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Adaptive Image Watermarking based on Mean-Shift Clustering

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Abstract

With the increase in usage of social media communication proving ownership rights on the multimedia content like video, audio, text, graphics, etc., is the major challenge faced by the researchers. Watermarking is the process of hiding digital content in multimedia which can be used for proving ownership credentials later. A lot of work is contributed by the researchers in this area, but still there is a need for more robust methods. In this paper we discover the features in the image by using mean-shift clustering method , which are then used for embedding the watermark content. Later, for watermark extraction again mean-shift clustering method is used to identify the features where the watermark is embedded and extraction is done from those features.

Keywords; *Image Watermarking; Discrete Cosine Transform; mean-shift Clustering;*

I. INTRODUCTION

Digital images used in social media communication are prone to modifications using various tools of image processing. Watermarking method is used to hide the ownership credentials in the digital multimedia data like audio, video, text, graphics and images. There is a need for authentication and validating the integrity of such data[1]. Hiding the data can be done in steganography and watermarking methods but, steganography is used to hide the secret data which is confidential and not to be revealed to man-in-the middle. In steganography secret data is hidden in source data. Steganography do not bother about what source is used. The only botheration in steganography is how secretly data is hidden in source data. Watermarking on the other way hide ownership details in the multimedia data which is used to prove who is the owner. Here in watermarking we are more bothered about the source data. Watermarking is used for properly authenticating the source data and confidently proving who the right owner is, for the source data and also prove that the content of the data is not tampered through various attacks [2].

Many methods were proposed for embedding the watermark in the multimedia data [2]. Most of the algorithms were developed by taking image as the source and embedded content is also mainly image. These methods still require more enhancements to make the source content more robust against various attacks. Clustering is one method where the attackers cannot find out where exactly the watermark content is stored. In this paper we will implement more robust method for clustering. We used mean-shift clustering method to identify the features in the source image, where the watermark image is embedded and latter extracted from the same features in the watermarked image.

The remainder of this paper is organized as follows. A brief study of the related work is done in section 2. The proposed methodology is discussed in section 3. The results of the proposed algorithm is discussed in section 4. The conclusion is done in section 5.

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Table 1.Abbrevations used

Abbreviations	Descriptions
DCT	Discrete Cosine Transform
DFT	Discrete Fourier Transform
DWT	Discrete Wavelet Transform
IWT	Integer Wavelet Transform
FCM	Fuzzy C-Means Clustering
KM	K-means clustering
SIFT	Scale Invariant Feature Transformation
HVS	Human Visul system
MSE	Mean Square Error
MSC	Mean Shift Clustering
CI	Cover Image
WM	Watermark Image
WI	Watermerked Image
IDCT	Inverse Discrete Cosine Transform

II. RELATED WORK

In this section a brief study of the clustering methods used by the researchers for embedding watermark is done

In 2009 Wei-che. et al.[4] used fuzzy c-means clustering. For FCM they embedded authenticated data by forming C different clusters where the data is embedded in the image and later used tamper detection procedure which will be used to identify whether the image is modified anywhere. They used FCM method to form C clusters made LSBs of pixels in those clusters as null values and embedded the watermark in those pixels. Here the watermark is embedded to prove the integrity of the image, that is if the image is tampered or not. This method does not prove who the right owner is if the LSBs of the watermark image is modified.

In 2010 Huawei Tian. et al.[5] used Scale Invariant Feature Transformation (SIFT) to identify the features where the watermark is to be embedded. After identifying the features the feature regions are then divided into k clusters using k-means clustering algorithm. They embedded one watermark bit in one cluster. They have divided the features into k-clusters and could embed maximum of k-bits of the watermark. If the watermark image is more than k-bits then there is need to increase the number of clusters.

In 2014 Mohamed Tahar Ben Othman [6] used clustering on color image where they divided clusters based on clustering index and then further subdivided into sub clusters based on red, blue and green colors of the pixels and then watermark is embedded in those clusters. And same procedure is implemented for extraction of the watermarked image. In this method the number of pixels contribution to watermark embedding are very less.

In 2013 Bassem S. Rabil et al.[7] used feature extraction algorithm to extract facial areas and then clustering is performed to form k number of clusters where watermark is embedded but if there is distortion in the facial area this method is fragile.

