Improved Image Watermarking using Fast Fourier Transform and Arnold Transform based SVD Technique

Jaspreet Kaur[1], Er.Varinderjit Kaur[2], Dr.Naveen Dhillon[3]
[1]P.G, Student, Department of CSE, RIET, Phagwara
[2]HOD, Department of CSE, RIET, Phagwara
[3]Principal of RIET, Phagwara

ABSTRACT:

Image watermarking is becoming popular method in digital image control because it has capability to secure the images by injecting watermarks in them. A new watermarking technique on the basis of the wavelet domain in combination with the Fast Fourier transform and Arnold transform based SVD will be proposed. This algorithm includes the benefits of the three transforms, therefore have significantly more robust results. The algorithm might help meet the robustness and imperceptibility traits of a good watermarking algorithm by considerably improving the visual quality of the watermarked image and being robust against common signal processing operations and attacks. Different type of multiple attacks will also be considered to evaluate the effectiveness of the proposed technique. The experiment has clearly shown that the proposed technique outperforms over the available techniques.

Index terms: Watermarking Scheme, FFT, Arnold transform, SVD technique

1. WATERMARKING SCHEME

The safety and authenticity issues of digital image are getting popular than ever, due to the rapid growth of multimedia and internet technology. On internet, digital images can be generally distributed among the various customers at various geographical places. Each and every day massive amount digital images are given over the internet in a variety of applications. As digital technology allows unauthorized imitation of digital images, the defence of the copyrights of digital picture is a very important issue. Image watermarking systems are used to protect the digital images. Watermarking is the procedure to cover up some information which will be named watermark or tag in to the original data(image, audio or video) in a way that watermark may be removed or recognized later to produce an assertion in regards to the object. Watermarks of varying level of visibility are put into demonstration media as a guarantee of authenticity, quality, ownership and source. The image watermarking systems have been popular to solve the copyright protection problems of digital picture related to illegal use or distribution .

Watermarking scheme quality is decided applying robustness, transparency and capacity. Transparency indicates after installation of watermark the initial picture should not be distorted. Robustness relates to attacks. If watermark treatment is hard to different attacks like rotation, scaling, compression, noise then watermarking scheme is robust. Capacity indicates volume, which are placed to cover image. More volume indicates it's possible to cover large amount of data **[1].**

2. TYPES OF WATERMARKING

Watermarking has been around for a number of ages, in the proper execution of watermarks found initially in basic report and consequently in report bills. But, the subject of digital watermarking was only produced over the last 15 years and it is today being useful for numerous applications. An electronic digital watermark is distinguishing way data to be protected. Watermarking practices can identify in to several categories. For example, watermarking can perform in the spatial domain and the frequency domain **[2].** Watermarking practices can identify in to these four groups in accordance with the type of the multimedia report to watermark. In line with the human understanding, digital watermarks can identify into three different categories like **-** Visible watermark, Invisible Robust watermark, Invisible Fragile watermark, Dual watermark.

I. Based on characteristics/robustness

a) Robust: Robustness watermarking is especially applied to indicator trademark data of the digital operates, the stuck watermark may resist the most popular modify control, image control and lossy pressure, and the watermark isn't destroyed following some assault and may still be noticed to offer certification. It resists various problems, geometrical or non-geometrical without affecting stuck watermark.
b) Fragile: Delicate watermarking is especially used for integrity safety, which should be very sensitive and painful to the improvements of signal. We could establish whether the data has been tampered based on the state of sensitive watermarking.
c) Semi fragile: Semi sensitive watermarking is effective at tolerating some degree of the change to a watermarked

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image, such as the supplement of quantization sound from lossy compression.

II. According to linked media/host indicate

a) Picture watermarking*:* This really is applied to cover up the specific data in to the picture and to later discover and acquire that specific data for the author's ownership.
b) Video watermarking: This provides watermark in the video supply to control video applications. It's the extension of picture watermarking**[3]**. This method involves real time removal and robustness for compression.
c) Audio watermarking*:* This request place is one of typically the most popular and warm situation due to internet audio, MP3.
d) Text watermarking: This provides watermark to the PDF, DOC and other text file to avoid the changes built to text. The watermark is introduced in the font shape and the room between characters and line spaces.
e) Graphic watermarking: It embeds the watermark to 2D or 3D computer generated graphics to point the copyright.

