Evaluation of the Usage of Graphical Effects within the Graphical User Interface of Hand Held IR-Cameras

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Master of Science Thesis
Stockholm, Sweden 2011
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Master’s Thesis in Computer Science (30 ECTS credits) at the Interactive Systems Engineering Master Programme Royal Institute of Technology year 2011
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TRITA-CSC-E 2011:068
ISRN-KTH/CSC/E--11/068--SE
ISSN-1653-5715
Abstract

Infrared cameras are used to visualize a quite abstract context; they can identify the amount of radiation emitted by objects and represent information about their temperature as visual feedback. However, thermography images usually have an erratic and not easily understandable form and users could be burdened and confused when trying to perform certain tasks. The latest development of graphical user interfaces for handheld systems such as mobiles, GPS, etc, has enabled the creation of more rich graphical user interfaces with innovative interaction techniques. The goal of this thesis is to identify where and how innovative interaction techniques can be beneficial to the user experience/usability of handheld IR cameras. This thesis focuses on three critical problem areas, chosen based on specific user tasks, over which prototype solutions are identified and proposed. The outcome of the design process is the implementation of three functional prototypes which in regard to the observations and the analysis made, make use of contemporary interaction techniques in order to combine multiple views of infrared data. The prototypes are developed in C++ and with an XML-like layer for the integration with the user interface and the aimed functionality. The evaluation of the prototypes takes place with the aid of 7 users based on the empirical evaluation and ‘think aloud’ methods. The outcome of the evaluation encourages the idea that multiple views of data combined with the use of different interaction techniques can be beneficial for the understanding of the IR.
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Chapter 1

Introduction

1.1 Introduction in the problem area

During the last years mobile technology and generally hand held devices have been evolving rapidly both in terms of hardware technology and in terms of the usability and flexibility of the UI (User Interface) used. What was described as ubiquitous computing by Weiser (1991), an absolute and natural integration of computers to the environment and to everyday life, is almost here. There are several examples of hand held devices that became famous during the last years and were so widely accepted by users that redefined several features in the HCI (Human Computer Interaction) field and affected the evolution of UIs.

The latest trends concerning those types of devices involve the growing integration of graphical effects and animation techniques in the UI, which combined with direct manipulation techniques, enrich the user experience. By the use of such techniques, functionalities that were considered confusing and troublesome are described and presented to the users in a meaningful way, allowing in the same time the evolution of more and more elaborate and specialized applications. Multimodal interaction, such as haptics, touch and other kind of interactivity had facilitated the use of new devices as well.

Similar evolutionary steps were made in the field of IR (Infrared) cameras; cameras that can visualize heat into images. Moving from a form of almost fixed, not easily movable devices to hand held devices, their use became broader and various products were designed to address different user needs. IR cameras today are used for a variety of applications; building diagnostics, medical purposes, electrical and mechanical industries, defense systems etc.

Therefore they address a wide scope of users with different needs and from different educational and cultural backgrounds. Just like mobile devices, the UI of IR cameras is not directed to one type of users, but instead it should be as inclusive and general as possible, focusing on usability and aiding the users’ understanding.

Based on those facts, one can argue that the techniques used for the design of UIs of other hand held devices, can be also beneficial for the case of hand held
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IR cameras. Graphic effects, animation techniques and direct manipulation can not only enrich the user experience in terms of IR technology, but also ease their understanding.

In a wider sense the scope of this thesis is based on all the above facts. The area addressed is that of hand held IR cameras and especially the redefinition of the design of the UI for such devices. The innovative elements proposed in this thesis, try to investigate the efficiency of use of animation techniques, graphic elements, direct manipulation and other contemporary UI techniques, in order to enhance the users’ understanding and improve the user experience for specific tasks when using IR cameras.

However, since this is a quite wide and abstract scope for a master thesis, the problem addressed had to be narrowed down and distinct areas of interest had to be defined. Focusing on the whole UI functionality of IR cameras would be too risky and the result would have to concentrate on a very wide user pool. Only some specific problematic procedures and functionalities of the camera UI were chosen, as descriptive and representative enough, to describe the problems connected to the understanding of the IR data. Consequently, this thesis aimed for the creation of a number proof-of-concept prototypes, that would efficiently describe the solutions proposed and investigate the reactions of the users regarding animation techniques, graphic effects and other innovative UI elements. The method and the way that the implementation and design of those prototypes was decided, will be explained in the following chapters.