In 2012 Lingling An. et al.[8] used k-means clustering to for k number of clusters in the image and then integer wavelet transformation(IWT) is performed on the cluster to embed watermark. Finally they proved that their method has better performance compared to embedding watermark in spatial domain.

In 2016 R.Suganya. et al [9] used k- means clustering method applied on the LSB bits in of the pixels. They have divided the clusters based on number of 0's and 1's in the LSB bits formed the cluster, They embedded watermark bits in those clusters. This method is used detect whether the image is tampered or not.

In 2008 Jianzhen Wi et al [10] performed FCM clustering on the DCT coefficients by using Q-quantization table in JPEG and embedded watermark in those clusters. The method is used to Extract the watermark from the watermarked image

The comparison of various algorithms and challenges of those algorithms are listed in the table 2.

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Table 2. Features and challenges of image watermarking based on clustering methods

Author [citation]	Method used	Features	Challenges
Wei-che. et al	FCM	• Used for tamper detection • Watermark image is imperceptible	• Restoration of tampered regions cannot be done • If all LSBs are modified we cannot prove the ownership
Huawei Tian. *et al*.	KM	• Algorithm is semi-blind • Algorithm is invariant to geometric distortions	• Embedded watermark size is very less • If watermark size is more then it take more time to increase the number of clusters
Mohamed Tahar Ben Othman	Pixel clustering	• Used for color images • Each cluster is subdivided into sub clusters if needed • Robust against rotation and cropping attacks	• Embedding watermark capacity is very less
Bassem S. Rabil et al	KM	• Used for watermarking in the face regions by identifying face features	• Doesn't work for heterogeneous stream of face images
Lingling An. et al	KM	• It is more reversible • It is more robust • Used transformation domain	• Less embedding capacity
R. Suganya. et al	KM on LSB	• Embedding watermark is easy • It is Blind Watermarking method	• Does not prove ownership if the image is tampered • Not Robust
Jianzhen Wi	FCM and HVS	• Used q-quantization method for FCM clutering • More Robust	• It require cove image to verify the watermark .. It is not blind watermark method

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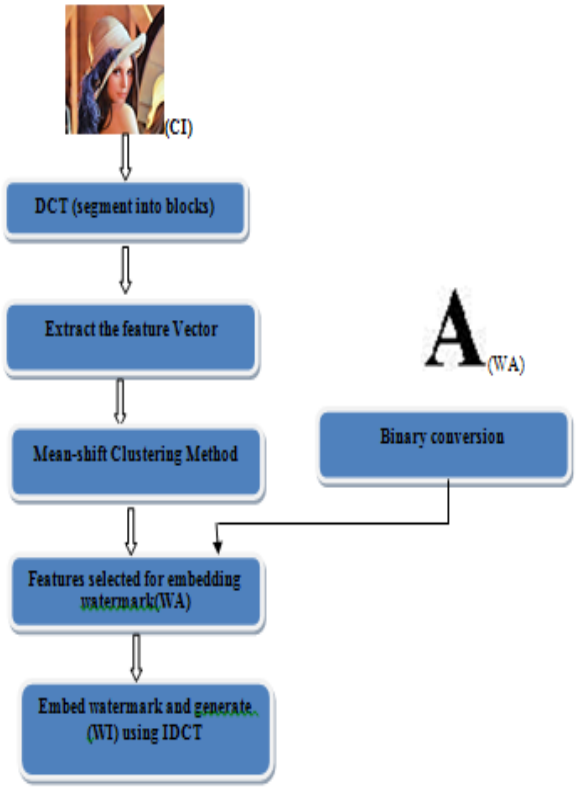

Fig. 1. proposed method of mean-shift clustering-based image watermarking

III. ARCHITETURAL VIEW OF PROPOSED ADAPTIVE IMAGE WATERMARKING BASED ON MEAN-SHIFT CLUSTERING

A. Proposed Methodology`

Although many methods of watermarking is been invented there is a need of more robust watermarking methods that will be used to prove ownership credentials. There is need of those algorithms which sustain against various watermarking attacks like collusion attacks etc,.[3]. The methodology here proposes more robust algorithm for embedding watermark in transformation domain by forming clusters using mean-shift based clustering algorithm is shown in fig 1.

The steps used in the proposed image watermarking algorithm is compiled in algorithm 1.