III. In accordance with perceptivity:

a) Visible watermark: The watermark that is seen in the electronic data like stamping a watermark in writing, (ex.) tv routes, like HBO, whose emblem is visibly superimposed on the part of the TV picture.
b) Invisible watermarking: There is engineering available which could insert information in to a picture which can not be observed, but can be interrogated with the proper software. You can't stop the theft of one's images in this way, but you can show that the picture that has been taken was yours, which can be almost as good.

3.FEATURES OF DIGITAL WATERMARKING

Different top features of watermarking are as follows,
a) Robustness: Robustness describes that the watermark embedded in data has the capability of surviving following a variety of control procedures and attacks. Then, the watermark must be strong for basic signal control function, geometric transformation and destructive attack.
b) Imperceptibility*:* Watermark cannot be seen by eye or perhaps not be noticed by individual head, just be found through specific control or devoted circuits. It could be found by an official organization only. Such watermarks are employed for material or writer certification and for sensing unauthorized copier.
c) Safety: A watermark process is considered secure, if the hacker cannot take away the watermark with no whole knowledge of embedding algorithm, detector and arrangement of watermark**[4]**. A watermark must only be accessible by licensed parties. That necessity is considered as a security and the watermark is generally attained by the usage of cryptographic keys. Watermark information owns the unique appropriate indicator to recognize, only the licensed people may officially detect, get and also change the watermark, and hence manage to obtain the objective of trademark protection.
d) Verifiability: Watermark must manage to give whole and trusted evidence for the possession of copyright-protected information products. It can be utilized to determine whether the object will be secured and monitor distribute of the data being secured, identify the authenticity, and get a grip on illegal copying.
e) Volume and knowledge payload*:* Volume of the watermarking program is defined as the most quantity of data that may be stuck in the cover work. How many watermark bits in an email in knowledge payload and the most consistency of knowledge payload in a picture may be the watermark capacity. Depending on the program some watermarking techniques need a knowledge payload exceeding 10,000 bits. A watermark may have large knowledge volume but minimal knowledge payload.
f) Computational charge: In order to reduce computational charge, a watermarking approach must be less complex. Watermarking techniques with large complicated algorithms will demand more application as well as electronics assets and thus incur more computational cost. The Computational simplicity is usually chosen in resource-limited environment like mobile devices.
g) Watermark recognition stability: To model powerful watermarking in a trademark security scenario, we can make use of a watermark that consists of a pseudo-random binary routine to represent the identity of a trademark holder. The relationship price involving the identity and a properly discovered watermark is generally quite high set alongside the relationship price involving the identity and arbitrarily selected watermark. In this instance a chart of relationship prices plotted against watermarks features a significant top at the properly discovered watermark which fits to the trademark holder's identity. That is watermark recognition outcome.
h) Blind or non-blind recognition of watermark: A watermarking strategy is said to be blind, if it does not require unique image to recuperate the watermark from the watermarked image. Alternatively, a watermarking strategy is said to be non-blind, if it requires unique image for getting the watermark from the watermarked image. The blind strategy is also referred as oblivious. The non-blind watermarking methods are far more strong than blind watermarking methods because of availability of unique cover image at the time of detection. However, blind or oblivious watermarking methods are far more popular. The oblivious watermarking methods decrease the overhead of price and storage for saving unique images.
i) Tradeoff between performance factors: A simple theory of watermarking would be to exploit redundancy in

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pictures for embedding the watermark information. Provided the truth that most of the present image pressure algorithms aren't perfect, watermarking is made probable by embedding extra data in the repetitive parts. Additionally, enhancing watermark robustness typically involves more image disturbances and increased redundancy. This causes decrease imperceptibility and more likely to be eliminated below destructive attacks.

