



DESIGN AND OPTIMIZATION OF VISION BASED  
LIGHT CONTROL SYSTEM  
FOR SMART DEPARTMENTAL STORE

A Thesis submitted to the  
Dept. of Electrical & Electronic Engineering, BRAC University  
In fulfillment of the requirements for the  
Bachelor of Science degree in Electrical & Electronic Engineering

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**DECEMBER 2013**

# Declaration

I do hereby declare that the thesis titled “Design and Optimization of Vision Based Light Control System for Smart Departmental Store “which has been modified and updated from previous thesis project titled “Smart Departmental store” done by thesis group Nabirul Islam(092210110),Shamima Islam Nifa(09221009), Kazi Tanjib Rizwan(09221008). This thesis is submitted to the Department of Electrical and Electronics Engineering of BRAC University, is the original work and was not submitted elsewhere for the award of any other degree or any other publication.

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## ABSTRACT

In our thesis work we explore the various possibilities of enhancing user comfort and operational cost of smart departmental store providing several range of method for maximum utilization of resources. We present a utility-based departmental store that can detect human intervention in every aisle and automatic control system that make adjustments based on conditions such as occupancy, daylight availability assurance as well as ensuring considerable energy saving. The wide array of products and services of departmental store require greater emphasis on maintenance of temperature and humidity and confirming the protection and contamination of the products. Thus the features of stabilizing temperature with the aid of varied sensors help to monitor the betterment of the entire environment. In this modern era, user-centric process of designing and functionality are greatly prioritized for ensuring satisfying user experience in which maximum emphasis is laid for fulfilling the needs, desires and limitation of end users. This paper aims to develop optimization formulation for the benefit of user comfort while reducing the energy cost of lights significantly. The methodology of the paper explores the process of learning human activity and adjusts the light setting in order to provide comfortable environment for the customers while saving energy by turning off unnecessary lights.

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# CHAPTER 1

## INTRODUCTION

### 1.1 MOTIVATION

The modern era beckons to solve the energy crisis along with increasing energy consumption day by day which is creating problem in everywhere. The role of automated control systems in helping to reduce the cost of production and provide production safety with ecological balance preservation is significantly important. Thus, the basic functions carried out in controlling the several parameters on major areas of departmental store as well as management, data exchange, information processing, accumulation and storage, all these methods are interconnected to bring about the improvement of product quality, internal environment, energy savings plans and essential increase in production efficiency. This paper also envisions a design process to optimize the lighting system of a smart departmental store in which the needs, wants and limitations of end users are given extensive attention at each stage. The chief idea behind the elaborate procedure would be allowing satisfaction and comfort rather than forcing the users to change their behavior. Therefore, developing a system model for the current generation lighting system that provides the customers with a comfortable environment and minimizing the energy consumption seemed a magnificent prospective. Furthermore, the essence of understanding the key principles of light, design concepts and lighting technologies that are available in the market are highlighted in this paper. It should be also noted that lighting energy consumption has increased drastically for the past couple of years with the ongoing systems that are grossly inefficient and lack depth of knowledge in the lighting design process. Moreover, through this system development we had done extensive research detailing the methodology to provide suitable light settings and offer user lighting preferences for different scenarios.



## **1.2 PROJECT OBJECTIVE**

Our ambition for this term paper is to achieve advanced functionality and intuitive to use and interpret. The approach to the content of this paper strives to generate needs of the user and engage in a process of automated control system that is focused on adoption, utility as well as efficient performance. Our approach is to develop an intelligent automatic control system aims to minimize power consumption as well as sustainable development of smart energy saving system for our future generation. Moreover, the usage of installed intelligent light controls that enables users to adjust levels according to their preferences inspired us to work on it. Thus, the integration of PIR motion sensors to the lights in low-trafficked areas and high-trafficked areas of departmental store would serve as a replacement of standard light bulbs with no energy-efficient plans. All these motion sensors that we have worked in our project aims to add a bit of energy-savings strategy fostering efficient method to curb the energy crisis. In this project, the internal environment of lighting system is controlled in such a way that when a person leaves or enters the working areas, the PIR motion sensor will sense their movement and switch the light on or off accordingly. The general principles and recommendations for proper lighting installations to enhance the performance and comfort of visual tasks-related activities are emphasized later in this paper. Furthermore, the energy-saving light controls provide comfort, productive visual environment, enhancing quality of work in the departmental store and finally the reduction of lighting costs. Security system ensures the security of the departmental store. All these advantages serve to find the best way to do a job in a departmental store and the way is developed and worked critically in our thesis work.

## **1.3 SCOPE OF PROJECT**

Arduino Uno is chosen to be the microcontroller board for this project as it provides open-source physical computing platform and can take inputs from a variety of lights, sensors and other physical outputs. One of the output leads to the LM35 temperature sensor mounted on a project board and

reads out the external data to the 14 inch display monitor. The other output goes all the way to the humidity sensor, HSM 20G which also reads out its external data via display monitor. Both these sensors are connected to their respective actuators with the help of 6 V Relay. The microcontroller can control the relay connection to the actuators. Among the actuators, a 12 V DC fan is also used in relay connection. For intelligent light controls, the intensity is maintained by the lamps influence on a smaller area of space around it. The motion will be detected by a sensor called PIR (Pyro electric infrared sensor) which will detect the human body in specific area and another is light sensor (LDR) which will detect the light intensity of the specified area. All these sensors will be connected to the microcontroller board with the aid of jumper wires.

## **Chapter 2**

### **System size, Model development and Space type**

#### **2.1 Introduction**

System size provides the factors for the automatic light, temperature, humidity control system in a departmental store to power up the actuators. This system will require a various range of sensors and actuators which will be connected with intelligent chip as microcontrollers. In our project a microcontroller “Arduinouno” is used to ensure better interfacing with the sensors. Sensors and the actuators will be connected with the arduinouno and other circuit components which includes relays that help the actuators to turn on and turn off according to the sensor reading and to the coding in microcontroller. The calculation for the departmental store size, number of LED lights, sensors, air condition and other components plays a vital role for the system size. Efficiency is the foremost concern for this system design.

#### **2.2 Model Development and space type for the departmental store**

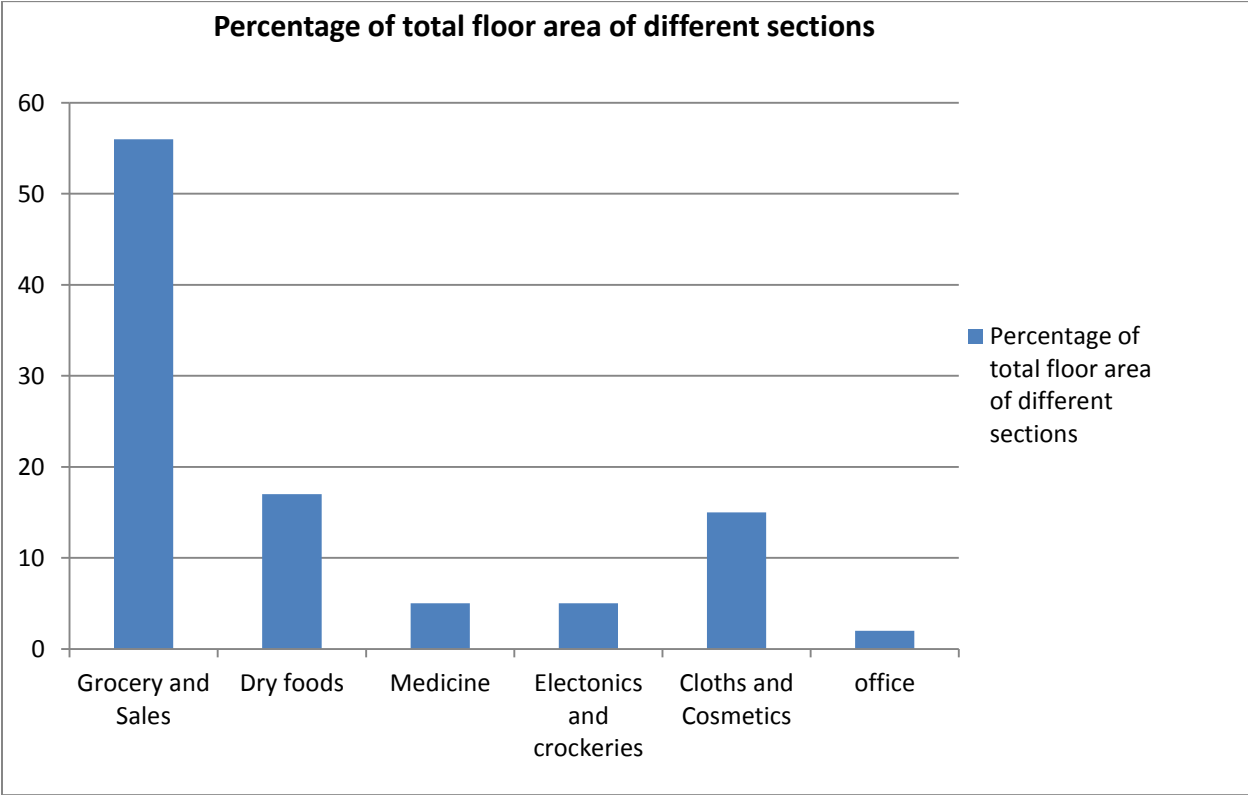
Model development and space type for the departmental store represents typical departmental store well enough to provide specific guidance to increase energy efficiency. This project adopts many aspects of the benchmark project departmental store. In a standard form of departmental store the space area for grocery section is the largest followed by Dry food section which has the second large area. For this project a departmental store of 25000 square feet is taken as a standard form. This departmental store contains six primary sections sales, produce, deli, bakery, dry storage and office. The layout of this project contains six space types, whose name and sizes are shown in table.

