RFID Refrigerator

Project Proposal

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Contents

1 Introduction

1.1 Objective

American families are always looking for ways to save money. One area that people are not doing enough to save is food. Each year, $165 billion dollars worth of food is wasted. For the average American family up to $2,200 per household is wasted in food that gets thrown out [1]. People throw away tons of food from the refrigerator because they aren't always aware of what is inside. Grocery shopping while not being fully aware of what you already own and how long it will last can lead to a lot of waste. In addition, whenever one opens the fridge, heat flows into the fridge and to compensate for it, the fridge must use more energy to keep the food cold.

The goal of our project will be to cut down on food waste by having a refrigerator with radio frequency identification (RFID) system. We will take advantage of most Americans owning a smartphone by having notifications from the RFID system to be sent to the phone. Examples of the kind of information that can be stored on RFID tags can be quantity, expiration date, date of purchase, etc. With this information in your pocket, people will always have an updating shopping list. The project can also know when food is expiring and let the owner eat the food before it goes bad. How this would work is that the user would scan the barcode using the installed barcode scanner (with a camera) and then the system would look up in the database and find the corresponding item. This database would also include the expiration date of the item. Then, the user indicates with his/her mobile device how many items there are and then the auto-tagger would tag each item and the RFID reader would sense that the food item is in the fridge. In addition, the RFID reader would also be able to detect if a food item has been removed from the fridge and then indicate it in the database. Then, if the user decides to put the item back in the fridge, it would automatically recognize it in the database without having to retag the item. Finally, we will design an app that will allow the user to browse the list of items in the fridge and alert the user a food item is about to expire.

1.2 Background

Wasting food is a big problem in society. Per the Food and Agriculture Organization [2], 40 percent of food in the US goes to waste. In addition, on a global scale, every year 1.3 billion tons of food gets lost or wasted, and consumers in rich countries waste almost as much food as the entire net food production of sub-Saharan Africa. We propose that with our solution of an RFID fridge, even though it might be a nuisance for the user to have to scan and tag each item individually, in the long run, it would save a lot of money, as the system we would be implementing would be a lot cheaper than the food loses in one year.

Currently, a company called Terso Solutions, Inc. makes RFID refrigerators, but they are not for commercial use [3]. Instead, it is more for use in hospitals, research labs, pharmacies, dental offices, and stockrooms where the RFID tag for specimens is extremely important. For commercial use, we do not need features such as remote temperature monitoring. Per their website, the main purpose of their refrigerators is to "eliminate paper work and reduce costs through automation and smarter purchasing." We aim to have our product to not have these expensive features and make it affordable and consumer friendly.

1.3 High Level Requirements

- RFID reader must be able to write and read information from tag
- Information must transfer from reader to a computer system to phone/tablet
- Tags must be reasonably easy to apply and remove from items

2 Design

2.1 Block Diagram

Figure 1 shows the block diagram of our project. The RFID refrigerator can be broken up into 4 blocks as shown. The power system is going to be comprised of a power supply that is plugged in directly into the wall, along with a voltage regulator so that the RFID circuit does not take too much power. The power system will power up the RFID circuit,

