Food Savers

ECE 445 Project Proposal

Team 66

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Introduction

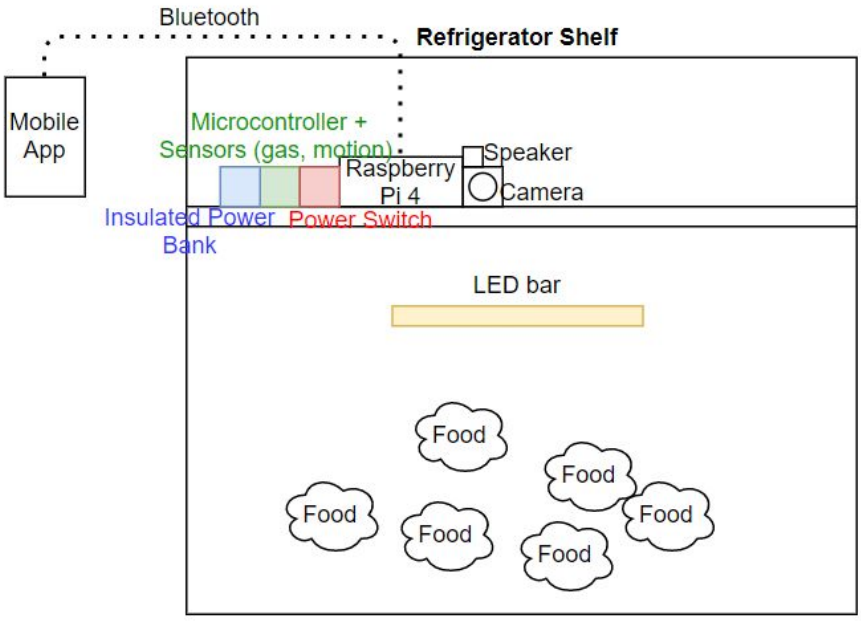
Objective

Our project proposes to create an image scanner/speaker combination that can be put inside of a small section of a refrigerator that will scan food using computer vision, estimate the expiration date based on the type of food, and automatically create timers. The product will keep track of the food in the fridge, updating its timers when it recognizes that the food has been removed for an extended time (eaten/used). If the food stays in the fridge for an abnormal amount of time (past its estimated expiration), the device will alert the user when the fridge is next opened. There will also be a gas-detecting sensor that will sense certain gases related to food expiration as a failsafe in case food expires past the expected expiration date. The difference between this solution and an app-based solution is that the user does not need to interact with the device at all, it will create and remove timers based on whether the food is in the fridge or not, only alerting the user when food has expired.

Background

Food is wasted because it expires without the customer knowing. Current food expiration timers require the user to input every food and its expiration date manually, which is a chore few are willing to do. Also, visually impaired people may have trouble reading the expiration date on food, possibly leading to situations where food expires in the fridge or on shelves unnoticed.

Physical Design

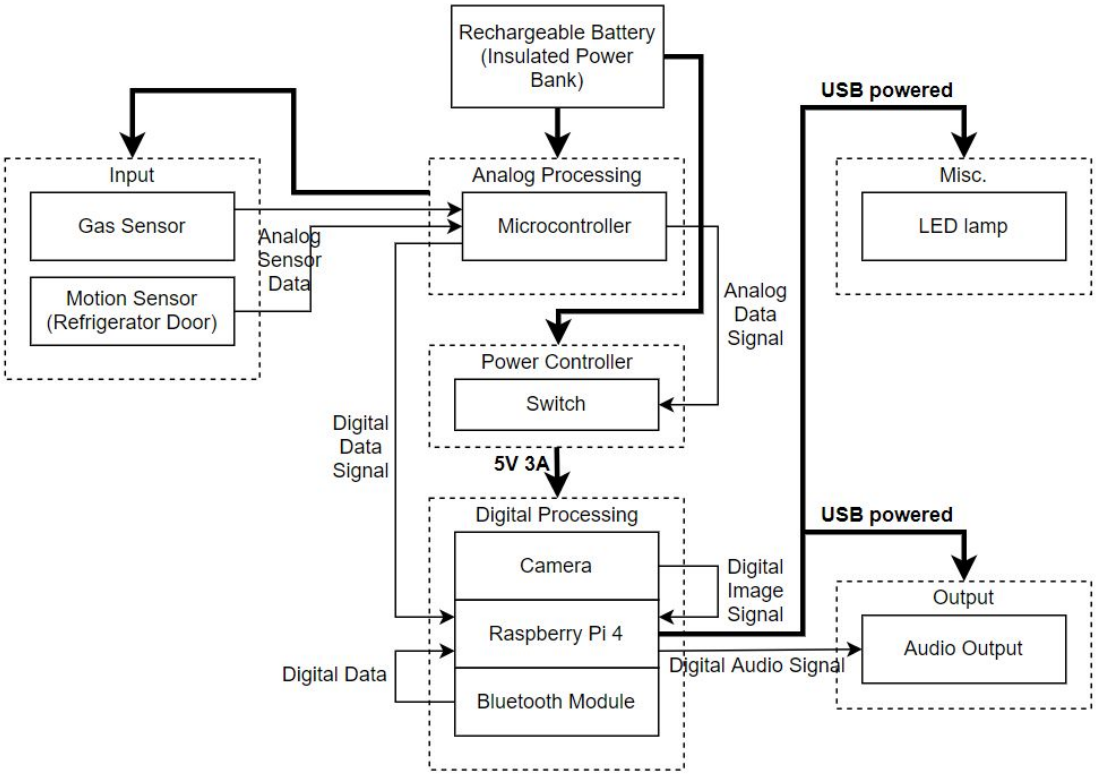


High-Level Requirements

- The device will be able to detect at least one dozen food items in the refrigerator space and classify them according to type.
- The device will be able to manage at least one dozen timers that are linked to specific food items. This includes the ability to create and delete timers based on internal logic, as well as alert the user when they expire through auditory output.
- The device will be able to sense the presence of gasses related to the expiration of food (gaseous ammonia or hydrogen peroxide).

