

Applications of the Color Conversion System Using the LUT and Interpolation to the Real-time Color Recognition

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Abstract This paper presents applications of the color conversion system using the LUT(Look Up Table) and interpolation to the real-time color recognition. This system can discriminate between target area and non-target area by using color information in real-time(30 frames/sec). The flesh tint extraction have been performed by this system as example showing its ability.

1. Introduction

In the field of image processing, there are many kinds of method to recognize a object such as edge detection, clustering in specified space and so on.¹ In case of using color information to recognize a object, these processes are corresponding with converting a color signal into the color which signs the specified segment.

We have developed the "color conversion system" for color correction, adjustment and so^{2, 3}. It can deal with full color image(24bit) in NTSC video rate(30 frame/sec). In this paper, this system is applied to the flesh tint extraction.

2. Color conversion system using the LUT and interpolation

The color conversion system using a LUT and interpolation is illustrated in Fig.1. The LUT stores only 729(9X9X9) output data at coarse lattice points corresponding to an input RGB color space, uniformly. The interpolated output signal O_i between lattice points is calculated by interpolating with neighbors in sub-divided space.^{4, 5, 6}

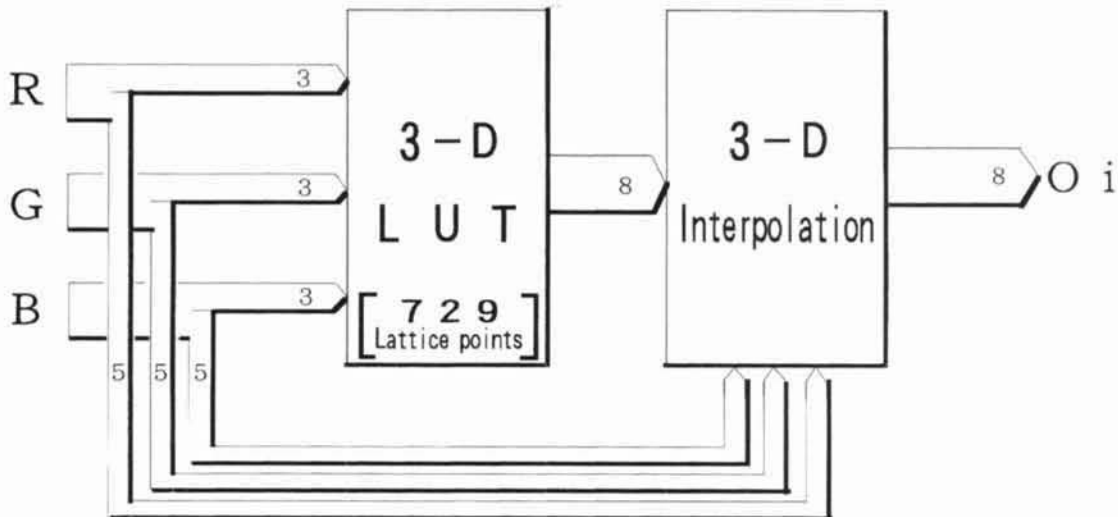


Fig.1 A color conversion system using the LUT and interpolation.

3. Applications to color area extraction

In this paper, two different methods which are "Multi-dimensional slice method" and "Maximum likelihood method" are used as color extraction method.

3.1 Multi-dimensional slice method

The extracted color area is given by thresholding three color signals 0α , 0β , 0γ and operating logical product them: that is,

$$\begin{cases} \alpha 1 \leq 0 \alpha \leq \alpha 2 \\ \beta 1 \leq 0 \beta \leq \beta 2 \\ \gamma 1 \leq 0 \gamma \leq \gamma 2 \end{cases} \quad (1)$$

where $\alpha 1$, $\alpha 2$, $\beta 1$, ..., $\gamma 2$ are threshold values for each coordinate. The extracted color area forms a rectangular parallelepiped in color space, as illustrated in Fig.2.

Generally, color distribution in RGB color space becomes broad for all coordinates. This method is not useful for the RGB color space. Therefore, it is necessary to convert RGB signals into specified color signals. The following three color spaces are tested; ① CIELAB parallel coordinates, as illustrated in Fig.3, ② YIQ parallel coordinates, ③ principal component coordinates.

The color conversion system is used to convert RGB signals into these color signals ① ~ ③. And then, thresholding processes and logical operation are introduced for converted color signals to perform eq.(1), as illustrated in Fig.4. The threshold values are decided in manual. The results of the flesh tint extraction are presented in Fig.5 (b),(c),(d).

