Asynchronous Online Examination Security System Using Occupancy Detection

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***Abstract*—The paper introduces the capabilities of Occupancy Detection to enhance online examination security. Occupancy Detection determines the presence of a person in a particular area and uses sensors networking which includes Passive Infrared Relay (PIR) sensor and Ultrasonic (US) sensor. PIR is designed to detect motion from a heat-emitting source (such as a person entering a room) within. On the other hand, Ultrasonic sensors produce low intensity, inaudible sound and detect changes in sound waves caused by motion. This study aims to determine the accuracy of Asynchronous Online Examination Security System (AOESS) in terms of occupancy detection and computer vision. The computer vision part includes face detection of an intruder behind the examinee. The PIR and Ultrasonic sensors act as occupancy sensors to monitor the presence of the examinee and identify suspicious movements and possible intruders. The sensors and external camera were integrated into a single hardware called Asynchronous Web-Based Test Security Unit (AWTSU) which may be used for the monitoring of an examinee during an online examination. 1**

***Index Terms*—asynchronous examination, occupancy detection, computer vision, passive infrared relay sensor, ultrasonic sensor**

I. Introduction

Nowadays, online examination is getting popular because it greatly reduces paperwork as well as examiner's effort in checking the test papers. [1] A study by Howarth shows that most students (82%) prefer online examinations rather than the conventional type. However, online examinations have lots of challenges in terms of security issues. In fact, Ref. [2] in the study entitled "Blatant cheating detected in an Online Examination" done by Simon, it was mentioned that a significant number of students cheated blatantly.

One of the existing technologies which may be utilized for online examination security problem is Occupancy Detection. [3] In the study "Real-time Occupancy Detection" by Hailemariam *et al*, they focused on "an intelligent building system capable to determine localized building occupancy in real time". It is the "central technology used in smart homes and office buildings, with an occupant detector at every area". Occupancy Detection is also commonly used for [4] energy management and dynamic seat allocation and [5] demand-controlled ventilation and security.

Ref. [6] Occupancy sensors can reduce lighting energy use by 30 to 60% depending on the frequency of room usage. These sensors were frequently used for monitoring purposes. For example, Ref. [7] PIR is equipped with sensor nodes to achieve the objective of human activity monitoring. Although occupancy detection uses sensors more often, Ref. [8] digital imaging technique may also be utilized. Computer vision, on the other hand, is also normally used for [9] people monitoring such as in a real-time people counting system and [10] to determine people direction movement.

Although occupancy detection is mostly applied on smart homes and establishment monitoring, limited studies have been found regarding the use of occupancy detection for online examination security. Thus, this study aims to develop a system that integrates occupancy detection to eliminate manual monitoring, to create a ubiquitous environment for online examination and to enhance online examination security. The proposed system may also serve as a basis for integrating security in other online applications.

II. The Developed System

The study focused on online examination cheating in forms of suspicious movements such as standing, leaving the area of examination and switching of examinees. The system will use Moodle as a platform for the simulation of the examination questionnaires.

To detect a moving target, the target must have a surface temperature that is substantially different than the surrounding ambient temperature. Although the usual targets of a PIR detector are warm-bodies, the PIR sensor will also detect a moving target that has a surface temperature that is significantly lower than the ambient temperature. The sensors warm-up period is around 1 minute at temperatures above +32 ℉ and will be extended up to 5 to 7 minutes at temperatures below -10 ℉.The PIR sensor coverage area is approximately conical in shape and has an angle of 110 ° with a range of 15 feet (4.5 meters). The target to be detected must pass either into or out of one of these zones in order to be detected. Small

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targets can sometimes move between these zones and not be detected because they never pass into or out of a zone.

The *Asynchronous Web-Based Test Security Unit (AWTSU)* was placed on a closed area (a cubicle or a closed room) ceilings lower than 13 feet (3.9 meters) to maintain the accuracy of Ultrasonic sensor. Temperature has an effect on the speed of sound in air that is being bounced back by the latter sensor. Operating temperature ranges from +32 to +158 ℉ (0 to +70 ℃).

