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Mixture of GMMs and Mixture of Multiple Histograms for Image Segmentation: A Review

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Abstract— **Segmentation process represents the eye for the computers-robots for commencing the object detection procedure in which the good segmentation process can spot the object easily without any neglected background areas and without any further noise, as known the single modelling of any object can cause some sort of errors which can be reduced when the object is partitioned and each modelled separately, in this paper, we have applied a novel algorithm for modelling the skin-color area of the human-skin pigment by dividing the feature area of that skin-color into several partitions and each of them is modelled using single Gaussian Mixture Model (GMM), and those several resulted GMMs and fused together into a single model called Mixture GMM with some calculated weights for each. Similarity, those feature area are modeleed using lookup table based histogram technique and all of those resulted histogram are fused in one superior technique, the both resulting techniques are compared together.**

We have achieved a promising results that dominate many other segmentation techniques with high accuracy of skin-color locating, we have applied four well-known color models in the skin-color field that are normalized RGB which referred as rgb, HSV, YCbCr and L*a*b*.

Index Terms— **Gaussian Mixture Model, GMM, Mixture of GMM, color model, skin color, rgb, HSV, YCbCr, histogram, segmentation technique.**

I. Introduction

The training samples of any gesture system can be increased [1] in the case of the segmentation is not well-done, since; many patterns we need to provide to cover one object especially in the cluttered background, however, this number of presented gestures can be reduced dramatically if the segmentation process produces accurate object classification and can help to speed up the overall performance of the system, contrary, the increasing of training sample can slow down the performance of the system as well as enlarge the database used to store the features extracted from those sample at training time, these problems have been address in [2][3][4][5] which are scaling, translation, rotation and illumination perturbations, several remedy can be done to such kind of problems, the scaling and translation problem can be managed by using of normalization operation after segmentation took place, illumination condition can be ignored since the good segmentation process should not rely on such element, chrominance component of each pixel value is more than sufficient to model the operation of the segmentation, the most problem that face many researchers is the rotation problem and can be cured by unifying the direction of objects, [6]; all the mentioned remedies can be melted down together to obtain high speed segmentation technique with minimum size of database used. However, traditional techniques trends to increase number of samples per gesture/object to fight rotation problem [7], 6, 40, 124, and 20 templates for each single posture in [8], [9], [10], and [11] respectively; but, however, some researchers choose to keep this number high but will suffer from rotation variance, this can be found in [12][13][14] and [15]. Page Layout

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II. Color Models Characteristics

Each color model has its own salient features in which can be adopted for specific task, the following is the features of each of the adopted color models [15]:

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TABLE I
ILLUSTRATING THE PERFORMANCE OF DIFFERENT COLOR MODELS EMPLOYED

Model	Effective parameter	Advantages	Disadvantages
RGB	R, G, B.	(1) No transformations required to display information on the screen, for this reason it considered as the base color space for various applications. (2) Used in video display because of additive property. (3) Considered as computationally practical system.	(1) Non useful for objects specification and recognition of colors. (2) Difficult to determine specific color in RGB model. (3) RGB reflects the use of CRTs, since it is hardware oriented system.
HSV	V	HSV colors defined easily by human perception not like RGB or CMYK.	Undefined achromatic hue points are sensitive to value deviations of RGB and instability of hue, because of the angular nature of the feature.
YCbCr	Y	(1) Perfect in image compression. (2) Used in saving images as a file format for image. (3) Y luminance can be use separately for storage in high resolution and the chromaticity components treated separately to improve the performance.	(1)The color range is restricted in the color TV images because of the information compression required for the displayed image. (2) The displayed color depends on the primaries RGB that displayed the signal.

However, Bayesian decision rule can play major role in determining the skin and non-skin pixel decision after application of statistical segmentation technique in order to spot the skin pixel, as follows [16][17]:

$$\frac{P(X \mid Skin)}{P(X \mid nonSkin)} \geq T$$

Where P(X | Skin) represents the pdf of skin colors, P(X | nonSkin) represents the pdf non-skin colors and T represents the threshold value which must be computed empirically.

We have presented in this paper a comparative study of two papers as in [18] and [19].

