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PersonalChef

Cooking Guidance Through an Interactive Multi-Display Kitchen Counter

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Diploma Thesis

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Aachen, June 19th, 2009
Sarah Mennicken

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Abstract

Cooking has become a popular hobby for many people. For beginners, as well as for more advanced hobbyists there are various ways to learn more about the preparation of food—cooking shows are one of them. However, a television show cannot adapt to each viewer's individual speed.

Information in paper recipes can be ambiguous and sometimes prior experience is needed to know what exactly to do. The final result depends on a lot of parameters and can fail every time, if one is not careful. This multiplicity of things to consider can be too demanding and stressful for beginners, and thus discourages them.

The world wide web is a popular resource for recipes. Because people can simply take their laptop with the recipe on the screen into the kitchen, it offers a fast and convenient way to have all the required information at hand. However, people are concerned about using their laptops in the kitchen.

With our system, PERSONALCHEF, we unravel the complexity of recipes to lower beginners' inhibits and offer them as much or as few information as needed in-situ—on two different displays, one in the kitchen counter and one behind the stove. At the same time, our system allows more advanced users to filter the information displayed, or read further details about ingredients or preparation steps. Our system was developed in an interdisciplinary collaboration between computer science and architecture. It is an interactive multidisplay system integrated into kitchen furniture design for this special use.

The system was developed in three iterations, in which we modified our initial design based on user feedback. The evaluation of our final prototype showed that PERSONALCHEF helps to support confidence of hobby cooks and simplifies recipes. Our system is a basis for further research on cooking and technology in the domestic environment.

Überblick

Kochen ist für viele Leute zu einem beliebtem Hobby geworden. Für Anfanger, sowie für fortgeschrittene Hobbyköche gibt es verschiedene Wege etwas über die Zubereitung von Essen zu lernen—Kochshows sind einer davon. Dennoch kann sich eine Kochshow nicht auf die Geschwindigkeit jedes einzelnen Zuschauers anpassen.

Informationen in Rezepten auf Papier können mehrdeutig sein und benötigen manchmal vorherige Erfahrung, um zu wissen, was zu tun ist. Das Endergebnis hängt von vielen Faktoren ab und kann jederzeit missglücken, wenn man nicht vorsichtig ist. Diese Vielzahl an Dingen, die es zu beachten gilt, kann zu anspruchsvoll und stressreich für Anfänger sein und sie dadurch entmutigen.

Das Internet ist eine beliebte Quelle für Rezepte. Da man das Laptop einfach mit einem Rezept auf dem Bildschirm mit in die Küche nehmen kann, ist es eine schnelle und bequeme Möglichkeit alle benötigten Informationen greifbar zu haben. Allerdings ist man auch besorgt, das Laptop in der Küche zu nutzen.

Mit unserem System, PERSONALCHEF, entwirren wir die Komplexität von Rezepten um die Hemmungen von Anfängern zu verringen und bieten soviel oder sowenig Informationen wie benötigt an Ort und Stelle—das heißt auf zwei verschiedenen Bildschirmen, einer in der Arbeitsfläche der Küchenzeile und einer hinter dem Herd. Zugleich erlaubt das System fortgeschrittenen Nutzern die dargestellte Information zu auszuwählen oder weitere Details zu Zutaten oder Zubereitungsschritten abzurufen. Unser System ist in einer interdisziplinären Zusammenarbeit zwischen Informatik und Architektur entwickelt worden. Es ist ein interaktives Multi-Display System, das in spezial dafür entworfene Küchenmöbel integriert ist.

Das System wurde in drei Schritten entwickelt, in welchen wir unser anfängliches Design basierend auf den Rückmeldungen von Nutzern verändert haben. Die Evaluierung des letzten Prototypen zeigte, dass PERSONALCHEF hilft, die Selbstsicherheit von Hobbyköchen zu unterstützen und Rezepte zu vereinfachen. Unser System bildet eine Ausgangsbasis für zukünftige Forschung über Kochen und Technologie im häuslichen Umfeld.

Acknowledgements

Zunächst möchte ich meinen betreuenden Professoren danken. Prof. Borchers danke ich für die Vorlesungen, die ich bei ihm besuchen durfte. Sie haben mir eine Perspektive in der Informatik aufgezeigt, die ich dort nicht vermutet hätte. Mein Dank gilt Prof. Russell für die besondere Möglichkeit meine eigene Idee mit voller Unterstützung seines Lehrstuhles umsetzen zu können.

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Conventions

Throughout this thesis we use the following conventions.

Definitions of technical terms or short excursus are set off in coloured boxes.

EXCURSUS:
Excursus are detailed discussions of a particular point in a book, usually in an appendix, or digressions in a written text.

Definition:
Excursus

The whole thesis is written in American English.

Independently of the real gender of our users we will use "she" when referring a single user. We will use "he" when referring to a chef or cook.

In 8—"Final System Evaluation" we use the following abbreviations:

min	minimal value of a questionnaire question
max	maximal value of a questionnaire question
σ	standard deviation
r	Pearson's correlation coefficient
p	probability
	p=0.05 is called the significance level

Chapter 1

Introduction

As cooking shows become more popular and more numerous on television, chefs are increasingly gaining celebrity status. For example in 2008 some cooking shows had audience ratings of more than twelve percents (taken from email correspondence [Misc, 2009]). These trends indicate that there is an increasing interest in cooking not just for the everyday nutrition but also as a hobby. Exotic ingredients become more readily available in local food stores, thus people have become inspired to experiment with recipes from cultures they may not be familiar with.

There is an increasing interest in cooking—not just for everyday nutrition but also as a hobby.

There are various ways to learn more about cooking. People can follow traditional paper recipes, watch TV shows about cooking to get inspired, or even participate cookery courses with professional chefs to learn by watching an expert (see Figure 1.1) or just to have a special experience with all senses.

People have various possibilities to learn more about cooking.

1.1 Complexity of Cooking

A good meal does not only smell good, it also should look good, should have the right consistency and temperature to create a pleasurable culinary experience. Especially for beginners it is hard to get everything right. Thus, they usually need to follow instructions, which can be quite different.

A culinary experience depends on various senses.

Figure 1.1: "Cooking Party" at the restaurant "Vieux Sinzig" with the chef Jean-Marie Dumaine

1.1.1 Traditional Cooking Methods

Structure of paper recipes can differ a lot.

When cooking with recipes, a standard method is a paper recipe. Most recipes use a similar structure, a list of ingredients followed by step-by-step instructions. Sometimes the ingredients are not listed separately, but the reader must find them in the instruction text. In some cases recipes do not even use clear instructions but prose text in the chef's first-person perspective to describe the preparation of a certain dish.

A recipe in a certain style can be more helpful for one person than for another.

Paper recipes can be pages in a cookbook, handwritten by friends or relatives, or even printouts from a website. Thus, the quality of the paper recipe can vary a lot. Furthermore a recipe of a certain structure can be more helpful for some person than for another. Novice cooks may often already

be put off by the complexity of a recipe or the quantity of different ingredients, discouraging them to try something new. One must be used to plan several steps in advance, organize everything on the kitchen counter clearly arranged, prepare each ingredient correctly, and put everything together in the right way.

Oftentimes information in recipes can be difficult to comprehend. What color are caramelized onions? Light brown or dark brown? How finely cut should diced potatoes be? 1 cm cubes or 0.5 cm? The final result depends on a lot of parameters and can fail every time, if one is not careful. This multiplicity of things to consider can be too demanding and stressful for beginners, and thus discourages them. On the other hand an advanced cook would be annoyed by all the information he already knows. It is hard to balance the amount of information in a way that both, beginners and advanced cooks, are able to use the same recipe.

Ambiguous information needs experience to be understood.

1.1.2 Modern Cooking Methods

Today the world wide web is a popular resource for recipes. Cooking communities like Chefkoch[1] offer more than 135,700 recipes and have more than 108 million pageviews and 11,5 millions visits on their website per month [Chefkoch, 2009]. In order to save time and paper to print a recipe, people can take their laptop displaying the recipe on the screen into the kitchen (see Figure 1.2). However, some people are concerned about using their laptop in the kitchen [Woodruff et al., 2007] or touching it with wet hands. Moreoever, it may not be possible to operate a laptop's touchpad with wet fingers.

Using a laptop is a fast and convenient way to display recipes in the kitchen.

Cooking shows are another way to learn about how to prepare a meal. However, recipes in cooking shows are rarely followed live while watching a show. Broadcasting time is too expensive to show all stages of a recipe in real-time, and for this reason time-consuming steps are prepared in advance. In any case, a television show could not adapt to each viewer's individual speed. Usually people do not

Cooking shows cannot adapt to each viewer's speed.

[1] http://www.chefkoch.de

Figure 1.2: Laptop on the kitchen counter. Image courtesy of Striatic [2009]

Procedures to cook while watching a cooking show are cumbersome.

merely rely on what they have seen in the TV show. They buy the related cookbook, download the recipes from the show's website, or ask via mail for the recipe (taken from email correspondence [Misc, 2009]). Possibly they use nevertheless the visual cues seen on the show to prepare the recipe. It would be possible to watch a recording of the cooking show after the actual broadcast and play and pause it manually while cooking. But it is easy to imagine this procedure being cumbersome especially for a novice cook, who is already struggling with the recipe itself.

1.2 Aesthetics in Domestic Environments

Aesthetics are especially important in the domestic context.

Even if aesthetics are highly subjective, we think that for creating a well-accepted system in the domestic context, there needs to be a strong focus on aesthetics as well. The product of creating an interactive system and well-formed furniture should be more than merely a composite of its features. A system's real value can be about fulfilling the user's emotional needs [Norman, 2005]. The outer appearance of PersonalChef should be appealing in the surrounding kitchen (see Figure 1.3) to attract people to use it.

Figure 1.3: PersonalChef

> "Why not have information displayed in a pleasant, comfortable way? Technology should bring more to our lives than the improved performance of tasks: it should add richness and enjoyment."

This quote by Norman [2005] describes what we plan to do. We do not want to create a kitchen tool to accelerate food preparation. We want to create a complete system to support and provide an entertaining and enjoyable cooking experience. In 3—"Creating a Personal Chef" we describe the challenges of technology in domestic contexts and our focus on aesthetics in further detail.

1.3 PersonalChef

Displaying one step at a time reduces the perceived complexity of a recipe.

Our system PersonalChef helps to unravel the complexity we described in 1.1—"Complexity of Cooking". Even complex, long recipes appear simple to the user by displaying just single steps with corresponding feedback for self-control. Unlike in written recipes, users are provided with information that is only relevant for the current step, and they are given hints for the correct preparation via video. Users can focus clearly on what they are doing and will not get lost in the whole context of a long recipe. They will not be surprised again when reading the next step, only to find out that they already should have preheated the oven at an earlier time.

Beginners can go stepwise through the recipe querying for more information if they need to.

PersonalChef advises at the right moment. Users see the exact color of caramelized onions and how big diced potatoes are on the display. They are able to compare their intermediate steps as in a cookery course, where one learns by watching the instructing chef. By succeeding in little steps, users gain more confidence and get a satisfactory sense of accomplishment. The visual representation alleviates people with illiteracy, foreigners, or young kids to prepare new dishes without disadvantage. Cooks are smoothly guided and the system waits for them whenever they need more time to finish an action. They can move away and interrupt their task. When they come back they are provided with visible feedback about their current context and can continue wherever they were.

Advanced users can filter the displayed information.

Advanced users can retrieve further information about ingredients or interesting details about a certain preparation step. But they do not necessarily have to watch the information provided for beginners. We will discuss these concepts in further detail in chapter 3—"Creating a Personal Chef".

1.4 Academic Context

This thesis was done in a collaboration between the Media Computing Group and the Computer Aided Architectural Design Group, both chairs at the RWTH Aachen University. Our project has a strong focus on the user centered development process of an interactive system, as well as aesthetics and design of the system setup. Given the chance to actually built the system as furniture with embedded technology, it was important to think about solutions to repurpose the devices and furniture afterwards as this thesis is not part of existing research at one of the chairs.

This thesis concentrates on a user-centered and design focussing development process

1.5 Structure

This thesis is organized as follows:

- We present similar work and systems about interactivity in the kitchen in 2—"Related Work". Here we describe features of those systems and differences to PersonalChef.
- The chapter 3—"Creating a Personal Chef" discusses ideas of interactive cooking in the kitchen and challenges of technology in the domestic context.
- In 4—"Paper Prototype: Organization in the Kitchen" we describe how we tested our ideas as an early and low fidelity prototype to prove our basic hypotheses.
- The 5—"Second Prototype: Testing Metaphors" was a medium fidelity prototype, which was an intermediate step to the final version. We used it to obtain informal feedback in an early implementation stage.
- Our last prototype, 6—"Final Prototype: Style and Design", was also built and integrated into furniture. This was the system we used to prove our hypotheses in the final user tests.

- In chapter 7—"Designing a Kitchen" we describe the design process and our thoughts about integration of technology in the kitchen as well as form factors.
- The 8—"Final System Evaluation" chapter presents the conduction of our user studies on the final prototype. We specify our hypotheses, describe our results and how we interpret them.
- The last chapter 9—"Summary and Future Work" sums up the work and results of this thesis and discusses possible future research ideas for PersonalChef.

Chapter 2

Related Work

"The man with a new idea is a crank until the idea succeeds."

—Mark Twain

Several existing systems have been developed in attempts to bring technical innovations into the domestic kitchen environment. In addition, researchers have also studied kitchen tasks as a problem of information dissemination. In this chapter, we will introduce a selection of existing systems and concepts to provide an overview of this research area.

2.1 Research on Interactive Kitchen Systems

2.1.1 CounterActive

CounterActive [Ju et al., 2001] is an interactive cookbook for the kitchen counter. The initial idea was to integrate cooking instructions of a recipe using multimedia into the kitchen counter invisibly. This lets the user focus on cooking with their kitchen implements and not with a computer.

Step-by-step recipes are projected on the kitchen counter.

The authors of CounterActive augment the ingredients with electronic tags to track the ingredients. They think that it is likely that food items will be sold with electronic ID tags in the near future. The recipes are projected as dynamic HTML recipe pages in a web browser onto the kitchen counter. The displayed recipe layout is split spatially into an interaction, a video, and a work area. By this, the user gets information by visual cues on the organization of ingredients and tools on the kitchen counter as you can see in Figure 2.1.

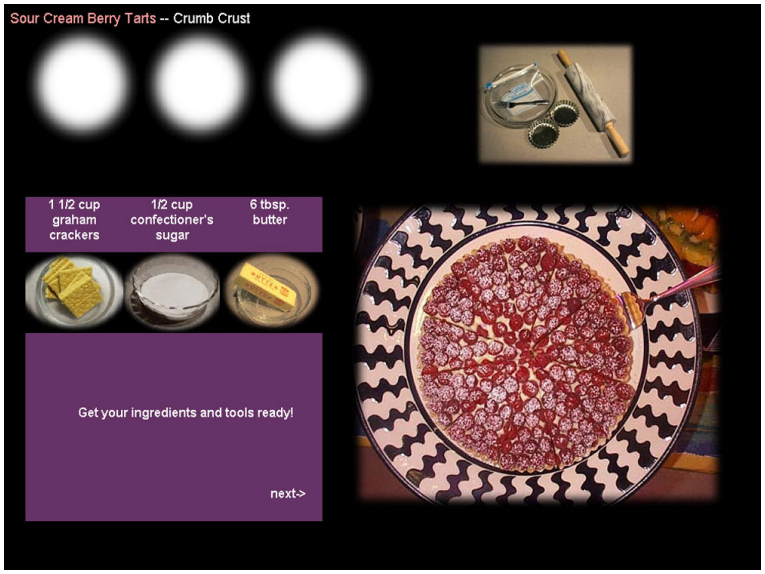

Figure 2.1: Sample screenshot of a recipe in CounterActive. This figure is taken from [Ju et al., 2001].

2.1.2 Kitchen of the Future

Videoconferencing supports the cooking process.

The work of Siio et al. [2004] implements various electronic devices into a standard kitchen unit. The embedded video cameras, displays, microphones, and other sensors facilitate communication and video conferencing for assistive interactive cooking using multimedia.

The user interface is identical to the interface of *Cooking Navi* (see 2.1.2—"Cooking Navi") since both applications

where developed at the same institute. They chose a top down perspective for their videos to convey information on food processing (see Figure 2.2).

Figure 2.2: User recording his cooking process in the Kitchen of the Future. This figure is taken from [Siio et al., 2004].

As we can see in Figure 2.3 they found out that it is important to represent the information without having the user changing her view. The distance between user and system should be minimal.

Distance matters when information has to be conveyed.

