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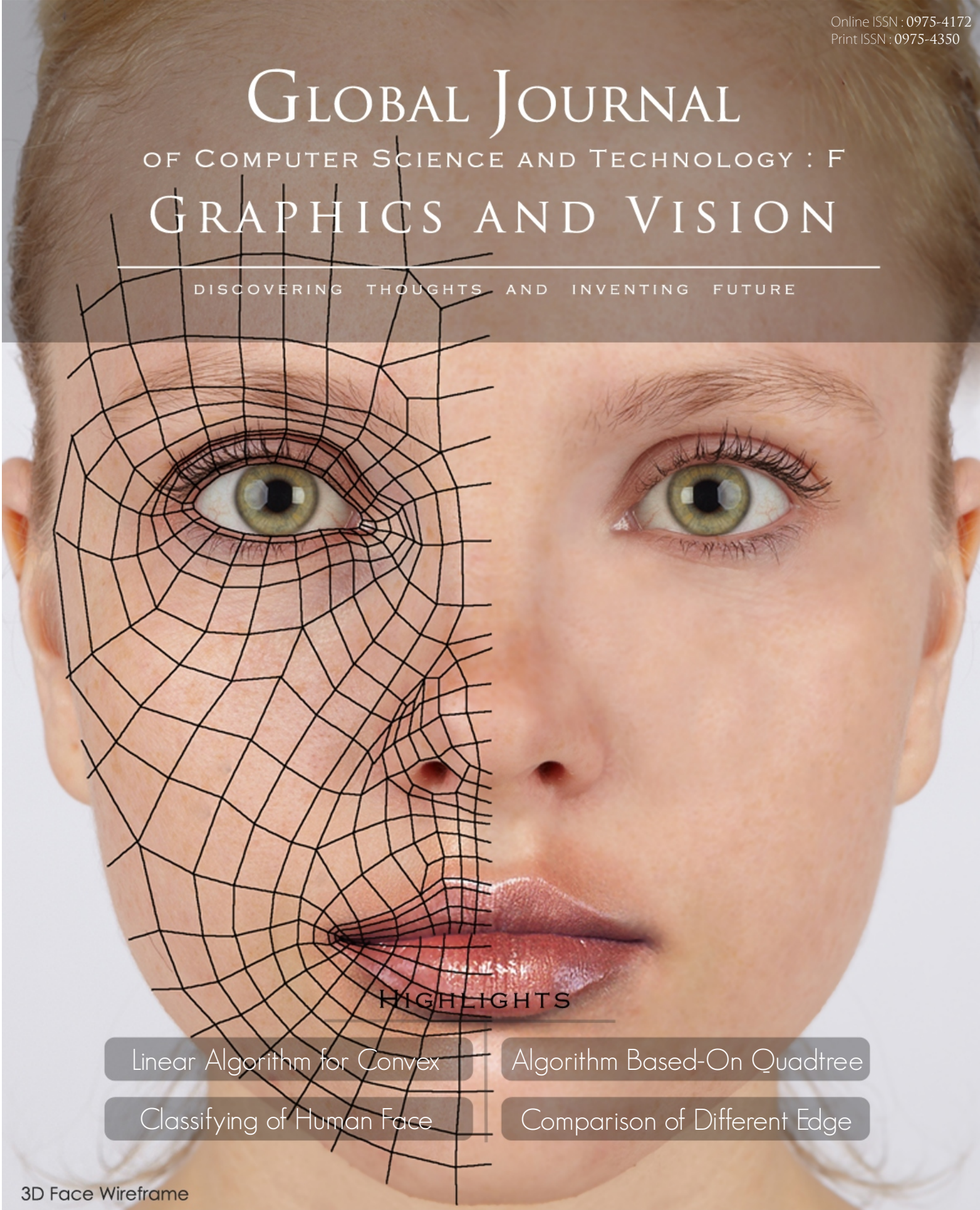
Graphics and Vision

DISCOVERING THOUGHTS AND INVENTING FUTURE



HIGHLIGHTS

- Linear Algorithm for Convex
- Algorithm Based-On Quadtree
- Classifying of Human Face
- Comparison of Different Edge

3D Face Wireframe

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Digital Watermarking

By Nidhi Rani
Dronacharya College of Engineering

Abstract - Today's world is digital world. Nowadays, in every field there is enormous use of digital contents. Information handled on INTERNET and MULTIMEDIA NETWORK SYSTEM is in digital form. The copying of digital content without quality loss is not so difficult .Due to this , there are more chances of copying of such digital information. So , there is great need of prohibiting such illegal copyright of digital media. Digital watermarking (DWM) is the powerful solution to this problem. Digital watermarking is nothing but the technology in which there is embedding of various information in digital content which we have to protect from illegal copying. This embedded information to protect the data is embedded as watermark. Beyond the copyright protection, Digital watermarking is having some other applications as fingerprinting, owner identification etc. Digital watermarks are of different types as robust, fragile, visible and invisible. Application is depending upon these watermarks classifications. There are some requirements of digital watermarks as integrity, robustness and complexity.

GJCST-F Classification : I.4.0

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Digital Watermarking

Nidhi Rani

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I. Introduction

The process of embedding information into another object/signal is termed as digital watermarking. In visible watermarking, the information is visible in the picture or video. Typically, the information is text or a logo which identifies the owner of the media. The image on the right has a visible watermark. When a television broadcaster adds its logo to the corner of transmitted video, this is also a visible watermark. In invisible watermarking, information is added as digital data to audio, picture or video, but it cannot be perceived as such (although it may be possible to detect that some amount of information is hidden). The watermark may be intended for widespread use and is thus made easy to retrieve or it may be a form of Steganography, where a party communicates a secret message embedded in the digital signal. In either case, as in visible watermarking, the objective is to attach ownership or other descriptive information to the signal in a way that is difficult to remove. It is also possible to use hidden embedded information as a means of covert communication between individual. The purpose of embedding the information depends upon application and need of user of digital media. Digital watermarking provides the solution for difficult problem of providing guarantee to organizer and consumer of digital content about their legal rights .Copyright protection for multimedia information is nothing but a golden key for multimedia industry. Digital watermarking is a technology that opens a new door for authors, producers, publishers and service providers for protection of their rights and interest in multimedia documents. In general sense, Digital Watermarking means "Author Signature".

Digital watermarking is the process of encoding hidden Copyright information in an image by making small modifications in it's pixel content. In this case watermarking doesn't restrict the accessing image information. The important function of watermarking is to remain present in data for proof of ownership. The use of digital watermarking is not restricted upto copyright.

II. Digital Watermarking

Digital Watermarking is hidden information inside signal. For watermarking several techniques has been developed. These can be categorized as:

- Spatial Domain Watermarking
- Frequency Domain Watermarking.

Spatial Domain

- Spatial domain watermarking uses blockxblock watermarking.
- e.g they embed the watermarks on a randomly selected 8x8 blocks of pixels of the image.

Frequency Domain

To embed a watermark, a frequency transformation is applied to the host data. Then, modifications are made to the transform coefficients. Possible image transformations include discrete Fourier Transform.

III. Properties and Classification

a) *Properties*

For better activeness, watermark should be perceptually invisible within host media, statistically invisible to unauthorized removal, readily extracted by owner of image, robust to accidental and intended signal distortion like filtering compression, resampling, retouching, crapping etc. For a digital watermark to be effective for ownership, it must be robust, recoverable from a document, should provide the original information embedded reliably and also removed by authorized users.

All these important properties of digital watermarks are described as:

i. *Robustness*

The watermark should be robust such that it must be difficult to remove. The watermark should be robust to different attacks. The robustness describes

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whether watermark can be reliably detected after performing some media operations.

ii. *Perceptual transparency*

This property describes that whether watermark is visible or invisible to human sensor organ. Perceptible watermarks are visible to human while imperceptible are not. Imperceptible watermarks are such that content remains same after applying digital watermarking technique.

iii. *Security*

Security property describes that how easy to remove a watermark. This is generally referred to as "attack" on watermarking. Attack refers to detection or modification of watermark.

iv. *Complexity*

This is important property which is to be considering in Real time applications like video. Complexity property is concerned with amount of effort needed to extract or retrieve the watermark from content.

v. *Capacity*

Capacity property of digital watermarks refers to amount of information that can be embedded within the content. The important point is that more data is used in watermark, watermark will become less robust. In addition to these properties, watermarks are having some extra properties as unambiguity, tamper resistance, inseparable from the works and able to undergo some transformation as works.

b) Classification

Digital watermarks are classified according to their applications. The watermarks are classified as perceptible watermarks and imperceptible watermarks, robust and fragile, public and private. This classification of watermarks is broadly described in following sections.

i. *Perceptible watermarks and imperceptible watermarks*

Perceptible watermarks are visible to human eye while imperceptible watermarks are invisible. The perceptible watermarks are useful for primary application i.e. for statement ownership or authorship. So for this reason it should be visible. .On the other hand imperceptible watermarks are useful for complex applications such as document identification in which content being watermarked must appear in unchanged form. Examples of visible (perceptible) watermarks are logos on TV, IBM's watermark and that of invisible (imperceptible) watermarks are ATT, NEC/MIT, UU etc.

Perceptible watermarks i.e. visible one are extension of the concept of logos. They are applicable to images only. These watermarks are embedded into image. They are applicable in maps, graphics and software user interface .Imperceptible watermarks i.e. invisible one remains hidden in the content. They can be detected only by authorized agency. These watermarks are useful for content or author authentication and for detecting unauthorized copier.

ii. *Robust watermarks and fragile watermarks*

Robust or fragile is nothing but degree to which watermarks can withstand any modifications of any types caused due to the transmission or lossy compression. Perceptible watermarks are more robust in nature than imperceptible one. But meaning of this is not that imperceptible watermarks are fragile one. Robust watermarks are those watermarks which are difficult to remove from the object in which they are embedded. Fragile watermarks are those watermarks which can be easily destroyed by any attempt to tamper with them. Fragile watermarks are destroyed by data manipulation.

iii. *Private watermarks and public watermarks*

Private watermarks requires at least original data to recover watermark information Public watermarks requires neither original data nor embedded watermarks to recover watermark information. Private watermarks are also known as secure watermarks. To read or retrieve private watermark, it is necessary to have secret key. Public watermark can be read or retrieve by anyone using specialized algorithm. In this sense public watermarks are not secure. Public watermarks are useful for carrying IPR information. They are good alternatives to labels.

IV. Relative Concepts and Attacks

a) Relevant Terms

Digital watermarking, steganography, information hiding, cryptography are closely related concepts. In each technique, a digital signal or pattern is inserted into, onto, before or after digital document. There are some difference between working principle of these techniques and their meanings. Information hiding is also called as 'Data hiding'. The hiding is concerned with making information imperceptible or keeping it's existence secrete. Information hiding means encompassing wide range of problems beyond that of embedding messages in content. Information hiding deals with communication security. It consists of encryption and traffic security. Encryption protects the content during distribution over an open network such as internet. The traffic security is related to concealing its sender, its receiver. Thus, here an attempt is made to have secreted communication between each two parties where existence is unknown to attacker.

i. *Steganography*

It is nothing but sub-discipline of information hiding. Here secrete information is hidden in harmless message, which is also known as cover message. Steganography is used to avoid drawing suspictions to transmission of hidden message so as to

remain undetected. The idea behind this is that to hide message in envelope or wrapper. In steganography, existence of hidden message in content is not known audience.

ii. *Cryptography*

This technique is related with data protection. It is commonly used for protecting digital information. Once, data is decrypted, it can't remain protected for long time i.e. there may be more chances of illegal copying of this data .So, there is great need of cryptography technique. Watermarking is special case of cryptography. Cryptography involves some suitable and complicated techniques so that no unauthorized user is allowed to access the data to protect. Authorization of user is checked by certain keys or signature.

iii. *Watermarking*

Watermarking is technology derived from steganography. It is also sub-discipline of information hiding. Watermarking is process of embedding secrete and robust identifier inside audio, video content. The purpose of watermarking is to establish the copyright of content creator. In this sense watermarks are also known as the hidden copyright messages. Watermarking secures the content, thus any attempt to modify the content can be easily detected. The watermarking can trace the path followed by content in distribution chain. This helps in tracing malicious users.

b) Attacks

Due to some reasons, there is need of adding, altering or removing false watermarks. Attacks on watermarks may be accidental or intentional. Accidental attacks may cause due to the standard image processing or due to the compression procedures. Intentional attacks includes cryptanalysis, steganalysis, image processing techniques or other attempts to overwrite or remove existing watermarks. Following are the methods of attacks vary according to robustness and Perceptibility.

i. *Mosaic attack*

Mosaic attack is the method in which pictures are displayed so as to confuse watermark-searching program, known as "Web Crawler". Mosaic is created by subdividing the original image into randomly sized small images and displaying the resulting image on webpage.

ii. *Geometric attack*

Geometric attack is related to geometric properties of data. It is concerned with images, documents and audio files. This attack is further classified as-

a. Subtractive attack

It involves the attacker in the area of located watermark if imperceptible and then removing the mark by cropping or digital editing.

b. Distortive attack

In this attack, attacker attempts to make some uniform distortive changes in the images such that mark becomes unrecognizable. These two watermark attacks are usually performed on robust watermark.

iii. *Stirmark attack*

Stirmark is generic tool developed for simple robustness techniques of image marking algorithms and steganographic techniques. In it's simplest version, stirmark simulates resampling process in which it introduces same kind of errors into an image to print it on high quality printer and scanning it again with high quality scanner. It includes minor geometric distortion. This testing tool is an effective program to remove fairly robust watermarks in images and become a form of attack on its own.

iv. *Forgery attack*

Forgery attack is also known as 'Additive attack' in some cases. Forgery attack includes the attacker who can add his or her own watermark overlaying the original image and marking the content as their own.

v. *Inversion attack*

Inversion watermark render the watermark information ambiguous. The idea behind the inversion attack that attacker who receives watermarked data can claim that data contains his watermark also by declaring part of data as his watermark. The attacker can easily generate the original data by subtracting the claimed watermark.

vi. *Cryptanalysis*

It is mostly associated with cryptography. It is a method in which attacker attempts to find the decryption key for an encrypted pieces of information so that it can be made useful again. Attacker can remove licensing watermark that decrypts the data, attacker would use cryptanalysis to find decryption key so that data can use in decrypted form free from its watermark.

V. Conclusion

The large need of networked multimedia system has created the need of "COPYRIGHT PROTECTION". It is very important to protect intellectual properties of digital media. Internet playing an important role of digital data transfer. Digital watermarking is the great solution of the problem of how to protect copyright. Digital watermarking is the solution for the protection of legal rights of digital content owner and customer.

- Modifications of all DCT coefficients distort the image drastically.
- Modification of low – frequency coefficients distorts the image, Gives the hacker a clue about where the watermark is embedded.

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A Linear Algorithm for Convex Drawing of a Planar Graph

By Thanvir Ahmad & Md. Shahidul Islam

Chittagong University

Abstract - A straight line drawing of a planar graph is called a convex drawing if the boundaries of all faces of that graph are drawn as convex polygon. A graph is planar if it has at least one embedding in the plane such that no two edges intersect at any point except at their common end vertex. Not all planar graphs have convex drawing. In this thesis, we study the characteristics of convex drawing of a planar graph. We develop a method for examining whether a face is drawn as a convex polygon or not.

Finally, using that method we develop a linear algorithm for examining whether a planar graph has a convex drawing or not.

Keywords : *Planar graph, convex drawing, linear algorithm.*

GJCST-F Classification : *I.4.7*

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A Linear Algorithm for Convex Drawing of a Planar Graph

Thanvir Ahmad [α] & Md. Shahidul Islam [σ]

Abstract - A straight line drawing of a planar graph is called a convex drawing if the boundaries of all faces of that graph are drawn as convex polygon. A graph is planar if it has at least one embedding in the plane such that no two edges intersect at any point except at their common end vertex. Not all planar graphs have convex drawing. In this thesis, we study the characteristics of convex drawing of a planar graph. We develop a method for examining whether a face is drawn as a convex polygon or not.

Finally, using that method we develop a linear algorithm for examining whether a planar graph has a convex drawing or not.

Keywords : Planar graph, convex drawing, linear algorithm.

I. Introduction

Some planar graphs can be drawn in such a way that each edge is drawn as a straight line segment and each face is drawn as a convex polygon, as illustrated in Figure 3.1. Such a drawing is called a *convex drawing.* The drawings in Figs. 3.2 are not convex drawings.

Although not every planar graph has a convex drawing, Tutte showed that every 3-connected planar graph has a convex drawing, and obtained a necessary and sufficient condition for a plane graph to have a convex drawing [5]. Furthermore, he gave a "barycentric mapping" method for finding a convex drawing of a plane graph, which requires solving a system of *O(n)* linear equations [6]. The system of equations can be solved either in *O(n3)* time and *O(n2)* space using the ordinary Gaussian elimination method, or in *O(n1.5)* time and *O(n* log *n)* space using the sparse Gaussian elimination method [LRT79]. Thus the barycentric mapping method leads to an *O(n1.5)* time convex drawing algorithm for planar graphs. In this chapter we first give a lemma for a face is drawn as convex polygon or not. Then using that lemma finally we device a linear time algorithm to examine whether a planar graph has convex drawing or not.

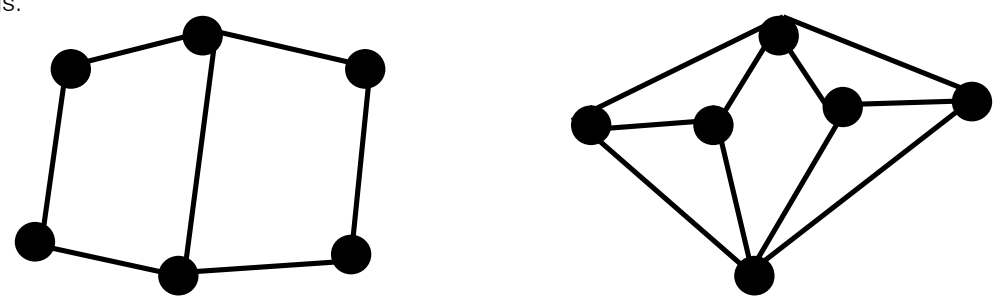

Figure 1.1 : Convex drawing of planar graph

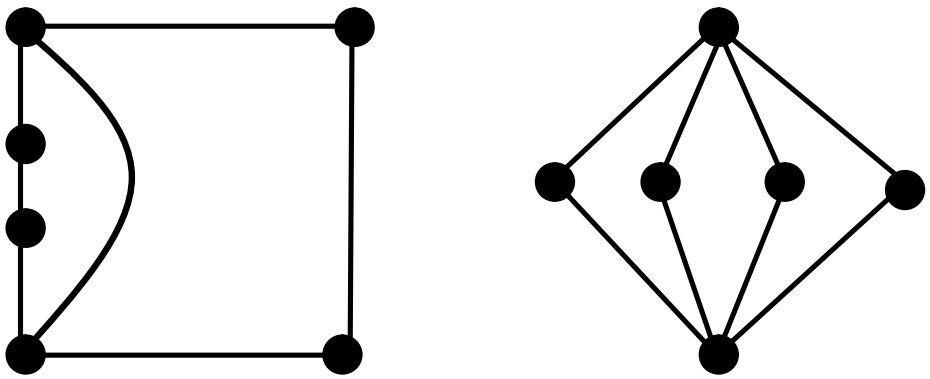

Figure 1.2 : Non convex drawing of planar graph

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II. Definition

By extensively examining the characteristics of convex drawing of a planar graph we derive a lemma for examining whether a planar graph has convex drawing or not. Before introducing the lemma we need to define some terms.

a) Convex Drawing of Planar Graph

A straight line drawing of a planar graph G is called a convex drawing if the boundaries of all faces of G are drawn as convex polygons [8]. Figure 3.3 depicts a convex drawing of a planar graph.

