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Graphics and Vision

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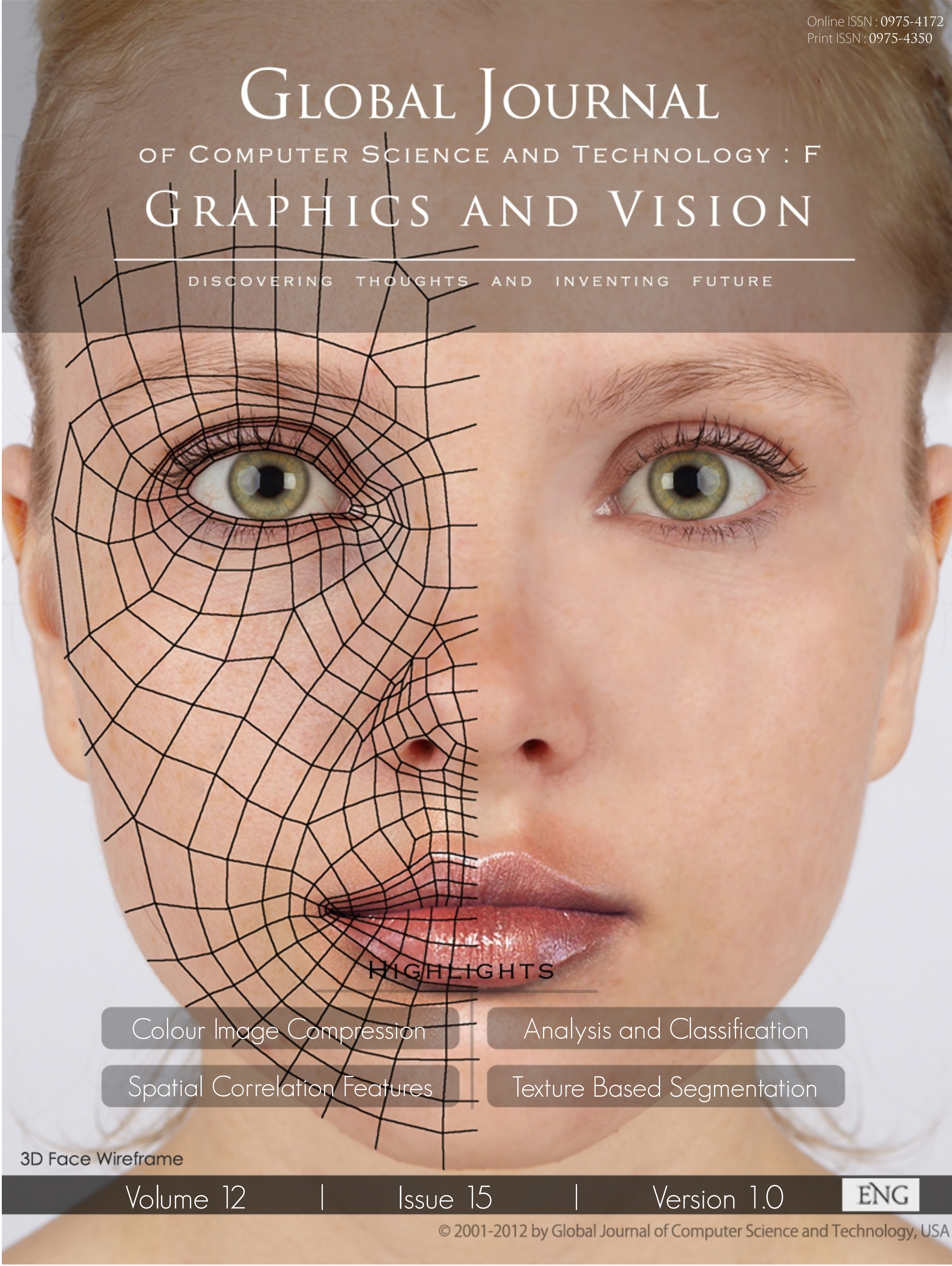

HIGHLIGHTS

- Colour Image Compression
- Analysis and Classification
- Spatial Correlation Features
- Texture Based Segmentation

3D Face Wireframe

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A Spatial Domain Image Steganography Technique Based on Plane Bit Substitution Method

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Strictly as per the compliance and regulations of:

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Ms.G.S.Sravanthi [α], Mrs.B.Sunitha Devi [α], S.M.Riyazoddin [α] & M.Janga Reddy [α]

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I. Introduction

The word Steganography is of Greek origin and means "concealed writing" from the Greek words steganos meaning "covered or protected", and graphein meaning "to write". The first recorded use of the term was in 1499 by Joharnnes Trithemius in his Steganographia, a treatise on cryptography and steganography disguised as a book on magic. Generally, messages will appear to be something else: images, articles, shopping lists, or some other cover text and, classically, the hidden message may be in invisible ink between the visible lines of a private letter. "Steganography niche in security is to supplement cryptography, not replace it. If a hidden message is encrypted, it must also be decrypted if discovered, which provides another layer of protection." There are several approaches in classifying steganographic systems. One could categorize them according to the type of covers used for secret communication. A classification according to the cover modifications applied in the embedding process is another possibility. Although in some cases an exact classification is not possible, the group steganographic methods are of six categories:

Substitution systems substitute redundant parts of a cover with a secret message; Transform domain techniques embed secret information in a transform space of the signal (e.g., in the frequency domain); Spread spectrum techniques adopt ideas from spread spectrum communication; Statistical methods encode information by checking several statistical properties of a cover and use hypothesis testing in the extraction process; Distortion techniques store information by signal distortion and measure the deviation from the original cover in the decoding step; Cover generation methods encode information in the ay a cover for secret communication is created.

But as we know steganography deals with hiding of information in some cover source. On the other hand, Steganalysis is the art and science of detecting messages hidden using steganography; this is analogous to cryptanalysis applied to cryptography. The goal of steganalysis is to identify suspected packages, determine whether or not they have a payload encoded into them, and, if possible, recover that payload. Hence, the major challenges of effective Steganography are:-

1. Security of Hidden Communication: In order to avoid raising the suspicions of eavesdroppers, while evading the meticulous screening of algorithmic detection, the hidden contents must be invisible both perceptually and statistically.
2. Size of Payload: Unlike watermarking, which needs to embed only a small amount of copyright information, steganography aims at hidden communication and therefore usually requires sufficient embedding capacity. Requirements for higher payload and secure communication are often contradictory. Depending on the specific application scenarios, a tradeoff has to be sought.

One of the possible ways of categorizing the present steganalytic attacks is on the following two categories

1. **Visual Attacks**: These methods try to detect the presence of information by visual inspection either by the naked eye or by a computer. The attack is based on guessing the embedding layer of an image (say a bit plane) and then visually inspecting that layer to look for any unusual modifications in that layer.
2. **Statistical Attacks**: These methods use first or higher order statistics of the image to reveal tiny alterations in the statistical behavior caused by steganographic embedding and hence can successfully detect even small amounts of embedding with very high accuracy.

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These class of steganalytic attacks are further classified as 'Targeted Attacks' or 'Blind Attacks' as explained in detail in the next few sections.

a) Steganography Mechansim

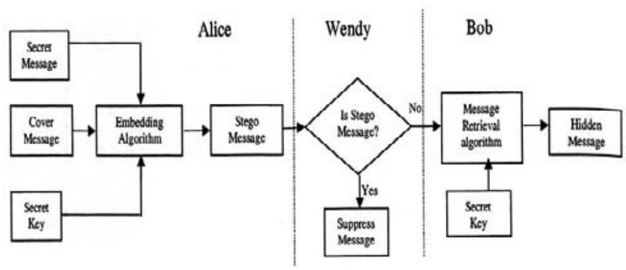


Fig.1.1 : Steganographic Mechanism

This system can be explained using the 'prisoners problem' (Figure 1.1) where Alice and Bob are two inmates who wish to communicate in order to hatch an escape plan. However communication between them is examined by the warden, Wendy. To send the secret message to Bob, Alice embeds the secret message 'm' into the cover object 'c', to obtain the stego object 's'. The stego object is then sent through the public channel. In a pure steganographic framework, the technique for embedding the message is unknown to Wendy and shared as a secret between Alice and Bob. In private key steganography Alice and Bob share a secret key which is used to embed the message. The secret key, for example, can be a password used to seed a pseudo-random number generator to select pixel locations in an image cover-object for embedding the secret message. Wendy has no knowledge about the secret key that Alice and Bob share, although she is aware of the algorithm that they could be employing for embedding messages. In public key steganography, Alice and Bob have private-public key pairs and know each other's public key. In this thesis we confine ourselves to private key steganography only.

b) Different Kinds of Steganography

Almost all digital file formats can be used for steganography, but the formats that are more suitable are those with a high degree of redundancy. Redundancy can be defined as the bits of an object that provide accuracy far greater than necessary for the object's use and display. The redundant bits of an object are those bits that can be altered without the alteration being detected easily. Image and audio files especially comply with this requirement, while research has also uncovered other file formats that can be used for information hiding.

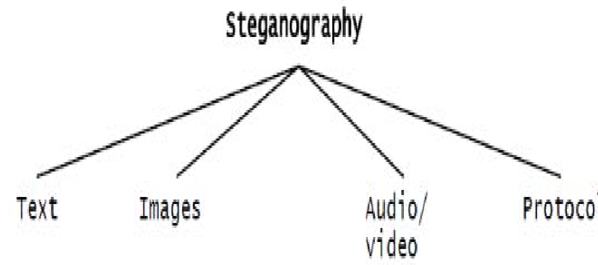


Fig.1.2 : Categories of Steganography

Hiding information in text is historically the most important method of steganography. An obvious method was to hide a secret message in every nth letter of every word of a text message. It is only since the beginning of the internet and all the different digital file formats that is has decreased in importance.

This Paper is organized as follows: In section II, "Literature Survey", we give a background of the existing state of the steganographic research. We cover briefly the main categories of steganographic algorithms covered till date although the survey is not exhaustive and we may have missed out some of the algorithms. In section III we discuss the method how the stagenography transformation takes place, in section IV we discuss the proposed PBSM an adaptive method for secured image steganography is discussed and in last section we tried to show the experimental results.

II. Literature Survey

Here we discuss the necessary background required for this work. In section 2.1 we discuss briefly some of the existing steganographic techniques. In section 2.2 we present some of the steganalytic attacks proposed till date as a counter measure to the steganographic algorithms.

a) Existing Steganographic Techniques

The steganographic algorithms proposed in literature can broadly be classified into two categories.

1. Spatial Domain Techniques
2. Transform Domain Techniques

Each of these techniques is covered in detail in the next two subsections.

i. *Spatial Domain*

These techniques use the pixel gray levels and their color values directly for encoding the message bits. These techniques are some of the simplest schemes in terms of embedding and extraction complexity. The major drawback of these methods is amount of additive noise that creeps in the image which directly affects the Peak Signal to Noise Ratio and the statistical properties of the image. Moreover these embedding algorithms are applicable mainly to lossless image-compression schemes like TIFF images. For lossy compression schemes like JPEG, some of the message bits get lost during the compression step.

The most common algorithm belonging to this class of techniques is the Least Significant Bit (LSB) replacement technique in which the least significant bit of the binary representation of the pixel gray levels is used to represent the message bit. This kind of embedding leads to an addition of a noise of 0:5p on average in the pixels of the image where p is the embedding rate in bits/pixel. This kind of embedding also leads to an asymmetry and a grouping in the pixel gray values (0,1);(2,3);. . . (254,255). this asymmetry is exploited in the attacks developed for this technique as explained further in section 2.2. To overcome this undesirable asymmetry, the decision of changing the least significant bit is randomized i.e. if the message bit does not match the pixel bit, then pixel bit is either increased or decreased by 1. This technique is popularly known as LSB Matching. It can be observed that even this kind of embedding adds a noise of 0:5p on average. To further reduce the noise, [19] have suggested the use of a binary function of two cover pixels to embed the data bits. The embedding is performed using a pair of pixels as a unit, where the LSB of the first pixel carries one bit of information, and a function of the two pixel values carries another bit of information. It has been shown that embedding in this fashion reduces the embedding noise introduced in the cover signal. In [21], a multiple base number system has been employed for embedding data bits. While embedding, the human vision sensitivity has been taken care of. The variance value for a block of pixels is used to compute the number base to be used for embedding. A similar kind of algorithm based on human vision sensitivity has been proposed by [22] by the name of Pixel Value Differencing. This approach is based on adding more amounts of data bits in the high variance regions of the image for example near "the edges" by considering the difference values of two neighboring pixels. This approach has been improved further by clubbing it with least significant bit embedding in [17].According to [17], "For a given medium, the steganographic algorithm which makes fewer embedding changes or adds less additive noise will be less detectable as compared to an algorithm which makes relatively more changes or adds higher additive noise." Following the same line of thought Crandall [17] have introduced the use of an Error Control Coding technique called "Matrix Encoding". In Matrix Encoding, q message bits are embedded in a group of $2^q - 1$ cover pixels while adding a noise of $1 - 2^{-q}$ per group on average. The maximum embedding capacity that can be achieved is $q / 2^q - 1$. For example, 2 bits of secret message can be embedded in a group of 3 pixels while adding a noise of 0:75 per group on average. The maximum embedding capacity achievable is 2=3 = 0:67 bits/pixel. F5 algorithm [17] is probably the most popular implementation of Matrix Encoding. LSB replacement technique has been extended to multiple bit planes as well. Recently [20] has claimed that LSB replacement involving more than one least significant bit planes is less detectable than single bit plane LSB replacement. Hence the use of multiple bit planes for embedding has been encouraged. But the direct use of 3 or more bit planes leads to addition of considerable amount of noise in the cover image. [17] Have given a detailed analysis of the noise added by the LSB embedding in 3 bit planes. Also, a new algorithm which uses a combination of Single Digit Sum Function and Matrix Encoding has been proposed. It has been shown analytically that the noise added by the proposed algorithm in a pixel of the image is 0:75p as compared to 0:875p added by 3 plane LSB embedding where p is the embedding rate.

One point to be observed here is that most of the approaches proposed so far are based on minimization of the noise embedded in the cover by the algorithm. Another direction of steganographic algorithm is preserving the statistics of the image which get changed due to embedding. Chapter 2 of this thesis proposes two algorithms based on this approach itself. In the next section we cover some of the transform domain steganographic algorithms.

ii. *Transform Domain*

These techniques try to encode message bits in the transform domain coefficients of the image. Data embedding performed in the transform domain is widely used for robust watermarking.

Similar techniques can also realize large-capacity embedding for steganography. Candidate transforms include discrete cosine Transform (DCT), discrete wavelet transform (DWT), and discrete Fourier transform (DFT). By being embedded in the transform domain, the hidden data resides in more robust areas, spread across the entire image, and provides better resistance against signal processing. For example, we can perform a block DCT and, depending on payload and robustness requirements, choose one or more components in each block to form a new data group that, in turn, is pseudo randomly scrambled and undergoes a second-layer transformation.

Modification is then carried out on the double transform domain coefficients using various schemes. These techniques have high embedding and extraction complexity. Because of the robustness properties of transform domain embedding, these techniques are generally more applicable to the "Watermarking" aspect of data hiding. Many steganographic techniques in these domain have been inspired from their watermarking counterparts.F5 [17] uses the Discrete Cosine Transform coefficients of an image for embedding data bits. F5 embeds data in the DCT coefficients by rounding the quantized coefficients to the nearest data bit. It also uses Matrix Encoding for reducing the embedded noise in the signal. F5 is one the most popular embedding schemes in DCT domain steganography, though it has been successfully broken in [17].

The transform domain embedding does not necessarily mean generating the transform coefficients on blocks of size 8×8 as done in JPEG compression techniques. It is possible to design techniques which take the transforms on the whole image [17]. Other block based JPEG domain and wavelet based embedding algorithms have been proposed in [17] with respectively.

b) Existing Attacks

The steganalytic attacks developed till date can be classified into visual and statistical attacks.

The statistical attacks can further be classified as

1. Targeted Attacks
2. Blind Attacks

Each of these classes of attack is covered in detail in the next two subsections along with several examples of each category.

i. *Targeted Attacks*

These attacks are designed keeping a particular steganographic algorithm in mind. These attacks are based on the image features which get modified by a particular kind of steganographic embedding. A particular steganographic algorithm imposes a specific kind of behavior on the image features. This specific kind of behavior of the image statistics is exploited by the targeted attacks. Some of the targeted attacks are as follows:

1. Histogram Analysis: The histogram analysis method exploits the asymmetry introduced by LSB replacement. The main idea is to look for statistical artifacts of embedding in the histogram of a given image. It has been observed statistically that in natural images (cover images), the number of odd pixels and the number of even pixels are not equal. For higher embedding rates of LSB Replacement these quantities tend to become equal. So, based on this artifact a statistical attack based on the Chi-Square Hypothesis Testing is developed to probabilistically suggest one of the following two hypothesis:

Null Hypothesis H0: The given image contains steganographic embedding Alternative

Hypothesis H1: The given image does not contain steganographic embedding the decision to accept or reject the Null Hypothesis H0 is made on basis of the observed confidence value p. A more detailed discussion on Histogram Analysis can be found in [24].

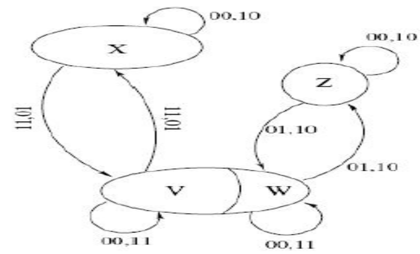


Figure 2.1 : Flipping of set cardinalities during embedding

2. **Sample Pair Analysis**: Sample Pair Analysis is another LSB steganalysis technique that can detect the existence of hidden messages that are randomly embedded in the least significant bits of natural continuous-tone images. It can precisely measure the length of the embedded message, even when the hidden message is very short relative to the image size. The key to this methods success is the formation of 4 subsets of pixels (X, Y, U, and V) whose cardinalities change with LSB embedding (as shown in Figure 2.1), and such changes can be precisely quantified under the assumption that the embedded bits are randomly scattered. A detailed analysis on Sample Pair technique can be found in [23].

Another attack called RS Steganalysis based on the same concept has been independently proposed by [25].

ii. *Blind Attacks*

The blind approach to steganalysis is similar to the pattern classification problem. The pattern classifier, in our case a Binary Classifier, is trained on a set of training data. The training data comprises of some high order statistics of the transform domain of a set of cover and stego images and on the basis of this trained dataset the classifier is presented with images for classification as a non-embedded or an embedded image. Many of the blind steganalytic techniques often try to estimate the cover image statistics from stego image by trying to minimize the effect of embedding in the stego image. This estimation is sometimes referred to as "Cover Image Prediction". Some of the most popular blind attacks are defined next.

1. **Wavelet Moment Analysis: Wavelet** Moment Analyzer (WAM) is the most popular Blind Steganalyzer for Spatial Domain Embedding. It has been proposed by [40].WAM uses a denoising filter to remove Gaussian noise from images under the assumption that the stego image is an additive mixture of a non-stationary Gaussian signal (the cover image) and a stationary Gaussian signal with a known variance (the noise). As the filtering is performed in the wavelet domain, all the features (statistical moments) are calculated as higher order moments of the noise

residual in the wavelet domain. The detailed procedure for calculating the WAM features in a gray scale image can be found in [17]. WAM is based on a 27 dimension feature space. It then uses a Fisher Linear Discriminant (FLD) as a classifier. It must be noted that WAM is a state of the art steganalyzer for Spatial Domain Embedding and no other blind attack has been reported which performs better than WAM.

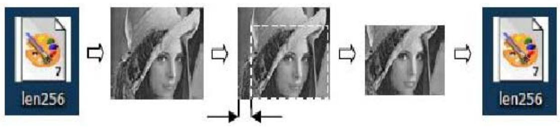


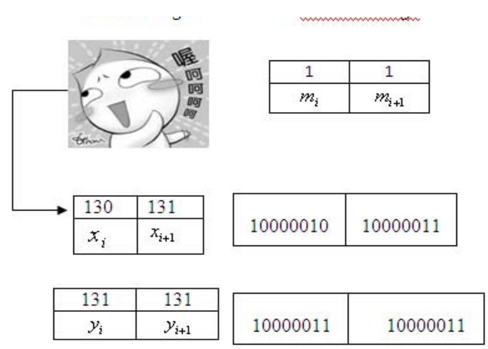
Fig. 2.2 : 4-pixels

2. **Calibration Based Attacks:** The calibration based attacks estimate the cover image statistics by nullifying the impact of embedding in the cover image. These attacks were first proposed by [17] and are designed for JPEG domain steganographic schemes. They estimate the cover image statistics by a process termed as Self Calibration. The steganalysis algorithms based on this self calibration process can detect the presence of steganographic noise with almost 100% accuracy even for very low embedding rates [26, 27]. This calibration is done by decompressing the stego JPEG image to spatial domain and cropping 4 rows from the top and 4 columns from the left and recompressing the cropped image as shown in Figure 2.2. The cropping and subsequent recompression produce a "calibrated" image with most macroscopic features similar to the original cover image. The process of cropping by 4 pixels is an important step because the 8×8 grid of recompression "does not see" the previous JPEG compression and thus the obtained DCT coefficients are not influenced by previous quantization (and embedding) in the DCT domain. Farid's Wavelet Based Attack: This attack was one of the first blind attacks to be proposed in steganographic research [17] for JPEG domain steganography. It is based on the features drawn from the wavelet coefficients of an image. This attack first makes an n level wavelet decomposition of an image and computes four statistics namely Mean, Variance, Skewness and Kurtosis for each set of coefficients yielding a total of $12 \times (n-1)$ coefficients. The second set of statistics is based on the errors in an optimal linear predictor of coefficient magnitude. It is from this error that additional statistics i.e. the mean, variance, skew-ness, and kurtosis are extracted thus forming a $24 \times (n-1)$ dimensional feature vector. For implementation purposes, n is set to 4 i.e. four level decomposition on the image is performed for extraction of features. The source code of this attack is available at [17]. After extraction of features, a Support Vector Machine (SVM) is used for classification. We would like to mention that although in [17] a SVM has been used for classification we have used the Linear Discriminant Analysis for classification. Some other blind attacks have also been proposed in literature. [17] Have modeled the difference between absolute value of neighboring DCT coefficients as a Markov process to extract 324 features for classifying images as cover or stego. [27] Have extended the features of [26] to 193 and clubbed them with 72 features derived by reducing the 324 extracted by [17].

III. Steganography Transformation

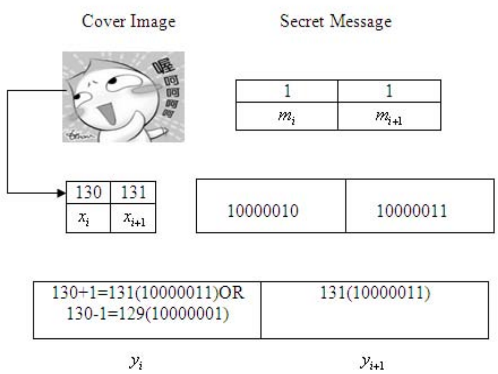
a) *LSB Replacement*

LSB replacement is a well-known steganographic method. In this embedding scheme, only the LSB plane of the cover image is overwritten with the secret bit stream according to a pseudorandom number generator (PRNG). As a result, and thus it is very easy to detect the existence of hidden message even at a low embedding rate using some reported steganalytic algorithms



b) *LSB Matching*

LSB matching (LSBM) employs a minor modification to LSB replacement. If the secret bit does not match the LSB of the cover image, then+1 or – 1 is randomly added to the corresponding pixel value. Statistically, the probability of increasing or decreasing for each modified pixel value is the same and so the obvious asymmetry artifacts introduced by LSB replacement can be easily avoided.



IV. Adaptive Method for Steganography

To increase the security and the size of stored data, a new adaptive LSB technique is used. Instead of storing the data in every least significant bit of the pixels, this technique tries to use more than one bit in a pixel in such a way that this change will not affect the visual appearance of the host image. It uses the side information of neighboring pixels to estimate the number of bit which can be carried in the pixels of the host-image to hide the secret data called PBSM.

a) Sending Algorithm

1. Convert the carrier image to binary.
2. Divide the secret message into blocks, each block consisting of 16 characters (128 bits).
3. Apply encryption process to convert each plain text block into a cipher text block.
4. Keep all the cipher text blocks together to form the complete cipher text.
5. Transform these cipher text to binary.
6. Embed the cipher text into binary image as per the embedding process discussed, and then we get the stego binary image. Now convert this stego binary image to stego image and then send to receiver.

