International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 1 (2016) pp 216-225

Robust Video Watermarking by amalgamation of Image transforms and optimized Firefly Algorithm

K. Swaraja
Department of E.C.E, GRIET, J. N.T.University, Hyderabad, India.

Y. Madhaveelatha
Department of E.C.E, MRECW, J. N.T.University, Hyderabad, India.

V.S.K. Reddy
Department of E.C.E, MRCET, J. N.T.University, Hyderabad, India.

Abstract
Illicit duplication, circulation and amendment of digitized works are well thought-out infringements aligned with intellectual property rights. Thus digital watermarking came into subsistence due to the evolving obligation of copyright protection and is a technique that inserts information, such as ownership and authentication information into digital data to avert on or after illegal copying. An innovative scheme is offered in the accessible paper to execute blind video watermarking based on the feature constraints extorted from an amalgamated domain in conjunction with the Discrete Cosine Transform (DCT), Singular Value Decomposition (SVD), Schur decomposition and an optimized Firefly Algorithm. In this paper, 2D DCT is applied on all 8x8 blocks of the luminance frame of the video and after relating Schur factorization merely on few of Selected_dct block of each frame which are chosen by firefly optimization technique, the stable largest eigen values of the upper triangle are used as robust locations for inserting with the singular values of watermark attained by SVD in each frame to secure transparency and robustness in conflict to numeral of attacks. The experimental outcome validate that the projected method handle to accord expertly with low computational complexity along with there is more endurable control to bit rate lift and at the same time perceptual quality can be kept in subsistence even after undergoing different attacks through an assortment of watermarking necessities.

Keywords: Discrete Cosine Transform (DCT), Singular Value Decomposition (SVD), Schur Decomposition, Firefly optimization Algorithm, NC.

INTRODUCTION

The thriving evolution of the Internet and the augmentation of the digital multimedia technology encompass not only permitted people to practice, dispense and accumulate digital content more effortlessly, however also have endowed the ability of replicating it swiftly and absolutely not including loss of quality, with no restriction on the number of copies, tampering by and reform illegally lacking authorization. This sort of compensation elevate the topic of how to guard the copyright ownership. Digital watermarking is such an effective and prominent solution to protect copyright of the digital multimedia data even after its transmission. Beneath these situations, authenticity and integrity confirmation of digital video happen to be an imperative research area in this day and age. Watermarking technology offer supportive result for such troubles by inserting the watermark information within the cover .Next to watermarking, there subsist further significant methods that can additionally offer security to the digital content e.g., cryptography, steganography etc. Steganography and watermarking mutually appear under data hiding techniques i.e., they are used to hide covert information within the cover. Yet, there keep going fine disparity with steganography and watermarking i.e. steganography mask the subsistence of covert information. If the subsistence of covert information is exposed, steganography seize up while, in watermarking the endurance of covert information can be identified .Ideally, the aspiration of watermarking is to make the removal/exploitation of covert information unfeasible. Digital watermark is classically used to spot the ownership or verify the authenticity of any digital data or multimedia. As the digital copy of data is identical to the original, digital watermarking is a reflexive security means and presently marks data, but does not demean it or control right to use the data.

Universally the watermark enclose information regarding the origin, ownership, destination, copy control, transaction etc. There subsist primarily three assessment constraints in video watermarking and at the similar time there is an intricate trade-off among these constraints, they are imperceptibility, robustness and Payload. Imperceptibility [1, 2, 3] is one in which the quality of the watermarked video must not alter still after inserting the watermark into the host video, Payload is the number of bits inserted in the original video signal for each unit time and Robustness is the resistivity of the watermark against common signal processing and malicious attacks and be supposed to be able to extract the watermark from the watermarked video. Simultaneously Security (authoritative persons only can spot the watermark) and Complexity (number of computations incorporated while embedding and extracting watermark) are the few requirements for the efficient and robust watermarking techniques. The secret message is inserted as an hidden mark [4] and recuperate behind the extraction of watermark. Predominantly there are two kinds of video watermarking methods: Spatial domain and Transformation domain scheme. When weighed against the spatial domain, the watermarking methods scheduled on the transform domain, principally on the DCT (discrete cosine transformation) domain, have the subsequent advantages: at the outset, the feature of human vision system can be used profitably in the frequency domain; Next, the watermarking methods can be well-matched with the video compression standards. At last, the working out intricacy of the watermarking algorithms in the DCT domain is frequently near to the ground.

The work projected in this paper presents numerous vital contributions to the field.

(1) **An intact investigation:** we carried out a fine study on the up to date watermarking methods. It is perceived that none of the topical watermarking methods can oppose the entire attacks.

(2) **Robustness and imperceptibility defend against attacks:** The projected video watermark is evidence for high level of protection and robustness in opposition to attacks by blending benefits of DCT, SCHUR, SVD and Firefly Optimization Algorithm based methods.

(3) **Flexibility and effectiveness:** This come into sight while extracting the watermark from video frames.

(4) **Relative inspection:** This is carried out by doing assessment of the projected method through dissimilar video watermarks and for diverse image and video processing attacks.

This paper is prearranged into six sections. The subsequent section investigates the associated work of recent watermarking technologies. Section 3 elucidates the key concepts of the DCT, SCHUR, SVD and Firefly based Algorithm. Section 4 depicts the niceties of the proposed DCT, SCHUR, SVD and Firefly based Algorithm for embedding and extracting the watermark from the watermarked video by fulfilling both Imperceptibility and Robustness. The Experimental outcomes are illustrated in Section5. Conclusions are accessible in Section 6 .