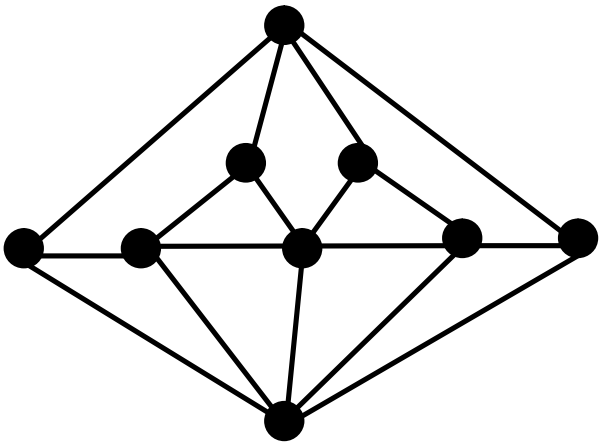


Figure 2.1 : Convex drawing of a planar graph

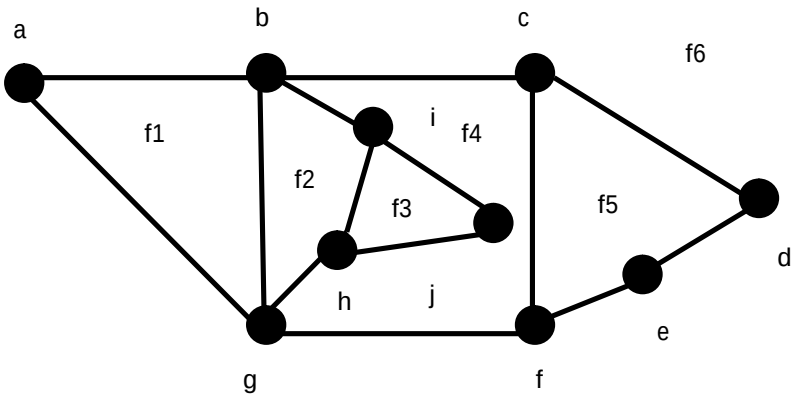


Figure 2.2 : A planar graph with six faces

It is easy to see from above graph that deg f_1=3, deg f_2=4, deg f_3=3, deg f_4=7, f_5=4. Note that the sum of all the degrees of the faces is equal to twice the number of edges in the graph, since each edge either borders two different faces (such as bg , cd, and cf) or occurs twice when walk around a single face (such as ab and gh). The Euler's formula relates the number of vertices, edges and faces of a planar graph. If n, m, and f denote the number of vertices, edges, and faces respectively of a connected planar graph, then we get n-m+f = 2.The Euler formula tells us that all plane drawings of a connected planar graph have the same number of faces namely, 2+m-n.

b) Face

If G is a planar graph, then any plane drawing of G divides the plane into regions, called faces [9]. That is, a face is an area bounded by the edges .One of these faces is unbounded, and is called the infinite face. If f is any face, then the degree of f (denoted by deg f) is the number of edges encountered in a walk around the boundary of the face f. If all faces have the same degree (g, say), the G is face-regular of degree g. For example, the following graph G depicts in Figure 3.4 has six faces, f6 being the infinite face.

III. Theorem

(Euler's Formula) Let G be a connected planar graph, and let n, m and f denote, respectively, the numbers of vertices, edges, and faces in a plane drawing of G. Then n-m + f = 2.

Proof We employ mathematical induction on edges, m. The induction is obvious for m=0 since in this case n=1 and f=1. Assume that the result is true for all connected plane graphs with fewer than m edges, where m is greater than or equal to 1, and suppose that G has m edges. If G is a tree, then n=m+1 and f=1 so the desired formula follows. On the other hand, if *G* is not a tree, let e be a cycle edge of G and consider G-e.

The connected plane graph *G-e* has n vertices, m-1 edges, and f-1 faces so that by the inductive hypothesis,

$$n- (m-1)+ (f-1)=2$$

Which implies that?

$$n- m+ f=2$$

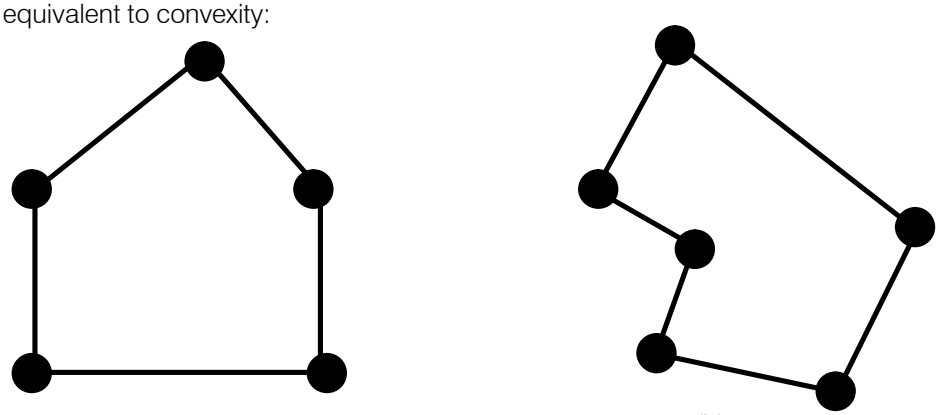
(Proved)

a) Convex polygon

A *convex polygon* is a simple polygons whose interior is a convex set [8]. The following properties of a simple polygon are all equivalent to convexity:

- Every internal angle is less than 180 degrees.
- Every line segment between two vertices remains inside or on the boundary of the polygon.

A simple polygon is *strictly convex* if every internal angle is strictly less than 180 degrees. Figure 3.5(a) and (b) depicts a convex and non-convex polygon respectively.



(a) (b)

Figure 3.1 : (a) A convex polygon and (b) non-convex polygon

(b) Lemma

A face is drawn as convex polygon if and only if the cross products of adjacent edges of each vertex of that face are same sign.

Proof

Let, a face is assumed to be described by N vertices ordered by,

$$v_0(x_0, y_0), v_1(x_1, y_1), v_2(x_2, y_2), \ldots v_{n-1}(x_{n-1}, y_{n-1})$$

Figure 3.6 (a) and (b) depicts a face in clockwise and anti-clockwise vertex ordering respectively. A simple test of vertex ordering for examining a face is drawn as convex polygon is based on considerations of the cross product between adjacent edges of each vertex of that face. If the cross product is positive then it rises above the plane (z axis up out of the plane) and if negative then the cross product is into the plane.

$$\text{cross product} = ((x_i - x_{i-1}), (y_i - y_{i-1})) \times ((x_{i+1} - x_i), (y_{i+1} - y_i))$$

$$= (x_i - x_{i-1}) * (y_{i+1} - y_i) - (y_i - y_{i-1}) * (x_{i+1} - x_i)$$

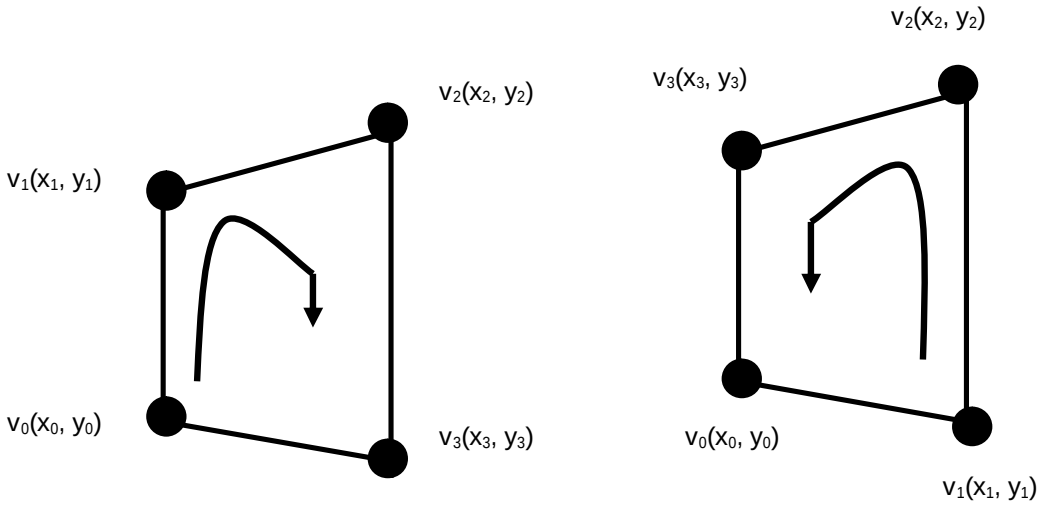


Figure 3.2 : A face in (a) clockwise and (b) anti-clockwise vertex ordering

Figure 3.2 (a) and (b) depicts the cross product sign of adjacent edges of each vertex face depicts in figure 3.2 (a) and (b) respectively.

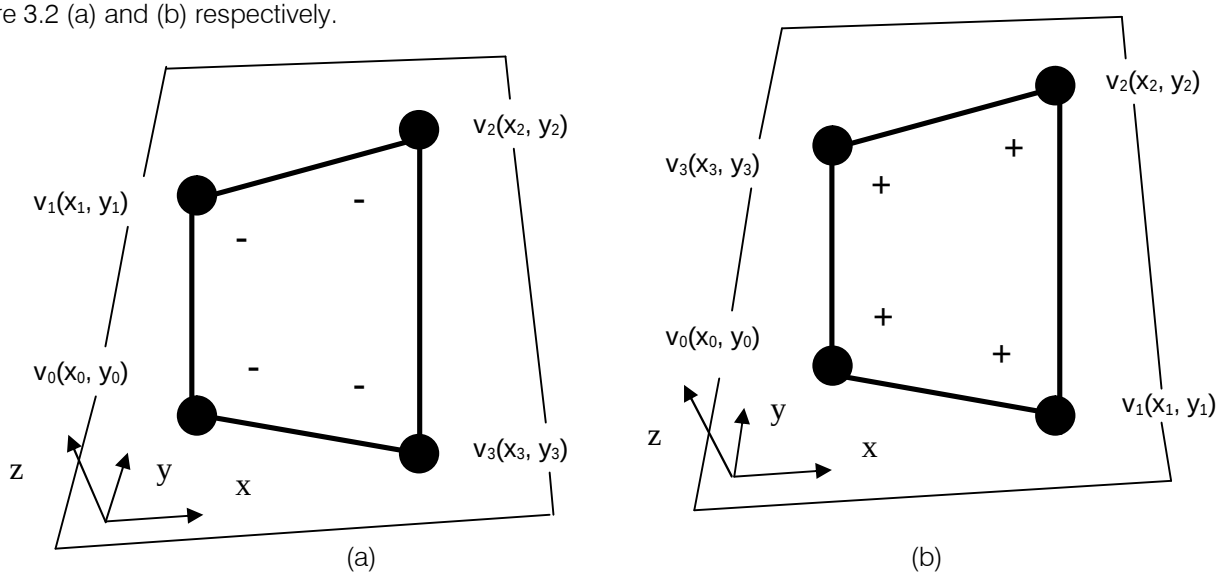


Figure 3.3 : (a) Cross products sign of adjacent edges in clockwise direction of convex face and (b) Cross products sign of adjacent edges in anti- clockwise direction of convex in the case of non convex face the cross product sign of adjacent edges of each vertex of that face depicts in figure 3.4(a) and (b)

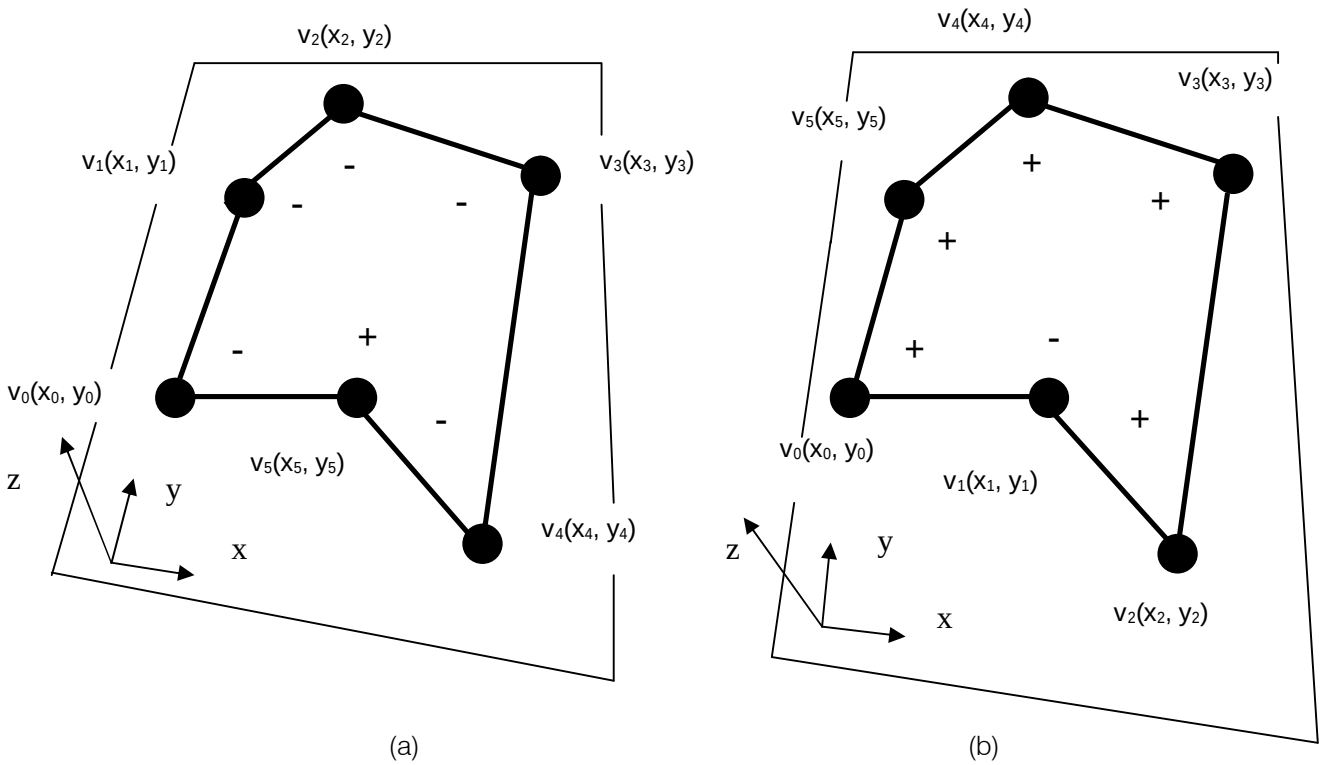
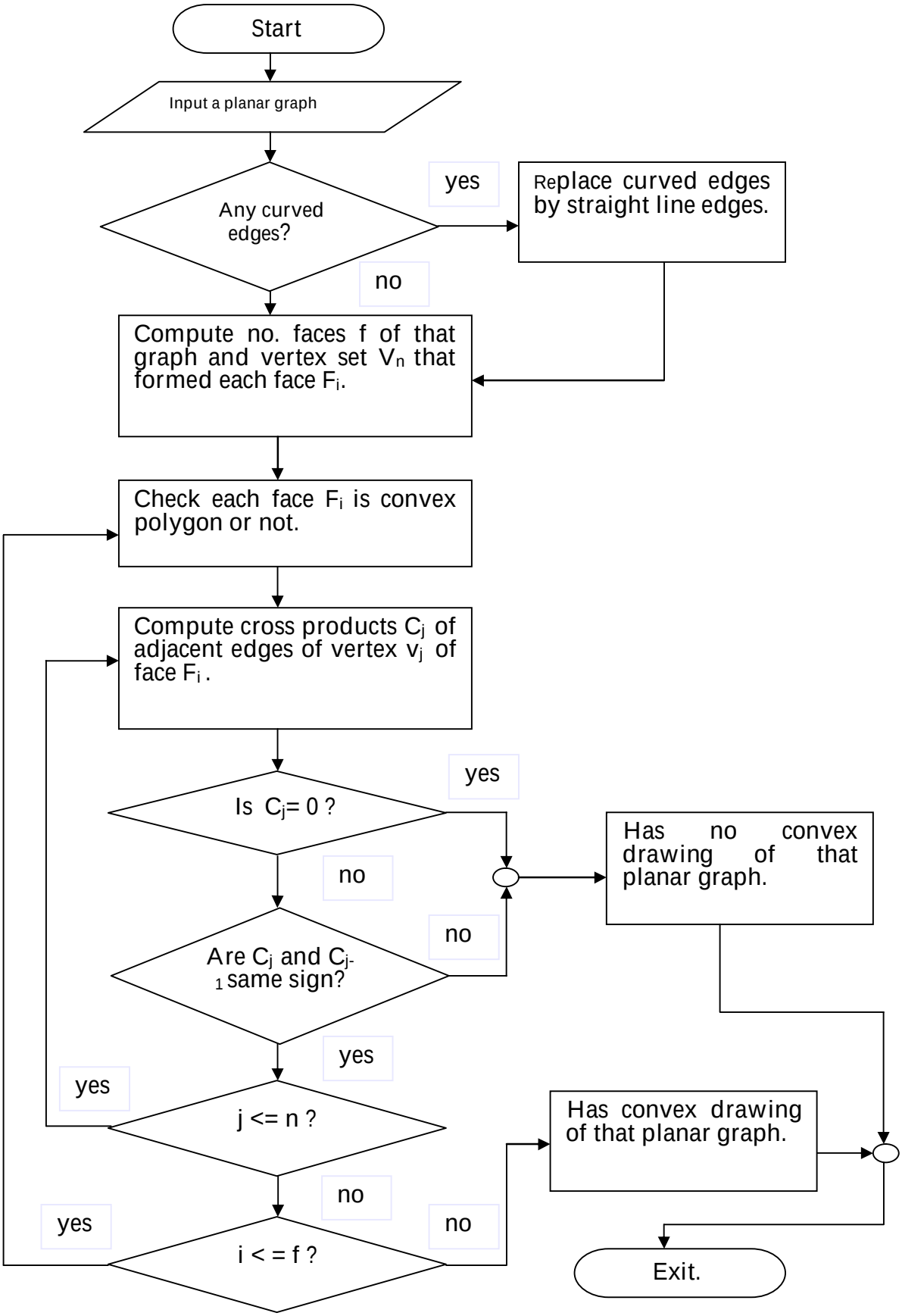


Figure 3.4 : (a) Cross products sign of adjacent edges in clockwise direction of non - convex face and (b) Cross products sign of adjacent edges in anti - clockwise direction of non-convex face

A non-convex face has mixture of cross products sign of adjacent edges of each vertex of that face. Hence, a face is drawn as convex polygon if and only if the cross products of adjacent edges of each vertex of that face are same sign.

[Proved]

(c) Flowchart : Convex_ Drawing (G)



(d) Algorithm: Convex_ Drawing (G)

Begin

Step 1: Check input planar graph has curved edges.
if (curved edges)
then replace curved edges by straightline edges.
else
go to step 2.
end if
Step 2: Compute no. faces f of that graph and vertex set V_n that formed each face F_i.
i.e. , $F_i = \{v_0, v_1, v_3 \ldots\ldots\ldots\ldots v_m\}$ where i=1 to f and m=0 to n.
Step 3. **3(a):** Check each face F_i is convex polygon or not.
for each face F_i where i=1 to no. of face f
do
j=0 to no. of vertex n to form that face F_i
compute cross product C_j of adjacent edges of vertex v_j.
cross product of adjacent edges of vertex v_j
$C_j = (Xj-Xj-1)*(Yj+1-Yj)-(Yj-Yj-1)*(Xj+1-Xj)$.
if (cross product $C_j = 0$)
then go to step 5.
else
go to step 3(b).
end if.
3(b): if (j=0)
then increment j by 1.
else
check cross product C_j and C_{j-1} are same sign.
if (cross product C_j and C_{j-1} are same sign)
then increment j by 1.
else
go to step 5.
end if
end if
end do
end for.
go to step 4.
Step 4: Has Convex drawing of that planar graph.
go to step 6.
Step 5: Has no convex drawing of that planar graph.
go to step 6.
Step 6: Exit.

End

IV. Conclusions

In this thesis we have studied the convex drawing of a planar graph. Not every planar graph has convex drawing. The results of this thesis are summarized as follows:

- We have derived a method for determining whether a face is drawn as convex polygon or not.
- Finally, using that method we develop a linear time algorithm for examining whether a planar graph has a convex drawing or not.

Some interesting directions in which the future research works can be done are as follows:

- We develop a linear time algorithm for examining whether a planar graph has a convex drawing or not. One can develop an algorithm for converting non-convex drawing of a planar graph to convex drawing.
- One can develop a convex grid drawing of a planar graph on an (n-2) x (n-2) grid.

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Novel Color Image Compression Algorithm Based on Quad tree

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Abstract - This paper presents a novel algorithm having two image processing systems that have the ability to compress the colour image. The proposed systems divides the colour image into RGB components, each component is selected to be divided. The division processes of the component into blocks are based on quad tree method. For each selection, the other two components are divided using the same blocks coordinates of the selected divided component. In the first system, every block has three minimum values and three difference values. While the other system, every block has three minimum values and one average difference. From experiments, it is found that the division according to the G component is the best giving good visual quality of the compressed images with appropriate compression ratios. It is also noticed, the performance of the second system is better than the first one. The obtained compression ratios ofthe second system are between 1.3379 and 5.0495 at threshold value 0.1, and between 2.3476 and 8.9713 at threshold value 0.2.

