Identification of Facial Features on Android Platforms

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***Abstract*—In this paper, we present and investigate the performance of an algorithm designed to identify facial features on an android mobile platform. Facial feature identification is the necessary step before many computer vision systems including emotion detection, face tracking and face recognition. The facial feature identification algorithm presented is based on an anthropometric face model , box-blur filtering, and non-maximum suppression to find eyes corners, mouth corners and nose centre. Skin colour detection is used to find regions in the image that have a higher potential of containing eyes. The anthropometric face model is used to reduce the computational complexity involved in localising facial regions. This algorithm is designed to be compatible with the limited hardware and memory capabilities of mobile devices.**

I. INTRODUCTION

Mobile devices have become very powerful. All sort of data are stored and accessed through these devices. Mobile banking, m-commerce and web-browsing are the kind of activities one often performs with smart phones or tablets. The security of the data stored in mobile devices like email, private documents and private mobile banking applications is therefore crucial. Authentication through face recognition is sometimes used to secure the mobile device. Face recognition is often based on the detection of facial feature points. The precise extraction of facial feature is very important to create a fully automated facial recognition system [1]- [12]. Processing images require a considerable amount of computational resources. This implies large consumption of processing time on the Central Processing Unit (CPU). A face detection algorithm to be used on mobile platform therefore needs to be designed and implemented in such a way that the consumption of the processing time will be reduced. We therefore use a mixture of statistical approaches to predict different facial regions and image processing techniques to accurately locate specific features. The rest of the paper is organised as follows. In section 2, the different techniques used for detecting face features are presented. In Section 3, we give a detailed description of our method to locate 7 important feature points. In section 4, the experiment results are presented and analysed and Section 5 is a conclusion to the paper.

II. PRIOR AND RELATED WORK

Face detection is a very active research area. Many techniques have been researched and implemented to detect faces and facial features [13]. These techniques are divided into three main categories: approaches based on colour information, facial geometry and statistical modelling of the face [3]- [4], PCA-based methods sometimes called knowledge based. The PCA is often applied on skin detected regions [5]- [6], template matching approach [7]. In all these methods, the most important facial features are the eyes. The localization of other facial features are largely dependent on the correct and precise localization of the eyes. A large amount of research has been dedicated into precisely locating them on the face [14]- [8]. They are very important for several reasons: Eyes and especially irises are found to have unique and sometimes invariant features for each individual [2]. Moreover when the eyes are correctly identified, the intra-ocular distance can help identify the face scale and the position of the one eye relative to the other will help identify the in plane rotation of the face. The positions of eyes in the statistical modelling of the face help in the localization of other facial features.

III. FEATURE POINTS EXTRACTION

In this section we present our method to process the frontal-view face image to detect the face region and the face features. Face features like eyes, nose and mouth are usually needed to describe and recognise a face. These features correctly identified are utilised in face tracking, emotion detection and face recognition. The first step to towards feature extraction is face detection which is done through skin segmentation.

A. Skin Segmentation

Skin segmentation is done to identify skin like regions in the image. It is assumed we have a picture containing shoulder and frontal face. The skin like region is therefore assumed to be the part of the region that contains the face. The RGB color image is transformed into the YCrCb color image using the following formula:

$$cb = -0.16874 * R - 0.33126 * G + 0.50000 * B + 128 \quad (1)$$

$$cr = 0.50000 * R - 0.41869 * G - 0.08131 * B + 128 \quad (2)$$

Skin like regions are extracted using the following filtering algorithm.

$$\begin{aligned} \text{if } (133 &\leq cr \text{ and } cr \leq 173 \text{ and } 77 \leq cb \text{ and } cb \leq 127), \\ \text{then pixels (i,j)} &= \text{skin pixel} \\ \text{else , pixels(i,j)} &= \text{non-skin pixel.} \end{aligned}$$

The boundary values are obtained fron Chin and Gan research [15], in which they found that the abovementioned ranges of Cr and Cb are most representative of the skin color reference map. The YCrCb color space was selected because it has been found to be robust against changing lighting conditions. The Y channel seems to be the one who is influenced by lighting variations, the Cr and Cb channels are therefore used for skin segmentation [16].

