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Design and Implementation of a Smart Automatic Door Opening System to Detect High Body Temperature and Provide Covid-19 Disinfection

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Abstract: To mitigate the spread of Corona Virus Disease-19 (Covid-19), monitoring body temperature and performing disinfection are essential preventive measures. Detecting body temperature aids in identifying potential Covid-19 cases, thereby reducing the risk of transmission by limiting contact with others. However, manual temperature screening is prone to inaccuracies and may lead to staff fatigue. Consequently, an automated system for temperature measurement and real-time data display is required to enhance efficiency and reliability.

In addition to temperature monitoring, hand disinfection serves as another crucial step in preventing infection. This can be achieved through an automated process that dispenses disinfectant gel upon hand detection. The proposed system integrates these two procedures sequentially: once an individual's body temperature is assessed and confirmed to be within the permissible range, the disinfection process is triggered. Implementation is facilitated through a gate mechanism equipped with two blades—where the first blade opens upon successful temperature verification, followed by the second blade after automatic hand disinfection. This contactless approach minimizes physical interaction, thereby enhancing safety. The system's development utilizes an Arduino Mega 2560 microcontroller, integrated with three MLX90614 sensors, three HCSR04 ultrasonic sensors, three E18-D80NK sensors, a relay, a DC motor pump, and two DC blade actuator motors. The permissible temperature threshold can be manually configured. Performance evaluations demonstrate the system's effectiveness, including successful disinfectant gel dispensing. Furthermore, temperature measurement validation indicates an average deviation of only 0.018% when compared to thermogun readings, affirming the system's precision and reliability.

Keywords: Smart Automatic Door. High Body Temperature Detection. Infrared Temperature Sensor. Covid19 Prevention. On-contact Temperature. Touchless Entry System. Buzzer Alarm for Temperature.

1. Introduction:

The outbreak of COVID-19, initially identified in Wuhan, China, quickly escalated into a global pandemic, affecting numerous nations, including India, which has a population exceeding 1.34 billion. Given its vast population density, controlling the virus's spread posed significant challenges. Preventive measures such as face masks and sanitizers have proven highly effective in minimizing transmission, particularly as COVID-19 spreads primarily through respiratory droplets and contaminated surfaces. Symptoms commonly associated with the virus include sfever, sore throat, fatigue, loss of taste and smell, and nasal congestion. The incubation period varies, sometimes extending up to 14 days, making early detection and preventive strategies crucial.

Governments worldwide implemented strict policies to curb the spread, including social distancing, mandatory mask usage, quarantine protocols, travel restrictions, and limitations on public gatherings. These measures significantly impacted daily life, affecting work, social interactions, entertainment, and sports activities. To enhance public health safety, authorities prioritized screening measures at critical entry points, such as city borders, workplaces, malls, and hospitals, ensuring individuals with elevated temperatures or without masks were denied entry.

To address this need, an intelligent access control system has been developed, integrating automated body temperature assessment, mask detection, and crowd monitoring. This system leverages advanced sensor technology to perform real-time health screening at entry points, reducing human intervention and enhancing efficiency. By combining temperature detection, occupancy tracking, and mask verification, this smart entry solution provides a comprehensive approach to mitigating infection risks while maintaining smooth public operations.

2. Purpose of the Project:

This project focuses on developing an automated access control system that integrates body temperature detection and hand disinfection to enhance public health safety. The primary goal is to prevent the spread of infectious diseases, particularly Covid-19, by minimizing physical contact and ensuring that individuals with elevated temperatures are identified before entering shared spaces.

The system employs non-contact infrared temperature sensors to assess body temperature accurately. If the measured temperature is within the predefined safe range, the system permits entry by automatically opening a dual-blade gate. However, if the temperature exceeds the threshold, access is denied, preventing potential transmission risks. Additionally, an automated hand disinfection mechanism is incorporated to further reduce contamination risks by dispensing disinfectant gel before final entry approval.

By utilizing microcontroller-based automation, the system enhances efficiency, reliability, and real-time monitoring capabilities. Unlike manual temperature screening, which is labor-intensive and prone to inconsistencies, this approach ensures uniform and precise measurements. The contactless operation not only improves safety but also optimizes resource utilization in high-traffic areas such as hospitals, offices, and public facilities.

Ultimately, this project contributes to creating a safer environment by integrating smart health monitoring and disinfection solutions, thereby reducing the likelihood of virus transmission and promoting public well-being.

3. Door Opening System:

3.1 Automatic Door Opening System:

Manually opening and closing doors can be an inconvenient and repetitive task, particularly in high-traffic areas such as hotels, shopping malls, and theaters, where a dedicated individual is often required to manage access for visitors. To address this challenge, an advanced motion-sensing automatic door system has been developed, offering a seamless and efficient solution for automated entry and exit.

