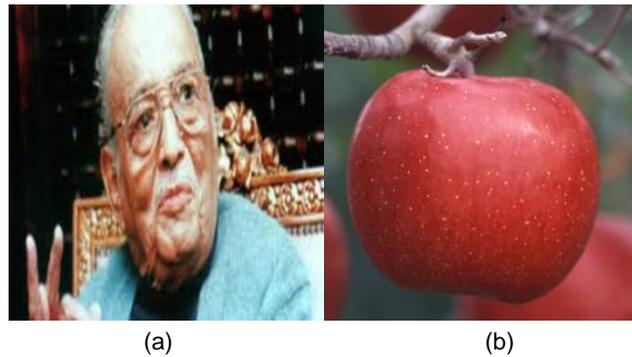


FIGURE 3: (a) The original image used (Madbouly) and (b) Watermark image.



FIGURE 4: The original image (a) before watermarking and (b) after watermarking.

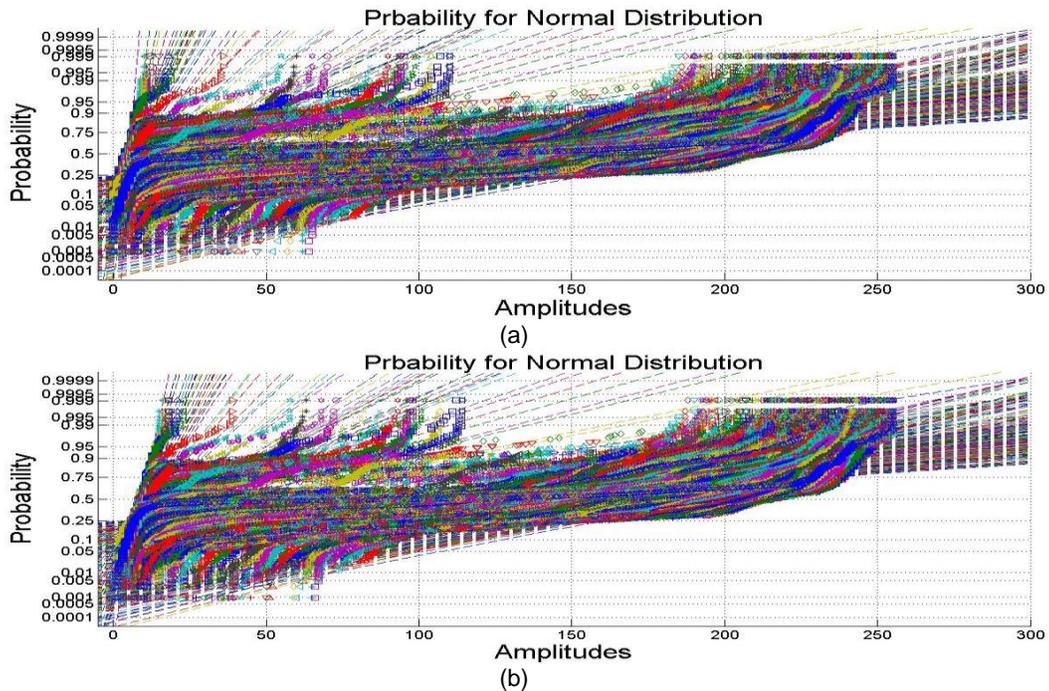


FIGURE 5: The normal distribution of the original image (a) before watermarking and (b) after watermarking.

