[M3] - Prototyping & Plans

Yilin Li Kashaf Usman Shitong Lyu Ziyi Li

Introduction

At the end of Milestone 2, to address the research questions and expectations outlined, we designed an experience focusing on three key design dimensions: Sustainability, Convenience, and Budget. These dimensions were chosen based on their prominence in users' decision-making regarding meal preparation, as highlighted in our diary study and survey data. From there we were able to research different ideas and devices that would work best as a solution. We learned that since time is a big pain point we want to address that in a way where users benefit off the device rather than spending time customizing the interface.

During this Milestone, we have finalized the project scope and design, such as what sensors and applications will be used in the design. We conducted user research to gain valuable insights into users' preferences and the problems they aim to solve with our product.We have determined the sensors and other IoT components that will enhance our users' meal preparation experience. Our plan involves leveraging a combination of voice output, camera, digital screen, and mobile application functionalities.

Study Design

Brainstorming and Ideation

Initially, the team brainstormed different features and functionalities that could enhance the user experience and streamline kitchen tasks, such as ingredient scanning, inventory management, and personalized meal suggestions; then we discussed different sensor options that could facilitate ingredient scanning and inventory management effectively. Options such as RFID (Radio Frequency Identification), barcode scanners, and camera modules were considered. Each sensor had its advantages and limitations, prompting discussions on the most suitable approach for the study. Each sensor option presented unique challenges and considerations, leading to deliberations on the trade-offs between accuracy, cost, and user experience.

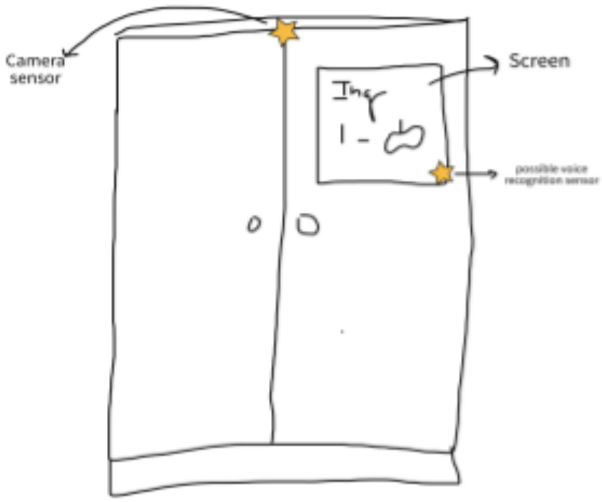

Figure 1 : Initial Sketch

Ultimately, the decision to integrate a compact camera module along with some auditory feature

into the smart fridge prototype was based on several factors. The camera offered the flexibility to scan a wide range of items without the need for additional tags or labels, enhancing user convenience. Advancements in image recognition technology also allows for efficient and accurate identification of scanned ingredients.

Execution

The prototype comprises a compact camera module integrated into the fridge, capable of scanning and recognizing ingredients placed inside or removed from the fridge. Additionally, it includes a user interface displayed on a screen, where users interact with the device, view ingredient inventory, and access personalized meal suggestions.

Four different participants were invited to a mock kitchen environment that mimics a typical home kitchen layout. The users were informed of the capabilities of our IoT device, and let the users pretend that the prototype is installed within the refrigerator placed in this setting, allowing participants to interact with it as they would with a real smart fridge.

Participants engage in scenarios where they put ingredients in and out of the fridge, and the device's camera would automatically scan the item. Then the device instantly recognizes the items and updates the inventory list on the UI.

Based on the scanned ingredients, the device generates personalized meal recipe suggestions tailored to the user's preferences and available ingredients. Participants can browse through the suggested recipes on the UI and select one for meal preparation.

Participants follow the instructions provided by the IoT device for preparing the chosen recipe. They may interact with the UI to view step-by-step instructions, ingredient quantities, and cooking tips.