1.2 Goals and Purpose

The goals and the purpose of this master thesis are closely connected with the problem area discussed above. This project aims at integrating, in a meaningful way, state of the art interaction techniques in the UI of IR cameras. The purpose of this integration is to investigate if those elements have actually an obvious effect to the users’ understanding and the user experience, always in terms of IR cameras.
1.2. GOALS AND PURPOSE

The motivation behind the goal of this thesis involves different and various reasons, arising from a variety of problems and issues presented in the IR cameras.

Initially, thinking about IR cameras and what they visualize, one can easily understand that infrared thermography aims to describe a very abstract context; that is the visual representation of temperatures. IR cameras are known for being able to identify the amount of radiation emitted by objects within a specific set of temperatures. The images acquired are called thermograms and they represent emissions which do not concern the visible light wavelength, but instead a part of the electromagnetic spectrum that humans understand as heat. One of the most known problems of thermography is that objects not only emit their own energy, but they also reflect infrared energy of other sources as well. This can lead to many problems of understanding and inaccurate measurements, see figure 1.2a.

In advance, the visual feedback acquired from IR cameras is not a stable and expected representation. Users can usually choose between different color palettes to describe temperatures and those choices affect the image acquired significantly, see figure 1.2c. Another quite decisive factor is the range of temperatures visualized by the IR camera each specific moment which alternates the representation and affects the users’ understanding, see figure 1.2b.

These characteristics of the IR representations are the ones that define one of the most important purposes of this thesis. When people use IR cameras for the first time it is usually quite difficult for them to understand the context of the image they are watching. Users usually have problems of navigation to space and identification of the objects contained in the pictures. The lack of real visual data, in comparison to common digital cameras, frustrates the user and reduces the correct perception of space and objects. Unfortunately, this is not the case only for new users; experienced users as well, deal with similar problems that affect the accuracy of the data they acquire and the creation of correct IR images for the problems detected.

Based on all those facts, this thesis aims to help the users of IR cameras to understand and easily use a continuously alternating visualization for an abstract context, such as temperatures. Applying new kind of interactivity to IR cameras might help users to face the problems arising from the constantly changing character IR data and might compensate in a small extent for the lack of real digital data in terms of physical navigation into space.

A further objective that could be reached with the designs proposed, is to allow for IR cameras become more known and widely used by public. Until today the high cost of the IR cameras is a decisive factor that affects the amount of users that decide to buy an IR camera. By making the UI more usable and enhancing, one can hope to expand the use of IR cameras into new areas, where they could be proved useful in ways that were not considered until now. Therefore, by applying changes in the UI of such cameras, there is a great chance that a wider amount of users might find them more accessible and usable to such a level, that would allow them to be used for further applications.
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Figure 1.2: Known problems of the IR representations: (a) Problem of reflection: The hot cup is reflecting on the table causing frustration (b) Changing the range of temperatures captured by the camera and alternates the final result (c) Changing the color palette affects the final result

1.3 Limitations

There are different kind of limitations that affected the design and specification of this thesis.

Initially, the first limitation that significantly influenced the final design, was the constraint posed by the hardware used. When dealing with hand held devices one must consider the problems that might be caused by the limited resolution of the screen, the processing power and the memory management. As it will be explained and argued further, a specific solution was chosen for the implementation of the prototypes proposed, that did not have to deal with the problems of processing power and memory management but instead only the screen resolution was taken into consideration it. Besides, allowing for hardware problems to affect and limit the thoughts and ideas regarding the UI would not be fair, nor appropriate for the case of a master thesis that seeks to investigate innovative solutions in terms of HCI. It is also a fact that problems such as memory management and processing power will be gradually solved in the future as the hardware of hand held devices is evolving continuously.

Another fact that constraint the final design, was the lack of similar research in the area of IR cameras. Although there has been some research regarding the IR data, their fusion with digital data and in what form they are easier perceivable by users, this scientific field is not yet too evolved, in order to provide a clear view for the understanding of such data by the users. The relative research that could be
found, investigates the way that humans tend to perceive the visual complexity of IR visualizations cognitively and is too little and not elaborated enough. There was also no relative research found regarding a preferable form of UI for IR cameras. Instead, inspiration can only be drawn by research made for other kind of UIs for computers or other hand held devices, such as mobile phones.

