Automatic Secure Locker

ECE 445 Senior Design Project Proposal, Spring 2019

Team 28: Jiaxuan Liu & Yanlin Chen
TA: Thomas Furlong

1 Introduction

1.1 Objective and Background

With the rapidly growing e-commerce industry and the increasingly mature logistics system, more people choose to shop online for their daily needs. However, although shopping online spares people the inconvenience of going to physical stores, the risk of package being stolen by random thieves also becomes rampant. Such a problem is more pervasive in apartments that are not equipped with package lockers or package receptionists. In this case, packages are usually left at the residents' front doors, which greatly increases the risk of package being stolen by people walking by.

In order to eliminate this kind of package thefts, we want to design an affordable automatic secure locker which can effectively help people securely store their packages and can be put right next to their front doors. This system is constituted by an electrically controlled locker, a control panel with an LCD display, a speaker and buttons, a security module with camera and alarm, a control unit that coordinates the operation of every other modules and a power supply. This secure locker normally remains locked until a courier enters last several digits of the shipping number from the control panel. During this process, the LCD display will give the courier enough hints on how to use the locker. Once the package is placed in the locker, the locker will relock itself to prevent someone else from accessing the package inside. To retrieve the package in the locker, the owner only needs to provide an owner-only password to unlock the locker. Other than enabling the owner to open the locker, entering the correct owner-only password will also give the owner the option to enter all the package information so that the couriers can open the locker with the shipping numbers. Although the electromagnetic lock is secure enough in most cases to keep the package inside safe, in order to prevent anyone from violently damaging the locker, the security module of the locker will be triggered if the locker is open without receiving a correct password. The camera will take a picture of the perpetrator and save it on a local SD card; the alarm will make a loud noise to scare the perpetrator away. In addition to all of the features above, this locker has another innovative feature: it can accept food delivery and tip the food delivery driver with the preset amount of cash. The locker will be open to the food delivery drivers after they enter the correct password (this password can be given to the drivers when the owner places the order).

In this way, no matter it is because the owner is too lazy to come out to accept the delivery, or the owner is not at home, food can always be successfully delivered.

1.2 High-Level Requirements

- The locker needs to remain locked until someone with permission to open it.
- Add-on modules such as security module and tipping module should be fully functional at any time.
- The total cost should be as low as possible to make this locker affordable for normal families.

2 Design

The entire automatic secure locker is constituted by a power supply, a locker module, a control panel, a tipping module and a control unit. A block diagram showing the interconnection between different modules is provided below.

