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Abstract

Peace of mind and affordable, multi-feature and simple Home/Business Intrusion Detection System with fast response times and multiple-channel alerts to safeguard your family, home or business.

**MEIS-Alert Home/Business Intrusion Detection System**

Affordable and Reliable Detection System

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| **MEIS-Alert**  **Home/Business Intrusion Detection System** |

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| TEAM MEMBER(S) | COLLABORATOR CONTACT INFORMATION |
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# PROJECT SUMMARY

Build an affordable, reliable and simple self-monitoring home/business intruder detection system based on the Raspberry Pi 4 platform, and PIR (Passive Infrared) and pressure sensors, and connected to the internet to relay home/business intrusion alerts via email notifications after double authentication intrusion system. The system will have the ability to detect human intrusion either by sound or infrared detection sensors, confirm it is a real-time intrusion and deliver real-time email alerts with pictures while alerting surrounding persons of the intrusion.

# PROGRAM COURSE/TOPICS EXAMINED

The Intrusion Detection System real-world project will aim to satisfy the requirements for the course Hardware Production Technology (CENG317) at Humber Institute of Technology and Advanced Learning within the Computer Engineering Technology program. As a result, the following related topics will be examined in order to complete it: electronic circuit design, 3D printing, PCB modelling and design using Fritzing or SketchUp, Raspberry Pi 4 technical information, Python programming (GPIO to handle input/output digital signals), Passive infrared (PIR) sensor, sound sensor, IoT devices connecting wirelessly to a network and transmit data, Simple Mail Transfer Protocol for electronic mail transmission and use of camera to capture pictures.

# PROJECT BACKGROUND

Break-ins occur every 90 seconds in Canada. [1] In 2015, statistics Canada showed that there were 159,338 burglaries across Canada and all types of properties. That is 444 reported burglaries per 100,000 persons. In other words, 4% of all Canadian households were burglarized; that is to say 1 out of 28 households were burglarized across the country. [2]

Close to home, in the City of Toronto, Statistics Canada reported that in 2018 there were 14,265 Break and entering cases reports; that is 227.36 reported burglaries per 100,000 persons, an increase of 3.81% from 2017. According to the report, 1,723 persons were charged with the offence; 145 youths between the ages of 12 and 17 years of age were charged. [3]

More disturbing, according to the Canadian Centre for Justice Statistics, a typical home/business invasion robbery in Canada is carried out by strangers 68% of the time in which a weapon is present 62% of the time (firearms 33%, Knives or cutting instruments 30% other weapons 42%) during the home/business invasion and victims sustain injuries in 50% of the cases. [4]

Taking into account the abovementioned statistics, it is not surprise that home/business owners are looking for a home intrusion detection system to safeguard their families and property. However, they are finding it more difficult to protect their families, homes and businesses with the skyrocketing pricing of commercial alarm systems. For example, Vivint will charge around $700 just for the basic starter equipment package and a monthly monitoring fee between $30 and $45 dollars per month on a 42 to 60 month contract; that is between $1300 and $2700 per year!

