May - June 2020
ISSN: 0193-4120 Page No. 3948-3954

Smart Classroom Setup Using Microcontrollers and Multiple Sensors

[1]T. M. Thamizh Thentral, [2]Sourav Panda, [3]Vignesh Balaraman, [4]R. Vignesh, [5]T. R. B Ramanathan, [6]A.Geetha

[1,6]Assistant Professor, [2,3,4,5]Students, Department of Electrical and Electronics Engineering,
SRM Institute of Science and Technology, Kattankulathur, Chennai (T.N.) – India
[1]thentral2kuna@gmail.com

Article Info
Volume 83
Page Number: 3948-3954
Publication Issue:
May - June 2020

Article History
Article Received:*19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *12 May 2020*

Abstract

This paper focuses on smart class rooms in college by installing small internet connected devices and various sensors in each classroom. Arduino is used as the brain of the whole controlling system. The input of the Arduino is connected to the multiple sensors which are fitted across the classroom. Relay, an electromechanical switch is connected to the appliances of the classroom. This relay module receives signal from the Arduino and operates the physical appliances. Sensory units will sense the students and automatically control the switching on and off of fans and lights, opening and closing of doors using RFID scanners and automatically update attendance. This project aims to simplify life and conserve electricity which is one of the most demanded resources in scarcity, make a secure and safe environment.

Keywords: *RFID, Piezoelectric, Smart Classroom*

1. Introduction

In this century, giving and grasping knowledge in the most efficient manner is necessary. Also, conserving energy is important. But the reality is that, this is not achieved and a lot of energy is wasted during teaching in classrooms. The main objective of our project is to bring a transformation in the conventional classroom, making it more secure and effective. This is done with the help of a central controlling unit which is branched into sub-units. Each sub-unit consists of sensory units, communication unit and controlling unit. The primary goal of the project is to provide a system that offers detection of phone usage, smart doors, power saving through both conventional and non-conventional methods. The implementation of the system in educational institutions will have a great impact on students and also will enhance the teaching and learning process. The system strives in minimizing the physical efforts with the help of digital technology. Making classrooms smart would be great step in the process of making India digitalized.

2. Piezoelectric Sensor

Piezoelectric sensors work on the piezoelectric effect. This effect involves a source of mechanical stress upon the sensor due to which electric charge accumulates inside it. The accumulated charge then acts as a voltage source. This piezoelectric effect is a result of the interaction of the mechanical and electrical states. They have a wide variety of applications ranging from medical, nuclear, aerospace industries to quality assurance and process control in various industries [1]. Piezoelectric sensors have sufficiently high modulus of elasticity ranging up to 106 N/m² making them withstand high amounts of stress. They also show negligible deflection and don't react to compression. Also, they are insensitive to electromagnetic radiations enabling operations under harsh conditions. Some of the major disadvantages of piezoelectric are, it has high temperature sensitivity and is used for dynamic measurement only. Piezoelectric crystals are water soluble and gets dissolve in high humid environment.

3. Node Microcontroller Unit (Node MCU)

NodeMCU, an open source platform module which runs on ESP8266 wifi SOC (System on a Chip) is also based on ESP-12 module. It refers firmware rather than referring development kits. NodeMCU is a single board microcontroller based type having XTOS as an operating system. Some specifications of NodeMCU includes it memory of 128kBytes, Storage capacity of 4 megabytes

May - June 2020
ISSN: 0193-4120 Page No. 3948-3954

and power source through USB. Node MCU is much powerful and compact comparing Arduino allowing inbuilt wifi function. Comparing with arduino atmega328, it has more powerful processor, 4MB of memory and more RAM. It is much cheaper than Raspberry Pi and also used for tracking device interactions. This Node MCU does not compile the application rather interprets it while running. This reduces the free space available. Every time there is a need to create free space, the system has to be reset. When the space gets full, it might stop responding to commands. Besides having less space, sometimes the restart system also ceases to start.

