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Graphics & Vision

Highlights

- Scheme of Fault Detection
- Robust Image Watermarking
- Texture Image Segmentation
- Video Stabilization Method

Discovering Thoughts, Inventing Future

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Texture Image Segmentation using Morphology in Wavelet Transforms

By K. Venkata Subbaiah & V. Vijay Kumar

Abstract- One of the essential and crucial steps for image understanding, interpretation, analysis and recognition is the image segmentation. This paper advocates a new segmentation scheme using morphology on wavelet decomposed images. The present paper provides a good segmentation on natural images and textures by dividing an image into non overlapping regions, which are homogenous in terms of certain features such as texture, spatial coordinates etc. using simple morphological operations. Morphological enhancement technique based on Top Hat transforms enhances the local contrast in this paper. The morphological treatment and followed by Otsu's threshold overcomes the problem of noise and thin gaps, and also smooth the final regions. The experimental results on four different databases demonstrate the success of the proposed method, compared to many other methods.

Keywords: *morphology, top hat transform, local contrast, otsu threshold.*

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Texture Image Segmentation using Morphology in Wavelet Transforms

K. Venkata Subbaiah [α] & V. Vijay Kumar [σ]

Abstract- One of the essential and crucial steps for image understanding, interpretation, analysis and recognition is the image segmentation. This paper advocates a new segmentation scheme using morphology on wavelet decomposed images. The present paper provides a good segmentation on natural images and textures by dividing an image into non overlapping regions, which are homogenous in terms of certain features such as texture, spatial coordinates etc. using simple morphological operations. Morphological enhancement technique based on Top Hat transforms enhances the local contrast in this paper. The morphological treatment and followed by Otsu's threshold overcomes the problem of noise and thin gaps, and also smooth the final regions. The experimental results on four different databases demonstrate the success of the proposed method, compared to many other methods.

Keywords: morphology, top hat transform, local contrast, otsu threshold.

I. Introduction

Research on texture segmentation has been carried out for decades; this is because image analysis, description, illustration, classification, image understanding and restoration are largely dependent on the segmentation results. The texture segmentation plays a vital role in a variety of applications such as medical imaging, textile designs, identification of human faces and expressions, various military applications, remote sensing, robot vision, cartography, identification of vehicles and quality assurance in industries etc. The texture is still a relatively poorly understood phenomenon. It is very easy and natural for human being to understand a texture; it is extremely difficult to define it. That's why many researchers attempted to define texture based on their application and a catalogue of texture definitions is available in literature [1].Texture segmentation [2, 3, 4, 5] break ups an image texture into dissimilar areas depending on a variety of attributes. The attributes can be texture, pixel intensities, color, shape or any other feature of interest according to the particular application. Researchers contributed significantly to the problem of image segmentation in the literature [6, 7, 8, 9, 10,11]. Color is one of the important attribute of the texture and there are many segmentation schemes that are based on color [10, 12, 3, 14, 15, 16, 17].

The segmentation methods based on wavelets [18], hidden Markov models [19],multichannel filtering [20], quadtree [21], fractal dimension [22], feature smoo thing [23], split-and-merge methods [24], autoregressive models [25], pyramid node linking [26], local linear transforms [27], Markov random field models [28], and selective feature smoothing with clustering [29] are proposed in the literature. The above methods [18-29] attained fine results for texture like mosaics (a tiny set of fine-grained texture); and failed to achieve a precise segmentation for natural texture images. The present paper considered Brodtaz and other natural textures and implemented segmentation on wavelet based images using morphological and thresholding techniques to obtain better results.

Edge-based [30, 31], region-based [32] and pixel-based segmentation [33] methods are also popular in the literature. Region-based segmentation can identify partitions in a given image. The region based methods [34, 41-43] arepopular in literature. The segmentation methods based on normalized cuts are also proposed [35-40] and among these, the multi scale normalized cut approach [39] obtained a precise segmentation. The histogram based [44-48] methods, fall in to pixel based segmentation approaches. Thetextonor shape based methods [49-52] also attained good results. The exactness of segmentation method is highly dependent on i) Type of textures ii) The type of attributes considered iii) The way the attributes are evaluated (global, local or region wise etc.). This indicates that segmentation methods are application dependent. The present paper initially decomposes the texture images using wavelet transforms. The segmentation scheme is applied on the decomposed image and quality assessment parameters are evaluated. The present paper is organized as follows: The section 2 describes the related work. The section 3 and 4 describes the proposed method and results and discussions respectively. The section five describes the conclusions.

II. Related Work

a) Mathematical Morphology (MM)

Mathematical morphology (MM) is the popular and wide spread non-linear theoretical model and widely used for image investigation, processing, analysis, and

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other applications. Mathematical morphology refers to image components like topology, shape, connectivity etc. The morphological operations are very simple, easy to understand, compute and analyze because they are basically derived from algebraic operators and it is proposed by Matheron and Serra and it is an extension of Minkowski's set theory [53], [54]. Morphology is gained much attention in solving and analyzing image processing problems related to geometrical variations and aspects of the image, whereas most of the non-morphological image processing methods are mostly unsuccessful in this aspect. These methods have additional advantages in dealing with textures, because the texture is basically nonlinear in nature. The morphology basically deals with shape or topological properties of objects. That is the reason they are most significant in segmentation problems. Using morphological operations one can easily represent or capture the various dissimilarities between geometrical properties such as size, connectivity, shape, which are considered as essential feature parameters that are basically needed to partition or segment an image texture. Many researchers used morphological operations extensively in various computer vision and pattern recognition applications like: preprocessing, boundary detection, removal of noise, image segmentation, image enhancement, image smoothening, image understanding and analysis of images. The main reason for the popular usage of mathematical morphology in image processing is they are based on dilation and erosion operations, which can be implemented in binary and gray leveldomains.

b) Gray Value Morphological Processing

The dilation operation, in gray level is given by equation 1. The images grow in size by dilation. The erosion is given by the following equation 2. The image size is reduced in size, based on the specifications of the structure element (SE). The morphological gray level opening and closing are defined in equations 3 and 4.

$$Dilation = \max_{[j,k]\epsilon Q}\{P[m-j,n-k]\} = \max_{Q} P \quad (1)$$

$$Erosion = \min_{[j,k]\in Q}\{P[m-j,n-k]\} = \min_{Q}(P) \quad (2)$$

$$Opening - O_G(P,Q) = \max_{Q}\left(\min_{Q}(P)\right) \quad (3)$$

$$Opening - O_G(P,Q) = \min_{Q}\left(\max_{Q}(P)\right) \quad (4)$$

Where P and Q are the original image and structuring element.

The Structuring element Q contains fixed number pixels, which are bounded and convex in nature. The erosion followed by dilation is called morphological opening. In opening the erosion of an image removes all structures that cannot fit inside. Further shrinks all other structures. Then by dilating the result of the erosion with the same structuring element, the structures that are survived by the erosion (were shrunken, not deleted) will be restored. Opening generally smoothes the contour of an image, splits slim isthmuses, and overcomes from thin protrusions affect. The closing smooth the image removes minute holes, and fills gaps in the contour. This retains the uniformity of a local region.

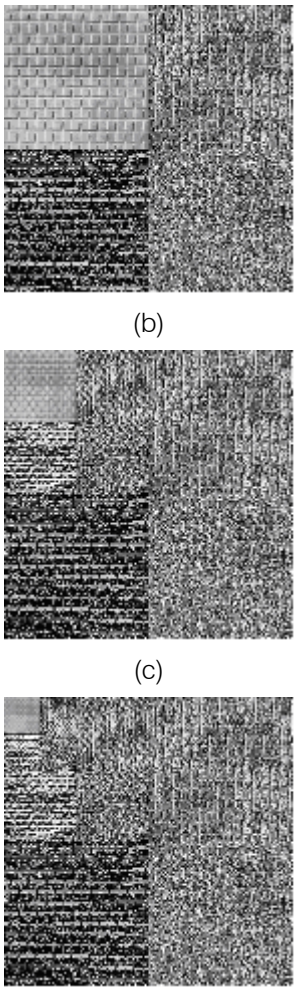
III. Methodology

To derive precise segmentation the present paper initially converts the color image in to gray level image using HSV color quantization. The present paper then convert the gray level image into discrete wavelet transform (DWT) using Harr wavelet transform.

a) Wavelet transforms

The mathematical function that is used to divide a given function into components of different frequency is called wavelet transform. And each component is studied by wavelets with a resolution that matches its scale. An image signal is passed through an analysis filter bank followed by a decimation operation and analyzed in wavelet transforms. This filter bank consists of a low pass and a high pass filter at each decomposition stage. The low pass filter, corresponds to an averaging operation. The low pass filters extracts the coarse information of a signal. The high pass filter extracts the detail information of the signal and it represents to a differencing operation. The image will be divided i.e., decomposed into four sub-bands i.e. denoted by low-low (LL), high-low (HL), low-high (LH) and high-high (HH). The LH1, HL1 and HH1 sub bands correspond to the detail images i.e., finest scale wavelet coefficients. The LL1 sub-band corresponds to approximation image (coarse level coefficients). By decomposing LL1 sub band alone, the next coarse level of wavelet coefficients will be obtained and they are denoted as LL2, LH2, HL2, and HH2. Similarly, to obtain further decomposition, LL2 will be used. The features obtained from these DWT transformed images are useful for texture analysis, namely segmentation. The

(a)



(b)

(c)

(d)

Figure 1: Shows the 1-level, 2- level and 3-level wavelet transformed image.

Figure 1(a) Original Brodatz Texture (b) Level-1 Wavelet Transformed Brodatz Texture (c) Level-2 Wavelet Transformed Brodatz Texture (d) Level-3 Wavelet Transformed Brodatz Texture.

b) Identification of interior regions by Top-hat transform

Initially the image is converted in to DWT image. To recognize details of interior regions and to improve the contrast of the image texture, morphological treatment is given by using Top Hat transform (THT). This paper used THT, instead of Histogram Equalization (HE) to deal with the natural textures with high and low mean brightness values; The present paper also overcomes the enhancement disadvantages that arises from the global content of the image. HE may produce over enhancement and saturation artifacts [55, 56]. That is why researchers are focusing on upgrading of the conventional histogram equalization. To overcome this present paper derive contrast enhancement based on THT of morphology. The THT is used to extract image features. There two types THTs: white top hat transforms (WTH) and black top hat transformation (BTH). The morphological WTH is applied to take out bright or over intensity features of texture mage. It is derived from equation 5.

$$P_{WTH} = P - (P \circ Q) \quad (5)$$

To extract the darker features of image texture the BTH is used and it is derived by equation 6.

$$P_{BTH} = (P \bullet Q) - P \quad (6)$$

To increase the contrast between the black and white regions of image the present paper derived a new contrast enhancement using MM operations as given below.

$$P_{CE} = P + P_{WHT} - P \quad (7)$$

where, P is the original image. P_{CE} is the final enhanced image. P_{WHT} represents the extracted white image regions. P_b represents the extracted black image regions.

To derive the uniform local regions of the texture image, closing operation is applied in this paper. This has connected the objects that are nearer to each other and it has filled small gaps.

c) Thresholding by Otsu method

To set upwell defined boundaries in the texture image, Otsu thresholding is applied in this paper. One of the important steps in segmentation is thresholding. Thresholding divides the texture image in to two or more units. Threshold will be chosen based on intensity attribute of the objects, sizes of the objects, number of different types of objects appearing in an image etc. One should have proper knowledge about the images and the application to choose the threshold. The Otsu method [57] is based on discriminate analysis. This method [57] selects the threshold by limiting the within-class variance of the two groups of pixels separated by the thresholding operator. A measure of region homogeneity is variance. The OTSU thresholddoes not depend on modeling the probability density functions and it is based on a bimodal distribution of gray-level values. The OTSU threshold operation performs the division of image pixels into two classes C0 and C1 (e.g., objects and background) at gray level.

IV. Results and Discussions

The performance of the texture segmentation schemes can be assessed by subjective evaluation, supervised and non-supervised evaluation: Comparing the approximate segmentation results with various other segmentation approaches is called subjective evaluation; The segmented output, is compared with the original image in supervised evaluation. The above two assessments are impractical and not popular because they are not automatic and requires human interaction. In "unsupervised approaches" [58, 59] comparison with ground truth or original images is not required. And they

take less time in evaluating the performance of the segmentation method. The proposed segmentation scheme is assessed by unsupervised parameters like: Discrepancy, Entropy, Standard deviation, internal region contrast as given below. The value of these indicates the following: If the value of discrepancy is high, then it indicates a better segmentation. Using entropy value one can recognize the Over segmentation and under segmentations. Over segmentation will be resulted if entropy value less than 1 and if it is above 1.5 then represents under segmentation. A better segmentation is estimated with lower values of standard deviation. Region uniformity should not be disturbed while segmenting. If the segmented image results a low internal contrast then it indicates a high uniformity.

$$Discrepancy = \sum_{r=1}^{n}\sum_{c=1}^{m}(A(r,c) - B(r,c)) \quad (8)$$

Where A(r,c) and B(r,c) represents the gray level original and segmented image.

Entropy of an image is given as

$$Entropy = -\sum_r \sum_c B(r,c)log\big(B(r,c)\big) \quad (9)$$

Where B is segmented image

Standard deviation of a given vector is expressed as

$$\text{Standared deviation S} = \left[\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2\right]^{\frac{1}{2}} \quad (10)$$

Where x_i and $\bar{x}$ are the value of vector and average of all values.

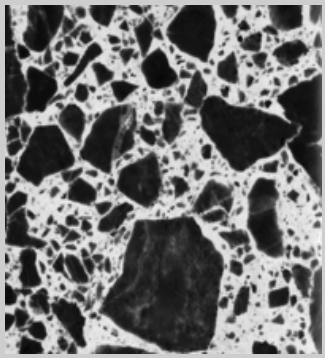
Internal region contrast is defined as

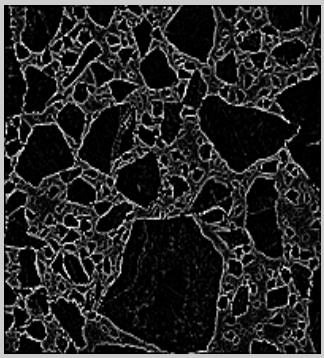
$$\text{Internal region contrast } I_j = \frac{1}{S_j}\sum_{s\in R_j} \max\{cont(s,t), t \in N_s \cap R_j\} \quad (11)$$

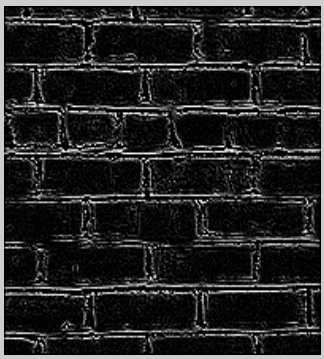
Where N(s) is the neighborhood and contrast (s,t) = $|C_x(s) - C_x(t)|$ is the contrast of pixel 's' and 't'. The region uniformity is measured by internal contrast, I_j. The I_j represents "region average Max Contrast".

The present method is tested on Brodtaz [60], Oxford flowers [61], Wang [62] and standard images from Google (Lena, Camera man, House, Mandrill, and Ship) [63]. The experiments are carried out by considering 100 images from each data base, thus it results a total of 400images.There are 1,000 natural images in Wang database and these images are selected manually from Corel stock photo database. These images are divided into 10 categories (each category consists 100 images). There are 17 classes (80 images per class) in Oxford flower database. There are 112 texture images in the Brodatz album with different background intensities. The proposed method is compared with three existing methods ISLGHEM [64], automatic thresholding method [65], wavelet based watershed method [66] and MULBP method [67]. To show the performance, the proposed integrated DWT segmentation scheme is applied on input images and results are shown in Fig.2, 3, 4 and 5 for Brodatz, Oxford, Wang and standard database textures respectively. The following are noted from the segmented outputs and they clearly establish the following facts.

1. The WHT enhanced the contrast of the local DWT regions of images.
2. The small holes are filled by the morphological treatment.
3. The Otsu threshold established local boundaries of the image effectively and also removed unwanted non-significant portions of the image.







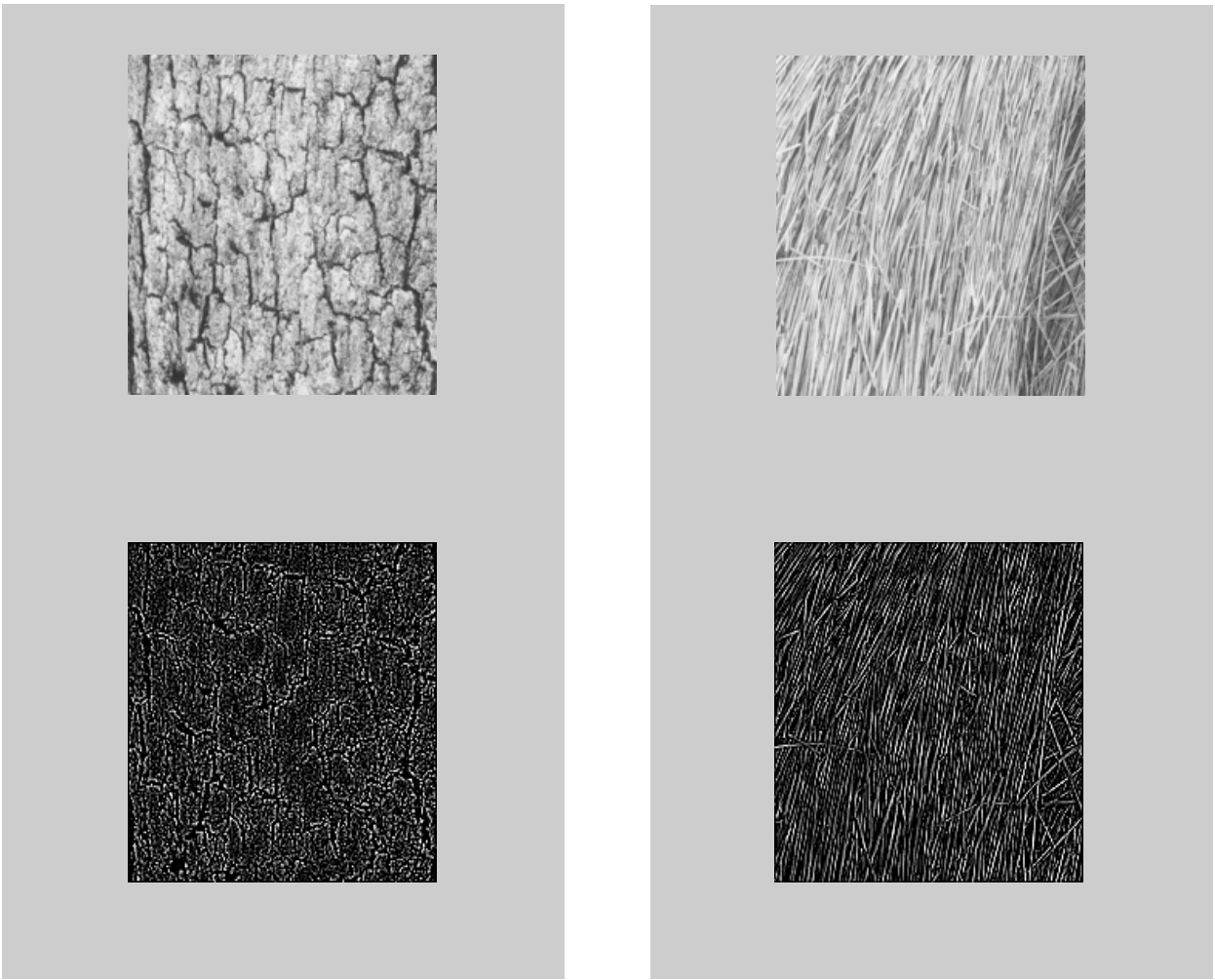
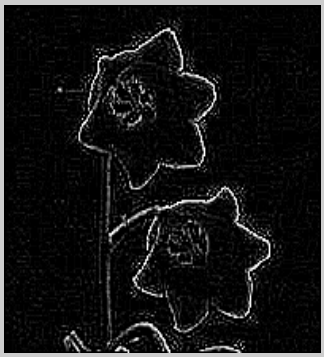


Figure 2: The segmented output Brodatz texture images by the proposed method.



