Detection and Controlling of Suspecious Behaviour in the Examination Hall

Partha Pratim Debnath, Md. Golam Rashed, Dipankar Das

Abstract— Within the examination hall, in general the eye gaze and the orientation of the head of the examinee provide us clue to the suspicious behaviors. Nowadays, most of the examinations are held within smart class rooms so that cheating activities can be monitored centrally and remotely. But most of the suspicious behaviors' monitoring procedures are manual. In this study, we proposed a smart system which can autonomously detect and track examinee's eye gaze and head orientation to robustly detect their cheating activities. With the help of the webcam installed within each of the smart devices placed on each of the examination desk, initially, real time video is captured during examination period. Then the video is analyzed to study the examinee's psychology regarding to the illegal approaches to build a knowledgebase of our system. Recently, we conducted experiments using our smart system within the examination hall under controlled environment to validate its effectiveness of our system.

Index Terms— Visual focus of attention, Eye center localization, Gaze detection, Sustained attention, Transient attention.

1 INTRODUCTION

The vision system of human enthusiastically seeks interesting scene in images to minimize the search effort in tasks, such as object [1] detection and recognition. Similarly, prominent actions in video sequences are more likely to attract our first sight than their surrounding neighbors. Detection and controlling of human's visual focus of attention (VFOA) in critical situations is a part of active research for many years [2]. However, the researchers of computer vision and artificial intelligence seek for an accurate method for fixation detection based on object detection by which human attention may be controlled. Basically, the term "Fixation" refers to a process of maintaining the visual gaze at a single location. Visual fixation is never perfectly steady, fixational eye movement occurs involuntarily, especially for the case of examination hall that offers short- term stimuli/attention of the examinee. But Visual attention and its controlling process can be integrated in a system to detect the suspicious characteristics based on attention/distraction [3][4] detection of the target person sitting in the examination hall. Adopting unfair means in the examination hall is a very common scene in our country. But since in most of the cases the human resources are limited, it is quite impossible to detect the suspicious behavior (such as the trying to copy) of particular students – especially in the large examination hall room. To accomplish this purpose, there are several techniques in vogue [5][6][7]. But most of them offer taking video from the surveillance camera. Unfortunately, this approach is not suitable if the examination hall is very large. In most of the case the detection accuracy is not optimal and there is a sustainable cost of deploying surveillance camera. In our approach, we have used the built in web camera installed in each of the laptop that comes with the idea of smart class room. Each of the laptop will be connected to our system's server via network. Our proposed technique starts with the study of psychological behavior of examinee in real time environment. This knowledgebase helps us to set the threshold values of crucial moments in different environments. A controlling signal from the server will automatically turn on the camera installed at each student's device if cheat-prone environment is detected. The camera will capture continuous video and the system will analyze each frame for suspicious behavior. To detect the VFOA of the target person, we have used the eye pupil rotation detection [8] [9] [10] combined with the head pose detection [11].

So, with the help of our system, it will be possible to detect the suspicious activities without being physically present in the examination hall. Consequently, the investment at the field of human resources is greatly reduced as well as the suspicious behavior can be tracked very efficiently. This kind of machine based detection also includes proper evidence (such as stored video clips) and ensures unbiasedness. Moreover, there is no need to keep the webcam "on" for all the time. Our proposed system detects the crucial time from its knowledgebase, and turns on the camera at the right time. For the case of smart class room (that provides laptop or tablet pc with built in webcam), there is no need of additional equipment installation. As a result our proposed system offers optimum suspicious behavior detection efficiency as well as cost efficiency.

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2 METHODOLOGY

Human cheating behavior is very peculiar in nature. For the case of exam hall, it becomes tougher to detect the correct cheating behavior and bypass the false ones. Our research work is divided into two successive parts as follows-

2.1 Knowledgebase Development

It is based on the psychological study of the examinee regarding to the suspicious activities happened in the exam hall. The main goal is the manual creation of a knowledge base connected with the system's server to detect the threshold value of suspicious behavior of the examinee that will automatically turn on the camera at the right moment. There are different parameters to represent the suspicious behaviors. Our approach begins with the identification of these parameters as well as different cheating Types. In real time environment, sometimes it happens that one or two exam halls are more cheat-prone than the others. It is due to the fact that, many educational institutions reshuffle the roll number of the students according to their prior performances. This causes that most of the weak students gather at the last of the register. Due to seat planning according to roll number, the weak students assemble in a particular exam hall and consequently, a massive trend of cheating and copying is identified there. Moreover, the cheating tendency varies with different exams. To fight with the toughest exams, the students adopt unfair means. So in different examinations, we also observed the student's psychological behaviors. Apart from this, the cheating tendency is time variant. With the start of the exam, even the weakest student tries to write something from his/her own memory. But after sometime when s/he finds nothing to write, s/he starts to cheat. And this cheating tendency is fatal during the last half hour. It is found that even the best students sometimes show suspicious behavior.