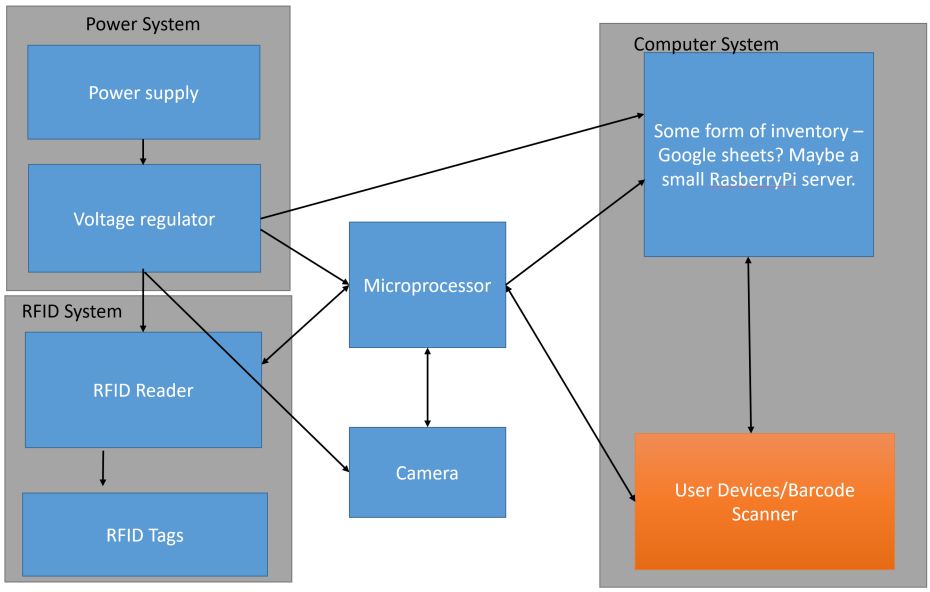

FIGURE 1: Block Diagram for the RFID Refrigerator

microcontroller and the camera. The RFID system will consist of an RFID reader, along with passive RFID tags that we will place on the food items. The barcode scanner will be an array of cameras that will read the barcodes from the food items and then use the microcontroller to communicate with the inventory using Wi-Fi, which will then look up to its database to recognize what food item it is. Finally, the system will need to read the RFID data along with the barcode data from the camera from the microcontroller and store that data in a list and be able to store that list in its inventory. Finally, there will be an app for users that will be the interface. That is, it will allow the user to communicate with the microprocessor and tell it whenever the user wants to add a new item into the fridge. In addition, it will also allow the user to browse the food items in the fridge and be notified if there is an expiring product.

2.2 Power System

The purpose of the power system is to output a 5 volt power supply from direct wall power. The power system is used to power the rest of the blocks and is constructed by using a power supply and a voltage regulator.

2.2.1 Power Supply

This will be an AC/DC power transformer. The AC power source will come from a wall outlet (120 V) and it will transform it into a 5V DC source, which will then go to our voltage regulator.

Requirement 1: The power supply must output a 5V DC Voltage with as little ripple as possible (around 10%)

2.2.2 Voltage Regulator

The voltage regulator will be a circuit in which the 5V will be able to maintain a constant voltage level.

Requirement 1: Must be able to provide a constant 5V DC power to power the other modules

2.3 RFID System

2.3.1 RFID Reader

We will purchase an antenna for the reader and design a circuit for the transfer in information. The reader should be powered with 5V. The frequency of the reader will determine the range that the tags can be used.

Requirement 1: Must be able to read within 6 inches
Requirement 2: The reader frequency will be in the UHF range which is 300 MHZ to 3 GHz. Will give us the range we need.

2.3.2 RFID Tags

The RFID tags will be placed on the items in the fridge and will store the information. The type of tag we will implement is a passive tag. Passive tags do not require a power source because it will use the energy used from the RF waves from the RFID reader to power itself while also transferring information.

Requirement 1: We want the tag to hold at least the amount the average passive UHF tag can hold, which is 512 bits of memory, thus transmission speed of the small amount of data will not be important.
Requirement 2: The tag must be able to write new data only when the reader sends a signal designating a write over the old data.

2.4 Camera

We will be using either one or an array of relatively cheap cameras that will take pictures of the barcodes of produce and transmit it to the microcontroller to be relayed to the user device for processing.

Requirement 1: The camera(s) must be able to take pictures clear enough that a barcode scanner can recognize it.
Requirement 2: The camera(s) should be able to capture barcodes of almost all produce stored in the fridge.