This system operates by detecting human movement in proximity to the door using a passive infrared (PIR) sensor. The human body naturally emits infrared radiation, which the PIR sensor identifies within a specific range. Once movement is detected, the sensor transmits a signal to the microcontroller, which then activates the motor responsible for opening and closing the door. The motor's operation is regulated through a motor driver integrated circuit (IC), ensuring smooth and precise motion control.

By utilizing this technology, the system eliminates the need for manual intervention, enhancing convenience and accessibility in public spaces. Furthermore, it contributes to improved hygiene by minimizing physical contact with door surfaces, making it particularly beneficial in environments where health and safety are a priority. This automated approach not only optimizes efficiency but also integrates seamlessly into modern infrastructure, providing a practical and intelligent entry management solution.

3.2 Automatic Door Opening System Circuit:

The schematic representation of an automatic door opening and closing system is illustrated below. This circuit is constructed using an Arduino UNO, a 16×2 LCD display, a PIR sensor, connecting wires, a breadboard, a 1 k ohm resistor, a power supply, a motor driver, and a DVD.

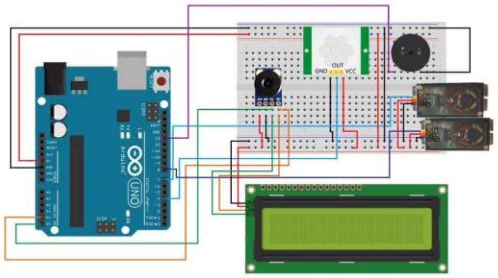

Fig (1) The circuit diagram of an automatic door opening and closing system

The circuit configuration (Fig1) for an automatic door opening system is illustrated above. The PIR sensor features three terminals: Vcc, Dout, and GND. The Dout pin is directly linked to pin 14 (A0) of the Arduino UNO. An LCD display is incorporated to indicate the system's status, with the RS and EN pins of the LCD connected to pins 12 and 13 of the Arduino, respectively. The data pins, D0 through D7, are connected to the Arduino's digital pins 8, 9, 10, and 11, while the RW pin is connected directly to the GND terminal. The motor driver L293D is interfaced with pin 0 and pin 1 of the Arduino to facilitate the opening and closing of the door. In this circuit, a motor is utilized to operate the door.

3.3 Automatic Door Opening System and It's Working:

This project focuses on an automatic door opening system that utilizes a PIR sensor to facilitate the automatic opening and closing of a door. The essential hardware and software components required for this project consist of an 8051 series microcontroller, a transformer, a PIR sensor, a motor for the sliding door, a motor driver integrated circuit, diodes, resistors, capacitors, a crystal oscillator, and a transistor. Additionally, the software development will be conducted using the Keil compiler, employing either embedded C or assembly language.

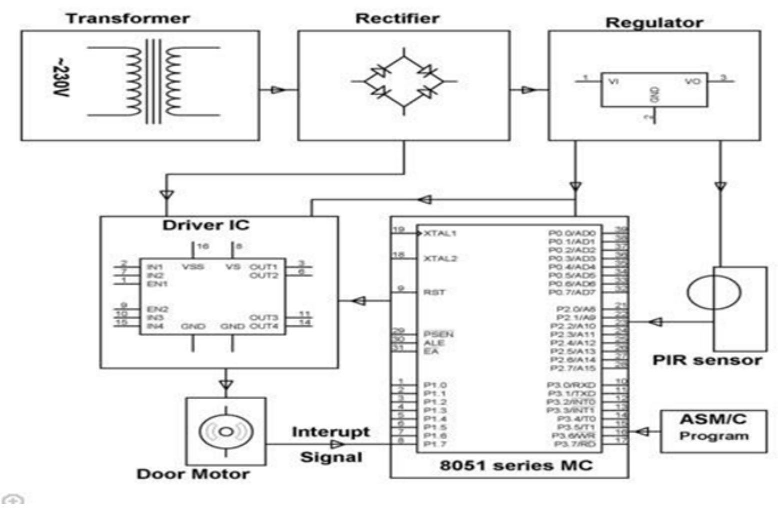

Figure (2) automatic door opening system project.

This proposed system employs a PIR sensor to detect human movement in proximity to the door. Typically, a human body radiates infrared energy in the form of heat, which the PIR sensor can detect from a certain distance. The signal generated by the sensor is then transmitted to an 8051 microcontroller, which controls a door motor through a motor driver integrated circuit. When an individual approaches the detection range of the PIR sensor, it triggers a signal to open the door. The door is programmed to close automatically after a specified time delay, provided there is no further movement detected within the sensor's range. To prevent the motor from entering a locked rotor condition, interrupt signals are utilized through limit switches. Additionally, the system can be enhanced by integrating a counting mechanism to monitor the number of individuals entering and exiting a designated area. This can be achieved by connecting an EEPROM to retain the data in the event of a power outage.

