Reversible Image Watermarking: A Detailed Survey

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Abstract— Since last 15 years the Watermarking techniques have drawn a lot of interest of the researchers, in reversing the original cover image as well as the watermarked information or also restoring the logo. This paper explores various reversible image watermarking techniques for digital images to achieve very high data embedding capacity while keeping distortion as low as possible. Various terms related to image watermarking are explored in this paper.

Key words: Histogram bin shifting, Difference Expansion (DE), Interpolation, Trigonometric functions, Location map, PSNR, KLD, SSIM

General Terms: Image Processing, Digital Watermarking

I. INTRODUCTION

In today's world digital media is available everywhere in the globe. It can easily be copied and used anywhere, anytime the people want to. Reversible Image Watermarking is also known as lossless data embedding where the data is embedded into the image in the reversible fashion. There are various attributes to be taken care of during watermarking an image. As this is for hiding data as well as to keep the image copy protected, there are some characteristics that should be withheld during watermarking the image. Robustness is the basic characteristic of any method, which is to stand by with all the preprocessing into the image. Another main characteristic is Data Hiding ability.

II. REVERSIBLE IMAGE WATERMARKING

A. Classification:

Image watermarking can be categorized with respect to carrier domain

1) Frequency Domain:

In this domain the watermark is added to the transform domain of the signal for example DCT, DWT, IDCT[11].

2) Spatial Domain:

In this domain the watermark is appended or added into the carrier image's pixel values to produce the watermark image. For example LSB Modification

The spatial Domain can further be divided into three more categories

a) Lossless Compression:

It uses coding redundancy in the image to add the watermark information. In this technique the image is compressed and the available space is used for embedding data into it.

b) Histogram Bin Shifting:

This method uses maximum and zero (minimum if no zero points are available) points of histogram and shifts the values between this points.

c) Difference Expansion:

In this technique the interpixel redundancy is used for embedding watermark. This scheme generates small values based on original image. It then expands the values to append the watermark.

B. Applications:

- Proof of Ownership: Multimedia owner may want to use watermark not for just identifying the copyright ownership but to prove ownership.E.g., Suppose A creates an image and puts it on his website, some B then steals the image, uses an image processing program to change the watermark then claims to own the copyright himself. In situations like given above watermarking is used [10].
- Authentication: As cameras increasingly embrace digital technology, the ability for undetectable tampering also increases. The content of digital photographs can easily be altered in such a way that it is very difficult to detect what has been changed. In this case there is not even an original negative to examine. There are many applications where the veracity of an image is crucial, especially in legal cases and medical imagingto detect whether the image is tampered or not [10].
- Owner Identification: The copyright are not more secure as they can be removed by cropping the image or by processing it. Watermarking prove itself very useful for the same purpose as it merges with the original image [10].
- Transactional Watermark(Fingerprint): One more application of watermarks is in the distribution of movie dailies. During the course of making a movie, the result of each day's photography is often distributed to a number of people involved in its production. These dailies are highly confidential, yet occasionally,a daily is leaked to the press. When this happens, studios quickly try to identify the source of the leak. Clearly, if each copy of the daily contains a unique transactional watermark that identifies the recipient, then identification of the source of the leak is much easier[10].
- Broadcast Monitoring: We can use watermarks for broadcast monitoring by putting a unique watermark in each video or sound clip prior to broadcast.

C. Properties:

1) Fidelity:

Perceptual similarity between original and watermarked image [11].

2) Tamper Resistance:

System resistance to hostile attacks.

There are two types of attacks namely

(1) Active attack
(2) Passive attack

(3) Collusion attack
(4) Forgery attack.

3) Data Payload:
Number of bits a watermark encodes within [11].

4) Robustness:
Ability to detect watermark after image processing[11]

5) Security:
The embedded information should not be disclosed or beyond the reliable detection by targeted attacks [11].

6) Computational Cost:
Different applications require the embedders and detectors to work at different speeds. In broadcast monitoring, both embedders and detectors must work in (at least) real time. The wide variation in cost and in speed requirements means that there is a wide variation in the required computational efficiency of watermark embedding and detection.