III. MIXTURE OF GMM

As known, GMM is used widely in the area of statistical image segmentation since it covers the feature space of the targeted segmented domain with multiple ovals, and those each single oval is trained using some Gaussian parameters, the mathematical model of GMM can by illustrated as follows:

$$P(x) = \sum_{j=1}^{K} w_j \cdot N(x \mid \mu_j, \Sigma_j) \qquad (1)$$

And w_j is the weight of the j^{th} mixture.

$$\sum_{j=1}^{K} w_j = 1 \quad \text{and} \quad 0 \leq w_j \leq 1 \qquad (2)$$

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Where μ is the mean and ∑ is the covariance matrix, and |∑| its determinant.

And the mathematical model of the proposed algorithm is given by [18]:

$$P(c|skin) = \sum_{m=1}^{M} W_m \, P(c;\mu_m,\Sigma_m) \qquad (4)$$

Where c, M, m and $P(c;\mu_m,\Sigma_m)$ represent the same parameters as in Equation 1, W_m represents the weight of m component which satisfies the same condition of Equation 2 that has the value of one as its overall summation.

W_m represents the missing value in the suggested MiGMM model, and can be found by calculating the classification rate, where W_m summarizes the classification rate of the algorithm. This metric parameter is calculated as seen in Equation 5.

$$W_m = \frac{CR_m}{\sum_{i=1}^{M} CR_i}, \forall\, m = 1,2,3,\dots,M \qquad (5)$$

After the application of equation 5, the following weights are obtained for the adopted color models :

W= {0.250438924, 0.249292548, 0.25049777, 0.249770759} for each of the rgb, HSV, YCbCr and L*a*b* respectively.

IV. Mixture of Histogram Based Segmentation

In this case, single lookup table us constructed for each adopted color model, this lookup table is build using the traditional histogram based segmentation as follows:

$$h(c|\,skin) = \frac{skin\ (c)}{n} \qquad (6)$$

Where $h(c|\,skin)$ represents the histogram probability which calculated as a ratio [19] of the value of each histogram bin for the skin color , to the summation of all histogram bin; and bin size is (8x8) for rg, (18x3) for HS, and (4x4) for CbCr .

The method is so called MxHT (mixture of histogram technique) [19] where each single color model is modeled using formula (6), and the three resulted models are combined together as the following formula:

$$P(c|skin) = \sum_{i=1}^{h} W_i h_i(c),\ for\ all\ i = 1,2,\dots,h \qquad (7)$$

Where W_i is the weight's value of the i^{th} selected color space as demonstrated in equation (5) previously.

V. Experimental Results

The following table represents the experiments of applying Mixture of GMM.

TABLE 2
METRIC PARAMETERS FOR THE PROPOSED AND SELECTED COLOR MODELS [18].

parameter	MiGMM	GMM of rgb
CDR	99.0149	99.6525
FDR	0.1291	0.4416
CR	99.0149	98.9036
Average	99.300	99.371

GMM of HSV	GMM of YCbCr	GMM of L*a*b*
97.9378	98.4020	99.3646
0.1156	0.1887	0.3703
97.9378	98.4020	99.0761
98.586	98.871	99.356

The following table represents the results of applying MxHT.

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TABLE 3
METRIC PARAMETERS FOR SKIN COLOR BASED HISTOGRAM APPROACH [19].

parameter	MxHT	GMM of rgb	GMM of HSV	GMM of YCbCr
CDR	99.2658	98.8910	99.3474	99.4345
FDR	0.2935	0.4433	0.2608	0.2260
CR	98.9349	98.8910	98.3485	97.8750
Average	99.3024	99.1129	99.1450	99.0278

If we compare the performance of MiGMM and MxHT in a single table, we can see the demonstration in table 3 as follows:

TABLE 4
PERFORMANCE EVALUATION OF EACH OF MIGMM AND MXHT.

parameter	MiGMM	MxHT
CDR	99.0149	99.2658
FDR	0.1291	0.2935
CR	99.0149	98.9349
Average	99.300	99.3024

VI. CONCLUSION

Segmentation technique plays major role in all vision based system since it represents the artefact that can discriminate the presence of the object in the given scene. Histogram technique has better efficiency since it finds out a separate probability of each single pixel value in the input image, while GMM cover the entire feature area with an oval which may lead to embody some non-skin pixels in this modelling.

Color models should be chosen carefully depending on the selected application and segmentation technique as well, each model has its own parameters and these parameters can be enhanced if the training set is increased.

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