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Comparative Analysis of Skin Segmentation Methods in Image Mining

S Vijayarani
Assistant Professor, Department of Computer Science
School of Computer Science and Engg.,
Bharathiar University
Coimbatore, India
vijimohan_2000@yahoo.com

M Vinupriya
Research Scholar, Department of Computer Science
School of Computer Science and Engg.,
Bharathiar University
Coimbatore, India
vinupriya.53@gmail.com

***Abstract*- Data mining is the process of analyzing data from different perspectives and summarizing it into useful information. It uses sophisticated mathematical algorithms to segment the data and evaluate the probability of future events. Several techniques are used in developing data mining projects such as clustering, classification, association rule mining, outlier analysis, etc. Some of the research areas in data mining are web mining, text mining, data streams, image mining, sequence mining and multimedia mining and so on. Image mining can be defined as the nontrivial process of finding out valid, original, potentially useful and ultimately understandable information from large image sets or image databases. Image mining is also an interdisciplinary research area which contains digital image processing, database, image understanding, artificial intelligence, pattern discovery, face recognition and so on. Face detection and localization is the task of checking whether the given input image contains any human face, and if so, the location of the human face in the image is determined. In this research work, the performance of segmenting the skin region and time taken to detect skin region are analyzed by Skin segmentation using HSV color and Gradient Vector Flow techniques. The skin regions that are segmented from the facial images are used for face detection. The performances of both segmentation methods are analyzed by applying performance factors and from the experimental results, it is observed that the skin segmentation using HSV color method works more efficient than Gradient Vector Flow method.**

Keywords-Data Mining, Image Mining, Face Detection, Segmentation, Preprocessing, Skin segmentation, Gradient Vector Flow

I. INTRODUCTION

Image mining facilitates the abstraction of hidden information which is not clearly accrued in the image. It is more than just an extension of data mining to image domain. It is used to detect unfamiliar patterns and abstract inherent and useful data from images stored in the large databases. Therefore image mining deals with making relationships between different images from large image databases. These images, if examined, can reveal useful information to the human users. Image mining deals with the abstraction of information, image data relationship, or other patterns not clearly stored in the images. It is distinct from low-level computer vision and image processing techniques. It uses methods from image processing, image retrieval, computer vision, machine learning, data mining, database, and artificial intelligence. Some methods allow image mining to have two different approaches. First method extracts images from image databases or collection of images. Second method mines a combination of associated alphanumeric data and collection of images [10].

Face detection is the problem of determining whether a sub-window of an image contains a face. Face detection has received much attention and has been an extensive research topic in recent years. It is the first step in many applications such as face processing (i.e. face, expression, and gesture recognition), computer human interaction, human crowd surveillance, biometric, video surveillance, artificial intelligence and content-based image retrieval. From all of these applications stated above, face detection requires a preprocessing step for obtaining the object. There have been various approaches proposed for face detection which could be generally classified into four categories. (i) Template matching methods (ii) Feature-based methods, (iii) Knowledge-based methods, and (iv) Machine learning methods. The great challenge in the face detection problem is the

large number of factors that govern the problem space. The long list of these factors consist of the pose, orientation, luminance conditions, facial expressions, occlusion, facial sizes found in the image, ethnicity of the subject, structural components, gender, the scene and complexity of image's background [11, 12].

Skin detection plays an important role in a wide range of image processing applications ranging from face tracking, gesture analysis, face detection, content-based image retrieval systems and to various human computer interaction domains. Recently, skin detection methodologies founded on skin-color information as a cue has gained much attention as skin-color presents computationally effective yet, robust information against rotations, partial occlusions and scaling [9].

The rest of the paper is organized as follows. Section 2 describes the literature survey of various segmentation methods and its comparison. Section 3 discusses about the Skin segmentation using HSV color and Gradient Vector Flow. Experimental results are analyzed in Section 4 and conclusion is given in Section 5.

II. LITERATURE REVIEW

Several researches have been carried on this face detection. This section presents a study on various segmentation methods that were proposed earlier.