Step1:Binaryfunction

$$f(y_i, y_{i+1}) = LSB([y_i / 2] + y_{i+1})$$

Primary1: $f(L-1, R) \neq f(L+1, R)$

Primary2: $f(L, R) \neq f(L, R+1)$

$\neq f(L, R-1)$

$f(129,140) = 1$

$f(131,140) = 0$

$f(130,140) = 0$

$f(130,140) = 0$

$f(130,141) = 1$

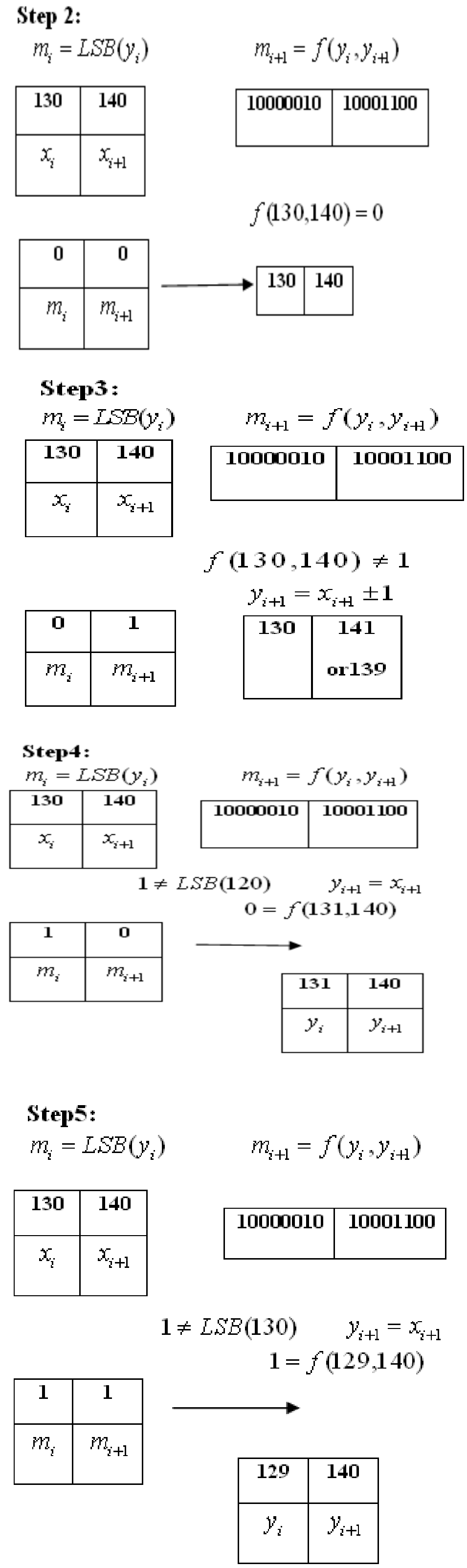
$f(130,139) = 1$

$$f(y_i, y_{i+1}) = LSB([y_i / 2] + y_{i+1})$$

$f(130,140) = 0$

$f(130,140) = 0$ $\quad f(130,141) = 1$

$f(130,139) = 1$



b) Embedding Algorithm

Input: l- bit secret message M, an uncompressed image IPe, Ps the cryptographic and steganographic keys.

Output: stego-image I'or failure

Parameters: the higher bit plane imax, the threshold the size m × n of the sliding window

1. Transform I into I′ from PBC to CGC according to 1
2. Decompose I′ into N-bit planes
3. Compress and encrypt M with Ke
4. Init the Pseudo-Random Generator with Ks
5. For i from imax to 1
   - Find all m × n flat areas in bit plane Bi with threshold t according to 4
   - Randomly embed the message in the bits of Bit of the non-flat areas using the pseudo-random sequence
6. If some bits of the message has not been embedded return failure
7. Transform I′ from CGC to PBC according to (2)
8. Return I′

c) Receiving Algorithm

Input: a stego image I′ Pe, Ps the cryptographic and steganographic keys

Output: the l-bit secret message M

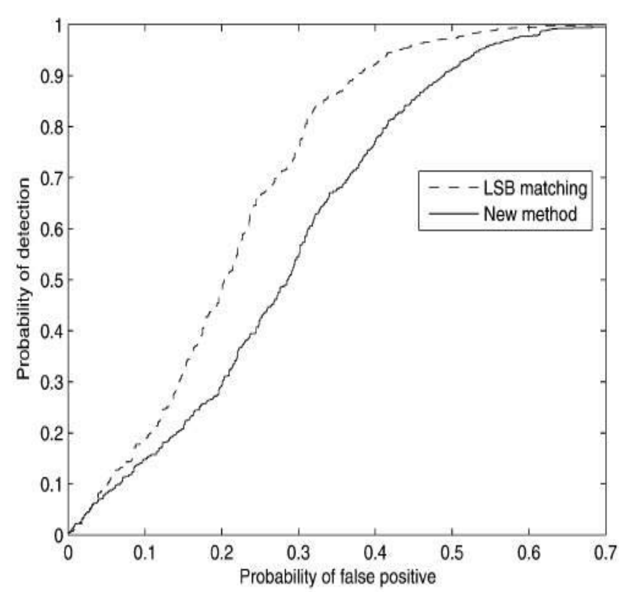
Parameters: the higher bit plane imax, the threshold the size m × n of the sliding window.

1. Transform I′ from PBC to CGC according to (1)
2. Decompose I′ into N-bit planes
3. Init the Pseudo-Random Generator with Ks
4. for i from imax to 1
   - Find all m × n flat areas in bit plane Bi with threshold t according to (4)
   - Extract the message M in the non-flat areas of Bi using the pseudo- random sequence
5. Decrypt M with Ke and decompress it 6. Return M
   - Find all m × n flat areas in bit plane Bi with threshold t according to 4
   - Randomly embed the message in the bits of Bit of the non-flat areas using the pseudo-random sequence
6. If some bits of the message has not been embedded return failure
7. Transform I′ from CGC to PBC according to (2)
8. Return I′

V. Experimental Results

$$m_i = LSB(y_i) \qquad m_{i+1} = f(y_i, y_{i+1})$$

x_i	x_{i+1}	m_i	m_{i+1}	y_i	y_{i+1}
1	1	0	0	2	1
1	1	0	1	0	1
1	1	1	0	1	0or2
1	1	1	1	1	1
1	2	0	0	0	2
1	2	0	1	2	2
1	2	1	0	1	2
1	2	1	1	1	1or3
2	1	0	0	2	1
2	1	0	1	2	0or2
2	1	1	0	3	1
2	1	1	1	1	1
2	2	0	0	2	1or3
2	2	0	1	2	2
2	2	1	0	1	2
2	2	1	1	3	2



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A Lossy Colour Image Compression Using Integer Wavelet Transforms and Binary Plane Technique

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Abstract - In the recent period, image data compression is the major component of communication and storage systems where the uncompressed images requires considerable compression technique, which should be capable of reducing the crippling disadvantages of data transmission and image storage. In the research paper, the novel image compression technique is proposed which is based on the spatial domain which is quite effective for the compression of images. However, the performance of the proposed methodology is compared with the conventional compression techniques (Joint Photographic Experts Group) JPEG and set partitioning in hierarchical trees (SPIHT) using the evaluation metrics compression ratio and peak signal to noise ratio. It is evaluated that Integer wavelets with binary plane technique is more effective compression technique than JPEG and SPIHT as it provides more efficient quality metrics values and visual quality.

GJCST-F Classification: I.4.2

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Strictly as per the compliance and regulations of:

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P.Ashok Babu [α] & Dr. K.V.S.V.R.Prasad [σ]

Abstract - In the recent period, image data compression is the major component of communication and storage systems where the uncompressed images requires considerable compression technique, which should be capable of reducing the crippling disadvantages of data transmission and image storage. In the research paper, the novel image compression technique is proposed which is based on the spatial domain which is quite effective for the compression of images. However, the performance of the proposed methodology is compared with the conventional compression techniques (Joint Photographic Experts Group) JPEG and set partitioning in hierarchical trees (SPIHT) using the evaluation metrics compression ratio and peak signal to noise ratio. It is evaluated that Integer wavelets with binary plane technique is more effective compression technique than JPEG and SPIHT as it provides more efficient quality metrics values and visual quality.

I. Introduction

Growingly, different images are attained and stored digitally especially in grayscale format, which are usually acquired from special equipments. These images are quite large in size and number in such situation, compression reduces the cost of storage and enhances transmission speed. In the recent period, image compression plays an important role in effective images related operations while for this, it is crucial that compression of images is of minor loss of information from the image, which may cause serious consequences [1]. Conventionally, the image coding techniques are classified as lossless or lossy where the small image information is of significantly important in advance imagining field.

a) Problem Statement and Related Works

i. Problem Statement

It is observed that in the recent period, different single or sequences of images can be transmitted over the computer networks to a large distance, which is used for several image analysis and diagnosis purposes. For example, it is essential that images is compressed and transmitted effectively in order to conduct reliable, enhanced, and fast analytical operations performed by several institutions around the world [2]. For this situation, image compression is the significant research problem. However, complexity lies in the adoption of effective compression technique, which is capable of providing high compression and preserved the significant characteristics of the images after the compression process is performed and this is situation of effective compression techniques. The difference coding in the Binary plane technique is proposed and named this technique as modified BPT. This technique is spatial domain technique, which is found better than the Set Partitioning in Hierarchical Trees (SPIHT) and Joint Photographic Experts Group (JPEG) technique [3].

ii. Related Research Works

It is identified that several advanced image compression techniques have been developed considering to the growing demands for image storage and transmission. The JPEG 2000 [4,5] combined embedded block coding with the optimized truncation (EBCOT) technique with the lifting integer wavelet transform to perform several advanced features and capable of provide high performance lossless compression as compared to JPEG low bit rate technique. The Wu and Memon [6,7] proposed the context based adaptive lossless image codec (CALIC) approach using enclosing 360 modeling contexts to attain the distribution of the encoded symbols and the prediction scheme. Moreover, William A. Pearlman and Said Amir [8] proposed Set partitioning in hierarchical trees (SPIHT) technique which utilizes the inherent similarities around the sub-bands in a wavelet decomposition of the image. The S.Mahaboob Basha, Dr. B. Sathyanarayana and Dr. T. Bhaskara Reddy [9] proposed a binary plane technique which is used to take advantage of repeated values in the consecutive pixels positions.

iii. Structure of Research Paper

This research is organized with the following sections where Section 1 provides the illustration of research problem, related paper and the online structure of the paper. Section 2 deals with the illustration of the overview of JPEG technique, SPIHT technique and BPT technique. moreover, Section 3 provide information related to the proposed methodology, section 4

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presented the results and discussion further Section 5 summarizes the overcall outcomes of the research study and proposed methodology with efficient recommendations concerning future study.

II. Overview of Research Techniques

a) Overview of Joint Photographic Experts Group (JPEG) Technique

The (Joint Photographic Experts Group) JPEG is a international compression standard for the continuous tone image of both colored or grayscale images. However, due to its distinctive requirements of applications the JPEG standard has two fundamental compression methods where the DCT based method is demonstrated for the lossy compression and predictive method specified for the lossless compression [10]. In the paper, researchers have discussed and utilized the lossy compression of JPEG standard method. The basis of the JPEG algorithm is the discrete cosine transforms which extract the spatial frequency information from the spatial amplitude samples where these frequency components are then quantized to reduce the visual data from the image, which is least perceptually apparent thus decreasing the amount of information which should be stored. The redundant properties of the quantized samples are exploited by means of Huffman coding to produce the compressed demonstration.

The JPEG is the lossy algorithm which means that visual information is selectively unnecessary to enhance the compression ratio. The overall algorithm of JPEG is illustrated as follows:

1. The uncompressed source of data is separated into 8x8 blocks of pixels where 128 is subtracted from the value of each pixel so that the new effective range is from -128 to 127.
2. Each block is then transformed into an 8x8 block of frequency coefficients as follows

$$F(v,u) = \sum_{x=0}^{7} \sum_{y=0}^{7} p(y,z) d_u[x] d_v[y]$$

Where F (v,u) is the frequency coefficient with vertical frequency v and horizontal frequency u and p(y,x) provides the value of pixel in row y an column x of the block.

3. These coefficients are quantized as follows

$$g_{vu} = N\frac{f_{vu}}{q_{vu}}$$

4. The entropy encoder is applied to the quantized coefficients
5. Then the specification of JPEG table is conducted to attain the compressed image data. However, JPEG decoding performs in reverse to the above steps of the encoding and decoding steps.

i. *Limitations of JPEG Technique*

- It is observed that the quality of JPEG formatted image is significantly reduced when the image is compressed on a greater level while the compatibility and distribution of data is another major limitation of JPEG [11].
- Since the JPEG algorithm is not a lossless approach, the data is usually discarded when the image file is compressed and this limitation is usually noticeable when required to be aggressively compressed or edited [12].
- Several institutions utilize compressed file for several purposes for instance evaluating the images for particular anomalies where the loss of data using the JPEG algorithm causes the images to be ineffectual for their proper evaluation [12].

b) Overview of Partitioning In Hierarchical Trees SPIHT Technique

It is observed that set partitioning in hierarchical trees (SPIHT) is the image compression algorithm that uses the inherent similarities across the sub bands in the wavelet decomposition of the image. The SPIHT algorithm codes the most significant transform coefficient first and then transmits the bits so that refined copy of the original image can be attained [8]. The SPIHT is based on three principles in three principles which include exploitation of the hierarchical structure of the wavelet transform by utilizing the three basic organizations of the coefficient , partial ordering of the transformed coefficients by magnitude with the data not clearly transmitted but recalculated by the decoder [13]. Finally, it orderes binary plane transmission of the refinement bits for the coefficient values. It leads to the compressed bit stream in which the most significant coefficients are transmitted first and then the values of all coefficients are progressively refined and relationship between the coefficients demonstrating the similar location at distinct scales in completely exploited for the compression efficiency. [14].

i. *Limitations of SPIHT*

- It is observed that SPIHT is quite vulnerable to bit corruption since the single bit error can introduce major image distortion relying on its location.
- The worse factor of this technique is the requirement of accurate bit synchronization as the leak in bit transmission lead to extensive misinterpretation from the side of the decoder as well as high memory requirements is also the major limitation of this technique [15].
- It is also identified that error resilience is not viable by the SPIHT algorithm and in the situation where the signification bits are toggled in the noise

channel then the decoder cannot duplicate the execution path of the encoder due to which even a simple bit fault can distort the en
process of image [16].

c) Integer Wavelet Transform

Integer wavelet transform maps an integer data data set into other integer data set. This transform is perfectly invertible and gives exactly the original data set. If the input data consist of sequences of integers, then the resulting filtered outputs no longer consist of integers, which do not allow perfect reconstruction of the original image. However, with the introduction of Wavelet transforms that map integers to integers we are able to characterize the output completely with integers. The best example of wavelet transforms that map integers to integers is the S-transform. The 2D S-transform can be computed for an image using equations (1a), (1b),(1c), and (1d). Of course the transform is reversible, i.e., we can exactly recover the original image pixels from the computed transform coefficients. The inverse is given in equations (2a), (2b), (2c), and (2d). The transform results in four classes of coefficients: (A) the low pass coefficients,(H) coefficients represent horizontal features of the image, (V) and (D) reflect vertical and diagonal information respectively. During the transform we ignore any odd pixels on the borders.

$$A_{i,j} = (I_{2i,2j} + I_{2i+1,2j}) / 2 \ldots \quad (1a)$$

$$H_{i,j} = I_{2i,2j+1} - I_{2i,2j} \ldots \quad (1b)$$

$$V_{i,j} = I_{2i+1,2j} - I_{2i,2j} \ldots \quad (1c)$$

$$D_{i,j} = I_{2i+1,2j+1} - I_{2i,2j} \ldots \quad (1d)$$

$$I_{2i,2j} = A_{i,j} - [H_{i,j}/2] \ldots \quad (2a)$$

$$I_{2i,2j+1} = A_{i,j} + [H_{i,j+1})/2] \ldots \quad (2b)$$

$$I_{2i+1,2j} = I_{2i,2j+1} + V_{i,j} - H_{i,j} \ldots \quad (2c)$$

$$I_{2i+1,2j+1} = I_{2i+1,2j} + D_{i,j} - V_{i,j} \ldots \quad (2d)$$

d) Overview of Binary Plane Technique

The binary plane technique is used in the first stage of compression where the compressed file which is usually maintained in two parts , the first part is bit plane which holds the bits '0' for each pixel similar to the previous pixel and bit ' 1' for each pixel different from the previous pixel [17]. While, the second part is the data table which holds only the essential pixel values that is for the set of consecutive repeated values and only one value is stored in the data table. In the technique, the current values are stored in the table if it is not similar as previous value and not stored if it is similar to the previous values and later the bit plane and data table are merged into one file[18]. However, the main aim of this technique is acquiring benefits of the similar value in the consecutive pixels and instead of storing all of them. Moreover, the main advantage of binary plane technique is that it helps to maintain the gray scale value while compression which provides better quality image as compared to other compression techniques.

e) Lossy Binary Plane Technique

The Method is based on Spatial Domain of the Image and is Suitable for Natural and Synthetic Image Compression. The main aim of the technique is to use the repeated values in consecutive pixels positions. For a set of repeated consecutive values only one value is retained. In the Binary Plane technique two codes are used to build the bit plane. The codes have been given below

Code 1(one) is used to indicate the current pixel, which is different from the previous pixel. In this case the current pixel is moved to the data table.

Code 0 (Zero) is used to indicate the current pixel in exactly the same way as the previous pixel. This eliminates the storage of the current pixel.

For e.g If the Image file contains the following pixels

128 80 80 80 300 90 90 180 180 180 180 20 20 223 99 99 99

Then the bit plane file contains

11001101000101100

and data file is as below

128 80 300 90 180 20 223 99

In the Lossy binary plane technique a scalar quantization is done for the data table using equation (3)

$$(PP-TV/2) >= CP <= (PP+TV/2-1) \ldots (3)$$

Where PP-Previous pixel, CP-current Pixel, TV-Threshold value then the range of data table will be modified as shown in the figure 1.

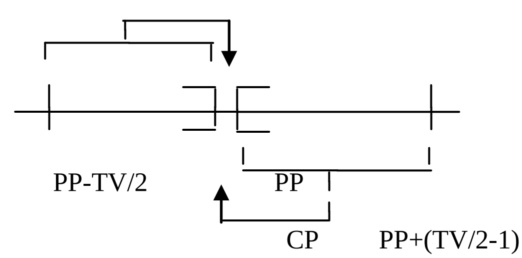


Figure 1 : Modification of the data table with threshold value

For eg: let us consider a numerical example, if the image file contains the following pixels

128 75 77 79 80 115 119 125 180 188 TV=4 ε [-2, +1] :

Table 1 : Modification of Data Table

CP	PP	RANGE	BP	DT
128	0	(-2,1)	1	128
75	128	126-129	1	75
77	75	73-76	1	77
79	77	75-78	1	79
80	79	77-80	0	--
115	80	78-81	1	115
119	115	113-116	1	119
125	119	117-120	1	125
180	125	123-126	1	180
188	180	178-181	1	188

The Data Table is 128 75 77 79 115 119 125 180 188
The Binary Plane is 1111011111

III. Proposed Methodology

In order to conduct the image concerning the compression of the images, the proposed algorithm is used by adopting the following steps:

1. The input image is decomposed into LL, LH, HL and HH components using integer wavelet transforms.
2. Consider the LL components which have the maximum information regarding the image and most of the redundant data and apply the binary plane technique.
3. In BPT a threshold of 4 [-2, +1] is used for removing the redundant data. The output of the technique is a data plane and bit plane.
4. Apply inverse BPT and obtain LL' components, and apply inverse integer wavelet transform with LL', LH, HL and HH components.
5. Thus obtained compressed image is compared against the standards like JPEG and SPIHT in terms of quality, bits per pixel.

The novel technique proposed in the research paper is based on the spatial domain of the image and it is quite suitable for the compression of images [19]. The proposed methodology is providing the ways for overcoming the limitations of SPIHT and JPET techniques. It is observed that the proposed techniques are overcoming the loss of data as found in JPEG algorithm during the compression of the images. The errors of bit distortion as observed in SPIHT technique are removed with the implementation of proposed methodology. It is also found that the SPIHT causes the misinterpretation from the decoder while requiring the high memory. The Integer wavelets transform, Binary Plane technique, difference coding technique, and inverse of difference coding technique are used to eradicate the use of extensive memory and reconstruct the image with higher quality. This technique also helps to remove the repeated values within the data to make the compression more effective. For instance, if the image file contains the following pixels.

128 80 80 80 300 90 90 180 180 180 180 20 20 223 99 99 99
Then the bit plane file contains
11001101000101100
and data file is as below
128 80 300 90 180 20 223 99

IV. Results and Discussion

a) Data Sets

The data sets were standard images and taken for evaluating the proposed algorithm resulting using different evaluation metrics. The proposed technique is evaluated on grayscale images data sets of individuals where one slice was selected from images in the random to evaluate the performance of the proposed methodology.

Table 2 : Image Quality Evaluation Metrics Using Different Compression Techniques

Image with Size	Algorithm Used	Compression Ratio	PSNR
Natural vitamins 512x512	JPEG	1.8993	37.1999
	SPIHT	1.8748	33.9696
	Modified BPT	4.2919	48.0254
Baboon 512x512	JPEG	3.8358	31.1519
	SPIHT	10.4399	30.9913
	Modified BPT	9.2298	55.0734
Koala 512x512	JPEG	2.4440	33.7970
	SPIHT	6.3792	33.2140
	Modified BPT	6.5382	54.4672
Lena 512x512	JPEG	1.7095	36.3617
	SPIHT	1.1843	33.1623
	Modified BPT	4.4561	52.3545
Peppers 512x512	JPEG	1.7438	35.4499
	SPIHT	1.8265	33.3657
	Modified BPT	4.7400	42.2312

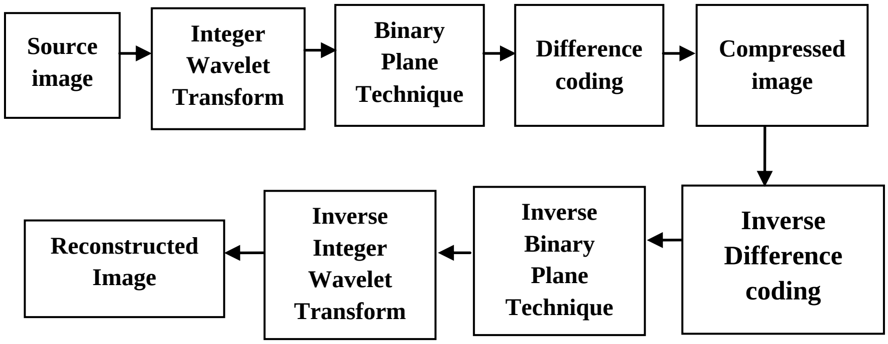


Figure 2 : Block Diagram of Modified BPT Algorithm

b) Quality Metrics

The research paper uses the following factors utilized to evaluate the performance of proposed technique in the gray scale images.

c) Compression Ratio (CR)

The Data Compression Ratio is also termed, as compression power, which is used to quantify the reduction, is data representation size generated by the data compression algorithm [4]. It is calculated as Compression Ratio is equal to compressed size by uncompressed size.

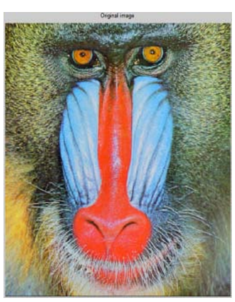
d) The Peak Signal-to-Noise Ratio (PSNR)

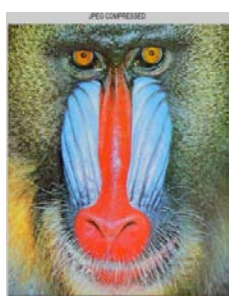
It is used to measure the quality of reconstruction of the lossy image compression and calculated as follows

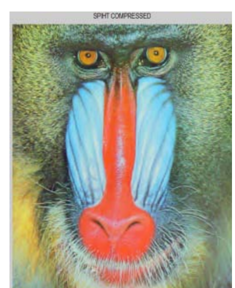
$PSNR = 10\log_{10}\left(\frac{MAX_I^2}{MSE}\right)$ Where MAXI is the maximum probable pixel value of the image, and Mean Squared Error

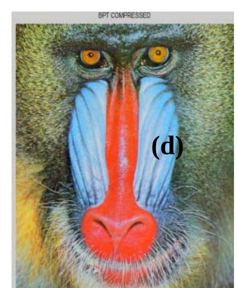
$$(MSE) = \frac{1}{m\,n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad \ldots\ldots\ldots(4)$$

Where the larger PSNR values correspond to good image quality [20].


