SURVEY ON PERFORMANCE AND COLOR SPACES ANALYSIS FOR FACE DETECTION

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ABSTRACT: The color of a person's face is very important. There are numerous advantages of using complexion as a characteristic for monitoring a face. Color processing is much faster than other facial expressions. Many research works have been submitted to determine the best color model for face detection but there is no consensus on a suitable color model for color segmentation. The objective of this paper is to present a comparison between the different color spaces used in skin modeling and present the best color model for detecting faces using color segmentation. In this work, we examine a comprehensive review of published color spaces and then classify these color models and their advantages and limitations based on the influence of external factors affecting skin tone detection and face detection. The result shows RHB, YCbCr, and HVS were able to identify skin detection approaches that are utilized to recognize the face utilizing color spaces. In the future, this result will be used to help researchers develop and improve skin tone detection through color segmentation for face detection.

KEYWORDS: *Color Segmentation, Skin Detection, Image Processing*

1.0 INTRODUCTION

The color of a person's face is very important. There are numerous advantages of using complexion as a characteristic for monitoring a face. Color processing is much faster than other facial expressions. Color is orientation invariant under certain illumination conditions. Because just a translation model is necessary for motion estimation, this characteristic makes motion estimation considerably easier. There are numerous issues in tracking human faces using color as a characteristic. Just as the color representation of a face acquired by a camera is impacted by a variety of variables such as ambient light, object movement, and so on, so is the color representation of a face obtained by a camera. Color provides useful information at an early stage for object detection (such as face detection) and tracking images or video, segmentation, indexing, and far more, during a complex view. Many research works have been submitted to determine the best color model for face detection, as there is no consensus on a suitable color model for color segmentation, so we present a comparison between the different color spaces used in skin modeling and presenting the color model Best for detecting faces using color segmentation. The characteristics used to distinguish one color from another are luminance (brightness) and chrominance (hue and saturation). Among the various methods for detecting and locating faces in color, images include Chrominance-based, complexion-based, AdaBoost-based, Segmentation-based, and Neural Network-based[1].To utilize color as a visible cue in image processing, multimedia, computer vision applications, and special effects, an appropriate method for representing the color signal is required. Different color spaces possess different characteristics as applied to varied visual tasks. The term color space is usually mentioned as a color model. Typical samples of color spaces are Red Green Blue (RGB), Hue Saturation Value (HSV), Hue Saturated Intensity (HSI), Chroma: Blue; Chroma: Red (YCbCr), Cyan Yellow Magenta and black (CMYK), etc. Choosing the simplest color space, whose performance is best for efficient face detection may be a difficult task since several of the first colors in a picture won't be suitable for analysis. Hence, they must be adjusted by transforming colors from one color model to a different one while maintaining the image's natural looks and original details at an equivalent time[2] . Face detection using complexion involves two major steps (i) representing the image using proper color space, and (ii) modeling the skin and non-skin pixels using inference methodology to get information from available skin samples and to deduce the results from given samples. Next, the is a complex model to locate the candidate facial regions. Many research papers have been submitted to find the simplest color model for face detection. Because there is no consensus on which color model is best for detecting faces using color segmentation, we present a comparison of the various color spaces used in skin modeling and the color model that is best for detecting faces using color segmentation. In this work, we examine a comprehensive review of published color spaces and then classify these color models and their advantages and limitations based on the influence of external factors affecting skin tone detection and face detection.

2.0 RELATED STUDY

Literature of some research work is presented to identify the only color model for a specific task, since no consensus on the suitable color model for image segmentation. as an example, a comparative study [3] was administered between the numerous color spaces in cluster-based image segmentation using two similar clustering algorithms. Their study involved the test of 4 color models namely, RGB, HSV, CMY, and YUV to spot the only color representation. They obtained good results using HSV color spaces, while CMYK presented the only results in most cases [4] proposed how that selected a specific color model supported a chromatic color analysis. This criterion evaluates the quality of the segmentation in each color model and selects the only approach[5]. The research shows that the choice of color space depends on the image to be segmented.[6] described a hand segmentation method by employing a threshold technique for hand gesture recognition. They made a comparison between HSV, HSL, and HTS color spaces. HTS gave better results than the others.[7] proposed a method for facial detection using YCbCr to extract skin color and through AdaBoost training. The result was superior performance compared to other techniques and was able to detect lateral and clogged faces in the input images.[8]The application of color segmentation using YCbCr color space was carried out to choose the face area and identify the characteristics of the face. The proposed method started through the pre-treatment step. Then a segmentation step using A thresholding and morphological process was performed.