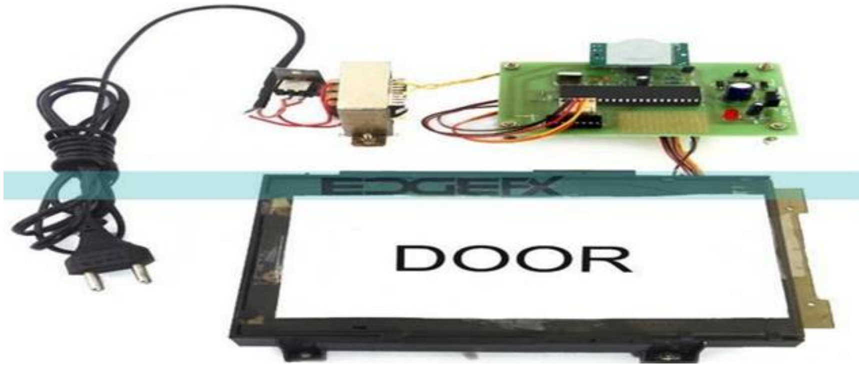

Figure (3) A sensor designed to detect human body movement in proximity to the door.

4. Materials Used:

4.1 Arduino:

The Arduino Uno is a widely used microcontroller board designed for embedded system applications, offering an accessible platform for prototyping and automation projects. It is built around the ATmega328P microcontroller and provides a balance between simplicity and functionality, making it a preferred choice for both beginners and advanced developers.

This board features 14 digital input/output pins, of which 6 can function as PWM outputs, along with 6 analog inputs that enable precise sensor interfacing. It operates at a clock speed of 16 MHz, ensuring efficient processing for various applications. The Arduino Uno is powered via a USB connection or an external power source ranging from 7V to 12V, allowing flexibility in different operational environments.

One of its key advantages is compatibility with the Arduino IDE (Integrated Development Environment), which facilitates easy programming using a simplified C/C++-based language. Additionally, the board supports various communication protocols, including I2C, SPI, and UART, enabling seamless integration with external modules such as sensors, displays, and wireless communication devices.

The open-source nature of Arduino Uno has led to the development of an extensive ecosystem, with numerous libraries and shields available for enhancing its capabilities. Whether used for automation, robotics, IoT applications, or academic research, this microcontroller provides a reliable and cost-effective solution for diverse engineering projects.

Fig (4) Arduino Uno

4.2 motion sensor:

A motion sensor is an electronic device designed to detect physical movement within a specific range. It operates by identifying changes in its surrounding environment using various sensing technologies such as infrared (IR), ultrasonic, microwave, or camera-based vision systems.

One of the most commonly used motion sensors is the Passive Infrared (PIR) sensor, which detects the infrared radiation emitted by living beings. When a heat source, such as a human body, moves within the sensor's range, it triggers an electrical signal, activating the connected system. Another type, the ultrasonic motion sensor, emits high-frequency sound waves and detects movement based on the reflection of these waves from nearby objects. Microwave motion sensors work similarly by emitting microwave signals and analyzing their reflection patterns, making them highly sensitive but more power-consuming. Camera-based sensors, often integrated with AI, provide advanced motion tracking and recognition for security and automation applications.

Motion sensors are widely used in home automation, security systems, industrial automation, and smart lighting. They enhance energy efficiency by automatically controlling devices based on detected movement, reducing unnecessary power consumption. Additionally, they play a crucial role in health monitoring, robotics, and IoT-based applications, contributing to advancements in smart environments and autonomous systems.

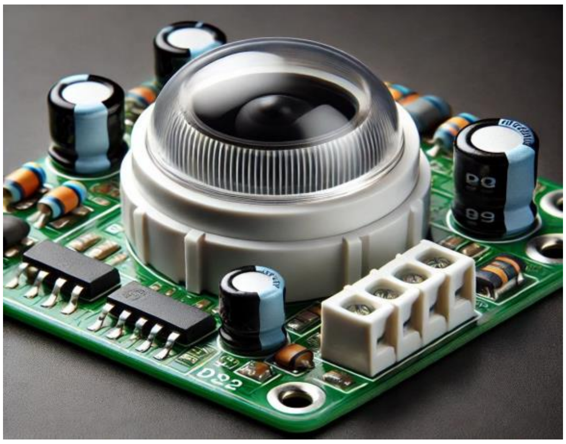

Fig (5) Motion Sensor

4.3 temperature sensor mlx90614:

The MLX90614 is an advanced infrared (IR) temperature sensor designed for non-contact temperature measurement. It operates based on infrared thermopile technology, detecting the thermal radiation emitted by objects to determine their temperature accurately. This makes it highly suitable for applications requiring remote temperature sensing.

