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Design Of High Speed Face Detection And Tracking By Skin Segmentation Using MATLAB

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ABSTRACT

Due to the rapid development of computer hardware design and software technology, the user demands of electric products are increasing gradually. The human face is central to our identity. It plays an essential role in everyday interaction, communication and other routine activities. Thus, face detection and tracking algorithms are of great importance for human-machine interaction. It is an extensively studied field and a large body of research has been done. This work gives a broad overview of basic principles and some representative methods for face detection and tracking. Face detection and tracking has been an important and active research field because it offers many applications, especially in video surveillance, biometrics, or video coding. The goal of this work is to design a real-time system to detect and track a human's face. The face detection algorithm involved color-based skin segmentation and image filtering. The face location is determined by calculating the centroid of the detected region. The algorithm is independently designed, implemented and tested for still image using MATLAB.

Keywords— **face detection, face tracking, segmentation, image filtering, centroid**

1. Introduction

Face detection and tracking is the process of determining whether or not a face is present in an image. Unlike face recognition—which distinguishes different human faces, face detection only indicates whether or not a face is present in an image. In addition, face tracking determines the exact location of the face. Face detection and tracking has been an active research area for a long time because it is the initial important step in many different applications, such as video surveillance, face recognition, image enhancement, video coding, and energy conservation. The applicability of face detection in energy conservation is not as obvious as in other applications. However, it is interesting to learn how a face detection and tracking system allows power and energy to be saved. Suppose one is watching a television and working on other tasks simultaneously.

The face detection system is for checking whether or not the person is looking directly at the TV. If the person is not directly looking at the TV within some time period (i.e. 15 minutes), the TV's brightness is reduced to save energy. When the person turns back to look at the TV, the TV's brightness can be increased back to original. In addition, if the person looks away for too long (i.e. more than one hour), then the TV will be automatically turned off.

Different approaches to detect and track human faces—including feature-based, appearance-based, and color-based have been actively researched and published in literature. The feature-based approach detects a human's face based on human facial features—such as eyes and nose. Because of its complexity, this method requires lots of computing and memory resources. Although compared to other methods this one gives higher accuracy rate, it is not suitable for power-limited devices. Hence, a color-based algorithm is more reasonable for applications that require low computational effort. In general, each method has its own advantages and disadvantages. More complex algorithm typically gives very high accuracy rate but also requires lots of computing resources.

The skin detection algorithm here is derived from the method describe in [1]. Color segmentation has been proved to be an effective method to detect face regions due to its low computational requirements and ease of implementation. Compared to the featured based method, the color-based algorithm required very little training. First, the original image is converted to a different color space, namely modified YUV.Then the skin pixels were segmented based on the appropriate U range. Morphological filtering is applied to reduce false positives. Then each connected region of detected pixels in the image is labeled. The area of each labeled region is computed and an area-based Input Image. Thresholding/Skin Detection Connected Component Labeling Morphological Filtering Centroid Computation Output Image.Area-based Filtering Area Calculation 8 filtering is applied. Only regions with large area were considered face regions. The centroid of each face region is also computed to show its location.

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2. Related Work

The problem of automatic face detection has been an active area of study for some time and numerous methodologies exist. These may be broadly categorised as appearance-based, feature-based or colour-based. Appearance-based approaches [2,3] treat face detection as a recognition problem and, in general, do not utilise human knowledge of facial appearances, but rely on machine learning and statistical methods to ascertain such characteristics. Feature-based methods detect faces by detecting features such as the eyes and the nose, or parts or combinations thereof [4,5], and usually rely on low-level operators and *a priori* heuristic rules of the human face structure. Finally, colour-based methods may be viewed as a special case of feature-based methods, where the feature in question is the colour of the human skin [6,7]. The advantage of colour-based face detection methods is that, while computationally efficient, they are generally robust to geometric transformations, such as scale, orientation and viewpoint changes, since such transformations do not affect the colour of skin, as well as to complex backgrounds and illumination variations. Our method also adopts the skin colour-based detection approach.

