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Smart Automated People Counting Device with Light Control Powered by IOT

Er. Naveen Mukati[1], Er. Abhishek Chourasiya[2], Er. Rohit Solanki[3], Er. Anand Kushwaha[4]

[1,2]Department of Electronics and Communication Engineering,
[3,4]Department of Computer Science Engineering,
[1,2,3,4]Prestige Institute of Engineering Management and Research (PIEMR), Indore, Madhya Pradesh, India

ABSTRACT

The integration of Internet of Things (IoT) technology in building management systems represents a significant advancement in enhancing operational efficiency and user comfort. This paper details the design, implementation, and evaluation of a novel IoT-enabled smart device that combines people counting with automated light control to optimize energy use and improve space utilization in various settings such as offices, retail environments, and public facilities. Utilizing advanced sensor technology and robust IoT infrastructure, this device accurately monitors occupancy levels and adjusts lighting conditions dynamically, thereby reducing unnecessary energy consumption and enhancing occupant comfort. We elaborate on the system's hardware and software architectures, including the specific sensors used, communication protocols employed, and data processing algorithms developed. Experimental results are provided to validate the accuracy and efficacy of the system in real-world applications. This study contributes to the broader field of smart building solutions, emphasizing sustainability and intelligent resource management.

KEYWORDS: *Counter system, Arduino UNO, Infrared sensor*

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I. INTRODUCTION

In the context of global efforts to enhance energy efficiency and sustainability, smart building technologies have gained considerable prominence. One of the key challenges in this domain is the effective management of lighting, which is a significant contributor to energy consumption in buildings. The deployment of IoT technology offers a compelling solution by enabling more granular control and responsiveness of building systems to actual usage patterns. This paper introduces a smart automated people counting device integrated with light control, leveraging IoT to achieve substantial energy savings and improved space management. We are in a world of digital transformation. In every aspect technology is one common thing people depend upon. If we look back in the 1970s, people used to count visitors manually by counting them or they used a manual tally counter. But today we can see that many methods have been introduced to count people without the need of any human presence. The sensors and cameras will simplify our job of counting the people. We just need to program them to perform the required task. The primary method of counting visitors include hiring people to stand and manually count the number of guests or workers who enter or exit from the venue or location. Even the tally counters are not user friendly and don't have many advantages. Therefore, these methods prove to be unreliable and come at a great cost.

Fig. 1: Smart building technologies

The core of our system lies in its sophisticated sensor array and IoT connectivity which facilitate real-time data acquisition and processing. The selection of sensors was guided by criteria such as accuracy, range, and non-intrusiveness. Infrared and ultrasonic sensors were chosen for their effectiveness in people counting applications. For system connectivity, we implemented MQTT (Message Queuing Telemetry Transport) protocol, known for its lightweight and open standards, ensuring reliable and secure data transmission.

In recent times, counting visitors has become an essential task for people working in sectors which include customers where the number is used as a satisfaction tool by the administrators. Hence, people began researching methods to count people efficiently without hindrance. Since then many methods have been introduced which are now used in various sectors around the world. However, there are certain disadvantages with every method and it is up to the administrators to decide the best method to count visitors. One method might be efficacious but extremely expensive. Another one can be quite feasible and cheap but not efficient.

The objective of this paper is to provide a suitable solution for counting people in an office or a place where the intensity of people is moderate to high. The solution used basic sensors such as IR and piezoelectric and are programmed using a development board called Arduino.

II. DEIGN

A. Infrared sensor:

An infrared (IR) sensor emits and detects infrared radiation. It is used to detect obstacles. An IR sensor consists of IR transmitter, receiver, operational amplifier (Opamp), variable resistor and an light emitting diode (LED) in brief. IR transmitter is an IR LED which emits light in the range of infrared frequency. IR light is invisible to us because the wavelength of IR radiation (700 nm – 1mm) is much higher than visible light. IR light have emitting angle of approximately 20-60 degrees with a range of approximately few centimeters to several feet.

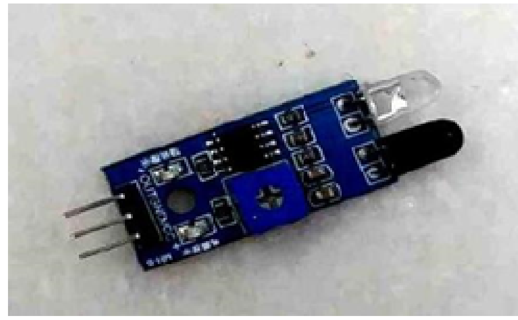

Fig. 2 Infrared Sensor

The photodiode receiver acts as the IR receiver which detects the reflected IR light. Photodiode is an LED with black color coated on its outer side. The Opamp is used as a voltage comparator in the IR sensor. The variable resistor is used tocalibrate the distance range at which the object should be detected. The sensor consists of three pins namely vcc, ground and vin. The vcc pin is connected to a 5 volts DC supply to power up the sensor. The ground pin is connected to ground. The vin pin is connected to one of the digital input/output (I/O) pins of arduino. Once powered up, the sensor transmits IR light. Whenever there is an obstacle in front of the sensor, the light will get reflected which is detected by the IR receiver.