RELATED WORK

The spatial-domain watermarking methods are on average uncomplicated but not as much of robustness. When weigh against methods sustained on frequency domain for instance the discrete Fourier transform (DFT)[5,6], discrete cosine transform (DCT)[7,8], discrete wavelet transform (DWT)[9,10], along with singular value decomposition (SVD) [11,12,13] permit the deployment of signal characteristics and human visualization properties to conquer enhanced robustness and invisibility. In the earlier period, quite a few watermarking algorithms have been built-up based on assorted incorporation of the above mentioned transforms [14, 15]. Owed to Multiresolution capability of DWT in time and frequency it turn into an eminent transform for image processing. For extremely allied image data, the DCT grasp outstanding energy compaction. Watermarking by means of DWT and DCT typically reveal high-quality recital in terms of robustness and invisibility. Besides these two transforms, SVD is a dominant numeric tool cooperative for applications akin to data hiding and image compression. A matrix is factorized into three component matrices in the SVD, which correspondingly enclose left singular vectors, singular values in diagonal, and right singular vectors. Either by modifying the singular values [17] or the singular vectors associated with the largest singular value a watermark bit can be inserted into an image block. Indeed, quite a lot of endeavors [16, 17, 18] have been made on the escalation of robust watermarking techniques in an amalgam domain relating the DCT, DWT and SVD.

The built-up algorithms vary not merely in inserting objective but moreover in dealing out procedures. Regardless of the assortment of their procedural design, one thing familiar to the entire former algorithms is with the intention that to embed information into anticipated matrices the SVD perform as a vehicle. A basic watermarking method using the discrete cosine transform (DCT) was projected in [19]. The input image is alienated into blocks and then DCT is applied on each block in parallel. For inserting the covert information the low-frequency coefficients of the DCT block were elected by quotient-embedding algorithm. The just noticeable distortion (JND) and DCT based robust watermarking scheme was projected in [20]. The DC coefficients are exploited for inserting the watermark beside that the JND value of the original image was made use as the embedding strength. The consistent recognition of the watermark and lacking necessity of the original image was addressed in [21] for watermark extraction which was inserted into the DCT domain by making use of the Maximum Posteriori probability condition. A series of real numerals was used as watermark, every numeral preferred discretely from the Gaussian distribution. In support of HVS an adaptive digital watermarking method [22] was projected. Quite a few existing watermarking techniques are enthused by the typical compression process and matrix decomposition. These encompass unsighted SVD technique that place in the bits of the mark within the singular values matrix and Schur transform also decomposes image, video or mark into unitary transform U and upper triangle matrix T, the diagonal access are Eigen values of all blocks in which the majority of the energy is potted. A blend of DCT and SVD [23], DCT and SCHUR [24], DCT DWT- SVD [25] methods seek to erect watermarking techniques robust in conflict to the majority of attacks. Owed to the refined properties of SVD technique, it is utilized in image watermarking, [26]. This technique endow with proficient means to extort algebraic features as of a 2-D matrix. The foremost properties of the matrix of the SVs can be extended in video watermarking. Little deviation arise in the matrix of the SVs, when a slight amendment ensue to the original video, which build this scheme robust in opposition to attacks [26] by means of this property, the watermark can be inserted to this matrix devoid of huge discrepancy in the acquired video.

We have carried out a comprehensive survey on the recent watermarking methods. It is specified that none of the up to date watermarking methods can defy the entire attacks. Commencing with this point of outlook, this paper projects DCT, SCHUR, SVD-based Firefly video watermarking method in which the DCT, SCHUR transform is combined with the SVD method which is applied to the watermark and this SVD based watermark is embedded in the selected DCT block (with large texture value which is identified by using Firefly optimization Algorithm) after performing SCHUR transform to this selected DCT blocks of the video frames. Experimental results confirm that the proposed video watermarking method is far robust in conflict to attacks based on the video characteristics such as frame swapping, frame averaging, statistical analysis, and histogram equalization, as well as robust in opposition to the image processing attacks which integrated rotation, cropping, scaling, and a joint attack which implicated amalgamation of all former distortions.

METHODOLOGIES

A. Discrete Cosine Transform

DCT based watermarking methods are further robust when put side by side to spatial domain watermarking methods. This method is robust in opposition to straightforward image processing operations akin to contrast and intensity amendment ,low pass filtering, etc. conversely, they are hard to execute and in addition, they are in favor of geometric attacks akin to cropping , rotation and scaling, etc. DCT is a technique converting a signal into elementary frequency components and is widely used in image and video coding. The DCT of an image which is an amendment of the Fourier transform is used to illustrate all n×n block into a frequencies map and amplitudes moderately than picture elements and colors. The value of a frequency render the significance of a swift adaptation, whereas the value of magnitude be in contact to the divergence allied with each color disparity. All n×n picture elements block are consequently related to n×n frequencies.

The DCT is expressed mathematically by :

$$DCT(u,v)=\frac{2}{n}C(u)C(v)\sum_{x=0}^{n-1}\sum_{y=0}^{n-1}p(x,y)\cos\left[\frac{(2x+1)u\pi}{2n}\right]\cos\left[\frac{(2y+1)v\pi}{2n}\right] \quad (1)$$

where p(x,y) is picture element of an image and

Inverse DCT is expressed by:

$$p(x,y)=\frac{2}{n}\sum_{u=0}^{n-1}\sum_{v=0}^{n-1}C(u)C(v)\,\mathrm{DCT}(u,v)\cos\left[\frac{(2x+1)u\pi}{2n}\right]\cos\left[\frac{(2y+1)v\pi}{2n}\right] \quad (2)$$

In either cases, the constant C is delineated as:

$$C(x)=\begin{cases}\frac{1}{\sqrt{2}} & when\ x=0\\ 1 & when\ x>0\end{cases} \quad (3)$$

The DC value of the image is indicated by the top left corner coefficient of the frequency domain matrix, and the left over coefficients correspond to the AC values. The magnitude of the energy obsessed by all DCT coefficients is signified by the absolute value of the magnitude.