2.1 Block Diagram

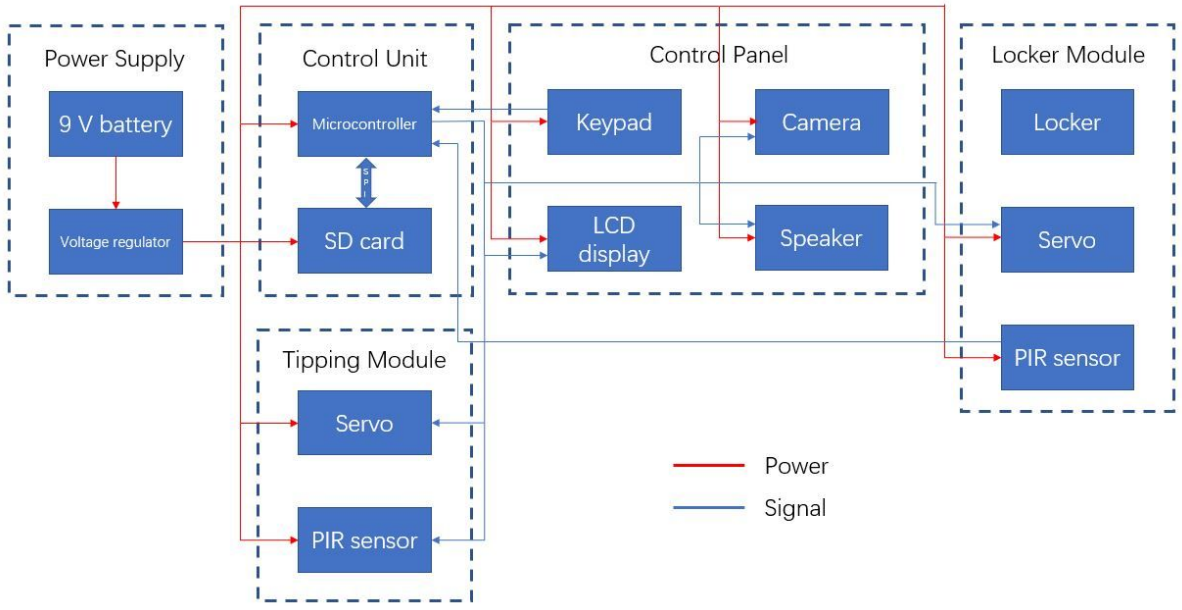

Fig. 1 Block Diagram of the Project

2.2 Physical Design

Fig. 2 shows the physical design of the automatic secure locker. The box on the locker is the control panel integrated with the security module and tipping module. The left part of the control panel is a 12-key keypad; the middle part of the control panel is a camera

that captures the face of the perpetrator; the right part of the control panel is the LCD display and speaker. The food delivery driver will get his/her tip from the slit on the front. Most electronics of the project will be placed inside this box. Underneath the box is the package locker. The lock of the locker is implemented by a servo controlled by the microcontroller. When the locker is unlocked, the servo will be in its 0 degree position; while the locker is locked, the servo will be in its 90 degree position, locked with the hook on the locker door to prevent one from opening the door. The four circles on the edges of the locker and door are magnets that make sure the locker can be successfully locked after the door is closed. A passive infrared sensor will be placed somewhere near the edge of the locker to detect whether the locker door is closed or open so that the locker can lock itself after the door is closed by the user or trigger the alarm if an unexpected opening of the locker occurs. This physical design only serves as a prototype of our final project, certain modifications will be made during the process of assembling.

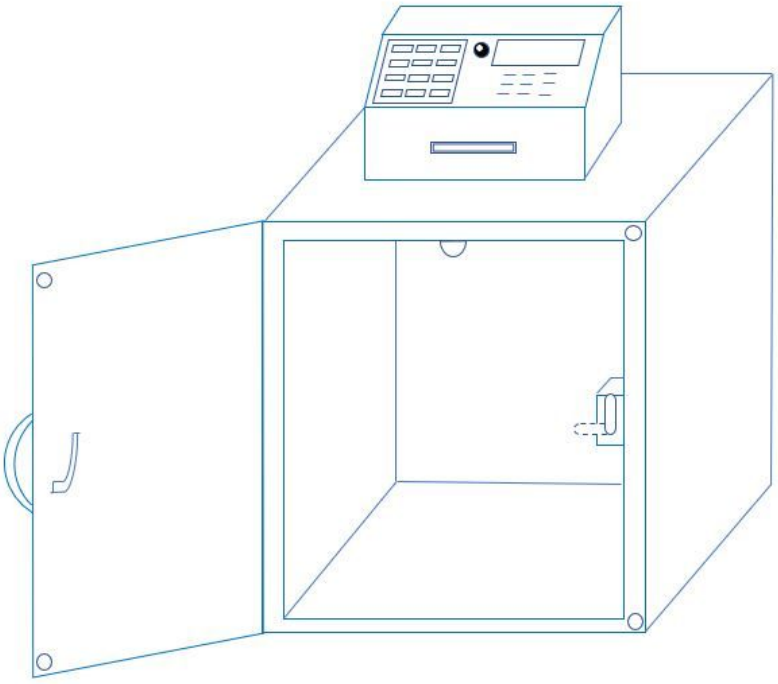

Fig. 2 Physical Design of the Locker

2.3 Power Supply

The power supply is necessary to keep all electronics of the locker work steadily and continually.

2.3.1 4x AA alkaline battery

The AA alkaline battery (1.5 V) is a typical choice to provide power to an ATmega328P based project, which is the core of the entire project. In addition, the battery is also used

to connect to a voltage regulator to provide power to other electronics such as servos, LCD display and speaker in the project.