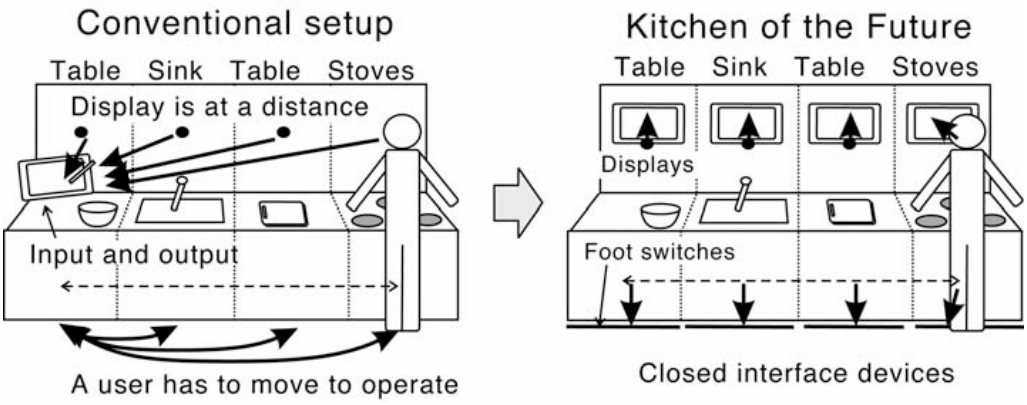

Figure 2.3: On the left side, first version of Kitchen of the Future. On the right side, improved version. This figure is taken from [Siio et al., 2004].

Cooking Navi

Cooking Navi is an assistant for daily cooking in kitchen, developed by Hamada et al. [2005]. They approached the topic not just as an entertainment problem, but as a time optimization problem when preparing a menu consisting of multiple recipes. They split up each recipe into basic Action Units (AUs) that have a logical order. For example the AU "break eggs" needs to be done before "fry eggs". Then they tried to optimize those AUs in order to have all dishes finished at the right time, preparing all courses of a meal in parallel.

Cooking can be seen as an optimization problem.

Cooking Navi consists of a touch display placed vertically onto the kitchen counter that can be controlled by a pen stylus. Instead of clicking the pen's buttons a foot switch can be used as well. The user interface itself consists of several elements: a movie player, a recipe structure panel, a schedule panel, a resource panel, and a couple of other panels for user information (see Figure 2.4).

2.1.3 eyeCOOK

A different approach to most of the other systems was taken in the system *eyeCOOK* [Bradbury et al., 2003]. It is a mul-

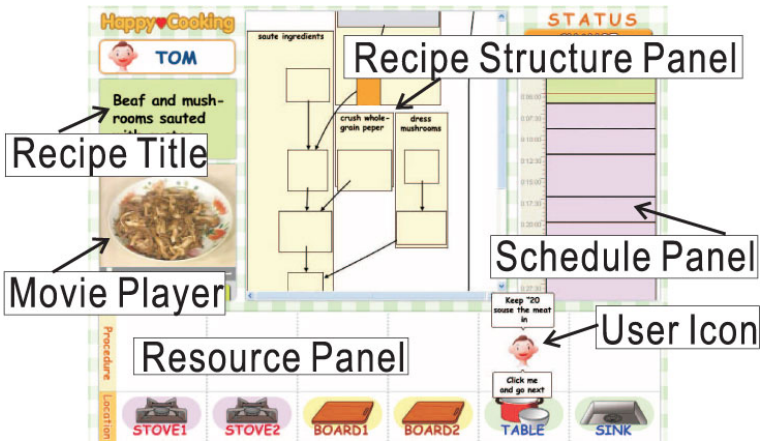

Figure 2.4: Window in Cooking Navi. This figure is taken from [Hamada et al., 2005].

timodal attentive cookbook that uses eye-gaze and speech commands to control the system. To display the information they placed a display vertically onto the kitchen counter. For speech control the user has to wear a headset. An eye tracker interprets the user's gaze. The user interface of the system is similar to a page in a cooking book (see Figure 2.5) with instructions, an image of the recipe's final result, and a list of ingredients.

Eye-gaze and voice commands are used for system control.

2.1.4 Smart Kitchen

Smart Kitchen is developed by Hashimoto et al. [2008]. Like several other systems before it uses multimedia contents to guide the user step by step through the cooking process. Its attempt is to reduce active user input. They call their approach "user centric" instead of "system centric". That means the user should not have to provide input, but the kitchen has to understand what the user is doing. They found it necessary to provide videos, because they convey information about the condition of food materials, which still images just cannot. To react on the user's behavior they developed three modules: tracking food, recognizing food material, and recognizing cooking actions. To track the cooking actions three optical cameras are installed above the three working areas (see Figure 2.6).

Active user input is reduced by tracking user's actions.

Figure 2.5: eyeCOOK in page display mode. This figure is taken from [Bradbury et al., 2003].

While most of the systems give the user a certain order of recipe steps to follow, this system lets the user decide the order by herself. The end of a cooking step is detected by user notification, use of electronic labels, and recognition of the cooking action and food material. Like CounterActive also Smart Kitchen uses RFID labels tagged to the food materials and instruments for object recognition.

2.1.5 Semantic Cookbook

The cooking process can be recorded, annotated, and shared with others.

The *Semantic Cookbook* is a system developed by Schneider [2007] in a technical prototype installation called *SmartKitchen* (see Figure 2.7). It is not only to display, but to record recipe preparation as well. The recorded cooking session then can be semantically annotated and shared with other users to support them while cooking. It is meant to facilitate the process of sharing cooking expertise. Audio and video of a cooking session are

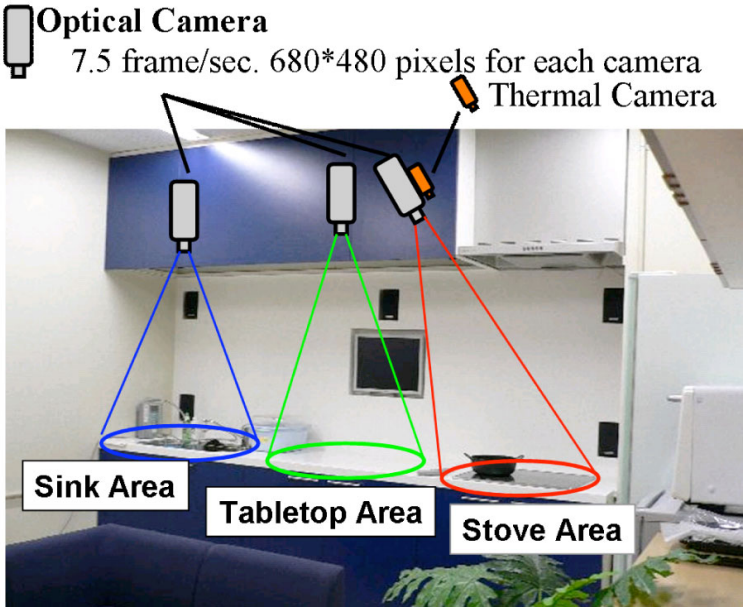

Figure 2.6: Technical setup of Smart Kitchen. This figure is taken from [Hashimoto et al., 2008].

Figure 2.7: The SmartKitchen prototype installation. Image courtesy of [Schneider, 2009].

recorded with the use of wide-angle cameras. RFID tags are used to locate and identify ingredients and utensils. An electronic scale transmits weight measurements to the kitchen server and based on the RFID tag of the object on the scale the amount of a certain ingredient can be determined. A software framework was written for the client-server architecture of the kitchen server, sensors, and RFID antennas.

The user interface consists of a video part, a list of objects and ingredients, and an information panel on the right side (see Figure 2.8). All information is provided on one large touch-sensitive kitchen display which stands on the working area of the kitchen counter.

Figure 2.8: User interface while cooking with Semantic Cookbook. Image courtesy of [Schneider, 2009].

2.1.6 Living Cookbook

The social aspects of cooking are supported.

Terrenghi et al. [2007] studied the field of domestic environments. Their focus is more about the social experience of cooking and collaboration, like recording recipes and sharing them with others. The setup for their system *Living Cookbook* consists of a tablet PC mounted verti-

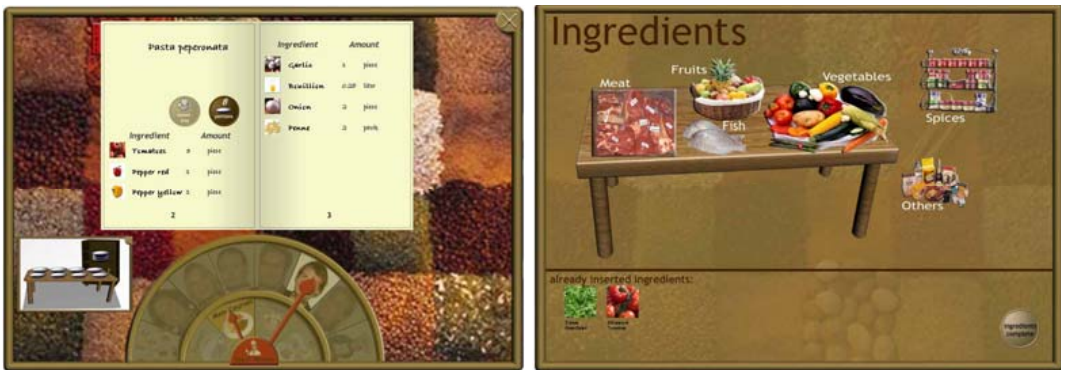

Figure 2.9: Two sample screens of the user interface of Living Cookbook. This figure is taken from [Terrenghi et al., 2007].

cally onto the upper kitchen cabinet. The display is touch-sensitive and can be controlled with a stylus.

The elements used for the user interface are taken from the kitchen context and mostly images instead of text, like showing a table with the ingredients on top of it (see Figure 2.9).

2.1.7 Personal Trainer: Cooking

The personal cooking instructor of Nintendo [2009] for the Nintendo DS is an interactive cookbook and gives live cooking demonstration (see Figure 2.10). Navigation can be done by touching the screen with the pen stylus and within the recipe with voice commands as well. For example by saying "Repeat" the last step will be displayed and read out aloud again. It gives you detailed information by showing videos if needed.

This portable device uses voice commands and stylus input for control.

2.2 Research on Cooking Tasks as Information

Cooking an Ontology by Ribeiro et al. [2006] is not about an actual system, but about the theory of recipe characteristics. Ribeiro et al. created an ontology to represent the key

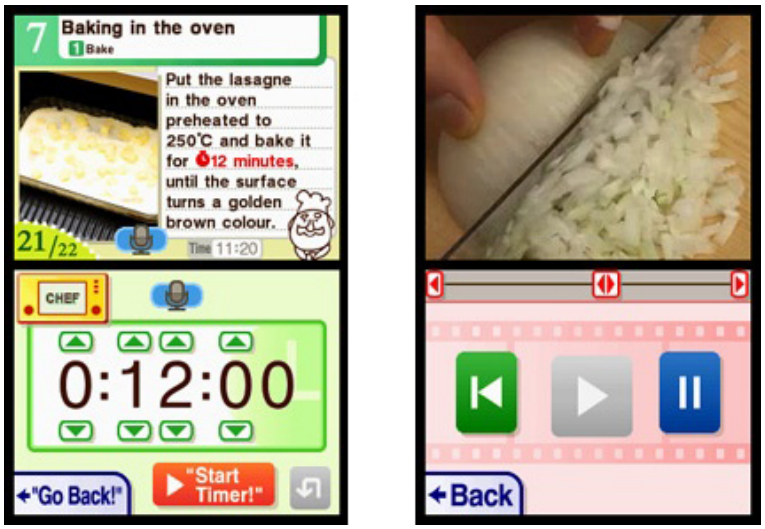

Figure 2.10: One step in a recipe and a video of how to cut onions. This figure is taken from [Nintendo, 2009]

Cooking is explored as information theory.

concepts of the cooking domain. They differentiated four modules: actions, food, recipes, and utensils, as well as three auxiliary modules—units and measures, equivalencies, and plate types. We can use these concepts to make a clear differentiation between the information provided to the user and the information handled by the system in the background.

2.3 Discussion

A virtual person behind the stove provides a more immersive experience.

The biggest difference to all the systems mentioned earlier is the use of our display behind the stove. That display creates a virtual room behind the kitchen counter with room for the chef to show how to cook. Our system focuses on cooking as an entertaining task, not to be optimized in time, but in fun and feeling sure about.

Hardware and its position are optimized for the use in a kitchen.

While almost all systems used just one single display or several displays providing the same information, we want to give additional help by showing different information on two different screens, in two different formats. Except CounterActive all displays were vertically placed, so there

was no interaction with the virtual objects on the screen themselves. We want to blend the border between real and virtual objects by displaying them in real size on the screen. For example, in contrast to our system, the Nintendo DS itself was not developed for the kitchen, so it is not placed in-situ. We can make use of a much larger display and integrate it to make the computer not another electronic device in the kitchen, but the kitchen counter itself. The authors of Cooking Navi expressed the importance of the proximity of information. Our display is integrated into the kitchen counter of our PersonalChef system, this way the user is not even forced to look up.

CounterActive (see 2.1.1—"CounterActive") is conceptually similar to PersonalChef. Both provide information insitu where it is needed and without forcing the user to change her view or focus while cooking. Both systems want to provide nice cooking experiences and therefore have their main focus on the user interface design and on providing more information than merely cooking instructions. While Cooking Navi aims to optimize time as well, and therefore depends on having some tasks finished within a certain time, our system waits for the user to be ready for the next tasks. For our prototypes we chose single recipes, but it should be future work to try merging several recipes into a menu tree that guides the user through the preparation of more than one single dish.

Our research focuses on entertainment and ease of use.

Cooking Navi has a user interface that could be perceived as crowded. Possibly in Japan it is perceived differently, due to the cultural difference. We hope to fit the needs of our target group by displaying only basic elements in our user interface, so we will reduce it to a resource panel, a movie display panel, and a recipe panel.

The interface is kept simple.

eyeCOOK provides a traditional representation of a recipe as its user interface. We want to go one step further and provide a remaining ingredients and tools panel. eyeCOOK lacks of video as cooking help and provides just an image of the finished dish. Subjects of the user tests of the Kitchen of the Future pointed out the necessity of moving images, which their system does not offer. We integrate videos in two different perspectives to give the user the information not just on the food itself but to give contextual

Videos will be the main source for information in our system.

cues as well. Our system has a strong emphasis on videos as source for information and help. Static images cannot transfer information about consistency or transformations in food conditions.

Like the Semantic Cookbook we want to use real life metaphors as well and show the objects instead of plain text representations of them. Our approach was to integrate technological innovations like the multitouch display into the kitchen environment taking advantage of its new features and to make it possible for people to follow their favorite cooking show live at home.

Another big difference to the other systems is our focus on design and aesthetics. Because of the collaboration with CAAD we consider design, material, and form factor aspects as well.

In table 2.1 some major properties of the different research projects can be seen to give an overview about the variety in research of interactive kitchen systems.

	CounterActive	Cooking Navi	eyeCook	Smart Kitchen	Semantic Cookbook	Living Cookbook	Personal Trainer: Cooking	PersonalChef
Object Recognition	✓	✗	✗	✓	✓	✗	✗	✗
Vertical Screen	✗	4 LCD Displays (17” estimated)	LCD Display (no information about size)	LCD Display	LCD Touch Display	LCD Touch Panel (17 “ estimated)	3” LCD Display	32” LCD Display for Video Playback
Horizontal Screen	71*51 cm Projection on Counter	✗	✗	✗	✗	✗	3” LCD Display	32” LCD Display with Multitouch Overlay
User Input	Touch on the Taufish Array	Foot Switches, Pen Device	Eye-gaze, Speech	Recognition of User Action by Webcam	Touch, Motion Tracking	Touch	Speech, Stylus	Touch
Light Insensitivity	✗	✓	✓	✓	✓	✓	✓	✓
Trivia about Recipe or Ingredients	✓	✗	✗	✗	✗	✓	✓	✓
Video Information for Recipe Step	✓	✓	✗	✓	✓	✗	✓	✓
Picture of Ingredients	✓	✓	✗	✗	✓	✓	✓	✓
Separate Picture of Intermediate Step Outcome	✗	✗	✗	✗	✗	✗	✗	✓
Recording of Cooking Process	✗	✓	✗	✗	✓	✗	✗	✗

Table 2.1: Comparison of the interactive kitchen systems

Chapter 3

Creating a Personal Chef

"Die Basis einer gesunden Ordnung ist ein großer Papierkorb."

—Kurt Tucholsky

A personal interest in cooking, technical gadgets, usability, and aesthetics were the inspiration for an interactive system in the kitchen. In this chapter we will explain our initial ideas and our vision, while the following chapters will describe their realization as prototypes.