BaozhuWang1 et al., [1] discussed about the procedures of face segmentation in the color image based on skin detection through the establishment of skin model and the segmentation of skin region. In particular, the scheme significantly increases the execution speed of the face segmentation algorithm in the case of difficult backgrounds. The experiments show that this method reduces the computation of the procedure and at the same time improves the detection speed and efficiency.

Mohammad Saber Iraji et al., [2] proposed an efficient and accurate method for human color skin recognition in color images with different light intensity. The inputted color image is first transformed from RGB color space to YCBCR color space and then accurate and appropriate decision on that if it is in human skin color or if not, it will be adopted according to YCBCR color space using fuzzy, adaptive fuzzy neural network (anfis) methods for each pixel of that image. In the proposed system, adaptive fuzzy neural network (anfis) has less error and system worked more accurate and appropriative than prior methods.

H C Vijay Lakshmi et al., [3] proposed an improved segmentation algorithm for face detection in color images with multiple faces and skin tone regions. Algorithm ingeniously combines different color space models, particularly HSI and YCbCr along with Canny and Prewitt edge detection techniques. Development over previous approaches by other researchers is demonstrated using example images where segmentation stage is critical for face detection.

Shivesh Bajpai, et al., [4] discussed about the comparison of Gradient vector flow and silhouettes, two of the most broadly used algorithms in the area of face detection. Both algorithms were applied on a common database and the results were compared. This is the first paper which estimates the runtime analysis of Gradient vector field methodology and compares with silhouettes segmentation technique. The paper also discussed about the factors affecting the performance and error incurred by both the algorithms. Finally, results are enlightened which proves the superiority of the silhouette segmentation method over Gradient vector flow method.

Mayank Vatsa, et al., [5] proposed an algorithm for face detection using Gradient Vector Flow in gray level images which overcomes the problem for localization and initialization. The algorithm has been tested on different face databases and the result shows an accuracy of 91% with invariance to pose and orientation.

III. METHODOLOGY

Face Recognition System is a computer application for automatically identifying or verifying a person from a digital image or a single frame from a video source. This can be done by comparing selected facial characteristics of the likeness and a facial database. It executes that by comparing the face of the accessing user with a database of faces previously stored in memory. The core objective of this research work is to find out the best segmentation method among skin segmentation using HSV color and Gradient Vector Flow. The system architecture is as follows:

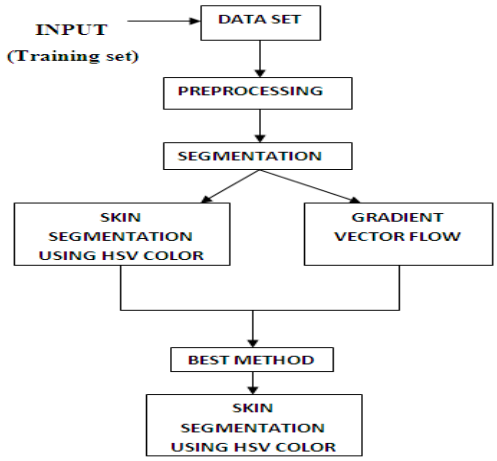

Figure 1. System architecture of segmentation

a. Data Set

To compare the image segmentation methods, different size of real time facial images are collected and the data set is created. This dataset consists of 22 different faces. Confusion matrix is used to analyze the performance of the segmentation methods.

b. Preprocessing

The aim of preprocessing is an improvement of the image data that suppresses unwanted distortions or enhances some image features important for further processing. Data pre-processing is an important step in the data mining process. The phrase "garbage in, garbage out" is particularly applicable to data mining and machine learning projects. Data gathering techniques are often loosely controlled, resulting in impossible data combinations, out-of-range values, missing values, etc. A study of data that has not been carefully screened for such problems can generate misleading results. Thus, the demonstration and quality of data is first and foremost before running an analysis. If there is much irrelevant and redundant information present or noisy and unreliable data in the image, then knowledge discovery during the training phase is more complicated. Data preparation and filtering steps can take significant amount of processing time. Data pre-processing methods includes cleaning, normalization, transformation, integration, reduction, feature extraction and selection, segmentation etc.

