Kitchen of the Future and Applications

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Abstract. A kitchen is a place where food is prepared and education and communication activities relating to food are carried out. As it is a place that witnesses more activity when compared to the other parts of the house, there are many potential ubiquitous computing applications that can be installed in a kitchen. We are developing a computer-augmented kitchen environment, the Kitchen of the Future, that incorporates various computing elements into a standard kitchen unit. In this paper, we describe an overview of the Kitchen of the Future system and three applications, that is, recording and replaying of a cooking process, videoconferencing cooking instructions, and interactive cooking navigation.

Keywords: Kitchen of the Future, Ubiquitous computing, computer-augmented kitchen, home computing, computer-aided cooking, remote instruction.

1 Introduction

A kitchen is not just a place of labor. Throughout history, the activity of preparing food has been accompanied by (and even used as an excuse for) social interactions and the development of social bonds. Modern lifestyles and convenience foods have reduced the time and effort required for cooking; however, at the same time, they have reduced opportunities for interactions. We believe that the introduction of computer technology in a kitchen not only improves cooking efficiency but also revitalizes the kitchen as a place of learning and communication. For example, installing support systems such as a system for communicating with friends and family members in remote areas and installing one for storing interactive multimedia contents that can provide guidance on cooking can make cooking an enjoyable experience.

For this purpose, we are developing a computer-augmented kitchen environment with embedded video cameras, displays, microphones, switches, sensors, and a network [6]. This “Kitchen of the Future” allows people to use applications for facilitating communication by placing cooking guides on the Internet, learning

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cooking by using these guides, supporting communication and learning through videoconferencing with kitchens in remote areas, and assisting interactive cooking by using multimedia. In this paper, we will report the benefits of the Kitchen of the Future that was ascertained by actually cooking with the aid of these applications.

2 Kitchen of the Future

The Kitchen of the Future is a computer-augmented kitchen environment that incorporates various computing elements into a standard kitchen unit, as shown in Figure 1. Our kitchen has four workplaces comprising a sink, cooking stoves, and two preparation spaces. In each workplace, we have installed a liquid crystal display (LCD), a camera, a microphone, and a foot switch, and we have connected them to a computer system and the Internet. We have implemented three such kitchens in remote areas and have networked them for the purpose of experimenting with the communication system with regard to activities such as remote cooking support.[1]

Fig. 1. Overview of the "Kitchen of the Future." Video cameras, and microphones, LCDs, and foot switches are installed under the cupboard, on the wall, and on the floor, respectively.

Downward-facing video cameras are installed under the cupboard so that the cooking process can be recorded clearly. Such a position for the cameras is also employed in other systems [7]. These cameras capture only the users' hand movements and not their faces and the interior of their rooms, and therefore invasion of privacy by the video cameras in a house can be avoided. When conducting a remote videoconference using this system, those who desire privacy might prefer such a position for the cameras.

[1] Two kitchen counters were installed in Tokyo, and another was installed in Hokkaido.

We have installed foot switches in the lower part of the kitchen counter, as shown in Fig.1. The foot switches are for recording sounds and images that illustrate the cooking process, switching between cameras and displays for remote communication, and controlling the multimedia contents that are used in the cooking process. Since these operations are performed during cooking, i.e., when the user's hands are occupied or wet, they should be performed using a hands-free method. The possible methods include voice recognition, gaze control, and gesture input. There are examples of the use of such methods [2], but we feel that foot switches are appropriate because people can use it without facing a recognition error.

In the following section, we will introduce three applications that are installed in the Kitchen of the Future: a system for recording and replaying a cooking process, a remote cooking support system, and a cooking navigation system.

3 Recording and Replaying of Cooking Process

3.1 Recording and Web Publishing

The Internet has proved popular for the sharing of cooking experiences, and there are recipe-based Web communities[2] with a million users per month. However, in a conventional kitchen where people's hands are occupied most of the time, it is difficult to record images of the cooking process. We believe that the Kitchen of the Future will help in creating web-ready recipes under such a circumstance. Therefore, we developed an application to record cooking in the Kitchen of the Future. The application monitors the operation of the foot switches. When a foot switch is pressed, the application takes a picture of the kitchen counter during cooking and records a five-second voice memo to explain the cooking process.

The images and sound data clip collected are automatically posted on the Internet as a recipe Web page, as shown in Fig.2. In this page, people can browse the images of the cooking process and listen to the voice memo. The Web page also provides editing functions such as the deletion of unnecessary images/sounds or the addition of hand-written notes by clicking on an image.

We actually cooked in the Kitchen of the Future to record the cooking process (Fig.3). Operating the foot switches was easy and we could record the images freely, which was like teaching a person near us how to cook. The total number of images that was taken was 67. The five-second voice memo seemed to be ok a sufficient duration.

