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FACE RECOGNITION USING THE HAAR CLASSIFIER CASCADE AND FACE DETECTION BASED ON DETECTION OF SKIN COLOR AREAS

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Summary. The article presents two methods of face detection. The first of these is a method Haar classifier cascade. The second is a face detection method based on detection of skin color areas. They propose a face detection algorithm based on skin color. The main emphasis lies on the effectiveness of the algorithm in order to properly recognize a human face. The results allowed to evaluate the effectiveness of the proposed method.

Keywords: face detection, Haar classifier cascade, face detection based on skin color

1. INTRODUCTION

Systems are used to classify recognition occurring in a real or artificial environment viewed by their models. Face recognition is based on specific functions performed by the algorithm [1, 2, 3]. By gradual processing of the image data, the algorithm tracks, analyzes and corrects the data [9].

An image that is delivered and on which the searched item exists (in this case the searched item is the face) contains difficult features, such as: lighting, which source is atypically located, colors, the object is not directed straight ahead, but in some other direction. In this case it is necessary to use a classifier [9].

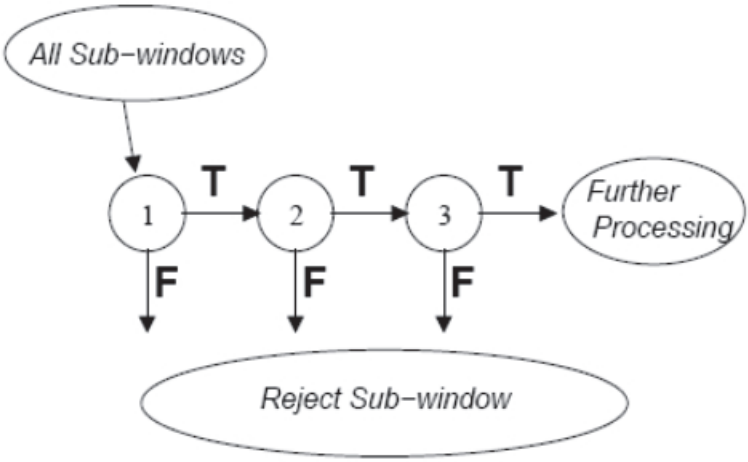

Fig. 1. The process of detection using a cascade classifier

Classification is the process of grouping objects in terms of similarities. Cascade classifier verifies by dividing this into stages (Figure 1). Haar classifier is to locate the searched object (here: the face) on the image where the face detection is performed by sliding the window along the image. A search box is moved along the picture to check whether the current area belongs to the object being sought. The algorithm is characterized by three features: edge (edge features), line (line features) and center surround (center-surround features). The main advantage of operating with Haar-like characteristics is their feature to compile information of the described areas under certain conditions. One example would be the edges or lines presented in a given area.

Face detection based on the detection of the image of skin color or skin-like color areas is an algorithm, which is to detect a field containing the characteristics of the face, such as skin color. Objects which meet certain conditions are filtered and are further analyzed and corrected. Shadows and different hue of light might cause difficulties. To meet the condition to find an area with characteristics similar to the human face including skin color, an appropriate color model of skin color must be adopted. In this case, the color palette for which the condition of detecting areas is fulfilled should be selected first. In that case the best is the TSL space, which is an area that is processed perceptually and determines the color as:

a) color, that is the degree to which a stimulus can be described as similar to or different from other stimuli described as red, green, yellow and white, and can be regarded as the tint with the addition of white [7]
b) saturation
c) light / brightness of a given stimulus, which appears to be white under similar viewing conditions or similar to it.

Both methods are effective when the face is directed vertically. In a situation where the face is pivoted the chance to recognize the decrease.

2. THE DETECTION ALGORITHM BASED ON SKIN COLOR

For test purposes the algorithm was developed to recognize the face based on skin color. For the purposes of testing algorithm was developed to recognize the face based on skin color.

