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Application of Rough Sets to Image Pre-processing for Face Detection

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***Abstract*- Both of face detection and Face recognition play important role in the technology of biologic character identify. During processing of face image, it is indispensable to pre-processing. In this paper, a Pre-processing method for face color image based on rough sets theory is put forward. In this method, the image is divided as foreground and background by condition attribution. In order to extract the skin color regions, foreground is segmented by two kinds of the skin color model, YCrCb and HSV color spaces. Then, the opening and closing morphological operation are used to remove the small regions. Experiment shows the new algorithm has been tested by the computer simulation, in terms of accuracy extracting the skin color, positive rate of face detection and error rate etc. The results show that it can improve accuracy of extracting the skin color and shorten operation time validly. The result of enhanced image is better and satisfies requirement of face detection.**

Index Terms - rough sets; face detection; face image pre-processing; condition attribution; indiscernibility relations

Ⅰ INTRODUCTION

With the ubiquity of new information technology and media, more effective and friendly methods for Human Computer Interaction (HCI) are being developed which do not depend on traditional devices such as keyboards, mice, and displays. The rapidly expanding research in face processing is based on the premise that information about a user's identity, state, and intent can be extracted from images, and that computers can then react accordingly, by observing a person's facial expression. Before the processing of face detection, image pre-processing is important to whole course, which can improve the rate of detection and image analysis. The common methods are image gray transform, smoothness, and filter etc. Among of these, histogram is an efficient method, but simple gray transform can not enough to protect the edge of image. Rough sets theory is applied to processing and analysis of image, which is more efficient in some aspect than hard computer methods.

Rough sets was proposed by Polish scholar Pawlak [1] in 1982, which deals with uncertain, incomplete and vague problems as a mathematics tool. As a soft computer method, the same as fuzzy method, genetic algorithm, neural networks, and rough sets is one of more potential intelligent information methods. Not only do rough sets provide new method for information science and acknowledge science studying incomplete data and vague knowledge, but also provide more effective processing technology for intelligent information processing. The method is completely different from statistic in dealing with uncertain problems, which does not adopt probability ways to describe uncertain of data, and be unlike traditional Fuzzy sets theory ways. The characteristic is simple algorithm, and need not to apply any foregone information besides data. According to description sets about problem, indiscernibility relation and equivalence class, rough sets calculate approximate region of problem, then find rule of the problem. Recently, some researchers have finished the application of rough sets in image pre-processing [2-10].

For example, Guo [5] introduced the definition of attribute histogram. Based on this, an image enhancing method based on rough sets and attribute histogram was proposed. In this paper, image segment method [5] is improved and extended, and applied to face image enhancing. A new face image pre-processing method based on rough sets is proposed; a good the result of enhanced image is obtained and the results satisfy requirements of face detection further.

ROUGH SETS THEORY

A Knowledge and Knowledge base

Let domain U be a limited non-empty class, R denotes equivalence relations, then knowledge base $K=(U,R)$ is called approximation space. Let x be a object in U, as a subsets of U, X named Knowledge. $R(x)$ denotes a sets composed by all of discernibility relations. When X can be described by attributes of R exactly, X is defining by R, we call that X is exact sets of R, Otherwise X is non-exact sets or rough sets.

B indiscernibility relations and domain

Let R is an equivalence class in U, U/R represent as the set of all equivalence class of R. $[X]_R$ denotes equivalence class of R which contain element $x \in U$. A knowledge base is a relation system $K=(U,R)$, where domain U is a limited non-empty sets, R is a group of equivalence relation in U.

If $P \subseteq R$ and $P \neq \varnothing$, then $\bigcap P$ (the intersection of all equivalence class) is a equivalence relation, called indiscernibility relation in P, marked $ind(P)$, and satisfy:

$$[x]_{ind(P)} = \bigcap [x]_R \quad (1)$$

Thus, $U/\mathrm{ind}(P)$ denotes correlative knowledge with all equivalence relation P, and called P base knowledge of U in K.

III FACE IMAGE PRE-PROCESSING ALGORITHM BASED ON ROUGH SETS

We transform image model into YCbCr and HSV, and normalize color range in $[0,1]$. Then, we can use fuzzy relation $R: X \times Y \to [0,1]$ to represent a 2-dimension face image U. Let pixel x is an object in U, we think that knowledge base $K = (U, R)$ is an image approximately space. There are two kinds of attributes in rough sets theory: condition attribute and decision attribute. In order to enhance the ability of face detection and face recognition, it is important to change certain gray value properly. Thus, in this paper, we segment image using equivalence concept of indiscernibility relation according to condition attributes set $C = \{c_1, c_2, c_3\}$, where c_1 denotes skin pixels value attribute, c_2 denotes image noise attribute, and c_3 denotes skin noise attribute.