(a)


(b)


(c)



(d)


(e)


(f)


(g)


(h)

(i) (j) (k) (l)

Figure 3 : (a) Original image (Baboon) , (b) JPEG Compressed(Baboon) (c) SPIHT Compressed(Baboon) (d) Modified BPT Compressed (Baboon) (e) Original image (Natural Vitamins) (f) JPEG Compressed (Natural Vitamins) (g) SPIHT Compressed (Natural Vitamins). (h).Modified BPT Compressed (Natural Vitamins) (i) Original image (Koala) (j) JPEG Compressed (Koala) (k) SPIHT Compressed (Koala). (l).Modified BPT Compressed (Koala)

In the research paper, the researcher analyzed the quality metrics CR, PSNR as well as evaluated the images results visually in comparison of the proposed method with the JPEG and SPIHT and observed that the proposed method has provided more effective values of the quality metrics as compared to the JPEG and SPIHT techniques. Moreover, the visual quality of the compressed image based on the proposed method is much clear and better than the JPEG and SPIHT images as observed in Figure 3. The quality metrics values of CR, PSNR of the proposed methodology is much better when compared to JPEG and SPIHT as observed in the table 2 and hence, it highlighted that the proposed technique is more efficient when compared to the existing two methods.

V. Conclusion

This research paper provides the proposed methodology for the compression of images to be used more effectively which is capable of providing much efficient quality metrics values and visual quality as compared to the existing expression techniques JPEG and SPIHT. However, for the future study the researchers are suggested to include more attributes of evaluation metrics along with PSNR and Compression ratio in order to analyze the results more efficiently. Moreover, researchers can also review the recent techniques in combination of the proposed methodology in order to attain more effective image results.

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Global Journal of Computer Science and Technology (F) Volume XII Issue XV Version I Year 2012

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Texture Analysis and Classification Based on Fuzzy Triangular Greylevel Pattern and Run- Length Features

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Keywords : run length features, fuzzy triangular greylevel pattern (FTGP), triangular neighbor pixels local greylevel matrix (LGM).

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TEXTURE ANALYSIS AND CLASSIFICATION BASED ON FUZZY TRIANGULAR GREYLEVEL PATTERN AND RUN- LENGTH FEATURES

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Texture Analysis and Classification Based on Fuzzy Triangular Greylevel Pattern and Run-Length Features

U Ravi Babu [α], Dr. V Vijaya Kumar [σ] & J Sasi Kiran [ρ]

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Keywords : run length features, fuzzy triangular greylevel pattern (FTGP), triangular neighbor pixels local greylevel matrix (LGM).

I. Introduction

Analysis of textures is a fundamental research topic in the area of computer vision and has many potential applications, for example, in industrial surface inspection, remote sensing, and biomedical image analysis. Classification refers to as assigning a physical object or incident into one of a set of predefined categories. Many texture classification problems usually require the computation of a large amount of texture features in order to characterize their associated patterns. This implies that texture classifiers frequently combine big sets of features without taking into account their relevance and redundancy. Thus, lowering the dimensionality of a feature set is necessary for preserving the most relevant features and it reduces the computational cost derived from unnecessary features [1, 2, 3, 34, 35].

Numerous algorithms of textural features extraction have been presented during the past decades [4, 5]. Textures are classified recently by various methods: preprocessed images [34], long linear patterns [35], edge direction movements [21], avoiding complex patterns [10], marble texture description [36], skeleton extraction of texture [7], long linear patterns using wavelets [8] wavelet transform [8, 9, 10]. and Gabor filters [11]. More recently, the local-binary-pattern (LBP) operator [12, 13, 14] is used for texture classification. LBP operator is a statistical texture descriptor of the characteristics of the local structure. LBP provides a unified description including both statistical and structural characteristics of a texture patch, so that it is more powerful for texture analysis. The concept of LBP is also extend in applications such as face recognition and age classification [15, 16, 17], industrial visual inspection [18, 19], segmentation of remote-sensing images [20], and classification of real outdoor images [21].

An efficient nonparametric methodology for texture analysis based on magnitude LBP (MLBP) [22, 23, 24, 25, 26] is recently proposed and it has been made into a powerful measure of image texture, in terms of accuracy and computational complexity in many empirical studies. To address the connectivity limitations of LBP and MLBP, we propose a matrix called Triangular Neighborhood Matrix (TNM), which generates 2×2 texton patterns. A fuzzy member ship is introduced on TNM to extract local texture information efficiently. The present paper derived run length matrix on the proposed scheme and evaluated runlength features for efficient, precise and accurate classification of textures.

The rest of the paper is organised as follows. Section 2 describes the proposed method. Section 3 describes the results and discussions and conclusions are given in section 4.

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II. Methodology

Derivation of TNM (Triangular Neighborhood Matrix)

The present paper derived FTGP to overcome the disadvantages of LBP and other local binary approaches. Runlength features are evaluated on FGTP for a precise classification in 5 steps.

Step 1: Formation of Local Grey level Matrix (LGM):

A neighborhood of 3×3 pixels is denoted by a set containing nine elements: P= {P1, P1 ...P9}, here P5 represents the intensity value of the central pixel and remaining value are the intensity of neighboring pixels as shown in Fig. 1(a). The Local Grey level Matrix (LGM) values of the neighboring pixels (LGMPi) are obtained by evaluating the absolute difference between the neighboring pixel and the gray value of the central pixel, as described by the Equation (1) as shown in Fig. 1.

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

(a)

$LGMP_1$	$LGMP_2$	$LGMP_3$
$LGMP_4$	$LGMP_5$	$LGMP_6$
$LGMP_7$	$LGMP_8$	$LGMP_9$

(b)

Fig. 1 : (a) A neighborhood of 3×3 (b) obtained LGM

$$\mathrm{LGMP_i} = \mathrm{abs}(\mathrm{P_i} - \mathrm{P_5}) \quad \text{for } \mathrm{i} = 1,2, \dots 9 \tag{1}$$

Where $LGMP_i$ is the obtained grey value of the pixel P_i of the LGM. The equation 1 demonstrates that always $LGMP_5$ value (central pixel value) will be always zero.

Step 2: Generation of Triangular Neighborhood Matrix (TNM) from LGM of step 1:

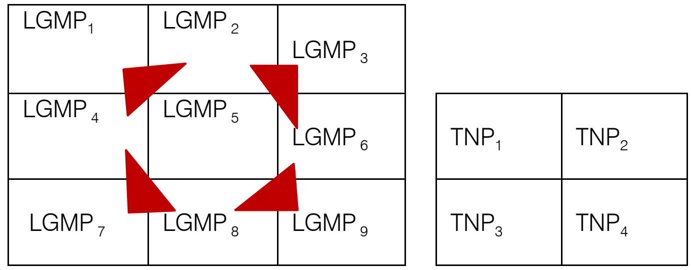
The 2 x 2 TNM is generated from LGM by taking the average value of the Triangular Neighbor Pixels (TNP) of the 3 x 3 LGM as shown in figure 3 and as given in equation 2,3, 4 and 5 . The triangular neighbors are considered because the central pixel of LGM is always zero. That is one need not necessary to consider this.

$$TNP_1 = \frac{(\mathrm{LGMP_1} + \mathrm{LGMP_1} + \mathrm{LGMP_1})}{3} \tag{2}$$

$$TNP_2 = \frac{(\mathrm{LGMP\ \ _2} + \mathrm{LGMP_3} + \mathrm{LGMP_6})}{3} \tag{3}$$

$$TNP_3 = \frac{(\mathrm{LGMP_4} + \mathrm{LGMP_7} + \mathrm{LGMP_8})}{3} \tag{4}$$

$$TNP_4 = \frac{(\mathrm{LGMP_6} + \mathrm{LGMP_8} + \mathrm{LGMP_9})}{3} \tag{5}$$



(a) (b)

Figure 3 : Generation process of a 2 × 2 TNM from LGM (a) LGM matrix (b) TNM

Step 3: Conversion of TNM in to FTGP (Fuzzy Triangular Grey level Pattern):

Fuzzy logic has certain major advantages over traditional Boolean logic when it comes to real world applications such as texture representation of real images. LBP patterns are formed and counted from 0's and 1's. However, the dangerous situation of LBP is that even if the difference is minimum let us say 1 or maximum i.e. 255, it converts it into 1. That is LBP treats even the difference of 1 and 255 as homogeneous. This clearly indicates the patterns of LBP will never gives totally useful and significant information. The above property misuses the power of LBP method. To address this in the proposed method fuzzy member ship is introduced. The aim of fuzzy approach in forming FTGP is to extract local texture information from TNM pixels for representing the texture information accurately. To deal accurately with the regions of natural images even in the presence of noise and the different processes of caption and digitization FTGP is introduced on TNM. For example, even if the human eye perceives two neighboring pixels as equal, they rarely have exactly the same intensity values. The fuzzy patterns are chosen in the present paper because, recently, fuzzy based methods have been used in texture analysis and in image segmentation [28, 29]. The FTGP consists of fuzzy patterns with 5 values {0, 1, 2, 3 and 4} instead of two patterns of LBP. Though the present paper considers five possible fuzzy grey level values, but at any time only a maximum of four fuzzy patterns will appear because the FTGP is a 2 x 2 matrix. In LBP binary patterns are evaluated by comparing the neighboring pixels with central pixel. The FTGP are derived by comparing the each pixel of the 2 x 2 TNM with the average pixel values of the TNM. The FTGP representation is shown in Fig. 4. The following Eqn. (6) is used to determine the elements, $FTGP_i$ of the TNM.

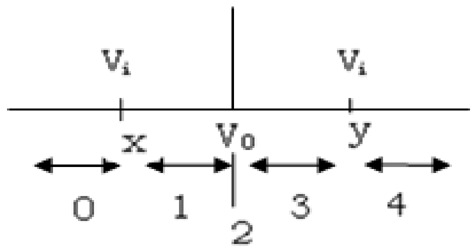


Fig. 4 : Fuzzy triangular grey level texture number representation

$$FTGP_i = \begin{cases} 0 & \text{if} \quad TNP_i < V_0 \quad \text{and} \quad V_i < x \\ 1 & \text{if} \quad TNP_i < V_0 \quad \text{and} \quad V_i \geq V_x \\ 2 & \text{if} \quad TNP_i = V_0 \\ 3 & \text{if} \quad TNP_i > V_0 \quad \text{and} \quad V_i > y \\ 4 & \text{if} \quad TNP_i > V_0 \quad \text{and} \quad V_i \leq y \end{cases} \quad \text{for } i = 1,2,3,4 \qquad (6)$$

Where x, y are the user-specified values.

$$where\ V_0 = \frac{\left(\sum_{i=1}^{4} TNP_i\right)}{4} \qquad (7)$$

For example, the process of evaluating FTGP from a sub TNM image of 2 x 2 is shown in Fig. 5. In this example x and y are chosen as $v_0/2$ and $3v_0/2$ respectively.

28	39
61	9

(a)

1	2
4	0

(b)

Fig. 5 : The process of evaluating FTGP from TNM (a) TNM (b) FTGP

Step 4: Generation of Run Length Matrices on Fuzzy Texture Grey level Pattern (RLM- FTGP)

The membership values of FTGP neighboring pixels are useful for characterization of textures. To address this difficulty the present approach derived Run length matrix (RLM) on the FTGP of the image.

Definition of the Run-Length Matrices: Galloway proposed the use of a run-length matrix for texture feature extraction [12]. For a given texture image, a run-length matrix P(i; j) is defined as the number of runs with fuzzy value i and run length j. Various texture features can then be derived from this run-length matrix.

For a given image, the proposed method defines a RLM (i,j) on FTGP as number of runs starting from location (i,j) of the FTGP image. The proposed method derived five different RLM- FTGP. The RLM-$FTGP_0$, RLM- $FTGP_1$, RLM- $FTGP_2$ RLM- $FTGP_3$ and RLM- $FTGP_4$ contain the run length values for zero, one, two, three and four.

Step 5: Extraction of Texture Features on RLM – FTGP:

Many researchers used three sets of texture features from RLM for texture classification. The first set of RLM Features (RF) is *Traditional Run-Length Features.* The five original features of run-length statistics derived by Galloway [27] are *Short Run Emphasis (SRE)*, *Long Run Emphasis (LRE)*, *Gray-Level Non uniformity (GLN)*, *Run Length Non uniformity (RLN)*, and *Run Percentage (RP)* are described by the Equation (8) to Equation (12). Chu *et al.* [30] proposed another set of two new features, such as *Low Gray-Level Run Emphasis (LGRE)*, and *High Gray-Level Run Emphasis (HGRE)* are described in Equation (13) to Equation (14). In a recent study, Dasarathy and Holder [31] described another set of four feature extraction functions following the idea of joint statistical measure of gray level and run length, as follows: *Short Run Low Gray-Level Emphasis (SRLGE)*, *Short Run High Gray-Level Emphasis (SRHGE)*, *Long Run Low Gray-Level Emphasis (LRLGE), and Long Run High Gray-Level Emphasis (LRHGE)* are described in Equation (15) to Equation (18).

The novelty of the present study is it evaluated the first five RFs as described in equations from 8 to 12 for efficient classification purpose on FTGP. For a comparative analysis the present paper also evaluated all the features for classification purpose.

$$SRE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{P(i,j)}{j^2} \qquad (8)$$

$$LRE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N} P(i,j) * j^2 \qquad (9)$$

$$GLN = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{P(i,j)}{j^2} \qquad (10)$$

$$GLN = \frac{1}{n_r}\sum_{i=1}^{M}\left(\sum_{j=1}^{N} P(i,j)\right)^2 \qquad (11)$$

$$RP = \frac{n_r}{n_p} \qquad (12)$$

In the above equations, n_r is the total number of runs and n_p is the number of pixels in the image.

$$LGRE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{P(i,j)}{i^2} \qquad (13)$$

$$HGRE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N} P(i,j) * i^2 \qquad (14)$$

$$SRLGE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{P(i,j)}{i^2 * j^2} \qquad (15)$$

$$SRHGE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{P(i,j) * i^2}{j^2} \qquad (16)$$

$$LRLGE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N}\frac{P(i,j) * j^2}{i^2} \qquad (17)$$

$$LRHGE = \frac{1}{n_r}\sum_{i=1}^{M}\sum_{j=1}^{N} P(i,j) * i^2 * j^2 \qquad (18)$$

III. Results and Discussions

Experiments are carried out to demonstrate the effectiveness of the proposed FTGP – with RF for stone

Global Journal of Computer Science and Technology (F) Volume XII Issue XV Version I Year 2012

texture classification. The present paper carried out the experiments on two Datasets. The Dataset-1 consists of various brick, granite, and marble and mosaic stone textures with resolution of 256×256 collected from Brodatz textures, Vistex, Mayang database and also from natural resources from digital camera. Some of them in Dataset-1 are shown in the Fig. 6. The Dataset-2 consists of various brick, granite, and marble and mosaic stone textures with resolution of 256×256 collected from Outtex, Paulbourke color textures database, and also from natural resources from digital camera. Some of them in Dataset-2 are shown in the Fig. 7. Dataset-1 and Dataset-2 contains 80 and 96 original color texture images respectively. For classification the proposed method initially divide the texture images into non-overlapping windows of size 32×32 and the resulting windows are then divided into two disjoint sets, one for training and one for testing. The distance classifier Euclidean distance (d) is used for classification in the present paper. The classifier computes the distance between the features for each sample and that of the texture classes and assigns the unknown sample to the texture class with the shortest distance. The classification results for each of the two Data sets are shown in Table I, Table II.

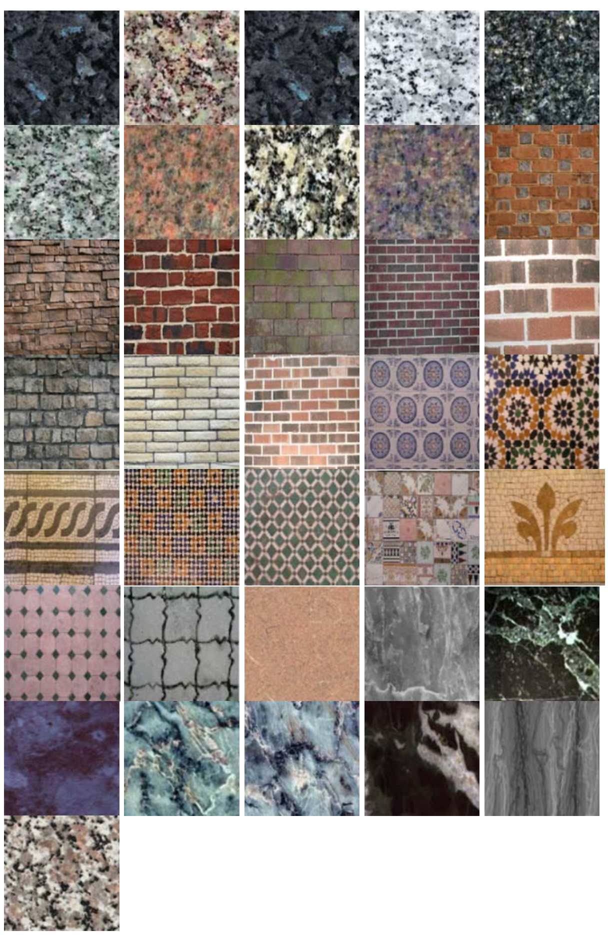


Fig. 6 : Input texture group of 9 samples of Granite, Brick, Mosaic, and Marble in Dataset-1

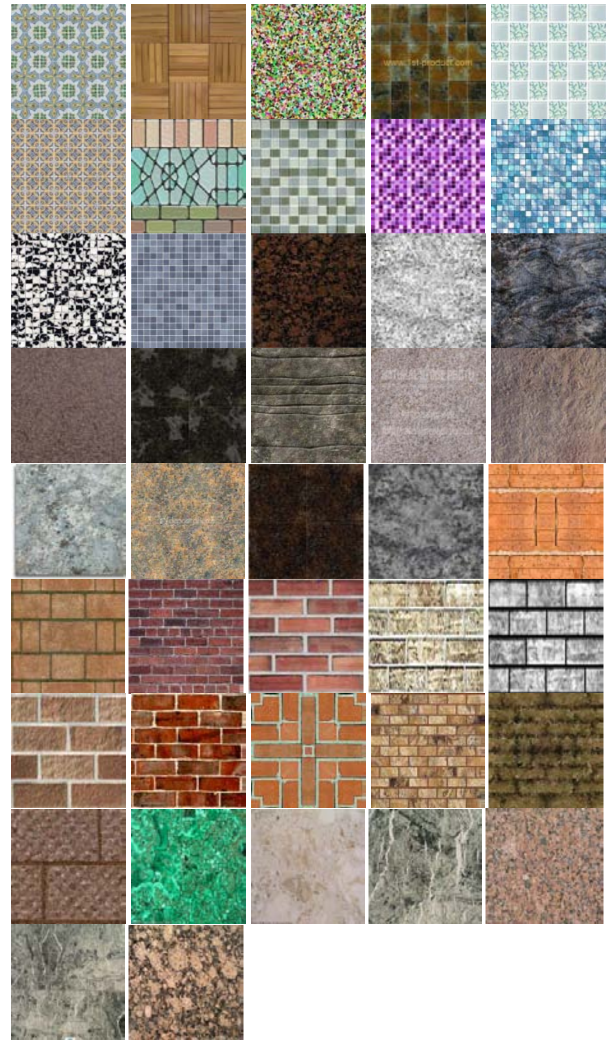


Fig. 7 : Input texture group of 12 samples of Mosaic, Granite, Brick, and Marble with size of 256×256 in Dataset-2

Table Ia : Results of texture classification by proposed RF on FTGP of mosaic and brick textures in Dataset-1

Sno	Texture Name	Classification Rate	Texture Name	Classification Rate
1	concrete_bricks_170756	94.22	Brick.0001	95.06
2	concrete_bricks_170757	94.58	Brick.0002	91.49
3	concrete_bricks_170776	89.64	Brick.0003	97.28
4	crazy_paving_5091370	95.2	Brick.0004	95.9
5	crazy_paving_5091376	96.56	Brick.0005	93.39
6	crazy_tiles_130356	93.54	Brick.0006	96.65
7	crazy_tiles_5091369	95.88	Brick.0007	94.51
8	dirty_floor_tiles_footprints_2564	93.17	Brick.0008	93.25
9	dirty_tiles_200137	93.99	Brick.0009	93.37
10	floor_tiles_030849	96.55	Brick.0010	95.96
11	grubby_tiles_2565	94.68	Brick.0011	92.46
12	kitchen_tiles_4270064	95.48	Brick.0012	94.52
13	moroccan_tiles_030826	96.35	Brick.0013	93.62
14	moroccan_tiles_030857	95.77	Brick.0014	91.48
15	mosaic_tiles_8071010	96.16	Brick.0015	93.61
16	mosaic_tiles_leaf_pattern_201005060	94.97	Brick.0016	92.01
17	mosaic_tiles_roman_pattern_201005034	90.91	Brick.0017	94.58
18	motif_tiles_6110065	95.34	Brick.0018	92.47
19	ornate_tiles_030845	96.44	Brick.0019	96.13
20	repeating_tiles_130359	90.84	Brick.0020	95.37

Table Ib : Results of texture classification by proposed RF on FTGP of granite and marble textures in Dataset-1

Sno	Texture Name	Classification Rate	Texture Name	Classification Rate
1	blue_granite	95.9	apollo	94.09
2	blue_pearl	96.32	canyon_blue	91.81
3	blue_topaz	93.26	cotto	95.53
4	brick_erosion	90.69	curry_stratos	94.02
5	canyon_black	91.48	flinders_blue	95.98
6	dapple_green	96.61	flinders_green	94.54
7	ebony_oxide	97.58	forest_boa	93.71
8	giallo_granite	96.46	forest_stone	94.82
9	gosford_stone	92.26	goldmarble1	92.03
10	greenstone	92.11	green_granite	93.14
11	interlude_haze	97.12	grey_stone	93.15
12	kalahari	91.43	greymarble1	94.02
13	mesa_twilight	92.98	greymarble3	94.69
14	mesa_verte	94.35	marble001	94
15	monza	94.46	marble018	93.39
16	pietro_nero	91.61	marble034	95.17
17	russet_granite	96.19	marble033	94.51
18	granite10	94.07	marble012	94.53
19	granite13	94.94	marble014	94.43
20	granite20	92.89	marble020	89.93

Table 2a : Results of texture classification by proposed RF on FTGP of mosaic & brick textures in Dataset-2

Sno	Texture Name	Classification Rate	Texture Name	Classification Rate
1	images_024	89.81	alternating_brick_3121141	95.18
2	images_027	93.9	alternating_brick_3121142	93.27
3	images_028	94.07	brick_1241070	96.13
4	images_044	95.99	brick_3141206	92.81
5	images_057	93.92	brick_3141207	97.09
6	images_065	92.65	brick_4161585	92.64
7	images_080	89.74	brick_and_wood_wall_3141270	95.81
8	images_101	93.48	brick_blotchy_litchen_2562	96.1
9	images_132	92.32	brick_closeup_5013216	93.51
10	images_133	94.09	brick_detail_6080096	95.03
11	images_144	92.21	brick_flooring_1010262	94.19
12	images_153	88.51	brick_lichen_closeup_2561	87.44
13	images_158	93.56	brick_P3012913	96.4
14	images_178	90.73	brick_removed_plant_2560	97.76
15	images_197	92.07	brick_square_pattern_9261479	93.39
16	images_239	93.3	brick_texture_221691	92.69
17	images_240	89.29	brick_texture_4161572	97.47
18	images_271	88.46	brick_texture_9181117	93.45
19	images_285	97.02	brick_wall_3141250	94.26
20	images_287	91.47	brick_wall_3141267	93.73
21	images_289	91.39	brick_wall_7070215	93.72
22	images_290	92.31	brick_wall_7070225	93.88
23	images_296	95.81	brick_wall_7070226	95.39
24	images_326	88.51	brick_wall_7070227	95.2

Table 2b : Results of texture classification by proposed RF on FTGP of marble & granite textures in Dataset-2

Sno	Texture Name	Classification Rate	Texture Name	Classification Rate
1	images_002	93.54	blotched_marble_2052007	97.21
2	images_006	95.75	bricklike_marble_2052068	93.94
3	images_009	96.29	coarse_marble_9261512	94.7
4	images_011	94.86	dotted_marble_2052053	92.68
5	images_020	97.23	dotty_marble_92398723	95.8
6	images_065	96.7	faded_marble_9160023	96.21
7	images_024	97.26	fine_textured_marble_9181141	97.12
8	images_030	96.05	fossils_A220534	96.63
9	images_032	95.04	marble_cracks_circles_4168	93.17
10	images_033	94.56	marble_fossils_4167	91.76
11	images_038	98.13	marble_texture_9181134	96.46
12	images_040	93.97	marble_texture_B231063	93.07
13	images_041	93.02	marble_with_fossils_4165	92.82
14	images_047	93.96	marble_with_fossils_4166	93.31
15	images_050	95.24	marblelike_stone_9261514	94.39
16	images_051	92.83	patterned_stone_C050573	93.12
17	images_052	96.92	rose_coloured_marble_9181131	96.27
18	images_053	95.3	rounded_markings_marble_2397234	91.46
19	images_058	93.28	rounded_pattern_marble_2052013	95.98
20	images_062	93.59	roundy_marble_297234	96.19
21	images_065	95.27	shiny_reflective_marblelike_stone_9261513	92.03
22	images_067	94.07	specked_marble_9261515	94.71
23	images_068	94.07	specked_marble_C050546	93.23
24	images_071	97.65	spotty_marble_4142267	95.51

a) Comparison of the Proposed RLMF on FGTP with other existing Methods

Table 3 shows the classification rate for various group of textures by the proposed FTGP-RF with other existing methods like compound local binary pattern (CLBP) of Faisal Ahmed et.al [32] and run-length features for image classification by Yung-Kuan Chan et.al [33]. From Table 3, it is clearly evident that, the proposed FTGP-RF exhibits a high classification rate than the existing methods. The graphical representation of the percentage mean classification rate for the proposed RLM-FTGP and other existing methods are shown in Fig.8.

