Facial features detection using Eyes-Nose template

Emad Nikkhouy† and Eimad Eldin Abdu Abusham††

Faculty of Information Science and Technology, Multimedia University
Jalan Ayer Keroh Lama,
75450 Bukit Beruang,
Melaka, Malaysia.

Summary
The researches on human face detection are playing an important role in the world of biometrics and several studies have been going on over the last decades. Face detection for human is very easy concept and with a glance, human can differentiate faces and non-faces, nevertheless face detection is very challenging when it comes to computers and digital world. The reason is faces have wide range of variability in size, texture, color and structure. There are numerous researches have been done in the field of face detection and some of them have been analyzed for functioning under dissimilar conditions such as facial expression, occlusion, illumination and head rotation. In this paper, a new proposed method has been implemented, the method use an unique template of eyes and nose for detection which makes our system fast, simple and suitable for real time face detection. The experiments conducted indicate that the proposed technique has inspiring performance compared to benchmark methods.

Keywords:
Image processing, correlation coefficient, viola-jones, template matching.

1. INTRODUCTION

Face detection systems are playing big role in our current life for the purpose of security and identification. Detecting faces in digital photos is the essential task for surveillance systems [1]. From media or news we always hear about computer crimes like credit card fraud, security breaches in government or in company, computer breaks by hackers and all these problems arise from fundamental weakness in conventional access control systems, which the systems do not give us permission to access by who we really are, but by what we have in our hand, such as passwords, ID cards, keys or PIN numbers; none of these really describe us but they are just give us authentication. Lately after improvement in technology and science, systems can authenticate us with individual identity. This technology is called Biometrics which analyze and measure human body characteristics, such as fingerprints, face recognition, DNA (Deoxyribonucleic acid), voice recognition and eye retinas. Among the different biometric methods, the physiological methods such as DNA, face detection and fingerprint are more stable and reliable than behavioral category like voiceprint. Face detection is one of few methods among others that have great accuracy and low invasiveness, for this reason face detection has attracted researchers' attraction in fields of security and image processing to computer vision.

The changes of brightness and posture are the main problem that we confront in face detection, and in addition glasses, beards and mustaches bring their own challenges [2]. Awareness about the information in the face is considered as face detection difficulty. There are many ways to extract this information and basically it can be classified into two main categories, the first one is view-based or image based which works on the image directly and the goal is to exploit noticeable and compact descriptions of faces of person whereas ignoring the other unneeded information; the second one is feature-based which attempt to exploit features of the image and match or compare it in contradiction of information of the face features [2].

There are many methods have been suggested to detect faces in a photo, but basically face detection methods can be categorized into four:

1.Template matching methods: in this method some patterns or templates are used, which these templates can be the whole face or they can be part of face like nose, eyes, lips, or mixture of them. Thus, these templates scanned through the image to check how much that template match with the facial features. The method that is used for checking the likelihood of match between template and the photo is correlation; so if the correlation between the template and the photo is above certain threshold then that feature of the face will be detected. Template matching is one the simplest and fastest methods to detect the face, so due to the simplicity and fast computation time it can be used for real time.

Approaches:
- *Predefined face templates:* Shape template [3]
- *Deformable Templates:* Active Shape Model (ASM) [4]

2. Feature invariant methods: these methods trying to position structural feature that exist even when the lightening or brightness condition, viewpoint, or posture change, and then apply these to locate faces.

Approaches:
- *Skin Color:* Mixture of Gaussian [5][6]
- *Texture:* Space Gray-Level Dependence matrix (SGLD) of face pattern [7]
- *Facial Features:* Grouping of edges [8][9]

- *Multiple Features:* Integrated of skin color, size and shape [10]

3. Knowledge-based approaches: in this method it encode human familiarity of what creates a typical face. Basically this method finds the relationship between facial features [11].

Approach:
- Multi resolution rule-based method [12]

4. Appearance-based methods: appearance-based is in substance a model-based algorithm and the model learned from many different images, so this method does not required to make models for faces [13].

Approach:
- *Eigenface:* Eigenvector decomposition and clustering [14]

2. BACKGROUND

As we mentioned earlier during the last decades many face detection algorithms have been developed, but amongst these algorithms three are famous due to performance figures. In this section concisely we introduce them.

Neural Network-Based Face Detection:
This algorithm firstly approximate the direction of any potential faces in the image, after that the image is rotated to upright direction and then processes it to improve the contrast and decreasing its variability, after that the image is consumed to a full profile, half profile, or frontal profile face detection network. The training of these networks needs samples of faces and none faces [15][16].

Robust Real-Time Objection Detection:
The fundamental idea of Viola-Jones algorithm is to scan sub-image capable of detecting or finding faces within the input image. One of the standard procedures is to rescale the image, and reduce its size, for example if the photo size is too large we need to reduce the size based on the sub-image size. This approach will help to reduce the time of calculation and help the algorithm to work more accurately.

Statistical Method for 3D Object Detection Applied to faces and Cars:
In this method both object-appearance and non-object statistics are calculated by using product of histograms. After that all histograms signify the combined statistics of a subclass of wavelet coefficients and their location on the object. This approach uses as many such histograms denoting a extensive variability of visual attributes [18].

