ECE 445

Umbrella Rental System

Project Proposal

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1 Introduction

1.1 Objective

Umbrella is something we don't want to carry but really wish we did when it starts to rain. Unfortunately, sudden rains often occur in our campus area, rendering many students unprepared. Walking in the rain is uncomfortable and will lead to many negative consequences like wet clothes and possible illnesses. One solution is to find the a near convenience store and buy a new umbrella, but it is definitely not economical if we are to buy an umbrella every time we forget to bring one with us.

Our answer to this problem is an umbrella rental system. The system will scan student IDs (campus solution) or other kinds of ID card to keep track of students' accounts in the database and determine if a user is eligible to rent. Accounts with unreturned rentals or damage records will be denied of service until those issues are resolved. If an account is eligible to rent, the system will decide if an umbrella is available; if there is one, it will unlock an available umbrella for the user, and record the time, slot number and ID. When a user return an umbrella to the rack, the system will record the time again to see whether a payment is required (for paid systems). We could also include account balance feature to be linked to accounts if we were going to make this a charged system, and also as security deposits in case of damage. This feature could either be done through computer linked database (paid online) or built into the physical system with a credit card reader. In order to prevent fake umbrellas (e.g. a stick) from being returned to the system, the basic redundancies include equipping each umbrella with a unique QR code or barcode which need to be scanned during checkout and return. For more secure solutions we can also add sensors that detect size and weight of the "umbrella" being returned, or substitute barcode with an embedded RFID chip in the umbrella.

1.2 Background

In the United States, there is hardly any place that offers umbrella rental service besides luxurious places and hotels. If rain starts pouring down and one person need to commute on foot, the only choice without wasting time or getting wet would be to buy a new umbrella. In the long term it is costly and inconvenient, for not bringing an umbrella again in the future means the person needs to buy another umbrella when raining.

Outside the US, however, there are many umbrella rentals operated by chain convenience stores. The rental requires a deposit in advance and a receipt upon return. The whole process is slow and requires an employee to operate. There is plenty of room to improve here too.

Our project will be able to provide a fast and convenient way to rent and return an umbrella without the need of a human employee. By scanning the membership card or an ID, the system can respond in an instant validating account eligibility and release an umbrella to the user. The card can be reused without paying extra deposit as long as there is no damage reported against the account.

Since every user account on file is linked to their valid ID along with a deposit (or cash balance), these will be used to protect against damages to the system or umbrellas. Renters will be prompted to check and report damage after an umbrella is released from the rack. If damage is reported during this period, master PC will track the last user who rented this particular umbrella, a damage case will be generated against that user and sent to system administrator, once approved the user will be charged full price of the umbrella. For added security, other redundancies like a security camera could be installed to monitor rental and return process to protect against intentional damage during this time or as evidence for future needs.

The return process is simple too, just walk up to the the system and scan the barcode on your umbrella, report any damage, and everything else will be taken care of by the system.

1.3 High-level Requirement

- Our system must be easy and convenient to use to attract users
- Cost of operation must be low, the system being unmanned gives it advantage over man operated services and ability to provide 24/7 service at low operation cost, but we need to minimize other costs like property damage to the umbrella, unreturned umbrellas, etc. Thus requiring redundancies built into the system. However these extra sensors/cameras/hardware in the redundancies should not increase cost too much that drags down cost effectiveness.