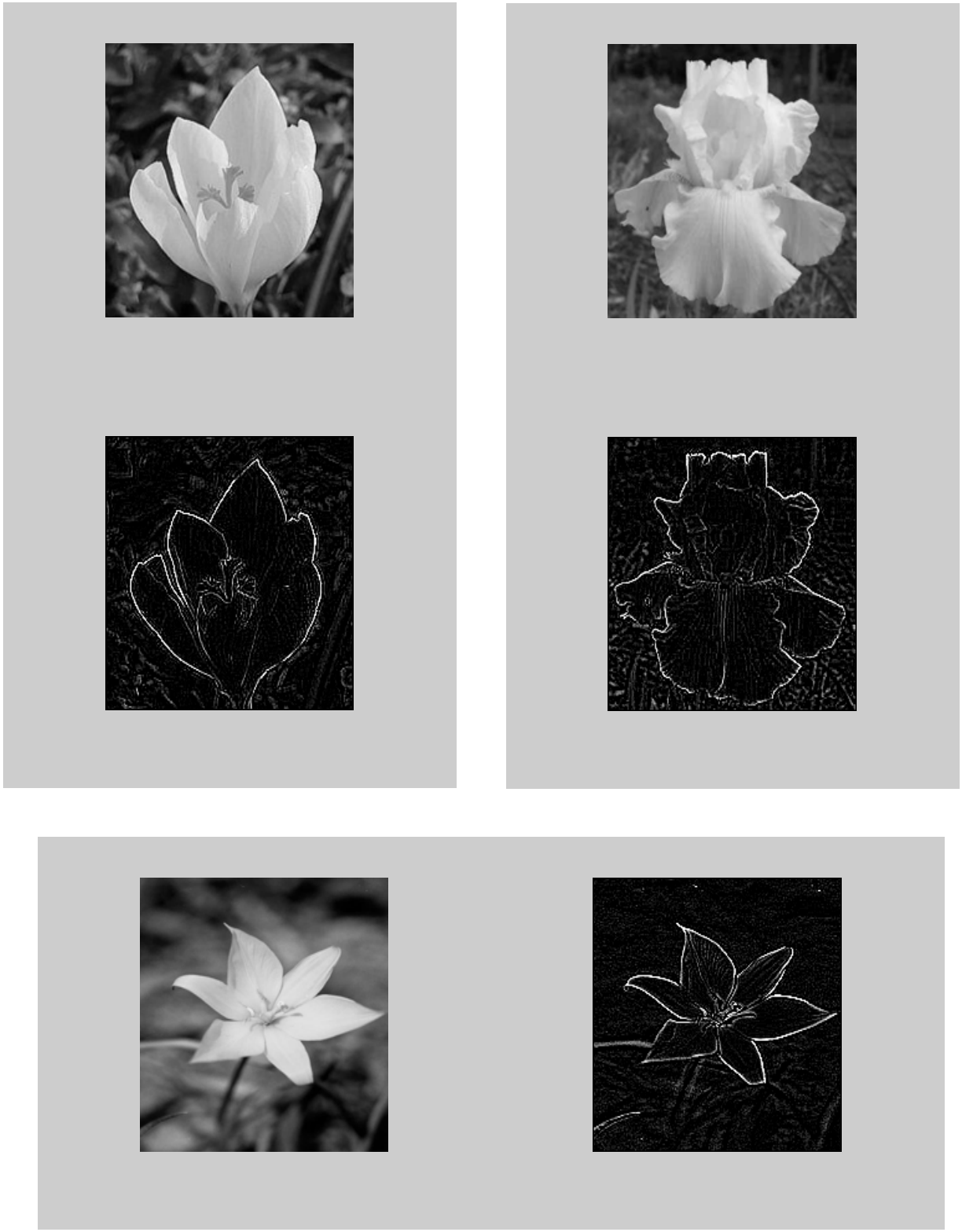
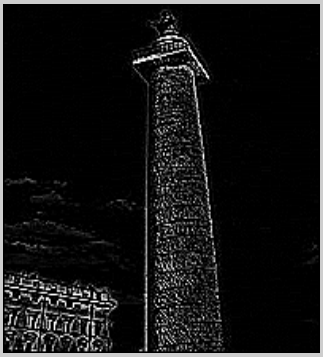
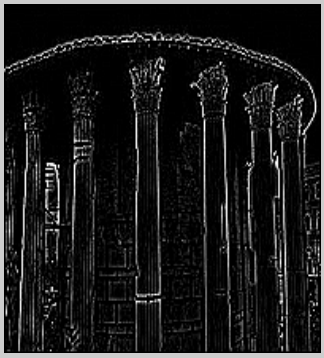


Figure 3: The segmented output Oxford flower texture images by the proposed method.





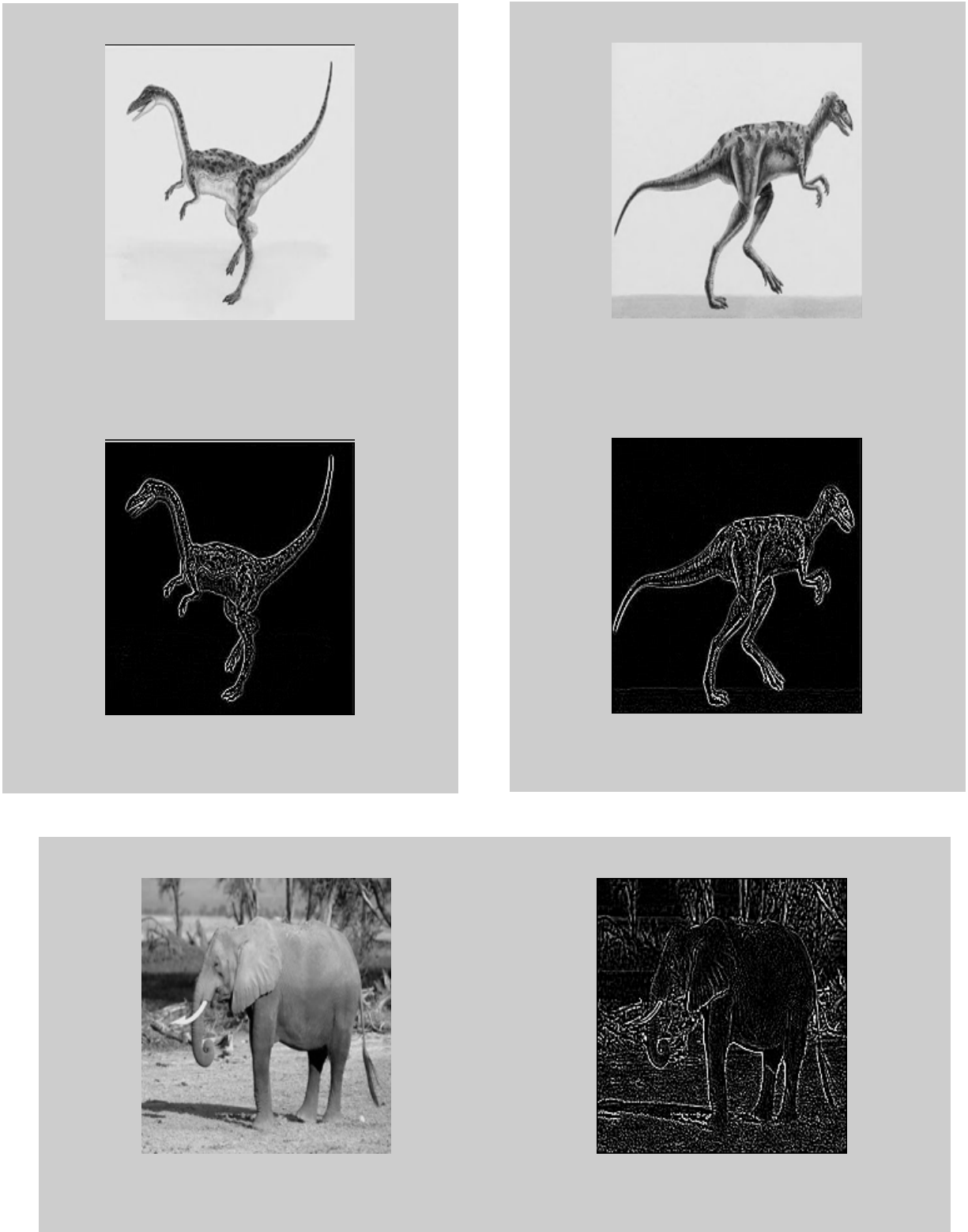
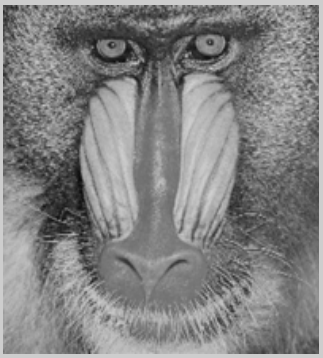


Figure 4: Final segmented texture images from Wang database.



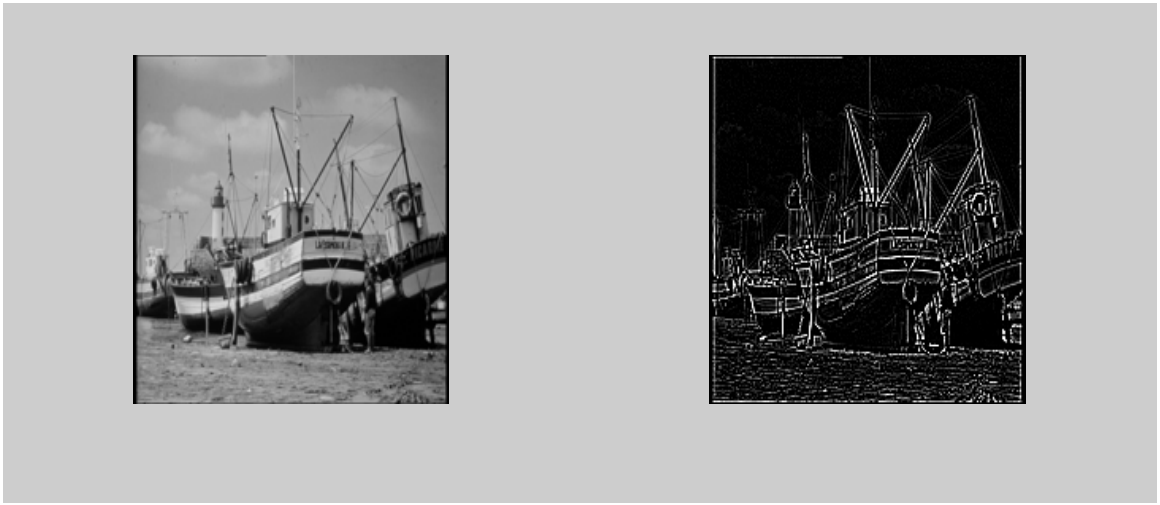


Figure 5: The segmented outputs of the standard image.

The present paper evaluated the above statistical parameter or unsupervised approaches on the proposed and the other methods. The results are displayed in Table 1, 2, 3 and 4 and also plotted in Fig. 6 to Fig.9.

The proposed method is compared with the existing methods [64, 65, 66, 67]. A high discrepancy rate is noted for all considered textures (14.56 to 15.66) except standard images of Google on the proposed method, which has shown low discrepancy rate of 12.19, and resulted an average value of 14.5.The average value of entropy, standard deviation and internal region contrast for the proposed methods are 1.26, 1.75 and 0.91 respectively, which clearly indicates a good segmentation. The proposed method resulted high discrepancy value and the low standard deviation over the other methods (Fig: 6 and Fig.9). This reflects a better segmentation of the proposed over the existing methods. The low value of internal contrast and a decent value of entropy also indicate the high performance of the proposed method over the existing methods.

Table 1: Average values of discrepancy.

Name of the data base	Proposed method	ISLGHEM [64]	ATM [65]	WWM[66]	MULBP method [67]
Brodatz texture	15.66	12.56	13.68	11.20	14.3
Wang	15.64	11.3	13.2	10.3	14.1
Oxford flower	14.56	11.4	12.3	10.6	13.2
Standard image	12.10	8.3	9.6	7.8	10.3
Average of all databases	14.49	10.37	11.67	9.65	12.42

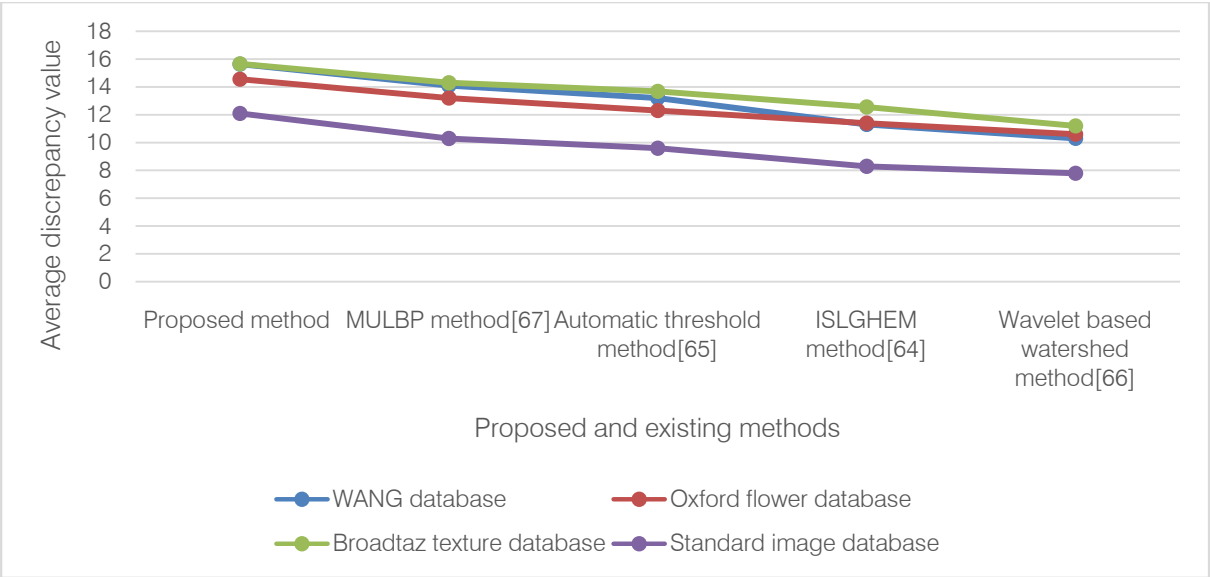


Figure 5: Comparison graph of proposed and existing methods in terms of Average discrepancy over considered databases.

Table 2: Average values of entropy.

Name of the data base	Proposed method	ISLGHEM [64]	ATM [65]	WWM [66]	MULBP method[67]
Brodatz texture	1.20	2.35	2.10	1.98	1.4
Wang	1.21	3.1	3.4	2.6	1.28
Oxford flower	1.36	2.7	3.1	2.6	1.44
Standard image	1.30	2	2.3	1.8	1.35
Average of all databases	1.26	2.475	2.85	2.225	1.36

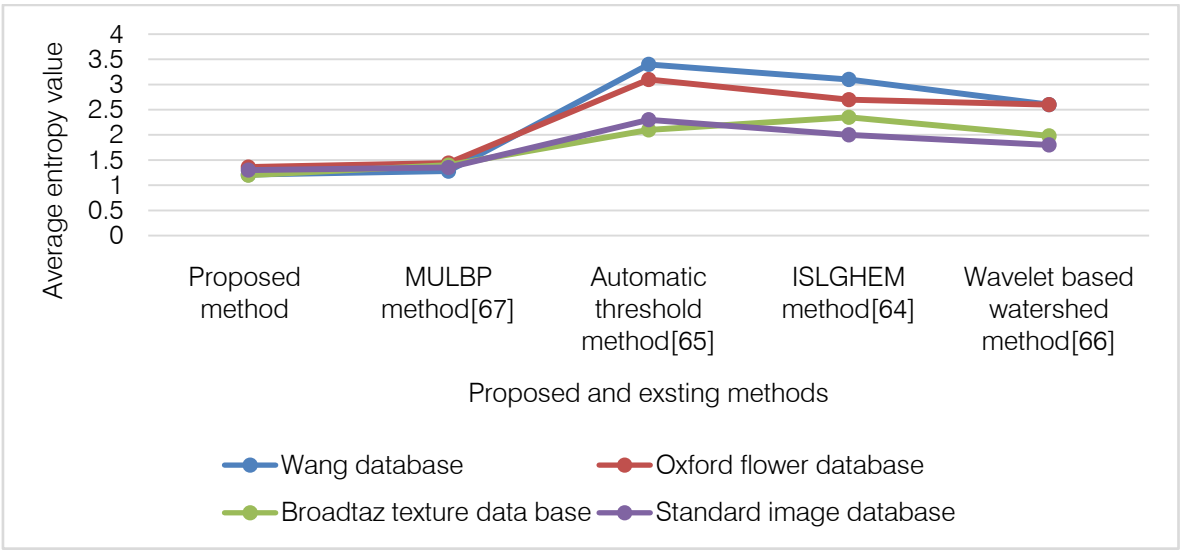


Figure 6: Comparison graph of proposed and existing methods in terms of Average entropyover considered databases.

Table 3: Average values of standard deviation.

Name of the data base	Proposed method	ISLGHEM method[64]	Automatic threshold method[65]	Wavelet based watershed method[66]	MULBP method[67]
Brodatz texture database	1.5	3.8	3.3	3.6	2.1
Wang database	1.98	4.4	4.1	3.8	2.7
Oxford flower database	1.86	4.4	3.5	4.2	2.1
Standard image database	1.69	4.3	3.5	4	2.6
Average of all databases	1.75	4.3	3.85	3.9	2.55

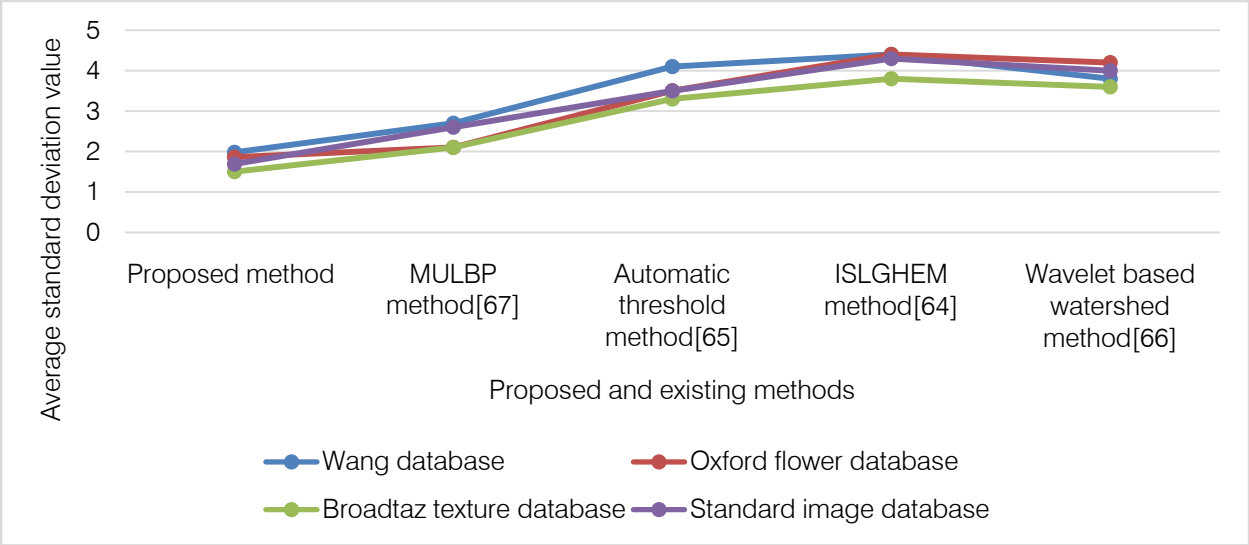


Figure 7: Comparison graph of proposed and existing methods in terms of Average standard deviation over considered databases.

