Automated Locker

Alex Kim, Keming Kuang, Hang Lin, Weijin Zhu,
Huangwei Ding, Redwan Ibne Seraj Khan, Jay Chen, Kevin Cheung

School of Engineering and Applied Sciences
University at Buffalo, The State University of New York
Spring 2019

Abstract

Opening a locker is an easy job for most of us in daily life. However, it turns out to be a difficult task for people with physical impairment. The goal of this project is to help students with impairment that may not able to open their lockers on their own in Depew High School. One of the ways is to design an automated locker that can automatically open the lockers for them. We came up with the solution by using RFID to assist them with these problems.

Contents

1 Introduction

1.1 Purpose of Document

This is a Requirements Specification Document for an Automated Locker that is going to be designed for three disabled students from Depew High School in Buffalo, New York. The existing lockers were designed for students without disability and hence are not suitable for satisfying the extra needs of disabled students. The new automated locker will provide disabled students with a system to open lockers without needing the help of anyone and hence will give them the ability to take control of their activities by themselves. This requirements document will provide a detailed documentation of the methods that we are proposing for implementing a locker that will be generalized to fit the students with disabilities related to visual and physical impairment. It will also act as a bridge between us and our clients so that there remains no ambiguity in understanding what we are proposing to fit the requirements. To ensure this we will take on an object oriented approach to explain our design and implementation of our proposed system. This document will talk about the problem statement in hand, the existing lockers' limitations and our proposed approach. To clarify our approach we would be listing the functional and non-functional requirements through use cases, interaction diagrams and class models.

1.2 Background

Penco. designs traditional lockers which have to be locked using separate locks. Students with physical disabilities have a hard time opening lockers. Disabled students need someone to assist them in opening the lockers which makes their daily life at school tedious and difficult. That is why they need a system that would aid them in opening the lockers by themselves. When Depew High School approached us, we agreed to build a locker system for the students with disabilities. When we we arranged a meeting with the students, we realized that our clients had various kinds of disabilities and hence we decided to build a system that will be general and convenient to use for all of the students.

1.3 Project Summary and Scope

The scope of this project is designing a lock system which will be operated automatically using an RFID card by disabled students i.e. students will not need to use a traditional manual lock with a key or with a number combination to unlock it using their hands or eyes. The designing of the door, locker internal space, number of compartments and coloring is not part of this project. The opening mechanism will be semi-automated, that is, students can only open it using an RFID card but will have to close it using their hands. This semi-automated functionality is going to be implemented in accordance with the wishes of our clients.

2 Problem Statement and Details

2.1 Clients' Conditions Descriptions

Students	Grade	Disability	Notes
Emily O.	7	Cerebral Palsy	Wheelchair bound and able to extend her arm fully
Cody C.	9	Cerebral Palsy	Has difficulties in using key-lock
Dylan U.	9	Cerebral Palsy and Visually Impaired	Wheelchair bound and has difficulties in using key-lock

2.2 Clients' Requirements

Clients require semi auto opening mechanism and auto unlocking mechanism. Clients agreed using FRID as unlocking mechanism. For the semi auto opening mechanism, locker door needs to pop out only. For the details of opening and unlocking mechanism, please refer to Section 4.

3 Existing Lockers and Limitations

There were many projects in the past which are based on automated lockers. All of them had the same purpose: help students with disabilities to open their lockers easily. However, they differ in terms of security system, which are divided into two main parts.

1. RFID System
    - Details: In order to unlock the locker, students move the pre-registered RFID tag to the scanner. Then, the scanner will read the tag and open the door accordingly. After 10 seconds of being unlocked, the door will be locked automatically as soon as students close the door.
    - Limitations: There is a possibility of power failure. In order to prevent this situation, backup lock has been installed which can be opened with a mechanical key manually. However, there is no automatic opening mechanism to the door for students who are unable to open the door themselves.
2. Touch Pad System
    - Details: In order to unlock the locker, students enter the passcode using touch pad, just like how people use to unlock their phones. Then, the system will match the passcode and unlock the door accordingly. Unlike RFID system, the door will not be locked automatically as long as the door is stayed open.

- Limitations: There is a possibility of power failure. In order to prevent this situation, backup lock has been installed which can be opened with a mechanical key manually. However, there is no automatic opening mechanism to the door for students who are unable to open the door themselves.

