# MAHMUBUL HOQUE

Mechatronics Engineering, UWaterloo 2018

**Smart Lock System**

## Contact Information

Email: MahmubulH@Gmail.com
Cell: (289) 689-5649
Website: www.mmhoque.com

## Objectives

- Easy to use product -> "Single button press"
- Integrate overtop of current infrastructure, not replace
- Improve convenience of home entry; keyless, automated without lack of security
- Allow for remote access
- Allow for sanity check -> "Did I lock the door?"
- Allow for future proofing

## Constraints

- Use low voltage peripherals (5V)
- Integrate with Alexa/Google Home
- Implement facial recognition

## Intended Users

- Physical/Mental Disability
- Airbnb hosts
- Parent

## Use Case Summary

1. Guest rings doorbell, leading to button event in Pi
2. Pi triggers camera to take a picture of the guest
3. Camera returns image to Pi
4. Pi sends image to Amazon's Web Services
5. Service performs facial recognition
   a. If recognize face && permission, Step 8
6. Service sends guest data and image to user cell
7. User can send:
   a. Voice commands to Alexa
   b. Web commands to Alexa
8. Service OR Alexa sends trigger to Pi
9. Pi triggers servo-motor to (un)lock deadbolt

*10. Pi triggers relays to AC devices (fan, lamp, etc.)

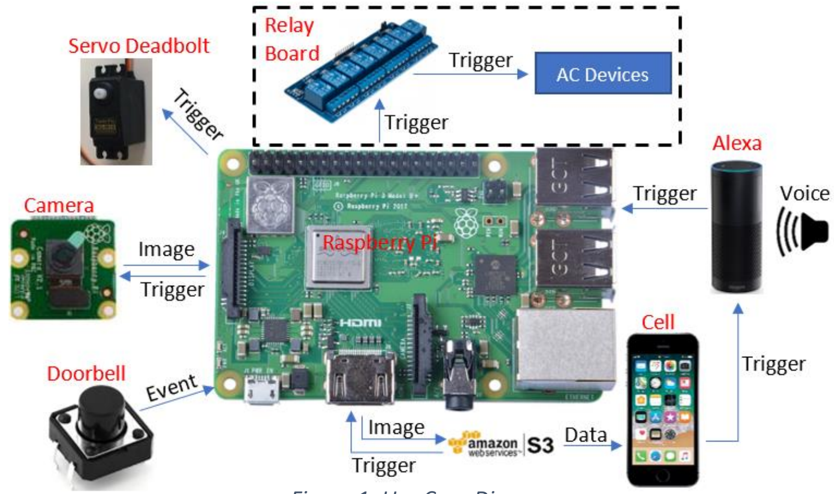


*Figure 1: Use Case Diagram*

## Mechanical

Any outdoor enclosures (doorbell and camera) should be made of weather resistant material (polycarbonate mold). Additionally, any thru-holes made to expose component to environment should be sealed (rubber interior) to prevent run-in. Consider a "cap" for camera to ensure water does not hit lens. Furthermore, the deadbolt enclosure to be designed using dynamic analysis. Use a high safety factor (N = 5) to prevent possible break-ins. Holes should have loose fit to account for user mounting error, surface level deviations, etc. Assume user will place deadbolt horizontally to reduce motor torque requirements. Moreover, Pi should be placed on interior for security reasons while maintaining camera wire length. Pi enclosure should allow additional space for heat sink with grills open to environment, allowing for better thermal dissipation.

## Electrical

Since the Pi comes with its own PCB, additional aren't required. All peripherals connected to Pi via wires, which includes data and power. The Pi is powered via long USB chord, providing 5V through standard phone charging adapter into outlet. Moreover, the camera is connected to Pi via SCI ribbon and doorbell connected via 22/24-gauge wires to any GPIO, no additional circuitry required. Furthermore, the motor requires power and signal wires. The signal wire requires a PWM signal; however, it can be connected to any GPIO on the Pi. This is because the Pi can produce a software PWM with a slight increase to processing load and minimal jitter in timing.

