HCI Design Project: Chef

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***Abstract*— This paper presents our design project "Chef", an Internet-of-Things device which can be placed inside your fridge and comes with a mobile application to help organize, customise, and diversify your daily meals. The IoT device is a Raspberry Pi coupled with a microphone, speaker, camera, and proximity sensor which connects to a cloud service to store the latest state of the fridge. A few design guidelines are proposed in the paper, in addition to a discussion about the future of using IoT in our daily lives.**

Keywords: smart fridge, food wastage, voice-command, meal management

I. INTRODUCTION

Managing your home-cooked meals and groceries can be quite time consuming, and sometimes even stressful. While many day-to-day obligations have become eased through modern digitalization, there has yet to be a solution that addresses a common pain-point we all face: what should I cook? We want to modernize this quotidian task and create a solution that organizes and diversifies what you eat. We envision a product, Chef, which will allow users to organize and diversify what they eat by monitoring whats in your fridge, managing your food inventory along with expiration dates, exploring potential recipes, as well as to plan your meals for the week.

II. RELATED WORK

There are many existing resources intended to help combat food wastage by notifying users before their food expires, in combination with identifying calorie count in your meal, such as Mealime [7] and FoodAI [1]. Most apps have users manually upload items, or take in other modes of input such a barcode scanning or taking a picture. Current expiration tracking solutions involve users having to manually input each item along with the expiry dates, which is repetitive and not user friendly [9].

Some alternatives to relying on manual input of each item to keep track of which food is about to expire or when you are running low on groceries is to do automated food recognition using feature-based machine learning techniques, such as done by DietCam [4]. Among the challenges that come with food recognition is the fact that deriving the food information still is heavily reliant on the dataset used to train the model, and has low object recognition accuracy [4]. Another alternative to manual input is to provide a visual image of the items in the fridge using a camera connected with a mobile application, and this is done by FridgeCam developed by Smarter. However, the application requires manual input for items that are not in the database.

LG SmartThinQ app [5] connects with the LG SmartThinQ Smart Refrigerator and allows you to manage your food, expiration dates, and checking your food list remotely, creating a shopping list and monitoring conditions of the fridge. Also, Samsungs Smart Fridge Family Hub [10] has a translucent screen in place of the fridge door, with draggable expiry date bubbles. However, this requires purchasing and installing a smart fridge. Several studies have been done regarding smart fridges, but the technology is too complex for most household users [12]. Also, smart fridges are very expensive. Thus, a simpler system is required for any user to be able to afford, and to handle.

The other aspect of the problem is managing your meals and current inventory. There are websites to explore recipes as well as application that allow you to manage recipes, such as Paprika Recipe Manager [8]. However, these websites and applications fail to allow users to include their current food inventory in order to filter down to more specific recipes. Priced at $30 for the desktop application, its a useful tool, however, it does not take into account what is already in the inventory and faces the same drawbacks as the aforementioned applications requiring manual entry of the grocery items. Moreover, its touch-based interface is not convenient during cooking, requiring users to manipulate the different tabs with their fingers.

Rouillard [9] researched this using the Pervasive Fridge (referring to the paradigm of pervasive computing), an app that can be used wherever - users can enter food data manually, using a barcode or scanner, as well as with speech. Their primary motivation was to create a system that takes multimodal input, since previous food managing and expiration tracking apps only allowed one. We wanted to use this concept of multimodal input for our system. Additionally, we would like to make use of the design guidelines for smart fridge interactions outlined in CloudFridge, a web service interface (testbed), which include the importance of adapting based on usage, and personal preferences [11]. It does not do automatic expiry date retrieving, but it makes use of object recognition system and infrared sensors which measure the position of objects placed in the fridge. Furthermore, they developed a couple end-user applications (not commercially available) including the cfTakeOut which uses a Text-to-Speech engine in conjunction with object tagging to update the system when objects have been taken out of the fridge [11].

