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Real Time Face Detection and Segmentation

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Abstract

Face detection is a computer technology used in a diversity of applications that identifies human faces in digital images. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. Face detection can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class. Face-detection algorithms focus on the detection of frontal human faces. It is analogous to image detection in which the image of a person is matched bit by bit. Image matches with the image stores in database. Any facial feature changes in the database will invalidate the matching process. There are many algorithms busied for this topic each of which has its own characteristics and level of accuracy. In this paper, some of those algorithms will be discussed in addition to Viola-Jones Algorithm after getting in to the details of Face Detection's notion and applications.

Keywords: Face detection, Segmentation, Application, Matching, Viola Jones Algorithm.

INTRODUCTION

One of the fundamental techniques that enable natural human-computer interaction (HCI) is face detection [1]. Face detection is the step stone to all facial analysis algorithms, including face position, face forming, face relighting, face recognition, face verification/authentication, head pose tracking, facial expression tracking/recognition, gender/age recognition, and many more [2,3]. Only when computers can comprehend face well will they begin to truly comprehend people's thoughts and intentions. Given an arbitrary image, the goal of face detection is to determine whether or not there are any faces in the image and, if present, return the image location and extent of each face [4].

While this seems as a trivial task for human beings, it is a very interesting task for computers, and has been one of the top studied research themes in the past few decades. The difficulty associated with face detection can be attributed to many differences in scale, location, orientation (in-plane rotation), pose (out-of-plane rotation), facial expression, lighting conditions, occlusions, etc, as seen in figure 1.

Figure 1. Examples of face images.

APPLICATIONS ON FACE DETECTION

Face detection has various implementations in different fields. It serves a great number of applications that uses this concept as its basic element. Some of these applications are:

Face recognition

A facial recognition system is a technology capable of identifying or verifying a person from a digital image or a video frame from a video source. There are many methods in which facial recognition systems work, but in general, they work by comparing selected facial features from given image with faces within a database. The first step to be done is to detect the face in the image [5]. Then using some techniques of artificial intelligence the person's face could be identified.

It is usually used in security systems and can be compared to other biometrics such as fingerprint or eye iris recognition systems. Recently, it has also become popular as a commercial identification and marketing tool [4].

Facial motion capture

Facial motion capture is the process of electronically converting the movements of a person's face into a digital database using cameras or laser scanners. This database may then be used to produce CG (computer graphics) computer animation for movies, games, or real-time avatars. Because the motion of CG characters is derived from the movements of real people, it results in more realistic and nuanced computer character animation than if the animation were created manually [4].

Photography

Some current digital cameras use face detection for autofocus. Face detection is also useful for selecting regions of interest in photo slideshows that use a pan-and-scale Ken Burns effect. Modern appliances also use smile detection to take a photograph at an appropriate time.

Marketing

Face detection is gaining the interest of marketers. A webcam can be integrated into a television and detect any face that walks by. The system then determines the race, gender, and age range of the face. Once the information is collected, a series of announcements can be played that is specific toward the detected race/gender/age. [5]

ALGORITHMS FOR FACE DETECTION

There are several techniques to detect a face in an image. They are the following: Knowledge based, Feature invariant based, Template matching method, Appearance-based methods, Part-based methods, etc.

Knowledge-based methods

These rule-based methods encode human knowledge of what constitutes a typical face. Usually, the rules capture the relations between facial features [6]. These methods are designed mainly for face localization, which aims to determine the image position of a single face.

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. To distinguish from the knowledge-based methods, the feature invariant approaches start at feature extraction process and face candidates finding, and later verify each candidate by spatial relations among these features, while the knowledge-based methods usually exploit information of the whole image and are sensitive to complicated backgrounds and other factors. Readers could find more works in. Face detection based on color information, random labeled graph matching fall in this category [6].

Template matching methods

In this category, several standard patterns of a face are stored to describe the face as a whole or the facial feature separately. The correlations between an input image and the stored pattern are computed for detection . These methods have been used for both face localization and detection. Deformable template matching falls in this category, where the template of faces is deformable according to some defined rules and constraints.

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 [6]. More significant techniques are included in. Examples of such type of methods are view-based face detection, Haar features and the Adaboost algorithm.

Part-based methods

With the development of the graphical model framework and the point of interest detection such as the difference of Gaussian detector (used in the SIFT detector) and the Hessian affine detector, the part-based method recently attracts more attention [6]. Some well-known approaches like face detection based on the generative model framework, component-based face detection based on the SVM classifier falls into this category.