3.2 Replaying of Cooking Process

The recipe Web pages mentioned above contain the information on the cameras that are used for recording and on the order of the recording; therefore, they can be used to indicate the cooking process at the appropriate workplaces at different times. This enables users to follow the original cooking process precisely and comprehend the different steps involved; therefore, a user can simultaneously perform two steps such

[2] For example, www.cookpad.com.

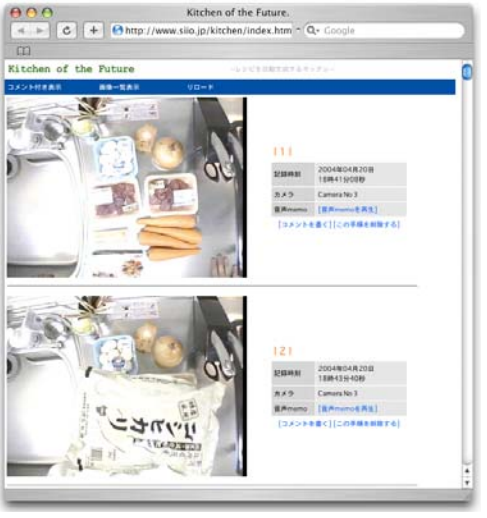

Fig. 2. An example of a recipe Web page with pictures and voice memo that show a cooking process. Simple editing functions such as deletion of unnecessary images/sounds or addition of hand-written notes are also provided.

Fig. 3. A user is recording his cooking process using cameras and microphones that are activated by foot switches

as washing vegetables while stewing on the stove. Therefore, we developed an application to show the originally recorded cooking process on four displays installed in the Kitchen of the Future. The application provides images and sounds to illustrate the cooking process on a particular display. When a user presses the foot switch of the workplace after completing an assigned work there, the next cooking process will be shown on the display at the next designated workplace. The user can follow the

cooking process by moving between the workplaces and following the instruction on the displays in order.

A subject (24-year-old male) who had little experience in cooking participated in an experiment. He tried to cook by browsing the recorded cooking process on our application (Fig.4) and was subsequently interviewed. Being a novice at cooking, it was beneficial for him to learn how to arrange the cookware and ingredients at each workplace. He mentioned that it was good to understand where to place the pots, pans, and ingredients by observing the images shown on the displays. He pointed out that the foot switches were operable even when his hands were wet, and the operation was not tiring. On the other hand, there were some drawbacks. The quality of some still images was not clear; for example, the image of the pieces of onion on the cutting board was not clear. The subject pointed out the necessity of providing moving images.

Fig. 4. A user is cooking while replaying the recorded pictures and sounds of the cooking process on the LCDs. The images are displayed on one of the four LCDs at the workplace. When he completes the displayed step, he can view the next step by pressing the foot switch.

4 Videoconference for Cooking Instruction

The computer-augmented kitchen allows remote communication. To support communication between kitchens, we conducted an experiment on providing cooking support through a videoconference system installed in a kitchen. If remote communication through videoconferencing is possible, parents, for example, can teach their children residing in remote areas to cook; further, people can learn cooking from a professional cook.

Two pairs of Kitchens of the Future in remote areas are networked and a dedicated videoconference system is installed. The videoconference system relies on the LCDs, microphones, speakers, and foot switches provided in the Kitchen of the Future. The system monitors the state of the foot switches, identifies the workplace where the switch is pressed, and shows the video chat window on a nearby display. As a result, users at both the kitchens can watch the other partner's activity from the same position.

Fig. 5. An expert (upper) and a beginner (lower) who are cooking in the distant kitchens

We conducted the experiment on remote cooking support by networking the kitchens in remote areas using this system (Fig.5). A cooking expert in one kitchen assisted a beginner in the other kitchen via videoconference. The experiment proceeded well in general. It seemed that the expert could assist the beginner as though they were cooking in the same kitchen. During the planning phase of the experiment, we expected that the video screen would help the beginner to understand how the expert cooked. In fact, however, the beginner had to concentrate on the assigned work and was busy listening to the oral instruction rather than looking at the display. The expert, on the other hand, viewed the video screen often to assess the status of the beginner and to give precise instructions. When seasoning, the beginner seemed to be puzzled because he could not understand how to salt the food properly. This kind of problem will be solved if we create a device to provide information on the salinity concentration via the Internet.

5 Interactive Cooking Navigation

5.1 Happy Cooking

Prior to this work, we had developed a multimedia cooking support application called "Happy Cooking" [3]. The input data of Happy Cooking are cooking recipes, movie files of the cooking processes, and index information for each scene of a movie. Using these data, Happy Cooking organizes the cooking process automatically to minimize the cooking time and to complete each dish on time. In the process, it displays the text and images in proper order and guides the users.

Fig. 6. An example image in the original version of Happy Cooking

Fig.6 shows an example image in the original version of Happy Cooking. The icons appearing at the bottom of the screen represent the instructions that the user must follow, and the movie of the activity is played repeatedly on the left side of the screen. At the same time, users can confirm the cooking process by looking at the flow graph at the top of the screen. When the users click the icon at the bottom of the screen after finishing the assigned work, it shows the next work to be done.