Observations:

DFT co-efficients are not smooth end-head discontinuities, these discontinuities basis a high frequency allotment in the consequent DFT. On the opposite, the DCT Co-efficients have flat end-head discontinuities.DCT possesses better energy compaction in low frequencies than DFT. Most energy of an image is contained in a small region of low frequency in the DFT domain. In terms of energy compaction, when compared with the optimal KLT, DCT is the best among DFT, DWT, DHT and discrete Haar transform.KLT is image reliant, not practical, complicate in nature and lot of computations are drawn in.

Merits:

The DCT can be realized by means of FFT. Owed to even symmetry of DCT co-efficients, DCT calculation essential for the DCT of an N -point is identical to that essential for DFT of the N-point sequence. Because of these two virtues, the DCT is the predominantly admired image transform used in image and video coding.

B. Singular Value Decomposition based watermarking

The singular value decomposition of a matrix is often referred to as the *SVD*. According to it, every real matrix G can be decomposed into a product of three matrices as defined by (4)

$$G = UDV^T \quad (4)$$

where *U* is orthogonal, D is diagonal, and *V* is orthogonal.

In the decomoposition $G = UDV^T$, G can be *any* matrix. We identify that if G is symmetric positive definite its eigen vectors are orthogonal and we can note down $G = Q\Lambda Q^T$. This is an exceptional case of SVD, with U = V = Q.

Each singular value signify the luminance of frame of video whereas the geometry of the frame is point to the subsequent pair of singular vectors. SVD matrix of video have fine stability.

Singular values comprise three vital properties:

- The Singular values of the frame are stable, which specify that inconsistency of its singular values does not arise even when a minute perturbation is added to a video.
- The Singular values show evidence of the algebraic and geometric invariance to hardly any point.
- The Singular values keep up a correspondence to the algebraic provenance of a video which are not visual and inherent.

These three properties of stability, algebraic and geometric invariance of the singular values are exploited in the direction of inserting the watermark image in the biggest singular values of the D matrix of the cover video. Conversely deviation in the singular values is a smaller amount, despite the fact that several attacks have a tendency to amend the singular values of the cover video. For this reason, the consequence on the delicacy of the watermarked video in stipulations to PSNR and NC of the extracted watermark is not as much of. The foremost benefit of the SVD is that the biggest singular values conserve the largest part of the energy and are defiant to minute perturbations and thus resistant to majority of the signal processing and image compression operations.

An image watermarking technique derived from SVD transform have proposed by Liu et al. , in which the watermark is added to the SVs of the overall image or to a division of it .Akin to the image watermarking ,the SVD transform can also be used for video watermarking where a diagonal matrix D and two orthogonal matrices U and V, are attained by exercising the SVD of Video . The watermark W is added to the matrix of SVs D, and at that moment a latest SVD transform is executed on the subsequent matrix D + βW to get Uw, Dw, and Vw **.**The parameter β is a scale factor that controls the effectiveness of the watermark inserted into the original Video. The watermarked Video Gw is attained by multiplying the matrices U, Dw, and V^T.

The hierarchy of inserting the watermark go over the main points as follows:

1. The SVD is performed on the original Video (G matrix) and is defined by Eq.(5)

$$G = UDV^T \quad (5)$$

2. The watermark (W matrix) is added to the SVs of the original matrix and is obtained using Eq. (6)

$$M = D + \beta W \quad (6)$$

3. The SVD is performed on the new modified matrix (M matrix) which is defined as follows:

$$M = U_w \times D_w \times V^T{}_w \quad (7)$$

4. The watermarked Video (G**w** matrix) is obtained using the modified matrix (D**w** matrix) and is defined in Eq. (8)

$$G_w = U \times D_w \times V^T \quad (8)$$

To extort the most likely degraded watermark from the probably indistinct watermarked Video, given Uw, D, Vw matrices, and the possibly distorted Video Uw, the aforementioned steps are inverted as go after:
1. The SVD is implemented on the almost certainly distorted watermarked Video ($G^*{}_w$ matrix) and is obtained by Eq. (9)

$$G^*{}_w = U^* D^*{}_w V^{*T} \quad (9)$$

2. The matrix that comprise the watermark is worked out and is defined in the following equation

$$M^*{}_w = U_w D^*{}_w V_w{}^T \quad (10)$$

3. The most likely degraded watermark is attained as follows:

$$W^* = \frac{(\mathrm{M}^* - D)}{\beta} \quad (11)$$

The ***** refers to the degradation owed to attacks.

C. Schur Decomposition

Contrast to SVD the computational intricacy of Schur decomposition is not as much of and consequently it is functional for real time applications. Schur decomposition can be of use to several real matrix.
There are two kinds of this decomposition[27]:
(i)The complex Schur decomposition and
(ii)The real Schur decomposition

In complex schur decomposition: **f = UTU'** (12)
where, U is a unitary matrix, U' is the conjugate transpose of U and T is an upper triangular matrix entitled the complex Schur type which has the eigen values of f by the side of its diagonal.
In Real version of Schur Decomposition : **f = VRV'** (13)
where, f, V, R and V ' are matrices that enclose just real information. herein , V is an orthogonal matrix, V ' is the transpose of V , and R is a block upper triangular labeled the real Schur type. Schur decomposition lead to about $\frac{8}{3}N^3$flops.SVD computation involve $11N^3$ flops. Eigen values in the Schur decomposition are as well extremely stable. If a square matrix T, with linearly independent eigen vectors has full rank later there subsist an invertible matrix Q, such that $Q^{-1}T\ Q=\Lambda$, where Λ is a diagonal matrix. however the entire square matrices are not diagonalizable. This shortage can be eased by schur factorization or QR factorization .According to schur each invertible matrix possibly will be expressed as a product of unitary matrix U and upper triangle matrix T, $T=U^H \times I \times U$. In matrix T, the diagonal entries of T are the eigen values of I. This decomposition refers to the structure of the matrix.