c. Segmentation

The Image segmentation is an important issue in pattern recognition, computer vision and image processing etc. It is typically used to locate objects and boundaries (lines, curves, etc.) in images. Segmentation is a process that partitions an image into regions, so as to change the representation of an image into something that is more meaningful and easier to analyze. In the problem of face detection, skin segmentation assists in identifying the probable regions containing the faces as all skin segmented regions are not face regions and aids in reducing the search space. The segmentation is crucial part of the process, because if the image is not properly segmented, further analysis may not be possible. A good example of image segmentation is skin detection which is achieved by classifying the image pixels into two groups: skin pixels and non skin pixels using skin color information. As all the skin segmented regions are not face regions, all segmented region is passed through a face classification algorithm to check whether the segmented region is face or not. Different types of image segmentations are threshold, clustering methods, compression based methods, Histogram based methods, Graph portioning methods, pixel based segmentation, skin segmentation, Gradient Vector Flow so on. Some of the practical applications of image segmentation are content based image retrieval, face recognition, medical imaging, video surveillance, object detection etc.

Skin Segmentation

Skin detection is a very popular and useful technique for detecting and tracking human-body parts. It obtains much attention mainly because of its wide range of applications such as, naked people detection, face detection and tracking, hand segmentation for gesture analysis, content-based visual information retrieval (CBVIR), filtering of objectionable Web images, hand detection and tracking, people retrieval in databases and Internet, etc. The major goal of skin color detection or classification is to build a decision rule that will distinguish among skin and non-skin pixels. The identification of skin colored pixels involves the process of finding the range of

values for which most skin pixels would fall in a given color space. This is a fundamental task for any application that looks for human sequences on image and video streams. Color is a useful piece of information for skin detection. The skin detection is the important approach for detecting important skin color, skin color detection may avoid exhaustive search for faces in an entire image [8]. There are various types of skin segmentations are

1. Skin segmentation using multiple thresholds.
2. Skin segmentation using color and edge information
3. Skin segmentation using color pixel classification
4. Skin segmentation using color pixel
5. Skin segmentation using skin color

Skin Segmentation Using HSV Color

Skin color is a robust cue in human skin detection. It has been widely used in various human-related image processing applications that skin detection techniques based on skin color information have gained much attention recently. Skin color is a very important feature of human faces. The distribution of skin colors clusters in a small region of the chromatic color space [9]. Processing color is faster than processing other facial features. Therefore, skin color detection is firstly performed on the input color image to reduce the computational complexity. Because of the accuracy of skin color detection affects the result of face detection system, choosing an appropriate color space for skin color detection is very important. Hue indicates the dominant color of an area; saturation calculates the colorfulness of an area in proportion to its brightness. Value indicates the color luminance. Separation between chrominance & luminance makes this color space popular in the skin color detection. The transformation of RGB to HSV is invariant to high intensity at white lights, ambient light and Surface orientations relative to the light source and hence, can form a very good choice for skin detection methods. The HSV (Hue, Saturation, Value) model, also known as HSB (Hue, Saturation, Brightness), defines a color space in terms of three constituent components:

- Hue, the color type (such as red, blue, or yellow)
- Saturation, the "vibrancy" of the color:
- Value, the brightness of the color

$$H = \arccos \frac{\frac{1}{2}((R-G)+(R-B))}{\sqrt{((R-G)^2+(R-B)(G-B))}} \quad (1)$$

$$S = 1 - 3\frac{\min(R,G,B)}{R+G+B} \quad (2)$$

$$V = \frac{1`}{3}(R+G+B) \quad (3)$$

The input image is skin segmented first using HSV color space. On this skin segmented regions, various morphological operations such as erosion and dilation with suitable structure element is carried out.