# **IMPLEMENTATION STRATEGY**

### Phase 1: Gather Materials Needed

|  |  |
| --- | --- |
| Raspberry Pi running Raspbian  (Price: CDN$ 89.00)  https://images-na.ssl-images-amazon.com/images/I/71LNCAd0tQL._SL1271_.jpg | Raspberry Pi 4 Model B 2019 Quad Core 64 Bit WiFi Bluetooth (4GB)   * 1.5GHz quad-core 64-bit ARM Cortex-A72 CPU * 4GB of LPDDR4 SDRAM * Full-throughput Gigabit Ethernet * Dual-band 802.11ac wireless networking * Bluetooth 5.0 * Two USB 3.0 and two USB 2.0 ports * Dual monitor support, at resolutions up to 4KVideoCore VI graphics supporting OpenGL ES 3.x4Kp60 hardware decode of HEVC video |
| USB Camera  (Price: CDN$ 30.99)  https://images-na.ssl-images-amazon.com/images/I/716xVEE4M3L._SL1500_.jpg | Smraza Camera Module for Raspberry Pi 4 (4gb, 2gb, 1gb) 5MP 1080p OV5647 Video Webcam Night Vision, Camera Compatible with Raspberry 4 Model B/Pi 3 2 Model B   * CCD size : 1/4 inch * Aperture (F) : 1.8 * Focal Length : 3.6MM (adjustable) * Diagonal : 75.7 degree * Sensor best resolution : 1080p * Provides 3.3V power output * Supports connecting infrared LED and/or fill flash LED * Dimension : 25mm \* 24mm |
| Sound Sensor  (Price: CDN$ 11.68)  https://images-na.ssl-images-amazon.com/images/I/61vt71Fju5L._SL1024_.jpg | DAOKI 5PCS High Sensitivity Sound Microphone Sensor Detection Module For Arduino AVR PIC   * Sensitivity adjustable * Working voltage: DC 4-6V * Digital switch output (1 s and 0 s + v) * Fixed bolt hole, convenient installation * Size:34mm\*16mm\*15mm(length\*width\*height) |
| Passive Piezo Buzzer  (Price: CDN$ 5.40)https://images-na.ssl-images-amazon.com/images/I/61qpGejLcyL._SL1000_.jpg | GAOHOU 5V Passive Buzzer Piezo Speaker Play Song Melody Module for Arduino STM32   * Operating voltage: 3.3 - 5.2VDC * Operating Current: 25mA (max) |
| PIR (Passive Infrared Sensor)  (Price: CDN$ 10.99)  https://images-na.ssl-images-amazon.com/images/I/71NlY-wqtrL._SL1500_.jpg | Aukru 3X HC-SR501 Human Sensor Module Pyroelectric Infrared PIR Sensor Detector   * Product Type: HC--SR501 Body Sensor Module * Operating voltage range: DC 4.5-20V * Quiescent Current: <50uA * Trigger: L (Default repeated trigger) * Delay time: 5-200S (adjustable) * Block time: 2.5S (default) * Board PCB Size:3.7x2.5x2cm (1.46x0.98x0.79inch) * Angle Sensor: <100  cone angle * Lens size sensor: Diameter: 23mm (Default) |
| Jumper Wires  (Price: CDN$ 10.99)  https://images-na.ssl-images-amazon.com/images/I/61xWyU4pjRL._SL1500_.jpg | Quimat 65pcs Assorted Length Multicolored Solderless Flexible Breadboard Jumper Cable Wires Male to Male for Arduino, Raspberry Pi Model A/Model B 1 1+ 2 3/Computer Module/Zero QY20 |
| Copper Covered PCB Printed Circuit Board  (Price: CDN$ 6.65)  https://images-na.ssl-images-amazon.com/images/I/51W0hfwA8lL._SL1100_.jpg | Aexit 5 Pcs Copper Cover Single Side PCB Printed Circuit Board 10cm x 7cm   * Thickness (Approx.) : 1.5mm / 0.06";Material : FR-4, Copper Foil * Product Name : PCB Board * Size(Approx) : 10 x 7cm/ 3.9" x 2.76"(L\*W) * Color : Copper Tone * Net Weight : 80g |
| Enable/Reset Alarm System Push Button (Price: CDN$ 5.99)  https://images-na.ssl-images-amazon.com/images/I/51JB7-akPpL._SL1000_.jpg | SunFounder Button Module for Arduino and Raspberry Pi   * Module Size: 12x12x5 mm size * Working voltage: DC 5V * Output digital signals; * PCB size: 2.0 x 2.0 cm * With power light and indicator of digital signal output |
| WiFi Wireless Transceiver  (Price: CDN$ 17.00)  https://images-na.ssl-images-amazon.com/images/I/61lVaa8hevL._SL1000_.jpg | Kuman 2 Pack ESP8266 ESP-01 WiFi Wireless Transceiver Module 1MB Flash in Anti-Static Foam for Arduino Compatible KY45   * 802.11 b/g/n * WiFi security modes: WPA, WPA2 * Serial/UART baud rate: 115200 bps * Integrated TCP/IP protocol stack * Input power: 3.3V * I/O voltage tolerance: 3.6V Max * Regular operation current draw: ~70mA * Peak operating current draw: ~300mA * Power down leakage current: <10µA * +19.5dBm output in 802.11b mode * Flash Memory Size: 1MB (8Mbit) * Module's dimensions: 24.75mm x 14.5mm (0.974" x 0.571") |
| Miscellaneous Items: | * Solder Iron 40 Watt * NR 211MP .035 inch. Flux-Cored Wire (10 lbs.) * Prototyping Board * Laser Printer * Fritzing Software * 220 Ohm Resistor for LED * 4 Amp Power Adapter * 16GB micro SD card |