3.1 The Vision

We found that people usually consult their mother, grandmother, or other relatives when they have questions on cooking. Possibly they would ask a professional chef, if they knew one. But obviously no one could be permanently present in our kitchen waiting for us. What is our vision of a personal chef like? What attributes and requirements do we have? One of our expectation is that we could watch him accomplishing any task, or look over his shoulder. A personal chef can guide us smoothly through the steps of a complex recipe.

A personal chef would have to meet a lot of expectations.

The following list describes some of possible ideals that we had in an early brainstorming. A perfect personal chef...

...shares his knowledge.

...guides me stepwise through a complex recipe.

...is always in my kitchen.

...has an answer to any question that I have, knows every ingredients, utensil, or preparation method.

...is entertaining and motivating.

...is patient and waits for me, whenever it takes me more time to finish a step.

...tells me when I am doing something wrong.

...looks neat.

...does not annoy me.

3.2 Back to Reality: A Personal Chef...

Usually the closest we get to a chef is by a cooking show. However, as described in 1—"Introduction" it can never adapt to every viewer's speed. Thus, we want to take advantage of technology to come closer to a personal cook. Because of this vision of a personal cook in our kitchen, we named our system "PersonalChef".

...shares his knowledge. To offer the apprentice cook the ability to understand easily what the chef is doing we provide different perspectives (see Figure 3.1).

1. **Look over his shoulder** First-person top down perspective on stove or counter screen
2. **Watch him accomplishing tasks** Upright mirror perspective behind stove

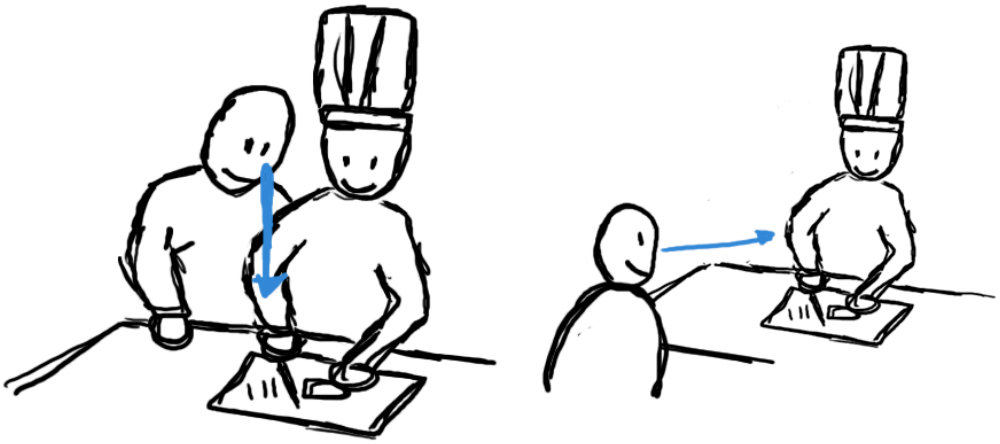

Figure 3.1: Two viewing perspectives for an apprentice cook to study a chef. On the left, the apprentice looks over the chef's shoulder. On the right, he watches the chef from a farther distance.

In our evaluation in 8—"Final System Evaluation" we want to find out if these perspectives work well and if the combination of both will provide information easily to follow a recipe.

Moving images are indispensible for certain information.

Time-dependent ways of preparation are difficult to convey by showing static images. For example, it is easier to obtain sense for a certain texture if one can watch somebody explaining and showing it at the same time. For example, it is hard to tell by looking at a still image how firm whipped cream should be.

In-situ information facilitates the conveying of information.

To address this issue, we considered incorporating video into PersonalChef. By playing video sequences of each individual recipe step the user would be able to compare her results with the desired ones at anytime. To facilitate this, there will be an LCD screen behind the stove showing actions in and on the stove, in mirror perspective. Another tabletop display on the counter will show ingredients and their preparation in the first-person perspective. The chosen perspective should help to transfer the information perceived from the display to own actions as effortlessly as possible. The user navigates from chapter to chapter,

choosing steps at her own speed and perhaps even her own order, without having to divert attention to controlling a computer system.

The apparent complexity is reduced by highlighting single steps.

...guides me stepwise through a complex recipe. To guide the user through a complex recipe, we need to simplify it. Since we cannot facilitate the preparation or reduce the steps, we would need at least to reduce the apparent complexity. We could do this by highlighting the current step and reducing the visibility of everything else. Single steps of a difficult whole can appear really simple (see Figure 3.2). People can easily understand what happens from one step to the other, while figuring out what happens between the first step and the final outcome is hard without further information.

Figure 3.2: Stepwise preparation of a rhubarb pie. Image courtesy of Byron [2009]

..is always in the kitchen. Satisfying this goal is relatively easy. We will not create a kitchen device that can be moved around, but instead integrate the technology into the kitchen. We want to create a kitchen module, since it seems to be more likely that new technologies will come as upgrades, piece by piece into our homes [Edwards and Grinter, 2001]. PersonalChef can be one of those upgrades.

PersonalChef is not a kitchen device, but part of the kitchen.

...has an answer to any question that I have, knows every ingredients, utensil, or preparation method. Sometimes we know an item, we just do not know its name. Accordingly, textual descriptions are not always sufficient, especially not for novice cooks. Our interface should have a strong visual focus; video will be our main source for information, and still images will always be used in combination with textual descriptions.

Sometimes the name of an item is not known, but the item itself is.

...is entertaining and motivating. While beginners may struggle with the recipe itself, cooking can be a relaxing and recreational activity for hobby cooks. Merely following instructions, no matter if with or without images, may be boring for them. We plan to provide additional information in some recipe steps, for example interesting trivia on ingredients or videos about uncommon preparation methods.

Additional information keeps advanced hobbyists entertained.

> "Serving customers means relieving them of frustration, of confusion, of a sense of helplessness. Make them feel in control and empowered. [...] If people don't really know what they want, then what is the best way to satisfy their needs? In the case of human-centered design, it is to provide them with the tools to explore by themselves, to try this and that, to empower themselves to success." [Norman, 2005]

After every step the user will see an image of the expected outcome that the user can check. We think, that this way of optional self-control can lead to a sense of achievement and thus be motivating. PersonalChef is not meant to be

Various ways for self-control empower the user to success.

We do not want to develop a labor-saving appliance, but maximize the ease to prepare a recipe.

another time-saving kitchen appliance. While its positive side effects could include saving time by optimizing cooking procedures, its main purpose should be to entertain and to support the learning process. A system that optimizes tasks is labor-saving and provides its final result well, but we explicitly exclude efficiency from our research for this project. As Bell and Kaye [2002] describe in their Kitchen Manifesto lots of research concentrates on how to optimize task in the domestic environment. We do not claim that people will cook faster or more efficiently with our system, since our focus will be on the fun and the ease to prepare a recipe.

Our system will wait for the user until an implicit or explicit action is performed.

...is patient and waits for me, whenever it takes me more time to finish a step. As mentioned earlier, we want to provide an enjoyable experience. Object recognition will help to reduce user input and pace the system at user's speed. The system should for example recognize when a user puts down a used tool and proceeds to the next step. Any step that cannot be recognized automatically will wait for explicit user notification.

Consistent feedback is important as there are no Undo functions in cooking.

...tells me when I am doing something wrong. It is easy to imagine that nobody wants to spend a lot of time just to find out at the very end that she failed in the first step. An image of the expected outcome and the possibility to countercheck in a video cannot completely prevent failing in a step, but gives early feedback about mistakes. Users will become co-actors with the kitchen as their stage and play their parts between video sequences of a real chef. If the user forgets a part of her role, a personal chef reminds her with visible cues. While most computer applications offer Undo/Redo possibilities, you cannot do that when you cook. Not just because you can use an ingredient usually just one time, but also because cooking is a time sensitive process, and failing in one step sometimes ruins the whole recipe. Therefore it is important to have consistent feedback during the whole process in every step.

...looks neat. Not just the interface of our planned program, but the complete system has to look neat. It seems that people tend to shape their home according to their liking to achieve coziness. Technology, however, in general appears complex, disturbing, and unaesthetic. Those attributes raise feelings of discomfort and oppression. Appropriate domestic technology must support human behavior only in the background and shift it into the focus only when you need it. Like furniture is already hiding necessary constructions, it will have to hide the increasing amount of technology in domestic spaces. Just as people already hide the unsightly mess of cables underneath their tables, they try to hide any visible overload. Being constantly surrounded by visible technology, could cause this overload, and would lead to discomfort. How we design and built the kitchen is described in chapter 7—"Designing a Kitchen".

Technology should be hidden to reduce visual complexity of the system itself.

...does not annoy me. While very beginners may appreciate a video about how to cut onions, others could be annoyed. Just basic information should be provided, any addition should be displayed just on request. At the same time requesting information has to be effortlessy, for example by a simple click or putting the object we want information about onto the display.

Information has to be balanced to address beginners as well as advanced hobbyists.

> "And what if you decide to do something that the house thinks is bad for you, or perhaps simply wrong. 'No,' says the house, 'that's not the proper way to cook that. If you do it that way, I can't be responsible for the result. Here, look at this cookbook. See? Don't make me say 'I told you so.' " [Norman, 2007]

This quote by describes a possible scenario of a discussion with a house, or in our case the kitchen. Some people consider cooking a relaxing activity for several reasons: For some it may be relaxing to prepare something really tasty, other may enjoy the processing of raw food materials to an elaborated whole, some enjoy the creativity and the variety of possible ways to prepare something. Whatever the

Users should not be forced to follow a specified concept.

reasons may be, no one would like to be forced to follow a certain way or have taken their freedom of decision.

People formed their own habits in cooking already for a long time; our design needs to match this diversity.

Another problem is, that people learned cooking in different ways. Having already been cooking for a long time, they had already built different mental models about the cooking process. For example in our evaluation our subjects (see 8—"Final System Evaluation") had been cooking for 16.5 years in average. That means, that they had established a certain style of cooking and organizing for quite a long time. They have different personal habits and preferences. Our system should be suitable for everyone, wether for people preferring just visual cues about how the recipe should look like or people who want to follow step-by-step detailed commands not leaving much room for improvisation.

Chapter 4

Paper Prototype: Organization in the Kitchen

"I would rather entertain and hope that people learned something than educate people and hope they were entertained."

—Walt Disney

Creating low fidelity prototypes at an early stage of interactive system development is good to have feedback on design decisions without having to invest too much effort and time.

4.1 Exkursus: Paper Prototype and Wizard of Oz

PAPER PROTOTYPE:
[...] a variation of usability testing where representative users perform realistic tasks by interacting with a paper version of the interface that is manipulated by a person 'playing computer', who doesn't explain how the interface is intended to work. [Snyder, 2003]

Definition:
Paper Prototype

A sketched interface allows for high level criticism.

The model for the interface is sketched with rough outlines intentionally. A more elaborated prototype suggests the test person that a lot of work was done already. In contrast, a sketchy interface lowers users' inhibits to give criticism and make them focus on high level design ideas, instead of concentrating for example on the shape of buttons, colors, or fonts.

A person acting as the computer to process user input, as in "Wizard of Oz" studies, helps designing the actual interaction between human and computer without implementing all the functionality.

Definition: *Wizard of Oz Study*

WIZARD OF OZ STUDY:
In a specially created setting, a human takes over a part of the processing of the to-be-developed system for which humans are especially well suited. [Jacko and Sears, 2003]

It is important for our study that the person 'playing computer' knows exactly what to interpret and which events to trigger, so the functionality tested can really be implemented.

The following section will explain how we took advantage of this methods for early user feedback.

4.2 Challenges and Solutions

Before actually creating the prototype we had to face two challenges, which we describe in this section.

4.2.1 Multimedia Interface on Paper

Creating a paper prototype for a multimedia system is rather difficult since it cannot display audio or video.

Figure 4.1: Cardboard prototype on kitchen counter simulates the counter screen.

A person acts as computer to simulate interaction.

Therefore we decided to make a low fidelity paper prototype in combination with "Wizard of Oz" functionality to control the movie playback, which will be shown on a laptop display.

A cardboard screen was used as placeholder on the kitchen counter.

The main purpose of this test was to see if size and position of the touch display in the kitchen in combination with the movie playback in a different location works, and if the user can understand the basic user interface elements. We could check as well how the user handles food and organizes the ingredients and tools on the counter when information is displayed underneath. To simulate this we used a background made of cardboard in the size of the actual display (see Figure 4.1).

Instead of recording all audio files for each recipe step, a preformulated text was read out aloud. Because we cannot display videos on the paper prototype itself, we printed images of the recipe step and put it onto the background to reserve that space on the screen and see how the user deals with it.

4.2.2 Media Content

Cooking shows could not be used because they do not have the right format.

Since we used a portrait format to display the information behind the stove, we could not use a video recording of a regular cooking show . We had to record the perspective behind the stove and the top down perspective on the kitchen counter ourselves. The recipe we picked was "Blueberry Pancakes".

Language chosen for video is German as we only have German subjects.

Before recording the video sequences we created a storyboard in which we defined what the focus of the clip should be, which perspective to record, and what text to use. Because all our test users are German we decided to record all videos in German. Figure 4.2 shows an example page of the storyboard.

Two sample videos can be found at:

- Top down perspective on kitchen counter[1]
- Mirror perspective of the stove[2]

4.3 Paper Interface

Recipe instructions are displayed as a rotatable wheel.

On the left side in Figure 4.3 we can see the wheel with the single recipe steps. To deal with all the steps in time and not to move every paper piece by itself, we mounted them on cardboard. The current step is marked by a green arrow pointing on it. This way we can just rotate the wheel and the user sees the current step as well as his progress in the recipe.

[1] http://hci.rwth-aachen.de/~mennicken/thesis/m-pp-counter-topdown.mov

[2] http://hci.rwth-aachen.de/~mennicken/thesis/m-pp-stove-mirror.mov

Text: Pfanne und Pfannenwender bereitstellen. Einen Stich Margarine in der Pfanne erhitzen. Die Blaubeeren aus dem Gefrierfach holen.

Text: In einer beschichteten Pfanne portionsweise die Margarine schmelzen und nicht mehr als drei kleine Pancakes auf einmal backen. Pro Blueberry Pancake 2 Esslöffel Teig in die Pfanne geben. Die Teigmenge reicht für ca. 12 Pancakes.

Text: Die Blaubeeren gleichmäßig über den Teig verteilen.

Text: Blueberry Pancake auf mittlerer Temperatur so lange backen, bis die Oberfläche leicht fest wird und sich kleine Bläschen bilden. Dann erst mit dem Bratenwender einmal umdrehen.

Text: von der anderen Seite ebenfalls goldbraun backen.

Text: Die fertig gebackenen Pancakes können im vorgeheizten Ofen bei 50° warmgehalten werden. Blueberry Pancake nach Belieben mit Puderzucker bestreuen.

Figure 4.2: Storyboard for the last steps of the blueberry pancakes recipe

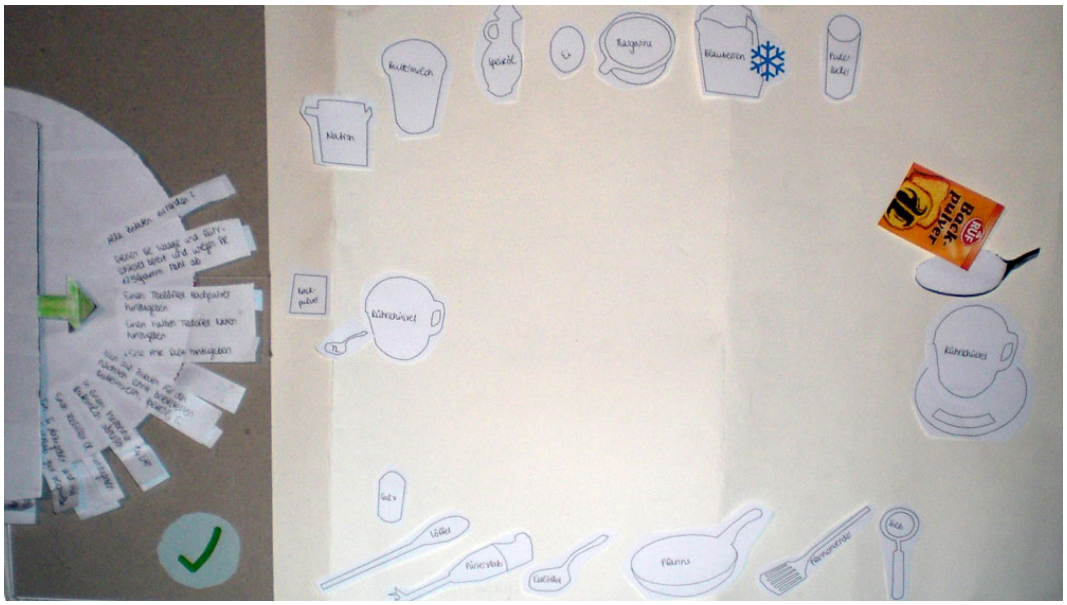

Figure 4.3: Sample screen of the paper prototype. On the left side, recipe wheel with single steps. On the right side, remaining ingredients and tools to be used.