B. Piezoelectric sensor:

The piezoelectric sensor has the ability to convert mechanical stress to electrical energy (AC output). The principle involved is piezoelectric effect. It is a reversible effect means if electric energy is provided, mechanical stress is induced. Common materials used in piezoelectric sensors are quartz, Rochelle salt. Synthetic materials including zinc oxide and gallium arsenide are also used. The sensor has two terminals namely positive and negative. The positive terminal is connected to one of the analog pins of arduino and the negative terminal is connected to ground. By pressing the sensor, the mechanical energy produced is converted to electrical energy.

Fig. 3 Piezoelectric Sensor

C. Arduino UNO

Arduino is an open-source microcontroller board based on ATmega328p microcontroller [11]. It is one of the popular development boards used for experimental purposes and it serves as an intermediate to Internet of Things (IoT) [12]. The board consists of other components such as serial communication, crystal oscillator, voltage regulator etc. It consists of 2 KB of RAM, 1 KB of ROM, flash memory of 32 KB and can be easily programmed with the open-source software Arduino IDE. It also includes 14 digital I/O pins for both reading and writing data, and 6 analog pins for reading input:

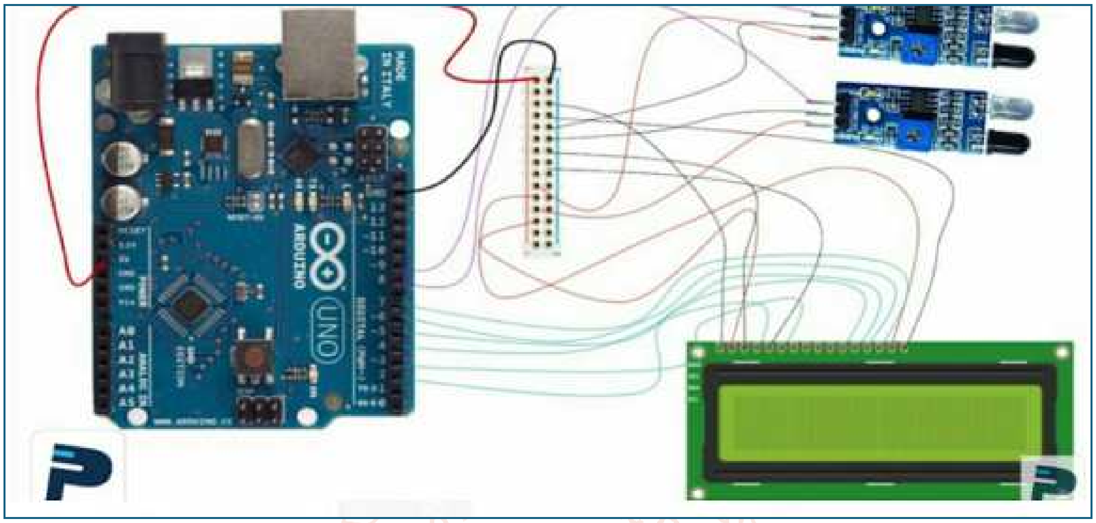

Fig. 4 Arduino UNO

- GND (3 pins): Abbreviation for 'Ground'. The board consists of 3 pins and is used as the negative terminal of any sensor or circuit connected to the Arduino.
- 5V & 3.3V: These pins supply 5volts and 3.3 volts of power to the circuit respectively. Most sensors are designed to be compatible with these 2 voltages.
- Power: All Arduino boards require a power source to run on. There are two ways to power the board. The first is by using a USB cable connected to a computer. Alternatively, the board can be powered by connecting it directly to a wall power supply using the barrel jack given. But the voltage of the power source should be in the range of 6-12V.
- Analog: Analog pins are designated under 'Analog In' label and consist of pins A0 to A5. These pins can read signals from analog devices such as piezoelectric sensors and convert it to binary data for the processor to read. whenever a person passes through the mat it records the signal and the value is high for a certain period of time. The person then passes by the IR sensor which detects the entry. The algorithm is designed in such a way that if both piezoelectric and the entry IR sensor are high at the same time, it detects the person and the count is increased by one.
- ATMEGA 328P-PU: ATmega328 is a single-chip microcontroller.
- Digital: The Digital pins are numbered from 0 to 13 on the Arduino UNO. They are used for both digital inputs like accepting data from a digital sensor and also as digital outputs like powering an LED.
- Reset button: Pushing the reset button restarts the code uploaded to the board.
- Main IC: The black cuboid with metal legs is the most important part of arduino, known as an Integrated Chip or IC. The IC used in arduino UNO is the microprocessor ATmega328P.