D. Firefly Algorithm flow

The projected method is resting on firefly algorithm which impersonate the behavior of fireflies. In the humid and moderate area during summer Fireflies flash light in sky. The intensity of the flashes created by means of the fireflies is the source in favor of this algorithm. They articulate each other with the assistance of intensity of flashes and fireflies attempt to progress in the path of the fireflies encompassing high intensity of flashes. With the distance the light intensity diverge from the other fireflies and a petite intensity is missing in middle. Light intensity is computed in this algorithm in the existence of a few variables in aid of intensity mislaid and distance among fireflies. The algorithm generate optimal outcome with a reduction of computational time and is enough random in nature .
The Firefly Algorithm is a latest nature encouraged procedure[28,29] that has commonly been used for solving NP tough optimization troubles. Xin-She Yang projected this Algorithm. Firefly Algorithm, is just elucidated by the consequent three idealized principles:

(a) Each and every Firefly is unisex with the intention that one Firefly will be concerned to other Fireflies despite of their sex.

(b) Attractiveness is relative to their intensity, as a result for any two flashing Fireflies, the less brighter Firefly will progress in the track of the brighter Firefly. The attractiveness is comparative to the intensity and they mutually turn down as their distance raises. Firefly will travel randomly, if there is no particular Firefly which is brighter than the existing one.

(c) The intensity of a Firefly is resoluted by the background of the objective function.

In the proposed method, the FA is used to trace the best DCT blocks with large texture value for inserting watermark and to minimize the error rate. The maximum optimization algorithm of the Firefly is depicted below. Earliest initial population of candidate solutions are created. Later, it estimate the light intensity for the entire Fireflies and locate the attractive Firefly (finest candidate) surrounded by the population. Followed by, analyze the attractiveness and distance for all Fireflies to progress all Fireflies towards the attractive Firefly in the explore region. As a final point, the attractive Firefly progress randomly in the explore region. This sequence is continual in anticipation till a termination criterion is met i.e., the utmost numeral of generations is attained. The projected approach is as expressed in below algorithm.

Firefly Algorithm for major optimization

Delineate Objective function f(x), x = (x1, ..., xd) ^{T}
Build initial population of fireflies x_k (k = 1, 2, ..., p)
Delineate α, β_o, highest generation numeral (HN) and γ
Output: The preeminent result $x_k$max with the leading objective function value

Begin
while (t < HN)
for u = 1: p all p fireflies
for v = 1: p all p fireflies
if $f(x_u) < f(x_v)$
calculate attractive fireflies by eq.14
calculate the distance between fireflies u and v by eq.15
move fireflies to the best solution by eq.16
else
move fireflies to the best solution randomly by eq.17
assess novel solutions and keep posted objective function
end if
end v
end u
end while
grade the fireflies and locate the existing global best $x_u$max
End

The process commence on or after an initial population of randomly created individuals. The eminence of each individual is calculated via Eq. (14) and the preeminent solution between them is chosen. In Firefly Algorithm, the type of attractiveness function of a firefly is represented by the succeeding:

$$\beta(d) = \beta_o e^{-\gamma d_m} \quad (14)$$

where, d = The distance among any two Fireflies

β_O = The early attractiveness at d = 0

γ = light absorption coefficient which direct the decline of the light intensity

The distance connecting any two Fireflies u and v, at positions X_u and X_v correspondingly, can be termed as a Cartesian or Euclidean distance as go after:

$$d_{pq} = x_p - x_q = \sqrt{\sum_{k=1}^{p}(x_{p,k} - x_{q,k})^2} \quad (15)$$

The movement of a Firefly u which is attracted by another brighter Firefly v correspond to the subsequent equation:

$$x_u = x_u + \beta_o e^{-\gamma d_{pq}}(x_q - x_p) + \alpha(rand - \frac{1}{2}) \quad (16)$$

If there are no Fireflies brighter than a particular Firefly u with maximum objective value then u will move randomly according to the Eq. (17).

where $x_{u\max} = x_{u\max} + \alpha(rand - \frac{1}{2})\,\mathrm{u}_{\max}$ (17)

In Eq. (16), the initial term is the recent location of a Firefly, the second term is utilized in view of the attractiveness of a Firefly , in the path of the intensity of light by nearby Fireflies and when it lacks the brighter ones ,the third term is exploited for the random progress of a Firefly (random part). The coefficient α is a randomization factor resoluted by the problem of curiosity, despite the fact that rand is a random number generator time after time disseminated in the space (0, 1). In Eq. (17), the progress of the preeminent candidate is finished randomly.

PROPOSED OPTIMIZED DCT BASED-SCHUR-SVD VIDEO WATERMARKING

A. Watermark Embedding

In the projected DCT-based-Schur-SVD video watermarking algorithm, the original video is alienated into non-overlapping frames. The watermark is embedded into the large texture value DCT Co-efficients of selected DCT blocks based on the Firefly optimization of the luminance Y of the video frames. For embedding watermark into video, we prefer YUV QCIF videos and partition the video clips into video scenes. The frames of video scene are evaluated. The frames of YUV video are in RGB color model and they are transformed to YCbCr color model. The luminance component is not that much of sensitive to amendments when contrasted with chrominance components (Cb & Cr). In view of that while inserting watermark, extort luminance component. One by one to embed the watermark into every frame the subsequent steps are adopted.