To meet the goal, we collected video data from different examination hall. Data were also taken in different exams and in different exam time by dividing the whole exam time in different time slots. Based on our study there are basically three parameters related to suspicious behavior-

1. Exam hall
2. Type of Exam
3. Time of Exam

We also classify the cheating activities in two major criteria-

Cheating Type-1: In this case the victim copies from the sources such as books, summary papers, mobile- phones ,written answers on hands etc. those exist hidden with him.

Cheating Type-2: The sources do not exist with the victim. He looks to and fro and tries to copy from his neighbors. Sometimes he also makes a verbal communication.

Now based on the cheating tendency, we designate each of the exam halls with a weight, w_1 ranging from 0 to 5. Based on our study, each of the exam is also given a weight, w_2 ranging from 0 to 5. Different time slots of the exam is assigned a weight, w_3 ranging from 0 to 3. These weights are stored in our knowledgebase in accordance with different parameters. Now the knowledgebase calculates the Cheating Weight, **W** for each of the parameters based on the following formulae

$$\mathbf{W} = \sum_{i=1}^{3} w_i \quad \text{.....(1)}$$

Now, if **W** > threshold value, our system will consider it as a crucial time and automatically turn on the camera on the particular exam day, at a particular exam hall and at a particular time. We can also change the threshold value to provide a very tight or loose invigilation.

2.2 Suspecious Behavior Detection

It is based on the sustained and transient [12] attention/distraction detection of the target person. When the system turn on the camera, it captures the images continuously and fed it to the system. A multistage frame by frame analysis method is described below to detect the suspecious behaviour of the examinee-

Head Pose Detection

The main goal of head pose detection is to track the head from the continuous image whether or not the head is in movement. In our work, we have used the Seeing Machine's faceAPI to detect and track the head pose, h_p of the target person. To detect the head, we have used haar cascade classifier as a 3-D head tracker [13]. We draw a rectangle outside of the head. For Cheating Type-2, the examinee moves the head within this head rectangle. The orientation of the middle of the face line within this face rectangle clearly defines the head movement at a particular direction as proposed by [14].

Face Points Extraction by Active Shape Model

Our modeling method works by examining the statistics of the coordinates of the labeled points in the head rectangle. In order to be able to compare equivalent points from different shapes, they must be aligned with respect to a set of axes. We achieve the required alignment by scaling, rotating and translating the shape so that they correspond as closely as possible. In this technique, we aim to minimize a weighted sum of squares of distances between equivalent points on different shapes. Finally, the facial feature points are extracted from the active shape model [15].

Iris Center Detection

The facial feature points are used to roughly detect the eye regions from the face. The Vector Field of Image Gradient (VFIG) is used to detect the iris center.

The VFIG iris center detection technique is described as follows:

Let I_c be the possible iris center and I_{gi} be the gradient vector in position I_{xi}. If I_{di} is the normalized displacement vector, then it should have some absolute orientation as the gradient I_{gi}. We can determine the optical center I_c* of the iris (darkest position of the eye) by computing the dot products of I_{di} and I_{gi} and finding the global maximum of the dot product over the eye image:

$$I_c^* = \text{argmax}_{I_c} \{\frac{1}{N} \sum_{i=1}^{N} (P \quad)\} \quad \text{.....(2)}$$

Where, $P = (I_{di}{}^{T} I_{gi})^2$

$$I_{di} = (I_{xi} - I_c) / (|| I_{xi} - I_c ||_2)$$

i = 1, 2,..., N and the displacement vector I_{di} is scaled to unit length in order to obtain an equal weight for all pixel position in the image.

We create an eye rectangle around our eye. The fluctuation of the coordinate of the eye ball within this eye rectangle provides us a clue transient attetion detection as proposed in [14]. Those short term stimulies is considered as Cheating Type-2 in the examination hall.