To choose the face area, some features Deviation, area, and texture features were used, and the highest accuracy was obtained in YCbCr color space.[9] The detection of human skin color was compared to HSV and YCbCr color space. complexion Detection is the process of separating surface and non-surface pixels. it's difficult to develop a uniform method for Segmentation or discovery of human skin detection because the degree of human complexion varies greatly for people from one region to a different. The results showed that RGB color space isn't favored for color detection and color analysis because of color mixing Information (chromaticity), intensity (luminance), and their irregular properties. based on luminance and hue an approach that distinguishes color and intensity information even under uneven lighting conditions. experimental result Demonstrates the efficiency of the YCbCr color space for segmentation and complexion detection in color images[10]. a performance analysis was carried out using a neural network-based-YCbCr skin recognition technique. The results of the analysis showed that the YCbCr color space model outperforms the RGB color space model. For the aim of face recognition, the research conducted by[11] shows that color models like YCbCr and YIQ, are suited to the popularity. Another study of the ten commonest color spaces for complexion detection was presented by[12] They concluded that *HSV* is the best color space to detect skin in a picture. And YCbCr color model is compared against YIQ in[13] then with RGB, HSV, YIQ, and YUV in[14] and with HSV in[5] .The YCbCr emerged because the best color model for complexion detection. (Li et al., 2021) The RGB, HSV, LAB, and YCbCr color models were compared in detecting the skin and helping to detect the face.

A comparison has been made in the system of introducing a new low face detection technology based on skin detection between RGB, *HSV*, YCbCr and YCbCr was achieving the best results in facial detection,[15] AadBoost was combined with skin color features to reduce the error detection rate and the YCbCr color model achieved the best results [2] And because the authentication used for micrometric systems is necessary in all areas of life has been used texture and color inform of face image and the YCbCr color model emerged the best results [16]. To improve skin tone, YCbCr was combined with RGB to improve skin tone and reveal skin color and integration was highly effective [15] RGB, YCbCr color models were compared, and the YY color model had the best results for skin color detection[17] .To detect the face under the changes in lighting was used RGB To improve color accuracy [18] Since attention to skin beauty has become one of the people's concerns and due to the high cost of beauty clinics, a system based on image processing was proposed and using the YCbCr color model to extract the skin area to deal with wrinkles and moles in the face area and help process images and the YCbCr color model was important in extracting the face area.[19].Facial detection techniques have encountered several problems including blockage, so a combination of color model RGB AND YCbCr To improve accuracy and detection rate.[20] The division of skin color has been used RGB, HSV, YCbCr. was YCbCr Best for extracting skin sets.[21] Because facial detection technology has become used in many different applications in all areas of life, and because facial detection depends on the detection of the bicycle units in the images and the image composition set was used RGB, HSV, YCbCr. WAS YCbCr Best in extracting configuration groups for images.[22] Hybrid model HS- YCbCr was used in the bio tress face detection system based on the automatic regression model.[23] Facial recognition was used as a self-regulating mapping method (SOM) and the color model was used HSV to extract the color feature.[24] Color fragmentation was used to detect the location of the eyes in real-time and the house of color models was integrated RGB, HSV, YCbCr. The possibility of detecting the false eye has been reduced. [25] The conversion was done from RGB to HSV to describe the color scheme of the skin, and it was proven that it is capable of being applied to different color images of different types and sizes.[26] The color spaces were used to improve the watermarking scheme with double encoding in the YCbCr color space.[27] Then LogitBOost was combined for pixel segmentation skin using YCbCr color spaces. LogitBOost, YCbCr space was effective in improving performance and accuracy [28] And the use of color segmentation is now used in many applications and was used to test many images of different types and different races. The Viola-Jones algorithm was combined with YCbCr and had a medium accuracy, compared to other color models that were low accuracy. [29] Since the face image contains many style features, which depend on the features of the skin tone, use RGB and convert to YCbCr to achieve the best models for the features of the skin tone[30] .The results showed that YCbCr gives the best results and the highest accuracy in detection. Table 1 depicts the performance of some color models considering the database and therefore the evaluation method used.

3.0 ANALYSIS AND RESULTS

In this section, the performance of color spaces for face detection purposes was analyzed. The analysis can be found in Table 1.