Table 4: Average values of internal region contrast.

Name of the database	Proposed method	ISLGHEM method[64]	Automatic threshold method[65]	Wavelet based watershed method[66]	MULBP method[67]
Brodatz texture database	0.82	1.20	1.68	2.3	1.13
Wang database	0.89	1.8	1.4	1.9	0.90
Oxford flower database	0.86	1.5	1.8	2.6	1.10
Standard image database	1.1	2.8	2.6	3.4	1.52
Average of all databases	0.91	2.175	1.95	2.675	1.28

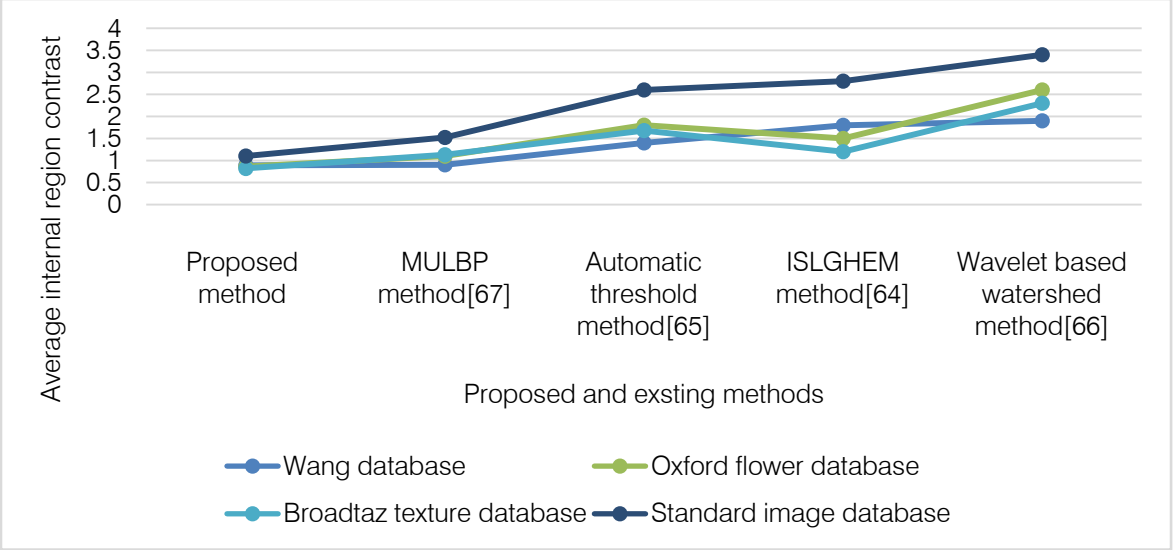


Figure 8: Comparison graph of proposed and existing methods in terms of Average internal region contrast over considered databases

V. Conclusions

The morphological operations covered the small holes with intensities and borders are connected for a better segmentation. The Otsu threshold established local boundaries efficiently and provided better contrast and also removed the unwanted local scenes of the image. The whole process of segmentation is automatic and requires no supervision. The present paper improves the contrast of sharp details in light and dark areas. The present method is experimented on the four standard databases namely Brodatz, Wang, Oxford flowers and standard images. The present method attained a good segmentation on the four datasets: however the proposed method have shown significantly high performance on Brodatz database textures when compared with other standard datasets; followed by Wang and oxford datasets. Further no over and under segmentation is reported by the present method on the considered databases. The present method is simple and suitable to real time applications because it achieved good segmentation with three basic steps.

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A Literature Review on Emotion Recognition using Various Methods

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Abstract- Emotion Recognition is an important area of work to improve the interaction between human and machine. Complexity of emotion makes the acquisition task more difficult. Quondam works are proposed to capture emotion through unimodal mechanism such as only facial expressions or only vocal input. More recently, inception to the idea of multimodal emotion recognition has increased the accuracy rate of the detection of the machine. Moreover, deep learning technique with neural network extended the success ratio of machine in respect of emotion recognition. Recent works with deep learning technique has been performed with different kinds of input of human behavior such as audio-visual inputs, facial expressions, body gestures, EEG signal and related brainwaves. Still many aspects in this area to work on to improve and make a robust system will detect and classify emotions more accurately. In this paper, we tried to explore the relevant significant works, their techniques, and the effectiveness of the methods and the scope of the improvement of the results.

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A Literature Review on Emotion Recognition using Various Methods

Reeshad Khan [α] & Omar Sharif [σ]

Abstract- Emotion Recognition is an important area of work to improve the interaction between human and machine. Complexity of emotion makes the acquisition task more difficult. Quondam works are proposed to capture emotion through unimodal mechanism such as only facial expressions or only vocal input. More recently, inception to the idea of multimodal emotion recognition has increased the accuracy rate of the detection of the machine. Moreover, deep learning technique with neural network extended the success ratio of machine in respect of emotion recognition. Recent works with deep learning technique has been performed with different kinds of input of human behavior such as audio-visual inputs, facial expressions, body gestures, EEG signal and related brainwaves. Still many aspects in this area to work on to improve and make a robust system will detect and classify emotions more accurately. In this paper, we tried to explore the relevant significant works, their techniques, and the effectiveness of the methods and the scope of the improvement of the results.

I. Introduction

Most common exposition of an idea of emotion could be found as "a natural instinctive state of mind deriving from one's circumstances, mood, or relationships with others". Which misses depicting the driving force behind all motivation which may positive, negative or neutral. This is very important information to understand emotion as an intelligent agent. It is very complicated to detect the emotions and distinguish among them. Before a decades or two emotion started to become a concern as an important addition towards the modern technology world. Rises the hope of new dawn for intelligence apparatus. Imagine a world where machines do feel what humans need or want. With the special kind of calculation then that machine could predict the further consequences and by which mankind could avoid serious circumstances and lot more. Humans are far more strong and intelligent due to the addition of the emotion but less effective than machines. But what if machines get this special features of human? It will be the strongest addition to the technology ever. And to make the dreams come true this is the first step; train a system to spot and recognize emotions. This is the start of an intelligent system. Intelligent Systems are becoming more efficient by predicting and classifying decision in various aspects of practical life. Particularly, emotion recognition through deep learning has become intriguing research area for its innovative nature and practical implication. This technique mainly consists of detecting emotion through various kinds of input taken from different human behavior and condition. A technology namely neural network detects emotion through deep learning. For its complication mentioned earlier, an emotion recognition system with stellar efficiency and accuracy is needed.

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II. Recent Related Work in the Relevant Field

Previous works are focused on eliciting results from unimodal systems. Machines used to predict emotion by only facial expressions [1] or only vocal sounds [2]. After a while, multimodal systems that use more than one features to predict emotion has more effective and gives more accurate results. So that, the combination of features such as audio-visual expressions, EEG, body gestures have been used since. More than one intelligent machine and neural networks are used to implement the emotion recognition system. Multimodal recognition method has proven more effective than unimodal systems by Shiqing et al. [3]. Research has demonstrated that deep neural networks can effectively generate discriminative features that approximate the complex non-linear dependencies between features in the original set. These deep generative models have been applied to speech and language processing, as well as emotion recognition tasks [4-6]. Martin et al. [7] showed that bidirectional Long Short Term Memory(BLSTM) network is more effective that conventional SVM approach.; In speech processing, Ngiam et al. [8] proposed and evaluated deep networks to learn audio-visual features from spoken letters. In emotion recognition, Brueckner et al. [9] found that the use of a Restricted Boltzmann Machine (RBM) prior to a two-layer neural network with fine-tuning could significantly improve classification accuracy in the Interspeech automatic likability classification challenge [10]. The work by Stuhlsatz et al. [11] took a different approach for learning acoustic features in speech emotion recognition using Generalized Discriminant Analysis (GerDA) based on Deep Neural Networks (DNNs). Yelin et al. [12] showed three layered Deep Belief Networks(DBNs') give better performance than two layered DBNs' by using audio-

visual emotion recognition process. Samira et al [13] used Recurrent neural network combined with Convoluted Neural Network(CNN) in an underlying CNN-RNN architecture to predict emotion in the video.
Some noble methods and techniques also enriched this particular research. They are more accurate, stable and realistic. In terms of performance, accuracy, reasonability and precision these methods are the dominating solutions. Some of them are more accurate but some are more realistic. Some take much time and require greater computation power to produce the more accurate result but some compromises accuracy over performance. The idea of being successful might differ but these solutions are the best possible till now.

Yelin Kim and Emily Mower Provos explore whether a subset of an utterance can be used for emotion inference and how the subset varies by classes of emotion and modalities. They propose a windowing method that identifies window configurations, window duration, and timing, for aggregating segment-level information for utterance-level emotion inference. The experimental results using the IEMOCAP and MSP-IMPROV datasets show that the identified temporal window configurations demonstrate consistent patterns across speakers, specific to different classes of emotion and modalities. They compare their proposed windowing method to a baseline method that randomly selects window configurations and a traditional all-mean method that uses the full information within an utterance. This method shows a significantly higher performance in emotion recognition while the method only uses 40–80% of information within each utterance. The identified windows also show consistency across speakers, demonstrating how multimodal cues reveal emotion over time. These patterns also align with psychological findings. But after all achievement, the result is not consistent with this method [15].

A. Yao, D. Cai, P. Hu, S. Wang, L. Shan, and Y. Chen used a well-designed Convolutional Neural Network (CNN) architecture regarding the video based emotion recognition [14]. They proposed the method named as HOLONET has three critical considerations in network design. (1) To reduce redundant filters and enhance the non-saturated non-linearity in the lower convolutional layers, they used modified Concatenated Rectified Linear Unit (CReLU) instead of ReLU. (2) To enjoy the accuracy gain from considerably increased network depth and maintain efficiency, they combine residual structure and CReLU to construct the middle layers. (3) To broaden network width and introduce multi-scale feature extraction property, the topper layers are designed as a variant of the inception-residual structure. This method more realistic than other methods here. It's focused on adaptability in real-time scenario than accuracy and theoretical performance. Though its accuracy is also impressive but only this method is applicable only in the video based emotion recognition. Other types of data rather than video, this method can't produce results [14].

Y. Fan, X. Lu, D. Li, and Y. Liu. proposed a method for video-based emotion recognition in the wild. They used CNN-LSTM and C3D networks to simultaneously model video appearances and motions [16]. They found that the combination of the two kinds of networks can give impressive results, which demonstrated the effectiveness of the method. In their proposed method they used LSTM (Long Short Term Memory) - a special kind of RNN, C3D – A Direct Spatio-Temporal Model and Hybrid CNN-RNN and C3D Networks. This method gives a great accuracy and performance is remarkable. But this method is much convoluted, time-consuming and less realistic. For this reason, efficiency is not that impressive [16].

Zixing Zhang, Fabien Ringeval, Eduardo Coutinho, Erik Marchi and Björn Schüller proposed some improvement in SSL technique to improve the low performance of a classifier that can deliver on challenging recognition tasks reduces the trust ability of the automatically labeled data and gave solutions regarding the noise accumulation problem - instances that are misclassified by the system are still used to train it in future iterations [17]. they exploited the complementarity between audio-visual features to improve the performance of the classifier during the supervised phase. Then, they iteratively re-evaluated the automatically labeled instances to correct possibly mislabeled data and this enhances the overall confidence of the system's predictions. This technique gives a best possible performance using SSL technique where labeled data is scarce and/or expensive to obtain but still, there are various inherent limitations that limit its performance in practical applications. This technique has been tested on a specific database with a limited type and number of data. The algorithm which has been used is not capable of processing physiological data alongside other types of data [17].

Wei-Long Zheng and Bao-Liang Lu proposed EEG-based effective models without labeled target data using transfer learning techniques (TCA-based Subject Transfer) [18] which is very accurate in terms of positive emotion recognition than other techniques used before. Their method achieved 85.01% accuracy. They used to transfer learning and their method includes three pillars, TCA-based Subject Transfer, KPCA-based Subject Transfer and Transductive Parameter Transfer. For data preprocessing they used raw EEG signals processed with a bandpass filter between 1 Hz and 75 Hz and for feature extraction, they employed differential entropy (DE) features. For evaluation, they adopted a leave-one-subject-out cross-validation method. Their experimental results demonstrated that the transductive parameter transfer approach significantly outperforms the other approaches in terms of the accuracies, and a 19.58% increase in recognition accuracy has been achieved.

Though this achievement is limited to the positive emotion recognition only. This method is limited in terms of negative and neutral emotion recognition. Yet a lot improvement needed to recognize negative and neutral emotion more accurately [18].

Table 1: Emotion recognition different approach and successes

Reference and year	Approach and Method	Performance
Wei-Long Zheng and Bao-Liang Lu (2016)	EEG-based affective models without labeled target data using transfer learning techniques (TCA-based Subject Transfer)	Positive (85.01%) emotion recognition rate is higher than other approaches but neutral (25.76%) and negative (10.24%) emotions are often confused with each other.
Zixing Zhang, Fabien Ringeval, Fabien Ringeval, Eduardo Coutinho, Erik Marchi and Björn Schüller (2016)	Semi-Supervised Learning (SSL) technique	Delivers a strong performance in the classification of high/low emotional arousal (UAR = 76.5%), and significantly outperforms traditional SSL methods by at least 5.0% (absolute gain).
Y. Fan, X. Lu, D. Li, and Y. Liu. (2016)	Video-based Emotion Recognition Using CNN-RNN and C3D Hybrid Networks	Achieved accuracy 59.02% (without using any additional Emotion labeled video clips in training set) which is the best till now.
A. Yao, D. Cai, P. Hu, S. Wang, L. Shan and Y. Chen (2016)	HoloNet: towards robust emotion recognition in the wild	Achieved mean recognition rate of 57.84%.
Yelin Kim and Emily Mower Provos (2016)	Data driven framework to explore patterns (timings and durations) of emotion evidence, specific to individual emotion classes	Achieved 65.60% UW accuracy, 1.90% higher than the baseline.

III. Proposed Method

In terms of emotion recognition, there is no indefinite way or method which is the univocal solution. A lot of solution have come and many to comes in near future with significant improvement in terms of efficiency, accuracy, and usability. In past and the current research shows that multimodalities dominated the area of emotion recognition than unimodality. Using EEG and audio-visual signal yields the best possible results according to the newest researches. We assume LSTM-RNN is the best way to handle multimodalities. So our proposal is focused on emotion recognition by EEG and audio-visual signal using LSTM-RNN. This type of research has been done before. But our challenge is to improve the model where it will be trained by EEG and audiovisual data at the same time and will make a relation between this data wherein, if one type of data is not available in a situation, the model could still produce the result; finding the relation within the data. So, the training will have two part; training for the data and training to understand the relations between the data.

IV. Future Work Scope

We are working towards a machine with emotions. A machine or a system, which can think like humans, can feel warmness of heart; can judge on events, prioritized between choices and with many more emotional epithets. To make the dream reality first we need the machine or system to understand human emotions, ape the emotion and master it. We just started to do that. Though there is some real example exists this days. Some features and services are getting popularity like Microsoft Cognitive Services but still there is a lot works required in the terms of efficiency, accuracy and usability. Therefore, in future Emotion Recognition is an area requires a great intentness.

V. Conclusions

In this Paper we discussed about the work done on emotion recognition and for achieving that all

superior and novel approaches and methods. We have proposed a glimpse of a probable solution and method towards recognition the emotion. Work so far substantiate that emotion recognition using users EEG signal and audiovisual signal has the highest recognition rate and has highest performance.

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PSO based Lossless and Robust Image Watermarking using Integer Wavelet Transform

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Abstract- In recent days, the advances in the broadcasting of multimedia contents in digital format motivate to protect this digital multimedia content form illegal use, such as manipulation, duplication and redistribution. However, watermarking algorithms are designed to meet the requirements of different applications, because, various applications have various requirements. This paper intends to design a new watermarking algorithm with an aim of provision of a tradeoff between the robustness and imperceptibility and also to reduce the information loss. This approach applies Integer Wavelet Transform (IWT) instead of conventional floating point wavelet transforms which are having main drawback of round of error. Then the most popular artificial intelligence technique, particle swarm optimization (PSO) used for optimization of watermarking strength. The strength of watermarking technique is directly related to the watermarking constant alpha.

Keywords: *image watermarking, IWT, PSO, SVD, PSNR, NC, SSIM.*

GJCST-F Classification: *I.2.2, I.3.3, I.4.0*

Strictly as per the compliance and regulations of:

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R. Surya Prakasa Rao [α] & Dr. P. Rajesh Kumar [σ]

Abstract- In recent days, the advances in the broadcasting of multimedia contents in digital format motivate to protect this digital multimedia content form illegal use, such as manipulation, duplication and redistribution. However, watermarking algorithms are designed to meet the requirements of different applications, because, various applications have various requirements. This paper intends to design a new watermarking algorithm with an aim of provision of a tradeoff between the robustness and imperceptibility and also to reduce the information loss. This approach applies Integer Wavelet Transform (IWT) instead of conventional floating point wavelet transforms which are having main drawback of round of error. Then the most popular artificial intelligence technique, particle swarm optimization (PSO) used for optimization of watermarking strength. The strength of watermarking technique is directly related to the watermarking constant alpha. The PSO optimizes alpha values such that, the proposed approach achieves better robustness over various attacks and an also efficient imperceptibility. Numerous experiments are conducted over the proposed approach to evaluate the performance. The obtained experimental results demonstrates that the proposed approach is superior compared to conventional approach and is able to provide efficient resistance over Gaussian noise, salt & pepper noise, median filtering, cropping, rotation, contrast enhancement, scaling and Histogram Equalization attacks.

