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HYBRID OPTIMIZATION MODEL OF VIDEO STEGANOGRAPHY TECHNIQUE WITH THE AID OF BIORTHOGONAL WAVELET TRANSFORM

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ABSTRACT

In this contemporary world of ours, a lot of people have tried to store their multimedia datasets as a contour of binary waves. During transmission, if a prohibited course of action occurs during an intermittent stage of transmission it could lead to delay in accessing data for individuals who have been provided authorization. In order to eliminate this undesired course of action, an efficient method has been adopted. Steganography is an efficient technique that can eliminate this undesired course of action and can be utilized for writing an eclipse missive. In this paper we have proposed an efficient optimal robust video steganography technique using the Biorthogonal Wavelet Transform (BWT) that has been incorporated with a hybrid model of the Artificial Bee Colony (ABC) with Genetic Algorithm (GA).The BWT is utilized to split the image into Low-Low (LL), Low-High (LH), High-Low (HL) and High-High (HH). The optimization technique ABC and GA are then utilized to attain best fitness values in the embedding and extraction processes. Analysis on the proposed technique is carried out with respect to the Peak signal to Noise ratio (PSNR) and the Normalized Correlation (NC). Experimental results show that the proposed technique can achieve good imperceptibility and robustness for an image.

Keyword: *Steganography, Biorthogonal Wavelet Transform, Artificial Bee Colony, Genetic Algorithm, Peak Signal To Noise Ratio, Normalized Correlation.*

1. INTRODUCTION

In order to achieve security and privacy of information, Steganography, Cryptography and Digital Watermarking methods can be applied. [1] The word steganography draws its name from the Greek word 'Steganos', which means covered or secret, and 'graphy' which means writing or drawing. Steganography is so named as it is the art of transmitting information in such a way that the existence of the data gets concealed. [2] When it comes to secret data sharing, steganography provides another layer of protection, which basically embeds the media. [3].The steganography technique utilizes three attributes, namely imperceptibility, capacity and robustness. [4] As a result of new developments on the internet, it is essential to transmit new forms of digital information over the internet. As a result, the main issue is to safeguard all binds of sensitive information during transmission. [5] This technology finds a lot of use in commercial applications such as in the copyright protection of digital forms of media like videos or images. Steganography makes sure that those signals that have been implanted but cannot be retrieved by any other person. [6] To make use of human awareness is what steganography technically does; human senses are not trained to look for files that have data hidden inside of them. [7] But fit must be noted that there are programs available that can do what is named as Ste analysis (Detecting use of Steganography). [8]

The "embedded" information is known as the 'hidden data' or 'cover data'. Information hiding is a general term covering several sub disciplines, which is a term around a wide range of issues beyond that of embedding message in content. [9] The term 'hidden data' is either making the data undetectable or keeping the existence of the data secret. [10] It is a technique of hiding secrets using redundant cover information such as images, audios, movies, documents, etc. [11] when it comes

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to steganography in video file; some of the most common methods are explained.

One model is LSB planes, which substitutes the least important bits of the host image with secret information. The thoroughgoing search technique would take a long period of time to detect an optimum substitution matrix for a k-bit LSB substitution. [12] Using an active programming strategy in the substitution matrix is also found to be effective. [13]. In this transform which is applied in the time domain, it is moved through low-pass and high-pass filters to remove the low and high frequencies respectively.[14] In order to analyse the transient time varying signals, wavelets have their energy determined in time and are well fitted. The 2D Wavelet Transform decomposes an image into a lower resolution approximation image (LL) as well as horizontal (HL), vertical (LH) and diagonal (HH) detail components. [15] With these two indices a two parameter system is built. The set of coefficients are named the DWT of a signal. Using predefined wavelets in 1D, 2D and 3D, the format of the image is transformed.

[16]In the Biorthogonal Wavelet Transform (BWT) domain, successive sub-band quantization and perceptual modelling are applied. BWT involves bi-level decomposition whereas DWT involves single level decomposition. Here, using BWT a robust watermarking is identified. In this scheme, utilizing the BWT, the original image is broken into four frequency sub-bands (LL, LH, HL and HH) and the concealed data is embedded into the mid-frequency range that constitutes either the HL or LH sub-band. [17] Orthogonal or Biorthogonal Wavelet Transforms can be Wavelets. An invertible transform is the Biorthogonal Wavelet Transform. [18] It has few favourable properties over the Orthogonal Wavelet Transform, chiefly, the property of perfect reconstruction and smoothness (vanishing points) which is a desirable feature for data concealing. A new kind of compressed video secure steganography (CVSS) algorithm also exists wherein, where both the embedding and detection operations are performed completely in the compressed domain, with no need for the decompression process. [19]

The section below comprises literature reviews based on existing endeavours in section 2, the proposed methodology in section 3, steganography embedding and the extraction process in section 4, the hybrid optimization model in section 5 and the various results and further discussion in section 6.

