A Novel Heuristic Algorithm Based Watermarking Technique

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***Abstract*—This paper deals with the development of watermarking scheme for digital images. Here, we deal with invisible watermarking. We implemented a hybrid approach of DCT and Bird Spam Algorithm to retain reliability of watermark after being adding into real image and to achieve improved quality of the image and diminish perceptual deprivation. A Hybrid approach is capable of dealing with Noise and maintain the integrity of the watermarking. Three evolutions of the proposed approach were conducted using PSNR. With the proposed technique, we obtained the PSNR value of 94db, which outperform the rest of the algorithm presented in the literature.**

***Index Terms*— Bird Swarm Optimization, DCT; Gray Scale; Histogram Equalization; Peak Signal To Noise Ratio; Watermarking.**

I. Introduction

Media display on the Internet has become essential as the usage of Internet increases each day. The social media websites especially has been the daily tools for the young generations. In this case, the inclusion of digital displays and images on the Internet is crucial for quick understanding of media content. However, digital images tend to be easily reproduced or replicated by other writers without acknowledging the original designers. In this regard, it is crucial to protect the designer of the images to protect the privilege of the writers. Due to this issue, virtual defense is a fundamental and inescapable. Digital watermarking is one of the techniques to acknowledge the original designer, hence preserving the work from unauthorized replication.

In most of the digital watermarking techniques, a canopy image is used to embed a watermark. In this method, the output is watermarked to specify the alteration made either by common place processing of data in a known atmosphere or cruel assaults in an unknown atmosphere. To resolve this challenge, this paper presents a new technique using Bird Swarm optimization.

A. Frequency Domain Techniques

This technique is very useful in comparison to other approaches, such as the spatial approaches. The goal of this technique is to add watermarks in the image spectral coefficients. The maximum utilized transforms are DCT, DFT and DWT. This technique ensures that the traits of human visual system are apprehended by using spectral coefficients. Human visual system is found to be highly sensitive for low-frequency coefficients, while insensitive for high-frequency coefficients. Further, low-frequency coefficients are perceptually colossal, which means that variations to individual accessories is a rationale alteration to normal image. However, high-frequency coefficients are considered as insignificant. As a result, processing methods, for example compression, are inclined to get rid of the excessive-frequency coefficients aggressively. To attain stability among robustness and imperceptibility, maximum algorithms add watermarks in midrange rates [1] [2].

i. Discrete Wavelet Transformation

DWT is presently utilized in an extensive type of signal processing functions. DWT has the vigor that focuses in interval and is suitable for evaluation of passing, time-changing indicators. This is due to the fact that the maximum of original life alerts are interval changing. Some of the crucial and essential challenge is to gain an improved trade-off among perceptivity and robustness. It may also be performed through enhancing the force of added watermark; however, visible distortion would be extended as good transformation. Nonetheless, Discrete Wavelet Transformation is commonly chosen since it offers watermark simultaneous spatial localization as well as frequency spread. The elemental suggestion of discrete wavelet developed into picture procedure is to multi-distinguish the decomposed image into sub-images of one-of-a-kind spatial domain and impartial frequencies [1] [3].

ii. Discrete Cosine Transformation

Discrete Cosine Transformation shows information in relation of frequency space. This is valuable as it resembles the best way of humans perceive so that the phase that is not perceived can be recognized and removed. Discrete Cosine Transformation methods are strong in comparison to spatial domain systems. These types of algorithms are amazing towards easy image processing. Nonetheless, they are complex when putting it into effect and are computationally extra high-priced. Moreover, they are feeble towards geometric. Discrete Cosine Transformation domain watermarking will also be categorized into international and Block founded DCT watermarking. Embedding within the perceptually large section of photo has some benefits considering the fact that maximum compression system eliminates perceptually irrelevant element of image [1] [4] [2].

