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Smart Laboratory

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ABSTRACT

In this era of Digitization and Automation, the life of human beings is getting simpler as almost everything is automatic, replacing the old manual systems. Nowadays humans have made internet an integral part of their everyday life without which they are helpless. Internet of things (IOT) provides a platform that allows devices to connect, sensed and controlled remotely across a network infrastructure. Our project basically focuses on Laboratory automation 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. The system designed is economical and can be expanded as it allows connection and controlling of a number of different devices.

KEYWORDS: *Internet of Things, automate lab components, save energy, face recognition*

1. INTRODUCTION

This section describes the term IOT and introduces the concept of IOT Technology. It also gives the overview of the Smart Laboratory which describes the deliverables of the project.

1.1 Overview

The Internet of Things is connecting everyday objects intelligently to the Internet to enable communication between things and people, and between things themselves. The devices can be any physical objects like smart-phones, Internet TVs, sensors and actuators [1]. For the objects to collect and exchange data electronics, software, sensors and network connectivity is embedded into them. This technology has endless possibilities and in night applications. Everyday devices are made smart and intuitive and by enabling them to share data intelligently they can be used to improve people's lives. It can be used to provide better personal safety, monitor health, save time and make better use of our natural resources. IOT has made a huge impact in the way people live, work and communicate. Internet of Things (IoT) deals with billions of intelligent objects which would be connected to sense collect the data and also communicate with surrounding people using mobile, wireless and sensor technologies. Main objective of IoT is to manage and control physical objects around us in a more intelligent and meaningful manner [1] and also improve quality of life by providing cost effective living including safety, security and entertainment. Smart objects gather useful contextual data autonomously and send to remote application servers for offering context aware or location-based services. The word "context" can refer to any location information, surrounding environment, people objects that are nearby etc. so that adaptive and personalized services can be provided to the user. Among many IoT applications, smart homes play an important role in realizing smart cities. Smart homes can be used for remotely monitoring and controlling electrical appliances. Fitted inside the home using smart intelligent physical infrastructure. The present Government of India (GoI) has proposed to develop 100 smart cities [3] across the country which will create a huge demand for smart home automation solutions in near future. In "Smart Home" the word "Smart Home" means context aware which can be realized using Information and Communication Technology (ICT) and IoT. Laboratory As shown in Figure 1.1, In this project we are going to build system which automate various laboratory component. System will provide the remote control of lights, fans, window curtain and door lock/unlock depend upon person presence. The System is managed to change environment on basis of the data provided by sensor. This system will reduce human effort for maintaining lab and also save energy.

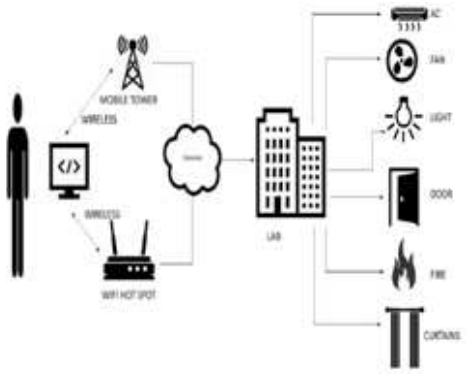

Figure 1.1: Concept of Smart Laboratory

2. Literature Survey

In this section we will see the various studies and research conducted in order to identify the current scenarios and trends in Home Automation and also introduce motion Base detection.

2.1 Automation technique with Raspberry Pi using IoT

Sensors and Systems present a proposed system for Smart Home Automation technique with Raspberry Pi using IoT and it is done by integrating cameras and motion sensors into a web application. To design this system, they have used a Raspberry Pi module with Computer Vision techniques [1]. Using this, we can control home appliances connected through a monitor-based internet. Raspberry Pi operates and controls motion sensors and video cameras for sensing and surveillance. For instance, it captures intruder's identity and detects its presence using simple Computer Vision Technique (CVT). Whenever motion is detected, the cameras will start recording and Raspberry Pi device alerts the owner through an alarm call [1].

2.2 Local Networking or by Remote control

Home automation is becoming more and more popular day by day due to its numerous advantages. This can be achieved by local networking or by remote control. There paper aims at designing a basic home automation application on Raspberry Pi through reading the subject of the algorithm for the same has been developed in python environment which is the default programming environment provided by Raspberry Pi. Results show the efficient implementation of proposed algorithm for home automation. LEDs were used to indicate the switching action [2].

