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Supervisory Control System Based on Multi-Agents Techniques for a Smart Computer Laboratory

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ABSTRACT

This paper provides a control and monitoring system for a computer lab with the aid of Arduino Uno connected to sensors to access and control equipment and devices using a computer application. It basically focuses on Laboratory automation using the data acquisition tool and Vision Assistant of LabVIEW. The proposed system consists of four agents; the first is an access control agent using human face recognition. The agent composes of two main parts: real-time face recognition and door control. OpenCV libraries are used for real time face detection and the PCA algorithm is used for real time face recognition and also sending a security alert message to the supervisor. In order to open the door automatically, a hardware circuit was designed to connect a computer with an electrical door. This agent is based on using the data acquisition tool and Vision Assistant of LabVIEW. Second, fire and smoke detection agent, Arduino Uno is used as the microcontroller at the transmitter part to control the sensor nodes and give alerts and send an SMS message to the supervisor when smoke and flame are detected. Third an audio processing agent for recording student's attendance. The identity of a student is verified by voiceprint by using the DTW algorithm, by comparing the voice signal of the speaker with pre-stored voice signals in the database and extracting the main features of the speaker voice signal using MFCC. Fourth, rationalizing electrical consumption agent is implemented by embedding the electrical appliances such as lights, air-conditioners, fans, and projectors in the laboratory with sensors for reducing the energy consumption. The proposed system was tested based on actual data sensed by sensors and the results showed that the proposed system works with high efficiency.

Keywords -- Supervisory Control System, Multi Agents, LabVIEW, Laboratory.

List of abbreviations

Real-Time Face Recognition Agent	R_TFR
Fire and Smoke Agent	S&FA
Audio Processing Agent	A_PPA
Rationalizing Electrical Consumption Agent	R_ECA
Internet Protocol Camera	IPC
Open-source computer vision	OpenCV
Principal Component Analysis	PCA
Mel Frequency Cepstral Coefficient	MFCC
Confusion Matrix	CM

I. INTRODUCTION

Supervisory control of a process means a human operator communicates with a computer to gain information and issue commands, while the computer, through sensors and actuators, implements these commands to control the process [1].

Lab automation means building automation for a lab, called a smart lab [2]. One definition of smart computer Lab is a Lab with a mechanized framework that contains sensors and gadget controllers to give an agreeable, insight, and secure framework to improve personal satisfaction also, control Lab machines effectively [3].

The need of face recognition in security systems is attributed to the rise of commercial interest and therefore the development of feasible technologies to support the development of face recognition [4]. Automatic personal identification in access control has become popular by using biometrics data instead of using cards, passwords or patterns. The advantage of this system is that face recognition does not require to be touched with any hardware [5].

The attendance in many institutions, colleges and organization is very important criteria for students and organization's employees. The methods in which manually taking and maintains the attendance records was very inconvenient work for teacher/faculty [6]. Using voice print as an indicator of user's identity have been widely used in many occasions such as verification to verify students' identities during attendance [7].

Laboratory equipment that is very valuable or that presents unattended fire hazards should be equipped with over temperature protection or smoke detection to shut down the equipment and summon assistance [8]. Fire detection and alert systems are very important for early fire detection and speeding the process of fire control [9].

National Instrument's Laboratory Virtual Instrument Engineering Workbench (LabVIEW) is defined as a system design software that gives developers a simple and efficient method to recruit the hardware and achieve system integration [10]. LabVIEW have the tools that can provide a high level of hardware integration. It is widely used in research and development domains, such as data acquisition, devices control, and building virtual hardware environments in a real-time computer system [11].

Therefore, this paper introduces a supervisory control based on multi-agents for a smart computer Laboratory using LabVIEW. The proposed system comprises of four agents. First agent, real time face recognition. Second agent, Protection lab and controlling in operation of

electrical appliances. Third agent, Recording student's attendance. Forth agent, saving electric energy.
The paper is organized as follows; section 2 contains related works, section 3 presents the proposed system framework, experimental work are presented in section 4, experimental results are presented in section 5 and section 6 presents the conclusions.

II. RELATED WORKS

Studies similar to the current study dealt with the employment of image processing in real-time recognition, sound processing in recording students' attendance, controlling laboratory devices to rationalize consumption, and determining fire and smoke.

Shrutika V. Deshmukh, et. al. had introduced a human face detection system for door security using Raspberry Pi. The Cascade Haar-like features are used for face detection and the histogram of oriented gradients. The support vector machine classifier was used for face recognition. Also, send a security alert message to the authorized person. In order to achieve higher accuracy and effectiveness, they use OpenCV libraries and python computer language. The analysis revealed that their system shows excellent performance efficiency and can be used for face detection even from poor quality images [12].

D Salánki et. al. proposed a security camera system for gait detection based on LabVIEW. The system can handle two cameras recording the walking, then the system analyzes the video file. Pattern recognition was used, which can exclude the false sensed points, and comparing the definite integral values of the functions instead of comparing the coefficients [13].

Sudha Rani et. al. introduced a face recognition office security system using LabVIEW. The NI-IMAQ-USB camera was used to capture face image and employing spatial histograms as robust features for face detection. A hierarchical classifier combining histogram matching and support vector machine was utilized to identify the face and non-face [14].

Simarpreet Kaur et. al. introduced a speaker identification system based on LabVIEW. An infinite impulse response filter is being used in pre-emphases stage and feature extraction by Formant Detection Method. Features are extracted and stored in a file to compare with the query by using Amplitude- Level measurement and Cross-Correlation tool [15].

Anshul Kumar Singh and Charul Bhatnagar had presented a biometric security system for watch list surveillance videos of the main entrance gate of GLA University. They divided face recognition process into three parts namely: Face Detection, Feature Extraction, and Face Recognition. The system detected a face using the Haar cascade classifier provided by Intel Open Source Computer Vision Library (OpenCV). They used the Principal Component Analysis (PCA) method for training and feature extraction. The Nearest Neighbor was used for classifying. The system was given accuracy of 77.57% [16].

A. E. E. EAlfi et. al. have used MATLAB to discover the face and its components (eyes, nose, and mouth) because these areas carry the most important emotion information [17].

A. E. E. EAlfi et. al. have presented paper to create an automatic system to identify the identity of the student in the distance examinations depending on face recognition techniques. [18].

A. E. E. EAlfi et. al. have used the Euclidean distance to find the similarity between reference image and student's image [19].

Siyu Yang et. al. had presented an automated student attendance tracking system based on voiceprint and location. The identity of a student is collaboratively verified by voiceprint and real-time location. The captured voice clip would be processed for noise reduction at first. And feature extraction produces formatted data that simplifies the recognition process. At last, the template marked as the caller's identifier will be compared with the formatted data, generating a match score. If the score is greater than the pre-defined threshold, then the service could assume that the person who requests the service actually owns that account [20].

Md. Nasir Uddin et. al. had developed a voice recognition system for student attendance. They used Fast Fourier Transform to become the audio wave amplitude over frequency. The voice recognition could recognize any voice command. It receives configuration commands or responds through serial port interface/software serial and voice recognition library for Arduino. The unknown voice can be recorded and then analyzed by the Arduino. They used the Minimum mean of the shortest distance between unknown voice and average of each volunteer train data. The results show that this project is beneficial in many ways especially for the lecturer at IIUM University [21].

Dimas Budianto, et. al. had developed a real-time lighting control system for smart home applications. The Fuzzy logic system was used to adjust the intensity of the lights. As a result, found the implementation was successful to control the lighting system with good performance. Thus, the fuzzy system can be built as a smart home concept that facilitates human life [22].

