Smart Door Locking System with Intrusion Detection

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***Abstract*— In this digital age, IoT based systems have become a common thing in the society. Most of the electronics nowadays have some or the other form of IoT technology embedded in it. Leveraging various wireless technologies provided by IoT can aid at creating efficient and effective machines. One of the sensors, which is an IR receiver diode with the help of a remote can help in creating various wireless electronic smart devices. ESP8266, the Wi-Fi module provided by IoT as well, enables one to connect to the internet via Wi-Fi. Utilizing these two sensors in this project, we can create a secure IoT based Smart Door Locking system which can detect intruders as well, with the help of PIR sensor. This module provides an extra layer of security, overcoming the various challenges of traditional door locking systems.**

Keywords—Security, door lock, Internet of Things, Arduino, wireless.

I. INTRODUCTION

We are currently in the digital age, where most of the traditional technologies are being replaced by newer and advanced technologies. Be it security or entertainment, IoT has enabled the creation of various new devices and gadgets which aid in the day-to-day life. With the advent of wireless devices, various bulky and complicated-to-carry devices have now started fitting in our pockets. But with all the boons the technology has given us, there is always a bane. That bane can be considered as a challenge to security. Be it privacy or security of physical locations, criminals are always trying to find a way to bypass the various digital security hurdles provided by technology. That is a huge reason why there needs to be an effective IoT based solution to the various problems pertaining to security. One of those problems is the problem of security doors, which many a times protect important documents or financial documents. Facilities considered under this problem statement include Banks, ATMs, Financial Institutions, Government Offices, etc. All these places have a very high risk-factor of infiltration by intruders or burglars.

The Smart Door Locking System with Intrusion Detection (SDLSWID) is an attempt at creating a solution to the above problem statement. It utilizes two of the wireless sensors provided by IoT, viz. the ESP8266 Wi-Fi module and the IR Receiver Diode which serves as a receiver for an infrared remote control. The SDLSWID has been designed keeping in mind various goal and objectives. The first goal of the SDLSWID is replacing the traditional door lock system. This includes a physical lock on the door which can be easily bypassed if not careful. A digital lock connected to a network can broadcast any break-in attempts to the respective owner. Another objective of this system is to design a safe and secure door locking system. The components in this system are chosen keeping in mind the financial aspects too, meaning anyone can use this SDLSWID.

II. HARDWARE REQUIREMENTS

Study was done on various components, their compatibility with each other as well as the feasibility. They were even tested on various simulator software available out there. The various hardware IoT components to be used are given below.

A. *Arduino UNO*

Arduino UNO is a standard Arduino development board. It was named UNO to mark the first version of the Arduino software. This is also the first USB board released by Arduino. It is considered a powerful function board used in various projects. Arduino.cc developed the Arduino UNO board.[1]

The Arduino UNO is based on the ATmega328P microcontroller. Compared with other boards such as the Arduino Mega board, it is easy to use. The evaluation board includes digital and analog input/output (I/O) pins, protectors, and other circuits. , 14 digital pins, USB connector, power connector and ICSP (Online Serial Programming) header connector. It is based on IDE for programming, IDE stands for integrated development environment. It can run on online and offline platforms.

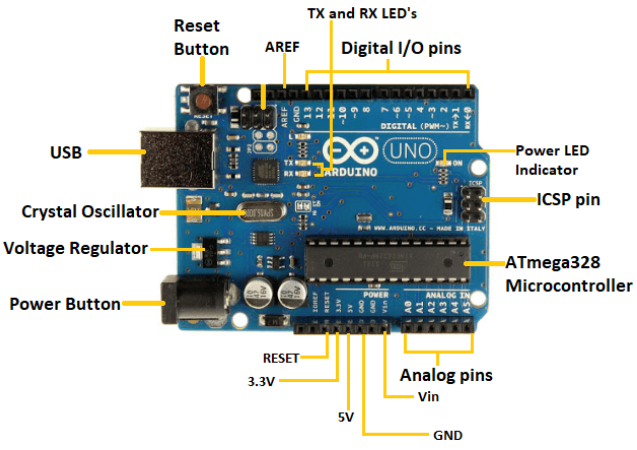

Fig 1 - Arduino UNO with their Components [1]

The Arduino Uno R3 board includes the following specifications. [1]