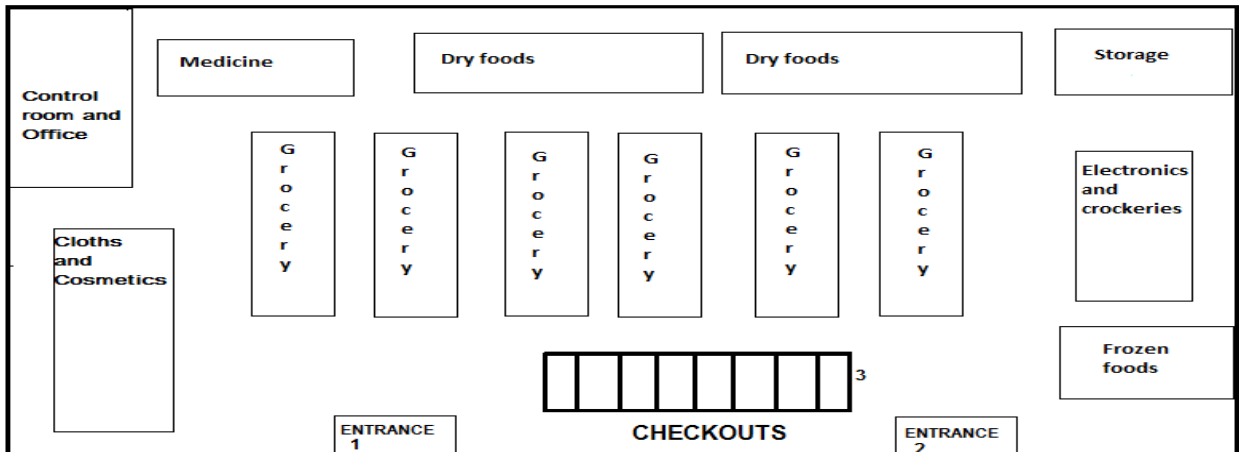
**Table 2.1 Model Development and space type for the departmental store:**

Space Type	Floor Area (ft <sup>2</sup> )	Floor Area (m <sup>2</sup> )	Percent of total
Grocery and sales	14000	1301	56
Dry foods	4250	395	17
Medicine	1250	116	5
Electronic and crockeries	1250	116	5
Cloths and cosmetics	3750	348.51	15
Office	500	46.45	2
Total	25000	2322.96	100

In this model the largest area is allocated for Grocery and Sales. In any departmental store the occupancy density in grocery section is much higher than any other sections and for this reason any departmental store requires larger space for this section. The standard space for grocery and sales section is 50 to 56 percent which says in 25000 square feet the floor area it will require is 14000 square feet or 1301 square meters. The area allocated for dry food is 4250 square feet or 395 square meters, for medicine section 1250 square feet or 116 square meters, for electronics and crockeries 1250 square feet, for cloths and cosmetics 3750 square feet and for office 500 square feet. The percentage area for the sections is given in the table and in the bar chart.

**Bar chart 2.2: Percentage of total floor area of different sections**

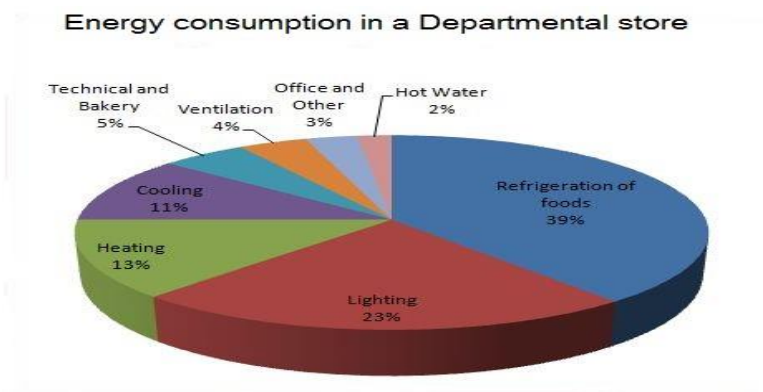




**Figure 2.3: Model and space type of departmental store**

### 2.3 Calculation of necessary power for LED lights

As for efficiency LED lights are optimum choice as it reduces energy consumption up to 88 percent. As in only 20 percent of power loss occurs. From this layout, the number of LED bulbs required for per square feet is determined. There are different calculations for different type of lighting systems. The NEC defines 3 watts per ft<sup>2</sup> for lighting is required in a departmental store and the brightness generally required is from 1100 lumen to 1300 lumen. Wattage 9 to 13 is obligatory for the expected brightness. In this project for power saving and human comfort purposes LED light of power capacity 12 watt and brightness 1100 lumen is used. In a typical departmental store 23 percent of total power consumption is taken by lighting system.



In a departmental store for each square feet area 3 watt is required for lighting purpose. In this project one LED bulb of 1100 lumen is used for every 4 square feet area. The number of bulbs needed is the total area of the departmental store divided by the area covered by each bulb.

$$\text{Number of bulbs needed} = \frac{\text{Total area}}{\text{Area covered by each bulb}} \dots \dots \dots (ii)$$

$$\begin{aligned} \text{Number of bulbs needed} &= \frac{25000}{4} \\ &= 6250 \end{aligned}$$

LED guide formulas are needed for calculating total power that used by the bulbs. There are some formulas for calculation below:

$$\text{Demand for Power}(kW) = \frac{\text{System input Wattage}(W)}{1000} \dots \dots \dots (iii)$$

$$\text{Energy Consumption}(kW) = \text{System input wattage}(kW) \times \frac{\text{Hours of operation}}{\text{Year}} \dots \dots \dots (iv)$$

$$\begin{aligned} \frac{\text{Hours of Operation}}{\text{Year}} \\ = \frac{\text{Operating Hours}}{\text{Day}} \times \frac{\text{Operating Days}}{\text{Week}} \times \frac{\text{Operating Weeks}}{\text{Year}} \dots \dots \dots (v) \end{aligned}$$

$$\text{Lighting System Efficiency(Lumen per Watt or LPW)} = \frac{\text{System lumen output}}{\text{Input Wattage}} \dots \dots \dots (vi)$$

$$\text{Uniot Power Density} \left( \frac{W}{sq. ft.} \right) = \frac{\text{Total System Input Wattage}(W)}{\text{Total Area}(Square Feet)} \dots \dots \dots (vii)$$

$$\text{Watt}(W) = \text{Volt}(V) \times \text{Current in Amperes}(A) \times \text{PowerFactor}(PF) \dots \dots \dots (viii)$$

$$\text{Voltage} = \text{Current in Amperes}(A) \times \text{Impedance}(ohm)[\text{Ohm Law}] \dots \dots \dots (ix)$$

In a 25000 square feet departmental store, 6250 diffused LED bulbs are needed. If one LED bulb consumes 12 watt, 6250 LED bulbs require power per day =

$$\begin{aligned} \left(12 W \times 6250 \times 18 \frac{\text{hrs}}{\text{day}}\right) &= 1350 \text{ kW} / \text{day} \\ &= (1350 \text{ kW} \times 365) / \text{year} \\ &= 492.75 \text{ MW} / \text{year} \end{aligned}$$

LED bulbs consume the least power and have the longest life span, lasting up to 40 or 50 years. LEDs cost about \$36 per bulb. This kind of bulb is both energy-efficient and environmentally friendly, as it does not contain mercury or lead like CFLs do. LEDs also function much better than CFLs when it comes to using dimmer switches. The LED color spectrum is still in development. As of right now, LED bulbs only come in two varieties, cool white light and warm white light. A cost-comparison analysis done by [Eartheasy.com](http://Eartheasy.com) shows that both LEDs and CFLs will save up to of \$10,000 over a 10-year period. The savings for consumers who use LED bulbs will add up to about \$2,000 more.

**2.4 Specific humidity**

Specific humidity is the ratio of water vapor to dry air in a particular mass, and is sometimes referred to as humidity [6] ratio. Specific humidity ratio is expressed as a ratio of mass of water vapor per unit mass of dry air.

$$\text{Absolute Humidity} = \frac{\text{mass of water vapour}}{\text{total volume of moist air}} \dots \dots \dots (x)$$

$$\text{Relative humidity} = \frac{\text{Partial Pressure of water vapor}}{\text{saturated vapor pressure of water at a given teperature}} * 100\% (xi)$$

$$\text{Specific humidity} = \frac{\text{Mass of water vapor}}{\text{Mass of dry air}} \dots \dots \dots (xii)$$

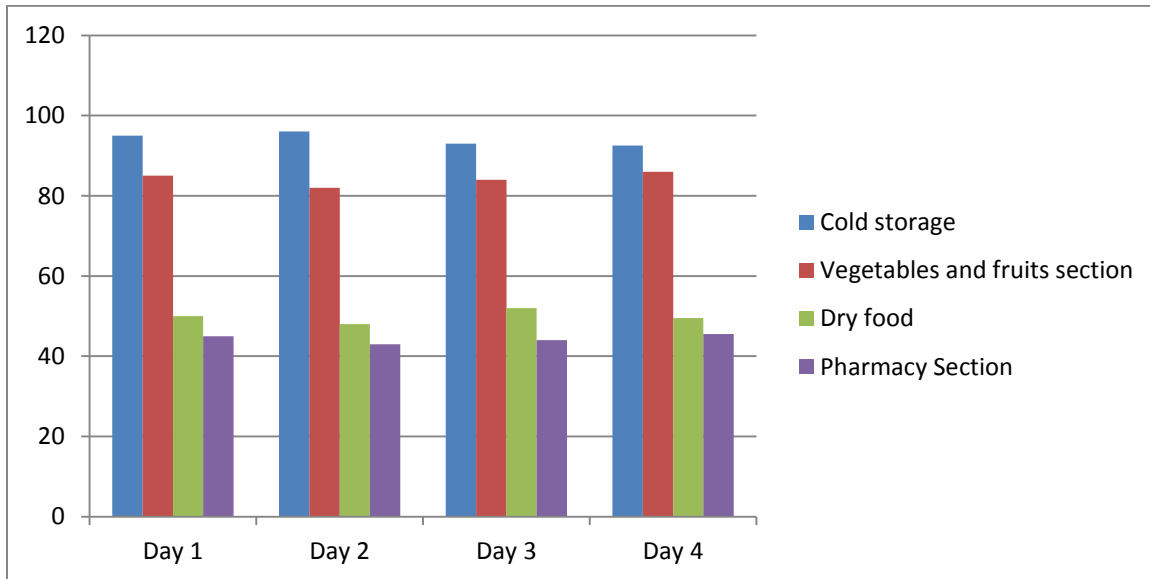
**2.5 Storage environment**

To reduce the risk of accidental contamination it is critical that packaged items be stored in a limited access area, where the storage shelves are clean and environment maintained. Personnel with appropriate attire and frequent hand hygiene are an integral aspect of ensuring an appropriate storage



environment. When relative humidity levels exceed 70% having a controlled storage environment helps reduce the risk of contamination.