Ingredients and tools queues act as status bar.

On the right side is the representation of the ingredients, here by their outlines. To see the ingredients and tools needed in the next step, there are two queues: one for the ingredients in the upper part of the screen and one for the utensils in the lower part of the screen.

4.4 User Tests

To decrease the unnatural feeling when verbalizing thoughts we asked questions to help our users commenting their activities.

The test was conducted as a "Think aloud"-observation, which means that we asked the users to talk aloud about what they are thinking while using the systems and what they are doing [Dix et al., 2004]. The problem with this kind of user test is, that permanently verbalizing our thoughts is unnatural [Nielsen, 1992]. We asked a couple of questions to help them commenting their activities.

These questions were:

- What are you looking at in this moment?
- What does this object mean to you?
- Do you have problems to perceive the next step?
- Do you like the visual representation?

After a short introduction and a short interview to get preliminary information on the subject, the user was given a box with ingredients and tools. Then she was asked to comment what she is doing while following the instructions on the screen to cook the pancakes. During the tests, whenever the user clicked on the check mark or rotated the wheel, the next recipe step was read aloud to the user and if there was a video for this step the playback was started. After the test she was asked further questions:

The text of a recipe step was read out aloud triggered by an implicit or explicit user action.

- Was the system a help for you?
- Did you ever feel lost in the recipe?
- Did you have problems to perceive the information of the screens?
- Was there anything that confused you?
- Could you understand the icon outlines?
- Did the videos or moving user interface elements distract you from your cooking tasks?
- Do you have further ideas for the system?

4.4.1 Subjects

The preparation of pancakes is easy and people which are used to cook, often know by heart or at least remember the preparation when given the ingredients. For this reason we needed rather cooking novices to test the system arrangement. If the people are dependent on the information provided, we can focus on high level characteristics to have

We had two subjects with low to medium cooking experience.

first feedback on our ideas. We had one female and one male subject. Both said not to have cooked blueberry pancakes before.

4.4.2 Setup in the Kitchen

To test the prototype we set up the laptop as close as possible to the stove and the actual paper user interface on the side (see Figure 4.4).

Observer played computer on defined events and read out the text of each recipe step.

A person played the computer and read out the instruction text of each recipe step after certain events. Those events were triggered wether by user notification or by events that could be triggered by the to-be-developed system, for example lifting up objects from the touch screen or putting them onto it.

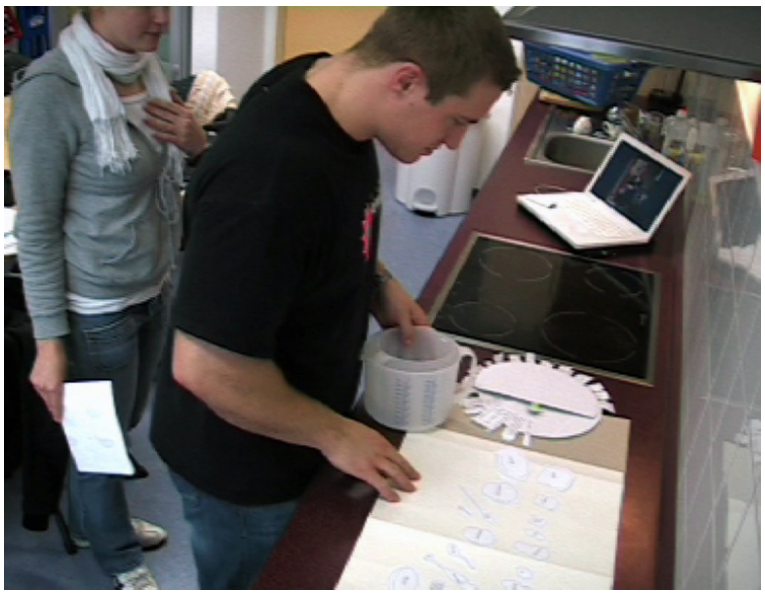

Figure 4.4: Setup of the paper prototype in the kitchen

4.4.3 Hypotheses

We conducted this early prototype to test if this representation of information will be accepted and preferred over traditional paper recipes. We did not ask for our hypotheses directly as we did not want to influence the test subject's answer.

Our basic hypotheses were:

1. The user will always feel confident about the right result of the single steps.
2. The user will use the screen as work area as well.
3. The user will feel in control about the pace of the recipe.
4. The icons of ingredients and utensils are understandable without further description.

4.4.4 Evaluation

Our subjects stated that they felt always confident about their results. Since pancakes are rather easy to prepare, it is left for further research in the following design iterations to find out if that hypothesis is true for more complicated recipes as well.

Users felt confident about their results.

The "paper screen" was used as work area as well. At the beginning of the recipe subjects put the ingredients around the screen. However, when currently needed, they put everything on the paper screen (see Figure 4.5).

People use the screen as work area.

Our test users said they felt that they were cooking at their own pace, even when the system started another video based on their actions. Subject A pointed out that for her as a cooking novice it was especially useful to have the organization of the objects visible from the start to the end. But she would have like a step-by-step line-up with naming every single ingredient in the beginning. Subject B has intermediate cooking skills, so we thought the organization

Prior organization of ingredients and tools was found helpful.

Figure 4.5: User following the video instructions

of the ingredients would be annoying or cumbersome for her. But when we asked what she liked about the system, she said that the prior organization and gathering for ingredients helped her to be faster and cook in a more organized way. As one subject pointed out that it would be helpful for him to have a list of all ingredients at the beginning we will implement this in the next iteration.

Users like confirming success of intermediate steps.

Contrarily to our presumptions both users did like the check mark button to confirm the end of a recipe step. But Subject A could imagine that it is cumbersome for longer or more complex recipes. User B liked confirming each step. She said to feel like she is having her own pace and checks everytime if her results are correct.

Icon outlines are not clear enough.

The outlines for the ingredients and utensils as icons were helpful, but labels were necessary to get the meaning instantly. The users did not read all information of each recipe step but instead preferred listening to the audio a second time.

Subject A found the meaning of the recipe step wheel on the left side was hard to understand and therefore he did

not use it at all. Subject B said that mainly audio guided her and she rarely read but skimmed the text. Just if one step included more ingredients with a certain amount she checked the text.

Audio information is especially important.

For our next iteration we will have to consider that the wheel metaphor for navigation in a recipe might not work. As well the interface could be too complicated because there are too many items on the screen.

Instruction wheel metaphor needs to be reviewed.

Chapter 5

Second Prototype: Testing Metaphors

"There are no shortcuts in evolution."

—Louis D. Brandeis

We wanted our system to be able to show users how to cook a possibly unknown recipe. They should be able to copy the actions that the TV chef does as they watch him cooking. It is important to convey the instructions in a way that the user can transfer what she sees to what she is doing. Moreover, she should not be constrained to concentrate too much. We tried to design the interface to adapt to real life situations and on how we learn things in everyday life.

We need to provide information that has to be reproduced by the users in real-time.

To test interactions with media content on the counter as well, we implemented a software prototype. Despite the results acquired with our paper prototype, we decided to try testing the instruction wheel again. We hoped that due to the better responsiveness of the actually implemented wheel, the user would understand the metaphor.

5.1 Challenges and Solutions

Events had to be passed from Windows to Mac

The technology we used for the touch tracking runs under Windows only. Since we want to take advantage of the Core Animation framework we implemented PersonalChef on a Mac. To pass the events from Windows to Mac we used UDP. We will describe the solution in further detail in the next section 5.2.1—"Technical Setup".

5.2 First Software Prototype

Our first software prototype already used the hardware for the final system. In this section we will describe the technical setup of our system as well as the user interface design.

5.2.1 Technical Setup

PersonalChef consists of two displays:

1. **Counter Screen**: a display inside of the kitchen counter which has a touch-sensitive multitouch overlay for user interaction.
2. **Stove Screen**: a display behind the stove for video playback.

We chose multitouch technology based on infrared light.

The technology we used for the multitouch overlay is from PQLabs[1] . Basically it is a frame which can be mounted on any LCD display of the right size. In two of the frame's edge profiles there are infrared light senders, in the other two there are receivers.

The PQLabs's driver currently runs only under Windows, while PersonalChef is implemented as a Mac OS X application. For receiving the events in the application we created a setup as it can be seen in Figure 5.1.

[1] http://www.multi-touch-screen.net

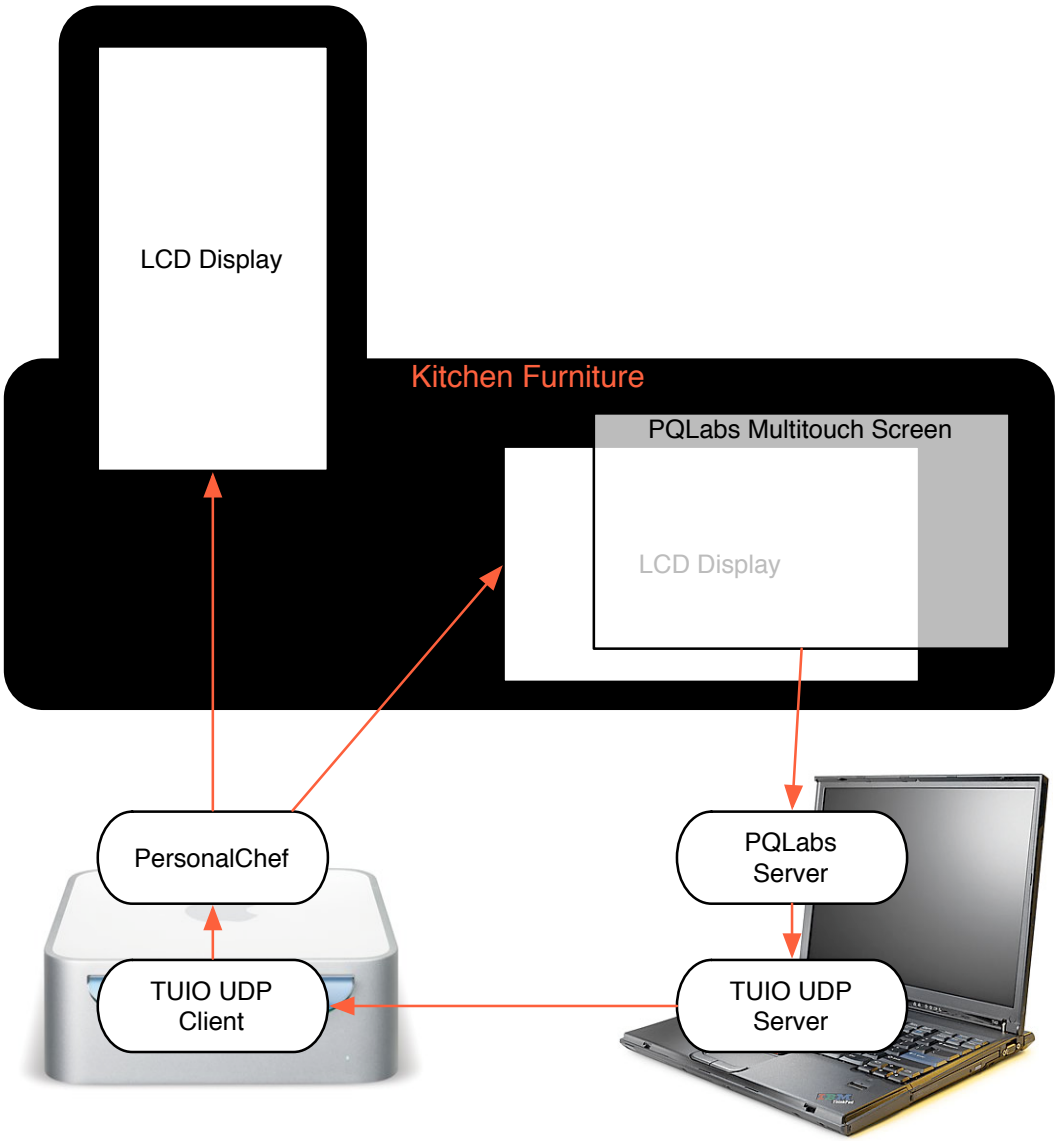

Figure 5.1: Technical setup of PersonalChef

The PQLabs server for receiving the touch events runs on Windows on a regular PC Laptop. We use an implementation of a TUIO server[2] and integrate it into our project source. TUIO is an open framework which defines an API and a common protocol for tangible multitouch surfaces. We chose it to have the possibility to control already imple-

We used the TUIO framework to pass events from Windows to Mac

[2] http://sourceforge.net/projects/reactivision/

Figure 5.2: User interface of the first software prototype

mented multitouch applications using the TUIO API. The TUIO[3] server streams events via UDP into the network. In our PersonalChef application we implement a TUIO client[4] which receives the events and processes them.

PersonalChef is implemented in Objective-C[5] using Cocoa[6] . The user interface elements are created with Core Animation[7] , which is a framework for creating animated user interfaces in an easy and fast way.

5.2.2 User Interface of the Counter Screen

While the stove screen is basically just a display to show the videos, the touch screen offers the interaction with PersonalChef. The user interface of the counter screen is split into various sections (see Figure 5.2).

We have a main menu on the left side for the cooking in-

[3]http://www.tuio.org
[4]http://code.google.com/p/tuioframework/
[5]http://developer.apple.com/documentation/Cocoa/Conceptual/ObjectiveC/
[7]http://www.apple.com/macosx/technology/coreanimation.html

structions. The user can scroll the instructions or click on one to have it repeated. At the same time it acts as a status bar because the user sees the current step she is in and the previous and next steps as well. The upper menu shows which ingredients the recipe contains and in which order. The lower menu shows the same for needed tools. Whenever a step is done, the next step becomes active and the corresponding ingredients and tools move into the center, to show the user which items are needed now. A video area on the right side provides the user with information about preparation processes in first-person perspective.

The interface layout is split into areas for instructions, ingredients, tools, and video.

GESTALT LAW:
Gestalt Laws are principles based on the Gestalt theory established in the 1920s by Koffka, Köhler, and Wertheimer. They were convinced that in order to explain psychological phenomena it is necessary to consider them as an organized and structured whole. [Zimbardo and Gerrig, 1999]

Definition: *Gestalt Law*

To reduce complexity on the screen and take advantage of the Gestalt Law of Experience, we used just the outlines of ingredients and tools. However, if the user is not sure about the correct identification she can hold her finger on the item and its name is displayed (see Figure 5.3).

We used outlines to represent ingredients and tools.

Figure 5.3: A textual description of an item is displayed when holding a finger on it.

5.2.3 Stove Screen

The design idea for the display behind the stove was not the metaphor of augmenting a room with virtual information, but rather providing a window into a virtual room (see Figure 5.4).

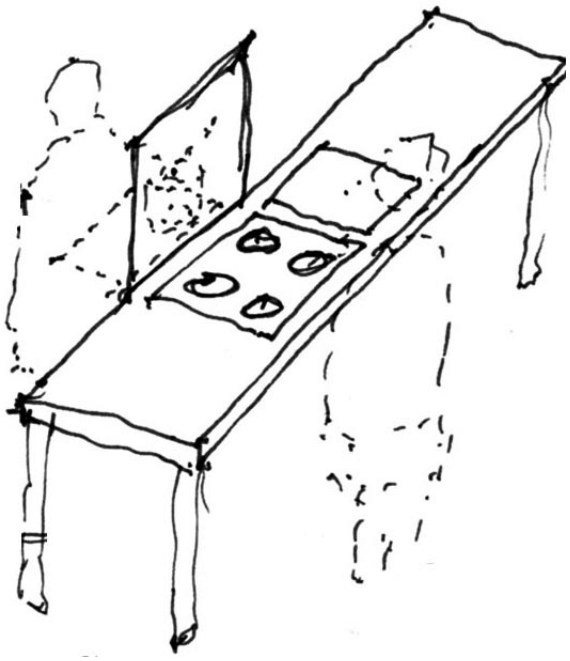

Figure 5.4: Window into the virtual kitchen of the chef.

Stove screen acts as window to another kitchen.

The user will see the chef in this perspective without any further virtual objects. As described in 3—"Creating a Personal Chef", the intention is to present a view for the user that is as natural as possible and without interrupting the illusion of a window to a different room. This unusual format and the additional screen is unique to our knowledge.