GJCST-F Classification : I.4.2

Strictly as per the compliance and regulations of:

Novel Color Image Compression Algorithm Based on Quad tree

A. A. El-Harby [α] & G. M. Behery [α]

Abstract - This paper presents a novel algorithm having two image processing systems that have the ability to compress the colour image. The proposed systems divides the colour image into RGB components, each component is selected to be divided. The division processes of the component into blocks are based on quad tree method. For each selection, the other two components are divided using the same blocks coordinates of the selected divided component. In the first system, every block has three minimum values and three difference values. While the other system, every block has three minimum values and one average difference. From experiments, it is found that the division according to the G component is the best giving good visual quality of the compressed images with appropriate compression ratios. It is also noticed, the performance of the second system is better than the first one. The obtained compression ratios ofthe second system are between 1.3379 and 5.0495 at threshold value 0.1, and between 2.3476 and 8.9713 at threshold value 0.2.

I. Introduction

Many modern imaging systems are still producing gray-scale images, color images are more preferred due to the larger amount of information contained by them [1]. There are many compression systems were used to compress the color images; these systems include those that use mathematical transforms such as Discrete Cosine Transform (DCT) transform [2-4], neural networks [5-8], wavelet transform [9-11], fractal [12-14], quad tree systems [15-17], and others [18-22]. Data compression provides two advantages: reducing storage space and transmission time by finding the humanly imperceptible differences [23-24].

The quad tree algorithms are based on simple averages and comparisons. Quad-tree image compression is a method for splitting an image into homogenous sub-blocks. Defining the whole image as a single block, the method is performed according to some problem specific homogeneity criteria. Each block is examined to check whether it is homogenous or not. If it is not, then it will be split into four same-sized blocks. The method terminates when there is no other blocks to be split or when all blocks to be split are smaller than a pre-selected size. The minimum size of the blocks is set, to avoid over segmentation [25-28].A major advantage of the quad tree system for data compression is the simplicity of its approach. Unlike many other compression systems, a quad tree algorithm can compress images relatively quickly on a personal computer [29, 30].

Usually, distortion in images is measured by the PSNR (Peak-to-peak Signal to Noise Ratio). This ratio is often used as a quality measurement between the original and a compressed image. There is no standard way of defining distortion and PSNR for color images. The simplest way is to just average the distortions of the three RGB color components [31, 32].

In this paper, an algorithm is applied on color images. The remainder of this paper is organized as follows: in Section 2, the proposed algorithm is illustrated. Experimental results and discussion are presented in Section 3 and finally, some conclusions are addressed in Section 4.

II. Proposed Algorithm

This algorithm contains two systems based on quad tree. Each one contains three different cases. The RGB color images are represented by three components. In gray-scale image there is a high correlation between neighbor pixels. In color image, in addition to this, there is also a high correlation between color components [2,3]. Therefore, the proposed systems are applied on the all components altogether. In the first system, one component is chosen to be divided using quad tree at specified threshold value. During the dividing of this component, even if the condition of quad tree division is not verified for the other two components, they are divided simultaneously using the same coordinates and block size of the chosen component. The condition is represented by difference value is greater than threshold value. There are three cases of this system are described as follows:

1. The image is divided according to the component R using quad tree. At the same time, the dividing process is applied on the other two components G and B respectively. After the dividing is completed, the three components will have the same numbers, sizes, and coordinates of all blocks.
2. This case is similar to the first one, except, the image is divided according to the second component G, and the dividing process is applied on the other two components R and B respectively.
3. The third case is similar to the previous two cases, except, the image is divided according to the third

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component, and the dividing process is applied on the other two components R and G respectively.

In each case, the image is divided giving the following information for the three components: number of blocks, sizes, minimum value and difference between maximum and minimum values for each block. The three components have the same coordinates and sizes for all blocks. In the three components, any block has three min values and three diff values, one for each component.

The second system is similar to the first one including the above three cases, except, the three difference values are averaged for each block. The obtained information of every block is one coordinates, one size, three minimum values and one average difference value. The two systems are illustrated in details in the next sub section.

Several quality measures can be found in the open literature of the field. The most used measures are (distortion evaluation): The mean squared errors (MSE) and the popular peak signal to noise ratio (PSNR) [2].With gray level images, the PSNR is expressed by:

$$\mathrm{PSNR} = 10 \times \log_{10} \frac{255^2}{MSE} \quad (1)$$

While, for color RGB images case [32], we have used the relation given in

$$\mathrm{PSNR} = 10 \times \log_{10} \left(\frac{255^2 \times 3}{MSE(R) + MSE(G) + MSE(B)} \right) \quad (2)$$

$$MSE = \frac{1}{N \times M} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \left(\mathrm{X}_{ij} - \mathrm{y}_{ij} \right)^2 \quad (3)$$

and, : are, respectively, the original and reconstructed intensities belonging to R, G or B component. The compressed image is evaluated with the compression ratio (CR) or withthebite-rateperpixel(bpp) defined as follows:

$$\mathrm{CR} = \frac{\text{Original RGB color image size in bits}}{\text{Compressed image in bits}} \quad (4)$$

$$\mathrm{bpp} = \frac{24 \text{ bits}}{\mathrm{CR}} \quad (5)$$

a) Example

This example is proposed to describe the processes of the two systems. The example is applied on a sample of color image for size 8x8x3. The R component is firstly chosen to be divided using quad tree. The other two components will be divided using the same coordinates and block size of the chosen divided component, even if the condition of quad tree division is not verified for one or both components. In the first system, each block has three min values and three difference values, one for each component. For instance, the block of coordinates (4, 0) has the three minimum values (80, 25, and 11) and the three difference values (5, 77, and 6), see Fig. 1 and table 1 for more details. While, the second system has three minimum values and one average difference. The above mentioned block of coordinates (4, 0) has the same three minimum values and one average difference value (29), see Fig. 2 and table 1 for other details.

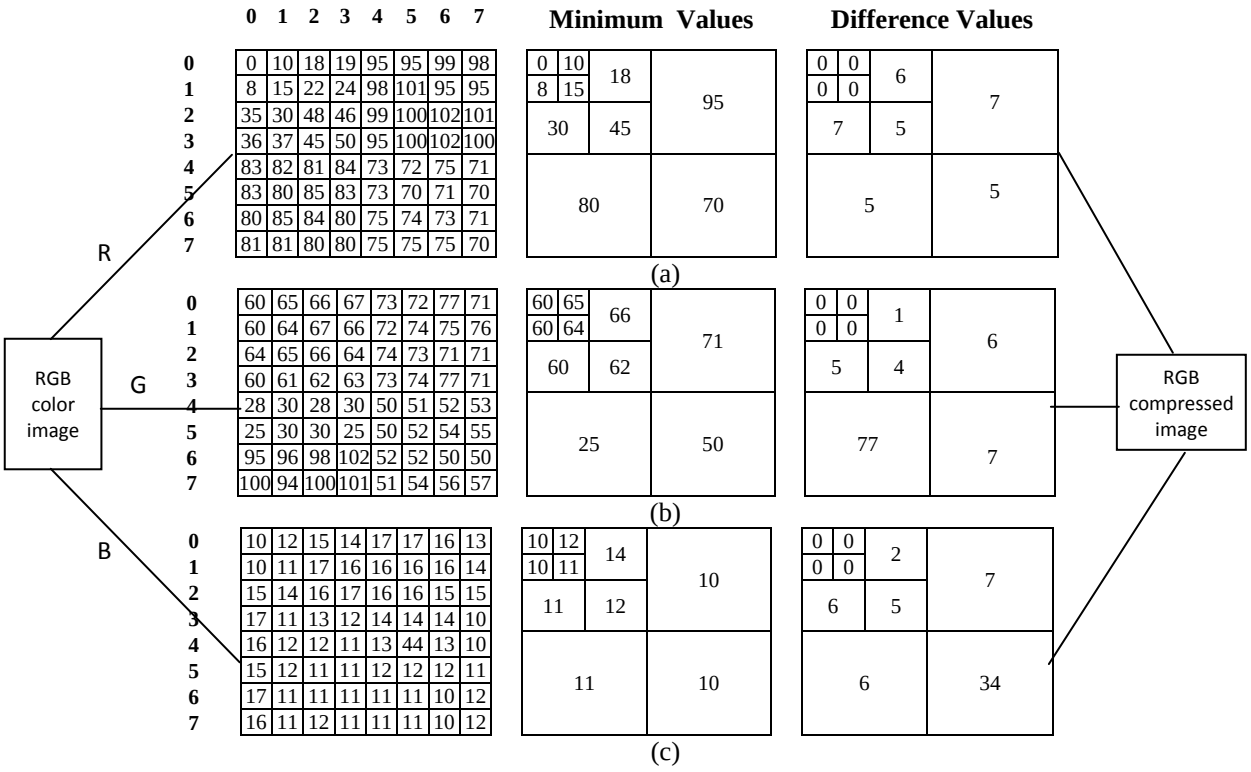

Fig. 1 : Diagram shows the processes of the first system

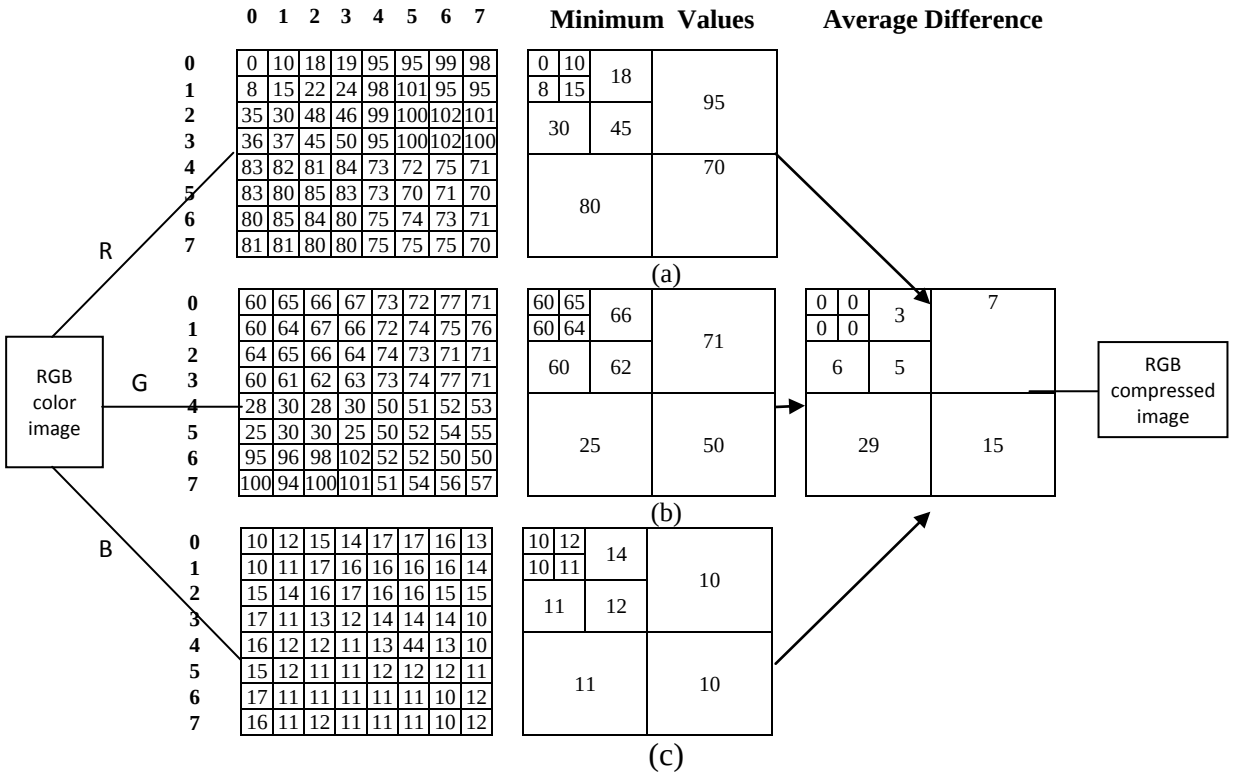

Fig. 2 : Diagram shows the processes of the second system

Table 1 : The obtained results of the two systems

Top-left Coord.	Size	Minimum values of both systems			Difference values of first system			Average difference of second system
		R	G	B	$S1_R$	$S1_G$	$S1_B$	
(0,0)	1	0	60	10	0	0	0	0
(0,1)	1	10	65	12	0	0	0	0
(1,0)	1	8	60	10	0	0	0	0
(1,1)	1	15	64	11	0	0	0	0
(0,2)	2	18	66	14	6	1	3	3
(2,0)	2	30	60	11	7	5	6	6
(2,2)	2	45	62	12	5	4	5	5
(0,4)	4	95	71	10	7	6	7	7
(4,0)	4	80	25	11	5	77	6	29
(4,4)	4	70	50	10	5	7	34	15

III. Experimental Results and Discussion

In order to test the performance of the two proposed systems, they are applied using the same settings on four famous color images. These images are called Splash, Lena, Sailboat, and Pepper; see Fig. (3).The dimension and the size of each image are 512x512x3 and 786432 bytes respectively. Ninety six experiments are done using the two systems, twenty four on each image. The first forty eight experiments are carried out using the first system; the threshold values are 0.1, 0.2, 0.3 and 0.5. The obtained results are shown in the first three columns of Figures (4-7). The columns S1R, S1G, and S1B represent the three components of the color image for the first system.

The other forty eight experiments are carried out using the second system using the same threshold values that are proposed with the first system. The obtained results are shown in the second three columns of the Figures (4-7). The columns S2R, S2G, and S2B are represented for the second system. The compression ratio is obtained by dividing the size of the original image file by the size of the compressed output file. From the above experiments of the two systems, Tables (2-5) show the obtained compression ratios, bpp, PSNR and number of blocks in the compressed images. All programs are written using the Matlab software.

From figures (4-9) and Tables (2-5), it can be seen the following:

- In the two systems, the number of blocks decreases when the original image has low details (for instance Splash image); see Table 5 and Figure (9).
- In the first system, the compression ratio is ranged between 1.0406:1 and 79.7275:1, while with the second system, the compression ratio is between 1.3379:1 and 102.5068:1. It is seen that the second system has the highest compression ratio.
- In the first system, the bpp is rangedbetween 23.0633 and 0.3010, while with the second system, the bpp is between 17.9381 and 0.2341. It is seen that the second system has the lowest bpp value.
- In the first system, the PSNR is rangedbetween 16.7784 and 10.7710, while with the second system, the PSNR is between 16.0773 and 15.5210.
- The visual quality of the compressed images and PSNR values are inversely proportional tothe compression ratio; see figures (4-7).
- In the two systems, the compression ratios increase when the original image has low details (for instance Splash image); see table 2 and Figure (8).
- The compressed images quality increase when the image is divided according to the component G.
- The compression ratios are proportional to the threshold values.

In Table 6, is presented comparative results among our proposed two systems and others, compression ratio is measured in terms of bpp and the image quality in terms of PSNR.

Fig. 3 : Original images

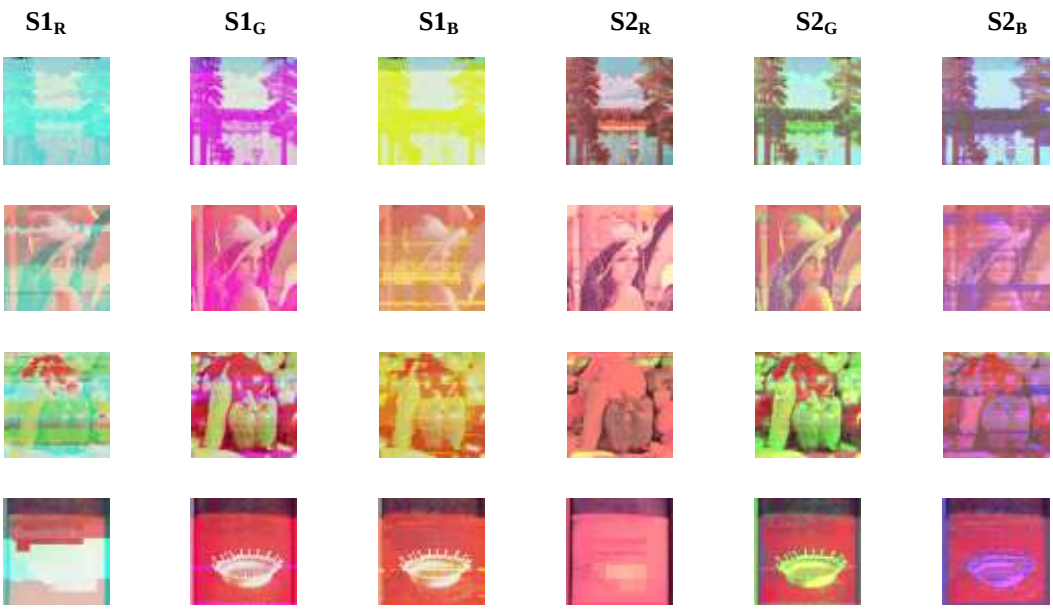

Fig. 4 : The compressed images at threshold = 0.1

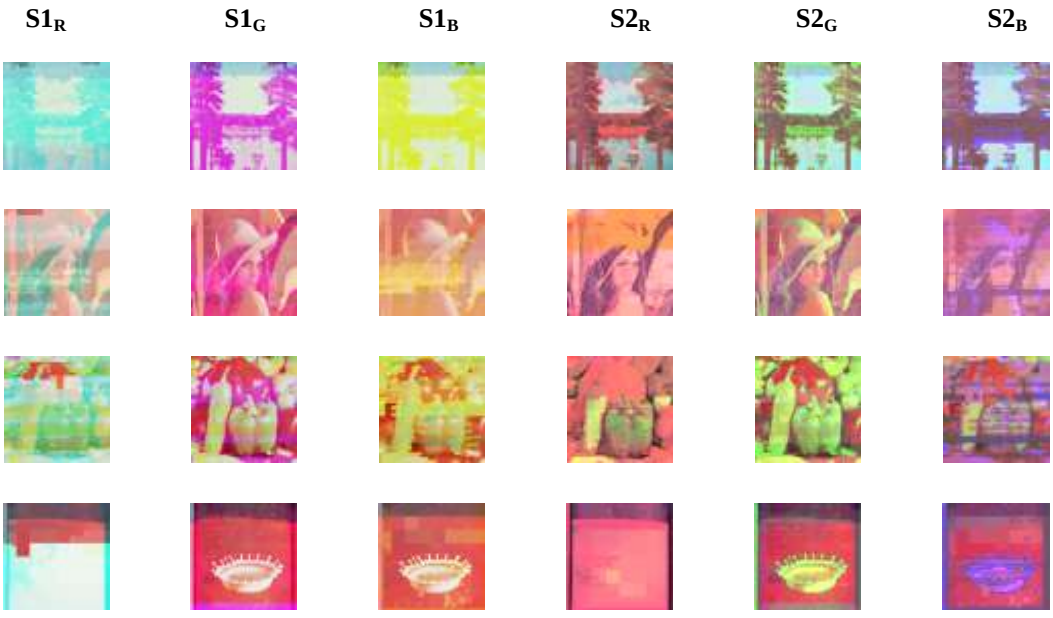

Fig. 5 : The compressed images at threshold = 0.2

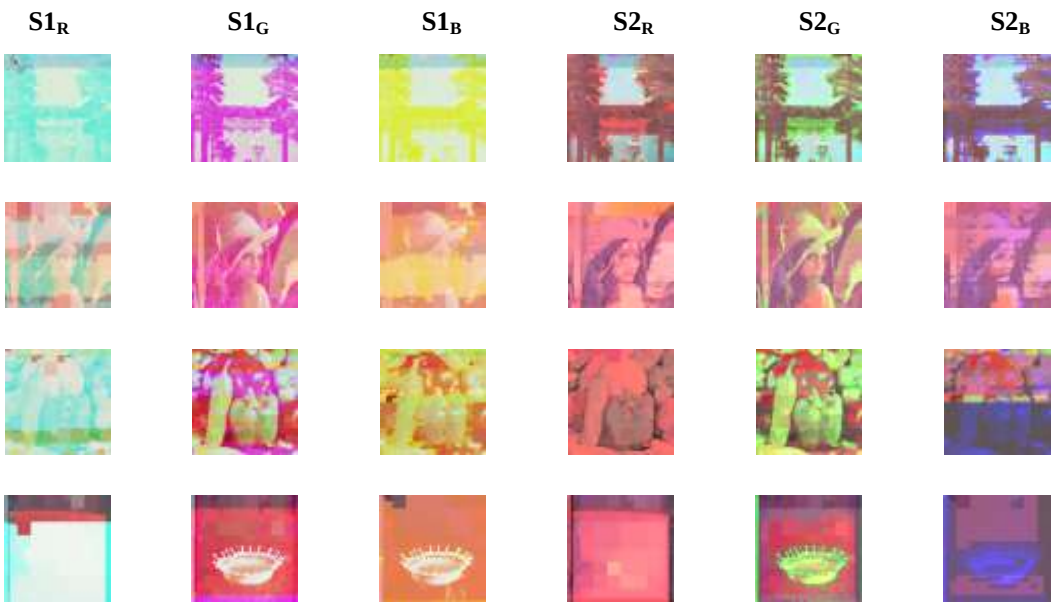

Fig. 6 : The compressed images at threshold = 0.3

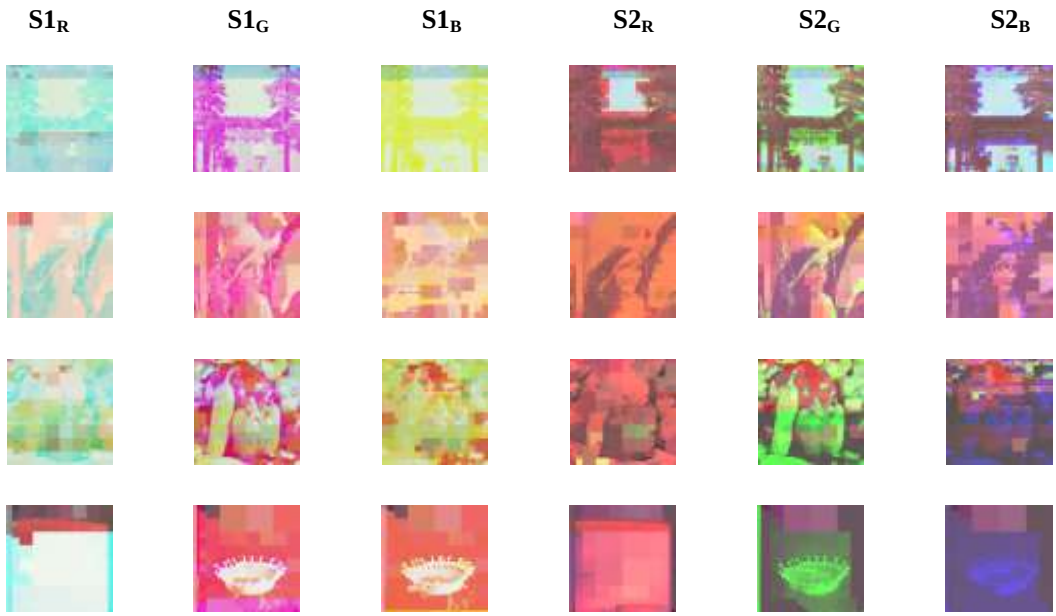

Fig. 7 : The compressed images at threshold = 0.5

Table 2 : The Compression ratios of the two systems

Image Name	Threshold = 0.1						Threshold = 0.2					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	1.5116	1.0406	1.2258	1.9435	1.3379	1.5760	3.5637	1.8259	1.9948	4.5819	2.3476	2.5648
Lena	2.9091	2.0848	2.3798	3.7403	2.6804	3.0597	5.9953	4.1028	5.1169	7.7082	5.2750	6.5789
Peppers	2.4177	2.1072	2.3802	3.1085	2.7093	3.0602	5.4146	3.7929	4.7747	6.9617	4.8766	6.1389
Splash	7.9207	3.9274	5.1788	10.1838	5.0495	6.6584	12.3142	6.9777	7.8694	15.8325	8.9713	10.1177