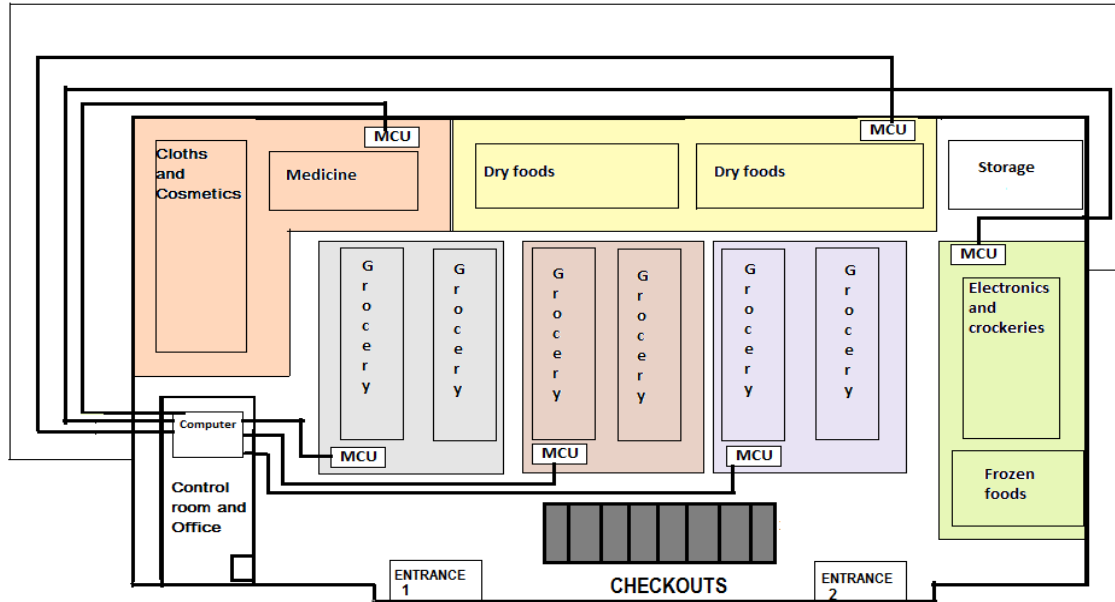
**Chart 2.4: Showing Relative Humidity Levels (%) each day in a departmental store:**



## 2.6 MODEL OPERATION

As the technology advances, more complicated systems emerge, requiring sophisticated components and equipment. After some rigorous researches, components and equipment suitable and available for the system have been selected to ensure the system performance and to please the major objective of the project. This section includes all the researches been done to confirm the appropriate method which are implemented through electrical circuits. These circuits confirm maximum output with minimum system requirements. There are four different individual circuits for each aspects and the final circuit is the integration of all four circuits. For better interfacing with the sensors and actuator the microcontroller used in this project is "Arduino uno". The individual and the complete both circuits are tested under definite experimental conditions and limitations. Temperature control system could not be completely developed because of unavailability of certain actuators.

Here is a model work for the departmental store which will be controlled by MCU.



**Figure 2.5: Control of the departmental store**

## **2.7 CONTROL OF LIGHTING SYSTEM**

Lighting control system is one most important part in departmental store. In this project we have use two different sensors one is LDR (photoresistor) and another is PIR (motion detector) sensor. Here photoresistor is used to determine the light intensity and PIR sensor is used detect human body. Here one part of the LDR is connected to the 5v and another point is connected to the resistor R1 in series. The voltage across R1 is the output voltage and this is the analog input to the microcontroller unit (MCU) arduino. For different light intensity the output voltage will be different. If light intensity rises then voltage across LDR will decrease and voltage across R1 will rise. Also if light intensity decreases then voltage across R1 will decrease. For different output voltage the MCU will turn on and turn the switches of light to control the light intensity in a specific area.

## **2.8 TEMPERATURE CONTROL SYSTEM**

For human comfort in departmental store temperature is one of the most important part which has been controlled. Especially the temperature needed for human comfort in departmental store is 21°C to 24°C. In temperature control we have used LM35 temperature sensor. There are three different pins in LM35 temperature sensor. The first pin is connected to the +5Vdc source from Arduino. The middle pin is connected to the 10Khm resistor in series. The last pin is connected to the ground. The voltage across 10Khm resistor is the output voltage. This output voltage is the input signal or analog signal for MCU.

In different temperature the LM35 temperature sensor provides different output voltage but it changes linearly according to temperature changes. When MCU will get signal from the sensor it will convert the signal and count it as in °C. For example if temperature is 25°C in a specific area then sensor will provide 0.25V across the resistor. Then MCU will convert it to actual temperature and write that value. In our project our purpose is to keep the temperature between 21°C to 24°C. In fig 2.6 shows how the total circuit will work.

When temperature in specific area is higher than 24°C then MCU will turn on the switch or relay by providing digital output to the relay which is equal to 5V. Then the AC will turn on. The temperature of the AC will be adjusted to 20°C. Again if the temperature is below 20°C then MCU will turn off the switch and AC will stop working. For winter season at low temperature inside the store heater will be used to control the temperature. Even in winter season the temperature will be between 21°C to 24°C.

## **2.9 HUMIDITY CONTROL SYSTEM**

In departmental store to keep fresh the vegetables, fruits and other items it is necessary to keep the specific humidity rate in those areas. For different items humidity rate will be different. In departmental store for vegetables and fruits the humidity rate will be 90% to 95% relative humidity. For fruits and vegetables the humidity rate will be 60% to 85% relative humidity. In our project to control humidity we have used HSM 20-G humidity sensor. There are four pins in this sensor where two of them are connected to ground and 5V dc source. And other two pins are the output pin for humidity and temperature. The output pin for humidity is connected with R1 resistor where R1=10Khm. The voltage across R1 is output signal provided by humidity sensor.

## **2.10 GRAPHICAL USER INTERFACE (GUI)**

In computing, Graphical User Interface is a type of user interface that allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation, as opposed to text-based interfaces, typed command labels or text navigation. GUIs were introduced in reaction to the perceived steep learning curve of command-line interfaces (CLI), which require commands to be typed on the keyboard. A window is a (usually) rectangular portion of the monitor screen that can display its contents seemingly independently of the rest of the display screen. A major feature is the ability for multiple windows to be open simultaneously. Each window can display a different application or each can display different files that have been opened or created with a single application.

In this project GUI is used for monitoring the different aspect like light intensity, temperature, humidity, human body detection and security message. In this design there are five windows which indicate the different aspects and two controlling buttons which are used for security purpose.

The purpose of Using GUI in our project is to monitor the light intensity, temperature, humidity, human body detection and security message. The all sensors and actuators will be connected to the MCU (Arduino Uno) where the MCU will connect to the computer of the control room. The MCU will write the values from sensors and through serial communication line computer will read the values and print those to the monitoring box. Here all circuit has been integrated with MCU.

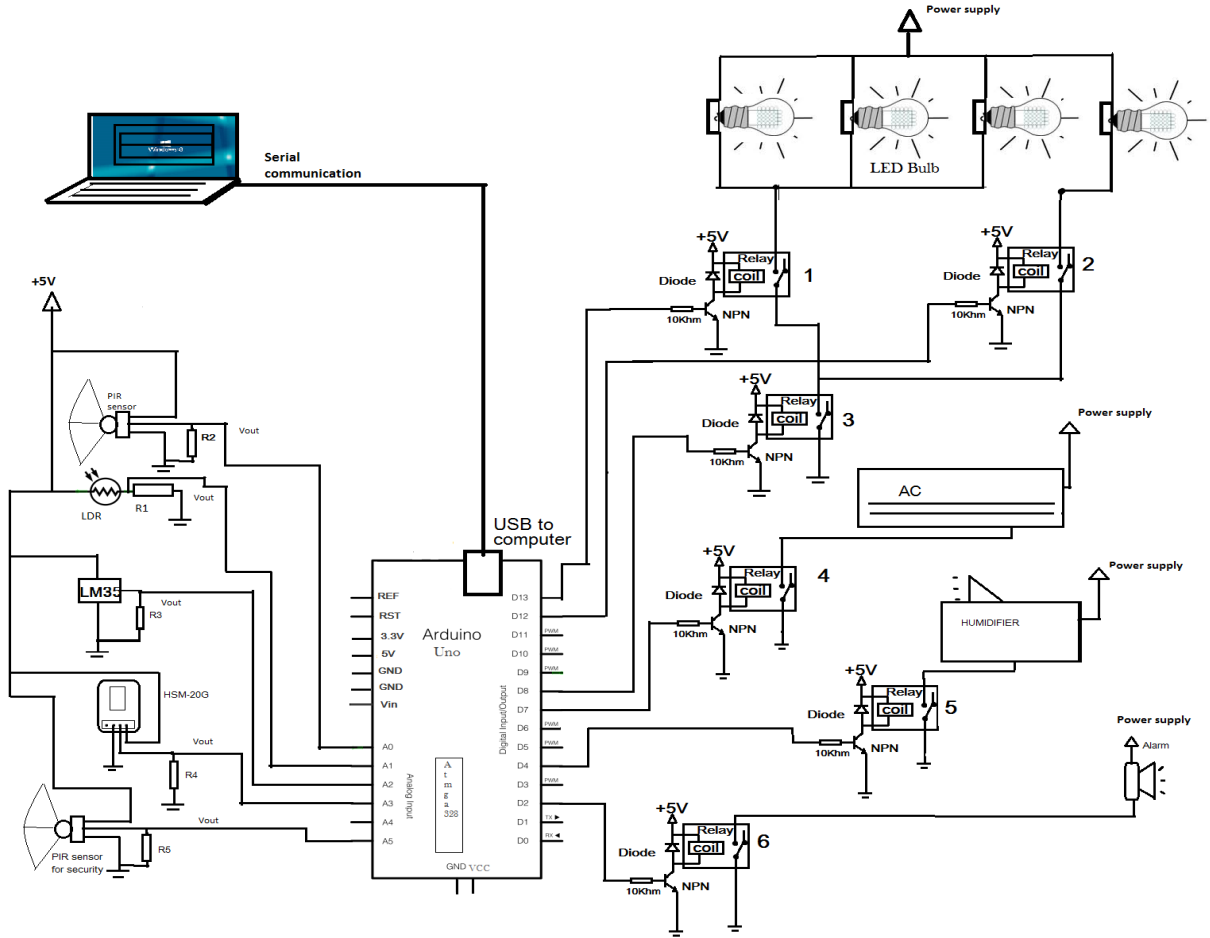
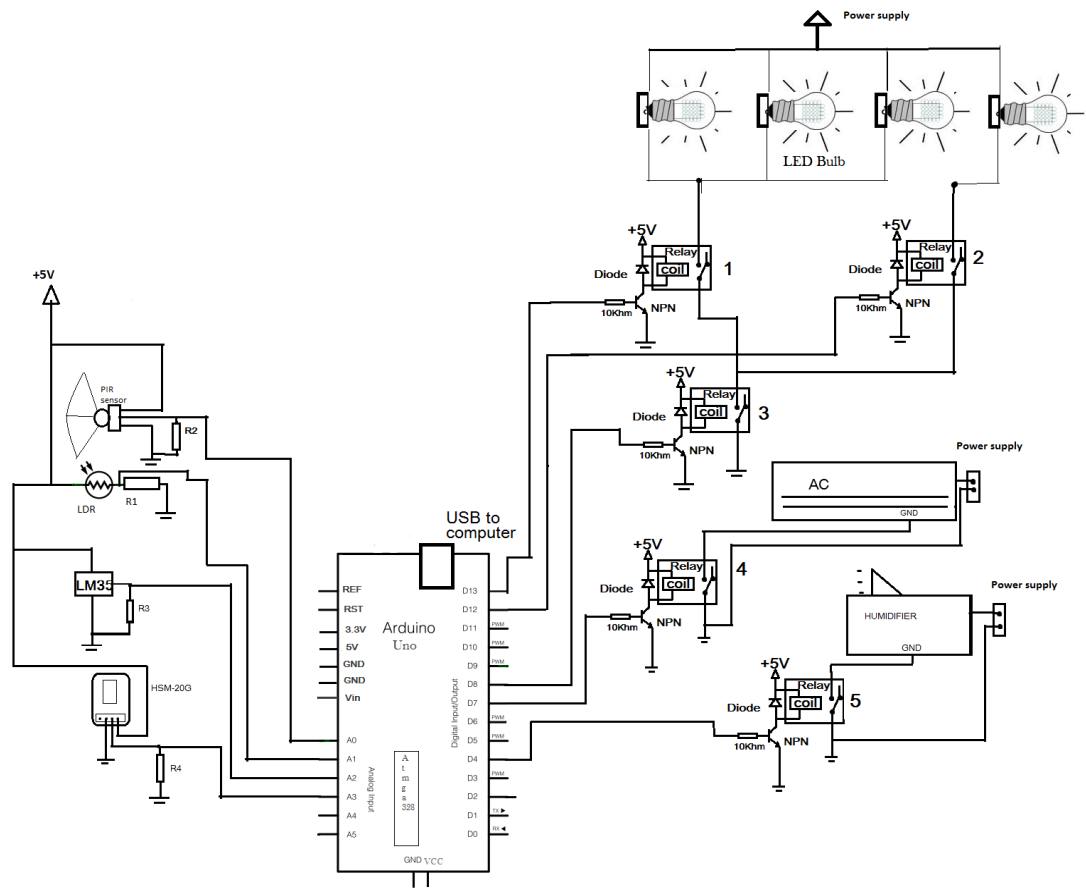