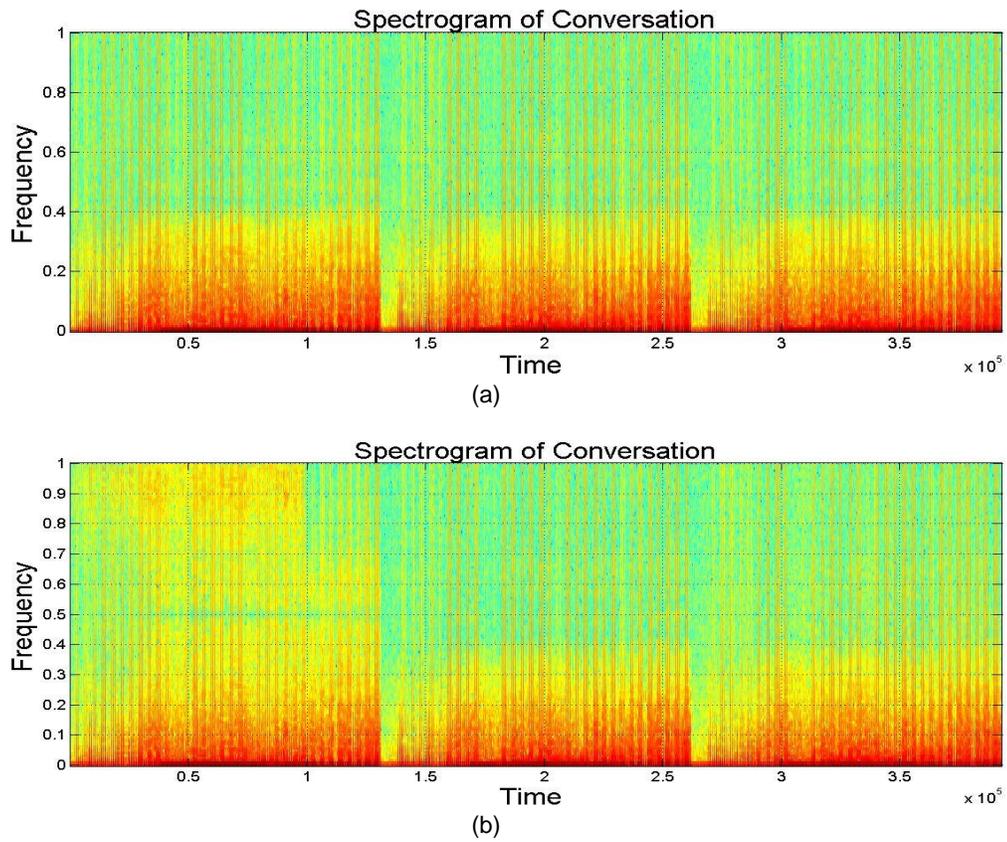


FIGURE 6: The spectrogram of the original image (a) before watermarking and (b) after watermarking.

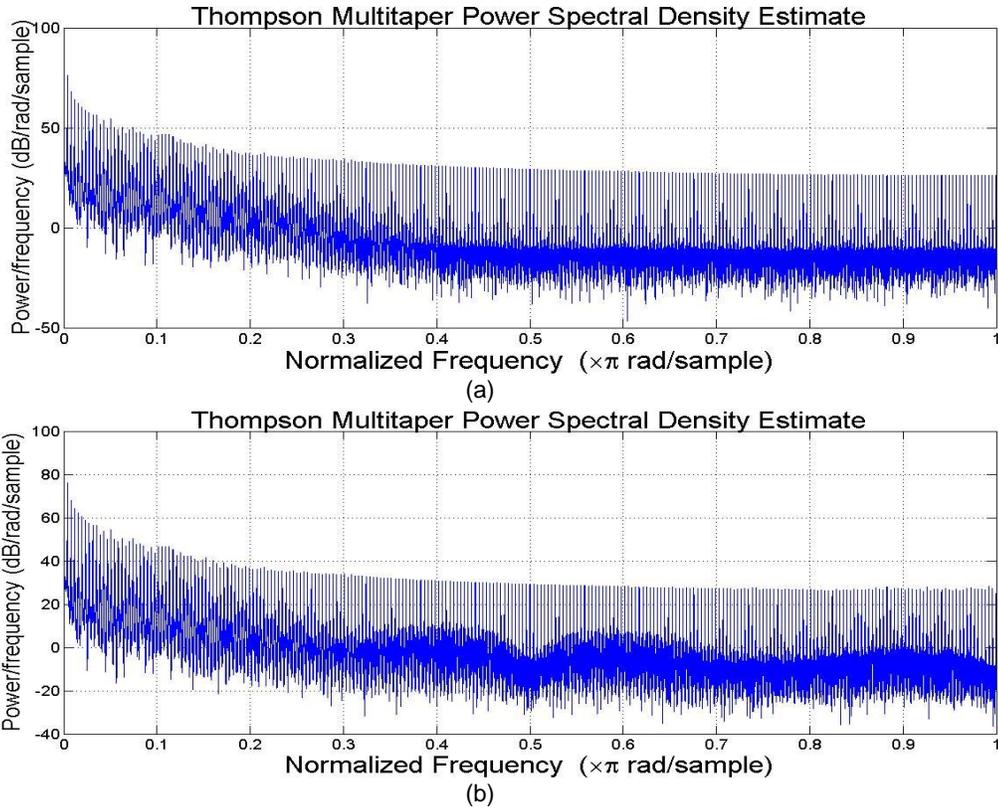


FIGURE 7: The power of the original image (a) before watermarking and (b) after watermarking.

