Fuzzy Based Skin Detection and Segmentation

Afia Nazir[1], Laiq Hassan[1], Alamzeb M. Zai[2], Rehanullah Khan[3]
[1] University of Engineering & Technology, Peshawar, Pakistan
[2] Gandhara Institute of Science and Technology, Peshawar
[3] Sarhad University of Science & IT, Peshawar, Pakistan

Abstract— **Skin detection being one of the most crucial tasks in image processing applications, is targeted in this work with special emphasis on fuzzy based skin detection and segmentation techniques. Using weka tool, this paper provides the performance evaluation of two well-known fuzzy based skin detection techniques, fuzzy inference system and Modified Fuzzy C-Mean algorithm (MFCM) on a standard dataset. For the inference system we used the Fuzzy Unordered Rule Induction Algorithm (FURIA) implementation, and Brute Force Search Algorithm implementation for the Modified Fuzzy C-Means algorithm. Based on the experimental results, fuzzy inference algorithm provides 80.4633 % of correct classification for skin pixels and MFCM has 85.2316 % of accuracy in identifying the skin pixels.**

Keywords: Skin modeling, color space, Fuzzy inference systems, Skin pixels, MFCM, Fuzzy inference system, fuzzy classification.

I. INTRODUCTION

With the advancement of World Wide Web technologies, people search out information in the form of images and photos, this makes the image processing a huge domain of research and study. Numerous work and studies have been conducted by the researchers in this domain. Skin detection is a part of such studies and efforts that brought the revolution in the image processing and World Wide Web technologies.

Regarding image processing, in this paper our focus is to provide a detailed overview of fuzzy based skin detection and segmentation techniques, and to discuss the different issues related to skin detection including, color spaces and skin modeling along with the performance evaluation of two fuzzy based classification methods in skin detection. To fulfill the target, Skin detection techniques have a great importance and have been planned in different ways, involving human-related image processing systems such as face recognition, lips reading, hand recognition, tracking through skin pixels [1]. Recently these applications are successfully functional to calculate the length of finger and shape of finger in case of hand detection, and support the user to identify, alert, and analyze the threats in case of video Surveillance. Skin detection refers to skin color and texture instead of geometric shapes; hence skin based detection algorithms involves these two attributes of skin, for achieving high recognition rate. We find different properties of skin based detection algorithms, involving a high processing speed due to its low level processing, invariance against rotations and pose changes. Skin based detection algorithms might have obstacles and challenges like illumination source variation, camera characteristics, individual characteristics etc that causes difficulties in the prediction of skin color. But due to the high performance rates skin based detection algorithms are best choices in many applications of image processing and computer vision. This paper has the performance evaluation of two fuzzy based skin detection methods i.e. fuzzy inference systems and Modified C-Means algorithm, on a standard dataset using weka tool.

II. RELATED WORK

Skin detection has applications in different fields, ranging from web technology to medical and video surveillance. Due to this versatility in applications, skin detection has been an area of great interest for the researchers. A detailed state-of-the-art of the skin detection with special emphasis on fuzzy based classification methods is presented here.

Ben Hmida et al. [2] proposed a system for human face detection considering the color and shape as features. Fuzzy based classification is used for the detection and analysis of human skin color. The same method of fuzzy classification is used by Moon Hwan Kim et al. [3] in their work for face detection. Their model is composed of fuzzy rules with skin color information. The fuzzy rules of this new fuzzy model are based on the linear matrix inequality.

A. Zaidan et al. [4] presented a hybrid system based on the skin color, for the skin detection using the fuzzy inference system. Along with the hybrid system for skin detection, they provided detailed information on the features and color space selection for skin detection and discussed different segmentation methods. They evaluated their proposed algorithm on images containing human skin with different backgrounds, and claimed for high reliability rate.

The similar work is presented by Sigal et al. [5]; they proposed an algorithm based on the skin color histogram for the skin segmentation and detection in video scenes. This algorithm uses markov model for updating the skin color histograms, for the skin predictions through the feedback from the current segments.