1. Load the photo.
2. Convert photo to YCrCb and HSV formats.
3. Create skin mask which allows only 1 or 0 values, fill it with zeros.
4. Detect skin pixels based on below rules:
   a. for RGB format (both rules sets are combined by logical OR):
      – skin pixels in daylight are expressed by this rule:
        (R > 95 && G > 40 & B > 20 && MAX(R,G,B) - MIN (R,G,B) > 15 && |R-G| > 15 && R > G && R > B)
      – skin pixels in artificial light are expressed by this rule:
        (R > 220 && G > 210 && B > 170 && |R - G| <= 15 && R > B && G > B)
   b. for YCrCb format:
      – (Cr <= 1.5862 * Cb + 20 && Cr >= 0.3448 * Cb + 76.2069 && Cr > -4.5652 * Cb + 234.5652 && Cr <= -1.15 * Cb + 301.75 && Cr <= -2.2857 * Cb + 432.85)
   c. for HSV format:
      – (H < 17 && H > 162)
5. Mark each pixel, which fulfills above rules combined by logical AND, on our skin mask by value 1.
6. Do some morphological operations. In our algorythm we use Erode, Dilate and Closing.
7. Group pixels in blobs.
8. For each area greater than 500 detect if this area is face by above rules:
   a) (box_ratio >= 0.35 && box_ratio <= 1.1)
   b) (eccentricity >= 0.25 && eccentricity <= 0.95)
   c) (extent >= 0.35)

NOTE: Box Ratio is ratio of width to height of the bounding box, Eccentricity is the ratio of the minor axis to major axis of a bounding ellipsem and Extent is the ratio of area of region to area of bounding box.

9. For each region that fulfills above rules combined by logical AND draw bounding box around it (regions with drawed box are our detected faces).
10. Save the image.

3. THE TEST METHOD

The test method consist of testing both algorithms by running them on virtual machines. The machines were equipped with an installed library OpenCV [6, 8] and Python version 3.5. Ubuntu operating system was installed on each machine. The test

involved the face in the 25 photographs. To be sure the result of each test was repeated 10 times. Before performing the tests, a number of training classifiers with 5,000 positive and 5,000 negative samples has been completed. An important element of preparation, since the task was to train a classifier. The training set consisted of 100 positive and 100 negative samples. The samples had a size of 50x50 pixels. In the picture (Fig. 2) was presented a positive sample in gray scale and Fig. 3 presented a negative sample. Examples of test samples are shown in the figures (Figs. 4-6).

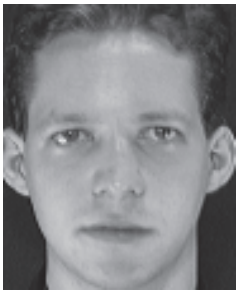

Fig. 2. Sample of positive

Fig. 3. Sample of negative

Fig. 4. A group of people on an inhomogeneous background

Fig. 5. A group of people on an homogeneous background

Fig. 6. Person on an homogeneous background

As shown in Figures 4-6, tested different types of images - because of the background color and the number of people in the pictures. We have not been studied images in which the faces are not compatible with a vertical axis of the picture.

4. RESULTS

Table 1 shows the results of the simulation for face detection based on skin color. As may be seen, this method works properly when in the picture is one person. If there are more people, algorithm effectiveness decreases. Based on these results it can be concluded that the effectiveness of the algorithm is of 90%.

Table 1. The results of detection based on skin color

Figure Number	**Faces on figure**	**Total number**	**No. of false**	**No. of positive**	**False detection**	**Detection summary**
1	1	1	0	1	0%	100%
2	1	1	1	0	100%	0%
3	1	1	0	1	0%	100%
4	1	1	0	1	0%	100%
5	1	1	0	1	0%	100%
6	1	0	0	0	0%	0%
7	2	4	2	3	50%	100%
8	4	4	0	2	0%	100%
9	1	3	2	1	67%	100%
10	8	5	1	5	20%	63%
11	12	14	3	11	21%	92%
12	8	8	0	8	0%	100%
13	3	3	1	2	33%	67%
14	1	3	0	2	0%	200%
15	1	2	0	1	0%	100%
16	2	4	2	2	67%	100%
17	2	3	1	2	50%	100%
18	1	1	2	1	50%	100%
19	1	1	0	1	33%	100%
20	1	0	0	1	0%	100%
21	1	1	0	0	0%	0%
22	1	1	0	1	0%	100%
23	1	1	0	1	0%	100%
24	4	4	0	4	0%	100%
25	1	1	0	1	0%	100%
				Average	**14%**	**90%**

These results are shown in figure 7. It can be seen that errors in the recognition of faces appeared for images from 8 to 18. As mentioned earlier, these images were more than one person.