III. HISTOGRAM BIN SHIFTING

The reversible watermarking works differently for different sides: 1) Sender embeds the data into the carrier image; 2) Receiver extracts data from the watermarked image. The basic prototype reversible watermarking is given below.

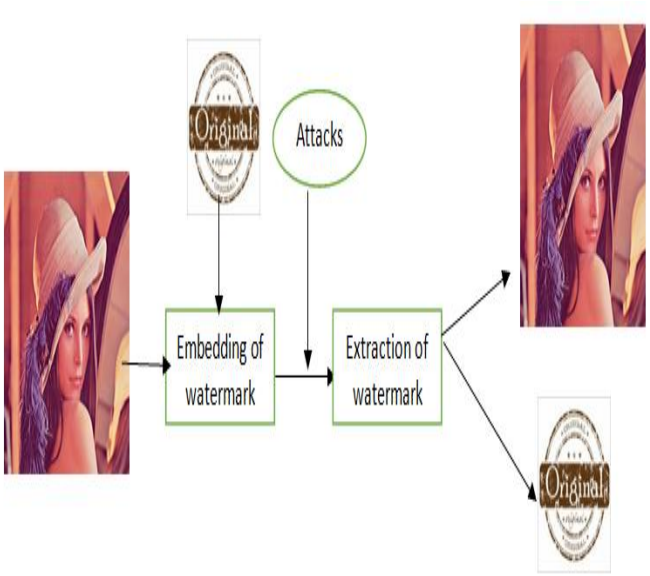


Fig 1: Basic block diagram of Reversible Image Watermarking

Technique	Description	Advantages	Disadvantages	PSNR (dB)
Interpolation Error Histogram Shifting[5]	Divide image into two parts. Three steps are there in Embedding as well as in Extraction: 1) Preprocessing, 2) Interpolation, 3) Watermark insertion.	Due to images modification in the first phases no overflow/underflow. Large boundary map is not to be used so data embedding capacity increases.	Does not use the pixels whose values are 0 or 255. Quality would degrade during multilayer embedding.	48.78
Invariant Image Classification and Dynamical Error Histogram Shifting[3]	Two methods are there 1) PSH: Used for the normal parts of the image 2) DEHS: For the parts where black background appears more.	In medical image where there are black backgrounds are covered in the major part of the image.	It is hard to identify the part of the image where to apply PHS and DEHS.	55.72
Maximum Histogram Gap of Image Blocks[2]	The image is first divided in 7 categories According to categories watermarking is added.	Increase embedding capacity in two ways: Divided whole image into non-overlapping blocks, Due to preprocessing on the receiving side no need extra information to predict the peak value.	Decreases embedding capacity in 6 categories with 2 bits while 3 bits will decreased in 7th category.	47.33
Rhombus Prediction and Histogram Modification[4]	Data embedding is performed by modifying the histogram of the generated errors.	Reversibility is achieved by saving the overhead information (including the pre computed location map) into the host image.	Certain expandable cells cannot be used for data embedding to avoid ambiguity at the decoder. Less helpful to improve the performance for high capacity embedding.	48
Improved Histogram Bin Shifting[6]	Create a histogram of image. Select zero point and peak point from it. Shift pixels between above points to the left. Add watermark bit into the peak point.	A variable point capable of accommodating the given watermark. Choose the optimal zero point if multiple zero points are present in the image to further enhance the distortion.	The embedding capacity is less compared to most other reversible watermarking technique.	54
Histogram Bin Shifting on Color images[1]	Uses YCbCr color model Two methods: 1) Pixel histogram, 2)Error histogram	The other techniques with RGB color results in relatively low embedding capacity as well as		53

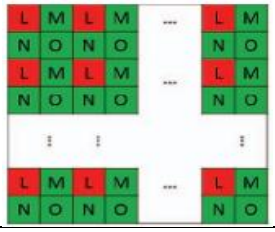
	Uses interpolation technique for predict the error values.	high distortion, YCbCrcolor model improved the both.		
Ripple Strategy and Histogram Shifting[7]	Set pixels in a block to several ripples. Generate the differences by subtracting pixels in the adjacent inner ripple from the pixels in the outer ripple. 	The three highest pixel difference bins occur most frequently at 1, 0, and 1, thus the proposed method need not remember the peak-point and zero-point information for secret extraction and image recovering.	Embedding capacity is still remains low compare to the previous version of it.	48.70

Table 1: Existing Techniques: Comparison (Histogram Bin Shifting)

IV. DIFFERENCE EXPANSION

The former development of Difference Expansion was proposed by Jun Tian[9]. The techniques use the average and the different value of adjacent pixels. The aim is to lower the difference and increase the average value. In 2012 the improved version of this algorithm with some modification is lunched [12]. The modified versions enhanced the data capacity as well as define two more terms for Structural Similarity Index and KLD which is for security measures.

