Sketching a set of multi-touch design principles

School of Arts and Communications - K3

Interaction design
Bachelor Thesis

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Abstract

Today multi-touch technology is the basis for many new techniques designed to improve interactions with computers and mobile devices. It seems that multi-touch screen interface makes the user handling very natural in the sense that there is no need for a manual in how to interact with the object on the screen.

The aim with this paper is to establish a fundamental set of design principles intended specifically for large multi-touch interfaces. To reach this goal we have implemented a couple of sub-goals beforehand:

It was essential that we acquired a good understanding of the current state of the multi-touch interface and the different implementations that exist today. To make this possible we constructed a multi-touch display, "Rosie". Knowing how the hardware is produced today will help us understand the limitations and also the possibilities of the design implementations today and in the future.

We also needed to devise a sound interaction design process that conveys the modern designers work. During this design process four methods were implemented that gave us deeper understanding how to reach the result in this paper (design principles). The methods are: Qualitative conceptualisation, Qualitative user-testing, Participatory design, and Iterative prototyping. Doing these methods we gained knowledge through the process and experience of for example, building, running workshops, doing video-prototypes and etc. Creative design was very relevant in our design process.

The result in this paper is a foundation for a set of design principles with relevance for multi-touch interfaces and a interesting design process for developing multi-touch applications.
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<td>2D</td>
<td>Two-dimensional</td>
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<td>3D</td>
<td>Three-dimensional</td>
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<tr>
<td>ACM</td>
<td>Association of Computing Machinery</td>
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<td>CHI</td>
<td>Computer Human Interaction</td>
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<td>CRT</td>
<td>Cathode Ray Tube</td>
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<td>CSCW</td>
<td>Computer supported cooperative work</td>
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<tr>
<td>DI</td>
<td>Diffused Illumination</td>
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<tr>
<td>DVD</td>
<td>Digital Versatile Disc (orig. Digital Video Disc)</td>
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<tr>
<td>FTIR</td>
<td>Frustrated Total Internal Reflection</td>
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<td>HCI</td>
<td>Human Computer Interaction</td>
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<tr>
<td>IR</td>
<td>Infrared</td>
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<td>LCD</td>
<td>Liquid Crystal Display</td>
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<td>OUI</td>
<td>Organic user interface</td>
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<tr>
<td>O/S</td>
<td>Operating System</td>
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<td>PDF</td>
<td>Portable Document Format</td>
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<td>PSD</td>
<td>Planar Scatter Detection</td>
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<td>SIGCHI</td>
<td>Special Interest Group on Computer-Human Interaction</td>
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<td>TV</td>
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Acknowledgements

Our work for this paper did not start with the course “Final Project”. It started almost one year before, when we met the representatives of two companies based in Sweden that are pioneers in their respective fields of multi-touch technologies.

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Over the past academic year we've had the privilege of focusing all our work on one single field of interaction design. The most interesting and active fields today both in computer science and interaction design are multi-touch interfaces. For giving us this opportunity we'd like to thank our teachers, instructors and staff at Malmö University, K3.

We'd especially like to thank our interviewees for their generosity with their time and expertise.

A tip of the hat to Kajsa Oehm for the excellent suggestions to this paper.
1. Introduction

Many of us had encounters with touch-sensitive interfaces in different shapes and forms that were incorporated into a range of divergent contexts, from travel kiosks to personal communication devices.

The most ubiquitous of these implementations are the self-service kiosks found at banks or airports. These interfaces usually allow for only one single input-point and have as such not forced any major adjustments to the most common interface paradigm used today - keyboard and mouse.

Because these single-point touch-sensitive interfaces resemble the mouse-type interaction we can assume it inherits a lot of the same qualities. As such the design principles for single-point touch-sensitive interfaces do not deviate a lot from general HCI principles.

Due to the relatively minor changes in design principles, the introduction of it has been less complicated than that of the multi-point touch-sensitive interface which still lacks a proper design definition.

As a consequence, multi-touch interfaces have not had the same impact on retail merchandise as the single-touch interfaces have. Even though the technology has been available for over 20 years (Mehta, 1982) most of the currently available platforms exist in research facilities around the world or in a purely educational format. Of course there are some exceptions, such as the popular iPhone and iPod Touch (Apple Inc, 2009).

With the introduction of packaged systems such as the Microsoft Surface (Microsoft Corporation, 2009), however, the public awareness of this type of interface has experienced an almost explosive development the past two years.

As the publicity grows, more resources are being invested into the area. But, most of these resources have been focused on perfecting old techniques or finding new solutions for implementing multi-point touch-sensitive interfaces in arbitrary environments.

Arguably, very little resources have been spent researching how this interface affects us and how we affect it. Questions such as “In which contexts does this interface make sense?” or “How do we exploit the technical features of this interface to the fullest when designing its use?” still remain partially unexplored.

Most of the known multi-touch interfaces today exist as a purely technical proof-of-concept, the interface and interactions have remained fairly static since Myron Krueger first published his work, Videoplace (Krueger, 1985).

Videoplace was the first work that successfully explored how the human body could be employed as the point of interaction. His work remains very topical still today, over 25 years post-publication. Today, this particular style of interaction is popularly referred to as "Organic Interaction" or “Organic User Interface”.

In their introductory article for the 2008 Communications of the ACM Vertegaal & Poupyrev (2008) define the term “Organic User Interface” such as:

“User interfaces with non-planar displays that may actively or passively change shape via analogue physical inputs.” (Vertegaal, R. & Poupyrev, I. 2008, p.5)

Of course, this is a rather broad definition and doesn't suit us very well. Instead, we would like to focus on the act of interaction rather than the composition of the interface.

The part/s of our body we use for everyday interaction with arbitrary artefacts is not limited to
fingers. The palms, the arm, the entire body, are all potentially usable.

We wish to employ the terms “organic” and “organic interaction” for such interfaces where the interaction is direct and the act more closely resembles what our bodies are capable of. Instead of clicking the login button we shake hands, instead of dragging an icon to the virtual trash with the mouse pointer can we rub on it with our palms (Barrajon & Göransson 2008).

This is not the entire truth though, a digital interface can only be extended so far to simulate the physical world and multi-touch interfaces are no exception.

In their comparative study, Terrenghi, et al., (2007) examined the differences between digital and physical interactions when manipulating and sorting media. They found that both the digital and the physical world had specific qualities that could not, and perhaps should not, be simulated by their counterpart.

“In terms of design, this implies that the simple mimicking of physical space through graphical representation, multi-touch input, and the like may not be sufficient to encourage interaction which is really like the physical world.” (Terrenghi, et al., 2007, p.8)

Terrenghi, et al., continue their conclusions stating that it is essential that we understand the differences between the qualities of the digital and the physical world since our lives change to become more digital every day. These changes need to be designed to improve our lives rather than obstruct and complicate it.

Our observation then is that the digital and physical design of the multi-touch interface needs to be adapted to exploit the qualities of the interface better than has been done so far.

One of our own hypotheses depicts the multi-touch interface as something socially intuitive. We believe that there exists a social quality in the large interactive screen that should be exploited as an essential ingredient when implementing it into an environment.

In the studies (Brignull, et al., 2004)(Peltonen, et al., 2008) the authors examined the implications large, shared, interactive screens have on public spaces. They focused on finding social patterns and conflict management between different user groups and also within specific user groups.

