Creation of a New Home Security System Using IoT Devices

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**Abstract** — This project presents the design and implementation of a moderately low-cost smart home door security system using IoT devices. This report will outline the devices used and why each was chosen compared with alternative devices for each situation, an outline of the rough costs for each component needed to create the device, pseudo code, diagrams to show logic and data flow within the device and a final implementation made with available devices including a reflection on how the project went.

**Index Terms** — Internet of Things (IoT), home security, HC-SR04 ultrasonic sensor, ESP32-CAM, smart devices, motion detection, real-time notification, intrusion detection, image capture, buzzer alarm system, pseudocode, logic diagram, smart home, design, implementation.

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# 1 Introduction

## Scenario

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onsider a scenario where someone attempts to break into a home. Without an effective home security system in place, it may go undetected. This is a reality many people face. With a house being broken into approximately every 173 seconds in 2023/24[1] home security is becoming an increasing concern for UK citizens. Due to this IoT based smart home devices are gradually becoming more popular among the public with approximately "one in five Brits now own[ing] a video doorbell"[2] this rise in popularity is primarily due to the increased capabilities and affordability of these devices.

Many traditional home security systems can either be expensive or complex to install and many low-cost alternatives lack the capabilities to be truly effective. This demonstrates the need for a simple, effective home security system which will not be overly expensive.

## Solution

This is where a simple system which can be installed at any door in a property can come in useful. The system will include a sensor to detect when a door opens and use a camera to snap a picture of the intruder before sending a notification to the user’s phone and then waiting for a bit to allow for the person to input a pin before setting off an alarm. This device is meant to scare the intruder to stop them from entering while still ensuring that they get caught due to the image capturing capabilities.

# 2 Details of the design

## Hardware components

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he system can be split into three sections:

Firstly, there is the trigger mechanism which will be made up of a tilt sensor rigged up to the door to detect a change in the angle and send a signal to the next section of the device.

This is better as opposed to the other options, such as a button positioned such that when the door is fully closed it would be pressed and when opened it would stop pressing the button. This is because while being effective it would be difficult to implement reliably.

Furthermore, a HC-SR04 ultrasonic sensor aimed at the door so when it moves the sensor would trigger would be able to be implemented easily enough. However, an issue with this approach is that it could be difficult to implement without the sensor triggering when other objects move in front of it causing a lot of false alarms.

Secondly, there is the camera and notification using the ESP32-CAM which will wait for a few seconds to allow for the door to be fully opened before taking a picture and sending it to the user's phone as a notification.

The ESP32-CAM would be the better choice over the other option which would have involved using a ESP8266 and an OV7670 camera module due to the ESP-32 being faster and having more memory and the OV7670 not supporting compressed images and offering lower resolution as opposed to the OV2640 (ESP32-CAM)[3].

Lastly, there is the alarm where it will then wait for a bit longer to allow the person a chance to input a pin on a membrane switch module to shut off the alarm which will use a buzzer and will trigger if the pin is not put in in time. However, the buzzer will still go off if the pin is input after the timer is over.

The membrane switch was chosen over alternatives such as a 3x4 matrix array keypad or an Interfacing AS608 Optical Fingerprint Sensor Module due to the membrane switch and keypad being very similar devices and the membrane switch being easier for users as the user does not need to go through the trouble of setting up a finger print scan for everyone who is allowed in as opposed to telling them the PIN for the membrane switch.

Also, the buzzer was chosen over alternatives such as a speaker as it is unnecessary to use a speaker as opposed to a buzzer due to not requiring the extra functions provided by the speaker.

### Wiring

#### Passive Buzzer Wiring

Buzzer GND --> Arduino GND

Buzzer --> Arduino pin 13

#### HC-SR04 Ultrasonic sensor Wiring

HC-SR04 VCC --> Arduino 5v

HC-SR04 ECHO --> Arduino pin 11

HC-SR04 TRIG --> Arduino pin 12

HC-SR04 GND --> Arduino GND

#### Membrane Switch Wiring

Matrix Row 1 --> Arduino pin 3

Matrix Row 2 --> Arduino pin 4

Matrix Row 3 --> Arduino pin 5

Matrix Row 4 --> Arduino pin 6

Matrix Column 1 --> Arduino pin 7

Matrix Column 2 --> Arduino pin 8

Matrix Column 3 --> Arduino pin 9

Matrix Column 4 --> Arduino pin 10

#### ESP8266 Wiring

ESP-01 TX --> Arduino pin 1

ESP-01 RX --> Arduino pin 0

ESP-01 GND --> Arduino GND

ESP-01 CH\_PD --> Arduino 3.3v

ESP-01 VCC/3.3v --> Arduino 3.3v

## Software design

### Pseudo-code

#### Arduino

*Define ultrasonic sensor*

*Define buzzer*

*Define duration*

*Define distance*

*Define keypad*

*Define email Sender Account*

*Define email Sender Password*

*Define smtp Server*

*Define smtp Server Port*

*Define email Subject*

*Define email Recipient*

*Define SSID*

*Define password*

*rows = 4*

*cols = 4*

*hexakeys[rows][cols] = {*

*Buttons on keypad*

*}*

*colpins[rows] = pins*

*rowpins[cols] = pins*

*void setup() {*

*Set input/output of the ultrasonic sensor*

*Set serial communication*

*Set buzzer output*

*WIFI.begin*

*}*

*void loop() {*

*Set buzzer off*

*Set ultrasonic sensor to low*

*Delay for two microseconds*

*Set ultrasonic sensor to high*

*delay for ten microseconds*

*Set ultrasonic sensor to low*

*Calculate the distance*

*Divide the speed of the sound wave by 2 (there and back)*

*if (distance>distance to door+10 or distance<distance to door-10) {*

*delay for 5 seconds*

*send serial message to python script to take picture*

*If (key pressed = #)*

*If pad = password*

*End*

*If pad != password*

*Buzzer on*

*Void read keypad() {*

*get key pressed*

*If key pressed != #*

*pad += new key pressed*

*}*

*delay 0.1 seconds*

*}*

#### Python

*Import serial*

*Import cv2*

*Import time*

*Import os*

*Set serial port*

*Set directory for saved images*

*Make the directory if it does not exist*

*Open camera*

*If the camera does not work, then exit*

*while true*

*if port has information waiting*

*read data*

*if command = take picture*

*take picture*

*if picture is taken*

*timestamp = year-month-day*

*file name = image-timestamp.jpg*

### Logic diagram

A flowchart of a photo

AI-generated content may be incorrect.

A diagram of a computer program

AI-generated content may be incorrect.

# 3 Implementation

## Limitations

Due to hardware limitations for this implementation, it instead used an HC-SR04 ultrasonic sensor as an alternative to the tilt sensor, an Arduino board with an ESP-82666 for Wi-Fi connection and a laptop webcam instead of an OV2640. This will slightly change how the project is implemented however these changes will not have significant effects on the functionality of the device.

## Camera

To use a laptop camera to take pictures, I had to make the Arduino code send out a message on the connected port to make a piece of python code use the laptop camera to take a picture and save it. Furthermore, each image is saved in a folder called Captured\_Images and named using a timestamp to avoid multiple files with the same name.

# 4 Discussion and conclusion

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