Automatic Ball Borrowing System

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1. Introduction

1.1 Objective

At the ARC of our university, sometimes we have to wait in a long line to borrow balls, like basketballs, from staff. It is time consuming for students and the university also need to spend money hiring people to give those balls to us. In addition, if student forgets to bring their I-card, they cannot get the balls.

As a result, we decide to build an Automatic Ball Borrowing System. Our system will be used to dispense golf balls. It will display the number of remaining golf balls inside the machine on an LCD screen. Students can scan the RFID to borrow the golf balls. Also, we provide a PIN pad, which can allow the students to type in their UIN to get the balls. When balls are returned from students, the machine will check its weight and size to determine whether it is a golf ball and not something else. If the weight and size does not match a golf ball, the alarms will be turned on.

1.2 Background

Shortly after the invention of vending machine, it became prevalent in many countries. For example, there are 5.5 million [2] throughout Japan. Then around 2000-2010, here entered specialized and smart vending machines. These machines can automatically serve products while reducing costs from labors and time that people need to wait in line. Based on this concept, there came automatic book rental machines, power bank rental machines and so on. We choose to build a machine for golf balls due to the large number of participants in the United States. There were around 23.82 million [4] participants in golf ball in the United States in 2016. The total sales of golf ball and related clubs are more than 2 billion dollars [4] in 2016.

1.3 High-level Requirements

- The mass of a golf ball should be 45.93 [1] grams. As a result, we expect the mass of the ball returned from the user should be between 40 grams and 50 grams. If the mass does not fit this range, the alarm will be turned on. The mass will be measured using pressure sensors.
- The diameter of a golf ball should be 42.67 [1] mm. As a result, we expect the diameter of the ball returned from the user should be between 38 mm and 47 mm. If the diameter does not fit this range, the alarm will be turned on. The diameter will be measured using two IR sensors.
- Our machine should dispense exactly 1 ball each time.

2. Design

The power supply will get power from a wall plug. Then it will use an AC/DC adapter to get the 12 V DC. Then the DC power will be sent to three regulators, which will produce three different voltages for different parts of the system. The 5 V will be used to supply power for microcontroller. The 3.3 V will be used to supply power for sensors, alarms, PIN pad, LCD, and alarm. The 9V will be used to supply power for motor. The sensors and pin pad will collect data and send them to microprocessor. Then the microprocessor will use them to control the motor, LCD, and alarm.

