# Lie Detection Using Image Processing

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***Abstract*— Eye Blink Pattern can be used for the identification of various human behaviors. This paper proposes a method for lie detection and detecting the truth of an alibi through image processing techniques. The lie detection mechanism is based upon the experimentally proven hypothesis derived from eye blink literature that liars experience more cognitive demand than truth tellers. Thus, their lies are associated with a significant decrease in eye blinks, directly followed by an increase in eye blinks when the cognitive demand ceases, after the lie has been told. Blink detection is done with the help of MATLAB using the HAAR Cascade algorithm. The decision regarding the open or closed state of the eyes is made by implementing skin detection algorithm on the histogram back projections of the detected eye images.**

***Keywords---Skin Detection, Eye Detection, Blink detection, Blink rate, MATLAB, Lie detection, Target period or Lie detection period, Threshold blink rate,HAAR Cascade.***

## *I.* INTRODUCTION

Extensive research done in the field of psychology has shown that eye blinking rate decreases when there is an increase in the cognitive demand [1-2].

Lying is more cognitively demanding than telling the truth because while lying the liar has to ensure that the lie can pass off as the truth under various plausible scenarios and thus has to think hard, to cover all the loopholes. This is particularly evident when one has to give a false account of one's whereabouts, and thus is forced to make up a false alibi [3].

The existing techniques of lie detection involve the use of sophisticated equipment and complex techniques like brain mapping etc. This paper proposes a method for lie detection in which blink rate of the participant is measured in the target period (lie detection period) and compared with the threshold value denoting the normal blink rate of a person.

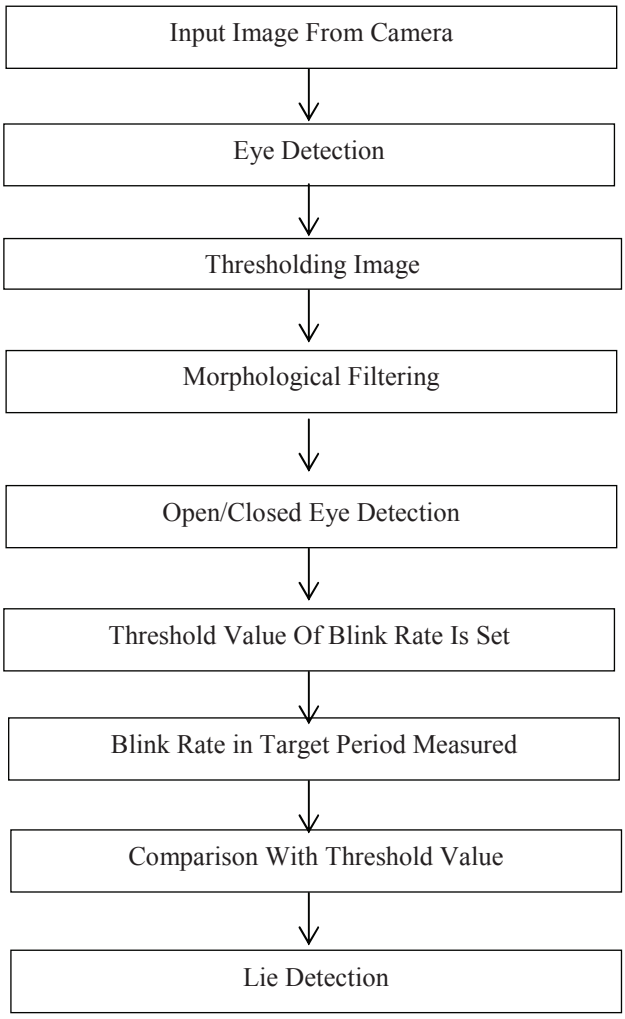


Fig. 1. Overview of Lie Detection Technique

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This technique is highly efficient when lying is cognitively more demanding than telling the truth [3], so can be readily used to determine if a participant is making up an alibi.