Image Name	Threshold = 0.3						Threshold = 0.5					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	9.8892	3.3950	3.5593	12.7147	4.3650	4.5763	36.5765	6.9000	7.4260	47.0270	8.8714	9.5477
Lena	15.1915	8.5660	12.1599	19.5319	11.0134	15.6342	39.1318	20.8299	46.5785	50.3123	26.7813	59.8867
Peppers	11.5844	6.3137	9.6789	14.8943	8.1176	12.4443	26.4471	10.8226	24.5109	34.0035	13.9147	31.5140
Splash	23.0740	10.7427	11.5021	29.6666	13.8121	14.7884	79.7275	17.5429	23.2583	102.5068	22.5552	29.9035

Table 3 : The bite-rate per pixel of the two systems

Image Name	Threshold = 0.1						Threshold = 0.2					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	15.8774	23.0633	19.5796	12.3491	17.9381	15.2285	6.7346	13.1443	12.0311	5.2380	10.2234	9.3575
Lena	8.2499	11.5120	10.0849	6.4166	8.9538	7.8438	4.0031	5.8497	4.6903	3.1136	4.5497	3.6480
Peppers	9.9267	11.3893	10.0833	7.7208	8.8583	7.8425	4.4324	6.3276	5.0265	3.4474	4.9214	3.9095
Splash	3.0300	6.1109	4.6343	2.3567	4.7529	3.6045	1.9490	3.4395	3.0498	1.5159	2.6752	2.3721

Image Name	Threshold = 0.3						Threshold = 0.5					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	2.4269	7.0692	6.7429	1.8876	5.4982	5.2444	0.6562	3.4783	3.2319	0.5103	2.7053	2.5137
Lena	1.5798	2.8018	1.9737	1.2288	2.1792	1.5351	0.6133	1.1522	0.5153	0.4770	0.8961	0.4008
Peppers	2.0717	3.8013	2.4796	1.6114	2.9565	1.9286	0.9075	2.2176	0.9792	0.7058	1.7248	0.7616
Splash	1.0401	2.2341	2.0866	0.8090	1.7376	1.6229	0.3010	1.3681	1.0319	0.2341	1.0641	0.8026

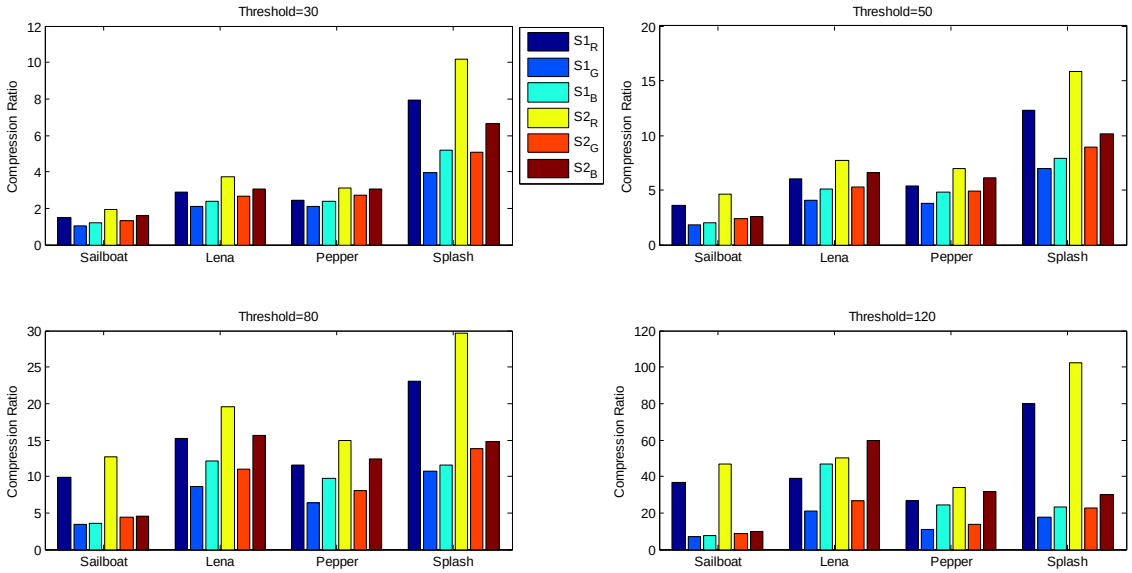

Fig. 8 : The compression ratios of the two systems at the proposed threshold values

Table 4 : PSNR for two systems

Image Name	Threshold = 0.1						Threshold = 0.2					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	15.4361	16.7784	16.7262	18.8796	16.0773	15.9801	13.7661	15.0063	15.0697	17.4199	16.3393	16.1908
Lena	18.7293	19.6201	18.9964	16.4421	17.5186	16.9536	16.8739	19.3587	17.0483	16.8418	18.2939	16.8419
Peppers	16.7775	20.0167	18.9491	15.2504	17.6726	14.8351	15.0769	17.5252	17.2620	15.6042	16.9327	15.4747
Splash	16.7762	22.3761	21.5052	15.5125	17.8204	17.0871	14.1374	19.5457	18.8715	15.4450	18.1920	15.7507

Image Name	Threshold = 0.3						Threshold = 0.5					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	11.8527	13.5657	13.3850	16.5140	16.6293	16.3797	10.5626	12.1440	11.7933	15.0449	17.0646	16.6874
Lena	14.8542	17.0269	14.6512	16.8986	17.7427	16.9181	12.1920	14.7676	12.8821	18.3826	17.3689	17.0477
Peppers	12.2413	15.9231	15.3282	15.2964	16.9355	14.6655	11.5015	14.2065	13.5195	15.8796	16.2712	14.6080
Splash	11.6013	17.3963	15.7024	15.4722	16.7581	13.3793	10.7710	13.7554	14.7283	15.5210	13.8537	13.0139

Table 5 : The number of blocks for the two systems

Image Name	Threshold = 0.1						Threshold = 0.2					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	30528	59800	50796	30528	59800	50796	7548	27240	27416	7548	27240	27416
Lena	13972	22924	19012	13972	22924	19012	3912	8368	6536	3912	8368	6536
Peppers	15556	22676	17548	15556	22676	17548	5612	10448	6888	5612	10448	6888
Splash	4068	9248	8416	4068	9248	8416	2592	5940	5720	2592	5940	5720

Image Name	Threshold = 0.3						Threshold = 0.5					
	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$	$S1_R$	$S1_G$	$S1_B$	$S2_R$	$S2_G$	$S2_B$
Sailboat	1084	9212	11152	1084	9212	11152	148	1756	1784	148	1756	1784
Lena	620	2324	1536	620	2324	1536	32	432	64	32	432	64
Peppers	2032	4964	2348	2032	4964	2348	732	2216	588	732	2216	588
Splash	1252	3868	3496	1252	3868	3496	380	1820	1136	380	1820	1136

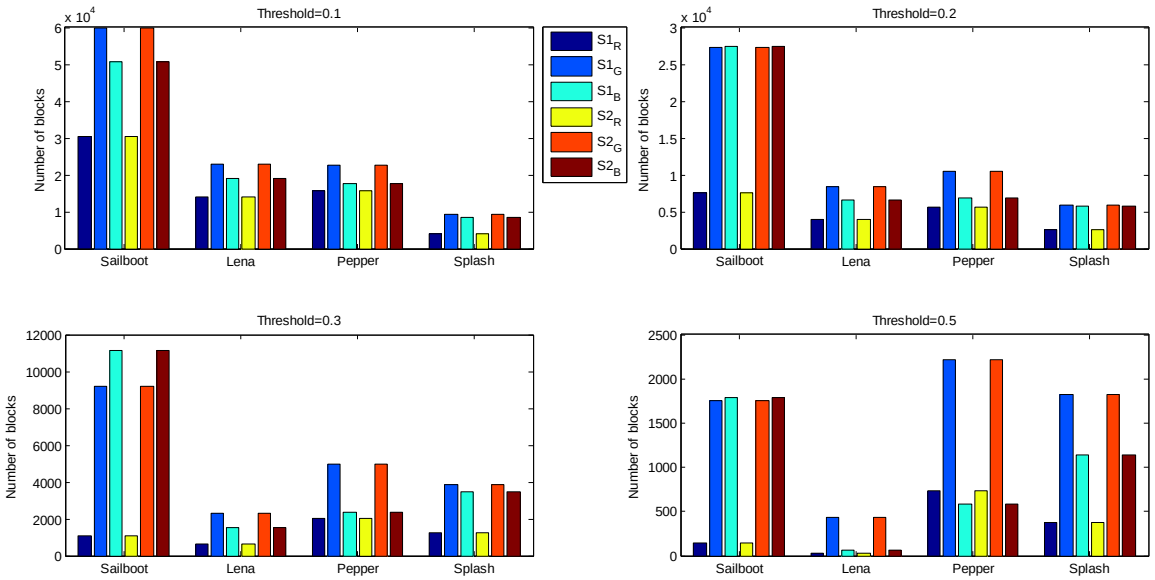

Fig. 9 : The number of blocks for the two systems at the proposed threshold values

Table 6 : Comparison between the proposed systems and others

Image	Proposed				Other Systems							
	System1		System 2		YCbCr [2]		CBTC-PF[32]		JPEG [32]		NNET [33]	
	PSNR	bpp	PSNR	bpp	PSNR	bpp	PSNR	bpp	PSNR	Bpp	PSNR	bpp
Lena	17.0483	0.5153	16.8419	0.4008	31.97	0.8101	31.93	1.17	32.7729	1.0073	21.9876	5.8
Pepper	11.5015	0.9075	15.8796	0.7058	30.059	0.809	30.15	1.5	30.47	1.47	---	---

IV. Conclusion

This paper presents two efficient systems that have the ability to compress colour images in easy way. The division processes of image into blocks for the two systems are based on quad tree. At the dividing of one component, the other two components are divided using the same division even if the condition of quad tree division is not verified for them. After the division process is completed, the three components will have the same number and size of blocks. During the experimental results, the compression ratios, bit rate per pixel and PSNR are computed. The compression ratios of images are increased by increasing the value of threshold while the quality of the compressed images may be decreased. It was also noticed, the division according to the G component is the best giving good quality of the compressed images with appropriate compression ratios, and the performance of the second system is better than the first one. The compression ratios of the second system are ranged between 0.25 and 0.80 at threshold value 0.1, and between 0.78 and 0.94 at threshold value 0.2.

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Classifying of Human Face Images Based on the Graph Theory Concepts

By Jassim T.Sarsoh, Kadhem M.Hashem & Mohammed A.Al-Hadi

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Abstract - The purpose of this paper is to propose an effective clustering algorithm. The principle idea of this algorithm depends on the graphic theory by using the terms and definitions of the graph and the tree. The proposed algorithm was applied on different human face images taken from ORL database, and it gives good clustering results with small rate of error. Matlab version (8) was used to implement this algorithm.

Keywords : *Image Processing ,Graph Theory ,Face Recognition ,Clustering, Neighborhood.*

GJCST-F Classification : *I.4.8*

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I. Introduction

We can recognize different human beings by looking at their faces. To identify an individual, we look at his external face characteristic .We can recognize many faces after several years of separation by comparing their faces outlines characteristics [1, 2].

The evolution of computer science aided the researchers to recognize human beings from their faces by using different techniques in the field of image processing and clustering [3, 4, 5].

Clustering is a grouping of data into clusters of similar objects. Each cluster consists of objects that are similar to each other and dissimilar with the objects of other clusters. Clustering technique represents many data by few clusters and hence, it models data by its cluster in spite of losing certain fine details [6]. The proposed algorithm is clustering algorithm that uses concepts of the graph theory. It classifies the given data into many disjoint clusters by represent each cluster by a tree, and these trees construct a forest (partition). Practically this algorithm is applied to classify the face image of each person of the studied data in one tree. We notice that there is small rate of error in the clustering of the studied data.

II. Clustering Techniques [5,6,7]

Clustering is the classification of given objects into groups (clusters), or more precisely, partitioning of the data set into subsets (clusters) so that the data in each cluster shares some common features, after proximity according to some defined distance measures. Clustering plays an important role in our life, since we encounter a large number of data needed to logical interpretation. This interpretation can be done by classifying these data into a set of categories or clusters. There are many different ways to express and formulate the clustering problems. As a consequence, the obtained results and their interpretations depend strongly on the used way.

The clusters type as follows:

- Exclusive (hard) cluster so that every object must belong to only one cluster.
- Overlapping (fuzzy) cluster so that one object may fall into several clusters.
- Probabilistic clusters so that an object belongs to each cluster with certain probability.
- Hierarchical clusters such that there is a crude division of objects into groups at high level that is further refined into finer level.

The proposed algorithm uses some terms and definitions of the graph theory. The clustering of the given objects depends on the real structure of these objects. In fact, some of the studied objects may be roots of the trees (clusters) that construct a forest (partition) which contains all these objects such that these objects are distributed into different disjoint trees of that forest according to some conditions. If an object **y** attracts another object **x** in order to be in same tree then **y** is called the classifier of **x** .The attraction process between the studied elements may be as follow:

- Each root of any tree must be the classifier of its successors (children).
- In general, each vertex of any tree is the classifier of its successors (children).
- For each vertex **x,** there is only one classifier (father).
- There is no classifier for the root of any tree.
- If **x, y** are two vertices at the same level, then neither **x** is classifier of **x**, nor **y** is classifier of **x**.

III. Neighborhood [8,9]

Neighborhood operation plays an important role in clustering techniques and digital image processing. The proposed method used the neighborhood operation through its implementation.

There are many ways to express the neighborhood term .We notice in the literature three types of the neighborhood operation: K_nearest neighbor, δ_nearest neighbor, and adaptive neighbor.

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- K_nearest neighbors mean that for each individual of the studied population, we must propose a positive integer **k** which determines the **k** individual which must be the nearest for any given individual.
- δ_nearest neighbors mean that for each individual of the studied population this individual is supposed as a center of a circle (ball) of radius δ, then the δ_nearest neighbor of that individual are all the individuals of the studied population whose locations are either inside or on this circle (ball).

Adaptive_neighborhood means that we must use an adaptive threshold such each individual of the studied population must have its specific adaptive threshold . In fact, using a constant threshold for all the studied individual in the clustering techniques many give good clustering results, but these results may not be the best. This especially, in case there where a real structure of the studied data that contains many groups that distributed in small regions while some other groups, were located in large regions, the adaptive neighborhood aids to give the best clustering.

In general, the adaptive neighborhoods must be used when the distribution of the studied individuals are not uniformly distributed in the plan (space).

IV. Some Concepts of Graph Theory

The following terms and definitions will be used in the proposed algorithm.

1. **Graph**: A graph G (V, E), consists of two sets V and E. V is a finite non empty set of vertices, E is a set of pairs of vertices, these pairs are called edges (arcs) of the graph There are two types of graphs:-
   - Undirected graph in which any pair of vertices represents an edge by using unordered pairs. The pairs (v1, v2) and (v2, v1) represent the same edge.
   - Directed graph in which each edge is represented by a directed pair such that (v1, v2). Thus, for the ordered pair (v1, v2) there exist only one directed arc from the vertex v1 to the vertex v2.
2. **Tree**: A tree is a directed graph which has the following properties:
   - It has a special vertex R called the root of the tree. R has no precedent vertex (father) and it has one or many successors (children).
   - There is no cycle in each vertex of the tree, and there is no cycle between its other vertices.
   - It has one or many terminal vertices, such that each one has only one precedent (father) and it has never successors (children). These vertices are called the leaves of the tree.
   - Each an intermediate vertex (neither root nor leaf) must have only one precedent and one or many successors.
   - There is never connection between the vertices in the same level of the tree.
3. **Forest**: A forest is the union of the disjoint trees concerned the studied data.
4. **Isolated vertex**: An isolated vertex is any vertex in the graph which does not connect with any other vertices of the graph. Thus, isolated vertex has never neighborhood

V. Graph Representation of the Proposed Method

Each individual of the studied population is represented by a vertex and between any two vertices (except the isolated vertices) there exits an edge according to some conditions. In order to classify the given data, we must compute the adaptive neighborhood for each vertex. The vertices which have never neighborhood are supposed as isolated vertices in the forest. Each no isolated vertex is either a root, a leaf, or an intermediate vertex.

The root is a special vertex which has not classifier (father) and may have one or many successors (children), each leaf of a tree has one classifier and it has never successors, while each vertex which is neither root nor leaf must have one classifier (father) and may have one or many successors. At the end of the execution of the proposed algorithm, some disjoint trees will be noticed and each tree represents its specific cluster.

VI. Related Works

In the literature, many papers was found in the field clustering of the human face images. The following are samples of clustering methods that are using the neighborhood operation:

- A clustering algorithm is proposed with some assistant algorithms to classify many different human face images with different rotation angles. It gives good results with small ratio of error [12].
- Another clustering algorithm was applied to classify some important parts of the human face images by using some important parts (regions) of the human face images. It was noticed that using eyes_ parts gives good clustering results. These results are better than using either the noses_ parts or the mouths _chins_ parts in clustering the same images [13].

VII. The Proposed Method

The basic idea of this method is to use the terms of the tree concepts to classify the individuals of the studied population. Each resulted cluster from this method represents a tree, and all the obtained trees will construct a partition (forest) where these trees are disjoint trees. An element **y** of the studied population is

called the classifier of the element x if y attracts **x**, and the two elements must belong to the same tree.

The following terms and definitions will be used in the construction of the proposed algorithm.

- E is the studied population(human face images)
- d(x,y) is the Euclidean distance between the two individuals **x** , **y** of the set E
- δ is the proposed constant threshold .
- V_δ (x)={ y/y ϵ E, d(x,y) $<$ δ) is the set of the neighborhood of the **x** w.r.t the constant threshold δ.
- Den(x) =cardinal (V (x)) is the density of **x** (number of neighborhood of **x** w.r.t the constant threshold δ.
- δ (x)= δ*den(x), is the adaptive threshold corresponding the individual **x.**
- $V^*(x)=V_{\delta(x)}(x)=\{ y/y \in E, d(x,y) < \delta(x)\}$, is the adaptive neighborhood of **x** w.r.t the adaptive threshold δ(x) .
- $Den^*(x) = den_{\delta(x)}(x) =$cardinal $(V^*(x))$, is the adaptive density of **x** w.r.t δ (x).