Selamat et al [6] presents a notable work for the detection of human body parts in an image. This work uses a modified version of fuzzy rules and known as mamdani fuzzy inference system. This model is designed especially to deal with the skin-lie pixels problem in skin detection and uses fuzzy rules with the skin modeling techniques. The authors also provided the comparison of the results of the proposed algorithm with the fuzzy sugeno method and concluded that this algorithm can perform better in situations where RGB value is not low.

III. Color Space Selection for Skin detection

Color space selection is a crucial factor in the skin detection processes, keeping in mind the fact that attributes like illumination, camera characteristics, individual characteristics etc causes difficulties in the prediction of skin color. Using non-visible spectrum i.e. infrared, spectral imaging, can overcome these factors but these further causes complications as it needs expensive equipments to use, so an efficient color space can overcome this problem of skin color prediction, which provides the color information of skin. Color space selection is not an easy process, the question that which color space is better for the detection of skin?, is still a frustrating question for researchers, and much work on skin detections have not reveal an authoritarian validation of color space selection so far. Some of the color spaces used in image processing includes, RGB, HIS and YC_rC_b , having different properties and are characterized by skin Color information, and very helpful in solving problem of skin color model.

IV. Overview of skin color modeling methods

In this section different skin color modeling methods are discussed.

Explicitly Defined Skin Region: Peer et al. [7] and Gomez et al. [8] proposed that the skin color modeling method (explicitly defined skin region) have a dependency on the choice of color space models, as it explicitly defines skin color boundaries in different color space. However, its simplicity and easy skin detection rules persuade the researchers to work on it e.g. [7, 9], and led to construct a skin classifier. The biggest challenge this model facing is the lack of a reasonable color space and decision rules. However this problem has been tackled by Gomez et al. [8], with machine learning algorithms.

Non-parametric Skin Distribution Modeling: This type of skin modeling is based on the estimation methods of skin color distribution. The performance of most of the non parametric skin modeling methods is different in different color spaces, so unlike “Explicitly defined skin region” modeling, this category of skin modeling needs no efforts for the selection of better color space [10]. Fast training and classification makes this method suitable choice for most of the skin detection applications. Non-parametric skin modeling is better in situations where the background in a scene is not fixed; however the requirement of huge storage space causes difficulties in the generalization of training data.

Parametric Skin-Color Modeling: The performance of parametric skin color modeling varies from color space to color space [11]. It has the ability to detect skin color under fixed lightening condition. The difficulty with parametric skin color modeling is in the detection of dark skin tones in normalized color space [12], and in face detection on Color Image [13]. This problem is tackled by detecting dark and light skin tone using YC_r color space. In comparison with non-parametric method it takes a little space for storage but slows down the training process.

V. Fuzzy based classification methods

Image classification is the main area on which this work focuses, we used fuzzy classifier to classify into skin valued pixel and a non skin valued pixel based on the skin color segmentation. Fuzzy classifier is based on the concepts of fuzzy rules, used for the classification of the skin and non skin pixels. Regarding this, many approaches of fuzzy skin detection uses various fuzzy classification methods like fuzzy logic methods, fuzzy interference system, Modified Fuzzy C Mean Algorithm, and Linear Matrix Inequality (LMI) Fuzzy Clustering. In this section a brief overview of these fuzzy techniques is presented.