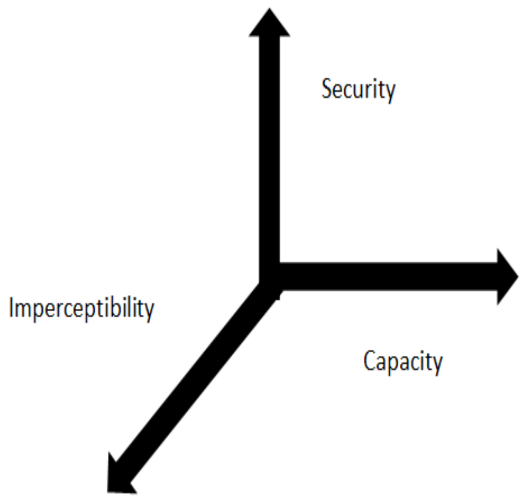

Figure 3.1: The Tradeoffs among Imperceptibility, Robustness, and Volume

4. WATERMARKING TECHNIQUES

a) Singular Value Decomposition: SVD is a successful numerical analysis tool used to analyze matrices. The Singular Value Decomposition of image I of size m x n is obtained by the operation:

$$I = USV$$

where U is column-orthogonal matrix of size m x m , S could be the diagonal matrix with positive or zero elements of size m x n and transpose of n x n orthogonal matrix V. The diagonal entries of matrix S are referred to as the singular values of I. The columns of U matrix are referred to as left singular vector and the columns of the matrix V are referred to as the proper singular vector of I**[5]**. Thus, each singular value represents the luminance of image layer and the corresponding couple of singular vector represents the geometry of the image layer. In SVD based image watermarking, several approaches are possible. A common method is to utilize SVD to the entire cover image and modify all of the singular values to embed the watermark. The important property of SVD based watermarking is that the large of the modified singular values of image will change by really small values for different types of attacks.

b) Fast Fourier Transform: FFT algorithm computes the Discrete Fourier Transform (DFT) of a string, or its inverse. Fourier examination switches a signal from its unique domain to a representation in the frequency domain and vice versa. A FFT quickly computes such transformations by factorizing the DFT matrix into a product of short (mostly zero) factors. Consequently, it handles to lessen the difficulty of research the DFT from, which arises if one simply applies the definition of DFT, to where is the information size. An FFT is a method to compute the exact same effect faster: research the DFT of N points in the trusting way, using the classification, takes $O(N^2)$ arithmetical operations, while an FFT can compute the exact same DFT in just $O(N \log N)$ operations. FFTs are of good value to a wide variety of programs, from digital signal processing and resolving partial differential equations to formulas for fast multiplication of large integers.

An FFT computes the DFT and creates exactly the same effect as analyzing the DFT classification immediately; the most crucial huge difference is that the FFT is much faster. (In the current presence of round-off problem, several FFT formulas will also be far more precise than analyzing the DFT classification immediately, as mentioned below.) Let $x_0, \ldots, x_{N-1}$ be complicated numbers. The DFT is identified by the system

$$X_k = \sum_{n=0}^{N-1} x_n e^{-i2\pi k \frac{n}{N}} \qquad \text{where } k=0,\ldots\ldots,N-1$$

c) Arnold Transformation: Different methods can be used for image scrambling. One of the method is Arnold transform. Picture scrambling identifies change of the picture, which rearranges the spatial position of the pixels according to some principles, and makes picture distortion for the goal of security. If the change principles and recommendations were not given, the original picture cannot be reconstructed. Frequent methods for scrambling include Arnold change, Miraculous change, Fractal Hilbert bend, Conway sport and Graycode change etc **[6]**.

Arnold change is employed to struggle watermarking image. This is a change proposed by Arnold in his ergodic theory named cat-face transformation. Think picture pixel coordinates are x and y, $x, y \varepsilon \{0,1,\ldots N\text{-}1\}$ (N may be the obtain of picture array), Arnold change is:

$$\begin{pmatrix} X' \\ Y' \end{pmatrix} = \begin{pmatrix} 1 & 1 \\ 1 & 2 \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix} \bmod(N)$$

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5. PROPOSED METHODOLOGY

I. Watermark Embedding Process

The detailed insertion process for the proposed approach is given below:
Step1: Consider the Cover Image of size N*N and let it be C1. If it is a color image select the color channel.