Algorithm

1. Pretreatment

For each x ϵ E, do the following:

- Determine its adaptive neighborhood $V^*(x)$
- Compute its adaptive density $den^*(x)$

2. Construction of forest trees

If $(den^*(x) = 1)$ then

X is supposed as an isolated individual in the graph.

Else

$\forall y \in V^*(x)$, $y \neq x$, compute the following:

- $\gamma_{xy} = (den^*(x) - den^*(y))/d(x,y)$
- $\gamma_x = \min \gamma_{xy}$, $y \in V^*(x)$

End if

If $(\gamma_x > 0)$ then

X is a root of tree.

Else if $(\gamma_x < 0)$ then

Search for an element w in $V^*(x)$ such that $\gamma_{xw} = \gamma_x$

Take w as the classifier of x (if there are many w such that $\gamma_{xw} = \gamma_x$ then choose one of them randomly)

Else

Define the following sets:

- T={ y/y $\in$ $V^*(x)$, and γ_{xy} =0}, where T=$\emptyset$ at the beginning of the execution.
- F= {z $\in$ T, and x is the classifier of z}.
- M=T-F.

If (M $\neq \emptyset$) then

Determine a such that d(x, a) =min (d(x,y), y ϵ M, take a as the classifier of put x and a at the same tree .

Else

X is a root of a tree

End if

End if

VIII. Algorithm Implementation

a) Expermintal Results

We applied the proposed algorithm on many selected human face images which were chosen from the ORL database and contains (600) human face images concerning 60 persons with (10) face image for each person [14]. The implementation has been achieved using matlab version 8:

1. The algorithm was firstly implemented on the 1st hundred human face images of the ORL database by using a constant threshold (9.958) and from this constant threshold we extract the adaptive threshold and the adaptive neighborhood for each image. We secondly used the same approach for the remain hundreds of ORL database. Figure [1] shows a sample of the results of our algorithm on the 1st hundred of the ORL database images.

No. of cluster	Images of the Tress(clusters)
1	
2	
3	
4	
5	

Figure 1 : Sample of clustering result by applying the proposed algorithm on the 1st hundred images of the ORL database

2. The same technique was used with all the data of the ORL data. Fiqure [2] shows a sample of the obtained results by using the proposed algorithm on the images of ORL(600 images)

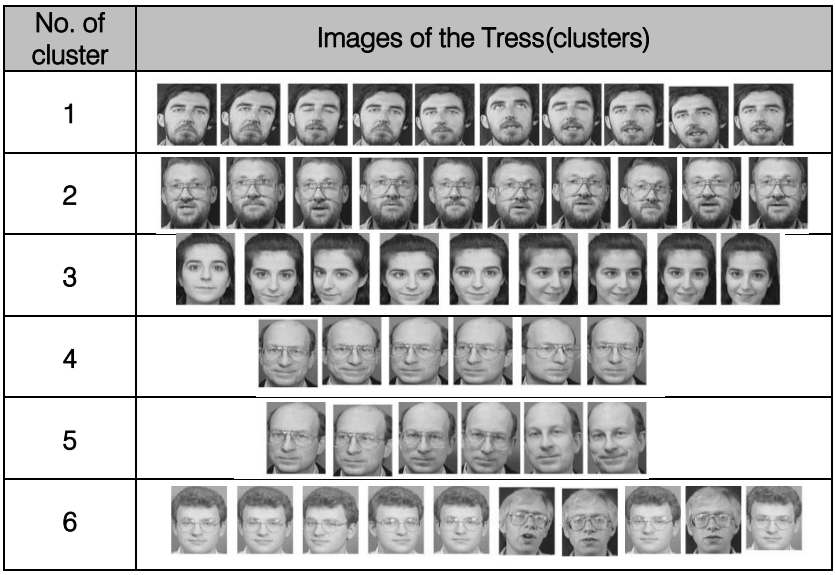

Figure 2 : Sample of clustering result by using the proposed algorithm on the all data of ORL database

b) Results Discussions and conclusions

1. For all the experiments, we firstly implement the proposed algorithm by using constant threshold value. Secondly we extracted adaptive threshold and the adaptive neighborhood for each tested human face image. We notice that the clustering results by using adaptive threshold are better than using a constant threshold
2. The following table shows the comparison between the results of the experiments

Experiment No.	Number of images	Number of clusters	Execution time(second)	threshold Interval	Success percentage	Error percentage
1st hundred	100	14	0.093518	9.000-9.011	[88%-93%]	[7%-12%]
2nd hundred	100	12	0.093522	9.008-9.991	[89%-95%]	[5%-11%]
3th hundred	100	8	0.083511	12.058-12.111	[80%-86%]	[14%-20%]
4th hundred	100	10	0.093518	8.999-9.011	[88%-92%]	[8%-12%]
5th hundred	100	11	0.995511	7.990-8.906	[78%-85%]	[15%-22%]
6th hundred	100	5	0.056650	13.233-14.343	[72%-80%]	[20%-28%]
All ORL data base	600	65	4.53200	10.921-11.323	[79%-84%]	[16%-21%]

Table 1 : Compression between the results of experiments

3. Two types of errors have been noticed:
– In few cases, face images for more than one person are lied in same cluster. This occurred for the most resemblance persons as shown in cluster (5) of figure [1].
– The face images of some person were partitioned in two clusters. This occurred when we use a small value for the constant threshold as shown in clusters (3, 4) of figure [1].

We conclude the following for the proposed algorithm:

1. It's an automatic algorithm since it does not need to give the number of the resulted clusters a priori. In fact the obtained results simulate the real structure of the applied data.
2. It's a hard clustering algorithm since its clustering results are such that the face images of each person will be in the same tree (cluster).
3. Using adaptive threshold is better than using constant threshold.
4. It's an effective clustering algorithm, since it gives a good clustering results with small rate of error and it taken a reasonable execution time for all the experiments.

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Study and Comparison of Different Edge Detectors for Image Segmentation

By Pinaki Pratim Acharjya, Ritaban Das & Dibyendu Ghoshal

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Abstract - Edge detection is very important terminology in image processing and for computer vision. Edge detection is in the forefront of image processing for object detection, so it is crucial to have a good understanding of edge detection operators. In the present study, comparative analyses of different edge detection operators in image processing are presented. It has been observed from the present study that the performance of canny edge detection operator is much better then Sobel, Roberts, Prewitt, Zero crossing and LoG (Laplacian of Gaussian) in respect to the image appearance and object boundary localization. The software tool that has been used is MATLAB.

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Keywords : Edge Detection, Digital Image Processing, Image segmentation.

I. Introduction

Edge detection [1-2] is a fundamental problem of computer vision and image processing. It has been a major concerning issue in image segmentation [3-7] and for the researchers. The purpose of image segmentation is to partition an image into meaningful regions with respect to a particular application where edges in digital images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality and image segmentation. For computer vision and image processing systems to interpret an Image, they first must be able to detect the edges of each object in the image [8-11]. There are several edge detection operators available for image segmentation and object boundary extraction of digital images. Each operator is designed to be sensitive to certain types of edges. Among them Sobel, Roberts, Prewitt, LoG, and canny is major concerning operators. The geometry of the operator determines a characteristic direction in which it is most sensitive to edges.

The presence of noise is a problem for image segmentation. Images are very much prone to be affected by a verity of noise like Gaussian noise, Rayleigh noise, Impulse noise and Speckle noise. It has been found from the parent study that in presence of noise the Canny edge detection [12-14] operator has yielded the best subjective segmented view of the test image in respective of appearance and object boundary localization then Sobel, Roberts, Prewitt, and LoG. The entropy which is a statistical measure of randomness that can be used to characterize the texture of the input image is studied along with peak signal to noise ratio (PSNR), mean square ratio (MSE) and execution times are also studied in this paper. The objective of the present study is to compare various edge detection operators and analyze their performance and also performances of such techniques is carried out for an image by using MATLAB software. In this literature the section 2 introduces comprehensive theoretical and mathematical background for edge detection and explains different computing approaches to edge detection. Section 3 presents the proposed approach. Section 4 provides the experimental results and discussion and section 5 contains a quick discussion about the conclusion.

II. Traditional Edge Detectors

a) Sobel

The sobel edge detector computes the gradient by using the discrete differences between rows and columns of a 3X3 neighborhood. The sobel operator is based on convolving the image with a small, separable, and integer valued filter.

+1	+2	+1
0	0	0
-1	-2	-1

Gx

-1	0	+1
-2	0	+2
-1	0	+1

Gy

b) Prewitt

Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images The Prewitt edge detector uses the following mask to approximate digitally the first derivatives G_x and G_y.

-1	-1	-1
0	0	0
1	1	1

Gx

-1	0	1
-1	0	1
-1	0	1

Gy

c) Roberts

In Robert edge detection, the vertical and horizontal edges bring out individually and then put together for resulting edge detection. The Roberts edge

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detector uses the following masks to approximate digitally the first derivatives as differences between adjacent pixels.

+1	0
0	-1

Gx

0	+1
-1	0

Gy

d) Laplacian of Gaussian (LOG)

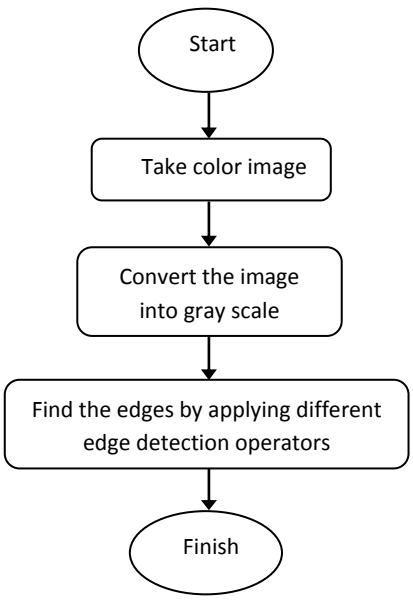
This detector finds edges by looking for zero crossings after filtering *f(x, y)* with a Laplacian of Gaussian filter. In this method, the Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively. It finds the correct place of edges and testing wider area around the pixel.

e) Canny Edge Detector

Canny edge detection is a multistage algorithm to detect a wide range of edges in images. This detector finds edges by looking for local maxima of the gradient of *f(x, y)*. The gradient is calculated using the derivative of a Gaussian filter. The method uses two thresholds to detect strong and weak edges and includes the weak edges in the output only if they are connected to strong edges.

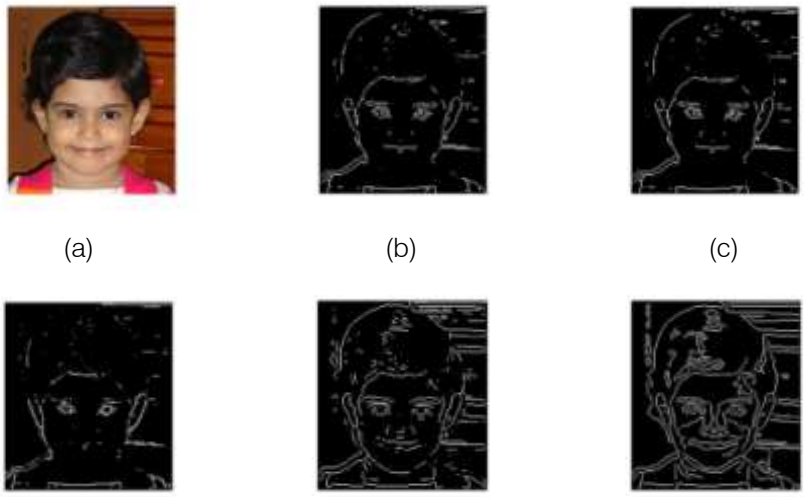
III. Proposed Approach

The flowchart of the proposed approach is given below. In proposed approach at very beginning a colored image is chosen and inserted into the Mat Lab software for processing. The image is converted into gray scale in the immediate step. A gray scale image is mainly combination of two colors, black and white. It carries the intensity information where, black have the low or weakest intensity and white have the high or strongest intensity. In final step different edge detection operators are applied to detect the object boundaries and edges.



IV. Experimental result

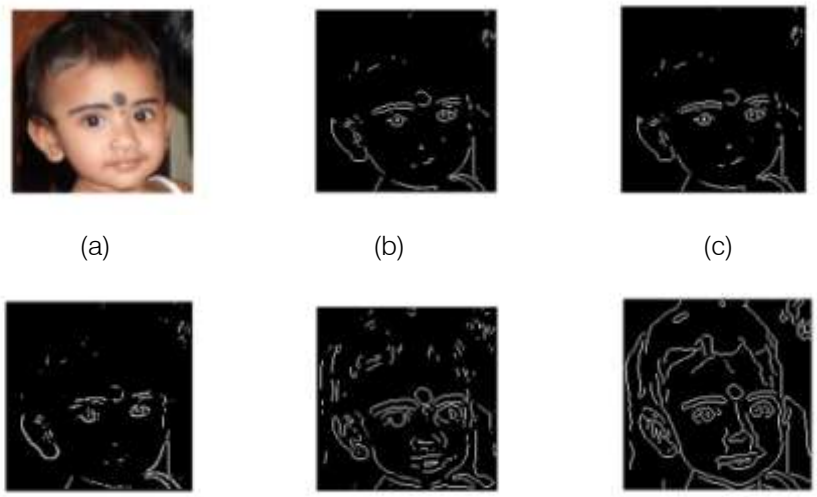
This section presents the relative performance of various edge detectors. Five edge detection operators have been chosen to carry out for edge detection and image segmentation. There are namely, Sobel, Prewitt, Roberts, LoG and Canny. The original image is shown in figure 1(a) and figure 2(a) and the segmented images have been shown in figure 1(b) to figure 1(f) and from figure 2(b) to figure 2(f) respectively. The entropy, PSNR, MSE and execution times of the segmented images have been calculated and are shown in Table 1. Peak signal to noise ratio (PSNR) is the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. It is the logarithmic function of the peak value of the image and the mean square error. Its value must be high. It have been observed that that the Canny edge detector produces higher accuracy in detection of object edges with higher entropy, PSNR, MSE and execution time compared with Sobel, Roberts, Prewitt, Zero crossing and LOG. On the other hand Roberts edge detector has the minimum entropy with PSNR, MSE and execution time compared with others. The statistical analyses for all the edge detectors are shown in table 1.



(a) (b) (c)

(d) (e) (f)

Fig. 1 : (a) Trisha (original image), (b) Sobel, (c) Prewitt, (d) Roberts, (e) Laplacian of Gaussian, (f) canny



(a) (b) (c)

(d) (e) (f)

Fig. 2 : (a) Diya (original image), (b) Sobel, (c) Prewitt, (d) Roberts, (e) Laplacian of Gaussian, (f) canny

Table I : Statistical measurement

IMAGE	ENTROPY	PSNR	MSE	EXECUTION TIME
Trisha with Sobel	1.2820	11.4067	4.7034e+003	1.052911 seconds.
Trisha with Prewitt	1.2792	11.3928	4.7185e+003	0.878266 seconds.
Trisha with Roberts	1.2306	17.1396	1.2564e+003	0.831094 seconds.
Trisha with LoG	1.4354	11.2313	4.8973e+003	0.978503 seconds.
Trisha with Canny	1.5701	10.9043	5.2803e+003	1.014961 seconds.
Diya with Sobel	1.2722	9.9365	6.5983e+003	0.851769 seconds.
Diya with Prewitt	1.2707	9.9374	6.5969e+003	0.855519 seconds.
Diya with Roberts	1.2493	9.9212	6.6215e+003	0.818108 seconds.
Diya with LoG	1.4318	9.9596	6.5633e+003	0.856581 seconds.
Diya with Canny	1.5477	9.6982	6.9705e+003	1.040114 seconds.

V. Conclusion

Since edge detection is the initial step in object boundary extraction and object recognition, it is important to know the differences between different edge detection operators. In this paper an attempt is made to review the edge detection techniques which are based on discontinuity intensity levels. The relative performance of various edge detection techniques is carried out with two images by using MATLAB software. It have been observed that that the Canny edge detector produces higher accuracy in detection of object edges with higher entropy, PSNR, MSE and execution time compared with Sobel, Roberts, Prewitt, Zero crossing and LOG.

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Face Recognition Methodologies Using Component Analysis: The Contemporary Affirmation of the Recent Literature

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Abstract - This paper explored the contemporary affirmation of the recent literature in the context of face recognition systems, a review motivated by contradictory claims in the literature. This paper shows how the relative performance of recent claims based on methodologies such as PCA and ICA, which are depend on the task statement. It then explores the space of each model acclaimed in recent literature. In the process, this paper verifies the results of many of the face recognition models in the literature, and relates them to each other and to this work.

Keywords : *Face recognition, PCA, ICA, LDA, LPP.*

GJCST-F Classification : *I.4.8*

Strictly as per the compliance and regulations of:

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T.Archana [α], Dr.T.Venugopal [σ] & M.Praneeth Kumar [ρ]

Abstract - This paper explored the contemporary affirmation of the recent literature in the context of face recognition systems, a review motivated by contradictory claims in the literature. This paper shows how the relative performance of recent claims based on methodologies such as PCA and ICA, which are depend on the task statement. It then explores the space of each model acclaimed in recent literature. In the process, this paper verifies the results of many of the face recognition models in the literature, and relates them to each other and to this work.

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I. Introduction

Face recognition is the mainly demanding work of the explore persons of the year of 1990's. The researchers gave acceptable results for the motionless images i.e., Images are in use under the forbidden conditions. If the image enclose the problems like elucidation, pose variation, aging, hair enclosure then the concert of the recognition progression leads to poor. Most of the researchers are absorbed on the real time submission. Many reviews are carried out on the issue of face recognition [9][63][19][19][49][20] they identify various existing method for feature extraction and the face acknowledgment process. Generally face acknowledgment is classified as the procedure of face detection, characteristic extraction and face acknowledgment. Image preprocessing work as eradicate the background information and normalize the image of revolution, scaling, resizing of the unique image is carried out before the face recognition process. The face recognition is to detect the face of the standardize image, then the feature mining process is used to extract the skin from the detected face and lastly the face recognition procedure is to recognize the face contrast with a face database which is previously stored [9][63][19][19][49][20]. Figure 1 denotes the procedure of face recognition.

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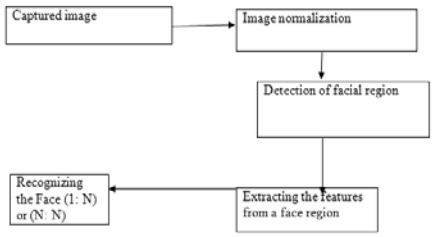


Figure 1 : Process of face recognition system

It is not possible to directly deal with raw information while the quantity of information is increased. Dimension diminution is the task to solve the above difficulty of extracting the prepared information and remove the redundant information. If the training images are augmented then the matrix of image also augmented then it is called as a difficulty of "Curse of dimensionality" which is resolved by dimensionality decline techniques [15] states that there two types of dimensionality decline techniques as linear and nonlinear dimensionality decline. The linear dimensionality diminution techniques are PCA, LDA, LPP, etc. And the nonlinear dimensionality methods are ISOMAP, LLE, and so on.

The aim of this paper is to give emerging procedure for the dimensionality decline in linear as well as nonlinear methods. It can be arranged as chase, section 2 contains the in sequence about the dimensionality decline. Section 3 have the the current state of the art in face recognition methods that are using using Component Analysis and section 4 enclose the conclusion of this paper.

II. Dimensionality Reduction Techniques

a) Overview

The most significant problem in face acknowledgment is the curse of dimensionality difficulty. The methods are useful to condense the dimension of the considered space. When the system starts to commit to memory the high dimensional information then it causes over fitting difficulty and also computational density becomes the important task. This curse of dimensionality difficulty is reduced by dimensionality decrease techniques [15].

Dimension decrease in data is the process of reducing the number of accidental variables under thought RN^RM (M<N), and can be divided into feature selection and feature extraction. The basic flow of measurement reduction in face acknowledgment is illustrated in figure 2.

