HUMAN FACE DETECTION FROM COLOR IMAGES: PRELIMINARY RESULT

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Abstract

Images containing faces are essential to intelligent vision-based human computer interaction where it is utilized in various applications (e.g. face recognition, face tracking, pose estimation, expression estimation, etc). This paper aims to provide preliminary investigation on human face detection from a color image. A successful and robust algorithm should capable in identifying all facial region within a given images regardless of its position, orientation and lighting conditions. Such problems are quite challenging because the faces are non-rigid and have a high degree of variability in size, shape, color and texture. Numerous approaches have been developed and proposed to localize facial region in a single image. Our study utilized YCrCb color space method in the detection of human face from a color image with a pre-determine chrominance and luminance parameters. The result obtained illustrates the feasibility of this approach where it exhibits high and accurate segmentation rate though possess minor flaws.

Key words: Face detection, face localization, chrominance and luminance.

1.0 INTRODUCTION

Face detection is defined as: Given an arbitrary image, a solution (algorithm) developed is able to determine whether or not there are any faces in the image and, if present, return the image location and extend of each face. Facial image detection algorithms are gaining more and more attention as it can be applied in various fields. Among the applications that implementing the concept of facial area detection are facial tracking, pose estimation and face recognition [1, 2, 3, 4].

Owing to several ill-posed problems and variability found in a given input image, challenges associated with face detection can be classified to the following factors [1]:

- **Pose.** The images of a face vary due to the relative camera-face pose (frontal, 45 degree, profile, upside down), and some facial features such as an eye or the nose may become partially of wholly occluded.

- **Presence or absence of structural components.** Facial features such as beards, mustaches and glass may or may not present and there is a great deal of variability among these components including shape, color and size.

- **Facial expression.** The appearance of faces is directly affected by a person's facial expression.

- **Occlusion.** Faces may be partially occluded by other objects. In an image with a group of people, some faces may partially occlude other faces.

- **Image orientation.** Face images directly vary for different rotations about the camera's optical axis.

- **Imaging conditions.** When the image is formed, factors such as lighting (spectra, source distribution and intensity) and camera characteristics (sensor response, lenses) affect the appearance of a face.

A typical face detection framework is illustrated in Figure 1.0 [31].

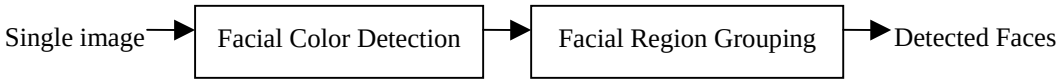

Figure 1.0: Framework of typical face detection system.

1.1 Detecting Faces in a Single Image

In this section, we review several existing techniques used to detect faces from a single intensity or color image. The single detection methods are classified into four categories; some methods clearly overlap category boundaries and are discussed at the end of this section.

1. **Knowledge-based methods.** These rule-based methods encode human knowledge of what constitutes a typical face. Usually, the rules capture the relationships between facial features. These methods are designed mainly for face localization.

2. **Feature invariant approaches.** These algorithms aim to find structural features that exist even when the pose, viewpoint, or lighting conditions vary, and then use these to locate faces. These methods are designed particularly for face localization operations.

3. **Template matching methods.** Several standard patterns of a face are stored to describe the face as a whole pr the facial features separately. The correlations between an input image and the stored patterns are computed for detection. These methods have been used for both face localization and detection.

4. **Appearance-based methods.** In contrast to template matching, the models (or templates) are learned from a set of training images which should capture the representative variability of facial appearance. These learned models are then used for detection. These methods are designed mainly for face detection.

Table 1 summarized the algorithms and representative works for face detection in a single image within these four categories.

2.0 METHODOLOGY

In this study, we have chosen skin color space which belongs to Feature invariant category to be used in the detection of human faces in a given color images. Generally, our system constitutes of three main steps: reading the images pixel value in RGB, YCrCb color space computation [50] and images' pixel thresholding [15, 30] according to a pre-determine parameters. Figure 2.1 illustrates the framework of our human face detection system.

Table 1: Categorization of Methods for Face Detection in a Single Image

Approach	Representative Works
Knowledge-based	Multi-resolution rule-based method [33]
Feature invariant	
- Facial Features	Grouping of edges [34, 35]
- Texture	Space Gray-level Dependence matrix (SGLD) of face pattern [36]
- Skin Color	Mixture of Gaussian [37, 38]
- Multiple Features	Integration of skin color, size and shape [27, 39]
Template matching	
- Predefined face templates	Shape template [16, 40]
- Deformable Templates	Active Shape Model (ASM) [41]
Appearance-based method	
- Eigen-face	Eigenvector decomposition and clustering [6, 42]
- Distribution-based	Gaussian distribution and multi-layer perceptron schemes [43]
- Neural Network	Ensemble of neural networks and arbitration schemes [3, 44]
- Support Vector Machine (SVM)	SVM with polynomial kernel [5, 45]
- Naïve Bayes Classifier	Joint statistics of local appearance and position [46]
- Hidden Markov Model (HMM)	Higher order statistics with HMM [47]
- Information-Theoretical Approach	Kullback relative information [48, 49]