4 Proposed Approach

4.1 System Overview

4.1.1 Purchased Components

(Going to purchase)

- Arduino UNO programmer board
- Lock Style Solenoid
  - Locking and unlocking door
- Small Push Pull Solenoid
  - For partial door opening mechanism
- Push Button Power Switch (Pololu high power)
  - Turning the Arduino on/off for battery conservation
- Parallax RFID reader and tag
  - Door locking interface
- 2x 1N4004 Diode and 2x TIP120 NPN Transistor
  - To regulate each solenoid
- 15x 3.7V 3600 mAH 18650 lithium ion battery
  - 3S5P configuration for 11.1V with an 18000 mAH capacity
- LI Ion battery charger 18650 11.1-12.6V with balance battery PCB protection board
  - Battery management system board, regulates charging
- Li Ion battery cell kit (VRUZEND battery kit)
  - Connect Li-Ion cells in series and parallel without spot welding
- 3S 11.1V Battery level indicator display board

- Large and small momentary push buttons
- XT60 female and male with AWG wires attached
- 12.6v XT60 charger/power supply
  - To charge the Li-Ion battery cells
- Arduino UNO size prototype PCB board
- RGB LEDs

4.2 Functional Objectives

4.2.1 Opening Mechanism

- A push pull solenoid on the left side of locker that pushes the door open when the locker is unlocked.

4.2.2 Locking Mechanism

- Extending the internal latch of solenoid when the door is push away by the push pull solenoid.

4.2.3 Unlocking Mechanism

- A push button on the front side of locker door to power the system.
- A RFID on the front side of locker door to scan and verify the key tag.
- A lock style solenoid on the side of locker door unlocks the door when RFID reads a key tag, and the key tag is valid.
- A RGB LEDs to indicate the state of system.

4.3 Non-Functional Objectives

4.3.1 Reliability

The locker can open only if the tag on the RFID is valid. Using other tags that do not match with the data store in the database will not able to open the locker. To prevent the situation when locker run out the battery, we also prepared a physical key for the user to unlock the locker if this situation happened.

4.3.2 Security

The security of the locker can be based on two ways. First, when our group came into deal with open mechanism, we were thinking about by using finger print to unlock the locker. However, we crossed out this idea since this method is insecure because the user's fingerprint has to be stored in the program's database. Some attackers might steel the fingerprint by hacking in the program. We decided to use RFID, which we pre-programmed the keys. Comparing to using fingerprint, the RFID is secure in the way that it does not require information from user. Second, our designed locker is semi-open, which means the door only pops out, but it does not open all the way. In this way the user would not getting injured if the door hits the user.

4.3.3 Supportability

Our objective mainly focus on supporting students with disability on cerebral palsy and vision. To achieve that, We use RFID wireless transmission technology. In this way, we hope that students with physical disabilities can use locker through their own efforts. At the same time, after considering the actual situation of students with disability, we also found individual students has insufficient hand strength. We adopted the semi-opening method, and hope that through this auxiliary opening mechanism, we can better help students to have a sound use ability like a normal student.

4.3.4 Performance

Firstly, it is efficient for students with impairment to use because the locker door can open automatically if the key tag is valid.Secondly, it is easier to learn because what students need just a key tag that can use to scan the RFID on front side of the locker.

4.4 Hardware Interface

- RGB LEDs:
  1. RED: System is on. RFID is running and reading key tags.
  2. GREEN: Key tag is valid. Door is opening.

- Locker Style Solenoid:
  1. Pull the latch to unlock.
  2. Extend to release the latch.

- Push Pull Solenoid:
  1. Push the latch to open the door.

- RFID:
  1. Read key tags.

4.5 Software Interface

4.5.1 Start Automated Locker

- void setup(): Activate the RFID reader and Timer
- void loop(): RFID starts reading the key tags, and Timer starts counting.

4.5.2 Unlocking

- void ReadSerial(): Read the tag number from the reader. Call solenoids and unlock function if tag number is valid.
- void solenoids(): Activate the locker style solenoid and push pull solenoid.
- void unlock(): Pull the latch of locker style solenoid and extend the latch push pull solenoid.
- void RGBgreen(): Set the RGB LEDs to color green to indicate that key tag is valid and the door is opening.

4.5.3 Locking

- void lock(): Extend the latch of locker style solenoid when the locker door is pushed away.
- void RGBred(): Set the RGB LEDs to color red for to indicate that RFID is reading.

5 Experimental

5.1 Methods

References