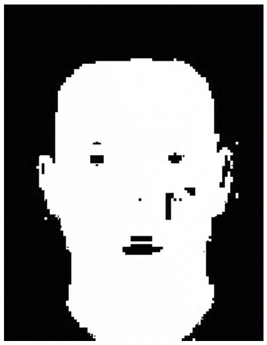

Fig. 1. Skin Segmentation.

B. Eyes Extraction

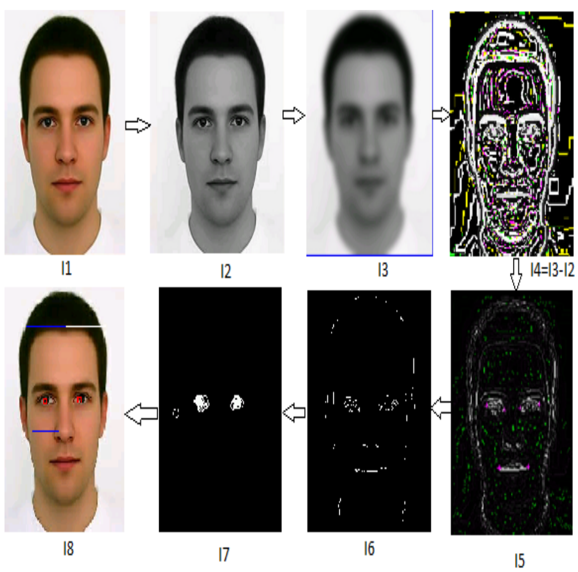

Fig. 2. Example of eyes detection.

The algorithm used to detect the eyes is presented in Figure 3. The extraction of the eyes is the most important part of this algorithm. All other features are found based on the position of the eyes and the intra-ocular distance. Once the skin region is found, eyes are to be found in that skin region. The skin region could consist of not only the face but also the neck and sometimes part of the chest. It is possible to extract the extract the face by using the following golden ratio formula [10].

$$h/w = phi \tag{3}$$

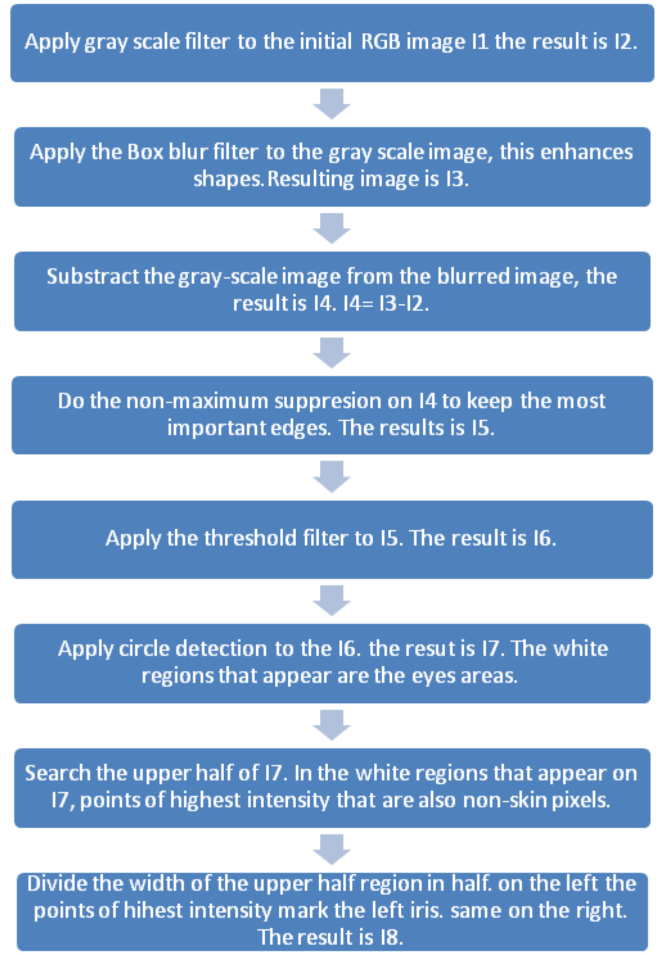

Fig. 3. Algorithm for eyes detectiono. I1 to I7 refer to labelled images in Fig. 2