5.3 Evaluation

We got feedback on this prototype by several Cognitive walkthroughs. For this method the developer presents the proposed user interface design to a test person or a group of test persons. The subject then tries to accomplish a given task by exploration of the system [Nielsen, 1994].

User interface design was presented to several people.

Our test users did not take advantage of the information provided by the ingredient and tool queues. Because the queues have to be updated whenever another recipe step is selected, there is a lot of movement on the screen. This could catch the attention unintentionally.

Movement on the screen could catch attention unintentionally.

The video content we used was the same as for the paper prototype. After getting better insight of the user interaction and the recipes, we found out which sequences we still need to record for the following prototype.

We need better media quality for a more elaborated prototype.

Although we already had found out earlier that the wheel metaphor and the outlined icons did not work properly in the paper prototype, we hoped that they would work in a software prototype. Now, our users could read a text description when they were not sure about a certain icon. Still the user needs to put effort in item identification, which is a frequent task. In the next prototype we will use photos to see if that solves this problem.

It is hard to identify icons merely by their outlines.

The wheel metaphor did not help to convey information and status of the progress in a recipe. In the next prototype we will keep it more simple and display all instructions as a simple list, highlighting the current step.

Wheel metaphor is still difficult to comprehend.

For our next prototype we have to consider that we cannot use object recognition with this hardware. That means that we will have to rely completely on user input.

Hardware does not allow for reliable object recognition.

Chapter 6

Final Prototype: Style and Design

"I may not have gone where I intended to go,
but I think I have ended up where I needed to be."

—Douglas Adams

We again improved our prototype based on the feedback from the second prototype. Since people did not appear to benefit from having the remaining ingredients and tools permanently displayed, we decided to show only the ingredients and tools needed for the current step.

In addition, we had the idea to introduce an image of the outcome of a certain step. Now the user can see input, processing, and output—needed ingredients and tools, a video about how it is prepared, and an image of the outcome.

Interface reflects idea of input, processing, and output.

This chapter describes the updated interface of our final prototype and how we solved the issues found in earlier user tests.

6.1 Challenges and Solutions

In this iteration of our development process we had two major challenges. The hardware we chose did not allow for reliable object recognition and the quality of the media we recorded was no longer sufficient.

6.1.1 Occlusion on the Multitouch Screen

Object tracking can be impeded by another object on the screen.

At the beginning we hoped to be able to track objects by their size and shape on the screen. However, the current firmware of the PQLabs multitouch screen does not support tracking three or more accurate points. On an infrared light based multitouch screen we always have the problem of occlusion: if an object lies on the screen it occludes some infrared lights. Any object in this "infrared shadow" cannot be tracked anymore. To prevent the occlusion problem, we decided to build a transparent plexiglass slider above the screen frame (see Figure 6.1). This construction prevents objects standing on the screen to cast "infrared shadows" hiding other objects and at the same time the user can move the slider away when there is a need to touch the user interface underneath it.

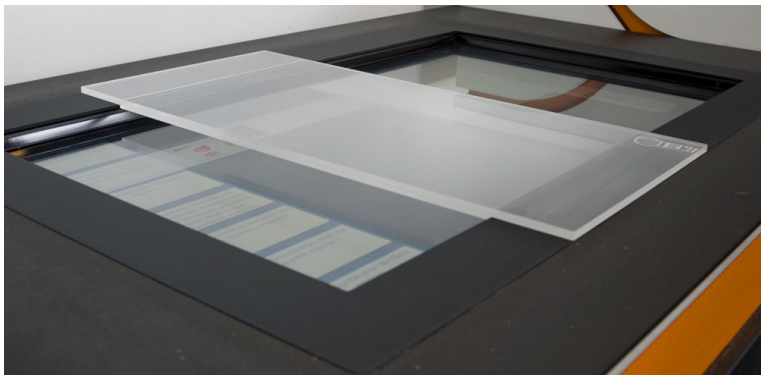

Figure 6.1: Transparent plexiglass slider prevents occlusion on the counter screen.

Because of the problems with the hardware we rejected our idea to recognize objects on the counter screen. This means for our interaction that the user will have to confirm each step. In our user tests with the paper prototype (see 4.4.4—"Evaluation") people actually liked confirming their success after every single step. We will need to take a close look on this for longer recipes and see if people still like it.

We rejected object recognition for our final prototype.

6.1.2 Media Content

We needed new media for this high fidelity prototype as the quality of the first videos recorded was not sufficient. In order to have comparable conditions in our evaluation we did not record specifically for PersonalChef customized media but for the cooking show condition as well. We will explain the different conditions in detail in 8.3.1—"Conditions".

Better quality of video recordings was needed.

For PersonalChef we needed to record videos in three different perspectives:.

1. Upright format behind the stove (see left side of Figure 6.2)
2. Top down wide format on the stove (see Figure 6.2 a))
3. Top down wide format on the kitchen counter (see Figure 6.2 b))

The cooking shows we needed for the other user test condition were cut from the different perspectives in order to give the viewer the same information as she gets with PersonalChef. Then we created DVDs to give the users in advance and asked them to watch it one day before. Samples of the cooking shows can be downloaded at

We tested the same media content for PersonalChef and the cooking shows in our user studies.

- Cooking Show for Salad[1]
- Cooking Show for Main Course[2]

[1] http://hci.rwth-aachen.de/~mennicken/thesis/m-cookingshow-salad.mov

[2] http://hci.rwth-aachen.de/~mennicken/thesis/m-cookingshow-pasta.mov

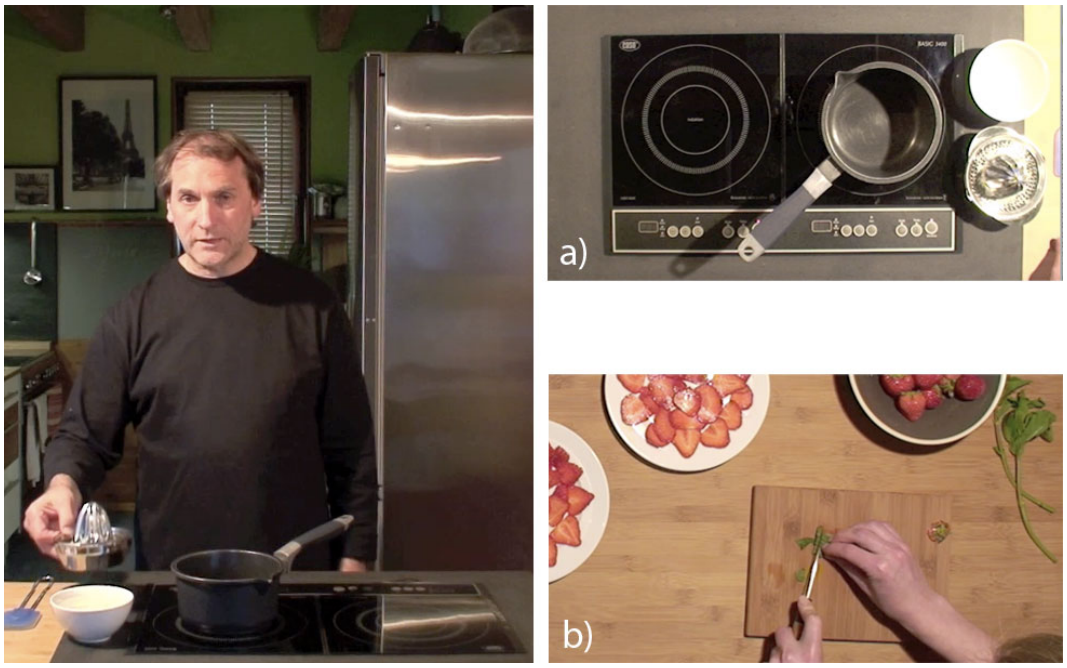

Figure 6.2: On the left side, upright format of video behind the stove. On the right side, a) Top down wide format of video on the stove, b) Top down wide format of video on the kitchen counter.

- Cooking Show for Dessert[3]

For PersonalChef we recorded 61 sequences, which can be found in the movies folder[4].

6.2 PersonalChef Setup

The actual design and construction was part of the final prototype as well. We will describe the physical design process in chapter 7—"Designing a Kitchen". As described in chapter 5—"Second Prototype: Testing Metaphors" PersonalChef consists of two displays: one behind the stove and one built in the kitchen counter.

[3] http://hci.rwth-aachen.de/~mennicken/thesis/m-cookingshow-dessert.mov

[4] http://hci.rwth-aachen.de/~mennicken/thesis/movies/

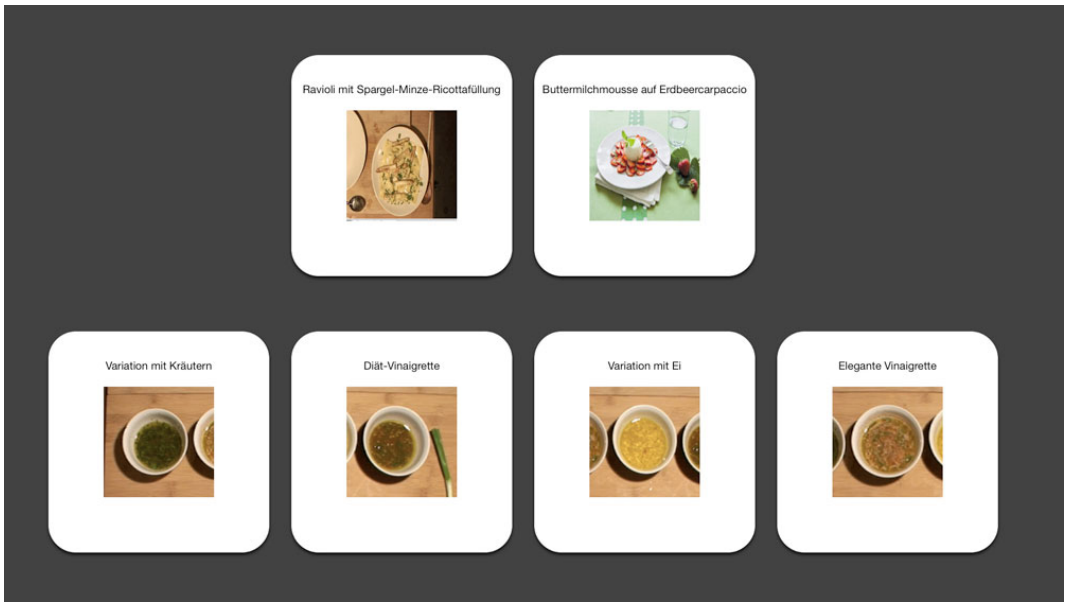

Figure 6.3: This screen offers the user different recipes to select.

6.2.1 Ingredients and Tools Screen

First screen to see by the user offers the selection of recipes.

With PersonalChef people mainly interact with the representation of the recipe on the kitchen counter. The first screen seen by our users is the recipe selection screen (see Figure 6.3). We used a label in addition to pictures of the final result of a recipe.

Alternatives of ingredients or tools are displayed by cards.

When a recipe is selected the user will see an overview of all ingredients and tools needed for that recipe (see Figure 6.4). In this view the user can select alternatives for certain ingredients or tools. For example in this recipe instead of using Parmesan Cheese she could use Grana Padano as well. Alternatives are displayed like holding cards in a hand (see Figure 6.5). If one alternative is clicked it moves to the front to clarify which one is selected. The ingredient chosen in this screen will be used for the text in the later recipe steps. If amount or unit varies, it will be changed in the following steps, too. The representation of ingredients and tools is consistent as they are always displayed as cards in the whole interface. If a user has problems to identify such a card, she can enlarge it by holding the finger onto it (see Figure 6.6).

Figure 6.4: An overview of needed ingredients and utensils gives a preview about the recipe.

Figure 6.5: On the right side: Alternative ingredients are represented as cards. The user can choose between Grana Padano or Parmesan cheese.

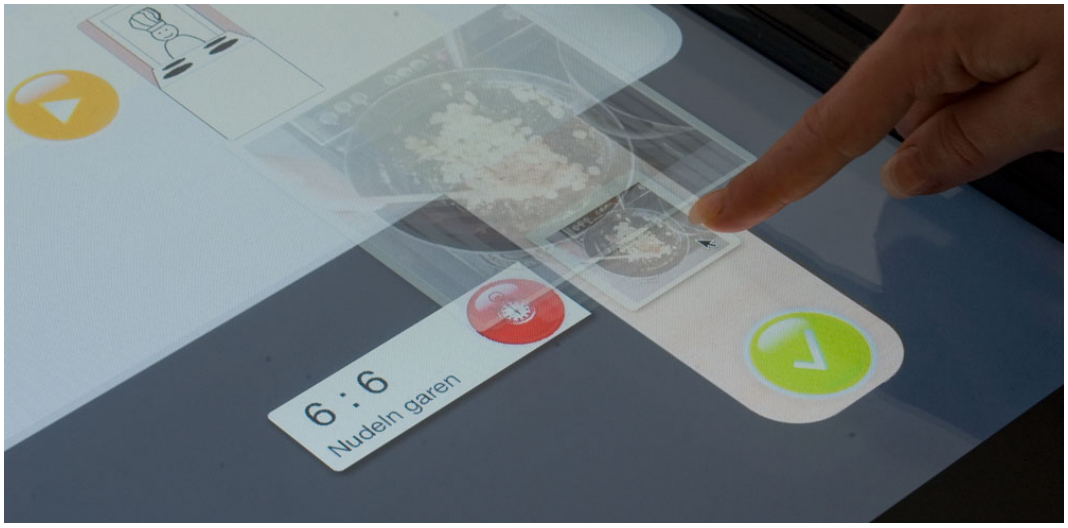

Figure 6.6: Items represented by cards can be enlarged by holding a finger onto them.

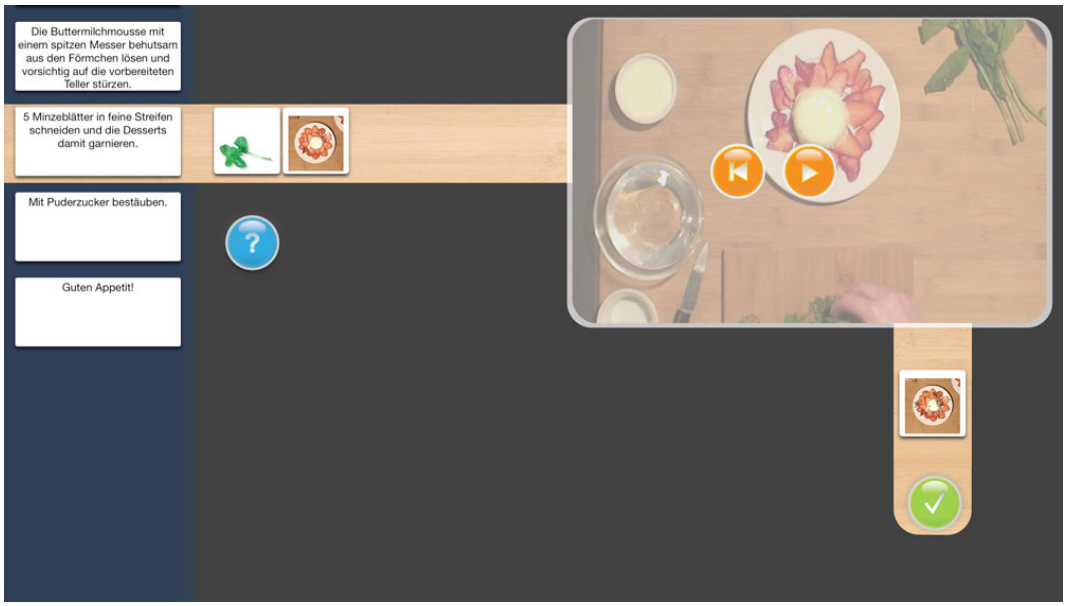

Figure 6.7: Standard interface of PersonalChef for a recipe step.

6.2.2 Preparation View

When the user selects the next step by clicking on the corresponding instructions or on the check mark button, she will get to the first instructional recipe step. The interface is organized as can be seen in Figure 6.7.

Gestalt Law of Continuity is used to create a connection between instruction, ingredients and tools, movie, and outcome.

On the left side is an ordered list of the instructions of the recipe steps. The current step is highlighted by a different background. On the right of the current step we can see the currently needed ingredients and utensils. The connection to the current step is represented by the same background. We use the Gestalt Law of Continuity and use a shape of the same background color to highlight all information about the current step. Good, continuous shapes can be perceived easier and more accurate [Zimbardo and Gerrig, 1999]. Even if the background shape is interrupted the user will perceive it as a whole and connected object.

