
INFRARED (IR) SENSORS WITH AN AUTOMATIC LIGHT CONCEPT BASED ON ARDUINO UNO R3

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Abstract

Nowadays, many people lack awareness in saving electricity by not turning off the lights during the day. Therefore, we took a project with the concept of automatic lights with infrared sensors based on Arduino UNO IDE. Infrared (IR) sensors are technology that utilizes infrared waves to detect objects or changes in temperature around them. In the automatic lighting concept, IR sensors are used to turn lights on or off based on detection of human presence or movement. This system works by detecting changes in infrared radiation emitted by the human body. When the IR sensor detects human movement or presence in a certain area, the lights will turn on automatically. Conversely, if there is no movement within the detection area for a certain time, the light will turn off. This technology not only improves energy efficiency by reducing unnecessary electricity use, but also provides user convenience with lighting automation. Implementation of this system can be found in various places, such as homes, offices and other public facilities, as a solution to save energy as well as increase comfort and security.

Keywords: Arduino UNO, Infrared sensors (IR), Lamp sensor

INTRODUCTION

Smart Hotels have emerged to meet the growing demand for clean, comfortable, and affordable accommodations, catering to guests who prioritize staying at tourist spots or meeting business colleagues over using full hotel facilities. (Ratih Dian Saraswati, 2024)

Therefore, business actors in the tourism sector, especially hotels, need to develop innovations with the latest technology to support the comfort of hotel facilities and attract tourists. Smart technology can attract visitors, but in Indonesia there are still few hotels that implement it. The brand to meet the needs of smart travelers, namely Formule1, is only available in two hotels in Jakarta, while in Australia there are 21 hotels. (Adiati, 2011).

This research discusses the application of smart keys to hotel lights to improve energy efficiency, user comfort and operational management. This technology automatically adjusts lighting based on guest presence or time of day, reducing electricity waste.

Research shows that 80% of energy saving success depends on human behavior, while 20% depends on technology. The proposed solution is an automation system, such as a lamp with an integrated PIR sensor IC NE555 or an ATmega 8 microcontroller, which is more energy efficient than motion sensor lamps on the market. Other designs use infrared sensors and LDRs for street lights, which turn on only when needed, such as when it is dark and a vehicle is detected, and turn off automatically when it is bright. This prototype supports energy savings by only using electricity as needed. (Desiana Br Ginting1, 2019).

This research aims to evaluate the impact of reducing operational costs and environmental effects by optimizing energy use. It also assesses the application of Internet of Things (IoT) technology in lighting management for centralized, real-time control, enhancing hotel operations and guest comfort. Therefore, attention is needed for developing smart technology systems in Indonesian hotels to attract visitors.

According to research by Rusmana (2019), this device is used to control traffic at intersections based on density levels using a microcontroller. The device employs a microcontroller processed with fuzzy logic to optimize traffic light control in real time. The automated control system consists of an ATMEGA 8535 microcontroller managing eight infrared sensors to detect road density. Each lane has two infrared sensors providing data to the microcontroller, which determines how long the green light stays on, managed by fuzzy logic. This tool could be applied at every road intersection..

Suryanto's (2017) research shows that electricity costs in hotels average 30% of total operational costs, so good energy management can improve financial performance. Energy use in hotel rooms is generally high (1 to 3 kW). For effective energy management, electrical installations with efficient control systems are required. This research uses a single zone installation with a key tag switch system, light sensors in the bathroom, and energy saving lamps. Installing card switches and LED light controls can save 1,000 kWh per month, reduce electricity costs and increase electrical efficiency.

This research explores Arduino-based infrared sensors for automatic hotel room lights to enhance guest comfort, safety, and energy efficiency. The system adjusts lighting based on guest presence, reducing manual effort and electricity consumption, supporting sustainable energy management in hotels.

LITERATURE REVIEW

Infrared sensor research has created a formula that connects the light emitted, the light received, and the distance based on light intensity. This formula was developed through tests and calibrations to ensure accurate sensor performance.

To solve a problem, a literature review is needed. This review covers how infrared sensors function and the theory behind using tools for monitoring hotel card detection and automatically turning on lights.

Infrared sensors use reflected light to measure distance. The process includes sending a signal at a 30° angle, detecting the reflection of that light, and measuring the time it takes for the signal to travel back after hitting an object, known as duration in Arduino code.