Table 3 : Classification rates of the proposed FTGP-RF with other existing methods

Image Dataset	Compound Local Binary Pattern (CLBP)	Run-length Features	Proposed Method (FTGP-RF)
Brodatz	90.29	93.79	96.31
VisTex	91.53	93.56	95.85
Mayang	92.34	94.43	97.32
Outtex,	91.59	93.63	96.96
CUReT	91.76	93.46	97.54
Paulbourke	90.98	94.56	96.77
Average	91.41	93.91	96.79

Global Journal of Computer Science and Technology (F) Volume XII Issue XV Version I Year 2012

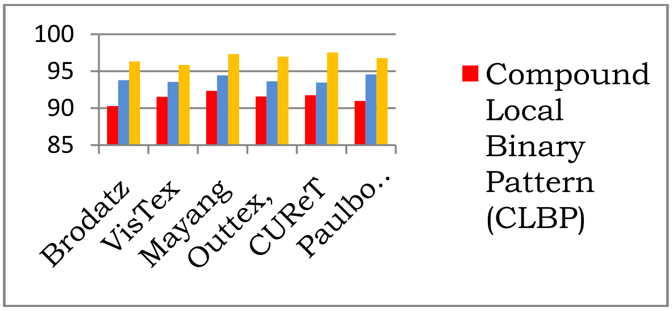


Fig. 8 : Classification chart of proposed FTGP-RF with other existing methods

IV. Conclusion

The proposed FTGP scheme reduces the overall dimension of the image while preserving the significant attributes, primitives, and properties of the local texture. The proposed RLM-FTGP overcomes the disadvantages of the previous Run length matrices for texture classification. LGM is an efficient tool that overcomes the traditional neighborhood problems. By directly using the entire run-length matrix for feature extraction, much of the texture information is preserved. The novelty of the proposed scheme is, it is proved that one need not necessary to evaluate all the RF on the FTGP for classification purpose. For a precise, significant and accurate classification, the present paper evaluated only 5 RLMF on FTGP, which reduced overall complexity. Comparisons of this new approach with the compound local binary pattern (CLBP) by Faisal Ahmed et.al [32] and run-length features for image classification by Yung-Kuan Chan et.al [33] demonstrated the supremacy of the proposed FTGP method.

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Fuzzy Based Texton Binary Shape Matrix (FTBSM) for Texture Classification

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Abstract - Texton is a extensively applied approach for texture analysis. This technique shows a strong dependence on certain number of parameters. Unfortunately, each variation of values of any parameter may affect the texture characterization performance. Moreover, micro structure texton is unable to extract texture features which also have a negative effect on the classification task. This paper, deals with a new descriptor which avoids the drawbacks mentioned above. To address the above, the present paper derives a new descriptor called Fuzzy Based Texton Binary Shape Matrix (FTBSM) for clear variation of any feature/parameter. The proposed FTBSM are defined based on similarity of neighboring edges on a 3×3 neighborhood. With micro-structures serving as a bridge for extracting shape features and it effectively integrates color, texture and shape component information as a whole for texture classification. The proposed FTBSM algorithm exhibits low dimensionality. The proposed FTBSM method is tested on Vistex and Akarmarble texture datasets of natural images. The results demonstrate that it is much more efficient and effective than representative feature descriptors, such as logical operators and GLCM and LBP, for texture classification.

Keywords : texton, micro structure, fuzzy, shape component.

GJCST-F Classification: I.3.5

FUZZY BASED TEXTON BINARY SHAPE MATRIX FTBSM FOR TEXTURE CLASSIFICATION

Strictly as per the compliance and regulations of:

Fuzzy Based Texton Binary Shape Matrix (FTBSM) for Texture Classification

P.Chandra Sekhar Reddy [α] & B.Eswara Reddy [σ]

Abstract - Texton is a extensively applied approach for texture analysis. This technique shows a strong dependence on certain number of parameters. Unfortunately, each variation of values of any parameter may affect the texture characterization performance. Moreover, micro structure texton is unable to extract texture features which also have a negative effect on the classification task. This paper, deals with a new descriptor which avoids the drawbacks mentioned above. To address the above, the present paper derives a new descriptor called Fuzzy Based Texton Binary Shape Matrix (FTBSM) for clear variation of any feature/parameter. The proposed FTBSM are defined based on similarity of neighboring edges on a 3×3 neighborhood. With micro-structures serving as a bridge for extracting shape features and it effectively integrates color, texture and shape component information as a whole for texture classification. The proposed FTBSM algorithm exhibits low dimensionality. The proposed FTBSM method is tested on Vistex and Akarmarble texture datasets of natural images. The results demonstrate that it is much more efficient and effective than representative feature descriptors, such as logical operators and GLCM and LBP, for texture classification.

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I. Introduction

Texture classification is a fundamental issue in computer vision and image processing, playing a significant role in a wide range of applications that include medical image analysis, remote sensing, object recognition, document analysis, environment modeling, content-based image retrieval etc. [1]. For four decades, texture analysis has been an area of intense research, however analyzing real world textures has proven to be surprisingly difficult, in many cases caused by natural texture in-homogeneity of varying illumination, scale changes and variability in surface shape.

Many researchers have put forward various algorithms to extract color, texture and shape features for texture classification. Color is the most dominant and distinguishing visual feature. Texture features provide an important information of the smoothness, coarseness and regularity of many real-world objects such as fruit, skin, clouds, trees, bricks and fabric, etc. [10], and texture based algorithms are also widely used in CBIR systems, including the gray co-occurrence matrixes [2], Markov random field (MRF) model [3], simultaneous auto-regressive (SAR) model [4], Wold decomposition model [5], Gabor filtering [6,7] and wavelet decomposition [8,9] and so on. Tang [11] demonstrated that textural features extracted from a new run-length matrix can produce great classification results over traditional run-length techniques. Chen etal. Proposed a set of statistical geometrical features based on the statistics of geometrical properties of connected regions in a sequence of binary images.

Textures are classified recently by edge direction movements [12], classification and recognition of handwritten digits using mathematical wavelet transforms using first and second order statistics [13], skeleton extraction [14] and avoiding complex patterns [15]. Fuzzy based methods also proposed in the analysis of textures [16, 17], age classification problems are also proposed [18, 19, 20] in the literature based on texture features. The above methods captured different topological configurations and texture properties of the image. As a consequence, their performance is best suited for the analysis of textures.

The term ''texton'' is conceptually proposed by Julesz [21] and it is a very useful concept in texture analysis and has been utilized to develop efficient models in the context of texture recognition or object recognition [22, 23]. The texton [21] has been used in several classification problems [24, 25], age classification problem, face recognition, image retrieval [26]. These methods need high classification rate, which is however still an open problem. The present paper put forward a new method of Fuzzy Texton Binary Matrix to describe texture features for texture classification. This method can express the spatial correlation of micro structure textons.

The rest of this paper is organized as follows. In Section 2, the proposed methodology is introduced. In Section 3, the texture classification performance resulted from logical operators, GLCM, LBP and our proposed method is compared by conducting two experiments over the Vistex texture database of MIT, Akarmarble images and those images which come from web. Section 4 concludes the paper.

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II. Methodology Construction of Fuzzy Based Text on Binary Shape Matrix (FTBSM) of Textures

Various algorithms are proposed by many researchers to extract color, texture and other features. Color is the most distinguishing important and dominant visual feature. That's why color histogram techniques remain popular in the literature. The main drawback of this is, it lacks spatial information. Texture patterns can provide significant and abundance of texture and shape information. The proposed method consists of three steps which are listed below. In the first step the color image is converted in to grey level image by using any HSV color model. The following section describes the RGB to HSV conversion procedure.

a) RGB to HSV Color Model Conversion

In color image processing, there are various color models in use today. The RGB model is mostly used in hardware oriented application such as color monitor. In the RGB model, images are represented by three components, one for each primary color – red, green and blue. However, RGB color space is not sensitive to human visual perception or statistical analysis. Moreover, a color is not simply formed by these three primary colors. HSV color space is a non-linear transform from RGB color space that can describe perceptual color relationship more accurately than RGB color space. In this paper, HSV color space is adopted.

HSV color space is formed by hue (H), saturation (S) and value (V). Hue denotes the property of color such as blue, green, red, and so on. Saturation denotes the perceived intensity of a specific color. Value denotes brightness perception of a specific color. Thus it can be seen that HSV color space is different from RGB color space in color variations. When a color pixel-value in RGB color space is adjusted, intensities of red channel, green channel, and blue channel of this color pixel are modified. That means color, intensity, and saturation of a pixel is involved in color variations. It is difficult to observe the color variation in complex color environment or content. However, HSV color space separates the color into hue, saturation, and value which means observation of color variation can be individually discriminated. Based on the above the proposed method adopted HSV descriptor for color space because it describes colour intensity and brightness's in a significant manner. In order to transform RGB color space to HSV color space, the transformation is described as follows:

The transformation equations from RGB to HSV color model conversion is given below

$$V = \max(R, G, B) \quad (1)$$

$$S = \frac{V - \min(R,G,B)}{V} \quad (2)$$

$$H = \frac{G-B}{6S} \quad if \quad V = R \quad (3)$$

$$H = \frac{1}{3} + \frac{B-R}{6S} \quad if \quad V = G \quad (4)$$

$$H = \frac{1}{3} + \frac{R-G}{6S} \quad if \quad V = B \quad (5)$$

Where R, G, B are Red, Green and Blue normalized in value [0, 1]. In order to quantize the range of the H plane is normalized with value [0, 255] for extracting features specifically.

b) Fuzzy Texton Matrix Detection

In natural images, due to the presence of noise, different illumination levels and various conversion factors, between neighboring pixels of a window represent as equal, though they rarely have exactly the same intensity value. To avoid this imprecision and be able to represent the vagueness within the processes, the present paper made use of fuzzy logic and fuzzy techniques in deriving fuzzy texton binary matrix for classification of textures. To deal classification effect by different shape components, with regions of natural images perceived as homogeneous by human beings, the present paper proposes a Fuzzy Based Texton Binary Shape Window (FTBSM) encoding.

The present paper labels eight neighbors of a 3×3 neighborhood using five possible fuzzy patterns or values {0, 1, 2, 3 and 4} derived from the fuzzy code as depicted in Equation 6 and the fuzzy membership function is represented as shown in Fig.1. From Fig.1, the element V_i represent the intensity values of the eight neighboring pixels on a 3×3 neighborhood, V_0 represents the intensity value of central pixel, x and y are the user-specified lag values.

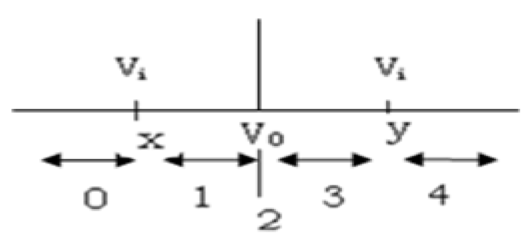

Fig. 1 : Fuzzy texture number (Base-5) representation

$$E_i = \begin{cases} 0 & if \quad V_i < V_0 \quad and \quad V_i < x \\ 1 & if \quad V_i < V_0 \quad and \quad V_i > x \\ 2 & if \quad V_i = V_0 \\ 3 & if \quad V_i > V_0 \quad and \quad V_i > y \\ 4 & if \quad V_i > V_0 \quad and \quad V_i < y \end{cases} \quad for\ i = 1,2,3,\dots,8 \quad (6)$$

For example, the process of evaluating fuzzy values on a 3×3 neighborhood is shown in Fig.2.

90	130	145
160	140	200
100	140	250

(a)

0	1	3
4	2	4
0	2	4

(b)

FV= {0, 1, 3, 4, 2, 4, 2, 0, 4}

(c)

Fig. 2 : Representation of (a) a 3×3 neighborhood (b) fuzzy values (c) set of fuzzy values

c) Micro Structure Texton Detection

Textons are fundamental micro structures in texture images and are considered as the atoms of pre-attentive human visual perception [21]. Textons have more powerful description ability than the pixels themselves. Texton are defined as a set of blobs or emergent patterns sharing a common property all over the image [21]. The different textons may form various image features. If the textons in the image are small and the tonal difference between neighbouring textons is large, a fine texture may result. If the textons are larger and concise of several pixels, a coarse texture may result. If the textons in image are large and consists of few texton categories, an obvious shape may result. If the textons are greatly expanded in one orientation, pre-attentive discrimination is somewhat reduced. If elongated elements are not jittered in orientation, the texton gradients at the texture boundaries are increased. To address this, the present study considered fuzzy based texton approach is used for classification of textures. The proposed Fuzzy texton approach utilized to detect micro-structures blocks from left-to-right and top-to-bottom through- out the image.

A fuzzy code is applied for overlapped window of the texton micro-structure for the construction of Fuzzy Texton Binary Shape Matrix (FTBSM). The FTBSM is used for detection of shapes for classification of textures. In a 3×3 block, if one of the eight nearest neighbors has the same value as the center pixel, then it is kept unchanged and marked with green color as shown in Fig.3(c); otherwise set it to '0'. Incase if the centre pixel is zero and one of the eight nearest neighbors has the same value as the center pixel, then these pixel values are also set to '1'. If all the eight nearest neighboring pixels are '0', then the 3×3 block is not considered as a micro structure. The marked pixels are treated as micro-structure and this structure is set to '1'. The working mechanism of proposed fuzzy texton binary matrix method is illustrated in Fig.3.

51	143	143	143	152	153
151	143	143	143	152	153
155	142	142	138	147	153
157	143	143	135	142	151
157	143	143	135	142	151
154	146	146	140	143	148

(a)

3	2	2	1	2	3
3	2	2	1	2	3
3	0	0	0	1	3
3	1	1	0	2	3
3	1	1	0	2	3
3	2	2	1	4	4

(b)

0	2	2	1	2	0
0	2	2	1	2	0
0	0	0	0	1	0
0	1	1	0	2	0
0	1	1	0	2	0
0	0	0	1	0	0

(c)

0	1	1	1	1	0
0	1	1	1	1	0
0	1	1	1	1	0
0	1	1	1	1	0
0	1	1	1	1	0
0	0	0	1	0	0

(d)

Fig. 3 : Illustration of the Fuzzy Texton Binary Matrix (a) Original texture image (b) Detection of fuzzy values (c) Fuzzy texton mapping process on a 3×3 neighborhood d) Fuzzy texton binary image

d) Fuzzy Texture Features on FTBM

The present paper evaluated fuzzy texture features for classification of textures based on proposed FTBSM. It consists of a 3×3 neighborhood for evaluating fuzzy shape components. It has derived five different fuzzy shape components named as Diamond, Diagonal, Vertical Line, Horizontal Line and Blob on a 3×3 neighborhood. Each of the fuzzy shape components is represented as shown in Fig.4.

	0	
0		0
	0	

(a)

0		0
0		0

(b)

0		
0		
0		

(c)

0	0	0

(d)

0	0	0
0		0
0	0	0

(e)

Fig. 4 : Representation of fuzzy shape components (a) Diamond(b) Diagonal (c) Vertical Line(d) horizontal Line (e) Blob

For the classification of textures the frequency occurrences of each of the fuzzy shape component with different texture patterns is counted using the Algorithm 1. The novelty of the present work is it uses only five different types of fuzzy shape components using the proposed FTBSM.

Algorithm 1: Classification of textures based on different fuzzy shape components on a proposed FTBSM.

1. Read the original Textures Tk, where k=1:n with dimension N×M.
2. Convert color texture image to gray image by using HSV as explained in Section II.
3. Convert each 3×3 neighborhood of the gray level texture image into a Fuzzy values (0, 1, 2, 3 or 4) by using fuzzy code as explained in Section II.

Global Journal of Computer Science and Technology (F) Volume XII Issue XV Version I Year 2012

4. Evaluate fuzzy texton binary matrix using fuzzy code and texton as explained in Section II.
5. Represent the given shape components on a 3×3 neighborhood, where i=1 to 5 as shown in Fig.4.
6. Compute frequency occurrence (FPi) of each shape component by convolving the entire texture image (Tk). Repeat the procedure for all shape components of all texture images.
7. Compute the percentage of occurrence of each shape component (SPi, i=1 to 5) for each of the texture Tk, k=1:24.

$$\forall_{i=1}^{5} sp_i = \frac{FP_i}{(N-2)\times(M-2)} \times 100$$

8. Classify textures using distance function of Step 7.
9. Calculate the average percentage of occurrence (APOi) of each shape component of all textures.

$$APO_i = \frac{\forall_{i=1}^{5} \sum_{k=1}^{n} T_k sp_i}{\max(k)}$$

10. A texture Tk will be placed in one of the two classes C1 or C2 in the following way.

for T_k, k=1:n
    begin
     if $(\forall_{i=1}^{5} T_k sp_i == 1)$ T_k is assigned to C_1
     else T_k is assigned to C_2
    end

III. Results and Discussions

To evaluate a good classification based on the fuzzy shape components, the present study initially computed the frequency occurrences of each shape component. The proposed methodology is tested with a set of different groups of textures as shown in Fig.6. The frequency occurrences of the derived fuzzy shape components are counted for all the original textures and the results are furnished in Table 1.

Table 1 : Frequency occurrences of fuzzy shape components on a 3×3 neighborhood of different groups of textures

Texture Name	Diamond	Diagonal	Horizontal Line	Vertical Line	Blob
Brick1	103	56	196	153	165
Brick2	298	187	498	270	338
Brick3	405	279	520	344	440
Brick4	41	20	130	61	85
Brick5	74	114	163	178	150
Brick6	476	259	627	312	569
Brick7	141	238	228	349	197
Brick8	165	465	260	556	225
Granite1	50	59	143	154	117
Granite2	99	31	185	104	168
Granite3	32	75	111	177	85
Granite4	43	7	157	40	147
Granite5	52	25	158	71	144
Granite6	2	2	26	7	16
Granite7	28	41	107	118	89
Granite8	137	91	224	195	219
Marble1	19	5	56	21	54
Marble2	12	19	79	54	80
Marble3	133	113	280	185	237
Marble4	62	57	185	153	155
Marble5	89	663	109	849	100
Marble6	99	400	142	552	140
Marble7	320	199	492	258	472
Marble8	300	148	465	214	422
Mosaic1	182	372	250	448	268
Mosaic2	508	412	592	433	575
Mosaic3	401	409	507	423	501
Mosaic4	441	366	542	393	533
Mosaic5	352	25	561	81	485
Mosaic6	322	19	546	70	471
Mosaic7	331	297	426	444	391
Mosaic8	344	337	475	408	422

From the results of Table 1, texture classification can be done by distance function. By using distance function, two textures are similar count the number of textures and the result are stored in the training database. The present study, classified textures based on the proposed method using distance function with a lag value. The distance among all groups of textures based on number of frequency occurrences of different shape components are calculated and are furnished in Table 2. The distance measure of different groups of textures is tabulated in Table 2, Table 3, Table 4 and Table 5 respectively. The classification group of textures with lag value for all textures is shown in Table 6, Table 7 and Table 8 and Table 9 respectively.