Step2: Apply Fourier transform to cover image C1 and name it C2.
A Fast Fourier transform (FFT) algorithm computes the discrete Fourier transform (DFT) of a sequence, or its inverse. Fourier evaluation switches a sign from its unique domain (often time or space) to a representation in the frequency domain and vice versa. A FFT quickly computes such transformations by factorizing the DFT matrix into a product of sparse (mostly zero) factors.

Step3: Apply DWT to C2 to decompose it in to four N/2 x N/2 sub-bands LL1, LH1, HL1 and HH1.
Applying DWT in 2D images corresponds to 2D filter image processing in each dimension. The input picture is divided into 4 non-overlapping multi-resolution sub-bands by the filters, particularly LL1 (Approximation coefficients), LH1 (vertical details), HL1 (horizontal details) and HH1 (diagonal details).

Step4: Consider HH1 band and then DWT comes into action to decompose DWT coefficients in to four N/4 * N/4 sub bands LL, LH, HL and HH.
The sub-band (HH1) is processed further to obtain the next coarser scale of wavelet coefficients.

Step5: Use SVD to HH, block by block and for each block calculate HH=U1*S1*V1, and get U1, S1 and V1.

Step6: Modify Singular values of SVD ie S1 by standard values of Arnold Transformation
such as $S2=S1*\begin{pmatrix}1 & 1\\ 1 & 2\end{pmatrix}$
Arnold Transformation is an image scrambling method to secure the image data by scrambling the image into an unintelligible format. To be specific to the digital image, the transformation of point (*x*, *y*) to some other point (*X'*, *Y'*) is:

Where $\begin{pmatrix}1 & 1\\ 1 & 2\end{pmatrix}$ are standard values
Step 7: Let W of size N/16 x N/16 to signify watermark.

Step 8: Now, modify S2 with watermark such that S=S2 + a* W.

Step 9: Obtain HH* by using HH*= U*S*VT.

Step 10: Apply inverse DWT to LL, HL, LH and HH* to get matrix HH1*.

Step 11: Apply inverse DWT to LL1, HL1, LH1 and HH1* to get cover image C2.

Step 12: Use inverse FFT to C2 to create C1 and set it to selected color channel to get watermarked image WI.

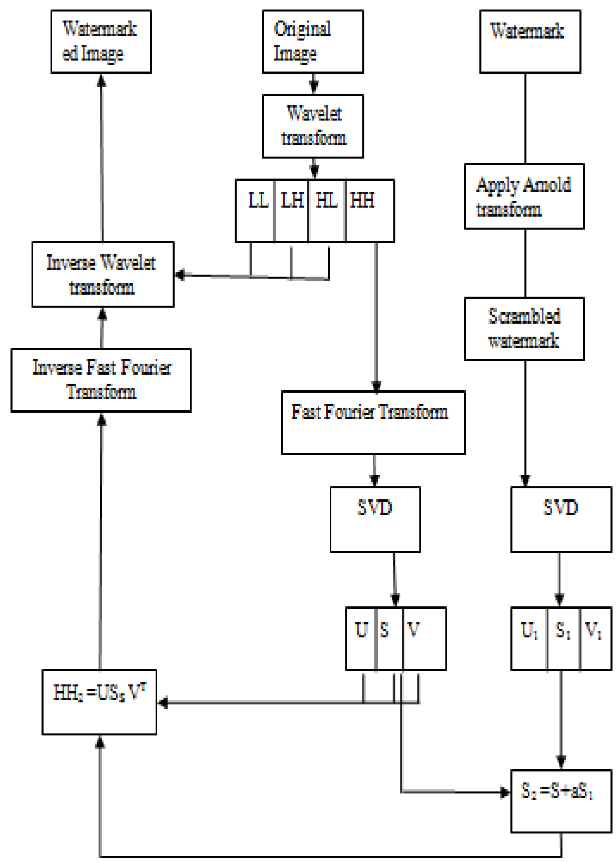

Figure 5.1: Flow chart of Watermark Embedding process

II. Watermark Detection Process

The Mining process has been alienated into following steps and is momentarily specified as given under:

Step 1: Choose color channel and apply FFT to WI to have C2.