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I. Introduction

In recent years, the design of robust techniques has become an important field for providing a certain degree of security and content verification of multimedia documents. Users can readily offer their creative digital multimedia data on Internet, including audio, image, video or animation in several multimedia applications. Consequently, an emerging problem is to prohibit unauthorized duplication and dissemination of copyrighted multimedia materials. Nowadays, digital image watermarking has been developed to solve the problem for copyright protection and content verification of multimedia data [1–3]. It allows owners to hide their ownership rights and access controls into their original images. The ownership rights or access controls are called watermarks which can be various data formats such as logos, tags, sound or any other copyright information. Image watermarking can be roughly classified into several categories according to the domain they are developed, reference to host image, visibility, and robustness. For the case of watermark embedding, watermarking techniques can be developed in three domains, spatial, frequency and blend domains. Spatial domain methods embed a watermark via modifications to the pixel values of an original image. Frequency-domain schemes embed a watermark via modifications to the coefficients of the corresponding transformed-domain image of an original image. Blend-domain techniques have been developed in both spatial and frequency domains, which simultaneously take the advantages of the spatial domain and frequency-domain. Similarly, the watermark extraction techniques are also classified into blind, semi-blind and non-blind types. Blind image watermarking techniques doesn't consider the original image during retrieval [4]. Semi-bling image watermarking just requires partial information such as watermark or extra information during retrieval. Finally, the non-blind image watermarking techniques require original images during extraction process. However, non-bling image watermarking technique introduces an ambiguity problem, i.e., the original image was provided by authorized user or an unauthorized user. There is a possibility to attack by providing the original image to watermarking technique at extraction process. This is termed as ambiguity attack [1]. However, the semi-blind and blind watermarking techniques don't have this ambiguity problem. Thus, generally, blind and semi-blind image watermarking techniques are preferred. Robustness and imperceptibility are the two properties generally considered during the design of any image watermarking technique. The imperceptible water-marking is the ability to not distinguish the watermarked image and original image. On the other hand, robust watermarking is the ability to detect the watermark image effectively from the watermarked image even under different transformations and also under different attacks.

This paper proposes a novel image watermarking technique based on Integer Wavelet Transform (IWT) and Particle Swarm Optimization (PSO). Compared to the conventional wavelet transforms, the IWT reduces the information loss in the extracted watermark. Since, there is problem of round of error in the conventional wavelet transforms; there is possibility of information loss. PSO is an optimization algorithm, used to optimize the watermarking constant, alpha. To

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show the efficiency of proposed approach, various images were processed for testing. Finally, the robustness of proposed approach was tested by applying various attacks on the watermarked image. Rest of the paper is organized as follows: section II illustrates the complete details about the related work. Section III illustrates the details about the indents of proposed watermarking technique such as particle swarm optimization, integer wavelet transform and the singular value decomposition. The complete detail of proposed watermarking methodology is illustrated in section IV. The performance evaluation of proposed approach is described in section V. a comparative analysis carried out between proposed and an earlier approach is also represented in this section. Finally, section VI concludes the paper.

II. Related Work

Generally, the image watermarking aims to achieve so many requirements such as robustness, imperceptibility, payload, security etc. Depends on the requirement, the watermarking technique can be developed. In the recent days, most of the work is focusing towards the improvisation of robustness and imperceptibility due to the enhanced multimedia applications. In the past decades, a lot of watermarking algorithms have been developed in transform domain, for example, discrete cosine transforms (DCT) [5] and discrete wavelet transforms (DWT) [6]. Comparing DWT for JPEG2000 with DCT for JPEG, DWT has merits such as no blockiness, fast processing time, and high compression ability; the robust watermarking scheme based on DWT has attracted great interest. Wavelet-based watermarking scheme can be classified into two categories: wavelet tree-based watermarking methods and block-based DWT watermarking methods. The wavelet tree-based watermarking methods are generally using the energy difference among grouped wavelet coefficients for invisible watermark embedding and extraction [7–11]. Wang and Lin [7] grouped two wavelet trees into a so-called super tree, and each bit is embedded into two supertrees. Lien and Lin [8] improved Wang's method by using four trees to represent two watermark bits in order to improve visual quality. Wu and Huang [9] embedded the watermark into the supertrees by structure-based quantization method. Compared to the unquantized supertree, the quantized version has strong statistical character in energy distribution, which can be used to extract watermark bits. Tsai [10] enhanced the security of wavelet tree quantization watermarking scheme by adopting the chaotic system. Run etal. [11] embedded a watermark bit in the maximum wavelet coefficient of a wavelet; this is different from those in [7–9] which use two trees to embed a watermark bit. And the embedding method modifies the magnitude of the significant difference between the two largest wavelet coefficients in a wavelet tree to improve the robustness of the watermarking. On the other hand, some researches embed a watermark using block-based DWT [12–17]. Davoine [12] proposed the watermarking methods based on the triplets and rectangular blocks of significant wavelet coefficients. Zhang et al. [13]divided the original image into blocks and transformed them into a DWT domain. The watermark is embedded by using the mean and the variance of a sub and to modify the wavelet coefficient of a block. Khelifi et al. [14] proposed an adaptive blind watermarking method based on DWT. The host image is separated into non-overlapping blocks classified as uniformor non-uniform blocks using a JND-based classifier. The watermark is embedded in the high sub band of each block according to its classification. In [15], the block-based watermarking in the wavelet domain is proposed. They applied the significant difference between the first and second greatest coefficients to distinguish the bipolar watermark. Verma and Jha [16] Improved significant difference-based watermarking technique using lifting wavelet coefficients. In [17], the embedding algorithm hides a watermark bit in the low-low (LL) subband of a target non-overlap block of the host image by modifying a coefficient of Ucomponent on SVD version of the block. The above-mentioned methods focused on locating the significant DWT component as embedding candidates and formulate appropriate strategy to modulate them without raising perceptual distortion. However, watermark extraction scheme is also critical for watermarking methods. In watermarking process, watermarking constant will plays an important role. It defines the strength of watermarking technique. If the selection of watermarking constant is optimal, it directs to the robust and imperceptible watermarking. Hence, there is a need of proper selection of watermarking constant. Generally artificial intelligence techniques will be used for optimization purpose. In [23], a watermarking approach was proposed based on Genetic Algorithm (GA). In [23], GA was used for the selection of watermarking constant. Recently, particle swarm optimization (PSO) wasevolved into the watermarking system. PSO is an intelligent algorithm that using the stochastic, population-based computer algorithm for problem solving. Zheng [18] applied the PSO to search the embedding location of the integer DCT coefficients in a block to optimize the requirement of imperceptibility and robustness in watermarking. Vahedi [19] utilized the PSO method to search for the optimal energy of embedding watermark to balance the quality and robustness of watermarked image. Hai Tao [24] applied PSO for the optimization of scaling factors to improve the robustness of watermarking scheme. 3-level DWT is used for feature extraction and PSO for optimization. Though the PSO was used, there is a non-recoverable information loss due to the 3-level DWT.

III. Basics of Watermarking

a) Particle Swarm Optimization

PSO is an evolutionary computational model and is developed by Kennedy [20] for problem solving. They simulated birds' swarm behavior in this model, and made every particle in the swarm move iteratively according to its historical experience and the best experience of the whole swarm. At the end of the simulation, the best experience of the whole swarm is the best solution for objective function. The swarm is modeled by particles in d-dimensional search space. Every particle *i* has its own positionp_{id} and velocity v_{id}. These particles search for optimal value of a givenobjective function iteratively, then keep track of their individualbest positionsp_{id}^{best} and find the global position p_{gid}^{best} from allbest positions through a search space.

$$v_{id} = w \times v_{id} + c_1 \times rand() \times \left(p_{id}^{best} - \chi_{id}\right) + c_2 \times rand() \times \left(p_{gid}^{best} - \chi_{id}\right) \quad (1)$$

$$p_{id} = p_{id} + v_{id} \quad (2)$$

Where$w$ denotes the inertia weight, p_{id} denotes the position of i_{th} particle in the d dimension. $\chi_{id}$is the current position. $v_{id}$is the movingdistance in one-step for a particle i and is limited within$[V_{min}, V_{max}]$,where V_{min} and V_{max} are the maximum and the minimummoving distance in one-step, respectively. rand() is a random number function and its values are between 0 and 1.$p_{id}^{best}$is the bestposition for p_{id}. p_{gid}^{best} represents the gidth global best position in all particles. c1 and c2 are constants. Eq. (1) is used to calculate the particle' snew velocity that refers to its previous velocity and the relations between the distance of its current position and its own best position and global best position of all particles. Then, the particle updates its new position by Eq. (2).

b) Integer Wavelet Transform (IWT)

The main problem with wavelet transform is its inability to reduce the loss of information in the original image. For example, if any one of the block of original image having integer pixel values and transformed through a floating point wavelet transform. If the transformed coefficients are changed during the embedding, then this wavelet transform will not provide any guarantee about the integer values of that particular block. The truncation of floating point values will result in loss of information, i.e., the original image cannot be reconstructed effectively. Furthermore, the conventional wavelet transform is, in practice, implemented as a floating-point transform followed by a truncation or rounding since it is impossible to represent transform coefficients in their full accuracy. To avoid this problem, an invertible integer-to-integer wavelet transform based on lifting [21] is used in the proposed scheme. It maps integers to integers and does not cause any loss of information through forward and inverse transforms. The main advantage with Lifting based wavelet transforms is fast and accuracy. They are easy to implement and also does not require any additional memory.

The forward transform of a typical lifting scheme usually consists of three steps: split, prediction and update. Consider a signal: $X = \{x(n), n \in Z\}$ with $x(n) \in R$. The implementation of the forward transform is illustrated as below:

Split: The original signal *X* is split into two subsets: even indexed samples $x_e$and odd indexed sample $x_o$by means of a sample operation:

$$\begin{cases} x_e = x(2n) \\ x_o = x(2n+1) \end{cases} \quad (3)$$

After the split operation is completed, the odd set and even set are obtained and the two sets are closely correlated. That is, adjacent samples are much more correlated than those far from each other. Itis natural that one can build a good predictor for one set with other set.

Prediction: Given the odd indexed samples x_o, a predictor *P* for the even indexed samples $x_e$can be designed:

$$\widetilde{x_o} = P(x_e) \quad (4)$$

The difference denoted as *d* between the predicted results and the odd samples is considered as thedetail coefficients of the signal *x*(*n*) , and it is expressed as:

$$d = x_o - \widetilde{x_o} = x_o - P(x_e) \quad (5)$$

Update: Knowing the even sample *e x* and the detail coefficients *d*, the approximation coefficients *c* arecalculated using the updating operator *U* as:

$$c = x_e + U(d) \quad (6)$$

The inverse transform can immediately be derived from the forward transform by running the lifting scheme backwards. The block diagram of the lifting scheme is given in Figure 1.

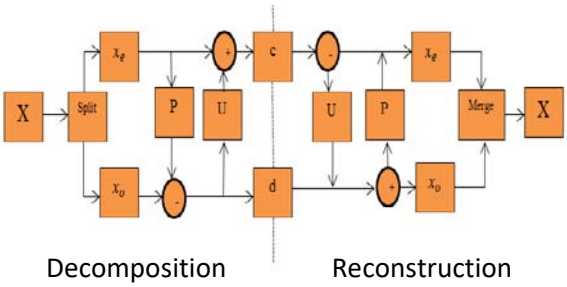


Figure 1: Lifting based decomposition and reconstruction

c) Singular value Decomposition

SVD [22] is an important tool in linear algebra, which is widely applied in many research fields such as principal component analysis, canonical correlation analysis and data compression. LetX denotes a matrix with size M×N. The decomposition for X can bere presented by (2),

$$X = \begin{bmatrix} X(1,1) & X(1,2) & \dots & X(1,N) \\ X(2,1) & X(2,2) & \cdots & X(2,N) \\ \vdots & \vdots & \ddots & \vdots \\ X(M,1) & X(M,2) & \cdots & X(M,N) \end{bmatrix}$$

$$= USV^T = \begin{bmatrix} U(1,1) & U(1,2) & \dots & U(1,M) \\ U(2,1) & U(2,2) & \cdots & U(2,M) \\ \vdots & \vdots & \ddots & \vdots \\ U(M,1) & U(M,2) & \cdots & U(M,M) \end{bmatrix}$$

$$\times \begin{bmatrix} S(1,1) & 0 & \dots & 0 \\ 0 & S(2,2) & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & S(M,N) \end{bmatrix}$$

$$\times \begin{bmatrix} V(1,1) & V(1,2) & \dots & V(1,M) \\ V(2,1) & V(2,2) & \cdots & V(2,M) \\ \vdots & \vdots & \ddots & \vdots \\ V(N,1) & V(N,2) & \cdots & V(N,N) \end{bmatrix}^T \quad (7)$$

Where U and V components are composed of eigenvectors of matrix X, and T represents the conjugate transpose operation. The U and V^Tcomponents are called the left eigenvector and right eigenvector, respectively. The two components are also orthogonal matrices, which can be specified by (8),

$$I_M = U_M^T U_M$$
$$I_N = V_N^T V_N \quad (8)$$

Where I_M and I_N are identity matrices with size M×M and N×N,respectively. The component S is a singular value matrix in SVDdomain, and is a diagonal matrix with non-negative real numbers,

$$S_{MN} = \begin{bmatrix} S(1,1) & 0 & \dots & 0 \\ 0 & \ddots & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & S(M,N) \end{bmatrix} \quad (9)$$

Where $S(1,1) \geq S(2,2) \geq S(3,3) \dots \geq S(M,N) \geq 0$

IV. Proposed Watermarking Scheme

The complete details of the proposed approach are illustrated in this section. The proposed approach is accomplished in two phases, embedding phase and extracting phase. The respective block diagrams for embedding and extracting in shown in figure.2 (a) and 2(b) respectively.

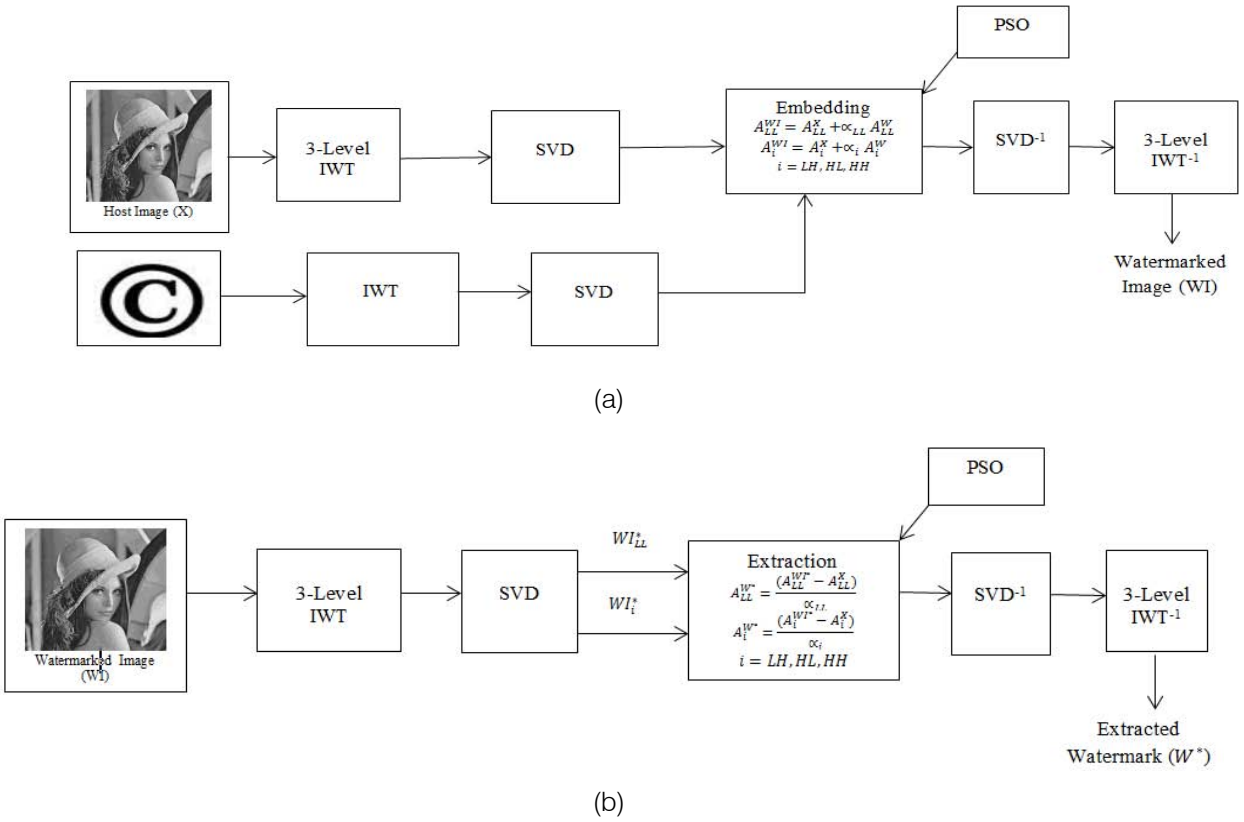


Figure 2: Block diagram of proposed watermarking approach (a) embedding (b) extracting

a) Embedding Procedure

The block diagram shown in figure.2 (a) describes the embedding procedure of proposed watermarking approach. Here, the PSO is used twice for the selection of watermarking constant alpha (∝). Generally, the singular values of LL sub-band are much more than the singular value of remaining sub-bands such as LH, HL and HH. So, two watermarking constants are derived through PSO. They are designated as $\propto_{LL}$ and $\propto_i, i \in LH, HL, HH$ for embedding of singular values of LL sub-band of Host image (X) with singular value of LL band of watermark image (W) and the embedding of remaining bands respectively. Since, it is already revealed that, as the value of watermarking constant increases, it increases the robustness but decreases the quality. Also, the LL band having fewer variations whose effect will be less on the watermark, the watermarking constant $\propto_{LL}$ will be chosen as high compared to $\propto_i$. For both, PSO gives the optimized value such that there will be a tradeoff between the robustness and imperceptibility. The details procedure of embedding is described below:

Step 1: Decompose the Host image (X) through IWT into the four sub-bands such as LL, LH, HL and HH.

Step 2: Perform SVD for LL band and also for remaining bands as

$$A_{LL}^X = U_{LL}^X S_{LL}^X (V_{LL}^X)^T \quad (10)$$

$$A_i^X = U_i^X S_i^X (V_i^X)^T, i \in LH, HL, HH \quad (11)$$

Step 3: Decompose the watermark image (W) through IWT into the four sub-bands such as LL, LH, HL and HH.

Step 4: Perform SVD for LL band and also for remaining bands as

$$A_{LL}^W = U_{LL}^W S_{LL}^W (V_{LL}^W)^T \quad (12)$$

$$A_i^W = U_i^W S_i^W (V_i^W)^T, i \in LH, HL, HH \quad (13)$$

Step 5: Modify the singular values (A^X) of every band of host image by embedding the singular values (A^W) of every band of watermark image as

$$A_{LL}^{WI} = A_{LL}^X + \propto_{LL} A_{LL}^W \quad (14)$$

$$A_i^{WI} = A_i^X + \propto_i A_i^W, \ i \in LH, HL, HH \quad (15)$$

Where A_{LL}^{WI} are the singular values of LL band of watermarked image, A_i^{WI} are the singular values of remaining bands of watermarked image. ∝is the scaling factor ($\propto_{LL} = 0.05$ for LL sub-band embedding and $\propto_i = 0.005$ for embedding the remaining bands (LH,HL and HH)).

Step 6: apply inverse SVD on the altered singular values of all bands. The new bands are denoted as

$$WI_{LL}, WI_{LH}, WI_{HL}, WI_{HH}$$

Step 7: The watermarked image is then obtained after applying the inverse IWT on the four sets of modified IWT coefficients.

$$WI = IWT^{-1}(WI_{LL}, WI_{LH}, WI_{HL}, WI_{HH}) \quad (16)$$

Where, WI represents the watermarked image.

b) Extraction Procedure

Figure.2 (b) describes the extraction procedure of the proposed watermarking technique. Here, the extraction is applied to extract the watermark image and also the host image. The main intention of IWT is to reduce the information loss. Here, the same IWT is applied on the distorted watermarked image denoted as WI^*. The same optimization procedure is carried out here through PSO to find the efficient watermarking constant for both LL band extraction and remaining bands extraction. The complete procedure is described below:

Step 1: decompose the distorted watermarked image WI^* through IWT into sub-bands such as LL, LH, HL and HH.

