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A hybrid method for face detection

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Abstarct

The face detection problem is the first part of user identification systems. The success of identification depends of effectiveness of face detection and localization. The are many popular methods for face detection, but not all of them are useful in real-time or on-line face recognition. The proposed hybrid method is useful for this kind of systems and creates possibility to build and develop a practical system for people identification. This method uses a skin detection algorithm with HSV colourspace. Verification of the potential area is performed by face template matching with the eyes image pattern.

Keywords: face detection, face localization, biometrics, face recognition, user identification.

Hybrydowa metoda detekcji twarzy

Streszczenie

Pierwszym elementem systemu identyfikacji użytkownika jest zagadnienie detekcji twarzy. Rezultat identyfikacji zależy od skuteczności procedury detekcji i lokalizacji twarzy. Istnieje wiele popularnych metod detekcji twarzy, które można podzielić na dwie grupy: (i) bazujące na detekcji koloru skóry, (ii) wykorzystujące dopasowanie wzorca. Do detekcji koloru skóry wykorzystuje się jeden z modeli barw, np. RGB, HSV, YCbCr, a następnie weryfikuje się czy wybrany obszar jest twarzą. W systemach dopasowania wzorca należy przeszukać cały obraz porównując fragmenty do wzorca. Te metody są czasochłonne i wymagające dużej mocy obliczeniowej. Większość z tych metod nie jest użytecznych w systemach typu on-line lub czasu rzeczywistego ze względu na czas obliczeń. Zaproponowana hybrydowa metoda jest użyteczna w tego typu systemach i daje możliwość budowy i rozwoju praktycznych systemów identyfikacji osób. Wykorzystuje ona elementy wspomnianych metod w taki sposób, aby skrócić czas obliczeń. Po wstępnej selekcji potencjalnych obszarów mogących zawierać twarz, weryfikacja następuje przy wykorzystaniu wzorca oczu, co znacznie skraca czas obliczeń.

Słowa kluczowe: detekcja twarzy, lokalizacja twarzy, biometryka, identyfikacja osób, rozpoznawanie twarzy.

1. Introduction

The face detection problem is very important in complex user identification systems. This is the first part of processing path. The success of identification (recognition) depends on effectiveness of face detection and localization. If there is no face – there is no recognition.

There are many methods for face detection. The most popular group of methods are methods based on skin colour detection. They use some colour space as RGB, HSV, YCbCr or others [1, 2, 3, 7]. Disadvantages of these techniques are following: many false positive errors, sensitive on change of lighting condition and type of light (bulb, fluorescent, sun).

The second group of face detection methods consists of methods using the template matching. The idea of these techniques is to make comparison of an input image with the pattern including the face [8]. They have good recognition rate but they are computationally expensive, because they need to analyse the whole image.

The methods using features form the third group of techniques of face detection. They can use Eigenface (PCA/KLT), Hidden Markov Models, Support Vector Machines or statistics. They are very effective but complicate and computationally expensive.

2. Skin colour detection

The face localization over colour image uses a technique named skin colour detection. This is made with quantization of colourspaces, segmentation of image and, next, separating the regions of skin. There is need to verify each region if it is face or not, obviously.

The most popular use colorspace are: RGB, HSV, YCbCr.

2.1. RGB

RGB is a colorspace originated from display devices, it describes colour as a combination of three coloured rays: Red, Green and Blue. It is one of the most widely used colour spaces for processing and storing the digital image data [7]. There can be used simple segmentation on RGB colorspace (1) [4]. The result of this technique application is shown in Fig. 1.

$$\begin{aligned} &\frac{R}{G}-\frac{B}{G} > Threshold \\ &R,G,B = 0..255 \end{aligned} \tag{1}$$

This procedure gives poor results and has problem with variable light conditions. The better way is to use the normalized RGB (2) [5, 7] which is resistant to different kinds of light. The result of this technique application is shown in Fig. 2.

$$\begin{aligned} r &= \frac{R}{R+G+B} \\ g &= \frac{G}{R+G+B} \\ b &= \frac{B}{R+G+B} \\ r+g+b &= 1 \\ R,G,B &= 0..255 \end{aligned} \tag{2}$$

2.2. HSV

Hue-saturation based colour spaces were introduced when there was a need for the user to specify colour properties numerically. They describe colour with intuitive values, based on the artist's idea of tint, saturation and tone. *Hue* defines the dominant colour (such as red, green, purple and yellow) of an area, *saturation* measures the colourfulness of an area in proportion to its brightness. The "value" is related to the colour luminance [7]. It may be use for skin detection (3) [3]. The result of this technique application is shown in Fig. 3.

$$
\begin{aligned}
&\text{Convert RGB to HSV :}\\
&M = \max(R,G,B)\\
&m = \min(R,G,B)\\
&r = \frac{M-R}{M-m}\\
&g = \frac{M-G}{M-m}\\
&b = \frac{M-B}{M-m}\\
&V = \max(R,G,B)\\
&\text{if } M = 0 \text{ then } S = 0 \text{ and } H = 180^\circ\\
&\text{if } M <> 0 \text{ then } S = (M-m)/M\\
&\text{if } R = M \text{ then } H = 60(bg)\\
&\text{if } G = M \text{ then } H = 60(2+rb)\\
&\text{if } B = M \text{ then } H = 60(4+gr)\\
&\text{if } H >= 360 \text{ then } H = H - 360\\
&H < 0 \text{ then } H = H + 360\\
&\text{Skin detection :}\\
&H < 0.15 \;\; or \;\; H > 0.95\\
&S < 0.68\\
&V > 0.3\\
&H,S,V = [0,1]\\
&R,G,B = [0,1]
\end{aligned}
\tag{3}
$$

Values H, S, V for skin detection were experimentally selected.

