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Fast and Illumination Invariant Face Tracker Algorithm for Complex Video Environments

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Abstract— Video surveillance applications present a problem for the designer of computer vision algorithms. In most cases lighting condition is poor due to the environment and the distance of cameras affect the accuracy of detection. In this paper we develop first an algorithm that detects faces from a video file with a poor illumination, and then an efficient tracker is used to follow the continuity of the faces. Some image pre-processing algorithms are applied like (histogram equalization and manual-dynamic thresholding) to reduce the false faces rate. Hybrid face detector is applied (for both frontal and pose orientation faces) using haar-cascades frontal face and profile face classifiers. The proposed system will be tested on a complex video environment (fast objects in movement) to evaluate the performance in terms of accuracy detection and the efficiency. Test results show that the detection rate accuracy of the faces in the video with the complex environment is very high and reach about 99.05%.

Keywords— Face Detector; Face Tracker; Frontal Classifier; Profile Classifier; Complex Video Enviroment

I. INTRODUCTION

Detection and recognition of faces in the video is one of the most important applications for the video surveillance system. Face detection for the live from camera or video sequences has become a big challenge and replace the traditional still image [1]. In [2] hybrid face detection and tracking method based on dynamic template matching is proposed. The detection is first applied on each frame and then the tracker is performed on the detected faces in next frames.

Detection and tracking of faces in live or offline video actually started as an independent topic because of the requirement of face recognition as a preprocessing step. Christian and Andreas present an illumination invariant method to face detection combined with a tracking mechanism that can be used for improving speed and accuracy of the system. They introduce illumination invariant local structure features for object detection. For an efficient computation a modified census transform is proposed [3]. Viraktamath et al present an application for automatic face detection and tracking on video streams from surveillance cameras in public or commercial places. Prototype is designed to work with web cameras for the face detection and tracking system based on open source platform OpenCV. The system is based on AdaBoost algorithm and abstracts faces Haar-Like features. This system can be used for security purpose to record the visitor face as well as to detect and track the face [4].

Hiremath et al propose a novel algorithm which segments the face region in video images using fuzzy geometric face model in key frame. The mean shift is used to track the face along the video sequence. Contrary to current techniques that are based on huge learning databases and complex algorithms to get generic face models, the proposed method handles simple face detection and tracking approach. The proposed method is implemented and evaluated with numerous experiments on videos containing large variations of head motion, light condition, and expressions [5].

Generally, there are three main processes for face detection based on video. At first, it begins with frame based detection. During this process, lots of traditional methods for still images can be introduced such as statistical modeling method [6], neural network - based method [7], BOOST method [8], color-based face detection [9], etc. However, ignoring the temporal information provided by the video sequence is the main drawback of this approach. Secondly, integrating detection and tracking, is detecting face in the first frame and then tracking it through the whole sequence. Since detection and tracking are independent and information from one source is just in use at one time, loss of information is unavoidable.

Finally, instead of detecting each frame, temporal approach exploits temporal relationships between the frames to detect multiple human faces in a video sequence. In general, such method consists of two phases, namely detection and prediction by update – tracking [10].

The proposed system is aimed to develop and implement a fast and illumination invariant face tracker algorithm for complex video environments. The objects in movement (faces) in the video sequences must be detected and tracked with minimum false alarms. This minimization leads to improve the face detection rate. In order to detect not only the frontal but different pose orientation of the faces, hybrid face classifiers based on Haar-cascade (frontal and profile) are used. Fig. (1) illustrates the general diagram of the proposed face detection and tracking methods applied on the complex video scenarios (fast face movements).

