PONDICHERRY UNIVERSITY, PONDICHERRY

EXECUTIVE SUMMARY OF FINAL REPORT OF THE WORK DONE ON THE PROJECT

Title of the Research Project	Human Skin Segmentation in Color Images using Mixed Statistical Models in Identifying the Criminals and Terrorists
Name and Address of the Principal Investigator	**Dr.S.Ravi** Associate Professor Dept of Computer Science School of Engineering and Technology Pondicherry University, Puducherry - 605014 E-Mail: ***sravicite@gmail.com***
Name and Address of the Institution	Dept of Computer Science School of Engineering and Technology Pondicherry University, Puducherry - 605014
UGC approval No. and Date	F.No. 41-628/2012(SR) Dated 16-Jul-2012
Date of Implementation	01-07-2012
Tenure of the Project	From 01.07.2012 to 30.06.2015.
Total Grant Allocated	Rs. 12,26,100/-
Total Grant Received	Rs. 8,80,600/-
Final Expenditure	Rs. 6,99,08\-
Title of the Research Project	Human Skin Segmentation in Color Images using Mixed Statistical Models in Identifying the Criminals and Terrorists
Objective of the Project	The main objective of this major research project is to study and analyze twenty different chrominance spaces for human skin detection techniques and propose the new class of skin color pixel classification algorithms using piece-wise linear decision boundary, Gaussian, Mixed Gaussian and Bayesian classifier algorithms with application to face detection in color images. The automatic human face detection (AHFD) was carried out in two stages: ▪ Automatic human skin Detection (AHSD) ▪ Automatic human face Detection (AHFD) Automatic human skin detection in color images is a preliminary step in many computer vision problems and many skin detection methods were proposed by the researchers. Automatic human skin detection (AHSD) methods can be grouped into three types of skin modeling, viz. parametric, non-parametric and explicit skin cluster methods. The Gaussian parametric models assume that skin color

	distribution can be modeled by an elliptical Gaussian joint probability density function. Non-parametric methods estimate skin color distribution from the histogram of the training data without deriving an explicit model of skin color. The simplest and more often applied methods build an "explicit skin cluster" which defines the boundaries of the skin cluster in certain color spaces. The underlying hypothesis of methods based on explicit skin coloring is that skin pixels exhibit similar color coordinates in an appropriately chosen color space. These binary methods are very popular as they are easy to implement and do not require training phase. The following research objectives are framed and achieved in this major research project: • Enlightening the skin detection model using rule-based and parametric-based approaches respectively with different color spaces under unconstrained environments. • Enlightening the performance of different color spaces on rule-based skin detection model. • Enlightening the performance of different color spaces on parametric-based skin detection model. • Enlightening the performance of combination of two color spaces on each of the aforementioned approaches. • Enlightening the effectiveness of different color spaces on the performance of skin detection approaches. • Enlightening the effectiveness of face detection techniques using facial feature detection using golden ratio. Enlightening the performance of face recognition techniques using Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Genetic Algorithm (GA) for detecting the terrorists and criminals if the respective face data bases are used.
Whether the objectives were achieved (Give Details)	This Major Research Project contributes to the field of computer vision. The major contributions from this Major Research Project are illustrated as follows: • Manifesting the potential of non-RGB color spaces on skin detection process using efficient classifiers under challenging factors. • Manifesting the potential of

	combination of two different color spaces over the usage of single color space using the same classifiers and factors. This approach results in the reduction of false positive with high true positive. • Developing an easy and reliable method for feature extraction, developing system for computing the accuracy of features and introducing a new enhancement-based fusion strategy algorithm. • The proposed algorithms are invariant with the cluttered background, skin races, indoor and outdoor lighting conditions. They can be used in the hand gesture recognition as well as face tracking to face recognition applications. • The effectiveness of of face detection techniques is enlightened using facial feature detection using golden ratio • The performance of face recognition techniques are enlightened using Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Genetic Algorithm (GA) for detecting the terrorists and criminals using the respective face data bases.
Achievements from the Project	Automatic skin detection is one of the essential requirements of real-time computer vision applications such as face detection, face tracking, face recognition etc. Nowadays, these applications are used in security applications. Human skin color is well suited for this task, but generally it suffers from false detection and the appearance of human skin color under changing lighting conditions that increases the complexity of skin detection. Finding the difference between skin and non-skin classes is the main objective of skin classifiers under unconstrained environments. The objective can be achieved by the appropriate selection of color space, skin color modelling and classification techniques as well as illumination adaptation approaches. Dropping the luminance component reduces the performance of skin detection process. It is clearly observed that there is a strong constraint between the degree of skin color