Table 2 : Distance measure of five fuzzy shape components of Brick group of textures

Diamond	Brick1	Brick2	Brick3	Brick4	Brick5	Brick6	Brick7	Brick8
Brick1	0	195	302	62	29	373	38	62
Brick2		0	107	257	224	178	157	133
Brick3			0	364	331	71	264	240
Brick4				0	33	435	100	124
Brick5					0	402	67	91
Brick6						0	335	311
Brick7							0	24
Brick8								0
Diagonal	Brick1	Brick2	Brick3	Brick4	Brick5	Brick6	Brick7	Brick8
Brick1	0	131	223	36	58	203	182	409
Brick2		0	92	167	73	72	51	278
Brick3			0	259	165	20	41	186
Brick4				0	94	239	218	445
Brick5					0	145	124	351
Brick6						0	21	206
Brick7							0	217
Brick8								0
Horizontal Line	Brick1	Brick2	Brick3	Brick4	Brick5	Brick6	Brick7	Brick8
Brick1	0	302	324	66	33	431	32	64
Brick2		0	22	368	335	129	270	238
Brick3			0	390	357	107	292	260
Brick4				0	33	497	98	130
Brick5					0	464	65	97
Brick6						0	399	367
Brick7							0	32
Brick8								0
Vertical Line	Brick1	Brick2	Brick3	Brick4	Brick5	Brick6	Brick7	Brick8
Brick1	0	117	191	92	25	159	196	403
Brick2		0	74	209	92	42	79	286
Brick3			0	283	166	32	5	212
Brick4				0	117	251	288	495
Brick5					0	134	171	378
Brick6						0	37	244
Brick7							0	207
Brick8								0
Blob	Brick1	Brick2	Brick3	Brick4	Brick5	Brick6	Brick7	Brick8
Brick1	0	173	275	80	15	404	32	60
Brick2		0	102	253	188	231	141	113
Brick3			0	355	290	129	243	215
Brick4				0	65	484	112	140
Brick5					0	419	47	75
Brick6						0	372	344
Brick7							0	28
Brick8								0

Table 3 : Distance measure of five fuzzy shape components of Granite group of textures

Diamond	Granite1	Granite2	Granite3	Granite4	Granite5	Granite6	Granite7	Granite8
Granite1	0	49	18	7	2	48	22	87
Granite2		0	67	56	47	97	71	38
Granite3			0	11	20	30	4	105
Granite4				0	9	41	15	94
Granite5					0	50	24	85
Granite6						0	26	135
Granite7							0	109
Granite8								0
Diagonal	Granite1	Granite2	Granite3	Granite4	Granite5	Granite6	Granite7	Granite8
Granite1	0	28	16	52	34	57	18	32
Granite2		0	44	24	6	29	10	60
Granite3			0	68	50	73	34	16
Granite4				0	18	5	34	84
Granite5					0	23	16	66
Granite6						0	39	89
Granite7							0	50
Granite8								0
Horizontal Line	Granite1	Granite2	Granite3	Granite4	Granite5	Granite6	Granite7	Granite8
Granite1	0	42	32	14	15	117	36	81
Granite2		0	74	28	27	159	78	39
Granite3			0	46	47	85	4	113
Granite4				0	1	131	50	67
Granite5					0	132	51	66
Granite6						0	81	198
Granite7							0	117
Granite8								0
Vertical Line	Granite1	Granite2	Granite3	Granite4	Granite5	Granite6	Granite7	Granite8
Granite1	0	50	23	114	83	147	36	41
Granite2		0	73	64	33	97	14	91
Granite3			0	137	106	170	59	18
Granite4				0	31	33	78	155
Granite5					0	64	47	124
Granite6						0	111	188
Granite7							0	77
Granite8								0
Blob	Granite1	Granite2	Granite3	Granite4	Granite5	Granite6	Granite7	Granite8
Granite1	0	51	32	30	27	101	28	102
Granite2		0	83	21	24	152	79	51
Granite3			0	62	59	69	4	134
Granite4				0	3	131	58	72
Granite5					0	128	55	75
Granite6						0	73	203
Granite7							0	130
Granite8								0

Table 4 : Distance measure of five fuzzy shape components of Marble group of textures

Diamond	Marble1	Marble2	Marble3	Marble4	Marble5	Marble6	Marble7	Marble8
Marble1	0	7	114	43	70	80	301	281
Marble2		0	121	50	77	87	308	288
Marble3			0	71	44	34	187	167
Marble4				0	27	37	258	238
Marble5					0	10	231	211
Marble6						0	221	201
Marble7							0	20
Marble8								0
Diagonal	Marble1	Marble2	Marble3	Marble4	Marble5	Marble6	Marble7	Marble8
Marble1	0	14	108	52	658	395	194	143
Marble2		0	94	88	644	381	180	129
Marble3			0	56	550	287	86	35
Marble4				0	606	343	142	91
Marble5					0	263	464	515
Marble6						0	201	252
Marble7							0	51
Marble8								0
Horizontal line	Marble1	Marble2	Marble3	Marble4	Marble5	Marble6	Marble7	Marble8
Marble1	0	23	224	129	53	86	436	409
Marble2		0	201	106	30	63	413	386
Marble3			0	95	171	138	212	185
Marble4				0	76	43	307	280
Marble5					0	33	383	356
Marble6						0	350	323
Marble7							0	27
Marble8								0
Vertical Line	Marble1	Marble2	Marble3	Marble4	Marble5	Marble6	Marble7	Marble8
Marble1	0	33	164	132	828	531	237	193
Marble2		0	131	99	795	498	204	160
Marble3			0	32	664	367	73	29
Marble4				0	696	399	105	61
Marble5					0	297	591	635
Marble6						0	294	338
Marble7							0	44
Marble8								0
Blob	Marble1	Marble2	Marble3	Marble4	Marble5	Marble6	Marble7	Marble8
Marble1	0	26	183	101	46	86	418	368
Marble2		0	157	75	20	60	392	342
Marble3			0	82	137	97	235	185
Marble4				0	55	15	317	267
Marble5					0	40	372	322
Marble6						0	332	282
Marble7							0	50
Marble8								0

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Table 5 : Distance measure of five fuzzy shape components of Mosaic group of textures

Diamond	Mosaic1	Mosaic2	Mosaic3	Mosaic4	Mosaic5	Mosaic6	Mosaic7	Mosaic8
Mosaic1	0	326	219	259	170	140	149	162
Mosaic2		0	107	67	156	186	177	164
Mosaic3			0	40	49	79	70	57
Mosaic4				0	89	119	110	97
Mosaic5					0	30	21	8
Mosaic6						0	9	22
Mosaic7							0	13
Mosaic8								0

Diagonal	Mosaic1	Mosaic2	Mosaic3	Mosaic4	Mosaic5	Mosaic6	Mosaic7	Mosaic8
Mosaic1	0	40	37	6	347	353	75	35
Mosaic2		0	3	46	387	393	115	75
Mosaic3			0	43	384	390	112	72
Mosaic4				0	341	347	69	29
Mosaic5					0	6	272	312
Mosaic6						0	278	337
Mosaic7							0	46
Mosaic8								0

Horizontal Line	Mosaic1	Mosaic2	Mosaic3	Mosaic4	Mosaic5	Mosaic6	Mosaic7	Mosaic8
Mosaic1	0	342	257	292	311	296	176	225
Mosaic2		0	85	50	31	46	166	117
Mosaic3			0	35	54	39	81	32
Mosaic4				0	19	4	116	67
Mosaic5					0	15	135	86
Mosaic6						0	120	71
Mosaic7							0	49
Mosaic8								0

Vertical Line	Mosaic1	Mosaic2	Mosaic3	Mosaic4	Mosaic5	Mosaic6	Mosaic7	Mosaic8
Mosaic1	0	15	25	55	367	378	4	40
Mosaic2		0	10	40	352	363	11	25
Mosaic3			0	30	342	353	21	15
Mosaic4				0	312	323	51	15
Mosaic5					0	11	363	327
Mosaic6						0	374	338
Mosaic7							0	36
Mosaic8								0

Blob	Mosaic1	Mosaic2	Mosaic3	Mosaic4	Mosaic5	Mosaic6	Mosaic7	Mosaic8
Mosaic1	0	307	233	265	217	203	123	154
Mosaic2		0	74	42	90	104	184	153
Mosaic3			0	32	16	30	110	79
Mosaic4				0	48	62	142	111
Mosaic5					0	14	94	63
Mosaic6						0	80	49
Mosaic7							0	31
Mosaic8								0

Table 6 : Classes of textures for the proposed method using lag value of Diamond shape component

Texture Group	Class	Classified Textures
Brick	C_1	{Brick1, Brick2, Brick3, Brick5, Brick7, Brick8}
	C_2	{Brick4, Brick6}
Granite	C_1	{Granite1, Granite2, Granite3, Granite4, Granite5, Granite7, Granite8}
	C_2	{Granite6}
Marble	C_1	{Marble3, Marble4, Marble6, Marble7, Marble8}
	C_2	{Marble1, Marble2, Marble5}
Mosaic	C_1	{Mosaic1, Mosaic2, Mosaic3, Mosaic4, Mosaic7, Mosaic8}
	C_2	{Mosaic5, Mosaic6}

Table 7 : Classes of textures for the proposed method using lag value of Diagonal shape component

Texture Group	Class	Classified Textures
Brick	C_1	{Brick1, Brick2, Brick3, Brick4, Brick5, Brick6, Brick7, Brick8}
	C_2	---------
Granite	C_1	{Granite1, Granite2, Granite3, Granite4, Granite5, Granite6, Granite7, Granite8}
	C_2	---------
Marble	C_1	{ Marble1, Marble2, Marble3, Marble4, Marble5, Marble6, Marble7, Marble8}
	C_2	---------
Mosaic	C_1	{Mosaic3, Mosaic4, Mosaic5, Mosaic6, Mosaic7, Mosaic8}
	C_2	{Mosaic1, Mosaic2}

Table 8 : Classes of textures for the proposed method using lag value of Horizontal Line shape component

S	Class	Classified Textures
Brick	C_1	{Brick1, Brick2, Brick3, Brick5, Brick7, Brick8}
	C_2	{Brick4, Brick6}
Granite	C_1	{Granite1, Granite2, Granite4, Granite5, Granite6, Granite7, Granite8}
	C_2	{Granite3}
Marble	C_1	{ Marble4, Marble6, Marble8}
	C_2	{Marble1, Marble2, Marble3, Marble5, Marble7}
Mosaic	C_1	{ Mosaic1, Mosaic2, Mosaic3, Mosaic4, Mosaic7, Mosaic8}
	C_2	{Mosaic5, Mosaic6}

Table 9 : Classes of textures for the proposed method using lag value of Vertical Line shape component

Texture Group	Class	Classified Textures
Brick	C_1	{Brick5, Brick7, Brick8}
	C_2	{Brick1, Brick2, Brick3, Brick4, Brick6}
Granite	C_1	{Granite4, Granite5, Granite7, Granite8}
	C_2	{Granite1, Granite2, Granite3, Granite6}
Marble	C_1	{Marble1, Marble2, Marble3, Marble4, Marble6, Marble8}
	C_2	{Marble5, Marble7}
Mosaic	C_1	{Mosaic2, Mosaic3, Mosaic4, Mosaic7, Mosaic8}
	C_2	{Mosaic1, Mosaic5, Mosaic6}

Table 10 : Classes of textures for the proposed method using lag value of Blob shape component

Texture Group	Class	Classified Textures
Brick	C_1	{Brick2, Brick3, Brick4, Brick5, Brick7, Brick8}
	C_2	{Brick1, Brick6}
Granite	C_1	{Granite1, Granite2, Granite4, Granite5, Granite6, Granite7, Granite8}
	C_2	{Granite3}
Marble	C_1	{ Marble2,Marble3, Marble4, Marble6, Marble8}
	C_2	{Marble1, Marble5, Marble7}
Mosaic	C_1	{Mosaic3, Mosaic7, Mosaic8}
	C_2	{Mosaic1, Mosaic2, Mosaic4, Mosaic5, Mosaic6}

By observing the results of Tables 6 to 10 the following facts are noted down. Table 7 clearly indicates that, it shows a uniform distance between each of them. The following facts are noted down from the classification tables of Table 6 to Table 10.

- The extracted diamond shape component on the FTBSM of Table 6 classified each of the Brick, Granite, Marble and Mosaic textures into two classes.
- The extracted diagonal shape component on the FTBSM of Table 7 classified each of the Brick, Granite and Marble textures into separate class only, and it classified the mosaic textures into two classes
- The extracted horizontal line shape component on the FTBSM of Table 8 classified each of the Brick, Granite, Marble and Mosaic textures into two classes.
- The extracted vertical line shape component on the FTBSM of Table 9 classified each of the Brick, Granite, Marble and Mosaic textures into two classes.
- The extracted blob shape component on the FTBSM of Table 10 classified each of the Brick, Granite, Marble and Mosaic textures into two classes.

The facts indicate that a good, precise and accurate stone classification is observed by the proposed FTBSM using diagonal shape components. The proposed method FTBSM also analyzed the percentage occurrence of each shape component represented in the Table 11. The Table 11 evaluated on FTBSM reveals that diagonal shape component classifies brick, granite and marble texture images accurately.

Table 11 : Percentage occurrences of each shape component with every group of textures

Shape Component	Brick	Granite	Marble	Mosaic	Average
Diamond	75	87.5	65	75	75.63
Diagonal	100	100	100	75	93.75
Horizontal Line	75	88	65	75	75.75
Vertical Line	65	50	75	65	63.75
Blob	75	88	65	65	73.25

IV. Conclusions

The present study created a new direction for classification of textures based on texture features derived from shape components on a 3×3 neighborhood. By investigating texture classification using different shape components with fuzzy logic the present study concludes that diagonal shape component contains more classification information than other shape components. Based on the experimental results the proposed FTBSM method concludes that one need not necessarily count the other shape components except the diagonal shape. Therefore the present study reduced a lot of complexity in the selection of shape components for classification purpose.

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A New Method for Gray Level Image Thresholding Using Spatial Correlation Features and Ultrafuzzy Measure

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Abstract - One of the most recent techniques employed to estimate an optimal threshold of a gray level image for segmentation is ultrafuzzy measures. In this paper, we introduce relative fuzzy membership degree (RFMD) taking spatial correlation among the pixels in the image into account. We also propose a novel thresholding technique by combining two-dimensional histogram, which was determined by using the gray value of the pixels and the local average gray value of the pixels using ultrafuzziness and RFMD. Compared to fuzzy membership degree, RFMD of type-II fuzzy sets and ultrafuzzy measure is able to better segment critical gray level images. It was observed that the outcome is so encouraging in objective and subjective perspectives over the existing method for all varieties of images.

Keywords : type-i fuzzy, type-ii fuzzy, ultra fuzziness, relative gray value.

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A NEW METHOD FOR GRAY LEVEL IMAGE THRESHOLDING USING SPATIAL CORRELATION FEATURES AND ULTRAFUZZY MEASURE

A New Method for Gray Level Image Thresholding Using Spatial Correlation Features and Ultrafuzzy Measure

CH.V.Narayana [α], E. Sreenivasa Reddy [σ] & M. Seetharama Prasad [ρ]

Abstract - One of the most recent techniques employed to estimate an optimal threshold of a gray level image for segmentation is ultrafuzzy measures. In this paper, we introduce relative fuzzy membership degree (RFMD) taking spatial correlation among the pixels in the image into account. We also propose a novel thresholding technique by combining two-dimensional histogram, which was determined by using the gray value of the pixels and the local average gray value of the pixels using ultrafuzziness and RFMD. Compared to fuzzy membership degree, RFMD of type-II fuzzy sets and ultrafuzzy measure is able to better segment critical gray level images. It was observed that the outcome is so encouraging in objective and subjective perspectives over the existing method for all varieties of images.

GeneralTerms : image segmentation, threshold, spatial correlation, 2d histogram.

Keywords : type-i fuzzy, type-ii fuzzy, ultra fuzziness, relative gray value.

I. Introduction

Ultimate aim of image processing is object recognition and extraction from the scene. In this regard, image segmentation become paramount in many computer vision and image processing applications for further analysis of the foreground objects in order to explore the features. Thresholding approach is the simplest and well-known technique for image segmentation. Accuracy of segmentation depends upon the process which is adopted. It is essential to fin optimal threshold value to group the image pixels into two well defined and non-overlapping subsets, representing image foreground and background. In general, histogram of an ideal image has a deep valley between two peaks. In pursuit of the threshold, valley region is the best place to search in bimodal histogram images because both the peaks, in most of the cases, represent the object and background but this criterion may not be suitable for all types of images.

Image segmentation plays a vital role in analysis of objects extracted from background in many image processing applications. The application areas such as document image processing, scene or map processing, satellite imaging and automatic material inspection in quality control tasks are some of the example that employ image thresholding to extract useful information from images. Medical image processing is another specific area that has tremendously using image thresholding to help the experts to better understand digital images for a more accurate diagnosis and to plan appropriate treatment.

Image segmentation based on gray level histogram thresholding is regarded as a two-class clustering approach to divide an image into two regions; object and background. Basically image thresholding can be considered as two types; one is global thresholding and other is local thresholding. If a single threshold value is applied for entire image to segment, pixels whose gray level is under this value are assigned to one region and the remainder to the other. Images are, generally, classified into unimodal, bimodal and multimodal depending on their histogram shapes. When the histogram doesn't exhibits a clear separation between two peaks ordinary thresholding techniques might under perform. Hence there is a demand for a robust methodology to binarise all types of images as specified above. Fuzzy set theory provides better convergence when compared with non-fuzzy methods. This paper records an automated approach using spatial correlation introduced in a novel way with fuzzy S-function and image ultrafuzziness as a fuzzy measure without using an entropic criterion function.

In case of ideal images the image histogram shows a deep valley between two distinct peaks, each one represents either an object or background and the threshold falls in the valley region. But in case of unimodal and bimodal images will not express clear separation of the pixels as two peaks, in such cases threshold selection become a difficult task. To solve this difficulty several methods have been proposed in the literature [1-6]. Otsu [7] proposed discriminant analysis to maximize the separability of the resultant classes. Interaction among the pixels is also a reasonable feature tried in two-dimensional Otsu method, in reference [8]. In entropy based algorithms proposed by Kapur et al. [10] extend the previous work of pun [9] that first uses the concept of entropy for thresholding. This method

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concludes that when the sum of the background and object entropies reaches its maximum, the threshold value is obtained. In Kapur et al. [10], images which are corrupted with noise or irregular illumination produce multimodal histograms in which a gray level histogram does not guarantee for the optimum threshold selection, because no spatial correlation is considered. In reference [11], Abutaleb extended Kapur's method using two dimensional entropies which are calculated from a two dimensional histogram which was determined by using the gray value of the pixels and the local average of neighborhood gray values of the pixels. As an improvement, later this technique is further simplified by A.D.Brink[12]. Entropy criterion function is applied on 2-D GLSC histogram to select optimum threshold by surpassing difficulties with 1-D histogram by Yang Xiao et al.[13,14]. This work is further extended by Seetharama Prasad et al.[16] using variable similarity measure producing improved GLSC histogram. The ordinary thresholding techniques perform poorly when non-uniform illumination corrupts object characteristics and inherent image vagueness is present. Fuzzy based image thresholding methods have been introduced in the literature to overcome this problem. Fuzzy set theory [5] is used in these methods to handle grayness ambiguity or inherent image vagueness during the process of threshold selection. Fuzzy C-partitions were used on entropic criteria to achieve optimum threshold value by Seetharama Prasad et al.[17]. In reference [15] Type-II fuzzy is used with GLSC histogram with human visual nonlinearity characteristics to identify the optimal similarity measure. Type-II fuzzy sets and a new fuzzyness measure called Ultrafuzziness are introduced by H.R.Tizhoosh [18] and Type-II fuzzy probability partitions methods are applied on GLSC histogram to obtain the threshold by Seetharama Prasad et al.[19]. Ch.V.Narayana et al.[20] used ultra fuzziness and type-II fuzzy sets for automatic image segmentation. In reference [21] Nuno Vieira Lopes et al. introduced fuzzy measures to threshold gray level images with no entropy criterion function to reduce the time complexity for computation and this technique is further automated by Seetharama Prasad et al.[22].

The remaining part of this paper is organized as follows: section 2 describes about some of the existing methods. Section 3 describes the proposed method, section 4 shows comparative results and improved yielding of our method and section 5 ends with conclusion.

II. Existing Methodologies

Abutaleb[11], Brink[12] did some good work in obtaining the segmentation of a gray image incorporating the spatial correlation among the pixels of the image by constructing the 2D histogram. Fundamentally these methods attracts maximum entropy criterion function to establish the optimal threshold for any given image. There comes another approach by existing method Tizhoosh[18] introduced a new fuzzy membership function along a new fuzzy measure called ultrafuzziness using type II fuzzy sets to compute a threshold for the image segmentation. Our paper basically aims to combine both these techniques to provide a methodology in obtaining a optimal threshold.

a) Fuzzy Based Methodology

Measures of fuzziness in contrast to fuzzy measures indicate the degree of fuzziness of a fuzzy set. The entropy of a fuzzy set is a measure of the fuzziness of a fuzzy set. The membership degree of any value in the universe of discourse can be estimated by using any fuzzy membership function. Thizhoosh [18] introduced a new fuzzy measure called ultrafuzziness which could replace the use of entropy in threshold calculations.

i. *Fuzzy S-membership function*

To measure the image fuzziness the most used S-membership degree function as shown in Equation (1) which comprises of three unknown quantities a, b and c must be estimated from the image statistics.

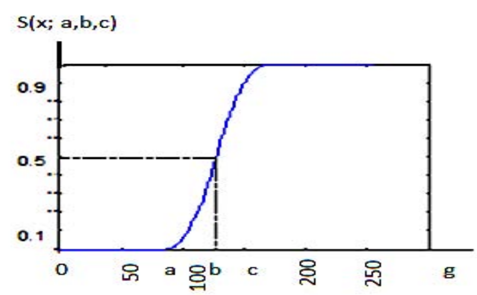


Fig. 1 : Shape of the S-function

The S- function from Figure 1 is used for modeling the membership degrees along with initial fuzzy seed subsets a and c are as shown in Figure 2. For object pixels

$$\mu_O(x) = S(x; a, b, c) = \begin{cases} 0 & x < a \\ 2\left\{\frac{x-a}{c-a}\right\}^2 & a \le x \le b \\ 1 - 2\left\{\frac{x-c}{c-a}\right\}^2 & b \le x \le c \\ 1 & x \ge c \end{cases} \quad (1)$$

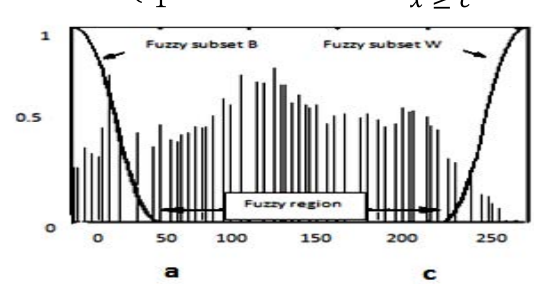


Fig. 2 : Multimodal image histogram and the characteristic functions for the seed subsets

From reference [31] initial fuzzy seed subset values a, b and c are computed. Let x (m, n) be the gray level intensity of image at (m,n). I={x (m, n) | I ∈ [1, M], j ∈ [1, N]} is an image of size M x N. The gray level set {0,1,2,….255}. The mean (μ) and standard deviation (σ) are calculated as follows:

$$\mu = \frac{1}{N}\sum_{i=1}^{n} x_i \times h(i) \quad (2)$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{n}(x_i - \mu)^{2}} \quad (3)$$

From Equations (2) and (3) fuzzy seed set values a, b and c as shown in Figure 2, are estimated as

$$b = \mu \quad (4)$$

$$a = \mu - \sigma \quad (5)$$

$$c = \mu + \sigma \quad (6)$$

ii. *Type I fuzzy sets*

The most common measure of fuzziness is the linear index of fuzziness. For a MxN image subset A⊆ X with gray levels g ⊆ [0, L-1], the linear index of fuzziness can be estimated as follows

$$\gamma_1(A) = \frac{2}{MN}\sum_{g=0}^{L-1} h(g) \times min\,[\mu_A(g),\ 1-\mu_A(g)] \quad (7)$$

Where μ_A (g) is obtained from Equation (1). So the optimal threshold can be obtained though maximizing the linear index of fuzziness criterion function that is given by

$$t^{*} = Arg\ \max\ \{\gamma(A:T)\},\ 0 \le T \le L-1 \quad (8)$$

iii. *Type II fuzzy sets*

Definition. A tupe II fuzzy set Ã is defined by type II membership function X $\mu_{\tilde{A}}(x,u)$, where x ∈ X and

$$u \in J_x \subseteq [0,1]$$

Ã can be expressed in the notation of fuzzy set as

Ã ={((x, u),

$$\mu_{\tilde{A}}(x,u)) \mid \subseteq \forall_x \in X,\ \forall_u \in J_x \subseteq [0,1]\},$$

in which $0 \le \mu_{\tilde{A}}(x,u) \le 1$

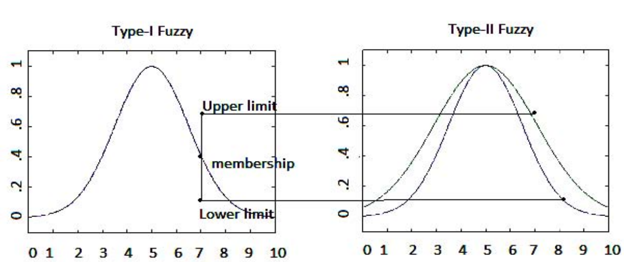


Fig. 3 : A possible way to construct type II fuzzy sets. The interval between lower/left and upper/right membership values (bounded region) will capture the footprint of uncertainty

A type II fuzzy set can be defined from type I fuzzy set and assign upper and lower membership degrees to each element to construct the foot print of uncertainty as shown in Figure 3. a more suitable definition for a type II fuzzy set can be given as follows:

$$\tilde{A} = \{X, \boldsymbol{\mu_U} \le (\boldsymbol{x}), \boldsymbol{\mu_L}(\boldsymbol{x}) \mid \forall_x \in X,$$

$$\boldsymbol{\mu_L}(\boldsymbol{x}) \le \mu(\boldsymbol{x}) \le \boldsymbol{\mu_U}(\boldsymbol{x}),\ \mu \in [0,1] \quad (9)$$

The upper and lower membership degrees $\boldsymbol{\mu_U}$ and μ_L of initial membership function μ can be defined by means of linguistic hedges like dilation and concentration:

$$\boldsymbol{\mu_U}(\boldsymbol{x}) = [\mu(\boldsymbol{x})]^{0.5},$$

$$\boldsymbol{\mu_L}(\boldsymbol{x}) = [\mu(\boldsymbol{x})]^{2},$$

Hence, the upper and lower membership values can be defined as follows:

$$\boldsymbol{\mu_U}(\boldsymbol{x}) = [\mu(\boldsymbol{x})]^{\frac{1}{\Delta}},$$

$$\boldsymbol{\mu_L}(\boldsymbol{x}) = [\mu(\boldsymbol{x})]^{\Delta},$$

Where Δ ∈ (1, ∞) but Δ>2 is usually not meaningful for image data.

iv. *Tizhoosh Ultrafuzziness*

The degrees of membership is defined without any uncertainty as type I fuzzy sets, automatically the ultrafuzziness also tend to zero. When individual membership values can be indicated as an interval, the amount of ultrafuzziness would increase. The maximum ultrafuzziness is one when the information of membership degree values totally ignored. For a type II fuzzy set, the ultrafuzziness is defined as γ for a M x N image subset Ã⊆ X with gray levels g ⊆ [0, L-1], histogram h(g) and membership function $\mu_{\tilde{A}}(g)$. The ultrafuzziness of the gray level image is formulated as follows:

$$\gamma(\tilde{A}) = \frac{1}{MN}\sum_{g=0}^{L-1} h(g) X\ [\mu_U(g) - \mu_L(g)] \quad (10)$$

