The Kitchen as a Graphical User Interface

Contacts
Leonardo Bonanni
MIT Media Laboratory
amerigo@media.mit.edu
www.media.mit.edu/~amerigo
USA

Chia-Hsun Lee
MIT Media Laboratory
jackylee@media.mit.edu
www.media.mit.edu/~jackylee
USA

ABSTRACT
Everyday objects can become computer interfaces by the overlay of digital information. This paper describes scenarios and implementations in which imagery is digitally painted on the objects and spaces of a kitchen. Five augmented physical interfaces were designed to orient and inform people in the tasks of cleaning, cooking, and accessing information: *Information Table, Information Annotation of Kitchen, HeatSink, Spatial Definition,* and *Social Floor*. Together, these interfaces augment the entire room into a single graphical user interface.

Keywords
Kitchen, spatial definition, physical interface, virtual space, human-computer interaction, gesture recognition, neural network.

Introduction
From indoor plumbing to microwaves, technology often enters the home through the kitchen. Kitchens are multi-functional, serving both as social hubs and as cooking laboratories. The overlay of digital information can help to organize these multi-use, highly technological rooms by facilitating contemporaneous use by different members of a family.

Approach
The decrease in price of multimedia projectors has made it possible to treat an entire space as a single, high-resolution display. With information projected throughout the space of the kitchen, users no longer have to carry around books or computers to inform their tasks. We dispersed projectors and other types of illumination throughout a kitchen to uncover the range of interactions between the kitchen and its users. Various input devices coupled with the projectors inform the projected content. Gesture sensing and interaction-free displays provide information where and when it is needed while requiring minimal interference (Hillerer, Feiner, & Pavlik, 1999).

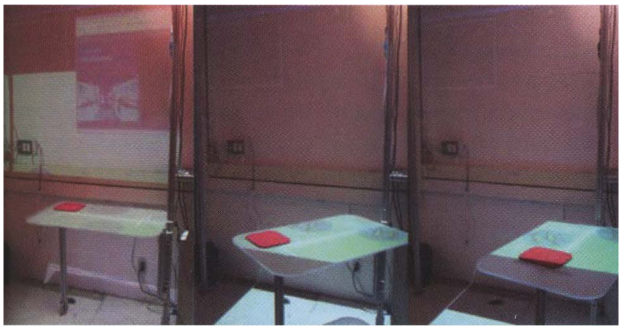

Figure 1. Information Table

Information Table
In *CounterActive* (Ju, 2001), recipes were projected on a countertop, informing activity in a fixed point in the kitchen. The *Anywhere Display* (Pinhanez, 2001) allowed a single projection to move on most of the surfaces of the space. This technology was expensive and not suitable to multiple users. In multi-use kitchens, information should be targeted to specific tasks and permit multiple users to move within the space while their information follows them. Information Table is an example of orienting imagery to follow users as they move through the space and perform different tasks (Fig. 1). A ceiling-mounted projector coupled with a digital camera senses the position of the table and moves the corresponding display to follow the tabletop. Simple vision-recognition algorithms recognize the form of the table, while a Flash program masks the projected output for a seamless tabletop projection.

In addition to following physical movements, *Information Table* changes projected content based on what task is being performed. When the movable table is placed against a wall, it acts as a countertop for single-user frontal work. For such work, projected information is best placed in front of the user on the wall where it will not interfere with hands or the work surface. The image shifts from the ceiling-mounted projector to a wall-mounted projector when the table approaches the wall of the kitchen. When the table is moved to the center of the room, it acts as a dining table. The projection shifts to the ceiling-mounted projector, and a concentric game or menu is displayed on the table.

Figure 2. Information Annotation of Kitchen

Information Annotation of Kitchen
The kitchen as a graphical user interface can coordinate the multiple events that take place within, from people working and playing to the autonomous behavior of the stove, dishwasher, and refrigerator. How can all of the users of a kitchen be made aware of the many visible and invisible operations under way in the kitchen?

We project textual annotations on the entire working environment, as shown in Figure 2. The refrigerator is "painted" with text and images to describe its contents and the items that need to be purchased, in addition to serving as a digital bulletin board. The dishwasher displays whether it is clean or dirty, empty or full. The electric range informs users on the temperature of its burners. A single multimedia projector can position the information directly on all of these appliances, where users will be certain to notice it. The same system used to annotate the kitchen can be used to decorate the space. Games and other interaction can be projected on work surfaces when the work is finished, while decorative textures can be mapped to change the mood and function of the space depending on its function.

Figure 3. HeatSink

HeatSink
Like *Information Annotation of the Kitchen, HeatSink* projects task-specific information directly onto the object being measured, in this case water itself. A microcontroller measures the temperature of water exiting the tap and projects colored light into the stream of water to indicate its temperature: red for hot and blue for cold (Fig. 3). Users can intuitively gauge the temperature of the water without getting their hands wet. Successive users automatically know what the prior water temperature was and avoid scalding themselves.

Spatial Definition
Some areas in the kitchen can be dangerous to newcomers. It would be helpful if certain conditions (such as a hot stove or a knife on a table) could be easily denoted and communicated to newcomers (Fig. 4). When someone enters these zones, some automated multi-media reminder would make one aware of unseen dangers. We have explored two ways for such zones to be easily denoted and stored in a computer: a kitchen design GUI and a gesture language.