Fakrulradzi Idris et. al. had presented an intelligent fire detection and alert system using LabVIEW. The system consists of two parts that are transmitter and receiver parts. The transmitter controlled by an Arduino board while the receiver controlled by LabVIEW GUI. The first and the second transmitter are designated as XBee1 and XBee2 respectively. The system can display the fire location and provides early warning to allow occupants to escape the building safely [23].

Zaid Abdulzahra Jabbar and R.S. Kawitk presented a smart home control by using low-cost Arduino. The system consists of an app developed using the Android platform and an Arduino Ethernet-based micro web-server. The Arduino microcontroller is the main controller that hosts the micro web-server and performs the necessary actions that need to be carried out. The sensors and actuators/relays are directly interfaced with the main controller. The smart home environment can be controlled and monitored from a remote location using the smart home app, which will communicate with the micro web-server via the internet. Any internet connection via Wi-Fi or a 3G/4G network can be used on the user device. The features that the proposed design offers are the control of energy management systems such as lightings, power plugs, and HVAC (heating, ventilation, and air-conditioner) systems; security and surveillance system such as fire detection and intrusion detection with siren and email notifications; automatic smart home environment control such as maintaining a certain room temperature; voice activation for switching functions and has user authentication to access the smart home system [24].

Studies dealing with the use of Arduino in education

M. Poongothai et. al. had presented an implementation of IoT based Smart Laboratory. The proposed work aimed to develop a smart laboratory system in the Coimbatore Institute of Technology campus based on IoT and mobile application technologies that operate in an intelligent manner. The IoT lab was implemented by embedding electrical appliances such as lights, air-conditioners, fans, and projectors in the laboratory with sensors and network connectivity. This software enabled physical objects to collect and exchange real-time data. From the results of implementation, it was observed that the appliances in their lab are remotely monitored and controlled, thereby reducing their energy consumption considerably [25].

Mary Cherian, et. al had introduced a secure and smart Lab with a wireless sensor network. The system architecture is divided into two modules: security and ambient lighting for the smart lab. The security was implemented by the PIR sensor. The ambient lighting was provided by the use of a photo-sensor. The proposed system was comprising the methods to implement the smart lab by the use of actual sensors. The experimental results were given strong hope for enhancing the present methodologies [26].

Deepak Adha, et.al. had introduced a laboratory automation by using smart phone and computer. The IOT devices controls and monitors the electronic electrical and the mechanical systems used in various types of buildings. The devices connected to the cloud server are controlled by a single admin which facilitate a number of users to which a number of sensor and control nodes are connected. A Smart Laboratory that uses internet-connected devices to enable the remote monitoring and management of appliances and systems, such as lighting [27].

The current study automates laboratories by merging four agents, the first one is to identify the faces of students and allow them to enter the laboratory or not, the second agent is used to record attendance through audio processing, the third agent is used to control laboratory devices to rationalize consumption and finally the fourth agent is used to predict fire through sensing heat and smoke.

III. PROPOSED SYSTEM FRAME WORK

The proposed system comprises four agents namely Real-Time Face Recognition agent (R_tFR), Fire and Smoke Agent $(S\&FA)$, an Audio Processing Agent $(A_P PA)$ and Rationalizing Electrical Consumption Agent (R_ECA). All agents integrated as shown in figure 1.

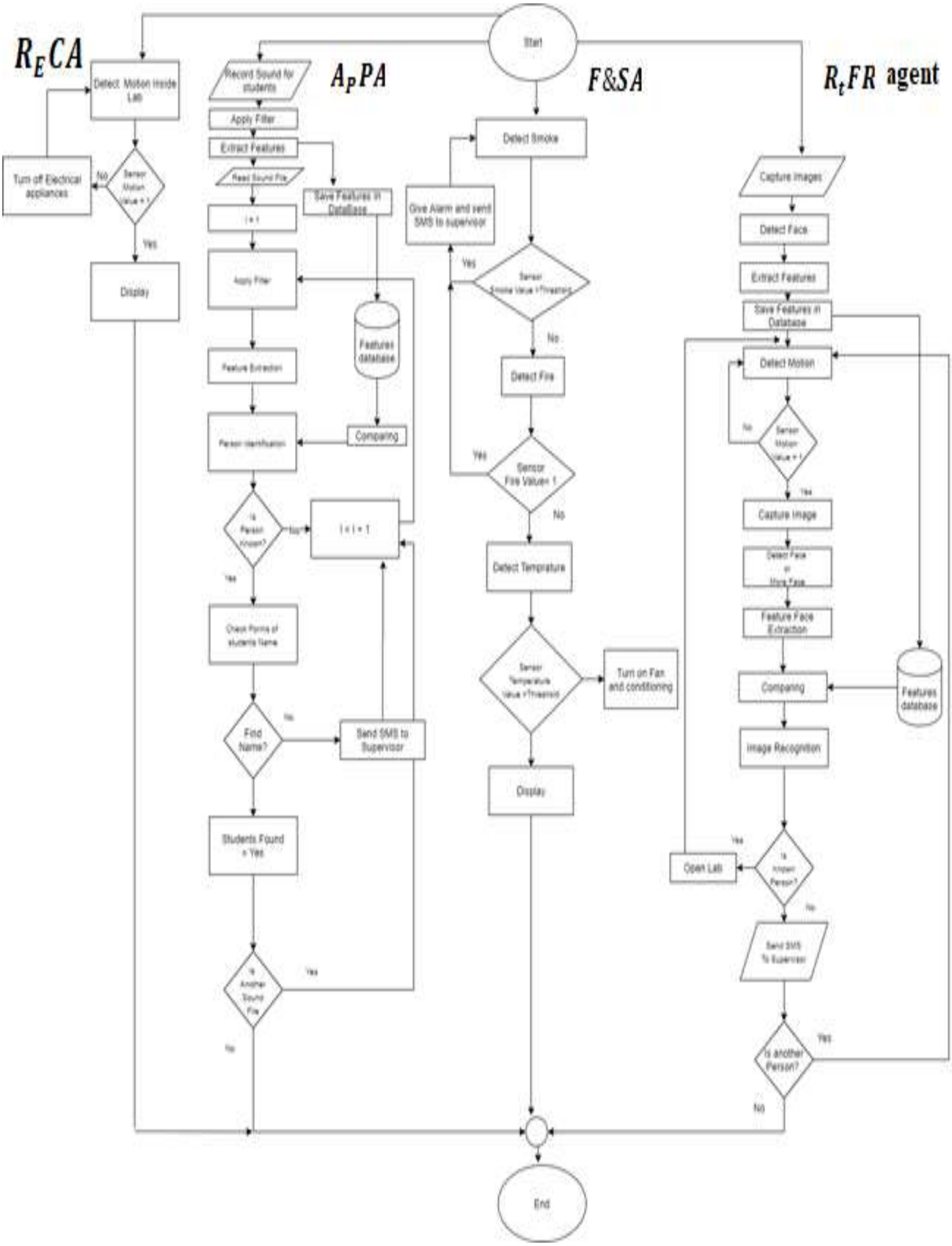

Fig 1. The proposed system framework

3.1 Real-time Face Recognition Agent

This agent aims to control students' entry to the Lab according to the official lecture timetables. Facial recognition technology is used after image processing that is recorded while movement outside the laboratory is detected by a motion sensor, and the images are compared with the database of students' images then a decision is made to open the lab door or not according to the decision tree as shown in figure 2.