4. Servo Motor

Here the servomotor used is a rotary actuator. It consists of four components namely a DC motor, control, gearing set and a potentiometer which acts as a position sensor. The small DC motor is Coupled with a sensory feedback. The feedback is the major difference between a servo motor and a stepper motor. To operate the feedback, a suitable controller is used in this closed loop mechanism. Servomotor has a unique design due to which they have high torque and are fast. They show very accurate rotation in a small range of angle. They are a perfect alternative to stepper motors with higher performance but a little more complicated setup due to the use of PWM tuning. Major disadvantage of a servo motor is its tuning. Tuning a servo motor is a very difficult process as it requires tuning to stabilize the feedback loop. It also requires safety circuits as it will become unpredictable when something breaks. Its peak torque is limited to 1% duty cycle and can be damaged by sustained overload. Feedback components that are necessarily to be used with servo motor makes it more costly than stepper motor.

5. Arduino

Arduino UNO is an open source microcontroller board which is based on microchip ATmega328 microcontroller having number of digital and analog input and output pins. The board consists of 14 digital and 6 analog pins labelled from A0 to A5 and uses one ‘type B’ USB cable. Each of the Digital and Analog pins use functions like pinMode(), digitalWrite(), digitalRead() to operate at the voltage of 5V. Each pin can send or receive signals at a maximum rate of 20mA. One major disadvantage is that if the rate of transmission exceeds 40mA, then permanent damage may be caused to the microcontroller. The ATmega328 provides 5V for serial communication with laptop, Arduino board or any other microcontroller. The transmission of any signal is communicated through digital pins 0 and 1 i.e; RX and TX. The LEDs of pins RX and TX will flash when any data is being transmitted through USB to serial chip which is connected to any computer. This serial communication to any pin is provided through a Software Serial library. Arduino is very versatile as it is compatible with different interfaces i.e. it can run on different operating systems like Linux, Macintosh OSX, Windows operating systems.

It is also user friendly and is flexible enough for advanced programming. It is an open source for both extensible software and hardware. Arduino uses C or C++ with a few small extensions and are not computational efficiency. A lot of the libraries of Arduino are not enhanced well and a lot of improvement is needed. Language of Arduino have been ported to a lot of microcontroller but still mere knowledge of Arduino would never leverage proper hardware level expertise which is required very much as embedded engineer/enthusiast. And finally Arduino strips your hardware level access barring you from many functions.

6. Radio-frequency identification (RFID)

As the name suggests, Radio Frequency Identification (RFID) uses radio signals to identify the tags attached to objects. The tags contain digital data in them. There are two types of tags. Passive tags are the ones which receive energy from any nearby RFID reader which at that time is searching for radio waves in its surroundings. Active tags are the ones in which there exists a local power source such as a battery and because of which they are able to operate hundreds of metres away from the RFID reader, unlike a barcode which needs to be in the line of sight of the reader. RFID is a method for Automatic Identification and Data Capture (AIDC) in the line of sight of the reader. RFID (Radio Frequency Identification) being an automatic ID system like a barcode or magnetic strip provides a unique identification code for scanning devices. It uses radio waves for communication and these waves get converted to digital data for the identification of the object that contains the tag. Scanning range of RFID is limited within its frequency range. It can also scan multiple items simultaneously within a few milliseconds. RFID systems are more expensive than barcode systems and have technology harder to understand. It is less reliable than barcodes and has usually larger RFID tags than barcode labels. All tags are specific i.e.; no one tag fits all. It has possibility of unauthorized reading of passport and also many tags can respond at the similar time.

7. Methodology

7.1. Energy Conservation Piezoelectric Sensor

The lighting is controlled based on the number of students present in the classroom to save energy costs. The lights and fans don’t work when the class is empty. And if students are sitting in a particular section of the classroom, then the appliances only above that particular section works. Rest all appliances remains switched off and thus results in energy conservation throughout the day. This process is carried out in following manner. Here, piezoelectric sensors are used which are sensitive pressure sensors. The chairs in the room are equipped with these sensors which respond to the occupancy. The presence of a student is detected by the piezoelectric sensor and then it sends the signal to Arduino and the corresponding appliances gets switched on. The circuit diagram for the same is shown below in figure 1 along with its hardware circuit.