Figure 2.6: Circuit of serial communication with MCU and computer.

### 2.11 INTEGRATED CIRCUIT DESIGN

With three of the major sensors and MCU light, temperature and humidity is controlled in this system. GUI in this system also plays a vital role in terms of detecting human body presence for security purpose during night and by showing the system status in different windows. In hardware implementation all the connections and total implementation was done with sincerity and intensity to ensure the circuits to work properly. In fig 5.13 shows the integrated circuit diagram of light, temperature and humidity control system. Here one MCU (Arduino) will control the total system.



**Figure2.7: Integrated circuit of light, temperature, humidity control system.**

# CHAPTER 3

## Factors That Affect Lighting Parameters

### 3.1 INTRODUCTION

Good lighting design is emphasized in this section as certain aspects of it directly involve in lighting efficiency. A lighting installation cannot be productive and effective without the careful consideration of all the aspect of lighting design. It requires a holistic approach for providing not only enhanced illumination but also comfortable, stimulating and interesting environment.

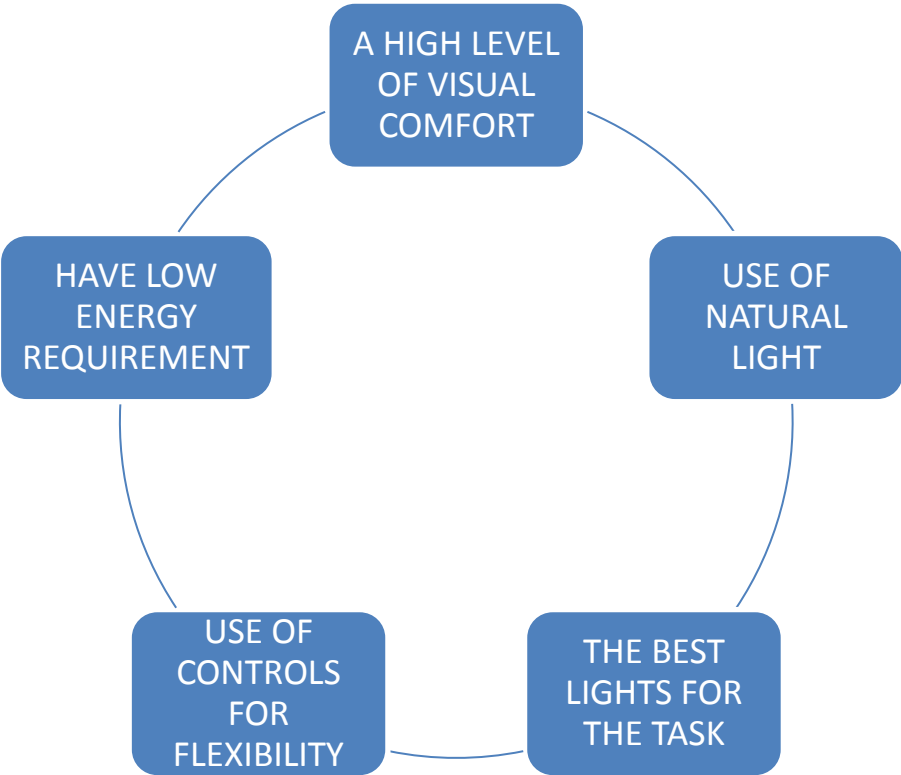


TABLE 3.1: EFFICIENT AND EFFECTIVE LIGHTING SYSTEM PROVIDES:

Proper lighting system is often neglected while considering cheaper alternatives just to keep up with the total expenses within the financial limits. The outcome may be less than satisfactory resulting in sub-optimal lighting conditions and low user satisfaction. Moreover, it is not known by many that initial investment in a well designed lighting installation usually repays in high return-of-investment and lower total cost of ownership during its life span. Before going straight into the selection of lights we had laid down structured design process broadly for the implementation of lighting installation. The steps of the design procedure are explained as we go further.

### 3.2 METHOD OF LIGHTING AND REQUIREMENTS

Considerable efforts are put in determining how the lights will be delivered, e.g. recessed light, mounted, direct or indirect or up-lighting. At this stage the use of daylight to minimize the need for artificial light is also considered. The primary stage involves gaining a full understanding of what the lighting installation is intended for:

### 3.3 Illuminance

The Illuminance  $E$  at a point on a surface can be defined as the luminous flux  $F$  (lumens) incident upon a element of the surface divided by the area  $A$  of that element represented as lumen per square meter or LUX. Typical examples of illuminance level are shown in Fig 4.2.

Light levels for working	Illumination levels
General office task	320 lux
Rough tasks with large detail	160 lux
Ordinary tasks with average detail	320 lux
Difficult tasks with fine detail	600 lux
Minute tasks, detailed inspection	1600 lux

TABLE 3.2: Representation of different Illumination levels for working environment.



While designing lighting schemes we should make predictions of illumination level in order to determine appropriate lights to be used. In some countries, for instance Australia's Building Code of Australia and Occupational Health and Safety Act impose legislation that require sufficiency i.e. adequate quantity of light (illuminance ) on workplace as well as areas where people circulate. Unlike the recommendations in lighting guides which focus on its features, the legislation is aimed for acceptance in quality as well as quantity.

### **3.4 GLARE**

Light that we actually see can be measured as the light leaving from a lamp or reflecting from an object's surface. It is measured in candelas/square meter( $\text{cd}/\text{m}^2$ ). In other words, Luminance is the measure of the amount of light emitted from a surface. The surface can be anything, a small LED surface or wall. Brightness is considered qualitative and depends on our eye adaptation at that time. So the eye can see luminance rather than illuminance and with the same illumination, the luminance of the surface can change proportionally by changing the surface reflectance. Thus, the brighter a task would be, the easier it is to see but if not properly controlled high brightness may result levels of glare that can either impair or prevent a desired task being performed. Glare can be either direct or reflected and causes discomfort or sometime disability. Direct glare may arise straight from the light source and reflected glare shows up on the task itself, for instance computer screen. Strategies implemented to reduce unwanted levels of glare are as follow:

- Indirect light fixtures should be installed as they distribute approximately 90 percent of the light upward rather than downward, diffusing the light and allow the light to reach the work area. They provide the most even illumination amongst other types of fixtures and allow least direct glare.
- Parabolic louvers help to diffuse the fixture's light output and shield the bulb from view. They can be contoured to control light and decrease brightness. Parabolic louvers are basically special shaped grids that concentrate and distribute light.
- Relocating the task until the glare is removed
- Relocating the light sources and changing the surface reflectance of the task

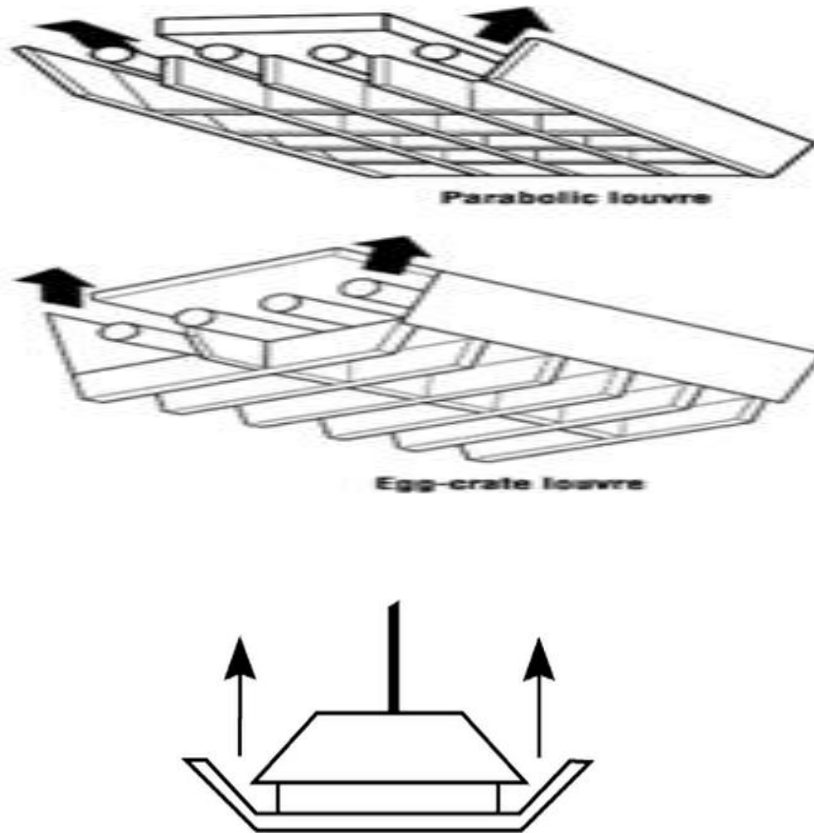


Fig 3.3: Parabolic louvre, egg-crate louvre and indirect light fixtures.