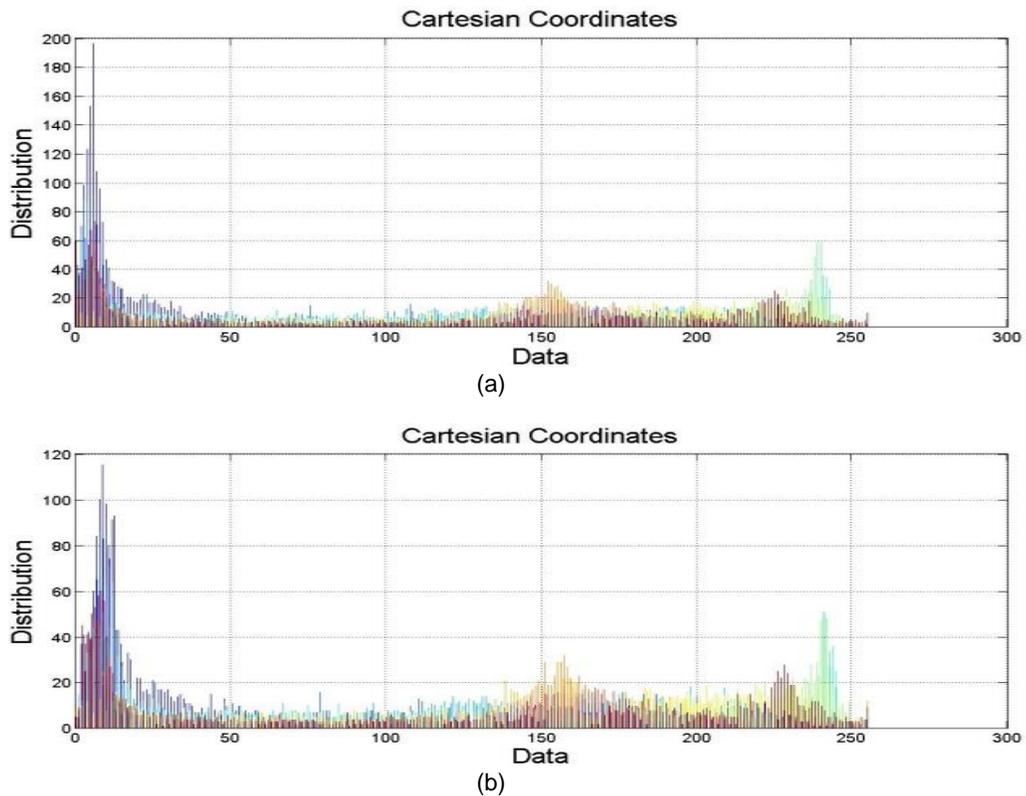
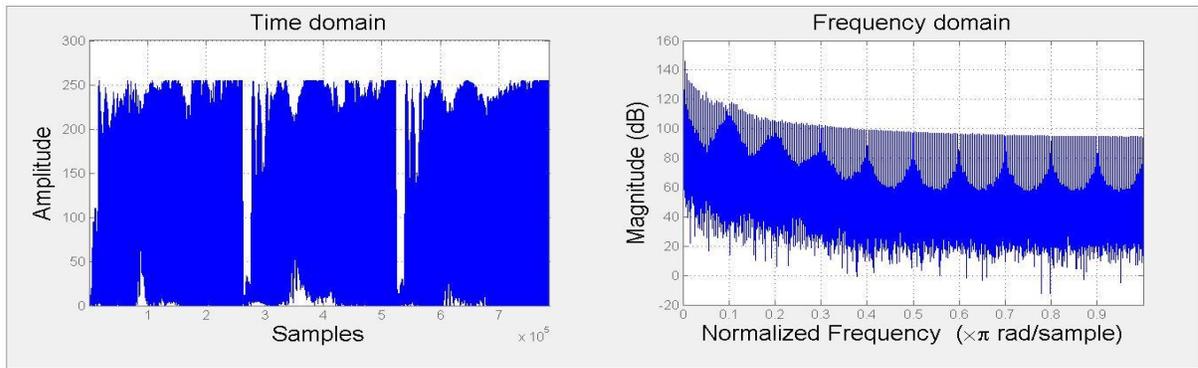
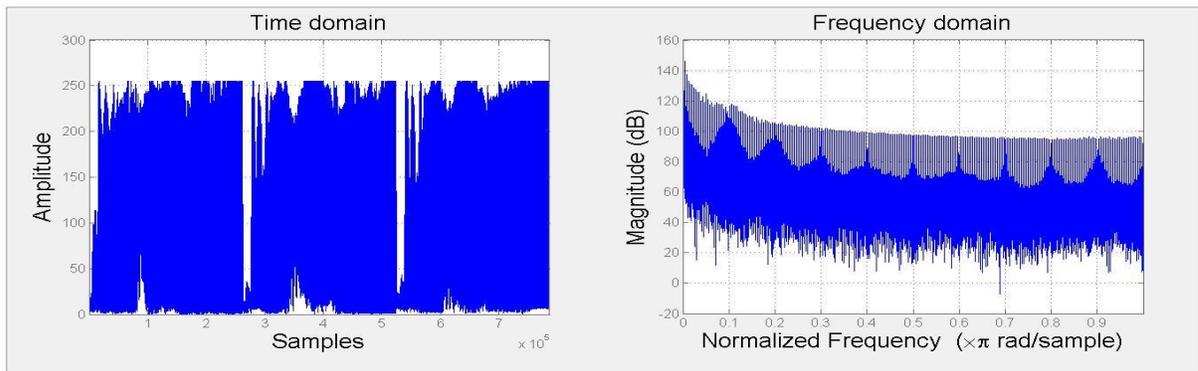