Gradient Vector Flow

Gradient Vector Flow (GVF) snake is an extension of the well known method snakes or active contours. Snakes, or active contours, are used extensively in computer vision and image processing applications, mainly to locate object boundaries. Amongst a variety of image segmentation methods, the Gradient Vector Flow (GVF) technique recently gains a wide attention due to its excellent performance to deal with concave regions. The GVF snake uses a spatial diffusion of the gradient of an edge map, which replaces image gradients as an external force. Traditional snake is inherently weak in two main aspects: Firstly, the initial border must be fairly close to the true boundary. Second active contours cannot automatically converge to boundary concavities. GVF Snake has a much larger capture range than traditional snake and can solve the main problems.GVF snake have been widely used in image segmentation.

The difference between traditional snakes and GVF snakes consists in that the latter converge to boundary concavities and they do not need to be initialized close to the boundary. Problems associated with initialization and poor convergence to concave boundaries; however, they have limited their utility. They are commonly used to locate head boundary or edges. The task is attained by initializing the snake in the nearby proximity or region

around the head. The snake provides the actual boundaries if released within approximate boundaries. The snake initialized joins onto the edges and subsequently assumes the shape of the head.

Finally the snake takes the shape of the object and the energy becomes minimum. The initialization of the snake is a difficult task as the suitable set of parameters is required as it is essential for the initialization process. It is difficult to automatically generate the set of parameters for the objects of interest. Hence these constants are decided by the user. Once the parameters are decided correctly and the snake is released in close proximity to the object, the face can be extracted successfully. It is an efficient method used in a number of applications requiring face detection.

IV. EXPERIMENTAL RESULTS

a. Accuracy measure

The following table shows the accuracy measure of segmentation methods. A confusion matrix is a specific table layout that allows visualization of the performance of an algorithm. Each column of the matrix represents the instances in a predicted class, while each row represents the instances in an actual class. A table of confusion (sometimes also called a confusion matrix), is a table with two rows and two columns that reports the number of false positives, false negatives, true positives, and true negatives.

From the analysis of Accuracy Measures of Skin segmentation using HSV color and Gradient Vector Flow from the Table 1, Skin segmentation using HSV color performs well when compared to GVF accuracy measures namely confusion matrix. As a result Skin segmentation using HSV color outperforms well when compared to Gradient Vector Flow.

TABLE I. CONFUSION MATRIX

Segmentation methods		
Methods	*Accuracy*	*Confusion Matrix*
Skin segmentation using HSV color	*87.5%*	*3 0* *1 4*
Gradient Vector Flow	*75%*	*6 0* *2 0*

From the graph, it is observed that Skin segmentation using HSV color attains high accuracy percentage. Therefore the Skin segmentation using HSV color performs well because it attains high percentage of accuracy when compared to Gradient Vector Flow.

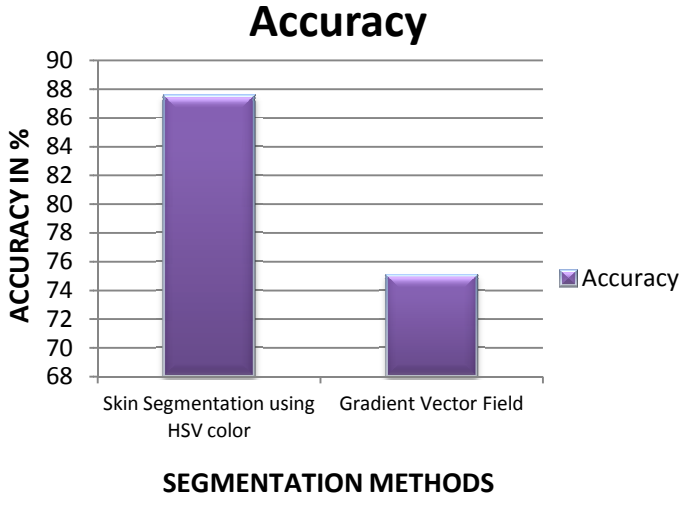

Figure 2: Accuracy measure

From the analysis of Accuracy Measures of Skin segmentation using HSV color and Gradient Vector Flow, Skin segmentation using HSV color detects skin region efficiently when compared to GVF. As a result Skin segmentation using HSV color outperforms well.