## LIGHTING A SPACE

It is often said that lighting is for people and there must be significant understanding of the visual quality users need for health, safety as well as enjoyment. The science of lighting means utilizing the enormous body of technical knowledge and updating it with new technology to ensure enjoyability of the space, area or subject. Good lighting is always a positive experience which creates a visually enjoyable atmosphere and can be altered from general everyday lighting to dynamic mood lighting. Hence a technologically successful lighting can be long-lasting, durable, energy saving and easy to use and maintain. Some example of issues taken into consideration when lighting a space to ensure that the psychological and behavioral aspects of the users are met:

### 3.5 Vertical and Horizontal Junction

It is important to ensure safe navigation through a space where vertical meets horizontal junctions. The following scenario is explained in fig below, the white hallway on the left in which the junction of vertical and horizontal are same in value and hue. This causes a visual problem for the aging eye. The room on the left also have the same problem but the loss of visibility is due to the specular reflective surfaces.

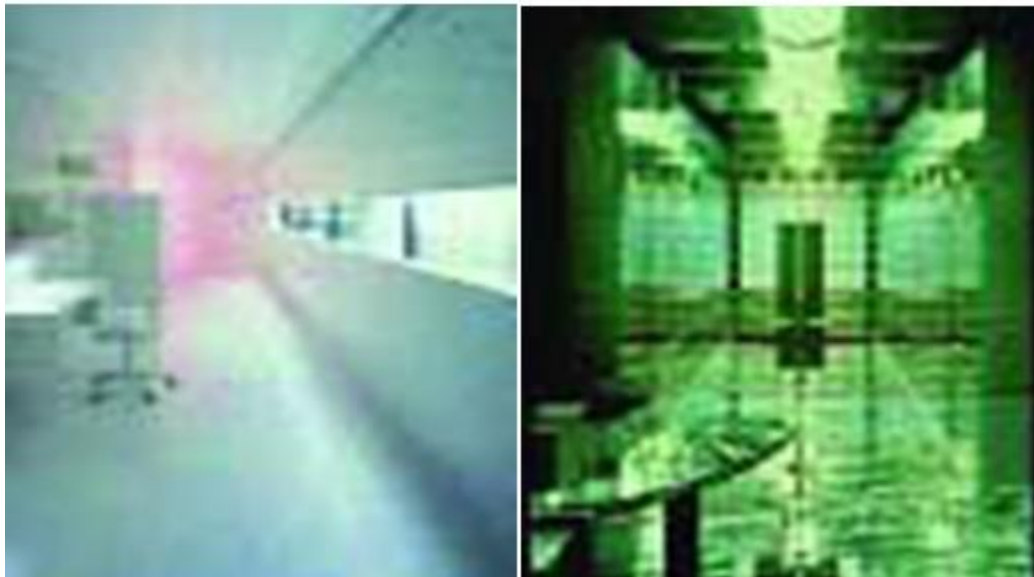


Fig 3.4: The Visibility of vertical and horizontal junctions.

### 3.6 BRIGHTEST PATH

Some research has been conducted for the study of human behavior regarding their response to changes in the levels of illumination. In the study of Taylor and Sucov (1974), 75% of people responded to the path that had a higher level of illumination resulting in his conclusion that people are basically like moths and are attracted to brightness. Brightness can also focus attention by creating a focal point between the object and the surrounding and thereby increasing the impact. Hence it is important to make stronger statement by creating following impression listed below:

**Pleasant:**

Use a non-uniform distribution of brightness in the space instead of majority of lights coming down from the ceiling. The brightness factor will depend on the visual tasks being performed within the space.

**Public:**

Usually rely on higher levels of illumination with a more uniform distribution of light from overhead lighting sources.

**Spacious:**

Provides high levels of illumination over the entire space with even distribution of lights on the walls and uniform lighting on all surfaces.

**Visually Clear:**

Provide higher luminance on the activity or task concerned with other small peripheral luminance.



Our goal of the lighting system also maintains the standard design practice considering the expected activity levels and expected costs. For instance, in our system model, which is a large department store with a crowded shopping pattern, needs a very public approach to lighting. The figure above shows a lighting design of a crowded departmental store.

### **3.7 SELECTION OF LIGHTING EQUIPMENT**

Once the method of lighting has been selected as in how lights would be delivered e.g. mounted, indirect or direct, up-lighting, also giving considerable attention on brightness factor. The next stage involves the choice of appropriate light source. A number of factors that were taken in to consideration for determining the choice of lamp are:

- Characteristic of the light source and control gear
- Luminaire Efficiency (i.e. % of lamp output that can be transmitted out of the fixture)
- Light Distribution
- Glare Control
- Appearance
- Size
- Accessibility of components for maintenance
- Ability to work under difficult and harsh conditions
- Thermal Management
- Aesthetics

### **3.8 CHOICE OF LAMP**

This section brings out the pros and cons, related to the efficacy and the contribution towards sustainability of various types of lamps available. It should be noted that choosing appropriate lamp contributes to enormous impact on energy efficiency. Although it is a part of the entire design chain, it can be directly leads to an inefficient lighting system. LEDs are emerging in the world market and claimed to be a very efficient but greater care must be taken in its selection as it involves various ranges of efficiency.

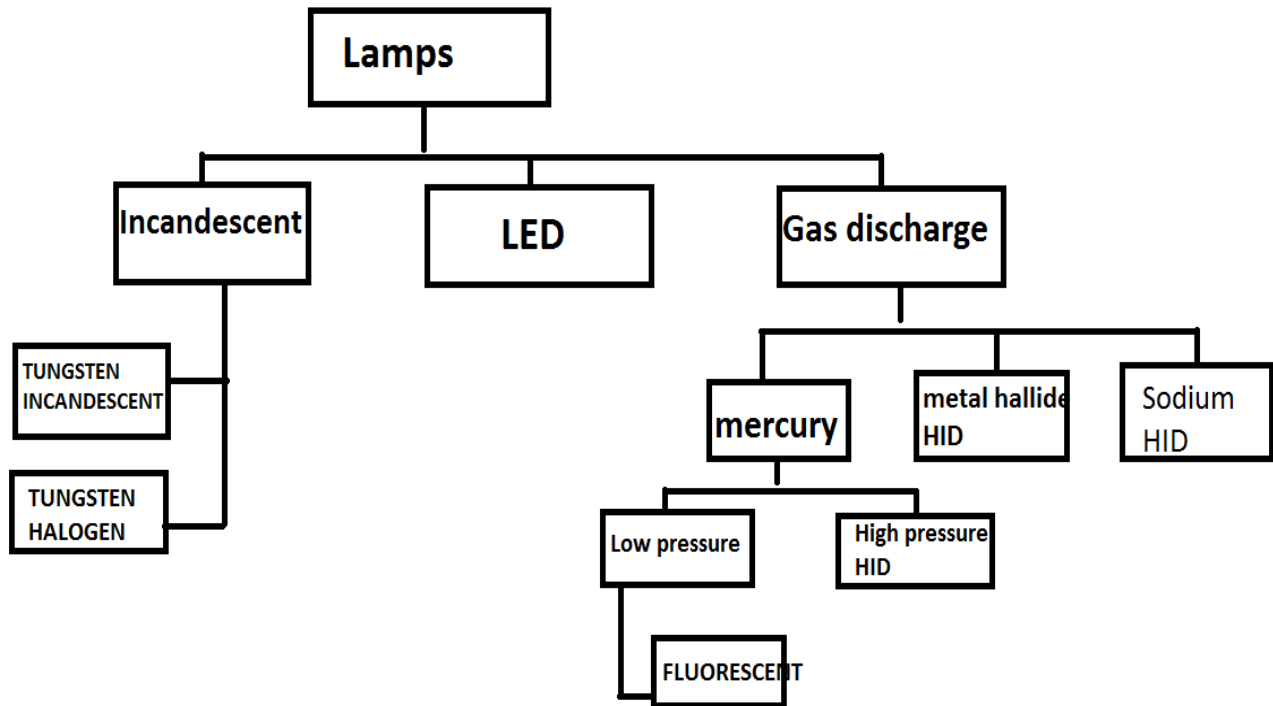


Fig 3.5: The main Categories of lamp

### 3.9 INCANDESCENT LAMPS

These are most commonly used in lighting. They are inexpensive to buy and have relatively higher operational or running cost. Its more suitable for areas where lighting is used infrequently and for short periods. The traditional pear-shaped incandescent lamps (GLS) are least efficient and waste around 95% of the energy mainly as heat. Hence these lamps could be phased out. They are referred as thermo-luminescence that means to create by means of heat. The electric current flow in a tungsten filament, and temperature of the filament is raised sufficiently enough so that visible light is emitted. The method is intrinsically ineffective as more heat is produced which comprises its output to only 5%. According to national and international standards, the average life of GLS lamps is specified as 1000 hours.

Performance summary	
Range	25 – 300 watt
Colour temperature	2,700 Kelvin
Life	1000 hours
CRI	100
Efficacy	12 lm/watt

Pros	Cons
Immediate on	Very expensive to operate
Immediate full light output	Low colour temperature
No extra equipment	Shorter lamp life
Cheap initial cost	300W maximum power

Table 3.6: Representation of some of the features of Incandescent Lamps.

### 3.10 TUNGSTEN HALOGEN LAMPS

Halogen lamps also fall under the type of incandescent lamp. They last up to 10,000 hours and very expensive. They are normally operate at 240 V, tubular structure and more efficient than traditional tungsten incandescent lamps. Tungsten halogen and tungsten incandescent are often discouraged for general purpose illumination. Low voltage halogen lamps can be found in the market but large quantities of lamps are required to light open spaces and not suitable for large spaces.

