Project Proposal – Saqib & Tawsif

OUR IDEA – CALORIC INTAKE TRACKER

Customer Problem

* Specify an organization or a well-defined group that has a problem that the project group will address with an engineered design, which will serve as the client or customer for this project.
  + The customer for this project is University of Waterloo freshmen, specifically those who are concerned about the "Freshman 15" problem. This problem refers to the potential weight gain that some students experience during their first year of university due to changes in diet and lifestyle. To ensure that the client is relatively well-defined, the total number of individuals that are to be considered part of the client is to be between 10 and 100,000 people, which is realistic considering the population of First-Year students at the University of Waterloo.
* Describe the problem that the client has, referencing sources that corroborate the problem description.
  + Problem Description: The client faces the challenge of promoting healthy eating habits and portion control. When adjusting to residence life, along with the stress from their classes, students often struggle with understanding appropriate portion sizes, which can lead to overeating and unhealthy diets. Other causes of this issue include:
    - Social Events, Eating later at night, Increased alcohol intake, lack of exercise.
  + How the Client's Life Would Be Improved if the Problem Was Solved: If the problem of unhealthy eating habits and portion control were successfully addressed, the lives of University of Waterloo freshmen would be significantly improved. They would experience several benefits, including:
    - Improved Physical Health, Enhanced Academic Performance, Long-Term Health Benefits
* List all stakeholders for this project and describe their needs and concerns with respect to the project.
  + Stakeholders:
    - a. University of Waterloo Freshmen (Client):
      * Needs: University freshmen need a practical tool to help them manage their food portions accurately and address concerns related to the "Freshman 15" problem. They require a solution that promotes healthy eating habits, portion control, and overall well-being.
      * Concerns: Their primary concern is avoiding weight gain during their first year at university and maintaining a healthy lifestyle while adjusting to college life.
    - b. University Health Services:
      * Needs: University health services may have an interest in promoting the well-being of their students and reducing the health-related challenges faced by freshmen. They need tools and resources to support students' health and nutrition.
      * Concerns: Their concern is the effectiveness and impact of the food weight tracker in helping students maintain a healthy weight and lifestyle.
    - c. Residence Services and Dining Facilities:
      * Needs: Residence services and dining facilities may want to support students in making healthier food choices. They need information on students' eating habits and portion control to improve their services.
      * Concerns: They are concerned about the feasibility and integration of the food weight tracker within the dining facilities and residence areas.
    - d. Graduate TA (Al-Baraa El Hag):
      * Needs: The TA evaluating the project is interested in the successful completion of the project, adherence to academic standards, and the demonstration of engineering and problem-solving skills by the student team.
      * Concerns: The TA's concern is that the project meets the course requirements and objectives and that it demonstrates engineering competence.
    - e. Suppliers (RigidWare Store & Creatron inc.)
      * RigidWare & Creatron inc must supply appropriate products in accordance with customer specification in addition to passing Canadian safety standards and regulations. Suppliers have it in their best interest for the customers to use the product in accordance with safety standards and product specifications,

Initial Requirements:

* Functional Requirements:
  + Weight Measurement Accuracy:
    - The system's load cell shall accurately and reliably measure the weight of the specified food item with a margin of error not exceeding ±1 gram.
  + User-Defined Food Input with Intuitive UI:
    - The system shall ensure that users have a seamless and user-friendly experience. To do this, our display needs to be at least 480 by 800 pixels.
  + Dietary Guidance:
    - Based on the user's BMR and dietary goals, the system shall calculate the recommended daily caloric intake.
    - Dietary goals may include Weight Loss (e.g., 500 calories deficit per day), Weight Maintenance (e.g., equal to BMR), Muscle Gain (e.g., 300-500 calories surplus per day)
  + User Engagement Reminders:
    - The system shall send regular meal reminders to users every 3 to 4 hours to keep your blood sugar consistent and for your stomach to optimally digest.
    - A light will blink to serve as the notification.
* Technical Requirements (how to achieve the functional requirements):
  + Load Cell and Weight Sensing:
    - The STM32 board shall interface with the load cell through analog-to-digital conversion to achieve weight measurement accuracy within ±1 gram.
  + Caloric Calculation Algorithm:
    - The system shall provide users with accurate caloric information with an error margin of less than 5% compared to reference values obtained from the CalorieNinjas API.
  + LED Integration with STM32 for Blinking Lights:
    - Custom code shall be developed in C/C++ using the STM32 HAL (Hardware Abstraction Layer) or a similar library to control the GPIO pins and create the desired LED blinking patterns (every 3 to 4 hours).
  + User Interface and Display using 4-inch 480×800 Pixels IPS LCD:
    - The system shall integrate a 4-inch 480×800 pixels IPS LCD display with resistive touch functionality.