Morris, et al., (2004) examined another interesting aspect of social interaction at large interactive screens. They focused on cooperative gestures and how they affect users of different backgrounds and in different contexts. Similar to Morris’ study, Linebarger, et al., (2005) analysed if synchronous work at a shared interactive screen would help the users form a set of common mental models of problems and solutions.

We consider all these discussions highly relevant for our continued work. To define a fundamental set of design principles for multi-touch interfaces we need to form an understanding of the different social configurations available at the large multi-touch screen.

The idea that we need to redefine the principles of interaction design as the interfaces evolve is fundamental for this work. We believe that the multi-touch interface needs a defining use that separates them from standard WIMP interfaces, both in their physical shapes and their digital implementations.

Our intentions are to establish this set of fundamental design principles for use at large multi-touch screens. We will begin our journey by defining a hypothetical set of principles and continue with several different methods that will aid us in constructing the foundation for this set of design principles.
1.1 Hypotheses

These are the hypotheses we have formed for this work, the report describes the process of elaborating and grounding their articulation in the empirical work we have carried out.

I. Single or multi-user interactions at a multi-touch surface might benefit from spatially related sound feedback.

II. Multi-user interactions at a multi-touch surface might benefit of the implementation of sound feedback that is individual to each user.

III. Gestures can easily be misused on multi-touch interfaces. They could expose the user to physical strain in the long run.

IV. Restricting the amount of needed objects on the screen to reflect the amount of available users currently active at the interface could possibly enhance the social interaction and hence also the collaborative effect on the group.

V. A multi-touch interface should not try to emulate a standard WIMP interface, interactions such as typing on a keyboard would perhaps not be suitable for a touch-sensitive interface due to the lack of tactile feedback.

VI. Collaborative interactions at a shared tabletop surface might form temporary social bonds between users, enhancing their experience of interacting as one large unit with a shared goal rather than several smaller units with similar goals.

VII. In a collaborative setting, the multi-user interface should moderate the individual ownership, focusing on the group of users rather than the single user.

VIII. In a non-collaborative work setting each user should have the ability to own their personal workspace and the objects within.

IX. The inherent ability of the human mind to memorize spatial position and landmarks should be exploited more in multi-touch interfaces since it is a more direct interaction compared to standard WIMP interfaces.

X. The standard graphical WIMP interface should not be used since it was mainly designed for keyboard and mouse interaction. The multi-touch surface allowing for several unique points of interaction should use either a different type of menu system or a completely new graphical interface.

XI. We need to develop a clear graphical standard what constitutes an interactive object and what actions this object supports. A button on a multi-touch might have a different use-case than it does in a WIMP interface.

XII. In a non-collaborative setting, the interface should support personal work around and on the interface.

XIII. Due to the more direct interaction, the applications available at a multi-touch interface should have a different way of visualising the interchangeable connections available compared to today's WIMP interfaces.

XIV. In a non-collaborative setting, users should have the possibility of owning the territory around and on the interface.

XV. Since the multi-touch interface is a more social interface than the keyboard & mouse counterpart, the conflict management should reflect this and rely more on the users' own ability to moderate themselves and each other.
1.2 Problem Statement

The essence of this work is to develop a set of design principles which goal is to aid the designer when developing applications intended specifically for use at multi-touch interfaces.

A majority of the currently available multi-touch applications have been developed as a technical proof-of-concept. There seems to be a distinct lack of accepted published standards for developing applications at large multi-touch interfaces.

Due to the size and the specific details of this work it is essential that we work closely knit as a group with the same goals to reach a well-defined fundamental set of principles and a sound design process.

Therefore we have taken the concept of collaborative design seriously, for that reason there is no clear division of work to be observed. We have jointly taken responsibilities for the work and share the same interest in the research questions posted.

1.3 Questions

What does the initial design process look like when establishing this foundation and how can we define a design process that can be re-used in arbitrary design environments as part of the design principles?

How can we define a fundamental set of design principles for large multi-touch screens and how should we convey them for the end-user?
1.4 Goals

Although a common strategy for acquiring knowledge in a specific field of development is to design a proof of concept application, we wanted to achieve a more holistic understanding of the multi-touch platform. In order to emphasize this approach we have been working closely with the materials of multi-touch technology (software and hardware).

During this time we studied the current field of multi-touch research and developed a process to understand the pre-conditions necessary for designing in new and unexplored fields such as multi-touch.

Our approach rests upon a belief in the strengths of both collaborative design and user participation in the design process.

Our primary goal for this work is to articulate a fundamental set of design principles intended specifically for large multi-touch interfaces.

To reach this goal we have set several sub-goals, each of the sub-goals respond to a specific task which is relevant for our project to succeed.

I. It's essential that we acquire a good understanding of the current state of the multi-touch interface and the different implementations that exist today.

II. Knowing how the hardware is produced today will help us understand the limitations and also the possibilities of the design implementations today and in the future.

III. We also need to devise a sound interaction design process that conveys the modern designers work.

Having successfully reached all these sub goals it should be possible to establish a foundation for a set of design principles and also pass on knowledge of a design process that can be implemented when designing applications intended for multi-touch interfaces.
1.5 Document Layout

Chapter one includes the introduction to this work. The background of the problem-area is explored and a problem statement is formed together with a set of questions for this thesis.

Chapter two contains a detailed explanation to the interface; it explains the technical details briefly. A short overview of the history of touch-sensitive interfaces is also introduced.

Chapter three presents projects related to this. Most of these projects are directed towards the social aspect of interfaces – cooperation and collaboration.

Chapter four explains in detail our approach for solving our problem. The core method is presented and within it each sub-method is introduced.

Chapter five details the conclusions for this work, our results are presented and analysed. There is also a brief exploration into the future for this field.

The DVD included in this work contains all video material presented in this work.
2. Definitions

2.1 Definitions of multi-touch

A multi-touch interface is a surface or object that is able to detect multiple simultaneous and unique touch-points of human fingers and/or hands. Movements created by using the hand/fingers across the display are known as gestures.

Gestures are any physical movement that a digital system can sense and respond to without the aid of a traditional pointing device such as a mouse or stylus (Saffer, 2009).

Any such sensing devices (multi-touch display) are also inherently able to accommodate multiple users simultaneously, which is especially useful for large shared-display systems such as interactive walls or tabletops.

2.1.1 Technical perspective and technical design

Today multi-touch technology is the basis for many new techniques designed to improve interactions with computers and mobile devices. It seems that multi-touch screen interface makes the user handling very natural in the sense that there is no need for a manual in how to interact with the object on the screen.

Minority report (Spielberg, 2002) is one the first films where computers responding to gestures are shown instead of physical interactions based on keyboard or mouse.

Since then, companies like Mitsubishi, Nokia, and Apple have all released products based on multi-touch technology; and because the multi-touch technology has a long history, dating at least back to 1982 (Mehta, 1982), all these companies provide different technical solutions.

During the development of the iPhone, Apple was very much aware of the long history of multi-touch (Buxton, 2007). iPhone for instance is based on electrical impulses. Its touch-sensitive screen includes a layer of capacitive material. The iPhone’s capacitors are arranged according to a coordinate system. Its circuitry can sense changes at each point along the grid. The DiamondTouch (Dietz & Leigh 2001) developed at Mitsubishi Electrical Research Laboratories is another interactive surface based on similar technology.

