Blind Video Watermarking with Optimal Frame Selection and SVD

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***Abstract* - Exchange of data in the form of multimedia requires better security and protection for proprietary rights.A video can also undergo several intentional attacks like frame dropping, averaging, cropping and median filtering and unintentional attacks thereby denying authentication. Blind Watermarking is a well-established authentication technique and in this paper, we propose a algorithm for watermarking videos. The proposed concepts include *optimal Frame Selection* using SD-BPSO to ensure the watermarks have least detrimental effects on the video as a whole. The integrity of the video is validated using the Peak Signal to Nose Ratio (PSNR).The robustness of the algorithm is also tested by subjecting the videos to several standard attacks such as -- rotation, cropping, image shift, and image sharpening. Bit Error Rate (BER) is also used, in order to determine the efficiency of the system in retaining the watermark.**

***Keywords*- Video watermarking, Blind watermarking, Binary Particle Swarm Optimization (BPSO), Standard Deviation, Singular Value Decomposition.**

I. INTRODUCTION

Watermarking which is used to hide proprietary information in digital media. [1], [2], [3], [4], [5]. Applications of video watermarking are many in copy right protection, broadcast monitoring, video authentication and soure tracking to name a few. In order to protect the interest of the content providers, over peer to peer network these digital contents must be watermarked. In this paper the authors have designed a blind video watermarking technique based on a optimal frame selection using Binary Particle Swarm Optimization called the SD-BPSO. The watermark thus embedded cannot be easily removed, without a significant degradation of the video sequence, from the watermarked signal even after being subjected to a number attacks, both intentional and unintentional.

II. PRILIMINARIES AND RELATED WORK

A. Binary Particle Swarm Optimization (BPSO)

PSO is an evolutionary optimization algorithm based on swarm behavior proposed by [6]. The algorithm introduces the concept of particles, each which represent a candidate solution. The algorithm is modeled by taking into account the social and cognitive influence factors inherent in swarm behavior. The first step involves initialization of possible paths defined by the particle size, to the goal state. The algorithm seeks to converge to the optimum path by using a heuristic defined by the fitness function. In this paper a discrete binary version of the particle swarm optimization method is used which was proposed by [7]. In the discrete version of Particle Swarm Optimization (PSO) each particle's position is a string of 1's or 0's. The positional values are determined by the sigmoid function and probabilistic rule. The particle velocity is modeled as a probabilistic function for positional update. Potential solution is represented as a particle having positional co-ordinates $X_i^t = [x_{i1}, x_{i2}, \ldots x_{iD}]$ in a D dimensional space where i denotes the particle number and 't' represents the iteration number. Each particle maintains a record of the position of its previous best performance in a personal best position vector Pbest. An iteration comprises evaluation of each particle and then stochastic adjustment of its velocity $V_{ti} = [v_{i1}, v_{i2}, \ldots, v_{iD}]$ in the direction of its own previous best and the best previous position of any particle in the neighborhood. The best position of any individual in the whole swarm is stored as the global best position G_{best}. PSO is described by the following

velocity and position update equations:

$$V_i^{t+1} = w.V_i^t + c_1.rand.(Pbest_i - X_i^t) + c_2.rand.(Gbest - X_i^t) \quad (1)$$

Where w = inertia weight, c_1 = cognitive parameter, c_2 = social parameter

$$X_i^{t+1} = X_i^t + V_i^{t+1} \quad (2)$$

For i=1 to P; P = number of particles. If r is a random number between 0 and 1, the equation that updates the particle position is

$$X_i^{t+1}=1 \text{ if } r<\frac{1}{1+e^{-V_i^{t+1}}}, \text{ else } X_i^{t+1}=0. \quad (3)$$

B.Standard Deviation.

It is a mathematical tool which is used to indicate variation or dispersion of values from the average (mean, or expected value) from a given set of values given by Eq. 4. A low standard deviation indicates that the data points tend to be very close to the mean, whereas high standard deviation indicates that the data points are spread out over a large range of values.

$$\sigma=\sqrt{\frac{1}{M}[(y_1-\mu)^2+(y_2-\mu)^2+...+(y_M-\mu)^2]} \quad (4)$$

Where σ = standard deviation, μ= mean; $y_1,y_2,...,y_N$ are the set of all M values. And,μ

$$\mu=\left(\frac{1}{M}\right)\times\sum_{k=1}^{M} y_k$$

C. Singular Value Decomposition (SVD)

Singular value decomposition (SVD) is a numerical technique used to diagonalize matrices in numerical analysis. It is an algorithm developed for a variety of applications. The main properties of SVD are:

- The singular values (SVs) of an image have very good stability, i.e., when a small perturbation is added to an image, its SVs do not change significantly
- SVs represent intrinsic algebraic image properties.