A *Sub-image segment based* c_1

Definition3.1 equivalence relation R_{c1}: if any skin value of two pixels satisfies $P_2 \geq f(i,j) \geq P_1$ in YCbCr and HSV, then both is correlative, thus they belong to equivalence class. Denote as follows:

$$R_{c_1}(i,j) = \{(i,j) | : P_2 \geq f(i,j) \geq P_1\} \quad (2)$$

where $f(i,j)$ is the skin value of pixel (i, j), P_1 and P_2 are skin threshold, $R_{c_1}(i,j)$ is a set of all more light pixels, which denotes skin regions of image, on the contrary, $\overline{R_{c_1}}(i,j)$ is a set of all more dull pixels, which denotes background.

B *Segment sub-image based* c_2

Definition3.2[3] equivalence relation R_{c_2}: the average gray value of sub-block $S_{m,n}$ and neighbor sub-block $S_{m\pm1,n\pm1}$ subtract, then get the integer of absolute value, if they are more than the threshold P_2, then we define as follows:

$$R_{c_2}(s) = \bigcup_m \bigcup_n \left\{ S_{m,n} | : | \overline{S}_{m,n} - \overline{S}_{m\pm1,n\pm1} | > P_2 \right\} \quad (3)$$

Where $\overline{\mathrm{S}}_{\mathrm{m,n}}$ gray value of average is $\mathrm{S}_{\mathrm{m,n}}$, $\overline{\mathrm{S}}_{\mathrm{m\pm1,n\pm1}}$ is average gray value of $\mathrm{S}_{\mathrm{m\pm1,n\pm1}}$, $R_{c2}(s)$ is the set of noise pixels.

C *Sub-image segment based* c_3

Though the noise of image can be controlled in 3.2, it is difficult to wipe off completely, and there may be some add noise in process of gray image to binary image and have some small regions in foreground. So it is necessary to smooth image in order to reduce small region.

Definition3.3 equivalence relation R_{c_3}: image set U is processed opening operation by structure element B, marked $U \circ B$, and defined as follows:

$$R_{c_3} = U \circ B = (U \Theta B) \oplus B \quad (4)$$

Where Sub-images R_{c_1}, R_{c_2}, R_{c_3} are incorporated into I_1 and I_2,

$$I_1 = R_{c_1}(i,j) - R_{c_2}(s) - R_{c_3}(s),$$
$$I_2 = \overline{R}_{c_1}(i,j) - R_{c_2}(s) - R_{c_3}(s). \quad (5)$$

It is obvious that I_1 and I_2 denote respectively pixels sets of non-skin region and background.

D *face image enhance image*

Based on sub-images segment in 2-dimension face image U, I_1 and I_2 are enhanced on contrast respectively. This course is called transform, and marked $T: T(U) = U'$. The arithmetic process both sub-image I_1 and I_2 by histogram transform, which can Not only enhance image, but also be beneficial to face detection and face recognition.

The steps of enhanced transform follow：

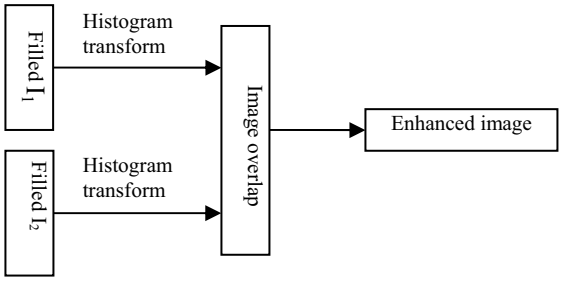

Fig.1 flowchart of Enhance transforms

In one word, face image pre-processing algorithm based on rough sets is composed of two parts, (1) image is segmented by attribute C; (2) change sub-images by enhanced transform $T: T(U) = U'$. Then we can get an enhanced out-image.

Ⅴ EXPERIMENT

In order to show the presented rough sets enhanced algorithm, by using test image of Stanford university [11], the new algorithm is compared with the enhanced method using single YCbCr color model.

Figure2 is downloaded form web set of Stanford university in order to compare enhance efficiency and following face detection rate.