- It is an ATmega328P based Microcontroller
- The Operating Voltage of the Arduino is 5VThe recommended input voltage ranges from 7V to 12V
- The I/P voltage (limit) is 6V to 20V
- Digital input and output pins-14

- Digital input & output pins (PWM)-6
- Analog I/P pins are 6
- DC Current for each I/O Pin is 20 mA
- DC Current used for 3.3V Pin is 50 mA
- Flash Memory -32 KB, and 0.5 KB memory is used by the boot loader
- SRAM is 2 KBEEPROM is 1 KB
- The speed of the CLK is 16 MHz
- In Built LED
- Length and width of the Arduino are 68.6 mm X 53.4 mm
- The weight of the Arduino board is 25 g.

B. *PIR Sensor*

PIR stands for pyroelectric infrared sensor or passive infrared sensor. PIR is an electronic sensor that can detect long-distance infrared light changes and send out electrical signals at its output based on the detected infrared signals. [2] It can detect any infrared emitting object, such as a person or animal, if it is within the range of the sensor, or is moving away from the range, or moving within the range of the sensor.

Fig 2 – PIR Sensor

The main technical specifications and dimension parameters of a PIR sensor can be learned from the following details:[2]

Recommended Model	D204B
Encapsulation Type	TO-5
IR Receiving Electrode	2x1mm, 2 elements
Window Size	5x3.8mm
Spectral Response	5-14micro-m
Transmittance	>=75%
Signal Output [Vp-p]	>=3500mV
Sensitivity	>=3300V/W
Detectivity (D*)	>=1.4x10^8 cmHz/W
Noise [Vp-p]	<70mV
Output Balance	<10%
Offset Voltage	0.3-1.2V
Supply Voltage	3-15V
Operating Temp.	-30-70C
Storage Temp.	-40-80C

Table 1 – Details of PIR sensor

C. *IR Receiver Diode*

Infrared receivers are also called infrared sensors because they detect radiation from the IR transmitter. Infrared receivers appear in the form of photodiodes and phototransistors. The difference between Infrared photodiodes and conventional photodiodes is that they only detect infrared radiation. [3] has different types of IR receivers based on wavelength, voltage, packaging, etc. When using for an infrared transceiver combination, the wavelength of the receiver must match the wavelength of the receiver.

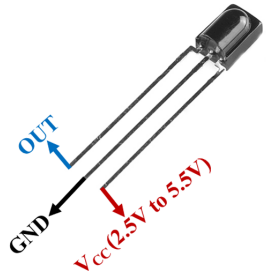

Fig 3 – IR Receiver Diode

Given below is its pin configuration:

Pin Name	Description
VCC	The Vcc Pin powers the module, typically with +5V
GND	Power Supply Ground
OUT	Output Pin

Table 2 – IR Receiver Diode Pin Configuration

Features and Specifications:[3]

- Operating Voltage: 2.5V to 5.5V
- Operating Current: 350µA
- Output Current: 5mA
- Carrier Frequency: 38 kHz
- Transmission Distance: 45 m
- Operating Temperature Range: -25 to 85 C
- Pd - Power Dissipation: 10mW

D. *ESP8266 Wi-Fi Module*

ESP8266 is a system on chip (SoC) module with Wi-Fi function developed by Espressif system. It is mainly used to develop integrated Internet of Things (IoT) applications.[4]

ESP8266 is a low-cost Wi-Fi microchip with a complete TCP/IP stack and microcontroller functions. It is headquartered in Shanghai Espressif Systems (Espressif Systems) Produced by a Chinese manufacturing company.

ESP8266 can host an application or download all Wi-Fi network functions from another application processor.[4]

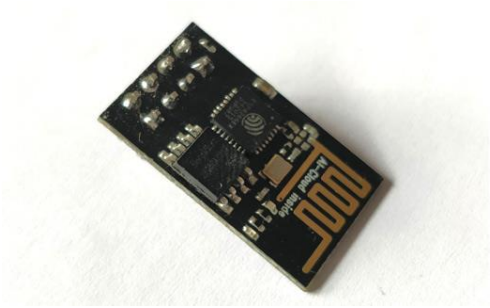

Fig 4 - ESP8266 Wi-Fi Module [4]

ESP8266-01 Features:[4]

