Surface Use in Professional Kitchens and Biomedical Laboratories

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ABSTRACT

Current smart interactive displays are most commonly found in meeting rooms, offices and domestic settings. In this paper, we contemplate what surface computing might face when it moves into other work settings. We present results from two studies of professional kitchens and biomedical laboratories. Through our study of the surfaces in these settings, we illustrate that 1) kitchen and lab interactions are local and contingent upon the particular surface in use, 2) surfaces are created, reused, merged and discarded quickly, and 3) the users of these settings approach surfaces in multiple ways. We then discuss how coupled interactive displays might support activities in similar settings.

Categories and Subject Descriptors

K.4.3 [**Computers and Society**]: Organizational Impacts—*Computer-supported collaborative work*

Keywords

Ethnographic studies, professional kitchens, biomedical engineering instructional laboratories, surface computing

1. INTRODUCTION

The move away from the computer desktop has been a central research theme in the last decades. [11, 6] In particular, tangible computing, reactive surfaces and tabletop interaction attracted many researchers and produced promising results. [2] These current incarnations of smart interactive displays are more commonly found in meeting rooms, offices and domestic settings. [4, 8] In this paper, we describe how two non-mainstream domains use surfaces as a part of their practice. We particularly wanted to learn about how surfaces are used as resources for collaboration, assembly tasks and creative problem solving in other non-traditional domains.

We present findings from two studies in professional kitchens and biomedical engineering instructional laboratories. We then identify three concepts that surface computing has not explored deeply so far. We frame these concepts within coupled interactive displays research and offer some possible future directions.

2. METHODS

To investigate different uses of surfaces we conducted qualitative studies of two professional kitchens and two sections of biomedical instructional laboratories. We utilized the ethnographic methods of participant observation, the generation of field notes, interviews and the collection and analysis of local documents.

We studied two kitchens with different types of service to see the contrasts and similarities between two styles of professional cooking. Meta[1] is a high-end a la carte restaurant that serves an urban population. Depending on the season, they serve from 150 to 500 meals a day. Tigers is a volume production kitchen that exclusively serves the athletic association of a university. Both the students and staff eat there, thus the establishment serves about 600 meals per day.

We also collected data in a biomedical engineering laboratory. Georgia Tech requires third year Biomedical Engineering students to take a problem-based laboratory associated with a systems physiology class. This lab is modeled to encourage scientific thinking and experimentation skills by giving students open-ended lab assignments each week. Therefore, every group in the lab has the opportunity to configure their own experiments. We chose to observe this particular type of laboratory due to the freedom it gives to the students. Since the students are not following a strict "lab recipe", we expected to see more interesting patterns of collaboration and space-resource use compared to a traditional systems physiology lab.

One researcher collected data as a participant observer in the kitchens, followed by a interviewing period. He worked in as many stations and shifts as possible. The study lasted two months in Meta and one and a half months in Tigers. Total time in the kitchens sums to 50-60 hours, not including the interviews. The same researcher also carried out a non-participant observation for a month with two lab sections. Field notes and notes from informal interviews were gathered. Additionally, we used photography to explore how space is used in the labs. For one lab module, we periodically took photos of different surfaces used by multiple groups.

Our analysis used standard ethnographic methods of analytic induction. We reconstructed each day from the field

[1] Meta and Tigers are pseudonyms.

notes. Based on the field notes, we wrote small entries describing what happened, what led to it, and what happened afterwards. These entries were reviewed for concepts and categorized on a weekly basis. Eventually we were able to cluster recurring concepts into categories. For the kitchen. Transcribed interviews were used to understand how the cooks articulated our emerging categories. For the labs, the photos were analyzed to find common patterns of equipment use, common layouts, and popular surfaces over the duration of an experiment. The final categories offered a more complete account of the activities in two types of professional cooking and instructional scientific inquiry.

3. FINDINGS

Unlike the sites in which common surface computing technologies are deployed today, work in kitchens and biomedical laboratories rely significantly on surfaces. Teams we interacted with in both settings described many objectives centered around their stations and benches. In the kitchen, all stations have different workbench layouts depending on their function. A prep cook has a wide, general purpose table with lots of bulk processing equipment at hand, where a sous-chef has a minimal, streamlined station with quick access to many cooking utensils, tableware and various cooking equipment. In the laboratories, the lab bench is the center of collaboration. The tables and carts holding the various machines are essential to carry out specialized portions of the lab protocol. Whiteboards, laptops and presentation screens are used for data analysis throughout the experiment.

Our studies yielded rich descriptions of the role of situated cognition, division of labor, and problem solving in kitchens and labs. Due to space constraints, we are focusing on two central themes: how surfaces are used in partitioning work and how configurations of surfaces are used to simplify seemingly complex tasks.