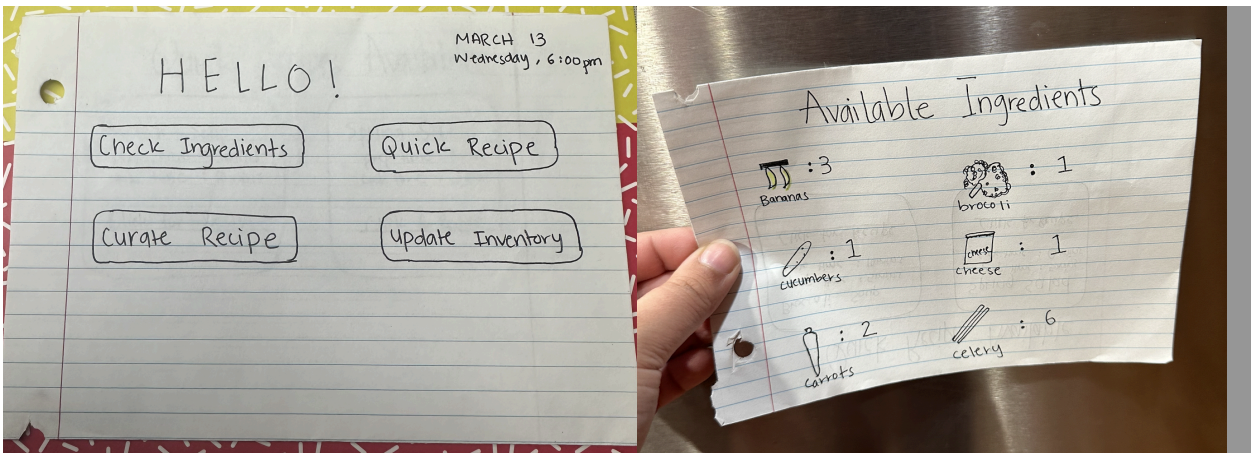

Figure 2 and 3: Design Interface used during execution

Study Results

Audible Alerts

Initially, our design primarily relied on a light to indicate successful scanning of different grocery items into the fridge. However, through user feedback and analysis, it became evident that incorporating a beeping noise alongside the visual cue would be crucial for enhancing user experience and functionality. The addition of auditory feedback would also then address accessibility concerns, providing a multi-sensory confirmation for users, especially in scenarios where visual cues might not be sufficient, such as low-light environments or for users with visual impairments.

Intuitive User Interfaces

Our product aims to provide personalized meal recipe suggestions according to user preference and the available ingredients in their fridge. Users can explore different cooking inscriptions and browse through suggested recipes. Throughout our study, our users expressed that they have used similar mobile applications to discover recipes and conduct meal planning. However, they said they all gave up using the app at the end because the interface is not very user-friendly and engaging. Users expressed the need of an engaging, user-centered, and self explanatory user interface and product. Although we are developing an IoT product, we will also put a lot of emphasis on creating smooth and engaging user experiences for our target audience.

Accuracy Concerns of Ingredients Recognition

The participants were satisfied with the capabilities of our product, however, they have raised a few concerns regarding the accuracy of the system that we should be aware of. Any technical glitches experienced, like delays in item recognition or system errors, would limit the system's capability. And participants might have trouble fitting large or irregular shaped items in the view of the camera. With the current position of the camera, items will be blocked or out of the camera view. Our team should implement more sensors in the fridge from different angles, to make sure all items would be detected.

Exploration of Different Cuisines and Dietary Restrictions

During our user interviews, most of the participants express concern regarding the limitations in offering a variety of recipes that cater to different cultural cuisines and dietary needs. Users expressed a desire for a more inclusive approach that recognizes and embraces culinary diversity. The feedback gathered from the interviews suggests that customization in recipe suggestions could significantly improve their satisfaction. It would not only make the device more appealing to a broader audience but also ensure that it serves as a truly helpful kitchen assistant that understands and adapts to individual user preferences and dietary restrictions.

Ideation and Selection

We intend to initiate the design process for our user interface prototype using Figma. Our initial steps will involve crafting wireframes and low-fidelity prototypes. Our goal is to test the concept and gather feedback from our target audience group. For the hardware aspect, we will start to explore different equipment choices and determine which one is the most suitable choice for our scenario and product.