3. Proposed Model

In this section, we describe the proposed framework in details. The block-diagram of the proposed approach is depicted in Fig.1 each step is described in the following sections.

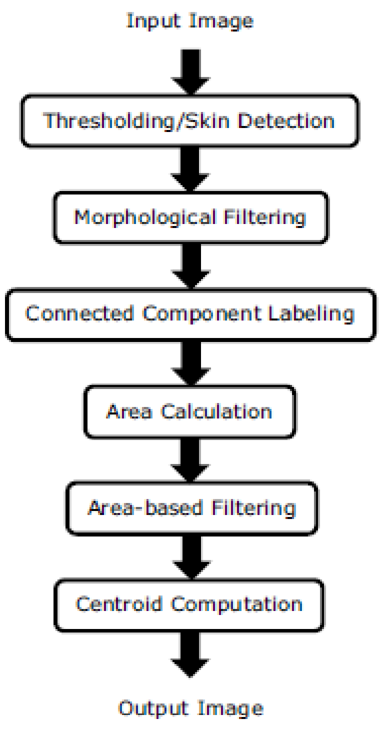

Fig. 1 Block-diagram of the Proposed Model

3.1 Modified YUV color space

Converting the skin pixel information to the modified YUV color space would be more advantageous since human skin tones tend to fall within a certain range of chrominance values (i.e. U-V component), regardless of the skin type. The conversion equations are shown as follows[1]

$$Y = R + 2G + B/4$$
$$U = R - G$$
$$V = B - G$$

These equations allowed thresholding to work independently of skin color intensity.

3.2 *Skin detection/Thresholding*

After skin pixels were converted to the modified YUV space, the skin pixels can be segmented based on the following experimented threshold.

$$10 < U < 74$$
$$-40 < V < 11$$

Therefore, the skin detection algorithm using here is based on the U component only. Applying the suggested threshold for the U component would produce a binary image with raw segmentation result, as depicted in Figure2.

Fig. 2 Result after Thresholding

3.3 *Morphological filtering*

Realistically, there are so many other objects that have color similar to the skin color. As seen in Figure 2, there are lots of false positives present in the raw segmentation result. Applying morphological filtering—including erosion and hole filling would, firstly, reduce the background noise and, secondly, fill in missing pixels of the detected face regions, as illustrated in Figure 3.

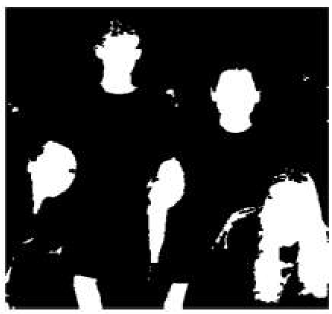

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Fig. 3 Result after Morphological filtering

3.4 *Connected Component Labeling and Area Calculation*

After each group of detected pixels became one connected region, connected component labeling algorithm is applied. This process labeled each connected region with a number, allowing us to distinguish between different detected regions. In general, there are two main methods to label connected regions in a binary image—known as recursive and sequential algorithms.

3.5 Area-based Filtering

Note that morphological filtering only removed some background noise, but not all. Filtering detected regions based on their areas would successfully remove all background noise and any skin region that is not likely to be a face. This is done based on the assumption that human faces are of similar size and have largest area compared to other skin regions, especially the hands. Therefore, to be considered a face region, a connected group of skin pixels need to have an area of at least 26% of the largest area. This number is obtained from experiments on training images. Therefore, many regions of false positives could be removed in this stage, as depicted in Figure 3

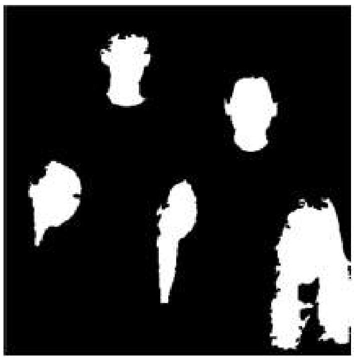


Fig. 4 Result after area based filtering

3.6 *Centroid computation*

The final stage is to determine face location. The centroid of each connected labeled face region can be calculated by averaging the sum of X coordinates and Y coordinates separately. The centroid of each face region in Figure 6 is denoted by the blue asterisk.