2. Design

2.1 Block Diagram
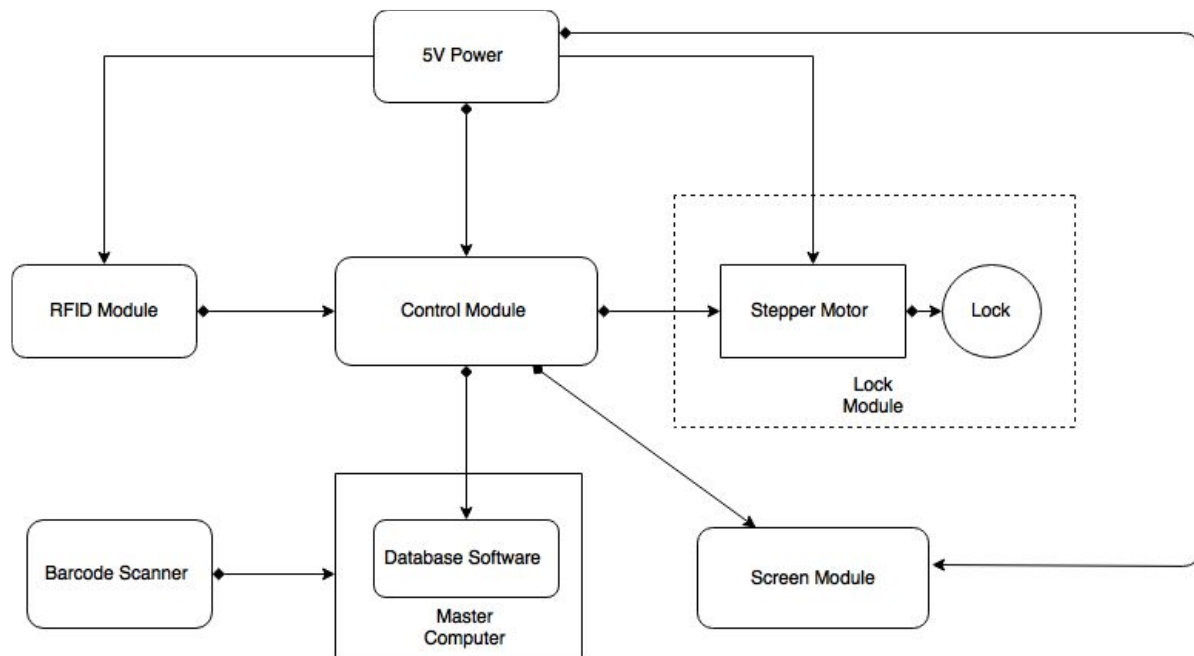
2.2 Physical Design
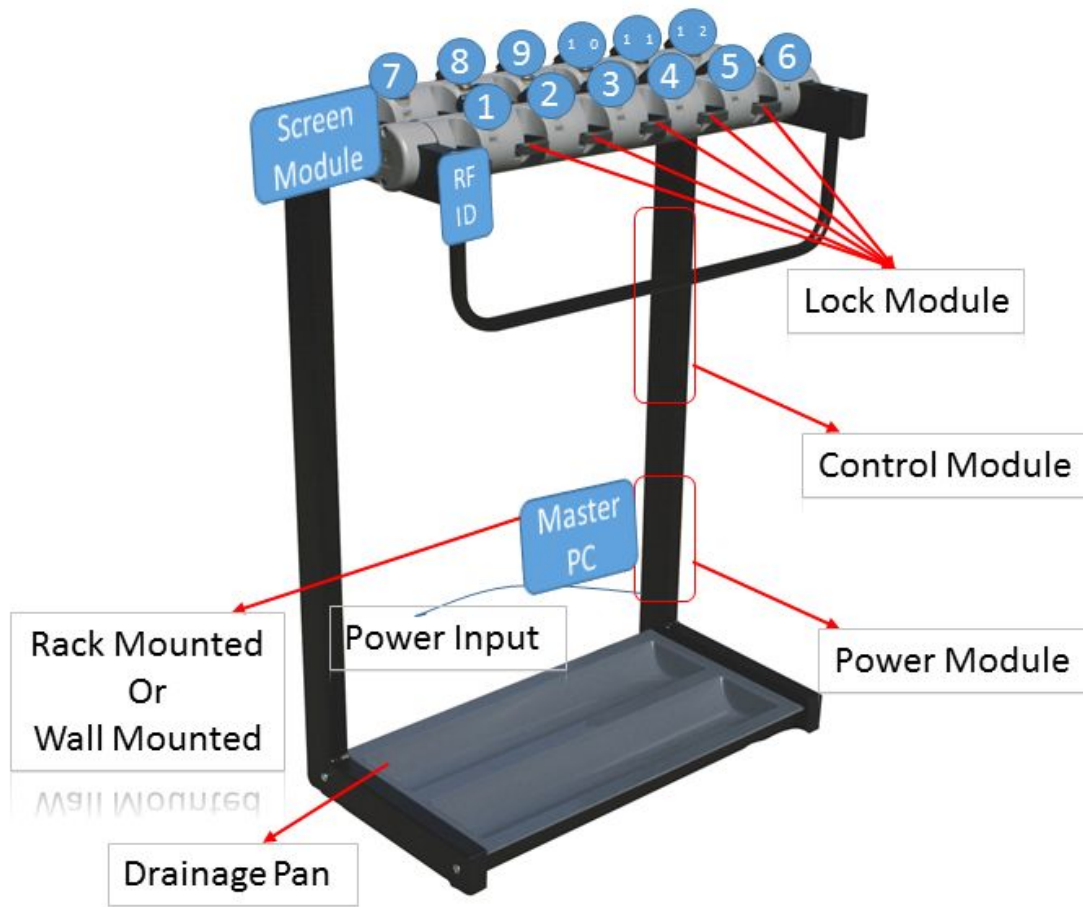
The draft above shows a rough schematic of the system, with the physical rack and various modules inside. The rack/system will be approximately 1.2m wide and 0.7m deep, height will be determined by the type of umbrella used but estimated around 1m tall.