- Low cost, compact and powerful Wi-Fi Module
- Power Supply: +3.3V only
- Current Consumption: 100mA
- I/O Voltage: 3.6V (max)
- I/O source current: 12mA (max)
- Built-in low power 32-bit MCU @ 80MHz
- 512kB Flash Memory-Can be used as Station or Access Point or both combined
- Supports Deep sleep (<10uA)
- Supports serial communication hence compatible with many development platforms like Arduino
- Can be programmed using Arduino IDE or AT-commands or Lua Script

E. 12VDC Lock-Style Solenoid

Solenoid valves are basically electromagnets - they are made of a large loop of copper wire with a armature (a piece of metal) in the middle. After the coil is energized, pull the bullet toward in the center of the coil. This allows the solenoid to be pulled out at one end.[7] The solenoid is particularly good at , sturdy and has a lug with an oblique cutout and a good mounting bracket. It is basically an electronic lock, designed for basic cabinets, safes or doors. Normally the lock is active so it cannot open the door because the solenoid plug has locked it. In this state, it will not use energy. When 9-12VDC is used, the bullet will enter such that it no longer penetrates the and the door can be opened. The solenoid comes with the slanted plug shown above as shown, but you can use two Phillips head screws to open it and then rotate it to make the so it rotates 90, 180 or 270 degrees to make it compatible with Match the door you want.

Fig 5 – 12VDC Lock-Style Solenoid

Specifications:[7]

Operating Voltage	12V DC
Drawing Current	650mA at 12V, 500 mA at 9V
Weight	147.71g
Wire Length	222.25mm / 8.75"
Normal Dimensions	23.57mm / 0.92" x 67.47mm / 2.65" x 27.59mm / 11.08"
Max Dimensions	41.85mm / 1.64" x 53.57mm / 2.1" x 27.59mm / 11.08"

Table 3 – Solenoid Lock Specifications (12V DC)

F. General Purpose LEDs

An LED or a Light Emitting Diode is semiconductor device that emits light due to Electroluminescence effect. An LED is basically a PN Junction Diode, which emits light when forward biased. Light Emitting Diodes are almost everywhere. You can find LEDs in Cars, Bikes, Street Lights, Home Lighting, Office Lighting, Mobile Phones, Televisions and many more. The reason for such wide range of implementation of LEDs is its advantages over traditional incandescent bulbs and the recent compact fluorescent lamps (CFL).

Few advantages of LEDs over incandescent and CFL light sources are mentioned below:[5]

- Low Power Consumption
- Small Size
- Fast Switching
- Physically Robust
- Long Lasting

Fig 6 – General LEDs [5]

G. *16x2 LCD*

The term LCD stands for liquid crystal display. It is an electronic display module that is widely used in various applications, such as various circuits and devices, such as mobile phones, calculators, computers, televisions, etc. These displays are the first choice for multi-segment and seven-segment LEDs. The main advantage of using this module is economy; animation can be made only by programming, and there are no restrictions on displaying custom characters or even special animations. [6]

Fig 7 – 16x2 LCD

The features of this LCD mainly include the following. [6]

- The operating voltage of this LCD is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8-pixel box
- The alphanumeric LCDs alphabets & numbers
- Is display can work on two modes like 4-bit & 8-bit
- These are obtainable in Blue & Green Backlight
- It displays a few custom generated characters

H. *IR Remote*

Fig 8 – IR Remote [8]

In electronic products, a remote control or clicker is an electronic device, generally used to remotely operate another device. In consumer electronic products, the remote control can be used to operate devices such as televisions, DVD players, or other devices. home appliances. The remote control can allow devices to operate that cannot be directly operated with the control. They work best when used at short distances. [8] This is primarily a convenient function for users. In some cases, such as when a garage door opener is activated from the outside, the remote control allows personnel to operate equipment that would otherwise be inaccessible.[8]

III. PROTOTYPE

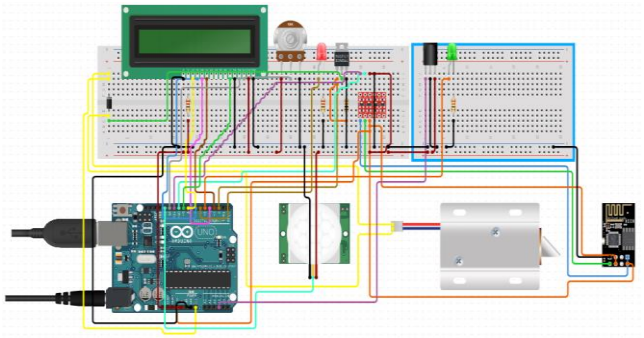

Fig 9 – Circuit Diagram

The working of the SDLSWID can be demonstrated as below:

- The microcontroller used for the project is Arduino UNO. The wireless sensors used for the project are ESP8266 and IR Receiver Diode. A PIR sensor for detecting motions is used. Some LEDs, along with LCD and a 12V DC Solenoid Lock are used for output purposes.
- Initially, the device will be in “locked” state, i.e., the Solenoid Lock would be activated and the LCD will display the “Enter PIN:” message. The PIR sensor will be active, ie, whenever a person loiters around the apparatus, in this case a security door, the PIR sensor will detect the movement and the Red LED will start blinking. Whenever the movement stops, the LED stops blinking.
- The owner will have a remote control, from which he can perform a number of actions. The first action is disabling the motion detector. This can be performed by pressing the power button on the remote control. As soon as the user presses the power button, the PIR Sensor stops detecting any motions and the Green LED lights up. This will indicate it is safe to approach the apparatus.
- The LCD will constantly ask for the PIN while the device is in locked state. Whenever the user enters an incorrect PIN and presses the submit button, the Red LED will blink for a bit and the message “Wrong Password!!” will display on LCD for some time.

- When the user enters the correct PIN and presses the submit button, the LCD will display the message “Door Unlocked!!” and the Solenoid Lock will open, along with disabling the PIR sensor, if not already disabled, thus giving the owner access through the door. The Green LED will also light up, thus having multi-purposes, one indicating that the PIR sensor is disabled, and the other being that the door is unlocked.
- Whenever the person wishes to lock the door again, they just have to press the power button, which re-enables the solenoid lock, and the LCD starts asking for PIN again. The PIR sensor is also reactivated, thus locking the door securely.
- The ESP8266 sensor can connect to a Wi-Fi network and transmit any break-in attempts detected by the PIR sensor to the ThingSpeak Cloud, which can be accessed by the owner.

IV. Future Scope

Since, the nature of the project (SDLSWID) is quite flexible, it is possible to add and implement various modules and wireless sensors which would make the system much more reliable with added security features. Prominent among those are Global System for Mobile Communication (GSM) and Global Positioning System (GPS) modules. In this proposed system, there is a scope for a GSM module. The module can enable one to connect to any mobile network and send/receive SMS and other communications. If a GSM module is installed in the system, then the owner can be notified about intrusions via SMS as well. This eliminates the need of constant Wi-Fi connection which is required by the ESP8266 module. Apart from this, the other components which can be used as an alternative can be buzzers and speakers. Whenever an intrusion is detected, the sound of alarm through speakers can be an indication of intrusion to the security personnel.

V. Conclusion

In today’s modern world where automation is at its peak, security issues are becoming more important and developed day by day. Due to the advancement in the field of Information Technology, the biggest compromise with the security is not completely understanding and neglecting the critical points in the system which is indeed the root cause of security threats. There are various dedicated technologies being made by hackers and intruders to bypass the various digital locking mechanisms.

This Smart Door Locking System with Intrusion Detection (SDLSWID) is thus an attempt at creating an enhanced door lock system using IOT and wireless networking has been made. The smart door locking system provides advanced security of today’s standard and can be utilized at highly sensitive places such as Banks, ATMs, Financial Organizations, Government Offices and Organizations etc., since these are the most common targets where unauthorized access takes place. An extra layer of security is also added in the form of motion detection with the help of PIR sensor. The entire control of the system can be wirelessly handled through an IR remote by the owner. The owner is also made aware of the intruders via ThingSpeak platform with the help of ESP8266 Wi-Fi shield. Various scenarios and test cases of intrusion activities are taken into consideration and accordingly actions corresponding to those events are designed and implemented in the proposed system. Since, the proposed system is majorly developed using wireless sensor network, it is quite flexible and easily installable system without having congested cabling, construction works and planning. The main reason behind this implementation is to provide a secure and enhanced form of security accessible to everyone thereby eliminating the chance of compromising with the security and protection of any particular system. This SDLSWID has tremendous potential to overcome the traditional door lock system because of its cost-effectiveness and easy-to-install capabilities[9].

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