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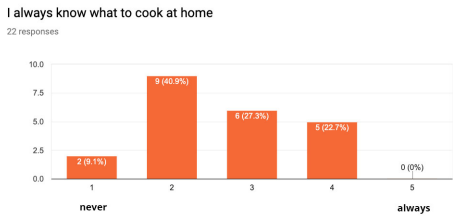
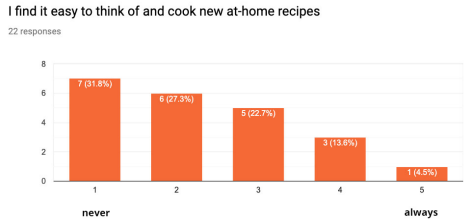
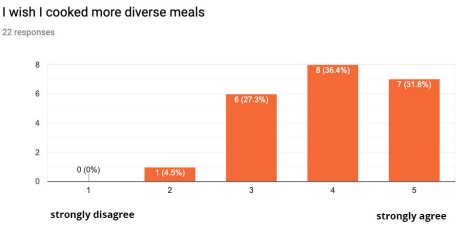
The other aspect of the problem is managing your meals and current inventory. Paprika Recipe Manager is one meal planning tool which is used for organising recipes, and making meal plans (Paprika). Priced at $30 for the desktop application, its a useful too, however, it doesnt take into account what is already in the inventory and faces the same drawbacks as the aforementioned applications requiring manual entry of the grocery items. Moreover, its touch-based interface is not convenient during cooking, requiring users to manipulate the different tabs with their fingers.

III. User Study

We began user research by creating a questionnaire to validate some assumptions we generated through personal introspection of our meal planning and grocery organizing. We received 22 responses after sharing the survey on social media, with responses from from friends and family. Respondents were primarily aged 18-26, with a few between 27 and 40. Some of the responses we received are pictured as follows:







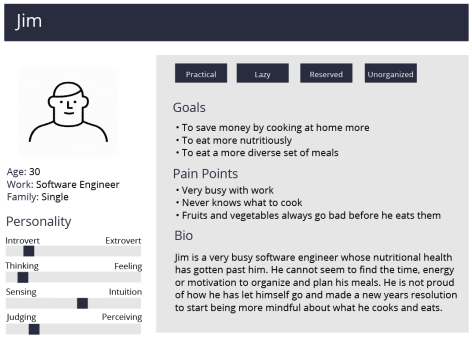
Furthermore, we conducted six in-person interviews - a few semi-structured intercept interviews and a few following the critical incident technique. These interviews allowed us to extract specific interaction points and key details to peoples current meal planning and grocery managing strategies. For example, we found that families generally decide what they will have for dinner during the day while they are apart, and that they often share grocery shopping duties. We also found that people like to create variations of recipes, often due to food restrictions or dietary specifications, and save them for later. Another pain point we found was that often food that goes bad is hidden in the fridge - since a camera cannot detect these items, multimodal forms of input is necessary.

In addition to interviews, we conducted a 2-week long diary study with two individuals who meal plan and are very intentional about what they eat, in order to get a fine-tuned and documented understanding of how these mindful eaters navigate their weekly meal planning. These studies showed that meal planners plan at the start of the week and like to use the same ingredients throughout the week, but often find themselves cooking the same meals because of this, wishing they could diversify their meal prep more easily, but finding it hard to think of different recipes that use the same types of ingredients. These studies allowed us to extract more specific design details for our Meal Planning feature, such as automatically generating grocery lists, and a Chefs Recommendation feature to let the system generate a meal plan.

IV. Design

A. Personas & Scenario

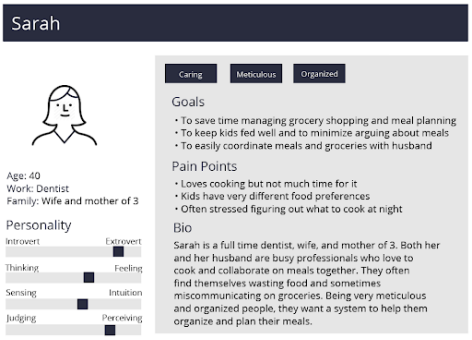
1) Design Scenario 1: Jim: Jim is a 30 year-old busy working professional who will use Chef to help him plan healthy meals using what is leftover in his fridge. In addition to helping him in organizing his grocery shopping, the Chef App is useful because it allows him to see what is in his fridge while he is at the grocery store, in order to know what ingredients I need to cook a certain meal.