FlatFrog is worth mentioning in this chapter because of its different technology. FlatFrog is one of the few companies at the moment that is developing big multi-touch displays. It’s technology is based on Planar Scatter Detection (PSD).

PSD is an optical in-glass technology with unprecedented performance through advanced opto-mechanics and signal processing. The FlatFrog system is developed to perform in many arbitrary environments, something that most other optical techniques find difficult. Many methods can be used to interact with the screen simultaneously: finger, gloved hand or several types of pointers. No pressure is needed, but pressure can be detected if required (FlatFrog, 2009).
2.1.2 Rosie

We would like to introduce our working prototype. Rosie is the name of our platform that we developed for this research and for future research work within this field at Malmö University.

Rosie is based on DI (Diffused Illumination) which is also one the best known methods implemented today within multi-touch technology. In our experience it can also be considered amongst the cheapest to set up.

Just like FTIR, DI works also with IR lights but in a different way. IR light is shone at the screen from either below or above the surface. IR light is mounted underneath a hard clear surface (i.e. Glass or acrylic) with a diffuser (i.e. tracing paper, mylar or semi-transparent material). When an object touches the surface it reflects more light than the diffuser or objects in the background; the extra light is sensed by a camera. Depending on the diffuser this method can also detect hover, and objects placed on the surface (Barrajón & Göransson 2009).

We developed Rosie to investigate the interaction and context of display among students at K3, Malmö University. It's designed for both horizontal and vertical operation enabling different types of interaction. The robust design maximizes resistance and it can be used in different environments due to the hardened glass surface.

Rosie consists of an all-in-one interactive surface, with a 40” display, a standard computer outside the box, and optical multi-touch surface that covers the viewable area, in this way providing direct manipulation of digital content with bare hands.

Rosie can support single- and multi-user interaction for the manipulation of the digital content.

Illustration 1: Rosie
2.2 Definition of interactions – our reality is both social and digital

The following text is going to introduce you to some basic terms within interaction design. This information will help to clarify some concepts in this work and set the stage for the theme this paper will develop.

According to Dourish, interaction is the means by which work is accomplished, dynamically and in context. Interaction can be digital and embodied interaction (Dourish, 2001).

"Embodied interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artefacts." (Dourish, P. 2001, p.126)

Embodied interaction is the interaction with computer systems that occupy our world, a world of physical and social reality, and exploit this fact in how they interact with us.

Another way to understand Dourish’s definition is that embodied interaction defines that computation is getting both more tangible and more social. Tangible is the way that new digital artefacts are emerging beyond the desktop computer, physical objects with computational qualities, interactive screens and toys, etc.

We need to emphasize that embodied interaction is not a technology or a set of rules but a perspective on the relationship between people and systems or artefacts.

Using the words of Ehn, P. and Linde, P. computers are more and more becoming embodied as embedded aspects in our experience of our everyday environment (Ehn & Linde 2004).

Anthropological and sociological approaches have been applied to uncovering the mechanism through which people organize their activity, and the roles that social and organization settings play in this process. Single-user interaction and multi-user interaction are two social behaviours that we are going to define in this chapter to give a better comprehension of our following work:

Single-user & multi-user

The complementary term, single-user, is most commonly used when talking about an operating system being usable only by one person at a time (Wikipedia, 2009).

“It’s one person sitting in front of one computer.” (Dourish, P. 2001, p16)

Multi-user is a term that defines an application or software that allows concurrent access by multiple users of a computer (Wikipedia, 2009). Under this social performance there are two important concepts for our paper: (i) Multi-user interaction non collaborative, (ii) Multi-user interaction collaborative

Multi-user interaction non-collaborative:

“People can occupy an area of the screen and focus on their own task irrespective of the activities on the their left or right.” (Peltonen, et al., 2008, p.1)

Multi-user interaction collaborative:

“Interactions that require explicit coordination between two or more users can lead to a increased sense of group cohesion and teamwork.” (Morris, et al., 2006, p.5)
3. Related work

3.1 History of touch-sensitive interfaces

Gestural and touch-sensitive interfaces are certainly not a new idea, the first functional concepts of this technology date over 40 years back today, to the late 1960's (Wikipedia, 2009).

One of the first systems where a touch-sensitive interface was implemented was the PLATO IV (Wikipedia, 2009) it included a 16-by-16 grid of infrared touch-sensitive locations.

In 1982 Nimish Mehta of The University of Toronto wrote his M.Sc. thesis on touch-sensitive interfacing with computers called Flexible Human Machine Interface (Mehta, 1982). It consisted of a TV camera focused on a pre-determined area on a frosted piece of glass, it can be described as the predecessor to the modern techniques developed by Jeff Han (Han, 2005) and others.

It was not until 1984 that the actual Multi-Touch screen was developed, it was Bell Labs that managed this by overlaying an array of capacitive sensors on a CRT screen. This screen allowed for simple manipulation of images using more than one hand.

During this particular time there were many advances in touch-sensitive research, some of which were more focused on interaction and interfaces rather than hardware techniques. Myron Krueger is often viewed as the father of the gestural interface. His system, Videoplace (Krueger, 1985), allowed users to interact with a rich set of human gestures using the entire body.

Myron Krueger was not alone in his research though, Bell Laboratories were also researching touch-sensitive user-interfaces. In the paper Soft Machines: A Philosophy of User-Computer Interface Design (Nakatani & Rohrlich 1983), Nakatani and Rohrlich describe the soft interface, seen in today's touch-sensitive devices such as the iPhone (Apple Inc, 2009), and
The predecessor to the iPhone came out on the market already in 1992, it was called Simon (Wikipedia, 2009) and was a cooperation between IBM and Bell South. It boasted the first hand-held touch-sensitive LCD display. Even though the Simon LCD display only allowed for a single-touch interface it is considered by many to be a major milestone in hand-held interface development and one of the first devices to be referred to as a smartphone (Wikipedia, 2009).

About ten years after Videoplace was shown to the public the interface design took yet another twist when Bricks – Laying the Foundation for Graspable User Interfaces (Fitzmaurice, et al., 1995) was published. It displayed the fundamental ideas behind the tangible interface; manipulating the physical environment to interact with a computer system. The best-known implementation of such an environment is the reacTable* (Jordà, et al., 2006) developed at the Pompeu Fabra University in Barcelona, Spain.

The first Multi-Touch interface to distinguish between users was released in 2001 by Mitsubishi Research Lab, it was called Diamond Touch (Dietz & Leigh 2001). The Diamond Touch platform is still actively used as a tool in Multi-User tabletop research.

The current state of Multi-Touch sensing can easiest be described with one word, iPhone (Apple Inc, 2009). It is the best known item on the market that incorporates Multi-Touch technology today. Companies such as N-Trig (N-Trig, 2009) and FlatFrog (FlatFrog AB, 2009) have developed their own Multi-Touch sensing technologies used as overlay on standard screens of all sizes.

In the future we will likely see the pixel-integrated technologies, such as the one developed and implemented by Toshiba Matsushita Display Technology in 2005 (Toshiba Matsushita Display Technology Co. Ltd., 2005), take the lead for touch-sensitive displays and interfaces.

3.2 Related projects

To create knowledge for our fellow designers, it’s imperative to understand the current state of multi-touch design. Without a good understanding it will not be possible to extend the current knowledge within this specific field.