3.1 Dividing work

Dividing and distributing work among different cooks is very common in the kitchens. The cooks in the kitchens we studied used it as a strategy to meet service deadlines. Being able to serve the required amounts for each type of food on the menu in a timely, hygienic and waste efficient manner was especially important in Tigers because around 300 people come at once to eat, twice a day.

One possible strategy is to cook dishes one by one as a team. Since the cooks are all skilled in high-volume cooking, this strategy might reduce the time needed to prepare each dish, thus save time at the end. However, instead of working on the same dish together, they chose to parallelize preparation by specializing on certain dishes at each station. By dividing work across an action station[2], a cold food station and a mains station, they were able to prepare the menu without having to coordinate the minute details of each dish with each other. The separation allowed them to bypass negotiation and shared resource bottlenecks. Moreover, since they worked alone at their own station, they were able to customize their workspace exclusively to the needs of the type of preparation they do. For example, the colds station was optimized for rapid sorting and cleaning of vegetables, action station was optimized quick, hot service.

[2]An action station is where daily specials like pasta and sandwiches are prepared

Merging their efforts was easy. All of the stations work at their own pace and style until the service time. Just before the guests arrive, cooks finish their dishes, transfer them to serving bowls and take them to the dining room.

Meta also had a similar way to bring together the products from the prep cooks. The prep cooks prepare their products, then pass them to a line cook or the sous-chef to put together for the final product. For example, one prep cook peels and boils potatoes, another prep cook cuts and marinades steak. The line cook uses the boiled potatoes to make an extremely fluffy potato puree, and grills the steaks to order.

We have seen a similar distribution in the labs as well. Students divided work among themselves by carrying out each piece simultaneously on specialized surfaces. For example, one team member carries all necessary dry reactants from the storage cabinet onto the workbench. This separation creates a temporary storage area that contains the relevant reactants to the experiment in a location that is convenient for the group. Each member who needs some quantity measures it on their own by taking the reactant jar to the desk where the high precision scale is. This desk is shared with other groups and it is only used for storing the jar from which the currently measured reactant came.

Groups also use different spaces synchronously. In one lab session, groups split into two subgroups. One subgroup carried out calculations for the next step while the other group migrated to the wet bench on the other side of the lab to mix the gel they will use for this next step. In doing so, each subgroup found the most suitable region for the task at hand. The group who stayed at the workbench made use of the dry surface to spread out their papers. The other subgroup avoided the cognitive load of being extra careful about spills by choosing a region which is designated to be wet.

3.2 Specialized surfaces

While the two kitchens were similar in terms of successful work divisions, Meta had a small difference. Meta had a very particular culture about seniority and it was very visible in the physical space. Unlike Tigers, cooks in Meta had to negotiate for utensils, equipment and benches across experience levels. The reason for this was chef's understanding of seniority and power in the kitchen. He believed that senior cooks in the kitchen should have more control and ownership of the utensils and equipment. Prep cooks shared their utensils and the preparation area with other prep cooks. However, a prep cook cannot use the utensils in a line station without the line cook's permission. Similarly, the line cooks are expected to avoid putting things on the chef's workbench, unless the chef explicitly asks for it.

While this schema sounds very inefficient, it actually contributes to further specialization at each station. Since the senior line chef does not need to accommodate the preparation style work in his station, he can further customize his station towards efficient cooking. Similarly, since a prep cook's bench would not be used by the line cook for preparing fine presentations for the customer, the prep cook can work with powerful, brute force tools in a very messy way to increase his throughput. In other words, the strict organizational hierarchy in Meta's kitchen directly affects how utensils, equipment and workbenches are used. This division of labor via differently structured work areas exposes different levels of the kitchen brigade in a very physical way.

The labs differ from the kitchens in the sense the that the laboratory design dictated the function of each surface. In Meta and Tigers, the chefs had a big influence on the function of each station and surface. In the lab, the students did not have a chance to pick how different surfaces would function, i.e., they did not have a say on where the wet bench would be. However, our conversations with the students suggested that they had a comfortable work environment. The workbenches were theirs to configure in a way that would make their current task efficient while the rest of the lab was reserved for occasionally useful equipment and stock that they would not want to maintain as a part of their every single experiment. In other words, the students used surfaces with different functional flexibilities to compose a functional system for each experiment setup. They forfeited control over the shared portion of the lab in exchange for low maintenance responsibilities, but retained a configurable portion that they had to maintain.

3.3 Local portable configurations

Throughout our studies, routines and rhythms were very visible. In the kitchen, menus remained considerably stable over time and the cooks did not need to learn a new dish everyday. In the lab, the duration of the experiments and the available equipment did not change throughout the semester. These stable constructs allowed the cooks and students to develop some routines, but there was a lot of variation interspersed through these routines. The line cooks had to modify their stations for breakfast, lunch and dinner everyday. The students needed to follow strict guidelines about reactions and mixtures, even if the product is a very common one. The persistent, repetitive patterns that call for adaptation and change at each step allowed us to see how configurations are created and torn apart in professional kitchens and biomedical laboratories.