### Phase 2: Setup Raspberry Pi 4 with Raspbian OS

|  |  |
| --- | --- |
| Download Raspbian for Raspberry Pi 4: | http://www.raspberrypi.org/downloads/ |
|  | |
| Software to write Raspbian to SD card: | https://www.raspberrypi.org/documentation/installation/installing-images/ |
| Install compiler | $ sudo apt-get install build-essential |
| Install required packages | $ sudo apt-get install cmake git libgtk2.0-dev pkg-config libavcodec-dev libavformat-dev libswscale-dev |
| Install optional packages | $ sudo apt-get install python-dev python-numpy libtbb2 libtbb-dev libjpeg-dev libpng-dev libtiff-dev libjasper-dev libdc1394-22-dev |

### Phase 3: Design Prototype Circuit Using GPIO.BOARD Pins (Input and Output sources)

|  |  |  |  |
| --- | --- | --- | --- |
| **PIR Sensor/Raspberry Pi 4 Connections** | | | |
| **PIR Sensor** | | | **Raspberry Pi 4** |
| VCC | | | 5V |
| Middle Pin (input) | | | GPIO pin 4 |
| GND | | | GND |
| PIR Sensor Adjustments | | | |
| * Orange screws are two potentiometers.   + First screw: adjusts sensitivity of sensor   + Send screw: adjusts amount of time sensor sends signal to Raspberry Pi 4. * Adjust potentiometers as needed. | | | |
|  | | |  |
| **LED Connections/Raspberry Pi 4 Connections** | | | |
| **LED** | | | **Raspberry Pi 4** |
| Short end of LED | | | GND |
| Long end of LED | | | GPIO pin 13 |
|  | | |  |
| **Buzzer Connections/Raspberry Pi 4 Connections** | | | |
| **Buzzer** | | | **Raspberry Pi 4** |
| -ve pin on buzzer | | | GND |
| +ve pin on buzzer | | | GPIO pin 8 |
|  | | | |
| **Sound Sensor Connections/Raspberry Pi 4 Connections** | | | |
| **Sound Sensor** | | | **Raspberry Pi 4** |
| VCC | | | 5V |
| GND | | | GND |
| Digital Output D0 | | | GPIO pin 7 |
|  | | | |
|  | | | |
| **Alarm Reset Connections/Raspberry Pi 4 Connections** | | | |
| **Push Button** | | **Raspeberry Pi 4** | |
| VCC | | 5V | |
| Signal Pin (input) | | GPIO pin 10 | |
| GND | | GND | |
|  | | | |
| **WiFi Wireless Tranceiver/Raspberry Pi 4 Connections** | | | |
| **WiFi Wireless Transceiver** | **Raspberry Pi 4** | | |
| VCC | 3.3V | | |
| RST | 3.3V | | |
| CH\_PD | 3.3V | | |
| GND | GND | | |
| TXD | GPIO 14 | | |
| RXD | GPIO 15 | | |
| GPIO0 | NO CONNECTION | | |
| GPIO2 | NO CONNECTION | | |
| ESP8266-module-pinout-diagram | | | |
|  | | | |
| **Pi Camera/Raspberry Pi 4 Connections** | | | |
| **Pi Camera** | **Raspberry Pi 4** | | |
| Camera module (blue side facing USB port backside) | Camera port | | |
|  | | |  |
| **Expected outcome:** | | | |
| The system should set off a visual and audible alarm whenever motion or sound is detected and engage the mailing system to send a time-stamped picture of the intruder to the home/business owner. | | | |