Distance Calculation Formula

Distance is calculated based on the basic formula for the relationship between speed, distance and time:

$$d = (I_o \cdot p \cdot A) / I_r$$

Where:

d is the distance (in cm)

v is the reflected speed of light (approximately 118.9 mW/m²)

t is the travel time of the reflection from the sensor to the object and back (in microseconds)

Division 2 is done because the time measured by the sensor is for the round trip (sensor to object and back to sensor)

Implementation in Code

The Arduino formula above is applied in the Arduino code.

After attaching the formula, we will explain the working principle of infrared sensors and their main components, as well as relevant physics concepts. We will also discuss the theory that supports the application of infrared sensors in temperature detection, distance measurement, and motion monitoring to provide a deeper understanding of this technology.

2.1 A system is two or more components that are interrelated and interact to form a group unity so as to produce one objective. (The Gift of Sustainable Light, 2020)

In a system, there are 3 main components that must be owned and are interconnected with each other. These components include:

1. Input

Input is anything that can be given as input into a system. It can be capital, raw materials, people, data, and services.

2. Process

A process is an activity that changes input into useful output. This process is complex and sequential, and without the process, the input will be useless and the output will not be achieved.

3. Output

Output is the final result obtained after the input given goes through the existing process, so it can be concluded that the system is an interaction between elements that work together in an activity and condition starting from input, process and output until the desired goal is achieved.

2.2 Control System

A control system is a combination of various devices that work together to control or regulate other systems. (Alfiah, 2020).

This is a tool or set of tools that are useful for regulating the state of a system. An automatic control system is a system that carries out control over the work process according to rules without human assistance, with the aim of making human work easier.

2.3 Automatic

Automatic means it works by itself. Automatic regulation consists of system, regulation, and automatic. A system is an arrangement of components for certain actions. Regulation is the activity of managing or controlling. The three main aspects of automated regulation are a clear plan, measurability, and action that can be taken. (Mei Prabowo, 2020).

2.4 Light

A lamp is a device that emits light with electrical energy. Energy-saving lamps help save electricity and reduce power loss. The energy crisis and climate change are global challenges. The government issued Presidential Instruction Number 10 of 2005 to save energy.

2.5 Electrical Energy

Electrical energy is very important in everyday life, supporting various human activities. The construction of multi-storey buildings increases electricity consumption, but its inefficient use can cause waste and high costs. According to the journal Ekananta *et al.* (2018), Indonesia is the most wasteful user of electricity in ASEAN with the potential for large savings. AD Santoso & Salim (2019) predicts that electricity demand in 2050 will reach 1,611 TWh, with households as the main consumers.

2.6 Microcontroller

A microcontroller is a computer system on a chip with input, output, and control via programs that can be written and erased. (Pribadi, 2020). According to the journal (Hafidhin *et al.*, 2020), there are two types of microcontrollers: RISC and CISC. The programmer gives instructions to the microcontroller.

2.7 Arduino Uno R3

Arduino is an ATmega-based microcontroller board with various types depending on the specifications. Arduino uses an ATmega328, is open source, and uses the C programming language. Equipped with a USB loader for programming, Arduino Uno allows the creation of physical devices that use sensors and microcontrollers.

Tabel 1. Specification table

Parameter	Specification
Microcontroller	ATmega 328p
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage Limit	6-20V
Digital I/O Pin	14 (Dimana 6 pin output PWM)
Analog Input Pin	6
I/O Pin DC Current	20 mA
DC Current For 3.3V	50 mA
Memori Flash	32 KB (ATmega), 0.3 KB used as Bootloader
SRAM	2 KB (ATmega328p)
EEPROM	1 KB (ATmega328p)
Clock	16 MHz

2.8 Motion Sensor

"The PIR (Passive Infrared Receiver) sensor is a sensor that detects infrared rays. This sensor is passive, only receives radiation from outside and is designed to detect human movement." (Juliansyah *et al.*, 2021).

"PIR sensors capture heat energy from passive infrared rays emitted by objects with temperatures above absolute zero. These rays are captured by pyroelectric sensors from materials such as gallium nitride, producing an electric current. When a person passes by the sensor, his body emits infrared rays that are different from environment. The amplifier circuit amplifies the current to produce output". (A Prize *et al.*, 2017).