Algorithm 1: Pseudo code of proposed watermark based on mean-shift clustering method
Input: Cover Image Step 1: Apply DCT to divide the cover image(CI) into blocks of size 8*x8 Step2: Compute the feature vector Step 3: Apply mean-shift clustering method to obtain C clusters Step 4: Select the highest density region where the watermark is to be Embedded Step 5: Apply IDCT and generate the watermarked Image

Here the source image(CI) is divided into blocks using DCT of size 8x8. Further each block is again divided into 2x 2 blocks from which features vectors is extracted by scanning both horizontally and vertically. After calculating feature vector for all the blocks of the source image the mean-shift clustering algorithm is applied and suitable features for embedding watermark is identified. These features and embedded with the binary watermark (WA). Then the Inverse DCT is applied on the resultant image which is the intended watermark Image(WI). The main advantage of this method is that the method is more robust against collusion attacks.

B. Objective of the Proposed Method

The main objective of the proposed method is to minimize MSE. Mean Squared Error (MSE) is a measure that tests if two pictures are similar. It is performed using the equation.

$$MSE = \frac{1}{MeNe}\sum_{x=1}^{Me}\sum_{y=1}^{Ne}\left[I_O(x,y) - I_W(x,y)\right]^2 \qquad (1)$$

Here I0(x,y) is the Cover image and Iw(x,y)is the watermarked image.

C. Mean-shift Clustering Method

The mean-shift clustering algorithm is based on calculating centroid repeatedly until no further modification to the cluster centroid is done. This algorithm is based on scanning the whole image using sliding-window. The sliding window scans the

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Image pixel by pixel and allocated the pixels with similar properties to the similar cluster. The centroid is shifted based on the mean of the available pixels in the cluster. All duplicated pixels are removed from the cluster during sliding window scanning. The pseudo code of mean-shift clustering is demonstrated in algorithm 2.

Algorithm 2: Pseudo code mean-shift clustering

Step 1: A circle with radios R is selected as the sliding Window.

Step 2: Select a random seed Cs called centroid in the sliding window

Step 3:For Each pixel.in the window distance between the pixel Dp and the centroid Dc is computed if $(|Dc - Dp| <= T)$ then the pixel is assigned to the cluster where T is the threshold

Step 4:Calculate the mean of all the pixels assigned in the cluster

Step 5: Shift the centroid Cs according to the mean

Step 6: Repeat step1 to step 6 until there no convergence

Step 7: select new random seed Cn from the pixels that is not allocated to the cluster.

Step 8: Repeat step1 to step 7 until all the pixels re allocated to the one or the other cluster.

Mean-shift clustering method unlike K-means algorithm is a method that doesn't require prior knowledge of number of clusters. During the calculation the centroid will move from non-dense areas to dense areas. The working principle of the algorithm is shown in Fig 2. The main advantage of mean-shift clustering is the number of clusters is not fixed. The disadvantage of mean-shift clustering is the complexity of the algorithm lies in the size of R radius of the circle of sliding window. The performance of mean-shift with different radius is shown in Fig 3 .

In an Image f(x,y) of size M xN ,in the sliding window of radius r the centroid density with c(x,y) is calculated as

$$f(x,y) = \frac{1}{M * N} \sum_{x=1}^{M} \sum_{y=1}^{N} \left[\left(c(x,y) - c_W(x,y)/r \right) \right]^2$$

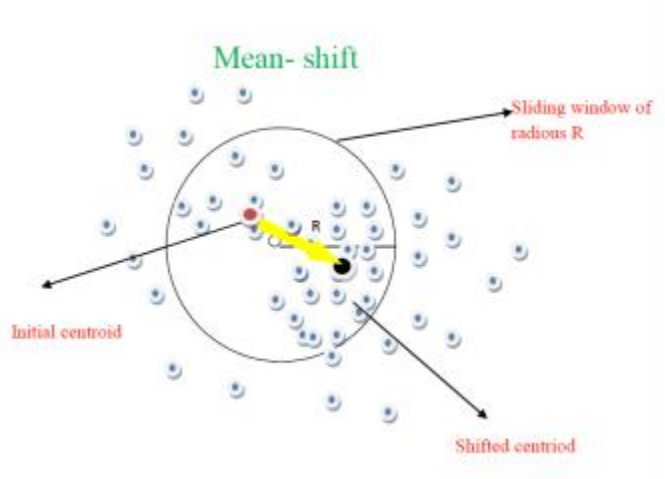

Fig.2 Mean-shift method

The cluster with maximum density is selected for inserting the watermark.