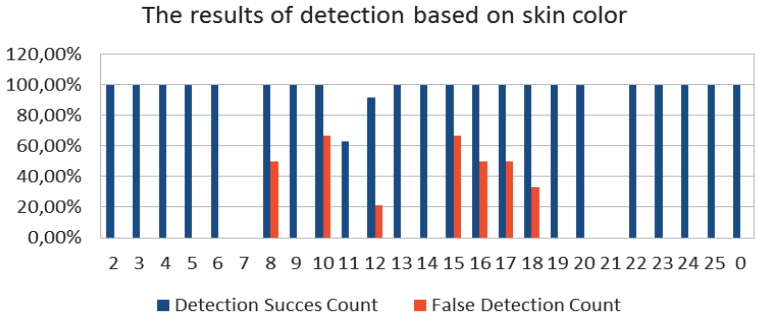

Fig. 7. Detection based on skin color

Table 2 shows the results of Haar classifiers algorithm. Tests were performed on the same set of images. For this algorithm, it is more important the orientation of face item relative to the vertical axis than the number of persons in the photo. The effectiveness of this algorithm is 92%.

Table 2. Haar classifier cascade

Figure Number	**Faces on figure**	**Total number**	**No. of false**	**No. of positive**	**False detection**	**Detection summary**
1	1	1	0	1	0%	100%
2	1	1	1	0	100%	0%
3	1	1	0	1	0%	100%
4	1	1	0	1	0%	100%
5	1	1	0	1	0%	100%
6	1	0	0	0	0%	0%
7	2	4	1	3	25%	150%
8	4	4	0	4	0%	100%
9	1	3	2	1	67%	100%
10	8	5	1	4	20%	50%
11	12	14	3	11	21%	92%
12	8	8	0	8	0%	100%
13	3	3	1	2	33%	67%
14	1	3	1	2	33%	200%
15	1	2	1	1	50%	100%

Table 2 cont.

16	2	4	1	3	25%	150%
17	2	3	1	2	33%	100%
18	1	1	2	1	200%	100%
19	1	1	0	1	0%	100%
20	1	0	0	1	0%	100%
21	1	1	1	0	100%	0%
22	1	1	0	1	0%	100%
23	1	1	0	1	0%	100%
24	4	4	0	4	0%	100%
25	1	1	0	1	0%	100%
Average					**28%**	**92%**

Results of the simulation are shown in figure 8. As shown, this algorithm exhibits a much more errors than the detection discussed previously. Its higher effectiveness due to the better facial recognition on photos with more people.

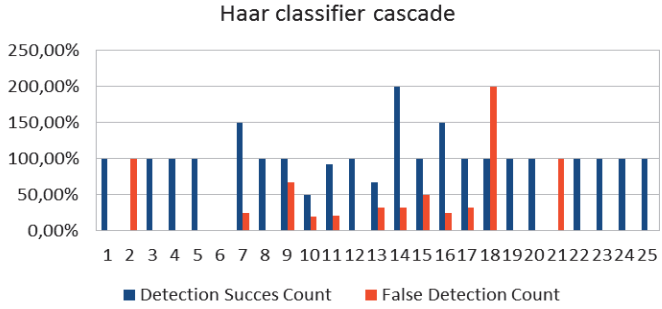

Fig. 8. Detection based on Haar classifier cascade

5. CONCLUSION

Based on the results in tables (Tab. 1. Tab. 2) and figure (Fig. 7. Fig. 8) it can be concluded that both methods are equally effective for color images. Although in the study the method based on Haar classifier cascade showed a higher percentage of errors, it can be more effective because it is able to recognize the face in black and white. Thus, it is more flexible than the other methods of detection.

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ROZPOZNAWANIE TWARZY METODĄ KASKADY KLASYFIKATORÓW HAARA I DETEKCJA TWARZY W OPARCIU O WYKRYWANIE OBSZARÓW O KOLORZE SKÓRY

Streszczenie

W artykule przedstawiono dwie metody detekcji twarzy. Pierwsza z nich to metoda kaskady klasyfikatorów Haara. W metodzie tej ważne jest położenie twarzy w stosunku do kąta obrócenia zdjęcia. Rozpoznawane są tylko „pionowe" twarze. Drugą stanowi metoda detekcji twarzy w oparciu o wykrywanie obszarów o kolorze skóry. Zaproponowano algorytm detekcji twarzy w oparciu o kolor skóry. Główny nacisk położono na skuteczność algorytmu w celu poprawnego rozpoznania ludzkiej twarzy. Otrzymane wyniki pozwoliły ocenić skuteczność zaproponowanej metody.

Keywords: rozpoznawanie twarzy, kaskady klasyfikatorów Haara, detekcja twarzy na podstawie koloru skóry