A. Conceptual Framework of the System

Fig. 1 shows the conceptual framework of the system. For the input, the system determines the presence of the examinee, the distance between the people around the examination area and the computer itself, and a live video surveillance of the actual examination. After getting the required inputs, the system monitors the presence changes of the examinee and the surrounding people, while the system camera identifies if the cause of suspicious movements was triggered by a human or not. If it is human, then the system will generate a report of the possibility level of blatant cheating and the image acquired from the human detection unit.

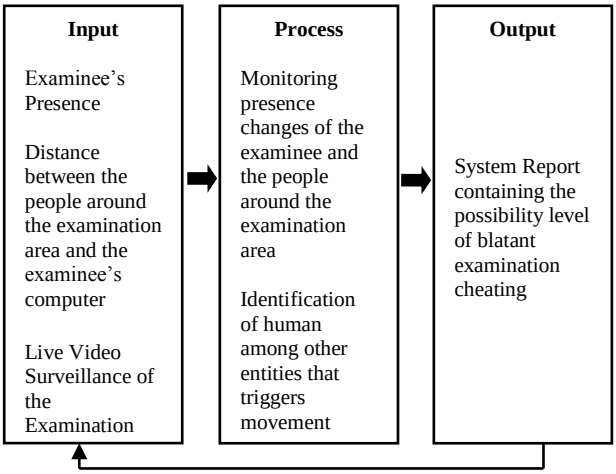

Figure 1. System flow

B. System Architecture

The proposed *AWTSU* is divided into four units that will complete the whole occupancy detection system for blatant cheating monitoring, as shown in Fig. 2.

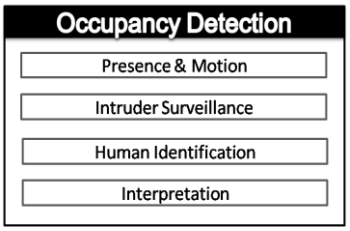

Figure 2. *AWTSU* system architecture

The topmost unit is the Presence and Motion detection unit which is primarily concerned with the examinee and closely monitors the suspicious movements such as leaving the seat and switching to another person. Using PIR sensor that can detect for presence and movements in its line-of-sight it monitors for the active presence of the examinee and alerts the system if the examinee leaves its seat or switch to another person. To have an accurate result from PIR sensor, the system fetched analog signals from it instead of digital signals to ensure that the data has an exact amount and can be manipulated to analyze movements.

The second unit is the Intruder Surveillance which is concerned with the people who are not expected to be present inside the examination cubicle/room. It prevents other people who may interfere in the examination site or who may coach or who may intend to replace the real examinee. Thus, the said surveillance for the whole examination area is needed. The ultrasonic sensor that is capable of detecting motion and distance without a direct line-of-sight is used to detect if a person is entered the examination area. Analog signals where used instead of digital signals to gather more accurate and exact result from the sensor. If motion is detected, the unit will activate the Human Detection Unit.

The third unit is the Human Detection which identifies whether a detected motion inside the room is caused by a human or an object or animals. Since Ultrasonic Sensors are not capable of identifying if a certain motion is created by a human being or an animal, this unit is needed. A video camera is used to capture image sequences behind the examinee. These image sequences will be processed and apply background reduction algorithm, which removes the saved background to the current image frame to detect if there is a difference between two images. From the current image, the unit will identify whether there is a human or not. If a human is detected, the captured image will be located and saved.

The last part is the Interpretation Unit which gathers all the results processed by all units and it identifies if cheating occurred. It will generate a system report to the examination administrator regarding the findings of the different units such as presence detected, possible captured intruder's image, and the cancellation of exam in case a blatant cheating occurred.

C. Research Methods and Techniques

The researchers used experimental method in this study. Independent variables helped the researchers to come up with the right accuracy level and reliability of the system. The system was tested in different conditions derived from the experimentation paper. The results were tabulated and interpreted after the actual data gathering.

