The report of describing camouflage techniques

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1. The summary of Haar cascade face detector

This algorithm can be broken down into the following three steps:

1.1. Extracting features

The Haar feature is used to extract the features of the original image. In this algorithm, the main reason for using features instead of pixels for recognition is that features can contain prior knowledge [1].

1.2. Selecting features

The features extracted by Haar feature should be reduced because their number is too many. A variant of Adaboost is used to select and train these features [1]. A weak feature is composed of a feature and its corresponding threshold. Multiple weak classifiers can be combined to form a strong classifier.

1.3. Using cascade structure to combine classifiers

In a picture, there are many regions that do not contain face elements. If all of the features are applied to one sub-window, the computing efficiency will be greatly reduced. Therefore, this algorithm uses cascade structure to combine the classifiers. This structure contains many stages, and each stage contains multiple classifiers. Only when all classifiers in all stages determine that the current sub-window is a face, the algorithm confirms that this sub-window is a face. If any classifier in any of the stages determines that the current sub-window is not a face, then the algorithm determines that the current sub-window is not a face, and the algorithm will be terminated at this stage. Several simple classifiers can be deployed on the first several stages of the cascade structure. In this way, only after passing the detection of simple classifiers in the first several stages for each sub-window, will it be detected by a large number of more complex classifiers. Such a cascade structure can exclude sub-windows that do not contain faces at an early stage, thus greatly reducing the number of sub-windows that need to be determined by all features.

2. The process of designing the camouflage

I have designed two types of camouflage altogether. I will introduce these two kinds of camouflage respectively. Two sets of pictures are shown below. The faces in the first group (Figure 1 and Figure 2) were expressionless, while the faces in the second group (Figure 3 and Figure 4) were smiling. Figure 2 and Figure 4 shows the results of this algorithm that identifies the Figure 1 and Figure 2 which don't have any camouflage.

Figure 1

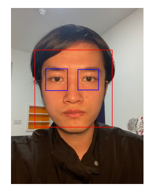

Figure 2

Figure 3

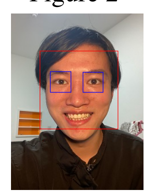

Figure 4

It can be seen that the recognition results of this algorithm on these pictures are correct. I will compare these two pictures with the results of using two types of camouflage that I used below.

2.1. The camouflage of covering the eyes

2.1.1 The description of this camouflage

I covered both of my eyes with a piece of white paper.

2.1.2 The principle of this camouflage

In the official website of OpenCV, I learned that a facial feature that is extracted and is used in this algorithm is that there is a significant difference in intensity between the eyes area and the upper cheeks area, and the eyes area is always darker than the upper cheeks area[1]. So I chose to use the paper which is more white than my upper cheeks to cover my eye area. Because of this, the classifier that contains this feature may decide that this image is not a face. Since this algorithm uses cascade structure, even if the classifiers containing other features consider this picture to be a face, the whole algorithm will also determine that this picture is not a face.

2.1.3 The pictures of experimental results

Figure 5 shows the results of this algorithm which identifies the image that I covered the eyes of the face with no expression, and Figure 6 shows the results of this algorithm which identifies the image that I covered the eyes of the face with smile. It can be seen that this camouflage is effective for both expressionless and smiling faces.

Figure 5

Figure 6

2.2. The camouflage of blacking the nos

2.2.1 The description of this camouflage

I black the nose area. Since I don't have a black makeup pen, I had to black the nose area of the facial picture. I think these two methods have the same effect.

2.2.2 The principle of this camouflage

One feature extracted and used in this algorithm is that the eyes area is always darker than the bridge of the nose, so I black the area around the bridge of the nose to make the bridge of the nose's intensity to be greater than the eyes'. Because of this, the classifier that contains this feature may decide that this image is not a face. Since this algorithm uses cascade structure, even if the classifiers containing other features consider this picture to be a face, the whole algorithm will also determine that this picture is not a face.

2.2.3 The pictures of experimental results

Figure 7 shows the results of this algorithm which identifies the image that I black the the bridge of the nose of the face with no expression, and Figure 8 shows the results of this algorithm which identifies the image that I black the the bridge of the nose of the face with smile. It can be seen that this camouflage is effective for both expressionless and smiling faces.

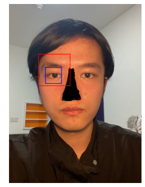

Figure 7

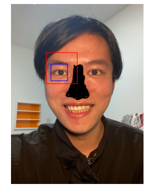

Figure 8

2.2.4 The analysis of experimental results

The important part of this camouflage is that the bridge of the nose should be blacked. If only the tip of the nose but not the bridge of the nose is blacked, the algorithm can still correctly identify the face. This indicates that the feature extracted by this algorithm is the intensity comparison between the bridge of the nose and the eyes, rather than the intensity comparison between the nose and the eyes. This conclusion can be confirmed by the following figures. Figure 9 is this algorithm's recognition result of the image without blacking the nose bridge, and Figure 10 is this algorithm's recognition result of the image with blacking the nose bridge.

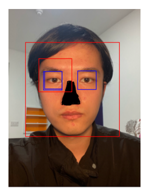

Figure 9

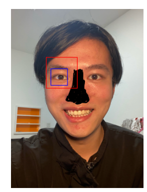

Figure 10

3. Further discussion

During the experiment, I have been using images with low pixels (231*308) for the algorithm to recognize. The algorithm always correctly identified the position of my face and eyes of the images without the camouflage. When I tried to get the algorithm to identify images with high pixels (2361*3148), the algorithm could still find the exact location of my face, but at the same time, it might identify the places that do not contain faces as faces, and the places that do not contain eyes as eyes. So I guess that as the pixel increases, more and more non-face regions in the image wrongly meet all the features extracted from the algorithm by accident. For example, the algorithm may identify the area where two black dots are close together on clothes as a face, so I don't think this algorithm can do high precision face recognition work. Figure 11 is the recognition result of this algorithm for high pixel images. Figure 12 is the recognition result of low pixel image by this algorithm.

Figure 11

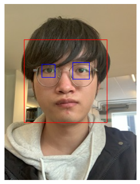

Figure 12

References

[1] Paul Viola and Michael Jones. Robust real-time face detection. *International journal of computer vision*, 57(2):137–154, 2004. 1