2. LITERATURE REVIEW BASED ON EXISTING ENDEAVOURS

In 2010, Sherly *et al.* [20] had proposed the compression video steganography scheme. The utility of this algorithm was depicted as an adept data hiding operation entirely in the compressed domain. Here, data were embedded in macro blocks of an I frame with maximum scene change and motion vectors having blocks of P and B frames with maximum magnitude. In the embedding process they utilized tri-way pixel-value differencing (TPVD), to enlarge the capacity of the hidden secret information and to provide an imperceptible stego-image for human vision. According to the proposed scheme, the entire process was only in the compressed domain. The necessity for a decompression domain did not arise.

In 2012, Manish Mahajan *et al.* [21] discusses Adaptive steganography based on the spatial and frequency domains with an extra layer of a mathematical model. It utilizes adaptive steganography which deals with the various significant features and values of the cover image prior to the embedding of secret information thus reducing fake or illegal access.

The purpose of steganography is to embed hidden data in an appropriate multimedia carrier, e.g., image, audio, or video as proposed by Ovidu Cosma et *al.* [22] in 2012. Excluding doubtful works of art, the payload implied the quantity of secret information that could be surrounded in the carrier, the toughness signified the level in which the secret information was influenced by the usual processing of the carrier e.g., firmness, and the strength signified how the occurrence of hidden information could easily distinguished by stego analysis methods. The suggested technique declares vast payloads and has substantial strengths.

In 2012, Paulpandi *et al.* [23] had proposed the hiding of information using the Motion Vector Technique in Video Steganography. In this paper, the author enhance the security of the data, the data was encrypted using the AES algorithm and then hidden. The data was hidden in the horizontal and vertical components of the moving objects. The PSNR value was calculated from the output file and as a result, the quality of the video after data hiding was evaluated.

In 2013, Tintu *et al.* [24] described a process to improve the video steganography performance with the help of Inter Pixel Value coding (IPV). The technique was used to hide secret information and

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to provide an imperceptible stego-image for human vision. There was no decompression domain for the embedding and extraction processes. The secret image was then scrambled using the Arnold transform. The proposed method of steganography was very similar to the two dimensional image steganography. The results showed that this modified version of steganography was highly secure with certain strengths in addition to good perceptual invisibility. The significant concept of the proposed technique was finding the entropy for each of the data schemes.

3. PROPOSED METHODOLOGY

3.1 Objective

The ultimate objective of our proposed work is to obtain an efficient and pure stegano video frame using the Biorthogonal and hybrid optimization techniques of ABC-GA. These proposed techniques amalgamate to much better PSNR value and NC values.

3.2 Biorthogonal Wavelet Transforms

Biorthogonal Wavelet Transforms are known as invertible transforms possessing properties of perfect reconstruction and decomposition functions. They possess two sets of low-pass filters for reconstruction and high-pass filters for decomposition. Two scaling factors are involved in this function and these accomplish an altered multi-resolution investigation and consequently a couple of altered wavelet functions. In Biorthogonal Wavelet decomposition and reconstruction, filters are attained from two disparate scaling functions with regard to two multi-resolution analyses in duality. When examining BWT with Orthogonal Wavelet Transform (OWT), decomposition of the image into diverse channels is a special valuable characteristic. This precisely states that the BWT performs better than the OWT and is well examined in the aforementioned assertion.