B. Spatial Domain Method

It can also be utilized as color separation. In this manner, watermark seems to be the handiest in comparison to most color bands. This renders watermark perceptibly elusive so that it is complex to realize beneath the average inspection. Nevertheless, mark seems to be identified right away when colors are detached for printing. These reduces file vain for printer; watermark will also be eliminated from color band. This method is utilized commercially for reporters to investigate cross-check photos from a photo-inventory apartment earlier than the purchasing unmarked types [1].

i. SSM Modulation Based Method

Spread-spectrum strategies are approaches where energy produced at a number of distinct frequencies is intentionally extent or allotted in time. That is completed for a style of causes, containing institution of comfortable communications, enhancing conflict to ordinary interference, and to restrict finding. When useful to background of image watermarking, SSM based watermarking algorithms add expertise with the aid of linearly merging host snapshot with a minor pseudo noise sign that is controlled by means of adding watermark [1].

ii. Least Significant Bit

Initial work of digital image watermarking systems adds watermarks in the Least Significant Bit of pixels. Assumed an image pixel, and every pixel being signified through an 8-bit set, watermarks are added within the final bit of designated pixels of image. This procedure is simple to put into effect and does not produce severe alteration. Nevertheless, it is not burning beside assaults. For example, an invader could easily randomize the entire Least Significant Bit, which comfortably finishes the concealed data [1].

II. PROPOSED METHODOLOGY

The methodology of our proposed work can be broadly categorized into two parts. First, we focus on the image integrity maintenance and second is on the image capacity enhancement.

A. Discrete Cosine Transform (DCT)

The DCT algorithm steps that we follow in our technique are given below:

DCT divides the picture into chunks of distinct incidences. The less significant incidences are eliminated over quantization, while the significant incidences are utilized to get picture among decompression. In associated to the additional input reliant transforms, it has several benefits:

1. DCT is executed in one combined circuit;
2. DCT has the capability to fold most data in least coefficients;
3. DCT reduces chunk like presence known as blocking artifact that outputs when edges among sub picture become visible [6]. The equation below shows the transformation of 1D_DCT:

$$P(u) = a(u) \sum_{N=0}^{N-1} f(x) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \quad (1)$$

for u = 0, 1, 2, … … …, N-1

In the same way, inverse transformation is explained as:

$$f(x) = \sum_{N=0}^{N-1} a(u) p(u) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \quad (2)$$

for x = 0, 1, 2, … … …, N-1

In the above equations $a(u)$ is explained as:

$$a(u) = \sqrt{\frac{2}{N}}\ for\ u \neq 0 \\ = \sqrt{\frac{1}{N}}\ for\ u = 0 \quad (3)$$

From the above equations, it is clearly seen that for $u = 0$,

$$P(u = 0) = \sqrt{\frac{1}{N}} \sum_{x=2}^{N-1} f(x)$$

First, the transform coefficient is the average value of sample series. In the past, this assessment is mentioned as DC Coefficient.

The equation below gives a transformation for 2D_DCT. This requires an addition of ideas offered in the previous segment to a 2-D space. Two-dimension DCT is a direct extension of one-dimension circumstance and is specified by

$$P(u,v) = a(u)a(v) \sum_{x=0}^{N-1} \sum_{y=0}^{M-1} f(x,y) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2M}\right] \quad (4)$$

Here, $a(u)$ *and* $a(v)$ are the same as defined in the earlier part in equation 3. All other transform coefficients are called the AC Coefficients. Inverse DCT is also defined as:

$$f(x,y) = \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} a(u)a(v)P(u,v) \cos\left[\frac{\pi(2x+1)u}{2N}\right] \cos\left[\frac{\pi(2y+1)v}{2N}\right] \quad (5)$$

DCT supports discrete image into segments of divergent significance. Discrete Cosine Transform is the same to the discrete Fourier grow to be: it converts a signal from spatial to frequency domain. DCT states a chain of various information aspects in relation to the amount of cosine capabilities wavering at special incidences. Discrete Cosine Transform is important to several functions in engineering and science, from lossy compression of audio and picture, to spectral for mathematical solution of fractional differential equations. Using cosine rather than sine capabilities is relevant in these functions: For compression, it turns out that these cosine functions are far more effective. However, variance equations cosines precise a certain alternative of edge circumstances. A Discrete Cosine Transform is a Fourier correlated change into just like the DFT, but making use of the simplest actual numbers [5].

