Project Proposal - Spoiled Milk Detector

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I. Introduction

The purpose of this device is to detect and alert the user when milk has gone bad, or "spoiled," to ensure that the spoiled milk is disposed of and not accidentally consumed. This device can additionally monitor the status of milk and remind the user to finish their milk bag or carton before it spoils.

II. Client

[1] reports a severe case of food poisoning in April 2023 involving 88 people in the town of Orangeville in Dufferin County. Although the article says that events like this are rare, this case shows that food poisoning is certainly an issue in Dufferin, and it helped motivate us to engineer a product that could help the citizens of this region prevent further cases of food poisoning. According to [2], there are approximately 66,000 people living in Dufferin; these citizens will be our client group.

III. Problem

The problem we are tackling is the severe illness caused by food poisoning that can lead to hospitalization [3]. We chose to focus on a more specific part of this problem: food poisoning due to spoiled milk. Milk is spoiled and becomes a health risk when it is left outside or in the fridge for an extended period of time. Illness caused by consuming spoiled milk is characterized by diarrhea, vomiting, nausea, and stomachaches [4]. This has a serious effect on personal health.

IV. Stakeholders

The parties that would be affected or hold an interest in this project are listed below:

Stakeholders Involved	
Project Teaching Assistant (TA)	The Teaching Assistant is responsible for evaluating the project's requirements.
Citizens of Dufferin County (our client)	The people living in Dufferin are directly impacted by this project as the project's solution is targeted to prevent the amount of food poisoning due to spoiled milk in that region. Our device will directly decrease the likelihood of milk food poisoning and improve personal health among this population.
Grocery Stores and Sellers	While the sale of milk would remain unchanged, the surfacing of this device would gain the attention of grocery store chains as they could potentially adopt this device to monitor their stockhold of milk in their storages. This would ensure that the milk being sold is always fresh and that a customer does not end up with spoiled milk, avoiding PR implications.

Waste Disposal Companies	As this device will continuously monitor the status of milk being stored, it would incentivize the user to finish the milk before it spoils and has to be disposed of. This will greatly reduce the amount of wasted milk produced for the companies to dispose of, whilst saving customers money.
Public Health Agency	With the benefits of reducing milk waste and food poisoning in Dufferin, the local and regional Public Health agencies will take notice and could adopt this device, or alternative, into a public health regulation to improve the health and well-being of Canadians, especially those vulnerable.
Electronics and PCB Manufacturers	A new electronic device presents more demand for PCB and electronics manufacturers. These companies will notice an increase in sales and revenue as they manufacture more PCBs to produce the spoiled milk monitoring devices. In addition to the interest of the electronics and PCB manufacturers, this project will also draw the attention of any stakeholders from these companies.
Households	Among the people living in Dufferin, households can especially benefit from our project because adults need to be responsible for the milk in their own fridges, unlike in restaurants or other shared food storage spaces where there may be a more established method of keeping track of spoiled food.
Stakeholders Not Included	
Dairy Farmers and Producers	This device is only capable of detecting spoiled milk and it will not directly affect the demand for milk as consumers will continue to buy milk regardless. Spoiled milk is a result of milk that is no longer fresh due to it being stored for too long after it has been purchased from the supplier. Dairy is one of the four food groups found in Canada's Food Guide and milk is used to produce various other dairy products, thus this device will not affect the business of dairy farmers.
Dairy Packaging Companies and Brands	Similar to the unchanged demand experienced by dairy farmers, dairy packaging companies will continue to have dairy products to pack and ship. The demand from consumers and grocery stores will not change as spoiled milk is an afterhand result of storing milk for too long, which happens after the customers purchase milk from the supplier.

V. Solution

To reduce the occurrences of illness due to spoiled milk, we propose a milk bag holder, placed in the fridge, which lights up and makes a buzzing sound if a milk bag has been left in the fridge for too long. It also considers the time that milk has been left outside (since this will cause the milk to spoil faster), and automatically resets its timer if a milk bag is replaced. The user does not need to worry about anything except changing the milk bag when the alarm rings.

VI. Requirements

Functional requirements:

- As noted in [5], milk can only last in the fridge for about 7 days before it becomes spoiled. Therefore, the device must alert the user (with a buzzer and/or LED) if a bag of milk stays in the fridge for more than 7 days.

- According to [6], outside of a refrigerator, milk spoils much faster — in about 2 hours. Thus, if a bag of milk is taken out of the fridge for 2 or more hours, the device must also alert the user.