### 3.11 FLUORESCENT LAMPS

Fluorescent lamps are very efficient in comparison to incandescent lamps and offers range of efficiency and ballast choice that has profound effect on efficacy. They are often termed as the most energy efficient form of lighting, much cheaper to run and last around 15,000 hours. Moreover, they can replace incandescent and halogen lights in most situations. Due to their high luminous efficacy and long life, all commercial and industrial lighting installations prefer fluorescent tubes.

Performance summary (linear fluorescent tubes)	
Range	8 – 300 watt
Colour temperature	2,700 – 6,500 Kelvin
Life	800 – 16,000 hours
CRI	50 – 98
Efficacy	35 – 104 lm/watt

Pros	Cons
Economical to operate	Expensive to purchase
Large colour range	Sometimes requires ballast and starter
Cool operation	Slow to full brightness
Long life	Often unattractive
Soft light	Contains mercury

**Table 3.7: Representation of features of fluorescent tubes**

### 3.12 CFL

Compact fluorescent lamps represent efficient choice for lighting purposes and have improved significantly in recent years in terms of its popularity. CFL can be designed to fit into conventional screw fitting light socket extending the scope of CFL applications. There are basically two types of CFLs such as Pin-based CFLs and Integral ballast CFL. Furthermore, Pin-based adds variety of styles of CFL, within each style there can be particular differences with pin positions of which is unique to the wattage of lamp.



Whereas the Integral Ballast CFLs are well known energy saving lamps that can be used extensively in smart homes. They can provide up to 80% energy saving over normal incandescent lamps. They are introduced in the market as compact lightweight version to produce warm effect lighting with excellent color rendering. Moreover, since the time of its invention, the integral ballast CFLs continually improved and worked on variety as well as size, lifetime doubling from 8000 hours to 15000 hours today. The CFLs range from single turn(3W) to quadruple turn(30W), available in range of wattages to replace other conventional lamps.

Special Integral Ballast CFLs:

The development of special integral ballast CFLs with unique features for several applications are shown as examples below:

- Integral ballast CFLs that can operate with a high or low light output can be controlled by the main switch. Thus the switch dimming feature can be introduced and suited to mood lighting in different places such as low level night time lighting on stairs.
- They can have infinitely variable light output.
- Energy saving CFLs that provide automatic outdoor security lighting via light sensors.
- The outer bulb is made of plastic and helps to reduce weight and can be designed to replace conventional incandescent reflector lamps.



**Fig3.8 Diagram consists of wide varieties of CFLs in the market.**

### **3.13 AMALGAM TECHNOLOGY**

Interior light installations at ceiling often results to light output loss due to higher than normal temperature. The fluorescence process become less efficient as high operating temperature increase the mercury vapour pressure in the lamp and causes reduced UV for the process. Therefore, higher wattage version of CFL should not be operated in compact enclosed fittings. For this reason, Amalgam lamps should be used in lighting system as it uses low mercury content alloy to stabilize the mercury vapor pressure inside the lamp. Hence, the lamp efficacy remains high over a wide range of ambient temperature and helps to eliminate the fluctuation of light output at different temperatures.

### **3.14 LED**

LEDs are considered as emerging technology with range of efficiency for any lighting purpose. They have long life compare to other lamps, around 50,000 hours, offering higher efficiency i.e. 40 to 60 lm/W, and are compact and rigid. LEDs provide high light output and operate very differently compared to other lamps. Examples of various LEDs manufactured in the market includes: Discrete LEDs, Radial LEDs, Surface mount LEDs, LED Modules etc. When electricity of correct voltage and polarity is applied to the LED via lead frame contacts, results in current flowing through the die, which is a very small piece of semi-conducting material. The different properties of layer in the die correspond to 90% of electrical energy to be efficiently converted into light at the junction by a process known as injection electroluminescence'. The process described above is more efficient than any other light source. The injection electroluminescence is unfamiliar to incandescence which require heating a filament lamp and to fluorescent tube that requires chemicals which glow. The phenomenon can be explained by atomic differences in the material caused by doping.

# CHAPTER 4

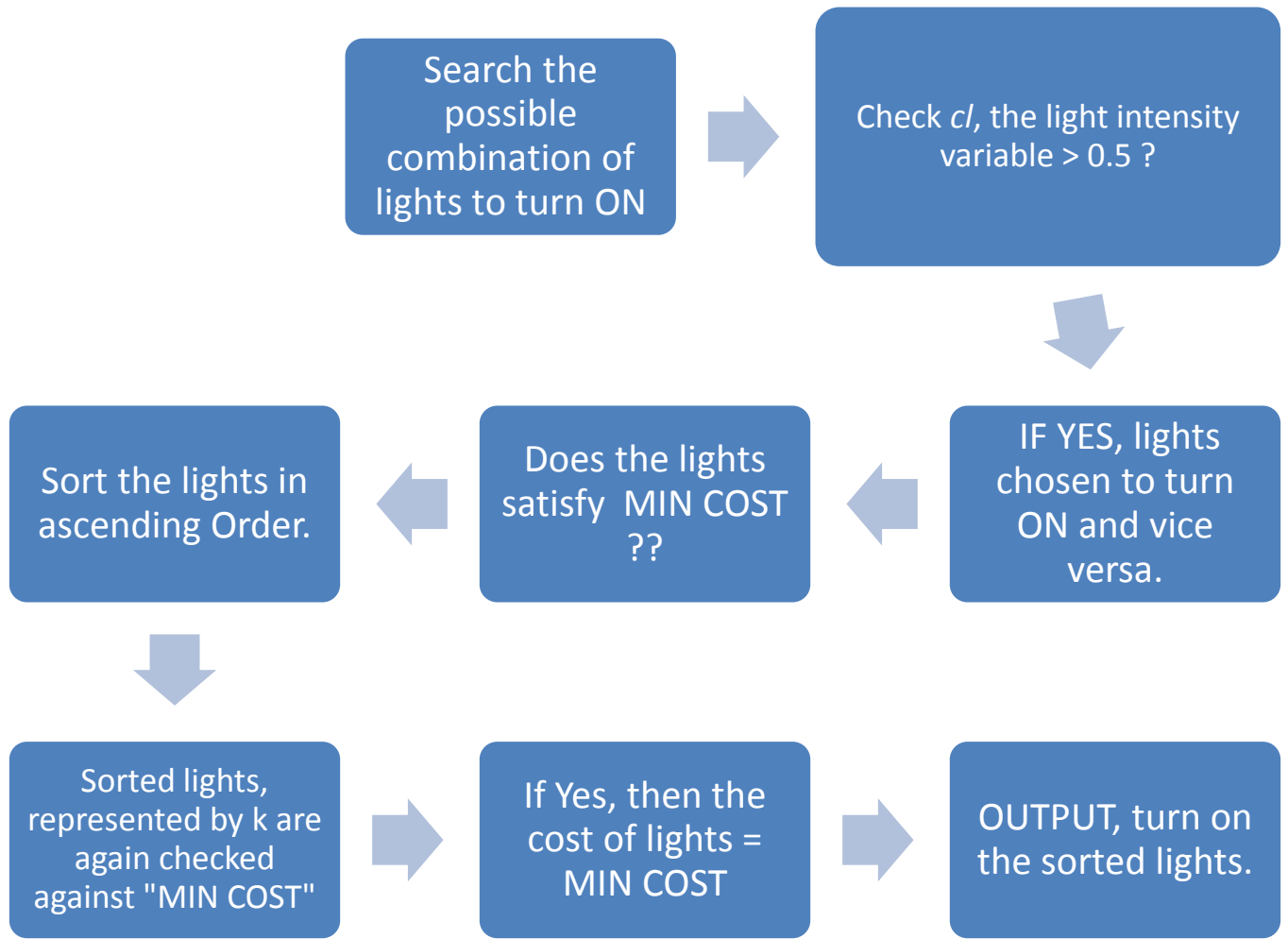
## SWITCH CONTROL MECHANISM

### 4.1 INTRODUCTION

This paper explores the methodology to minimize the energy consumption of the lights and maintaining the user satisfaction of the light condition in a smart departmental store. These lights are connected to a digital system and we opted for 8-bit ADC 0809 analog to digital converter which will convert the analog signal to digital value with respect to the reference voltage which is considered 2.5V. Therefore 2.5 V is considered at full light intensity and 0 V is considered as darkness.

### 4.2 FLOWCHART OF SWITCH CONTROL

We consider a light system in which the lights can be switched on or off. The process involves searching all the possible combination of the  $2^L$  possible solutions if number of lights, e.g.  $L \leq 20$ . Hence for larger systems it is very time consuming and thus we would propose an algorithm for this type of light switch control. In the proposed algorithm shown in fig 3.5,  $c_l$  denote the variables of light intensity of the lighting system concern. We have to find  $d_l$  (output), such that if  $d_l$  is one then the lights  $l$  should be turned on and if  $d_l$  is zero, the lights  $l$  will remain off. Another variable  $b_l$  is set 1 when  $c_l > 0.5$  and sets  $b_l$  to 0 otherwise for all  $l$ . Therefore we need to first find the values of  $(c_l - 0.5)$  for all lights,  $l$ . Then we swap each bit of the solution and check if it gives a lower cost. If the solution obtained gives a lower cost, then we keep the new solution.