As mentioned earlier, we believe a significant quality of the large multi-touch interface is the social setting. The way it can foster direct interaction between people and the conflicts that are born out of those interactions.

Because this work is focused on the social aspects we will present some related works that examine specific genres within the social space.

Wigdor et al. identified in their study (Wigdor, et al., 2006) six different design requirements for table-centric collaborative interfaces.

Their research is focused on how to coalesce multiple distributed interfaces to create what they call “around-the-table” interaction between the operators and giving them the complete control over all the distributed interfaces through one – central – display.

The authors base their work on Heath and Luff's research (Heath & Luff 1992) which identifies a set of meta-level activities performed by the users, which led Wigdor, et al., to believe that a real-time collaborative interface should support and reduce the activity required to operate it.

Of the six design requirements defined by Wigdor, et al., there are at least three that could be useful for this continued research.

- **Contextual Association** states that objects on the screen that are related to each
other also visually show this relation. There are several different ways of creating such a visual connection between objects, colour coding is one, drawing lines between objects is another.

- **Maintain Direct and Absolute Input Paradigm** that basically states that the input surface, multi-touch in our case, is the same as the output screen, mapped to each other in an absolute one-to-one scale.

- **Support for Non-Interfering Concurrency** means that all users currently interacting with the surface should maintain the ability to work on sub-tasks without interfering with each other's tasks, be it physically or virtually.

Gross, Fetter and Liebsch (Gross, et al., 2008) explored how to create new interaction concepts for cooperative and competitive applications on a multi-touch interface. The authors present the cueTable (Gross, et al., 2008), which is based on Han's research (Han, 2005) in multi-touch technologies, and the Puh game on which they base their studies of cooperative and competitive interactions.

The game itself is loosely based on the game Pong (Wikipedia, 2009) by Atari Inc. where players are meant to bounce a ball into the other player's goal area. When one player has reached a number of goals the game will end. The Puh-game however is intended to be played by up to four players in two teams, cooperating to win the game.

The authors conducted a study of about 100 users playing the game with 25 settings, 2 teams per setting and 2 players per team. They also executed several unstructed interviews with the users after the playing-sessions.

Through their study the authors discovered several interesting insights into multi-touch cooperative and competitive interactions, some of which we present here.

- **Learning** – users possess different capabilities of learning interactions at novel interfaces.

- **Recognition** – the human brain recognises and adapts new patterns to already known patterns.

- **Reconfigurability** – users often want to configure and adapt their interfaces to suit their needs and expectations.

- **Competition, Attention and Awareness** – they found that the participants often used subtle gestural and speech interaction within the teams and gaze awareness between team-members and between competing teams.

- **Gaze-hand coordination** – old keyboard-mouse interfaces often requires the user to perform eye-hand coordination, in this touch-based interface the eye-hand coordination is transformed into a gaze-hand coordination that has less load on the user.

- **Territoriality** – cooperative applications with distinctly divided territories should support inter-team territories with cooperative properties and group-territories with competitive properties.

In their study, *Beyond “Social Protocols”: Multi-User Coordination Policies for Co-Located Groupware* (Morris, et al., 2004), the authors examined the types of conflicts that arise when multiple users share one tabletop display. Their study consists of analysing previous works
within the field and a user-study they performed with applications they developed for this purpose.

The authors then define, from the observed tests, two key conflict dimensions (i) conflict type and (ii) conflict initiative. Having defined the key conflict dimensions the authors managed to establish a Coordinating policy map for resolving the conflicts.

There are three observed conflict types, global, whole-element and sub-element.

I. Global conflict refer to conflicts that affect the entire application, this could be exciting an application.

II. Whole-element conflict, a reoccurring example would be users trying to access the same object or functionality.

III. Sub-element conflicts refer to changes within objects, editing the same place of an image could be an example.

They also observed three different types of initiative for resolving these conflicts: proactive, reactive and mixed-initiative.

I. Proactive is a hierarchical or rank-based conflict solution, the owner of the object decided the outcome.

II. Reactive means that the object produces a reaction that is based on actions of the other users in regards to the object.

III. Mixed-initiative determines the outcome of a conflict by looking at the information from all parties involved in the conflict.

Hornecker and Buur introduce a framework structure around four themes and a set of corresponding concepts. Some of those themes are relevant for our work and it provides a broader understanding of tangible interaction (Hornecker & Buur 2006).

Themes are:

Tangible Manipulation refers to the material representations with distinct tactile qualities, which are typically physically manipulated in tangible interaction.

Spatial Interaction refers to the fact that tangible interaction is embedded in real space and interaction therefore occurs by movement in space.

Embodied Facilitation highlights how the configuration of material objects and space affects and directs emerging group behaviour.

Expressive Representation focuses on the material and digital representations employed by tangible interaction systems, their expressiveness and legibility

As we can see, Hornecker and Buur discussed how social interaction and collaboration might be the most important and domain feature in tangible interaction, with this they develop a better understanding of the user experience of tangible interaction and concepts for analysing its social aspects with knowledge aiding collaboration design.

“Zooming interface paradigm” is one of the subjects that Raskin (Raskin, 2000) talks about within the subject interface design. According to him, humans have always been notoriously bad at mazes. If we could handle them easily, they wouldn’t be used as puzzles and traps.

According to his book humans are not good at remembering long sequences of turnings, which is why mazes make good puzzles and why the navigation within computers and systems confuse the users. What the humans are better at is remembering landmarks and positional
cues. This last part makes his reading more interesting because, we could use this metaphor in our work. The way people interact with a display seems natural already. Furthermore we could add this aspect and create a more intuitive interface using natural aspects as guiding tools.

Macintosh, and some versions of Linux, have already implemented this aspect in their interfaces, becoming this “Zoom World” an elegant solution to the navigation problem and also providing a way around the problem of the limited screen real estate that any real display system must confront.

3.3 Review of related projects

The presented works here are mostly oriented towards the social space, interactions between users, direct or indirect.

We focus on the social aspects of the interaction rather than the physical act of interaction with an interface, something these related works reflect rather well. Design requirements such as those defined by Wigdor et al. (Wigdor, et al., 2006) look at the social context of the interface and how we can design for a shared cooperative space.

Sharing a limited space will undoubtedly spawn new types of conflicts which we need to be prepared for. Apart from defining key conflict dimensions Morris, et al., note that social protocols do not always suffice when several users interact with the same shared display.

However, all conflicts are not bad, playfulness is one sort of conflict that supports for creating contacts and meetings. Nevertheless, conflict management is a key component when designing applications, both single-user and multi-user. An understanding of how conflicts develop will help our continued work.
4. Methods

The research in this thesis has been mainly focused on qualitative results. This decision to focus just on qualitative results was motivated by the lack of previous research within the field of multi-touch design. We believe that a well-designed qualitative exploration of the platform would grant us the proper base to start defining design-guidelines intended for large-screen multi-touch displays.

The design research has been achieved using four different methods. The methods has been developed to investigate different aspects of single interaction, collaborative- and non-collaborative multi-user interaction using Rosie as platform.

These are the four methods on which this design research is built:

- Qualitative conceptualization (QC)
- Qualitative user-testing (QUT)
- Participatory Design (PD)
- Iterative Prototyping (IP)

All four research methods have equal impact on the work overall, however each method has specific qualities and as such also had specific impact on distinct parts of this work.

