Interactive Fridge: A Solution for Preventing Domestic Food Waste

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Abstract. This paper presents a design study of an interactive fridge aimed at encouraging people to prevent domestic food waste. The project implemented a prototype which consists of three main objects: i) Stickers help grouping similar food together; ii) Sliders visualize food expiration date into colors in order to help people be aware of food states; iii) LCD Screen provides graphic and sound feedback when people use their fridge to make the fridge more fun to use. To ground our design, we used design thinking as a guideline process. We evaluated the prototype using qualitative analysis of interview data. The findings show that the prototype motivated people grouping food and increased their awareness of the availability of food items in the fridge, the prototype also encouraged people in using food before expiration date. This paper offers three main contributions. Firstly, we identified three major problems that lead to domestic food waste. Secondly, we proposed a new design to address the problems. Thirdly, we applied design thinking as a design method to solve problems that related to domestic food waste.

Keywords: Food waste · Interactive fridge · Consumer behavior · Visualization · Design thinking · Human-computer interaction · Interaction design

1 Introduction

Nowadays, food waste is becoming a crucial issue. A report by Institution of Mechanical Engineers [10] has found that 30-50% (or 1.2 - 2 billion tonnes) of all food produced ended up waste. In the developed countries, the largest quantities of food are wasted at the consumer end of the supply chain [10][7]. For example in the UK, about seven million tonnes (worth about £10.2 billion) of food is thrown away from homes every year [10]. The United Nations predicts that the world population is set to reach around 9.5 billion by 2075, which could mean an extra three billion mouths to feed by the end of the century. With current practices wasting 30-50% of all food produced, it creates an urgent need about sustainable ways to reduce food waste, especially for consumers at the end of the supply chain. So in this paper, we focus on finding solutions to prevent food waste at household level.

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2 Background and Related Work

By 2015, lot of research about preventing domestic food waste has been conducted. Most of the research projects focused on changing consumer's behaviors or supporting consumers store food and consume food more effectively. A study which applied eco-feedback on household food waste with the prospective to increase awareness and explore its impact on food related decision-making was conducted by [8]. Using social networks to enhance relationships in communities or to enable sharing food and cooking experiences is a food waste preventing strategy that has been received focus from many researchers [6][12]. EUPHORIA, a mobile application being developed to reduce food waste in households by recommending recipes to a group of connected people via social network [15]. In addition, some research about intelligent fridge applications has also been conducted. PerFridge, an augmented refrigerator that detects and presents wasteful usage for eco-persuasion, focus on sensing wasteful behaviors [9]. To investigate the usefulness of grouping similar food types together, [4] conducted a study using paper-based color schema for increasing the awareness of available foods for consumers. They suggested that participants wasted less during the study period of a month.

2.1 Design Thinking

Design Thinking is a specific method, which is introduced and shaped by the design consultancy IDEO [2], to solve wicked problems and foster creativity. The method has become more and more popular among companies as well as educational institutions around the world. Design thinking process consists of six main steps: Understand, Observe, Point of View (POV), Ideation, Prototyping and Testing [13]. Design thinking is making its way into food industry. It has also been used to solve many food related problems (Ifooddesign.org, thinkingfooddesign.com, ideo.com/expertise/food-beverage). Following that vision, we use design thinking as a design process in order to help us identify what are the main causes of domestic food waste and foster the problem-solving process.

2.2 Information Visualization Using Colors

Visualization is a powerful way to convey data and visually represent abstract data (geographic information, text, number, etc.) to reinforce human cognition. Color, in particularly, is a very effective way for information coding so it is usually used for displaying data in categories, labeling, measuring and enlivening data [14]. There are four psychological primary colors – red, blue, yellow and green. Each color affects mood, feelings and emotions of people in very different ways. For example, green is a cool color that symbolizes nature and the natural world, it represents health, safety or good condition. Yellow is an intention getter, while red is a bright, warm color that evokes strong emotions. Based on the meaning of the colors and how they affect mood, feelings and emotions of users, we chose red, yellow and green for visualizing food expiration date.