2.5 Microcontroller

The microcontroller will be powered by the 5 volt power system that we have designed. It will serve as the liaison between the fridge and the user. It is responsible for transmitting the pictures of the barcodes to the user device for scanning and processing, and it is also responsible for receiving that information and uploading it to the inventory and RFID system to pair the tags with each food item. Currently, we are considering using the 8051 Microcontroller, as it is one of the most popular options for interfacing with RFID

Requirement 1: The microcontroller must be able to be powered by a 5 volt power system.
Requirement 2: The microcontroller must be able to capture and process image data from a camera. (Must have an analog input for camera)
Requirement 3: The microcontroller must be able to process data and send that data via Wifi or Bluetooth to the inventory

2.6 Computer System

2.6.1 Inventory

We will need to keep an inventory of the items in the fridge and make it accessible to the user from other devices, such as their phones. This inventory does not need to be particularly complex - existing online services such as Google Sheets could potentially be used. The inventory must keep track of what items are stored, how long they have been stored, and an estimate of how much longer than can be stored. It should also be updated immediately once an item has been removed.

Requirement 1: Our inventory must be able to receive data from a tablet and store it online, where it can be easily accessed by the user.
Requirement 2: For multiple users on different refrigerators, we must prevent other users from accessing each other's data

2.6.2 User Devices

The user device is a key component of this project. It is what allows the user to interact with the inventory of produce, and manually edit the inventory should that be necessary. We imagine a simple app will be used to pull information from the inventory and display it for the user. The user device will also be used as the barcode scanner, because of the wide library of SDK's already available for that purpose.

Requirement 1: Display must be able to show inventory data and expiration date
Requirement 2: User must have ability to manually edit the inventory

2.7 Risk Analysis

The biggest risk is the interaction between the RFID tags and the RFID reader. There is a chance that the reader may misread the RFID tags, leading to the food items being incorrectly cataloged. That is, when we take out a food item, if the RFID reader doesn't detect that, then it may lead to incorrect cataloging. Also, we need to determine whether for multiple items it would be better to tag the bag itself (for example, a bag of apples), or

just tag each apple individually. In addition, having the system be able to pair each barcode with each RFID tag is another big risk, as the pairing system would have to be perfect. Otherwise, items could be incorrectly cataloged. That is, one RFID could be labeled with another food item.

3 Ethics and Safety

The main safety we might encounter with our project is the RFID circuitry. The moisture within the fridge could damage our circuitry, leading to short-circuits. We will need to ensure that our casing is able to sufficiently block out moisture to protect the user. Since the components of our RFID circuity will probably not 110/120 volts, we will most likely be using batteries to provide power. Lithium-ion batteries can explode under certain conditions, so we must monitor battery temperature and cut it off from the circuit should the temperature drift outside safe operating conditions.

As engineers, we are called "to improve the understanding of technology; its appropriate application, and potential consequences", as stated in #5 of the IEEE Code of Ethics [3]. We believe that our project will have a positive impact on the application of RFID technology, and will serve to improve the environment by reducing waste. However, we are responsible for all information sent through our technology, and it is known that RFID tags can be compromised, and have their information extracted, deleted, or rewritten. In event that the tags are compromised, a user could lose track on items in the fridge, which could result in potential waste. However, we believe that the likelihood of a dedicated attack on our system is small, simply because of the low value of goods that our system is intended to deal with. Some users may attempt to use our project to facilitate in their storing of items that may be deemed illegal, or could be used to harm others. While we do not have a method to ensure that our project is used solely for legal purposes, we do not believe that limiting the functionality of our system is the right course of action, as they can easily use any number of alternatives. Furthermore, we believe that the ability to reduce the amount of food waste has huge benefits that would far outweigh the potential negative effects.

References

[1] "Americans waste $2,200 worth of this every year ...", CNBC, 2017. [Online]. Available: http://www.cnbc.com/2015/04/22/americas-165-billion-food-waste-problem.html. [Accessed: 08- Feb- 2017].

[2] "FAO - News Article: Cutting food waste to feed the world", Fao.org, 2017. [Online]. Available: http://www.fao.org/news/story/en/item/74192/icode/. [Accessed: 08- Feb- 2017].

[3] "Terso Solutions", Terso Solutions, 2017. [Online]. Available: https://www.tersosolutions.com/solutions/rfid-refrigerators/ts074-rfid-refrigerator/. [Accessed: 08- Feb- 2017].

[4] "IEEE IEEE Code of Ethics", Ieee.org, 2017. [Online]. Available: http://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 08- Feb- 2017].