2.9 Arduino Uno IDE

Quoting from a journal written by (Lonteng *et al.*, 2020), "IDE is short for Integrated Development Environment, or in simple terms it is an integrated environment used for development". The Arduino IDE application is used to create, open, and edit programs for Arduino boards. Designed for ease, Arduino IDE has a simple programming language and complete functions, suitable for beginners.

2.10 Projectboard

A project board is a visual management tool used to plan, organize, and monitor the progress of a project. It is often used in Agile or Scrum, but can also be used for other projects. A project board consists of columns that depict the task stages, such as Backlog, To Do, In Progress, Review, and Done. Each column contains task cards that include important information. Cards move between columns as progress progresses, facilitating team collaboration and early detection of issues. Digital tools such as Trello and Jira assist in project management.

RESEARCH METHOD

Smart key hotel design starts from hardware design. Figure 1 is the component design, namely the interface between the Arduino and the infrared sensor and the hotel card as input. The output component to turn on the 5 Volt LED and will display ON or OFF using a 16×2 I2C LCD, the power supply for each component comes from the Arduino's 5V dc Vout which is connected in series because if it is connected in parallel the 5V dc pin on the Arduino is less.

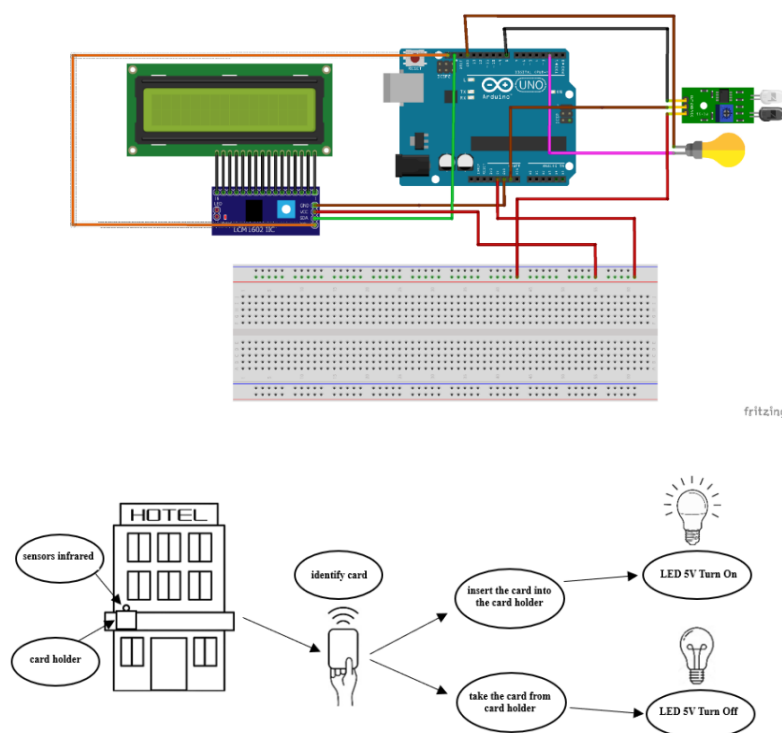


Figure 1 Schematic of the hotel smart key circuit

The hardware design was continued by creating a hotel smart key design as in Figure 2. The hotel smart key was made using used cardboard to save costs and aims to recycle used materials that are still suitable for use.

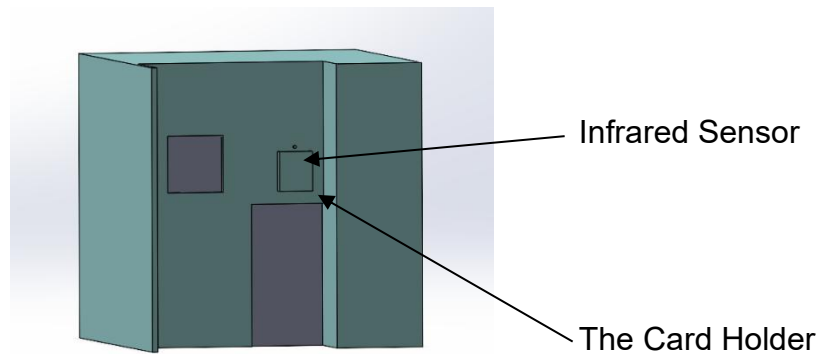


Figure 2 Hotel room design

The part of the hotel smart key above the door is where the hotel card and infrared sensor are located. The card is placed for the sensor to read. If the card is present, the 5V LED lights up and the LCD displays ON. If the card is lifted, the LED is OFF and the LCD is OFF. The hotel smart key program flowchart will be presented in Figure 3.