VI. Overview of fuzzy algorithms used

Fuzzy interference systems: Fuzzy inference systems are based on the fuzzy logic containing the logical operations and if-else rules. It is defined as the mapping process from a set of inputs to outputs. Decision rules are extracted based on these input output mapping. A fuzzy inference system is a convenient method, as its name fuzzy suggests that the key idea of this method is the use of partial truth, providing the true values containing a range of value between 0 and 1.
Different types of fuzzy inference systems are available, e.g. Mamdan, Sugeno and much more. Takagi Sugeno fuzzy inference system (FIS) was proposed by Hamid et al. [2] for pixel classification and Mamdani was proposed by Selamat et al [6]. However in this paper we are using Fuzzy Unordered Rule Induction Algorithms (FURIA) by Jens Hühn et al. [14], as a classifier in Weka tool for the fuzzy inference system. FURIA is a modified version of RIPPER and is considered as its great competitor. As the name suggests, FURIA is based on unordered search and selection of fuzzy rules which is very effective in solving the priority and sorting problems of rule list approaches.

Modified Fuzzy C-Mean Algorithm (MFCM): Fuzzy c-means methods are based on the pixel intensity only, and based on this intensity information of a pixel performs the segmentation; however the researchers have proposed modified versions of fuzzy c-means methods such as presented by chahir et al. [15], to incorporate spatial information in segmentation and uses an algorithm that creates a region for the identification of skin and non skin pixel values using the neighborhoods information. In this work, we used Brute force search algorithm class in weka tool for the modified fuzzy c-mean algorithm implementation. It is a powerful searching algorithm that goes through the all possible solutions and finds the best solution.

VII. Dataset

For the evaluation of both fuzzy based classification methods i.e. Fuzzy Inference systems and Modified Fuzzy C-Means Algorithm for skin detection, we used a standard dataset used Sigal in his work [5]. This dataset is available online for the research purposes and can be downloaded from the author's web page. The dataset contains the high quality scenes from the movies and has a variety of scenes including the images of people belonging to different ethnicity, images with variation in background, source of illumination and camera characteristics. The dataset contains the images with individuals as well as crowded images with occlusion and background cluttering.

Figure 1: Images from dataset used for evaluation [5]

VIII. Flow Chart

Figure.1 depicts the basic work flow of the experimentation setup we used in our work. 1st step regarding the collection of data from web pages is considered to be the first step of any skin detection process. For the performance evaluation of both fuzzy based skin detection algorithms we used standard datasets. These images are passed through preprocessing phase for the removal of text and noise. During pre-processing of the images, the irrelevant information are removed leaving the human images only. 3rd step is regarding the extraction of features showing the color information, and selection of color space and skin modeling. In background subtraction the object of interest are separated from the image and in the final step fuzzy classification is performed for the detection of skin in a scene.

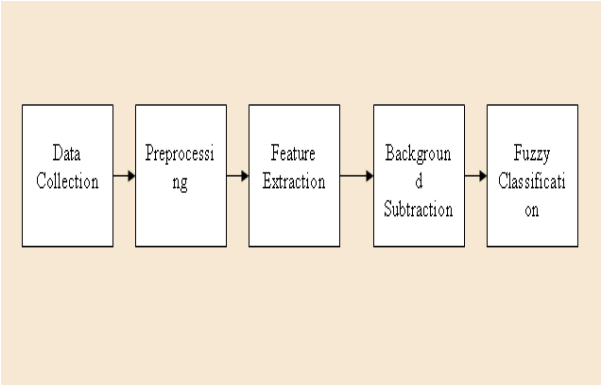

Figure.2: Flow chart of experimentation setup

IX. Evaluation Results

For the evaluation of both fuzzy based classification algorithms we performed the experiments in weka tool. For the Fuzzy inference system we used the FURIA classifier and Brute Force Search algorithm implementation for the MFCM. The main focus in experiments was on the analysis of fuzzy rules performance in skin detection, and that how the fuzzy classifier performs in skin detection. The evaluation criterion is based on the amount in percentage of correct classification of skin pixels. The following table.1 shows the evaluation results of both fuzzy based classification algorithms in skin detection. From the experimental results it is clear that Modified Fuzzy C-Means algorithm has 85.2316% correct classification of skin pixels and Fuzzy inference system has performed 80.4633% of correct classification.