Finally, another limitation posed on this thesis was the lack of public documentation for case studies on real users. Since the IR cameras are clearly an object of interest of private companies mostly, data or guidelines regarding the UI of such cameras or user testing cases, are kept and saved for inner use of the companies and are not publicly available. Compared for example with the cases of other hand held devices, mobile phones or PDAs, where the market is more open and there is a wider interest, in the case of IR cameras the domain of interest is so restricted that the information flow is relatively small.

1.4 Method

The methodology followed for the implementation of this thesis is mostly deductive.

At the beginning of the thesis the question posed was to investigate in what ways animation, graphical effects and other innovative interaction techniques could be used in the case of hand held IR cameras in order to enhance the users’ understanding and improve the user experience. Then, distinct and representative areas of interest were defined in order to reduce the scope of this thesis. Based on the definition of those distinct user cases, prototypes were created and hypotheses were made on the user behavior and reactions for each prototype. Then an evaluation experiment was conducted to support or oppose to the hypotheses made. Different qualitative and quantitative data were gathered out of the experiment, in the form of observations and questionnaires, in order to finally conduct an analysis over the hypotheses argued and conclude to some useful results.

1.5 Overview

This thesis is going to be presented into five following chapters.

In the second chapter, related literature and research will be presented following a historical approach. The research presented is also categorized in chapters which are defined by the level of abstraction and association to the work conducted in this thesis.

The next chapter, chapter three, is going to present in detail the specification procedure followed, the design choices made for the prototypes created and the methodology used. Chapter four is about analyzing the implementation of the prototypes created for each case and the tools used. Moreover, in chapter five, the design of the experiment will be argued as well as the evaluation procedure will
be discussed. The results acquired from the evaluation will be also presented and analyzed.

The last chapter is a discussion on the conclusions acquired out of the analysis of the data and a presentation of future work that can be conducted on this field.
Chapter 2

Background

2.1 Animation in the UI

The idea of integrating animated elements and animation techniques in the UI, emerges in the HCI field around the year 1990, when different research proposals on this specific subject, are presented almost simultaneously. Around this time, some of the most significant suggestions, regarding the use of animation in the UI, were made, arising from a strong background of publications which were encouraging the use of static images in the UI. Before the integration of animation techniques was proposed, static images in the UI were used to facilitate the learning procedure and speed up the users’ performance, by reducing the amount of errors (Lodding, 1983).

Two of the first critical works arguing in favor of the integration of animation techniques in the UI were presented by Baecker and Small (1990) and Baecker, Small and Mander (1991).

Baecker and Small (1990) try to identify the ways that animation can shift from its traditional case of use and be proved useful for the UI. They describe the ways that the UI can become more comprehensible for the users when animation techniques are used to:

- Review what has been done
- Show what can be done
- Show what cannot be done
- Guide a user as to what to do
- Guide a user as to what not to do

More specifically, they describe eight distinct questions that can be answered on behalf of the users, when animation techniques are applied in the UI. Those questions have to do with:

1. Identification (what is this?)
2. Transition (from where have I come, to where have I gone?)
3. Choice (what can I do now?)
4. Demonstration (what can I do with this?)
5. Explanation (How do I do this?)
6. Feedback (what is happening?)
7. History (What have I done?)
8. Guidance (What should I do now?)

In advance, Baecker et al. (1991) give a solid definition of the term of animated icons. They refer to them as symbols which represent either a whole application or specific parts of it, which are used in a sequential group of meaningfully alternating frames, in order to describe the whole application or a specific functionality. Therefore, as they mention, animated icons are depictions of functionalities and have the ability of “... clarifying their meaning, demonstrating their capabilities, and even explaining their method of use” (see Baecker et al., 1991, p. 1). They also claim that animation is a good way of visualizing the evolution of different processes and actions in terms of time. As in their previous work, (Baecker and Small, 1990), they are motivated by the hypothesis that animated icons could aid the user both in terms of identification tasks and in terms of demonstration tasks. Following an iterative process regarding the design of animated icons, they argue that animations should be as visually and as conceptually simple as possible. They stress out that animations used as UI elements cannot be absolute and complete explanations of the procedures that they describe, since their design faces both spatial and time limitations.