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Step 2: Apply DWT to C2 to get LL1, HL1, LH1 and HH1*

Step 3: Choose HH1* band and apply DWT to it to get LL, HL, LH and HH*.

Step4: Apply SVD to HH*, block by block and for each block calculate HH*=WU1*WS1*WV1, and acquire WU1, WS1 and WV1.

Step 5: Obtain W=(S-WS1)/a.

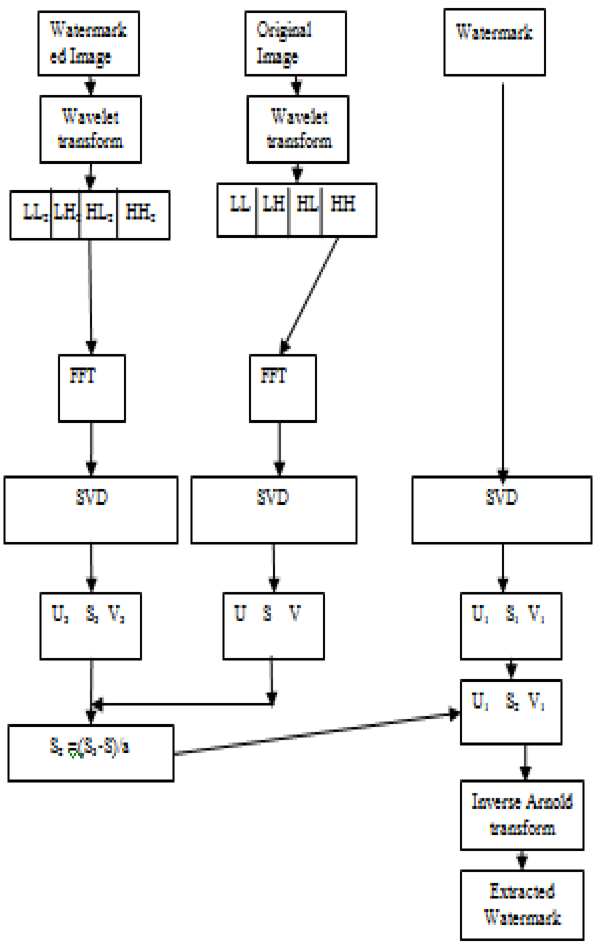

Figure 5.2: Flow chart of Watermark detection process

6. RESULTS AND DISCUSSION

(a)Cover image **(b)Watermark image** **(c)Watermarked Image of Proposed work**

Figure 6.1: Input Images for Results

Figure 6.1 indicates the input images for experimental analysis. Fig.6.1 (a) is showing the Cover image and Fig.6.1 (b) is showing the Watermark image. The overall purpose is to combine relevant information from multiple images into a single image that's more informative and suitable for both visual perception and further computer processing. Figure 6.1 (c) has shown the watermarked image of proposed technique. Comparing the watermarked image with the original cover image does not feel the presence of the watermark. Therefore the algorithm achieves visual invisibility.

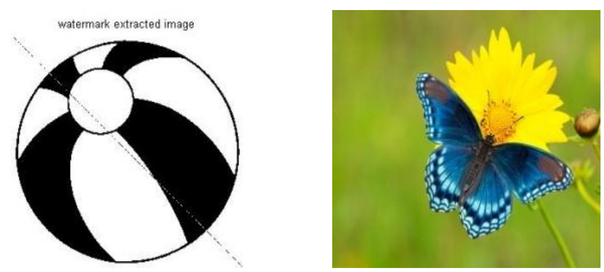

Figure 6.2: Extracted watermark of proposed technique and Effect on Watermarked image of Proposed approach without attack

Figure 6.2 has shown the extracted watermark of proposed technique without any attack. The output image contains standard SVD line in image. This line shows that only the diagonal elements are different from original watermark. In this proposed work we see the improvement in the objective quality of the image.
Another figure shows the effect on Watermarked image without any attack. In this case Watermarked image is not affected.