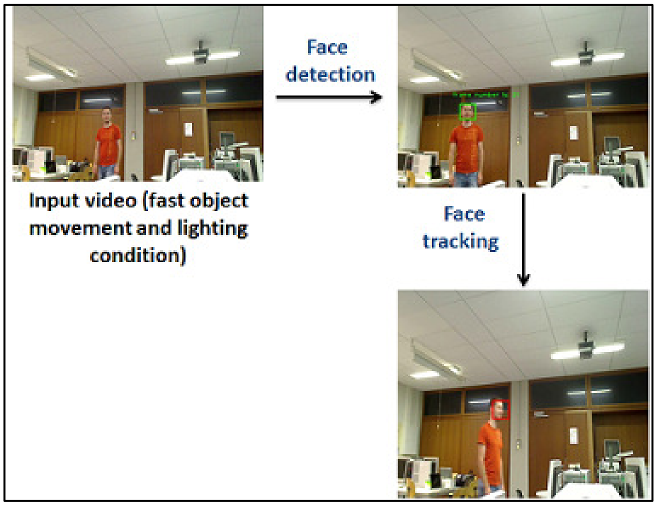

Fig. (1) General diagram of the system

The rest of the paper is organized as follows. Section II presents the proposed face detection and tracking schemes in detail. In Section III different types of false alarm are described and some algorithm steps are applied to minimize the false faces and increase the accuracy of detection rate. Section IV shows the experiment test results and some discussions are presented. Conclusions are summarized in section V.

II. PROPOSED SCHEME STEPS

A. Face Detection

The simplest face detector which is based on still images is adapted and used for video scenarios. It first detect the frontal faces using frontal classifier developed by Viola – Jones and followed by a profile classifier which take into account all the faces with different pose orientations. The implementation is based on the OpenCV library for only face detection step. The description of the face detector algorithm steps is as follow:

- Load video file or capture the live video stream from the camera or webcam
- Setup and configure the parameters of the detector
- Run the detector
- Identification of the face (positive and negative)
- Classify the results (face and non-face)

In Fig. (2) the algorithm steps of the proposed face detection is shown.

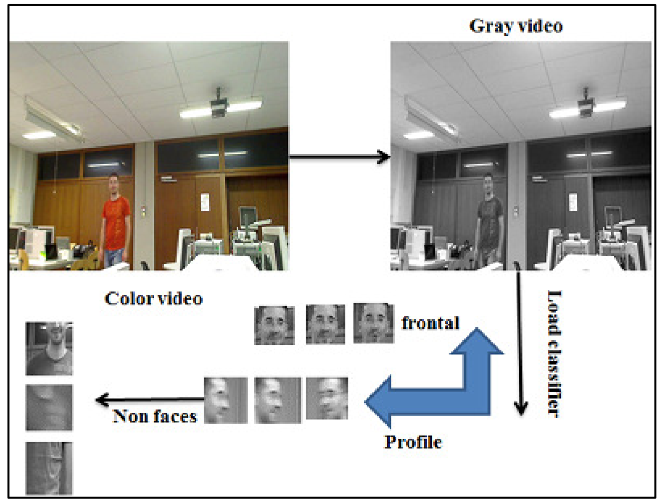

Fig. (2) Face detection for both frontal and non-frontal faces

B. Face Tracking

The tracker can be initialized based on the detected face that is getting from the current frame. Because of the small change of the position of faces between two consecutive frames, the template position of the face is firstly found from the current frame and a region of interest is performed to the next frame in order to reduce the search area. The ROI is selected according to the properties of the face template (top left location, width, height). The size of the ROI is chosen to be twice than the size of the face template in condition that the ROI window does not exceed the frame size. The ROI size depends on the size of the template in the current frame (i.e., growth and shrink dynamically).

Face tracking process is followed by the face detector so that the objects (face) in the next frames are simply founded to avoid any miss detection. Each tracked face template can be considered as a reference for initializing the tracker itself in the next frames in case the detector is failed to detect (false negative alarm).

In Fig. (3) the face tracking process between two successive frames is depicted.

C. Hybrid Face Detection System

As the video scenario used in this paper is very complex (i.e., fast faces in movement) with special light condition (illumination invariant), a hybrid classifier is needed to detect both frontal non-frontal faces. Fig. (4) presents the hybrid face detection system.