Scenario 1: Jim opens Chef App, he first opens Inventory and views what is in his fridge, and then looks at the list to check how many beers he has left to see if he needs to pick up some on the way home from work. He opens Recipes/Explore and adds a filter for Low Calorie and Chicken. He scrolls through some potential recipes and selects 3 that he likes and adds them to Saved. He opens Meal Plan, opens Monday and clicks (+) for lunch, this opens Explore/Saved where he adds the first meal. He does the same thing for Tues Fri. He decides he wants to switch the order, so he moves one meal to another day of the week and deletes one. He then uses Chefs recommendation to add a meal to the open slot. Next, he opens up Groceries to view what he needs to get at the grocery store. He goes

to the grocery store and checks the items off the list while hes there, the items automatically upload to the inventory section once they are clicked. He gets home and clicks on the meal for Monday to view the cooking instructions. Since the meal is for both Monday and Wednesday, it tells him to make portions for two servings.

2) Design Scenario 2: Sarah: The second persona is Sarah, a working mother of 3, who uses Chef to manage her grocery inventory and to get input from the rest of the family on which meal they prefer. Using the application helps to easily choose potential meals and narrow down the meal to cook for the night.



Scenario 2: Sarah opens Chef App, she browses Recipes and filters by whats in her fridge to find something to cook for tonight. She adds three potential recipes to the Meal Plan section for tonight's dinner and then shares it with her family, that way her husband and three kids can vote on which meal they prefer for tonight. Each family member is notified and votes. The winning meals ingredients is added to the Groceries section, which she then shares with her husband so he can pick up the missing ingredients on the way home from work.

V. SYSTEM DESIGN

Our solution is an IoT device connected to an application which allows you to organize, diversify, and customize what you eat. The IoT device, which we call Chef Jeff, has both eyes and ears, which allows you to view whats in your fridge even while you are still at the office. He can also listen to you! Tell him commands such as running low on milk or opened pasta sauce, expires in 7 days and Chef Jeff will update Chef App. Chef App will then notify you the day before the pasta sauce will expire, to ensure you dont waste it.

Chef App not only manages your grocery inventory, but it can also recommend potential recipes to cook based off of what you already have in your fridge. Furthermore, you can even create a custom meal plan for the week using the Meal Plan feature, which will automatically produce a shopping list if you need to pick anything up from the grocery store. 1).

VI. IOT DEVICE

For the IoT device, we integrated a camera, motion sensor and a microphone onto a Raspberry Pi. The camera

Fig. 1: Initial IoT setup

is activated by a motion sensor to sense the distance between the refrigerator door and the object. When the distance is smaller than the threshold, e.g. when the door is closed, the camera will take a picture and save/upload it to server. The server will automatically update the latest image, so that users can see the objects in the refrigerator.

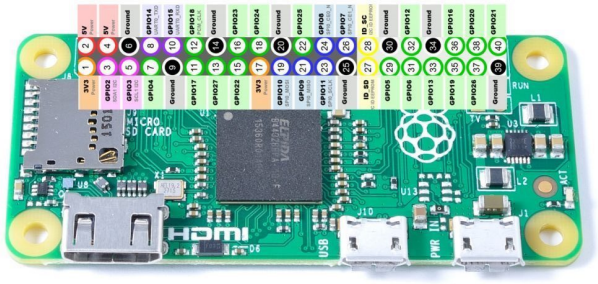


Fig. 2: The Raspberry Pi Zero W we used

Hardware Specifications:

- Raspberry Pi Zero W
- APDS9960 Proximity sensor
- Microphone and speaker

Software Specifications:

- Python v3.7.1
- Google Assistant SDK
- Sketch
- VNC Viewer

VNC Viewer was used to access the files and to establish communication with the Raspberry Pi. Vim text editor was used to transfer files between our laptop and the Raspberry Pi.