B. Bird Swarm Optimization (BSO)

The BSO algorithm steps that we follow in our technique are given below:

A Bird Swarm optimization technique is proposed for the purpose of digital watermarking. Our first step is to find the gradient of input image. After finding the gradient of image, we initialize the algorithm by making use of $3 * 3$ matrix windows. This window is further processed to check all pixels. Window of Linear array is passed to BSO for optimization. Pixels of Linear window are compared with the threshold value to find Minimum pixels around it. The pixel lies on the edge if the pixel value is greater than the threshold

value. To implement the proposed technique, we follow these steps:
1: Calculate the gradient image g of an image; Find all pixel whose gradient is nonzero and make a sort a;
2: choose window of sizeNxN.
3: Apply BSA on function to determine the value of global optimumf_{max}.
4: If f_{max} >threshold value, consider window to be curve.
Input: N: number of birds checked by population
M: extreme amount of iteration
FQ: bird's frequency flight behaviors
P: foraging probability
$C, S, a1, a2, FL$: Constant parameters
$t = 0$; Initialize population and outline associated parameters

Evaluate the N individuals' fitness value, and find the best solution.

```
While (t, M)
    If (t % FQ– 0)
        For i = 1: N
            If rand (0, 1), P
                Birds forage
            Else
                Birds keep vigilance
            End if End for
    Else
    Divide swarm into two parts: producers and scroungers.
        For i = 1: N
            If i is a producer
                Producing
                Else
                Scrounging
            End if End for
End if Evaluate new solutions
```

If novel solutions are superior to their past ones, update them. Find the current best solution.

$$t = t + 1; \text{ End while}$$

With the help of BSA we find optimum location for water mark embedding. The embedding process follows DCT decomposition and the embedding factor α.

Steps for Data Hiding:

1. **Input image:** Image is engaged as an input for decomposition. On the other hand watermarked image is engaged for hiding purpose.
2. **Interpolation:** Interpolation is the procedure to determine the values of a purpose at positions lying between its samples. It attains this process by adding a continuous function through the discrete input samples. This process is applied on both steps in simple image and watermarked image as well.
3. **DCT:** After image interpolation, DCT is applied on both the images for the decomposition. To get higher entropy, region is applied. Discrete Cosine Transform shows information in relation to the frequency instead of an amplitude space. DCT divides picture into fragments of distinct incidences and less significant incidences are eliminated by quantization and significant incidences are utilized to get picture among decompression. It is applied on both images for decomposition.
4. **BSO:** After DCT, BSO technique is applied in input image. It is applied to get the optimum position for hiding the data. Our first step is to find the gradient of input image. After finding the gradient of image, we initialize the algorithm by making use of matrix windows. This window is further processed to check all pixels. Window of Linear array passed to BSO for optimization. Pixels of Linear window are compared with threshold value to find Minimum pixels around it. Pixel lies on the edge if the pixel value is greater than the threshold value.

After applying all the above mentioned steps, a watermarked image is obtained by adding the key and embedding factor. The key is applied on input image and embedding factor is applied on watermarked image. To get an original image, inverse DCT is applied on resultant image.