## Hardware

1. System (R.Pi 3 @ $30)
- Voltage: 5V
- GPIO Voltage: 3.3V, 5V
- GPIO Current: 16mA/pin
- Processor: 64-bit
- Wi-Fi: Yes

2. Servo Motor (@ $12)
- Voltage: 4.8V ~ 6V
- Torque: 0.5N

3. Camera (PiCamera @ $30)
- Voltage: 5V
- Resolution: 5MP

4. Doorbell (Generic PB @ $2)
- Voltage: 5V
- Current: 16mA

## Software

1. Raspbian OS (for Pi)
- Open source, Linux based
- Requires 32-bit processor
- Simple, lots of support

2. Amazon Web Services
- Open source software
- Requires Wi-Fi
- Offers facial recognition, tracking, and storage
- Backend -> no load on Pi

3. ServoPi (motor APIs)
- Efficient libraries
- Simple, easy coding

4. PiCamera (camera APIs)
- Efficient libraries
- Simplifies complex control

MAHMUBUL HOQUE
Mechatronics Engineering, UWaterloo 2018

**Smart Lock System**

Contact Information
Email: MahmubulH@Gmail.com
Cell: (289) 689-5649
Website: www.mmhoque.com

Next Steps

1. Replace AWS backend software with personal Python script. It performs facial tracking and recognition on low resolution, black and white images using PCA decompression and OpenCV. The benefit is being able to perform facial tracking and recognition locally, rather than another service; helping with patentability. The downside is the increased electrical load on the Pi due to additional processing requirements. Fortunately, the script uses low quality, B/W images to reduce the storage requirements. In addition, the Pi's built-in 1GB RAM is enough to perform the processing relatively quickly.

2. The Pi is the brain of the product and while it is open source, one can replace with another, simpler Pi-like system. A big reason for doing this is because the Pi has some redundant features. Basic requirements are:
   a. Power Supply @ $V_{SS}$ = 5V, I = 2.5A -> standard
   b. (BCM2837) 32-bit processor -> Raspbian OS to run Python scripts and internet connection
   c. 1GB RAM -> run multiple applications simultaneously
   d. (SDC4/8GB) 8Gb Micro SD Card Slot -> store OS, Python scripts, face images, and eigen faces
   e. (BCM43143) Wireless LAN capabilities -> remote access & Alexa integration
   f. Minimum 1 $V_{CC}$ = 5V, 1 GND, 1 Digital I/O @ 16mA, and 2 serial I/O

3. If Pi is mounted on interior of door, depending on how far outlet is, it may be impractical. For convenience, move Pi closer to outlet while maintaining connection to peripherals via RF transceivers and RadioHead open source library. Transceivers should have:
   a. $V_{SS}$ = 5V, I = 16mA -> powered off Pi
   b. Frequency = 433MHz -> legality and availability
   c. $P_{Transmit}$ = 10dBm -> distance = 100m; avg. house of 250m$^2$
   d. $S_{Receive}$ = -95dBm -> in case of signal degradation

*Figure 2: Transceiver Diagram*

4. If Pi moved away from peripherals at door, they will still require a processing unit. As such, Arduino can be used; but to minimalize, an Arduino-like board can be created with the following basic requirements:
   a. USB Serial-in @ $V_{SS}$ = 5V, I= 2.5A -> provide enough power and convenience in programming
   b. (ATmega328) 8-bit MCU -> download Uno bootloader
   c. 16MHz Chrystal (w/ 2 x load capacitors if not built-in)
   d. Minimum 1 $V_{CC}$ = 5V, 1 GND, 3 Digital I/O @ 20mA, 2 PWM pins @ 20mA, and 2 $I^2C$ (data and clock)

5. A simple PCB will be required if Arduino-like board created, with:
   a. Layers = 2 -> simple, cheap
   b. Material = Phenolic Cotton Paper -> cheap, common
   c. Thickness = 0.5mm -> common
   d. Surface Finish = HASL -> cheap, available, reworkable, good shelf life

6. The Arduino-like board will require a power supply, which can be a basic LIPO battery with the following:
   a. $V_{CC}$ = 5V, I = 2A
   b. Power = 2500mAh -> 25 hours if running "estimated" 100mA continuously