In the kitchen, certain products cannot come close to each other. This is to avoid cross-contamination. For example, raw chicken is a health hazard because it can spread *salmonella*. Therefore, it has to be isolated from other products during storage and processing, and the processing setup has to be cleaned throughly. In a realistic scenario, the first cook has to make sure that the water from the packaged chicken is completely drained. He then needs to find a dedicated, empty station for cutting. While cutting the breasts, he needs to make sure that the cut pieces are safely put in a container, not touching any other ingredient. After cutting all the breasts, he needs to wipe the surface dry, wash and rinse it with soapy water, apply disinfectant, rinse again, and dry the surface. Moreover, he needs to properly dispose of any towels and containers used in the process.

While all of these steps are necessary for healthy food, setting up and tearing down is cumbersome. Very large kitchens can afford to have dedicated processing areas where the cooks have tables with sanitized wooden tops, dedicated to cutting chicken only. However, this is not possible for small kitchens. Without the dedicated areas or involved cleaning routines, the small kitchens employ a different technique to solve this problem: color-coded cutting boards. Both kitchens in our study had sets of cutting boards in different colors. Each of these boards are intended for a specific product–the red board is used only for meat, the blue board is used only for seafood etc.

Kitchen staff uses these cutting boards to create special areas. When a cook wants to remove tendons in a roast, he uses a red board. When he is done, all he has to do is to put the cutting board in the dishwasher instead of following an involved clean up procedure. This layering leaves the surface underneath the cutting board clean most of the time. The cutting boards also allow multiple cooks to work on the same bench. One cook can process shellfish on a blue board, another cook can share the same workbench and cut vegetables on a green board. This sharing not only uses space more efficiently, but also creates learning opportunities for the cooks to learn from each other by watching. In other words, creating and quickly tearing down a specialized surface in a kitchen lets the cooks to work more efficiently on their own, and allows for working configurations where different cooks share prep skills.

3.4 Creating new perspectives

When we started our studies, our focus was describing the different uses of surfaces. The surfaces we initially had in mind for observation were objects like benches, walls, trays and containers, tables, shelves, charts, carts, screen etc. We thought of these objects as "platforms" on which interaction happens. As we progressed in our observations, we realized that there were other surfaces that were used as resources but they did not have any physical components to them.

In one of the experiments, two students had to fill a gel holding apparatus with three types of liquid mixtures. The task was to layer these mixtures between two plastic layers separated a millimeter apart by dropping them slowly from the top. This fill had to be done with precision to avoid clogging the path. The temperature of the mixture had to be right, the pipette should have no air bubbles in it, the rate at which the liquid is released had to be regulated carefully. More importantly, only the exact required amount of liquid for each layer was to be used. Otherwise, the students had to disassemble the holding apparatus, clean it and perform the fill again from scratch.

To control the precision, the group used two virtual surfaces throughout a significant portion of their lab assignment. One student was responsible for pipetting the liquid. He stood up to have quick access to the various beakers and pipettes. The other student was responsible for making sure that they added enough liquid. She knelt down to look at the levels of liquid in the holding apparatus. The first student filled his pipette and started to drop the first liquid. He was looking at the tip of the pipette to make sure that there are no air bubbles. He also paid attention at the liquid streaming down the side of the plate to check his pipetting rate. The other student was looking at the irregular line that formed as the liquid hit the bottom and gelled. At the same time, she gave verbal feedback to the first student. When she decided that they had enough liquid in the apparatus, the first student immediately stopped pipetting and the second student stood up to pass the first student the second liquid and a new pipette. They filled the whole apparatus using the same technique.

The students effectively worked on two different tasks but shared the same equipment. The first student assumed a position that allows him to see if his pipetting technique is right for the task. The second student chose a position where she can verify the appropriate amounts they needed. In other words, to be able to separate their concerns, they created two "points of view" for their experiment on different planes. At the intersection of these two views was the center of their activity. When this portion of the experiment was over, they resumed working on the rest of the lab. The students temporarily changed their work configuration by kneeling and standing instead of using the lab stools and deliberately narrowing down their attention to a particular aspect of the work. As they were doing this, they created two planes of activity: one for self-feedback, one for external regulation and verification. When they were done and changed back to their ordinary stance, both of these concerns immediately ceased to exist and they resumed working with no overhead.

4. DESIGN OPPORTUNITIES

In this section we offer possible research directions and implications for design. We suggest areas where coupled displays might be offered as a part of the solution. We also point to areas for which new theories could be developed.