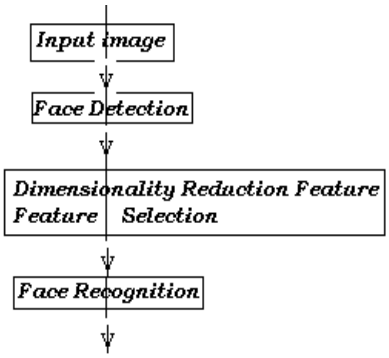


Figure 2 : Necessary flow of dimensionality reduction techniques

The author [66] says that the various methods exist for resolving the problem of curse of dimensionality. Out of those techniques some are linear methods and others are nonlinear. Linear technique is to transform statistics from high dimensional subspace into small dimensional subspace by linear map but it fails to work on the nonlinear statistics structure where as non linear methods are easily worked on the compound nonlinear statistics structure. Compared to linear methods, nonlinear methods are very capable while processing the problematic image like hair addition, lighting state and so on. Principal constituent Analysis (PCA), Linear Discriminant Analysis (LDA) and Locality protect Projections (LPP) are some accepted linear methods and nonlinear methods include Isometric Mapping (ISOMAP) & Locally Linear Embedding (LLE)

According to the writer [93], Feature range is to find a subset of the original variables. Two approaches are filtered (e.g. Information gain) and wraps (e.g. Genetic algorithm) approaches. It occurs sometimes that data examination such as decay or classification can be done in the reduced space extra accurately than in the unique space. Quality extraction is relay a mapping of the multidimensional space into a liberty of fewer dimensions. This means that the unique feature space is transformed by concern a linear transformation. The brief prologue of feature extraction techniques is illustrated in the next section.

b) Linear Feature Extraction of Dimensionality Reduction Techniques

Usually the face acknowledgment process is divided into 3 areas such as Holistic way use the unique image as an input for the face acknowledgment system. The examples of holistic methods are PCA, LDA, and an ICA and so on. In a Feature based way, the local characteristic point such as eye, nose, and mouth are first taken out, then it will be sent to the classifier. Finally, a cross method is used to identify both the local feature and whole face region [9][63][19][19][49][20].

In Dimensionality decrease, Feature removal is an important task to collect the set of features from a picture. The feature alteration may be a linear or nonlinear mixture of original features. This review provides some of the significant linear and nonlinear methods are listed as follows.

i. *Principal Component Analysis (Pca)*

PCA is one of the well-liked technique for both dimensionality decrease and face acknowledgment since 1990's. Eigen faces [17] built with the PCA technique is introduced by M. A. Turk and A. P. Pentland. It is a holistic move toward where the input image is straight used for the process. PCA algorithm can be used to discover a subspace whose basis vectors marks to the maximum variation directions in the original *n* dimensional freedom. PCA subspace can be used for appearance of data with minimum error in renovation of original data. More survey papers are providing the information for PCA techniques [9][63][19][19][49][20]. MPCA and KPCA are fully based on the PCA technique.

ii. *Linear Discriminant Analysis (Lda)*

LDA is one of the most famed linear techniques for dimensionality reduction and data organization. The main objective of the LDA consists in the judgment a base of vectors providing the finest discrimination among the classes, trying to exploit the between-class difference, minimize the within-class ones by using spread matrices. It also suffers from the small sample size trouble which exists in higher dimensional pattern acknowledgment task where the number of available models is smaller than the dimensionality of the samples. D- LDA, R-LDA, and KDDA are variations of LDA. This technique also discusses in more survey papers [20][15][93][66][74][73][75][46][70].

iii. *Singular Value Decomposition (Svd)*

SVD is a significant factor in the field of signal dispensation and statistics. It is the best linear dimensionality decrease technique based on the covariance medium. The main aim is to reduce the dimension of the information by finding a few orthogonal linear combinations of the original variables with the largest variation [66]. Most of the researches have also used this technique for face gratitude.

iv. *Independent Component Analysis (Ica)*

ICA is a geometric and computational technique for informative the hidden factors that underlie sets or chance variables, measurements, or signals. ICA is apparently related to principal component analysis and factors examination. The ICA algorithm aims at finding S component as self-governing as possible so that the set of experimental signals can be spoken as a

linear combination of statistically independent components. It uses cosine measures to perform the covariance matrix and also it is improved than the PCA and LDA performance.

v. *Locality preserves Projections (Lpp)*

LPP can be seen as an option to Principal constituent Analysis (PCA). When the high dimensional data deceit on a low dimensional manifold set in the ambient space, the position protects Projections are obtained by finding the optimal linear approximation for the Eigen purpose of the Laplace Beltrami operator on the various. As a result, LPP shares many of the data symbol properties of nonlinear techniques such as Laplacian Eigenmaps or Locally Linear embeds [15].

vi. *Multi Dimensional Scaling (Mds)*

Multidimensional scaling (MDS) is a loaner copy for dimensionality reduction. MDS generates low dimensional code placing emphasis on preserving the couple wise distances between the data points. If the rows and the discourse of the data matrix D both have mean zero, the bulge produced by MDS will be the same as that produced by PCA. Thus, MDS is a linear Model for dimensionality decrease having the same limitations as PCA.

vii. *Partial Least Squares*

Partial smallest amount squares are a classical arithmetical learning method. It is widely used in chemo metrics and Bioinformatics etc. In new years, it is also applied in face acknowledgment and human detection. It can avoid the small sample size problem in linear discriminant analysis (LDA). Therefore it is used as an alternative method of LDA.

c) Non Linear Feature Extraction of Dimensionality Reduction Techniques

Non-linear way can be broadly confidently into two groups: a mapping (either from the high dimensional space to lower dimensional embed or vice versa), it can be viewed as a beginning feature extraction step and image is based on neighbor's data such as distance measurements. Investigate on non-linear dimensionality reduction method has been explored widely in the last few years. In the following, a brief opening to several non-linear dimensionality reduction techniques will be given.

i. *Kernel Principle Component Analysis (Kpca)*

Kernel PCA (KPCA) is the reformulation of customary linear PCA in a high-dimensional gap that is constructed using a kernel function. In recent existence, the reformulation of linear technique using the 'kernel trick' has led to the suggestion of winning techniques such as kernel ridge decay and Support Vector machinery. Kernel PCA computes the principal eigenvectors of the kernel matrix, slightly than those of the covariance matrix. The reformulation of usual PCA in kernel space is clear-cut, since a kernel matrix is similar to the in product of the data points in the high-dimensional gap that is constructed using the kernel function. The application of PCA in kernel space provides Kernel PCA the possessions of constructing nonlinear mappings.

ii. *Isometric Mapping (Isomap)*

Often of the linear methods do not take the neighboring information end into an account. ISOMAP is a technique that resolves this problem by efforts to preserve pairwise geodesic (or curvilinear) distance between data points. The estimate of geodesic distance divides into two classes. For, adjacent points, Euclidean distance in the input space provides a good approximation to geodesic distance and faraway points, geodesic space can be approximated by adding up a sequence of "short hops" between neighboring points. ISOMAP shares some recompense with PCA, LDA, and MDS, such as computational efficiency and asymptotic meeting guarantees, but with more agility to learn a broad class of nonlinear manifolds [15].

iii. *Locally Linear Embedding*

Locally linear establish (LLE) is another approach which addresses the problem of nonlinear dimensionality decrease by computing low dimensional, neighborhood preserving embedding of high-dimensional data. It is a method that is similar to ISOMAP in that it also constructs a chart representation of the data points. It describes the local property of the manifold in the region of a data point x_i by writing the data point as a linear combination we (the so-called rebuilding weights) of its k nearest neighbors xij and attempts to retain the reconstruction weights in the linear combinations as well as possible [101][102].

iv. *Laplacian Eigenmaps*

A directly related approach to locally linear embed is Laplacian eigenmaps. Given *t* point in «-dimensional space, the Laplacian eigenmaps Method (LEM) start by constructing a biased graph with *t* nodes and a set of edges among adjacent points. Similar to LLE, the area graph can be constructed by finding the *k* nearest neighbors. The final objectives for both LEM and LLE contain the same form and change only in how the matrix *is* constructed [101].

v. *Stochastic Neighbor Embedding*

Stochastic Neighbor Embedding (SNE) is a probable move toward that maps high dimensional data tip into a low dimensional subspace in a way that conserve the relative distances to near neighbors. In SNE, alike objects in the high dimensional space will be put near in the low dimensional space, and dissimilar objects in the high dimensional space will usually be put distant apart in the low dimensional gap [102]. A Gaussian distribution centered on a point in the tall dimensional gap is used to define the probability

sharing that the data point chooses other data points as its neighbors. SNE is better to LLE in observance the relative distances between every two data points.

vi. *Semi Definite Embedding (Sde)*

Semi definite Embedding (SDE), can be seen as a variation of KPCA and an algorithm is base on semi definite training. SDE learns a kernel matrix by maximizing the variance in feature space while preserving the space and angles among nearest neighbors. It has some interesting property: the main optimization is convex and sure to preserve certain aspects of the local geometry; the system always yields a semi positive definite kernel matrix; the eigen spectrum of the kernel matrix provides a guess of the basic manifold's dimensionality; also, the system does not rely on guess geodesic distances between far away points on the manifold. This scrupulous combination of recompense appears unique to SDE.

III. Contemprary Affirmation of the Recent Literature

a) Face recognition using 2 Dimensional PCA

Sirovich and Kirby [2], [3] first used PCA to proficiently symbolize pictures of character faces. They dispute that any facial image could be renovated approximately as a prejudiced sum of a small group of images that define a facial origin (eigen images), and a mean representation of the face. Within this circumstance, Turk and Pentland [4] accessible the well-known Eigen faces technique for face recognition in 1991. Since subsequently, PCA has been widely investigated and has turned into one of the most successful move toward in face recognition [5], [6], [7], [8]. Penev and Sirovich [9] converse the problem of the dimensionality of the "face space"while Eigen faces are used for demonstration. Zhao and Yang [10] tried to describe for the arbitrary possessions of illumination in PCA-based apparition systems by generating a diagnostic closed form prescribed of the covariance matrix for the container with a special lighting circumstance and then generalizing to a random illumination via an illumination equation. However, Wiskott et al. [11] piercing out that PCA could not confine still the simplest invariance unless this in sequence is explicitly offered in the training information. They projected a technique known as expandable bunch graph matching to defeat the weaknesses of PCA.

Recently, two PCA-related technique independent constituent analysis (ICA) and kernel principal component analysis (Kernel PCA) contain been of wide apprehension. Bartlett et al. [12] and Draper et al. [13] projected using ICA for face demonstration and found that it was enhanced than PCA when cosines were used as the comparison measure (however, their presentation was not considerably different if the Euclidean detachment is used). Yang [14] used Kernel PCA for face characteristic extraction and acknowledgment and showed that the Kernel Eigen faces technique outperforms the traditional Eigen faces method. However, ICA and Kernel PCA are together computationally more exclusive than PCA. The untried results in [14] demonstrate the ratio of the working out time required by ICA, Kernel PCA, and PCA is, on standard, 8.7: 3.2: 1.0.

In the PCA-based face acknowledgment technique, the 2D face representation matrices must be formerly transformed into 1D representation vectors. The consequential image vectors of faces frequently lead to a high dimensional representation vector space, where it is complicated to assess the covariance matrix accurately owed to its large size and the comparatively small number of preparation samples. Fortunately, the eigenvectors (Eigen faces) can be considered efficiently via the SVD techniques [2], [3] and the procedure of generating the covariance matrix is essentially avoided. However, this does not involve that the eigenvectors can be assessed accurately in this way since the eigenvectors are statistically resolute by the covariance matrix, no substance what method is adopted to gain them.

In this circumstance Jian Yang et al [1] developed a straightforward representation projection procedure, called two-dimensional principle component analysis (2DPCA) for representation feature extraction. As contrasted to conventional PCA, 2DPCA is the pedestal on 2D matrices slightly than 1D vectors. That is, the representation matrix does not require to be previously altered into a vector. Instead, a representation covariance prevailing conditions can be constructed openly using the original representation matrices. In contrast to the covariance matrix of PCA, the dimension of the image covariance matrix via 2DPCA is much smaller. As a consequence, 2DPCA has two significant advantages over PCA. First, it is easier to assess the covariance matrix precisely. Second, less time is necessary to determine the equivalent eigenvectors.

Observation: A new procedure for image feature withdrawal and demonstration two-dimensional principal constituent analysis (2DPCA) was urbanized. 2DPCA has many rewards over conventional PCA (Eigen faces). In the primary place, since 2DPCA is pedestal on the image matrix, it is simpler and further straight onward to use for image feature withdrawal. Second, 2DPCA is enhanced than PCA in terms of gratitude accuracy in all research. Although this trend appears to be consistent for dissimilar databases and conditions, in some research the differences in the presentation were not statistically momentous. Third, 2DPCA is computationally further efficient than the PCA and it can pick up the speed of image attribute extraction considerably. However, it must be pointed out that

2DPCA-based image demonstration was not as capable as a PCA in terms of storage necessities, since 2DPCA requires further coefficients for image demonstration than PCA. There are tranquil some aspects of 2DPCA that earn further study. When a diminutive number of the primary components of PCA are worn to represent a representation, the mean square error (MSE) among the approximation and the unique pattern is negligible. Does 2DPCA have a comparable property? In accumulation, 2DPCA needs extra coefficients for image demonstration than PCA. Although, as a sufficient alternative to contract with this difficulty is to use PCA after2DPCA for extra dimensional reduction, it is motionless unclear how the width of 2DPCA could be summarized directed.

IV. Face Recognition Using Kernel Based PCA

Popular demonstration methods for face acknowledgment include Principle Component Analysis (PCA) [16], [17], [18], shape and consistency ('shape-free' representation) of faces [10], [5], [21], [22], [23], and Gabor wavelet demonstration [24], [25], [26], [27], [28]. The discrimination technique often tries to achieve the function of high separability among the different model in whose classification one is concerned [18], [29]. Commonly used intolerance methods contain Bayes classifier and the MAP rule [30], [28], Fisher Linear Discriminant (FLD) [31], [4], [33], [23], and further recently kernel PCA technique [34], [38], [35], [36].

Chengjun Liu et al [1] offered a novel Gabor-based kernel principle Component Analysis (PCA) technique by integrating the Gabor wavelet demonstration of face images and the kernel PCA technique for face recognition. Gabor wavelets [25], [37] principle derives attractive facial features distinguish by spatial frequency, spatial locality, and direction selectivity to cope with the dissimilarity due to illumination and facial appearance changes. The kernel PCA technique [38] is then extended to include a fractional power polynomial replica for enhanced face recognition presentation. A fractional power polynomial, though, does not necessarily describe a kernel function, as it may not define a constructive semi-definite Gram matrix. Note that the sigmoid kernels , one of the three modules of widely used kernel occupation (polynomial kernels, Gaussian kernels, and sigmoid kernels), do not essentially define a constructive semi-definite Gram matrix, either [38]. Nevertheless, the sigmoid kernels contain been effectively used in practice, such as in edifice support vector machines. In regulate to derive real kernel PCA skin, we apply only those kernel PCA eigenvectors that are connected with constructive eigenvalues.

Observation: Chengjun Liu et al [1] initiate a novel Gabor-based kernel PCA technique with fractional supremacy polynomial models for forward and pose-angled face acknowledgment. Gabor wavelets first obtain desirable facial features distinguish by spatial frequency, spatial neighborhood, and orientation selectivity to survive with the variations due to clarification and facial appearance changes. The kernel PCA technique is then extended to comprise fractional power polynomial models for superior face recognition presentation. The feasibility of the Gabor-based kernel PCA technique with fractional power polynomial replica has been effectively tested on both fore and pose-angled face recognition, via two data sets from the FERET catalog and the CMU PIE catalog, respectively.

V. Gabor Filters and KPCA for Face Recognition

Over the previous ten years, many approaches enclose been attempted to decipher the face recognition difficulty [40] –[52]. One of the very flourishing and popular face acknowledgment methods is based on the principle components psychiatry (PCA) [40]. In 1987, Sirovich and Kirby [40] demonstrate that if the eigenvectors equivalent to a set of training face images are achieved, any image in that database can be optimally modernized using a linear weighted grouping of these eigenvectors. Their exertion explored the demonstration of human faces in a lower-dimensional subspace. In 1991, Turk and Pentland [17] worn these eigenvectors (or Eigen faces as they are identified) for face acknowledgment. PCA was used to yield shelf directions that exploit the total scatter across all faces in the preparation set. They also extended their loom to the real time acknowledgment of a moving face illustration in a video sequence [53]. Another admired scheme for the dimensionality decline in face recognition is owing to Belhumeur et al. [4], Etemad and Chellappa [48], and Swets and Weng [31]. It is a pedestal on Fisher's linear discriminant (FLD) analysis. The FLD uses division membership in sequence and develops a set of attribute vectors in which variations of dissimilar faces are emphasized while dissimilar instances of a face due to clarification conditions, facial expressions and orientations are de-emphasized. The FLD technique deals directly with inequity among classes whereas the eigen face acknowledgment (EFR) method deals with the information in its entirety without paying any exacting attention to the underlying class organization. It is generally supposed that algorithms pedestal on FLD are better to those based on PCA when adequate training samples are accessible. But as exposed in [54] this is not constantly the case.

Methods such as EFR and FLD exertion quite well offer the input test pattern is a countenance, i.e., the face representation has already been harvested out of a

scene. The difficulty of recognizing faces in motionless images with a cluttered setting is more general and complicated as one does not recognize where a face pattern might emerge in a given representation. A good face recognition scheme must own the following two properties. It should:

1) Detect and distinguish all the faces in a prospect, and
2) No tainted classification of localized patterns as faces.

Since faces are frequently sparsely dispersed in images, even a hardly any false alarms will cause to be the scheme ineffective. Also, the performance must not be too receptive to any threshold selection. Some effort to address this condition is discussed in [17], [30] wherever the use of reserve from eigen face spaces (DFFS) and reserve in eigen face gaps (DIFS) are suggested to distinguish and eliminate unrelated faces for vigorous face recognition in a muddle. In this revise, we show that DFFS and DIFS by themselves (in the non appearance of any in sequence about the background) are not adequate to discriminate against random background patterns. If the porch is set high, conventional EFR invariably ends up absent faces. If the threshold is subordinate to capture the face, the procedure incurs many counterfeit alarms. Thus, the proposal is quite susceptible to the option of the threshold value.

One possibility looms to handle muddle in still images is to use a superior face detection component to find face prototype and then feed only these prototype as inputs to the traditional EFR proposal. Face detection is a study problem in itself and different approaches exist in the prose [55], [56], [57]. Most of the work imagines the pose to be forward. For a recent and inclusive survey of face recognition techniques, see [58], [59]. Rajagopalan et al [39] projected a new methodology inside the PCA framework to robustly distinguish faces in a given test representation with background muddle (see figure 2). Toward this end, assemble an "eigen background space" which symbolize the distribution of the conditions images equivalent to the given analysis image. The background is educated "on the fly" and provides a resonance basis for eradicating false alarms. An appropriate outline classifier is resulting and the eigen conditions space together with the eigen face gap is used to concurrently detect and distinguish faces.

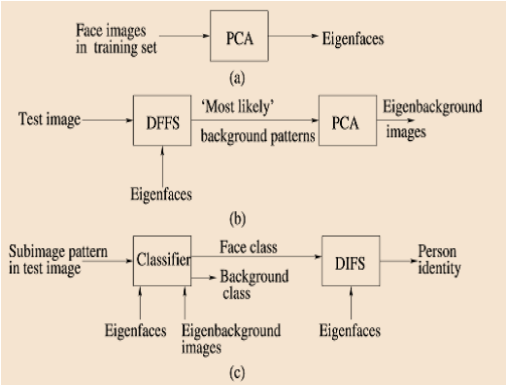


Fig. 2 : Architecture of the projected system. (a) Working out of Eigen faces. (b) Structure of eigen background space. (c) Face detection and acknowledgment

Linear subspace analysis, which regard as a feature space as a linear arrangement of a set of bases, has been extensively used in face acknowledgment applications. This is generally due to its usefulness and computational efficiency for aspect extraction and demonstration. Different criteria will construct different bases and, accordingly, the transformed subspace will also have dissimilar properties. Principal constituent analysis (PCA) [16], [17] is the most admired technique; it produces a set of orthogonal bases that confine the directions of maximum discrepancy in the training information, and the PCA coefficients in the subspace are not associated. PCA can preserve the global configuration of the image gap, and is optimal in terms of demonstration and reconstruction. Because simply the second-order addiction in the PCA coefficients are abolished, PCA cannot capture even the simplest invariance except this in sequence is explicitly offered in the training information [64]. Independent constituent analysis (ICA) [65], [28] can be considered a simplification of the PCA, which aims to find some self-governing basis by methods receptive to high-order statistics. However, [67], [68] description that ICA gave the same, occasionally even a little worse, acknowledgment accuracy as PCA. Linear discriminant psychiatry (LDA) [4] seeks to find a linear conversion that maximizes the between-class distribute and minimizes the within-class distribute, which preserve the discriminating in sequence and is suitable for acknowledgment. However, this method needs further than one image per person as a preparation set; furthermore, [54] shows that PCA can better LDA when the training set is small, and the previous is less sensitive to different preparation sets. Locality preserving protuberance (LPP) [71] obtains a face subspace that finest detects the necessary face manifold structure, and conserve the local in sequence about the image gap. When the proper aspect of the subspace is selected, the acknowledgment rates using LPP are enhanced than those using PCA or LDA, based

on dissimilar databases. However, this termination is achieved only if multiple preparation samples from each person are obtainable; otherwise, the LPP will give a comparable performance level as PCA. With the Cover's theorem, nonlinearly distinguishable patterns in an effort space will become linearly distinguishable with a high prospect if the input space is transformed nonlinearly into a high-dimensional characteristic space [72]. We can, therefore, map a contribution image into a high-dimensional characteristic space, so that linear discriminant methods can then be engaged for face acknowledgment. This mapping is usually recognized via a kernel function [38] and, according to the technique used for recognition in the high-dimensional characteristic space, we have a set of kernel-based technique, such as the kernel PCA (KPCA) [38], [34], [36], [76] or the kernel Fisher discriminant psychiatry (KFDA) [77], [78], [79], [80]. KPCA and KFDA are linear in the high-dimensional characteristic space, but nonlinear in the low-dimensional representation space. In other expressions, these methods can determine the nonlinear structure of the face descriptions, and encode higher order information [76]. Although kernel-based technique can overcome many of the confines of a linear transformation, [71] piercing out that none of these methods openly consider the structure of the various on which the face images perhaps reside. Furthermore, the kernel purpose used are devoid of explicit physical connotation, i.e., How and why a kernel purpose is suitable for an outline of a human face, and how to gain a nonlinear organization useful for discrimination.