**TABLE 4.1: REPRESENTS A BLOCK DIAGRAM OF SWITCH CONTROL MECHANISM.**

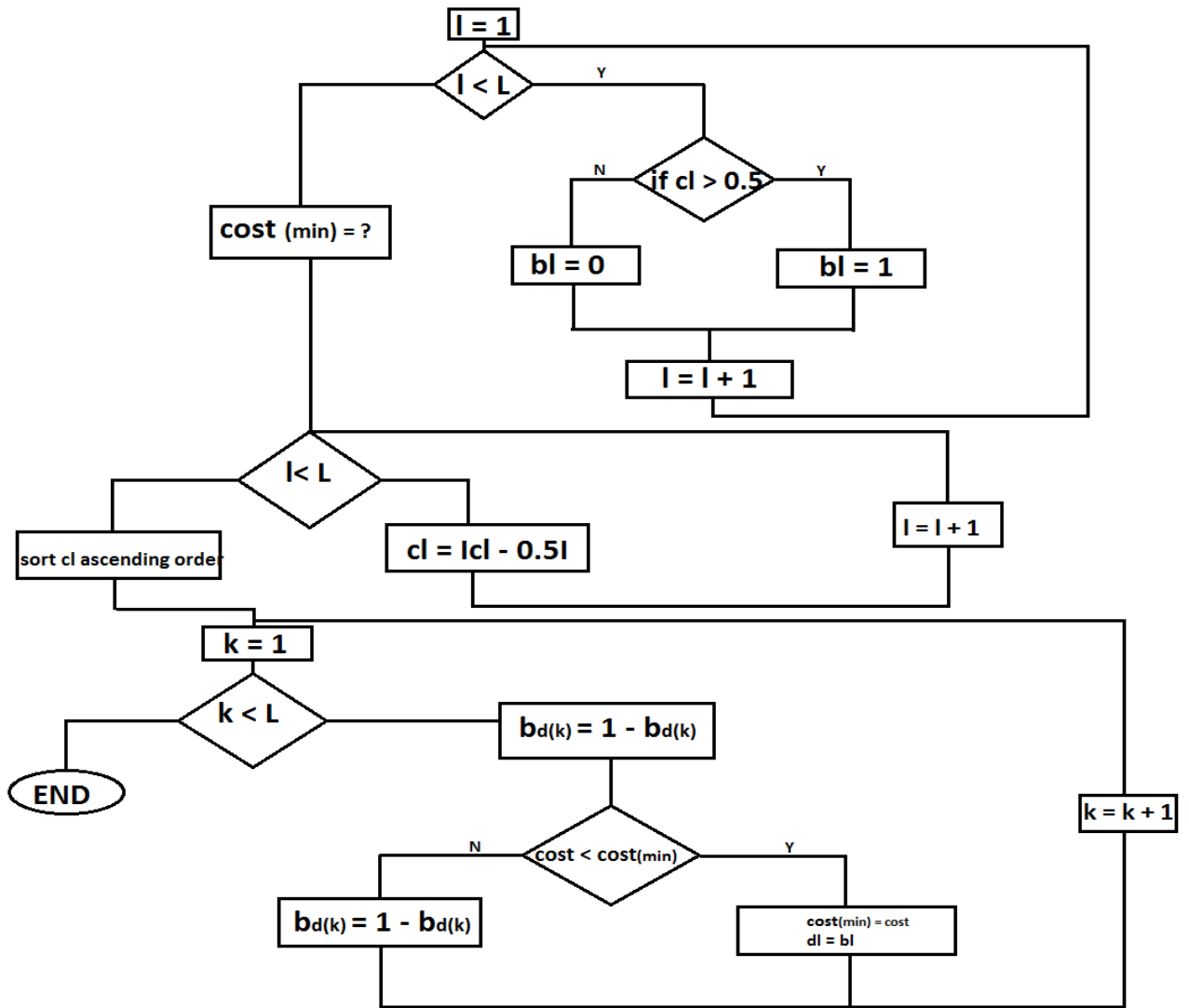


Figure 4.2: FLOWCHART REPRESENTING SWITCH CONTROL MECHANISM.

Thus, the system can adopt to adjust light setting and provide comfortable environment for the end users as well as develop an optimization formulation for the benefit of user comfort while reducing the energy cost of lights significantly.

# Chapter 5

## Calculation for Power Saving

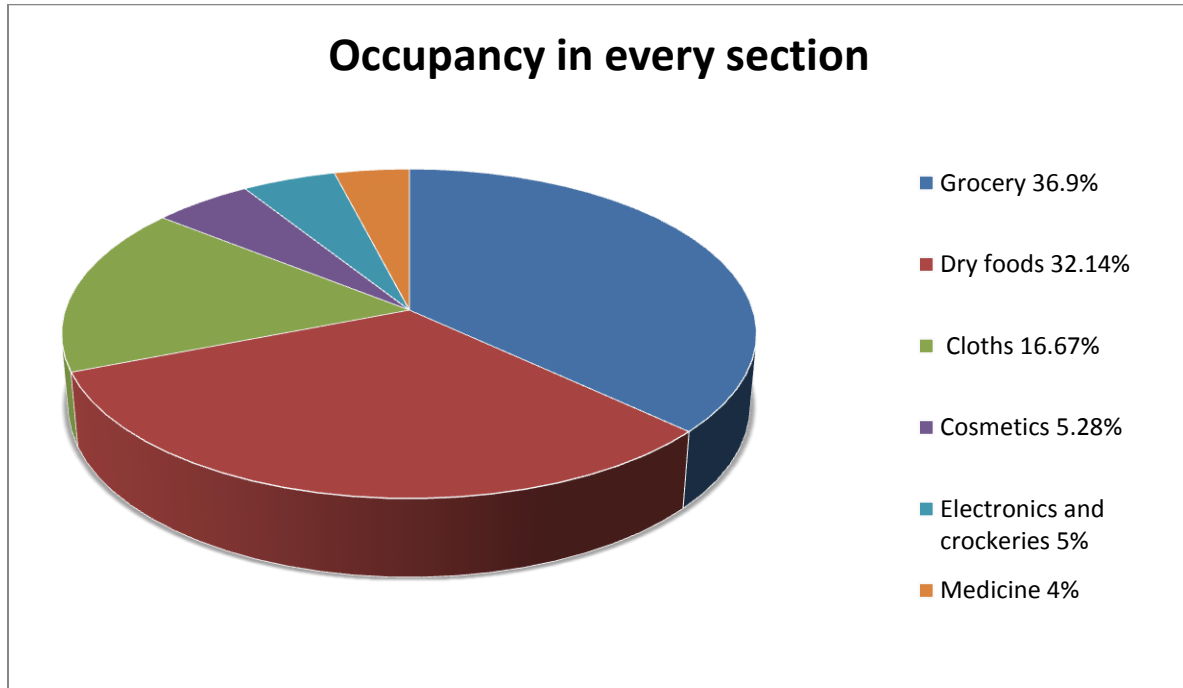
### 5.1 Introduction

The modern era indicates to resolve the energy crisis along with increasing energy consumption day by day which is creating problem in everywhere and energy crisis is any great bottleneck in the supply of energy resources to an economy. There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Energy efficiency, means using less energy to provide the same level of energy. In this project the prime objective is to minimize maximum use of electricity by using energy saving lighting system and occupancy sensor. A present departmental store is taken as an example to show the project energy efficiency. Different occupancy density and percentages of occupancy in different sections are shown for power calculation and the yearly saving of energy is also shown in this segment.

### 5.2 Occupancy density

The *occupant density* refers to the amount of persons that can safely fit into the space available and occupancy density of a departmental store is very essential for calculating occupancy in every section which helps further to calculate energy saving. In this project we take an existing departmental store as an example to determine yearly power consumption. The occupancy in different section varies in order to space type. Occupancy is highest in Grocery section which is 36.9 percent, in Dry food section 32.14 percent, in cloths section 16.67 percent, in cosmetic section 5.28 percent, in electronics and crockeries section is 4 percent and in medicine is 4 percent.

Pie chart 5.1: Occupancy in every section



Occupancy in different section also varies in different hours. The operating hour of the store is from 8 am in the morning to 10 pm in the night. According to the store manager occupancy is higher in morning and evening. So these hours are divided into peak hours and nonpeak hours. Occupancy is higher in peak hours and number of people drops to one third in nonpeak hours.

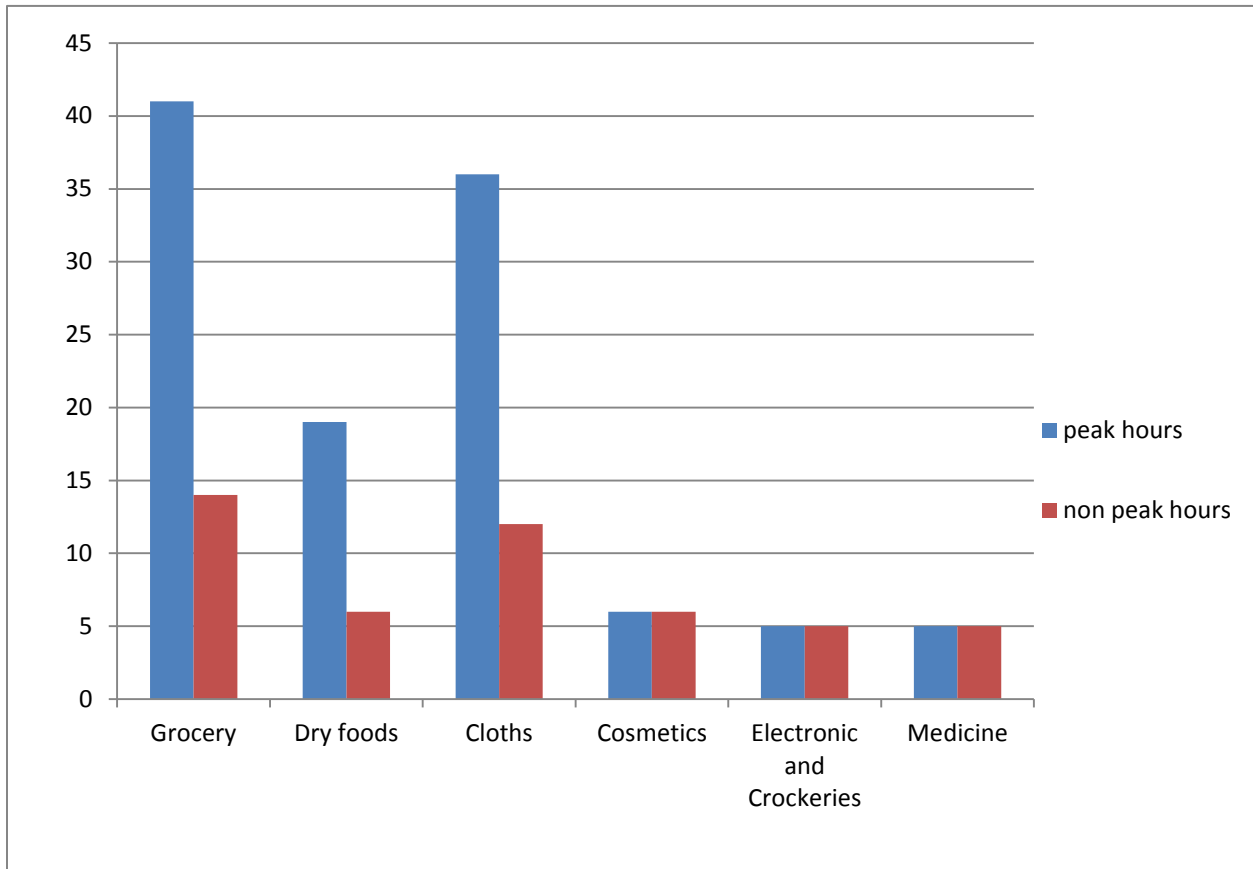
Operation hour of departmental store = 8 am to 10 pm=14 hours

Peak hours =9 am to 12 am and 5 pm to 9 pm= 7 hours

Nonpeak hours = 8 am to 9, 12 pm to 5 pm and 9 pm to 10 pm= 7 hours

It is observed that during peak hours the number of people visit in grocery section is 41, in dry food section 19, in cloths section 36, in cosmetic section 6, in electronics and crockeries section 5 and in medicine section 5. In nonpeak hours the number drops to one third of peak hours. It is also observed that in cosmetic, electronics and crockeries and in medicine section the occupancy remains relatively constant in both peak and nonpeak hours. A bar chart is given below for better interpretation.