### Phase 4: Design PCB Board Procedure

|  |  |  |
| --- | --- | --- |
| **PCB Board Etching Procedure** | | |
| **Phase** | **Phase Task** | **Procedure** |
| 1 | PCB Board Design | Design board using Fritzing |
| 2 | Print PCB Board Design | Print design onto shiny side of transfer paper |
| 3 | Prepare copper plate surface for transfer | Sand copper plate till surface is rough so design stick to it when transferred.  Use gloves to handle Copper Plate. |
| 4 | Remove filings from copper plate | Wash copper surface with water and rubbing alcohol  Let plate dry |
| 5 | Design placing on copper plate | Cut Out design and place it face down on copper plate |
| 6 | Run plate through laminator | Run copper plate with the design face down through laminator a few times  Alternatively, use an iron to transfer design to copper plate |
| 7 | Place copper plate in cool bath | Place plate in cold bath  Agitate bath until the paper floats off |
| 8 | Etch design onto copper plate | Place the PCB into etching solution  Leave copper plate in solution for 25-30 minutes until all copper has disappeared around design |
| 9 | Wash etching solution off copper plate | Remove copper plate from etching solution and rinse with cold water.  Let etched design dry.  Use rubbing alcohol to wipe off any remaining toner from PCB board |
| 10 | Drill holes onto etched PCB board | Drill holes on PCB board. |
| 11 | Dispose of etching solution safely | Dispose of etching solution in hazardous materials container |

### Phase 5: Implement Python code for each sensor (sample code for sound detection)

|  |
| --- |
| #!/usr/bin/python  import RPi.GPIO as GPIO  import time  #GPIO SETUP  # define pin #7 as input pin  inputsignal = 7  # use board pin numbers  GPIO.setmode(GPIO.BOARD)  GPIO.setup(inputsignal, GPIO.IN)  #setting up infinite loop to check input signal from sound sensor  While 1:  if GPIO.input(inputsignal) == GPIO.LOW  print "No Intrusion Detected - Sound Sensor NOT Trigered!"  time.sleep(1)  else:  print "IntrusionDetected - Sound Sensor Trigered!"  time.sleep(1) |

### Phase 6: Upload Code, Deploy and Testing Alarm System

The MEIS-Alert IDS will use unit testing. A unit test is a smaller test that checks that a single component operates in the proper manner. The unit test will help isolate component failure, circuit shorts, wrongfully coded commands and PCB board design mistakes in the application and allow the designer to fix it faster.

### Phase 7: Design and 3-D Print Intrusion Detection System Enclosure

Using any of the freely available 3-D modelling software, like SketchUp, 3D SLASH, TinkerCAD or FreeCAD, a virtual representation of the MAIDS enclosure will be made to assist in the making of and visualization of the enclosure more fully. 3D Modeling in general makes the product design process more efficient. Modeling programs allow the designer to create and visualize final products, modify and optimize the designs, and document designs, measurements, and materials easily.

There are many different 3D printing processes that can be grouped into seven categories [8]: Vat photo polymerization, Material jetting, Binder jetting, Powder bed fusion, Material extrusion, Directed energy deposition and Sheet lamination. 3D printing will be conducted at Humber College and will depend on the availability of the 3D printing process accessible at the college.