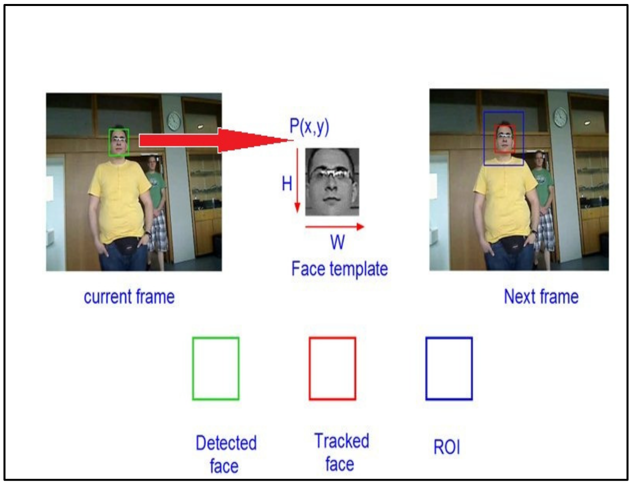

Fig. (3) Face tracking stage

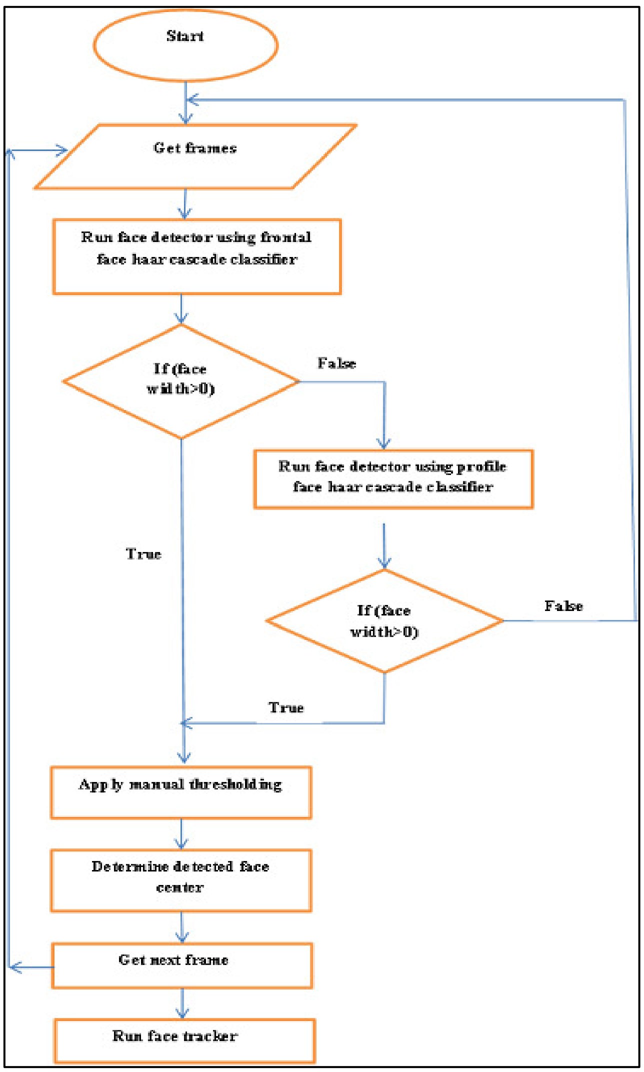

Fig. (4) Proposed hybrid face detector

III. False Alarms Minimization

In face detection based still images a false positive is a number of detected objects that are not faces while in the sense of video are a number of detected faces that are representing the face of another person. The scenarios which are used to run the face detector and tracker aim to track a nearest person who is walking toward the webcam. This situation leads to have both types of false positive alarms. Therefore the main objective of using tracking is to reduce the false positive alarms to get a high detection rate. some algorithms are applied to the proposed face detector to reduce false alarm types and increase the accuracy of detection rate.