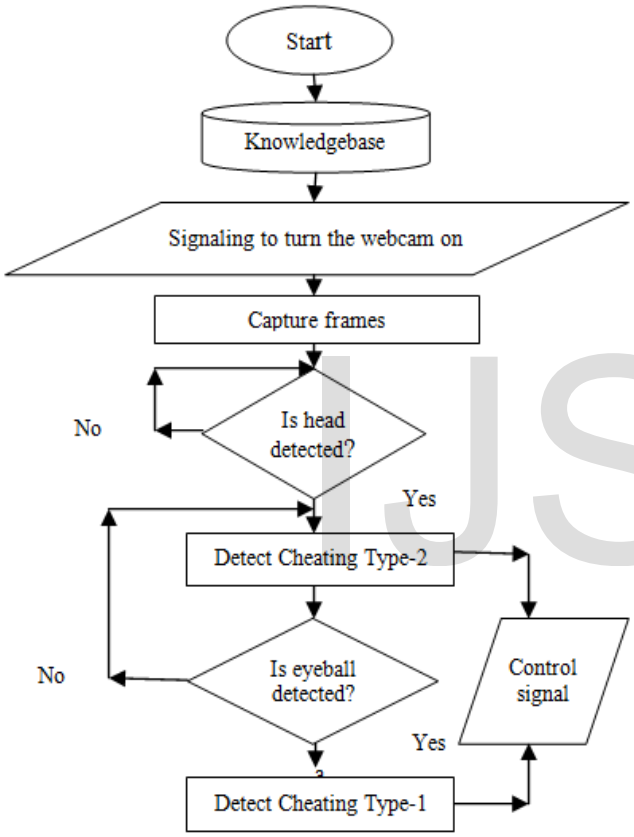

Fig. 1: Flow chart of the proposed system

3 DATA COLLECTION

Data collection is divided into two phases as follows-

3.1 Data Collection for Knowledgebase Development

We performed two Types of experiments those are conducted in two separate environments. The 3 unpaid participants (3 male) were students at Bangladesh Army University of Engineering and Technology. (mean age 20 years and standard deviation 0.775 years)

Experiment-1

We collected data from three different examination halls running the semester final exams. In this experiment, data is collected from an examination room where quiz test is running. The quiz test is in the form of multiple choice questions to be filled up on the screen of the computer with the help of mouse provided to each of the examinee. Each of the exams comprises of 1.00 hour. In total 30 students seated for examination into each of the considered Examination halls. Apart from looking behind, the victim is capable of copying from its neighbor. Our following tables summarize the studies from different halls according to different time slots. Each of the students were very closely monitored to detect the suspicious behavior in terms of random head movement or eyeball fluctuation. Table-1 and Table-2 reveals that cheating activities is crucial in final 20 minutes for all the Examination halls.

Table 1: Cheating Type -1 detection from different Examination hall in different time slots

	Cheating Type-1		
	Hall -1	Hall-2	Hall-3
First 20 minutes	0	1	0
Second 20 minutes	0	2	1
Final 20 minutes	1	2	3

Table 2: Cheating Type -2 detection from different Examination hall in different time slots

	Cheating Type-2		
	Hall -1	Hall-2	Hall-3
First 20 minutes	7	10	8
Second 20 minutes	15	13	17
Final 20 minutes	25	27	28

Experiment-2

Based on the previous cheating records, we identified 3 different victims. Without their conscious, they were monitored very closely in the different examinations. We updated their cheating profile as follows.

Table 3: Cheating profile of the victim -1

	Cheating Type-1			Cheating Type-2		
	Exam			Exam		
	1	2	3	1	2	3
First 20 minutes	0	0	1	3	1	2
Second 20 minutes	0	1	2	4	3	5
Final 20 minutes	1	2	4	5	5	6

Table 4: Cheating profile of the victim -2

	Cheating Type-1			Cheating Type-2		
	Exam			Exam		
	1	2	3	1	2	3
First 20 minutes	1	0	0	1	1	2
Second 20 minutes	0	0	2	4	4	5
Final 20 minutes	1	2	4	5	5	5

Table 5: Cheating profile of the victim -3

	Cheating Type-1			Cheating Type-2		
	Exam			Exam		
	1	2	3	1	2	3
First 20 minutes	1	4	4	5	2	3
Second 20 minutes	1	5	5	6	4	5
Final 20 minutes	4	6	6	7	5	7

3.2 Data Collection for Controlled Environment

There were 3 unpaid participants (3 male) who were students at Bangladesh Army University of Engineering and Technology (mean age 20 years and standard deviation 0.775 years.) We collected videos in two steps-

Cheating Type -1 Rrecognition

The participants were asked to look within the Left Near Peripheral Field of View (LNPFV) and Right Near Peripheral Field of View (RNPFV) with keeping their head in non – moving state, that means in Central Field of View (CFV). They were instructed to copy the answer from some written documents. The eyeball transient duration was 1, 2 and 3 seconds repectively. We collected 3 different videos with the average length of 2 minutes. The illumination of the room was 200 Lux and the distance from the camera was 0.5 meter.