Criteria

- User Satisfaction: Prioritizing features that enhance user satisfaction and overall experience.
    - Engaging and user-friendly interface: Focusing on intuitive, user-friendly interface design that facilitates seamless interaction with the smart fridge prototype.
        - Easy to Use: The interface is easy to understand, explore, and navigate without extensive guidelines or instructions.
        - Clear Communication: Users should be able to quickly understand the goal of the product and what problems are the product aiming to solve
        - Responsiveness and Accessibility: The interface is accessible to all users and different screen sizes.
        - Help and Error: When users encounter errors and problems, the interface should guide the user to the help page and help users to troubleshoot issues efficiently.
- Efficiency and Convenience: Emphasizing features that improve efficiency in meal preparation tasks and enhance convenience for users.
    - Self-explanatory and efficient design: We aim to create features which can help users to easily grasp information when needed. The interface should provide user immediate feedback to user actions. Users should be able to have features which can show them all the possible recipes or cooking ideas at a first glance.
- Feasibility: Considering the feasibility of implementing proposed features within the constraints of technology and resources.

Ensuring the design is user-centered, we will utilize the criteria to evaluate the user experience of the product and use the above criteria to help us to make design decisions and ensure the efficiency of the product.

System Proposal

Our system is an innovative, IoT device embedded in the refrigerator to help individuals manage their kitchen tasks, from ingredient inventory management to meal preparation. By integrating

advanced image recognition technology, user-friendly interfaces, and personalized meal suggestions, our system aims to address key user needs around sustainability, convenience, and budget. The system is proposed to be developed with current technological capabilities and refined to be market-ready within the next 5 years.

Basic Features:

- Camera Module with Object Recognition: identify and track inventory in real-time.
- Auditory Feedback System: Provides audible alerts for successful item scans
- Mobile Application Integration: Offers remote inventory management and recipe access

The proposed system utilizes existing technologies such as RFID (device that reads information contained in a wireless device or "tag" from a distance without making any physical contact or requiring a line of sight), barcode scanning, and particularly object recognition. The integration of a camera to detect what is inside the fridge is technically feasible today, and will be developed to have greater performance and lower costs over the next few years. The auditory feedback mechanism and touch-screen interface are well-established technologies, so implementing them into our system is straightforward. Developing the personalized meal recommendation requires data collection and machine learning, and it is achievable within the proposed time frame. Overall, the system we designed is a plausible project that could be brought to market readiness in approximately 5 years.

Demo Proposal

Because of the limited technology availability and technical skill for such a complicated IoT system, our team decided to utilize the method of Wizard of Oz to stimulate the capabilities of our system and make sure our prototype would produce the desired interactions with users. A possible effect on experience is that the whole environment may be less immersive so that users may not see the full potential of item recognition capabilities as will be possible in the final product.

First, our team will create a physical mock-up of the refrigerator using materials such as cardboard and tape. The "fridge" will have a door and should be able to store items. Then, our team decided to develop a circuit with light and voice output, which can be controlled by a mobile device, to demonstrate whether the item is updated in the system successfully. For instance, once the item is put into the fridge, our team will control the circuit showing a green light and a voice output to inform the user that the ingredient is input in the system.

The other major part of the demonstration is the change on the digital display, either a screen on the fridge or a mobile app. Since full app functionality requires more development time and backend integration, our team will use Figma to develop a digital prototype, with a few

placeholder user interfaces that will indicate the inventory update of the ingredients and several recipes.

Based on our proposed IoT system, our team have decided to demonstrate the system in the following steps:

1. Set up the environment: refrigerator, screen, a few items to put in and out
2. Introduce the system to the audience
3. Have the users walk through the journey of adding items to the fridge, showing how the camera identifies them, and how the app updates in real-time
4. Display an inventory update on the screen
5. Display a few suggested recipes based on the current inventory

Conclusion

At the end of this milestone, the project has made significant progress in evaluating different aspects. We have a clear idea of a prototype that would involve integrating a compact camera module for ingredient scanning and recognition, along with a user interface displayed on a tablet and/or smartphone. Participants expressed high satisfaction with the prototype's ability to streamline meal preparation tasks and provide personalized meal suggestions based on scanned ingredients.

An area of further research would be in regards to different cuisines and dietary restrictions. The device is not competent to generate unique recipes from different cuisines, which may be a turn off for some users. Additionally, experimentation with alternative interface types such as gesture or voice control could provide insights into preferred interaction methods among users.

We will prioritize creating a seamless, automated, and user-friendly experience. To achieve this, we have chosen to employ digital screens, light and voice output functionalities, along with the integration of mobile applications for our IoT product.To evaluate our design, we will rely on three key criteria: user satisfaction, efficiency and convenience, and feasibility. These criteria will enable us to develop more user-friendly design solutions and provide guidance for making effective design decisions.