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A Study on Color Fuzzy Decision Algorithm in Video Object Segmentation

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Abstract

In this paper, we propose the color fuzzy decision algorithm to face segmentation in a color image. Our algorithm can segment without the user's interaction by fuzzy decision marking. And it removes small parts such as a noise using wavelet morphology in the image obtained by applying the fuzzy decision algorithm. Also, it merges and chooses the face region in each quantization image through rough sets. This video object division algorithm is shown to be superior to a conventional algorithm.

Key words : Fuzzy Decision, Face segmentation, Wavelet Morphology, Rough Set, Video Object

1. Introduction

Information in society is increasingly to centering the digital multimedia, there is a necessity for the standardization for quick transmission and efficient storage in the situation that the boundary of the digital multimedia(complex media by binding animation, sound and communication) becomes vague. In 1988, the MPEG(Motion Picture Experts Group) meeting was organized, and it resulted in MPEG-1, MPEG-2 and MPEG-4 standardization [1]. MPEG-4 standardization introduced the object-based coding concept that the processing of an object unit is available by encoding each other objects. Having to do the object segmentation by the preprocessing process for the encoding of an object unit, the technology that separates the video object from a natural image. The object segmentation method and time processes independently from the encoding process because of the goal that the conventional object segmentation methods segmented the object exactly. So, the object segmentation process and the encoding process are done independently. Recognition is separated into two parts: generalization and specification, and face recognition belongs to the latter. It recognizes atomizing exactly having similar identifying marks. There is a method to recognize a face pulling out characteristic sets using the facial geometric parameters representatively. This field has been studied mostly because all face images have resembling edge and geometric information [2,3]. And much research was done to recognize each individual's face with similar face images from each different viewpoint. Other access methods are by correlation; it is the method to hold of whole face by the characteristic parameter. The method for human face segmentations divided of their spatial and temporal object segmentation [4-6]. This paper uses the spatial object segmentation to detect and divide by a real time without a user's interaction. Firstly, the spatial property is brightness and color value of pixels, and scales of the object and the form and the elemental area etc., this paper divides the face by applying the fuzzy decision algorithm in the color distribution area. It heightens the division scale and detection accuracy using wavelet morphology and rough sets. This is paper investigates the division algorithm of the face skin area through a fuzzy decision algorithm, and also explains the wavelet morphology algorithm for the face segmentation in section 2. Section 3 presents the proposed algorithm structure and rough sets, and section 4 applies the proposed algorithm and the conventional algorithms to other size images for the simulation and verification. Finally, the conclusion and future works are presented in sections.

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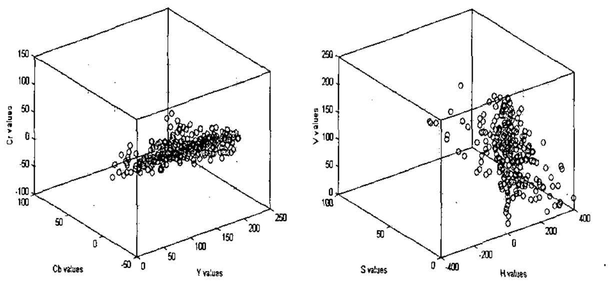
2. Fuzzy Decision Algorithm and Wavelet Morphology Algorithm

2.1 Skin Color Segmentation using Fuzzy Decision

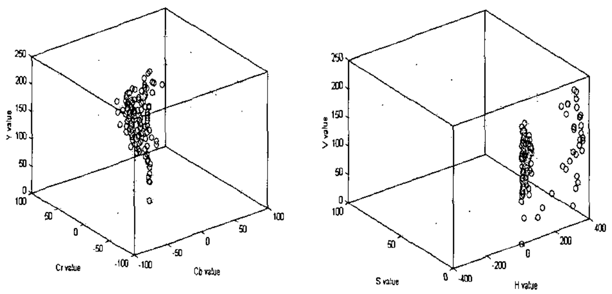
Usually, the hardware standard models use to color monitor and RGB(red, green, blue) model for many kind of a color video camera, MPEG and JPEG's color printer, picture and the YCbCr(Luminance, chrominance-blue, chrominance-red) model for TV station, the HSV(Hue, Saturation, Value) model for a color image manufacturing and a computer graphic [7]. Our model uses 30 fuzzy rules applying IF-THEN expert system with extent used in the YCbCr to get the skin color automatically. This divides the face from the color distribution space by applying the fuzzy decision algorithm based on the YCbCr model. Here, the luminous intensity is done the symbol by the Y, and the blue information and the red information, the color part of the video signals, are done the symbol by the Cb, the Cr. And there is various method to change the YCbCr and RGB each other, (1) is the recommendation 601-I of CCIR(International Radio Consultative Committee), it is the typical method being used in JPEG zip.