3 Design Process

3.1 Understanding and Ideation

We use design thinking [2] as a guideline to ground our design. The process starts with understanding and ideation. In order to understand what are the main causes of food waste in domestic environment, a survey was conducted using a 10-question questionnaire, which comprised five question categories (shopping habits, eating habits, cooking style, food sharing and wasting behaviors). 27 participants was recruited to participate in the survey as well as semi-structured interviews. The main goal of the survey and the interviews is to investigate users' behaviors and habits on storing food, which are practices tied up with food waste by consumers [5]. The collected data was analyzed using selected methods from grounded theory [11]. The results showed that there are three major reasons that lead to food waste in domestic environment:

- **Consumers are not aware of the availability of their food.** There are two possible explanations for this. Firstly, people usually forget about the food that they bought long time ago. Secondly, people are not aware of the food that bought by other members in their family.
- **Consumers are not aware of the state of their food.** According to our survey, vegetable is the food kind that is thrown away the most. The reason is vegetable does not has exact expiration day and people usually forget when they bought them.
- **Consumers have no interest in consuming left-over and old food.** Many participants confessed that although they have no interest in consuming left-over food, they still want to keep it in their fridge because they do not want to have the feeling that they are wasting food or they do not know what to do with the food.

3.2 Prototyping

With the aim of solving the three listed problems above, we developed a prototype which comprises three objects: Stickers, Slider and LCD Screen. Stickers and Slider are developed in order to help user categorize food and be aware of the availability as well as the state of food, while the main goal of the LCD Screen is to make the fridge more fun to use and encourage users cooking.

Stickers. There are four types of stickers which were designed for four types of food: Meat, Fish and Eggs; Dairy products; Cereals; Vegetables and Fruits. Users are free to choose how use the stickers, however it is recommended that each layer in a fridge should be used for storing only one type of food and an appropriate sticker will be used to mark that layer.

Sliders. Sliders divide layers of a fridge into blocks (Fig. 1) based on expiration date of food in the layers. We recommend that each layer should have no

more than three blocks in order to prevent fragmentation and make it easier to find food. When users buy new food, they can store the food in a new block and then set the timer of the block correspond to the expiration date of food in that block. The timers will help users "remember" when did they buy the food and remind users about the condition of the food by changing its color. The Sliders have two separate timers for both sides, so it removes the effort to move food from one block to another. The Sliders have four states based on food expiration day: Green (safe mode) is for food over seven days. Yellow (medial mode) is for food from three to seven days. Red (warning mode) is for food under three days. The last state is when food is expired, the Red-Blinking mode alerts user that it is dangerous to consume. The Slider was built using an Arduino board two rows of RGB LEDS.

The Front LCD Screen. The LCD Screen was designed as a "living creature" (Fig. 1). The creature has two emotional states: Happy State will be activated when all blocks are green. Cooking State will be activated when there is red or yellow block. In this case, the "living creature" will "think" and show suggestions how to cook with food from the blocks and when users consume food in the blocks, the "living creature" will responses with applause sound.

Fig. 1. The prototype with Sliders, Stickers and LCD Screen

3.3 Testing

According to [3], perceived usefulness and perceived ease of use can lead users to accept or reject a novel information technology product. We evaluated the two dimensions using qualitative interviews with 10 participants (ages 20-35) to learn more about user intentions in using the prototype. Our findings are limited by intention to use and can not give implications on user experience of real usage or technology acceptance. We first demonstrated the prototype to participants

and then conducted semi-structured interviews. Finally, we used coding method [1] to analyze the collected data and discuss four assumptions below.

- **The prototype helps users to categorize their food.** All users thought that using the prototype will help them to categorize their fridges, find food easier because of well-organizing and remarkableness. In addition, some users said that the prototype would be useful when they share fridge with others.
- **The prototype makes the fridge interesting to use.** "The colorful fridge is interesting" - they thought but one user complained "Lights are good but I prefer no flashing". Many users said that the "living creature" is cute but not all of them think that the prototype will affect them.
- **The prototype makes people aware of their food state.** Users were familiar with the color scheme and its meaning, but sometimes the flashing mode caused the negative effects.
- **The prototype motivates people to reduce food waste.** Users agreed that food waste would be reduced when they are reminded about their food states. Because they can remember and consume it before expiration date.