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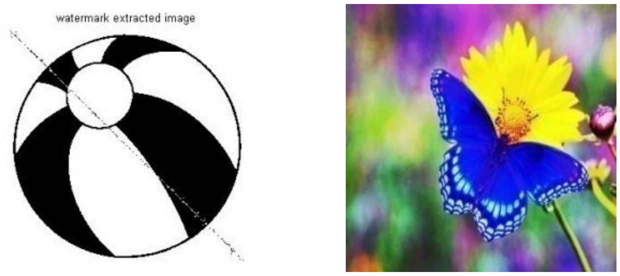

Figure 6.3: Extracted watermark of proposed technique and Effect of Histogram on Watermarked color Image of Proposed Technique

Figure 6.3 has shown the extracted watermark of proposed technique after Histogram attack. As diagonal elements of SVD are not effective therefore the output image contains standard SVD line on inserted watermark. In this proposed technique the objective quality of the image is improved.
Another figure has shown the effect on Watermarked image after Histogram attack. As we know that after applying attacks to Watermarked image it produces distortions in the Watermarked image. But in this case watermarked image is not affected by Histogram attack as Histogram attack allows the images to gain higher contrast by adjusting image intensities therefore image quality is improved.

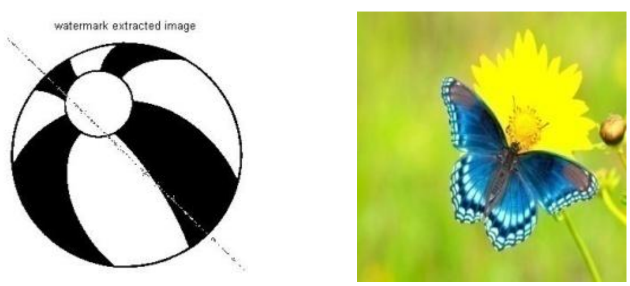

Figure 6.4: Extracted watermark of proposed technique and Effect of Gamma Correction on Watermarked color Image of Proposed Technique

Figure 6.4 has shown the extracted watermark of proposed technique after Gamma Correction attack. The output image contains standard SVD line on inserted watermark as only the diagonal components being different from the original watermark image. In this proposed work there is an improvement in the objective quality of the image.
Another figure has shown the effect on Watermarked image after Gamma Correction attack. As we know that after applying attacks to Watermarked image it produces distortions in the Watermarked image. But in this case watermarked image is not affected by Gamma Correction attack as it could increase the intensity of the Watermarked image as shown. Therefore it shows an improvement in the quality of image.

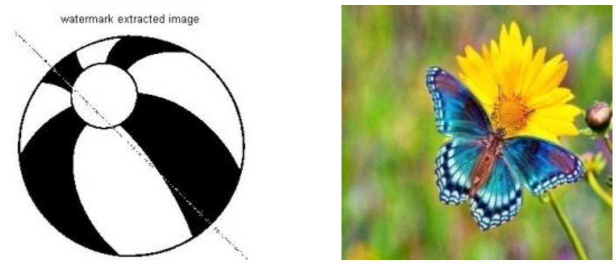

Figure 6.5: Extracted watermark of proposed technique and Effect of Sharpening on Watermarked color Image of Proposed Technique

Figure 6.5 has shown the extracted watermark of proposed technique after Sharpening attack. This image also has standard SVD line inserted on watermark which shows the diagonal elements are not effective.
Another figure has shown the effect on Watermarked image after Sharpening attack. As we know that after applying attacks to Watermarked image it produces distortions in the Watermarked image. But in this case watermarked image is not affected by sharpening attack as this attack allows the image to spotlight fine details in an image because they are created primarily by high frequency components. So the image obtained is effective.

7. PERFORMANCE ANALYSIS

The proposed algorithm is tested on different images. The algorithm is applied using different performance indices Mean Squared Error (MSE), Peak Signal to Noise Ratio (PSNR), Root Mean Square Error (RMSE).