$$\begin{aligned} Y &= 0.29900R + 0.58700G + 0.11400B \\ Cb &= -0.16874R - 0.33126G + 0.50000B \\ Cr &= 0.50000R - 0.41869G - 0.08131B \end{aligned} \tag{1}$$

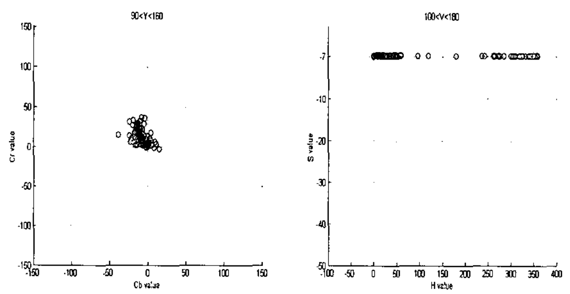
Fig. 1 is a 3-D graph that displays the color space distribution using the YCbCr and the HSV. Fig. 1 shows a wider HSV color distribution than YCbCr color distribution, the density shows that YCbCr is superior to HSV. Fig. 2 detected the samples of the face skin area about 4900 in various images and composed the distribution chart. And it searched for their distribution region and applied as the fuzzy model's region. Fig. 2 is a 3-D graph appearing in the color space distribution chart by detecting only the skin color area in Fig. 1.



(a) (b)
Fig. 1. The color space 3 dimensions graph using (a)YCbCr and (b)HSV



(a) (b)
Fig. 2. (a)YCbCr and (b)HSV sample skin color area in a 3 dimensions distribution chart

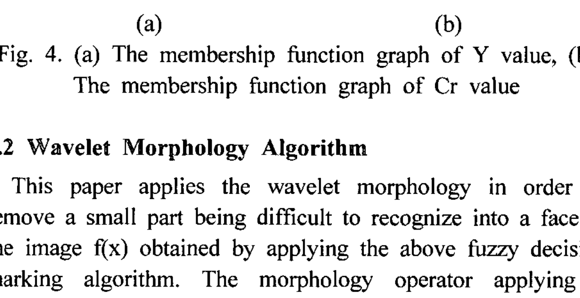


(a) (b)
Fig. 3. (a)CbCr and (b)HS sample skin colors area in a 2 dimensions distribution chart

Fig. 3 is a 2 dimensional graph of CbCr and HS sample skin colors. A 2 dimensional distribution chart of CbCr shows gathering in fixed region on Fig. 2 and 3, and a 2 dimensions distribution chart of HS gathers all in S value and it is distributed extensively in H value. So, the YCbCr model shows being superior to the HSV model in detecting for the skin color area. We applied the fuzzy model with the skin color area presented in the YCbCr model to detect the value of the area of very hard to distinguish by the human's eye by using fuzzy rules. We use IF-THEN expert system for the fuzzy membership function. The dimension of Y value is divided into 5 regions to get the rule, and the dimension of Cr value is divided into 7 regions. The region of Y value is "Very dark region = YVD", "Dark region = YD", "Middle region = YML", "Light region = YL", "Very light region = YVL", and region of Cr value divided by "Very dark region = CVD", "Dark region = CD", "Darker region = CLD", "Middle region = CML", "Light region = CLL", "Light region = CL", "Very light region = CVL". The result composed 2 areas indeed, "Yes" and "No". The 30 rules are similar to the following.

If (Y is YVD) AND (Cr is CLD)
Then (f(x) is Yes)
Else If (Y is YVL) AND (Cr is CML)
Then (f(x) is Yes)
Else If (Y is YL) AND (Cr is CLD)
Then (f(x) is Yes)
Else If ·
⋮
Else If (Y is YVD) AND (Cr is CML)
Then (f(x) is No)
Else If (Y is YVD) AND (Cr is CVL)
Then (f(x) is No).