Safety:

Requirement 1:

*The design must not consume, transfer, discharge, or otherwise expend more than 30W of power at any point in time and within any component of the design during its operation. This includes all forms of energy, including but not limited to: electric energy, electric potential energy, mechanical kinetic energy, or mechanical potential energy.*

Through the project, the power consumption is something that will closely be monitored in various ways to meet the safety requirements of the project itself. It will have firmware designed to maintain close eye on the power consumption. The firmware will be designed in such a way where it will be put to a lower power consumption setting when not actively processing tasks. We will also ensure that all the components that are being used are power efficient. There will be interrupts designed to flag when the power expenditure is being too high, shutting down events that are not relevant to the process that is being used. The system will be always monitored, to ensure all safety requirements are met, for the safety of the user. There will be low amounts of power discharge as all firmware will be designed to use the least amount of power possible when running the product as well as when at rest. User will be able to shut down the device through an external button, whilst the scale is not in use.

Requirement 2:

*The design must not store or otherwise contain more than 500mJ of energy at any point in time. This includes all forms of energy, including but not limited to electric energy, electric potential energy, mechanical kinetic energy, or mechanical potential energy.*

To not contain more than 500mJ of energy at any point in time, there will be many processes put in place to not violate the safety standards put into place. There will be energy efficient algorithms to not put too much stress and load on the microcontroller. The firmware will be designed to not over compute any unnecessary calculations and allocate memory effectively to reduce the amount of energy consumption. If the energy consumption is too high at any given point, there will be an interrupt designed to shutdown the system, to meet safety standards. No mechanical energy or mechanical potential will be stored in our system, as there are no mechanical components included in the design.

Principles:

1. Newton's Law of Motion

Equation:

The principle utilizes Newton's second law, F=ma, where F represents force, m is mass, and a is acceleration.

Contribution to Problem Solving: We will apply this principle to calculate the food’s weight accurately using force measurements. By measuring the force exerted on a load cell or weight sensor (mass) and considering the acceleration due to gravity, we can determine the food’s weight. This principle ensures precise weight measurements, a critical component of our food weight tracker.

2. Harris-Benedict Principle for BMR Calculation:

Equation:

For men:

For women:

Where:

* m is the weight in kg
* h is the height in cm
* t is the age in years

The Harris-Benedict principle provides equations to calculate Basal Metabolic Rate (BMR) based on factors such as age, gender, weight, and height.

Contribution to Problem Solving: By applying the Harris-Benedict principle, we can estimate the user's BMR, which represents the number of calories they burn at rest. This information is essential for personalizing dietary recommendations. It helps users understand their calorie needs and contributes to promoting healthier eating habits and portion control.

3. Circadian Rhythms and Eating Patterns:

Circadian Rhythms give us an equation for your recommended bedtime:

Where:

* b is your bedtime
* s is the time of sunset

Let w be your wake-up time as well as the time of your breakfast, based on the above formula, and the fact that the average person should have each of their meals 4 hours apart, we can derive another equation for when our notification system should go off to remind our user to eat their meal:

Where:

* t is the time for your meal and reminder notification.
* x is the number of your meal (i.e., lunch = 1, dinner = 2, dessert = 3)

Principle: Circadian rhythms are the body's natural, internal processes that regulate various physiological functions, including sleep-wake cycles and eating patterns.

Contribution to Problem Solving: Understanding circadian rhythms and their impact on eating patterns can help design a notification system that delivers reminders at times when users are most likely to be receptive to dietary guidance. For example, notifications can be timed to align with periods of heightened alertness and reduced likelihood of unhealthy snacking, contributing to better adherence to dietary goals.

Bibliography

[1] C. Vadeboncoeur, N. Townsend, and C. Foster, “A meta-analysis of weight gain in first year university students: is freshman 15 a myth?,” *BMC Obesity*, vol. 2, no. 2, p. 22, 2015, doi: <https://doi.org/10.1186/s40608-015-0051-7>.