Step 2: Perform SVD for LL band and also for remaining bands as

$$A_{LL}^{WI^*} = U_{LL}^X S_{LL}^X (V_{LL}^X)^T \quad (17)$$

$$A_i^{WI^*} = U_i^X S_i^X (V_i^X)^T, i \in LH, HL, HH \quad (18)$$

Step 3: extract the singular values of all bands ($A_{LL}^{W^*}$ and $A_i^{W^*}$) of watermark image form the singular values of distorted watermarked image as

$$A_{LL}^{W^*} = \frac{(A_{LL}^{WI^*} - A_{LL}^X)}{\propto_{LL}} \quad (19)$$

$$A_i^{W^*} = \frac{(A_i^{WI^*} - A_i^X)}{\propto_i}, i \in LH, HL, HH \quad (20)$$

Step 4: then the distorted bands will be obtained by performing SVD on the obtained singular values of all bands as $W_{LL}^*, W_{LH}^*, W_{HL}^*, W_{HH}^*$.

Step 5: Then the final watermark can be extracted by applying inverse IWT on the obtained distorted wavelet bands as

$$W^* = IWT^{-1}(W_{LL}^*, W_{LH}^*, W_{HL}^*, W_{HH}^*) \quad (21)$$

Where W^* is the extracted watermark.

V. Simulation Results

In this section, the performance of proposed approach was analyzed under various experiments. For performance evaluation, the considered host mages and watermark images are shown in figure.3 and figure.4 respectively. To investigate the robustness of proposed approach, the watermarked image was subjected to eight attacks such as: (1) Gaussian noise Attack (GNA) with noise variance 0.01, (2) salt & pepper noise attack (SPA) with noise variance as 0.01, (3) Median Filtering attack (MFA) with average window size of 3X3, (4) Histogram Equalization attack (HEA), (5) Rotation attack (RA) with rotation of 30^0, (6) Contrast Enhancemnet attack (CEA) with contrats limit of 0.03,

(7)cropping attack (CA) and (8) Scalling Attack (SA) with bi-cubic.

(a) (b)

Figure 3: Host images (a) Lena, (b) Baboon

(a) (b)

Figure 4: Watermark images (a) Logo(b) Rose

To evaluate the performance of proposed approach, four perfomrance metrics such as Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Normalized Correlation (NC) and Structural Similarity Index Measure (SSIM) were considered and the respective mathematical formulation is given as,

$$MSE = \frac{1}{MXN}\sum_{i=1}^{M}\sum_{j=1}^{N}(w(i,j) - w^*(i,j))^2 \quad (22)$$

Where

w=original watermark image

w^* = extracted watermark image

$$PSNR = 10 * \log\left({255^2}/{MSE}\right) \quad (23)$$

$$NC = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{w(i,j)*w^*(i,j)}{(w(i,j))^2*w^*((i,j))^2} \quad (24)$$

$$SSIM = \frac{\sum_i\sum_i w(i,j)\otimes w^*(i,j)}{\sum_i\sum_i(w(i,j))^2} \quad (25)$$

The NC is also used for the evaluation of fitness function of PSO. The fitness function of PSO is defined as

$$fitness\left(s_j\right) = 1 - Average(NC_j)$$
$$NC_j = \frac{1}{n_{attack}}\sum_{k=1}^{n_{attack}} NC(w, w_j^{*,k}) \quad (26)$$

Where $w_j^{*,k}$ represents the extracted watermark through the proposed approach characterized by the position of the j_{th} particle. The smaller fitness value means the better robustness. Let, n_{attack} signifies the number of attacks, here the n_{attack} is set to 8. Because, totally eight types of attacks are simulated in the simulation.

Performance metrics was evaluated for both No attack and Attack scenarios. At each and every stage, the proposed approach was compared with the conventional3-level DWT based watermarking using PSO [24]. Complete attacks are applied on the watermarked images and the obtained results are shown below.

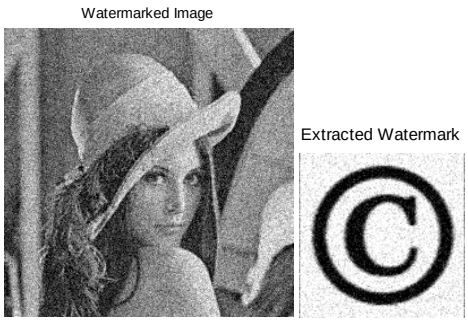
a) No attack scenario

(a) (b)

Figure 5: (a) watermarked image (b)exrated watermark image

b) Attack Scenario

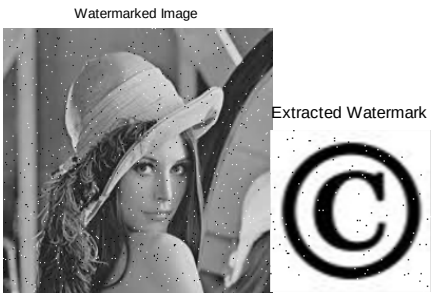
i. *Gaussian Noise Attack*



(a) (b)

Figure 6: (a) watermarked image (b)exrated watermark image under gaussian noise attack

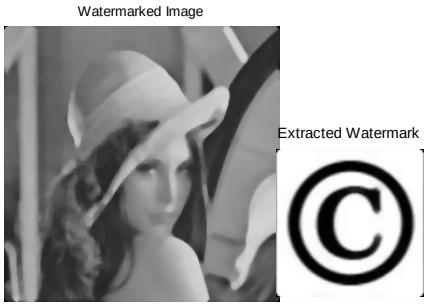
ii. *Salt & Pepper Noise Attack*



(a) (b)

Figure 7: (a) watermarked image (b)exrated watermark image under salt & pepper noise attack

iii. *Median Filtering Attack of average size 5X5*



(a) (b)

Figure 8: (a) watermarked image (b)exrated watermark image under Median Filtering attack

iv. *Histogram Equalization Attack*

(a) (b)

Figure 9: (a) watermarked image (b)exrated watermark image under Histogram Equalization attack

v. *Rotation Attack at 30^0*

(a) (b)

Figure 10: (a) watermarked image (b)exrated watermark image under Rotation attack

vi. *Constrast Enhancemnet Attack*

(a) (b)

Figure 11: (a) watermarked image (b)exrated watermark image under Contrast Enhancemnet attack

vii. *Cropping Attack*

(a) (b)

Figure 12: (a) watermarked image (b)exrated watermark image under Cropping attack

viii. *Scalling Attack*

(a) (b)

Figure 13: (a) watermarked image (b)exrated watermark image under scalling attack

The evaluated PSNR, MSE, NC and SSIM in the both attack and no attack scenarios are represented in the following tables.

Table 1: Performance analysis in the case of no attack scenario

Metric	Lena With Logo		Lena with Rose	
	Conventional[24]	proposed	Conventional[24]	proposed
MSE	1.2910	0.8380	0.9951	0.7573
PSNR	47.0215	48.8982	48.3305	49.3382
NC	0.9788	0.9812	0.9875	0.9898
SSIM	0.9829	0.9842	0.9795	0.9836

Table 2: Performance analysis in the case of attack scenario for Lena With Logo

Attack	Conventional[24]				Proposed Approach			
	MSE	PSNR	NC	SSIM	MSE	PSNR	NC	SSIM
GNA	1.7205	45.7742	0.8792	0.9612	1.2018	47.3325	0.8812	0.9621
SPA	2.6590	43.8836	0.9442	0.9122	1.4960	46.3814	0.9585	0.9422
MFA	1.6895	45.8531	0.9405	0.9296	1.2384	47.2021	0.9563	0.9386
HEA	229.19	24.5287	0.8588	0.9137	123.21	27.2241	0.8823	0.9274
RA	763.60	19.3021	0.8563	0.8752	456.80	21.5335	0.8797	0.8831
CEA	106.53	27.8557	0.9208	0.9585	70.7490	29.6336	0.9298	0.9589
CA	1030.0	17.9992	0.6566	0.8069	846.91	18.8524	0.7238	0.8093
SA	14.0240	35.9989	0.9691	0.9751	13.8416	36.1328	0.9721	0.9788

Table 3: Performance analysis in the case of attack scenario for Lena with Rose

Attack	Conventional[24]				Proposed Approach			
	MSE	PSNR	NC	SSIM	MSE	PSNR	NC	SSIM
GNA	2.4591	44.2231	0.8282	0.9589	1.9330	45.5685	0.8598	0.9591
SPA	3.2422	43.0224	0.9331	0.9222	1.6824	45.8714	0.9399	0.9286
MFA	2.1114	44.8852	0.9453	0.9274	1.9753	45.1744	0.9467	0.9387
HEA	210.45	24.8993	0.8788	0.9093	125.99	27.1274	0.8998	0.9228
RA	1039.5	17.9627	0.8590	0.8741	601.68	20.3371	0.8887	0.8896
CEA	141.03	26.6382	0.9418	0.9591	72.3853	29.5343	0.9485	0.9596
CA	1060.6	17.8574	0.6798	0.8092	667.63	19.8854	0.7028	0.8154
SA	21.2506	34.8571	0.9703	0.9755	13.4213	36.8519	0.9722	0.9783

Table.1 represents the evaluated metrics for the case of no attack scenario. In such case, the PSO is applied without subjecting the watermarkedimage to any attack. By simply chaning the value of swarms the best fitness value was found out. The values of PSNR, NC and SSIM are observed to be more compared to the values obtained in the case of attack scenario. Table.2 and Table.3 represents the values of metrics obtained in the case attack scenario for lena with Logo and for Lena with Rose respectively. The obtained PSNR, NC and SSIM results for the conventioal and proposed approach are represented in the figure.14, figure.15and figure.16 respectively.

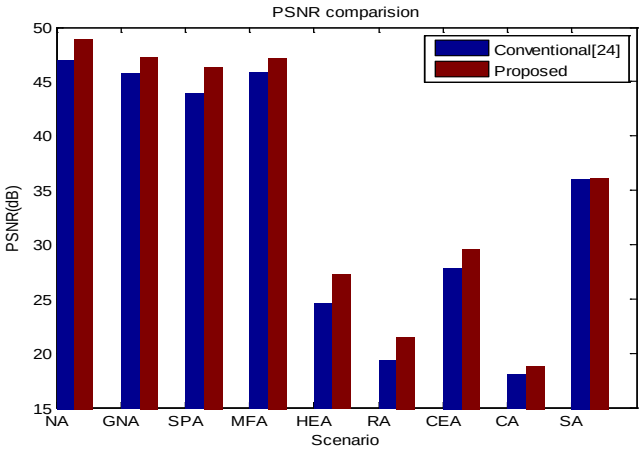


Figure 14: PSNR comparision of Lena with Logo

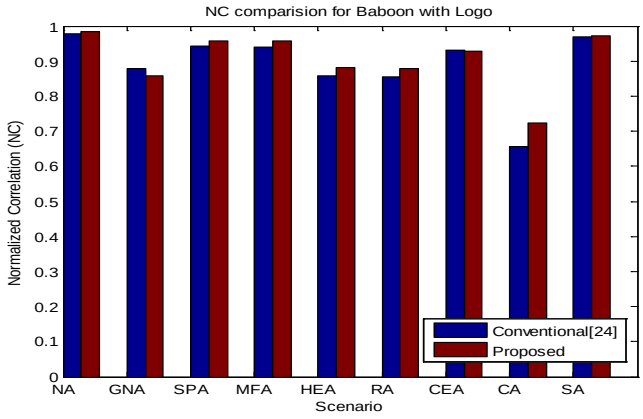


Figure 15: Normalized Correlation comparision of Baboon with Logo

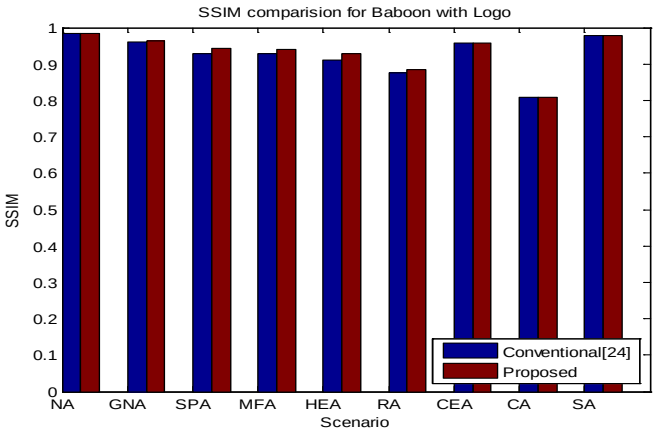


Figure 16: SSIM comparision of Baboon with Logo

Simlarly, the observed PSNR, NC and SSIM for the test case of Lena with Rose is represneted in figure17, figure.18 and figure.19 respectively. These figures reprsneted the results of both the conventional and proposed approachees.

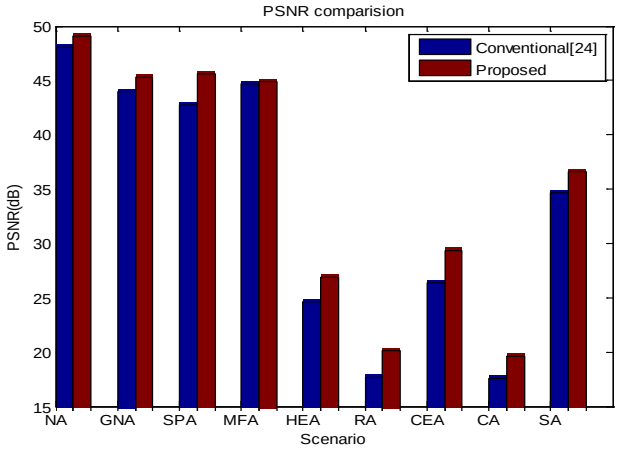


Figure 17: PSNR comparision of Lena with Rose

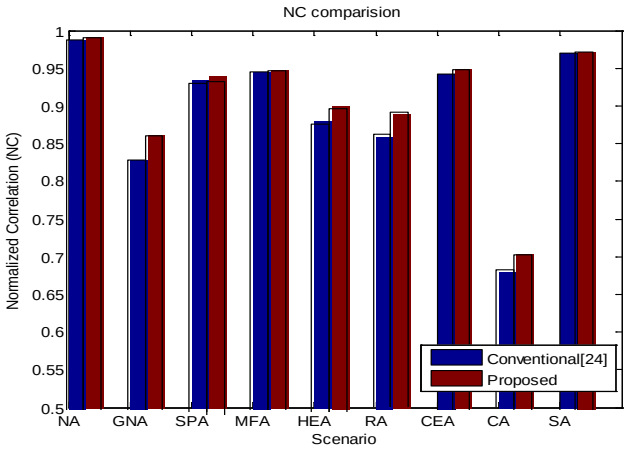


Figure 18: NC comparision of Lena with Rose

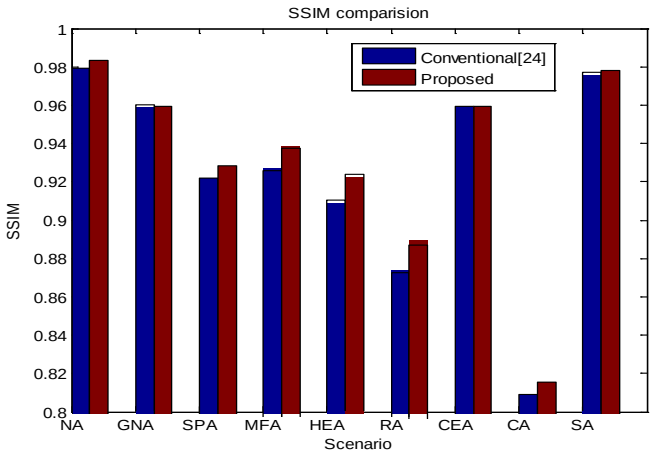


Figure 19: SSIM comparision of Lena with Rose

From the above figures,it can be observed that, the proposed approach having an optimal performance.

To further analyze the performance of proposed approach, a smilar case study was performed by embendding Logo into the Baboon image and the obtained PSNR, NC and SSIM for both the conventional DWT-PSO and the proposed approach are represented in table.4.

Table 4: Performance analysis for the test case of Baboon with Rose

Attack		Conventional[24]			Proposed Approach			
	MSE	PSNR	NC	SSIM	MSE	PSNR	NC	SSIM
NA	2.8002	48.3883	0.9898	0.9818	2.6003	49.3960	0.9921	0.9859
GNA	4.3210	44.2809	0.8305	0.9612	3.8007	45.6263	0.8621	0.9614
SPA	5.1245	43.0802	0.9354	0.9245	3.5214	45.9292	0.9422	0.9309
MFA	4.2130	44.9430	0.9476	0.9297	3.8645	45.2322	0.9490	0.9410
HEA	212.30	24.9571	0.8811	0.9116	127.89	27.1852	0.9021	0.9251
RA	1041.02	18.0205	0.8613	0.8764	603.52	20.3949	0.8910	0.8919
CEA	143.254	26.6960	0.9441	0.9614	74.566	29.5921	0.9508	0.9619
CA	1064.20	17.9152	0.6821	0.8115	669.58	19.9432	0.7051	0.8177
SA	23.1005	34.9149	0.9726	0.9778	15.338	36.9.97	0.9745	0.9806

The compariitve analysis between the proposed and conventional approaches with respect to PSNR, NC and SSIM for Baboon with Rose is shown in figure.20, figure.21 and figure.22 respectively.

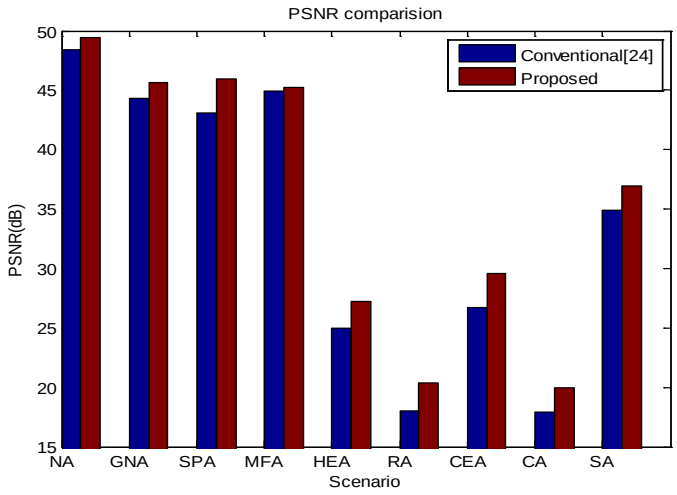


Figure 20: PSNR comparision of Baboon with Rose

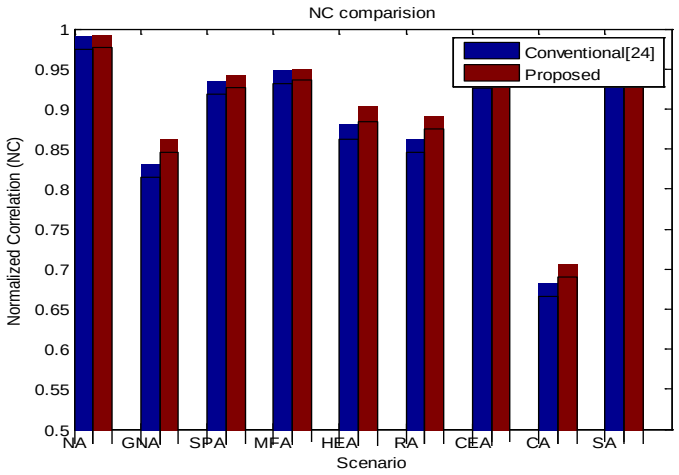


Figure 21: NC comparision of Baboon with Rose

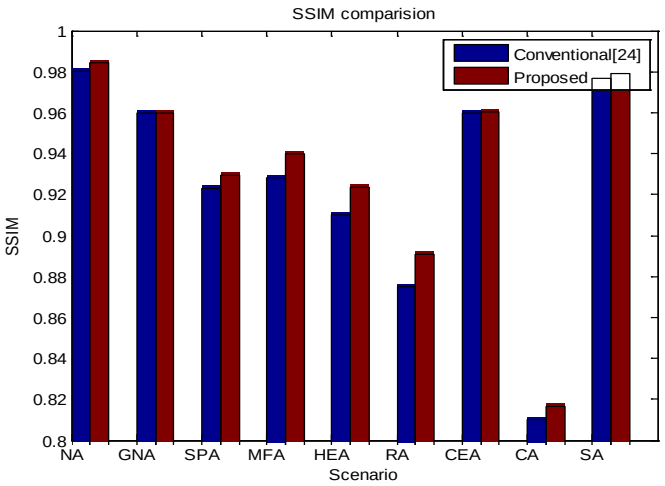


Figure 22: SSIM comparision of Baboon with Rose

From the above figures, it can be observed that, for every case, the proposed approach having otimal PSNR, NC and SSIM compared to DWT-PSO [24]. Due to the dual optimization of watermarking constnat at LL band and at remaining bands, the proposed approach achieved a better performance compared to conventional approach. Along with this, the quality of extracted watermark is also increased. The

enhanced quality is represneted with PSNR. Compared to the conventional approach, the proposed approach ibtained higher PSNR in all cases.