4.1 Qualitative Conceptualization

Qualitative conceptualisation is about generating non-working concept-presentations for how specific tasks or applications are implemented. This presentation is done within a very confined time-space; at the end of each presentation a discussion of each video-prototype is held.

We had a total of 59 participants on three different occasions in this stage of the research. The group of participants were both of academic and professional backgrounds.

The qualitative conceptualisation method is divided into four major phases:

1. A brief introduction about multi-touch technology
2. Brainstorming on multi-touch concepts
3. Prototype development (video prototype)
4. Review of prototypes

**Phase one** should be executed with the whole group of participants: In this part the participants get a brief presentation about multi-touch technology. They are introduced with video prototypes and work that has been done by others from the HCI-community.

**Phase two and three** are executed in smaller groups of three to four people each. The participants generate a multi-touch concept that was produced during the brainstorming phase. Any creative help (camcorder, cardboard and etc.) can be used to show the concept-idea. The focus in this part is the concept and not the technology behind the concept itself (Saffer, 2007).

**Phase four** should also be executed with main group (all the small groups together) to allow for the most feedback and discussion. (Saffer, 2007).

The aim of this method is to examine how the participants experience a multi-touch interface
without any experience in the field from before (Ehn, 1988).

This method should grant us specifically two understandings: "How can we find new ways of designing applications intended for a multi-touch screen that would make use of all the qualities of this interface?" and "What possible and plausible interactions exists for a Multi-Touch interface?".

The following list contains the most representative video-prototypes done during this method by our participants.

4.1.1 TouchTris

About
(Concept by: Tony Olsson, David Cuartielles, Ola Wassvik)

TouchTris is a multi-player co-operative game meant to be played by two teams with two players in each. The game was inspired by the classic game Tetris (Wikipedia, 2009) but with the main focus on multiple user interactions with both competitive and co-operative elements.

Using a touch-sensitive table top display as a game, the specific qualities of the platform change and the game was designed for this purpose, a more direct social interaction rather than a purely result-based competition.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=4Y_wuf6DdNk&feature=channel_page)

4.1.2 TouchEarth

About
(Concept by: Andreas Göransson, Ivar Boson, Magnus Lönnegren)

TouchEarth started out as a database navigational tool, transcending large database collections quickly. We found the historical/geographical illustrations the best way of communicating the navigational concept.

The touch-sensitive interface in this prototype was mounted vertically, we also discussed a semi-vertical display as physically more gentle on the user, but we decided to focus on the navigations.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=kfN9BIAKyQE&feature=channel_page)

4.1.3 OrganicEditing

About
(Concept by: Fernando Barrajon, Robin Berggren, Jonas Stenberg)

The concept was to show how media editing can be done on large touch-sensitive interfaces, in this prototype the interface was a table top display but we felt it could just as easily have been vertical or semi-vertical.

This prototype was an exploration of how editable objects can be interacted with in advanced ways through gestures, i.e. without utilising menus or a keyboard input.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=voYjV4UC__M&feature=channel_page)
4.1.4 AniMate

About
(Concept by: Andreas Göransson, Tony Olsson)

AniMate is a content creation tool for animators and graphical artists. It's key focus is quick and easy animation of 2D drawings.

The discussions when developing this prototype were directed towards hybrid interfaces and co-operative creation, separation between different users and tangible interfaces such as pens.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=heGRChwxb50&feature=channel_page)

4.1.5 touchmyMind

About
(Concept by: Fernando Barrajon, Anders PJ, Rob Nero)

This prototype was designed as an aid and complement to brainstorming sessions for creative professionals.

The discussion when this prototype was developed revolved around co-located collaborative work.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=eP-BoJl1XhQ&feature=channel_page)

4.1.6 Multi-Touch game

About
(Concept by: Björn Röjgren, Richard Lundqvist)

The prototype discusses interactions at a top-down strategy type game. Reviewing specific tasks rather than a whole concept game, for example moving troops or assigning actions to units.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=59sy687ebC4&feature=channel_page)

4.1.7 PhotoshopAddon

About
(Concept by: Ulrika Persson, Joar Jakobsson, Daniel Scott, Kristian Zagar)

The PhotoshopAddon prototype explores discusses topics such as tangible interfaces and parallel-use collaboration.

They examined how the users can combine gestures and tangible interfaces (pens) at the same time, and the qualities of both elements.

(Video is available on the included DVD disc or worldwide web at: http://www.youtube.com/watch?v=KIWmJdPORCI&feature=channel_page)
4.2 Qualitative user-testing

This method is intended to examine how people experience a multi-touch interface with focus on non-collaborative interaction (single-user). The intention of this method was to collect details and views from a single-user perspective. Combining our participation with the demo-applications allowed us study how users adopted the system for interaction. The demo applications we used for this method were developed by NUI (Natural UI AB, 2009).

This method was done with the participation of 20 persons in total. The group of participants were both of academic and professional backgrounds. All the observations took place with a single person at a time.

Every participant was assigned a couple of tasks based on multi-touch demo-applications. They would go through the different tasks without getting any help from us.

Once the participants went through all the tasks and were familiar with the demo-applications; we held an unstructured interview with them, focusing on usability and interaction issues.

A questionnaire was also handed over to the participants at the end of every session.

The result of this method is listed in chapter V.

The questionnaire used in this method can be viewed in Appendix 1.

4.3 Participatory Design

In this part, the main focus was on multi-user interaction: collaborative and non-collaborative. A different way to look at the interaction design issues raised by interactive displays is to observe how people interact to each other as a group or maybe as individually (Brignull, 2004). In this part a multi-user application mock-up was built and designed.

A number of different approaches were used to collect the relevant data:

- A video camera capturing the embodied and social interaction around the system
- A sound recorder to record the conversations during the testing
- A mock-up artefact to interact with

The application was tested with 11 participants in total. The group of participants were both of academic and professional backgrounds. The observations took place with groups of two to three persons for every session. They were introduced to the main concept behind the application: collaborative work. During the testing we asked them question focusing on usability and interaction from a multi-user perspective.

The participants didn't get any questionnaire at the end of the session. However we were asking questions during the test-time.

More about these results in chapter V.

4.4 Iterative Prototyping

Iterative prototyping gives form to the many possible different solutions of our design openings. Here is where we refine the concepts increasing fidelity and reflection on our design decisions (Zimmerman, 2007). “Todos” is the name of our prototype application used in this method.

“Todos” (which means everybody in Spanish) is a multi-user collaborative application for
designers in general. It's main focus is quick and easy brainstorming. The application ("Todos") was tested with 11 participants in total. The observations took place with groups of two to three persons for every session. A number of different approaches were used to collect the relevant data:

- A video camera capturing the embodied and social interaction around the system
- A sound recorder to record the conversations during the testing
- A mock-up artefact to interact with
- List of tasks

We collected the qualitative data using same tools as in PD-method. The group of participants were both of academic and professional designers. In this process the group of people has to be representative of the future target users. It's important to know who is the target-group we are designing for (Isaacs, 2001).

We also watched demo-applications that supported similar ideas like ours, we watched people using those applications and saw what worked and what didn't work according to our criteria.

Once we spoke with all the groups, we looked for patterns in the way people did things and the problems they encountered. In this part a pre-list of tasks was already created with some features that we believed would solve interaction problems.