TABLE II. EXECUTION TIME OF SKIN SEGMENTATION USING HSV COLOR AND GRADIENT VECTOR FLOW

Segmentation methods	
Method	***Time(in sec)***
Skin segmentation using HSV color	*8.03*
Gradient Vector Flow	*31.8*

From the graph, it is observed that Skin segmentation using HSV color detects skin regions in fewer seconds than Gradient Vector Flow.

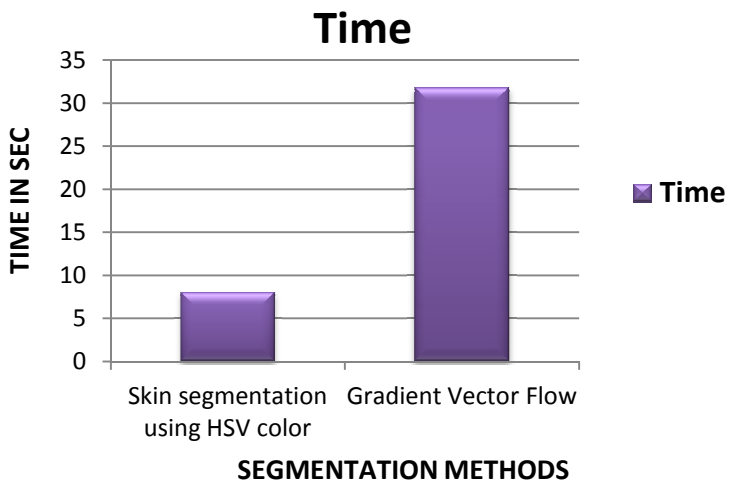

Figure 3: Execution time for Skin segmentation using HSV color and Gradient Vector Flow

Figure 4: Skin segmentation using HSV color

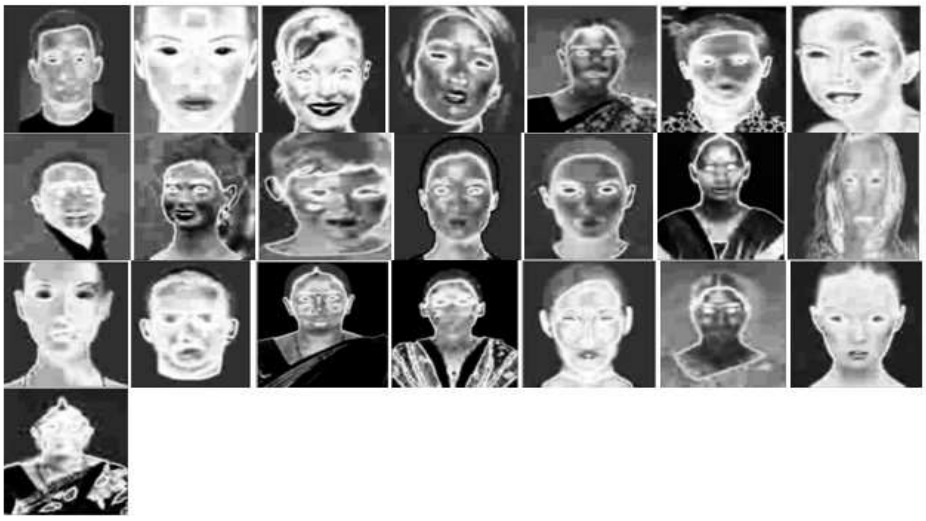

Figure 5: Gradient Vector Flow

V. CONCLUSION

Data mining or knowledge discovery is the computer-assisted method of digging through and analyzing huge sets of data and then extracting the meaning of the data. In the problem of face detection, skin segmentation helps in recognizing the probable regions containing the faces as all the skin segmented regions are not face regions and it also aids in reducing the search space. In this paper, segmentation methods namely Skin segmentation using HSV color and Gradient Vector Flow are used to segment the skin regions that are used to detect human facial images from the given data set. From the experimental results, it is clear that the Skin segmentation using HSV color performs better than Gradient Vector Flow method.

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