Where

$$\mu_U(g) = [\mu(g)]^{\frac{1}{\Delta}},$$

$$\mu_L(g) = [\mu(g)]^{\Delta},\ \Delta \in (1, 2)$$

v. *Thresholding with of type II fuzzy sets*

1. Initialize the position of the membership function
2. Shift the membership function along the gray-level range
3. Calculate in each position the amount of ultrafuzziness from Equation (10)
4. Find out the position g_{opt} with maximum ultrafuzziness
5. Threshold the image with $t^{*} = g_{opt}$

b) Spatial Correlation Based Approach

One dimensional histogram based methods does not consider the spatial correlation between pixels in an image. This is simple to implement and does not consider the physical location of pixel and its interaction with neighboring pixels. When different images with an identical histograms, will result in the same threshold value, to avoid this kind of problems spatial methods are employed. In the later approach it involves the local average gray values of the pixels and their probability distribution in making two dimensional entropy based segmentation procedure, resulting in better than its earlier methods. From the literature many researchers worked and made many betterments to the existing methods.

i. *Entropy based methods*

The gray level of each pixel and the average gray level value of its neighbourhood are examined. A.S. Abutaleb [11] first tried with this approach as the frequency of occurrence of each pair of gray level and local average gray level called bin is computed. For any generalized gray level image having no fuzziness possessed in the image, produces two peaks with one valley corresponds to foreground and background respectively. They can be separated by choosing the threshold that maximizes entropy in the two groups. Later A.D. Brink [12] improved by not considering some portion of the 2D histogram as the off diagonal bins being contributed by edges and noise in the image where as bulk of the histogram, including the peaks, lies on or near the leading diagonal of the 2D histogram.

a. *Abutaleb's method*

Let the gray level be divided into m values and the average gray level also divided into the same m values. At each pixel, the average gray level value of the neighbourhood is calculated. This forms a pair: the pixel gray level and the average of the neighbourhood. Each pair belongs to a dimensional bin. The total number of bins obviously m×m and the total number of pixels to be tested is N×N. The total number of occurrences, f_{xy}, of pair (x,y) is divided by total number of pixels, N^2, defines the joint probability mass function.

$$p_{xy} = \frac{f_{xy}}{N^2} \text{ x and y} = 1, \ldots, m.$$

The two groups represents object and background O,B, with two different probability mass functions. If the threshold is located at the pair (s, t) then the total area under p_{xy} (x = 1, …, s and y = 1, …., t) must equal one. The entropy base function, ψ(s, t) = H(O) + H(B) where H(O) is entropy of the object and H(B) entropy of the back ground. This algorithm searches for the values of s and t that maximizes ψ(s, t). There the threshold is located.

b. *Yang Xiao et. al method*

Yang Xiao et al. [13-15] further simplified this approach by defining a GLSC histogram is constructed by considering the similarity in neighborhood pixels with some adaptive threshold value as similarity measure (ζ). Let *f*(x, y) be the gray level intensity of image at (x, y).F= {*f*(x, y)|x ϵ[1,Q], y ϵ[1,R]} of size Q x R. The gray level set {0, 1, 2, ... 255} is considered as G throughout this paper for convenience. The image GLSC histogram is computed by taking only image local properties into account as follows. Let g(x ,y) be the similarity count corresponding to pixel of image *f*(x, y) in N X N neighborhood, where N is any positive odd number in range [3, min(Q/2,R/2)].

g(x+1,y+1)=

$$\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} ?\left(|f(x+1,y+1) - f(x+i,y+j)| \le \zeta\right) \quad (11)$$

Where, $?\left(|f(x+1,y+1) - f(x+i,y+j)|\right) =$

$$\begin{cases} 1 & if \ |f(x+1,y+1) - f(x+i,y+j)| \le \zeta \\ 0 & otherwise \end{cases} \quad (12)$$

GLSC histogram is constructed with the correlated probability at different gray level intensities from equations (11) and (12) as follows.

$$h(k, m)=P(f(x, y)=k \text{ and } g(x, y)=m) \quad (13)$$

Where, P is the gray level correlation probability computed for all pixels with intensity k ϵ G with correlation m ϵ {1, 2,..NXN} and histogram is normalized [12]. As author discussed in [11-12] with similarity measureζ=4 and N=3. Seetharama Prasad et al.[16] made few changes by taking local and global parameters in deciding the similarity measure ζ. Due to the computational penalty of the Otsu method, a statistical parameter Standard Deviation has been adopted to decide the similarity measure for every NXN map, keeping global standard deviation unchanged. Therefore ζ is computed as the difference between global standard deviation of the entire image and standard deviation of local NXN map. $\zeta = |std_g - std_l|$ From this discussion it is so clear that pixel individual gray value and its positioning in the image are taken into account for entropy computation for background and object, produces optimum threshold where the maximum entropy occurs.

III. Proposed Method

The optimal threshold is determined by optimizing a suitable criterion function obtained by taking ultrafuzziness into account from the gray level distribution of the image and spatial correlation features of the image.

Let f(x, y) be the gray value of the pixel located at the point (x, y). In a digital image {f(x, y) | x∈1, 2, …., M} y∈{1, 2, …., N}} of size M × N, let the histogram be h(r)

For r ∈{0, 1, 2, …., 255}. For the sake of convenience, we denote the set of all gray levels {0, 1, 2, …., 255} as G.

In order to make use of more information present in the image , construct a index table by this way exploit the spatial correlation that exist among pixels of an image in pursuance of optimal threshold value as two-dimensional histogram serve in 2-D entropic approaches. To construct index table of a given image we proceed as follow. Calculate the average gray value of the immediate neighborhood of each pixel. Let g(x, y) be the average of the neighborhood of the pixel located at the point (x, y). The average gray value for the 3 × 3 neighborhood of each pixel is calculated as

$$g(x, y) = \frac{1}{9}\sum_{i=-1}^{1}\sum_{j=-1}^{1} f(x+i, y+j) \qquad (14)$$

Now g(x, y) holds the local average value for the corresponding value at f(x, y). **for g= 0 to 255**

$$k = \sum_{i=o}^{m-1}\sum_{j=0}^{n-1} g(m,n) \ \ when\ f(m,n) = g$$

Second order statistics yields refined results than the first order statistics. We have employed the second order statistics by considering average of each pixel's averages computed throughout the image

$$kavg(r) = k/h(r)\ ;\ r \in \{0, 1, \ldots, 255\} \qquad (15)$$

Where kavg is a vector holds all relative gray numbers for the corresponding gray number, g.

a) Fuzzy concepts

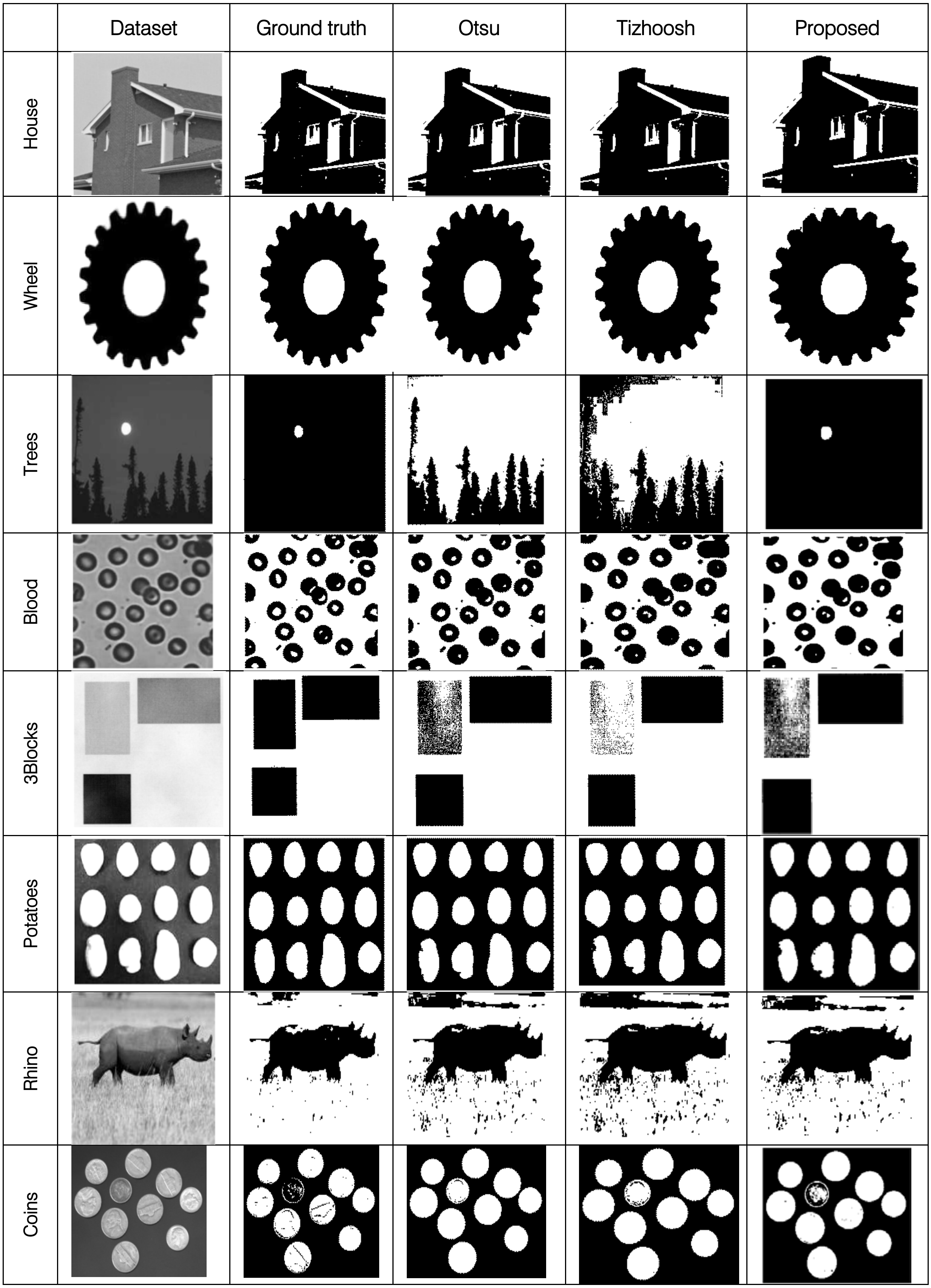
Fuzzy membership degree (FMD), μ_g of each gray has been computed using S- fuzzy membership function from equation (1). The upper and lower membership values $\mu_U(g)$ and $\mu_L(g)$ can be generated for type-II fuzzy sets which are useful in ultrafuzzy calculations. As spatial correlation of the image is serving better with entropic approaches the same concept can be exploited towards fuzzy approaches. In this regard the relative gray value is computed from local averages of the gray image with 3×3 map for every gray value. Relative fuzzy membership degree (RFMD) of every gray value is the FMD of its relative gray value to use in ultrafuzzy computation.

b) Proposed algorithm

1. Calculate image histogram.
2. For each pixel find the local average with a 3×3 map.
3. For the pair: gray value and its average gray value find the number of occurrences, called a bin.
4. For the each gray value, compute the average gray value of all bins and call it as relative gray value.
5. Construct an index table putting gray values and their corresponding relative gray values together.
6. Select S-membership function, μ(g).
7. Initialize the position of the membership function.
8. Shift the membership function along the gray-level range and compute fuzzy membership degrees (FMDs).
9. Calculate in each position the upper and lower membership grades $\mu_U(g)$ and $\mu_L(g)$.
10. RFMD of any gray value is the FMD of its relative gray value sourced from the index table.
11. Compute the ultrafuzziness value for each gray value by substituting its corresponding RFMD, using Equation (10).
12. Find out the g_{opt} with minimum ultrafuzziness.
13. Threshold the image with $T = g_{opt}$.

IV. Results and Discussions

To illustrate the performance of the proposed methodology we consider 14 images as an image set having similar and dissimilar gray level histogram characteristics, varying from uni-model to multimodal. Gold standard groundtruth images are generated manually to measure a parameter efficiency (η) based on misclassification error [3] and Jaccard Index [4].



Dataset
Ground truth
Otsu
Tizhoosh
Proposed
House
Wheel
Trees
Blood
3Blocks
Potatoes
Rhino
Coins

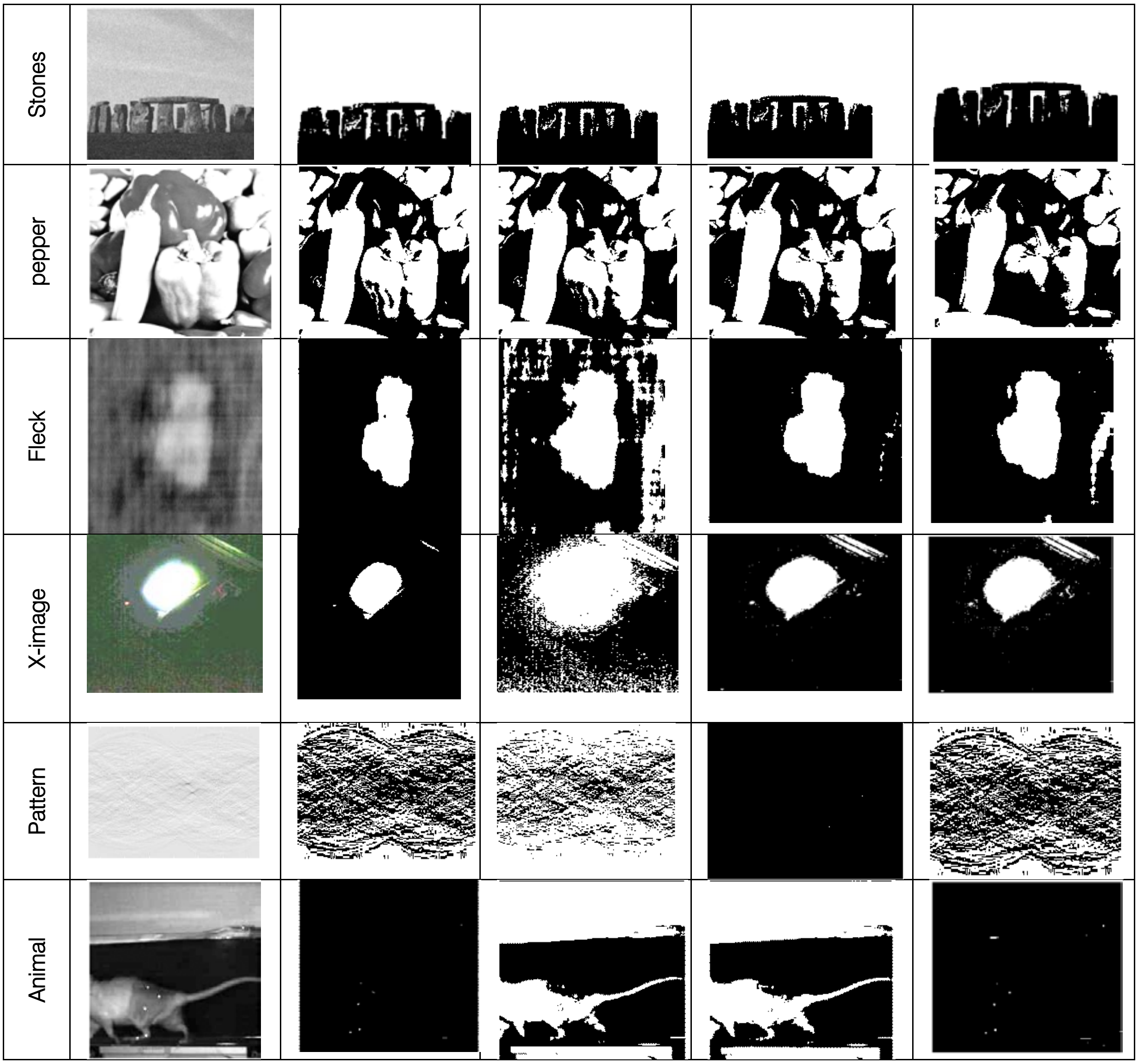


Fig. 4 : (From left to right) Data set, ground truth images and corresponding results for the three algorithms, Otsu, Tizhoosh and Proposed

a) Misclassification Error

$$\text{Misclassification Error } (\boldsymbol{\eta}) = \frac{|\, \mathbf{IMG_O} \cap \mathbf{IMG_T} \,|}{|\, \mathbf{IMG_O} \,|} \text{ X } 100 \qquad (16)$$

Where, IMG_O, IMG_T are gold standard image and resultant image respectively and |*| is the Cartesian Number of the set gives number of pixels. This η would be 0 for absolutely dissimilar and 100 for exactly similar image as result. Figure 4 shows original image set and their possible gold standard threshold image set. From the experiments for each image we obtain misclassification error values against its corresponding ground truth image from different methods including Otsu's, H.R.Tizhoosh and Proposed in Table 1.

Table 1 : Efficiency using Misclassification Error (η %)

Sl. no	Image	Otsu	Tizhoosh	Proposed
1	House	99.64	98.48	98.48
2	Wheel	98.58	99.27	97.44
3	Trees	30.89	27.42	99.86
4	Blood	96.95	98.53	95.5
5	3Blocks	93.46	87.16	92.56
6	Potatoes	98.79	97.15	96.83
7	Rhino	92.92	96.97	93.69
8	Coins	96.17	98.61	97.84
9	Stones	99.42	99.49	99.06
10	Pepper	90.28	85.96	99.68
11	Fleck	77.44	99.03	94.99
12	X-image	66.85	95.69	94.64
13	Pattern	74.51	51.33	100
14	Animal	50.99	49.99	99.53
MEAN (μ)		83.93	85.32	96.48
STD (σ)		21.38	23.78	2.97

From the experiments for each image we obtain **η** % for Otsu, Tizhoosh and proposed methods as shown in TABLE 1. These values are compared with assumed gold standard image data. Figure 5 confirms a variation in above said methods on histogram range for image set considered against Otsu method. Efficiency (η) is calculated for each technique on image set with Equation (16). A mean (μ) and standard deviation (σ) are calculated on efficiency in order to show the effectiveness of the proposed and other methods as in TABLE 1. A mean 96.48 and standard deviation 2.97 is obtained from the proposed method which confirms the qualitative improvement over the existing methods.

b) Jaccard Index

The another similarity measure is the Jaccard Index [4] known as Jaccard similarity coefficient, very popular and frequently used as similarity indices for binary data. The area of overlap A_j is calculated between the binary image B_j and its

Table 2 : Efficiency using Jaccard Index (%)

Sl.no	Image	Otsu	Tizhoosh	Proposed
1	House	99.23	97.01	97.01
2	Wheel	97.19	98.55	95.01
3	Trees	18.27	15.89	99.72
4	Blood	94.08	97.10	91.43
5	3Blocks	87.73	77.24	86.14
6	Potatoes	97.61	94.47	93.89
7	Rhino	86.78	94.12	88.13
8	Coins	92.62	97.27	95.77
9	Stones	98.85	99.00	98.14
10	Pepper	96.88	91.27	82.28
11	Fleck	63.18	98.09	90.46
12	X-image	50.22	91.75	89.83
13	Pattern	59.37	34.53	100
14	Animal	34.22	33.32	99.07
	MEAN (μ)	76.88	79.97	93.34
	STD (σ)	26.96	29.02	5.47

corresponding gold standard image G_j as shown in Equation (17).

$$\text{Jaccard Index } (A_i) = \frac{|B_i \cap G_i|}{|B_i \cup G_i|} \times 100 \qquad (17)$$

If the thresholded object and corresponding gold standard image G_j (associated ground truth image) are exactly similar then the measure is 100 and the measure 0 represents they are totally dissimilar, however the higher measure indicates more similarity. Table 2 represents the effectiveness of the proposed method, and Figure 6 shows the superiority of the proposed method against Otsu and Tizhoosh methods. The proposed method has highest average performance of 93.34% with the lowest standard deviation 5.47% when evaluated with Jaccard Index as listed in TABLE 2. In contrast Otsu algorithm with 76.88% average performance and 26.96% standard deviation and Tizhoosh method average performance of 79.97% and 29.02% standard deviation. Hence the proposed method is clearly showing much better performance over existing methods.

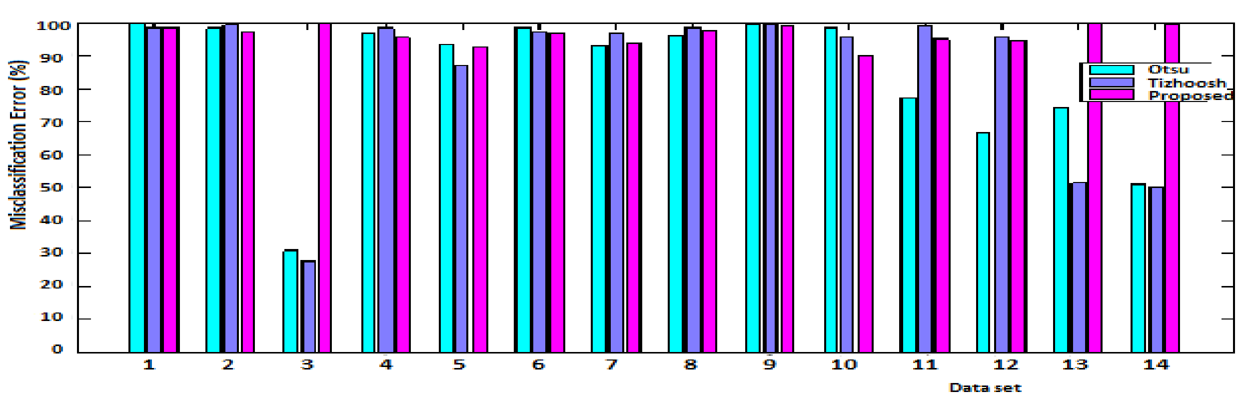


Fig. 5 : Efficiency comparison of the proposed method against Otsu and Tizhoosh using Misclassification error

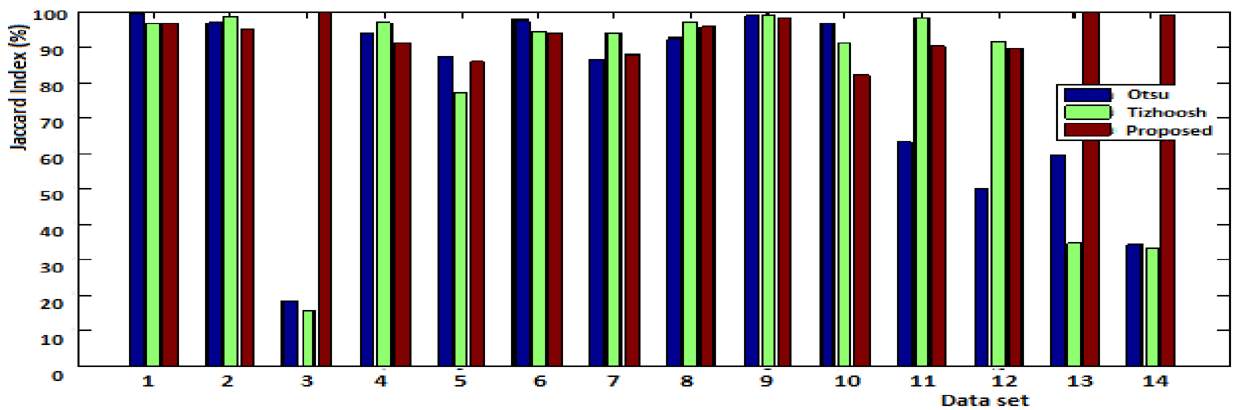


Fig. 6 : Efficiency comparison of the proposed method against Otsu and Tizhoosh using Jaccard Index

V. Conclusion

In this paper a new methodology for segmentation based on spatial correlation in gray image and ultrafuzziness of type-II fuzzy sets is addressed. To decide the fuzzy membership degree we have introduced a new concept called relative gray value and its corresponding relative fuzzy membership degree which is computed from a novel approach employed with two dimensional histogram. This is performing quite good on many complex images over standard methods in the literature. We tried Otsu and Tizhoosh ultrafuzzy methods to compare the results with our method. However, this method can be further improved in the lines of spatial correlation features where some alternate approaches using 5×5, 7×7 or any higher order local maps. Our method is effectively working on low contrast images whose objects are not clearly distinguished from background. Efficiency of threshold selection is demonstrated with experimental results. We assume a reasonable contrast enhancement for low contrast images. Performance evolution is carried out with the help of two popular approaches; Misclassification error and Jaccard Index on the proposed work.