VIOLA-JONES ALGORITHM

A face detector has to tell whether an image of arbitrary size contains a human face and if so, where it is. One natural framework for considering this problem is that of binary classification, in which a classifier is made to minimize the misclassification risk. Since no objective distribution can define the actual prior probability for a given image to have a face, the algorithm must decrease both the false negative and false positive rates in order to complete an acceptable performance. This task needs an accurate numerical description of what sets human faces apart from other objects. It turns out that these features can be extracted with a significant team learning algorithm called Adaboost, which relies on a team of weak classifiers to form a strong one through a voting mechanism. A classifier is weak if, in general, it cannot meet a predefined classification target in error terms. An operational algorithm must also work with a realistic computational budget. Techniques such as integral image and attentional cascade make the Viola-Jones algorithm [8] highly efficient: fed with a real time image sequence generated from a standard webcam, it performs well on a standard PC [7].

Steps of this algorithm:

Features and Integral Image

The Viola-Jones algorithm uses Haar-like features, that is, a scalar product between the image and some Haar-like templates. To compensate the effect of different lighting circumstances, all the images should be mean and variance normalized beforehand [9]. Those images with difference lower than one, having little information of interest in the first place, are left out of consideration.

Feature Selection with Adaboost

How to make sense of these features extracted in the first step is the focus of Adaboost. For face detection, it assumes the form of $f : Rd \rightarrow \{-1,1\}$, where 1 means that there is a face and -1 the contrary and d is the number of Haar-like features extracted from an image [9].

Attentional Cascade

In theory, Adaboost can produce a single committee of decision stumps that generalizes well. However, to achieve that, an huge negative training set is needed at the outset to gather all possible negative patterns. In addition, a single committee implies that all the windows inside an image have to go through the same lengthy decision process. There has to be another more cost-efficient way. The prior probability for a face to appear in an image bears little relevance to the presented classifier construction because it requires both the empirical false negative and false positive rate to approach zero. However, our own experience tells us that in an image, a rather limited number of sub-windows deserve more attention than others. This is true even for face-intensive group photos. Hence the idea of a multi-layer attentional cascade which embodies a principle akin to that of Shannon coding: the algorithm should deploy more resources to work on those windows more likely to contain a face while spending as little effort as possible on the rest [9].

Dataset and Experiments

The training process lasted for around 24 hours before producing a 31-layer cascade. It took this long because it became harder to get 2000 false positives (1000 for training and 1000 for validation) using Algorithm 9 with a more discriminative cascade: the algorithm needed to examine more images before it could come across enough good examples [9].

Figure 2. Flow Chart of Viola-Jones Algorithms.

VIOLA-JONES ALGORITHM IN MATLAB

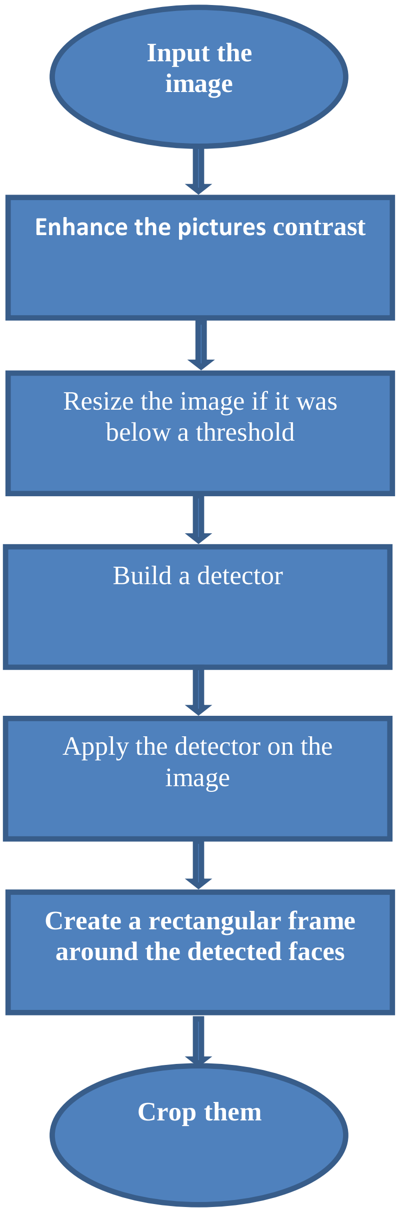

Figure 3. Flow Chart of Viola-Jones Algorithm Each step has a predefined function that is to be called.