2.3. YCbCr

YCrCb is an encoded non-linear RGB signal, commonly used by the European television. The colour is represented by Y, which is luminance, computed from non-linear RGB, constructed as a weighted sum of the RGB values, and two colour difference values of chrominance *Cr* and *Cb* that are formed from components of RGB [3,7]. The result of this technique application is shown in Fig. 4.

$$
\begin{aligned}
&Y = 0.299R + 0.587G + 0.114B\\
&Cb = 128 - 0.168736R - 0.331264G + 0.5B\\
&Cr = 128 + 0.5R - 0.418688G - 0.081312B\\
&Y > 80\\
&85 < Cb < 135\\
&135 < Cr < 180\\
&Y, Cb, Cr = 0..255
\end{aligned}
\tag{4}
$$

Fig. 1. Result of RGB mask (1) for skin detection
Rys. 1. Wynik działania maski RGB (1) do detekcji twarzy

Fig. 2. Result of Normalized RGB mask (2) for skin detection
Rys. 2. Wynik działania maski znormalizowanego RGB (2) do detekcji twarzy

Fig. 3. Result of HSV mask (3) for skin detection
Rys. 3. Wynik działania maski HSV (3) do detekcji twarzy

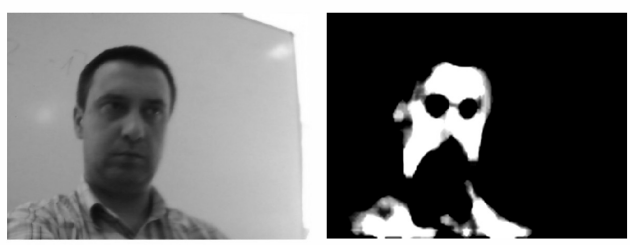

Fig. 4. Result of YCbCr mask (4) for skin detection
Rys. 4. Wynik działania maski YcbCr (4) do detekcji twarzy

3. Template matching

The template matching technique is used for classifying the object which compares the part of image to another and can be used to recognize a similar object. The template matching method for face detection uses the face pattern [3, 6, 8]. The face pattern is comparison with the whole input image from the top to bottom, and from the left to right. It is computationally very expensive. In addition, this type of face detection methods are characterized by frequent non-face errors.

4. The proposed method for face detection

The presented above face detection methods have some advantages and disadvantages. Therefore, the author presents his own detection method.

This method uses a skin detection technique for selection of potential areas containing a face. HSV colour space is used in this step. Next, the template matching technique is applied to verify each region if it is the face or not. The difference between this method and the others is that it uses as the image of eyes as a pattern (Fig. 6), not the whole face as most methods.

Algorithm:

1. Start
2. Take a frame(image) from video stream.
3. Make a quantization to HSV colour space.
4. Analyse image with equations (3).
5. Make a mask.
6. Select areas of skin.
7. For i=1 to numbers_of_skin_areas

7.1 Take size of area.
7.2 Scale pattern of eyes adequately to size of skin area.
7.3 Compare pattern with area: if distance<threshold than save coordinates of face.
8. If number_of_ frame= end than STOP, else go to 2.

Fig. 5. Samples of eyes pattern
Rys.5. Przykładowe wzorce oczu

5. Practical application

The propose above method for face localization can be used in practical real-time or on-line face identification system. The schematic diagram of that system is shown in Fig. 6. The hybrid method for face localization using skin detection and template matching is applied as the first part of the system. When the face is localized then it is normalized. Next, the wavelet transform is used for features extraction. Hidden Markov models are used for training and testing procedure. The decision is made on the basis of maximum likelihood [9].

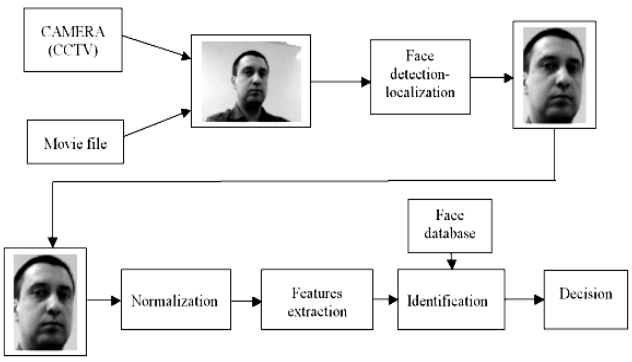

Fig. 6. Schematic diagram of real-time face recognition system
Rys. 6. Schemat systemu rozpoznawania twarzy w czasie rzeczywistym

6. Conclusion

In this paper popular methods for face detection are presented. Not all of them are useful in real-time or on-line face recognition. The proposed hybrid method is useful for this kind of systems. It creates possibility to build and develop a practical system for people identification.

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