Table 1: Performance of Color Spaces for Face Detection

Color space	Database	Evaluation method	Factors considered in the dataset	Best color space
RGB, YCbCr [2]	Manual images from camera	Detection rate	Skin pixel	YCbCr
YCbCr [31]	From web	False positive and Detection rate	Skin pixel	---
HSV [32]	From web	Detection rate and Execution time	Region Of Interests (ROIs)	----
YIQ and YCbCr [13]	AVAS	Detection rate	Skin pixel	YCbCr
HSV and RGB [33]	Manual images from camera	Execution time	Frontal view faces, Number of pixels	---
RGB, HSV, YCbCr, YIQ, and YUV [14]	Not revealed	True Positive Rate/False Positive Rate	Skin pixel	YCbCr
YCbCr [34]	From web	Detection rate	Color, position, scale and orientation	---
HSV and YCbCr [35]	FEI and complex background database.	Detection rate	Skin pixel	-----

HSV and YCbCr [5]	---	False Negative Rate / False Positive Rate	Region Of Interests	YCbCr
YCbCr [36]	Not Revealed	False Positive/Face Detection	Background complexity	
RGB, HSV, LAB and YCbCr [8]	AFA database	Detection rate	Skin pixel	YCbCr
HSV and YCbCr [9]	Not Revealed	Detection rate and Execution time	Skin pixel	YCbCr
RGB, HSV, YCbCr [37]	From web	Detection rate	Skin pixel	HSV
RGB, YCbCr [10]	Not Revealed	False Negative Rate / False Positive Rate	Skin pixel	YCbCr
HSV + YCbCr [38]	From web	Detection rate	Skin pixel	---
HSV + YCbCr [39]	From web	False positive and Detection rate	Region Of Interests	---
RGB, HSV, YCbCr [40]	From web	True Positive Rate/False Positive Rate	Skin pixel	---
RGB, HSV, YCbCr, YIQ) [41]	Not revealed	Detection rate	Region Of Interests	---
RGB + YCgCb [42]	From web and Camera	Detection rate	Skin texture	---
HSV + YCbCr [43]	Not revealed	False Positive/Face Detection	Region Of Interests	---
HSV + YCbCr [15]	TAN, FvNF	Detection rate	Region Of Interests	---
HSV, YCbCr [7]	From web	Detection rate	Skin pixel	YCbCr
nRGB, mnRGB and YCbCr [44]	Compaq	Detection rate	Skin pixel	mnRGB
RGB, HSV, YCbCr [15]	TAN,FVNF	False Negative Rate / False Positive Rate	Region Of Interests	YCbCr
RGB, HSV+AdaBo [45]	Entrance of sales shop	Detection rate	Skin pixel	YCbCr
RGB, HSV, YCbCr [46]	CASIA-FASD	Detection rate	Skin pixel	YCbCr

RGB, YCbCr,HSL [26]	COLOR-FERET	Detection rate	Skin pixel	---
RGB , YCgCb [47]	UCI	True Positive Rate/False Positive Rate	Skin pixel	YCbCr
RGB , YCgCb [18]	BAO,MUCT,OP EN CV	Detection rate	Skin texture	---
HSV, YCbCr [19]	Not revealed	Detection rate	Region Of Interests	---
HSV, YCbCr [20]	COLOR-FERET, WEB	Detection rate	Region Of Interests	HSV+YCbCr
RGB, HSV, YCbCr [21]	COLOR-FERET, WEB	False Negative Rate / False Positive Rate	Skin texture	---
RGB, HSV, YCbCr [22]	Not revealed	Detection rate	Skin pixel	---
HSV, YCbCr [23]	From web BIOID	Detection rate	Skin texture	HS- YCbCr
HSV, YCbCr [48]	Stored facial data	Detection rate	Skin pixel	---
RGB, HSV, YCbCr [25]	Not revealed	Detection rate	Region Of Interests	---
RGB , HSV [26]	Input personal image	False Positive/Face Detection	Skin texture	---
RGB , YCgCb [20]	Host image	Detection rate	Region Of Interests	YCbCr
YCgCb +LogitBoost [28]	C Varirus database	False Positive/Face Detection	Region Of Interests	YCbCr
YCgCb + Viola-Jones ([29]	Form web	Underdetction/ more detection	Skin pixel	YCbCr
RGB , YCgCb [49]	Form web	Detection rate	Skin texture	YCbCr