2.3 Reduction in Cost and Power supply of wireless system

Given the reduction in cost and power supply of wireless systems along with the increasing demand for conserving energy when controlling consumer electronics and home appliances, smart home automation systems are more popular than ever before. A home automation system designed for reducing electricity consumption typically uses different sensors located in different areas of the house that communicate with a process unit to control the lights, HVAC system, consumer electronics, etc., so that the process unit turns these systems on only when needed [3].

3. Problem Definition

To implement a smart Laboratory system using Internet of things that is capable of controlling and automating laboratory component and environment through an easy manageable web interface.

3.1 Need of Automation

Automation is the technology by which a process or procedure is performed with minimum human assistance [1] Automation [2] or automatic control is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat-treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention. In industry there are very huge labs having hundreds or thousands of computers and some other electronic components such as Fans or AC's, Lights etc. to control them requires much human efforts, sometime unnecessarily some devices get on because of that energy get lost.

3.2 Basic Concept

Lab automation is building automation for a lab, called a smart lab. A lab automation system will control lighting, fans, curtains, and other appliances. It may also include lab security such as access control and alarm systems. When connected with the Internet, lab devices are an important constituent of the Internet of Things.

4. Analysis

In this section we describe the project plan adopted and determines the requirement analysis.

4.1 Project Plan

The following Table 4.1 describes the project Analysis. It compares normal lab with smart lab. Following formula is considered for analysis:

- Energy = Power * Time
- 1 KWh = 1 Unit = Rs 5

Sr. No.	Normal Lab	Smart Lab
1	Fans 1 hr = 70 W = 0.07 kW, 0.07 * 5 = 0.35 paise/hour 9 hrs for 1 fan 9 * 0.35 = Rs. 3.15 for 20 fans per day 20 * 3.15 = Rs. 63 So for 1 month total cost for 20 fans 20 * 63 = Rs. 1260	Fans 1 hr = 70 W = 0.07 kW, 0.07 * 5 = 0.35 paise/hour 7 hrs for 1 fan 7 * 0.35 = Rs. 2.45 for 20 fans per day 20 * 2.45 = Rs. 49 So for 1 month total cost for 20 fans 20 * 49= Rs. 980
2	TubeLights 1 hr = 38 W = 0.038 kW, 0.038 * 5 = 0.19 paise/hour 9 hrs for 1 Tubelights 9 * 0.19 = Rs. 1.71 for 30 Tubelights per day 30 * 1.71 = Rs. 51.3 So for 1 month total cost for 30 Tube-lights 30 * 51.3 = Rs. 1026	TubeLights 1 hr = 38 W = 0.038 kW, 0.038 * 5 = 0.19 paise/hour 7 hrs for 1 Tubelights 7 * 0.19 = Rs. 1.33 for 30 Tubelights per day 30 * 1.71 = Rs. 40 So for 1 month total cost for 30 Tube-lights 30 * 40 = Rs. 800

Table 4.1: Statistics of power consumption in Normal lab and Smart lab

5. Design

In this Section describes the System Requirement Specification (SRS) to be implemented for Smart Laboratory system. It also explains the architecture of the system and external interface requirements. We have also described the Risk assessment strategy and the Data Flow Diagram which explains the ow of the project.

5.1 Software Requirement Specifications

The Software Requirement Specification describes the scope of the project, operating environment, user characteristics, design and constraints. It also elaborates the system architecture of the Smart Laboratory system.

5.1.1 Project Scope

Internet of Things (IoT) is creating an environment of convergence in the society. This technology environment brings a paradigm shift in our professional and personal life. As a connected environment, IoT adds customer value and loyalty. Today, IoT is being implemented everywhere which is of human concern like smart city, smart environment, security, smart business process, smart agriculture, home automation and health care [3].

Now a days, automation plays a crucial role in all work places and living homes. Presently automation techniques are implemented either using micro-controller or computer. The Raspberry Pi is a single board computer and it can be used to overcome these problems. Simply, the Raspberry Pi system functions like a computer with small setup as shown in Fig. 5.1. It contains GPIO and USB ports. Using these ports, we can control the appliances with the sensors as well as interface the camera for surveillance. Raspberry Pi can be used for multiple purposes based on our requirement.