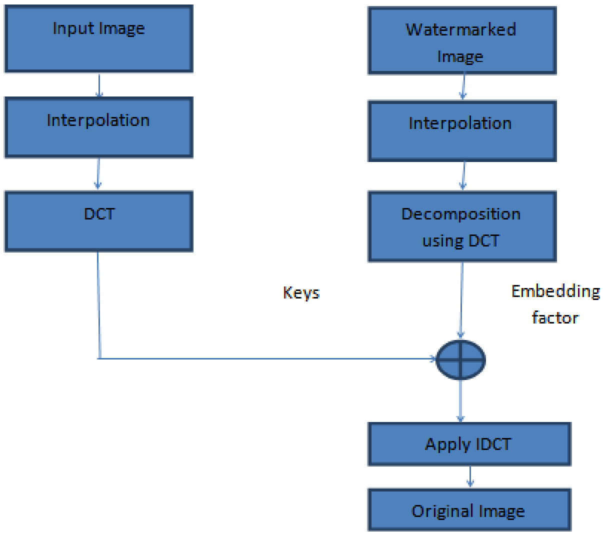

Figure 1: Flow chart for finding entropy regions

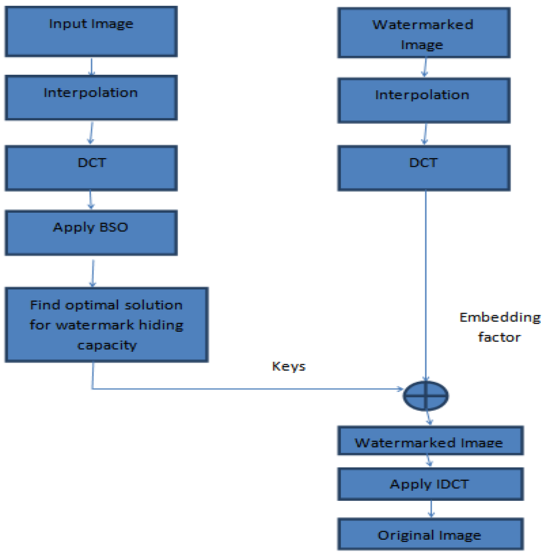

Figure 2: Flow chart for data hiding

III. RESULTS

The proposed algorithm dealt with image watermarking. The proposed technique has been applied to grey scale images of size 256*256 and is of format png, tiff, bmp, jpg. Also watermark which is to be added is of size equals to or less than that of the dimension of real image. The technique is applied to the different images and the same watermark image. The proposed technique can hide the entire watermark directly in to the equalized image. The research work also retains reliability of watermark image after being embedded into real image. Hiding information in the Bird Swarm optimization coefficients provide results in less computation time, more security and more invisibility. The evaluation of the algorithm is calculated in terms of PSNR, SSIM, NCC and SCC. The research has resulted in a good PSNR, value and improved security with the help of the secret key.

In this section, a few practical outputs are explained to show the success of the proposed watermarking scheme. For checking the output of this algorithm, the experiment is presented with MATLAB. Gray-level “baboon” picture is utilized as the host to insert the watermark. Additional “Cameraman” image is used as the watermark. The real host and watermarked image are exposed in Figure 3(a) and 3(c). In vision impression, this watermarked image is relatively close to real image. There is no difference between these two images. We can say that this algorithm can conceal watermark well. We can see that the watermark is invisible and the watermarked image looks almost the same as the original.

A. Performance Analysis

For the analysis of output, we utilized six images as watermark image. We utilized diverse real images and identical watermark image to get watermarked image and comparing PSNR, SSIM, NCC, SCC of diverse real and watermark image as exposed below.

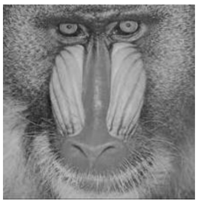
Fig 3(a): Real Image

Fig 3(b): Watermark imaged

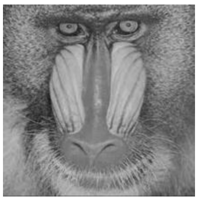
Fig 3(c): Watermarked image


Fig 4(a): Real Image

Fig 4(b): Watermark imaged


Fig 4(c): Watermarked image


Fig 5(a): Real Image

Fig 5(b): Watermark imaged


Fig 5(c): Watermarked image


Fig 6(a): Real Image

Fig 6(b:) Watermark imaged


Fig 6(c): Watermarked image


Fig 7(a): Real Image

Fig 7(b): Watermark imaged


Fig 7(c): Watermarked image


Fig 8(a): Real Image

Fig 8(b): Watermark imaged


Fig 8(c): Watermarked image

In the above results, we have taken input image and merged it with the watermark image. As a result, we get watermarked image as shown in the figures above.

Table 1
Comparison table of all the parameters

Images	PSNR	SSIM	NCC	SCC
Lena	33.271	0.99381	1.0015	0.99819
baboon	23.271	0.87817	1.0026	0.97954
Pepper	32.699	0.98394	1.0012	0.995031
House	33.271	0.989934	1.0015	0.99514
Flintstone	26.279	0.923445	1.0079	0.97654

Table 1 shows that Lena has the highest PSNR, SCC, SSIM values as compared to other images: House has the highest value. On the other hand, NCC is almost similar for all the images. After comparison, graphs are plotted versus each result. Five images were considered for the analysis.

Apart from the above results, we also implemented our proposed technique on each frequency band differently (red, green and blue). We applied watermark image on three different bands. From very beginning, we divided the image into three different bands and divided the same watermarked image into three different bands. Then, we merged two images (real and watermarked image). Two images are merged in such manner so that watermark image is properly hid. We perform this operation on color image for the purpose of distinction.