4.1 Locality and territoriality

The teams in the kitchen and the labs divided the work among different specialized surfaces. Each different surface achieved a certain part of the task without knowing about the whole, then the whole product is assembled. This distributed notion of work over surfaces might be more welcoming to certain deployment patterns than others. For example, instead of monolithic end-to-end systems representing exclusive centers of "smartness", cooks might find it easier to engage with distributed, locally intelligent systems. [10] By augmenting the work environment in a familiar way, systems in these areas might attain higher adoption rates.

We have also seen how social hierarchy regulates access in a kitchen. While there were many specialized surfaces contributing to the work, individuals were organizationally limited in their choice of surfaces. We found that the cooks spend most of their time in a certain location, their home base, and occasionally work on other locations as the senior cooks permit. This has implications in terms of access. If we design a clever ingredient tracking system for the prep cook, but position it in a way that it is closer to the chef, we will not be able to see the intended effect.

At a more theoretical level, we need to explain how multiple interactive surfaces affect work practices as a group. Previous work explored territoriality in the tabletop computing area to explain how users of a shared space negotiate ownership. [7] While we recognize the importance of territories on a shared surface when we work together, we currently do not have any theoretical means to characterize what happens when we collaborate over multiple intelligent surfaces. Based on our findings, we advocate that collaboration, collective problem solving and object manipulation across multiple surfaces be central areas of theoretical inquiry for surface computing.

4.2 Fluid creation and degradation

Consider how the cooks decide to move the work on a surface (workbench) to another surface (cutting board). In the ideal kitchen with a dedicated poultry workbench, the workbench contains the task and provides the boundaries for it. By moving the cutting task on the cutting board from the surface itself, the cooks shrinks the task area and makes the task portable.

Despite the change from the surface to the cutting board, the goal of the task remains the same. This is an interesting finding because it allows us to characterize certain work-related artifacts as surfaces. Cutting boards are certainly artifacts resting on a surface. However, they are functionally equivalent to the surface itself for a cutting task. Thus, the cutting board could be thought of as a surface on its own and benefit from design recommendations applicable to intelligent surfaces. Moreover, design recommendations for intelligent surfaces in general can be generated by observing how such objects are being used.

One such design recommendation is supporting fluid creation and degradation of surfaces. In both settings we studied, we observed fast creation of specialized areas. The kitchen staff augmented surfaces and created zones with special functional meaning, students switched into task-oriented collaborative stances. This type of fluidity is not supported by the underlying technologies of current intelligent environments. The screens, smart boards, tangible surfaces are all capable resources, but it is hard to summon one easily as needed. Similarly, tearing down these smart setups is hard, they have to stay in the environment whether they are used or not.

There is promising research in terms of creating connected, continuous, on-demand surfaces.[1, 3, 5] Connectables are very prominent in this area, in the sense that they use first hand domain objects (tables) to support a collaboration as a first class task. [9] The notion of combining surfaces can be taken a step further by conceptualizing surface-on-surface interactions. These might be as simple as layering (putting a PDA on a smart table), or as complex and distributed as connecting multiple surfaces with each other to create a completely new type of resource.

4.3 Planar Computing

The way that the students achieved an accurate filling of the gel plate suggests new interactions with surfaces. The viewpoints that the students created for paying attention to different parts of the activity was cognitive resources for them. They focused their attention by changing from their usual viewpoint to an unusual one. This allowed them to exclude other concerns by creating an fresh, unfamiliar plane. For constructing this setup for exclusion, they did not make use of any physical items, they only choose two planes to focus their attention.

This behavior might be supported in a new design space where the interactive surfaces are not necessarily backed by physical slabs. More systematic studies of this behavior is needed to inform the design of infrastructures where a "plane of interaction" is a primary system object. Such an infrastructure can support usage scenarios where users deliberately choose to engage with the same activity on a physical surface from different virtual surfaces.

5. CONCLUSION

We reported results from two studies in non-traditional work domains, kitchens and labs, to encourage thinking about what surface computing might face as it evolves to be the primary mode of computer use. Through our analysis, we discovered how activities are shaped by the space and layout around them. We observed a flexible, fluid approach to setting up special areas and quickly moving between them. We encountered organizational strategies which enables users to enhance their workflows by configuring work surfaces as a group. We also encountered cognitive strategies that generalize the concept of a surface to achieve a focused mode.

Current smart interactive displays are most commonly found in meeting rooms, offices and domestic settings. These static, neat environments have different needs than more dynamic environments, like professional kitchens and labs. By studying these domains, we draw attention to the need to augment our understanding of future computing environments with more dynamic concepts. We identified three of these: importance of local interactions, the need to support quick creation of surfaces and supporting not only tangible but virtual surfaces. We believe that technologies discussed in this workshop have the potential to be suitable platforms to address these needs.

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