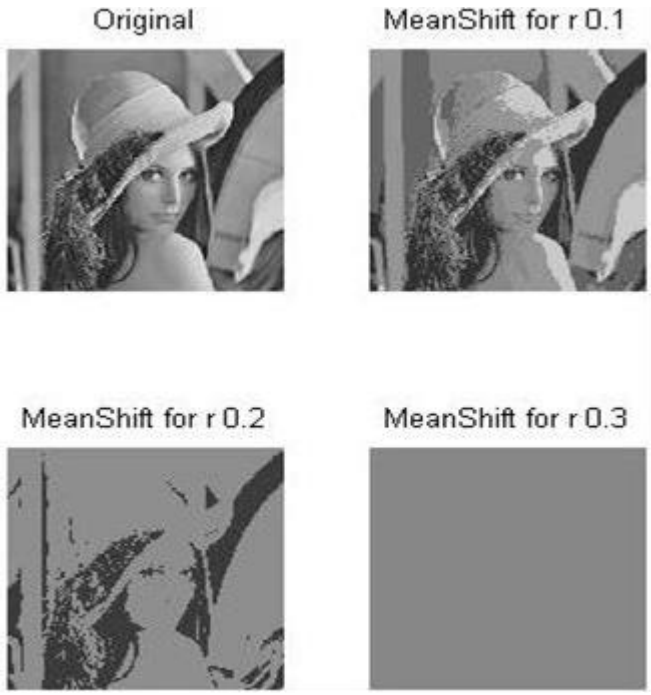

Fig 3. Performance of MSC with varied radius(r) for gray scale image.

D. Watermark Embedding

For Embedding watermark in the clustered image the watermark image (WA) is converted to binary representation of 1-d vector. In the selected pixels of the WA set LSB bit to 1 if WA is 1 otherwise 0.

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Algorithm 4: Algorithmic for watermark embedding

Input: Selected pixels i and j for embedding ineach block

Step 1: For each selected pixel in clustered image

if WA(i,j)=1 then set LSB bit to 0

otherwise

WA(i,j)=0

Output: Watermarked blocks

E. Extraction

The extraction of watermark from the watermarked image(WI) is done by applying the reverse methodology.

Process is demonstrated in the Fig 4.