Following that shape or path to the right side of the screen the user arrives at the movie area. This space is reserved for movie clips about the preparation of a recipe step. Right underneath it is an image of the intended outcome of the

step. This image has the same background color as the other items of the current step to represent their relation. When activating a new step, there will be as many shapes as ingredients moving along that path to the outcome area. Following the Gestalt Law of the Common Fate people perceive elements moving in the same direction and at the same speed as belonging together [Zimbardo and Gerrig, 1999]. Our users should therefore perceive those ingredients and tools as grouped. The movement of the shapes across the video to the outcome image should demonstrate their purpose: they have to be processed in the way demonstrated in the video until the outcome looks like the photo underneath the video.

Gestalt Law of Common Fate is used to demonstrate the relation of items.

People can navigate between steps by dragging the recipe step to the current step position, by clicking on a step, or by clicking on a green check mark to go one step further. As our users had problems to identify the ingredients or utensils as plain black and white icons in our earlier prototypes, we used photos this time instead.

We provide various ways for proceeding in a recipe.

6.2.3 Help and Trivia

We have another button which stands for further information. If people are curious about a certain ingredient or preparation step they can click the question mark and get interesting facts or trivia about some ingredient used in that recipe step or the about the preparation itself. For example in Figure 6.8 the user would get further help on how to cut the asparagus into halves.

Further information can be displayed on explicit request.

6.2.4 Timer Function

Another help on the counter screen is the timer function. In Figure 6.9 a) there is a timer on the right screen, left to the result representation of this recipe step. When it is clicked the button of the stopwatch symbol turns red and the time is counting down (see Figure 6.9 b)). When the result of the earlier step is needed, the user will see the remaining time above the ingredient representation (see Figure 6.9 c))

Timer has as a lock-out function to keep defined preparation times.

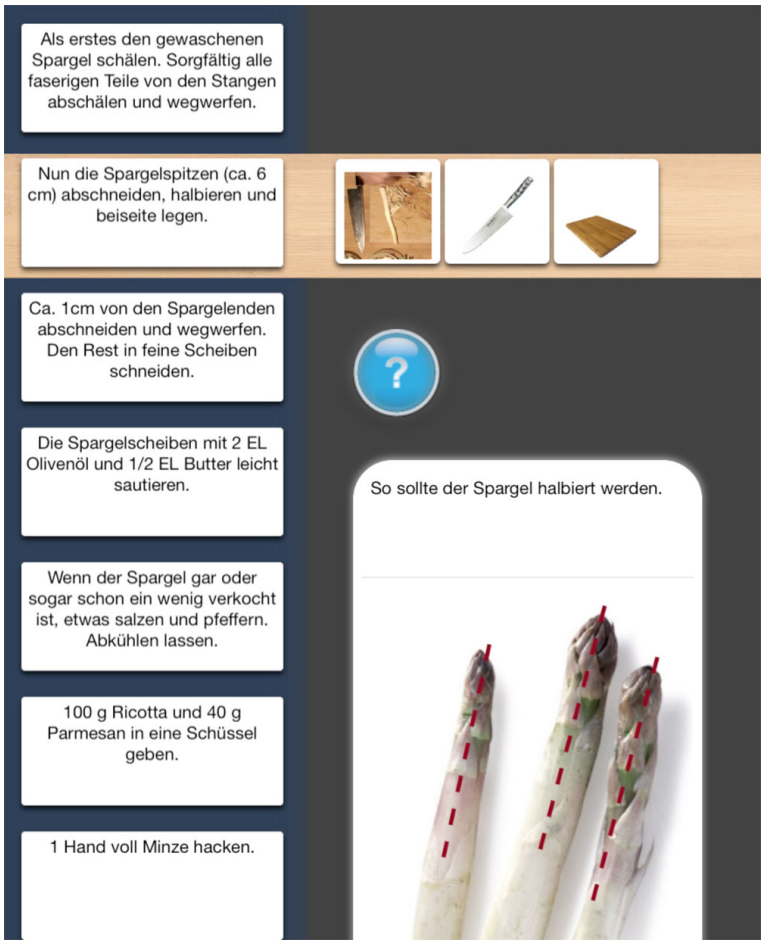

Figure 6.8: Help or trivia for certain ingredients or preparation methods is shown on explicit request.

to prevent him using it too early. Showing the time indicator above the cortresponding ingredient creates a light lockout function. A lockout as described by Norman [2002] is a forcing function which prevents one from entering a "dangerous" state. We cannot physically obviate the user from using ingredients too early, but we can try to remind him.

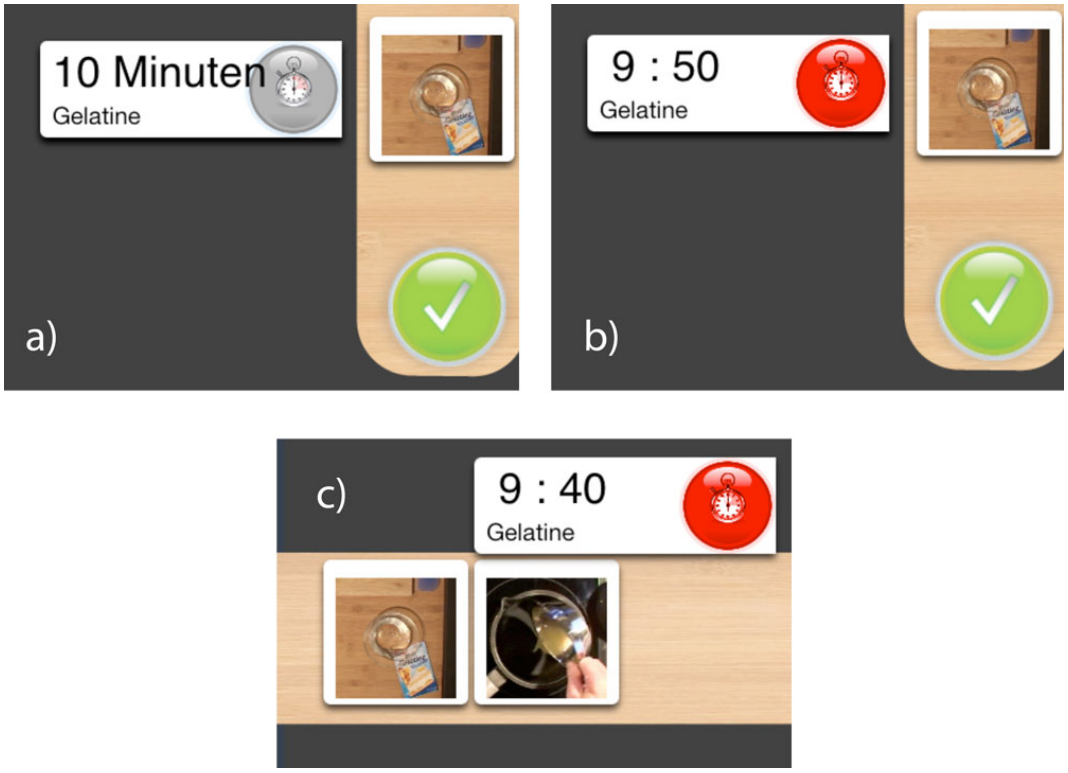

Figure 6.9: Timer representation: a) Timer is not started yet. b) Timer is counting down. c) Timer is displays remaining time above the corresponding item to prevent premature use.

Chapter 7

Designing a Kitchen

"Never trust a computer you can't throw out a window."

—Steve Wozniak

We designed PersonalChef and CAAD kitchen contemporaneously.

In 3—"Creating a Personal Chef" we described the importance of aesthetics; this chapter deals with the actual realization and the physical design process. We integrated PersonalChef into the kitchen belonging to the chair of Computer Aided Architectural Design (CAAD). This kitchen itself was also at an early design stage, so there was a contemporaneous design process of both—CAAD's kitchen and PersonalChef.

Besides aesthetics we had to consider the following conditions, which we describe in this chapter.

- Design should match the general CAAD kitchen design.
- Prototype should be completely usable.
- Construction should allow for reutilization.
- Standard hardware is to be integrated.
- Whole system has to be portable.

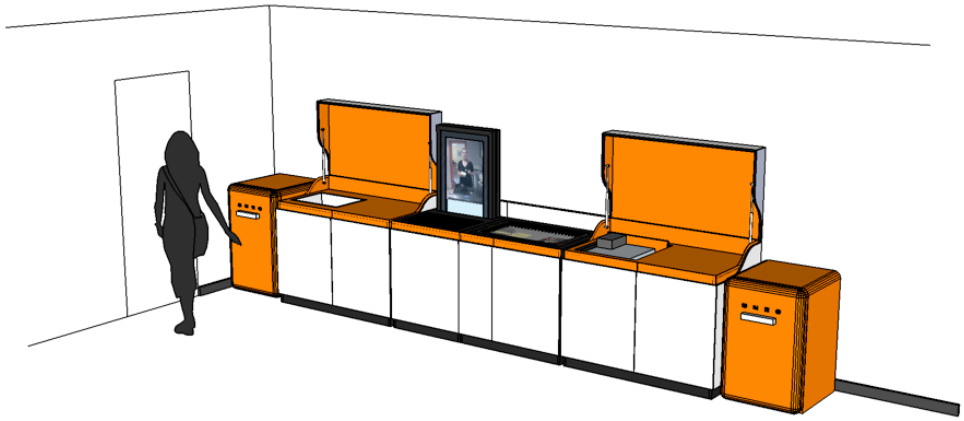

Figure 7.1: The Design of CAAD Kitchen as a 3D model in Sketchup

7.1 Matching Design

The PersonalChef elements should match the style of the CAAD kitchen.

Before constructing the real kitchen, Patrick Lingenberg modelled the CAAD kitchen in Sketchup[1] and we modelled the parts for PersonalChef. All elements should have the same style and fit together (see Figure 7.1). Besides matching materials and colors, that meant for the PersonalChef elements we have fixed measures as well: height, depth, and plinth height.

PersonalChef differs only in the material for the doors.

CAAD kitchen consists of inner and outer corpora. The inner corpora is made of black medium density fiberboards (MDF). The doors are made of MDF as well and have an orange cover made of a new material that consists of aluminium and Resopal[2] . The actually built PersonalChef elements differ only in the material of the front doors. They are constructed in simple MDF as they are to be changed when they are repurposed (see Figure 7.2).

[1] http://sketchup.google.com/

Figure 7.2: PersonalChef in the middle of CAAD kitchen

7.2 Full Functionality

The final goal of this thesis was to have the prototype tested by users cooking on it. For kitchen functionality we would have wanted the screen to be flat and even with the kitchen counter. The hardware at hand, that could be built in flatly, could not be used in a kitchen due to its sensitivity to water or ambient light.

It would be optimal to have the screen embedded evenly into the kitchen counter.

Yet it needed to be used in our user tests the system in a sufficiently illuminated room with direct light for comfortable food preparation. People will use it as regular kitchen counter, therefore we could not obviate the hardware to be spoiled with water or that it needs to be cleaned after use. The PQLabs' screen is a frame of 1.7 cm height with tempered glass underneath. While this causes a disadvantage due to the reduction of working space, we could actually test in real conditions.

System has to be water resistant and insusceptible to ambient light.

7.3 Possibilities to Repurpose

Exchangeable countertops allow repurposing.

The kitchen was to be used without any restrictions as functional CAAD kitchen elements afterwards. For this reason we decided to construct the PersonalChef elements as several modules instead of one single kitchen counter block. As the corpora are planned to be repurposed we decided not to fix the countertop onto the corpus, so it can be changed easily (see Figure 7.3). The countertop with the integrated multitouch technology can be used with a transport box we created for that purpose. Thus, its functionality is independent of the use in the corpora.

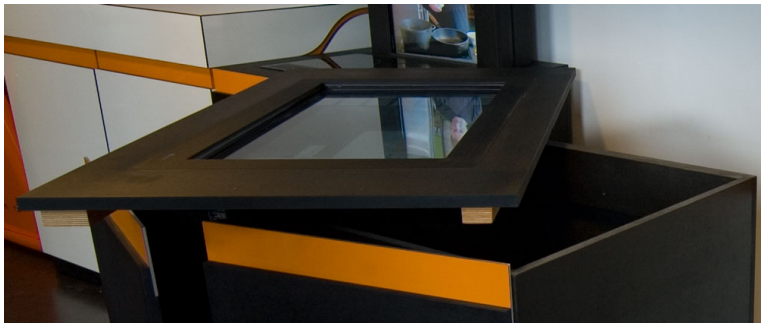

Figure 7.3: Countertop can exchanged quickly. The interactive functional unit can be put in a transport box.

7.4 Integration of Standard Technology

Standard technology has to be protected from dangerous conditions in the kitchen.

We did not use technology which is specially designed for the use in a kitchen. As a kitchen is considered as a rather dangerous environment for technology [Woodruff et al., 2007], we needed to find a design that hides the technology or at least hides the visual aspects of it that seem to be damageable. Heat, humidity, and working tools can become dangerous to delicate materials or parts of the used devices. Therefore, we had to think about how to embed the devices in a way that prevents damage.

The display behind the stove needs to be protected from the heat of the stove, possibly steam of boiling water, and oil

splatters when frying something in a pan. We constructed a box for the display which is open in the back to ensure heat abstraction . The box is basically a wooden frame with embedded washable glass. The multitouch screen itself is very robust and will be sealed into the counter wood. That protects the underlying display (see Figure 7.4) from other damage.

Figure 7.4: PQLabs multitouch overlay on top of LCD TV

Since there were small gaps in the construction of the multitouch screen, which should not be a risk for the technology but could appear doubtful for the users, we decided to cover it with a thin layer of black plexiglass (see Figure 7.5).

Perceived robustness is different to real robustness.

Besides the function of the furniture to protect the hardware, it is important as well to make the hardware invisible to the user to lower inhibitions to use it [Borchers, 2001]. The hardware we used is invisible if the doors are closed giving the impression of a regular kitchen counter (see Figure 7.6).

Figure 7.5: Plexiglass was used to cover gaps between of the multitouch display and kitchen counter.

Technology is integrated, not merely appended.

Especially because the hardware was not designed for kitchen use, we wanted to create a self-contained system. PersonalChef is not furniture with appended technical gadgets, but a part of the kitchen.

7.5 Portable System

Furniture is mounted on castors and designed as modules to keep it portable for demonstrations or other purposes.

For keeping the possibility to move the interactive part of the kitchen away, it is constructed as a kitchen in a box in several modules on castors. Moving will be interesting to give demos about its functionality in other locations than just at CAAD. Since the induction cooker does not need high voltage current, PersonalChef can be demonstrated with full functionality in any place with water and regular power supplies. The box constructed for the screen behind the stove can be lowered inside of the corpora for transport purposes. Inside of the furniture it is protected and can be moved around without any difficulty.

Figure 7.6: On the left side: The open kitchen element reveals the hardware. On the right side: Closing the kitchen element hides all internal hardware.

Chapter 8

Final System Evaluation

"The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' but 'That's funny...'"

—Isaac Asimov

During the development process of our software prototype our feedback was mainly based on Cognitive walkthroughs with colleagues, interested people, and friends. To statistically prove or reject our hypotheses, which we will explain in the following section, we conducted a formal user test on a larger scale.

We found it rather difficult to create realistic user test conditions as cooking in a realistic condition would be at the subject's home, with her utensils and in a familiar atmosphere.

People rate the quality of cooking differently.

Defining how to measure these qualities was hard as well because cooking quality is a highly subjective attribute. When we asked our users what they like about cooking they had quite different opinions: Some people enjoy the process of cooking itself and enjoy cooking a couple of hours, other people prefer to cook as fast as possible and liked especially a successful outcome of a recipe. Given these subjective measurements of quality we decided to adjust our hypotheses to this and asked people mainly about

how they personally perceived information and how confident they felt about their results.

8.1 Hypotheses

The three main hypotheses we wanted to prove are:

1. With PersonalChef users perceive cooking an unknown recipe to be more simple than with a cooking show or paper recipe.
2. With PersonalChef users feel more confident about the success of the intermediate steps than with a traditional paper recipe or a cooking show.
3. The setup[1] of PersonalChef reduces being users' inhibitions of using technology in a kitchen for fear of damaging it.

As well we expected to make the following findings:

- Every user will have enough information but is not annoyed with too much information no matter if she has low or advanced cooking skills.
- The user will have more fun preparing food using PersonalChef than with the other conditions.

8.2 Subjects

We had twelve subjects with an average age of 35.75 years.

For our test we had twelve participants: seven female and five male subjects. They were between 17 and 73 years old, and with an average age of 35.75 years. Five of our participants were students, but their background was varying. We had two housewives, four employees, and one pupil.

[1] By setup of PersonalChef we mean the whole system with form factors, chosen design, and materials used.