D. Asynchronous Web-Based Test Security Unit

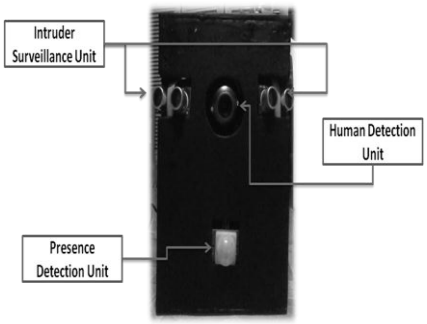

Figure 3. Asynchronous Web-Based test security unit

The Asynchronous Web-Based Test Security Unit (AWTSU) is composed of the occupancy sensors (PIR and Ultrasonic) and external camera, as shown in Fig. 3.

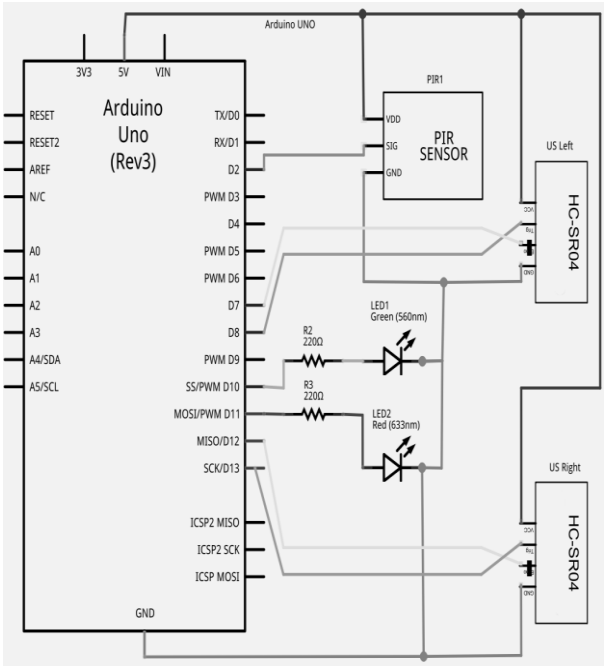

Figure 4. Schematic Diagram of AWTSU

The AWTSU was attached to the examinee's computer and to a separate laptop where the control software was installed. The Ultrasonic sensors were installed in the left and right side of the unit while the PIR sensor was located under the external camera to monitor the examinee's presence. The laptop, occupancy sensors and external camera were interconnected via Arduino UNO. Fig. 4 shows the schematic diagram of Asynchronous Web-Based Test Security Unit (AWTSU), which comprises the hardware part of the system. The PIR sensor is connected to the 5 volt power while the signal is connected to the D2 pin of the Arduino. The left ultrasonic sensor's trigger is connected to the D8 pin while the echo is connected to the D7 pin. The right ultrasonic sensor's trigger is connected to the D13 pin and the echo is connected to the D12 pin. The positive side of the green LED is connected to a resistor with 220 ohm resistance which is connected to the D10 pin of Arduino. The red LED is also connected to a resistor with 220 ohm resistance which is connected to the D11 pin. Meanwhile, the negative sides of the LED are connected to ground of the PIR, Ultrasonic and Arduino.

III. Discussion And Results

The study aims to determine the degree of detection accuracy of the developed system given by the parameters for occupancy sensors such as the distance of the examinee using PIR sensor and the distance of the people around the examination area using Ultrasonic sensor, and for computer vision such as resolution of the video and movement speed. For the distance of the examinee using PIR sensor, the researchers used a) 1 foot, b) 2 feet and c) 3 feet. For the distance of the people around the examination area using Ultrasonic sensor, the researchers used a) 10-50 cm, b) 51-100 cm, c)101-150 cm and d) 151-200 cm. For video resolution, the researchers used a) 320x240px, b) 640x480px and c) 800x600px. And lastly for movement speed, the researchers used a) 0.8mps, b) 1.4mps and c) 2mps. Simple averaging was used to get the accuracy rate. The number of detections were summed up and divided by the total number of trials times 100.