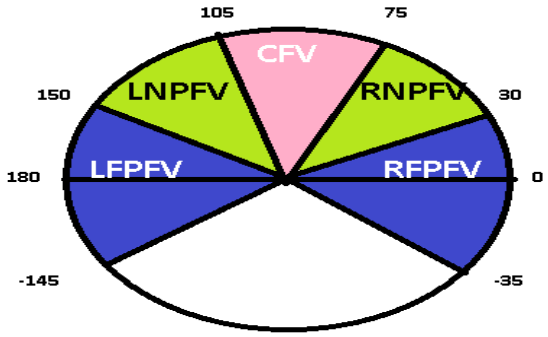

Fig. 2: Field of View (FOV) of the examinee

Cheating Type -2 Recognition

In this case, the participants were asked to copy the answer of the questions from their neighbours' laptop. They were asked to rotate their head with varying rotation time i.e 1, 2 and 3 seconds repectively. We collected 3 different videos with the average length of 3 minutes. The illumination of the room was 200 Lux and the distance from the camera was 0.5 meter.

Fig. 3: Scenerio of cheating Type-2 in smart class room

Fig. 4: Experimental setup in controlled envirionment

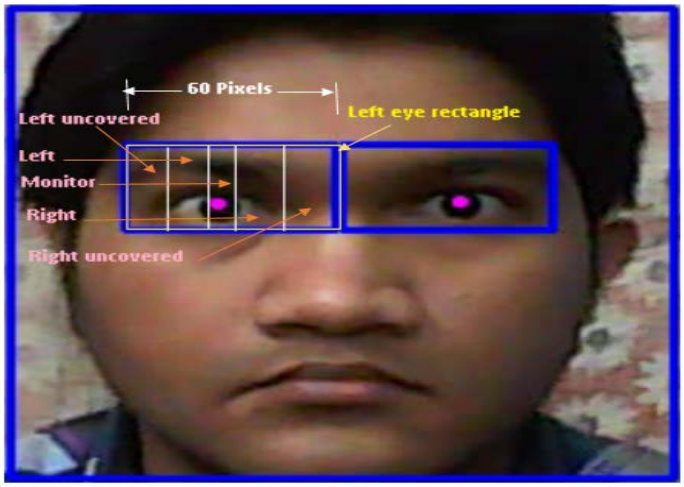

Fig. 5: Cheating Type-1 detection based on eyeball fluctuation

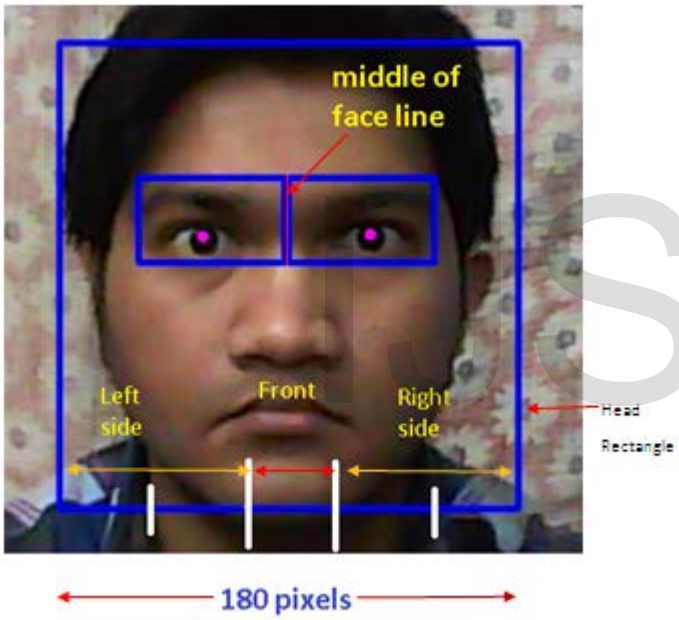

Fig. 6: Cheating Type-2 detection based on head rotation detection

4 Performance Evaluation

Based on the data tables from experiment-1 and experiment-2, we develop the following experimental knowledge-base containing the weights (see Table 6).