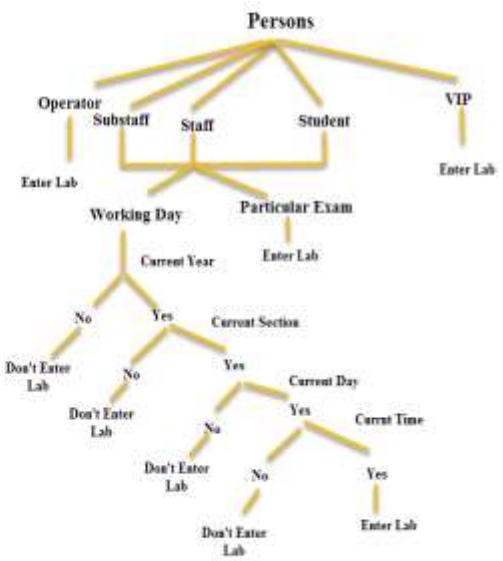

Fig 2: Decision tree for determining who can enter the laboratory

- This agent is composed from motion sensor, camera and relay.
- The circuit diagram is shown in figure 3.
-The rules and actions are:

Rule 1:
If (data of motion sensor = 1)
Then

1. Open camera.
2. Take a picture.

Rule 2:
If (Person=known)
Then
Open the door lock
Else

1. Send SMS message to supervisor phone
2. Alert.

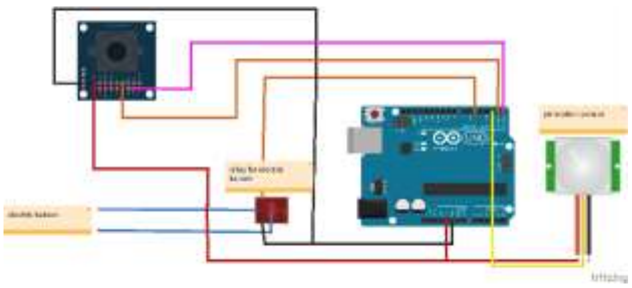

Fig 3: Circuit diagram for real-time face recognition agent

The main steps of this agent are acquiring images, detecting face, extracting features and finally image classification.

3.1.1 Acquiring Images from IP Camera

An Internet Protocol camera (IPC) is used to capture an image every 2 seconds and save it in a specified folder. The used camera has the same features like the analog camera in addition to its ability to compress and encode video and audio signals, and then use its own processor to process the stored signals remotely [28].

3.1.2 Face Detection

After processing visual signals from the camera, human faces are identified using a computer vision technique that identifies faces and their location. OpenCV is an Open-source computer vision library that aimed at real-time computer vision [29].

3.1.3 Extract Features

Principal Component Analysis (PCA) **is** used in face recognition systems that belong to the Eigen face approach. PCA has been extensively exploited for face recognition algorithms, where characterized by helping to reduce the dimensionality of the original data [30]. The steps of the PCA algorithm used to extract the features are presented in ref. [31].

3.1.4 Image Classification

Calculate Euclidean distance between the test feature vector and all the training feature vectors.

$$\varepsilon_K = \sqrt{\| \Omega_{test} - \Omega_i \|^2} \qquad (1)$$

Where, Ω_{test} is test feature and Ω_i is training feature vectors

3.2 Fire and Smoke Agent

- This agent is composed from sensors (fire, smoke DHT22 temperature **sensors**), two relays and buzzer.
-The circuit diagram is shown in figure 4.
-The rules and actions are:

Rule 1:
If (data of smoke =high or data of fire=1)
Then

1. Alert.
2. Operate led.
3. Send SMS to supervisor phone.
4. Turn on fire extinguisher.
5. Cutting off the electrical power to the devices.

Rule 2:
If (temperature =high)
Then
Turn on air conditioner.

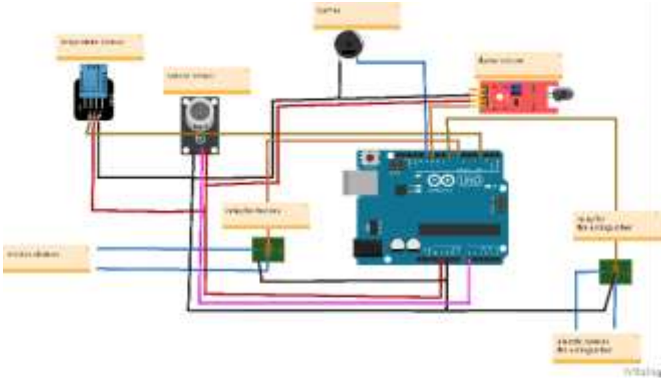

Fig 4: Circuit diagram for Fire and smoke agent

3.3 An Audio Processing Agent

Voice processing technique used to record students' absence in the laboratory.

-The rule action of this agent are:
Rule:
If (student=known)
Then
Recording attendance.
Else
Send SMS message to supervisor.
There are three main steps to voice processing:

3.3.1 Speech Acquisition

A high quality microphone is used to capture the speech signal (recorded file format = *.wav) from students for subsequent analysis. Five sounds were recorded for each student.

3.3.2 Speech Feature Extraction

The feature extraction process computes the discriminative speech features. Mel Frequency Cepstral Coefficient (MFCC) is one of a number of robust speech features [32]. MFCC is used to extract the speech features [33], then the global features are used as a second filter to reducing MFCC features extracted to save the duration of processing time such value of Min, Max, Mean, Median, Mode, Standard Deviation and Variation [34].

3.3.3 Classification

Dynamic Time Warping (DTW) is an algorithm that focuses on matching two sequences of feature vectors by repetitively shrinking or expanding the time axis until an exact match is obtained between the two sequences [35]. It is generally used to calculate the distance between the two-time series that vary in time. A real-time application of DTW in voice recognition is that it should be able to recognize the user's voice even when spoken at different speeds. In order to check the similarity between two voice signals or the time series is warped non-linearly. In other words, the DTW is an optimal algorithm that looks for the similarity between two signals. DTW equation is given by [36]:

$$d\,(qi, cj) = (qi - cj)2 \qquad (2)$$

$$D(i,j) = \min[D(i-1), D(i-1,j), D(i,j-1)] + d(i,j) \qquad (3)$$

3.4 Rationalizing Electrical Consumption Agent

- This agent is composed from motion sensor, relay.
- The circuit diagram is shown in figure 5.

-The rule of action is:
If (data of motion =0)
Then
Cutting off the electrical power to the devices.

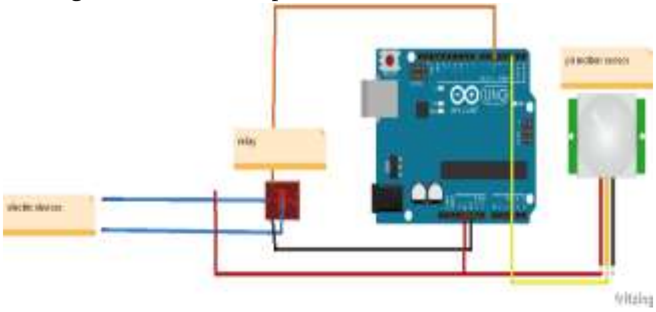

Fig 5: Circuit diagram for rationalizing electrical consumption agent

IV. EXPERIMENTAL WORK

The personal database was designed for features of those dealing with the lab, including employees, workers and students, in addition to the students 'academic database, which included students' study schedules.