In this section we are going to elaborate more on template matching and its approaches. As we mentioned earlier template matching is one of simplest regarding the algorithm and fastest regarding of calculation so these features make it suitable for real-time face detections like camera face detection or surveillance in public or private places for security purposes. As discussed earlier there are two approaches for template matching the first one is predefined face templates and the second one is deformable templates. In predefined face templates some templates for individual, whole or both portions of a face are stored and then base on these templates the correlation between the templates and the image will be calculated. In deformable templates flexible facial feature model is fitted in as a reference model where these templates are kind of the object of interest [19].

For better understanding of these two approaches we are going to demonstrate them in below figures. Figure one displays Predefined Face Templates:

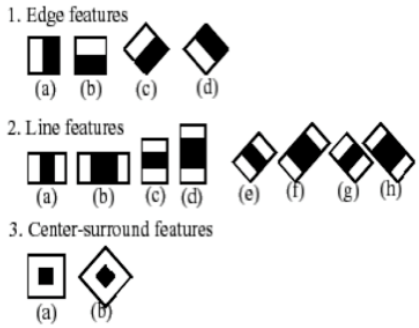

Figure 1 - Predefined Templates

As it is displayed in the above figure each of these templates are capable of detecting specific feature on the face for example feature 1-b is capable of detecting eyebrows because forehead has lighter color than eyebrows so it is suitable match for eyebrows, as displayed in figure two.

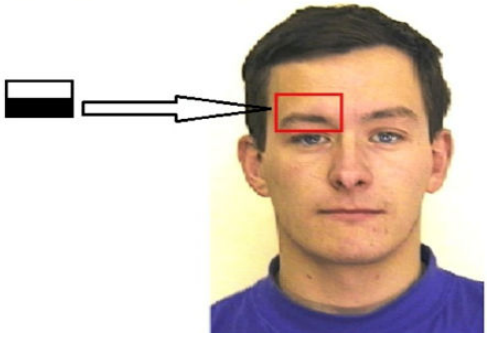

Figure 2 - Possible match for template 1-b

Figure three demonstrate two different Deformable Templates:

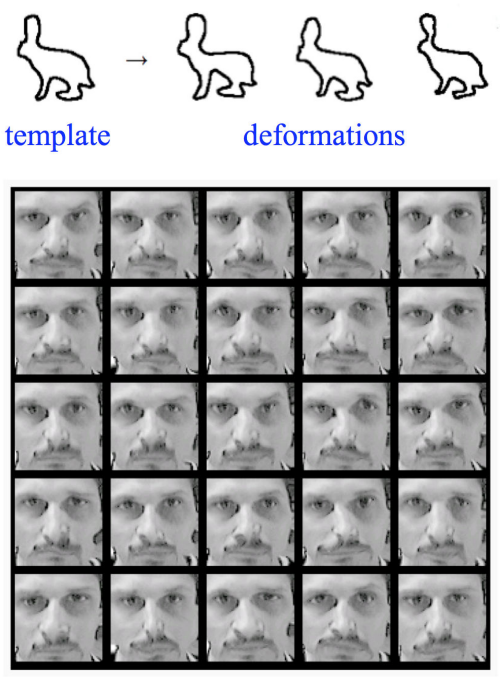

Figure 3 - Example of Deformable Template [20]

Figure four shows how deformable templates are working:

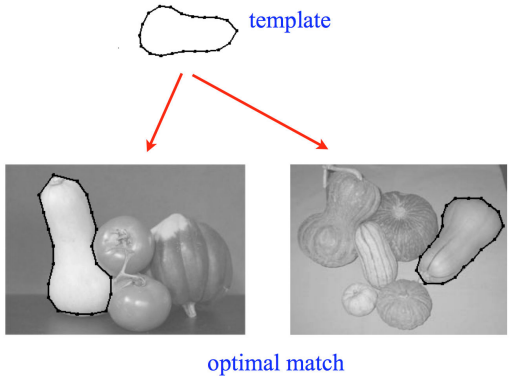

Figure 4 - Detecting an object with Deformable Template [20]

3. EYES AND NOSE TEMPLATE MATCHING

As we mentioned earlier in the background section we defined two different approaches for Template matching. The first one that was predefined templates is our interest because we are using this approach to detect the face in this paper. Before we discuss about the approach we used in this project we need to consider correlation, because correlation is one of the early steps for face detection in template matching.

Correlation: correlation is the computation between two images to determine how much is the percentage that the first image matches with second image. In correlation both images should have same size, or if they are not having same size as the situation that we face in template matching; template's size are usually smaller than the image that we want to find face in it, so the solution is to cut the image with the same size of template and then find their correlation, after this we need to continue cutting the image and find the correlation between that portion of photo and the template until we cover the whole image. Basically we are scanning the template through the image and finding all the correlations. So after all the correlations have been computed then the maximum correlation is our point of interest that shows the maximum match between the template and the image.
Below formula shows the calculation between two image of A and B which are having the same size:

$$result = \frac{\sum_m \sum_n (A_{mn} - \bar{A})(B_{mn} - \bar{B})}{\left[\sum_m \sum_n (A_{mn} - A^2)\right]\left[\sum_m \sum_n (B_{mn} - \bar{B}^2)\right]}$$

[2]

One of the most important things in template matching is the size of the image; if the size of image is too big then it requires more calculation time. Thus one of the basic things that should be done before any calculation is resizing. Resizing is playing an important role for time saving in face detection algorithms; different approaches use different resizing, in this project we resize the image to 0.04, so for instance if there is image size 480x640 then the resized image will be 20x26.