Figure1 shows the detailed implementation of the Lie-Detection Algorithm. This algorithm can be implemented effectively with both MATLAB and OPENCV, here it has been implemented with the help of MATLAB. The camera that has been used is a 0.3M, 1.0M (720p HD) webcam.

Continuous video input at the rate of 60fps is provided by a camera interfaced with MATLAB. The individual frame image from the video input is separated and the location of eyes is detected by making use of the HAAR cascade method as proposed by Paul Viola [4]. The next step is deciding whether the eyes are in a closed or an open state. This is done by obtaining the histogram back projection of the YUV image of the detected eyes. The probability of skin presence in each pixel is given by the back projections. The result is adjusted, if required, by morphological operations like erode, dilate etc. The closed eyes are detected if there is a high percentage of skin coloured pixels in the eye region, otherwise the eyes are open. Then the blink rate for the lie detection period is calculated and is compared with the threshold value.

If the participant is lying, there will be a major decrease in the blink rate in the target period as compared to the threshold value for some time (during Lying), followed by a significant increase in the blink rate above the threshold value, once the lie has been told. Alternately, if the blink rate showed very little variation from the threshold value during the entire process, it is concluded that the person is telling the truth.

## II. Proposed Algorithm For Lie Detection

The block diagram of proposed work is given in Figure1. Main parts of the experiment are skin, eyes, blink and lie detection.

### *A. Eye Region Detection*

The participant's eyes are detected by making use of the HAAR cascade classifier as proposed by Paul Viola [4]. The image of the eyes thus obtained is separated for further operation. The skin color histogram is found out by making use of a sequence of images of the face. Then HAAR Cascade is applied for finding the location of the eye region from the face region.

### *B. Open /Closed Eye Detection from back-projected YUV histogram*

We make use of the Histogram back-projections to create a probability map over the obtained image of the eye. The image of the eyes is converted to modified YUV format and then all the skin color components are selected from the image after applying a prope threshold. Non-skin colored components are assigned black color to separate out the background disturbance. The number of white pixels in this back projected image helps to obtain the probability of finding the location of the object (skin in our case) in the image. Thus, we normalize the histogram and detect the skin pixels with the help of the U values. Thus the probability of the presence of the skin pixels is detected and now we detect closed eyes as a high percentage of the skin color pixels and open eyes by a lesser percentage of the skin color pixels in the eye region.

### *C. Thresholding and Morpholoical operation*

The results of the back projection are adjusted by various Morphological operations including erode and dilate. Erode is used to replace the current pixel by the local minimum found in the neighborhood. Dilate is used to replace the current pixel by the local maximum that is found by the Dilate function itself.

The back projected image is sure to have a high concentration of the skin pixels when the eyes are closed. We set such a threshold for the U values that when we consider the image of the eye region the percentage of the skin pixels can be maximized. Thus, for closed eyes we get a back projected image that has only white pixels or a very small percentage of black pixels (Non skin colored components) and a higher percentage of black pixels in the eye reigion for open eyes.

### *D. Blink Rate Calculation And Lie Detection*

The blink rate is calculated for the target period and is compared with the threshold value. Threshold is set either as 26 Blinks/min, found by Anna Rita Bentivoglio [5] or a separate threshold can also be measured for every participant by calculating the average blink rate using the blink detection algorithm as mentioned in this paper. Based upon the difference in the blink rate measured in target period and the threshold value it is determined if the participant is lying or not.

## III. Technical Aspects

For blink detection the camera must be on and directly facing the face of the person throughout the procedure. He/she must not be wearing any fancy glasses or colored goggles to minimize complexity. The skin thresholding should be done properly and the eyes should be easily visible to the camera. Algorithm is based upon the method of the color segmentation because when compared to feature based method, this color based algorithm needs very little training.

First, eye detection is accomplished by using the HAAR cascade algorithm. After separating the image of the eye region, we have converted this image in to a different color space, named modified YUV. Then the threshold for the skin pixel is set according to the appropriate U range. Hence the back projected YUV image is obtained. The detection of closed or open eyes is done by considering the percentage of skin pixels present in the image of the eye region.