FIGURE 8: The distribution of the original image (a) before watermarking and (b) after watermarking.



(a)



(b)

FIGURE 9: The Time/Frequency domain of the original image (a) before watermarking and (b) after watermarking.

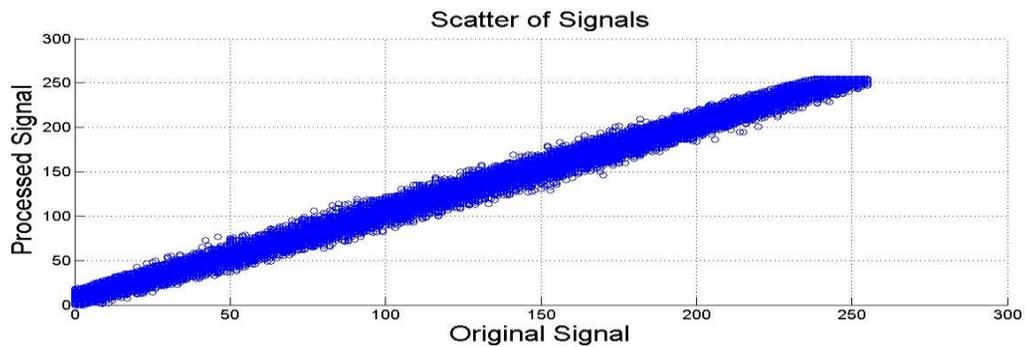


FIGURE 10: The scattering between the original image and watermarked image.

3.2. Extracting Process

In this case, the inserted image is extracted and the resulted is compared with the original to determine the best algorithm that suit the cloud and give high performance. In Fig. 11, the original and extracted watermark images are showed where extracted has distinguishable change from the original but still can be recognized. The normal distribution, which displayed in Fig. 12, indicates the change in watermarked image than original and it is visible change especially in medium amplitudes. Fig. 13 shows the spectrogram of each which indicates the relation between the image amplitude and the frequency and how much it is close to the original. The power of each image is monitored in Fig. 14 where a small change but visible occur in low and medium frequencies and big change happen in high frequencies. In Fig. 15 display the distribution of the

images where it almost has the same value and a remarkable change in high value from the original. Fig. 16 represents the data contained in original and watermarked in time and frequency domain where it shows the similarity between both. The scattering between the original and the extracted is represented in Fig. 17 where it gives an indication how the correlation between them is high.