where h is the height of the head, w is the width of the head and phi is the symbol representing the golden ratio 1.618. The width of the skin region is to be measured and considered to be the head width. The above formula will be used to calculate the head height. Figure 1 is showing the skin segmentation of a picture. Once the head is located and enclosed in a box we can start looking for the eyes. The eyes are usually located in the upper half of the face, that is the region of interest. The eyes are also usually on the face the region with the highest intensity [17].

C. Predicting Feature Regions

In order to identify facial features we will use the non-maximum suppressed image and apply a threshold lower than the one used to locate the eyes. This will give a edge detected image with only the regions of importance. Once the eyes are located we will use the golden ratio and the anthropometric model derived from the rules obtained in [11]- [9]- [10], to predict the nose and the mouth regions. The distance between the two eyes is D.The following rules are applied:

1-

$$N/D = 0.33 \tag{4}$$

where N is the vertical distance between the eyes and the nose tip.

2-

$$M/D = 1.10 \tag{5}$$

where M is the vertical distance between the eyes and the mouth centre.

3- The width of the nose E is 0.8D.

4-

$$E/L = phi \tag{6}$$

where E is the nose width and l is the distance from the nose to the mouth.

5-

$$K/E = phi \tag{7}$$

where K is the length of the lips.

6- The width of the eyes is similar to the nose width.

D. Localising Features Points

On the binary image obtained from applying the threshold to the non- maximum suppressed image we notice that we have an edge detected image where only the most important parts of the face are highlighted. On the mouth region, the left most white pixels and the right most white pixels consist of the mouth corners. The same happens in the eye region. The centre of the nose is identifying the midpoint between the nostrils that appear as holes in the binary image.

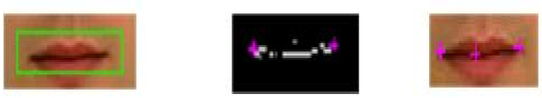

Fig. 4. Mouth Corners.

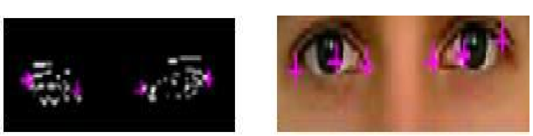

Fig. 5. Eyes corners.

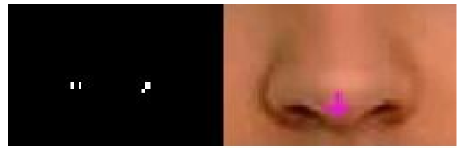

Fig. 6. The centre of the nose.

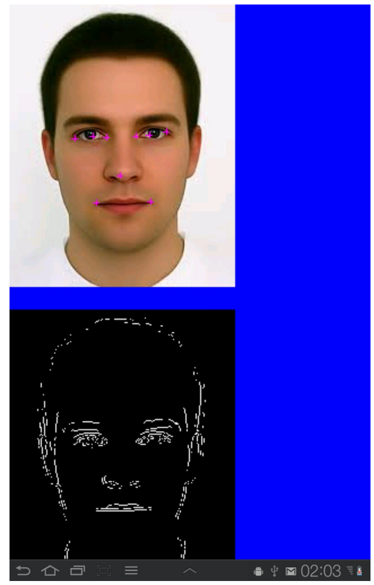

Fig. 7. Corners identified.

IV. EXPERIMENTAL RESULTS

A. Database And Testing Methodology

The accuracy of the prediction using the face geometric model and golden ratio rule was tested on 500 facial images of different individuals obtained from the UJ database. The size of each image is 480 * 624.The images are named 0000x.jpg, where x ranges for 000 to 500. For different subjects, the images are taken under different conditions: facial expression $openeyes, smiling/non-smiling$ and facial details $glasses/no-glasses$. Eyes need to be open so that the eyes centre can be identified. All the images are taken against a grey homogeneous background and the test subjects are in upright, frontal position (with some tolerance for some side movement).The testing conditions is the same for all the pictures. Figure 8 gives example of face images from the UJ face database.