1. Let 'V' be the original video and is partitioned into groups of k frames ,'W' is the watermark to be embedded into the video 'V'.
2. Each frame of the group is altered from the RGB into the YCbCr color model and the luminance values Y of the frames are afterward practiced.
3. Each luminance frame of the video 'V' is partitioned into non overlapping blocks of 8x8.
3. Compute 2D DCT on all 8x8 blocks of the luminance frame of the video 'V' .
5. Firefly optimization technique is used mainly to opt for some of 8x8 blocks represented as Sel_dctblock to insert watermark in each frame to secure transparency.
6. As there is relevance bounded by Texture and AC Coefficients, the dct block with large texture value is identified by using Firefly optimization for inserting watermark.
7. Then Schur transform is applied only on some of 8x8 blocks of each frame which are selected by Firefly optimization technique where it decompose video into unitary transform U and upper triangle matrix T. The diagonal entries are Eigen values of every block. Bulk of the energy is potted in the eigen values of the video and we acquire Us and Ts, such as: Vv=Us×Ts×UsT. Us matrix is kept as a private key
8. SVD is applied to the watermark and is decomposed into Uw, Dw, Vw then σ(watermarked) is defined in (18)

$$\sigma(watermarked) = \sigma_v + \frac{bheta \times \sigma_w}{S_{\max}} \quad (18)$$

where, S_{max} is the largest singular value of watermark, σ_v are the upper triangular eigen values obtained when schur transform is applied on the selected dct blocks of each frame and σ_w are the singular values obtained when svd is applied on watermark .

9. Relate singular values of watermark by taking diagonal of σ(Watermarked).
10. Relate inverse Schur to obtain Sel_dctblock and is defined in the following equation:

$$(sel\_dctblock)' = U_s \times T_s watermark' \times U_s^T \quad (19)$$

11. Remap (Sel_dctblock)' into largest Eigen values of the SVD transform denoted by Dw.
12. Relate inverse SVD transform to M' which is defined in (20)

$$M' = U_w \times D_w watermark \times V_w^T \quad (20)$$

13. Watermarked video is obtained by amalgamating all 8×8 DCT blocks.

B. Watermark Extraction

1. The acquired watermarked video is alienated into groups of k frames.
2. Each frame of the group is altered from the RGB into the YCbCr color model.
3. Every luminance frame is altered into the 2D DCT domain.
4. Sector each luminance frame of the video 'V' into non overlapping blocks of 8x8.
5. Apply 2D DCT on all 8x8 blocks of the luminance frame of the video,'V' and extort the dct block with large texture value denoted as Sel_dctblock by using Firefly optimization where watermark is embedded.
6. Apply Schur to Sel_dctblock, it decomposes into USI, TSI, USI^T.
7. The diagonal entries of TSI are upper triangular eigen values σ_{VI} .
8. Reiterate the exceeding steps 1to 4 on video 'V'. The singular values of video are σ_V.
9. Extort singular values of Watermark σ_{ext} using (21).

$$\sigma_{ext} = \frac{(\sigma_{VI} - \sigma_V)}{bheta} S_{\max} \quad (21)$$

10. Acquire $D_w ext$ from σ_{ext} .
11. To search out extracted watermark attain inverse Singular value Decomposition which is defined in (22)

$$M' = U_w \times D_w ext \times V_w^T \quad (22)$$

EXPERIMENTAL RESULTS AND ANALYSIS

A. Imperceptibility test

To evaluate the imperceptibility of the projected method, a succession of tests have been accomplished. The watermark image taken for inserting into the videos is depicted in Fig.1. Original videos taken for testing and the corresponding Watermarked videos obtained after inserting the watermark are exposed in Fig.2. In the experiments, no visible artifacts can be empirical in all of the test video sequences. In addition to subjective inspection, PSNR(Peak Signal to Noise Ratio) is typically in use to estimate the perceptual quality. Fig.3. exemplifies the Y-PSNR (luma PSNR) discrepancy provoked by inserting the watermark even after different types of attacks for the three different videos. We examine that the watermarked video is not discernible as of the original video. Fig.3. depicts the PSNR values for distinct videos and we view that it is nearly not viable to distinguish the degradation in video quality caused by inserting the watermark even after variety of attacks .

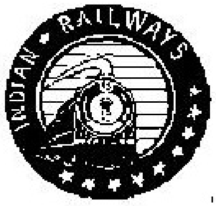

Figure 1: Watermark image

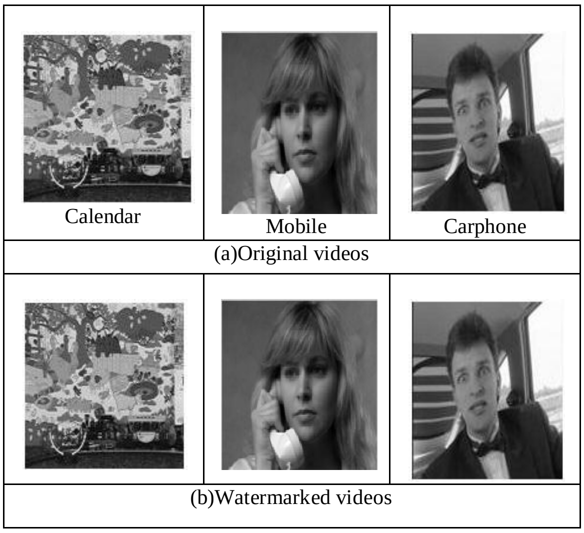

Figure 2(a): Original videos and (b)Watermarked videos of Calendar, Mobile and Carphone.

To evaluate the performance of the proposed scheme, we also examined other SVD, DCT, SCHUR, Firefly-based methods [31], [32], [33]. As depicted in Table 1, the Y- PSNR achieved by the proposed method is typically maximum if the watermark logo is inserted in the video and at the same time NC value is also preserved when evaluated with existing methods [31], [32], [33] and there is no much deviation along with the original and the watermarked video sequence and the PSNR obtained by our method is improved than the existing methods. As we are taking three different videos based on the movement rapidity, the Y-PSNR values also differs for the three videos.