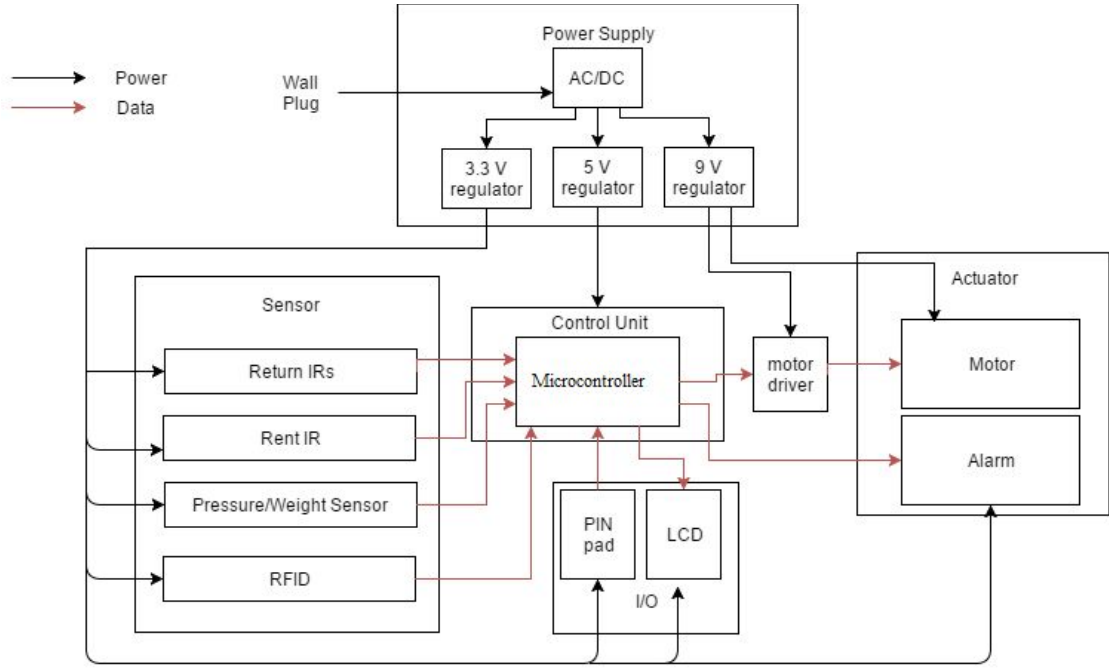


Figure1. Block Diagram

As for the physical design, PIN pad, RFID scan, and LCD screen will be placed at the top of the system. The bottom channel will contain the golf balls. There is a slope at the end of the channel. As a result, the ball will fall back into the channel if the motor stops. When the IR sensor at the exit detects the ball, the motor will stop. As a result, exactly one ball will be dispensed from the machine.

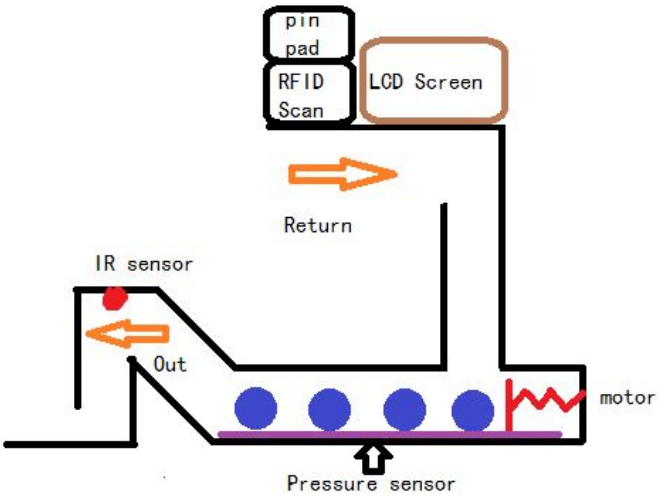


Figure 2. Physical Design Diagram (update me)