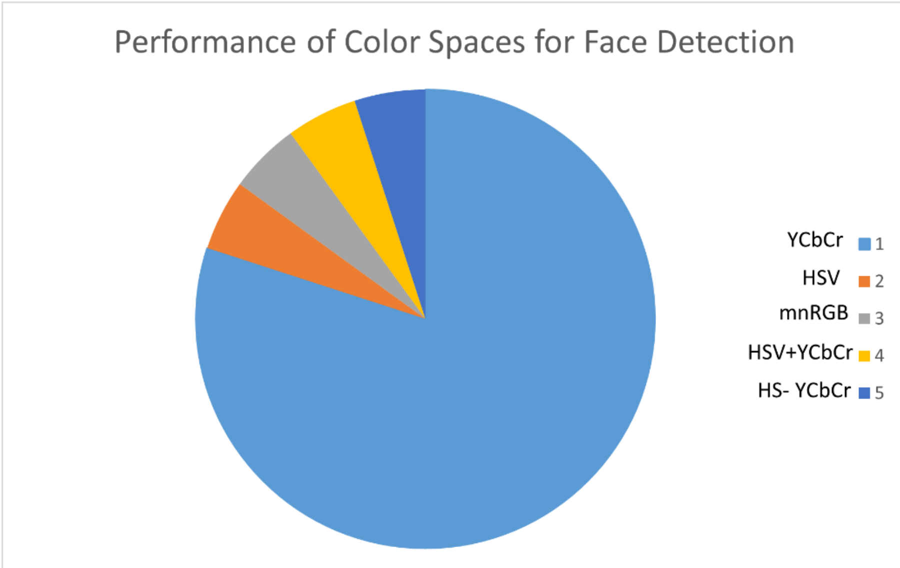

Figure 1: Performance of Color Spaces for Face Detection

Figure 1 shows the factor analysis used by the techniques proposed by previous researchers. After analyzing skin detection techniques and color spaces RHB, YCbCr, and HVS, to prevent lighting sensitivity, the RGB color space is transformed into the YCbCr color space. RHB is the default color for storing digital photos and is also extremely sensitive to lighting, unlike the YCbCr color space, which is not sensitive to lighting. After reviewing and studying many studies on color segmentation models, the YCbCr color model appeared as the best color used in destination detection, which includes luminance and coloration in which colors are represented by a region and one component luminance (y), and coloring (Cr, Cb).

3.1 Skin detection

Skin detection is one of the important things in many modern technical applications, such as face detection technology, anti-pornography applications, hand detection, recognition, and real-time skin detection (tracking apps), and plays an important role in the detection of skin diseases.

i. Face detection

Skin detection plays a very important role in many different vital applications in face detection, and since the use of face detection techniques has become common in many areas of life, the use of face detection has many uses, such as use for security purposes, combating pornography, and revealing the identity of wanted people. To be fair, therefore, skin detection is considered one of the first steps in detecting the face and is considered a means of identifying the face. It was used to improve the accuracy of detection and improve the performance of the detectors and inhabit them to distinguish between real human skin and other things**.**

ii. Anti-pornography applications

Skin detection technology was used to identify pornography, and since current technology is utilized in many applications and anybody may post on social media platforms and websites, the skin detection technology was used to adapt between pornographic photos to limit their spread. The YCbCr color space was chosen as the best color space since it is non-pornographic, and extracting shape features from skin detection, and aiding in the fight against pornography.

iii. Hand detection

Human-computer interfaces (HCI) have recently appeared in the field of human-computer interfaces, the hand detection technology to identify handprints and detect and identify the skin of the hand to help take handprints and identify the hand for health and security purposes, so skin detection was used as an essential step in hand detection.

iv. Recognition

Human skin detection is a crucial field in computer animation and graphics, and it's employed in a variety of applications like biometric systems, picture filtering, and facial recognition. It is used to recognize faces in videos by extracting skin detection patterns from moving data.

v. Tracking apps

Skin detection technology is widely utilized in computer vision applications, and it is also used in modern human medicine to track human motions and human-computer interaction. using skin detection, and it is also used in modern human medicine.

vi. Detecting skin diseases

With modern technological progress, modern medicine is using skin detection techniques to detect skin diseases. Because the skin is one of the largest organs in the body, and because the skin can be detected and early detection of skin illnesses and skin cancer is one of the best methods now utilized in detection About dermatology, modern medicine is adopting skin detection techniques to detect skin disorders.