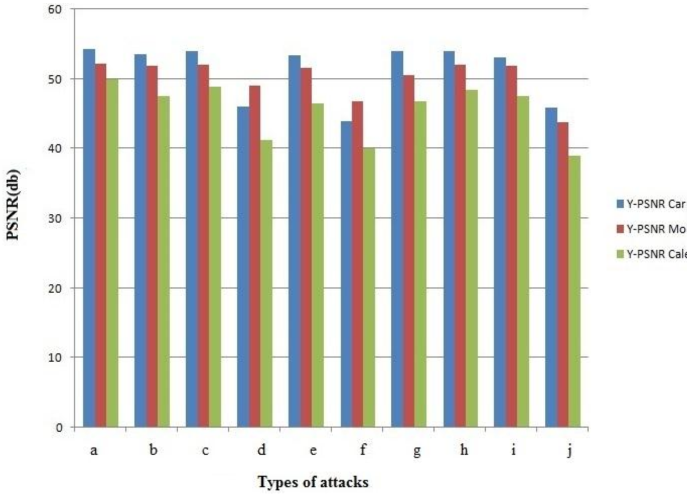

Figure 3: Disparity of Y-PSNR provoked by inserting watermark for (a)Calendar, (b)Mobile and (c)Carphone.

Table 1: Y-PSNR Values After Applying Different Types Of Attacks On Watermarked Video.

Attacks applied	Y-PSNR Carphone	Y-PSNR Mobile	Y-PSNR Calendar
(a) No attack	54.23	52.14	49.98
(b) Resizing	53.52	51.87	47.51
(c) Rotation	54.00	52.08	48.86
(d) Cropping	45.98	48.98	41.24
(e)Frame swapping	53.34	51.54	46.53
(f) Sharpening	43.92	46.87	39.99
(g)Frame Averaging	53.99	50.59	46.78
(h)Salt&Pepper noise	54.02	51.98	48.50
(i)Gaussian noise	53.12	51.85	47.54
(j)Histogram Equalization	45.86	43.78	38.98

B. *Robustness to common signal processing attacks*

For disparate applications, the properties of watermarking systems are deliberated to be unlike. For copyright protection in a robust watermarking technique, an attacker aspire to take away the inserted information or build it untraceable while enduring the inserted data helpful. Thus, the inserted information ought to be robust in conflict to malicious attacks. Highest possible robustness of the watermarking scheme is achieved in the proposed work as we are using the amalgamation of image transforms with Firefly algorithm which is a recent optimization technique. To evaluate the robustness of the proposed approach, the watermarked video is tested against several kinds of attacks such as: (1)Geometrical attack: Resizing, Rotation, Cropping and Frame swapping (2)Noise attack: Gaussian noise, Salt & pepper noise (3)Denoising attack: Frame Averaging (4) Image-processing attack: Histogram equalization

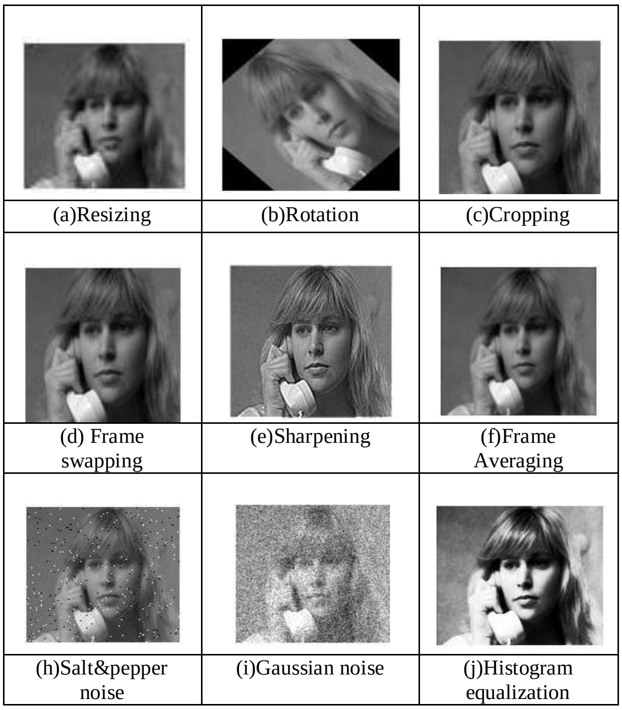

Figure 4: Different types of attacks applied on watermarked video

C. Normalized Correlation(NC)

For comparing the similarities between the original and extracted watermarks, the two-dimensional normalized correlation (NC) value was employed. The NC value can be anywhere between 0 and 1. In principle, if the NC value is closer to 1, the extracted watermark is getting more similar to the embedded one. NC is computed by using Eq. (23)

$$NC(V,V') = \frac{\sum_{i=1}^{R}\sum_{j=1}^{C}[V(\mathrm{i, j}).V'(i,j)]}{\sum_{i=1}^{R}\sum_{j=1}^{C}[V(\mathrm{i, j})]^{2}} \qquad (23)$$

Besides quantitative study of the robustness of our approach, we moreover require the visual perceptions of the extorted watermark. Different types of attacks applied on watermarked videos is shown in Fig.4. As of the experimental results, we come across that even if the watermarked video has undergone acute physical alteration, the extorted watermark is still identifiable and the NC value is depicted in Table.2. for unlike attacks by distinguishing with different similar methods. In this experiment, we evaluate the projected method in conflict to the related DCT-SCHUR based watermarking scheme [30] in their competence to endure disparate kinds of attacks. The eminence of the extorted watermark is resoluted by NC value and the PSNR of the watermarked video. In [30], the authors apply the triangular matrix of the mark obtained after the Schur decomposition to the host image. It is not robust to all attacks and also the imperceptibility is to be improved, further it is applied to the image.

Table 2: Relative NC Values with Earlier Methodologies.