Each membership function of Y and CR is a 2-D graph as in Fig. 4, below.



(a) (b)
Fig. 4. (a) The membership function graph of Y value, (b) The membership function graph of Cr value

2.2 Wavelet Morphology Algorithm

This paper applies the wavelet morphology in order to remove a small part being difficult to recognize into a face in the image f(x) obtained by applying the above fuzzy decision marking algorithm. The morphology operator applying a wavelet decomposition is the concept of a mathematical morphology by a tool for drawing useful image elements to express and describe border, skeleton, area form such as convex by geometric elements of some image. This method is used to clarify the inherent structure of an object continuously behind image preprocessing work or early object classification. The basis operation in binary morphology consists of dilation and erosion. Gray scale morphology introduces the Top Surface concept and Surface's umbra concept of set extended binary morphology[8,9]. From such definition, gray scale erosion uses the minimum operation and the set operation of subtraction. Therefore, the interpretation is easy because it can take advantage of the inexistence of a data properly in the space area if the designer chooses a suitable structural element and operation. First, the basic equation of a wavelet analysis to apply to the image f(t) obtained through the fuzzy decision algorithm is similar to (2) [10,11].

$$\phi(t) = \sum_n h(n)\sqrt{2}\phi(2t-n) \quad (2)$$

And can be expressed by a scale function without a wavelet function in scale j+1 with (3).

$$f(t) \in V_{j+1} \Rightarrow f(t) = \sum_k c_{j+1} 2^{(j+1)/2}\phi(2^{j+1}t-k) \quad (3)$$

Need a wavelet component for detailed components not getting to scale j in one delay step resolution. Here, $2^{j/2}$ item keeps single norm of basis functions in several scale.

$$f(t) = \sum_k c_j(k)2^j\phi(2^jt-k) + \sum_k d_j(k)2^j\psi(2^jt-k) \quad (4)$$

Here, a scale function coefficient is similar to (5).

$$c_j(k) = \sum_m h(m-2k)c_{j+1}(m) \quad (5)$$

Equation (6) arranges a wavelet coefficient.

$$d_j(k) = \sum_m h_1(m-2k)c_{j+1}(m) \quad (6)$$

The image obtained by a wavelet can express function and the set interval by link to use a mathematical morphology, one of most important link in the function and the set interval is the umbra's concept, and it is similar to (7) if there is a 1 dimension function c_j(x) in area $D \subset R^n$ or $D \subset Z^n$.

$$x \in D \rightarrow c_j(x) \in R \quad (7)$$

It can use in the gray scale image by extending the basis operation of a mathematical morphology defined in the binary image, when the wavelet coefficient of c_j and k are the function of a space E^N in the gray scale and x is a point of a space E^N, the wavelet dilation of two function is defined by a surface with the wavelet dilation of umbra of two functions and c_j wavelet dilation by k is similar to (8).

$$c_j \oplus k = T[\ U[c_j] \oplus U[k]\ ] \quad (8)$$

If this changes the wavelet dilation in order to get a maximum value by sum set, $c_j \oplus k$ can calculate with (9).

$$(c_j \oplus k)(x) = \max_{\substack{z \in D \\ x-z \in K}} \{ c_j(x-z) + k(z) \} \quad (9)$$

$c_j(x)$ is a sampling function $c_j(i)$, $i \in Z$, and if K are a structural set, the output of a 1 dimension wavelet dilation filter amounts to (10). And $x \in D$, $K = [-v, \cdots, 0, v]$.

$$\begin{aligned} y_j(i) &= [c_j \oplus K](i) \\ &= \max\{ f_j(i-v), \cdots, f_j(i), \cdots, f_j(i+v) \} \end{aligned} \quad (10)$$

This result selects a maximum value of $c_j + k$ in neighborhood defined by a structure element, and a general result has 2 qualities when this is achieved the wavelet dilation about the grayscale image. Firstly, if the value of structural element is all positives, an image is tended to bright than the input image. Secondly, the growing dark can explain that the value of a structural element is decreased or removed. Therefore, the value and the shape of the grayscale image are related to a structural element being used to the wavelet dilation. Definition about the wavelet erosion is defined by the method such as the wavelet dilation's definition, the wavelet erosion represent as $c_j \ominus k$ and is defined with (11).