RESULTS OF OUR EXPERIMENTAL

We tried a group of 150 images on two methods. One of the methods is optimized according to the chart above; the other doesn't use image enhancement or resizing.

The results are given in the table below:

TABLE 1. THE FACE DETECTION ERROR RATE FOR EACH IMAGE IN BOTH METHODS

Image	Old method	Our method
Im1	No error	No error
Im2	1/19	No error
Im3	4/21	1/21
Im4	2/7	No error
Im5	6/15	3/15
Im6	3/8	1/8
Im7	6/57	1/57
Im8	1/5	1/5
Im9	No error	No error
Im10	2/4	2/4
Im11	3/14	1/14
Im12	2/6	No error
Im13	No error	No error
Im14	8/10	4/10
Im15	No error	No error

Below also you can see the difference between two images under the deployment of both methods.

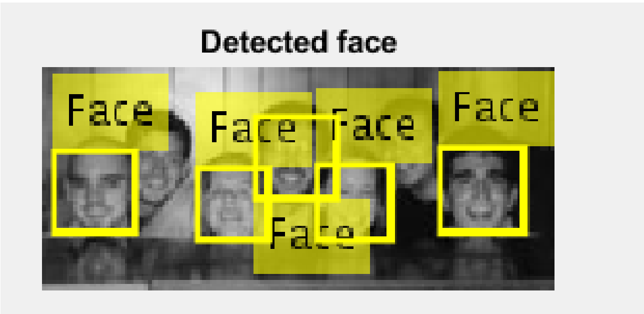

Figure 4. Image with 5 detected faces according to old method.

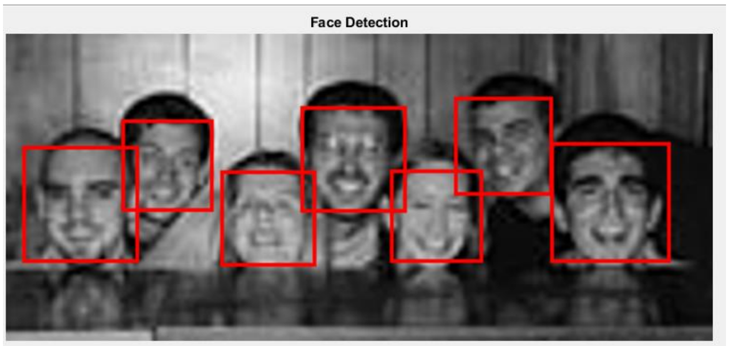

Figure 5. Image with 7 detected faces according to our method.

Figure 6. Image with 9 detected faces according to old method.

Figure 7. Image with 12 detected faces according to our method.

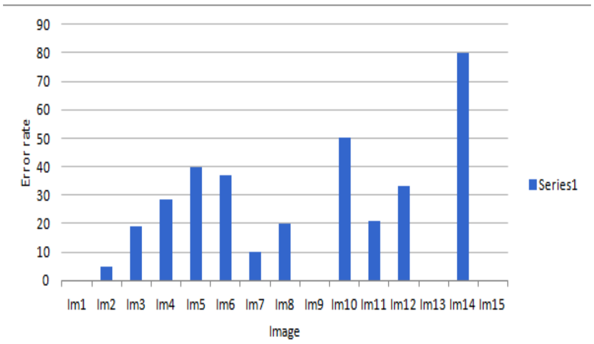

Figure 8. Old method results.

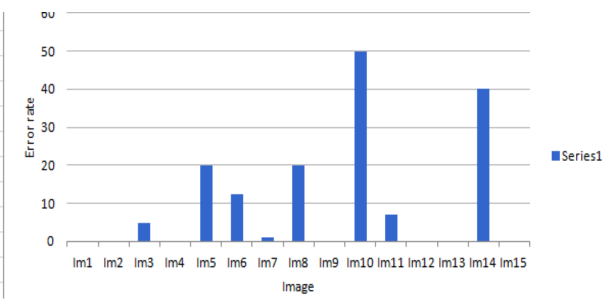

Figure 9. Our method results

CONCLUSION

Face detection is a very important basic step for different applications. It is the localization of human faces in a digital image using different algorithms a deliberated in this paper. Viola-Jones algorithm has figured out a fast way to make this detection in an easy manner.

This can be used in several applications like detecting the number of people in conferences or political strikes. Or figuring out those who are responsible for the chaos in a specific protest.

Using our method mentioned, we can see how much the error rate has decreased. Notice that we can reach a low error rate but never could we avoid it completely.

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