During the design process we kept testing “Todos” once again to maintain a constant perspective of our critical design.
5. Results

5.1 Qualitative Conceptualization

The focus of the study was to qualitatively examine the video prototypes that were developed and the accompanying discussion notes. Theoretically exploring different use scenarios and interactions were of great interest in this method, trying to pin down new ideas and form an understanding of the interface and its possibilities.

The following is a compiled version of the most representative observations and comments extracted from the analysis.

<table>
<thead>
<tr>
<th>Comments extracted from Qualitative Conceptualisation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi-touch does not necessarily mean ten fingers for each user – most likely it will mean that more users are able to interact with single, dual or triple touch gestures.</td>
</tr>
<tr>
<td>The table-top touch-interface works well for social interactions that extend over a longer period of time, such as games.</td>
</tr>
<tr>
<td>Separation of territories might be an important aspect.</td>
</tr>
<tr>
<td>Navigation through large databases or across big computational depths could possibly be made easier in touch-sensitive interfaces, utilizing the common zoom-gesture.</td>
</tr>
<tr>
<td>There is enough depth in the simple gestural interfaces to cover most of the common actions needed in a simple media-editing tool.</td>
</tr>
<tr>
<td>A pen interface is well adapted for the table-top metaphor, it's used with ease by most people.</td>
</tr>
<tr>
<td>A more adaptable interface might be needed for multiple user scenarios.</td>
</tr>
<tr>
<td>Keyboard interface could be replaced with actual writing on the screen, either with pen or with finger.</td>
</tr>
<tr>
<td>User interactions can easily be limited to single- or dual-touch.</td>
</tr>
<tr>
<td>Advanced interactions can be completed using single- and dual-touch combined with simple menus.</td>
</tr>
<tr>
<td>A pen interface is well adapted for the table-top metaphor, it's used with ease by most people.</td>
</tr>
<tr>
<td>Co-located collaborative work doesn't have to mean sharing the exact same physical space, while sharing the same surface it's not necessary to share the same space on this shared surface.</td>
</tr>
</tbody>
</table>

Table 1: Comments extracted from Qualitative Conceptualisation.
5.2 Qualitative user-testing

The motivations for this study were three-fold, both introducing participants to the interface and
having them articulate their impressions and discussing our observations of their use in an
unstructured interview.

The following is a resume of the most representative observations and comments:

- Users wants to manipulate objects directly on the screen rather than using menus etc.
- User doesn't want menus and other “normal” interface parts, believes Multi-Touch should
  have a different type of graphical interface.
- User felt it was natural to interact with hands instead of input devices like mouse and
  keyboard.
- User felt it was hard to determine if some objects could be interacted with or not.
- Perhaps it's important to establish some standards on how touch interfaces should look,
  not just buttons and standard objects.
- User mentioned he was confused about the lack of standards on how to interact with
  objects on the screen.
- User thinks applications that use standard input like keyboard (word processing) wouldn't
  fit well, or it would need to figure out another way of doing the typing.
- User was unsure about any standard interactions with the interface, needs more clear
  rules and ideas!
- User noted the “feeling” you get when interacting with objects, perhaps this is an important
  affordance of the interface? - Remove menus and other “old” types of interfaces.
- User interacted with objects rather than menus or functions, most things she wanted to
  interact with had an object-feel to it rather than function-feel.
- User wanted to use objects on the screen instead of functions in the menu.
- User was awkward around the interface, had expected some other interactions. - He
  expected more physical interaction than that which was implemented now.
- User mentioned that the lack of standardisation was confusing, wants the interface to be
  more “object oriented” meaning that applications and objects should be more free to
  “interact” with each other rather than the save-load-print functions of normal applications.
- User was very confused about the interface, sometimes he wanted to use menus a lot
  other times he just wanted to manipulate objects directly.
- User wants to be able of manipulating objects, not being locked down to accessing
  standard looking menus.
- User prefers to interact directly with objects, rather not go through menus etc.
- User doesn't want to use menus, she manipulates objects directly. She also noted that the
  tangible “feel” of the interface is nice, gives a completely different dimension.
- User mentioned that the main menu (the rotating starting menu) has a nice feel to it,
  useful easy and functional. (Standard WIMP menus doesn't fit in this interface?)

Table 2: Comments extracted from Qualitative User Testing.
5.3 Participatory Design

The focus of the study was to examine the qualitative data from the videos. The analysis of observed patterns of interaction demonstrates how the application played out. Of particular interest here is how the test-participants were able to exploit the prototype as a collaborative surface.

The following is a resume of the most representative observations and user-experience during the test:

- Our first ideas of focusing the menu-actions to one place didn't enhance the collaborative feel for them.
- They didn't want symbols on the constellations-The many of them can be very individual.
- They experienced it competitive at first. Does the time limit and single word fountain enhance the competitive feeling?
- Collaborative equals common goals.
- Non individual choices, the participants viewed the word-islands and words as a common property.
- They wanted a paused-function as a way to enhance social interaction around the display.
- Menus on each corner of the table.
- The participants stand quite close to each other. They share same area on the screen.
- They work in parallel with different approaches and at the same time sharing the same goal.

Table 3: Comments extracted from Participatory Design.
5.4 Design principles

This is the set of design principles that have been developed in this work, a deeper analysis of them is presented later in this chapter.

5.4.1 General guidelines

I. Single- or multi-user interactions at a multi-touch surface might benefit from spatially related sound feedback.
   **Example:**
   Sound would provide positional feedback relative to actions on the screen.

II. Multi-user interactions at a multi-touch surface might benefit of the implementation of sound feedback that is individual for every user.
   **Example:**
   Each participant has a personal sound as feedback to distinguish personal actions.

III. Gestures can easily be misused on multi-touch interfaces. They could expose the user to physical strain in the long run.
    **Example:**
    Executing gestures all the time might require a physical effort that can be exhausting in the long run.

IV. Restrict the amount of needed interactive objects on the screen depending on the amount of available users.
    **Example:**
    We can pay attention to only one object at a time, a system should not display more than one object for each graphical input device on the system.

V. A multi-touch interface should not try to emulate a standard WIMP interface, interactions such as typing on a keyboard would perhaps not be suitable for a touch-sensitive interface due to the lack of tactile feedback.
   **Example:**
   When possible, avoid the keyboard metaphor.

VI. The inherent ability of the human mind to memorize spatial position and landmarks should be exploited more in multi-touch interfaces since it is a more direct interaction compared to standard WIMP interfaces.
   **Example:**
   The differences of navigating a command line environment such as MS DOS vs. a desktop environment such as MS Windows (Microsoft Corporation, 2009).

VII. The standard graphical WIMP interface should not be used since it was mainly designed for keyboard and mouse interaction. The multi-touch surface allowing for several unique points of interaction should use either a different type of menu system or a completely new graphical interface.
   **Example:**
Design-elements that allow for direct manipulation rather than menu based interactions.

VIII. We need to develop a clear graphical standard what constitutes an interactive object and what actions this object supports. A button on a multi-touch might have a different use-case than it does in a WIMP interface.

**Example:**
The object in the screen must offer sufficient information of interaction and must show sings of relevant information.

IX. Due to the more direct interaction, the applications available at a multi-touch interface should have a different way of visualizing the interchangeable connections available compared to today's WIMP interfaces.

**Example:**
Easy “load” function of a picture from a drawing application to an image viewer application. Dragging the object from the draw application to the viewer.