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Analysis on Images & Image Processing

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Abstract - This paper deals with the analysis on images and image processing. It explains the types of images, operations performed on it, types of image formats and image processing principles, techniques, algorithms, compression methods and examples.

GJCST-F Classification: I.4.8

ANALYSIS ON IMAGES IMAGE PROCESSING

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Analysis on Images & Image Processing

B.Priyanka

Abstract - This paper deals with the analysis on images and image processing. It explains the types of images, operations performed on it, types of image formats and image processing principles, techniques, algorithms, compression methods and examples.

I. Introduction

Thinking about images or any particular one gives a clear picture in our vision. But to draw or make our vision in reality involves many things. Images can be drawn, painted and also captured. Capturing images is nothing but digital photography. Viewing the digital images in computer make us to think that how the image is developed, viewed, and also how can a black and white image is converted to color and vice versa. Explaining these things about the image is our article.

An image is a matrix form of square pixels which are arranged in the form of rows and columns. There are two general groups of images: vector graphics and bit map. The following are the types of images:

1. *Binary image:* It is a form of digital image where each pixel of it has only one of two colors usually black and white. Here the each pixel is stored in the form of a single bit either 0 or 1.
2. *Gray scale image:* The type of monochromatic image in which both black and white colors combines to give a gray color. The intensity among levels differs with in an image. Pixel value ranges from 0-255.
3. *Palette images:* It manages the finite set of colors in the digital images. There are grayscale (8-bit) and RGB (24-bit) palettes.
4. *RGB image:* The type of image in which the three colors(red, green, blue) are added to form various array of colors. it is of 24 bit.
5. *RGBa images:* It stands for red, green, blue alpha. It is one used for combining multiple images for the creation of visual effects.

As the image files are quite large, so the files type needs large disk usage which in turn slower the download. So, for this many file formats have been introduced like.

JPEG (Joint photographic experts group): In digital photography JPEG is a method used for lossy compression. Here the degree of compression is adjusted by balancing storage size and image quality. It gives a little perception loss in quality of images. This compression algorithm smoothens the variations of tone and color in photographs. It is a lossy compression method and is not suitable for drawings and other textual or iconic graphics.

GIF (Graphics interchange format): It is a bit map format supported in world wide web for its wide support and portability. It supports 8 bits per pixel and is used for animated images and low resolution film clips. As it has limitations regarding color so it is well suited for simpler images such as logos and graphics.

TIFF (Tagged image file format): It is supported by image manipulation applications and also a format used for storing images. It handles the images and data within a single file. It can be re-saved with same image quality. As it is flexible and adaptable, it supports CMYK images, tiled images, YCbCr images. It cannot be created or opened by common desktop applications.

BMP (Bit map): It is a raster graphics image file format used to store bitmap digital images. It is used for 2D digital images. As the BMP files are relatively large file size due to lack of compression, but many BMP files can be compressed with no loss of data such as zip. It is saved as an extension of .BMP,. DIB.

HDF (Hierarchical data format): It is a set of file formats and libraries to store large amounts of numerical data. It is supported by many commercial and non-commercial software platforms. There are two major versions of HDF, HDF4 and HDF5. HDF4 format has many limitations which lacks a clear object model. It supports many different interface styles leads to complex API. To overcome the limitations of HDF4 another version of HDF5 is proposed.

HDF5 simplifies the file structures namely datasets and groups.

PCX (Personal computer exchange): It was designed during the development of pc hardware. But the formats that are used to support this type are no longer in use. Computer fax programs uses the multi page version of pcx, which uses file extension as .dcx

PS (Post script): It is a programming language used in electronic publishing. These are not produced by humans. Characters % is used for posting comments. Due to the introduction of graphical user interface post script has become successful. It is saved with an extension of .ps.

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PSD (Photoshop document): It is a Photoshop format that keep all the information in an image including all the layers.

XWD(X windows dump image): It manages the network client server computers.xwd files contain different amount of colors. These files are very large in size as they are uncompressed.

PNG (Portable networks graphics): It is a bitmapped image format which gives lossless data compression. Png supports palette, RGB, grayscale images. It doesn't support non RGB images. It is saved with an extension of .png

SECTION II

II. Image Processing

Conversion of an image into a digitized form and performing some operations for enhancing an image or to extract some useful information from it. We can import images through optical scanners or by digital photography. Manipulation of images can be done by compressing or enhancing them for which the output results is to be an altered image.

III. Image Processing Principles

They work on two principles: improvement of pictorial information and processing of scene data. Image is a replica of an object. Images are of different types like gray tone images, line copy images and half tone images i.e the conversion of grayscale to binary ones. There are various steps in image processing like preprocessing, segmentation, representation, recognition, interpretation, and knowledge base.

Purpose of image processing:

1. Visualization: It observes the objects that are not visible.
2. Image sharpening: It helps to view the image better.
3. Image retrieval: The interested image is retrived.
4. Measurement of pattern: Different kinds of patterns and objects are measured.
5. Image recognition: Image objects are distinguished.

Image processing techniques:

1. Image Embellishment: Enhancing the image makes better visualization which makes the information better visibility. Which is performed by the following two techniques:

Histogram equalization: It redistributes the intensities of the image of the entire range of possible intensities.

Unsharp masking: Substracts smoothed image from the original image to emphasize intensity changes.

2. Undulation: It operates on pixel neighborhood *Highpass filter*: it emphasizes with rapid intensity changes.

Lowpass filter: Smoothes the images, blurs regions with rapid changes.

3. Numerical processes: It performs various function on images like

Add images: Adds two images pixel by pixel.

Subtract images: Subtracts second image from first image pixel by pixel.

Exponential or logarithm: Raises exponential to power of pixel intensity or takes log of pixel intensity

Scalar add, substract, multiply, divide: Applies the same constant values as specified by the user to all pixels one at a time. Scales pixel intensities uniformly or non-uniformly.

Dilation: Morphological operation expanding bright regions of image.

Erosion: Morphological operation shrinking bright regions of image.

4. Noise filters: It reduces the noise in images by performing some stastical deviations.

Adaptive smoothing filter: It sets the pixel intensity value between original and mean value.

Median filter: In neighborhood pixel it sets the intensity value to median intensity of pixel. It eliminates the intensity spikes.

Sigma filter: It sets the pixel intensity equals to mean. It eliminates the signal dependent noise.

5. Trend removal: It removes the intensity directions on the image.

Row column fit: It fits the image intensity in a row or column by subtracting fit from data and even chooses the column or row according to trendy that has least sudden changes.

6. Edge detection: It is used to sharpen transition of intensity regions.

First difference- It subtracts intensities of adjacent pixels.

Edge detection- It finds the difference between expanded and shrunken image version.

7. Image analysis: It extracts the image information

Extraction of image- It extracts some portion of image or full image and creates a new one with the areas that have been selected.

Images statistics- It calculates the statistics (mean, median, standard deviation, variance, average) of the image.

IV. Section III

a) Image processing algorithms

Algorithm1 Histogram equalization algorithm is used for improving the constrastion of the image. Usually it increases the constrast of images, especially done when the usable image data is represented by contrast values which are close. Through this adjustment of intensities it can be better distributed on the histogram. It allows the lower local area contrast to gain a higher contrast. It can be accomplished by effectively spreading the most frequent intensity values. It improves the better visualization of bone structure in x-ray images, and also in photographs. It often produces unrealistic effects in photographs which are very useful for scientific images like thermal. X-ray or satellite images. It even produces the undesirable effects of images with low depth in color.

Consider a simple grayscale image {D} and let pj be the number of occurrences of gray level *j*.

$$K_d(j)=K(d=j) = P_j/P, \qquad 0<=j<M$$

M being the total number of gray levels in the image,P being the total number of pixels in the image, and $K_d(j)$ being in fact the image's histogram for pixel value j, normalized to [0,1].cumulative distribution function corresponding to K_d as

$$hfi_d(j) = \sum_{v=0}^{j} K_d(v),$$

$$hfi_s(j)= jC$$

$$s=T(d)= hfi_d(d)$$

$$s^1 = s.(\max\{d\} – \min\{d\}) + \min\{x\})$$

Algorithm 2 An image deblurring algorithm was proposed by Richardson–Lucy deconvolution

$$U_{l} = \sum d_{lj} t_j$$

$$t_j^{(g+1)} = t_j^{(g)} \sum_{m} u_l/b_l \, d_{lj}$$

$$b_l = \sum_{j} d_{lj} \, t_j^{(g)}$$

$$p(x,y) = \{1, q(x,y) > q^1 ; 0, q(x,y) \le q^1$$

$$q(x,y) = \{a, p(x,y) = 0 ; b, q(x,y) = 1$$

V. Section IV

Several important relationships between pixels is shown here. An image is denoted by f(x,y)

a) *Neighbor of a pixel*

A pixel p at co-ordiantes(x,y) has four horizontal and vertical neighbors whose co ordinates are given by (x+1,y), (x-1,y),(x,y+1)(x,y-1)

This set of pixels called the four neighbours of p is denoted by $N_4(p)$. each pixel is a unique distance form (x,y) and some of the neighbours of p lie outside the digital image if(x,y) is on the border of the image.

The four diagonal neighbors of p have co ordinates(x+1, y+1), (x+1,y-1),(x-1,y+1),(x-1,y-1) and are denoted by $N_D(p)$. These points, together with the four neighbors, are called the eight neighbors of p, denoted by $N_8(p)$. As before, some of the points in $N_D(p)$ and $N_8(p)$ fall outside the image if (x,y) is on the border of the image.

b) *Adjacency of the pixel*

4-adjacency: Two pixels p and q with values from v are 4-adjacent if q is in the set $N_4(p)$

8-adjacency: two pixels p and q with values from v are 8-adjacent if q is in the set $N_8(p)$

M-adjacency: two pixels p and q with values from v are m-adjacent if

1. Q is in $N_4(P)$ or
2. Q is in $N_D(p)$ and the set $N_4(p) \cap N_4(q)$ has no pixels whose values are from v.

c) *Distance measure*

For pixels p,q and z with co ordinates (x,y)(s,t)(v,w) respectively, D is a distance function are metric if

1. D(p,q)>=0(D(p,q)=0 if p=q),
2. D(p,q)=D(q,p), and
3. D(p,z)<=D(p,q)+D(q,z)

Distance between p and q is defined as

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

d) *Intensity of the pixels*

1. Declare two files conside f1 and f2
2. Open the file f1; Input, the image file in the bin folder Open the file f2
3. Imgshow('cameraman.tif')
4. Imgread('cameraman.tif')

Here the output is the matrix form of the image.