$$c_j \ominus k = T[\ U[c_j] \ominus U[k]\ ] \quad (11)$$

$c_j \ominus k$ can calculate with (12) if the wavelet erosion change to get by the minimum value of a difference set.

$$(c_j \ominus k)(x) = \min_{\substack{z \in D \\ x-z \in K}} \{ c_j(x+z) - k(z) \} \quad (12)$$

$c_j(x)$ is a sampling function $c_j(i)$, $i \in Z$, and if K is a structural set, the output of a 1 dimension wavelet erosion filter is similar to (13). And $x \in D$, $K = [-v, \cdots, 0, v]$.

$$\begin{aligned} y_j(i) &= [c_j \ominus K](i) \\ &= \min\{ f_j(i-v), \cdots, f_j(i), \cdots, f_j(i+v) \} \end{aligned} \quad (13)$$

The wavelet erosion can understand by the wavelet coefficient $c_j(x)$ transfer rather than a structural element k transfer, and the wavelet erosion selects the minimum value of $c_j(x) - k$ in the neighborhood that is defined by a structural element. When it achieved the wavelet erosion about the grayscale image, if all elements of a structural element is a positive, the general result are that an output image grows dark than an input image, and the light part of an image is decreased and disappeared according to the shape of a morpheme and the size of a value.

3. Proposal Video Object Segmentation System

Present, the data of the image transmission, the image signal and the database and the image processing etc., are composed mostly by color images. Primitively, it worked most with the face model pattern [12] to detect [13] the face sphere in the gray scale area. Then, it worked by way to compose or detect a necessary part after divide the color space distribution by several scales since coming the color generation [6]. E. J. Lee [14] used the color distribution information of an image instead of the method using a binary image in the conventional NxM-grams. Also, Wu and Chen [15] detected the face region with the color distribution area, but it is showed the bad performance to detect the face in a small frame image. But there is shortcoming that must have the data model of hairstyle beforehand and 2 formats fuzzy model of the skin color and hair color. Also, the face became focus to detect more a correct face picture than a real time because it detected in the image of a graphic and still image at early. But, it happened a problem having to use by a real time being applied to MPEG and JPEG. While it used the neural and the artificial intelligence [13,15] at early, it began to look away eye to the color space distribution [3,6,16,17] gradually. This paper embodies the Human Face Detection(HFD) to use the color space distribution, it wish to find the correct distribution in the parallel structure that is not the conventional single structure. Also, this paper handled the wavelet morphology operation to be suitable at real time instead of clustering used the conventional FCM(Fuzzy Cluster Mean) and c-Mean. And this removed easily the area of a simple noise or other color distribution. The mergence part uses rough sets theory, it does to select if it is judged to be suitable image among images recognized necessary image data to be one dimension without the conventional min-max or tree structure. The proposed whole structure of algorithm has the parallel structure, and it is consisted of whole 5 steps, that the quantization, the color division, the clustering, the mergence and the image segmentation.

3.1 Color quantization of image

The first step of the proposed structure applies the quantization in a color image to reduce the skin color distribution information in the face region. Because this reduces a similar skin color space distribution in an image region applying in the original color image, also magnifies the common color space area. Because the basic principle compares and applies the color vector value of the original image in the value in the codebook, and the value existing to the codebook does mean the value of a clustering of the color distribution by the value in the fixed color position area. This paper is structure applied in a parallel structure form not applied the quantization in a single structure unlike the conventional method. Resolutions used in simulation uses 16, 32, 64 resolutions. 2, 4, 8, 128 resolutions omits because it does hardly influence detecting the facial skin space area in a color.