The sensor features a built-in 17-bit ADC and DSP processor, providing high precision and a wide measurement range from -40°C to 125°C for ambient temperature and -70°C to 380°C for object temperature. It communicates using the I²C protocol, allowing easy integration with microcontrollers like Arduino and Raspberry Pi.

Due to its non-invasive nature, the MLX90614 is widely used in medical thermometers, industrial automation, smart home systems, and thermal monitoring in electronics. It offers fast response time, low power consumption, and high accuracy, making it ideal for real-time applications where traditional contact-based sensors are impractical

Fig (6) temperature sensor

4.4 Servo motor:

It is a special type of electric motor that is used to control position, speed, and acceleration with high precision. Its operation depends on electrical signals containing the required direction and speed information. It usually consists of three main parts: the motor, the controller, and the position sensor (encoder). The sensor measures the rotation angle and compares it with the reference signal coming from the controller. Based on this measurement, the error is corrected to achieve the desired position accurately. This type of motor is used in various applications such as robotics, industrial control systems, and medical equipment. It is characterized by its ability to provide high torque even at low speeds. The servo motor is an ideal choice for systems that require precise and smooth control of motion.

-The working principle of the servo motor is based on the Closed-Loop System. When the motor receives a control signal (PWM - Pulse Width Modulation), this signal determines the required rotation angle. The controller compares the current rotation angle measured by the position sensor (Encoder) with the specified reference angle. If there is a difference (error) between the current position and the desired position, the controller sends signals to the motor to adjust its movement until it reaches the desired position. This process continues continuously to ensure a fast and accurate response to any changes. The performance of the servo motor depends on the speed of response and the accuracy of measurement, making it ideal for controlling applications that require precise and smooth control such as robotic arms and 3D printers.

Fig (7) Servo Motor

4.5 Buzzer:

It is an electronic component used to produce audible alert signals or tones. It works by converting electrical energy into mechanical vibrations that produce an audible sound.

Fig (8) Buzzer

4.6 LCD:

It is an electronic display unit that contains 16 columns and 2 rows, allowing up to 32 letters or numbers to be displayed at a time. It is based on liquid crystal display (LCD) technology and is easily interconnected with microcontrollers such as Arduino. It supports various control commands such as moving text and changing the display position. It is used in electronics and embedded systems projects to display data and information.

Fig (9) Lcd 16*2

5. Working Principle:

This device operates on a temperature sensor that measures the temperature of objects passing in front of it. When the sensor detects a temperature above 37 degrees Celsius, an electrical signal is sent to the control gate to remain closed, preventing the person from passing. If the temperature is below 37 degrees Celsius, the sensor sends a different signal that allows the gate to open and allow passage.

In addition to the temperature sensor, the device also contains a motion sensor that detects anyone passing through the device after the sterilization process is completed. When the sensor detects movement, it ensures that the system continues to operate to adjust the timing of opening and closing the gate smoothly and effectively.

This dual mechanism (temperature sensor and motion sensor) helps improve safety and efficiency. It ensures monitoring the temperature of people and preventing those with high temperatures from passing, in addition to facilitating the movement of individuals after sterilization without the need for human intervention.

This technology is used in health facilities, public facilities, airports, and other locations that require accurate health monitoring and effective sterilization to protect individuals from the transmission of infections and diseases.

Fig (10) Smart Entry Gate

6. Result:

A sterilization gate has been developed to prevent the Corona virus by relying on a special sensor to measure the human body temperature. This gate works when a person approaches the sensor, where the temperature is accurately measured. If the temperature is within the normal range, the gate opens and allows passage. However, if the temperature is high and abnormal, the gate remains closed to prevent passage. This system is based on the fact that people infected with the Corona virus often suffer from a high temperature, which makes it easier to identify them and take appropriate preventive measures.

7. CONCLUSION:

It can be inferred that the development of a smart gateway utilizing temperature detection technology contributes significantly to mitigating the risks associated with virus transmission. This system aids in identifying individuals exhibiting symptoms while minimizing human intervention in the screening process. Furthermore, it has an immediate social impact by promoting a structured and controlled entry system. The approach relies on a meticulous entry procedure facilitated by a temperature sensor, ensuring that visitors comply with public health regulations and reducing the spread of COVID-19 in public spaces.

The proposed solution is designed to be both cost-effective and user-friendly for fever screening applications. It is particularly suitable for installation in fixed indoor locations, such as entry corridors and checkpoints. The system's sensors have been calibrated appropriately, and the fever threshold has been set to a predefined normal temperature in degrees Celsius. As a result, the smart portal presents a viable and effective tool with a direct societal impact in the current health landscape.

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