III. PROPOSED ALGORITHM

The generic watermarking system consists of two phases. The first being the watermarking phase shown in Fig. 1 followed by the extraction of watermark and authentication shown in Fig. 2. Principal contributions have been made in the watermarking stage and the following section provides a formal discourse of the same.

A. SD-BPSO based frame Isolation

A new variant of BPSO called the SD-BPSO is proposed here. The SD-BPSO algorithm is a novel technique which selects potential frames from the original images where the watermark may be embedded in order to achieve maximum PSNR. It also generates a unique key which can then be used to extract and evaluate the watermark.

A flow chart of the SD-BPSO is shown in Fig. 3. To begin with, each video sequence is split into its corresponding frames. This allows the SD-BPSO algorithm to process the video as individual images whilst retaining the correspondence between the subsequent frames.

The SD-BPSO algorithm begins with 'Q' particles each positing potential frames to be watermarked. A particle is a binary array of size 1xN where N is the number of frames in the original video sequence. In this array, a binary '1' implies that the frame is to be watermarked and binary '0' skips the frame. For example, a 24fps video lasting for 20 seconds would ideally contain 480 frames; each particle in BPSO will then have a size of 1480 which may resemble Fig. 4. Initial frame estimate of each of the particle is purely random. A measure to evaluate the solutions of each of the particle is required. We propose the use of standard deviation Eq. 7 as a fitness evaluator, playing a crucial role in the algorithm. The Standard Deviation is obtained for every frame of the video sequence. The net standard deviation is computed using Eq. 5 by adding the standard deviations of only those frames that were chosen by a particle.

$$SD_{net}=\sum_{i=1}^{N} P_i \times SD(F_i) \quad (5)$$

Where, N is the total number of frames, SD(•) is the standard deviation, F_i is the i_{th} frame, and P_i is the particle's value corresponding to the i_{th} frame, which can be written as

$$P_i=\begin{cases}1 & \text{if frame } F_i \text{ is to be watermarked}\\ 0 & \text{if frame } F_i \text{ is to be skipped}\end{cases}$$

This value is then normalized over the total standard deviation of all frames inclusive. This will be the fitness function and it can be mathematically expressed as in Eq. 6

$$\text{Fitness}=\frac{SD_{net}}{SD_{total}} \quad (6)$$

Where, SD_{total} is the sum of standard deviations of all frames. This process is repeated for frames suggested by each of the 'Q' particles. At the end of the BPSO algorithm, the particle with the highest fitness value is chosen and those frames are watermarked. Best particle's array can also be used as the 'KEY' which will then be used by the receiver in order to extract the watermark.

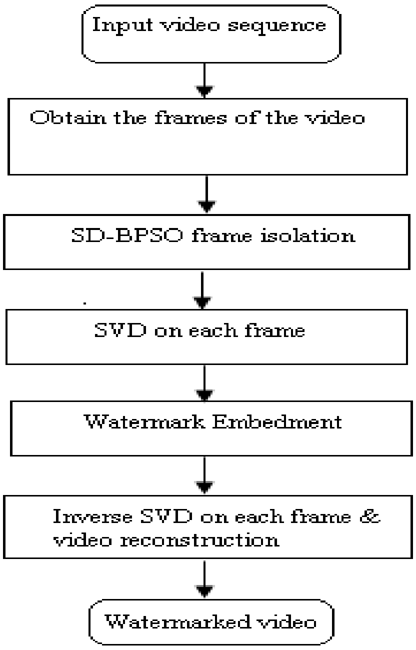


Fig.1. Top level overview of the proposed water marked Stage

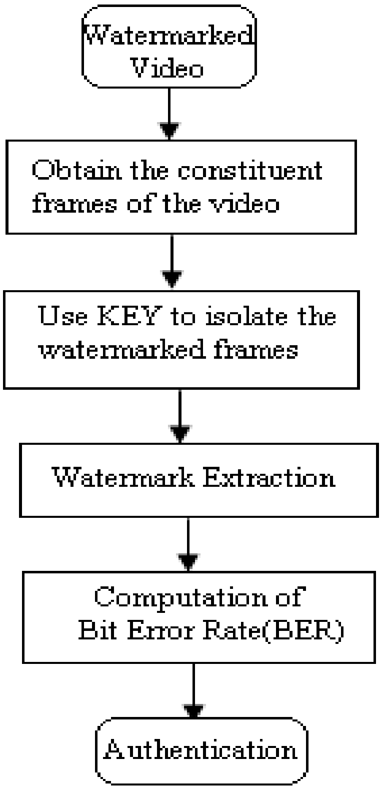


Fig.2. Top level overview of the corresponding Extraction Stage

B.Embedding Process

The first step in embedding is the application of SVD transform to each frame individually. This produces 3 matrices U, S and V.