III. METHODOLOGY

The system consists of a piezoelectric mat. The piezoelectric sensors are distributed evenly on the mat and the connections are made to the analog pin of Arduino UNO board. Two IR sensors are installed at either end of the mat at a sufficient height from the ground. The first IR sensor which is programmed to detect the entry of a person is placed on the exit side of the mat. The second IR sensor which is programmed to detect the exit of a person is placed on the entry side of the mat.

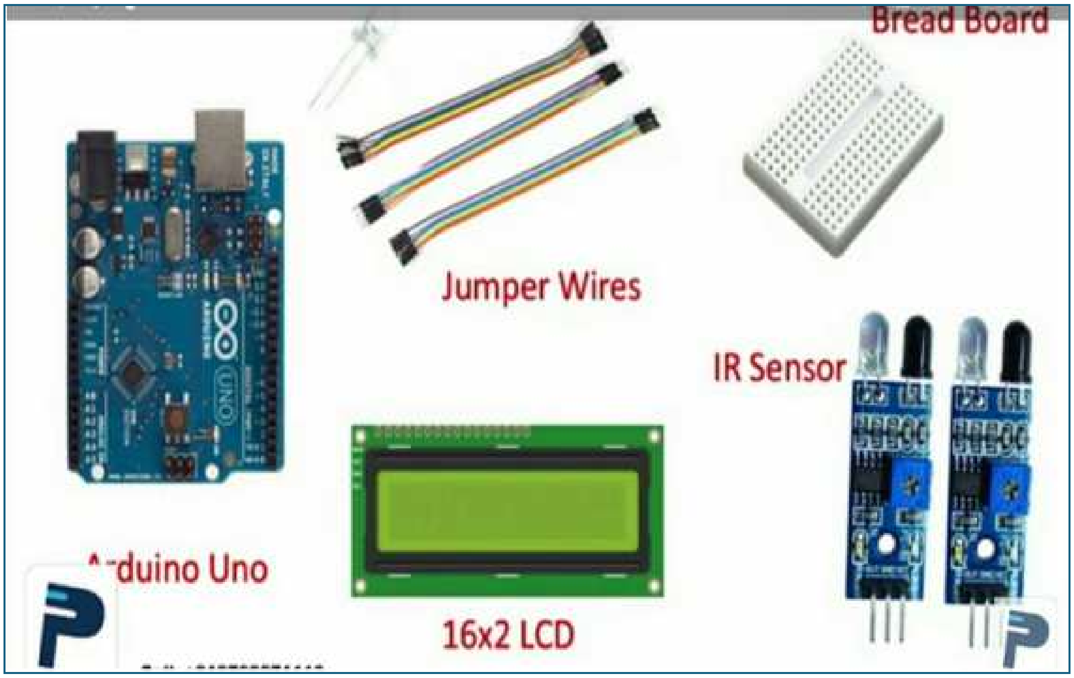

Fig. 5 Hardware design project components

When a person enters and passes through the mat, the weight of the person, which is in the form of external stress to the piezoelectric sensor, is converted into an electrical signal. The electric signal is greater than a certain threshold, and the digital output is high. The threshold value is set so that When a person exits and passes through the mat, the weight of the person is converted to an electrical signal, which surpasses the threshold and is set high. The person then passes by the IR sensor which detects the exit. Now since both the sensors (piezoelectric and exit IR sensor) are set high, the system detects the person is leaving and the count is decreased by one. The person passes through both the IR sensors but since there is a delay in activating the piezoelectric sensor, only one of the sensors get time to detect by the time a person passes through the system and count is detected. The system is designed so that even if two persons enter or exit simultaneously the threshold is set to detect the two persons and the count is increased by two.

IV. DESIGN AND DEVELOPMENT

This image (Fig. 6) depicts a breadboard-based prototype of a smart automated people counting device with light control, likely part of an Internet of Things (IoT) project.

Ultrasonic Sensors: The ultrasonic sensors are connected to the Arduino board via jumper wires. The sensors have four pins: VCC (power), GND (ground), Trig (trigger pulse input), and Echo (echo pulse output).

LCD Display: The LCD is interfaced with the Arduino using multiple wires for data (D4-D7), control (RS, E), and power (VCC, GND). A potentiometer is also visible, likely used to adjust the contrast of the LCD.

ESP8266 Module: Connected to the Arduino through serial communication pins (TX, RX), along with power connections.

LED Indicator: The LED is connected to a digital output pin of the Arduino, with a current-limiting resistor to prevent damage to the LED.