	clustering and the performance of skin detection techniques in pixel-based approaches. Histogram approach is suitable in large datasets, but it requires large memory storage as compared to mixture and NN models. Bayesian and fuzzy approach-based skin classifier is feasible as compared to NN model as well as other techniques when small datasets are available. Since Bayesian is a non-parametric approach that requires large memory storage as compared to fuzzy approach. The latter can be taken theoretically as the best approach among these techniques. Comparison between fuzzy approach and GA has not been done until now; that can be considered as a new open (research) problem to detect their success rate in real-time. Skin detection problems based on only color features is a difficult task. This problem is minimized by using region-based (texture) information with pixel-based approaches. Getting a robust and an efficient skin segmentation model under varying and unpredictable situations is quiet a problem. However, color constancy and dynamic adaptation approaches are effectively used as a pre-processing step to overcome the difficulties. Color constancy algorithms are scene constraint-based approaches. So, the performance can vary with unconstrained situations. Dynamic adaptation approaches upgrade the existing skin detection techniques so that it can adapt the environmental changes effectively and produce a robust skin detection model. But the problem is that there is no standard dataset with which performance of existing skin detection models can be compared in the real-world.
Summary of the findings(in 500 words)	The study is carried out to test the performance of twenty different color spaces with the images usable in both skin and face detection problems. The main aim of the study is to discover the performance of color spaces for skin detection process under the variety of challenging factors. To address the issue, color spaces with the rule-based approach, Bayesian based and Gaussian-based approach under complex environmental situations have been tested. It is experimentally found that rule-based approach has outperformed the Gaussian-based approach. YCbCr model with rule-based approach has outperformed all other models and classifier pairs. YCC, YES, YUV and YPbPr with rule-based approach have also performed well. In Gaussian-

	based approach, YUV model has outperformed other color models. It is also found that all the color spaces have performed well with Gaussian-based approach with respect to RGB model except XYZ and YDbDr color model. Color spaces that are not impinge with the factor like *shadow* are RGB, YCbCr and YUV; *ethnicity* is RGB, YCC, YDbDr, YCbCr and YUV; and *cap* are RGB, HSV, YDbDr, YCbCr, YUV and YIQ. All of the color spaces are approximately affected by two major factors: *illumination and cluttered backgrounds*. • Skin detection based on the human skin color furnishes computationally efficient information against geometric transformations for several applications of image processing, pattern recognition and computer vision to enhance the findings of human faces and limbs in images or video frames. A statistical evaluation of skin detection approaches is provided using relevance measure over twelve different color spaces. Unlike single color space, the combinations of two color spaces have produced better results with the altering human face skin tone color as well as lighting conditions. The experimental results reveal the following findings: • YCbCr, RGB-YCbCr, YCbCr-YES and YCbCr-YCC are the color spaces that perform well with the rule-based approach as compared to RGB color space; • YUV, YIQ, HSL-YUV, HSL-YPbPr, YUV-YPbPr are the color spaces that perform well with the Gaussian model as compared to RGB color space; • There is a significant difference in the selection of a color space with the selection of skin detection approach; • Rule-based approach outperforms the Gaussian-based approach; • YUV is the color space that performs well with both the rule-based and Gaussian-based approach; • The transformation of color space has not consistently improvised the performance of skin detection; and • YCbCr-YCC color space has got the first rank using rule-based approach. Experimentally, it is found that the proposed techniques have outperformed the traditional