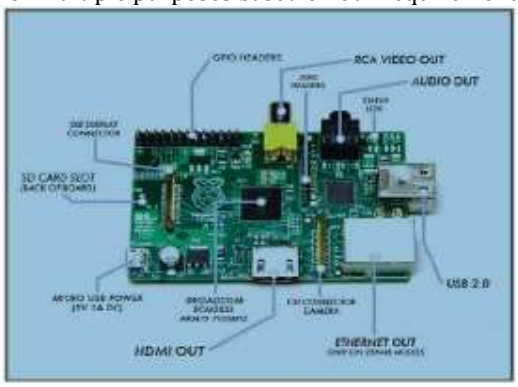

Figure 5.1: Raspberry Pi

5.1.2 Operating Environment

We propose a System which will automate lab environment that will reduce human effort as well as time ultimately save energy consumption. Furthermore, this system has facilities remote control all features.

5.1.3 User Classes and Characteristics

The user who is going to operate the system should have the good Internet connection to control remotely the application.

5.1.4 Face Detection using Open CV

With improving technology security is important things in industrial lab, there already system to unlock door using fingerprint scanner but it not secures easily hack-able. So, we going to use face detection to unlock door.

Figure 5.2: Simple Face Detection Demo

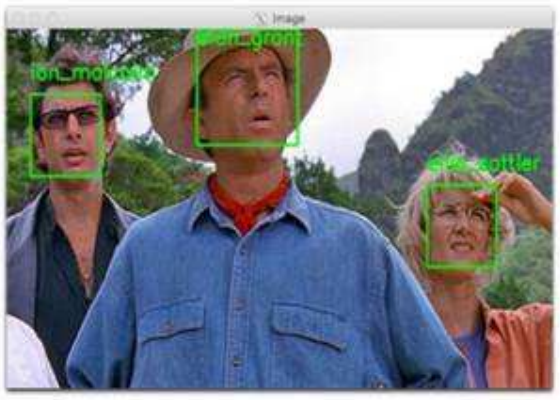

Figure 5.3: Targeted Face Detection Demo

5.2 System Architecture

In the smart laboratory system, there are the various hardware platforms available as shown below. The embedded board connect to various sensor which takes input from surrounding environment. The output data of various sensor will analyze by our software running on embedded board in our case it is a raspberry pi. Depending upon sensor output the actuation will perform.

This System comprises a set of sensors that manages laboratory real-time environmental condition, camera module that provides face authentication, PIR sensor which detect motion of object, LDR sensor detect intensity of light, DHT11 sensor which detect temperature and humidity also there are fire sensor for fire detection and air sensor for air quality monitoring.

There will be web application to controller smart laboratory system which can able to access on mobile phone as well as computer system.

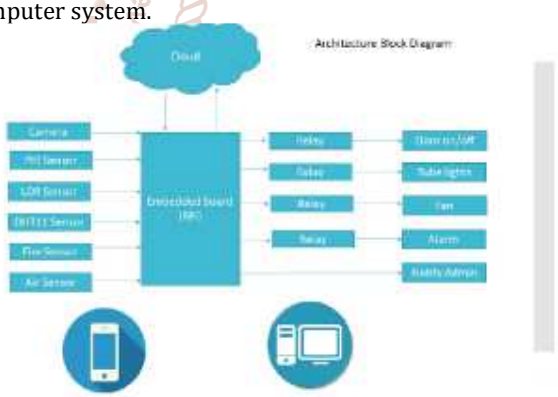

Figure 5.4: Smart Laboratory System Architecture

5.3 External Interface Requirement

5.3.1 User Interfaces

Desktop Application: Using the desktop application the end user will be able to controller smart laboratory system.

5.3.2 Hardware Interfaces

Raspberry Pi:

The Raspberry pi is embedded board. It is a main component in whole system it like "Brain" of our system.

SD card:

The SD card is the Pi's "hard drive", so everything is stored on it, the OS, applications, games, and your data. So yes, it needs to be inserted if you want the Pi to boot up.

5.3.3 Communication Interfaces

The Raspberry PI supports all of these protocols and interfaces. The easies will probably be I2C, and SPI, then UART Serial.

5.4 Software System Attribute

Reliability:

The Lab Automation system built using the IOT should ensure that the SD card is mounted on RPi. Internet facility must be available for controlling the elements remotely.

Availability:

The Lab Automation system shall be available and running in a stable state at all times.

Maintainability:

The Lab Automation system shall be available to the developers for developing and adding more features.