Table 6: Weight calculation

Hall weight, w_1			Exam weight, w_2			Time weight, w_3		
Hall 1	Hall 2	Hall 3	Exam 1	Exam 2	Exam 3	Time 1	Time 2	Time 3
2	3	4	2	4	5	1	2	3

Now to detect whether the system will turn on the camera or not on a particular scenario, let us at first consider that we set the threshold value=7.

Now for hall-2, on the day of exam-2, at the time slot-3 the cheating weight, **W** is calculated based on Equation-1 as follows-

$$\mathbf{W}=w_1 + w_2 + w_3 = 3 + 4 + 3 = 10$$

Since W> threshold value, our system will detect this as a crucial moment and turn on the camera.

To derive the percentage of accuracy of Cheating Type -1 and Type-2 detection, we apply the following approach.

With the right distance from the camera and proper lighting, the efficiency of the transient detection is based on the following formulae-

Transient Detection Accuracy =

$$\frac{\#\text{ of transient attention detected}}{\#\text{ of transient attention occured}} \times 100\% \quad \ldots\ldots(3)$$

And similarly the efficiency of head rotation detection is expressed as-

Head Rotation Detection Accuracy =

$$\frac{\#\text{ of head movement detected at a particular direction}}{\#\text{ of head movement occured at that particular direction}} \times 100\% \quad \ldots\ldots(4)$$

In our proposed approach, equation (3) reveals the accuracy of Cheating Type–1 detection. The results of our experiments is illustrated in Fig. 7.

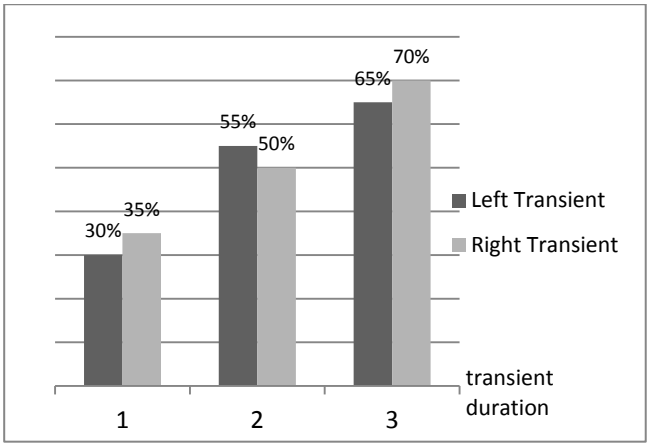

Fig. 7: Cheating Type -1 detection accuracy

Equation – 4 stands for the accuracy of Cheating Type -2 detection which is illustrated in Fig. 8.

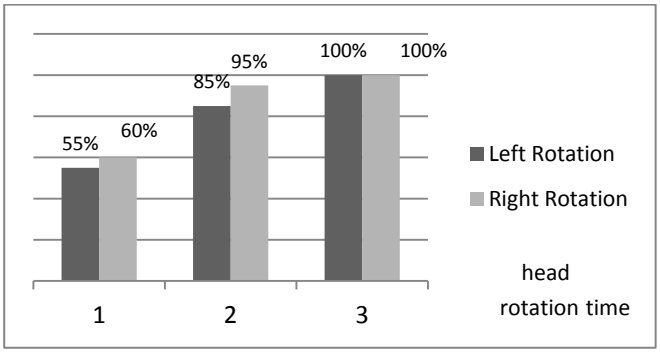

Fig. 8: Cheating Type -2 detection accuracy

It is revealed from the above result that While detecting Cheating Type-1 (based on eyeball rotation only), it is found that the accuracy varies with the transient duration. For the transient duration of 3 seconds, the accuracy is the best. Cheating Type -2 (eyeball fluctuation combined with head rotation) detection is also head rotation time depended. For the rotation time of 3 seconds, the proposed system is able to detect the suspicious behavior with 100% accuracy. Provided that, proper lighting condition and right distance from the camera must be ensured. So, we may conclude that our proposed system offers optimum results in detecting cheating activities of the examinee within the examination hall if the transient duration and head rotation time is considerably high. The initial result reveals that our proposed smart system offers optimal accuracy in automatically detecting cheating activities of the examinee.

5 Conclusion

In this paper, a smart system has been proposed to detect suspicious behaviors of the examinee automatically during the examination period within examination hall. In this work, we only considered eye gaze and head orientation information as clues of detect suspicious behaviors of the examinee. We tested the effectiveness of our proposed system under controlled environments. In future, we would like to conduct experiment in real examination hall to detect and track examinee's suspicious behaviors in real time.

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