When a movement is detected, the camera is triggered to take images and the beginning of the processing stages through an ***RtFR*** agent, during which the faces are identified, the features are extracted, and compared to the stored database, the identity of the person is determined, and then the validity of entering the laboratory or not. In the case of similarity, the laboratory door is opened automatically, while in case of dissimilarity, a text message is sent to the lab supervisor's phone. In both cases, information about the person and the time and date on which the photo was taken is stored in a text file that can be viewed later.

The proposed system automates laboratories by merging more than an agent, one to identify the faces of students and allow them to enter the laboratory or not, as well as recording attendance through an audio processing agent and an agent to control laboratory devices to rationalize consumption and finally an agent to determine fire and smoke. LabVIEW version 2014 and Arduino was used.

4.1 Real-time Face Recognition Agent

The ***RtFR*** agent contains IP camera and motion sensor. The main steps of this agent are acquiring images, detecting face, extracting features and finally image classification.

An IP camera was used to feed the video to the computer. It's used not only to reading live camera's feed but also to take a snapshot, detect a face, extract features then recognize. The block diagram for taking a snapshot and motion sensor is shown in Figure 6.

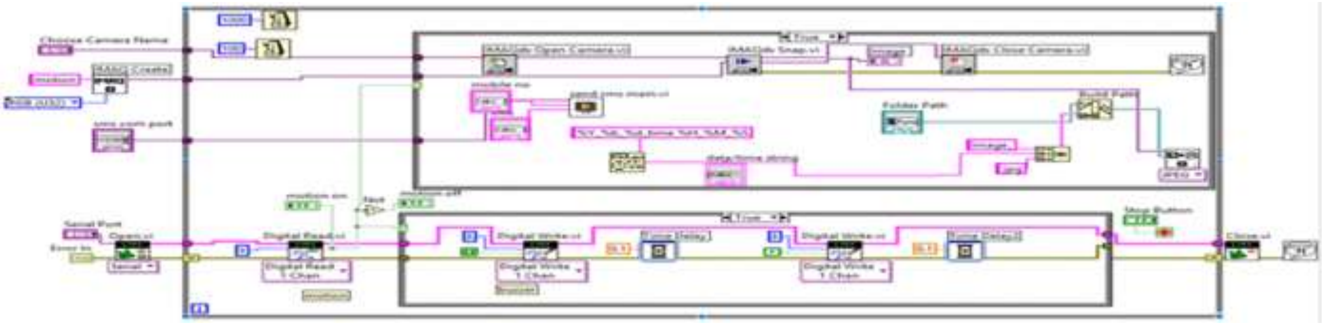

Fig 6: Block diagram for IP camera and motion sensor

4.1.1 Acquiring Images from IP Camera

An Internet Protocol (IP) cameras used to capture an image every 2 seconds and save it in a specified folder. Figure 7 shows the block diagram for acquiring images. Intel OpenCV is an open-source C/C++ based Computer Vision and Image processing library used to detect a single face or three faces from captured images. The block diagram for used OpenCV that detects the faces is illustrated in figure 8.

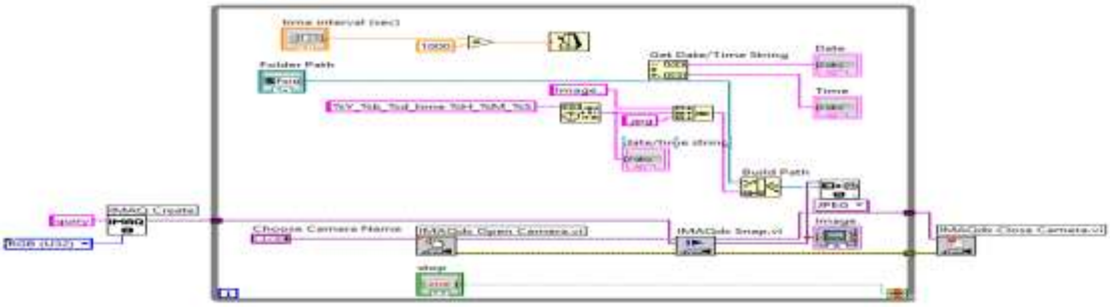

Fig 7: Block diagram for acquiring images by IP camera

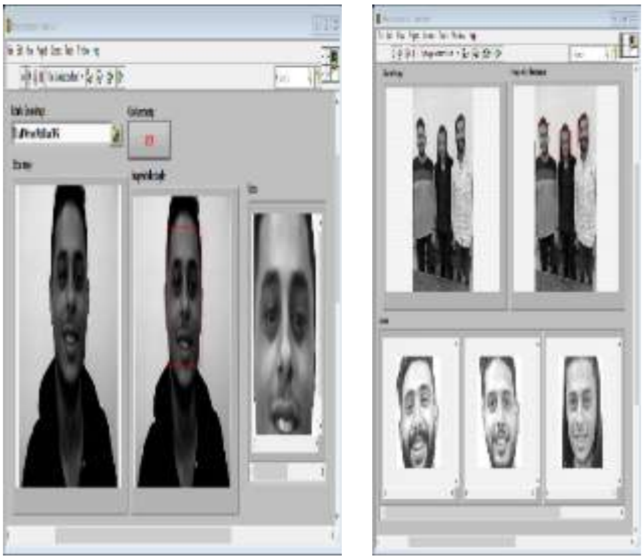

Fig 8: Front panel for detecting single face & multiple faces

4.1.2 Extract features

PCA algorithm used to extract the image features, as shown in figure 9, LabVIEW PCA Algorithm source code shown. There are eight steps namely:

Step 1: Prepare database for the training set of faces.

Step 2: Compute the average face vector.

Step 3: Subtract the average face vector (ψ).

Step 4: Calculate the covariance matrix (CM).

Step 5: Calculate the eigenvectors and eigenvalues of CM.

Step 6: Calculating feature weight for training images.

Step 7: Testing and classification.

Step 8: Calculate Euclidian Distance between the test feature vector and all the training feature vectors.

4.1.3 Lab Door Automation

Automating the process of unlocking a lab's door, can be implemented by using an electric lock connected with the relay and Arduino platform as shown in Figure 10.

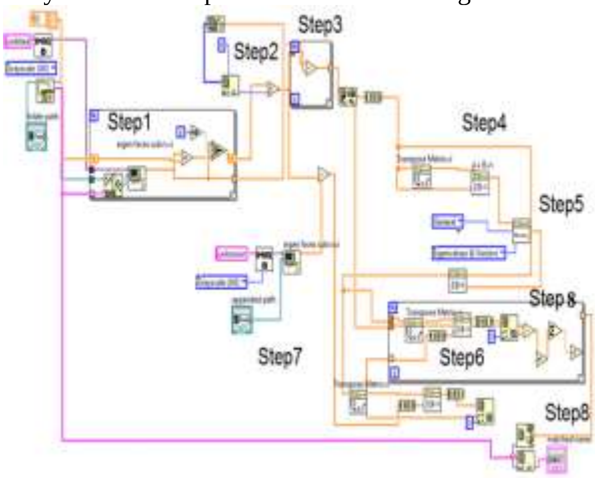

Fig 9: PCA steps block diagram

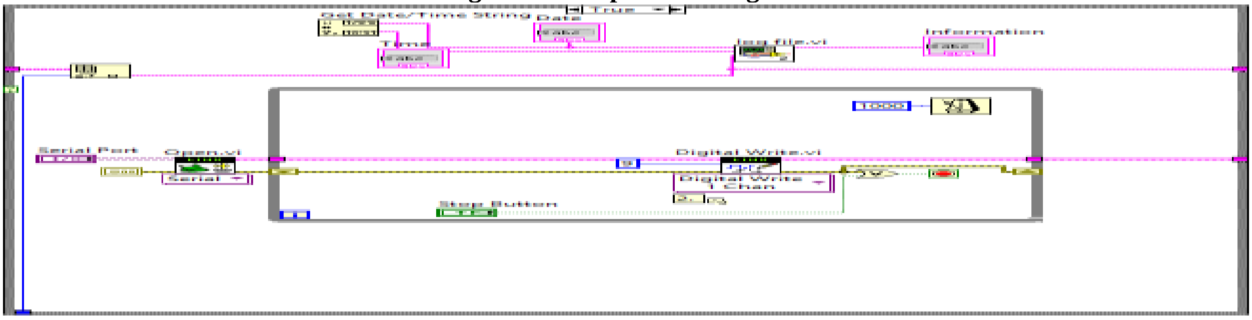

Fig 10: Block diagram for controlling in entering lab's door

Fig 11: Front panel for R_tFR agent

Figure 11 shows a practical example to identify a student's identity through the proposed system and opening the lab door automatically.