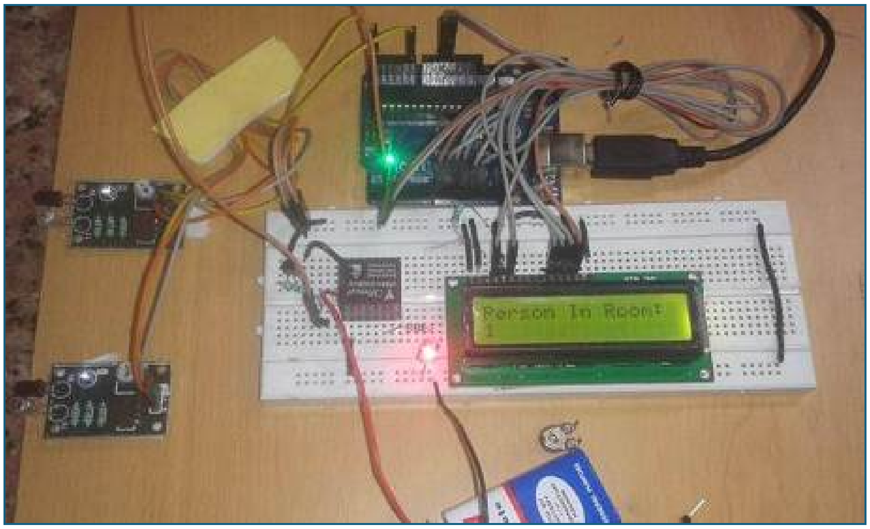

Fig. 6 Experimental setup for Light Control devises

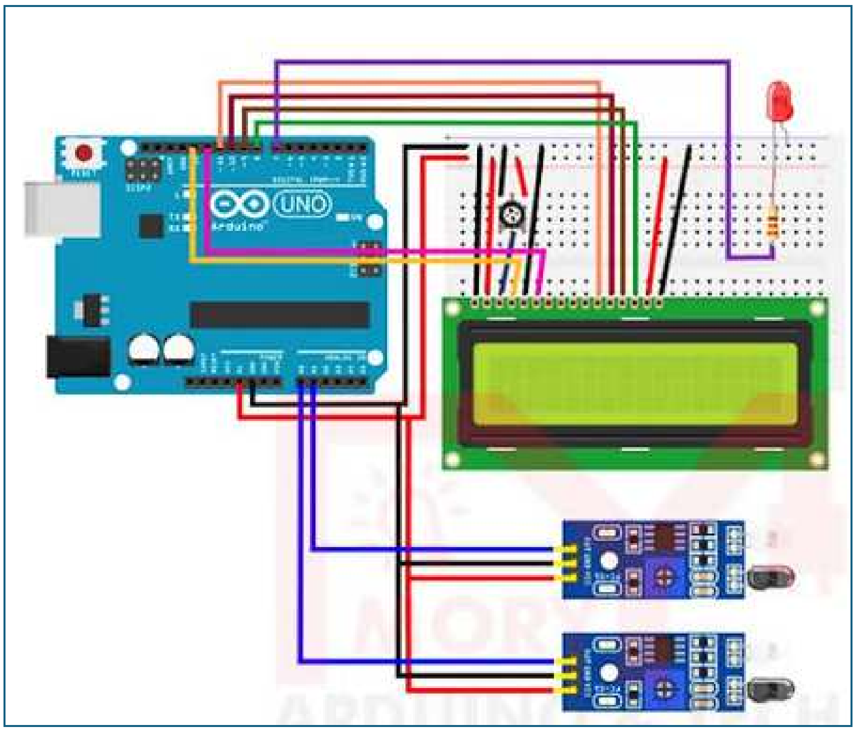

Fig. 7 Circuit design for Light Control

This image (fig. 7) depicts the circuit diagram of a smart automated people counting device with light control, built using an Arduino Uno, infrared sensors, an LCD display, and an LED indicator. This circuit diagram effectively demonstrates a simple yet functional implementation of a smart automated people counting system with an LCD display and an LED indicator. The use of Arduino and IR sensors ensures accurate detection and real-time updates, making it a valuable project for applications in smart building management systems. The modular design allows for easy expansion and integration with additional IoT components for more advanced functionalities.

V. CONCLUSION

5G drone technology heralds a new era in agriculture, presenting transformative opportunities to enhance how we cultivate and manage our food resources. By providing real-time data collection, enabling precision agriculture, and increasing operational efficiencies, this technology equips farmers with the tools to optimize their practices, maximize yields, and reduce environmental impacts. The high-speed, low-latency connectivity offered by 5G ensures that drones can deliver timely insights, allowing for immediate adjustments to farming strategies based on accurate, up-to-date information. Despite its significant potential, the widespread adoption of 5G drone technology in agriculture faces several challenges that must be addressed to fully capitalize on its benefits. Issues such as ensuring consistent connectivity and comprehensive coverage, safeguarding data privacy and security, and navigating a complex regulatory landscape are paramount.

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