VI. Conclusion

In this paper, a new image waterarking approach was proposed based on Integer wavelet transform and particle swarm optimization. The main objective of IWT is to reduce the information loss which is the main drawback with conventional folating point wavelet ransforms. PSO is utilized to optimize the strength of watermarking constnat such that there should be a tradeoff between the robustness and the imperceptibility. Simulation is carreid out over various images and also over various attacks. An optimized alpha value is selected by considering all the attacks through PSO algorithm. In this approach, the alpha optimization is carried out for two phases, one is for low varinat information (LL band) and another is for high varinat information (LH,HL and HH bands). The range of watermarking constnat derived through PSO for LL band is high compared to the watermarking constant of remaining bands. The sumulation results also revealed that the proposed approach is robust for all types of atacks compared with conventional approach.

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A Video Stabilization Method based on Inter- Frame Image Matching Score

By Qinghe Zheng
Shandong University

Abstract- Video stabilization is an important video enhancement technology which aims at removing annoying shaky motion from videos. In this paper, we propose an robust and efficient video stabilization algorithm based on inter-frame image matching score. Firstly, image matching is performed by a method combining Maximally Stable Extremal Regions (MSERs) detection algorithm and Features from Accelerated Segment Test (FAST) corner detection algorithm, which can get the matching score and the motion parameters of the frame image. Then, the matching score is filtered to filter out the high frequency component and keep the low frequency component. And the motion compensation is performed on the current frame image according to the ratio of the matching score before and after the filtering to retain the global motion and remove the local jitter. Various classical corner detection operators and region matching operators are compared in experiments.

Keywords: video stabilization, video warping, motion estimation, motion compensation, partial compensation.

GJCST-F Classification: F.2.2, I.3.3, I.4.0

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A Video Stabilization Method based on Inter-Frame Image Matching Score

Qinghe Zheng

Abstract- Video stabilization is an important video enhancement technology which aims at removing annoying shaky motion from videos. In this paper, we propose an robust and efficient video stabilization algorithm based on inter-frame image matching score. Firstly, image matching is performed by a method combining Maximally Stable Extremal Regions (MSERs) detection algorithm and Features from Accelerated Segment Test (FAST) corner detection algorithm, which can get the matching score and the motion parameters of the frame image. Then, the matching score is filtered to filter out the high frequency component and keep the low frequency component. And the motion compensation is performed on the current frame image according to the ratio of the matching score before and after the filtering to retain the global motion and remove the local jitter. Various classical corner detection operators and region matching operators are compared in experiments. And experimental results illustrate that the proposed method is effective to stabilize translational, rotational, and zooming jitter and robust to local motions, and has the state-of-the-art processing speed to meet the needs of real-time equipment.

Keywords: video stabilization, video warping, motion estimation, motion compensation, partial compensation.

I. Introduction

Video enhancement is getting more and more attention with the increasing popularity of digital visual media. As one of the most important ways of enhancement, video stabilization is a technique for removing abnormal image offsets such as jitter and rotation, etc., by digital image processing. One of the most obvious differences between professional and amateur level video is the quality of camera motion; hand-held amateur video is typically shaky and undirected while professionals use careful planning. Given the unstable video, the video stabilization is designed to synthesize new image sequences seen from the new stable camera trajectory.

The typically algorithm mainly consists of the following parts: feature point extraction, feature point matching, motion estimation, motion compensation, synthesis of new video sequences. Prior techniques for software video stabilization follow two main approaches, providing either high quality or robustness and efficiency. At present, the most commonly used video image stabilization method is 2D stabilization [1], which is widely used in commercial software and military. This method is suitable for the 2D motion models, which is very effective for the affine or projection transformation of the current frame. However, due to the inability to simulate the camera movement caused by the disparity and other issues, the two-dimensional motion model is very fragile and poor stability. Then, 3D video stabilization technique was proposed by Buehler in 2001 [2] and developed by Liu in 2009 [3], which shows a strong stability and has the ability to simulate the camera's 3D trajectory. In this method, a new structure-from-motion (SFM) technique [4] is used to construct the 3D model of the background and camera motion, and then various new filtering ideas are started around the new 3D trajectory model [5, 6]. But SFM is a fundamentally difficult problem, and the generality of current solutions is limited when applied to the diverse camera motions of amateur-level video. The problem with 3D stabilization and 2D stabilization is opposite: the 3D model is too complex to be calculated in real time and the robustness is too poor. So it is difficult to use the 3D image stabilization technology in daily business and medical treatment. In general, requiring 3D reconstruction hinders the practicality of the 3D stabilization pipeline.

In this paper, we introduce a robust and efficient method for software video stabilization. In spite of the image stabilization platform has been widely used in professional equipment and achieved good results, it still requires additional hardware support, and isn't suitable for amateur consumers. For example, video quality will be severely reduced due to camera vibration in situations like taking pictures by a tourist enthusiast on a bumpy car.

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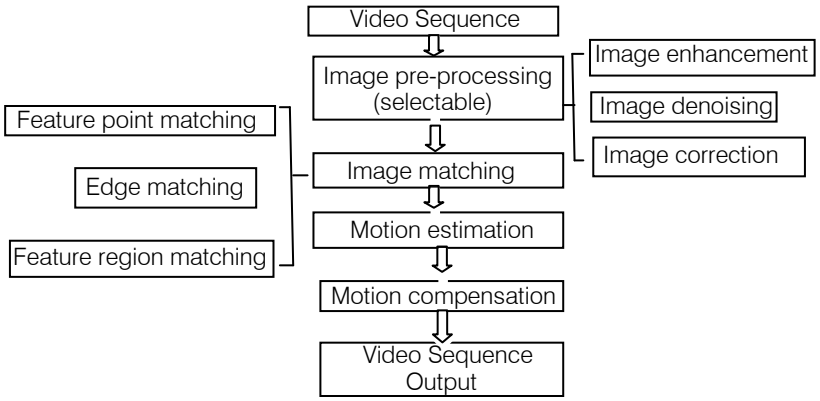


Figure 1: Video frame stabilization algorithm flow chart

II. Video Stabilization Algorithm

Video stabilization mainly includes four stages: image pre-processing, image matching, motion estimation and motion compensation (see Fig. 1). Image pre-processing is to eliminate the interference of fuzzy, gray shift and geometric distortion caused by the inconsistency of the light in the process of obtaining the video, which is able to reduce the difficulty of image matching and improve the accuracy of image matching. Image matching is the key step of video stabilization, which directly determines the quality of the final video. The purpose of image matching is to find a spatial transformation, so that the coordinates of the overlapping parts in the image can be accurately matched. Image matching algorithm needs not only to ensure the accuracy of image matching, but also to minimize the amount of computation. Motion estimation is a complete set of techniques for extracting motion information from video sequences. The main content of motion estimation is how to get enough motion vectors quickly and effectively according to the coordinates of matching feature points. Motion compensation is to predict and compensate the current image by the previous image, and to compensate the corresponding motion information of the previous frame according to the motion vector. The key of motion compensation is to distinguish local jitter and global motion effectively, which makes the final video get a good visual effect.

III. Image Matching

In this part, we will introduce two classical image matching algorithms which are used in the fourth part: MSERs algorithm [7] proposed in 2014 and FAST corner detection algorithm [8] proposed in 2012 used for video stabilization.

a) Region-based matching algorithm

MSERs use the concept of a watershed in the terrain to find a stable local area. Previous watershed transforms were mainly used for image segmentation. The algorithm focused on the water level at the time of regional merging. At this time, the small water puddles and ponds were unstable and the connected water volume changed drastically. Strictly defined from the mathematical point of view, MSER is a region which has the smallest change in the number of pixels at a given threshold. MSERs is currently recognized as the best performance of the affine invariant region.

Algorithm Steps

- The pixels of a given image are ordered in gray scale values.
- Add the pixels into images in accordance with ascending or descending and link the area.
- Define Q as an arbitrary connected region in the binary image corresponding to the threshold value. When threshold changes in (i-Δ, i+Δ), connected regions corresponding to $Q_{i+\Delta}$ and $Q_{i-\Delta}$. Within this range of variation, the region q(i) with minimal change rate is considered to be MSERs.

b) Feature-based matching algorithm

FAST is a corner detection method, which can be used for the extraction of feature points and the completion of tracking and mapping objects. The most prominent advantage of this algorithm is its computational efficiency and good repeatability. The basic principle of the algorithm is to use a circumference of 16 pixels (a circle with a radius of 3 pixels drawn by the Bresenham algorithm) to determine whether the center pixel P is the corner point. Then the center pixel is called the corner point: If the brightness of N pixels on the circumference are larger than the sum of center pixel and a threshold *T*, or smaller than the difference between the center and the threshold *T*. In an image, the non corner points are more easily measured and accounted for the majority of the pixels. Therefore, the first elimination of non corner points will greatly improve the detection rate of corner points.

Algorithm steps

- Detect the non corner points on the circle.
- Determine whether the center point is a corner point and make a corner detection for each point on the circle if it is true.
- Remove the non-maximum corner and get the output corner point.

- Calculate the score function and compare it in the neigh borhood of 3*3.

IV. Motion Estimation

2D parametric motion model is used for the motion of the camera (see Fig. 2). The moving camera is attached to the coordinate system *O-XYZ* and the corresponding projection onto the image plane is attached to the system *O-PQ*. The camera motion consists of two components: a translation $(T_x, T_y, T_z)^T$ and a rotation $(\alpha, \beta, \gamma)^T$, which represent roll, pitch and yaw of the motion. A point with an image coordinate (p, q) in the space (x, y, z) will move to another location (x', y', z') with an image coordinate (p', q') and the focal length f_c will become f'_c through inter frame motion. The relationship of corner points in space and the image plane is defined by Eq. (1) and Eq. (2), respectively. a, b, c, d, e, f, g, h, i among the equation is the parameters of motion matrix.

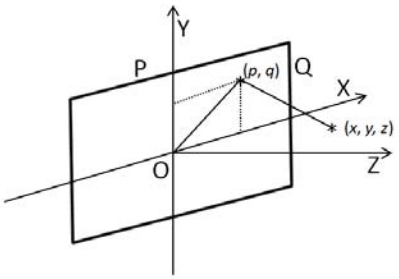


Figure 2: Image plane and the coordinate plane

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \end{bmatrix} - \begin{bmatrix} T_x \\ T_y \\ T_z \end{bmatrix} \tag{1}$$

$$\begin{cases} p' = f_c' \dfrac{ap + bq + cf_c - f_c T_x / z}{gp + hq + if_c - f_c T_z / z} \\ q' = f_c' \dfrac{dp + eq + ff_c - f_c T_y / z}{gp + hq + if_c - f_c T_z / z} \end{cases} \tag{2}$$

If the rotation angle of the collected video sequence frame image in the camera motion process is less than 5°, Eq. (2) can be approximated as:

$$\begin{cases} p' = f_c' \dfrac{p + \alpha q \gamma f_c - f_c T_x / z}{\gamma p - \beta q + f_c - f_c T_z / z} \\ q' = f_c' \dfrac{-\alpha p + q + \beta f_c - f_c T_y / z}{\gamma p - \beta q + f_c - f_c T_z / z} \end{cases} \tag{3}$$

Let $$s = (\gamma p - \beta q + f_c - f_c T_z / z) / f_c' \tag{4}$$

Then Eq. (2) can be expressed as:

$$\begin{cases} s \cdot p' = p + \alpha q - \gamma f_c - f_c T_x / z \\ s \cdot q' = -\alpha p + q + \beta f_c - f_c T_y / z \end{cases} \tag{5}$$

Two equations are provided by each set of matching corner points, thus 2N equations will be provided by N pairs, and subsequently, the motion parameters can be obtained by the least square solution.

a) Feature point selection

In the traditional method, the motion equation is obtained by detecting and matching the feature points between the frames. Since there are a large number of matching feature points in two adjacent frames to solve a motion equation containing only four parameters, there is a large computational redundancy. At the same time, image feature point matching is prone to mismatch. So the traditional methods need to add a wild point elimination function, which used to remove unreliable feature points that easily lead to false matches. We propose a novel feature point detection method for solving the equations of motion combining the advantages of feature point detection method and region detection method. Firstly, MSERs detection is performed on each image in the video sequence (see

Fig 3.a). The second step uses the rectangle to label the elliptical areas which have a stability of the top three. The third step is the FAST feature points detection in the marked area (see Fig 3. b).

(a) (b)

Figure 3: The MSERs area marked by rectangleand FAST corner point detection

b) Feature point selection

To track feature points, a window *P*P* centered at each selected point is designed and matched using diamond search (DS) method and the sum of absolute difference criterion (SAD) [9]. The searching area is $(P+2M)\times(P+2N)$, where M and N are maximum horizontal and vertical displacements, respectively. Thus, the corresponding point is at the center of the matching window. Moreover, two issues are considered in deciding the proper size of the feature window: A large size would cause a dislocation of pixels, but a small size offers less information. In practical use, a feature window with a size 9*9 has a good performance experimentally. Next, the first chapter of the N pictures in each second of the video sequence is set as a reference frame, and the remaining images in each second are matched with the reference frame for feature points. Finally, the least squares method is used to solve the motion equation through the coordinates of matching feature points. In this way, stable and effective feature points can be obtained, which is more robust to noise such as illumination. At the same time, the reduction of the number of feature points can solve the equations of motion more quickly.

c) Computing motion parameters

The Eq. (6) indicates that the motion includes four parameters: the rotation $\Delta\theta$, the translation $(\Delta x, \Delta y)$, and the scaling $\Delta\lambda$. Given a set of N matched pairs, $\Delta\lambda$ can be defined as:

$$\Delta\lambda = \frac{\sum_{i=1}^{N} d_i \times d_i'}{\sum_{i=1}^{N} d_i \times d_i} \tag{6}$$

where,

$$d_i = \sqrt{(u_i - U)^2 + (v_i - V)^2} \tag{7}$$

$$d_i' = \sqrt{(u_i' - U')^2 + (v_i' - V')^2} \tag{8}$$

where (U, V) represents the bary center of the points in the current frame, and (U', V) represents the bary center in the reference, respectively.

Then applying Eq. (6) to a set of N pairs of matching feature points, $2N$ linear functions can be obtained with three unknowns $m=[\Delta\theta, \Delta x, \Delta y]^T$. The final function $B=Am$ is in the form of a matrix, as shown in Eq. (9).

$$B = \begin{bmatrix} u_1 - \Delta\lambda u_1' \\ v_1 - \Delta\lambda v_1' \\ \dots \\ u_N - \Delta\lambda u_N' \\ v_N - \Delta\lambda v_N' \end{bmatrix}, A = \begin{bmatrix} -\Delta\lambda v_1' & 1 & 0 \\ \Delta\lambda u_1' & 0 & 1 \\ \dots & \dots & \dots \\ -\Delta\lambda v_N' & 1 & 0 \\ \Delta\lambda u_N' & 0 & 1 \end{bmatrix} \tag{9}$$

To get the motion parameters, the initial solutions are obtained by pseudo inverset transformation and then refined by Levenberg-Marquardt (LM) method [10]. Firstly, $n(n\geq 2)$ pairs of points with minimal SAD in the template matching processing are selected and the initial value of m can be computed by $m = (A^TA)^{-1}A^TB$. Then, the L-M method is used to refine solutions by minimizing the square of coordinate differences. Let $(u_i, v_i)^T$ and $(U_i, V_i)^T$ denote the known feature points and the estimated points, respectively. The object function is defined as Eq. (10).

$$E = \sum_{i=1}^{N} \left[(u_i - U_i)^2 + (v_i - V_i)^2 \right] = \begin{bmatrix} u_i - U_i \\ v_i - V \end{bmatrix}^T \begin{bmatrix} u_i - U_i \\ v_i - V \end{bmatrix} = e^T e \tag{10}$$

V. Motion Compensation

At this stage, it is clear that only the unwanted camera jitter should be removed in the motion of the camera. We suppose that the motion of the camera is usually smooth with slow variation and unwanted camera jitter involves rapid variation. From another point of view, the high frequency component of the motion vector is considered to be an unwanted camera jitter and can be filtered out by a low pass filter. On the basis of this idea, we propose a partial backward compensation method with a novel filtering algorithm. Firstly, the matching scores $G_i$of i-th image and

reference image in the video sequence are defined as: the number of successful matching corner points divided by the total number of corners. The higher the approximation degree between the reference frame and the current frame, the higher the matching score. On the next step, one dimensional discrete wavelet transform (DWT) is used to remove the high frequency information, and then one dimensional discrete wavelet reconstruction (IDWT) is performed. The Haar wavelet is used to carry out the wavelet transform. Wavelet transform is the inheritance and development of traditional Fourier transform. Because the multi-resolution analysis of wavelet has good localization property in spatial domain and frequency domain, it can be used to analyze the arbitrary details of the object gradually. Retaining the low-frequency information, which is equivalent to retaining the global movement and removing the jitter. Finally, adopt the partial compensation principle: the motion parameters are compensated according to the ratio of the matching scores before and after the filtering, which is given by Eq. (11), where G_{ib} and G_{ia} is the image matching score before and after the wavelet transform. A strategy will be used in the mage matching score calculation phase: remove the current frame with matching scores below a preset threshold N (30 in this paper). In the end, the processed image frame is made into a new video.

$$\begin{bmatrix} \Delta x' \\ \Delta y' \\ \Delta \theta' \\ \Delta \lambda' \end{bmatrix} = \frac{G_{ib}}{G_{ia}} \begin{bmatrix} \Delta x \\ \Delta y \\ \Delta \theta \\ \Delta \lambda \end{bmatrix} \tag{11}$$

Compared to the traditional algorithms, which need to filter the horizontal displacement, the vertical displacement and the rotation angle, our method only needs to filter the image matching score, which improves the efficiency and meet the real-time requirement. At the same time, the partial compensation method based on the image matching score can better retain the global motion and avoid the phenomenon of over smoothing.