Figure 1: Flow Diagram

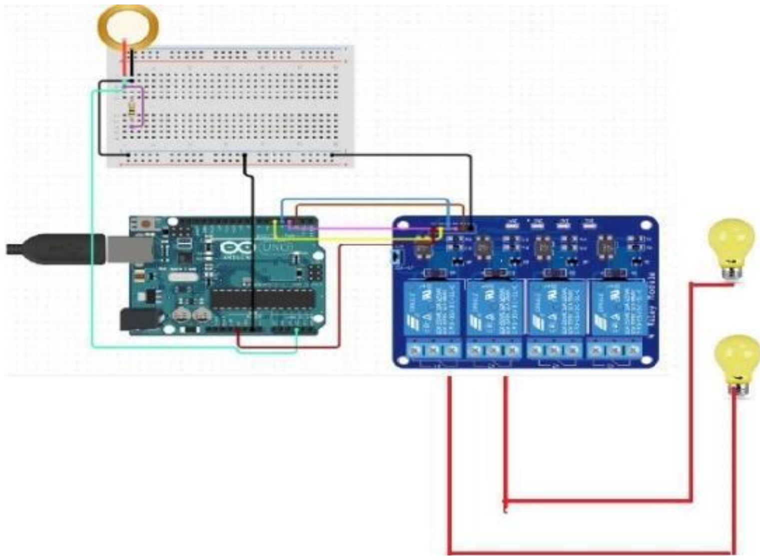

Figure 2: Circuit Diagram

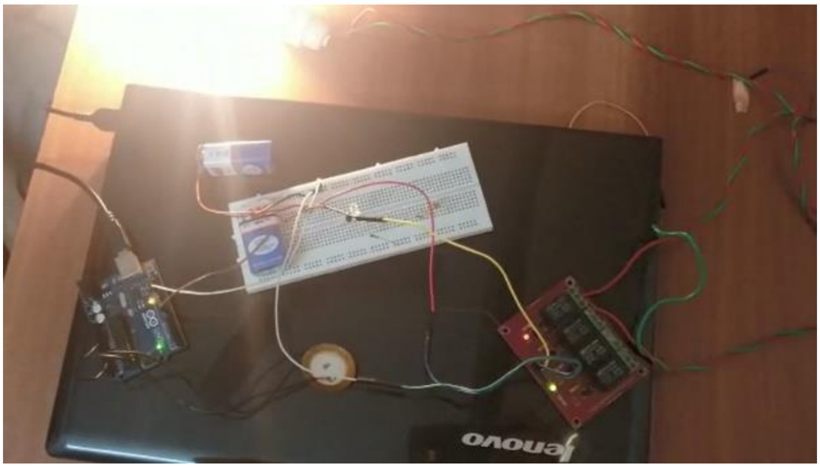

Figure 3: Hardware Circuit

7.2. Energy conservation Image Processing

Image processing is a process of capturing the data, processing it, compress it, store it, print it and accordingly displaying that image. Images should be taken using digital camera. Camera should be perfectly placed covering the entire classroom. In this the camera captured real time images with some intervals of time and reference image is taken only once in a time for setting. The images after being captured are run in the main program using certain algorithms.[3] The real time image which is captured is a coloured one. The image is then split into many cells and each cell is simply the area covered.

The image processing code consists of 2 parts:

May - June 2020
ISSN: 0193-4120 Page No. 3948-3954

- Face Recognition
- Sending the coordinates of detected face to Arduino.

The first face recognition part consists of taking the image from camera input which may or may not consist face. The detected image or camera image checked for face using HAARCASCADE file which gives the coordinates of upper left corner of face in (x,y,w,h) where x,y are the top left corner coordinates and w,h are width and height to make a rectangle for the detected face. Now the x,y of face is tested to check the region were face is situated. The whole image input is divided into four planes 1,2,3,4 and face detected in any one of the plane changes the value of coordNumber[i] array to 1 which consist only 0 initially [6].