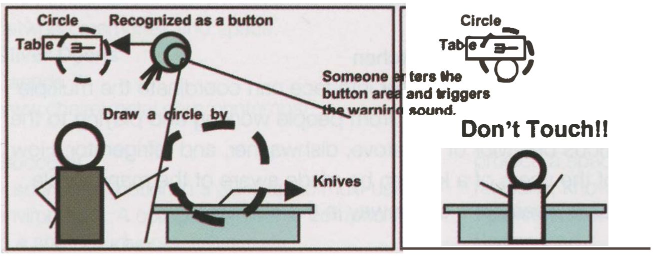

Figure 4. Spatial Definition

The kitchen design GUI consists of a plan of the kitchen projected on a countertop with a drawing interface that allows users to denote areas as dangerous. Users can also annotate an area such as the table to show the menu when users sit around it.

Gesture recognition techniques (Bretzner, Laptev, & Lindeberg, 2002) are widely used as intuitive input interfaces. Our gesture language allows users to specify a reminder zone directly on the space itself so that anyone entering that zone triggers an audiovisual reminder. Video cameras dispersed through the space recognize a basic gesture language and create virtual zones to map the physical environment accordingly. To find the position of a user's hand, we use image-processing techniques that track color and motion in Visual C++. The hand acts as a spatial pen so long as certain recognizable gestures are made in front of the webcams. A back-propagation Neural Network (Haykin, 1998) trains pre-defined shapes (circles, triangles, arrows, and crosses.) The network recognizes simple gestures if the path of the hand follows one of the predetermined shapes. The gesture language for spatial definition denotes an audio reminder zone with a circle, a danger zone with a triangle, and a visual reminder zone with an arrow.

Once a zone is programmed by the gesture language, the same webcams serve as motion detectors to detect when someone enters the zone. Each part of the kitchen can be programmed with reminders without interfering with the tasks being performed.

Sociable Floor
The floor is the architectural surface that receives the most physical interaction. By monitoring use of the floor and projecting onto it, many useful functions can be played out.

We use a modular tile floor with capacitive sensors under the 12-inch x 12-inch raised modules. Ceiling-mounted projectors paint the floor with information gathered from where and when people stand on the various tiles (Fig. 5).

Figure 5. Sociable Floor

Sociable Floor can augment the sensing already discussed by judging exactly where different users of the kitchen are standing. The system can warn users when they are working too closely and allows for projected information to accurately follow individual users as their tasks carry them through the kitchen.

DISCUSSION
The pervasive virtual world is becoming an important part of our lives. Unfortunately, we are only able to look at information in books or on computer monitors. Computers, projectors, and video cameras have become sufficiently affordable to allow for vision recognition and projection on all the available surfaces of a space. These systems can

improve productivity and reduce the need for books and portable computers, as well as allowing for more free space.

All five of the interfaces discussed were presented at the Things That Think (TTT) consortium meeting at the MIT Media Laboratory in October 2003.

These interfaces stand to be considerably improved. Information Table currently has only two modes: countertop and dining table. Considering the numerous functions possible on a work surface in a kitchen, the system can only gain richness by being conceived for additional uses.

Information Annotation of Kitchen would be even more helpful if it could respond automatically to events before and during their occurrence. For example, before we try to open a hot pot, it should tell the temperature of the pot and record our body and hand positions.

In the Spatial Definition system, we have suggested a solution to better describe the spatial events of the kitchen. We only use the spatial regions as virtual buttons, pressed or released to trigger events. Once the system can accurately judge the activities being performed, it will be able to automatically deliver useful information. In the future, we will use a thermal imaging camera to better recognize human activities and monitor temperatures in the kitchen.

CONCLUSION

This paper describes using dispersed task-specific annotation to make information available throughout a kitchen. We present digital information on walls, countertops, tables, appliances, the floor, and water itself. The resulting annotated space can help people to collaborate, to work more efficiently, and to avoid accidents. The appliance and kitchen design industries have been working to use appliances to communicate with each other and with users. Our approach is to annotate the entire kitchen space for the many purposes that were not designed to be contemporaneous but often are. This paper promotes the possibility and value of using cameras and projectors to make total interfaces from traditional kitchen spaces (Cruz-Neira, Sandin, & DeFanti, 1993).

The use of the physical world as a user interface is becoming a reality. Inexpensive hardware can now be utilized to react to where people are and what they are doing. Such context-aware (Selker & Burleson, 2000) use of sensors and effectors to model tasks and augment performance is becoming more and more possible.

REFERENCES

Bretzner, L., Laptev I., & Lindeberg,T. (2002). Hand gesture recognition using multi-scale colour features, hierarchical models and particle filtering. In Proceedings of 5th IEEE International Conference on Automatic Face and Gesture Recognition.

Cruz-Neira C., Sandin, D., & DeFanti, T. (1993). Virtual reality: The design and implementation of the CAVE. Proceedings of SIGGRAPH 93, 135-142.

Haykin, S. (1998). Neural networks: A comprehensive foundation, 2nd Edition. Prentice Hall.

Hillerer T., Feiner S., & Pavlik, J. (1999). Situated documentaries: Embedding multimedia presentations in the real world. In Proceedings of ISWC'99, 79-86.

Ju, W. (2001). The design of active workspaces. Master's thesis. Massachusetts Institute of Technology, Cambridge, Massachusetts.

Pinhanez, C. (2001). Augmenting reality with projected interactive displays. In Proceedings of International Symposium on Virtual and Augmented Architecture (VAA'01).

Selker T. & Burleson, W. (2000). Social floor. Proceedings of OZCHI, Interface Reality in the New Millennium.

Selker, T. & Burleson, W. (2000). Context-aware design and interaction in computer systems. IBM Systems Journal, 39(3&4).