4.2 Fire and Smoke Agent

The aim of $S\&FA$ is to provide an early warning of fire and smoke inside laboratory in addition to detect temperature for controlling on air conditioner device. This agent depends on an Arduino connected to sensors and buzzer. The Arduino Uno [37] is an open-source microcontroller that uses ATMEGA 328, an Atmel AVR processor that can have programmed by the computer in LabVIEW language via USB port. Figure 12 shows the front interface of the heat smoke and fire determination agent in the laboratory, While figure 13 illustrates a $F\&SA$ block diagram. The user must choose the port for the Arduino Uno. If the fire or smoke is detected, a sound alarm will be issued and a text message will be sent to the supervisor's phone.

The waveform chart that in front interface is attempts to display the data from the smoke sensor as a real-time signal that moves across the display. It determines how fast the smoke sensor responds to changes in smoke rates in the laboratory. X-Axis for time and Y-Axis for response.

when smoke sensor is sensed due to smoke, sensor will sense and when the value will exceed the threshold limit buzzer can will be operate.

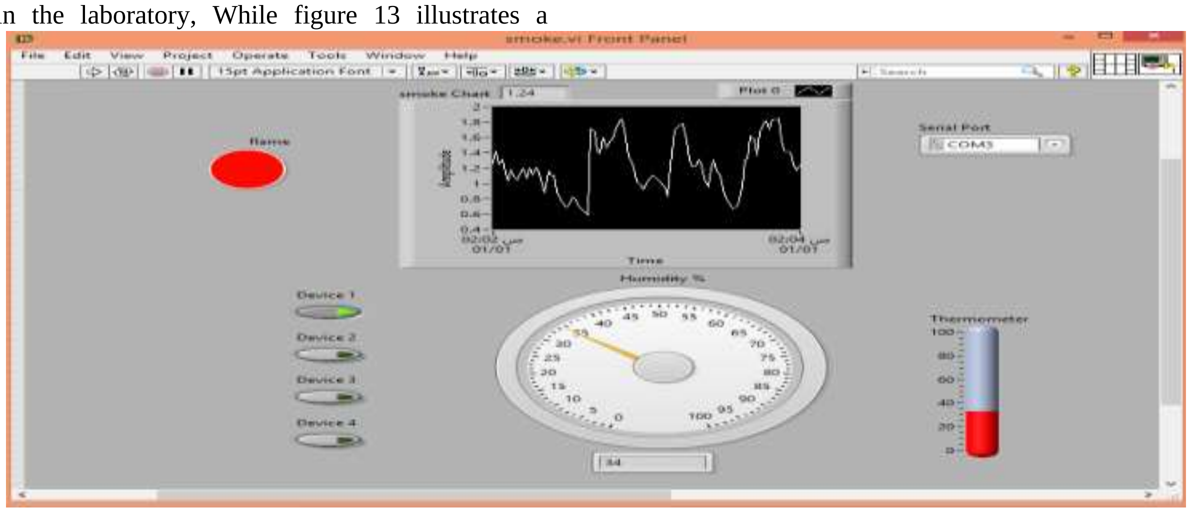

Fig 12: $S\&FA$ agent front panel

Fig 13: $S\&FA$ agent block diagram

4.3 An Audio Processing Agent

The aim of this agent is to record attendance inside the laboratory. The identity of a student is verified by a voiceprint. The agent is responsible for capturing students' voices and submitting verified attendance records. Once a student wants to submit his presence in the class, the agent would be used to verify his identity. The captured voice clip and student's stored voiceprint features will be compared to determine if they come from the same person. If it is, the student registers as an attendee, otherwise, the agent will send a warning message to the lab supervisor's phone. Mel-frequency cepstral coefficient (MFCC) algorithm is used to extract the sound features. The MFCC algorithm is applied to 7 consecutive steps are Pre-Emphasis, Frame Blocking, Windowing, Fast Fourier Transform (FFT), Mel Filter Banks, Mel spectrum, and MFCC parameters as shown in figure 14.

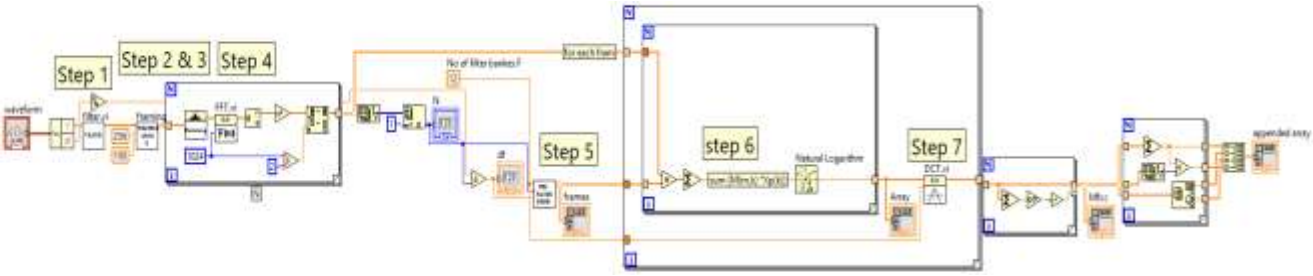

Fig 14: MFCC block diagram

Then, absence for students is recorded by comparing the student's voice features with the features stored in the database, this is done according to a DTW algorithm that calculates the minimum distance between the features as shown in Figure 15.

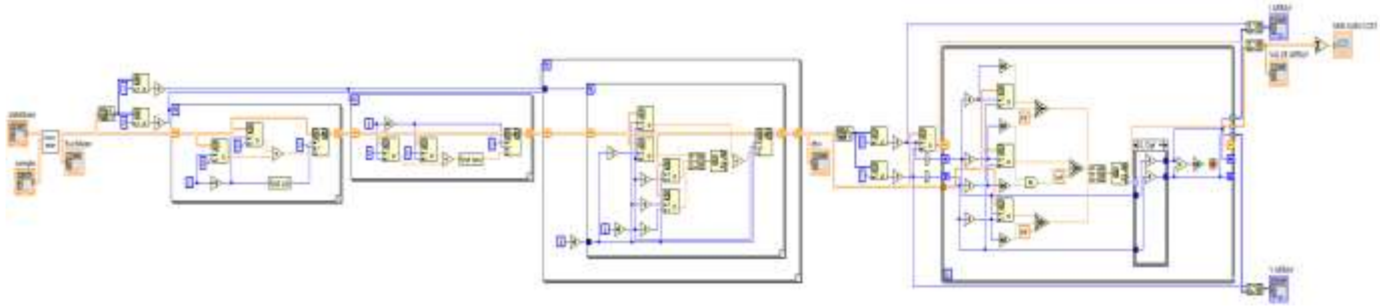

Fig 15: DTW block diagram

Figure 16 shows an example of the case of determining the absence of a student after having similarities between the features.