4 Conclusion

This paper has presented a design called interactive fridge which is a set of objects (Stickers, Slider and LCD Screen) that help people in organizing food in their fridge, remind them about the availability of their food as well as motivate them to use their food before expiration date. We built a prototype and tested it with four assumptions: The prototype helps users to categorize their food, the prototype makes the fridge more interesting to use, the prototype makes people aware of their food state and the prototype motivates people to reduce food waste. The findings show that the prototype motivated people grouping food and increased their awareness of the availability of food items in the fridge, the prototype also encouraged people in using food before expiration. This paper offers three main contributions. Firstly, we identified three major problems that lead to domestic food waste. Secondly, we proposed a new design to address these problems. Thirdly, we applied design thinking as a design method to solve problems that are related to domestic food waste. The paper described a design process and a new concept that is not completely functional yet. Therefore we could not evaluate real use or even behavioral changes in domestic food waste. Instead we focused on investigating perceived usefulness and perceived ease-of use as two strong indicators from the technology acceptance model. Further research includes improving prototype in order to deploy it in real-life and explore how the design can help people preventing food waste as well as gathering new using experience. Our findings so far give us confidence that emotional and friendly interactions can motivate people changing behaviors which lead to negative effects. We believe that design thinking is a good candidate to develop new technology use cases in the future.

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References

1. Basit, T.: Manual or electronic? the role of coding in qualitative data analysis. Educational Research **45**(2), 143–154 (2003)
2. Brown, T.: Design thinking. Harvard Business Review **86**(6), 84 (2008)
3. Davis, F.D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 319–340 (1989)
4. Farr-Wharton, G., Foth, M., Choi, J.H.-J.: Colour coding the fridge to reduce food waste. In: Proceedings of the 24th Australian Computer-Human Interaction Conference, OzCHI 2012, pp. 119–122. ACM, New York (2012)
5. Ganglbauer, E., Fitzpatrick, G., Molzer, G.: Creating visibility: understanding the design space for food waste. In: Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia, MUM 2012, pp. 1:1–1:10. ACM, New York (2012)
6. Gross, S., Toombs, A., Wain, J., Walorski, K.: Foodmunity: designing community interactions over food. In: CHI 2011 Extended Abstracts on Human Factors in Computing Systems, pp. 1019–1024. ACM (2011)
7. Gustavsson, J., Cederberg, C., Sonesson, U.: Global Food Losses and Food Waste. Food and Agriculture Organization of the United Nations, Technical report (2011)
8. Lim, V., Jense, A., Janmaat, J., Funk, M.: Eco-feedback for non-consumption. In: Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct Publication, UbiComp 2014 Adjunct, pp. 99–102. ACM, New York (2014)
9. Murata, S., Kagatsume, S., Taguchi, H., Fujinami, K.: Perfridge: An augmented refrigerator that detects and presents wasteful usage for eco-persuasion. In: 2012 IEEE 15th International Conference on Computational Science and Engineering (CSE), pp. 367–374, December 2012
10. Institution of Mechanical Engineers: Global Food - Waste Not. Want Not. Technical report 01 (2013)
11. Strauss, A., Corbin, J.M.: Basics of qualitative research: Grounded theory procedures and techniques. Sage Publications Inc. (1990)
12. Svensson, M., Höök, K., Cöster, R.: Designing and evaluating kalas: A social navigation system for food recipes. ACM Trans. Comput.-Hum. Interact. **12**(3), 374–400 (2005)
13. Thoring, K., Müller, R.M., et al.: Understanding design thinking: A process model based on method engineering. In: International Conference on Engineering and Product Design Education (2011)
14. Ware, C.: Information visualization: perception for design. Elsevier (2013)
15. Yalvaç, F., Lim, V., Hu, J., Funk, M., Rauterberg, M.: Social recipe recommendation to reduce food waste. In: CHI 2014 Extended Abstracts on Human Factors in Computing Systems, CHI EA 2014, pp. 2431–2436. ACM, New York (2014)