3.2 Proposed Color image Segmentation Algorithm

This paper detects the skin color area in the color image utilizing the YCbCr model in the fuzzy decision in each quantization image with the parallel structure, and it proposes the face detection system to detect the skin color area exactly using the Rough Set Merge(RSM) after do a noise exclusion and an image simplicity because done the wavelet morphology operation. The structure of the face detection system is same with Fig. 5. G. Tziritas [18] applied I frame of MPEG macro block level(macro-block level:16x16 pixel) to the skin color filtering. This used by process dividing the face area part and non-face area part by a binary, but this achieved shortening a macro block size repeatedly. If it is a big frame size, it is prolonged by a time because a performance region is many. So, it modifies a macro block by dividing to a small or big image via 128x128 pixel image because it calculates beforehand the size of an image. And it does lest should run above repeat if it is a small more than 80x48 pixel. So, it is lost without reconstructing a partial face image. The size division of an image used in the conventional method may not consider in this paper, and also the skin area easily separated and removed from other color area without damage using the wavelet morphology operation. And it applied rough sets theory in order to merge the selected color in each image obtained after applying the fuzzy decision model to the quantization skin color images. Set is inexact thing because of having a boundary, and a boundary of set grows, exactness of the set drops. The accuracy measure to display correctly uses (14) [19,20].

$$\alpha_R(X) = \frac{card\,\underline{R}}{card\,\overline{R}} \qquad (14)$$

Here, $X \neq \emptyset$, and all R and $X \subseteq U$ are $0 \leq \alpha_R(X) \leq 1$, the R-boundary area of X is empty set and set X is R-definable if $\alpha_R(X) = 1$. X has R-boundary area and set X is R-undefinable $\alpha_R(X) < 1$. Equation (15) is that display this by set X inexact degree.

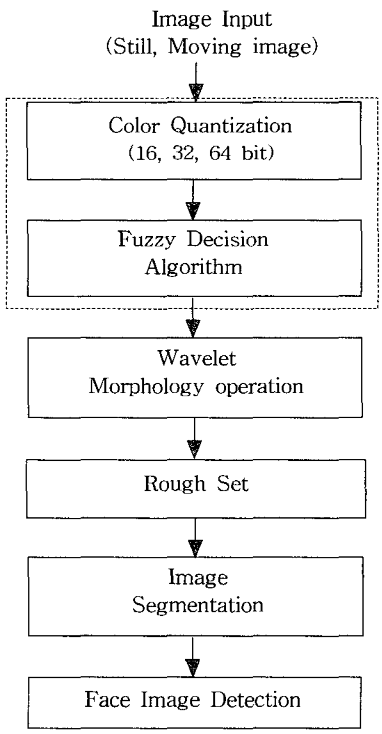


Fig. 5. Proposal Face Detection System Structure using Fuzzy Decision Algorithm and Rough Set

$$\rho_R(X) = 1 - \alpha_R(X) \qquad (15)$$

Here, ρ_R is about the R-rough degree. This expresses degree of inexact of knowledge R about set X. For example, it is same with Fig. 6.

$K=(U, R)$, $U=\{x_0, \cdots, x_{25}\}$, $R \in IND(K)$, equivalence class is same with lower part.

$$E_1=\{x_1, x_2, x_3, x_4, x_5, x_6\},\ E_2=\{x_7, x_8, x_9\},$$
$$E_3=\{x_{10}, x_{11}\},\ E_4=\{x_{12}, x_{13}, x_{14}\},\ E_5=\{x_{15}, x_{16}\},$$
$$E_6=\{x_{17}, x_{18}, x_{19}\},\ E_7=\{x_{20}, x_{21}, x_{22}, x_{23}, x_{24}, x_{25}\},$$
$$A=\{x_7, x_8, x_9, x_{10}, x_{12}, x_{13}, x_{14}, x_{15}, x_{17}, x_{18}, x_{19}\},$$
$$B=\{x_7, x_8, x_9, x_{10}, x_{12}, x_{13}, x_{14}, x_{16}, x_{17}, x_{18}, x_{19}\},$$
$$C=\{x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{15}, x_{17}, x_{18}, x_{19}, x_{22}, x_{23}, x_{24}\}.$$

Here, A, B, C are each set. Lower and upper approximations, boundary area, accuracy measure, rough degree measure of this sets is same with lower part.

$$\underline{R}A=E_2 \cup E_4 \cup E_6,\ \overline{R}A=E_2 \cup E_3 \cup E_4 \cup E_5 \cup E_6,$$
$$BN_R(A)=E_3 \cup E_5,\ \alpha_R(A)=9/13,\ \rho_R(A)=1-9/13=4/13$$
$$\underline{R}B=E_2 \cup E_4 \cup E_6,\ \overline{R}B=E_2 \cup E_3 \cup E_4 \cup E_5 \cup E_6,$$
$$BN_R(B)=E_3 \cup E_5,\ \alpha_R(B)=9/13,\ \rho_R(B)=1-9/13=4/13$$
$$\underline{R}C=E_2 \cup E_3 \cup E_6,\ \overline{R}C=E_2 \cup E_3 \cup E_4 \cup E_5 \cup E_6 \cup E_7,$$
$$BN_R(C)=E_4 \cup E_5 \cup E_7,$$
$$\alpha_R(C)=8/19,\ \rho_R(C)=1-8/19=11/19$$