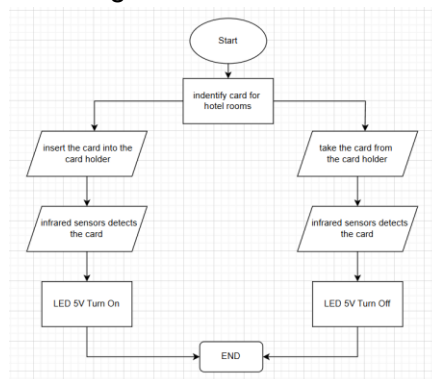


Figure 3. Flowchart of the hotel smart key program

Software design includes programming infrared sensors, 16x2 LCD, and lighting settings in the hotel. There is a menu for entering hotel card placement and an algorithm for turning on the lights. The program is divided into several sketches, with one main sketch. Figure 4 shows the calculation of lamp and sensor voltage.

The following is the sensor calculation

Received Light Intensity (I_r)

$$I_r = I_o \cdot p \cdot A / d^2$$

for a distance of 2 cm

$$I_r = 118.9 \times 0.8 \times 0.00126 / (0.02)^2$$

$$I_r = 118.9 \times 0.8 \times 0.00126 / 0.0004 = 299.3 \text{ mW/m}^2$$

for a distance of 30 cm

$$d = \sqrt{118.9 \times 0.8 \times 0.00126 / 299.3}$$

$$d = \sqrt{0.1197 / 299.3} = \sqrt{0.0004} = 0.02\text{m} = (2\text{cm})$$

I_r = Intensity of light received

p = Reflectance = 0.8 (assuming the object is white)

A = circular object with radius 2cm = 0.02m:

$$A = \pi r^2 = \pi (0.02)^2 = 0.00126 \text{ m}^2$$

d= sensor distance to object= 2 cm to 30 cm

LED emitting angle: angle = 30°

[14.36, 12/8/2024] Distance Based on Light Intensity

If

$$I_r = 299.3 \text{ mW/m}^2$$

$$d = \sqrt{118.9 \times 0.8 \times 0.00126 / 299.3}$$

$$d = \sqrt{0.1197 / 299.3} = \sqrt{0.0004} = 0.02 \text{ m} = (2 \text{ cm})$$

$$\text{If } I_r = 1.33 \text{ mW/m}^2$$

$$d = \sqrt{118.9 \times 0.8 \times 0.00126 / 1.33}$$

$$d = \sqrt{0.1197 / 1.33} = \sqrt{0.09} = 0.3 \text{ m} = (30 \text{ cm})$$

Light reflection angle (Or)

If light comes at an angle $O_i = 30^\circ$, then based on the law of reflection: $O_r = O_i = 30^\circ$

HOW THE PROJECT WORKS:

1. Connect the Arduino to a power source.
2. Make sure the Arduino is connected and has an electrical power supply.
3. Insert the hotel card into the place provided.
4. If the sensor detects the presence of a 5V LED light card it will light up.
5. The I2C LCD will display the "TURN ON" display if the light is on.
6. Pull the card from the card holder, and the light will turn off.
7. If the I2C LCD light goes off, it will display the "TURN OFF" display.

RESULTS AND DISCUSSION

Experiment Results



Figure 1 Shows the lights on.

In the picture above, the light is on if the hotel card is placed in the hotel card holder and the I2C LCD shows the "TURN ON" display.



Figure 2 Shows the light off.

In the picture above, the lights are off if the hotel card is taken from the hotel card holder and the I2C LCD shows the "TURN OFF" display.

CONCLUSION

Hotel Smart Keys can function well and provide comfort, security and convenience for tourists when checking in and checking out. The infrared sensor has an accuracy in reading a distance of 2-30 cm, which is influenced by the performance of the LED and a detection delay of 100 mS. This sensor suffers from losses due to insufficient light reflection. Our project is ineffective because it only uses two variables for the lights. The "Turn On" display shows the 5V light is on, while "Turn Off" shows the 5V light is off. Testing our projects is simple and does not require a long time or many samples for analysis.

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