In this context, Xudong Xie et al [60] projected a novel method for face acknowledgment, which uses only image per person for training, and is vigorous to lighting, expression and perception variations. In this technique, the Gabor wavelets [28], [81], [82] are worn to extract facial skin, then a Doubly nonlinear plot Kernel PCA (DKPCA) is proposed to complete the feature conversion and face recognition. Doubly nonlinear plot means that, besides the predictable kernel purpose, a new mapping purpose is also defined and used to accentuate those features having superior statistical probabilities and spatial significance of face images. More purposely, this new mapping function regard as not only the statistical allocation of the Gabor features, but also the spatial in sequence about human faces. After this nonlinear plot, the transformed features have a superior discriminating power, and the significance of the feature adapts of the spatial significance of the face images. Therefore, it has the capability to reduce the effect of characteristic variations owing to illumination, appearance and perspective interruption.

Observation: Xudong Xie et al [60] dispute that in the context of facial expressions as features to distinguish faces PCA based face acknowledgment models are not constant. Hence projected a novel especially nonlinear mapping Gabor-based KPCA for human countenance recognition. In this loom, the Gabor wavelets are used to mine facial features, then a particularly nonlinear mapping KPCA is projected to perform feature conversion and face recognition. Compared with the conservative KPCA, an additional nonlinearly mapping is carried out in the original space. Our new nonlinear plot not only considers the arithmetical property of the input skin texture, but also adopts an eigen mask to accentuate those features derived from the significant facial feature points. Therefore, after the mappings, the distorted features have a higher discriminant supremacy, and the significance of the feature adapts of the special significance of the face image. In categorize to improve the face recognition accurateness Jie ZOU et al [61] proved that merge multi-scale Gabor features or multi-resolution LBP skin generally achieves higher categorization accuracy than the character feature sets, which is not measured in the model projected by Xudong Xie et al [60], also not measured that Gabor features are susceptible to high incline and their orientations.

VI. ICA and PCA Compatibility for Face Recognition

Recently, a technique closely related to PCA, self-governing component analysis (ICA) [83], has acknowledged wide attention. ICA can be observed as a generalization of PCA, while it is concerned not only with second-order addiction between variables but also with high-order dependencies among them. PCA makes the information un-correlated while ICA makes the information as independent as potential. Generally, there are two influences for using ICA for face demonstration and recognition. First, the high-order associations between image pixels may hold information that is important in acknowledgment tasks. Second, ICA seeks to find the guidelines such that the projections of the information into those directions contain maximally "non-Gaussian" distributions. These ridges may be interesting and useful in categorization tasks [83], [86]. Bartlett et al. [84], [65] here along with the first to apply ICA to face representation and appreciation. They used the Infomax algorithm [87], [88] to realize ICA and recommended two ICA architectures (i.e., ICA Architectures I and II) for face demonstration. Both architectures were appraised on a subset of the FERET face record and were found to be successful for face recognition [65]. Yuen and Lai [90], [91] assume the fixed-point algorithm [89] to attain the independent mechanism (ICs) and used a householder transform to increase the least square solution of a face representation for representation. Liu and Wechsler [92], [28], [94] worn an ICA algorithm given by frequent [100] to perform ICA and assessed its presentation for face

recognition. All of these researchers maintain that ICA outperforms PCA in face acknowledgment. Other researchers, though, reported differently. Baek et al. [95] description that PCA outperforms ICA as Moghaddam [36] and Jin and Davoine [97] reported no major performance difference between the two methods. Socolinsky and Selinger [98] description that ICA outperforms PCA on observable images but PCA outperforms ICA on infrared descriptions.

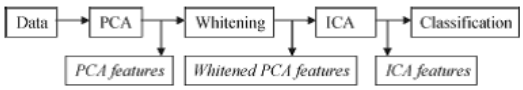


Fig. 1 : Illustration of the ICA progression for feature removal and classification

Recently, Draper et al. [99] endeavor to account for these actual contradictory results. They retested ICA and PCA on the FERET face catalog with 1196 individuals and completed a comprehensive assessment of the performances of the two techniques and found that the relative presentation of ICA and PCA generally depends on the ICA architecture and the detachment metric. Their investigations consequences showed that: 1) ICA Architecture II with the cosine detachment significantly outperforms PCA with L1 (city wedge), L2 (Euclidean), and cosine detachment metrics. This is dependable with Bartlett and Liu's results; 2) PCA with the L1 detachment outperforms ICA Architecture I. This is an errand of Baek's results; and 3) ICA was planning II with L2 still significantly outperforms PCA with L2, even if the degree of consequence is not as great as in the ICA Architecture II with cosine over PCA. Moreover, it must be noted that this last consequence is still inconsistent among Moghaddam and Jin's results.

An interesting by merchandise of comparative examine into ICA and PCA is the finding that dissimilar versions of ICA algorithms seem to execute equally in face-recognition errands. Moghaddam [36] show that the basis images resulting from Hyvärinen's fixed-point algorithm is very similar to those from Cardoso's JADE algorithm [104]. Draper et al. [99] substantiate that the presentation dissimilarity between Infomax algorithm [87] and FastICA [89], [103] is irrelevant.

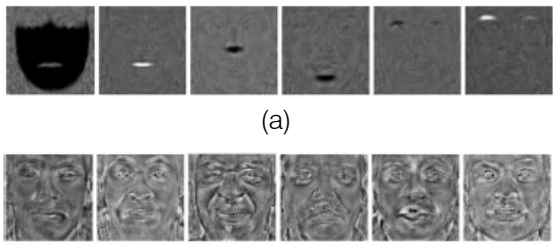
The preceding researchers [84], [99] usually use standard PCA as the baseline algorithm to assess ICA-based face-recognition scheme. This, however, begs the difficulty as to whether typical PCA is a good choice for appraising ICA. The ICA process, as exposed in Fig. 1, involves not only a PCA procedure but also a whitening treads. After the whitening tread, we get the whitened PCA skin tone of information. How is the presentation of these whitened PCA features in disparity to standard PCA features and ICA features? This concern has not been addressed yet. The purpose of the whitening step, mainly its potential effect on the recognition presentation, is still unclear. In the container where the performance of ICA is considerably different from that of PCA, it is critically significant to determine what causes this dissimilarity, whether it is the whitening procedure or the succeeding pure ICA projection.

If the whitened PCA skin texture can perform as well as ICA features, it is definitely unnecessary to use a computationally exclusive ICA projection for additional processing. It seems that typical PCA is not as an appropriate baseline algorithm as "PCA + Whitening" (whitened PCA) for assessing ICA.

In this circumstance, Jian Yang et al [82] evaluate two ICA-based image representation architectures (see figure 3) and get that ICA Architecture

I involves a vertically centered PCA progression (PCA I), while ICA planning

II involves a whitened flat centered PCA progression (PCA II).



(a)

(b)

Fig. 2 : Basis images equivalent to ICA Architecture I and ICA Architecture II. (a) Origin images equivalent to ICA Architecture I. (b) Basis images matching to ICA Architecture II

Therefore, it is usual to use these two PCA descriptions as baseline algorithms to check the performance of ICA-based face-recognition scheme. It should be confirmed that in this correspondence, our objective is not to find whether ICA or PCA is enhanced but to investigate first what position the PCA whitening stride and centering mode cooperate in the ICA-based face recognition scheme and second what effect the pure ICA protuberance has on the presentation of face recognition. We also consider how the performances of two ICA architectures depend on their correlated PCA versions. It is hoped that this examination may clarify why ICA outperforms PCA in some cases and why not in additional cases.

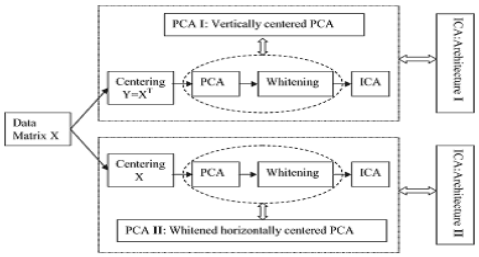


Fig. 3 : Design of two ICA-based image-representation architectures

Observation: By examining two ICA-based image depiction architectures and establish that Ist ICA Architecture absorb a vertically centered PCA process (PCA I), while IInd ICA Architecture involves a whitened flat centered PCA process (PCA II). In this procedure then used these two PCA descriptions as baseline algorithms to reconsider the performance of ICA-based face-recognition scheme. From the testing results explored, it is considerable to conclude that

- First, there is no important performance dissimilarity between ICA Architecture I (II) and PCA I (II), though in some cases, there is a significant dissimilarity between ICA Architecture I (II) and typical PCA.
- Second, the presentation of ICA strongly depends on the PCA procedure that it involves. Pure ICA outcrop seems to have only a trivial effect on presentation in face recognition.
- Third, the centering manner and the whitening step in the PCA I (or II) play a vital role in inducing the presentation differs among ICA Architecture I (II) and typical PCA.

The added selective power of the "independent features" fashioned by the pure ICA ledge is not so satisfying. Therefore, the prospect task is to explore successful ways to attain more power self-governing features for face demonstration.

VII. Super-Resolution as a Feature in Face Recognition

Super-resolution is flattering gradually more important for several multimedia applications [106]. It refers to the process of rebuilding a high-resolution image from low-resolution frames. Most techniques [107], [108], [109], [110], [111] assume knowledge of the statistical warp of each study and the nature of the blur. However, the efficiency of such rebuilding- based super-resolution algorithms, that do not include any exact previous information concerning the image being super-resolved, has been exposed to be inherently partial [112], [113]. A learning-based method has been recommended in [112] to super-resolve face images. It uses a prioritized based on the fault among the gradient values of the corresponding high-resolution pixel in the training image and in the expected image. But this makes it sensitive to image arrangement, scale, and noise. Gunturk et al. [114] perform super-resolution in the eigen face spaces. Since their aim is face recognition, they rebuild only the weights along the principal components in its place of trying to make a high-resolution approximation that is visually superior. In [115], a method exists which super-resolves face by first finding the finest fit to the comments in the eigen face domains. A patch-based Markov network is then used to attach remaining high-frequency content. Some additional learning-based approaches are discussed in [116], [117], [118].

In this environment a substantial model referred as "learning-based method for super-resolution of faces that uses kernel principal component analysis (PCA) to get previous knowledge concerning the face class" introduced by Ayan Chakrabarti et al [105]. Kernel PCA is a nonlinear extension of traditional PCA for capturing higher-order correlations in a data set. The proposed model is using kernel PCA to take out valuable previous information in a computationally well-organized manner and shows that it can be used within a maximum a posteriori (MAP) framework along with the observation model for improving the quality of the super-resolved face image.

Observation: Ayan Chakrabarti et al [105] proposed a learning-based method for super-resolution of face images that use kernel PCA to construct a previous model for frontal face images. This model is used to normalize the rebuilding of high-resolution face images from blurred and noisy low-resolution remarks. By nonlinearly mapping the face images to a higher-dimensional characteristic space and performing PCA in the characteristic space, we capture higher-order correlations there in face images. The presentation of the proposed Kernel-base face hallucination is required to be confirmed by competing with low resolution (LR) face image and the rebuild high resolution (HR) image recognition models. This method is based on global approaches in the sense that processing is done on the entire of LR images concurrently. This inflicts the constraint that all of the training images should be internationally similar, which terminate that they should be a similar class of objects. Therefore, the global approach is appropriate for images of an exacting class such as facial images and fingerprint images. However, since the global approach needs the supposition that all of the training images are in the same class, it is hard to apply it to arbitrary images. In the similar context, an application of the Hebbian algorithm is described, where kernel PCA is used for image zooming by prognostic an interpolated version of the low-resolution image onto the high-resolution principal subspace. The method is, however, partial to using a single image and does not include any knowledge of the imaging process.

VIII. Face Sketches Recognition

Face sketching is a forensic method that has been regularly used in criminal investigations [120], [121]. The achievement of using face sketches to recognize and capture fugitives and criminal suspects has often been revealed in the media coverage, mainly for high-profile cases [122], [123]. As a special forensic art, face sketching is usually done manually by police sketch artists. As an effect of fast advancements in computer graphics, realistic animations, human

computer interaction, visualization, and face biometrics, complicated facial composite software tools have been manufacturing and utilized in law enforcement agencies. A latest national survey has pointed out that about 80% of state and local police departments in the U.S. have used the facial composite software, and about 43% of them still relied on trains forensic artists [124].

However, there are concerns regarding the correctness of face sketches, mainly those generated by software. Studies have shown that software kits were lower to well-trained artists [125], [126]. One of the disadvantages of composite systems is that they follow a "piecemeal" approach by adding up facial features in a remote manner. In contrast, artists tend to use a more "holistic" plan that highlight the overall structure. Considerable hard work has been made to put together holistic dimensions into composite systems, using rated psychological parameters and clever to develop face models [127], [128]. Recently, a caricaturing procedure has been employed to additional progress the presentation of facial composite systems [129]. The quality of a sketch (whether by software or an artist) is dependent upon a lot of factors such as an artist's drawing skill and experience, the exposure time for a face, and uniqueness of a face, as well as the memory and emotional position of eyewitnesses or victims [120], [121], [125], [130], [131]. The impacts of these factors on sketch excellence and their complex interrelationships have not been well understood on a quantitative basis.

Sketch-recognition research is powerfully provoked by its forensic applications. The previous works include a study of matching police sketches to mugshot photographs [132]. Sketches were first altered into pseudo photographs through a sequence of standardizations and were then evaluated with photographs in an eigenspace. Tang and Wang [133] reported a further complete investigation on hand-drawn face sketch recognition. They developed a photograph-to-sketch alteration method that synthesizes sketches from the original photographs. The method improves the resemblance between the sketches drawn by artists and the synthesized sketches. They also establish that the algorithms performed competitively with humans using those sketches. In [134] and [135], they further proposed an altered function that treats the shape and texture individually and a multi scale Markov random field model for sketch synthesis. Recently, a study on searching sketches in mugshot databases has been reported [136]. Sketch–photograph identical was performed using a set of extracting local facial features and global capacity. Sketches were drawn with composite software, and no alteration was applied to sketches or photographs. Along a a little different research line of using caricature model for face representation and recognition, Wechsler et al. [137] provided a framework based on the self-organization characteristic map and found that caricature maps can improve the differences between subjects and hence, enhance the recognition rate.

Information fusion is a significant method for improving the presentation of various biometrics [138], [62], [85], including face, fingerprint, voice, ear, and gait. Bowyer et al. [69] have established that a multi sample approach and a multimodal approach can accomplish the same level of performance. Large increases in face-recognition correctness were also reported in studies of multiple video frame fusion [47], [32], [42]. In research of evaluating face composite recognition [96], it was establish out that the mixture of four composite faces through morphing was rated improved or as good as the best individual face. Therefore, it is natural to argue that the fusion of multiple sketches may also add to the chance of finding a correct sketch–photograph match. Multi sketch fusion can be carried out using the sketches from the similar artist or the sketches from different artists.

Yong Zhang et al [119] motivated by face composite recognition [96] suitable to its potentiality to offer more diverse information regarding a face. And then performed a qualitative approach to analyze Hand-Drawn Face Sketch Recognition by Humans and a PCA-Based Algorithm for Forensic Applications. Another issue that subjective the work carried out by Yong Zhang et al [119] is, if the sketches resultant from different eyewitnesses are assumed to be mostly non correlated, multi sketch fusion may cancel out definite recognition errors.

With these influencing factors Yong Zhang et al [119] study the efficiency of hand-drawn sketches by comparing the performances of human volunteers and a principle component analysis (PCA) -based algorithm. In the process of making simpler the task, the sketches were obtained under an "ideal" condition:

Artists drew sketches by looking at the faces in photographs without a time constraint. This type of sketches permits us to address some basic issues that are of interest to both criminal investigators and researchers in biometrics and cognitive psychology:

1) Does the face sketch recognition rate alter very much from one artist to another? If so, we may harness the inter artist difference through a multi sketch fusion method;
2) The ideal sketches can be used to set up a recognition baseline to benchmark the performance of sketches that are drawn under a more forensically sensible condition; and
3) In a sketch–photograph matching, does human vision use a certain sketch or photo metric cues more power than a computer algorithm, or vice versa? What kinds of sketch features are more informative to human vision or the algorithm? How can the forensic artists and composite software developers advantage of the findings?

Observation: By the qualitative study explored by Yong Zhang et al [119], we can observe that

1) There is a big inter artist difference in terms of sketch recognition rate, which is likely associated with the drawing styles of artists rather than their talent.
2) Since multi sketch fusion can considerably develop the recognition rate as being observed in both PCA tests and human evaluations, using multiple artists in a criminal investigation is suggested.
3) Other than the correctness of major sketch lines, pictorial details such as shadings and skin textures are also helpful for recognition.
4) Humans showed a better performance with the cartoon like sketches (considered as more difficult), given the particular data set used in this study. However, considering the fact that a PCA algorithm is more sensitive to intensity difference, it is not clear whether human vision is more broadminded about face degradation in general. More study efforts are wanted, mainly those that use shape information extracted by an active appearance model.
5) Human and PCA performances seem gently correlated, based on the correlation analysis results, although experiments relating more artists and sketch samples are required.
6) Score level fusion with the sum rule seems efficient in combining sketches of dissimilar styles, at least for the case of a small number of artists.
7) PCA did a better job in recognizing sketches of less characteristic features, while humans utilized tonal cues more professionally. However, cautions should be taken when commerce with sketches that have been processed by advanced alteration functions [133], [134] because those functions may alter the textures and hence, the tonality of a sketch considerably.
8) It is value mentioning that sketch–photograph matching is more demanding than photograph–photograph matching because a sketch is not a simple copy of a face but rather the one apparent and rebuild by an artist. Therefore, we may have much more to increase by examining how humans and computer recognize sketches and caricatures.
9) One significant issue is that the sketches that are drawn based on the verbal descriptions of eyewitnesses may effect in a much inferior recognition rate because of the uncertainties related to the memory loss of eye witnesses. Therefore, more thorough investigations are wanting to address different issues related to sketching recognition under a forensically realistic setting, such as the impact of target delay [45]. In [45], face building was conducted with a two-day delay, and the manually generated sketches have been found to be outperformed other traditional face build methods.
10) Another talented research direction is to rebuild a 3-D sketch model from the original 2-D sketches. Using the 3-D model, a series of 2-D sketches of dissimilar view angles can be generated to make easy the identified purpose. This 3-D modeling approach can be helpful in the cases where a subject was non cooperative and observed at a distance [41].

IX. Conclusion

One of the face recognition methodology is the holistic approach that takes the whole face image as a raw data and recognizes the face. In other methodology referred as feature based approach, the objectives of a face like mouth, nose and eyes are extracted and then attempt to recognize the face. The third methodology labelled as hybrid approach is the combination of both the Holistic and feature based methods. This paper concentrated on the contemporary affirmation of the recent literature on face recognition techniques. The three processes necessarily are done are face detection, dimensionality reduction and face recognition. The dimensionality reduction is used to solve the curse of dimensionality. It can be divided into two parts they are Feature Extraction and Feature Selection. The feature extraction process can be broadly classified into four types they are linear method, nonlinear methods, Multi linear methods and tensor space methods. Here in this paper we reviewed the information about the various methods included in the linear and nonlinear feature extraction process.