3.3 Wavelet Filter Bank

The scaling equations on the scaling function and wavelets highlight the decomposition and reconstruction of a signal from a resolution to the next one by using perfect reconstruction filter banks. [28]

$$x_1[n] = x_0 * h_1[2n]$$
$$and$$
$$c_1[n] = x_0 * g_1[2n]$$
$$with$$
$$h_1[n] = h[-n] \;\; and$$
$$g_1[n] = g_1[-n]$$

3.4 Overall Process of Proposed Methodology

Initially, the video is utilized for shot segmentation and is segmented based on the distance between two frames. These segmented shots are utilized for the partition of frames; where the frames are used to segregate the particular frame from the previous process of shot segmentation, after which the blue component is extracted from each frame. These blue components utilize the BWT for band decomposition. Here the single level decomposition is used. After decomposition, the process of embedding the image is done with the help of ABC-GA. After that inverse BWT is applied to retrieve the stegano video. Then BWT is applied again to the stegano video in order to retrieve information from the stegano video. The extracted image and the original informative image are utilized to attain an optimal value for NC.

Block Diagram for Overall Embedding and Extraction Process

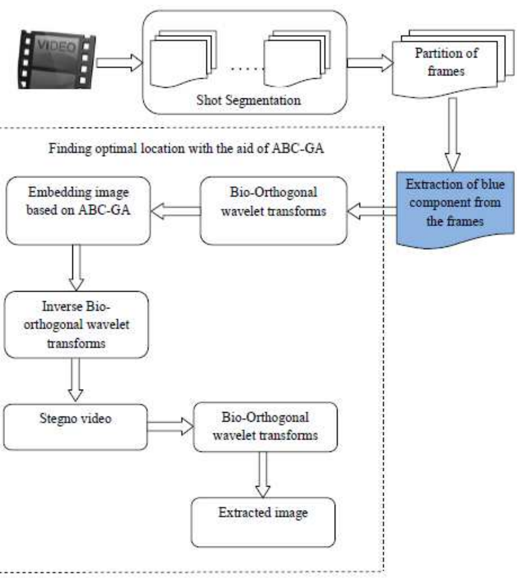

Figure: 1 Comprehensive Block Diagram Of Embedding And Extraction Process

4. STEGANOGRAPH EMBEDDING AND EXTRACTION PROCESS

4.1 Embedding Process

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Input:
Original video sequence $V_o[a,b]$, stegano image $I_s[a,b]$

Output:
Steganograph video $V_s[a,b]$

Procedure:
Using shot segmentation technique, the input video sequence $V_o[a,b]$ is segmented into a number of non-overlapping shots $D[a,b]$. Then, identify the number of frames $E[a,b]$ involved in each segmented shot $D[a,b]$ for embedding.

Convert stegano image $I_s[a,b]$ into vector form of image $W[a,b]$.

- ❖ In a video sequence having R, G and B values, we have to find the blue components of each frame.
- ❖ For embedding each vector sample $W[a,b]$ into the blue components of each frame, the blue components $B_E[a,b]$ of all the separated frames are extracted.
- ❖ Decompose the blue components $B_E[a,b]$ of each partitioned frame $E_p[a,b]$ into four sub-bands such as HH, HL, LH and LL with the aid of the Biorthogonal Wavelet transform to attain the transformed $T_f[a,b]$ frames.
- ❖ To embed the stegano image $I_s[a,b]$, select the low frequency sub-bands (**HL, LH**) from the transformed frames.
- ❖ Find the similarity matrix of the video $V_o[a,b]$ in order to embed into the selected sub-bands. The upper part U_p of the similarity matrix is embedded into the HL sub-band and the lower part L_p of the similarity matrix is embedded into the LH sub-band.
- ❖ The HL and LH sub-bands used to embed the stegano image are divided into four parts as per the similarity matrix. The lower part $F_p[x,y]$ of the similarity matrix of the HL and LH bands is chosen for embedding the two similar parts of the stegano image.
- ❖ In the HL sub-band, the upper part U_p of the similarity matrix is embedded using the following steps: Calculate the mean value $mean(F_p)$ and the maximum value $\max(F_p)$ of the chosen embedding part F_p .

$$I(F_p)=\sum_{n=1}^{j}F_p(n)$$

- ❖ Embed the watermark bits 0 or 1 in a zig-zag manner in the chosen embedding part, since the steganograph is the image. Two scenarios with respect to the stegano image emerge.

Case 1: With respect to embedding the watermark bit '1'.