Fig. 2 original image from Stanford university

Figure3 and figure4 are the respectively images of two kinds of Pre-processing methods.

Fig.3 the enhanced method using single YCbCr color mode

Fig.4 the enhanced algorithm based on rough sets

We can compare Figure4 with Figure3. There is more skin color information which is segmented in Figure 4. The numbers of faces in Figure 4 are more extracted and the edges of faces are clearer.

In order to illustrate that the new algorithm is better in face detection, we adopt face detection system by Mikael Nilsson [12] to deal with above three images, Figure2, Figure3 and Figure4. The performing results are following:

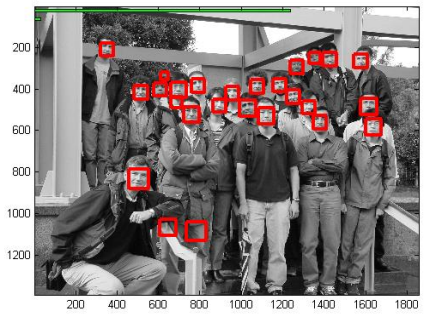

Fig.5 Non-preprocessing of face detection

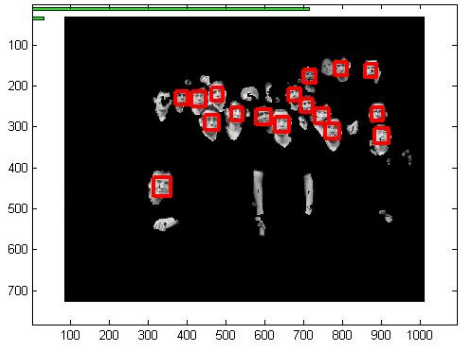

Fig.6 Pre-processing of single YCbCb color model

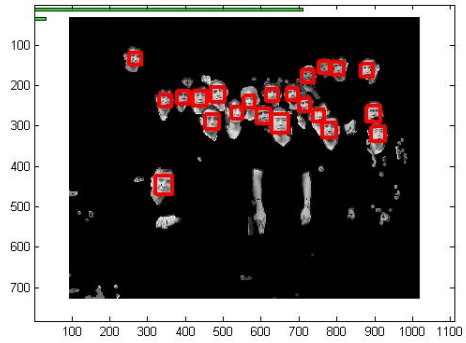

Fig.7 Pre-processing of new algorithm

The following Table 1 shows the performance of different versions of the detector. There are 23 faces in the original images. In the table, the Correct Number means the number of detecting faces correctly. False Number means the number of detecting faces incorrectly. Run Time means the performing time of average single face and unit is second. Non-preprocess indicates that original image is not pre-processed and directly detected. Single YCbCr model indicates that original image is pre-processed based on single YCbCr model, i.e. Fig.3. Based rough set indicates that

original image is pre-processed by rough set method that is Fig.4.

TABLE 1
Comparison with Original Image and Compared Image

Preformance / Methods	Correct Numbers	False Numbers	Run Time	Detect Rate	False Rate
Non-preprocess	23	3	9.454	100%	0.13%
Single YCbCr model	17	0	1.520	73.91%	0
Based Rough Set	22	0	1.664	95.65%	0

Based on the results shown in Table 1, we conclude that there are 22 faces detected in new algorithm, the Detect Rate is 95.65%, the False Rate is 0 and Run Time is 1.664s. In Original non-preprocessing, the Detect Rate is 100%, but the False Rate is 0.13% and Run Time is 9.454s. Nevertheless, the algorithm of single YCbCr model missed 6 faces though it uses less times, the False Rate is 0 and the Detected Rate is just 73.91%.

It follows from Table1 that the pre-processing method based on rough sets is better than the Pre-processing based on single YCbCr model. The new algorithm is beneficial to further image processing in face detection or face recognition and improve detect rate and performing efficiency.

Ⅵ CONCLUSIONS

During practical application in face detection or face recognition, because of environmental condition, such as illumination, instrument and weather etc, image is unavoidable to be noised. Moreover, the performances of accuracy and real-time are important to any device. Thus, how to improve capability of image pre-processing plays an important role in all of processing. In this paper, we proposed a new pre-processing method for face detection based on rough sets. We segment sub-image using indiscernibility relation of condition attributes, and reduce noises. The experiment shows that the enhanced algorithm can obtain the better enhancement effect and lay a good foundation for face detection and recognition. Of curse, there has some problems about the algorithm such as that it can not get key information when the face is masked most. So in the future study, we should further improve algorithm in order to obtain better processing.

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