In the above result α_R and ρ_R, the smallest C omits.

x_1	x_2	x_3	x_4	x_5
x_6	x_7	x_8	x_9	x_{10}
x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
x_{16}	x_{17}	x_{18}	x_{19}	x_{20}
x_{21}	x_{22}	x_{23}	x_{24}	x_{25}

Fig. 6. Basic block to apply rough set

4. Simulation Result and Analysis

The test images are the various MPEG video and the test video used at DiVAN project estimation step to evaluate the performance of the proposal algorithm. The video image is a picture offered by France's Institut National AudioVisual and the Greek ERT television, and generally the proof pictures. The test images use 100 pictures, 100 pictures have 114 faces, and have various face size. The proposed algorithm detects the region of a face applying the fuzzy decision to YCbCr model in the quantizing 16, 32, 64 bit. This time, it detects a region similar to face in each quantized image by doing cluster using the wavelet morphology to simplify the sphere of a face region. The image, being a little more than 20x20 in this detection image region excludes in the selected face region. After the above process in 16, 32, 64 and original image, this paper embodies the face detection system to choose the final face region using rough sets to do the mergence. Table 1 expresses quality for each picture.

Table 1. Face quality in test image

Face Form	Face Number
Front face	58
A little side face	25
Side face	18
Tip face	13
Total	114

Figure 7 is the test image results compared with [18] of the conventional algorithm.

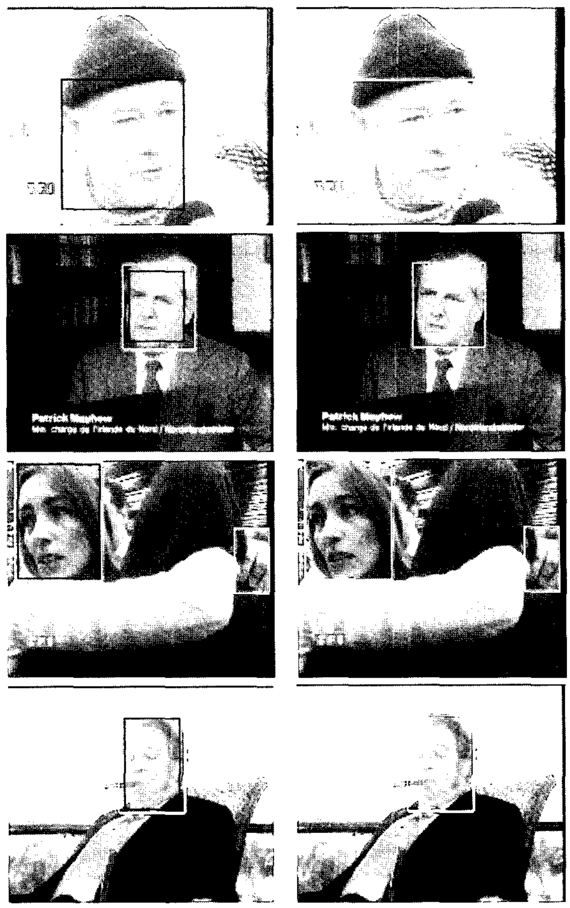


Fig. 7. Image result compared the proposal algorithm(left:black box) with the conventional algorithm(right:white box)[18]

The conventional algorithm[18] presented in Fig. 7 utilized the HSV model by a method to detect a face using a single quantization. Left images in Fig. 7 are the result images(black box) of the proposal algorithm, and right is the result images(white box) of the conventional algorithm. The proposed algorithm results show detecting more correct face regions than the conventional algorithm. Fig. 8 is part of result images applying the proposed face detection algorithm on 100 test images. This result includes images with different sizes, colors, positions and several faces.