A. Manual Thresholding Technique

As the Viloa-Jonse failed to reduce the all the false types in the video and before running the tracker a simple thresholding algorithm is applied to reduce the positive false alarm (not faces) during the face detection process. In this case with the video test scenario the number of false positive is reduced from 44 to 18.

B. Dynamic Thresholding Technique

In the manual thresholding process some false positive alarms are not totally reduced. To solve these types of alarms, a dynamic threshold algorithm is developed and implemented to apply with a face tracker. This lead to decrease the positive false alarm form 18 to 6.

The algorithm steps are described below:

Step 1: Get frame.
Step 2: Run face detector.
Step 3: Apply manual thresholding as mentioned above
Step 4: Determine the center of the detected face.
Step 5: Get next frame.
Step 6: Run face tracker.
Step 7: Determine the center of the tracked face.
Step 8: Determine Euclidian distance between the centers of the detected and tracked faces.

C. Template Matching

There is still a problem of having undetected face between frames due to the fast movement of the face objects, the effect of the illumination and the distance from the camera. A new contribution is added to reduce such type of false (negative false alarm). The template matching algorithm based on the square difference is implemented with the tracker. This leads to reduce the number of false negative from 91 to 2.

The final result after applying the above algorithms on the video scenario used in this work improve the detection rate compared with the traditional Viola-Jones face detector and increased from 86.89 % to 99.05%.

IV. TEST RESULTS AND DISCUSSIONS

In table (1) the properties of the video scenarios (1 and 2) are described.

Video No.	Video Description
Scenario 1	Length=00:01:05, Size=4.71 MB, Frame width=640, Frame height =480, Frame Rate=15 Frame/ Second, Type: DivX Video, System color: RGB. Frame No. 1000
Scenario 2	Length=00:00:35, Size=3.87 MB, Frame width=640, Frame height =360, Frame Rate=30 Frame/ Second, Type: DivX Video, System color: RGB. Frame No. 847

Table (1) Video scenarios description

This test is based on the work proposed in [2] for the reason of comparison. They succeeded for a simple scenario which is using frontal face in front of the camera and the distance between the face and the camera is relatively small (scenario 1). But when the video scenario used in this work is tested, they failed to detect the faces correctly.

In table (2) the test results obtaining from [2] is shown when applied on video scenario 2 with 847 frames.

Methods	Detected as faces	TP	FP	FN	DR %
Viola -Jones	712	673	39	135	79.45
Manual Thresholding	691	673	18	156	79.45
Template Matching	845	824	21	2	97.28
Dynamic Thresholding	845	834	11	2	98.46

Table (2) Detection rate with method in [2]

The detection rate accuracy is calculated as in equation (1).

$$DR = \frac{TP}{TP + FP + FN} \% \quad (1)$$

Test results in table (2) show that the proposed face detection system in [2] cannot reduce the false positive rate (other objects detected as face).

The same test is performed when the proposed face detector and tracker is applied as shown in Table (3).

Methods	Detected as faces	TP	FP	FN	DR %
Viola -Jones	780	736	44	67	86.89
Manual Thresholding	756	738	18	91	87.13
Template Matching	845	824	21	2	97.28
Dynamic Thresholding	845	839	6	2	99.05

Table (3) Detection rate with proposed method

V. CONCLUSIONS

The proposed method can effectively reduce and minimize the false type alarms (positive and negative) which exist continuously in the video frames in scenario 2. Based on the test results presented in section IV, some conclusions related to the accuracy of proposed hybrid method have been investigated:

1. Test results of Viola-Jones video based detection with optimal parameters showed maximum number of false alarms.
2. The Viola-Jones detector improved in terms of detection rate and time using proposed method.
a. DR = 86.89% improved to DR= 99.05%.
b. FP = 44 reduced to 6
c. FN = 67 reduced to 2
3. Reduction of false positive and negative alarms.
4. Hybrid method can be considered as an efficient detector for non-frontal faces.
5. An improvement of the best scenario that consider illumination, fast object movement and pose invariant (Scenario 2) is yield.

ACKNOWLEDGMENT *(HEADING 5)*

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