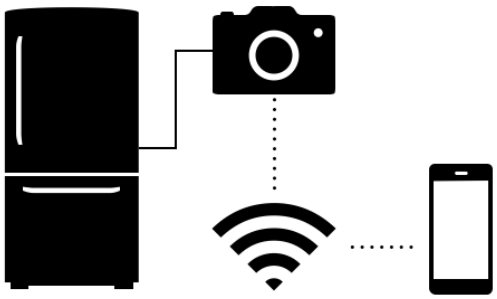


Fig. 3: Architecture

A. *Monitoring*

Many customers have a common need to see the current situation of the fridge when they are shopping in the market. So we implement a function of monitoring. The idea is to take a picture inside the fridge when the door of the fridge is closed. We use a Raspberry pi with a camera and a distance sensor. The sensor detects the distance between the side of the door and the back of the fridge. When the distance is smaller than the threshold, the camera will be triggered to take a picture and the picture will be saved in the server folder of the Raspberry. So customers can access this picture anywhere.

B. *Voice Command*

For expiration tracking app, the complex part is the input. Adding items one by one using virtual keyboard on the screen is common but inconvenient. And for those cuisine apps, it's also hard to use them with dirty hands when cooking. And voice command is a great solution for both.

We develop this function with Google assistant API. Users can add and delete items in list. But this API is not highly customized. In the future, we will use some low-level voice recognition API to fully implement this function.

VII. Chef App

Before we started the design, we identified the core function points based on the User Study and scenario, and also classified the functions. The similar functions form one core module. Figure 2 below is our information architecture.

Before making a high-fidelity user interface, we first need to reach a consensus within the team on this wire-frame. So according to our information architecture, we used Axure to draw the wireframe of each module. and then found our users to conduct a simple test. Through several discussion on interaction details and functional priorities, We get the final determined wireframe shown in Figure 3. As you can see from the figure, in order to make the layout of the interface more reasonable, we draw the approximate layout of each interface in Axure. At the same time, the interaction details are explained by text notes and navigation lines. Although it can't be used to test directly to users, it is helpful to explain and get feedback from professionals or within group.