People were given a questionnaire in advance to answer some preliminary questions about their cooking skills and behaviors, as well as experience with technology. In average people rated their cooking skills with 3 on a scale from 1(not experienced at all) to 5 (highly experienced) ($min = 2, max = 5, \sigma = 1$). Experience with technology was rated in average with 2.5 on the same scale ($min = 1, max = 5, \sigma = 1.24$).

One test person knew one recipe, so we did not use her answer on the question about rating the simplicity of this recipe.

8.3 User Tests

To verify our hypotheses we asked them to do the following tasks (see right side of Figure 8.1).

1. Prepare a dessert.
2. Prepare a salad vinaigrette.
3. Prepare a main course, self made filled pasta.

8.3.1 Conditions

Each task was to be completed under a different condition (see left side of Figure 8.1) and for each subject in a different order.

P Prepare the recipe with the help of a paper recipe.

C Gave them a cooking show to watch one day before. Prepare the recipe with the help of a paper recipe.

PC Prepare the recipe with the help of PersonalChef.

After the completion of all tasks the user was given another questionnaire, which can be found in appendix A—"Questionnaire". We tried to avoid direct questions about

Figure 8.1: Different conditions and task of the final user tests. On the left side the different conditions can be seen: cooking with a paper recipe, cooking with a paper recipe and having seen a cooking show before, and cooking with PersonalChef. On the right side, there are the different tasks: preparing a salad, pasta, and a dessert.

Indirect questions about the tasks helped avoiding leading questions about the conditions.

the different conditions and used indirect questions about their preferences when preparing a certain recipe. For example instead of asking how much fun he had while using PersonalChef, we asked how much fun he had during the preparation of salad/main course/dessert. In the end we could transform the answers to evaluate the different conditions.

When the setup for the user test and the tasks for the various conditions had been defined, we had one test person cooking all dishes with PersonalChef to find out possible system break downs. This pilot user test provided worthwhile feedback as we adjusted volume of the video playback, brightness, and background color afterwards. Another thing we changed was for example the position of the question mark button as it was not noticed in none of the dishes by our pilot user. This problem did never occur before, when testing the interface in a setting without actually cooking.

After the pilot test we adjusted some settings to optimize our system.

8.3.2 Results

The analysis of our results was done with SPSS[2] , which is a tool for advanced statistical analysis. With its help, we were able to prove some of our hypotheses fully, some with limitations. The SPSS output for hypotheses can be found in the appendix B—"SPSS Results".

First Hypothesis: Simplicity The recipe perceived as easiest is significantly related to the recipe prepared with PersonalChef ($r = .7, p = .05$), when restricting the group to users who prepared main course and dessert with PersonalChef.

Second Hypothesis: Confidence The recipe in which people felt most confident about the success of the results of the intermediate steps is significantly related to the recipe prepared with PersonalChef ($r = .6, p = .02$).

Third Hypothesis: Unconcern In the average people did not fear damaging the technical devices (see Chart 8.2). As well, there is no significant relation between the experience with technology and being concerned to damage the hardware.

[2] http://www.spss.com/

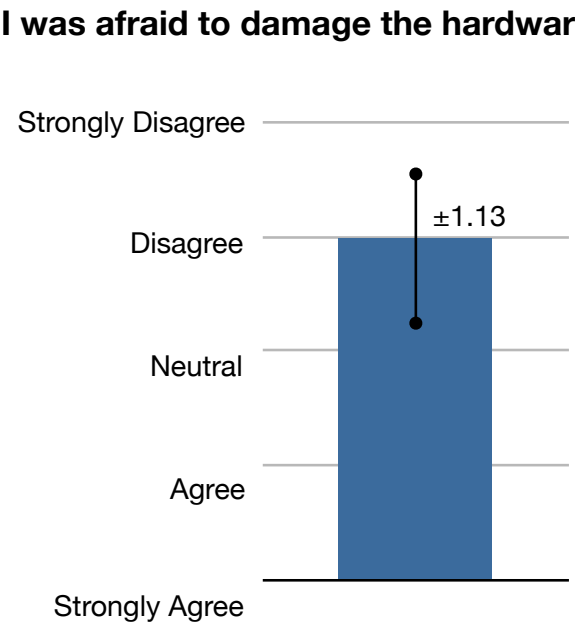

Figure 8.2: Chart about concerns to damage the hardware in our user tests

Information Adjustment There is no significant relation between subject's cooking skills and if they had enough or too much information. Analyzing and comparing the information content of all conditions, or just with PersonalChef we had $r < .38, p > .22$ for all combinations.

Fun There is no significant relation between how people rated fun and under which condition they cooked. But for the main course and dessert people had more fun with PersonalChef than with the other conditions in average (see Chart 8.3).

Other Findings The item icons in the paper prototype were hard to identify for our users; in our final prototype we used photos instead. We asked people how well they could recognize what the items on a Likert-Scale from 1(I strongly agree) to 5 (I strongly disagree). The average of this was 1.42 ($min = 1, max = 2, \sigma = .52$).

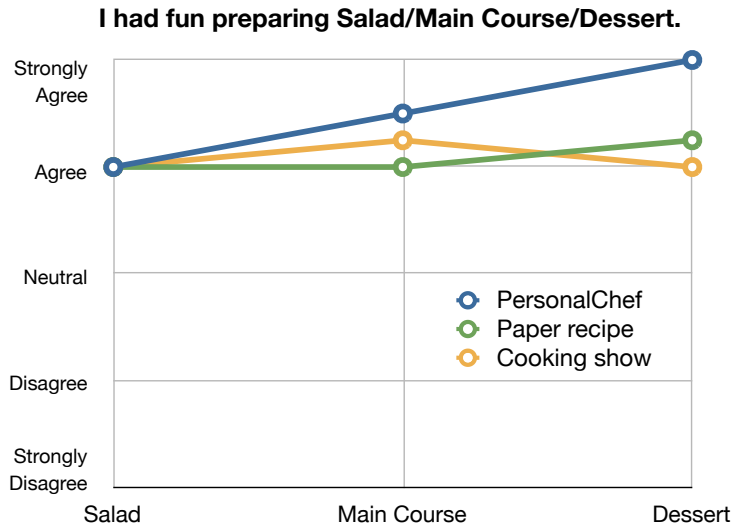

Figure 8.3: Fun rating comparison of the different user test conditions

Subjects were asked if they found the stove screen and the counter screen useful or uncomfortable, both or none. In the average people found both screens useful (see Chart 8.4), with a weaker result for the stove screen.

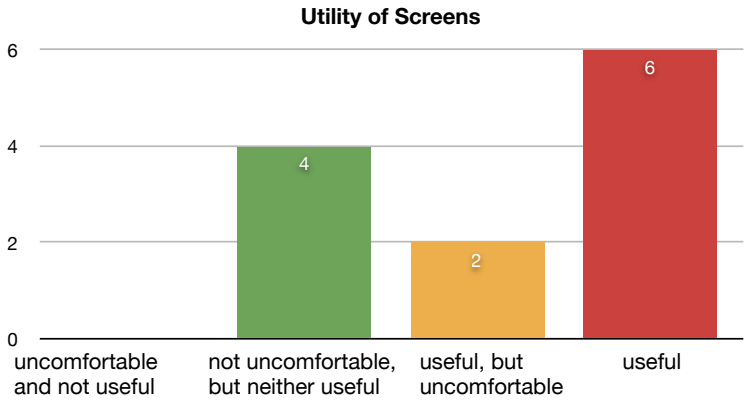

Figure 8.4: Utility comparison of stove screen and counter screen

8.3.3 Discussion

PersonalChef helps to simplify complex recipes.

First Hypothesis: Simplicity We could not prove that all users perceived cooking with PersonalChef as significantly easier in general. But people found preparing main course or dessert with PersonalChef significantly easier.

We did not find an improvement of simplicity for easy recipes.

We think we cannot make a general statement because the recipe for the first dish, a salad, was that easy that people did not need any instructions at all. We assume that PersonalChef performs better than P or C with more difficult recipes, because the helping effect is too weak for easy recipes.

Our system helps to support confidence.

Second Hypothesis: Confidence People feel more confident about the success of the recipe when using our system. Based on our results we think that PersonalChef helps to support confidence during the cooking process.

Users did not fear to damage hardware.

Third Hypothesis: Unconcern We could not find any relation between experience with technology and being concerned to damage the hardware. That means for us that unexperienced people can use our system without any disadvantage.

Since experience with technology might not help lowering thresholds to use it in a different context, it could be interesting to see if that can be shown generally for systems in domestic contexts.

People had just the right amount of information.

Information Adjustment We derive from our results that advanced users are not bothered by the information density of PersonalChef, while beginners always have enough information to let them feel confident. Apparently it is not contradictory to design a single kitchen system for beginners as well as advanced hobby chefs.

Fun In our studies people had fun in general. We could see a light tendency to enjoy cooking with PersonalChef a bit more. This fact needs to be examined in further research with different recipes.

PersonalChef is fun.

Some people stated that they found the stove screen too close and intimidating. The screen, which shows another person in a perspective close to a conversational perspective is just 50 cm away from the user. Sometimes it is even less if the user wants to take a look into the pot or pan while preparing the dish. The private sphere in Germany is defined up until 50 cm. Entering into that zone provokes rejection or even aggression [Preußer, 2008]. This could be a reason why people did not like the stove screen as they liked the counter screen. On the other hand people perceive video windows as windows on another world, rather than a pair of eyes in a remote world [Grayson and Anderson, 2002]. If this is valid for our system as well, the cooking person in PersonalChef should have been perceived as more distant than 50 cm and therefore not in their private sphere.

Proximity of stove screen might invade user's private sphere.

We could not find any relation between time spent on preparing a recipe and a certain condition. Most people that were slower than the average with PersonalChef were slower than the average in the other conditions as well. For the C condition we used just the preparation time and did not add the time to watch the video before.

Using PersonalChef does not take more time than the other conditions.

Similar to the findings in Ju et al. [2001] people stated already in the paper prototype tests that they mainly concentrate on audio, especially when they start working in parallel to a video. Hence it is important to have the person in the video continuously commenting on what he is doing. This way the viewer has always the chance to follow the video even if he does not watch at it closely the whole time.

Audio feedback is especially important.

People with fewer experience took the pictures of tools very literally. This was also observed by Ju et al. [2001] who had children testing their system. For this reason we have to chose the pictures to represent utensils carefully. If for example a big bowl is needed to prepare the dough, than the picture representing this bowl needs to be easily recognized as a bowl of a size that is big enough. Especially when the

Beginners take pictures very literally.

color or the material of the bowl in the picture is different to the utensils in the viewer's kitchen an ambiguous image could lead to misunderstandings. While the bowl on the left side in Figure 8.5 is a big salad bowl, the bowl on the right side is a smaller one. Because of their representation, beginners assumed they have almost the same size.

Figure 8.5: Two different sized bowl are perceived as similar sized.

People seem to cross-check their mental model against the video. If they have any doubt about their understanding of an instruction they check the video focusing on the special thing they wanted to know.

> "There [in the video] I could check up how full a table spoon butter has to be."

Users check their understanding of an instruction in the video to gain more confidence about decisions.

This quote of a test user expresses very well, what she liked about the videos. Especially for vague units such as a table spoon, a pinch, or a handful, people used the possibility to watch videos. But the users do not just follow without reflecting what the videos show, but they abstract what they see and apply it to their own task. Even when the user decided not to follow the instructions given in the video, she felt more confident about her decision. When users did not have the chance to check their ideas of a certain instruction in a video, they became insecure and started asking the test's observer for help. For further tests the experiment observer should be in another room, because answering questions influences the experiment and not answering

them can make the subject insecure.

The system was used in different ways and few mixed those ways:

- Some read all recipe steps on the side bar and just clicked on a certain step if they want to have more detailed information.
- Some watched the videos instead of reading instructions and continued the cooking process by clicking the check mark.
- Some clicked the recipe step they want to do, took all information they could get and continued by clicking on the instructions of the next recipe step.

This result strengthens our assumption that people already have strongly formed habits to cook in a certain way. We could not observe any relation between cooking experience and those groups.

8.4 Further User Comments and Surprising Facts

Most people stated that they especially liked the taste of the dessert, independently from the condition. Possibly they did think about the fun of the whole experience and not merely the preparation process, when rating their fun. This must be taken into account for future tests.

Better taste may influence rating of recipe preparation.

The oldest test user had fewest problem interacting with the touch screen. For example when a button did not react immediately most users tended to hold their fingers for a longer time on the button or pressed harder. In the first case the display will never receive an up event in the defined click interval and no click event will be detected. The second case does not make a difference, because the touch is tracked with infrared light barriers. We think this is because people transfer the metaphors of the computer interface that they usually work with on our system.

People transfer known metaphors to different contexts.

Another example is the use of the tooltip help. People which knew capacitive touch technology like the iPhone expected to see a tooltip or a bigger representation of the object when they clicked it. People who had few or no experience with touch technology understood the ”Hold finger on object” metaphor to get further information easier.

People started talking to the chef in the video as with a real person.

Sometimes our users interacted with the person on the screen like with a real person. They talked to him, or did not do what he does on purpose. It would be interesting to see their reactions if the media content would start conversations with them to provide an immersive feeling.

The analysis of the user test results leads to us to new feature ideas and opportunities to optimize PersonalChef, which will be discussed in the chapter 9.2—“Future Work”.

Chapter 9

Summary and Future Work

"All I ever wanted to do was to make food accessible to everyone; to show that you can make mistakes—I do all the time—but it doesn't matter.""

—Jamie Oliver

In the chapters before we explained our ideas and described the development process of our system—PersonalChef. This last chapter summarizes our work and gives an outlook on future research.

9.1 Summary and Contributions

PersonalChef is an interactive multi-display system for cooking guidance designed for the domestic context of a kitchen. To support the users, they are provided with textual, visual, and audio information while cooking. This information is displayed in-situ on two different displays:

PersonalChef provides multimedia support on two displays.

Stove Screen The display behind the stove offers help to the user by displaying a video in a mirror perspective and a video showing a top down perspective onto the stove.

Screen behind stove shows information about the preparation in this location.

Screen inside the kitchen counter is for interaction with our system and shows preparation of food on the kitchen counter.

Counter Screen The display in the kitchen counter has a multitouch overlay for user interaction. On this display the user gets textual instructions, images of ingredients, tools, and the outcome of a recipe, as well as videos using a top down perspective onto the kitchen counter.

During the development of PersonalChef we created three prototypes, analyzed their value by testing them with users, and modified our design for the next iteration.

1. The paper prototype helped us mainly to see how users deal with information on the kitchen counter and with the planned data representation.

2. The second prototype was implemented in Objective-C. Cognitive walkthroughs provided us with useful feedback about the user's perception of our user interface.

3. The final prototype included the furniture design as well. Presenting the whole system, software and furniture, to the user gave us the chance to observe users when actually cooking with and on our system.

From the basic idea of providing a way to playback cooking shows in an adequate way in the kitchen, we arrived stepwise at our final system. In every iteration we obtained helpful feedback that led to the final version of PersonalChef, which was found helpful by our users and at the same time entertaining.

9.2 Future Work

Based on the features we could not implement, ideas that arouse during the development process, and the feedback of our test users, we will describe possible future research in this chapter.

9.2.1 Object Recognition

In the beginning of this thesis it was planned to implement object recognition to minimize user input . Due to our hardware we were not able to implement this reliably, and therefore we rejected this idea. In our paper prototype we defined some events that the person "playing the computer" tracked, for example lifting up or putting down bigger objects. This was liked by our test persons and should be considered for future research.

Recognition of objects could help to reduce active user input.

9.2.2 Sensors for Context-Sensitivity

We found out that other sensors could be helpful to blend the virtual cooking process in PersonalChef into the real cooking process. For example a temperature sensor above the stove could provide the user with feedback about if the water is already cooking, or if a certain vegetable is done.

Sensors could couple virtual and real cooking processes.

9.2.3 Better Adaptation of Media

We recorded videos to fit the cooking show as well as the PersonalChef system. For future research the system would benefit if the media was directed specifically for . Such customized videos could help people to use the system itself. For example after the explanation of the preparation by the chef in the video, he could give the user positive feedback as "Well done, let's continue with the next step", or he could give clues about the user interface elements. "Now that we have finished this, we need to wait half an hour. Just click the timer next to the video, so you will know when the time's up!"

Instructing chef on the screen could directly interact with the user and give clues about the user interface. PersonalChef

Besides the better adaption of media content, it could be interesting to bring the mirror perspective to an extreme. The eye-gaze and position of a user could be tracked and video content recorded by a 3D camera could be shown in the right perspective (see Figure 9.1).