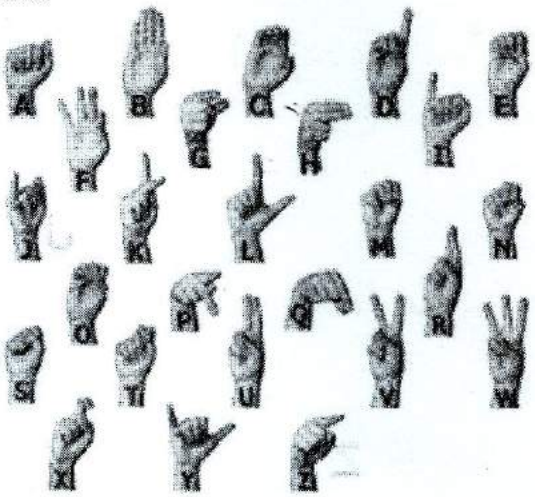
	enhancement techniques. The fusion strategy is adapted to reduce the FPR and increase the TPR. Since, the accuracy of face detection results depends on the accuracy of skin region extraction from an image. Therefore, the proposed algorithm fixes the delocalization problem of bounding box by correctly identifying skin color with minimum FPR, and to locate the human face. The advantage of the proposed approach is its simplicity and accuracy at the penalty of time complexity.
Contribution to the society (Give details)	The primary applications of skin detection system are: ❖ **Facial analysis** As we know that human's first impression is the best impression. It is assumed that there is always strong connection between the facial feature and personality traits for impressing someone. Identification of skin regions helps in locating, identifying and recognizing human faces by reducing search space in an image or video frames. After that facial feature attributes are considered for verification of human faces in the image. ❖ **Gesture analysis** It is related to the language technology with the aim of interpreting human gestures through mathematical algorithms. It is originated from the body movement either from face or hand. Gesture recognition enables humans to communicate with the machine and interact naturally without using any mechanical devices. Hand gesture recognition acts as a highly adaptive interface between machines and their users. It allows operations of complex machines using only a series of finger and hand movements as shown in figure 1, eliminating the need for physical contact between operator and machine. 

Figure 1 Basic hand gestures of American Sign Language ("Sign Language" 2016)

❖ **Video surveillance**

It is used by the government for monitoring the behaviour, activities or intelligence gathering to prevent crimes (shown in figure 2). It is also used by the criminals to plan and commit crimes such as robbery, kidnapping, killing or any other terrorist activities.

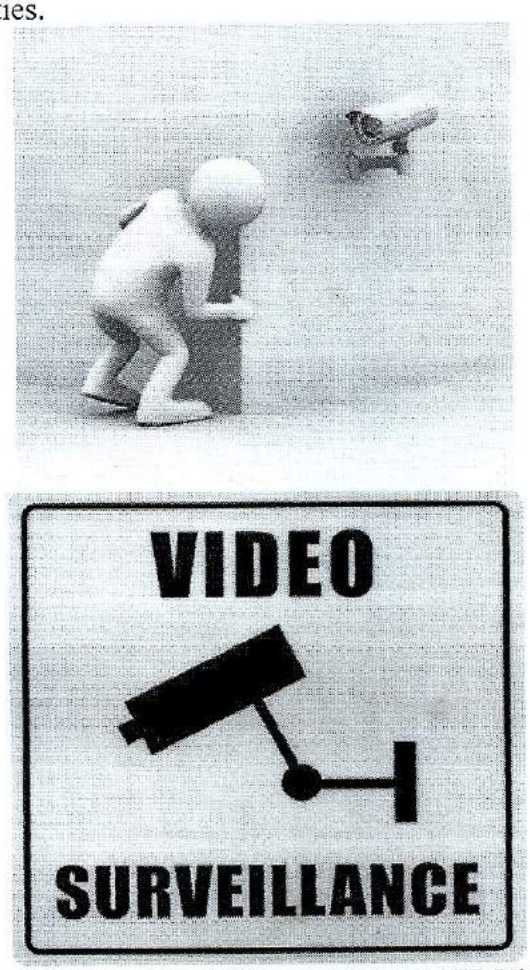


Figure 2 Video surveillance camera ("IP Video Surveillance NJ" 2016 ; "Action Nogent" 2016)

❖ **Human-machine interface**

It is the space where machines and human interaction occur. It allows seeing and sensing the human being. This interface depends on the accuracy of its face localization component that tracks head pose and head movement. It is useful insecurity concerns, track problems and others.

❖ **Image content filtering**

It allows you to block pornographic images or videos from websites by analysing its content as shown in figure 3.

It blocks all the suspicious images having

80-90% skin color appearance. The need to block and filter this kind of undesirable content is to prevent people especially children to see the illegal, violent and harmful content available on adult content websites.