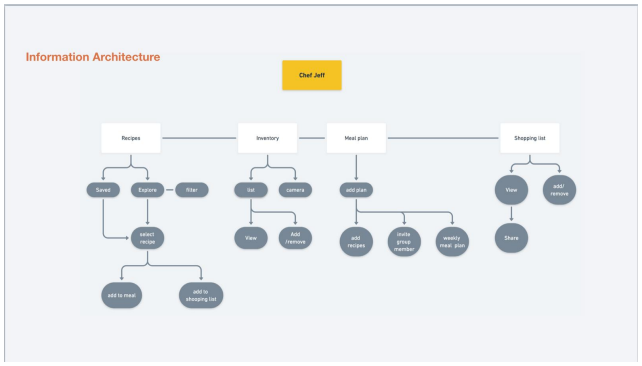


Fig. 4: information architecture

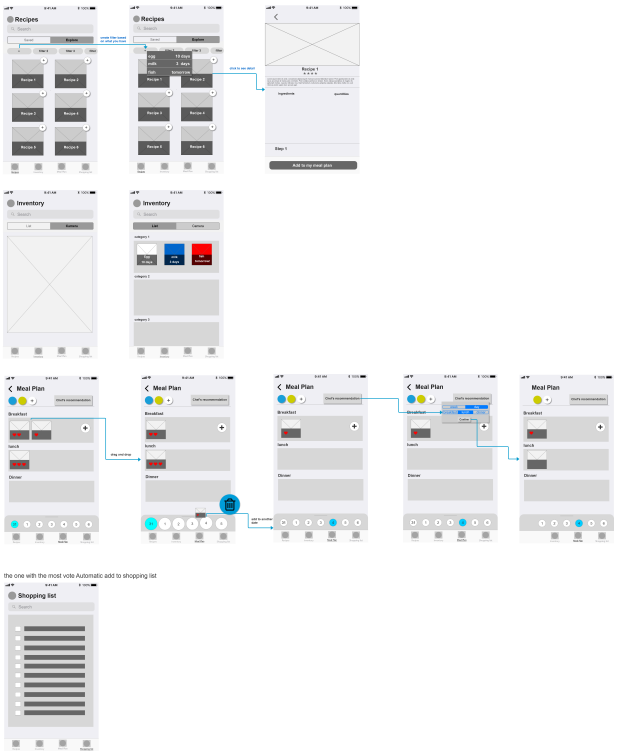


Fig. 5: Wireframe

After determining the wireframe, we set out to design the well-designed and intractable user interface. First of all, we have considered a lot of solutions for UI design. The first is Axure. We can drag and drop its built-in components to quickly build a basic interface, but there are many restrictions on customized design. Then we considered using Photoshop, which allows us to freely design the interface we want, but because its strength lies in graphics processing, UI design of different formats and sizes in Photoshop is not fast, and the basic template is missing. After considering the balance of time and effect, we chose

to use sketch to make our final user interface. Sketch, while containing a variety of different UI components, gives designers great freedom to customize the design.

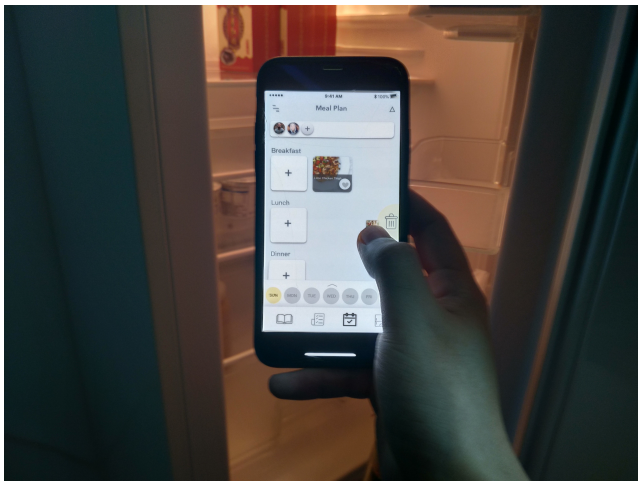


Fig. 6: interactable prototype made using Principle

The interface for Chef App is divided into four core modules: Recipes, Inventory, Meal Plan and Groceries.

A. *Recipes Module*

In Recipes, a user can search a wide variety of recipes, view each recipes ingredients as well as detailed steps and instructions on how to cook the particular recipe. Users can filter the meal according to their dietary preferences and even create their own tags using ingredients that the app knows is in their fridge.

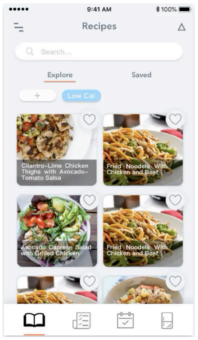


Fig. 7: Recipes

B. *Inventory Module*

In Inventory, using IoT technology, a user can see the food in the refrigerator through the camera on Chef Jeff. However, the user can also view in list form, which will also include expiration dates and other information such as if the item is running low. These details can be inputted manually or simply by speaking to Chef Jeff when the fridge is open: Opened pasta sauce, expires in 7 days. Common products will have expiration dates automatically included.