2.3 Functional Overview

Power Module:

- Powers the Control Module, the RFID Module and Stepper Motor with 5V DC voltage or array of AA battery to provide 4.5V DC.

Requirement: Most modules in this system operate at around 5V DC, including RFID, microcontroller, screen, and motor in lock module. Must provide stable power output with +/- 5% voltage.

RFID Module:

- Consist of an RFID card reader.
- This module reads the student IDs and output them as digital signal to Control Module.

- Powered by the power module through 5V DC voltage.
- Data used to authenticate users.

Requirement: Able to scan and send ID card data to microcontroller.

Control Module:

- Consist of a microcontroller.
- Powered by the power module through 5V DC.
- Takes input from RFID module for user ID (and possibly umbrella RFID), relay the data to master PC. Once authorized by master PC, it will output digital signal to Screen Module to update display content, as well as control signal to Lock Module for umbrella release.
- During normal operation microcontroller also reports umbrella positions to master PC.
- This module verifies if the user is authorized, coordinates which lock should be open/closed, provide info to users by controlling Screen content and sends data to master PC for logging

Requirement: Microcontroller should operate at similar voltage as other main modules, around 5V DC.
Requirement: Microcontroller shall respond and process signal inputs as programmed at low latency.
Requirement: Microcontroller should have enough digital input/output (for RFID module, Screen Module) support
Requirement: Microcontroller shall include a programmable Flash for temporary storage (e.g. 8K)

Lock Module:

- May consist of multiple sets of stepper motors and physical locks.
- Powered by power module through 5V DC.
- Takes digital control signals from Control Module.

Requirement: Motor or actuator with controllable speed and acceleration for umbrella locking mechanism, as well as turning angle. Together with mechanical design should lock the umbrella in place, and able to report current open position.

Screen Module:

- Powered by power module through 5V DC voltage.
- Takes digital signals input from Control Module.

Requirement: Display shall have enough pixels to display at least three to four rows of text at readable size from viewing distance of 0.5m. For example 128x64 resolution.
Requirement: Mono LCD display is sufficient with low power consumption and low cost.
Requirement: Takes digital input from microcontroller, full ASCII support.

Master Computer:

- Consist of a physical PC and database software.

- Takes digital signal input from Control Module that includes user ID data and umbrella lock position on rack.
- (Tentative) Accepts digital input from barcode scanner for umbrella return identification.
- Software database recording all user data and rental information (time stamp, umbrella ID)
- Independent power source.

Requirement: Minimal PC size and power consumption with basic performance for database requirement.

Requirement: I/O port support for control module relay connection.

Barcode Scanner(Tentative):

- Connected to Master Computer, send the code scanned in digital signal.
- This module helps ensure the integrity of returned umbrella.

Requirement: Connection with master PC support extension cord to allow user movement of barcode scanner for convenient usage on oversize item like long umbrella.