5.4.2 Multi-User non-collaborative

I. In a non-collaborative setting, the interface should support personal work around and on the interface.

**Example:**
The user has the freedom to reserve part of the interactive surface for its own personal use.

II. In a non-collaborative work setting each user should have the ability to own their personal workspace and the objects within.

**Example:**
Every user should have the ability to own its personal objects.

III. In a non-collaborative setting, users should have the possibility of owning the territory around and on the interface.

**Example:**
Every user should have the ability to own its personal area.

IV. Due to the more direct interaction, the applications available at a multi-touch interface should have a different way of visualizing the interchangeable connections available compared to today's WIMP interfaces.

**Example:**
Every user should have sufficient amount of personal menus and tools.

5.4.3 Multi-user collaborative

I. The application must facilitate the social interaction between the users.

**Example:**
Pause-function, might facilitate a dialog between the users.
II. In a collaborative setting, the multi-user interface should moderate the individual ownership, focusing on the group of users rather than the single user.

Example:
Common menus and tools. The work-area has to be adaptable.

III. Collaborative interactions at a shared tabletop surface might form temporary social bonds between users, enhancing their experience of interacting as one large unit with a shared goal rather than several smaller units with similar goals.

Example:
Create a big size interactive surface where just one user-interaction is not sufficient. Application can be designed in a way so everyone in the group is responsible for a specific task. The sum of all the tasks could make the application interesting for all users.

5.5 Analysis
As stated previously the focus of the study was to develop a set of design principles - which goal is to aid the designer when developing applications intended specifically for use at multi-touch interfaces.

5.5.1 General guidelines
Many of the traditional interface conventions within HCI seems to work well in multi-touch interfaces: scrolling, copy-paste, give feedback and etc. The general guidelines that we address in this section are more specific for multi-touch interaction.

• Gestures can easily be misused on multi-touch interfaces. They could expose the user to physical strain in the long run.

In the different methods it has been noticed that gestures are an important tool in terms of interaction with interactive surfaces (Saffer, 2008). Gestures are used all the time to interact with multi-touch displays. In our research we noticed that once the participants understood how they could interact with the interface using gestures; gestures became a very intuitive feature to interact with among our test-participants. It seems like most people experience this feature as something positive most of the time, even if it means requiring more effort for infrequent tasks. This pattern using gestures unnecessarily could bother the user in the long run. It might be possible that developers and interaction designers in a soon future use the gesture-feature as a solution for most problems related with interaction. What happens if this scenario becomes real? A way to avoid this problem could be to think about what you're trying to let people do and find a way to do it without disturbing them so often.

• A multi-touch interface should not try to emulate a standard WIMP interface. Interactions such as typing on a keyboard would perhaps not be suitable for a touch-sensitive interface due to the lack of tactile feedback.

There are demo-applications out there illustrating this WIMP-metaphor on multi-touch displays. It seems that there’s a strong interest among developers to convert applications from old systems to new systems, for instance multi-touch displays. As we see it, there's a lack of understanding on tangible principles. Results gathered from the QUT- and PD-methods show that this statement has relevance and make it a pertinent principle for developing multi-touch applications.
“User thinks applications that use standard input like keyboard (word processing) wouldn't fit well, or it would need to figure out another way of doing the typing.”
(Result, 5.2 Qualitative User Testing)

This above conclusion shows that a better understanding of tangible manipulation is very relevant in design decisions. Hornecker, et al., argue that tangible objects can invite us to interact by appealing to our sense of touch, providing sensory pleasure and playfulness. It's very difficult to believe that digital graphics can replace the user's tactile experience because of the simple reason that it's new and different, without taking into account the principles of tangible design.

- Due to the more direct interaction, the applications available at a multi-touch interface should have a different way of visualizing the interchangeable connections available compared to today's WIMP interfaces.

The freedom that we get of using organic interaction give us more ideas on how to bring more natural elements in to the digital world. Already using our hand and gestures as medium of interaction, people experience new natural elements that could possibly be used within this field.

"User doesn't want menus and other "normal" interface parts, believes multi-touch should have a different type of graphical interface.”
(Result, 5.2 Qualitative User Testing)

"User prefers to interact directly with objects, rather not go through menus etc."
(Result, 5.2 Qualitative User Testing)

"User mentioned that the lack of standardisation was confusing, wants the interface to be more "object oriented" meaning that applications and objects should be more free to “interact” with each other rather than the save-load-print functions of normal applications.” (Results, 5.2 Qualitative User Testing)

These conclusions listed above gave us a bigger understanding of how the participants experienced the interface, using demo applications. The Participants most of the time wanted to have all the data on the screen and didn't want to go through menus. Direct interaction with objects was something very important for the users. This "naked" way to experience the interface gave us the idea to get rid off menus and windows. In general humans have an inherent tendency to remember position and landmarks (Raskin, 2000). If this element can be implemented on a multi-touch interface the performance might be experienced as more intuitive than a standard WIMP-interface.

According to Raskin, humans are not good at remembering long sequences of turnings, which is why mazes make good puzzles and why the navigation within computers and systems confuse the users. Furthermore we could add this aspect and create a more intuitive interface using natural elements. We can already see this design ideas on Macintosh and on Linux O/S. The known feature “zooming interface paradigm” is the elegant solution to the navigation problem and also provides a way around the problem of the limited screen real-estate that any real display system must confront (Raskin, 2000).

- We need to develop a clear graphical standard what constitutes an interactive object and what actions this object supports. A button on a multi-touch might have a different use-case than it does in a WIMP interface.

Actually touching the screen has a different “feel” than using an input device such as a mouse which is why we asked ourselves if the touch sensitive user interface should inherit the standard look & feel of a common WIMP interface or if the graphical qualities should be
Chapter V

different due to the more direct interaction. The following observations support this argument.

"User felt it was hard to determine if some objects could be interacted with or not" (Results, 5.2 Qualitative User Testing)

"User was very confused about the interface, sometimes he wanted to use menus a lot other times he just wanted to manipulate objects directly" (Results, 5.2 Qualitative User Testing)

"User wants to be able of manipulating object, not being locked down to accessing standard looking menus." (Results, 5.2 Qualitative User Testing)

"User prefers to interact directly with objects, rather not go through menus etc." (Results, 5.2 Qualitative User Testing)

Each object on the display should allow a basic interaction, or at least provide feedback that no interactions are possible.

- Single or multi-user interactions at a multi-touch surface might benefit from spatially related sound feedback.
- Multi-user interactions at a multi-touch surface might benefit of the implementation of sound feedback that is individual to each user.

These two hypotheses listed above share something in common: sound as a way to give other kinds of feedback (Isaacs, 2002). Due to the limited timetable of this work we couldn't verify if these two ideas could work on Rosie. We decided to give priority to those design-openings that had more interesting-elements in common. Yet we believe that sounds are effective for letting people know when something has occurred or that a task is in progress (Isaacs, 2001). At the moment we can only speculate that sound can also be useful within this field. There are already commercial products like the iPod's wheel that makes an audible click that can be heard without headphones (Saffer, 2007).

5.5.2 Collaborative interaction

The idea behind this design-opening is that all the users around the display should have common goals. We can see this as a social prerequisite before designing multi-touch applications where there is involved collaborative interaction. Another way to see this is how the whole group act as individual where they share their ideas and work. Every user is responsible for a certain task, which is part of larger project. Gross, et al., present similar conclusions in their work about cooperative and competitive interactions known as "territoriality".