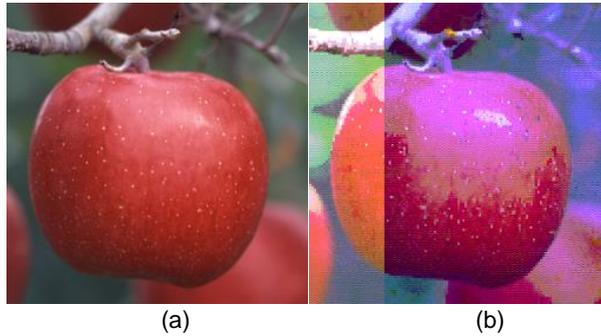


FIGURE 11. The watermark image (a) original and (b) extracted.

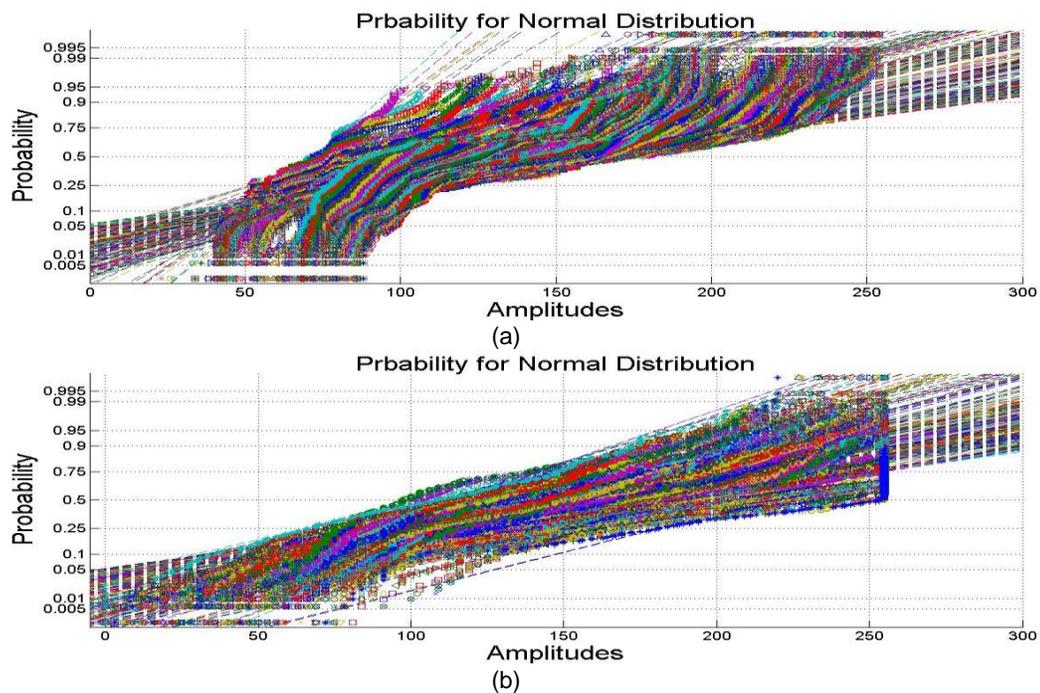


FIGURE 12. The normal distribution of the watermark image (a) original and (b) extracted.