PCA, LDA and ICA are the most well known linear feature extraction process for the past more than 10 years whereas KPCA, ISOMAP, LLE are the famous technique in non linear feature extraction. Now the researchers are concentrating on combining both linear and nonlinear methods to reduce the dimensionality reduction and also for feature extraction methods. The contribution of this paper is to identify the research scope in face recognition methods and given details about the models that are cited in recent literature. Though There are so many techniques available, still there are issues such as higher level dimensionality, resolution changes and divergent expressions, which is an evidence of future research scope in face recognition systems. The future work will concentrate on the issues claimed.

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A Robust Online Method for Face Recognition Under Illumination Invariant Conditions

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Abstract - In case of incremental inputs to an online face recognition with illumination invariant face samples which maximize the class-separation criterion but also incorporates the asymmetrical property of training data distributions. In this paper we alleviate this problem with an incremental learning algorithm to effectively adjust a boosted strong classifier with domain-partitioning weak hypotheses to online samples, which adopts a novel approach to efficient estimation of training losses received from offline samples. An illumination invariant face representation is obtained by extracting local binary pattern (LBP) features NIR images. The Ada-boost procedure is used to learn a powerful face recognition engine based on the invariant representation. We use Incremental linear discriminant analysis (ILDA), in case of sparse function for active near infrared (NIR) imaging system that is able to produce face images of good condition regardless of visible lights in the environment accuracy by changes in environmental illumination The experiments show convincing results of our incremental method on challenging face detection in extreme illuminations.

Keywords : *Incremental learning; online and offline; Adaboost; sparse function.*

GJCST-F Classification : *I.4.8*

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Keywords : *Incremental learning; online and offline; Ada-boost; sparse function.*

I. Introduction

During the past decade, face recognition has drawn significant attention from the perspective of different applications [1, 2]. A general statement of the face recognition problem can be formulated as follows [2, 3]. Given still or video images of a scene, the problem is to identify or verify one or more persons in the scene using a stored database of faces. Face recognition under varying lighting conditions is challenging, especially for single image based recognition system. Exacting illumination invariant [4] features is an effective approach to solve this problem. However, existing methods are hard to extract both multi-scale and multi-directivity geometrical structures at the same time, which is important for capturing the intrinsic features of a face image. The environment surrounding a face recognition application can cover a wide spectrum – from a well controlled environment to an uncontrolled once, means offline respect to online [5].

In a controlled environment, frontal and profile photographs of human faces are taken complete with a uniform background and identical poses among the participants. In the case of uncontrolled environment, recognition of human faces is to be done at different scales, positions, luminance and orientations; facial hair, makeup and turbans etc. In conditions such as these, invariance to changing lighting is perhaps the most significant practical challenge for face recognition algorithm boosting. The illumination setup in which recognition is performed is in most cases impractical to control, its physics difficult to accurately model and recover, with face appearance differences due to varying illumination often larger in magnitude than those differences between individuals Additionally, the nature of most real-world applications is such that prompt, often real-time system response is needed, demanding appropriately efficient as well as robust matching algorithms [6]. This challenging and interesting problem has attracted researchers from various background i.e., psychology, pattern recognition, neural networks, computer vision and computer graphics [7]. The challenges associated with face recognition can be attributed to the following factors:

- Pose: The images of a face vary due to the relative camera-face pose (frontal, tilted, profile, upside down).
- Presence or absence of structural components: Facial features such as beards, mustaches, and glasses may or may not be present and there is a great deal of variability among these components including shape, color and size.
- Facial expression and emotions: The appearance of faces is directly affected by a person's facial expression and emotions.
- Occlusion: Faces may be partially occluded by other objects. For an example, in an image with a group of people, some faces may partially occlude other faces.
- Image orientation: Face images directly vary for different rotations about the camera's optical axis.
- Imaging conditions: When the image is formed, factors such as lightning and camera characteristics affect the appearance of a face.

In general, face recognition algorithms can be divided into two groups based on the face representation [8], they are:

- Appearance-based which uses holistic texture features and is applied to either whole-face or specific regions in a face image.

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- Feature- based which uses geometric facial features (mouth, eyes, brows, cheeks etc.) and geometric relationships between them.

Holistic based method uses the whole face region as input to the recognition system. Subspace analysis is done by projecting an image into a lower dimensional subspace formed with the help of training face images and after that recognition is performed by measuring the distance between known images and the image to be recognized. The most challenging part of such a system is finding an adequate subspace. Some well known face recognition algorithms for face recognition are Principal Component Analysis (PCA), Independent Component Analysis (ICA), Linear Discriminant Analysis (LDA) [9, 10], Incremental LDA allows highly efficient learning to adapt to new data sets. A solution closely agreeing with the batch LDA result can be obtained with far lower complexity in both time and space; there are very few works on incremental learning for sparse LDA. Computational models of faces have been an active area of research since late 1980s, for they can contribute not only to theoretical insights but also to practical applications, such as criminal identification, security systems, image and film processing, and human-computer interaction, etc.

One of the difficulties might be due to the fact that the sparse LDA problem is non-convex and NP-hard. It is not straightforward to design an incremental solution for sparse LDA. Computation cost and memory requirements for training an AdaBoost detector are extremely high. Viola and Jones spent weeks on training a detector with 6060 features (weak learners) on a face training set of 4916, the fast implementation of AdaBoost methods and forward feature selection (FFS) for fast training under online boosting. The illumination based incremental LDA [11,12] algorithm can also be incorporated into a classic semi-supervised learning framework and applied to many other problems in which LDA-like discriminant components are required. However, developing a computational model of face recognition is quite difficult, because faces are complex, multidimensional, and subject to change over time [13, 14].

II. Illumination Invariant

First, A traditional method for dealing with illumination changes in tracking algorithm has been to use illumination invariant features [1, 11], such as edges. In principle, the entire sets of contour-tracking algorithms are invariant to illumination. However, the computer vision community has recently witnessed the development of several excellent tracking methodologies that are based primarily on tracking photometric, i.e. illumination dependent, variables (such as intensity, color, or texture). Second, Shadow compensation method that compensates for illumination variation in a face image so that the image can be recognized by a face recognition system designed for images under normal illumination condition. Generally, human faces are similar in shape in that they are comprised of two eyes, a nose and a mouth. Each of these components forms a shadow on a face, showing distinctive characteristics depending on the direction of light in a fixed pose. By using such characteristics generated by the shadow, we can compensate for illumination variation on a face image caused by the shadow and obtain a compensated image that is similar to the image taken under frontal illumination. There could be two approaches to illumination invariant face recognition: by a highly nonlinear face matching engine with an illumination variant representation or by an illumination invariant face representation with a less complicated face matching engine. Work in illumination invariant face recognition focused on image representations that are mostly insensitive to changes in illumination the image representations and distance measures are evaluated on a tightly controlled face database which varied face pose, illumination and expression. The image representations include edge maps, 2D Gabor-like filters, first and second derivatives of the gray-level image and the logarithmic transformations of the intensity image along with these representations; under normal illumination condition shown in figure 1.

Figure 1 : Common conditions of illumination-invariant

Generally, human faces are similar in shape in that they are comprised of two eyes, a nose and a mouth algorithm for illumination-invariant change detection that combines a simple multiplicative illumination model with decision theoretic approaches to change detection. The core of our algorithm is a new statistical test for linear dependence color of vectors observed in noise. This criterion can be employed for a significance test, but a considerable improvement of reliability for real-world image sequences is achieved if it is integrated into a Bayesian framework that exploits spatial-temporal contiguity and prior knowledge about shape and size of typical change detection masks.

a) Extrapolation in Illumination Specifications

The Recognition in uncontrolled situations is one of the most important bottlenecks for practical face recognition systems. We address this by combining the strengths of robust illumination normalization, local texture based face representations and distance transform based matching metrics [11]. Specifically, here

make three main contributions: (i) we present a simple and efficient preprocessing chain that eliminates most of the effects of changing illumination while still preserving the essential appearance details that are needed for recognition; (ii) we introduce Local Ternary Patterns (LTP), a generalization of the Local Binary Pattern (LBP) local texture descriptor that is more discriminant and less sensitive to noise in uniform regions; and (iii) we show that replacing local histogramming with a local distance transform based similarity metric further improves the performance of LBP/LTP based face recognition, which is an illumination invariant signature, to generate face images under arbitrary illumination conditions proposed a method to eliminate the influence due to illumination variation by using a 2D shape model, which separates an input image into a texture model and a shape model for retaining shape information.

An incremental method is tries to alleviate the effect of uneven illumination by using the techniques of local normalization of local binary pattern. In order to handle pose variation, Pentland [2], proposed a view-based Eigen-space method and Huang, used a neural network with a view-specific eigen-faces for face recognition [6, 7].

Ralph Gross, presented the concept of light field to characterize the continuous pose space, and (Liu-2005), are proposed a Gabor-based kernel PCA using Gabor wavelets and a kernel. However, most of 2D image-based methods deal with either illumination or pose variation, and so it is difficult to apply them directly when both illumination and pose variations are present.

b) Face recognition under low illumination and high Dirt

It is difficult to exclude impact of human factor upon recognition result. In condition of environment and light factor is fully effective on camera properties and performance and it is defected accuracy of result, although fingerprint identity recognition technology has been mature. However, it is not applicable to a complicated environment under low illumination and high dirt [1, 6, 11]. Low illumination and high dirt identity recognition technology based on facial features has an extensive application prospect since it is needed in many industry sectors. Under low illumination and high dirt environment, compared with other biological features (fingerprint, voice, DNA, etc.), it is the most direct and natural method to use facial features in identity verification technology.

c) Illumination by Sparse Function representation

In the statistical signal processing community, the algorithmic problem of computing sparse linear representations with respect to an over complete dictionary of base elements or signal atoms has seen a recent surge of interest. Much of this excitement centers on the discovery that whenever the optimal representation is sufficiently sparse, it can be efficiently computed by convex optimization [9], even though this problem can be extremely difficult in the general case. We exploit sparse representation [1, 2] for robust visual tracking with the intuition that the appearance of a tracked object can be sparsely represented by its appearances in previous frames. One reason often asserted for the superiority of 3D is that it is ''illumination independent'' whereas 2D appearance can be affected by illumination in various ways.

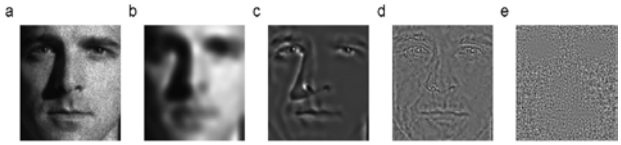

Figure 2 : Illumination based image classification (a) Noise-blur-red image, (b) low-pass sub-band, (c) strong edges, (d) weak-edges and (e) noise

The challenges in designing a robust visual tracking algorithm are caused by the presence of noise, occlusion, varying viewpoints, background clutter, and illumination changes [11, 12]. To overcome these challenges, we develop a robust visual tracking framework by casting the tracking problem as finding a sparse approximation in a template subspace. It is true that 3D shape per se is illumination independent, in the sense that a given 3D shape exist the same independent of how it is illuminated. However, the sensing of 3D shape is generally not illumination independent changes in the illumination of a 3D-shape can greatly affect the shape description that is acquired by a 3D sensor. Sparse Bayesian learning is used in; online [2, 5, 10] multiple instance learning is used in to achieve robustness to occlusions and other image corruptions. A new tracker is proposed by bootstrapping binary classifiers with structural constraints, and the tracker is shown to be reliable in long sequence tracking.

III. Incremental Method Under Face Recognition

In this section we review only the most relevant visual tracking work, focusing on algorithms that operate directly on grayscale images. An incremental method is:

- Sequentially one by one Compute and updates
- Successively updating an earlier model as new observations

Number of incremental versions of LDA have been suggested, which can be applied to on-line learning tasks, an incremental version [5, 10] of LDA, which includes a single new data point in each time step. A major limitation is the computational complexity of the method when the number of classes C is large, as the method involves an eigen-decomposition of C $\times$ C-sized scatter matrices. Incremental linear discriminant analysis (ILDA) in its two forms: a sequential ILDA and a Chunk, ILDA. In experiments;

Step (1) updating the within-class scatter matrix; {S_W}
Step (2) updating the between-class scatter matrix; {S_B}
Step (3) updating sparse total scatter matrix: {S_T}

Respectively S_B, S_W, and S_T are well arranged to boosting of each training samples incrementally;

$$\mathbf{S}_W = \sum_{i=1}^{C} \sum_{\mathbf{x} \in C_i} (\mathbf{x} - \mathbf{m}_i)(\mathbf{x} - \mathbf{m}_i)^T \quad (1)$$

$$\mathbf{S}_B = \sum_{i=1}^{C} n_i (\mathbf{m}_i - \boldsymbol{\mu})(\mathbf{m}_i - \boldsymbol{\mu})^T \quad (2)$$

$$\mathbf{S}_T = \sum_{all\ \mathbf{x}} (\mathbf{x} - \boldsymbol{\mu})(\mathbf{x} - \boldsymbol{\mu})^T \quad (3)$$

Here C the total number of classes, n_i the sample number of class i, mi the mean of class i, and μ the global mean, and total scatter matrix;

$$S_T = S_B + S_W \quad (4)$$

Inspiration for incremental LDA can be drawn from work on incremental PCA. Numerous algorithms have been developed to update eigenbases as more data samples arrive (Table-I). However, most methods assume zero mean in updating the eigenbases except where the update of the mean is handled correctly. In the methods, the size of the matrix to be eigen-decomposed is reduced by using the sufficient spanning set (a reduced set of basis vectors spanning the space of most data variation). As the computation of the Eigen problem is cubic in the size of the respective scatter matrix, this update scheme is highly efficient. Similarly to the proposed tracker is essentially an eigen-tracker, where the eigen-space is adaptively learned and updated online.

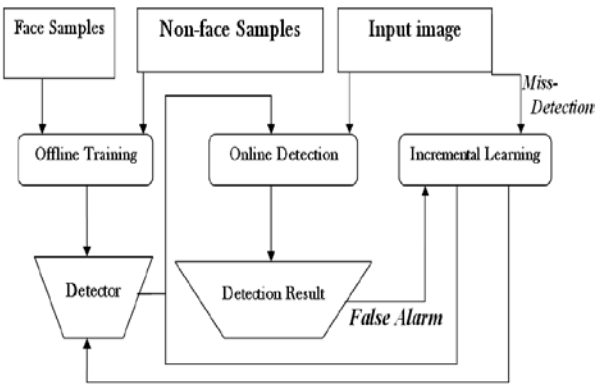

Figure 3 : A Framework of incremental learning based Offline and Online Recognition and Detection

The appearance of a target object may change drastically due to intrinsic and extrinsic factors as discussed earlier. The incremental LDA solution of first performs incremental PCA then updates LDA bases. The method similarly takes a single new data point as input and suffers when C is large, introduced a scheme for updating the between-class and within-class scatter matrices. Linearly combines it in an optimal way into a stronger classifier,

$$\mathbf{S}(\mathbf{x}) = \boldsymbol{sign} \sum_{i,j=0}^{T} \boldsymbol{Xm_i\ \mu mi} \quad (5)$$

An AdaBoost learning procedure is aimed at deriving Xmi and μmi, so that an upper error bound is minimized, therefore, to produce a robust tracker, it is important to adapt the appearance model online, while tracking, to reflect these changes.

IV. Proposed Framework Working Mechanism

In this Approach we help Sparse approximation is a key technique developed in engineering and the sciences which approximates an input signal, X_i, in terms of a "sparse" combination of fixed bases N. Main keys of sparse approximation is;

- High dimension data reduced to Low Samples.
- Matrix based Eigen value Decomposer.
- Comparative with PCA, LDA, etc.

Unlike many existing algorithms which are based upon online boosting, our framework makes use of SLDA based feature selection which aims to maximize the class-separation criterion. It is relies on an optimization algorithm to infer the Maximum A-Posteriori (MAP) weights W that best reconstruct the signal, given the model .The Sparse LDA (SLDA) maximizes a generalized Eigen-value (generalized Rayleigh) quotient) in a cardinality-constrained subspace (variable subset). Sparse LDA methods are preferable over regular LDA methods. In presented a MATLAB technique to compute optimal sparse linear discriminants using branch and bound approaches. Nevertheless, finding the globally optimal solutions for high dimensional data is computationally infeasible. ILDA instead tries to find a nearly optimal solution to this problem in a greedy way. This gives an exact formulation of sparse generalized [1, 2] Eigen Value Decompositions and also suggests a simple post-processing step (variation renormalization) for improving continuous solutions.

Input: training data *D* (*person; illumination*),
Filtered data *F* (*person; illumination*),
Sparse function *S*, Filter *F*.
Output: estimate S (X, *μ*)

1. **Initialization**
   p (X*μ*) = 0
2. **Simulated matching iteration**
   For all illuminations *i; j* **and** persons p
3. **Initial separation**

$S_B \geq S_T \leq S_W = \{S, F\}$;

Then *Sparse function equities of Illumination filter*

4. Iteration

For all $p = S_T$

5. Separation given

$\{S, M\} = \{p(X, \mu)\}$

6. Update incremental density estimate

$D_{ij} \geq S, F, p(X, \mu)$

7. Smooth the output

$S \equiv F \equiv D$

Algorithm 1: Illumination separation with sparse function

Although our algorithms performs well in the most of scenes, it may lose the target if the object experiences a large out-of-plane rotation video is recorded in an indoor environment with large illumination changes from the sunlight, our algorithm is not only suited for planar tracking like experiment but also is effective and efficient compared with ordinary tracking algorithms like Particle Filter and Ensemble Tracking , performance of our proposed object tracking algorithm is more promising to cope with various appearance changes and illumination variance. Some Computational efficiency tested experimentally as;

Table 1 : Eigenvalues Computed for Sparse Feuture Extraction.(Input Same)

Eigenvalues determined using Liu's method	Eigenvalues determined by our experiment
1.00000000e+00	3.31404839e+04
1.00000000e+00	2.39240384e+04
1.00000000e+00	1.67198579e+04
1.00000000e+00	1.01370563e+04
1.00000000e+00	6.88308959e+03
1.00000000e+00	7.41289737e+03
1.00000000e+00	2.70253079e+03
1.00000000e+00	5.53323313e+03
1.00000000e+00	3.46817376e+03

In experimental purpose, we use Yale B face databases, Sony 16MP camera based image under Intel Quad 64-bit processor with 6GB of RAM, for MATLAB 7.0.1., and generated some critical results as;

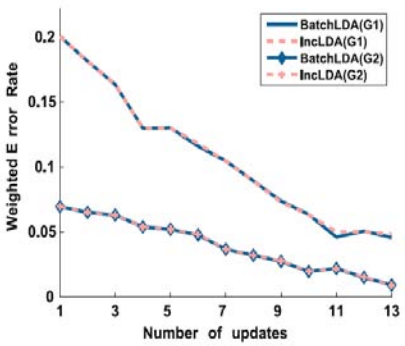

Figure 5 : A comparison under online weighted error detection

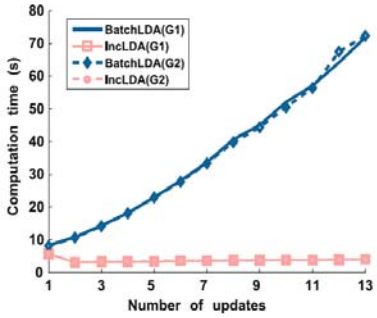

Figure 6 : A comparison under online computational complexity

Because the initial training of online ILDA is the same as offline ILDA, here we briefly explain the time complexity of SLDA; Let us assume we choose decision stumps as our weak learners. Let the number of training samples be ***N***, finding an optimal threshold of each feature needs ***O (N log N)***. Assume that the size of feature sets is ***M***. The time complexity for training weak learners is ***O (M N log N)***.

Table 2 : Complexity Factor of Figure 6

Factor	Batch LDA	Incremental LDA
Time	$O(NM^2+\min(N,M_3)^3)$	$O(d_{T,1})^3+d_{B,1}+N\,d_{T,3}+3d_{B,3}$
Space	$O(NM_3+NC_3)$	$O(Nd_{T,3}+Nd_{B,3})$

Both time and space complexity of the proposed incremental LDA are independent of the size (d_T and d_B); of the total sample set and the total number of classes. During ILDA learning, we need to find mean ***O (n)***, variance and correlation ***(OT²)*** for each feature.

V. Conclusion

In this paper we discuss why the face recognition rate is changed via different illumination invariant case under the optometry of camera or other input source is automatically changed depend the problems of light variant. Major idea is incrementally changed the AdaBoost based object detector can be trained to achieve a high detection performance for online face processing, recognition, detector efficiency, we devise a new edge orientation based features, which is approximately invariant to illumination variance through the theory proof. Besides, to reduce the amount of computation and increase the efficiency of particles, another preprocessed layer is added to cut the particles according to the difference between the average value of edge orientation in the particle region and the original target region. It is obviously seen that our proposed algorithm achieves excellent results even under large illumination variances.

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- Leave out information that is immaterial to a third party.

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- 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.
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- 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
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- 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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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

S

T

U

V

W

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