Morphological filtering is used to reduce the impact of false positives.

Having detected open as well as the closed state of the eye, the next step is to calculate the blink rate in the target period, when the lie might be told. Variations in blinking during the target period are calculated for the participant and the decision on the truth of his/her alibi is made. Step by step breakup of the technicalities involved in the practical implementation of this algorithm are given below.

### *A. Eye Detection*

Eye Detection using HAAR feature-based cascade classifiers is an effective object detection method proposed by Paul Viola [4]. It is based upon machine learning where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

First we load the required XML(Extensible Markup Language) classifier. Then frame by frame image is obtained from the video that was provided as the input, and then we compute the smallest rectangular area which can fully cover the estimated eye region. Then the image of the eye region is separated in a different figure.

### *B. Modified YUV Colour Space*

The human skin falls within a certain range of chrominance value (U-V components), hence we obtain YUV projection of the image.

$$Y = \frac{R + 2G + B}{5}$$
$$U = R - G \qquad \text{(i)}$$
$$V = B - G$$

### *C. Thresholding and back projection*

Setting of a threshold in order to obtain a binary image of different regions of the body is a very important concept that finds it's use in skin color segmentation[12], Skin Lesion Segmentation[11], ESD(Eyelid State Detection) [8].We are also using thresholding for skin detection.

The modified YUV image can be used for the calculation of the skin colour histogram so that the skin pixel can be segmented in the back projected YUV image. This skin pixel is segmented as follows to obtain the skin.

$$10 < U < 70 \; AND - 40 < V < 11 \qquad \text{(ii)}$$

The setting of the threshold value for skin pixels is accomplished in the testing phase of the code. Finally, the threshold is set in such a manner that non skin color components like the eye brows, eye lids, iris etc, get assigned the black color, while the skin is depicted by white pixels. Now, the ratio of black to white pixels can be determined which is used for finding if the eyes are closed or open.

### *D. Morphological Filtering*

The results of the back projection can be modified by morphological filtering in order to amplify small difference between open and closed eyes. It is achieved in MATLAB by making use of in built functions imerode and imdilate, which perform the function of erode and dilate. These also help in removing the background noise from the back projections.

### *E. Open/Closed Eye Detection And Blink detection*

As mentioned earlier, the threshold for the back projection of the YUV image is set in such a manner that for the back projected image of the closed eye there is a maximum percentage of white pixels (that represent the skin) and minimum percentage of black pixels (that represent the non skin components). Thus, we conclude that the eyes are open if there are a high percentage of black pixels present in the image i.e, if the ratio of black to white pixels is greater than ten percent, the eyes are open, else they are closed. Generally, the isolated image of the closed eyes has no non skin components so it does not have any black pixels.

### *F. Lie Detection*

The blinking rate of the participant during the target period was recorded and compared to the threshold value of the blink rate to deduce if the participant is lying or not.

Threshold value of blink rate can also be set for each participant individually by modifying the code and running it on MATLAB for a threshold setting period of 60 seconds during which the participant is asked generic questions about himself. The video input from the camera was obtained at the rate of 60 fps and we found the average conversational Blink rate per min of the participant by calculating the number of blinks. This was now used as the reference(threshold blink rate) for the lie detection process.

We decided whether the participant's alibi is true or not based upon the following experimentally verified cases[3]-

#### *1) Case-I*

No drastic variation in the blink rate observed in the target period as compared to threshold blink rate value shows that the participant is telling the truth.

#### *2) Case-II*

A significant decrease in the blinking rate during the target period followed by a sudden increase in the blink rate as compared to the threshold blink rate value shows that the person is lying. Thus the alibi he/she is giving is not true.