Technique	**Description**		**Advantage**	**Disadvantage**	**PSNR (dB)**
Difference Expansion[10]	Embedding Calculating difference values, Partitioning difference values into four sets, Create location map, Collect original LSB, Data embedding, Inverse transform.	Extraction Calculate the difference values, Create two sets, Collect LSBs, Decode the location map, Content authentication and restoration.	Uses its own pixel values' average and difference for embedding the information into it. It also provide high data capacity with high visual quality.	There is no any method to restore the original content after attacked or manipulated the image.	44
Modified Difference Expansion[12]	It works same as Tian's algorithm with some modifications. It gives two more methods for Contrast comparison (SSIM) and security measure (KLD).		It increases the embedding capacity as well as make some modifications for contrast comparison with original image.	Enhancement in algorithm has increased the complexities during watermark embedding and extraction	46

Table 2: Difference Expansion

V. INTERPOLATION AND TRIGONOMETRIC FUNCTIONS

In this method the data is embedded into the cover image using interpolation techniques and some Trigonometric functions. For the purpose the grey level is used for embedding the data [8]. The interpolation can be done by any method. Trigonometric functions are used to complexity the watermark image as compared to the original cover image. The data capacity using this algorithm has been improved with PSNR nearing to 50.

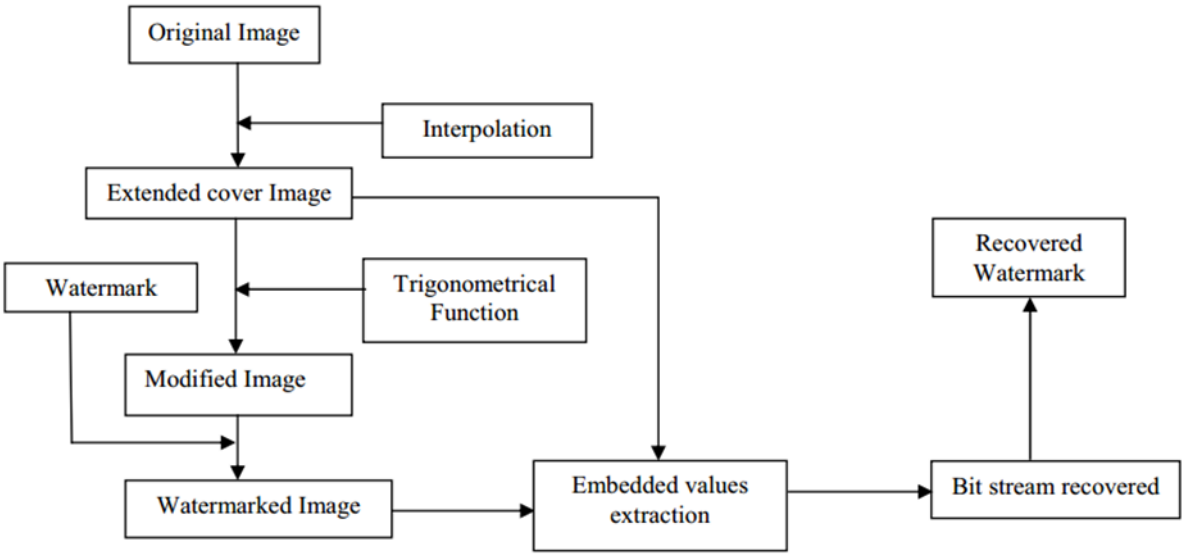


Fig. 2: Block diagram of Interpolation Technique

VI. CONCLUSION

This paper explores the comparison of various image watermarking algorithms that could be useful to the researchers. With their advantages and the disadvantages researcher can get best options for their interest of study in reversible image watermarking.

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