[2] M. Matys, “Avoiding the Freshman 15,” *Your Health Matters*, Sep. 02, 2015. <https://health.sunnybrook.ca/sunnyview/avoiding-freshman-15/> (accessed Sep. 16, 2023).

[3] N. L. Mihalopoulos, P. Auinger, and J. D. Klein, “The Freshman 15: Is it Real?,” *Journal of American College Health*, vol. 56, no. 5, pp. 531–534, Mar. 2008, doi: <https://doi.org/10.3200/jach.56.5.531-534>.

[4] R. Raman, “The Freshman 15: Causes and Prevention Tips,” *Healthline*, Apr. 21, 2021. <https://www.healthline.com/nutrition/freshman-15#what-causes-it> (accessed Sep. 16, 2023).

[5] A. ADMIN, “How Accurate Should My Scale Be?,” *Truweigh*. <https://www.truweigh.com/blogs/news/how-accurate-should-my-scale-be> (accessed Sep. 16, 2023).

[6] L. Bruton, “User interface guidelines: 10 essential rules to follow - UX Design Institute,” *www.uxdesigninstitute.com*, Jul. 27, 2022. <https://www.uxdesigninstitute.com/blog/10-user-interface-guidelines/> (accessed Sep. 26, 2023).

[7] D. Barbagallo, “How To Make A Health & Fitness App More Engaging,” *Medium*, Jan. 12, 2021. <https://cardian.medium.com/how-to-make-a-health-fitness-app-more-engaging-28d47c375c23#:~:text=Reward%20%E2%80%94%20If%20a%20player%20(user> (accessed Sep. 26, 2023).

[8] “Scheduled Eating- Why It’s Beneficial and How to Start – Center for Healthy Eating and Activity Research,” Chear, Mar. 27, 2020. <https://chear.ucsd.edu/blog/scheduled-eating-why-its-beneficial-and-how-to-start> (accessed Sep. 28, 2023).

[9] “20kg Load Cell Weight Sensor Electronic Kitchen Scale + HX711 AD Weighing Module Geekstory : Amazon.ca: Industrial & Scientific,” *www.amazon.ca*. <https://www.amazon.ca/gp/product/B079FQNJJH/ref=ox_sc_act_title_2?smid=A1GUQD3SRXOFFI&psc=1> (accessed Sep. 26, 2023).

[10] “API Documentation - CalorieNinjas,” *calorieninjas.com*. <https://calorieninjas.com/api> (accessed Sep. 26, 2023).

[11] “Haitronic 300pcs 3mm, 5mm led Assorted 5 Color LED DIY KIT for Prototyping Arduino/breadboard, Teaching Students Electric Circuitry, Christmas Tree Decoration red Yellow Blue Green White : Amazon.ca: Industrial & Scientific,” *www.amazon.ca*. <https://www.amazon.ca/Haitronic-assorted-Prototyping-breadboard-circuitry/dp/B01MYWS9IW/ref=sr_1_5?keywords=led+electronics&qid=1695770434&sr=8-5> (accessed Sep. 26, 2023).

[12] K. Magdy, “STM32 HAL Library Tutorial – HAL Library Examples,” *DeepBlue*, Jun. 02, 2020. <https://deepbluembedded.com/stm32-hal-library-tutorial-examples/> (accessed Sep. 26, 2023).

[13] “4inch 480×800 Pixels IPS LCD, Resistive Touch, 8080 Parallel Interface,” *www.waveshare.com*. <https://www.waveshare.com/4inch-resistive-touch-lcd.htm> (accessed Sep. 26, 2023).

[14] the Physics Classroom, “Newton’s Second Law,” *The Physics classroom*, 2021. <https://www.physicsclassroom.com/class/newtlaws/Lesson-3/Newton-s-Second-Law> (accessed Sep. 16, 2023).

[15] “Harris-Benedict Calculator - Omni,” *www.omnicalculator.com*. <https://www.omnicalculator.com/health/bmr-harris-benedict-equation> (accessed Sep. 16, 2023).

[16] “Circadian Rhythm Calculator,” www.omnicalculator.com. <https://www.omnicalculator.com/health/circadian-rhythm> (accessed Sep. 28, 2023).