Then if A were to be the frame, we may express it as

$$A = USV^T \quad (7)$$

Here, if s1 and s2 are the singular values present in the S matrix then columns of U and V are respectively, left right singular vectors for corresponding singular values. Among the S matrix only middle singular values are chosen. The watermarking of each bit is modeled using the following equations Firstly calculate the remainder by having S and Q.

The embedding bit W_i is 1 then

$$W_i = \begin{cases} 1 & \text{if remainder} \leq Q/4 \\ 0 & \text{if remainder} \geq 3 * Q/4 \end{cases}$$

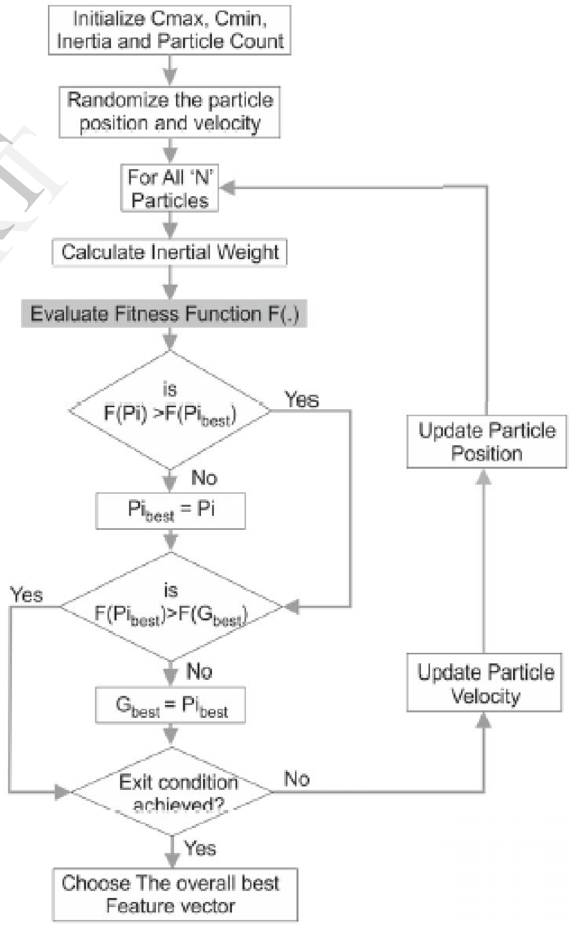


Fig.3. Flowchart of the proposed SD-BPSO Algorithm

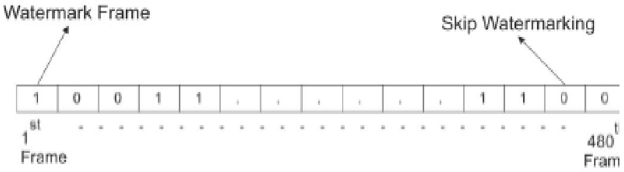


Fig.4. The constituents of a particle for a 24fps video lasting 20 seconds

Here, Si is individual element in the S matrix, each time S_i is modified. Q is the quantization value wi is the bit to be embedded .The new matrix after embedding may be denoted as S'. Once all the bits have been embedded, inverse SVD is used to obtain to obtain the frames. The inverse SVD given by

$$A'=US'V^T \quad (9)$$

$$S'=diag(s'_1 s'_2, s'_3, \ldots, s_r') \quad (10)$$

Now the image is watermarked.

This process is repeated for all the selected frames until the all the selected frames until the bits of watermark have been successfully embedded. After all frames have been watermarked, the video sequence is reconstructed to obtain the watermarked video.