It was decided that the participant was lying when the blinking pattern matched with the one expected in case-I and a message was displayed on the screen stating the same. When the blink variation pattern matched with the one predicted in case-II, it was deduced that the participant was

telling the truth about his whereabouts and his alibi was true.

## IV. SIMULATION RESULTS

### *A. Open Eyes Detection*

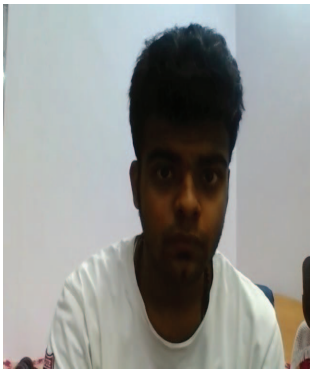

Fig. 2. Input Image (1)

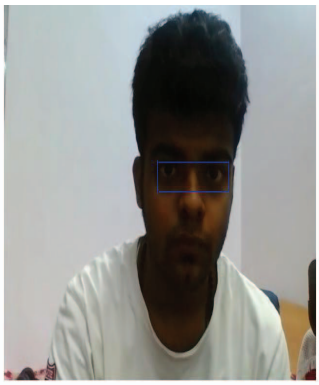

Fig. 3. Eye Detection (HAAR Cascade)

Fig. 4. Isolated Eye Image

Fig. 5. YUV Image of Eyes.

Fig. 6. Backprojected Histogram (YUV)

### *B. Closed Eyes Detection*

Fig. 7. Input Image (2)


Fig 8. Eye Detection(HAAR Cascade)

Fig. 9. Isolated Eye Image

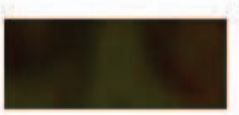

Fig. 10. YUV Image of Eyes

Fig. 11. Back projected Histogram
(YUV)
(No Non-Skin component present)

TABLE 1 . LIE DETECTION RESULTS

| Participant Number | Threshold Blink Rate | Target Period Blink Rate | Post Target Period Blink Rate | Verdict |
|---|---|---|---|---|
| 1 | 26 blinks/min | 13 blinks/min | 30 blinks/min | Lie |
| 2 | 24 blinks/min | 26 blinks/min | 25 blinks/min | Truth |
| 3 | 22 blinks/min | 20 blinks/min | 24 blinks/min | Truth |
| 4 | 18 blinks/min | 22 blinks/min | 22 blinks/min | Truth |
| 5 | 20 blinks/min | 10 blinks/min | 25 blinks/min | Lie |

In order to implement the algorithm with a high efficiency, we must ensure that the camera quality is very good and that the lighting conditions are sufficiently bright, moreover while taking in the video input the participant should face the camera directly and should not change the orientation of his head from straight to a tilted position. The complete face should be captured by the camera and the camera should be sufficiently close to the face to ensure that even the isolated eye images are of a good quality.

## V. FUTURE APPLICATIONS

In this paper a new method is proposed for efficiently tracking and keeping a count of the eye blinks of a person from an input video image. The inter eye blink interval and the blink rate that has been obtained as a result of the successful implementation of this technique can be easily used for testing if a person is telling the truth about his whereabouts of a particular recent time [3]. As the very basis of this technique is the detection of the variation in the blinking rate of an individual and it's deviation from normality, we can make use of this blink detection algorithm for different eye related behaviour analysis. It can be used for fatigue test of drivers, sleep driving[6], physical eye related diseases like dry eyes, Parkinson's disease etc. The individuals suffering from these diseases show the symptoms of excessive blinking which can be detected quite easily by the above mentioned technique.

By implementing the same algorithm with some modifications in OPENCV,we can develop an alibi checking application which can ensure whether a participant is making things up or telling the truth by using the front camera of a phone to record the video of the participant and then processing it with the above mentioned algorithm. Professional lie catchers can make use of this algorithm and the subsequent application to suit their purpose. We hope that this paper will be able to give more impetus to the use of computer vision and other technologies for lie detection and also for the analysis of different human behaviour.

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