Apart from the results in Figure 9 to 12, we also implemented our proposed technique on each frequency band differently (red, green and blue). We applied watermark image on three different bands. From very beginning, we divided the image into three different bands and divided the same watermarked image into three different bands. Then we merged the two images (real and watermarked image). Two images are merged in such manner so that watermark image is properly hid. We performed this operation on color image for the purpose of distinction.

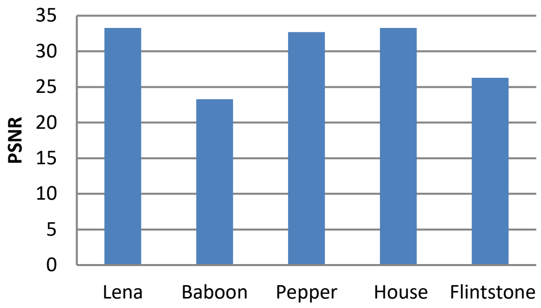

Figure 9: Comparison graph of PSNR and other images

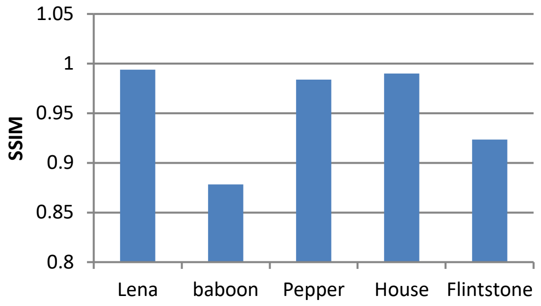

Figure 10: Comparison graph of SSIM and other images

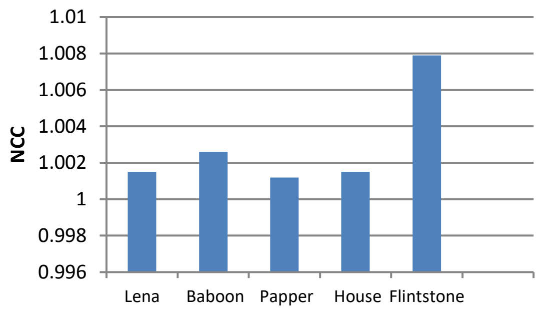

Figure 11: Comparison graph of NCC and other images

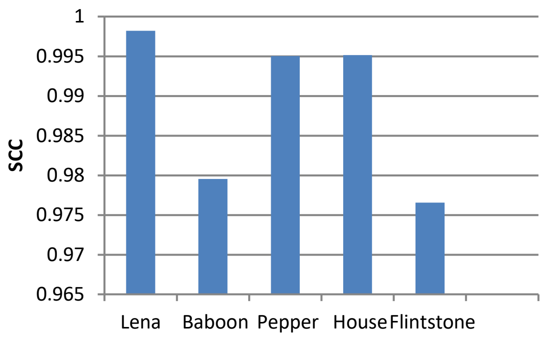

Figure 12: Comparison graph of SCC and other images

Table 2 relates the performance of projected technique with the previous techniques. In the table below, the first value of "Wu and Guan" is given in comparison with the two watermarked images i.e. "Camera man and Baboon". From the table, it is clearly seen that PSNR value in the case of Camera man is large i.e. 33.87 as compared to the value of Baboon which is 31.34

In the Second "Reddy and Varadarajan" paper survey PSNR value in both cases lies closer to each other i.e. 32.70 in the case of Camera man and 32.63 in the case of Baboon image. But when we compare the two previous techniques, "Reddy and Varadarajan", we achieved higher PSNR value as compared to "Wu and Guan". The third comparison, "Ganic and Eskicioglu" was performed on the basis of PSNR but we attained low value as compared to the previous ones.

The survey in the table below shows that "Jin et al" attain higher PSNR value in the past. The maximum PSNR value attained was 50.57 in the case of Camera man image but this PSNR value is low in case of Baboon image i.e. 46.82 which is high in past comparison.

In the case of our proposed technique, this PSNR value is high both in Camera man as well as in Baboon Image. In the proposed DCT technique which is totally dedicated towards robustness of the algorithm, it gives higher PSNR value as compared to previous techniques. In the case of Camera- man value of PSNR is 89.3 and the value of PSNR in Baboon is 84.75, which is very large as compared to the previous values.