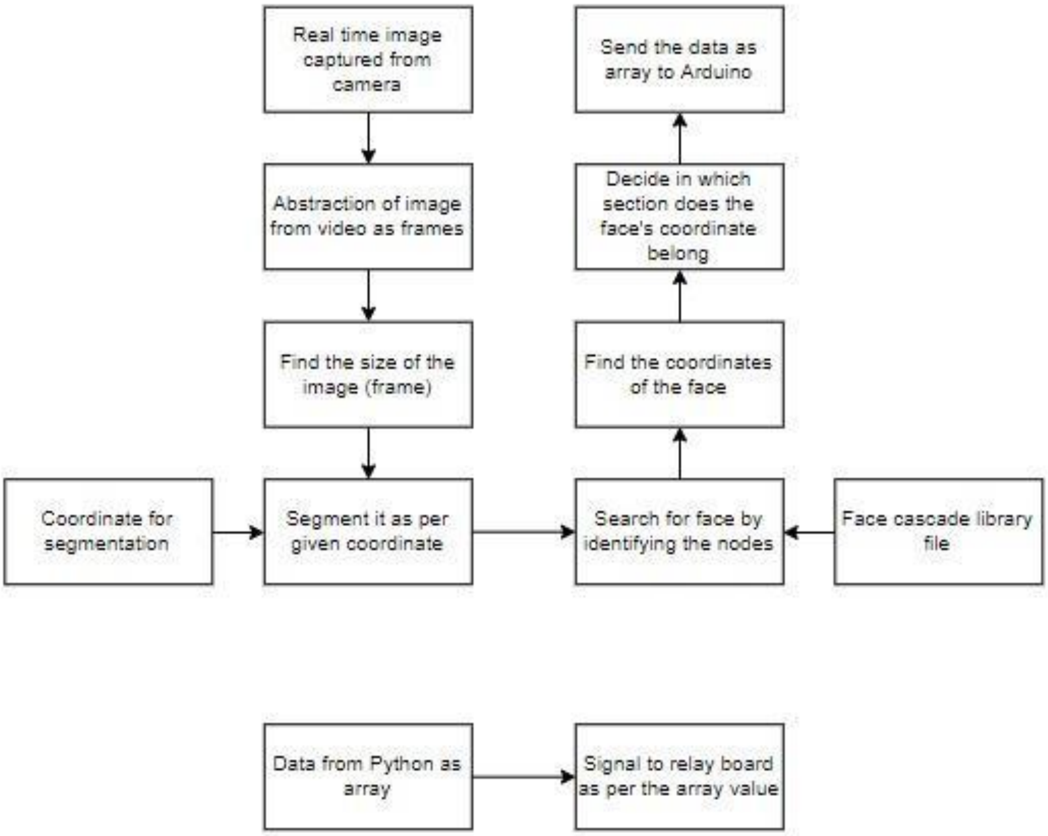

Figure 4: Flow Diagram

For sending the coordinates, the coordNumber[i] array is checked for 0 or 1. If coordNumber[i] has value 1, then using serial writing method ‘1’ is sent to Arduino and if coordNumber[i] is 0 then ‘0’ is sent to Arduino. In Arduino, the receiving serial input is stored in an array a[i] of size 4. Each array index is linked with Arduino pin 13,12,7 and 8. If array input a[0] is ‘1’ then 13 pin light switches on and if it is ‘0’ then 13 pin light switches off. Similarly, the switching for 12, 8 and 7 pin with a[1], a[2] and a[3] is done. Counter variable is also used to put some delay in output so that there will not be any instant switching.

On the human face the parts which are detected are located at a particular relative distance from each other. These are referred to as nodes. There are a total of 5 nodes on a human face. When all these nodes are detected, it counts as one face. The image is then converted from RGB form to Gray form[3]. The circuit diagram for image processing has been depicted below along with its physical demonstration using the laptop camera which also includes its hardware circuit.