Table 1: The performance of various classical corner detection operators and region detection operators

Method	Mean value of corners	Computational time(s)
SIFT [11]	81	299.62
SURF [12]	165	151.96
Harris [13]	135	96.68
FAST	59	36.14
MSERs+SIFT	21	146.88
MSERs+SURF	47	60.29
MSERs+Harris	34	29.18
MSERs+FAST	19	**12.82**

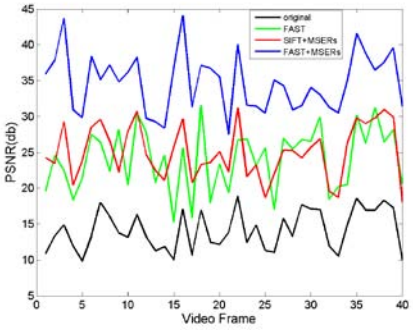
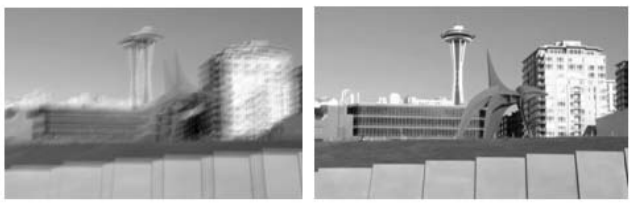


Figure 4: Comparison of PSNR of several classical operators



(a) Original video sequence **(b) Stabilized video sequence**

Figure 5: The mean image of 10 consecutive frame image

VI. Experimental Results

This part presents experimental results obtained from a video sequence, which is widely used by various video processing laboratories. The experiments are carried out on MATLAB R2013a with a i5-4460 CPU. The input video has a resolution of 360×240 and includes 400 frame images in 10s.Firstly, we compare the performance of various classical corner detection operators and region detection operators(see Tab.1). The experiment results show that method combining MSERs and FAST has a faster computing speed than the tradition algorithm by finding and matching the feature points of the entire image. To make an objective evaluation of the video stabilization algorithms, the peak signal-to-noise ratio (PSNR) can be used as a measure. In Fig. 4, we compare the PSNR of 40 mean images processed by a variety of operators and traditional algorithm. We can see that the performance of the new algorithm is generally better than the traditional algorithm from the experiment results. To make a subjective evaluation of the results, the mean image of first 10 consecutive frame images in the original and stabilized video sequences are given respectively, as shown in Fig. 5.

VII. Conclusions

A robust and fast video stabilization method is proposed, which consists of image matching based on MSERs detection and FAST corner detection, motion estimation and motion compensation based on inter-frame matching score. The partial compensation method based on inter-frame matching score efficiently removes fluctuations and retains global motion. The speed optimization of algorithm and its low cost and low requirements of equipment hardware makes it possible to be used for non-professional camera enthusiasts and the portable electronic equipment like hand-held visual communication device. The most time-consuming phase of the algorithm is the area detection. A more simple and effective feature region detection method and fast sorting algorithm can make it faster, which needs to be further optimized in future research.

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Digital Image Encryption Technique Using Block Based Scrambling and Substitution

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Abstract- A novel non-chaos based digital image encryption technique using a combination of diffusion and substitution process has been presented. A secret key of 128 bit sizes is used in the algorithm. In the diffusion (permutation) method, image is divided into different dynamic blocks which are key dependent. Further, each block is made to pass through eight rounds of permutation process. In this process, a zigzag mechanism is used to scramble the block pixels within the block. Then the resultant image i.e. the partially encrypted image is divided into various key based dynamic sub-images. Pixels of the sub-images are replaced with another pixel values within the block when each of the sub-images are passed through the substitution process. The substitution process comprises of four rounds. The proposed scheme is then compared with the standard AES algorithm. Investigation outcome shows that the proposed design methodology is efficient, fast and secure.

Keywords: information security, image encryption, secret key, diffusion, substitution, AES.

GJCST-F Classification: B.4.2, H.2.8

Strictly as per the compliance and regulations of:

Digital Image Encryption Technique Using Block Based Scrambling and Substitution

Punita Kumari [α] & Kalpana Jain [σ]

Abstract- A novel non-chaos based digital image encryption technique using a combination of diffusion and substitution process has been presented. A secret key of 128 bit sizes is used in the algorithm. In the diffusion (permutation) method, image is divided into different dynamic blocks which are key dependent. Further, each block is made to pass through eight rounds of permutation process. In this process, a zigzag mechanism is used to scramble the block pixels within the block. Then the resultant image i.e. the partially encrypted image is divided into various key based dynamic sub-images. Pixels of the sub-images are replaced with another pixel values within the block when each of the sub-images are passed through the substitution process. The substitution process comprises of four rounds. The proposed scheme is then compared with the standard AES algorithm. Investigation outcome shows that the proposed design methodology is efficient, fast and secure.

Keywords: information security, image encryption, secret key, diffusion, substitution, AES.

I. Introduction

Due to the increasing use of computers and several advancements in information and technology, huge bulk of digital data is being transferred over the network. The transmitted information over the network needs security to protect the data [1, 2]. Not only this, due to the rapid growth of internet, cell phones, multimedia technology in our society, digital image security is the most critical problem. Therefore, security of the digital data has become a major concern during its transmission and storage. Digital data can be secured in three different ways from unauthorized access. They can be classified as cryptography, steganography and watermarking [3-6]. Among the three different techniques, cryptography provides a high level of security. Cryptography deals with converting the information into its coded form and then again decoding it into its original form. While communicating securely using cryptography, which is the main goal of our proposed work, in which encryption and decryption mechanisms are performed by one or more keys. Encryption and decryption techniques that use the same secret key are classified under private key cryptography and the algorithms are categorised under symmetric key cryptography [7-9]. When the key used in the encryption and decryption process are different, then such algorithms are categorized under asymmetric key cryptography [10-12].

In the present day scenario, security of digital images has become the fundamental need and has their own uses in numerous fields such as medical imaging, internet communication, Tele-medicine, multimedia systems, military communication etc. It includes various aspects like authentication, integrity, confidentiality, access control etc. It has been observed that traditional encryption algorithms like DES, AES etc [13-19] are not suitable to encrypt images directly because of the two reasons, firstly; the size of image is larger than that of text. Therefore, traditional encryption algorithms will take more time to encrypt and decrypt images as compared to that of text. Secondly, in text encryption, both the size of the original and decrypted text must be equal. But this is not possible in case of images because due to the characteristics of human perception, decrypted image with small distortion is usually acceptable. We can reduce this observable information by decreasing the correlation among image pixel elements using different techniques.

This paper reports a novel non-chaos based digital image encryption technique for the design of a secure and efficient encryption scheme.

II. Chaos and Non-Chaos Based Image Encryption Technique

For encryption and decryption of an image data different techniques have been used to protect the information from an unauthorized user. These techniques include (a) Non-chaos based image encryption schemes, and (b) Chaos-based image encryption schemes. In this paper, we discuss in brief about these techniques.

a) Chaos based encryption technique

Chaos refers to a state which is not deterministic in nature [20-22]. A chaotic system is dynamic and very sensitive to initial conditions; therefore the system depends completely on the initial condition. Hence, the results deviate largely with a small change in the initial conditions.

A chaotic system is also very useful and applied in various disciplines like physics, economics, environmental science, computer science etc.

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b) Non-chaos based encryption technique

A non-chaotic system refers to a state having deterministic behavior [23] like DES, AES etc.

In this paper, a non-chaos based image encryption technique has been proposed. A novel diffusion-substitution technique for image encryption has been applied to encrypt a digital image along with its performance and security parameters to test the histogram analysis, correlation coefficient, entropy etc. However, the proposed methodology is used to achieve an efficient and secure image transmission over the network.

III. Proposed Methodology for Digital Image Encryption Based on Block Based Scrambling and Substitution

In the present work, an image encryption technique design is proposed. Detailed architecture of the diffusion-substitution mechanism in the proposed image encryption algorithm has been described. To design the encryption technique, scrambling of the image pixel values is performed and then further modification in the pixel values of the partially encrypted image is being done so as to reduce the correlation among the pixels of an image. In this scheme, a secret key of 128 bit size is used. Then, image is separated into various dynamic blocks. Diffusion process involves eight rounds and block size in each round is kept different which depends on the secret key used in the proposed scheme. In this scrambling process, shuffling of the pixel values within the same block is performed by a zigzag path which is shown in Figure 2. After the diffusion process, substitution process is applied. In this process, the blocks are reframed and are then passed through four rounds. Since each block depends on the secret key, therefore block size in substitution process differs from the diffusion process. In substitution mechanism, modification in the pixel values are performed within each block and the pixel values are replaced with another pixel values.

The proposed scheme is performed to achieve a secure and efficient multimedia communications while its transmission over the network. Moreover, performance and security of the proposed image encryption technique is assured by performing the NIST (National Institute of Standard and Technology) test.

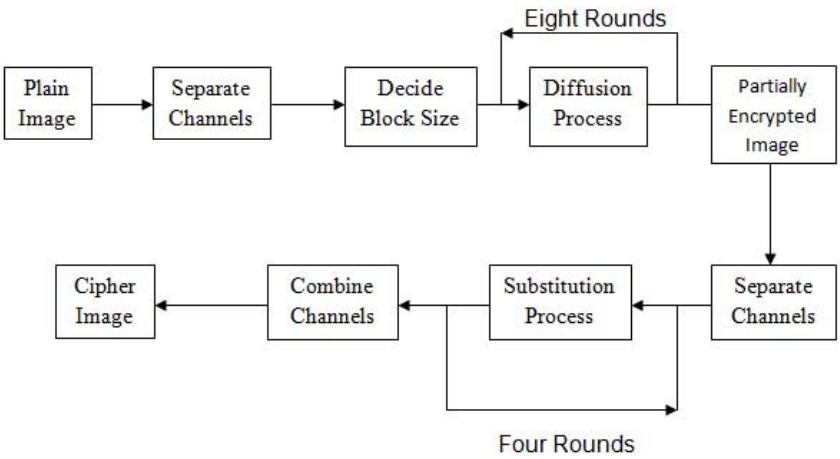

Figure 1: Design flow of block based scrambling and substitution based encryption Scheme

The design flow given in Figure 1 shows the working of the proposed technique for the encryption of an image. Different units along with their functions that are used in the proposed scheme have been described below in detail.

a) Block size of plain image

In the permutation and substitution process, the image pixels are partitioned into various non-overlapping squared dynamic blocks. The size of these blocks is a secret key dependent which is used in the algorithm. The plain image block sizes in diffusion process are decided by using Equation 1.

$$B_r = \sum_{p=1}^{4} K_{(4*(r-1)+p)} \quad \text{(Permutation process)} \ldots \quad (1)$$

where, $K_i = i^{th}$ subkey and

B_r = block size in r^{th} round.

b) Diffusion process

In the diffusion process, pixel values of each dynamic block are shuffled by a zigzag mechanism. For example, the pixels of a block having the size 8*8 are rearranged by a path which is shown in Figure 2. In this figure, suppose the pixel location is at (2, 3) before traversing, the pixel path is found to be at (3, 2) when the traversing process is completed. The block pixels are organized sequentially i.e. row by row and column by column in the same block during the traversing mechanism. The pixels are separated into three RGB channels (red, green and blue). All of these channels pass through eight rounds of scrambling process. The

image pixels in each round are partitioned into various non-overlapping squared dynamic blocks which is discussed above in subsection **a**. When traversing is started, the path in blocks of r^{th} round of a pixel (X_r, Y_r) depends on a secret key which is shown in Equation 2.

$$X_r = \sum_{p=1}^{3} K_{(4*(r-1)+p)},$$

$$Y_r = \sum_{p=2}^{4} K_{(4*(r-1)+p)} \quad \ldots\ldots \quad (2)$$

where, K_i is the i^{th} subkey.

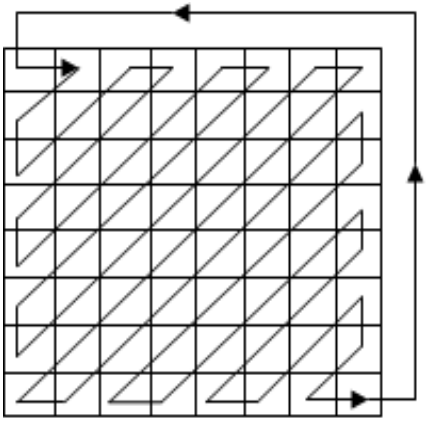

Figure 2: A zigzag mechanism to shuffle pixels of a block.

c) Substitution process

In the substitution process, a simple computation is performed on pixels to change their properties. Each RGB channel of pixels comprises of four rounds. In each round, pixels are partitioned into various non-overlapping dynamic squared blocks which is explained earlier in sub-section **a**.

In this process, bitwise XOR operation is accomplished on the pixels with randomly selected sub-key so that their properties can be changed. In the proposed methodology, four rounds are used in the substitution mechanism and each round is secret key dependent used in the algorithm. To illustrate substitution process for random selection of sub key, we have used srand() function of C++ programming language. For first round, seed value for srand() function is used as summation of first four sub keys i.e. $K_1..K_4$ and for second round, seed value for srand() function is chosen as summation of next four sub keys i.e. $K_5..K_8$ and so on. Substitution process is described below:

Row= Pixels in image width
Col= Pixels in image height
Initialize variable c by 1
For each round (Total 4 rounds)
{
Sum= $\sum_{c}^{c+3} K_c$
Randomise srand function by sum
For each row
{
for each column
x= rand() modulus 16
modify current pixel by x using session key
}
Increment variable c by 4
}

d) The proposed Methodology: Algorithm

In the proposed encryption algorithm, which consists of two major processes - permutation and substitution [24-26]. Both permutation and substitution processes completely depends on the secret key.
The steps of algorithm are described below.

Input: Plain image p with m*n size, Secret key
Key Size: 128 bits
Output: encrypted image with m*n size
Begin
Procedure: Diffusion

1. Get plain image (p) with m*n size.
2. Sub-keys are obtained from the secret key which is partitioned into blocks of 4 bits each i.e.
   $K=K_1K_2K_3 \ldots K_{32}$ ..... (3)
   where, K_i are digits from 0 to 15. (hexa-number)
3. The red, green, blue channels are obtained when color image is separated. This channel passes through the following steps.
4. Round = 1 to 8
   i. Decide block size which is secret key dependent. Equation 1 is used to decide the block size.
   ii. Diffusion process is performed in which scrambling of the pixel values is done through a zigzag approach.
5. Go to 4.

Procedure: Substitution
Row= Pixels in image width
Col= Pixels in image height
Initialize variable c by 1
For each round (Total 4 rounds)
{
Sum= $\sum_{c}^{c+3} K_c$

```
    Randomise srand function by sum
    For each row
     { for each column
       x= rand() modulus 16
       modify current pixel by x using session
key
      }
    Increment variable c by 4
   }
End.
```

IV. Experimental Results

The data sets required to evaluate the proposed methodology was generated using USC-SIPI image database (http://sipi.usc.edu/database/). The implementation of the proposed algorithm has been performed in C++ programming language and for the analysis of the image data, MATLAB application tool has been used. The permutation and substitution based methodology is evaluated with performance and security measures by which the performance and security of the proposed image encryption algorithm is tested and analysed.

a) Pixel distribution

The plain images and its corresponding encrypted images of different sizes are examined and evaluated by histograms. The proposed image encryption algorithm is consistent with the security defined by Shannon [27, 28].

A preferred image "Lena" is analysed by histogram analysis. Histograms of RGB channels of plain image (Figure 3(a)) are shown in Frames (b), (c) and (d) of Figure 3 respectively. In Frames (f), (g) and (h) of Figure 3, the histograms of RGB channels of the encrypted image (Figure 3(e)) for the proposed scheme is shown. In Frames (j), (k) and (l) of Figure 3, the histograms of RGB channels of the encrypted image (Figure 3(i)) for AES algorithm is shown respectively.

From the histogram analysis of the original, proposed and AES algorithm encryption scheme, we analyze that the histograms of the encrypted image of the proposed methodology i.e. its RGB components are very close to the uniform distribution which is not in case of the original image and do not correspond to the original image. Therefore, the cipher image does not reveal anything about the original image.

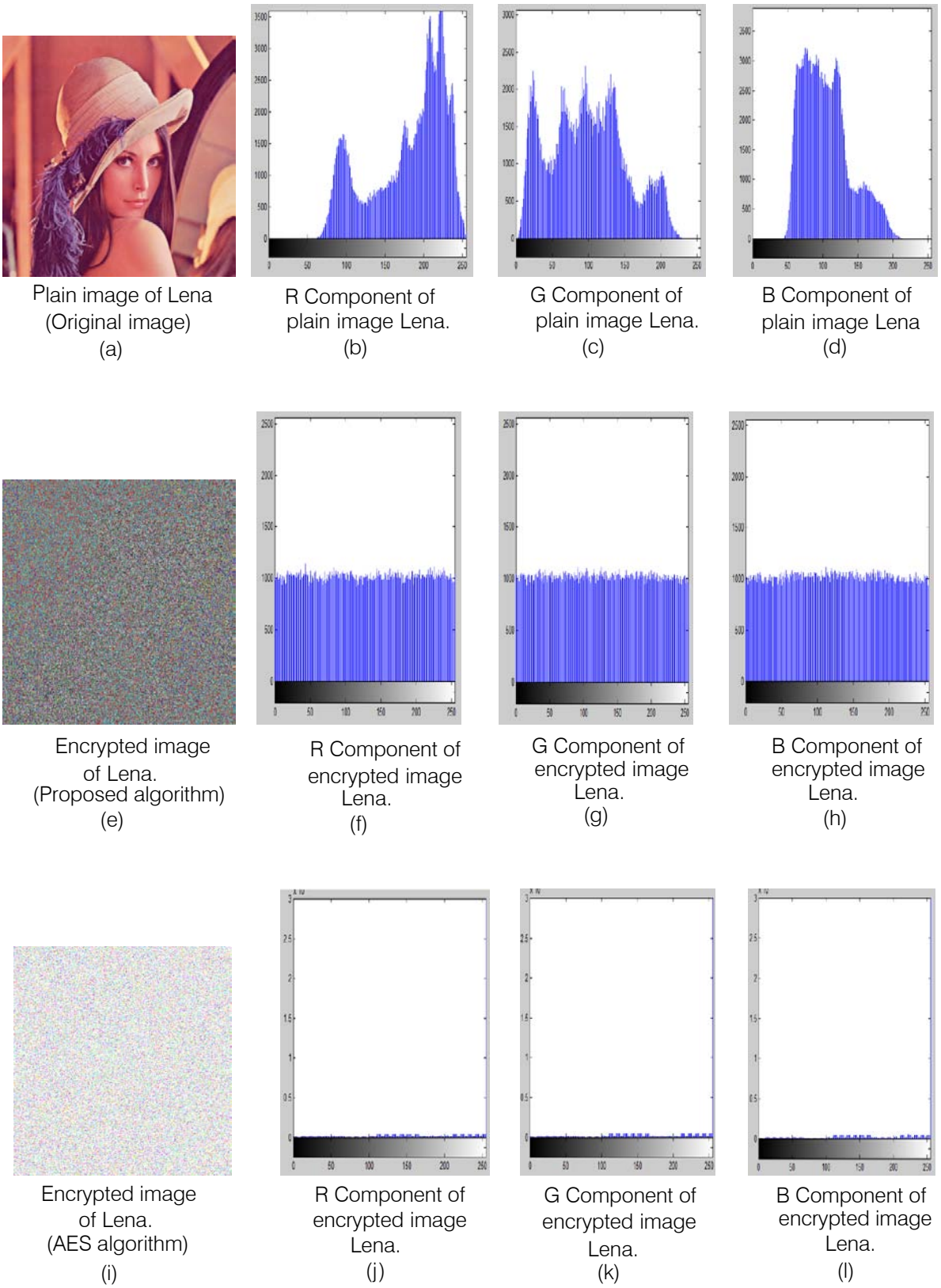

Figure 3: Histogram comparison of proposed methodology with AES algorithm of plain image 'Lena' and its corresponding encrypted image.

b) Correlation between original and encrypted images

The correlation coefficient between the different colour channels of the plain and its corresponding encrypted image is calculated using the proposed image encryption scheme and AES algorithm. In Table 1 and Table 2, for some images, the results have been calculated. Since the correlation coefficients calculated are very low (C≈ 0) which is shown in Table 1 and Table 2, which therefore indicates that the plain images are different from the encrypted images. And this shows that our result is consistent with the full security defined by Shannon.