Table.1

Instances	Correctly classified	Incorrectly classified
Fuzzy inference system	80.4633 %	19.5367 %
Modified Fuzzy C-Mean Algorithm(MFCM)	85.2316 %	14.7684 %

Table.1: Evaluation results of both Fuzzy based classification algorithms in skin detection

X. Conclusion

After the detailed analysis of the reliability rate of various skin detection techniques and different fuzzy classification methods, it is concluded that fuzzy classification methods can be a good choice for the skin detection. Another important benefit of the fuzzy techniques is that it not only improves the skin detection performance in images on web technologies, but also favors the applications of skin detection in face, hand and naked images detection and in cosmetic industry. As in our work, we examined the two well-known fuzzy classification methods for skin detection through extensive experimentation; the experimental results show that Modified Fuzzy C-Means Algorithm (MFCM) performs better than the Fuzzy interference system.

References

[1] A Abi-Dargham, E van de Giessen, M Slifstein, "Baseline and amphetamine-stimulated dopamine activity are related in drug-naive schizophrenic subjects", Biological .2009 .

[2] Ben Hmida, M. Nat, Ben Jemaa, "fuzzy classification, image segmentation and shape analysis for human face detection", Electronics, Circuits and Systems, 2006. ICECS '06. 13th IEEE International Conference .

[3] M. H. Kim, J. B. Park and Y. H. Joo , "New Fuzzy Skin Model for Face Detection", AI 2005, 557-566.

[4] A. A. Zaidan, H. Abdul Karim, N. N. Ahmad, Gazi Mahabubul Alam and B. B. Zaidan , "A new hybrid module for skin detector using fuzzy inference system structure andexplicit rules", Accepted 27 September, 2010.

[5] Sigal, L. Sclaroff, S. ,Athitsos, V. "skin color-based video segmentation under time varying illumination", pattern analysis and machine intelligence,july 2004.

[6] Selamat, A. Fac, Maarof, M.A.,Tey Yi Chin, " Fuzzy Mamdani inference system skin detection", Hybrid Intelligent Systems, 2009. HIS '09. Ninth International Conference, 2009.

[7] PEER, P., KOVAC, J., AND SOLINA, F. 2003. Human skin colour clustering for face detection. In submitted to EUROCON 2003 – International Conference on Computer as a Tool.

[8] GOMEZ, G., AND MORALES, E. 2002. Automatic feature construction and a simple rule induction algorithm for skin detection. In Proc. of the ICML Workshop on Machine Learning in Computer Vision, 31–38.

[9] AHLBERG, J. 1999. A system for face localization and facial feature ex-traction. Tech. Rep. LiTH-ISY-R-2172, Linkoping University.

[10] ZARIT, B. D., SUPER, B. J., AND QUEK, F. K. H. 1999. Comparison of five color models in skin pixel classification. In ICCV'99 Int'l Workshop on recognition, analysis and tracking of faces and gestures in Real-Time systems, 58–63.

[11] ALBIOL, A., TORRES, L., AND DELP, E. J. 2001. Optimum color spaces for skin detection. In Proceedings of the International Conference on Image Processing, vol. 1, 122–124.

[12] TERRILLON, J.-C., SHIRAZI, M. N., FUKAMACHI, H., AND AKAMATSU, S. 2000. Comparative performance of different skin chrominance mod- els and chrominance spaces for the automatic detection of human faces in color images. In Proc. of the International Conference on Face and Gesture Recognition, 54–61.

[13] HSU, R.-L., ABDEL-MOTTALEB, M., AND JAIN, A. K. 2002. Face detection in color images. IEEE Trans. Pattern Analysis and Machine Intelligence 24, 5, 696–706.

[14] Jens Hühn and Eyke Hüllermeier,"FURIA: An Algorithm For Unordered Fuzzy Rule Induction".

[15] Y Chahir, A Elmoataz, " Skin-color detection using fuzzy clustering", Proceedings of the ISCCSP, 2006.