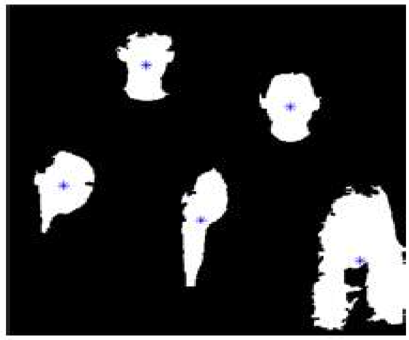
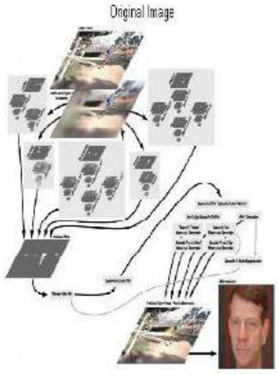


Fig. 5 Result after centroid computation

4. Experimental results

The final result is a complete system that is capable to detect and track faces of at most two people in real time. Although it is not able to track each face separately when there were three people or more, it could still detect the presence of their faces. Experiments also showed that different light settings did not significantly alter the final results. Furthermore, the system is able to ignore background noise very well—mostly came from light reflection. When there were objects that had color similar to skin color, both spatial and temporal filtering helped erode these detected regions, therefore reducing the number of false positives.



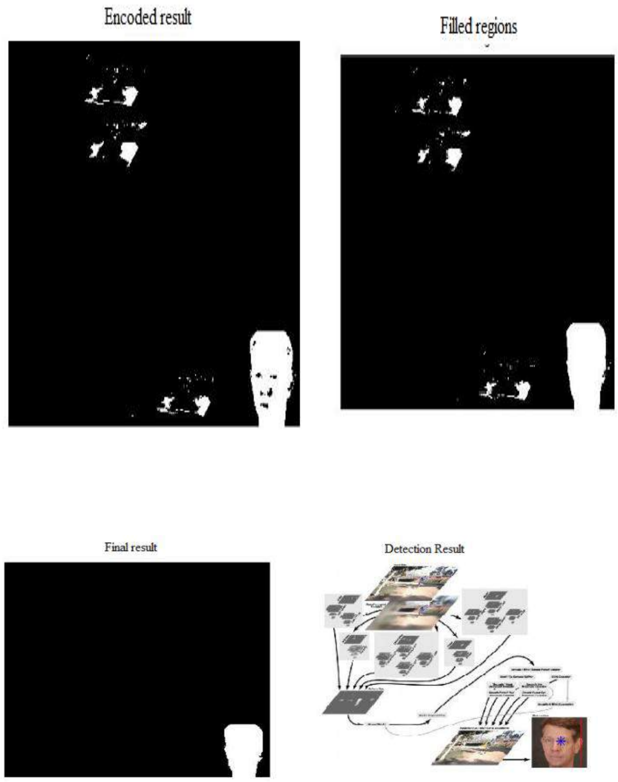


Fig.6 Sample results

5. CONCLUSION

In this project, the goal of implementing a system to detect and track human faces in real time is achieved. A software implementation of the algorithm is examined in MATLAB to verify its accuracy. The face detection algorithm is derived from a skin detection method. Face tracking is achieved by computing the centroid of each detected region, although it only worked in the presence of at most two people. We have presented an approach for face detection which minimizes computation time while achieving high detection accuracy. The approach was used to construct a face detection system which is approximately 15 times faster than any previous approach. Preliminary experiments, which will be described elsewhere, show that highly efficient detectors for other objects, such as pedestrians or automobiles, can also be constructed in this way. Different types of filter were applied to avoid flickering and stabilize the output displayed on the screen. This implementation is proved to work in real time with no lagging and under varying conditions of facial expressions, skin tones, and lighting. Experimental results show that such a method is robust enough to ensure successful detection and tracking of faces even under conditions where the size, orientation and viewpoint of faces are varied.

6. ACKNOWLEDGEMENT

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