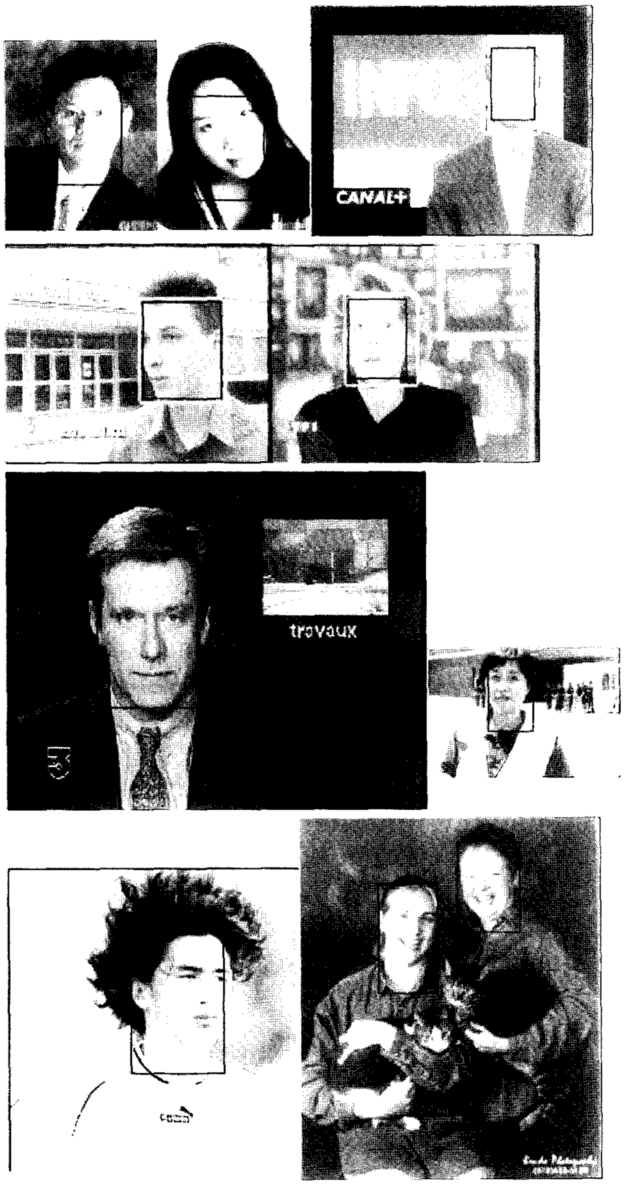


Fig. 8. Part images of result applying the proposal method in test images

As seen in Fig. 8, it detected the region of a face part regardless of various dimensions, several faces, shades, intensities. Table 2 displays the result of face detection in 100 test images.

Table 2. Number of face detection

	CMU[13]	[18] algorithm	The proposed algorithm
Face detection rate	85%	92%	93%
Failure rate	15%	8%	7%

As seen in table 2, the detection rate of a proposed algorithm is about 93% and the conventional algorithm is about 92%. Although a numerical thing is an important, but the quality of an image or correctness is difficult to appear numerically, and it will seem to be right to confirm directly in Fig. 7, 8. Also, the CMU detector among the conventional algorithms shows the detection rate of 85%, but this did not compare directly here because it designed to be detected in the grayscale image.

5. Conclusions

This paper applied the spatial object division and color space distribution, using the YCbCr model in the fuzzy decision algorithm, for face segmentation. Also, it used the spatial quality for division and detection in a real time without a user's intervention. The DiVAN system of the conventional algorithm suffers from the need to control the size to search a correct face and from difficulty to detect a small image. The CMU project suffers from using the grayscale image and taking the speed of one frame party about 5-10 second, and has high failure rate in the face detection. This paper divided searching the face part using the color distribution area in several quantizations, and their simplified it by using the wavelet morphology, detected and segmented the face area exactly using rough sets. It improved the segmentation correctness of face detection using a fuzzy skin color division method, wavelet morphology and rough sets. In this paper, Fig. 8, we showed detection regardless of the size of an image by applying the proposed algorithm is about 1% more than the conventional algorithm of the DiVAN system as shown in table 2. Also, as shown in the superior detection rate is about 8% higher than the CMU detector of the conventional algorithm.

In the future, the proposed algorithm is expected to increase the accuracy to face recognition by using it for security control recognizer, gate security, etc.

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