Requirement: The batteries must provide sufficient power to all electronics used in the project in a safe and steady manner for at least 15 days if the locker is used once per day.

2.3.2 Voltage regulator

Since the maximum operating voltage for the microcontroller we chose is only 5.5 V, a voltage regulator circuit is needed to provide additional power rails.

Requirement: The voltage regulator must provide 5 V ± 5% and 3.3 V ± 5% from the 4x 1.5 V AA batteries.

2.4 Control Unit

The control unit is the core of the entire design because it contains the microcontroller that controls the operation of all electronics used in our project. The SD card is required due to the very limited memory the sole microcontroller offers.

2.4.1 Microcontroller

The microcontroller is used to control and coordinate the operation of every other electronic part in the project such that the locker operates as we expected. It is chosen to be an ATmega328P microcontroller.

Requirement: The microcontroller must control the operation of every other electronic part in our project without running into an unknown state of operation. Since the project is battery-powered, the microcontroller needs to be put into sleep mode when not used and waken up when any key is pressed by the user.

2.4.2 SD card

The SD card is necessary to store information such as new shipping number/password to enable authorized user to open the locker. It is also used to store sound files that instruct the user how to use the locker and pictures taken by the camera on the control panel.

Requirement: The SD card must communicate with the microcontroller via SPI and perform basic read and write operations. The storage should be big enough to store at

least a 1 MB sound file, a text file with 10 shipping numbers/passwords and 10 picture files taken by the camera.

2.5 Control Panel

The control panel includes all the electronics visible to the user on the control panel box. It serves as a user interface for authorized people to easily and conveniently control the locker. The security module is also integrated into this panel.

2.5.1 Keypad

The keypad is designed to be a 4x3 keypad made of pushbuttons (see Fig. 3). It is necessary for the user to enter passwords to unlock the locker.

Requirement: The keypad should provide the user with enough buttons to operate the locker. It also sends digital signals to the microcontroller with correct information received from the user to enable the microcontroller to enter the next operation state.

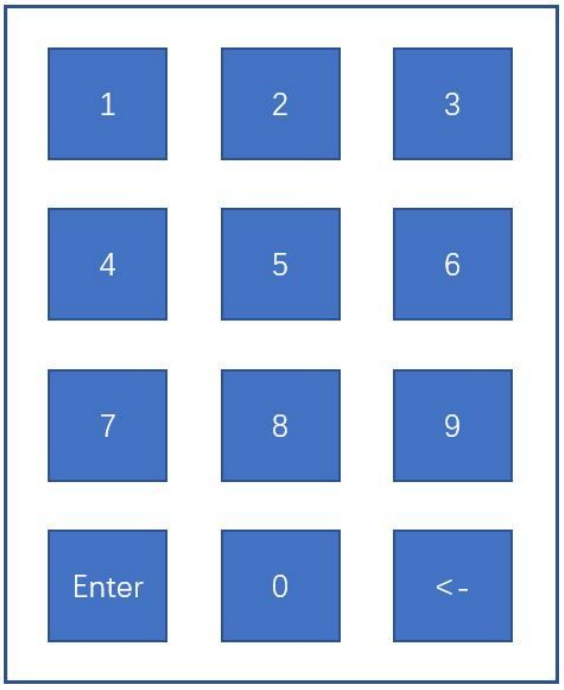

Fig 3. 4x3 Keypad Design

2.5.2 LCD display

The 16x2 LCD display visually provides the user with information necessary to operate the locker.

Requirement: The LCD display should communicate with the microcontroller to print correct information to the user to help the user control the locker whenever the user enters valid information from the keypad. In addition, the backlight of the LCD display should self adjust to the appropriate level based on the external light intensity.

2.5.3 Camera

The camera is an important part of the control panel to keep the security of the locker. Whenever the locker is unexpectedly open, the camera should be turned on automatically and take pictures of the perpetrator to help identify his/her identity.