To be able to implement the proposed algorithm, design and implementation has been performed in MATLAB using image processing toolbox. In order to do cross validation we've also implemented partial blind watermarking scheme using DWT-sub sampling. The developed approach is compared against some well-known watermarking techniques available in literature. Results shows our proposed approach is better than the existing techniques.

1) Mean Square Error Evaluation

Table 7.1 shows the quantized analysis of the mean square error. As mean square error have to be reduced which means proposed algorithm is showing the better results compared to the available methods as mean square error is less in all of the cases.

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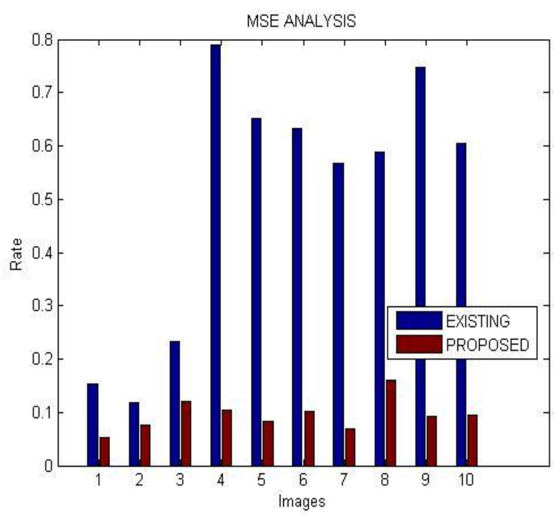
Table 7.1: Mean Square Error Evaluation

Cover Images	Watermark Images	Existing Technique	Proposed Technique
Barbie c1	Clock w1	0.1534	0.0531
Bird c2	English w2	0.1184	0.0751
Butterfly c3	Ball w3	0.2328	0.1200
Flower c4	Teddy w4	0.7904	0.1042
Leena c5	Flower w5	0.6510	0.0827
Lake c6	Icecream w6	0.6332	0.1027
Parrot c7	Punjabi w7	0.5673	0.0694
Peppers c8	Cherry w8	0.5884	0.1591
Duck c9	Dolphins w9	0.7462	0.0915
Stones c10	Butterfly w10	0.6044	0.0956



Graph 7.1: MSE of Existing Technique & Proposed Approach for different images

Figure 7.1 indicates the quantized analysis of the mean square error of various images using watermarking by Existing Technique (Blue color) and watermarking by Proposed Approach (Red Color).

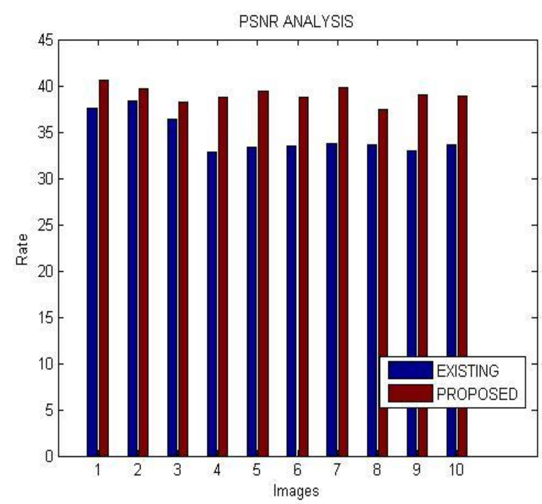
It has clearly shown from the plot that there is decrease in MSE value of images with the usage of proposed method over other methods in all images. This decrease represents improvement in the objective quality of the image.

2) Peak Signal to Noise Ratio Evaluation

Table 7.2 shows the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR have to be maximized; so the main goal is to increase the PSNR as much as possible.
Table 7.2 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm provides better results compared to the available methods.