2.0 Golf ball facts, etc

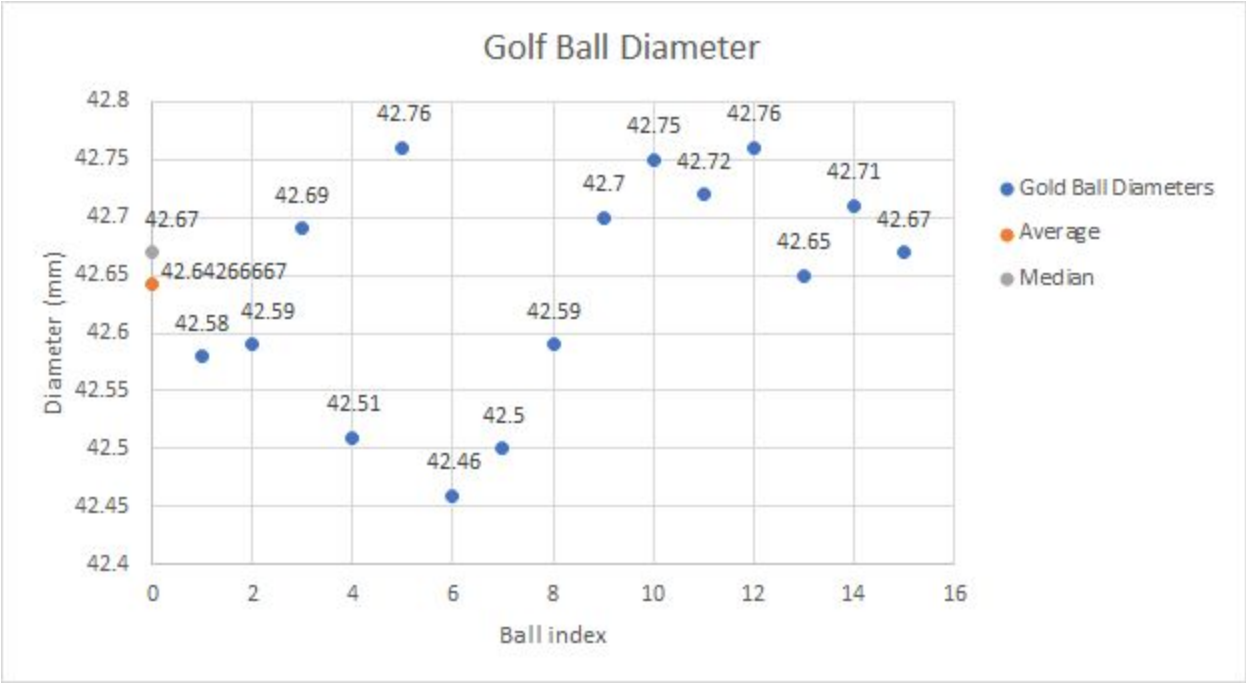


Figure 3. Golf Ball diameter distribution (15 balls)

Maximum = 42.76 mm
Minimum = 42.46 mm
Average/Mean = 42.64267 mm
Median = 42.67 mm
Standard Deviation = 0.098812 mm

2.1 Power Supply RV tables & ckt schematic for each component

We will use power supply to power microcontroller, motor, data transmission, IR sensor (QRE1113), PIN pad (COM-08653), LCD and RFID reader (rc522). The microcontroller, IR sensor, LCD and data transmission need 5V. The motor needs around 12V. The PIN pad and RFID reader needs 3.3V power supply. We will use an adapter (TOL-09442 ROHS) to transfer 110V AC to 12V DC. 12V is enough for our use. 12v is for motor running. Then we use Voltage regulator-5V (COM-00107 ROHS) to provide 5V for microcontroller and data transmission. We use Voltage regulator-3.3V (COM-00526 ROHS) to provide 3.3V for PIN pad and RFID reader.

Requirement	Verification
1. Provide 12V power supply to motor. The deviation will be +/-0.5V. 2. Provide 5V power supply to microcontroller and data transmission. The deviation is +/- 0.5V. 3. Provide 3.3V power supply to PIN pad and RFID reader. The deviation is +/-0.2V.	1. Measure the output voltage of motor when running by multimeter and check that whether the value is in the range 11.5V to 12.5V. 2. Measure the output voltage of microcontroller and data transmission when operating by multimeter and check that whether the value is in the range 4.5V to 5.5V. 3. Measure the output voltage of PIN pad and RFID reader when operating by multimeter and check that whether the value is in the range 3.1V to 3.5V.

2.1.1 AC/DC

AC/DC is an adapter which will be used to convert the 110 V AC voltage to 12 V DC voltage.

Requirements: It should convert the 110 V AC voltage from the wall plug to a DC voltage between 11 V and 13 V. current requirement!!!

2.1.2 3.3 V regulator

3.3 V is the voltage used to supply power for all the sensors, pin pad, LCD, and alarms. It

is gained by using voltage regulator.

Requirements: It should use voltage around 12 V to supply voltage between 3 V and 3.5 V.

2.1.3. 5 V regulator

5 V is the voltage used to supply power for the microcontroller It is gained by using voltage regulator.

Requirements: It should use voltage around 12 V to supply voltage between 4.5 V and 5.5 V.

2.1.4. 9 V voltage

9 V is the voltage used to supply power for the motor and motor driver. It is gained by using voltage regulator.

Requirements: It should use voltage around 12 V to supply voltage between 10 V and 8 V.