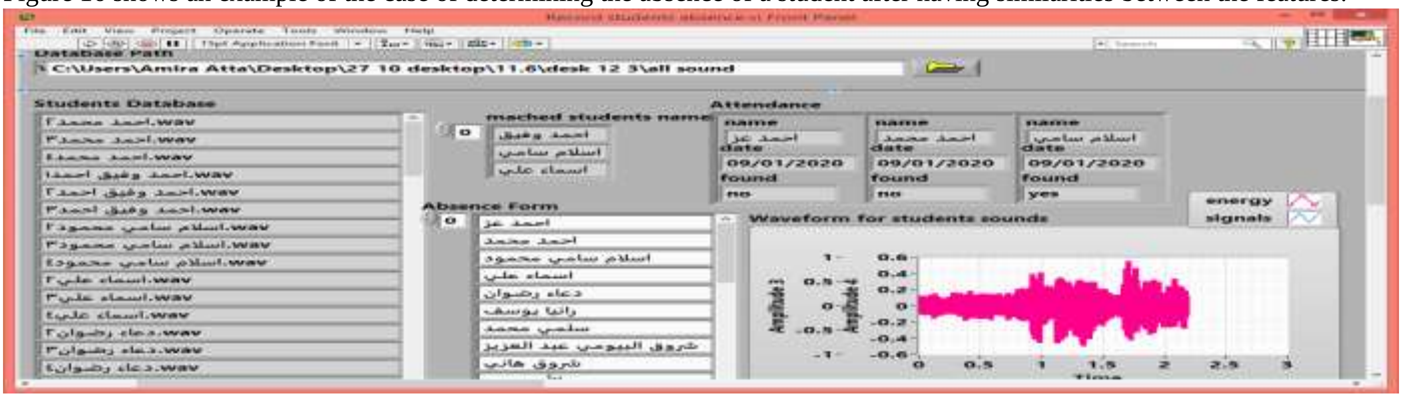

Fig 16 :Front panel for A_pPA agent

4.4 Rationalizing Electrical Consumption Agent

This agent shows that simple installation of commercially available motion sensors can contribute to reduce the electricity bill from the increase of energy efficiency such as turning off lights and devices inside the Laboratory when it is not in use. This agent depends on a motion sensor and relay connected to Arduino. Figure 17 shows a $R_E CA$ block diagram, while figure 18 illustrates the front interface of the control Laboratory devices agent.

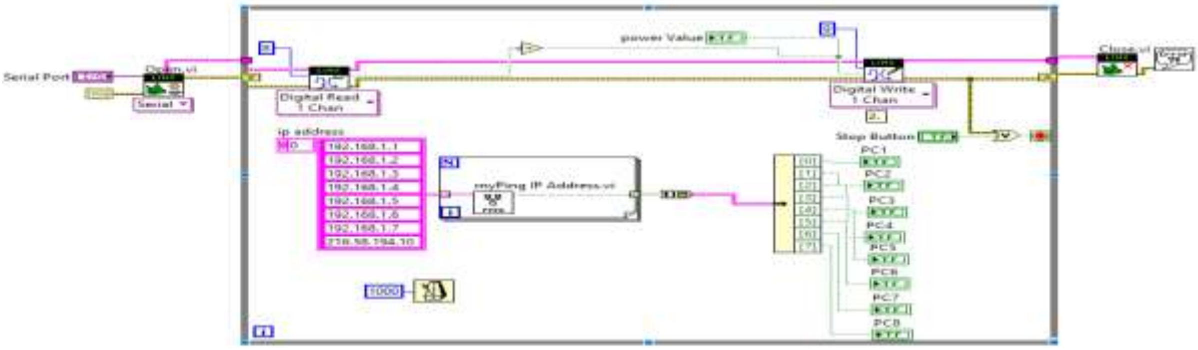

Fig 17: Block diagram for $R_E CA$ agent

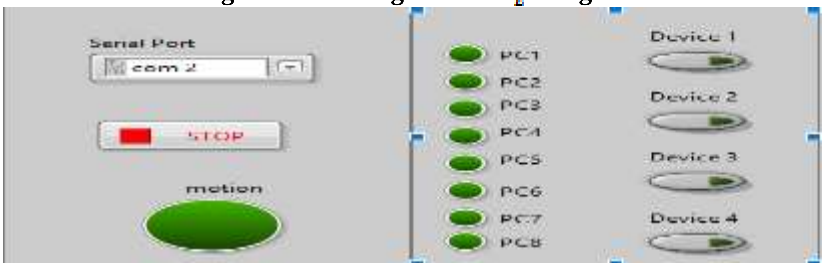

Fig 18: Front panel for $R_E CA$ agent

V. EXPERIMENTAL RESULTS

The confusion matrix (CM) was used to evaluate the proposed system which summarizes the faces similarity performance with respect to some test data. CM calculates the number of correct and incorrect predictions which is further summarized with the number of count values and breakdown into each class [38]. It can be used to get precision, accuracy, recall, etc. Table 1 shows the confusion matrix with True Positive (TP), True Negative (TN), False Positive (FP), and False Negative (FN).

5.1 Results for Real-time Face recognition Agent

The experiment on live videos has been conducted for about 1-hour duration in a real-life environment and our proposed approach is for real-life scenarios so the experiments in the surveillance videos of the lobby for the computer lab. An arrangement has been set for lab workers recognition from videos taken by an IP camera. The system detects a face or more faces by (OpenCV). The training database contains 100 images. 20 images have participated in live tests. The test is being conducted at approximately one hour of video on different days and different conditions.

Table 1: Confusion Matrix

		Actual Values	
Predicted Values		Positive(1)	Negative(0)
	Positive (1)	TP	FP
	Negative (0)	FN	TN

Table 2 : confusion matrix for $R_t FR$ agent performance evaluation

Categories Numbers Array		System's Prediction										Classes Names
		class 1	class 2	class 3	class 4	class 5	class 6	class 7	class 8	class 9	class 10	

System categories numbers array: **[1 3 5 9 10 7 2 1 8 1 6 3 8 3 9 4 6 9 1 5]** **Actual categories numbers array:** **[1 3 3 9 10 7 2 3 8 4 5 3 7 5 9 4 6 9 8 5]**	**Actual**	**class 1**	1	0	0	0	0	0	0	0	0	0	**Class 1= Ahmed**
		class 2	0	1	0	0	0	0	0	0	0	0	**Class 2=Khaled**
		class 3	1	0	2	0	1	0	0	0	0	0	**Class 3= Shymaa**
		class 4	1	0	0	1	0	1	0	0	0	0	**Class 4= Marwa**
		class 5	0	0	1	0	1	0	0	0	0	0	**Class 5= Mohamed**
		class 6	0	0	0	0	0	1	0	0	0	0	**Class 6 = Ali**
		class 7	0	0	0	0	0	0	1	1	0	0	**Class 7= Mena**
		class 8	0	0	0	0	0	0	0	1	0	1	**Class 8 = Hossam**
		class 9	0	0	0	0	0	0	0	0	3	0	**Class 9 = Abdallah**
		class 10	0	0	0	0	0	0	0	0	0	1	**Class 10= Abeer**

After conducting tests and full examination of videos, all the positive and negative values were calculated to measure the performance of the system.