Finally, given the results of an empirical evaluation, animated icons compared with static icons, are proved more helpful for the user’s understanding, regarding the functionality of specific elements in the UI. However, the writers also point out that each animated element should be designed carefully in line with the limitations posed by the entire UI (size, duration, visual complexity), (Baecker et al., 1991).

Another one of the most crucial publications around that time is connected with the work of Chang and Ungar (1993). The first breakthrough that this work achieves has to do with the reasoning presented, regarding the need of cartoon techniques in the UI. The writers begin by emphasizing on the constantly alternating character of the UI, where multiple changes take place continuously according to the actions performed by the users. This specific characteristic of the UI, as they claim, opposes to the use of static representations for the UI elements. Static elements do not imply any kind of visualization for the changes that take place when actions are performed by the users. On the other hand as they point out, cartoons have a strong descriptive nature, which allows viewers to follow what is going on and easily perceive and apprehend a situation. By comparing the UI elements with cartoon characters, they argue that just like cartoon characters are concrete and constant representations and do not behave in a sudden and unexpected way, the UI elements as well, must
be formed gradually and naturally, not unexpectedly. In that way animation can become a means of understanding for the effect of the users’ actions, (Chang and Ungar, 1993).

Based on these simple arguments, they propose the use of animation techniques to express changes of the system status in the UI. They believe that smooth transitions from one state to another, would allow the users to reduce their cognitive load, by subconsciously shifting part of their understanding to the visual perception system. They also claim that, users are less destructed from the task performed and more relaxed if they are not surprised by sudden visual changes, (Chang and Ungar, 1993).

Their proposal refers to the integration of suitable known animation techniques used for cartoons to the UI, (Chang and Ungar, 1993). They examine those techniques by categorizing them in three groups: *solidity*, *exaggeration* and *reinforcement*.

The notion of *solidity* is defined as; designing the UI elements as tangible solid components, so as to be identified as individual entities, which interact with the environment and follow natural physical movement. The features that define an UI element as solid are together with others, *motion blur* and *arrivals-departures*. *Motion blur* fills the gaps between the old and the new position of an UI element and users are able to follow the results of their actions on those elements. By adding constant *arrivals-departures* to the movement of the UI elements, their materialization does not happen in a strange unnatural and sudden way, but instead it is described by natural events containing easing in/out intervals, like in reality.

The notion of *exaggeration* has do to with designing elements of the UI in such a way, so as to enhance the user’s attention, in comparison to being designed modestly allowing the users to overlook them. *Anticipation* is part of the exaggeration technique and is connected to emphasizing a preceding effect, so that the user expects what is going to happen in the future.

Finally, the term of *reinforcement* refers to features such as *easing in/out*, *follow through* and *arc-like movements*, which aid the user to conceive events that take place in the UI more easily and cognitively interpret metaphors acquired from reality.

The writers conclude by emphasizing that the differences between cartoons and the UI are outstanding. The most important differentiation relates to cartoons being totally “passive mediums”, (see Chang and Ungar, 1993, p. 9), while the UI is a completely interactive entity, where the user should perform actions without having to wait for animations to finish and should always be in control. In addition, the cartoons’ main purpose is to entertain, while the UI’s main purpose is to aid the user to complete a specific task. However, carefully chosen and meaningfully adapted attributes borrowed from cartoons, can facilitate the user to reduce the cognitive load and adds up a new level of amusement when using UI elements.
2.2 Specialized use of animation techniques in UI solutions

These publications were the first ones to address such matters and were followed by a significant number of other publications which explore the use of animation in the UI, under more specific situations and between different contexts. Empirical evaluations are conducted in each of these experiments proposed which by using various software tools, cause a simultaneous shift towards more descriptive and complex tools for the implementation of UIs.

The work of Hudson and Stasko (1993) presents a toolkit designed to address the need for the integration of animation techniques in the UI. The toolkit implemented is named *Artkit* and its goal is to ease the blending of complex animation elements together with the traditional UI features in a flexible, robust and reusable way. The animation abstractions designed cover a wide range of animation techniques including *timing, slow in-out transitions, arcs, motion blur, squash and stretch, anticipation* and *follow through*. One of the most innovative elements proposed in this work, has to do with the definition of transitions not only as a movement of an object from one place to another, but as a transformation of it from one shape to another. The writers propose a structure called transition object, which encapsulates the notions of interface objects, time intervals and trajectories, as components over which the animations are built on. The ideas presented in this paper have formed an early basis for more complex software tools addressed almost explicitly towards similar objectives.