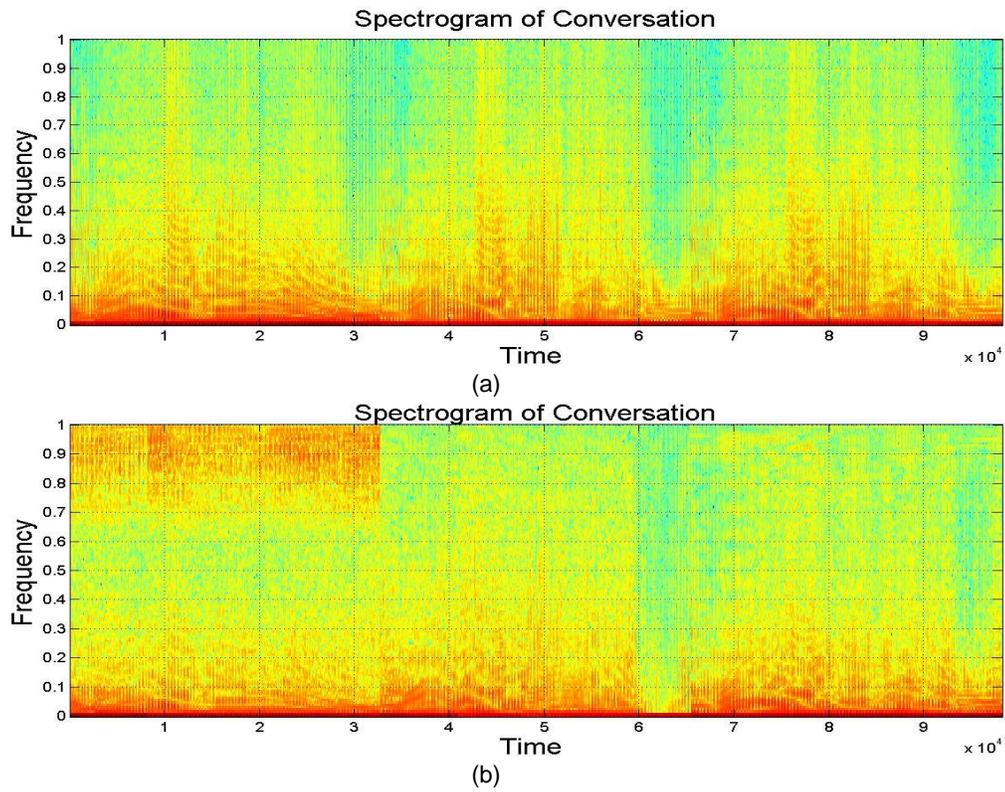


FIGURE 13. The spectrogram of the watermark image (a) original and (b) extracted.