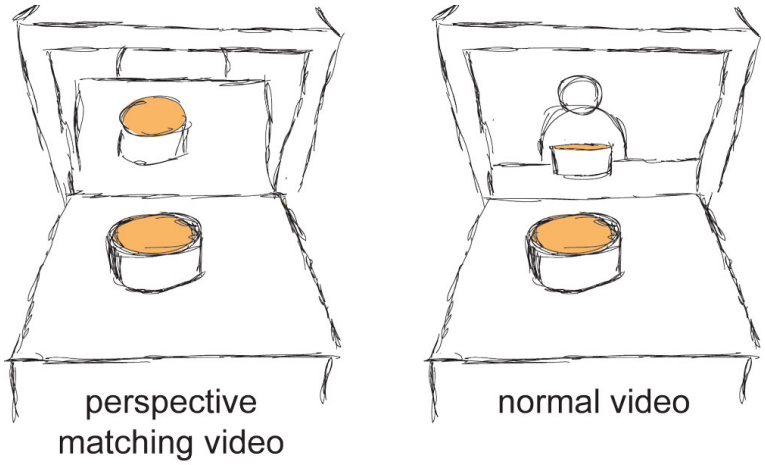

Figure 9.1: On the left side: Perspective matching video playback on the stove screen. On the right side: Regular video playing on the stove screen.

9.2.4 Possible Additional Features

Besides changes of our system itself and additional context-sensitivity, various features could be implemented into the existing system.

Audio recording could help to annotate recipes.

Notes A lot of people add annotations to paper recipes in order to take advantage of their experience with that recipe for the next time they prepare it. In PersonalChef we could extend regular text annotations and record audio, video, or images as well. It could be helpful to install a webcam above the counter screen to enable people to capture a certain state of their cooking process.

Several subjects in our user tests pointed out that an audio annotation function would be helpful as it is easier to record by voice while continuing to cook instead of writing something on the touchscreen.

Entertainment During the cooking process it is likely to have some steps that are pretty time consuming but do not

need a lot of attention for the actual task, for example peeling potatoes or stirring risotto for a long time. Some people in our user tests said they usually feel bored pretty fast and would like to have some possibility to listen to their music library or radio, watch TV or a movie. Other people prefer to talk to friends in the meantime. Including Skype[1] or a phone connection, video telephony could connect them to other people to keep them entertained. Watching and talking to other people in their kitchens is also possibly helpful if one can profit of the other's cooking skills or let them cook the same recipe together.

Offering possibilities to watch movies or talk to friends could entertain people while doing annoying tasks.

Integrated Kitchen Functionalities One test user pointed out that she would like using the plexiglass slider as a kitchen scale so no further equipment would be necessary. Creating the slider with another material would allow to use it as a cutting board as well. Having a barcode scanner or a webcam that could recognize food on the screen would help people to keep track of their food stock. If the system knows about the food stock of a user it could give suggestions for meals with the food in stock or what food to eat for her diet. A helpful feature could be to load a list of missing ingredients onto a mobile device or print out as a shopping list.

Integrating kitchen devices into PersonalChef can create a smoother work flow.

New technical devices in the kitchen like a stove or an oven often have a lots of settings for optimal food processing, for example steam injection into the oven. Possibly it is too demanding for people not used to it. If PersonalChef could connect to that device and change settings, people familiar to the technical device could give settings suggestions and add it as annotation to the recipe, that a beginner user could use.

Integrating video conferencing or communication with other people would allow users to benefit from other's experience.

Features for Nutrition Awareness If the system would be connected to the internet and by this to numerous nutrition databases it could link from ingredients directly to the information in the database. It could offer possibilities to calculate how many calories should be consumed every day and how many calories the user already had.

PersonalChef could act as reminder for nutrition facts or diets.

[1] http://www.skype.com

We could offer the possibility to show suggestions on how to serve a certain dish.

Information could also be about positive side effects or just interesting trivia about ingredients, like where they come from or when it is main season for a certain vegetable, or just connect to the Wikipedia[2] entry about it. If the user chose a certain recipe it could give suggestions by images or video how to serve the food in a decorative way or which beverages are suited to be served with.

Local companies could advertise special offers about ingredients of the recipe chosen by the user.

Commercial Functions PersonalChef could have a connection to the surrounding supermarkets and highlight recipes with ingredients that are on sale. Possibly in the future you could also just click on a recipe, the system checks what you have at home and orders the missing ingredients in the closest supermarket, where they can be picked up or you can have them delivered at home.

As more and more new buildings have possibilities for home automation, the screen in the kitchen could become a screen for house controlling as well. For example you could want to get information about the heating in certain rooms, if windows are opened or the time remaining till the washing machine finishes. In a lot of cultures the kitchen is a center of the life in a home [Bell and Kaye, 2002] and this position could be optimal as a "control center" for the whole house.

Recipe could be offered as free or well-priced Podcasts.

Supply of Recipes If people could record their own recipes, it would be possible to offer these videos in a format readable by PersonalChef. Some people said they would imagine getting recipes as Podcasts[3] in iTunes[4] . They would have a digital library online where people can offer their recipes for free or chefs would offer professionally recorded "PersonalChef recipes" for a fair price.

[2] http://wikipedia.org/
[3] http://www.apple.com/itunes/whatson/podcasts/
[4] http://www.apple.com/itunes/

9.2.5 Other Ideas

It could be interessting to apply the concept of in-situ information in two different perspectives to other problems in the domestic or professional context as well. To find that out, it would be helpful to have a smaller mobile version of the system, that people can carry to their location of their problems, as outside for changing tires on a car, another room for sewing a dress or even changing diapers.

Further research should test the two-display concept in different domestic situations.

In our user tests more than half of the people cook at times or regularly with someone else. Therefore implementing features to support collaborative cooking could be interesting as well. Not just cooking with somebody else in person but cooking with somebody via video transmission could help to support especially beginners.

Chapter 10

Epilogue

This chapter describes my personal experiences in this interdisciplinary project. It is not a scientific part of this thesis.

Obviously, I have a strong interest in cooking but I like technical gadgets as well. So a combination of both just seemed perfect for me. Having specialized in media computing and with my subsidiary studies in architecture, I had the chance to make this idea become real. Developing in an interdisciplinary context sometimes required patience and appreciation. But more importantly, it created interesting and fruitful discussions. It is essential to find the right way to communicate opinions and positions. I found two things really interesting while working in an interdisciplinary context:

Progess can be invisible to someone else's eyes. While architectural progress can often be seen and followed (for example when creating a building plan), programming can be invisible. Sometimes I had to work on "invisible" things for the architects, for example integrated the UDP server implementations. For more than a week, there was few visible results. The biggest sense of achievement was finally getting console output. So several days of work may not change anything in a visible way, but one day after finally everything works.

Thinking in only one discipline may limit your ideas. Trying to solve a problem that occurred in the development kit of the hardware, I wanted to solve it with programming. I struggled with the SDK of the hardware we used for some time, thinking that if I just spent enough time on it, I would finally find a solution. When I found out, that the hardware just does not allow for the function I was looking for, I started to become desperate. I thought, that this will ruin everything. When talking with an architect, he made me realize that sometimes even virtual problems can be solved by adapting with real life objects to the disadvantageous circumstances. A simple slider of plexiglass solved the problem.

It was a unique experience and if there had not been all those dialogues with both sides, PersonalChef would have never been a completely built, working, and good looking system.

Appendix A

Questionnaire

Benutzerstudie zu PersonalChef

ich bitte Dich, die folgenden Fragen zu beantworten. Falls Du Dir bei irgendetwas nicht sicher bist oder Fragen hast, warte mit dem Ausfüllen einfach bis zum Nutzertest.

Besten Gruß und vielen Dank für Deine Teilnahme,

Name:	Geschlecht: ☐ männlich ☐ weiblich
Alter:	Beruf:

Einverständniserklärung

Hiermit gebe ich mein Einverständnis zur Verwertung angegebener Informationen und Daten, sowie der Videoaufnahme des gesamten Nutzertests.

Bei der Verwendung meiner Angaben in Veröffentlichungen oder Präsentationen, wird mein Name, sowie jegliche Information die mich eindeutig identifizieren würde geändert oder weggelassen. .

Die Videoaufnahmen werden benötigt, um die Ergebnisse des Tests zu einem späteren Zeitpunkt detaillierter auswerten zu können.

Die Aufnahmen werden ausschließlich für Zwecke der Diplomarbeit verwendet und an niemand Drittes weitergegeben.

Falls es zu einer Verwendung von Bildmaterial in Veröffentlichungen kommen sollte, wird mein Gesicht entweder unkenntlich gemacht oder meine explizite Erlaubnis erfragt.

Datum, Unterschrift: _____

Kocherfahrung

Ich koche seit ___ Jahren. (grobe Angabe genügt)	
Meine Kochfähigkeiten benote ich mit folgender Note zwischen 5 (sehr erfahren) und 1(sehr unerfahren).	_____
Schaust Du Kochsendungen?	☐ nie ☐ selten ☐ hin und wieder ☐ regelmäßig
Ich habe schonmal ein Rezept aus einer Kochsendung nachgekocht.	☐ ja ☐ nein

Ich koche meistens nach...	☐ Kochbüchern ☐ selbstgesammelten/selbstgeschriebenen Rezepten ☐ ohne Rezept ☐ Kochsendung ☐ anderes _____ (bitte eintragen)
Wie oft kochst Du?	☐ jeden Tag ☐ mehrmals die Woche ☐ mehrmals im Monat ☐ seltener ☐ garnicht
Kochst Du gerne?	☐ überhaupt nicht ☐ nein ☐ neutral ☐ ja ☐ ja, absolut
Aus welchen Gründen kochst Du?	☐ alltägliche Ernährung ☐ Hobby ☐ soziale Aktivitäten (z.B. Feste, Freunde einladen)
Kochst Du mit jemanden gemeinsam?	☐ nie ☐ selten ☐ hin und wieder ☐ regelmäßig

	Ich stimme absolut zu.	Ich stimme zu.	neutral	Ich stimme nicht zu.	Ich stimme überhaupt nicht zu.	keine Antwort
Bei unbekannten Rezepten fühle ich mich unsicher.	☐	☐	☐	☐	☐	☐
Häufig sind mir Fachbegriffe in Rezepten nicht bekannt.	☐	☐	☐	☐	☐	☐

Technikerfahrung

Meine Kenntnisse im Umgang mit Computern benote ich mit folgender Note zwischen 5 (sehr erfahren) und 1 (sehr unerfahren).	_____
Wie oft benutzt Du den Computer?	☐ jeden Tag ☐ mehrmals die Woche ☐ mehrmals im Monat ☐ seltener ☐ garnicht
Hauptsächlich nutze ich den Computer zu folgenden Dingen...	(bitte eintragen) _____ _____

	Ich stimme absolut zu.	Ich stimme zu.	neutral	Ich stimme nicht zu.	Ich stimme überhaupt nicht zu.	keine Antwort
Ich kenne den Umgang mit Touch-Technologie. (z.B. durch Kiosksysteme, iPhone„)	☐	☐	☐	☐	☐	☐
Im Umgang mit Computern fühle ich mich sicher.	☐	☐	☐	☐	☐	☐

Benutzerstudie zu PersonalChef

Testreihenfolge: 1) D: 2) V: 3)H: Datum:

Name:	Geschlecht: ☐ männlich ☐ weiblich
Alter:	Beruf:

Fragen zum Benutzertest

	Vorspeise	Hauptspeise	Nachspeise
Ich hatte das Gefühl die Zwischenschritte immer richtig ausgeführt zu haben am stärksten bei der Zubereitung der....	☐	☐	☐
Am einfachsten nach zu kochen war für mich die...	☐	☐	☐
Kanntest du das Gericht der .... ?	☐ ja ☐ nein	☐ ja ☐ nein	☐ ja ☐ nein

		Ich stimme absolut zu.	Ich stimme zu.	neutral	Ich stimme nicht zu.	Ich stimme überhaupt nicht zu.	keine Antwort
Ich hatte stets ausreichend Informationen zur Zubereitung des aktuellen Kochschrittes.	Vorspeise	☐	☐	☐	☐	☐	☐
	Hauptspeise	☐	☐	☐	☐	☐	☐
	Nachspeise	☐	☐	☐	☐	☐	☐
Ich hatte zuviel Informationen, die für mich nicht relevant waren.	Vorspeise	☐	☐	☐	☐	☐	☐
	Hauptspeise	☐	☐	☐	☐	☐	☐
	Nachspeise	☐	☐	☐	☐	☐	☐
Das Kochen des Rezeptes hat mir Spaß gemacht.	Vorspeise	☐	☐	☐	☐	☐	☐
	Hauptspeise	☐	☐	☐	☐	☐	☐
	Nachspeise	☐	☐	☐	☐	☐	☐

Fragen zu PersonalChef

	Ich stimme absolut zu.	Ich stimme zu.	neutral	Ich stimme nicht zu.	Ich stimme überhaupt nicht zu.	keine Antwort
Die zusätzlichen Informationen zu den Zutaten und Utensilien waren hilfreich.	☐	☐	☐	☐	☐	☐
Ich hatte Sorge, dass die Geräte beim Kochen Schaden nehmen könnten.	☐	☐	☐	☐	☐	☐
Ich war abgelenkt durch die Bewegungen auf dem Bildschirm.	☐	☐	☐	☐	☐	☐
Die Abbildungen der Gegenstände waren zu erkennen.	☐	☐	☐	☐	☐	☐

Ich könnte mir vorstellen, PersonalChef zuhause zu nutzen.

☐ ja zu welchen Gelegenheiten? (bitte eintragen)

_____

_____

☐ nein aus welchen Gründen nicht? (bitte eintragen)

_____

_____

Den Herdbildschirm fand ich...

☐ fand ich störend.

☐ fand ich nicht störend, aber auch nicht nützlich.

☐ fand ich nützlich.

☐ fand ich nützlich, aber auch störend.

Den Bildschirm in der Arbeitsfläche fand ich..

☐ fand ich störend.

☐ fand ich nicht störend, aber auch nicht nützlich.

☐ fand ich nützlich.

☐ fand ich nützlich, aber auch störend.

Am Herdbildschirm fand ich gut:

(bitte eintragen)

_____

_____

Am Herdbildschirm fand ich schlecht.

(bitte eintragen)

Es wäre toll, wenn PersonalChef auch folgende Sachen könnte.

(bitte eintragen)

Weitere Ideen, Meinungen, Kritik und Vorschläge

(bitte eintragen)

Vielen Dank für Deine Teilnahme am Benutzertest und an der Umfrage!

Appendix B

SPSS Results

	Recipe prepared with PersonalChef	
Recipe perceived as easiest	Pearson Correlation	.707
	Sig. (2-tailed)	.050

Table B.1: Correlation between recipe prepared with PersonalChef and recipe perceived as easiest

	Recipe prepared with PersonalChef	
Recipe in which user felt most confident with	Pearson Correlation	.642
	Sig. (2-tailed)	.024

Table B.2: Correlation between recipe prepared with PersonalChef and recipe users felt most confident in

Recipe prepared with PersonalChef	min	max	$Mean$	σ
Salad	2	4	3.00	1.155
Main Course	3	5	4.50	1.000
Dessert	4	5	4.5	.577

Table B.3: Descriptive statistics about concerns to damage the hardware

Test Condition	N	min	max	$Mean$	σ
Paper	12	1	3	3.00	.42640
Cooking Show	12	1	3	3.00	.66856
PersonalChef	12	1	4	4.00	.90453

Table B.4: Descriptive statistics of fun rating

Rating of stove screen	Frequency	Percent
uncomfortable and not useful	0	0
not uncomfortable, but neither useful	4	33.3
useful, but uncomfortable	2	16.7
useful	6	50.0
Rating of counter screen		
uncomfortable and not useful	0	0
not uncomfortable, but neither useful	1	8.3
useful, but uncomfortable	4	33.3
useful	7	58.3

Table B.5: Descriptive statistics about the utility of the two displays

	Rating of Cooking Skills	
Salad		
I had enough information to prepare the recipe steps.	Pearson Correlation	.250
	Sig. (2-tailed)	.516
I had too much irrelevant information.	Pearson Correlation	.375
	Sig. (2-tailed)	.320
Main course		
I had enough information to prepare the recipe steps.	Pearson Correlation	-.204
	Sig. (2-tailed)	.598
I had too much irrelevant information.	Pearson Correlation	-.341
	Sig. (2-tailed)	.278
Dessert		
I had enough information to prepare the recipe steps.	Pearson Correlation	-.202
	Sig. (2-tailed)	.602
I had too much irrelevant information.	Pearson Correlation	.380
	Sig. (2-tailed)	.223

Table B.6: Correlation between skills and information amount. Skills are rated from 1 (not experienced at all) and 5 (highly experienced).
The statements are rated on a Likert-scale from 1 (I strongly agree) to 5 (I strongly disagree)

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