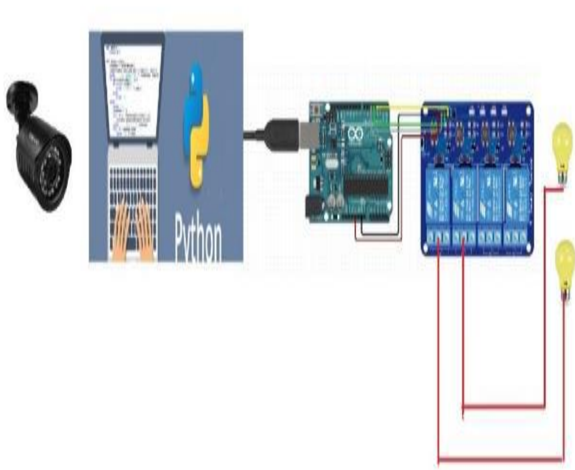

Figure 5: Circuit Diagram

TEST Engineering & Management

May - June 2020
ISSN: 0193-4120 Page No. 3948-3954

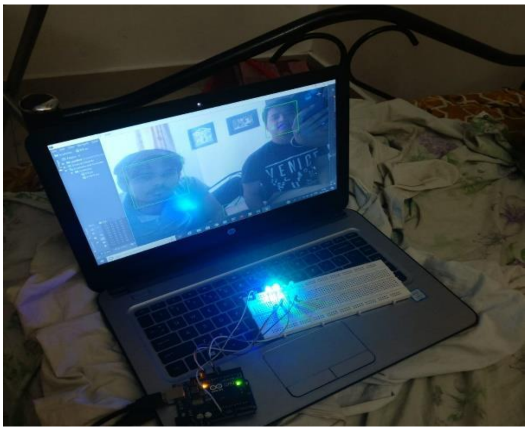

Figure 6: Hardware Circuit

7.3. Auto update of attendance using RFID and implementation of smart door using servo meter

Here attendance of the student is captured automatically through the radio frequency identification and electromagnetic fields. Every RFID tag has a data holding capacity of 2kB. This 2kB of data in RFID can be used to store various information such as registration number, name, post (as in our case can be used to differ a person as student or staff), level of staff or year of study in case of student. RFID-EM18 is used to scan and read the data stored in RFID cards. RFID-EM18 is connected to Arduino.

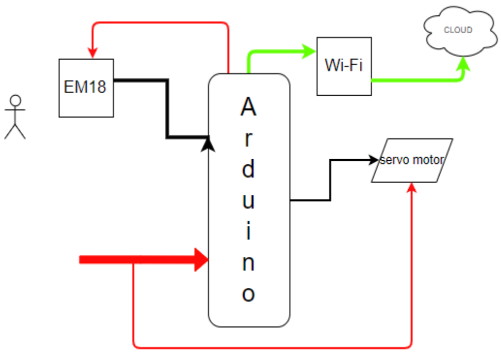

Figure 7: Flow Diagram

RFID-EM18 receives power of 3.3 V from the Arduino. The RFID-EM18 has nine pins namely VCC(this pin is connected to the positive terminal of the power source in our case Arduino), BUZZ(this pin is connected to the buzzer which allows user to know about the action has taken place), 2 NC pins(no connection is given to this pin), SEL(this is an input pin which is used as a selector for output if SEL = 1 the output is at rs232 and if SEL = 0 then the output is WEIGAND, TX(data pin of RS232), GND, (ground pin is used to power up the IC and generate the electromagnetic wave required to read data from RFID card by completing the circuit).

Once the data is sent to Arduino through SPI interface it stores the data in an assigned cloud location and sends signal to the servo motor which is used to open or close the door after authentication of the particulars. It is quite often found that students enter class or move out of the class without permission. To avoid this, smart door has been designed which employs opening and closing of the door at stipulated time on scanning the RFID card. Thus entering and leaving the class has been accounted for by RFID which also helps us to auto update the attendance making the whole process more systematic. Once the teacher enters the class and scans the RFID card, the reader finds the presence of the teacher and disables the system after a delay of 5 minutes, so that no one interrupts the class once teaching process has been started [5].