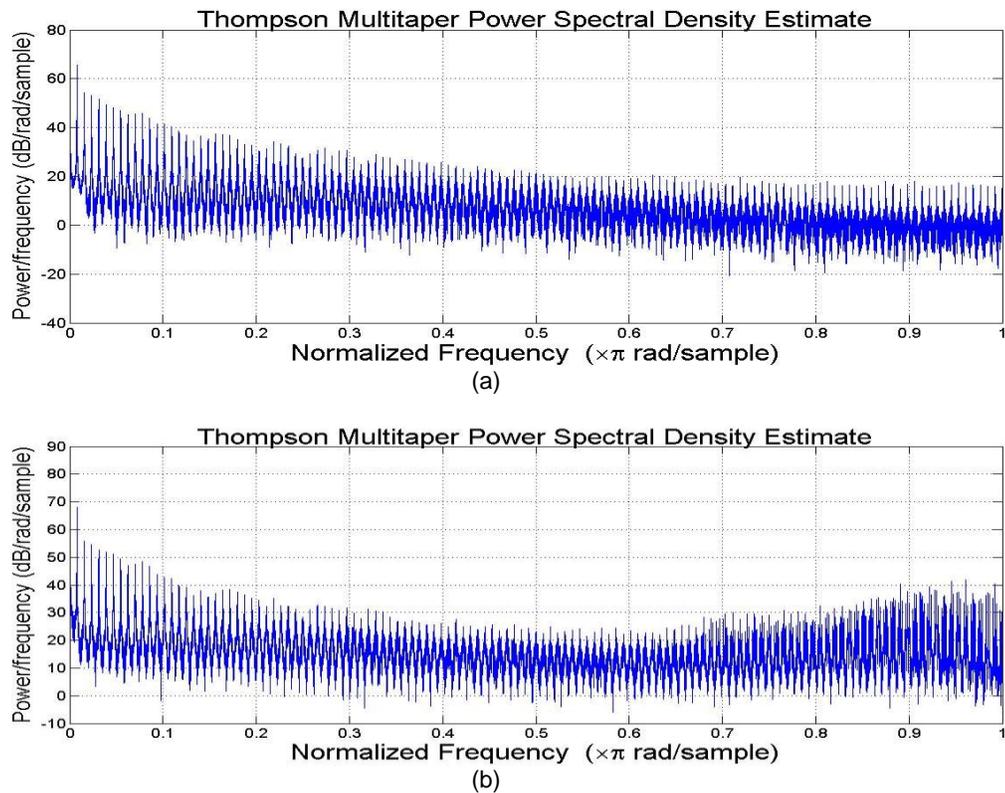
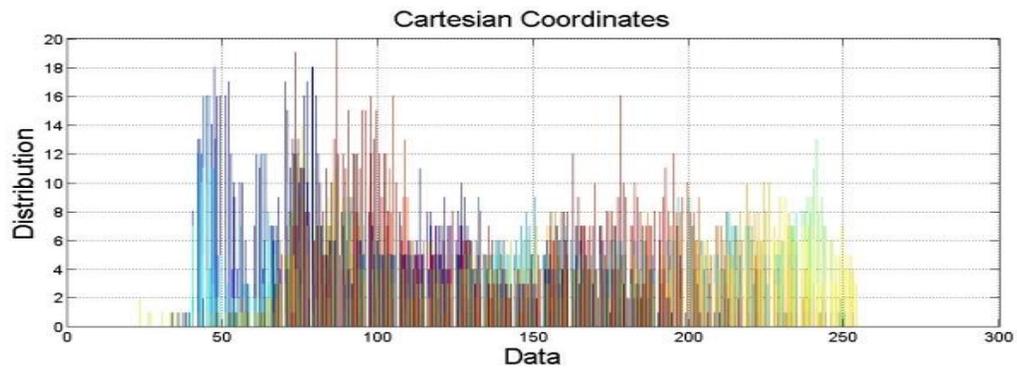
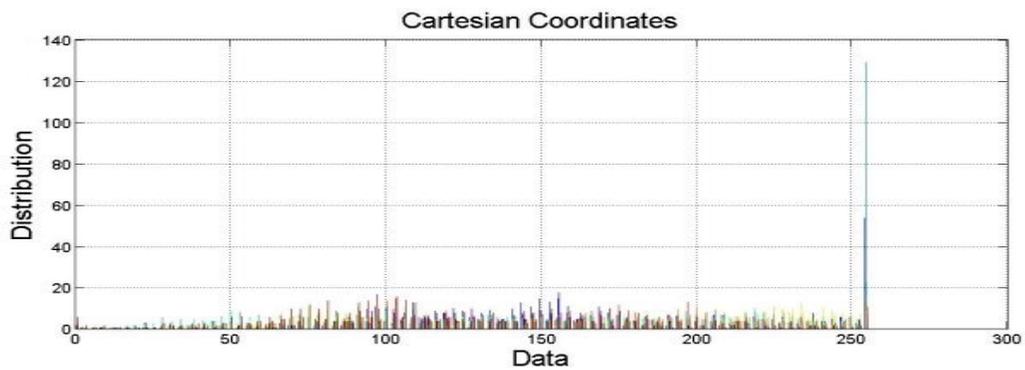


FIGURE 14. The power of the watermark image (a) original and (b) extracted.

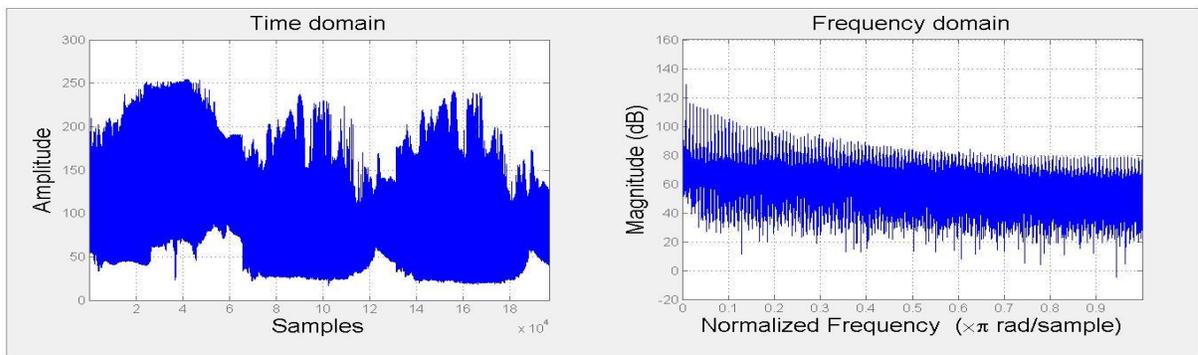


(a)