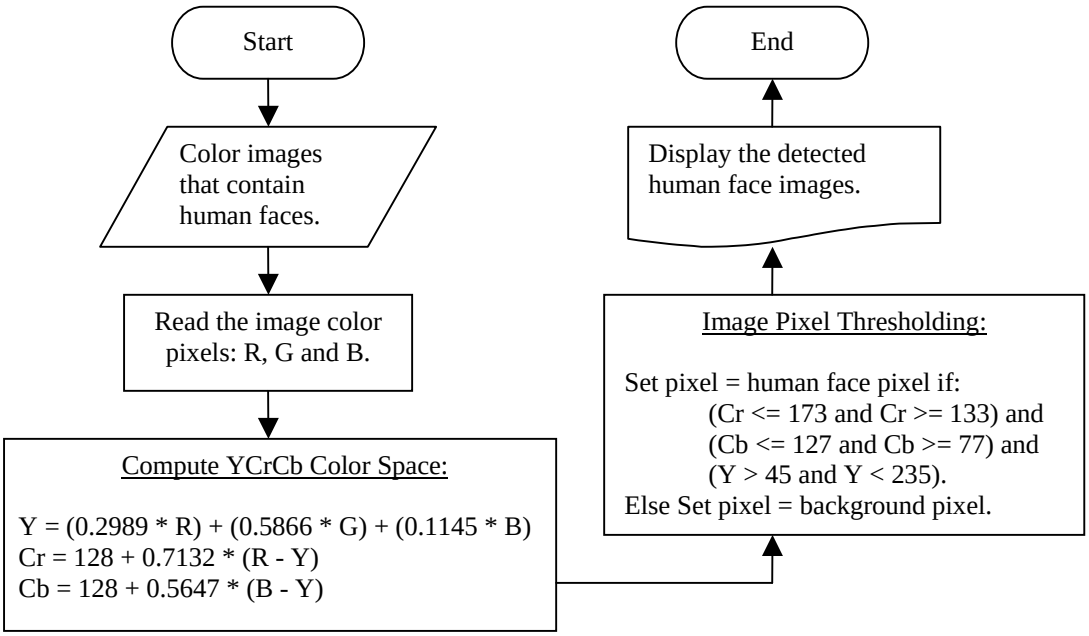

Figure 2.1: Framework of Human Face Detection.

2.1 Human Face Detection Algorithm

This section explains the implementation of the human face detection using YCrCb color space:

1. Read a given color image's pixel value (R,G and B) that contains human face from left to right and from top to bottom.

2. According to [50], for each set of pixels (R, G and B) read, compute the YCrCb color space value corresponding with them by using formula (2.1).

$$
\begin{aligned}
Y &= (0.2989 * R) + (0.5866 * G) + (0.1145 * B) \\
Cr &= 128 + 0.7132 * (R - Y) \\
Cb &= 128 + 0.5647 * (B - Y)
\end{aligned}
\qquad (2.1)
$$

3. Perform image pixels thresholding with a pre-determine threshold value [15, 30] for Y, Cr and Cb respectively.

$$
\begin{aligned}
&\text{Set pixel = human face pixel if:} \\
&\quad (Cr <= 173 \text{ and } Cr >= 133) \text{ and} \\
&\quad (Cb <= 127 \text{ and } Cb >= 77) \text{ and} \\
&\quad (Y > 45 \text{ and } Y < 235). \\
&\text{Otherwise Set pixel = background pixel.}
\end{aligned}
\qquad (2.2)
$$

4. Display the detected human face images for result observations.

3.0 EXPERIMENTAL RESULTS

In this section, we have conducted several experiments on color images that consist of human face. Their dimension is fixed at 1920 x 480 pixels.

Figure 3.1(a) and Figure 3.2 (a) are the sample color images. Figure 3.1(b) and Figure 3.2 (b) illustrate the human face detection results obtained from these color images where only CrCb color space is utilized. The results derived where YCrCb color space is used to localize human face are shown in Figure 3.1 (c) and Figure 3.2 (c) respectively.

Figure 3.1(a) – Input color image.

Figure 3.2(a) – Input color image.

Figure 3.1(b) – Detected human face using only CrCb color space.

Figure 3.2(b) – Detected human face using only CrCb color space.

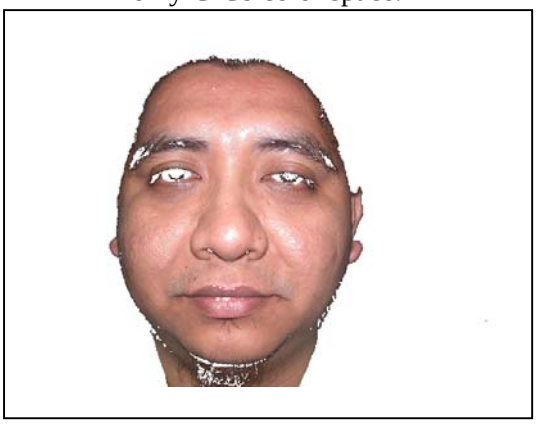

Figure 3.1(c) – Detected human face using YCrCb color space.

Figure 3.2(c) – Detected human face using YCrCb color space.

4.0 CONCLUSION

From Figure 3.1 (b) and Figure 3.2 (b), it can be concluded that noise occur (where pixels possess similarity color space with human face color space are classified as face pixels) when only CrCb color space is applied. However, with the use of luminance component, Y, the face detection scheme is improved (Figure 3.1c and Figure 3.2c) where most of the detected pixels are belonging to the face color space. In order to better classify the facial area, a comprehensive technique should be introduced.

5.0 RECOMMENDATION OF FUTURE WORKS

From the output results produced in Section 3.0, our face detection system still have several aspects that can be improved; these include:

- Utilization of artificial intelligence for the sake of enhancement in face segmentation accuracy.
- A mechanism should be introduced to generalize an appropriate parameters range (Y, Cr and Cb) to be used when deal with different circumstances (for example: the different between the skin fairness of Asian and African).

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