The CM had been implemented in the dataset of images containing 100 images with ten classes. 20 images were entered as a test.

Table 2 shows the CM with TP, FP, FN, TN. TP refers to label which was predicted positive and is actually positive, TN label which was predicted negative and is actually negative, FP label which was predicted as Positive, but is actually Negative and FN labels which was predicted as negative, but is actually positive.

The diagonal points of the CM, which shaded in yellow illustrate the correct classified samples and other points which aren't diagonal, represent the miss classified face samples. Calculating Accuracy, Specificity, Precision, F-Measure and Recall for each class in Table 3.

Accuracy, Specificity, Precision, F-Measure and Recall are calculated as follows [39]:

Accuracy $\frac{TP + TN}{TP + FP + TN + FN}$

Specificity $\frac{TN}{TN + FP}$

Precision (p) $TP/(TP + FP)$

Recall (R) $TP/(TP + FN)$

F-Measure $2 * P * R/(P + R)$

The system gives an accuracy of 93 % percent.

Figures 19,20,21 showing (Precision, Recall and F-Measure) curves for $R_t FR$ image retrieval.

Table 3: The confusion matrix with TP, FP, FN, TN and Accuracy, Specificity, Precision, F-Measure and Recall for $R_t FR$ agent

	TP	TN	FP	FN	Accuracy	Specificity	Precision	Recall	F-Measure
class 1	1	17	2	0	90	89.4736842	33.33333	100	50
class 2	1	19	0	0	100	100	100	100	100
class 3	2	15	1	2	85	93.75	66.66667	50	57.142857 1

class 4	1	18	1	0	95	94.7368421	50	100	66.666666 6
class 5	1	16	1	2	85	94.1176471	50	33.333333 3	40
class 6	1	18	1	0	95	94.7368421	50	100	66.666666 6
class 7	1	18	0	1	95	100	100	50	66.666666 6
class 8	1	17	1	1	90	94.4444444	50	50	50
class 9	3	17	0	0	100	100	100	100	100
class 10	1	18	0	1	95	100	100	50	66.666666 6
Overall					**Mean (Accuracy) = 93**	**Mean (Specificity) = 93.96**	**Mean (Specificity) = 70**	**Mean (Recall) = 70.33**	**Mean (F-Measure) = 70.66**

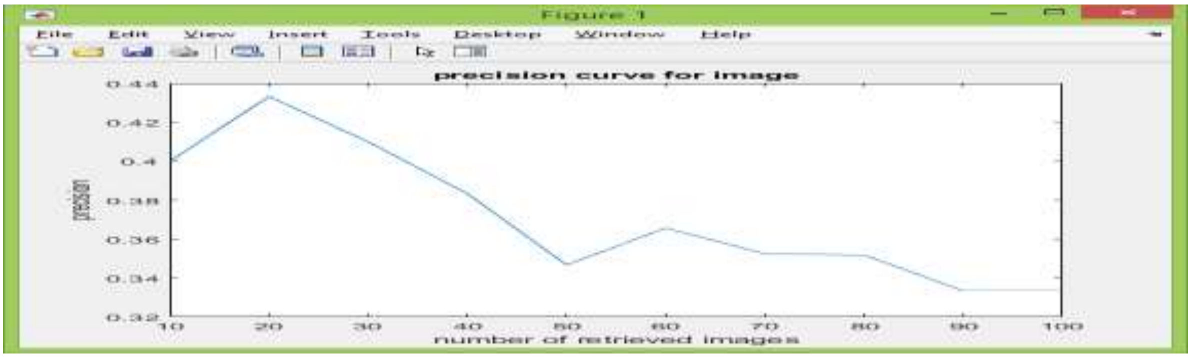

Fig 19: Precision curve for R_tFR image retrieval

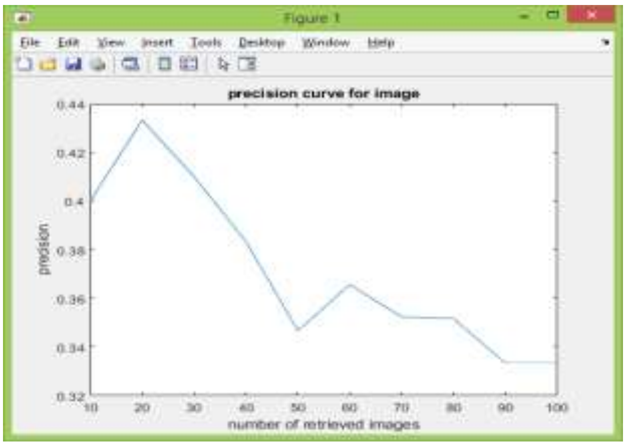

Fig 20: Precision curve for R_tFR image retreival

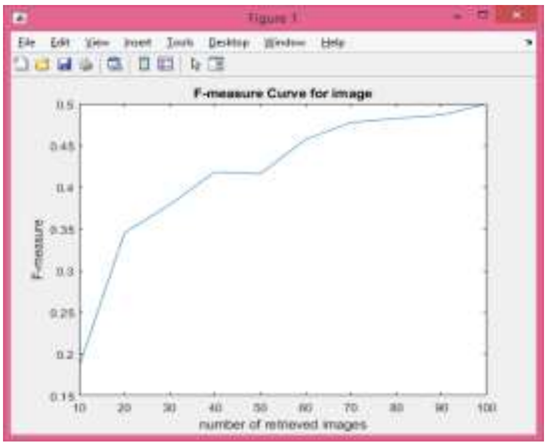

Fig 21: F-Measure curve for R_tFR image retreival

5.2 Results for Fire and Smoke Agent

After connecting and programming all the components, all the components will be run by the whole system. The sensors are placed at a suitable side of the Lab. Conditioning is turned ON or OFF using a temperature sensor. When temperature increases, the current will flow and the relay switch turns ON the Conditioning automatically as shown in figure 22 and figure 23.

Fig 22: Case relay turn on

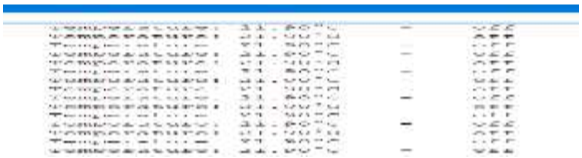

Fig 23: Case relay turn off

When the fire or smoke is detected, then buzzer is turned on automatically then sending SMS message to supervisor's phone number as show in figure 24.

Fig 24: Alert for fire and smoke detection

5.3 Results for an Audio Processing Agent

The experiment on recording students' attendance has been conducted for about a 2-hour duration. The experiment was evaluated using a confusion matrix where it applied to 26 sounds as a test. The training database contains 110 sounds. Confusion matrix for $A_P PA$ agent performance evaluation in Table 4.