# **TENTATIVE PROJECT SCHEDULE**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Total Completion Time** | | **10 Weeks** | | | |
|  | | | | | |
| **Project Phase** | | **Start** | **Finish** | **Duration**  **(Weeks)** | **Issue Resolution/Problem Management** |
| 1 | Materials Gathering | 09/06/2019 | 09/20/2019 | 2 | * Have extra replacement components in case original components fail |
| 2 | Setup Raspberry Pi 4 with Raspbian OS | 09/21/2019 | 09/27/2019 | 1 | * Setup 2 SD cards with Raspbian OS for backup |
| 3 | Setup Prototype Circuit and Design PCB board | 09/28/2019 | 10/11/2019 | 2 | * Know and Follow component specification limits * Try different efficient configurations |
| 4 | Python Code Implementation Strategy | 10/12/2019 | 10/25/2019 | 2 | * Debug Python Code if fails |
| 5 | Upload Code and Testing | 10/26/2019 | 11/08/2019 | 2 | * Test all components individually * Assemble and test completed |
| 6 | Design and 3-D print intrusion detection system enclosure (case) | 11/09/2019 | 11/15/2019 | 1 | * Have enough materials and funds to print case * Book specific lab time in 3-D printing facilty |
| 6 | Project Presentation | As outlined in course plan. | | 1 |  |

# **TENTATIVE PROJECT BUDGET**

|  |  |  |  |
| --- | --- | --- | --- |
| **Item Description** | | **No. of Units** | **Total Cost (CDN $)** |
| 1 | Raspberry Pi running Raspbian | 1 | 89.00 |
| 2 | USB Camera | 1 | 30.99 |
| 3 | Sound Sensor | 1 | 11.68 |
| 4 | Passive Piezo Buzzer | 1 | 5.40 |
| 5 | PIR (Passive Infrared Sensor) | 1 | 10.99 |
| 6 | Jumper Wires | 1 | 10.99 |
| 7 | Copper Covered PCB Printed Circuit Board | 1 | 6.65 |
| 8 | Enable/Reset Alarm System Push Button | 1 | 5.99 |
| 9 | WiFi Wireless Transceiver | 1 | 17.00 |
| **TOTAL PROJECT COST** | | | **188.69** |

# **SIMILAR PRODUCTS IN MARKET**

The top five home/business security system in Canada similar to MEIS-Alert are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Provider** | **Monitoring Price** | **Installation Type** | **Smart Home Integrations** | **Pros** | **Cons** |
| Vivint | $29.99–$44.99/mo. | Professional | Yes | * Top-notch equipment and detectors * Home automation integrations * Mobile control | * Pricey equipment * Camera support only on $44.99 per month plan |
| ADT | $33.99–$53.99/mo. | Professional | Yes | * Reliable monitoring * Wide availability | * Pricey monitoring plans * No camera support * Mobile control on premium plan |
| Frontpoint | $34.99–$49.99/mo. | DIY | Yes | * Easy installation process * Excellent customer support * Low equipment cost | * 3-year contract required * Camera and phone access only on Ultimate Plan |
| [Brinks](https://www.reviews.org/go/brinks/home-security/#_blank) | $29–$39/mo. | DIY | Yes | * Multi-channel security alerts * Fast response times | * 3-year contract required * Camera and phone access only on Home Complete with Video Plan |
| Ring Alarm | $5–$15/mo. | DIY | Yes | * Affordable equipment * Low-priced professional monitoring * Camera and phone access on all plans | * No Google Assistant support |
| 5] – [7] Multiple references. | | | | | |

# **MEIS-ALERT IDS ADVANTAGE**

Most of the security company plans available in Canada have similar features but pricey equipment or costly monitoring monthly fees and are limited in features.

MEIS-Alert Intrusion Detection System differs from the above commercial detection systems in the following:

1. Low-price equipment (less than $200 per system)
2. Easy DIY system installation.
3. No monthly monitoring fee (self-monitoring system).
4. Rapid response times email contact.
5. High reliability (double authentication process)
6. Camera and phone access (tentative).
7. No contract required.

# **CONCLUSION**

The MEIS-Alert Intrusion Detection System is an affordable, reliable and simple self-monitoring home/business intruder detection system based on the Raspberry Pi 4 platform that uses PIR and sound sensors to detect and alert in real-time of break-ins in the home or business. Alerts will be sent out to a particular individual via email using WiFi within 30 seconds of the break-in to maximize intruder apprehension, minimize police response times and provide picture of intruder to police.

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