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8793466913157041310720131907212367640123734420898
7292020898793521208987934620898792112089879275012
3813612381240000000000001000000000000000000000000
0012370122089898049123705212454124124539612451841
2370762089898547123705212453960160013226881237144
2147156514256123710420888048391322688123714412376
5612388841239140002562561238248200928698712520123
7144012388842561065568196610327684458758589832720
9068519809830541114128124520213762761507350163842
4176949819005722031646216272022937942424868255594
2268701628180902949164308023832113123342386347346
0360453437356083866682399775641288304259904439097
8452205246531264784200491527450463485177422530849
6543957055706445701718583279259638666094940622601
44259936439097845220524653126478420
```

VI. Section v

a) Conversion and compression techniques

Converting a color image to grayscale image: If each color pixel is described by a triple (R, G, B) of intensities for red, green, and blue

Lightness: this method averages the most prominent and least prominent colors: (max(R, G, B) + min(R, G, B)) / 2.

Average: this method simply averages the values: (R + G + B) / 3.

Luminosity: this method is a more sophisticated version of the average method. It also averages the values, but it forms a weighted average to account for human perception. We're more sensitive to green than other colors, so green is weighted most heavily. The formula for luminosity is 0.21 R + 0.71 G + 0.07 B.

Compression: it reduce the number of bits which are used to represent the coded image. Further it can be stored in original format.Two different kinds of compression we can see:

Lossy compression: A lossy compression involves a loss of information compared to the original image. So the image that has been reconstructed is not original once it has been compressed.

Lossless compression: a lossless compression does not involve a loss of information and the reconstructed image is original one even after the compression.

Compression can be explained by Huffman coding.

Algorithm:

1. Firstly, search for the two nodes which has low frequency and which are not assigned to the parent node.
2. Join these two nodes together to a new interior node.
3. Add both frequencies and assign this value to the new interior node

Consider an example:

Symbol	Frequency	Code	Length	total Length
A	24	0	1	24
B	12	100	3	36
C	10	101	3	30
D	8	110	3	24
E	8	111	3	24

Before compression 186 bit
After compression 136 bit

VII. Conclusion

This paper deals with types of images and how the images are represented in a digitized form and also the types of image formats and their significances. Image processing techniques, algorithms and also compression method have been explained.

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A New Texture Based Segmentation Method to Extract Object from Background

By M.Joseph Prakash & Dr.V.Vijayakumar
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Abstract - Extraction of object regions from complex background is a hard task and it is an essential part of image segmentation and recognition. Image segmentation denotes a process of dividing an image into different regions. Several segmentation approaches for images have been developed. Image segmentation plays a vital role in image analysis. According to several authors, segmentation terminates when the observer's goal is satisfied. The very first problem of segmentation is that a unique general method still does not exist: depending on the application, algorithm performances vary. This paper studies the insect segmentation in complex background. The segmentation methodology on insect images consists of five steps. Firstly, the original image of RGB space is converted into Lab color space. In the second step 'a' component of Lab color space is extracted. Then segmentation by two-dimension OTSU of automatic threshold in 'a-channel' is performed. Based on the color segmentation result, and the texture differences between the background image and the required object, the object is extracted by the gray level co-occurrence matrix for texture segmentation. The algorithm was tested on dreamstime image database and the results prove to be satisfactory.

Keywords : texture, color, image segmentation, GLCM.

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Abstract - Extraction of object regions from complex background is a hard task and it is an essential part of image segmentation and recognition. Image segmentation denotes a process of dividing an image into different regions. Several segmentation approaches for images have been developed. Image segmentation plays a vital role in image analysis. According to several authors, segmentation terminates when the observer's goal is satisfied. The very first problem of segmentation is that a unique general method still does not exist: depending on the application, algorithm performances vary. This paper studies the insect segmentation in complex background. The segmentation methodology on insect images consists of five steps. Firstly, the original image of RGB space is converted into Lab color space. In the second step 'a' component of Lab color space is extracted. Then segmentation by two-dimension OTSU of automatic threshold in 'a-channel' is performed. Based on the color segmentation result, and the texture differences between the background image and the required object, the object is extracted by the gray level co-occurrence matrix for texture segmentation. The algorithm was tested on dreamstime image database and the results prove to be satisfactory.

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I. Introduction

Color segmentation is an essential, critical, and preliminary process in a lot of vision-based tasks such as object recognition, visual tracking, human– computer interaction (HCI), human–robot interaction (HRI), vision-based robotics, visual surveillance, and so forth, because color is an effective and robust visual cue for characterizing an object from the others. Recently, there has been growing interest in the insect segmentation, which aims at detecting insects in an image.

However, color segmentation is not robust enough to deal with complex environments. Especially, changing illumination condition and complex background containing surfaces or objects with similar colors to a target are the major problems that limit its applications in practical real world. The former changes the characteristics of a color and the latter results in increasing false positive pixels. Generally, it is known that robustness in color segmentation is achieved if a color space efficiently separates chrominance and luminance in a color image and a plausible model of chrominance distribution is used [1]. Such chrominance information may be utilized to locate possible regions of a color in a color space and additional features may be adopted in order to validate the hypothesis. Ruizdel-Solar and Verschae [2] have compensated for their color segmentation methods with additional features to obtain more valuable results robust to brightness variations. However, this approach is not included in a pure research area of color segmentation. Dai and Nakano [3] have enhanced skin regions by converting red–green–blue (RGB) color signals to YIQ representation and using the I component, which includes color components from orange to cyan. Fieguth and Terzopoulos [4] have developed a tracking algorithm by heavily relying on a color cue composed of red (R), green (G), and blue (B) color components. Evaluating each component of several color spaces, Gomez [5] has listed top components and made a hybrid color space from those. In above researches, a color is dependent on the intensity of a pixel [6]. In real world cases, however, it is not always possible to control illumination condition. Therefore, many researches have been carried out for invariant detection of a color under illumination variations. Yang and Waibel [7] proposed color histograms in normalized red–green (RG) chromatic color space [6]. McKenna et al. [8] have proposed, however, Gaussian mixture models for the task, which outperform single Gaussian model. Also, color segmentation algorithms have been proposed in order to obtain the robustness toward changes in illumination and shadows by dropping the intensity. Sobottka and Pitas [10] have used chromatic information in hue–saturation–intensity (HSI) color space together with a best-fit ellipse technique to improve robustness of color segmentation. Tomaz et al. [11] have proposed an algorithm for color segmentation in TSL color space. Moreover, various color models have been proposed by using several color spaces such as YCbCr [12], YUV [13], and CIE Lab [14]. Actually, Phung et al. [15] have ascertained that most color space transformations do not bring the assumed benefits. Especially, Jayaram et al. [28] have verified that the best performance of skin color segmentation was obtained in HSI color space, keeping an intensity component. That is, color segmentation is largely unaffected by the choice of a color space. However, segmentation

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performance degrades when only chrominance channels are used in classification. [28] Cho et al. [29] have proposed a method called an adaptive skin color filter that detects skin color regions in a color image by adaptively adjusting its threshold values. Soriano et al. [30] have demonstrated a chromaticity-based constraint to select training pixels in a scene. In [31], histograms have been dynamically updated, based on feedback from the current color segmentation and prediction of a Markov model to get changing geometric parameters of color distribution and to track those. Adaptive or learning methods for color segmentation dynamically allocated a color through various illumination conditions while those models were adjusted for every image sequences and the adjustment needs heavier computational load to track targets than a static color model. Since there are a number of models for color segmentation as above, Martinkauppi et al. [32] have selected four types of color segmentation and compared their performance each other under significantly changing illumination conditions. Phung et al. [15] have investigated nine different color pixel classification algorithms. It was found for the Bayesian classifier to have higher classification rates than the other tested classifiers.

Generally, color image segmentation approaches can be divided into the following categories: statistical approaches, edge detection approaches, region splitting and merging approaches, methods based on physical reflectance models, methods based on human color perception, and the approaches using fuzzy set theory [33], [34].Histogram thresholding is one of the widely used techniques for monochrome image segmentation [35]. As for color images, the situation is different due to the multifeatures [36]. Since the color information is represented by tristimulus R, G and B or some linear/nonlinear transformation of RGB, representing the histogram of a color image in a three-dimensional (3-D) array and selecting threshold in the histogram is not a trivial job [37]. One way to solve this problem is to develop efficient methods for storing and processing the information of the image in the 3-D color space. [38] used a binary tree to store the 3-D histogram of a color image, where each node of the tree includes RGB values as the key and the number of points whose RGB values are within a range centered by the key value. [39] also utilized the same data structure and similar method to detect clusters in the 3-D normalized color space (X, Y, I). Another way is to project the 3-D space onto a lower dimensional space, such as two-dimensional (2-D) or even one-dimensional (1-D). [40] used projections of 3-D normalized color space (X, Y, I) space onto the 2-D planes (X-Y, X-I, and Y-I) to interactively detect insect infestations in citrus orchards from aerial color infrared photographs. [41] Provided segmentation approaches using 2-D projection of color space. [42] Suggested a multidimensional histogram thresholding scheme using threshold values obtained from three different color spaces (RGB, YIQ, and HSI). This method used a mask for region splitting and the initial mask included all pixels in the image. For any mask, histograms of the nine redundant features (R, G, B, Y, I, Q,H,S, and I) of the masked image are computed, all peaks in these histograms are located, the histogram with the best peak is selected and a threshold is determined to split the masked image into two sub regions for which two new masks are generated for further splitting. This operation is repeated until no mask left unprocessed, which means none of the nine histograms of existing regions can be further thresholded and each region is homogeneous.

This paper proposed a new color texture based image segmentation approach for insect extraction from complex background. In section II, GLCM was discussed. Automatic OTSU threshold was discussed was given in section III. Methodology of the proposed algorithm was presented in section IV. Results & discussions were given in section V. Finally, conclusions were given in section VI.

II. Glcm

Your Gray level co-occurrence matrix (GLCM) has been proven to be a very powerful tool for texture image segmentation [16,17]. The only shortcoming of the GLCM is its computational cost. Such restriction causes impractical implementation for pixel-by-pixel image processing. In the previous works, GLCM computational burden was reduced by two methods, at the computation architecture level and hardware level. D. A. Clausi et. al. restructures the GLCM by introducing a GLCLL (gray level co-occurrence linked list), which discard the zero value in the GLCM [18].This technique gives a good improvement because mostly GLCM is a sparse matrix where most of its values are equal to zeroes. Thus the size of GLCLL is significantly smaller than GLCM. Then the structure of the GLCLL was improved in [19, 20]. Another work is presented in [21] where fast calculation of GLCM texture features relative to a window spanning an image in a raster manner was introduced. This technique was based on the fact that windows relative to adjacent pixels are mostly overlapping, thus the features related to the pixels inside the overlapping windows can be obtained by updating the early calculated values. In January 2007, S. Kiranyaz and M. Gabbouj proposed a novel indexing technique called Hierarchical Cellular Tree (HCT) to handle large data [22]. In his work, it was proved that the proposed technique is able to reduce the GLCM texture features computation burden.

GLCM is a matrix that describes the frequency of one gray level appearing in a specified spatial linear relationship with another gray level within the area of investigation [23]. Here, the co-occurrence matrix is computed based on two parameters, which are the relative distance between the pixel pair d measured in pixel number and their relative orientation φ. Normally, φ is quantized in four directions (00, 450,900 and 1350) [23]. In practice, for each d, the resulting values for the four directions are averaged out. To show how the computation is done, for image I , let m represent the gray level of pixels (x, y) and n represent the gray level of pixels (x±dϕ0, y±dϕ1) with L level of gray tones where 0 ≤ x ≤ M −1, 0 ≤ y ≤ N −1 and 0 ≤ m, n ≤ L −1. From these representations, the gray level co-occurrence matrix Cm, n for distance d and direction ϕ can be defined as.

$$C_{m,n,\emptyset} = \sum_x \sum_y P\{I(x,y) = m \,\&\, I(x \pm d\emptyset_0, y \mp d\emptyset_1) = n\} \quad (1)$$

Where P{.} =1 if the argument is true and otherwise, P {.} =0. For each ϕ value, its ϕ0and ϕ1 values are referred as in the Table 1.

Table 1 : Orientation constant

ϕ	ϕ_0	ϕ_1
0^0	0	1
45^0	-1	-1
90^0	1	0
135^0	1	-1

In the classical paper [24], Haralick et. al introduced fourteen textural features from the GLCM and then in [25] stated that only six of the textural features are considered to be the most relevant. Those textural features are Energy, Entropy, Contrast, Variance, Correlation and Inverse Difference Moment. Energy is also called Angular Second Moment (ASM) where it measures textural uniformity [23]. If an image is completely homogeneous, its energy will be maximum. Entropy is a measure, which is inversely correlated to energy. It measures the disorder or randomness of an image [23]. Next, contrast is a measure of local gray level variation of an image. This parameter takes low value for a smooth image and high value for a coarse image. On the other hand, inverse difference moment is a measure that takes a high value for a low contrast image. Thus, the parameter is more sensitive to the presence of the GLCM elements, which are nearer to the symmetry line C (m, m) [23]. Variance as the fifth parameter is a measure that is similar to the first order statistical variables called standard deviation [26]. The last parameter, correlation, measures the linear dependency among neighboring pixels. It gives a measure of abrupt pixel transitions in the image [27].

III. Otsu Thresholding

This method, as proposed by [25] is based on discriminate analysis. The threshold operation is regarded as the partitioning of the pixels of an image into two classes C0 and C1 (e.g., objects and background) at grey-level t, i.e., C0 = {0, 1, 2, t} and C1 = {t + 1, t +2,….L-1}. Let σ2w, σ2B and σ2T be the within-class variance, between-class variance, and the

$$\lambda = \frac{\sigma_B^2}{\sigma_W^2}, \eta = \frac{\sigma_B^2}{\sigma_T^2}, \kappa = \frac{\sigma_T^2}{\sigma_W^2} \quad (2)$$

The optimal threshold t is defined as

$$t = \text{ArgMin } \eta \quad (3)$$

$$\sigma_T^2 = \sum_{i=0}^{L-1} [1-\mu_T]^2 P_i, \qquad \mu_T = \sum_{i=0}^{L-1} [iP_i] \quad (4)$$

$$\sigma_B^2 = W_0 W_1 (\mu_0 \mu_1)^2 \quad (5)$$

$$W_0 = \sum_{i=0}^{t} P_i, \qquad W_1 = 1 - W_0 \quad (6)$$

$$\mu_1 = \frac{\mu_T - \mu_t}{1-\mu_0}, \mu_1 = \frac{\mu_t}{W_0}, \mu_t = \sum_{i=0}^{t} (iP_i) \quad (7)$$

$$P_i = \frac{n_i}{n} \quad (8)$$

$$n = \sum_{i=0}^{L-1} n_i \quad (9)$$

Where ni is the number of pixels with grey-level and n is the total number of pixels in a given image defined as total variance, respectively. An optimal threshold can be determined by minimizing one of the following (equivalent) criterion functions with respect to:

Moreover, Pi is the probability of occurrence of grey-level i. For a selected threshold 't' of a given image, the class probabilities w0 and w1 indicate the portions of the areas occupied by the classes C0 and C1. The class means μ0 and μ1 serve as estimates of the mean levels of the classes in the original grey-level image. Moreover, the maximum value of η , denoted by η*, can be used as a measure to evaluate the separability of classes C0 and C1 in the original image or the bimodality of the histogram. This is a very significant measure because it is invariant under affine transformations of the grey-level scale. It is uniquely determined within the range 0≤ η≤1.The lower bound (zero) is obtained when and only when a given image has a single constant grey level, and the upper bound (unity) is obtained when and only when two-valued images are given.

IV. Methodology

In the first step RGB image is converted to 1976 CIE LUV color space. This color space is approximately perceptually uniform. The perceptual non-uniformity of this color space greatly improves over the CIE XYZ color space. In CIE LUV color space, L* specifies brightness of colors on a scale from 0 to 100, u* specifies color location approximately along the red-green axis with grey located at 0 and v* specifies color location approximately along the yellow-blue axis with grey located at 0.The color corresponding to $u^*=v^*=L^*=0$ is black and $u^*=v^*=0, L^*=100$ is white.

Each color space has its own appear background and application region. When segmenting a color image, the selection of color space plays a decisive role on the segmentation results. The common color spaces used in color image processing include RGB color space, HSI color space, CIE color space, and so on. At present, the general color digital images are RGB format. RGB color space is based on the theory of three-basic color to build. RGB format is the most basic color space. Other color space models can be obtained through the RGB format conversion. But the RGB color space is not a homogeneous visual perception space, it is not conducive to image segmentation based on color feature. HSI color space uses color characteristics of a direct sense of the three quantities: the brightness or lightness (I), hue (H), saturation (S) to describe the color. This method is more in line with the human eye habits to the description of the color, but the expressed colors are incomplete visual perceived color.

One problem with the CIEXYZ colour model is its lack of perceptual balance. Colours which are the same distance from one another are not necessarily perceptually equidistant. In 1976, the CIE proposed the CIE LUV colour model to address this problem. CIELUV is a perceptually uniform colour space. This means that distance and difference can be interchanged as required. If colours A and B are twice as far apart as colours C and D, then the perceived difference between A and B is roughly twice the perceived difference between C and D. The equations for computing CIE LUV assume you have (X, Y,Z) of the colour to convert, and (Xw,Yw, Zw) of a standard white. Given these values, the corresponding LUV colour is:

$$L^*=116(Y/Y_w)1/3-16,(Y/Y_w)>0.01 \quad (10)$$

$$u^*=13L^*(u'-u'_w) \quad (11)$$

$$v^*=13L^*(v'-v'_w) \quad (12)$$

$$u'=(4X)/(X+15Y+3Z) \quad (13)$$

$$v'=(9Y)/(X+15Y+3Z) \quad (14)$$

$$u'_w=0.2009, v'_w=0.4610 \quad (15)$$

L* encodes the luminance or intensity of a given colour, while u' and v' control its chromaticity.

The 'v' component is extracted from the transformed LUV color space in the second step. In the third step the extracted v- component is subjected to OTSU thresholding. The two-dimensional OTSU algorithm automatically selects the optimal threshold for segmentation. Because two-dimensional OTSU algorithm not only takes into account the grayscale information of pixels, but also considers the space-related information of pixels and their neighborhoods. GLCM is obtained for the otsu thresholded image. For each image and with distance set to one, four GLCMs having directions 0°, 45°, 90° and 135° are generated. The co-occurrence matrix is often correlated with the directions. It is necessary to select more than one direction of gray level co-occurrence matrix for a comprehensive statistical processing. The synthetic gray level co-occurrence matrix of an image can be got by averaging the values of energy matrices in 0 degree, 45 degree, 90 degree and 135 degree.

In the fifth step, image negative is applied for better enhancement of insect region. In the last step, morphological closing operation is performed in order to fill small holes. A hole is defined as an area of dark pixels surrounded by lighter pixels or may be defined as a background region surrounded by a connected border of foreground pixels. This process can be used to make objects in an image seem disappear as they are replaced with values that blend in with the background area. This function is useful for image editing, including removal of extraneous details or artifacts.

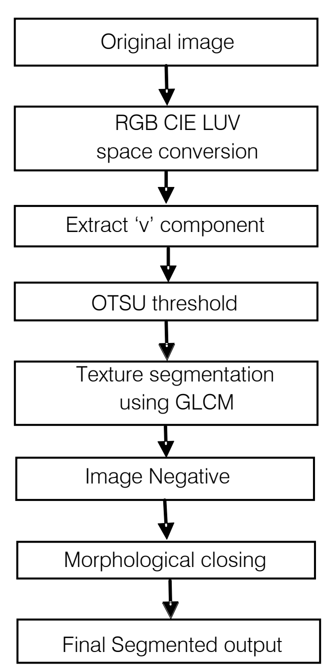


Fig. 1 : Flowchart of proposed algorithm

V. Results

The proposed algorithm is tested on dreamstime image database. In this paper step wise results of insect images are shown in Figs.2-4. The results in Figs.2-4 clearly show the extraction of insect from the background. The results clearly indicate that the green and yellow backgrounds in the images are converted to black Otsu threshold is applied for enhancing the 'v' component output. The Figs.2-4 (d) show that the object is smoothened after texture segmentation. The Figs.2-4 (f) clearly show that morphological closing step is applied to fill small gaps in the object for obtaining the final segmented insect region.

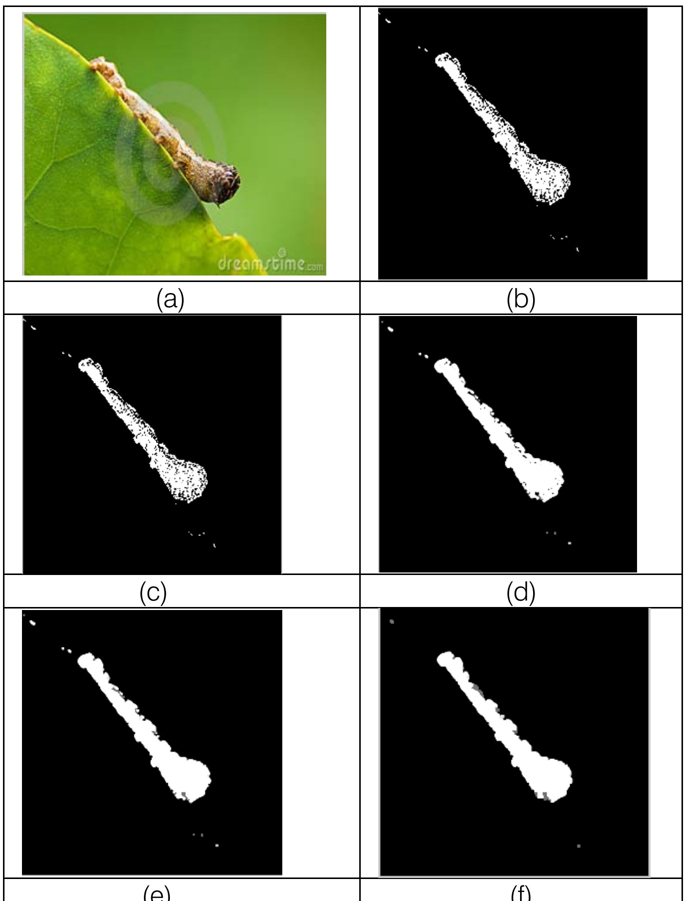


Fig. 2 : Step wise results of the proposed algorithm for insect extraction

(a) Original image (b) 'v' component
(c) OTSU thresholded (d) GLCM output
(e) negative (f) final output

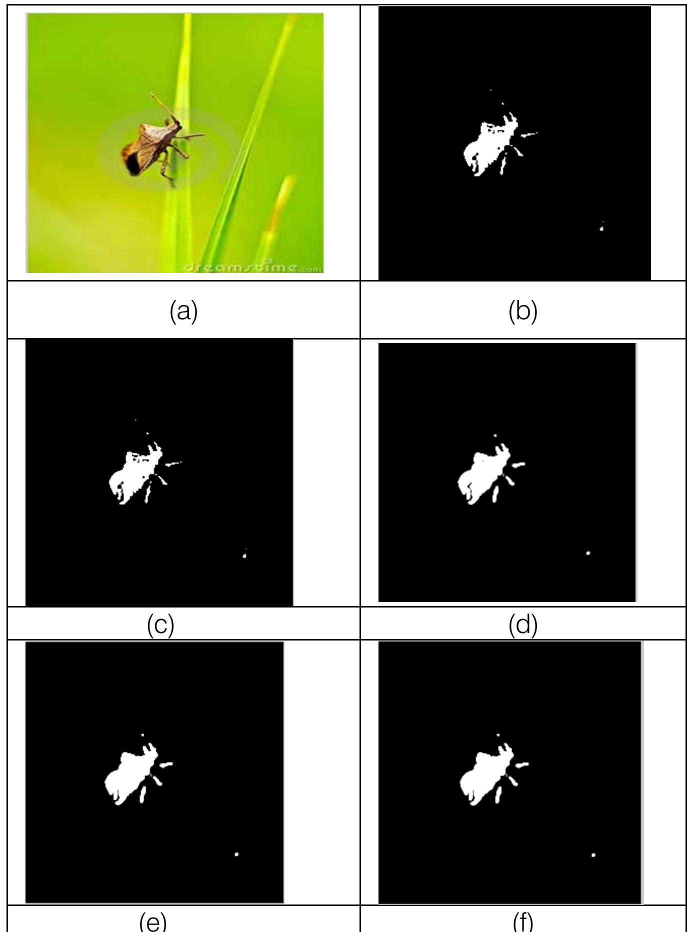
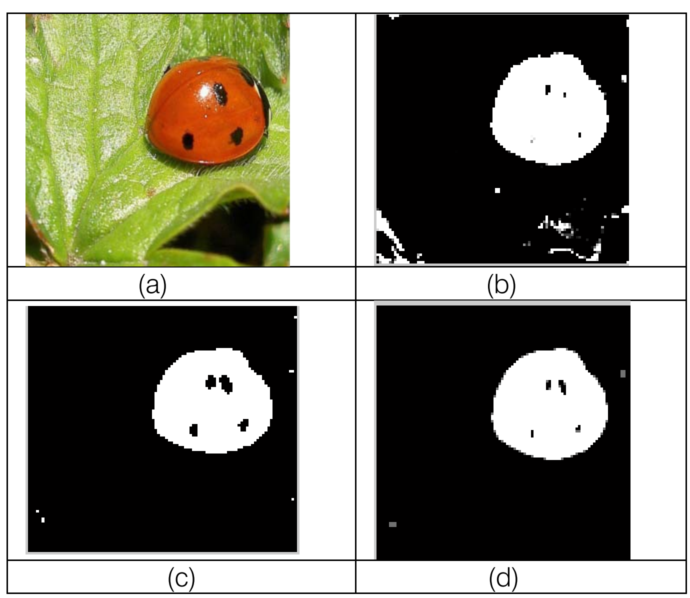


Fig. 3 : Step wise results of the proposed algorithm for insect extraction

(a) Original image (b) 'v' component
(c) OTSU thresholded (d) GLCM output
(e) negative (f) final output



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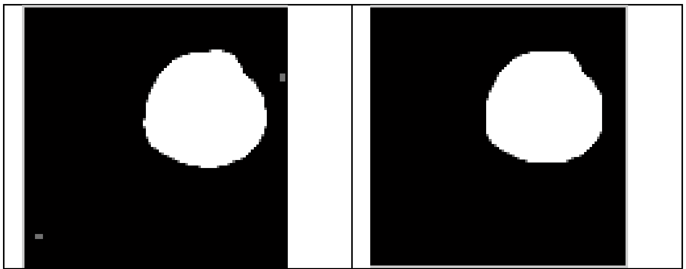

(e) (f)

Fig. 4 : Step wise results of the proposed algorithm for insect extraction

(a) Original image (b) 'v' component
(c) OTSU thresholded (d) GLCM output
(e) negative (f) final output

VI. Conclusion

The information which the commonly used grayscale images contain is not enough for insect segmentation. The images consisting of insects when collected in nature, the background is generally more complex and more close to the target color, so there are some limitations in these conditions if we only use gray level information. However, the color images are able to provide more information. There are colors and color depth information, in addition to its provision of brightness and color images can be expressed by a variety of color space. Therefore, segmentation based on color image can overcome some shortcomings of gray-scale image. In this algorithm both color and texture features are considered. In this method, segmentation speed is faster and without human participation, the segmentation result is also deal. The results show the efficiency of the above algorithm.

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Comparitive Study on Face Recognition Using HGPP, PCA, LDA, ICA and SVM

By Hardik Kadiya
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Abstract - We are comparing the performance of five algorithms of the face recognition i.e. HGPP, PCA, LDA, ICA and SVM. The basis of the comparison is the rate of accuracy of face recognition. These algorithms are employed on the ATT database and IFD database. We find that HGPP has the highest rate of accuracy of recognition when it is applied on the ATT database whereas LDA outperforms the all other algorithms when it is applied to IFD database.

Keywords : face recognition, PCA, LDA, ICA, HGPP, SVM.

GJCST-F Classification: I.5.0

COMPARITIVE STUDY ON FACE RECOGNITION USING HGPP, PCA, LDA, ICA AND SVM

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Comparitive Study on Face Recognition Using HGPP, PCA, LDA, ICA and SVM

Hardik Kadiya

Abstract - We are comparing the performance of five algorithms of the face recognition i.e. HGPP, PCA, LDA, ICA and SVM. The basis of the comparison is the rate of accuracy of face recognition. These algorithms are employed on the ATT database and IFD database. We find that HGPP has the highest rate of accuracy of recognition when it is applied on the ATT database whereas LDA outperforms the all other algorithms when it is applied to IFD database.

Keywords : face recognition, PCA, LDA, ICA, HGPP, SVM.

I. Introduction

Today, we have a variety of biometric techniques like fingerprints, iris scans, and speech recognition etc. but among of them face recognition is still most common technique which is in use. It is only due to the fact that it does not require aid or consent from the test subject and easy to install in airports, multiplexers and other places to recognize individuals among the crowd. But face recognition is not perfect and suffers due to various conditions like scale variance, Orientation variance, Illumination variance, Background variance, Emotions variance, Noise variance, etc [15]. Due to these challenges, researchers are very keen to find out the rate of accuracy for face recognition. So they are always trying to evaluate the best algorithm for face recognition.

Various comparisons had been performed by the researchers [1], [3], [4], [5], [10], [11], [16]. Here we are also compare five algorithms like PCA [17], LDA [19], ICA [2], SVM [7], and HGPP [20] on the basis of rate of accuracy of face recognition. The brief description of all above said algorithms are given below:

II. Face Recognition Algorithms

a) *Principal Component Analysis (PCA)*

It is an oldest method of face recognition which is based on the Karhunen-Loeve Transform (KLT) as Hotelling Transform and Eigenvector Transform), works on dimensionality reduction in face recognition.

Turk and Pent land used PCA exclusively for face recognition [17]. PCA computes a set of subspace basis vectors for a database of face images. These basis vectors are representation of an images which is correspond to a face.

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- Like structures named Eigen faces. The projection of images in this compressed subspace allows for easy comparison of images with the images from the database.

The approach to face recognition involves the following initialization operations [17]:

- Acquire an initial set of N face images (training images).
- Calculate the eigenface from the training set keeping only the M images that correspond to the highest eigenvalues. These M images define the "face space". As new faces are encountered, the "eigenfaces" can be updated or recalculated accordingly.
- Calculate the corresponding distribution in M dimensional weight space for each known individual by projecting their face images onto the "face space".
- Calculate a set of weights projecting the input image to the M "eigenfaces".
- Determine whether the image is a face or not by checking the closeness of the image to the "face space".
- If it is close enough, classify, the weight pattern as either a known person or as an unknown based on the

Euclidean distance measured.

- If it is close enough then cite the recognition successful and provide relevant information about the recognized face from the database which contains information about the faces.

b) *Linear Discriminant Analysis (LDA)*

LDA also known as Fisher's Discriminant Analysis, is another dimensionality reduction technique. It is an example of a class specific method i.e. LDA maximizes the between – class scattering matrix measure while minimizes the within – class scatter matrix measure, which make it more reliable for classification. The ratio of the between – class scatter and within – class scatter must be high [19].

c) *Independent Component Analysis (ICA)*

Generalization View of the PCA is known as ICA. It minimizes the second order and higher order dependencies in the input and determines a set of statistically independent variables or basis vectors. Here we are using architecture I which finds statistically independent basis images.

d) Support Vector Machines (SVMs)

The Support Vector Machine is based on VC theory of statistical learning. It is implement structural risk minimization [17]. Initially, it was proposed as per a binary classifier. It computes the support vectors through determining a hyperplane. Support Vectors maximize the distance or margin between the hyperplane and the closest points.

e) Histogram of Gabor Phase Patterns (HGPP)

HGPP is the combination of spatial histogram and Gabor phase information. Gabor phase information is of two types. These are known as Global Gabor phase pattern (GGPP) and Local Gabor phase pattern (LGPP). Both of the Gabor phase patterns are based on quadrant-bit codes of Gabor real and imaginary parts (Quadrant–bit codes proposed by Daugman for iris recognition [6]. Here GGPP encodes orientation information at each scale whereas LGPP encodes the local neighborhood variations at each orientation and scale. Finally, both of the GPP's are combined with spatial histograms to model the original object image.

Gabor wavelet is well known algorithm for the face recognition. Conventionally, the magnitude of the Gabor coefficients are considered as valuable for face recognition and phase of the Gabor coefficients are considered useless and always discarded. But use of the spatial histograms, encodes the Gabor phases through Local binary.

Pattern (LBP) and provides the better recognition rate comparable with that of magnitude based methods. It shows that combination of Gabor phase and magnitudes provides the higher classification accuracy. These observation paid more attention towards the Gabor phases for face recognition.

III. Research Methodology

We used ATT and IFD database for comparison of different face recognition algorithms such as PCA, LDA, ICA, SVM and HGPP. Based on algorithm, we extract different features from a training set. Using these feature we trained the classifier. We extract features from testing set and find the accuracy of the algorithm.

IV. Data Analysis

We used ATT and IFD databases for training and testing different algorithms. We took 40 persons images from ATT and IFD database. 5 images of each person are used for training and 5 images of each person are used for testing algorithms. From Fig. 3 it is observed that all algorithms give better result on ATT database then IFD database. HGPP give best result on ATT database and LDA give best result on IFD database.

V. Experimental Results

Here, two face databases have been employed for comparison of performance. These are - 1. ATT face database and 2. Indian face database (IFD). These two databases have been chosen because the ATT contains images with very small changes in orientation of images for each subject involved, whereas the IFD contains a set of 10.

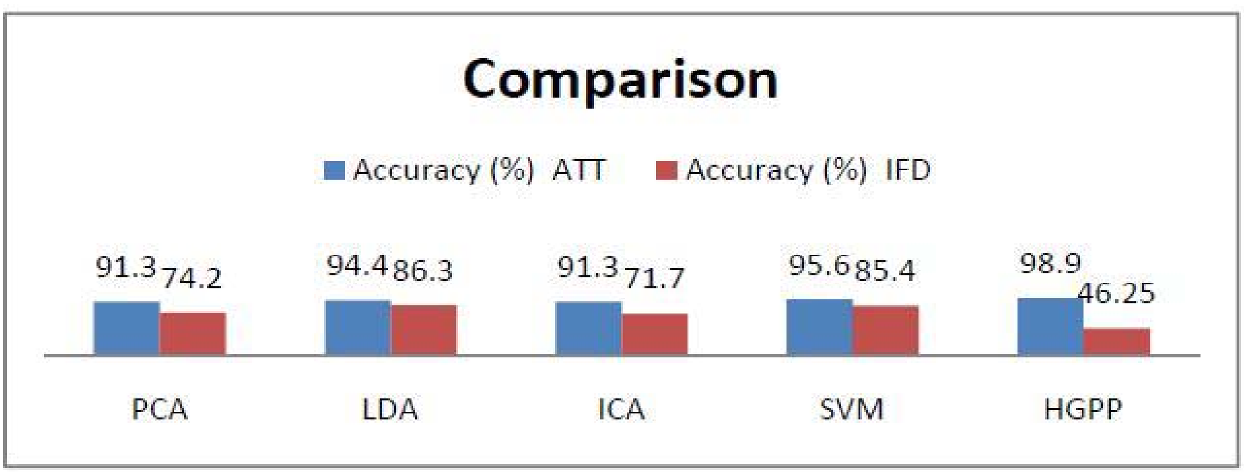

Figure : Comparative Study of Five Algorithms on the Basis of Recognition Accuracy

Images for each subject where each image is oriented in a different angle compared to another.

The evaluation is carried out using the Face Recognition Evaluator. It is an open source MATLAB interface.

Comparison is done on the basis of rate of recognition accuracy. Comparative results obtained by testing the five i.e. PCA, LDA, ICA, SVM and HGPP algorithms on both the IFD and the ATT databases.

VI. Performance Analysis

Above analysis shows the performance of the five algorithms on the database of the ATT and IFD. Following points we have observed in this experiment.

- It is observed that recognition rate of the ATT database is higher as compare to IFD database. This observation is due to the nature of images contain in the IFD database. In this database, each subject is portrayed with highly varying orientation angles. It also shows that each image has rich background region than the ATT database.
- It is observed that HGPP has 98.9% rate of accuracy of recognition. LDA and SVM have the almost same rate of accuracy of recognition, which outperform the PCA and ICA.
- It is observed that when five algorithms employed on IFD database then LDA outperform all remaining four algorithms. LDA has highest rate of accuracy of recognition i.e. 86.3%. Although LDA has the highest rate but it is marginally higher than SVM i.e. 85.4%. PCA and ICA the moderate rate of accuracy of recognition i.e. 74.2% and 71.7% respectively. HGPP has the lowest rate of accuracy of recognition i.e. 46.25%. It shows that HGPP is effective but suffers from the local variations.

VII. Conclusion

Here, we have employed five algorithms of face recognition i.e. PCA, LDA, ICA, SVM and HGPP. The performance was calculated in terms of the recognition accuracy. It is observed that recognition rate of the ATT.

Database is higher as compare to IFD database. This observation is due to the nature of images encompassed in the IFD. It is observed that HGPP has 98.99% rate of accuracy of recognition for ATT. It is observed that when five algorithms employed on IFD database then LDA outperform all remaining four algorithms. LDA has highest rate of accuracy of recognition i.e. 86.3%. HGPP is effective but suffers from the local variations that's it has the lowest rate of accuracy when HGPP employed on IFD database.

VIII. Future Scope

Lot of work can be done in field of face recognition such as most of the algorithms give good result on Frontal.

Face recognition but at different angles they do not give good result. To recognize a face at an angle we have to give some 3D face recognition algorithm. We can club other modality with face recognition algorithm for best results example face- iris, face-fingerprint, face-iris-fingerprint. Face recognition algorithm rate can be improved by first detecting the face from image and then crop the detected face and process it for recognition.

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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.

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- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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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

INDEX

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