2.4 Operation Flowchart
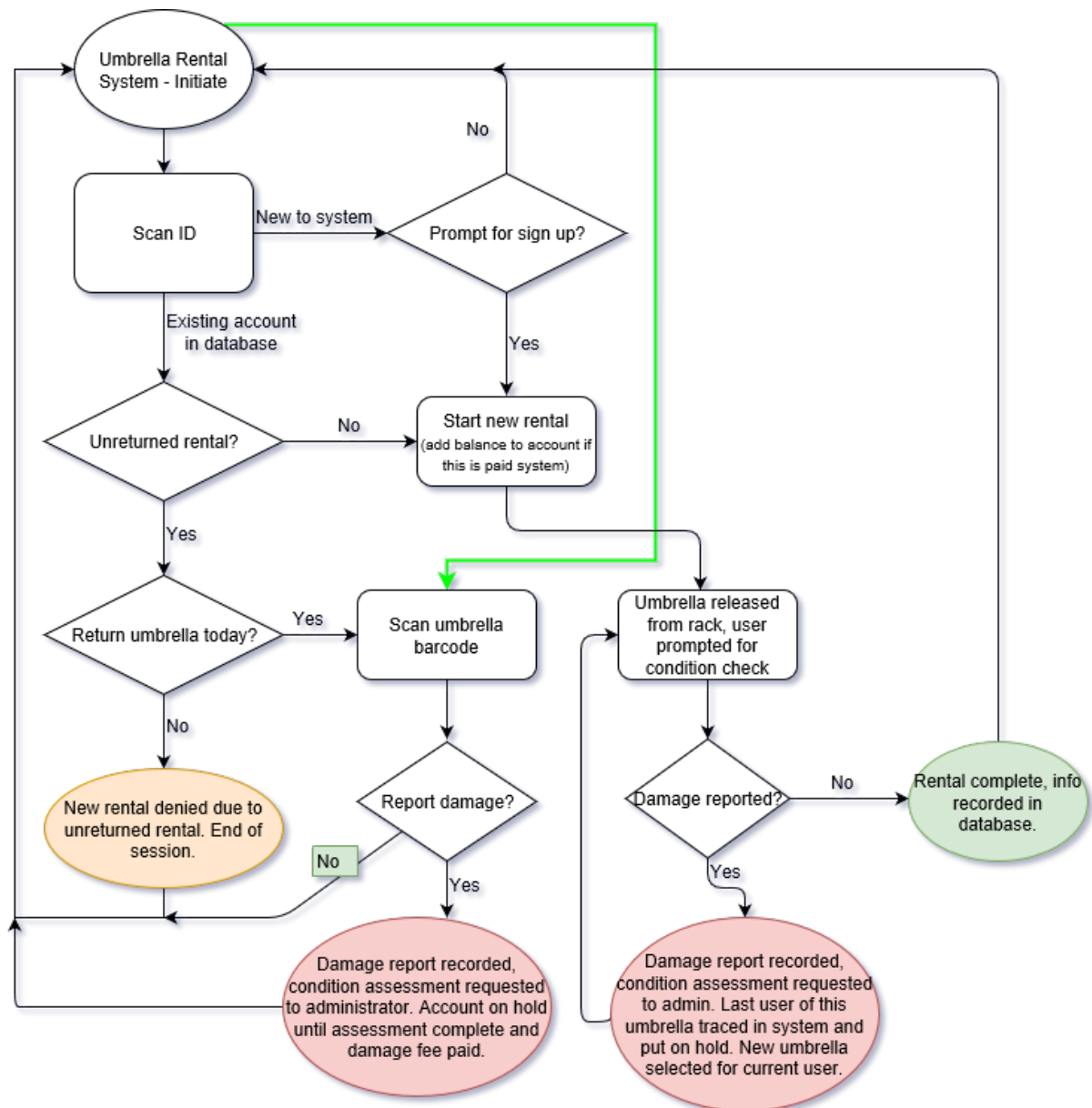
2.5 Risk Analysis

The block that poses the greatest risk to successful completion of the project is the control module. It has to communicate between RFID module, master PC, Screen module and Lock Module and be programmed to process all data correctly at low latency.We have to carefully select our chip to meet all I/O requirement and as well as capability of onboard Flash memory for temporary data storage. The communication protocols between the microcontroller and master computer may be complicated and have more of an impact on the performance of the microcontroller than that of I/O with other modules.

The physical design of the rack and locking mechanism must be solid enough to not only hold all umbrellas but also lock them in place when programmed to do so.

3. Ethics and Safety

The IEEE and ACM codes of ethics both states that we should avoid harm to others, especially our users. By design, our product is only a verification and logging system for access of a shared resource (umbrellas), and is not likely to make frequent direct contact with our users. Therefore, the functions of our product are quite impossible to physically harm our users. Our system may fail if its circuit comes into contact with water (from the umbrellas), but its maximum voltage of 5V DC is safe enough from causing any serious harm to human.

The ACM Code of Ethics also states that we should respect privacy (Chapter 1.7). We log user activities by recording their IDs, leasing and return time (and possibly video recordings of them if we decide to utilize a security camera). We plan to limit our data collection by automatically deleting archived files when a certain time period has passed.

Our project takes responsebility of IEEE code of ethics #1 "To accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment." This system will benefit the community by providing great convenience and will not cause harm to public safety or the environment.

We will also try to do our best to follow IEEE code of ethics #3 "to be honest and realistic in stating claims or estimates based on available data." We will make sure that our function works based on the data we collect. To follow IEEE code of ethics #7, we will also be open to accept any critic or comment on our design and the technical implementation. All suggestions are helpful towards a successful project.