- [7] explains that after 1 hour, people only retain about 50% of the information they learn. This also means that they have a 50% chance of remembering a specific fact. Therefore, our device will not be effective if it only alerts the user once; instead, it must do so at least once every 1 hour until the milk bag is changed, since the user has more than a 50% chance of having forgotten to change it. In other words, after an hour, the user is more likely to have forgotten to change the milk than to have remembered.

- [8] states that it is critical for milk to be stored under 40 °F or 4.4 ℃, otherwise, it will "begin to develop signs of spoilage". This means our device should indicate to the user if the temperature of the refrigerator it is in is higher than 4.4 ℃. This can be measured with a temperature sensor.

Technical requirements:

- According to [9], the density of milk is approximately 1033 g/L. [10] states that an Ontario milk bag contains 4 L of milk. Therefore, the weight of a bag of milk is 4 L * 1033 g/L = 4,132 g. This means that the device must be able to measure weight from 0 to at least 4,132 grams, which is required for the auto-reset function of the device; if a full (heavy) bag replaces an empty (light) bag then the device knows that a bag was replaced.

- [10] also mentions that each bag of milk in Ontario consists of 3 smaller bags, each with 1.33 L of milk, or with a volume of around 1,330 cm^3. Therefore, the device must have three adjacent containers, each with an inner volume of at least 1,330 cm^3, in order to store the 3 small bags of milk.

- [11] states that sounds exceeding 70 dB are annoying to the average person, and anything beyond this level is either very annoying or unsafe. Therefore, the sound intensity of the buzzer alarm must not exceed 70 dB; this way, the buzzer will only be a way of conveying information to the user rather than an annoyance.

- The average ideal temperature of a refrigerator according to [12] is within 1.6-3.3 ℃. This means that the device, which operates in the fridge, must stay functional in the temperature range of 1.6-3.3 ℃ (the scale must measure weight, the LEDs must light up, and the buzzer must ring).

Safety requirements:

<u>These are the requirements outlined in [13]:</u> No more than 30W of power at any given time is to be consumed, transferred, or discharged within any component of the device during its operation; No more

than 500mJ of energy is to be stored within the device at any given time (includes electric, electric potential, mechanical kinetic, and mechanical potential energy); and if any component needs to be connected to a 110V AC power outlet, the component has to be CSA approved.

VII. Principles and Standards

Principles and standards:

1. We will use (write and read with) the JSON file standard, specified in full in the ECMA-404 standard [14], to store data on how long a bag of milk has left until it expires, how heavy a milk bag is when it is removed, and at what time a milk bag was last removed. The JSON file format is a popular way of storing data values or series of values under a key in a human-readable text format.
2. We will make use of a moving average. The moving average of *k* data points at point *t*, where y_n is the data value at point *n*, is:

$$\frac{1}{2k+1}\sum_{j=-k}^{k} y_{t+j} \quad [15]$$

   The moving average is a good indication of data trends compared to using raw data which can be hectic due to sensor inaccuracy or sensor error. Our project makes use of a force sensor to detect when milk bags are changed, and it will query the sensor data periodically to see if the milk bag is removed or replaced. However, the sensor data could be inconsistent depending on the quality of the sensing device we choose, and there may be occasional jumps or other data anomalies. Therefore, we will use the moving average to "smooth out" our stream of sensor data values to ensure a consistent force/weight reading.

3. Finally, we will make use of the concept of torque, $\vec{r} \times \vec{F}$ [16], where $\vec{r}$ is the displacement vector from the fulcrum to the point at which the force vector $\vec{F}$ is applied. Also, [16] states that when a lever system has no angular acceleration, the sum of torques is equal, and we can use this fact to "scale" the range of forces required for the force sensor to measure into the same range that the force sensor is rated for.

   For example, if all forces are perpendicular to the lever arm, the milk bag is placed d_1 away from the fulcrum, the force sensor is placed $d_2 = 2 * d_1$ away from the fulcrum, and the whole system is in equilibrium, then: the torque applied by the milk bag's weight F_1 and the torque applied by the force F_2 that the sensor pushes back on the lever with (i.e. the force measured by the sensor) are equal. Thus,

   $d_1 \times F_1 = d_2 \times F_2$ (cross-product becomes scalar multiplication if vectors are perpendicular)

   $d_1 \times F_1 = 2 \times d_1 \times F_2$

   $F_2 = \frac{1}{2} \times F_1$

and the input force has been scaled down by a factor of 2. Again, this is only an example with arbitrary numbers, but based on the actual specifications of the weight sensor, we can use the same principle to properly and accurately scale down the weight of the milk bags to be suitable for the sensor.

VIII. References

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