The values in the embedding part $F_p[x,y]$ are compared against the maximum value $\max(F_p)$ and modified as follows: If the value in the chosen embedding part is greater than 1, take the absolute value and embed the same. Otherwise, if the value in the embedding part is lesser than 1, add the corresponding pixel with the maximum value and embed the modified value.

$$\begin{aligned}
&if\ F_{p(M)} > 1\ then\\
&\quad F_p[x,y] << abs\left[F_{p(m)}\right]\\
&else\\
&\quad F_p[x,y] << F_{p(m)} + \max(F_p)\\
&end\ \ if
\end{aligned}$$

Case 2: With respect to embedding the watermark pixel '0'

If the value in the embedding part $F_p[x,y]$ is less than 0, take the absolute value and embed the same. Otherwise, if the value in the embedding part is greater than the 1, subtract the corresponding pixel with the maximum value $\max(F_p)$ and embed the modified value.

$$\begin{aligned}
&if\ F_{p(m)} < 0\ then\\
&\quad F_p[x,y] << abs\left[F_{p(m)}\right]\\
&else\\
&\quad F_p[x,y] << F_{p(m)} - \max(F_p)\\
&end\ \ if
\end{aligned}$$

- ❖ Similarly, the lower part L_p of the similarity matrix is embedded into the LH sub-band. Also, each image is embedded into all the frames of every shot.
- ❖ Divide all the embedded frames with the embedding strength to enhance the quality of the video.
- ❖ Map the modified sub-bands into its original position and apply the Inverse Coiflets Wavelet Transform to attain the watermarked video sequence $V_s[a,b]$.

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4.2 Extraction Process

After embedding the stegano image into the original video sequence, the embedded stegano image extracted without affecting the original video.

Input: Steganograph video sequence $V_s[a,b]$, size of the stenography image.

Output: Recovered stegano image $I_{rs}[a',b']$

Procedure

- Using shot segmentation technique, the input video sequence $V_s[a,b]$ is segmented into a number of non-overlapping shots $D'[a,b]$. Then, the number of frames $E'[a,b]$ involved in each segmented shots $D'[a,b]$ to be extracted are identified.
- In order to extract the embedded steganograph pixels, the blue components $B_E'[a,b]$ of all the partitioned frames are extracted.
- The blue components of the frames are decomposed with the aid of the Biorthogonal Wavelet Transform into four sub-bands HH, HL, LH and LL.
- To extract the stegano image, the low frequency sub-bands (HL, LH) from the transformed frames are selected.
- The stegano image from the embedding part is extracted in a zig-zag manner from the HL and the LH sub-bands with the aid of the following steps. If the embedded bit value is greater than the mean pixel value, then the extracted pixel value is one. If it is lesser, then the extracted pixel is zero.

$$Z_M'[a,b'] = \begin{cases} 1, & F_p(n) > mean(F_p),\ where\ \ 0 < n < j \\ 0, & otherwise \end{cases}$$

- Form the matrix with the size of the steganograph image and the extracted image is placed in it to attain the stegano image.
- By applying the reverse process of vector finding operation, the stegano image $A_{rs}[a',b']$ is obtained.

5. HYBRID OPTIMIZATION MODEL

To augment both the quality and robustness of the stegano image, we utilized ABC for the initialized solution and GA for selecting the optimized location for embedding the stegano image into the original video file. These optimized techniques are utilized for the embedding and extraction processes, so that the PSNR and NC of steganograph video due to intensity of the stegano image can be computed. The details of ABC followed by the GA process are described as follows,

5.1 Employee Bee

The Employee Bee operation is a part of the ABC algorithm. This randomly generates a solution with regards embedding the image to original video file. Nowadays, population calibre plays a crucial role in representing a solution to the problem. The initial population set up is done by creating a population set P that contains a set of chromosome vectors having half the size of the HL or LH sub-band. Subsequently, a value of 1 was assigned with the size of the steganograph (hiding) image in that vector in a random manner. In the remaining cases, they were filled down by a zero value. After that the initial set of locations are spawned arbitrarily with the minimum number.