2.2 Control Unit RV tables & ckt schematic for each component

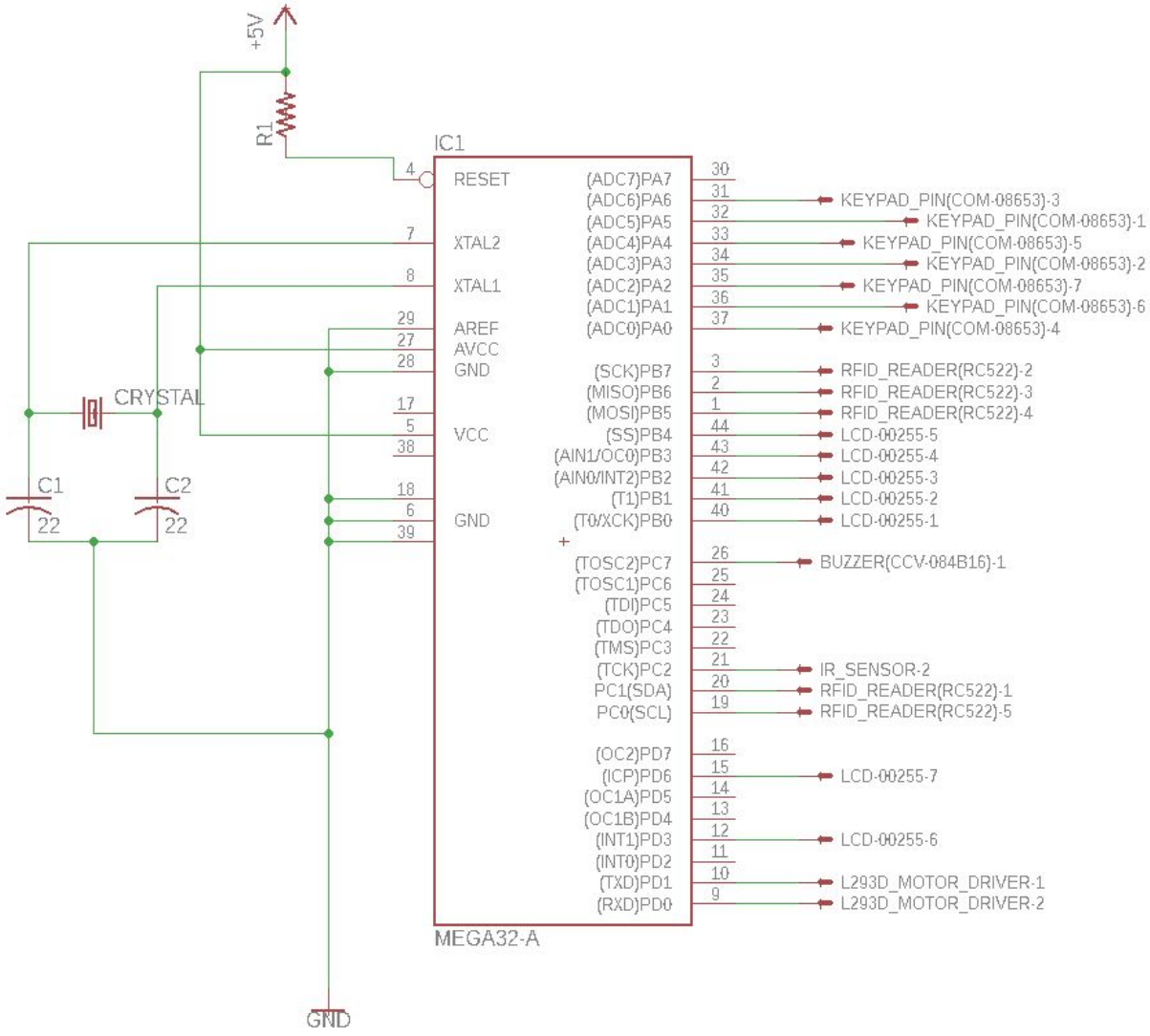
2.2.1 Microcontroller

The microcontroller will collect data from sensors and pin pad, then control the LCD screen and motor.

Requirements: It should be able to store some data and have at least 30 I/O pins. Here is the list of usage of those I/O pins.

Usage	Number of pins
Rent IR sensors	2
Return IR sensors	4
Pressure/weight sensors	10
RFID reader	4
LCD	6
Motor	2
Alarm	2
Total	30

Table 1. I/O pin number requirement



2.3 I/O RV tables & ckt schematic for each component

2.3.1 PIN pad

The PIN pad will be used to read input from user. The user can choose the action (return or borrow) for the machine. Also, it can also allow the users to type their UIN to borrow the ball.

Requirements: It should have 12-key input.

2.3.2 LCD

The LCD screen will be used to display the remaining number of golf balls inside the machine. Also, it will give instructions to the user.

Requirements: The LCD screen should have at least two lines. 16 characters must be able to be printed on each line.

2.4 Sensors RV tables & ckt schematic for each component

2.4.1 Return IR sensors

There will be two return IR sensors. These sensors will be used to meet the second high-level requirement. Since the golf ball must have a diameter between 38 mm and 47 mm, we decide to place two IR sensors at these heights. The IR sensor at 38 mm must detect the ball and the IR sensor at 47 mm should never detect the ball. If both requirements are met, we believe that the returned item has the correct diameter.