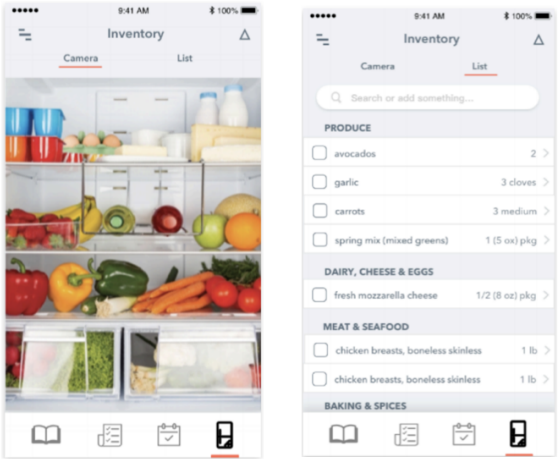


Fig. 8: Inventory

C. *Meal Plan Module*

In Meal Plan, users can create a weekly meal plan. Users can use the chef recommendation function, where the app will automatically create a meal plan using what you already have in your fridge. The Meal Plan section can also be used for family meals, where someone can propose a few recipes and family members can vote on which they prefer.

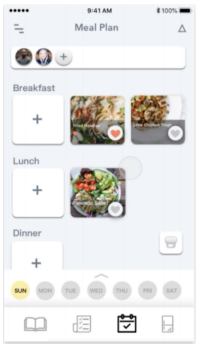


Fig. 9: Meal Plan

D. *Groceries Module*

In Groceries, all ingredients that need to be purchased will automatically be added to the shopping list according to the specific meal plan selected. At the grocery store, users can use this section to check off items, once an item is checked, it is automatically placed into the inventory list

VIII. Limitation and Future Work

Limitations of this project lie in the homogeneity of our user interview and questionnaire design since most participants were recruited from the same curriculum with a similar background. In the future, we could expand the span of participants backgrounds. Another key limitation of our user research is that we were unable to identify and

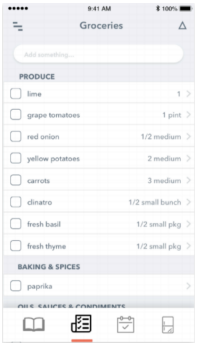


Fig. 10: Groceries

interview current users of competitor apps, this would have been valuable to do a proper competitor analysis.

At the current state of our design, we have a polished high-fidelity prototype, yet we still need to develop the application on iOS and Android and connect the application to the IoT device.

Some future design plans we have are collaborative cooking and grocery sharing with neighbors, social functionality such as sharing recipes, rating, commenting, etc., as well as adding a scanner to the IoT device to include nutrition tracking, similar to Yuka. Furthermore, once we have enough users, we have a blue sky vision to gather the IoT data on common ingredients/meals/etc. and to provide this data to private food suppliers, grocery stores, and farmers, allowing them to better gauge household food and beverage consumption in specific locations, and helping to reduce net food wastage.

As a larger number of households begin installing connected devices in their homes, the moral and ethical dilemma of this is obviously something of critical importance to reflect on. With technological monitoring in your home, the potential for security and privacy issues arises. The private data that is generated, in our case exactly what food and meals a particular individual purchases and consumes, could potentially be infiltrated by private organizations such as insurance companies to pin against you. This potential is unavoidable, but being mindful and hiring a Data Protection Officer (DPO) early on is critical to ensure safety of privacy for our users. The DPO will provide advice on how to process personal data collected with usage of the IoT device application while respecting individuals rights. Furthermore, there needs to be security control, and an ability to override the transfer of data in the case of a data breach.

IX. CONCLUSION

In this report, we identified pain points people have with their current grocery managing and meal planning regimes, and ideated an efficient and easy-to-use system that will help them manage it all. Using a mobile app alongside an IoT device that goes inside your fridge, Chef allows you to manage your food and beverage inventory by allowing items to be inputted through multiple modalities, a concept which past research [9] and our user research has deemed necessary. It also allows users to use these items as a filter when exploring recipes, that way they can easily find potential recipes to cook using the ingredients they already have. We hope this solution can be used to ease users day-to-day lives and to allow for more mindful, healthy, and organized food planning and consumption.

ACKNOWLEDGMENT

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