One of the key aspects in this work is how people can share information, work independently and collaborate at the same time. We believe that social interaction may create new elements that might influence the applications interface and concepts around the multi-touch context. Doing our fieldwork it shows that social interaction influence how the users act around the display and not the opposite – the interface controlling the users social interaction.

However, there is also the possibility (depending on the circumstances) that the interface influence the other way around – the social environment around the display.

- Restricting the amount of needed objects on the screen to reflect the amount of available users currently active at the interface could possibly enhance the social interaction and hence also the collaborative effect on the group.
- The application must facilitate the social interaction between the users.
Social interaction and collaboration might be the most important and essential feature in tangible interaction (Hornecker & Buur 2006). As we see it you can develop a better understanding of the user experience of tangible interaction and concepts for analysing its social aspects with knowledge aiding collaborative design.

“They wanted a paus-function as a way to enhance social interaction around the display.” (Results, 5.3 Participatory Design)

Under this design idea our participants provided us with different design-openings based on time. All interaction takes place over time (Saffer, 2007). Sometimes an interaction can occur instantaneously and sometimes it can involve long durations. What if we mix this basic element with social interaction? Apparently this time-feature opens a new perspective within collaborative work. It seems like creating this possibility in the interface it enhances the social interaction among the users.

- In a collaborative setting, the multi-user interface should moderate the individual ownership, focusing on the group of users rather than the single user.

Another aspect of the collaborative work is the openness on the screen. We wanted to counteract the personal property as a way to develop teamwork across the screen. The interactive display can provide flexibility both in terms of physical and digital arrangements, it is really important to respect the principle of open property. We can have multi-touch displays with many users at the time but the understanding of territories might be quite different among the participants.

“Non individual choices, the participants understood the word-islands and words as a common property.” (Results, 5.3 Participatory Design)

“The participants stand quite close to each other. They share same area on the screen.” (Results, 5.3 Participatory Design)

The above observations tell us how the participants experience the interface and the physical space around the table. They decided to have it in this way because it looked like it was the best option to develop a collaborative interaction. However for non-collaborative interaction the understanding of space is the opposite. More about this under “non collaborative”.

- Collaborative interactions at a shared tabletop surface might form temporary social bonds between users, enhancing their experience of interacting as one large unit with a shared goal rather than several smaller units with similar goals.

There are different ways how to understand this rule, either by designing a multi-touch application where the users in the group are responsible for some parts of the application or by highlighting the embodied facilitation in the project (Hornecker & Buur 2006). This can be achieved by analyzing the embodied interaction between the users and the interface (Dourish, 2001). Our mock-up shows for instance how the application influence the users collaborative interaction so everyone around the display interact together and share common goals across the table. Another way to interpret this performance in a more natural way is that the group at some point becomes individual. The group itself has its own structure and is composed of small entities that interact together; like a living organ and its cells.

5.5.3 Non collaborative interaction

- In a non-collaborative setting, the interface should support personal work around and on the interface.
• In a non-collaborative setting, users should have the possibility of owning the territory around and on the interface.

• In a non-collaborative work setting each user should have the ability to own their personal workspace and the objects within.

• Since the multi-touch interface is a more social interface than the keyboard & mouse counterpart, the conflict management should reflect this and rely more on the users’ own ability to moderate themselves and each other.

The result in this section shows a strong tendency of single user interaction. These observations have been done during the fieldwork where we observed how people can organize parallel and develop different activities at the screen (Peltonen, et al., 2008).

This is another aspect of this interface. People around the display can be interacting at the same time but this doesn’t mean that the whole group is sharing the same ideas or application. Peltonen, et al., presents similar insights within multi-touch collaborative and non-collaborative interaction. In their study this observation is known as “Parallel-use”, where each of the users tries to use the screen as an individual, not paying attention to what the others do.

The territory plays an important aspect in this part. The personal territory seems to be where there is most activity and it is performed independent of the other users (Gross, et al., 2008). If the user shows a individual interaction it can also be necessary to provide personal menus and tools to create an easy-going single user performance. Providing personal menus and tools would also solve some conflict management at the table. In this manner there will not be multiple users trying to handle the same document or multiple users trying to handle the same menu (Morris, et al., 2004).

Our attempt to observe as many as possible aspects of the physical world in multi-touch interaction allowed us to elicit and understand the fundamental differences between collaborative and non-collaborative interaction in a multi-touch display.

Something that is important to mention at the end of this paper is the design process behind this work.

5.5.4 Reflection on our design principles

We view our work as a statement that the design of applications intended for multi-touch interfaces should not be done hastily.

While many standard principles still apply, the multi-point touch-sensitive interface presents a different set of qualities than other interfaces possess today. These qualities need to be examined thoroughly and expressed in such a way that we can begin to understand the use-scenarios for this interface.

Our work should be viewed as a preliminary foundation for this set of principles. The principles are an addition to already accepted standards for interactive artefacts and should be employed when necessary together with them.

Illustration 3 below depicts our set of principles and how they co-exist with the accepted general design principles, when employed for large multi-touch interfaces.
5.5.5 The Process

At the end of this thesis, it's important to mention the design process behind this work. The way we approached our conclusions was quite different than the way researchers in general usually do. We introduced the methods, without having read results from peoples previous work. In this way we were not influenced by the related data from other related projects. The research was done in a clockwise manner: collecting data, writing conclusions and finally comparing them with other peoples work. In this way we could find out if the obtained observations were relevant for our research. Another important aspect behind this approach was the ethnological aspect - to experience the result of every method as something new and exotic without any expectation from before.

We would like to point out the difficulty behind this area (multi-touch technology) because multi-touch is a new field where there's still a lot do. In five years time there will be more collected knowledge than what we have today.

The innovation process developed in this paper has the same relevance status as our results. We didn't have just one main goal but two main goals:

I. Set up a list of observations that have a high relevance for designing multi-touch interfaces.

II. An interesting design process for developing multi-touch applications.

As we see it, it's very important to be aware about how we got this final result (guide-lines). We basically gained knowledge through the process and experience of, for example, building...
Rosie, running workshops (qualitative conceptualization) and etc. Creative design was also very relevant during in our design process.

And the last but not least important “non-present” final intention behind this research is also to create competence for ourselves and other interaction designers within this field.

5.5.6 Future work

In this paper we present the first part of our “work in progress” prototype - “Todos”. We decided not to make this final prototype also part of this work which is why it is not mentioned either in our goals or in the introduction.

However we are still working with it and hopefully we will release “Todos” in the near future.
References


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Appendix

Appendix 1 – Questionnaire used in QUT-method

Questionnaire – Test 1
Introduction to Multi-Touch

Name: ____________________________________________

E-mail: ____________________________________________

Background: ________________________________________

For this test we're not interested in the technical details or “bugs” of the framework or the application/s. Try to focus on your experience rather than technical flaws.

(I detta testet är vi främst intresserade av dina upplevelser med plattformen “Multi-touch”, inte de tekniska specifikationerna eller eventuella fel i programvaran.)

Which application/s did you test? (Circle the right one/s)
(Vilken/vilka applikation/er har du precis testat?)

Wong  Pong  Puzzle  Draw  PDF-viewer  Particles  3D-viewer  Media  Gravitoy - Sandbox

What was your experience of “Rosie” and the application/s in particular?
(Hur upplevde du “Rosie” och den/de applikation/er du testade?)