C. Extraction

In the extraction process the watermarked video is broken down into frames. The only parameter that is required at the receiver end is the content of the best particle's array (the KEY). This is used to select the KEY). This is used to select the watermarked frames among all the frames that are present in the RGB domain. Then the SVD transform is applied to obtain the modified matrix S'. This modified matrix contains the bits that are embedded These bits are extracted using equation 11

First Calculate the remainder by having S_i and Q

$$W_i = \begin{cases} 0 \text{ if } \text{remainder} < Q/2 \\ 1 \text{ if } \text{remainder} < Q/2 \end{cases} \quad (11)$$

This is repeated for all watermarked frames . Similar methods have also been found in [10], [11], [12], [13]. The watermark thus extracted from the video sequence is strikingly similar to the watermark used for the embedding process albeit with subtle variations, refer Fig. [5].

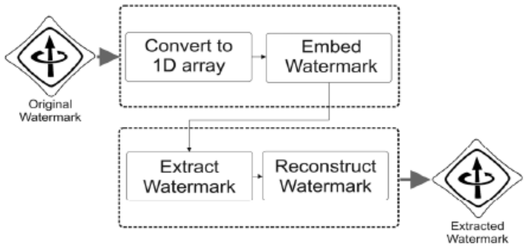


Fig.5.Watermarking and Extraction

IV.EXPERIMENTAL RESULTS

To test the algorithm, videos were chosen randomly from the internet [18], [19], [20].Frames of these videos are shown in Fig. 7a. The watermark shown in Fig. 6 was resized and converted into an 1D array using raster scanning technique, and the resulting vector was embedded in all the three videos. All the video sequences are of the resolution 1280 x 768 and the length of the watermark sequence is 1380 bits. All the videos were watermarked using the technique we have proposed in the aforementioned sections. Screenshots of the frames in Fig. 6a are watermarked and are shown in Fig. 6b. All the codes were implemented on MATLAB [17].

(a) (b)

Fig.6. Top to bottom-" Hall monitor"and " Ball"

(a) Original Frames (b) Watermarked Frames

To validate the robustness of the algorithm, the Peak Signal to Noise Ratio (PSNR) and Bit Error Rate (BER) are computed. PSNR depends on Mean Squared Error (MSE), given by Eq. 12

$$MSE = \frac{\sum_{M,N}\left[I_1(m,n)-I_2(m,n)\right]^2}{M \times N} \quad (12)$$

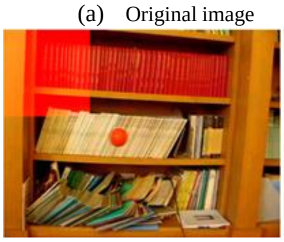
Here, M and N are rows and columns of an image. With this PSNR can be calculated using Eq. 13

$$PSNR=10\log_{10}(\frac{R^2}{MSE}) \quad (13)$$

R is the maximum fluctuation in the input image data. BER is the Bit Error Rate and it can be defined as the number of bits that are erroneous in the extracted watermark to the total number of bits in the original watermark.

PSNR of the first 30 selected frames of "Hall Monitor" video is shown in Table I.


(a) Original image (b) Rotation




(c) Crop (d) Sharpen

(e) Salt and pepper noise

Fig .7. Attacks on watermarking videos

Video sequences may also undergo a lot of changes due to various factors. This effect is called an 'attack', these attacks may either be intentional or may be unintentional, but for a watermark to be robust it should be resistant to any such attack. Different attacks are considered and their effect on a particular video is shown in Fig. 7. The efficacy of the algorithm to withstand these attacks is evident in the results tabulated in Table II. To obtain the results that were tabulated in Table II, all the frames were exposed to the attack. The BER thus calculated is the absolute maximum error rate that can occur under any circumstance. The technique is promising, in that the results obtained are on par with, and in many cases much better than, those presented by the work of [14], [15], [16].

TABLE I.

PSNR OF THE FIRST 30 SELECTED FRAMES OF "Hall monitor" VIDEO

Frame number	PSNR(db)				
1 to 5	41.38	41.69	41.77	41.84	41.45
6 to 10	41.07	41.31	41.55	41.86	41.77
11 to 15	41.95	41.66	41.29	41.78	41.69
16 to 20	41.35	41.56	41.87	41.58	41.76
21 to 25	41.77	41.39	41.83	41.29	41.65
26 to30	41.67	41.88	41.69	41.28	41.62

Table II

Maximum BER and PSNR range for different attacks on the video sequence

Video	Attack	BER	PSNR range (db)
Hall monitor	Image rotation By5 degrees	0.154000	13-14
	Image cropping (100x100) pixels	0.129237	22-25
	Image sharpening using unsharp mask	0.290894	22-24
	Salt and pepper noise	0.068281	27-29
Ball	Image rotation By5 degrees	0.093219	14-15
	Image cropping (100x100) pixels	0.117638	19-20
	Image sharpening using unsharp mask	0.372256	23-24
	Salt and pepper noise	0.050169	27-28

CONCLUSION

The proposed algorithm is frame adaptive due to the use of swarm optimization for selection of frames, it is also a blind watermarking technique in that a measure (BER) is used to compare and find out the strength of the watermark.