Requirement: The camera should remain idle to save power normally; when the locker is opened unexpectedly, the camera should be turned on immediately and take 10 consecutive pictures of the perpetrator. The camera should be at least 2 megapixels to ensure the definition of the photos. Photos taken should be stored in the SD card in the control unit.

2.5.4 Speaker

The speaker of the control panel serves as an alarm that makes noise stored in SD card when the locker door is unexpectedly open to forces the perpetrator to leave the locker.

Requirement: The speaker can successfully play the sound files stored in the SD card with a human-hearable loudness.

2.6 Locker Module

The locker module is a physical implementation of the locker and electronics necessary to be placed in the locker to control the operation of the locker.

2.6.1 Locker

The locker is where the package and food is stored. To help the locker door locked in an easier manner, the magnets are needed at both locker edge and door edge.

Requirement: The locker should be large enough to contain two USPS large boxes, therefore, the dimension of our locker should be at least 35 cm x 35 cm x 20 cm. However, for the demonstration purpose, the actual dimension of our locker may be smaller than expected.

2.6.2 Servo

The servo is used to collaborate with the hook on the inner side of the locker door to lock the locker.

Requirement: When the user enters the correct password from the control panel, the servo will be set to 0 degree position (unlocked); otherwise, the servo will remain at 90 degree position (locked).

2.6.3 PIR sensor

The PIR sensor used as an proximity sensor to be placed at the edge near the door to help the microcontroller determine whether the locker door is closed or not.

Requirement: The PIR sensor sends valid analog signal to the microcontroller based on the distance between the sensor and the door.

2.7 Tipping Module

The tipping module is essential if the locker is also designed to receive food delivery as tipping the food drivers is always an appreciation for their job. However, how to effectively give the driver the correct amount of cash as tip still remains a big problem of our design. Compared to coins, cash is way harder to dispense as cash is too thin and light. Currently, we do not have a clear idea of how to do it because the mechanical design is not the focus of this project. Therefore, the detailed implementation of the tipping module will be designed and tested after the main part of the project is done.

2.8 Risk Analysis

There are two major risks that pose the greatest difficulty to implement in our project. The first risk is the power supply. Since we choose to use batteries to power our automatic secure locker, whether they can power the locker in a relatively long period is what we concern the most. The microcontroller itself is not a very big issue because in the sleep mode the power consumption of the microcontroller can be reduced to a very low level. However, both servo, LCD display and camera consumes a fairly amount of power when operating. If they are not taken special care of, the batteries need to be replaced very often, which greatly increases the cost of using our product. Therefore, a series of energy conservation measures is required for all power-intensive electronics in our design. For example, since the camera is only needed when the locker is unexpectedly open (which is not usual to happen), the camera can be turned off for most of the time; the LCD backlight should be adjusted based on external light intensity to save power; since the locker is not used for most of the night time, the locker can be

turned off manually by the user to save power. With the power saving plans stated above, our goal is to make our locker work for at least 15 days if one item is placed in and retrieved from the locker per day.
The second risk has been stated in section 2.7, the implementation of the tipping module has not been determined yet. If we are not able to figure out how to effectively tip the food drivers with cash, we may choose to tip them with coins as coins are easier to dispense.

3 Ethics and Safety

3.1 Ethics

Considering the main function of our product is to keep the security of the user's package, there is not too much ethics concern in our design. The only thing to be aware of is that when the security system of the locker is triggered, the camera needs to take pictures of the possible perpetrators. This might offend the person's right in some ways. However, considering the pictures taken are only used to identify the identities of the perpetrators, the ethics issue involved is too minimal to be considered.

3.2 Safety

The general safety of our design can be guaranteed because no hazardous or volatile material is used in our design. The mechanical design of our product is also benign to the users. The only safety concern might come from the overheating of some electronic components. In order to reduce such a possibility as much as possible, an additional temperature sensor can be placed inside the control panel box (where most electronics are placed) to monitor the temperature inside the box. If the temperature goes unexpectedly high (higher than the maximum temperature rating of any component used), the power should be immediately shut off to avoid possible burning of any component.