Table 4 : confusion matrix for $A_P PA$ agent performance evaluation

Categories Numbers Array			System's Prediction											Classes Names
			class 1	class 2	class 3	class 4	class 5	class 6	class 7	class 8	class 9	class 10	class 11	
System categories numbers array: [9 11 5 10 1 2 6 10 5 11 5 11 10 3 4 8 6 9 11 7 3 8 4 11 3 5 8 1] Actual categories numbers array: [9 11 5 10 1 2 6 10 5 11 11 3 4 7 6 8 11 7 3 8 5 11 3 4 9 1]	Actual	class 1	2	0	0	0	0	0	0	0	0	0	0	Class 1= Mai
		class 2	0	1	0	0	0	0	0	0	0	0	0	Class 2=Noura
		class 3	0	0	3	0	0	0	0	0	0	0	0	Class3=Mahmoud
		class 4	0	0	0	1	1	0	0	0	0	0	0	Class 4= Mona
		class 5	0	0	0	1	2	0	0	0	0	0	0	Class 5= youmna
		class 6	0	0	0	0	0	2	0	0	0	0	0	Class 6 = Islam
		class 7	0	0	0	0	0	0	1	1	0	0	0	Class 7= Esraa
		class 8	0	0	0	0	0	0	0	1	1	0	0	Class 8 = Walla
		class 9	0	0	0	0	0	0	0	1	1	0	0	Class 9 = Shrook
		class 10	0	0	0	0	0	0	0	0	0	2	0	Class 10= Mariam
		class 11	0	0	0	0	0	0	0	0	0	1	4	Class 11= Maha

After conducting tests and full examination of sounds, all the positive and negative values were calculated to measure the performance of the system. Table 5 shows the confusion matrix with TP, FP, FN, TN. Noted that the accuracy of the proposed system in recognizing sounds is 95.8%. The accuracy ratio is due to two reasons: The first reason is the interfering sounds occurred at the time of database preparing which leads to decrease in sound quality. The second reason is the sound saved in the database was recorded in a fast or a slow way while, the tested sound was spoken in an opposite way.

Table 5: The confusion matrix with TP, FP, FN, TN and Accuracy, Specificity, Precision, F-Measure and Recall for $A_P PA$ agent

	TP	TN	FP	FN	Accuracy	Specificity	Precision	Recall	F-Measure
class 1	2	22	0	1	96	100	100	66.666	80
class 2	1	23	0	1	96	100	100	50	66.6666
class 3	3	22	0	0	100	100	100	100	100
class 4	1	22	1	1	92	95.652	50	50	50
class 5	2	20	1	2	88	95.238	66.66	50	57.1428
class 6	2	23	0	0	100	100	100	100	100
class 7	1	23	1	0	96	95.8333333	50	100	66.6666
class 8	1	22	0	2	92	100	100	33.333	50
class 9	1	22	1	1	92	95.6521739	50	50	50
class 10	1	21	0	1	95.65217	100	100	50	66.6666
class 11	4	20	0	1	96	100	100	80	88.8888
Overall					**Mean(Accuracy)=95.8**	**Mean(Specificity)=97.4**	**Mean(Precision)=78.7878**	**Mean(Recall)= 76.66**	**Mean(F-Measure)= 76.56**

Figures 25,26,27 showing (Recall, F- Measure and Recall) curves for $A_P PA$ sound retrieval.

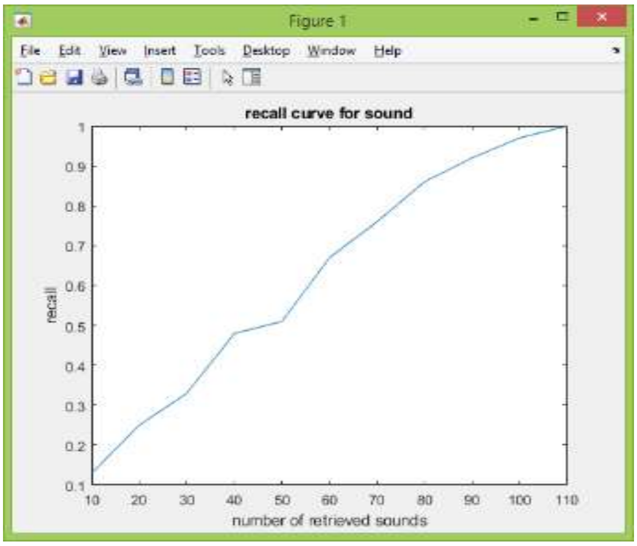

Fig 25: Recall curve for $A_P PA$ sound retrieval

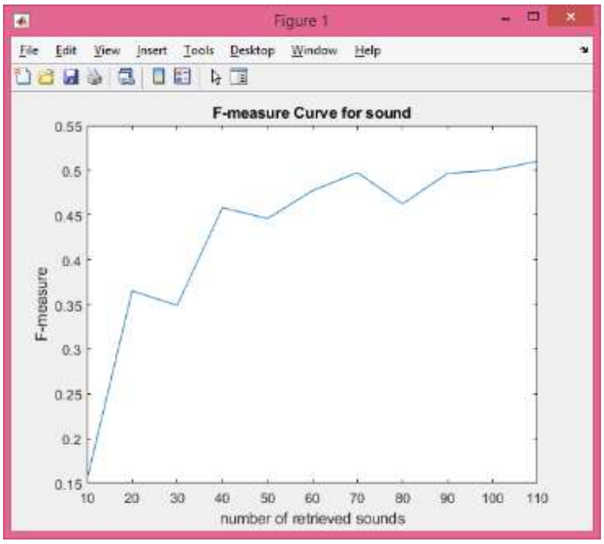

Fig 26:F-Measure curve for $A_P PA$ sound Retrieval

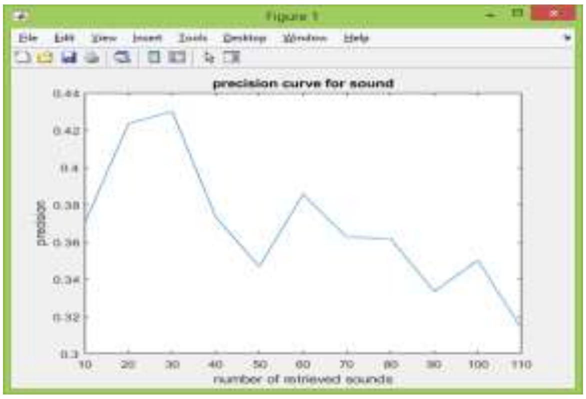

Fig 27: Precision curve for A_PPA sound retrieval

5.4 Results for Rationalizing Electrical Consumption Agent

This agent relies on the use of a motion sensor and a relay switch connected to all electrical devices in the laboratory. The agent has been tested in the absence of movement, the electricity is cut off from the electrical devices and turn off the relay in figure 28, and in the case of there is movement, the relay is turned on to connect electricity to the devices as shown in figure 29.

```
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
motion : 0 - Temperature: 31.20°C - off
```

Fig 28: Case no movement inside lab

```
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
motion : 1 - Temperature: 31.10°C - on
```

Fig 29: Case there are movements inside lab

VI. CONCLUSIONS

The system has been designed to provide several basic features. First, the main motive of the R_tFR agent is to identify and recognize any individual from his/her biometric information like face. The system is able to work in real life conditions by using single face and more than face of a person. It was concluded PCA approach is considered good for recognizing faces from a video or live video in addition to it is one of the best dimensionality reduction approaches face recognition. Finally, the proposed system gives an accuracy of 93%. In future recognition can do with high quality camera. And by doing this might improve system accuracy.

Second, for the $F\&SA$ Agent, having come to an end of the construction of temperature, smoke and fire with SMS alert. This agent constructed a fire prevention and smoke system that can instantly activate an alarm device to issue warnings and messages are sent to the supervisor. In addition, shut off the condition air when it detects a high temperature in the lab.

Third, the aim of an A_PPA agent is recording student's attendance by voice recognition. The results confirmed that the use of MFCC with DTW for voice recording student's attendance is good. The proposed system gives an accuracy of 95.8%.

Fourth, for the R_ECA agent, the daily consumption and disability times after using motion sensor are less than daily consumption and disability times before using motion sensor.

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