Happy Cooking was generally operated using a pen tablet display. Therefore, users had to place the kitchenware aside to pick up the pen device for operating the display. As a result, users cooking under a time constraint panicked. In addition, when users cooked at a kitchen counter away from the display of Happy Cooking, they had to move back and forth between the kitchen and the display to check the instructions. A cooking support system requires a hands-free interface and the display to be located near the users. It is important for the distance between the users and the system to be minimal.

5.2 Improvement of the User Interface

Happy Cooking is an interactive support system that users rely on during cooking. However, as mentioned earlier, there are various restrictions on the activities in a kitchen. It was found that the existing interface could cause many problems that could seriously affect the usability of the software. Therefore, we installed Happy Cooking in the Kitchen of the Future to make it an interactive cooking support system using multi displays and foot switches.

First, the movement of the users can be minimized by showing the assigned instructions on the displays installed in all the four workplaces of the kitchen. For example, users can be taught cooking by showing them instructions such as “cut an onion into small pieces” on the display near the cutting board or “heat two tablespoons of butter in a pan” on the display near the stove. Replaying the cooking

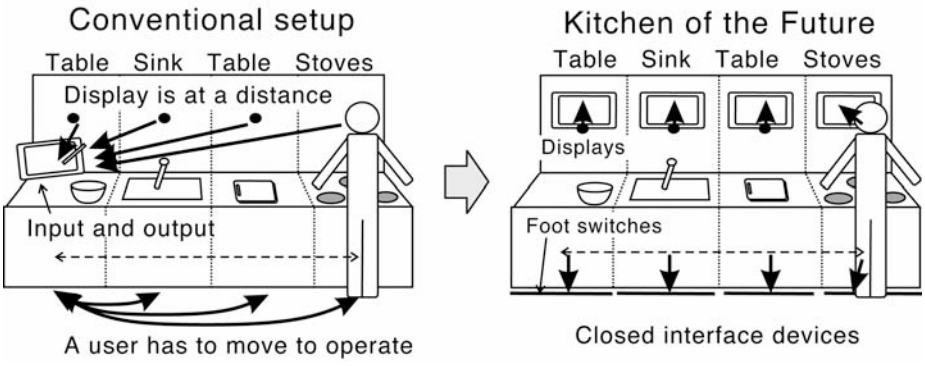

Fig. 7. Original (left) and improved (right) Happy Cooking user interface

image enables the users to imitate the activity and enhances their learning dramatically.

Next, we utilized the foot switches on the floor of all the four workplaces so that users could operate the system comfortably even though their hands were occupied or wet. This enabled the users to operate the system without moving from the workplaces. Since their hands were free and they did not have to change their posture for the operation, the stress level due to the interaction with the system can be considered to be minimal. Fig.7 illustrates the conventional interface and the new user interface that is optimized by the Kitchen of the Future environment.

For the purpose of comparing the conventional user interface with the Kitchen of the Future, three subjects participated in an experiment. Each subject cooked one dish. All of them responded that the foot switches were easily operable when compared to a conventional pen tablet interface. Furthermore, the subjects liked the multi display facility, which enabled them to cook uninterruptedly by displaying the quantity of ingredients in large fonts right in front of their eyes.

6 Related Works

Many conventional computer technologies that are used in offices and factories have the potential of being employed in the kitchen.

Cooks Collage [7] is a memory aid system to help people keep track of a cooking process while being interrupted by everyday events such as conversations with family members, telephone calls, and visitors. Our system, “Kitchen of the Future,” focused on the communication and educational aspects in a kitchen environment.

Counter Intelligence [1] displays information in a kitchen environment by using image projection on walls and worktables and uses embedded displays in the handles of the drawers in a kitchen counter. Intelligent Kitchen [5] has a mobile robot that indicates the next action by inferring a user’s actions in the kitchen. We adopted stable devices such as LCDs and foot switches to realize a practical cooking support system.

Gaze and voice interfaces that are designed for kitchen use, are installed in some interactive recipe systems such as eyeCOOK [2]. CounterActive [4] projects recipes on the surface of the kitchen counter. We aimed to realize practical recipe browsing in a kitchen environment by using clear on-wall displays and recognition-error-free foot switches.

7 Summary and Future Plan

This paper introduced the Kitchen of the Future, a computer augmented kitchen environment with embedded displays, video cameras, microphones, sensors, switches, and networked remote kitchen counters. We have implemented three kinds of applications in the kitchen, i.e., recording and replaying of a cooking process, videoconferencing for cooking instructions, and interactive cooking navigation.

We are planning to enhance the current applications by adding facilities for motion picture handling, cooking time measurement, and image and voice quality improvement. We are also developing new devices such as a remote salt-sensing system and multifunction foot switches using Radio Frequency Identification (RFID) tag readers.

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