Attacks applied	Proposed scheme	[31]	[33]
(a) No attack	1	1	1
(b) Resizing	1	0.98	1
(c) Rotation	1	1	-
(d) Cropping	0.95	-	0.8
(e) Frame swapping	0.90	-	-
(f) Sharpening	1	-	0.99
(g) Frame Averaging	0.99	0.97	-
(h) Salt&Pepper noise	1	0.98	0.99
(i) Gaussian noise	1	1	0.99
(j) Histogram Equalization	0.85	0.34	1

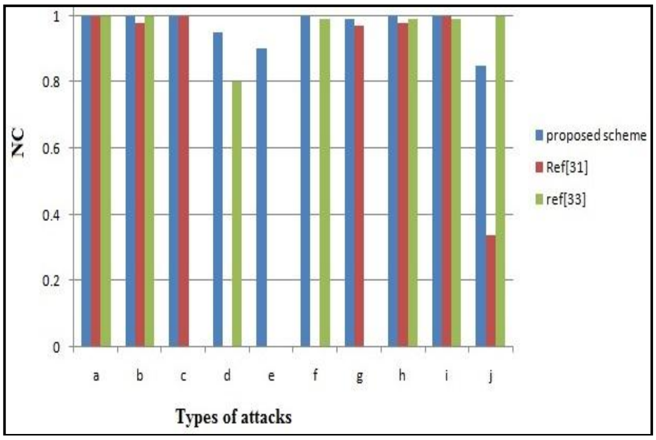

Figure 5: Comparison of NC value of proposed method with Ref[31]& Ref[33] after different types of attacks.

Fig.5. depicts the comparison of NC values of proposed method with Ref[31] & Ref[33] after different types of attacks. In the proposed work, we are amalgamating the image transforms (DCT, SVD, SCHUR) with Firefly algorithm for the reason that the DCT grasp outstanding energy compaction and the watermarking by means of DCT typically reveal high-quality recital in terms of robustness and invisibility. Besides this Schur and SVD are the dominant numeric tool cooperative for applications akin to data hiding and image compression. So, the robustness to different attacks and PSNR concert of our projected approach is prominent than the further related approaches. As there are very few papers to relate the results which are using these type of amalgamation on videos, so we are comparing the results with image watermarking techniques only. Fig.6. depicts the extracted watermark image which is similar to the original watermark image yet after dissimilar kind of attacks. Fig.7.depicts that there is no much deviation among the original videos and watermarked videos even after different types of attacks.

Figure 6: Extracted Watermark image after different types of attacks.

Figure 7(a): Original videos, **(b)** Watermarked videos , **(c)** Watermarked videos after different types of attacks

CONCLUSION

Augmented demand is there for the advancement of secure watermarking algorithms with the aim of maintaining prominent level of robustness and imperceptibility in conjunction with payload. To convene the demand a pristine secure watermarking method based on Discrete Cosine Transform, Schur transform and Firefly Algorithm along with Singular Value Decomposition is presented in this paper. The foremost concern of the projected work is accomplished by Firefly Algorithm which is an optimization technique and after relating Schur factorization merely on few of Selected_dct block of each frame which are chosen by Firefly optimization technique, the stable largest eigen values of the upper triangle are used as robust locations for inserting with the singular values of watermark attained by SVD in each frame to secure transparency and robustness . The amalgamation of Singular Value Decomposition and Schur decomposition lead to a high amount of compression, condenses the number of bits desirable to efficiently signify the watermark and the video and convene the security prerequisite. On top, the imperceptibility and robustness aspects of the projected algorithm are set up to be enhanced in conjunction with improved payload to that of further contemporary algorithms owing to its high ability in compressing both video and watermark. The experimental outcome confirm that the projected method handle to pact competently with low computational complexity through a range of watermarking necessities.

REFERENCES

[1] R. Naskar and R.S. Chakraborty, "A Generalized Tamper Localization Approach for Reversible Watermarking Algorithms", ACM Transactions on Multimedia Computing Communications and Applications, vol. 9, no. 3, Jun. 2013, pp. 19:1 19:22.

[2] R. Naskar and R.S. Chakraborty, "Histogram–Bin–Shifting based Reversible Watermarking for Color Images", IET Image Processing, vol. 7, no. 2, Mar. 2013, pp. 99-110.

[3] P. Nagaraju, R. Naskar and R.S. Chakraborty, "Improved Histogram Bin Shifting based Reversible Watermarking", International Conference on Intelligent System and Signal Processing (ISSP) 2013, Anand, Gujarat, India.

[4] N. Dey, S. Samanta, S. Chakraborty, A. Das, S.S. Chaudhuri and J.S. Suri, "Firefly Algorithm in optimization of Scaling Factors for Manifold Medical Information Embedding", Journal of Medical Imaging and Health Informatics, vol. 4, no. 3, June 2014, pp. 384-394

[5] Tao P, Eskicioglu AM, " An adaptive method for image recovery in the DFT domain", J Multimedia 2006:36–45.

[6] Tsui TK, Zhang X-P, Androutsos D, "Color image watermarking using multidimensional Fourier transforms", IEEE Trans Inform Forensics Sec 2008;3:16–28.

[7] Lin SD, Chen C-F,"A robust DCT-based watermarking for copyright protection", IEEE Trans Consumer Electron 2000;46:415–21.

[8] Patra JC, Phua JE, Bornand C, " A novel DCT domain CRT-based watermarking scheme for image authentication surviving JPEG compression", Digital Signal Process 2010;20:1597–611.

[9] Chamlawi R, Khan A, Usman I, " Authentication and recovery of images using multiple watermarks", Comput Electr Eng 2010;36:578–84.

[10] Shen H, Chen B, "From single watermark to dual watermark: a new approach for image watermarking", Comput Electr Eng 2012;38:1310–24.