3.2 Skin Color Detection

Because the degree of human skin varies widely for people from one place to another, it is difficult to design a consistent approach for segmentation or skin detection. There are numerous color space ways to detect skin color, detecting When it comes to the skin, the two most typical problems are skin pixels and non-skin pixels. The basic processes for recognizing skin in an image are to use color information, which means reducing the picture pixels in an acceptable color space.

i. Skin-Color-Modeling and Classification

Modeling the skin and non-surface pixels with appropriate distribution, and so on. skin color distribution is modeled primarily either by Histogram model or single, Gaussian mixture mode.

ii. Color Spaces

It is a mathematical model that uses multiple color models such as computer graphics, pictures, and processing to express color information in the form of three or four separate color components. Skin detection is the first stage in categorizing skin hues and is based mostly on color spaces. Other color spaces can be obtained by converting RGB color space to grey to extract texture features and helps to distinguish between the skin and non-skin pixels and using different types of color spaces, such as RGB, YCbCr, YIQ, *HSV*, etc. RGB color is the default color space, and other color spaces can be obtained by linear or non-linear conversion of RGB.

iii. The Most Widely Used Color Spaces for Skin Detection

- RGB-based color spaces (RGB, NORMALIZED RGB, CLEXYZ)

RGB The most used default color space for storing digital images, and the data is captured by the camera in the form of RGB, and corresponds to the three main colors: red, green, and blue, respectively, to reduce dependence on lighting and is greatly affected by lighting conditions and the consequent race.

- HUE-based color spaces (HSI, HSV, HSL, TSL)

In white lights and ambient lighting, it is considered a non-linear transformation and is not significantly variable. Following prior research, it was discovered that the picture in HVS is split into three components: hue, saturation, and value, Simple photos with a single backdrop worked well with HSV.

- Luminance-based color spaces (YCbCr, YIQ, YUV, YES)

The YUV and YCbCr color spaces are employed to standardize the images for television. The YU space is the base for color coding for NTSC system, while the YCbCr is the standard for digital television. In these models the components that define them feature three planes: the luminance (Y) and the other two called chrominance components, (UV and CbCr for spaces YUV and YCbCr, respectively) Color is represented as statistically independent components in orthogonal color spaces, which reduces redundancy in RGB color channels. This color space is suitable for skin detection because the lighting and coloring components are clearly acceptable. It represents the YCbCr area, with color as luminance (y), calculated as the sum of the RGB values, and coloring (Cr, Cb), calculated by subtracting the luminance component from the R, B values. It is a non-linear signal that is used in television to compress pictures, making it simpler to remove superfluous colors. the YCbCr space is widely employed for image processing, mainly for compression applications, the YUV model is less used.

- Perceptually Uniform Color Spaces(CLE, LAB and CLE-LUV)

Perceptual uniformity is a nonlinear transformation of the RGB color space, used in mapping and Xyz coordinates for skin detection, and represents how more than one color differs in appearance to a secret observer, calculating luminance (L) and obtaining chroma (UV, AB), and is a nonlinear transformation of the RGB color space, used in mapping and Xyz coordinates for skin detection. Table 2: The most widely used color spaces for skin detection.

Table 2: The most widely used color spaces for skin detection

COLOR SPACES TYPE	RGB based color spaces	HUE BASED COLOR SPACES	luminance based color spaces	PERCEPTUALLY UNIFORM COLOR SPACES
Color spaces	RGB, NORMALIZED RGB, CLEXYZ	HSI, HSV, HSL, TSL	YCBCR, YIQ, YUV, YES	CLE, LAB AND CLE-LUV
SUMMARY	RGB The most used default color space for storing digital images, and the data is captured by the camera in the form of RGB, which corresponds to the three main colors: red, green, and blue, respectively, to reduce dependence on lighting and is greatly affected by lighting conditions and the consequent race.	In white lights and ambient lighting, it is considered a non-linear transformation and is not significantly variable. Following prior research, it was discovered that the picture in HVS is split into three components: hue, saturation, and value, Simple photos with a single backdrop worked well with HSV.	Color is represented as statistically independent components in orthogonal color spaces, which reduces redundancy in RGB color channels. This color space is suitable for skin detection because the lighting and coloring components are clearly acceptable. It represents the YCbCr area, with color as luminance (y), calculated as the sum of the RGB values, and coloring (Cr, Cb), calculated by subtracting the luminance component from the R, B values. It is a non-linear signal that is used in television to compress pictures, making it simpler to remove superfluous colors.	Perceptual uniformity is a nonlinear transformation of the RGB color space, used in mapping and Xyz coordinates for skin detection, and represents how more than one color differs in appearance to a secret observer, calculating luminance (L) and obtaining chroma (UV, AB), and is a nonlinear transformation of the RGB color space, used in mapping and Xyz coordinates for skin detection.