Portability:

The Lab Automation system can be transfer from one lab to another lab.

6. Modeling

This section includes the modeling technique which describes the smart laboratory system. It also describes the functionality of the different features of the lab automation system.

6.1 Class Diagram

The class diagram shows the building blocks of any object-oriented system. Class diagram depicts a static view of the model or part of the model, describing what attributes and behavior it has rather that the detailing the methods of achieving operations. Class diagrams are most useful in illustrating relationships between classes and interfaces. Generalizations, aggregations, and associations are all valuable in reacting interface, composition or usage and connections receptively. The Figure 6.1 illustrates aggregation relationships between classes. The lighter aggregation indicates that the class Object Explorer used Thumbnail, but does not necessarily contain an instance of it. The strong, composite aggregations by the other connectors indicate ownership or containment of the source classes by the target.

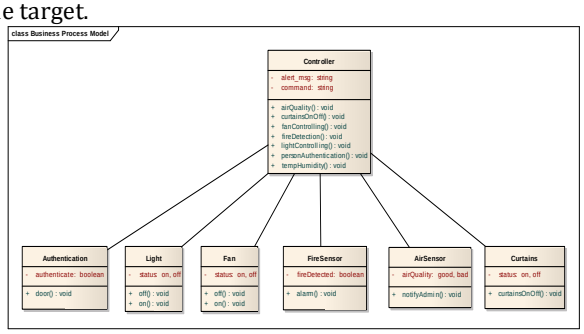

Figure 6.1: Class Diagram

7. Implementation and Results

This section consists of the various implementation details of smart laboratory system as per its methodology.

7.1 Implementation Details

This section describes the various features of the smart laboratory system and also describes the implementation methods. Following are some of the features explained with their implementation details:

- **Unlock the Door Using Facial Recognition:**
  The Multilingual feature is one of the most important features provided by the framework. The framework provides support for the Hindi language along with English; which is a primary language. The framework can provide support for more languages if required. This is implemented using the language packs of the respective language. Using the Language button on the transparent bar the user can switch between the languages. The user input is recorded in a text _le and depending upon the user language selection the typeface of the content titles is changed. The content like theory animations also can be changed to respective language if recorded in that language.

- **Light Controlling Mechanism:**
  This mechanism automating the light controlling system, in which a person enters in the lab the PIR sensor detects the motion of object(person) and sends the signal to Rpi. According to the output of PIR sensor that is if PIR sensor gives high output (i.e. person is detected) then next module will called that is LDR sensor. It will check present intensity level if present intensity level is below the threshold value then light will be going to turn ON otherwise lights will remain turn OFF.

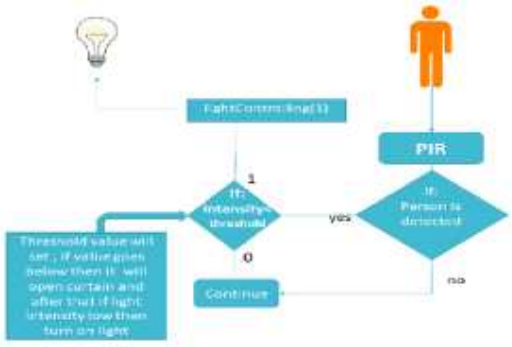

Figure 7.1: Light Controlling Mechanism

- **Fan/AC Controlling Mechanism:**
  This mechanism will automate the manual procedure of controlling fan or AC. In this mechanism when person enters in lab it gets detected by PIR sensor, according to the PIR sensor signals next module will called. If PIR send high signal then Rpi checks the temperature of the lab by DHT11 sensor. If DHT11 sends value of temperature above the threshold value then Fans/Ac get turn ON otherwise it remains turn OFF.

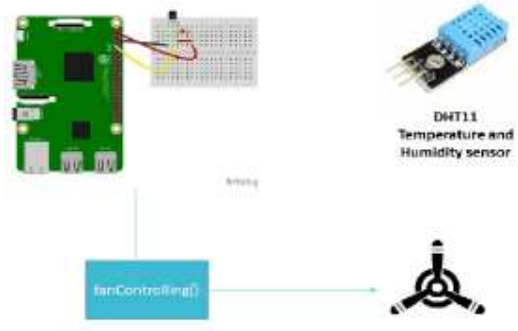

Figure 7.2: Fan/Ac Controlling Mechanism

- **Fire Detection Mechanism:** In this mechanism Rpi detects the fire by using sensor. If fire is detected buzzer will on by Rpi.