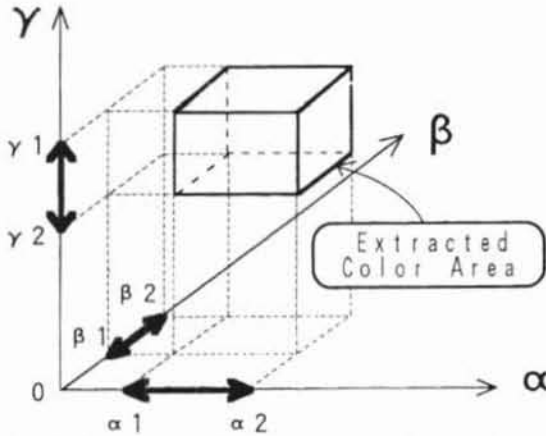


Fig.2 A multi-dimensional slice method.

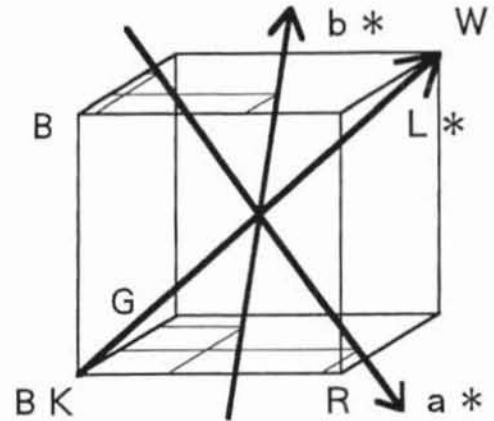


Fig.3 CIELAB parallel coordinates used multi-dimensional slice method.

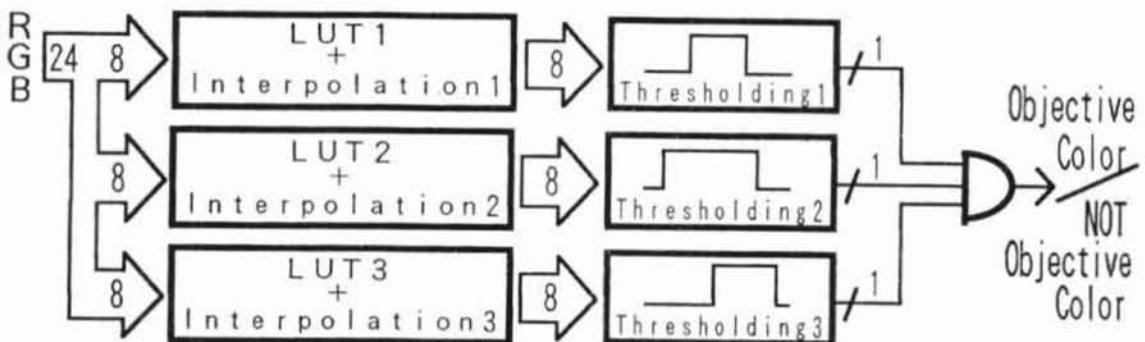


Fig.4 A color extraction system added thresholding processes and logical product to color conversion system

3.2 Maximum likelihood method

The Maximum likelihood method finds out the cluster which input color belongs to by means of the probabilistic judgement using sampled data. Several clusters are modeled with a probability density function in RGB color space, as illustrated in Fig.5. According to the Bayes theory, the decision rule is given by the following quadratic discriminant function $f_i(X)$ when the multi-Gaussian distribution is assumed.

$$f_i(X) = (X - \mu_i)^T \Sigma_i^{-1} (X - \mu_i) + \log |\Sigma_i| \quad (2)$$

where i denotes each cluster, X denotes input color vector, μ_i denotes the average vector of sampled area corresponding to cluster i , Σ_i denotes the covariance matrix of sampled area corresponding to the cluster i and $|\Sigma_i|$ denotes the determinant of Σ_i . The $f_i(X)$ is calculated for each cluster i with sampled RGB data from the test image, and then a color X is assigned to the cluster which gives the MINIMUM value of the $f_i(X)$. This method is implemented to our color conversion in the following way.

The color conversion system consists of the LUT and interpolation in Fig.4 is used to calculate the $f_i(X)$, but the system can not detect the minimum value of the $f_i(X)$. Therefore the DDF (Difference Discriminant Function), as given by eq.(3), is calculated instead of the minimum value of the $f_i(X)$.

$$DDF_i = f_{a_0}(X) - f_i(X) \quad (i = a1 \sim a3) \quad (3)$$

where a_0 denotes the flesh tint area and i denotes other color area. And it is possible to judge which the input color X belongs to either "flesh tint area" or "NOT flesh tint area", as eq.(4)

$$X = \begin{cases} \text{flesh tint} & (DDF < 0) \\ \text{boundary} & (DDF = 0) \\ \text{NOT flesh tint} & (DDF > 0) \end{cases} \quad (4)$$

In short, the color extraction system can perform the maximum likelihood method by means of using color conversion system as calculator of the DDF and setting the threshold value to zero. This system can not discriminate multiple color areas simultaneously. However it is a merit that four clusters are given in color space with three LUTs and interpolation units. The results of flesh tint extraction are presented in Fig.6(e).