[11] Su Q, Niu Y, Zhao Y, Pang S, Liu X, "A dual color images watermarking scheme based on the optimized compensation of singular value decomposition", AEU – Int J Electron Commun 2013;67:652–64.

[12] Lai C-C," A digital watermarking scheme based on singular value decomposition and tiny genetic algorithm", Digital Signal Process 2011;21:522–7.

[13] Chang C-C, Hu Y-S, Lin C-C," A digital watermarking scheme based on singular value decomposition", In: Chen B, Paterson M, Zhang G, editors. Combinatorics, algorithms, probabilistic and experimental methodologies. Berlin, Heidelberg: Springer; 2007. pp. 82–93.

[14] Tsai H-H, Jhuang Y-J, Lai Y-S, " An SVD-based image watermarking in wavelet domain using SVR and PSO", Appl Soft Comput 2012;12:2442–53.

[15] Wang B, Ding J, Wen Q, Liao X, Liu C," An image watermarking algorithm based on DWT DCT and SVD", IEEE Int Conf Netw Infrastruct Digital Content 2009:1034–8.

[16] Divecha NH, Jani NN, " Image watermarking algorithm using DCT, DWT and SVD", In: IJCA Proc on National Conference on Innovative Paradigms in Engineering and Technology; 2012. p. 13–6.

[17] Murty S, Kumar PR,"A robust digital image watermarking scheme using hybrid DWT–DCT–SVD technique", Int J Comput Sci Netw Sec 2010;10:185–92.

[18] Bedi SS, Kumar A, Kapoor P, "Robust secure SVD base DCT–DWT oriented watermarking technique for image authentication", In: Proc Int Conf on IT to Celebrate S Charmonman's 72nd Birthday; 2009, pp. 461–7.

[19] C. Y. Yang, W. C. Hu, and J. Y. Lai, "DCT-based Watermarking By Quotient-Embedding Algorithm", ICICIC'08, IEEE 2008.

[20] H. U. Seo, J. S. Sohn, B.I. Kim, T.G. Lee, S.I. Lee, and D.G. Kim, "Robust Image Watermarking Method Using Discrete Cosine Composition And Just Noticeable Distortion", ITC-CSCC 2008.

[21] M. Barni, F. Bartolini, V. Cappellini, A. Piva, and F. Rigacci, "A M.A.P. Identification Criterion For DCT-Based Watermarking", pp. 17-20, 1998. [22] H. Qi, D. Zheng, and J. Zhao, "Human visual system based adaptive digital image watermarking, Science Direct", Signal Processing 88, pp. 174-188, 2008.

[23] A. Sverdlov, S. Dexter, A. M. Eskicioglu," Robust DCT-SVD domain image watermarking for copyright protection : embedding data in all frequencies", 13th European Signal Processing Conference (EUSIPCO 2005), Antalya, Turkey, September 2005, pp. 4-8.

[24] Henri Bruno Razafindradina , Nicolas Raft Razafindrakoto , Paul Auguste Randriamitantsoa , "Improved Watermarking Scheme Using Discrete Cosine Transform and Schur Decomposition", IJCSN International Journal of Computer Science and Network, Volume 2, Issue 4, August 2013,ISSN (Online) : 2277-5420 www.ijcsn.org.

[25] S. S. Bedi, A. Kumar, and Piyush Kapoor, " Robust Secure SVD Based DCT – DWT Oriented Watermarking Technique for Image Authentication ", International Conference on IT to Celebrate S. Charmonman's 72nd Birthday, March 2009, Thailand.

[26] Dixit M, Kulkarni P, Somasagar P, Angadi V, "Variable scaling factor based invisible image watermarking using hybrid DWT–SVD compression–decompression technique", In: IEEE students' conference on electrical, electronics and computer science (SCEECS). 2012. pp. 978–81.

[27] B. Chandra Mohan and K. Veera Swamy Z, " On the use of Schur Decomposition for Copyright Protection of Digital Images", International Journal of Computer and Electrical Engineering, Vol. 2, No. 4, August, 2010,pp. 1793-8163.
[28] Z. A. Elizee, A. Babazadeh, S. Mohammad and S. Hosseini, "Optimizing Product Design through a Particle Swarm Induced Logistic Regression Model," Majlesi Journal of Mechanical Engineering, Vol. 3/ No. 2/ Winter -2010.
[29] E. Yang, A. T. Erdogan, T. Arslan and N. Barton, "An Improved Particle Swarm Optimization Algorithm for Power-Efficient Wireless Sensor Networks," 2007 ECSIS Symposium on bio-inspired learning and intelligent system for security, 2007.
[30] Henri Bruno Razafindradina ,Nicolas Raft Razafindrakoto, Paul Auguste Randriamitantsoa, " Improved Watermarking Scheme Using Discrete Cosine Transform and Schur Decomposition", IJCSN International Journal of Computer Science and Network, Volume 2, Issue 4, August 2013 ISSN (Online) : 2277-5420 www.ijcsn.org.
[31] Priyanka Singh, and Suneeta Agarwal, "A Hybrid DCT-SVD Based Robust watermarking scheme for copyright protection", International Conference on Emerging Trends in Engineering and Technology (ICETET'2013) Dec. 7-8, 2013 Patong Beach, Phuket (Thailand),pp.1-5.
[32] Hwai-Tsu Hu, Ling-Yuan Hsu, "Exploring DWT–SVD–DCT feature parameters for robust multiple watermarking against JPEG and JPEG2000 compression", Computers and Electrical Engineering xxx (2014) xxx–xxx.
[33] Anurag Mishra, Charu Agarwal, Arpita Sharma, Punam Bedi, "Optimized gray-scale image watermarking using DWT–SVD and Firefly Algorithm", Expert Systems with Applications 41 (2014) 7858–7867.