Figure 7.3: Fire Detection Mechanism

- **Real Time Air Quality Mechanism:** The sensor MQ135 (Carbon Dioxide Sensor) will sense the Air Quality and send the information to Rpi. Rpi will generate the report and send it to the admin.

Figure 7.4: Air Quality Mechanism

- **Curtains Opening Closing Mechanism:** In this mechanism there are two servo motors connected to the curtains. Admin has options to ON and OFF the curtains.

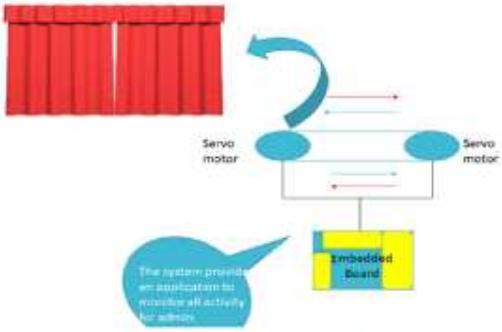

Figure 7.5: Curtains Opening Closing Mechanism

- **Web Interface Manually:**

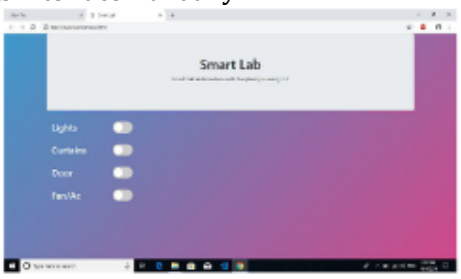

Figure 7.6: web user interface

7.2 Summary

In this we discussed the implementation details of the Smart Laboratory System and also the implementation of various features included in the system. We also saw the results in the form of snapshots of the Smart Laboratory System.

8. Technical Specifications

8.1 Advantages

- This system will save energy.
- System will provide security, to enter in laboratory uses facial recognition with authentication mechanism.
- This system will provide low cost design for the laboratory, system reduces human effort for maintaining lab.

8.2 Limitations

- System required continues power supply.
- Internet required for remote access.

8.3 Applications

This system can be used in following areas:

- Home Automation.
- To automate the huge Industrial Labs.

8.3.1 Hardware Requirements

- Raspberry Pi
- PIR Sensor (Motion Detector)
- DHT11 Sensor (Temperature and Humidity)
- MQ135 Sensor (Air Quality)
- Relay
- Smoke Detector Sensor

8.3.2 Software Requirements

- Python
- OpenCV
- Atom Editor

9. Future Scope

The project Lab Automation system is useful in lab automation scenario using IOT. Although we tried to deliver a project that meets the present requirements of the Automation but there are endless future possibilities. Some are listed below:

- We can use calendar to set task on day, an Artificial Intelligence application will monitor all task. For example, lab admin can set holiday in calendar so that day all system will shut down.
- This project will provide solution at low cost to automation problem.
- Lab Automation system will have a future where developers will be able to add their own features.

10. Glossary

- **IoT:**
  Internet of Things (IoT) is an ecosystem of connected physical objects that are accessible through the internet.

- **RPi:**
  The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse.

- **Computer Vision:**
  Computer vision is a field of computer science that works on enabling computers to see, identify and process images in the same way that human vision does, and then provide appropriate output.

- **Python:**
  Python is an interpreted, object-oriented, high-level programming language with dynamic semantics. Its high-level built in data structures, combined with

dynamic typing and dynamic binding, make it very attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together.

- **Open CV:**
  Open CV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. Open CV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products.

- **Atom Editor:**
  Atom is a free and open-source text and source code editor for macOS, Linux, and Microsoft Windows with support for plug-ins written in Node.js, and embedded Git Control, developed by GitHub.

11. Conclusion

Now days things are getting automated. Need of automation increasing day by day. Adding some 'smarter' components brings more flexible control. A Smart Laboratory that uses internet-connected devices to enable the remote monitoring and management of appliances and systems, such as lighting. By considering this need our project automating the events in laboratory. Our Project will save the energy as the components remains turn of if there is no one in lab. Saving energy is directly proportional to the cost. The main purpose of our system is to reduce human efforts. We are providing face recognition to authenticate the person, so that security is maintained. There is also a manual mode by which events can manage by manually.

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