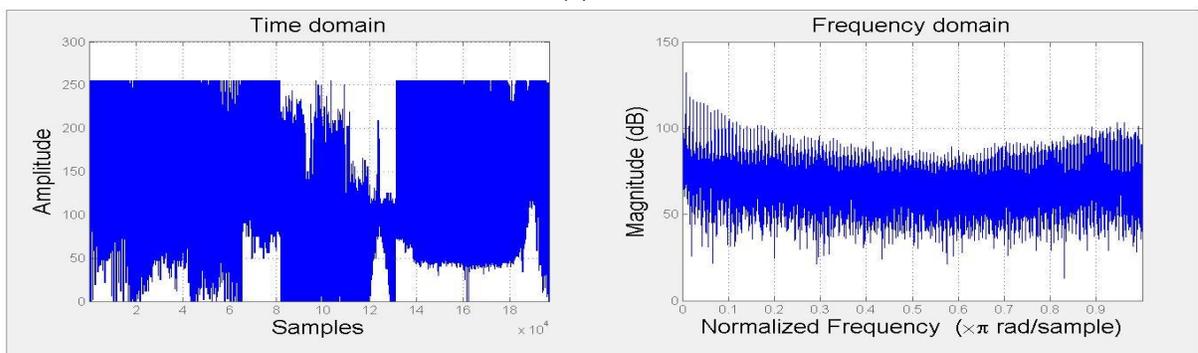


(b)

FIGURE 15. The distribution of the watermark image (a) original and (b) extracted.



(a)



(b)

FIGURE 16. The Time/Frequency domain of the watermark image (a) original and (b) extracted.

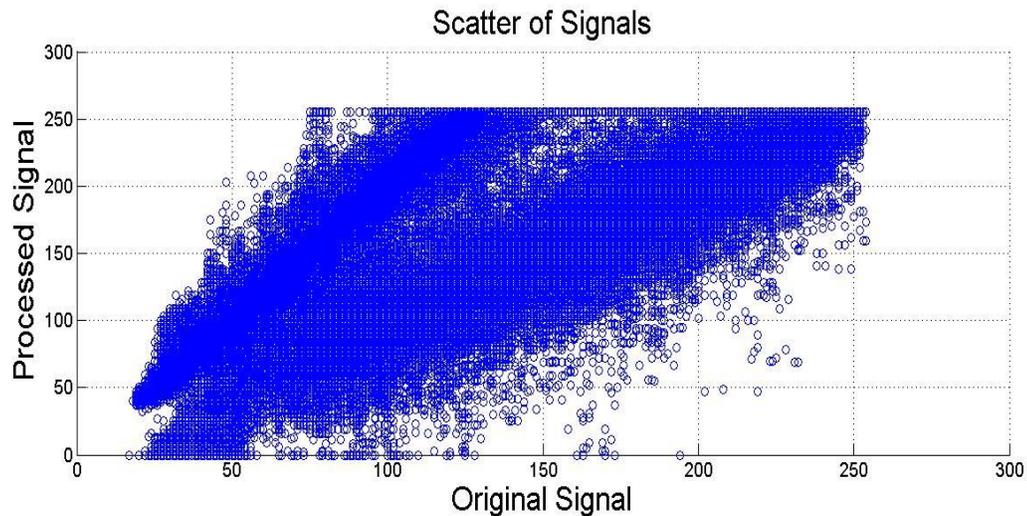


FIGURE 17. The scattering between the original watermark image and extracted image.

4. CONCLUSION

This technique provide a good solution for watermarking a color image and has good performance in embedding process but it has some drawback in extracting process where it has a remarkable change but it still can be distinguishable. This solution can maintain the security required for ERTU cloud and then protect the entire content of the cloud. It is used for insure the privacy of the content in the cloud. It is also can maintain the requirement for any department of according to its function and the policies of the cloud.

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