B. Prediction Accuracy Of The Nose And Mouth

The accuracy of the prediction of the mouth and nose area is shown in table 1. This prediction is done is two steps. The first step consists in finding the mouth and the nose from the eye distance and the midpoint between the eyes. The mouth or the nose is correctly found if the cross falls on any lips or anywhere on the nose. The following figure indicates correct mouth and nose localisations.

Fig. 8. UJ database image examples.

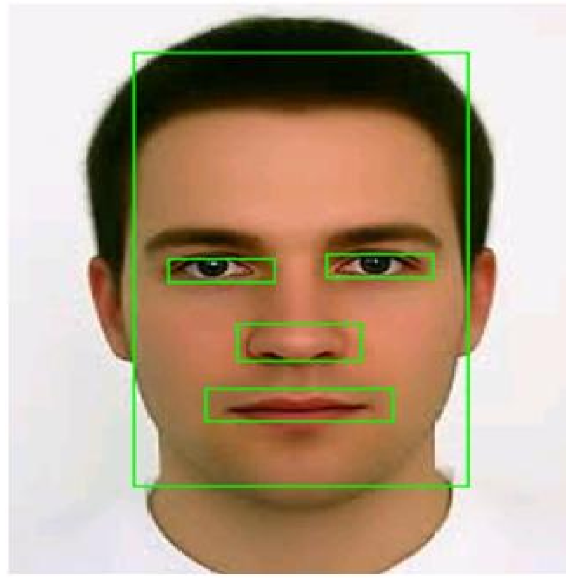

Fig. 10. Correct mouth, nose, eyes areas predictions.

Fig. 9. Correct mouth and nose localisation.

If the points fall outside the mouth regions or outside the nose regions, we have a miss. The nose, the mouth and the nose areas are to be found and bounded in rectangles according to rules 3, 4 and 5 of section III.C above. The testing of the accuracy of the algorithm is done by manually marking the eyes, nose, and mouth regions in each image and comparing it against the automatic output of the algorithm.

If one of the corners of the mouth or of eyes appears outside the rectangles the prediction is wrong. If one of the nostrils appears outside of the nose rectangle we also have a miss. If the sides of the rectangles are more than 5 pixels away from the corners the prediction is also wrong.

TABLE I
FEATURE AREAS PREDICTION ACCURACY

-	mouth	mouth area	nose	nose area
accuracy(percentages)	97.2	93	85	86.6

C. Performance Of The Feature Detector

The algorithm was implemented in Java for android operating system and tested on an android device:the Samsung galaxy 10.1 tablet. The processing capabilities of this tablet are: *(1 GHz dual core NVIDIA Tegra 2 processor, and 1GB RAM)* The java implementation was run on 45 images, the average processing time is recorded in table 2.

TABLE II
TIME PERFORMANCE ON THE SAMSUNG GALAXY TAB 10.1

-	locating eyes	predicting nose, eyes and mouth regions	corners indentification	total time
time*(secs)*	2.52909	0.00099	0.09215	2.62224

The system takes approximately 2.62 seconds to detect facial features. The part of the algorithm that seems to be very expensive is the extraction of the eyes which takes a little more than 2.5 seconds and includes the skin segmentation step.

V. CONCLUSION

The automatic detection of facial features with high precision is not easy. In this paper we proposed a method that is fast, precise and accurate. Many face recognition systems assume that the features are correctly localised and work on that basis but sometimes the features are manually selected which is not a problem for the purpose of comparing algorithms but not when one wants to create a fully automated face recognition system. The algorithm has been designed and tested on an android platform and could be used for a facial recognition system for the purpose of authentication. The time performances are reasonably good, the features detection part is taking less than 3 sec. It is expected that an authentication would be done in less than 4 seconds.

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