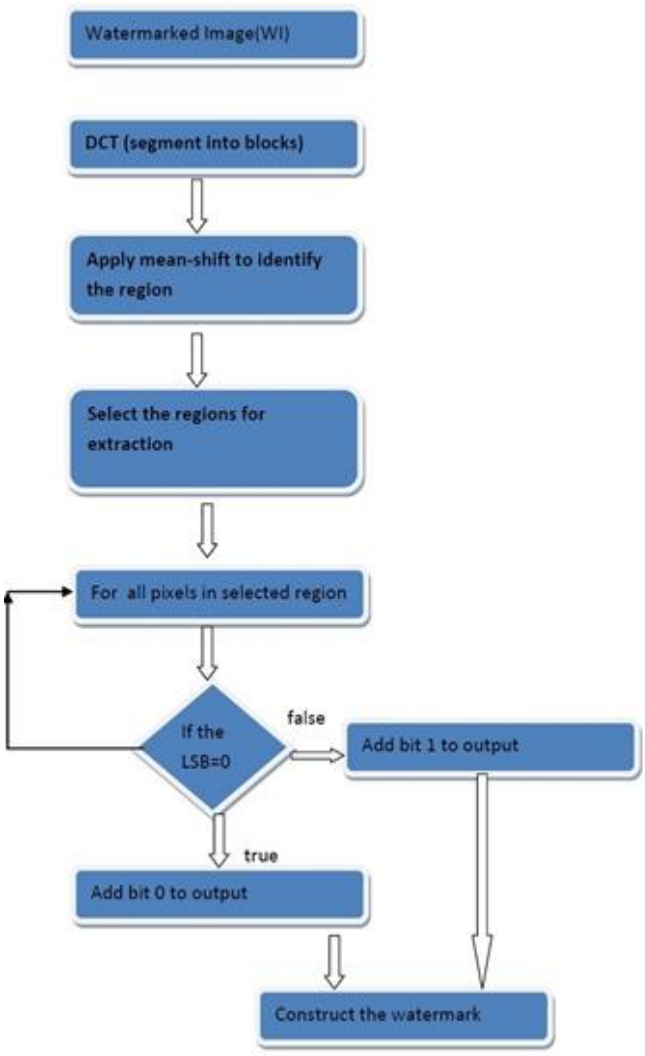

Fig 4. watermarking Extraction

IV. RESULTS AND DISCUSSIONS

Evaluation of the proposed adaptive watermarking method based on mean-shift clustering is done in this section. The algorithm is applied on various categories of images like dark, smooth, classic, pattern images etc.

The cover image(CI) is embedded with watermark(WA). Watermarked Image (WI) generated after embedding. Later WA is extracted from WI. Watermarking using different watermarking algorithms are shown in fig 5. Performance of various algorithms using performance measures like MSE , SSIM is shown in table 3. Table 3 clearly shown that proposed algorithm has better performance. The watermark extraction for the smooth images like the one used in Fig 5(b) got failed using DWT and DCT-DWT algorithms.

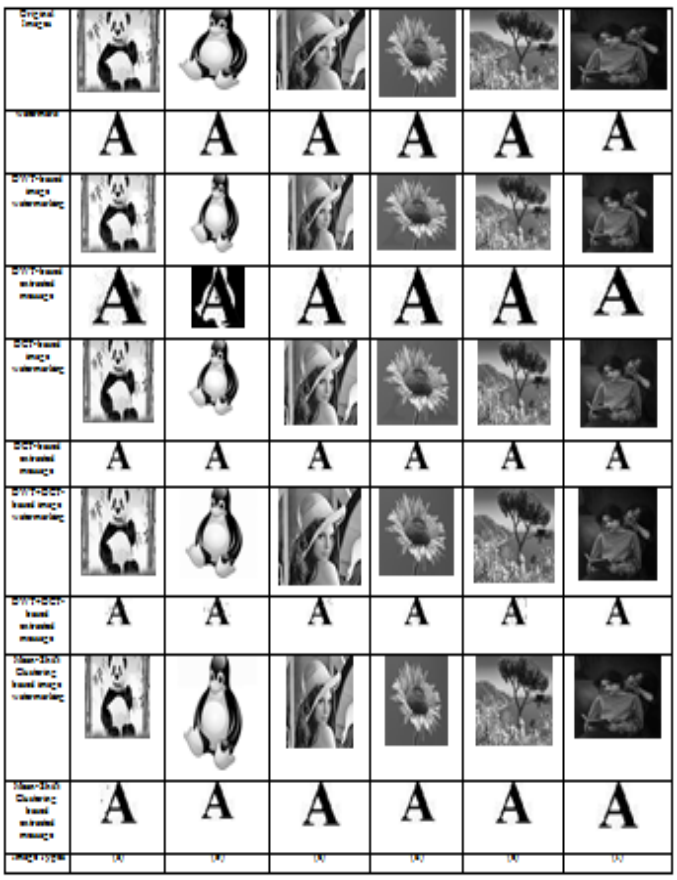

Fig 5.Experimental Results of watermarked

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images and extracted images of different image types

Table 3. Analysis on different error measures for different categories of images

Error Measures	DWT [29]			DCT [28]			DWT+DCT [29] [28]			Mean- Shift Clustering					
	Image 1	Image 2	Image 3	Image 1	Image 2	Image 3	Image 1	Image 2	Image 3	Image 1	Image 2	Image 3	Image 4	Image 5	Image 6
SSIM	1.0	1.0	1.0	0.96	0.93	0.98	0.98	0.97	1.0	0.98	0.97	1.0	0.98	0.97	1.0
MSE	0.007	0.007	0.007	0.0001	0.0001	0.0001	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}	7.23×10^{-5}

V. CONCLUSION

In this paper we proposed an adaptive mean-shift clustering method to embed the watermark in the cover image. We proved that the performance of the proposed watermark image is better that the conventional methods. Our adaptive method of shifting the cluster point until convergence makes the method more robust compared to other methods of clustering.

In future work we will cluster the watermark as well and embed the each cluster of watermark in different cluster of the image.

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