The figure below shows the circuit diagram involving the servo motor and the RFID card reader. Below the circuit diagram is an image of the hardware circuit involved.

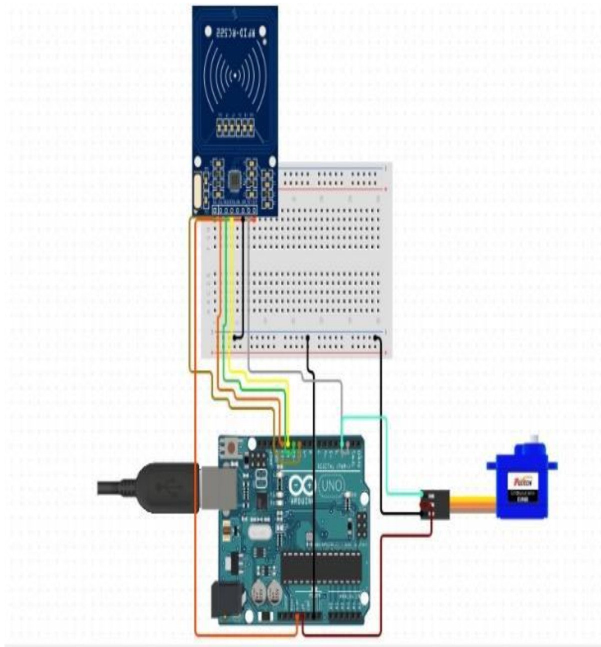

Figure 8: Circuit Diagram

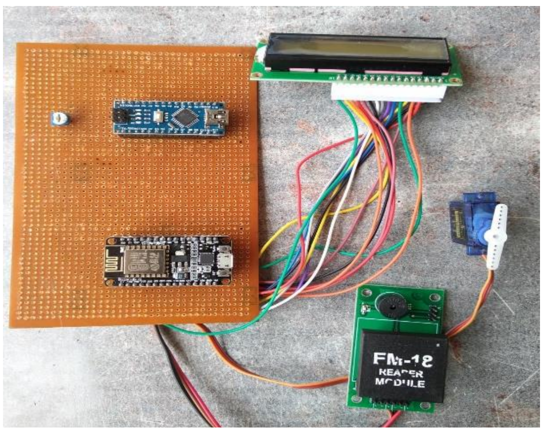

Figure 9: Hardware Circuit

8. Calculation for Energy Savings

For one classroom:

Light: 40 Watts

No. of lights: 9

Fan: 70 Watts

No. of fans: 7

General Case:

Power consumed by all fans in one hour: 70 x 7 = 490 Watt-hour

Power consumed by all lights in one hour: 40 x 9 = 360 Watt-hour

Total power consumed by all equipments in one hour: 490 + 360 = 850 Watt-hour

Number of working hours in a day: 9 hours

Assumed number of lectures per classroom in a day: 6 hours

Assumed number of buffer hours (when someone sits in the classroom during his/her free hour and switches 'ON' all lights and fans) per classroom in a day: 2 hours

Assumed number of hours when all equipments are in 'OFF' state: 1 hour

Total number of hours all equipments are working: 8 hours

Total power consumed by all equipments in one day: 850 x 8 = 6800 Watt-day

Total number of working days in a month: 22 days

Total power consumed in a month: 6800 x 22 = 149.6 kW

Cost of electricity per kW for educational institutions in Tamil Nadu: Rs.6.35/kW

Total cost of electricity consumption in one month per classroom: 149.6kW x 6.35 = Rs.950 Our case (Smart Classroom)

2 hours buffer

2 lights and 2 fans working due to minimal number of students Power consumed by 2 lights: 40 x 2 = 80 Watt-hour Power consumed by 2 fans: 70 x 2 = 140 Watt-hour