On the other hand, when we check the capacity to hind watermark, the proposed technique of DCT and BSO based Watermarking shows the results of having maximum PSNR value is 94, which is high as compared to the others. The other value is 86.19 in case of Baboon image.

Our proposed technique unitized both the feature of BSO and DCT to enhance the value of PSNR. From the table, it is clear that performance of our recommended technique is better than the existing technique.

Table 2
Comparison Table

	Camera Man	Baboon
Wu and Guan [13]	33.87	31.34
Reddy and Varadarajan [14]	32.70	32.63
Ganic and Eskicioglu [15]	31.11	29.92
Jin *et al.* [16]	50.57	46.82
First and Qi [17]	37.97	32.82
Proposed DCT	89.3	84.75
Proposed DC and BSA based Watermarking	94	86.19

Table 2 compares the performance of the proposed technique with the previous techniques. From the table, it is clear that the performance of our proposed method improve in relation to the current technique.

Figure 13 shows the graphical representation of the Table 2. Figure 13 (a) and (b) show the graphical illustration of PSNR of Cameraman and Baboon images with the same watermark of signature. The PSNR takes the original images of baboon, cameraman, and watermark image of signature.

Figure 14 (a) to (h) show the partition of the original image into three different frequency bands i.e. red, blue and green. After this, we appled our watermarked image into each image. Figure 14 demonstrates the original image in blue, green and red band on left hand side, watermark image in the middle and output of the final results is shown in the Figure 14 (f), (g) and (h) images respectively.

IV. CONCLUSION

Watermarking is utilized to hand over copyright data over exposed network. Unseen watermark is embedded to real image to make it very secure. Integrity of information added in real image recollects. It is perceived that the proposed methods arises with a better PSNR value and improved security. Any stalker cannot discover that some watermark is emerged into real image and when annoying, person fails and would not be able to replicate or remove anything. Also we have calculated PSNR for different images and value of

PSNR is approximately equal to 94.The overall performance of the brand new algorithms also confirmed through comparisons with different methods within the literature to verify its superiority. Such opinions have been executed through the use of widespread gray scale and colour photos in conjunction with the watermarks of various dimensions.

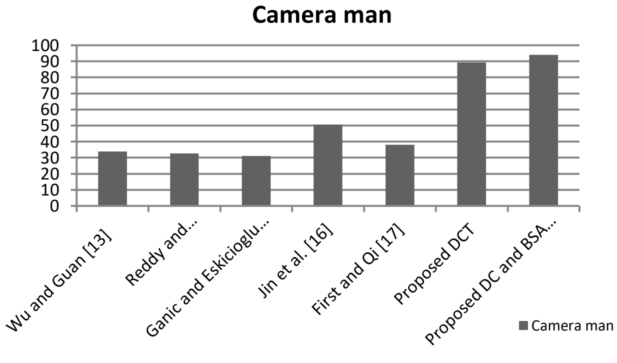

Figure 13(a) PSNR value comparison for Camera man

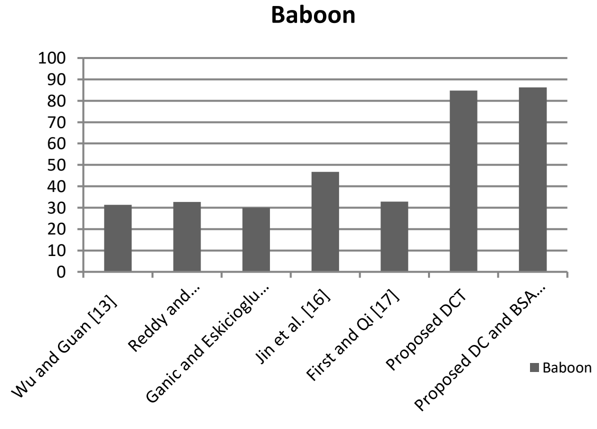

Figure 13(b) PSNR value comparisons for Baboon

Fig 14 (a) Original Image

Fig 14 (b) Blue band

Fig 14 (c) Green band

Fig 14 (d) Red band

Fig 14 (e) Watermark image for red, blue and green band

Fig 14 (f) Watermarked image for Blue band

Fig 14 (g) Watermarked image for Green band

Fig 14 (h) Watermark image for red band

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