In her PhD thesis, Gonzalez (1995) defines animation as

“a series of varying images presented dynamically according to user actions in ways that help the user to perceive a continuous change over time and develop a more appropriate mental model for the task”.

In a later work, Gonzalez (1996) tried to identify the advantages of the use of animation regarding decision making. She is therefore creating an experiment in order to compare decision making inside interfaces using realistic or abstract images, smooth or abstract transitions and parallel or sequential interactivity. The results of her experiment point out towards several decisive guidelines. First, the accuracy of decisions is closely connected to the satisfaction of the users when interacting with animated realistic representations, which alternate smoothly and follow a parallel way of interaction. In addition, animation is useful in different ways and depends on the task, its structure and the previous experience of the users with computers (Gonzalez, 1996).

The correlation of animation techniques with the notion of direct manipulation is also addressed by various researchers.

Shneiderman (1991) investigates in his work the meaning of direct manipulation in the UI, relating it to instant feedback to the users’ actions, incremental changes and reversible effects.

The work of Thomas and Calder (1995) proposes a different approach, in order
to create the feeling of direct manipulation in UI elements. Their proposal differentiates from other strategies on direct manipulation, in the sense that objects in the UI do not only have a solid nature, but they also behave and are perceived as solid components with the help of animation techniques. They claim that by adding animation cues in the UI objects, multiple new levels of information can be conveyed to the user like; the intention of the direction of a movement, the degree of change of an object and possible constraints. Therefore, the manipulation of different UI elements should happen in a straightforward way not with fixed shapes but instead with alternating vector-shaped objects which allow flexible actions.

In a later work, Thomas and Demczuk (2000) go one step further by proposing the use of the same kind of animation techniques to support the understanding of effects on the UI elements caused by indirect actions (buttons, commands etc), indirect manipulation. They claim that, cartoon style transitions can be used to decrease the disorientation introduced by immediate changes and to create preliminary views for the actions that could be performed on the UI.

In (Thomas and Calder, 2001), the writers’ work is summarized. They clearly articulate their ambitions by mentioning that

“our goal is to apply the animation to the interface itself- to enhance or augment the effectiveness of human interaction with applications that present a graphical interface.”

(see Thomas and Calder, 2001, p. 199). Therefore, they epitomize the results of their previous publications in four important principles:

1. The principle of attachment: The elements bearing direct manipulation in the UI should always stay attached to the pointer when being moved or transformed so that the user feels in control of them.

2. The principle of reluctance: The elements bearing direct manipulation in the UI should be designed in such a way so that to provoke the users to act on them in order to change the state of the system.

3. The principle of smoothness: The change from one state to another should take place in a continuous and smooth way to minimize the cognitive load needed and not to surprise the user.

4. The principle of anticipation: The outcome of the actions performed from the user on the UI should be expected and apparent to minimize the cognitive load and the use of the short term memory.

They conclude that animation in the UI can be used to add up to the visual feedback of direct manipulation and to make the manipulation more dynamic and enjoyable.

Bederson and Boltman (1999) try to identify if animating viewpoint changes in the UI, can help the users to build a mental maps for the understanding of spatial information. They also define a new metric called, total system response time, in which they include for the first time, the animation time. In the experiment designed, they try to investigate if animating viewpoint changes can help the user to
“navigate through the information space, recall information, and to re-
construct the information space”

(see Bederson and Boltman, 1999, p. 3). Their conclusions indicate that although animation might help to comprehend the spatial position, it did not add up in terms of navigation or in terms of recall. However, it did not have a negative result either and it was generally preferred by the users.

The work of Tversky, Morrison and Bétrancourt (2002) is opposing to a certain degree to the previously presented works, regarding the benefits of animation techniques in the UI. The writers begin their argumentation by attempting to approach animation as an evolutionary step of graphics used in the UI. They state that graphics have been proven effective when used to represent visuospatial elements (maps, architectural drawings) or when used to represent more abstract terms as metaphors. Animation can then be considered as a progressive step in the evolution of graphics, possibly having the ability to display change over time. However, as the writers point out while reviewing older works in favor of animation, the comparison made between the static and animated graphics in the UI is not fair, since sometimes animation techniques are confused with interaction techniques. Therefore, they claim that throughout the majority of the tests conducted, the animated graphics provide a wider level of information to the user in comparison to the equivalent static representations. They also claim that in different experiments, it is a common phenomenon, animated graphics to be enriched with great amount of interactivity, in comparison with static versions. They point out that animations are time consuming and not easily perceived in many of the cases. Finally, they conclude that the above arguments should be carefully considered and interaction should be used to allow the user to control the amount of animation in the UI, so that his perception is facilitated.