TABLE I. Detection Rate Under Given Parameters

					AVERAGE
PIR	1 foot	2 feet		3 feet	80%
	75%	85%		80%	
Ultrasonic	10-50cm	51-100cm	101-150cm	151-200cm	73.75%
	55%	85%	90%	65%	
Video Resolution	320X240px	640X480px		800X600px	76.67%
	70%	75%		85%	
Movement Speed	0.8mps	1.4mps		2mps	71.67%
	95%	85%		35%	

The researchers did collaborate with the test administrator to test the developed system. AWTSU was connected to one (1) computer used by the examinee during the departmental online midterm examination which is conducted twice a semester for the college students of the department of Computer Science of the Polytechnic University of the Philippines. The said examination utilized Modular Object-Oriented Dynamic Learning Environment (Moodle) for their subject "Fundamentals of Information Technology" as an eLearning platform. There were 102 examinees but the system focused only in monitoring the behavior of the

examinee who is using the PC with attached AWTSU on the top of the student's computer unit as shown in Fig. 5.

Figure 5. AWTSU on top of examinee's computer

Table II shows the overall accuracy rate of the occupancy sensors during the actual online examination.

TABLE II. DETECTION RATE DURING THE ACTUAL EXAMINATION

	Detection Result	**Blatant Cheating Result**
Passive Infrared Sensor	91.98%	False
Ultrasonic Sensor (RIGHT)	Too near	True
Ultrasonic Sensor (LEFT)	Too near	True
Computer Vision (Extreme Motion)	32.64%	True
Computer Vision (Face Detected)	0.08% (24 faces gathered)	True

On the actual online examination (see Table II), the results show that the PIR sensor has a 91.98% detection rate; thus, the examinee was present in the whole exam duration. The left and right ultrasonic sensor shows that a speculated intruder was detected, so there is a possibility of blatant cheating in terms of the examinee's surroundings. The computer vision part in terms of extreme motion has a detection rate of 32.34% while the face detection has 0.08% face detection, so there also has a possibility of blatant cheating.

IV. CONCLUSION

Through the analysis and implementation made by the researchers of the study entitled "Asynchronous Online Examination Security System using Occupancy Detection", the following conclusions has been derived.

- In terms of PIR sensor, 2 feet, which got the highest detection rate of 85%, is the most preferable distance between AWTSU and the examinee. 1 foot and 3 feet have lower accuracy rates since 3 feet has a farther distance from the PIR and 1 foot is closer to the sensor. The average detection rate of the PIR sensor considering all distances is 80%.
- For the ultrasonic sensor, 101cm to 150cm is the most accurate distance. The average detection rate of Ultrasonic sensor considering all distance ranges is 73.75%.
- For the video resolution, pixel has a huge impact on the image quality and speed processing and thus, 800x600px got the highest accuracy rate of 85%. Considering all camera resolutions, the face detection accuracy rate is 76.67%.
- For the movement speed, 0.8 meters per second or slight movements gets the highest accuracy rate. On the other hand, 2.0 meters per second, which is the fastest movement speed, got the lowest detection rate. The faster the movement is, the lesser the chance that the face can be detected. The average accuracy rate considering all movement speeds is 71.67%.
- Based on Table II, it shows that the Asynchronous Online Examination Security System using Occupancy Detection was able to detect accurately in an actual online examination. It was also able to obtain data regarding the possibility of blatant cheating.

Given the following results, the researchers therefore concluded that Asynchronous Online Examination Security System may be utilized for enhancing the security aspect of online examinations.

V. RECOMMENDATIONS AND FUTURE WORKS

The researchers would like to recommend the future researchers to further develop the study. First, the usage of an external camera with better specs and high camera resolution for better computer vision accuracy rate. Additional sensors are also recommended such as sound and light, other than occupancy sensors that can gather more data for making blatant cheating. Advanced and long ranged occupancy sensors could also be used to make the system more sensitive and can detect intruders in a wider range. The future researchers may also develop additional security features such as centralized face recognition for user authentication. Lastly, other learning environment systems aside from Moodle can be also integrated with the security system.

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