5.2 Onlooker Bee

It is a part of ABC algorithm. The cardinal function of the ‘bee’ is to determine the probability values for all the locations. The ‘bee’ analyzes all the food sources for the ‘bee’. For every solution in the population set, the steganography embedding process is repeated until all the locations defined in the solutions have been determined. Here, the locations for embedding are identified by the ‘1’ bits placed in the solution, and the embedding process and extracting process are carried out using the procedures defined in sections 4.1 and 4.2. The next step is to calculate the probability value of ABC, which is utilized for computing the PSNR and the measure of the NCC value. The formula for finding the fitness value of GA is mentioned below.

$$probability = PSNR + NCC$$

The formula for computing the value for PSNR and Normalised Correlation Coefficient (NCC) is given below,

$$PSNR = 10\log_{10}\frac{E_{\max}^2 \times S_w \times S_h}{\sum\left(S_{ab} - S_{ab}^*\right)}$$

$$NCC = \frac{\sum_{a=0}^{q}\sum_{b=0}^{p} I_S(a,b) \times E_S(a,b)}{\sum_{a=0}^{q}\sum_{b=0}^{p} I_S(a,b)^2}$$

Where,

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S_w and S_h	width and height of the stegano image
S_{ab}	original image pixel value at coordinate (a, b)
S^*_{ab}	stegano image pixel value at coordinate (a, b)
$E^2_{\max}$	largest energy of the image pixels (i.e., $E_{\max}$ = 255 for 256 gray-level images)
$I_S(a,b)$	original steganograph image
$E_S(a,b)$	extracted steganograph image
p and q	width and height of the steagnograph image

The optimal locations for embedding and extracting the stegano image into original video file have to be determined within these levels. Based on the scout bee operation the locations have to be updated. The function of this 'bee' is to randomly search locations for living. In our proposed endeavour, the scout bee have affixed for the mutation operation.

5.3Mutation Operation

Mutation is the function of generating new offspring's from a single parent source and maintaining the diversity of each chromosome. There is a chance that the genes of a child might change randomly. The child's gene performance is better than that of the 'old parents'. Mutation takes place in two ways random or alternate. In our study, we make use of the random mutation operation in order to determine accurately optimal solution for embedding and extracting the stegano image. With this aforementioned condition, we annex candour and robustness to the steganograph video sequence.

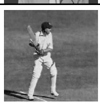
5.4 Termination

If the mutation operation is applied, we have a new solution for both operations. It can be evaluated using the probability value. It is continued, until we get an authentic optimal solution for both operations.

6. RESULTS AND DISCUSSION

Proposed results based on Biorthogonal based hybrid ABC-GA

Table 1.PSNR & NC Values For Without Attack (Biorthogonal Based Hybrid ABC-GA)

S.No	Original frame	Embedded image	Stegno frame	Extracted image	PSNR	NC
1					29.12985408	0.966710089
2					35.95364786	0.971957555
3					30.96784462	0.948790551

The aforementioned table provides information regarding the Biorthogonal based hybrid, ABC-GA, without attack over all processes and their discrete element output. In this table, the Peak Signal to Noise Ratio (PSNR) and Normalized Correlations (NC) are evaluated for three dissimilar videos. The PSNR and NC values are higher in the second video frame. The PSNR values are calculated by correlating the original frame with the stegano frame and its execution is extrapolated in terms of PSNR value. The NC values are computed for the embedded image and the extracted image.

Biorthogonal based ABC-GA for dissimilar attacks

Table 2.Biorthogonal Based ABC-GA For Dissimilar Attack

Video	Attacks	PSNR	NC
	Filter	30.44403804	0.946673447
	Noise	30.45345751	0.938404764
	Blurring	30.10308152	0.94342244
	Filter	28.87453456	0.965100888
	Noise	28.36730722	0.94356102

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	Blurring	28.67885676	0.960345094
	Filter	35.87665376	0.969666358
	Noise	35.64655785	0.959647179
	Blurring	35.5674607	0.965406029

By applying an 'attack' in the Biorthogonal based hybrid ABC and GA stegnography, the values obtained for PSNR and NC values are listed above for dissimilar attacks. Overall, our proposed Biorthogonal based hybrid ABC-GA gives a much better result when compared with the auxiliary distinctive ABC or GA.