3.3 Advantages and disadvantages of color spaces

In this section, after studying many scientific fields and the effect of color from the view of the most common color spaces available in image processing A comparison was made between the color spaces used for face detection. Table 3: Advantages and disadvantages of color spaces.

Table 3: Advantages and disadvantages of color spaces

Color space	Advantages	Disadvantages
RGB	It is the default color space for storing digital pictures and is convenient for image acquisition and presentation.	Non-uniform illumination is sensitive; color differences are not linear.
HSV	Based on human color perception; robust in the presence of non-uniform light; chromaticity and intensity are separated	Singularities that can't be removed
YUV, YCbCr	Color information for TV signals is efficiently coded.	The component channels have a connection due to the linear transformation, albeit it is not as strong as in the RGB space.
LAB	Effective at detecting minor color differences; The intensity is separated from the chromaticity	As with other nonlinear transformations, the singularity problem exists.

Table 3 shows the advantages and disadvantages of each color space. After analyzing skin detection techniques and color spaces RHB, YCbCr, and HVS, we were able to identify skin detection approaches that are utilized to recognize the face utilizing color spaces. Because the aim of skin detection is to identify skin regions in pictures, there are two types of skin detection in pixels: pixel-based and region-based. Skin pixels are in place, and they're organized in a way that improves performance. Following prior research, it was discovered that the picture in HVS is split into three components: hue, saturation, and value. The conversion of YCbCr is determined by the threshold value. Simple photos with a single backdrop worked well with HSV. To prevent lighting sensitivity, the RGB color space is transformed into the YCbCr color space. RHB is the default color for storing digital photos and is also extremely sensitive to lighting, unlike the YCbCr color space, which is not sensitive to lighting.

4.0 DISCUSSION

From the survey of the color segmentation techniques, the subsequent are often concluded. Only few studies considered the matter of color space selection and provided justifications for the optimality of their choice. ii. there's no chosen color model for complexion detection iii. Most of the techniques find it difficult to simply segment the count enhance from the facial background and iv. There are not any standard databases for the benchmark comparison.

The Chosen Color Mode, YCbCr color model has been defined in response to increasing demands for digital algorithms for handling video information and has become a widely used model during a digital video. It belongs to the family of television transmission color models. Other members of the family include YUV and YIQ. YCbCr may be a digital color system while YUV and YIQ are analog spaces for the respective PAL (Phase Alternating Line) and NTSC (National Television Committee) systems. These color spaces separate RGB into luminance and chrominance information and are useful in compression applications. The importance of using YCbCr color space for skin detection is for the following reasons. Its principle is like the process of human eyesight. The YCbCr color space format is usually used in the TV viewing area. It is also used in video compression encoding such as the Film Experts Group (MPEG) and the Joint Photographic Experts Group (JPEG). Its space coordination removes the brightness component from the color components making it robust against changing intensity. Its representation of spatial coordinates and the process of calculating the space coordinate is easier than others. The blocking properties of skin are the best in the YCbCr color room. YCbCr color space and RGB color space can transform from each other. Thus, it is very attractive to discover the face of the skin. In the YCbCr color space, the Y component represents the luminance information; The Cb component represents the blue chromatics information, and the Cr component represents the red chromatin information.

5.0 CONCLUSION

The detection of skin color is one of the main techniques often used in detecting the face in videos and images, the researchers are excited to conduct the study to determine the most appropriate way to build an effective face detection, and the study of color space conversion models is one of the main techniques to ensure the accuracy of color conversion between different development devices. Many research works have been submitted to work on the simplest color model for face detection, as there is no consensus on a suitable color model for color segmentation, so we present a comparison between the different color spaces used in skin modeling and study reference materials and techniques related to this field and present the best color model for facial detection using color segmentation. After reviewing and studying many studies on color segmentation models, the YCbCr color model appeared as the best colors used in destination detection, which includes luminance and coloration in which colors are represented by a region and one component luminance (y), and coloring (Cr, Cb). In the future, this result will be used to help researchers develop and improve skin tone detection through color segmentation for face detection.

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