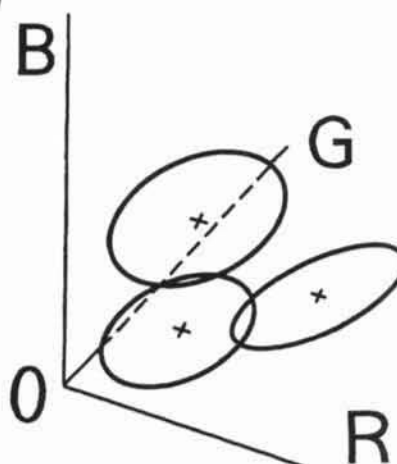


Fig.5 Maximum likelihood method

4. Results of the flesh tint extraction

The standard test image used for flesh tint extraction is presented in Fig.5(a). The flesh tint area recognized by color extraction system corresponds to white area, and another area corresponds to black area. The effectiveness of LUT-interpolation color conversion for applications to the color area extraction can be seen from this results. The recognition score is listed in Table 1.

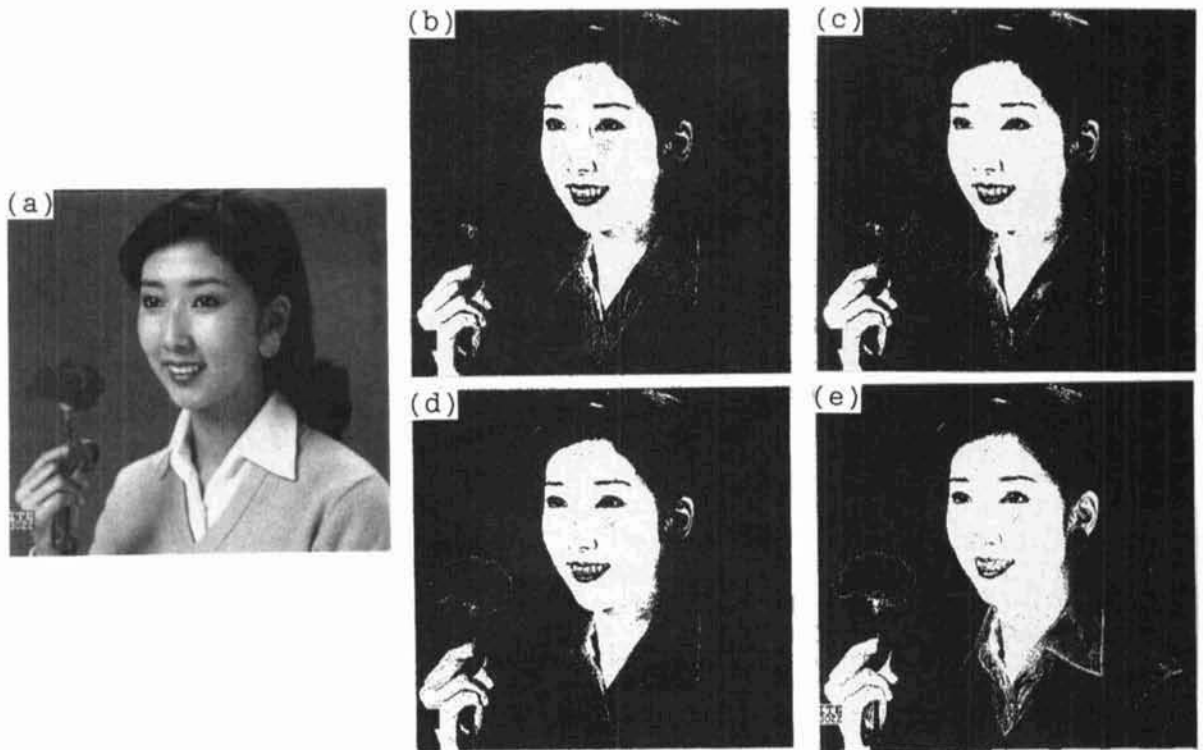


Fig.5 Results of the flesh tint extraction.
 (a)The standard test image.
 (b)CIELAB parallel coordinates.
 (c)YIQ parallel coordinates.
 (d)Principle component coordinates.
 (e)Maximum likelihood method.

Table 1 Recognition score

CIELAB parallel	YIQ parallel	Principle component	Maximum likelihood
92.71%	92.67%	95.82%	92.56%

5. Conclusions

The color conversion system using the LUT and interpolation has been applied to a color area extraction. It can execute many types of color discrimination algorithm in real-time.

6. References

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