Comparisons of PSNRs without attack for dissimilar videos and transforms

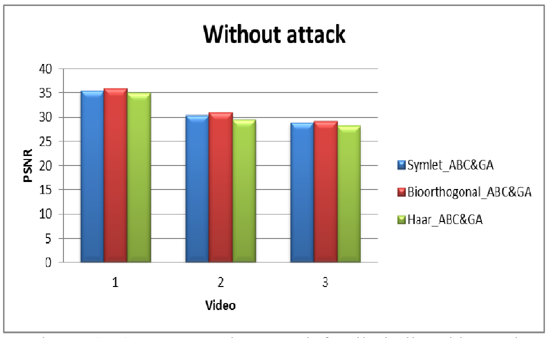

Figure: 2 PSNR comparison graph for dissimilar video and transform based on 'without attack'

PSNR Filter Comparison graph for dissimilar videos and transforms

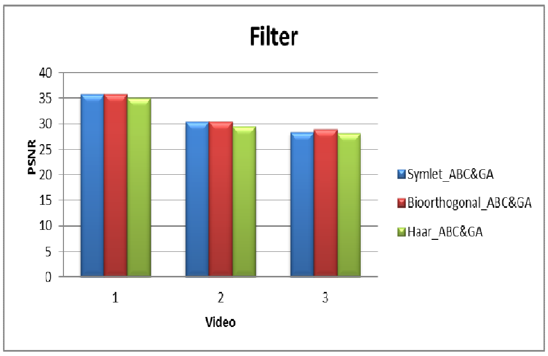

Figure: 3 PSNR comparison graph for dissimilar video and transform based on 'filter attack'

PSNR Noise comparison graph for dissimilar videos and transforms

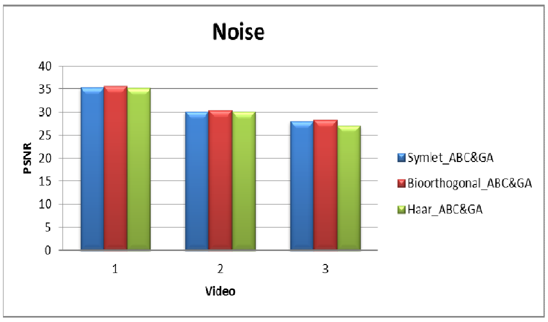

Figure: 4 PSNR comparison graph for dissimilar video and transform based on 'Noise attack'

PSNR Blurring comparison graph for dissimilar videos and transforms

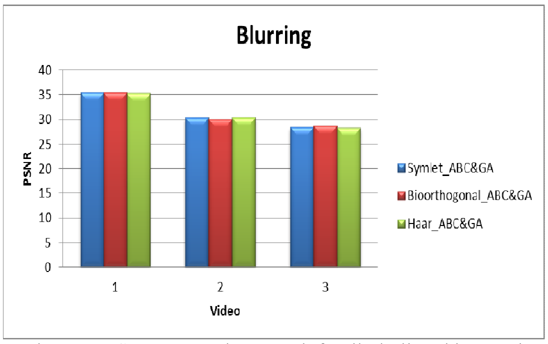

Figure: 5 PSNR comparison graph for dissimilar videos and transform based on 'Blurring attack'

From the aforementioned graphs (i.e figure 3–figure 6) it seems to indicate that that our proposed bio-orthogonal based hybrid ABC-GA provides better results. Based on the graph we can come to the conclusion that our proposed technique is superior in all cases while applying attack and also in the case of 'without attack'.

NC without attack comparison graph for dissimilar videos and transforms

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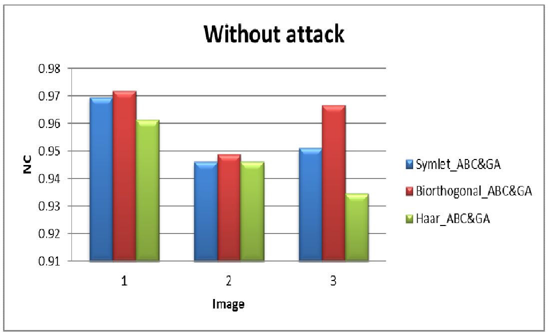

Figure: 6 NC comparison graph for dissimilar video and transform based on 'without attack'

Normalized Correlation filter comparison graph for dissimilar video and transforms

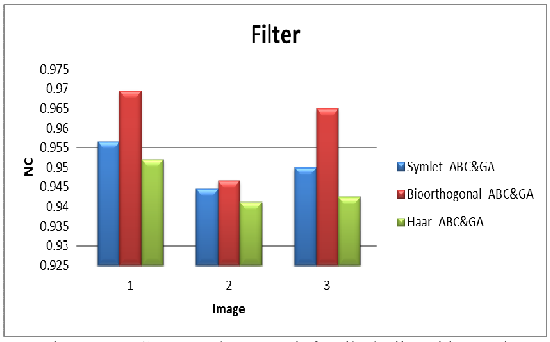

Figure: 7 NC comparison graph for dissimilar video and transform based on 'filter attack'