However, the use of animation is slowly being established in the design of UI and several later researches try to examine its effects on even more precise cases of use.

The work of Klein and Bederson (2005), tries to investigate the profits of animated scrolling when used for reading text documents. Through an empirical evaluation, they conclude that animated scrolling reduces the average task time, from 5.3% to 24%, according to the type of the document read and the duration of the animation used. It also minimizes the errors made and increases users’ satisfaction.

The work of Baudisch, Tan, Collomb, Robbins, Hinckley, Agrawala, Zhao and Ramos (2006), introduces a new kind of animation in the UI, differentiating from the previous solutions proposed. They present the idea of Phosphor objects, which are defined as objects that can be manipulated directly, by providing an immediate feedback on the users actions, but in the same time each change on them becomes obvious as an afterglow effect, shown for some time after the action. The concept behind this kind of objects is based on the belief that users should not have to wait for an animation to finish, in order to perform another action, nor they should not be facilitated by the benefits of animations to convey changes over time. The writers
propose a variety of animations for the design of the afterglow effects and their behavior when manipulating group of objects. They also present two user studies from which they draw their conclusions. Based on the first user study, they claim that Phosphor objects aid the users to be more confident when applying changes on the UI and that reduces the task completion time. They also believe that afterglow effects, aid users preserving their actions in the working memory. The second user study, aiming to compare traditional styles of animation with phosphor objects, points towards comparable results between the two interaction styles, since task performing is proved quicker in specific cases and is not opposed to quality of task performance.

2.3 Animation in small displays

As the use of animation in the UI slowly becomes established in the scientific community of the HCI, in the same time it invokes and supports the transition from the desktop metaphor towards different kinds of UIs and devices.

One of the most crucial works presented, aiming to redefine the form of the UI, has to do with the work of Bederson and Hollan (1994). The idea behind the new form of UI proposed by the writers, supports the concept of a more dynamic kind of UI, following new physics of appearance, relevant to the amount of data included. As the writers mention

\[\text{"we envision a much richer world of dynamic persistent informational entities that operate according to multiple physics specifically designed to provide cognitively facile access"} \]

, (see Bederson and Hollan, 1994, p. 2) The effort of their work is focused on adding different scales on which informational data can be viewed. They define semantic zooming, as the act being able to view the detailed version of an object when zooming in and in the same time viewing an altered representation of it when zooming out. Therefore, each element of the UI should have an alternating form, relative to the scale that it is being shown.

Following this initial idea, a later work of Khella and Bederson (2004), is presenting an innovative solution regarding the implementation of an image browser on small display devices (PDAs). This proposal is addressing problems connected to the resolution of the screen, the processing power and the memory management of small display devices. The writers propose a Treemap layout for the organization and display of collections of images, which together with animated navigation and semantic zooming, (Bederson and Hollan, 1994), form a valuable solution for image browsing in a limited and restricted display space. Finally, in the results presented in this work, even though they are mainly qualitative, they justify the need for animation techniques in small display interfaces in order to augment the user experience to a new level.

Around the same time, Gutwin and Fedak (2004) publish some very interesting research results, regarding the efficiency of different navigation techniques for UIs on
small screens. Their work is comparing the *Fisheye, Zoom and Panning Techniques* for different kind of tasks, taking place in small displays, concerning browsing a larger UI. The benefit of their work is that not only they address the known problem of large information spaces on small displays from a different point of view, but in the same time they present a complete inside view of possible solutions. Out of the experiments conducted, they conclude that each one of the navigation techniques can be proved more efficient according to the specific tasks conducted. There is also a well established argumentation for the disadvantages of each technique, which could be shortly summarized, by mentioning problems of speed in the panning system, time consuming cognitive adjustment for the different zoom levels and time consuming switching between different navigation modes.