Table1: Correlation coefficient for the proposed algorithm between plain images and their corresponding encrypted images.

Image size	C_{R1R2}	C_{R1G2}	C_{R1B2}	C_{G1R2}	C_{G1G2}	C_{G1B2}	C_{B1R2}	C_{B1G2}	C_{B1B2}
Lena 512*512	-0.0013	-0.00095	0.0001	-0.0006	-0.0022	0.00094	0.00027	-0.0027	0.00044
Baboon 200*200	-0.0039	-0.0081	-0.0031	-0.0120	-0.0019	0.00079	-0.0101	0.00061	-0.00054
Peppers 200*200	-0.0012	0.0012	0.0039	0.00052	0.0020	0.0012	-0.0020	-0.00005	0.0052
Tiger 800*600	0.00046	-0.00065	-0.0009	-0.00006	-0.0008	-0.0007	0.00025	-0.0008	-0.00009
Sunset 440*262	0.00045	0.0036	0.0024	0.0016	0.0057	0.0015	0.00051	0.0021	-0.0003
Airplane 512*512	0.0044	0.0045	0.0021	0.0042	0.0042	0.0015	0.0041	0.0036	0.00081

Table 2: Correlation coefficient for the AES algorithm between plain images and their corresponding encrypted images.

Image Size	C_{R1R2}	C_{R1G2}	C_{R1B2}	C_{G1R2}	C_{G1G2}	C_{G1B2}	C_{B1R2}	C_{B1G2}	C_{B1B2}
Lena 512*512	0.0015	0.00001	0.0021	0.00068	0.00062	0.0020	-0.00014	0.0012	0.0014
Baboon 200*200	-0.0084	0.00097	0.0055	-0.0013	0.0041	0.0018	-0.0014	0.00054	0.0017
Peppers 200*200	-0.0020	0.0022	-0.0024	0.0020	-0.0065	-0.0026	0.0011	-0.0020	0.0014
Tiger 800*600	-0.0015	0.00045	0.0012	-0.0020	0.00066	0.0014	-0.0020	0.00028	0.00088
Sunset 440*262	0.0040	0.0013	0.0021	0.0015	0.0012	0.0030	-0.0042	0.0031	0.0043
Airplane 512*512	0.0036	0.0031	-0.00035	0.0021	0.0031	-0.00048	0.0021	0.0028	-0.00069

c) *Information entropy*

Below Table 3 shows the entropy value for the proposed encryption scheme and AES algorithm for different images. The information entropy value obtained for the proposed scheme is 7.99 which is very close to the ideal case but in case of AES algorithm, the value obtained is 2.91 which deviates a lot from an ideal case. This shows that the proposed image encryption algorithm achieves a high order of diffusion and substitution and has a robust performance.

Table 3: Entropy values for proposed and AES algorithm for different images.

Images	Entropy of plain images by proposed and AES Algorithm	Entropy of encrypted images by Proposed Algorithm	Entropy of encrypted images by AES Algorithm
Lena	7.7502	7.9997	2.9109
Baboon	7.6430	7.9983	2.9184
Peppers	7.7150	7.9982	2.9234
Tiger	7.8261	7.9999	2.9076
Sunset	7.3460	7.9988	2.9097
Airplane	6.6639	7.9995	2.9127

V. Conclusion

The paper presents a block based scrambling and substitution based image encryption technique for designing an efficient, robust and secure encryption scheme for digital data. The proposed image encryption scheme is designed to secure the communication of multimedia data. The necessary security and performance constraints are incorporated in the proposed methodology which provides a good, secure and an efficient image encryption algorithm. The results clearly elaborates that the proposed method is able to generate an encryption scheme which is secure and efficient as compared to the popular standard algorithm.

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Enhanced Logarithmic Search Technique for Motion Estimation with Three Step Reduction

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Abstract- Video compression is the one which has highest demand in the area of video processing. Motion estimation (ME) is the basic of Video compression. There are several algorithms to estimate the motion estimation of current block in reference frame. In the view of this a new novel technique has been proposed in namely Logarithmic Search with Three Step Reduction (LSTSR) which is computationally more efficient than many of the existing techniques. Simulation result shows that it performs better than that of Three Steps Search (TSS), New Three Step Search (NTSS) and reduces the checking points by almost 50% than that of TSS.

Keywords: motion estimation (ME); motion vector (MV); BMA; PSNR; TSS; NTSS.

GJCST-F Classification: I.3.7, I.4.8

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Enhanced Logarithmic Search Technique for Motion Estimation with Three Step Reduction

Pranob K Charles [α], Dr. Habibulla Khan [σ] & Dr. K.S. Rao [ρ]

Abstract- Video compression is the one which has highest demand in the area of video processing. Motion estimation (ME) is the basic of Video compression. There are several algorithms to estimate the motion estimation of current block in reference frame. In the view of this a new novel technique has been proposed in namely Logarithmic Search with Three Step Reduction (LSTSR) which is computationally more efficient than many of the existing techniques. Simulation result shows that it performs better than that of Three Steps Search (TSS), New Three Step Search (NTSS) and reduces the checking points by almost 50% than that of TSS.

Keywords: motion estimation (ME); motion vector (MV); BMA; PSNR; TSS; NTSS.

I. Introduction

Video Processing has a lot of demand now a days as because lot of videos are to be transferred here and there especially when comes to the mobile communication. As video requires much more space to store than still image, video compression is very much useful in reducing the storage space and which will eventually lead to lesser cost. The main concept in video compression is to predict the future position of the current block by taking the reference of either past frame or future. The maximum displacement of an object from one frame to another is given by the coordinate of that position called *motion vector (MV)*. The process by which we find out the best matching block in reference frame corresponding to each macro block of current frame is called motion estimation (ME). As video contains both spatial and temporal redundancy, we need to use Hybrid codec to reduce them. In hybrid codec, we predict the video and when we subtract it from input video, we get the residual error. Now if we encode this residual signal and pass it to decoder, we need not to encode each frame separately. This will require lesser bits to encode the video.

In the encoder side, the motion estimator compares the stored frame to that of incoming frame to find the MV. The motion compensator uses both the sored frame and MV to predict what the position of the current block will be. Then with the help of predicted video and encoded residual signal, the decoder produces the compensated frame of the current frame.

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II. Previous Work

For motion estimation we need to search for the best match in the reference frame which will give us the best MV. The search is done in many ways and depending upon the search pattern, in different techniques the complexity, time and PSNR values per macro block varies. The first and foremost technique was to search each point of search area for best match. This is called Full Search (FS) [14]. This has very high computation per macro block and also has high PSNR value. We can consider the result as optimal one. Due to high computational complexity, many Block based fast motion estimation techniques are implemented and few of them are Three Step Search (TSS) [21], New Three Step Search (NTSS) [3], Diamond Search (DS) [6], 2 Dimensional Logarithmic Search (2DLS) [16] and Cross Search (CS) [2]. According research and experiment, it is seen that TSS checks an avg. of 25 points, NTSS checks an avg. of 17 to 33 points, DS checks an avg. of 13 points and 2 DLS takes avg. of 13 to 17 checking points per macro block. More and more techniques are being developed to reduce the computational complexity as well as increase the PSNR value of compensated image.

In this paper, a new algorithm is proposed named as Logarithmic Search with Reduced Three Step Reduction (LSTSR). This technique is applied on various video sequences and results are compared with already existing techniques in terms of search points required and PSNR values. In this paper section III defines the types of predictions used, Section IV explains the Block Matching Algorithm (BMA) concepts and matching criteria, section V defines the proposed method, section VI defines the Experimental Setup and Results Section VII gives Analysis of RTSLS followed by comparison, conclusion and references.

III. Types of Estimation

We can estimate the best matching position of current block in the reference frame by using both past frame and future frame as a reference. If we use the past frame to predict the future position of the current block, we refer it as forward prediction and as we need to move back in time, so it is also called backward motion estimation. On the other hand if we use the future frame as a reference to predict the past, it is

called backward prediction and which is also known as forward motion estimation.

IV. BMA and Matching Criteria

Matching of two macro blocks has to be done in different frames to compute the displacement. The matching can be done in pixel to pixel basis or block by block basis. However Pixel by pixel matching is time consuming as it needs more computations. So we match the center pixel along with its neighbor pixels. For that we divide the frame into blocks of size 8x8 or 16x16 and matching is done between corresponding blocks of current frame and reference frame. This process is called block matching and the algorithm is called block matching algorithm (BMA).

We used the matching criteria between two blocks as Mean Absolute Difference (MAD)

The performance measure used here is PSNR which is known as peak signal to noise ratio and calculated as:

$$PSNR = 10 \log 10 (2552 / MSE)$$

For performance comparison PSNR difference is also calculated. It is defined as the difference in PSNR of the proposed algorithm with respect to FS algorithm. Within a video codec it is also advisable to calculate bit rate at different quantization parameters for the rate-distortion (bit rate versus PSNR) comparison.

V. Proposed Algorithm

Many techniques have been proposed to compute motion estimation in lieu of reducing number of computations, reduction in search points which are required per each macro block. We have seen the technique named as "Three step search" which searches for best matching macro blocks and continues for three steps only. The quality of the techniques is judged by the number of search points required and the PSNR ratios along with the quality of the compensated image. If we want to reduce the number of search points there are chances of low quality compensated image. Those techniques which give better compensated image but they require relatively higher number of search points.

Here we have proposed one algorithm which is computationally more efficient than earlier Three Step Search algorithm and few other already existing block matching algorithms.

a) Logarithmic Search with Three Step Reduction (LSTSR)

It is because this search technique completes in three steps it can be called as three step search. However we reduced these steps and thereby calling this as reduced Three Step Search and mainly we have reduced the number of search points and is further called as logarithmic search because each time, step size is reduced by 2 i.e. logarithmically. For the searching purpose, we define the search range as +7 and we consider the block size of mxn. The steps are:

i. We place the candidate block at the center of the reference frame and within the search range we start searching with initial step size 4. In 1st step we search 5 points including one center and 4 points at the end of a plus '+' for minimum cost. The point with minimum cost will become the center of the next search step and we reduce the step size by 2.

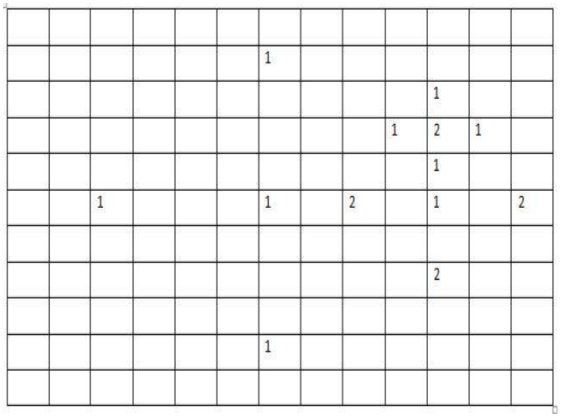


Fig.1: Search pattern in LSTSR

ii. Now we again start searching points at the ends of plus '+' with step size 2 for minimum cost. We don't calculate cost at those points at which cost is already calculated in last step. So we need to check only 4 points. We again shift the center to the point with minimum cost and reduce the step size to 1.

iii. This is the last step and we again search in similar fashion with step size 1 around the center. We again have to calculate cost at only 4 points for minimum cost and the point with minimum cost will be our required position and it will give us the final motion vector.

In the above mentioned algorithm the number of search points required per macro block is 5+4+4=13.

VI. Experimental Setup

In our experiment we have taken the mean absolute difference (MAD) as a measure of matching criteria. We have implemented the techniques by taking both macro block size of 16x16 and 8x8.The maximum displacement in search area is taken as +7 and the search area as (2x7+1)*(2x7+1)=225.The simulation is performed on different sequences with different frame length as listed in table 5.1. The results and outputs are obtained as Average no. of searching points required

per macro block, the PSNR ratios. The various results obtained from experiment are discussed below.

Table 1: Video sequences for analysis

Frame format(Numbers of Frames)	Sequences
.avi (240x360,80 frames)	SampleVideo
.ras(288x352, 30 frames)	Missa

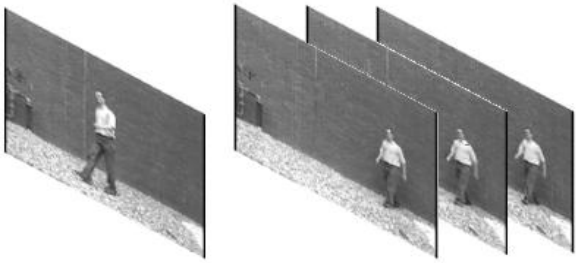


Fig.2: Video used for experiment "SampleVideo.avi"

Experimental Results:

a) Comparison between compensated image obtained using mbsize of 8x8 vs 16x16

(a) Reference frame #4 (b) Current frame #6 (c) Compensated Frame #6

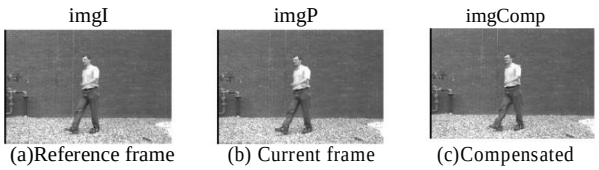
Fig.3: Forward prediction using mbsize of 8x8

(a) Reference frame #4 (b) Current frame #6 (c) Compensated Frame #6

Fig.4: Forward prediction using 16x16 mbSize

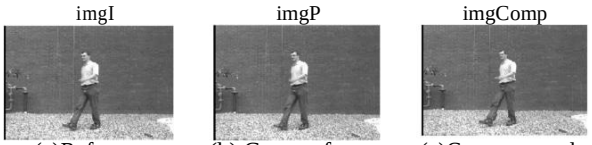
In the above figures, the compensated images are obtained using macro blocks of size 8x8 and 16x16. The fig.3 is obtained when we used macro block of size 8x8 so a total of 20134 computations are needed. In fig.4 is obtained by using 16x16 size macro block where the total of 4910 computations is required.

b) Forward prediction and backward prediction



(a)Reference frame #55 (b) Current frame #56 (c)Compensated Frame #55

Fig 5: Forward prediction using 16x16 mbSize



(a)Reference frame #55 (b) Current frame #54 (c)Compensated Frame #55

Fig 6: Backward prediction using mbSize of 16x16

In the fig 5, we obtained the compensated image by using forward prediction and in fig.6, we obtained the compensated image and resulted motion vector using backward prediction method.

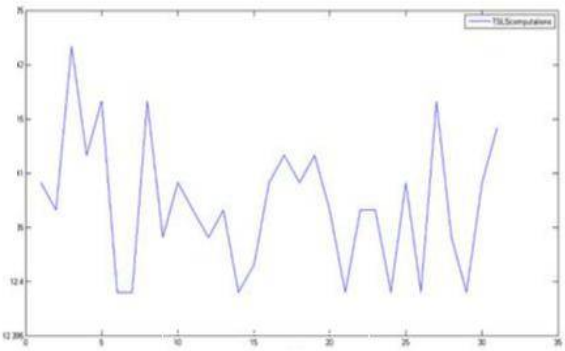


Fig.7: Average number of computations per macro block of 'missa' Sequence

The number of computations required per macro block using RTSLS on 'missa' video sequence is shown in fig. 5.5. From the figure it can be seen that it only requires an average of 12.3990 numbers of computations per macro block and PSNR value becomes 35.5951.

VII. Analysis & Comparison

When we see the outputs obtained by using RTSLS and many other already existing techniques, we can clearly observe that RTSLS takes lesser time and lesser computations than that of few already existing BMA. For the same video sequences Three Steps search checks an average of 25 points per macro block, New Three step search checks 17 points in best case and 33 points at worst case but the newly developed RTSLS checks only 13 points per macro block. While the new technique has reduced the number of

computations per macro blocks but still it retains similar quality of the compensated image with that of TSS and NTSS.

RTSLS: This is a modification of both TSS and NTSS. This technique gives us the motion vector in relatively 60% of the steps required by other two. It takes approximately 5+4+4=13 points to check per each macro block while producing similar results. This comparison with other techniques is best understood from the following table 2.

Table 2: Avg. computations and PSNR values of RTSLS with others

	SampleVideo(16x16)		Missa(16x16)	
	Avg. PSNR	Avg. Computations	Avg. PSNR	Avg. Computations
TSS	32.7325	23.0182	36.5393	23.26515
NTSS	32.4105	16.1636	36.53965	19.3586
RTSLS	32.2018	12.3273	36.16315	12.4103

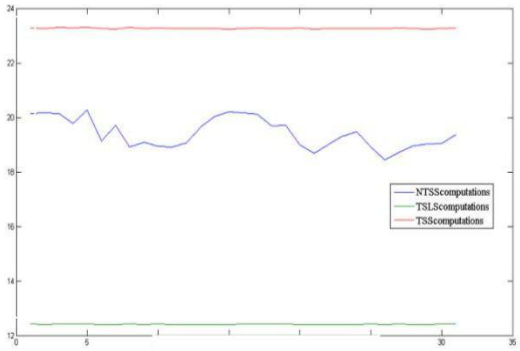


Fig.8: Average number of computations per macro block of 'missa' sequence

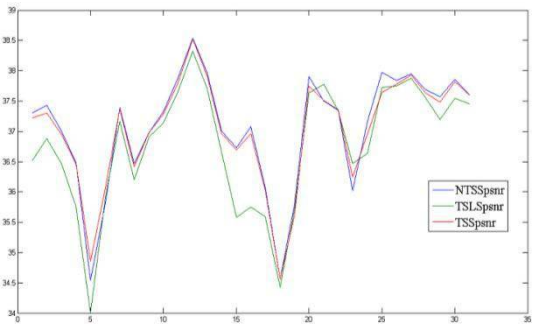


Fig.9: PSNR values per macro block of 'missa' sequence of different techniques

VIII. Conclusion

Based on the TSS algorithm and 2 DLS, we have proposed **Logarithmic Search with Three Step Reduction (LSTSR)**. From the results obtained in simulation using different techniques on 'missa' video sequence with mbSize 16x16, it is observed that the RTSLS is consuming almost 50% of the computations than that of TSS and 60% of computations than that taken by NTSS. From fig.9, it can be seen that though LSTSR checks at much lesser no. of points still retained its PSNR values and they are almost similar than that of TSS and NTSS. So the quality of the compensated image is similar as produced by other two. It can be concluded that LSTSR is the most efficient among the discussed techniques.

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It is mandatory to read all terms and conditions carefully.

AUXILIARY MEMBERSHIPS

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as "Institutional Fellow of Open Association of Research Society" (IFOARS).

The "FARSC" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as "Institutional Board of Open Association of Research Society"-(IBOARS).

The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of "Open Association of Research Society, U.S.A (OARS)" so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

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- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
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- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

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The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

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You can use your own standard format also.
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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

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(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

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22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

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27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

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31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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