Requirements: The two IR sensors should be able to detect the golf ball.

2.4.2 Rent IR sensor

There will be one rent IR sensor at the exit of the channel. Since there is a slope at the end of the channel, if the motor stops, those golf balls will fall back into the channel. As a result, if the IR sensor detects the ball, the motor will stop. Then only one golf ball will come out from the channel. This IR sensor will be used to meet the third high-level requirement.

Requirements: The IR sensor should be able to detect the golf ball.

2.4.3 Pressure/Weight sensors

There will be around five weight sensors inside the channel. When the users choose to return the ball, the microcontroller should get the sum of weight inside the channel. After the ball is returned, the microcontroller should get the sum of weight inside the channel again to find the difference. As a result, the system can know the weight of returned item. If the returned item does not have mass between 40 grams and 50 grams, the alarm will be turned on. Those weight sensors will be used to meet the first high-level requirement.

Requirements: Those pressure/weight sensors should be accurate enough to detect the weight change around 45 grams.

2.4.4 RFID Reader

The RFID reader will be used to determine if a user can borrow a ball. If the user does not have a correct RFID, the machine will not rent a ball.

Requirements: The RFID scanner should be able to read different RFID tags.

2.5 Actuators RV tables & ckt schematic for each component

2.5.1 Motor

The motor will be used to push the golf balls out from the channel. It will be controlled by the microcontroller.

Requirements: The motor should be power enough to push around 10 balls at the same time.

2.5.2 Alarm

The alarm will be turned on if the mass or size of the returned item does not meet the first and second high-level requirement.

Requirements: The alarm should not use too much power and should be loud enough for people to hear.

2.6 Others

2.6 1 Motor driver RV tables & ckt schematic for each component

The motor driver will be used to control the motor.

Requirements: The motor driver should be able to use voltages around 9 V to control the motor.

2.7 Software Design

flowchart

3 Risk Analysis

The pressure sensors are the most important part of our design. The pressure sensor should be very sensitive to a small change to weight since the mass of golf ball are only around 45 grams. We expect the ball to have mass between 40 grams and 50 grams. The difference between the upper level and lower level is only 10 grams, which is even less than 0.1 newtons. As a result, we expect our weight sensors should be sensitive enough to detect weight change around 0.1 newtons.

4 Ethics and Safety

Since our machine is an automated system, the main safety concern when using the machine are the moving parts. People's hands or clothing could get stuck in the machine if people try to access the inside of the machine. In our design, we keep the moving parts of the project to the minimum, only one motor should be used and we will build in safety protocols based on the sensors in the machine to uphold the IEEE Code of Ethics, #1: "to hold paramount the safety, health, and welfare of the public…" [3].

When working with power supply units, and other electronics, components could carry an excessive amount of current which may lead to harmful situation. When working inside the lab, it is critical to follow the safety guideline and remember the lab safety training.

According to IEEE Code of Ethics #8, our product will target on all users and "treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression" [3].

During the process of making the project, we may collect wrong data or some unexpected results. We will not make up data or results on our reports. We will follow IEEE ethics that we will treat wrong data and results honestly [3]. We will honestly report the actual data and analyze which part we do wrong. Then, we will correct errors.

Since our project has many electric parts, it is possible to have some risks about exploding if we did some steps wrong. So, when we do electrical parts, we will make sure no other people around to ensure we don't injure other people. We also follow the safety guidelines, like never let current to excess safety current limits [5], to deal with any electrical component to prevent risks. If we need to handle the high voltage, we will report our action and complete additional training.

We will treat our project professionally and strive to make higher quality of our product.

This is to not only improve the quality of our project, but also make sure we are safe during making the project.

We will promise that we will not do the project individually in the lab. We will always make sure at least two people deal with the project at lab.

5 Reference

[1] Wikipedia. (2018). Golf ball: https://en.wikipedia.org/wiki/Golf_ball
[2] Vending machine: https://en.wikipedia.org/wiki/Vending_machine
[3] IEEE Code of Ethics: https://www.ieee.org/about/corporate/governance/p7-8.html
[4] Golf Statistics and Fact: https://www.statista.com/topics/1672/golf/
[5] Safety Guidelines: https://courses.engr.illinois.edu/ece445/guidelines/safety.asp