NC Noise comparison graph for dissimilar videos and transforms

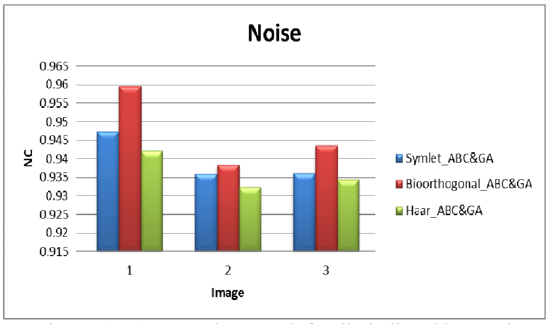

Figure: 8 NC comparison graph for dissimilar videos and transform based on 'Noise attack'

NC Blurring comparison graph for dissimilar videos and transforms

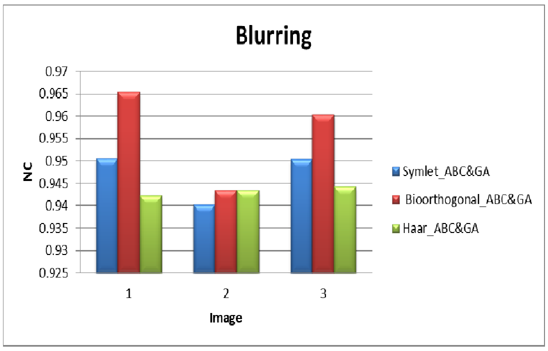

Figure: 9 NC comparison graph for dissimilar video and transform based on 'blurring attack'

Biorthogonal based dissimilar optimization algorithm for calculating PSNR

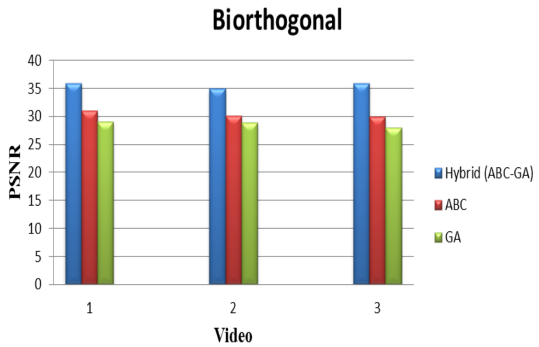

Figure: 10 Biorthogonal based dissimilar optimization algorithm for calculating PSNR value

In the above mentioned graph PSNR value is evaluated for dissimilar optimization algorithm by means of Bio-orthogonal. This exhibit that our proposed Biorthogonal based hybrid technique is superior to other two algorithms (ABC & GA).

Biorthogonal based dissimilar optimization algorithm for NC value

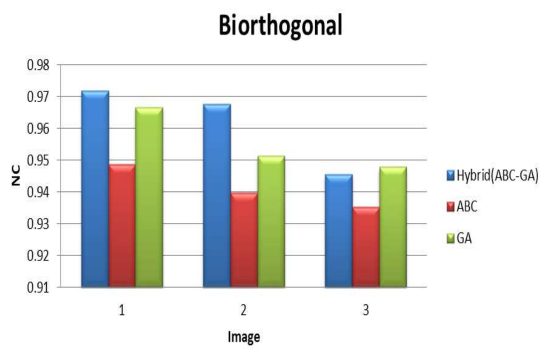

Figure: 11 Biorthogonal based dissimilar optimization algorithm for calculating NC value

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In the case of NC also our proposed bio-orthogonal plays a superior role for dissimilar algorithms.

6. CONCLUSION

In this paper we have proposed an optimization based Biorthogonal Wavelet Transform and we have assayed that our proposed Biorthogonal Transformation with the aid of a hybrid model gives better results which is clearly explained in the aforementioned results and discussion. The achieved Peak Signal to Noise Ratio is 35.95 for the1st video frame, 30.96 for the 2nd video frame and 29.12 for the 3rd video frame. Then, the Normalized Correlation is 97.19% for the1st image, 94.8% for the 2nd image, 96.6% for the 3rd image. For the aforementioned cases, our proposed technique performs better and is able to retrieve the optimized result much more efficiently. More work should be done to reduce the computational time taken for this process without compromising on its efficiency.

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