After resizing another important section in template matching is the template. Templates are the most important segment in template matching. The templates that we use in our system are different with Viola-Jones algorithm. The template that has been used in our system is detecting eyes and nose at the same time, which can save a lot of time. Other algorithms usually detecting eyes and nose separately which increase the number templates and as a result the calculation time will increase. Because eyes and nose are close to each other so it is better to detect all of them in one time to increase the speed of the algorithm. With the resizing scale which mentioned above and new technique which is used for template, made our program very fast compare to many algorithms which we are going to show the result later in the result section.

In this system we used 5 different templates, we believe that the main explanation for the better performance of the proposed system, is that if the number of templates increase the detection rate also increase but the speed will decrease due to more calculation. Figure five shows an example of our proposed template:

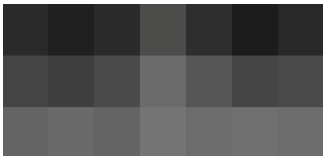

Figure 5 - Proposed Template

Figure six shows an example of detected face with our proposed method:

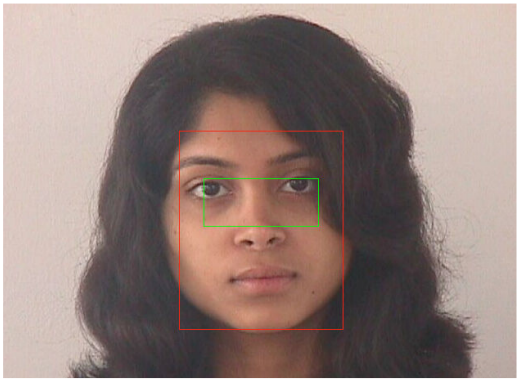

Figure 6 - Detected face

In this section we are going to discuss about advantages of our system:

1. Simple: the system that we developed is very simple compare to Viola-Jones algorithm, because in Viola-Jones method there are so many operations like neural network, cascading and integral image, which make it complicated and slow.

2. Fast: due to resizing scale and the template that we used which is mixture of eyes and nose together this system is fast.

3. Adoption: different countries can easily adopt this system and they can have their own set of templates.

4. Ease of use: the system that we developed is easy to use in any operating system platforms (64 or 32bit) like Macintosh, Linux or windows.

4. RESULT

For evaluation purpose, 50 images from Indian database [21] were processed and we are going to show 20 of them. Results are in seconds, which has been shown in table 1. As it can be seen from the table one, the developed system is fast enough to compare with the chosen system.

In order to evaluate the overall performance of the system, the developed system was compared against OpenCV 2.1 (P. Viola and M. Jones, 2001) and SMQT and snow classifier (M. Nilsson and J. Nordberg and I. Claesson, 2007) [22].

The evaluation was done using Apple iMac, Intel quad Core i5 (2.7 GHz), 8GB RAM, but on virtual windows XP with allocated 3 GB RAM and 2 cores of the processor.

Image	OpenCV	Developed System	SMQT
1	0.4622	0.1492	5.8290
2	0.3512	0.1531	5.4276
3	0.5029	0.1556	6.1289
4	0.3975	0.1557	6.2623
5	0.4661	0.1539	6.0402
6	0.6140	0.1579	6.1994
7	0.4499	0.1552	7.0586
8	0.5039	0.1555	7.0618
9	0.4376	0.1545	6.8988
10	0.4465	0.1547	7.0020
11	0.4216	0.1525	6.2139
12	0.5037	0.1536	6.3572
13	0.4625	0.1515	6.2238
14	0.5014	0.1520	6.0092
15	0.4075	0.1641	6.1020
16	0.3697	0.1551	6.0267
17	0.3547	0.1556	6.0957
18	0.3176	0.1533	5.9263
19	0.3693	0.1519	5.6857
20	0.4896	0.1555	5.9248
Total:	8.8294	3.0904	124.4739
Average:	0.4415	0.1545	6.2237

Table 1 - Performance Comparison (in Second)

The comparison of detection rate between developed system and OpenCV is shown in table 2:

OpenCV	90%
Developed System	92%
SMQT	100%

Table 2 - Detection Rate Comparison

As you can see in table 2, detection rate for SMQT algorithm is very high compare to OpenCV and our developed system but it is not suitable for real-time face detection due to slow computation.

5. CONCLUSION

This paper presents a competent method for face detection based on eyes and nose template matching. The advantage of our method over other existing methods is the fast computation, ease of use in any operating system platforms, which can make it easily to be applied in real-time systems. In future this system can be expanded to multi-view face detection.

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