Total power consumed: 80 + 140 = 220 Watt-hour

Total number of buffer hours in a day: 2

Total power consumed in a day: 440 Watt-day

Total number of working days in a month: 22 days

Total power consumed in a month: 440 x 22 = 9.68 kW

Cost of electricity per kW for educational institutions in Tamil Nadu: Rs.6.35/kW

Total cost of electricity consumption in one month: 9.68kW x 6.35 = Rs.61

6 hours lecture

Out of 6 hours:

(a) 3 hours full strength, so all equipment are working Power consumed in one hour: 850 Watts

Number of hours in this scenario: 3

Total Power consumed in a day: 850 x 3 = 2.55 kW

Total number of working days in a month: 22 days

Total power consumed in a month: 2.55 x 22 = 56.1 kW

Cost of electricity per kW for educational institutions in Tamil Nadu: Rs.6.35/kW

Total cost of electricity consumption in one month: 56.1 kW x 6.35 = Rs.356

(b) 3 hours less strength, so 4 Fans and 6 Lights are working

Power consumed by 2 lights: 40 x 6 = 240 Watt-hour

Power consumed by 2 fans: 70 x 4 = 280 Watt-hour

Total power consumed: 240 + 280 = 520 Watt-hour

Total number of hours in a day: 3

Total power consumed in a day: 520 x 3 = 1.56 kW

Total number of working days in a month: 22 days

Total power consumed in a month: 1.56 x 22 = 34.3 kW

Cost of electricity per kW for educational institutions in Tamil Nadu: Rs.6.35/kW

Total cost of electricity consumption in one month: 34.3 kW x 6.35 = Rs.218

May - June 2020
ISSN: 0193-4120 Page No. 3948-3954

Total cost of case (a) and case (b) and buffer case: Rs.356 + Rs.218 + Rs.61 = Rs.635

Total saving in one month for one classroom: Rs.950 – Rs.635 = Rs.315

Number of working months per calendar year: 9 months

Total saving in 9 months for one classroom: Rs.315 x 9 = Rs.2835

Assumed number of classrooms in one building: 20

Total saving in 9 months for 20 classrooms: Rs.2835 x 20 = Rs.56700/year

9. Conclusion

The Smart Classroom project which includes a number of parts has been proposed. Energy conservation using piezoelectric sensors and image processing, smart doors and auto update attendance using RFID tags have been demonstrated by implementing the hardware circuit. Also, a rough estimate of cost savings is also calculated if such smart classrooms are adapted in a college building. The huge amount of saved money despite little high initial setting up costs depicts that upon real life implementation, it can be highly effective.

References

[1] Li Tianze; Zhang Xia, Jiang Chuan, Hou Luan "Analysis of the characteristics of piezoelectric sensor and research of its application"

[2] S. Zhong, Xiaoliu, Li Haixia, Du Jing, & Nie Fengua (2014), "Smart Classroom: From Conceptualization to Construction" 2014 International Conference on Intelligent Environments. doi:10.1109/ie.2014.56

[3] F. MarquCs B. Marcotenui, F. Zanoguera P. Correia R.Mech, M. Wollborn, "PARTITION - BASED IMAGE REPRESENTATION AS BASIS FOR USER-ASSISTED SEGMENTATION" -7803-6297/7/2000 IEEE

[4] Zhang YueNan, "Based on the Matlab Image Enhancing Technology and Implementation", – IEEE Smart City - 7383995

[5] Eun-Kyu Lee, Peter Chu, Rajit Gadh, "Fine-Grained Access to Smart Building Energy Resources", IEEE Internet computing, 2013

[6] Saber Talari, Miadreza Shafie-khah, Pierluigi Siano , Vincenzo Loia, Aurelio Tommasetti and João P. S. Catalão , "A Review of Smart Cities Based on the Internet of Things Concept".

[7] V. S. Shah, Mr. S. A. Shah 'Paper Title Power Saving by Using Image Processing '.