Table 7.2: Peak Signal to Noise Ratio Evaluation

Cover Images	Watermark Images	Existing Technique	Proposed Technique
Barbie c1	Clock w1	37.5678	40.6465
Bird c2	English w2	38.3192	39.6411
Butterflyc3	Ball w3	36.3584	38.2813
Flower c4	Teddy w4	32.8151	38.6905
Leena c5	Flower w5	33.3775	39.3584
Lake c6	Icecream w6	33.4578	38.7331
Parrot c7	Punjabi w7	33.7765	39.8677
Peppers c8	Cherry w8	33.6705	37.4625
Duck c9	Dolphins w9	32.9816	39.0682
Stones c10	Butterfly w10	33.5930	38.9399



Graph 7.2: PSNR of Existing Technique & Proposed Approach for different images

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Figure 7.2 has shown the quantized analysis of the peak signal to noise ratio of various images using watermarking by Existing Technique (Blue Color) and watermarking by Proposed Approach (Red Color).

It has clearly shown from the plot that there is increase in PSNR value of images with the usage of proposed method over other methods. This increase represents improvement in the image quality.

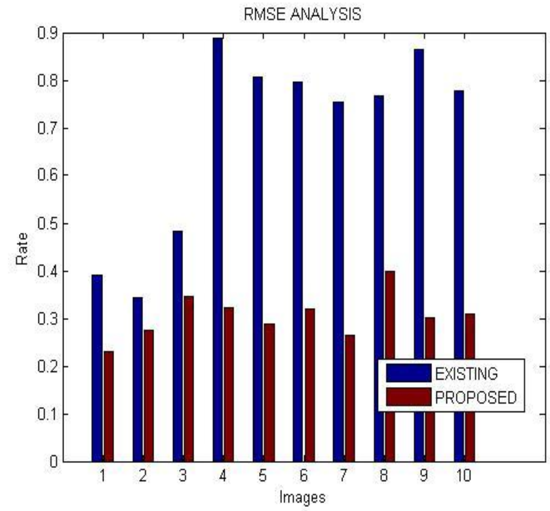
3) Root Mean Square Error Evaluation

Table 7.3 shows the quantized analysis of the root mean square error. As root mean square error have to be reduced which means proposed algorithm is showing the better results compared to the available methods as root mean square error is less in all cases.

Table 7.3 has clearly shown that the RMSE is minimum in the case of the proposed algorithm therefore proposed algorithm provides better results compared to the available methods.

Table 7.3: Root Mean Square Error Evaluation

Cover Images	Watermark Images	Existing Technique	Proposed Technique
Barbie c1	Clock w1	0.3917	0.2303
Bird c2	English w2	0.3441	0.2740
Butterfly c3	Ball w3	0.4825	0.3464
Flower c4	Teddy w4	0.8890	0.3228
Leena c5	Flower w5	0.8068	0.2876
Lake c6	Icecream w6	0.7957	0.3204
Parrot c7	Punjabi w7	0.7532	0.2635
Peppers c8	Cherry w8	0.7671	0.3989
Duck c9	Dolphins w9	0.8639	0.3024
Stones c10	Butterfly w10	0.7774	0.3092



Graph 7.3: RMSE of Existing Technique & Proposed Approach for different images

Figure 7.3 shows the quantized analysis of root mean square error of various images using watermarking by Existing Technique (Blue color) and watermarking by Proposed Approach (Red Color).

It has clearly shown from the plot that there's decrease in RMSE values of images with the usage of proposed method around other methods in all the images. This decrease represents improvement in the objective quality of the image.

CONCLUSION:

The existence of an invisible watermark is able to turn out to be established employing a suitable watermark origin and diagnosis algorithm. With this particular researching most of us reduce a few of our worry about inconspicuous watermarks. A new watermarking technique on basis of wavelet domain in combination with the Fast Fourier transform and Arnold transform based SVD will be proposed. This algorithm combines the advantages of the three transforms, therefore have significantly more robust results. Also the watermark scrambling using the Arnold transform is used to safeguard watermark further. Different kind of multiple attacks may also be considered to to evaluate the effectiveness of the proposed technique. The proposed technique is designed in MATLAB tool with the aid of image processing toolbox. The experiments has clearly shown that the proposed technique outperforms over the available techniques. The experiments has clearly shown the improvement in PSNR is 3.2 %. This shows that our proposed technique is better than the available techniques.

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