**Bar chart 5.2 occupancy in peak and nonpeak hours**



During nonpeak hours the number of people in departmental store drops to one third of the number during peak hours. In peak hours Grocery, Dry foods and Cloths sections are remain 100 percent occupied and in nonpeak hours the percentage of hours remained occupied in these three sections is 75 percent, 68 percent and 60 percent. The number of people in cosmetics Electronics and medicine sections remains relatively constant all day. A table is given below to calculate the operation hours of lights with PIR sensor and without PIR sensor.



**Table 5.3: Operation hours of lights with PIR sensor and without PIR sensor**

Space type	Number of people per peak hour	Number of people per nonpeak hour	Percentage of hour remain occupied		Operation hour of lights with PIR sensor		Operation hour of lights without PIR sensor
			During Peak hours	During nonpeak hours	During Peak hours	During nonpeak hours	
Grocery	41	14	100	75	7	5 hrs 15 mins	14
Dry foods	19	6	100	68	7	4 hrs 45 mins	14
Cloths	36	12	100	60	7	4 hrs 12 mins	14
Cosmetics	6	6	50	50	3 hrs 30 mins	3 hrs 30 mins	14
Electronics	5	5	50	50	3 hrs 30 mins	3 hrs 30 mins	14
Medicine	5	5	50	50	3 hrs 30 mins	3 hrs 30 mins	14

### 5.3 Calculation for power saving

If one LED bulb of power capacity 12 watt and 1100 lumen connected with PIR sensor replaces fluorescent bulb of power capacity 30 watt and similar brightness power consumption drops to a very lower value.

**Table 5.4: Power calculation for one LED light**

Space type	Operation hour of lights with PIR sensor			Operation hour of lights without PIR sensor	Total consumption in watt per day	
	During Peak hours	During nonpeak hours	Total		With PIR sensor and one LED bulb of power capacity 12 watt	Without PIR sensor and with one fluorescent bulb of power capacity 30 watt
Grocery	7	5 hrs 15 mins	12 hrs 15 mins	14	147	420
Dry foods	7	4 hrs 45 mins	11 hrs 45 mins	14	141	420
Cloths	7	4 hrs 12 mins	11 hrs 12 mins	14	134.4	420
Cosmetics	3 hrs 30 mins	3 hrs 30 mins	7	14	84	420
Electronics	3 hrs 30 mins	3 hrs 30 mins	7	14	84	420
Medicine	3 hrs 30 mins	3 hrs 30 mins	7	14	84	420
Total					674	2520

Here calculations are shown for six bulbs in six sections to find the power consumption by a single bulb.

Total consumption in watt per day in six sections by LED bulbs of 12 watt with PIR sensor = 674 watt

Average total consumption in watt per day by one LED bulb of 12 watt with PIR sensor = 112.33 watt

Total power consumption by a single LED bulb with PIR sensor per year = 112.33 watt × 365 days

$$= 41000.45 \text{ watt per year}$$

$$= 41 \text{ kW per year}$$

Total consumption in watt per day by six fluorescent bulbs of 30 watt without PIR sensor = 2520 watt or

$$2.52 \text{ kW}$$

Total consumption in watt per day by a single fluorescent bulbs of 30 watt without PIR sensor = 420 watt

Total power consumption by a single fluorescent bulb without PIR sensor per year

$$= 420 \text{ watt} \times 365 \text{ days}$$

$$= 153300 \text{ watt per year}$$
$$= 153.3 \text{ kW per year.}$$

So power saving per year by a single LED light with PIR sensor = ( 153.3 kW – 41 kW)

$$= 112.3 \text{ kW}$$

The departmental store was 6000 square feet in area and 2000 fluorescent bulb was used in lighting system. Power consumption by 2000 bulb is 840000 watt or 840 kW.

In that departmental store 350 KVA or 280 kW of power is being used in every hour that's means in 14 hours power consumption is 3920 kW and power consumption by bulbs is 840 kW which is 21.42% that close to 23% per day.

If 2000 LED bulbs with PIR sensors replace fluorescent bulbs they will consume 224660 watt or 224.66 kW of power which is 5.73% of the total power per day.

So it reduces power consumption by 15.69%.

Considering all the above calculations and data from the tables, it can be concluded that using occupancy sensor and LED lighting system reduces amount of energy consumed, as well as energy-saving and cost effective at the same time. The calculated data confirms that this lighting system will be efficient enough.

# CHAPTER 6

## FUTURE WORK

### 6.1 PRACTICAL IMPLEMENTATION

We are also keen to work on developing wireless camera network system compatible with the IEEE 802.15.4 protocol standard for the departmental store that intently focuses on low-cost communication between devices with less sophisticated infrastructure to exploit low power consumption to a greater extent. Moreover, we also envision examining human motion and analyzing them through various stages of vision applications. The levels include image compression, target tracking, occupancy sensing and so on.

### 6.2 IEEE Std. 802.15.4

IEEE 802.15.4 protocol is definitely the right choice for the standardization of communication protocols of WSN sensor network. The ZigBee Alliance could be chosen to commercialize this lighting control system as it enables reliable, cost-effective, low-power, wireless network monitoring and control product based on LR-WPAN technology. The camera sensor nodes will be able to communicate with local gateway computers that are connected to the Internet. The sensors can perform pre-processing functions on captured images and send the result over the network to a centralized server. The server could route the information to various clients for further processing and visualization.

### 6.3 CMOS IMAGE SENSOR

A low voltage 1.3 megapixel CMOS image sensor called OmniVision OV9655 is an appropriate choice for the camera platform and offers full high tech functionalities essential for image processor. The camera should be able to support image size of 1280 \* 1024 VGA, CIF capable of operating at 30 frames per second (fps) in case of VGA, CIF, lower resolutions and 15 fps in SXGA. It can be designed to perform better in lower light conditions with typical power consumption of 90mW (15fps @SXGA).

## **APPLICATIONS**

We could also explore the capacity and performance of our proposed model via vision based applications: image compression, target tracking, occupancy sensing. The algorithms that are all fitted, tested and can be implemented in C/C++ on the camera nodes and base-station.

### **6.4 IMAGE COMPRESSION**

The network will be able to push captured images to a back-end server for further processing. Some quantitative measure is taken to determine the speed of compression, rate-distortion and time-distortion between two compression schemes which are JPEG and Compressed Sensing CS. In the embedded Linux OS that includes the IJG library, JPEG compression can be implemented.

### **6.5 TARGET TRACKING**

Our concern for detection of moving target and video based scene analysis is briefly explained in this section. It focuses mainly on smaller regions of interest in order to reduce the complexity undergone for data processing. The main purpose of the moving target analysis is extracting the moving object from video background. Various video object detection algorithms have been developed for tracking, behavior and understanding of post-processing. In this system model, we could choose the general method of detection which is Background Subtraction Method. The simplest procedure to approach background subtraction from video data is through frame differencing which explained as we go further. Each incoming frame with a background image model can be classified with pixel variation as part of the moving foreground. The foreground pixels are then processed for identification and tracking. Some challenges faced during such task includes shadows, visual clutter etc.

### **6.6 FRAME DIFFERENCE METHOD**

The frame difference method could be used to detect the moving target of the image with the help of threshold value and the time difference based on the pixel from the two or other frames of the captured

images by the video sequence. For instance, when we consider the frame K and the frame (K-1) respectively,  $y_k(i,j)$  and  $y_{k-1}(i,j)$  and obtain the difference image.

$$D_k(i, j) = \left| y_k(i, j) - y_{k-1}(i, j) \right|$$

$$M_k(i, j) = \begin{cases} 255, & D_k(i, j) \geq T; \text{ foreground} \\ 0, & \text{otherwise; background} \end{cases}$$

Each pixel in the image sequence is determined by a threshold value T to determine whether it can be identified as a foreground or background. The image  $M_k(i, j)$  of the moving foreground region could be further extracted. Hence if the difference of a pixel intensity of current frame and pixel intensity of previous frame is greater than threshold then the pixel is classified as foreground pixel, otherwise it is referred as background. The result would be a segmentation output  $M_k$  grouped together as blob, any blob smaller than specified threshold will be removed. Finally a set of boxes  $S_t$  comprising of resulting blobs in  $M_k$  are computed in the base station and can be used for tracking.

## 6.7 Occupancy Sensing

The paper explores human activity analysis utilizing a distinctive classifier model developed for recognizing daily activities of human by sensors in a smart departmental store. Since many researchers had proved that the discriminative method referred as Conditional Random Fields (CRF) work well to classify activities and perform automatic recognition of activities. Smart systems are equipped with sensor networks that are able to automatically recognize activities of the occupants and assist humans in an intelligent manner. Here the sensor data collected are analyzed to build activity models for further means of pattern recognition. Since different human activities represents dissimilar temporal structures. For instance, activities such as jumping may exhibit different postures in short period whereas activities such as walking, lying, picking up garbage from the floor consists of image features that are non-repetitive and more or less same in each frame. Therefore these different temporal structures have its own particular context during observation and evaluation.

# CHAPTER 7

## CONCLUSION

Smart departmental store, an automatic light, temperature and humidity control system is an energy efficient system in different ways such as the use of LED light and PIR sensor which save a vast amount of power every year. Unlike typical lighting system which consumes large amount of power this system is able to minimize the power consumption as well as the yearly cost. Choosing the LED lamp over other lighting source, not only makes the system further energy efficient but also makes it cost effective and be easy to maintain in the long run. Compared to other lamps LED consumes much less power and has a very high life. Although the initial cost is slightly more than the other lamps, considering no maintenance and replacement cost, makes it the best choice for this project.

The proposed Vision Based Light Control System shed some light on the conception of suitable light settings for different scenario considering the ability of the system to learn user's activity, adjust light setting for comfortable environment, and saving energy by turning off unnecessary lights. We later discussed how proper lighting installation guidelines should be followed in order to prevent inefficiency. In the future we would also believe to work on human activity analysis by including large varieties of applications and build adaptation of the utility functions with advanced technology. A better user interface device can be made which could provide location information of the user and allow adaptation providing feedback to the system.

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