Design

Block Diagram



Functional Overview

Gas Sensor - A sensor that can detect gas, mainly ammonia, would work in conjunction with the food expiration estimate to create a robust system to detect spoiled food.

Camera - A camera connected to the onboard logic that can be used to scan food items and guess what type of food it is (eggs, milk, bread, fruit, meat, etc.) We are planning to use OpenCV with open-source resources running on a Raspberry Pi for image recognition.

Speaker - An external speaker connected to the onboard logic that will be used to transmit information to the consumer. This can be particularly useful to visually impaired people as it would allow for conveying information without a screen.

Microcontroller - A microcontroller (Microchip PIC) that will be able to sense when the door of the refrigerator has been opened and will wake up the Raspberry Pi when the door closes again. This microcontroller will also control the gas sensor, sending information to the main computer when either gaseous ammonia or hydrogen peroxide is detected.

Onboard Computer - A Raspberry Pi that will have the open-source image recognition software running on it. This is also where the scripts to start the timers and to play the audible reminders will be located. This computer will remain inactive until it receives the wake-up call from the low-power microcontroller. This also will house the Bluetooth transmitter, to transmit the announcement to the user's smartphone.

Onboard memory - Onboard memory to store products and expiration dates. This will be stored directly on the Raspberry Pi

Power circuit - This will power both the low-power microcontroller and the Raspberry Pi, and will be able to route power to the Raspberry Pi when told to by the microcontroller.

Mobile Application - An app that can pair with the device using Bluetooth and has an interface to modify any incorrect or outdated information.

Block Requirements

Input System - Gas Sensor, Motion Sensor, and Camera

- A gas sensor should be able to detect amounts of ammonia [1] that expiring foods give out at a temperature inside the refrigerator (1C +/- 2C), which would be over 50ppm.
- A motion sensor should be able to detect the movement of the fridge door, which would be trivial as there would not be a moving object inside the fridge
- A camera must provide good enough picture qualities to show the layout of the food in a limited amount of lighting so they can be used for image recognition (image quality cannot be objectively measured but a 5MP camera would be enough based on the quality of the sample images that the open-source software uses and the lighting we would be using).

Power System - Power bank and Power Controller

- The power system must be able to supply at least 2.5A to the rest of the system continuously at 5V +/- 0.1V to meet the power requirement of a Raspberry Pi and should be insulated to ensure the longevity of the operation

Processing System - Analog and Digital Processors

- The processing system must be protected from moist with a plastic case to prevent potential malfunctionings (including the components attached to them: input sensors and a power controller)
- A Raspberry Pi has strong enough processing power for image recognition [2][3], 2GB memory and Bluetooth module attached to it, and 32GB Micro SD card would be used for an OS and a general storage unit
- A microcontroller must have enough ports to hold the sensors, minimum of 2, and A/D and D/A converters to communicate with both analog sensors and a Raspberry Pi

Others - Speaker and LED lamp

- A speaker must leverage strong enough power, at least 1W, to deliver an audible volume to a user when the refrigerator door is opened.
- An LED lamp must leverage strong enough power, at least 1W, to deliver sufficient lighting when the camera takes a picture of food.

Risk Analysis

The largest risks in our system will be from the Power System and Input System.
The Power System will need to supply power to the project at temperatures below 10° C for a reasonable amount of time, to avoid constant replacement. To combat this, we plan to use a Lithium-Ion battery, which has an operating temperature between 0° C and 45° C. It is also one of the most energy-dense forms of battery storage. [4]

The Input system will have the requirement of being able to detect different types of food and classify them according to their type. This is a fairly complex task and may be hard to accomplish in the dark refrigerator environment. For this, we are proposing an LED lamp that will be used to illuminate the food.

Ethics and Safety

Since the device is operating inside a refrigerator with low temperatures and a high possibility of condensation, the device will need to be at least compliant with IP 66 protection guidelines, meaning that it is “waterproof against hose-directed water, rain or snow”. [5] This is to ensure that there is no short-circuiting, especially due to the presence of batteries in the device. We are also using Lithium Ion cells, which typically have a protection circuit, which provides an added layer of protection. The device being in a cold environment does provide one positive in that it drastically decreases the chances of overheating.

There is an ethical concern in the operation of this device with the presence of an on-device camera that is autonomously operated. To assuage all concerns, we plan to have all image processing be anonymized and on-device, so that the user does not have to worry about their privacy being compromised. This is under the IEEE Code of ethics #1 “to protect the privacy of others”. [6]

References

[1] Prajitna, Sely. “EVALUATION AND ANALYSIS OF BEEF CONTAMINATION BY LOW LEVELS OF AMMONIA.” (2011)
https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1012&context=foodscidiss

[2] Raspberry Pi 4 Tech Specs
https://www.raspberrypi.org/products/raspberry-pi-4-model-b/specifications/

[3] Image Recognition With TensorFlow on Raspberry Pi
https://www.instructables.com/Image-Recognition-With-TensorFlow-on-Raspberry-Pi/

[4] What is a lithium-ion battery and how does it work?
https://www.cei.washington.edu/education/science-of-solar/battery-technology/

[5] IP ratings
https://www.iec.ch/ip-ratings

[6] IEEE Code of Ethics
https://www.ieee.org/about/corporate/governance/p7-8.html