- **Face tracking**

It allows the security agencies and mobile industries to track human faces in an entire video.

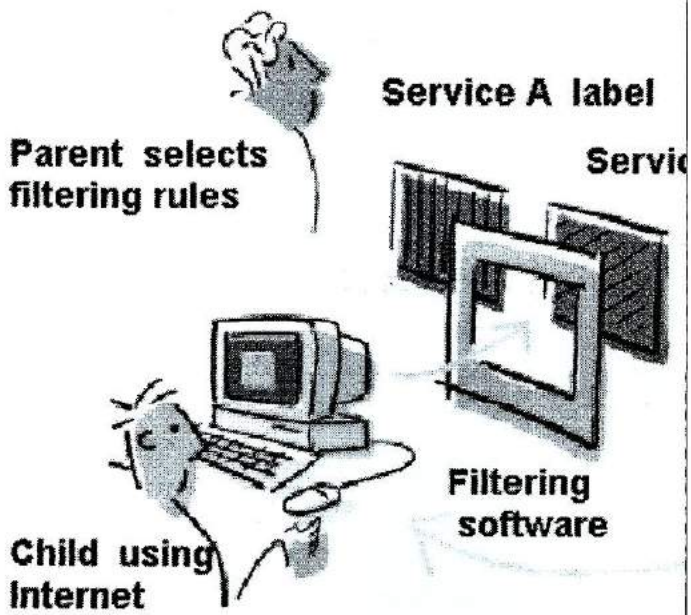


Figure 3 Image content filtration ("PICS, Censorship, and Intellectual Freedom FAQ" 2016)

- **Steganography**

It is a new security approach for the transmission of hidden secret data in another transmission medium to achieve secret communication. It is concentrated on the degree of invisibility. Skin tone steganography is one of the secured ways of data hiding in the real time images.

Therefore, skin detection has proven to be useful and robust cue for detecting human parts in images or frames (Vezhnevets et al. 2003; Jones and Rehg 2002). It is invariant to orientation and size. Usage of color images gives an extra dimension compared to grey scale methods that increases computational efficiency while processing. Besides, it limits the search space that helps in several applications such as face detection, tracking to recognition, hand recognition, adult content filtering and others to perform fast computation. In spite of the benefits, the performance of it is limited by certain factors. The aspect of varying illumination (appreciable property that shows the effect of light in color images) conditions while capturing an

	image. Suppose, a person stands near window, may be part of his face facing daylight and part facing room lighting. This shows how the appearance of skin tone color looks different within the image under unconstrained lighting conditions. In addition, different people belonging to different regions often have different skin colors. Asian, African, Caucasian, Hispanic and Indian are the ethnicities taken into account for skin detection. These races ranges from the white, yellow, pink, brown to black colors of human skin. The existence of objects in the cluttered background similar to skin-like color (pinkish, golden etc.) also results in challenges for finding the exact discrimination boundary of human skin color. These factors influence the performance of skin detector if the environment is uncontrolled. Thus, the aim is to overcome the aforementioned constraints without debasing the performance of skin detection.
Whether any Ph. D Entrolled/Produced out of the project	Yes – 2 Ph. Ds
Number of Publications out of the project (Please attach	**RESEARCH PAPERS PUBLISHED:** **INTERNATIONAL JOURNALS:** [1] Richa Mishra, Ravi Subban, "Human Face Localization Using Normalized RGB Color Space", "Advances in Natural and Applied Sciences" with ISSN-19950772, , 9(6) Special 2015, Pages: 322-326 [2] Ravi Subban* and Richa Mishra, "The Design and Analysis on Human Face Detection in Color Images using Artificial Neural Networks", "International Journal of Applied Engineering Research (IJAER) with ISSN 0973-4562, Volume 10, Number 21 (2015) , pp.19931-19936, **(SCImago Journal Rank (SJR): 0.2) (Impact Factor – 0.14)** [3] PasupathiPerumalsamy, Ravi Subban, et.al., "Morphological Based Skin Segmentation Using Computer Graphics Color Model", Advances in Natural and Applied Sciences, 9(12) Pages: 95-99 ISSN:1995-0772, EISSN: 1998-1090, August 2015

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