It can be observed that the proposed watermarking algorithm can be extended to larger vector lengths. Table II helps us better understand about the efficacy of the algorithm, it can be seen that the number of bits that are in error are negligible in case of salt and pepper noise ,Cropping and Image shift . SD-BPSO is a novel algorithm which serves as an effective optimizer by selecting suitable frames for better imperceptibility

REFERENCES

[1] C. I. Podilchuk and E. J. Delp, Digital Watermarking: Algorithms and Applications, IEEE Signal Processing Magazine, July 2001, pp. 33-46.
[2] E. Vellasques, E. Granger, R. Sabourin, Handbook of Pattern Recognition and Computer Vision, 4th ed., World Scientific Review, 2010, Ch. Intelligent Watermarking Systems: A Survey., pp. 687-724.
[3] I. J. Cox, M. L. Miller, and J. A. Bloom, Digital Watermarking, Morgan Kaufmann Publishers, 2002.
[4] R.G.V. Schyndle, A.Z. Tirkel, C.F. Osbrone, A digital watermark, Proceedings of IEEE International Conference on Image Processing, vol. 2, 1994, pp. 86-90.
[5] Vidyasagar M. Potdar, Song Han, Elizabeth Chang, A Survey of Digital Image Watermarking Techniques, 3rd International Conference on Industrial Informatics(INDIN 2005)
[6] J. Kennedy, R. C. Eberhart, Particle Swarm Optimization, IEEE International Conference on Neural Networks, 1995.
[7] J. Kennedy, R. C. Eberhart, A Discrete Binary Version of the Particle Swarm Algorithm, Proceedings of IEEE International Conference on Systems, Man, and Cybernetics, vol. 5, p. 4104-4108, October 1997.
[8] Kundur. D., Hatzinakos, D., Digital Watermarking using Multiresolution Wavelet Decomposition, Proc. IEEE Int. Conf. On Acoustics, Speech and Signal Processing, Seattle, Washington, vol. 5, pp. 2969-2972, May 1998.
[9] Kaewkamnerd, N., Rao, K.R., Wavelet based image adaptive watermarking scheme in IEE Electronics Letters, vol.36, pp.312-313, 17 Feb.2000
[10] Gaurav Bhatnagar and Balasubramanian Raman, A new robust reference watermarking scheme based on DWT-SVD, Computer Standards and Interfaces 31 (2009), pp.1002-1013
[11] R. Liu, T. Tan, An SVD-based watermarking scheme for protecting rightful ownership, IEEE Transactions on Multimedia 4 (1) (2002), pp.121-128.
[12] V.Santhi and Dr. Arunkumar Thangavelu, DWT-SVD Combined Full Band Robust Watermarking Technique for Color Images in YUV Color Space, International Journal of Computer Theory and Engineering, Vol. 1, No. 4, October2009, pp. 1793-8201
[13] Wenhai Kong, Bian Yang, Di Wu, and Xiamu Niu1, SVD Based Blind Video Watermarking Algorithm, Proceedings of the First International Conference on Innovative Computing, Information and Control, 2006
[14] Qiang Li, et al, Adaptive DWT-SVD Domain Image Watermarking Using Human Visual Model proceedings of 9th international conference on advanced communication Technology, Volume 3, pp. 1947 - 1951, Feb.2007.
[15] Cheng-qun Yin, Li Li, An-qiang Lv and Li Qu, Color Image Watermarking Algorithm Based on DWT-SVD Proceedings of the IEEE International Conference on Automation and Logistics, pp. 2607 2611, August 18 - 21, 2007
[16] Qing-Ming Ge,Zhe-Ming Lu, Xia-Mu Niu. Oblivious Video Watermarking Scheme with Adaptive Embedding Mechanism. Machine Learning and Cybernetics, 2003 International Conference on Volume5, 2-5 Nov, pp. 2876 - 2881
[17] Matlab, www.mathworks.com/products/matlab/
[18] Olympics, http://www.youtube.com/watch?v=meF60gScJ5g
[19] Women, http://www.youtube.com/watch?v=rYEDA3JcQqw
[20] Tennis, http://www.youtube.com/watch?v=z rJYiTkmu