A more recent work of Shanmugasundaram and Irani (2008) is again addressed to the efficiency of animated navigation, for interfaces containing navigation by the use of zooming techniques. The writers try to investigate the effect of animating viewpoint changes, when moving from one level of scale to another. They begin by referring to the basic defects when using animated transitions, mentioning the rise of the system response time and the possible diversion of the users' attention. However, based on results from the experiments conducted, they conclude that animated transitions in *zoomable* interfaces, reduce the task completion time and the processing time.

The scientific interest during the last years, has been moving towards specializing on mobile interfaces. Mobile phones have been gradually recognized as a powerful ubiquitous device, bearing different potentials for interaction, not only in the mobile environment itself, but even when used as a control device for other systems as well.

A work presented by Huhtala, Mäntyjärvi, Ahtinen, Ventä and Isomursu (2009) is investigating the effects of different kind of transitions, in order to convey changes of the states of objects, in mobile menus. There are four main design proposals considered in this work; the blank screen transition, the direct change transition, the sliding transition and the blinking animation. Based on a large scale experiment conducted, the writers present both qualitative and quantitative results, that can be shortly summarized by mentioning that animated transitions acted in favor of the user performance, posing some questions regarding the appropriate duration of the animation and the visual irritation caused by blinking effects.

In their latest work, (Huhtala, Sarjanoja, Mäntyjärvi, Isomursu and Häkkilä, 2009; Huhtala, Sarjanoja, Mäntyjärvi, Isomursu and Häkkilä, 2010), try to investigate differences between various kind of animated UI transitions in the mobile UI, in terms of duration, design and of how they are perceived by the user. The writers have conducted a complicated experiment, where they compare 24 different sequences of screen transitions, differentiated in terms of duration of screen changing, of the total duration of the animation and of the existence of zoom effects. The main question that the writers try to answer, is which kind of navigation is perceived as quickest by the users. According to the results presented, users seem to perceive changes, where the second screen/image becomes apparent more quickly in the transition, as more quick in general. Therefore as the writers point out the
most important value on such transitions is how quickly the new state of the system is presented to the user.

### 2.4 State of the art for IR imagery

The research conducted in the IR field until lately has been focusing on a different direction than the concerns of the HCI field. Most of the publications made regarding the use of IR images, investigate the improvement of the users understanding regarding such data, proposing solutions of fused IR and digital imagery and quantity metrics for those solutions.

The first work presented by Burt and Kolczynski (1993), is investigating a new technique of fusion between different images, acquired either from the same or different sensors. The proposed algorithm is focusing mostly on the combination of IR and digital imagery, in order to improve understudying of the environment. The work of Piella (2003), is also investigating a sufficient fusion technique between IR and digital data. Piella (2003) is pointing out that, successfully fused data can benefit various parts of the scientific research as defense systems, geoscience, medical imaging, robotics and industrial engineering.

The work of Chen and Varshney (2007), is proposing a new quality metric for the fused imagery, which is inspired by the human vision system. The writers claim that the variety of IR applications and user cases burdens the creation of a general metric for the fused data, and that the creation of such a metric should be based mainly on the way that users' tend to perceive fused imagery.

The work of Toet, Ijspeert, Waxman and Aguilar (1997) is examining specific cases of use of fused data for observation, localization and detection and try to identify how those tasks are aided by a high level of detail. According the results acquired from an experiment conducted with the help of real users, the writers support that the accuracy and confidence of the users is aided, when using fused data (digital and IR), in comparison to using data of one form only (digital or IR).

Toet and Franken (2003) present a large scale experiment, in order to compare the benefit of fused images, in comparison with digital images for specific tasks. The experiment is conducted under night time conditions and for different color representations for the fused data. The results point towards an advantage in favor of the digital data in cases of situational awareness and in favor of fused data in cases of object discovery. The latest work of Toet, Hogervorst, Nikolov, Lewis, Dixon, Bull and Canagarajah (2010) is trying again to address the problem of combining different sensor data in one image and of how those kind of fused images are understood and perceived cognitively by the users. Therefore, the writers initially try to investigate how the users apprehend visual and IR data as independent entities and moreover in a combined source. Their work is focusing on using fusion techniques on specific parts of the digital imagery, that are semantically meaningful to the users.
Chapter 3

Design Process for the Prototype UI Solutions

3.1 Problem identification and specification

This chapter is going to present in detail the design process followed and the implementation made. The presentation is going to take place step by step, specifying the methods followed for each level of the design. Firstly, as mentioned earlier, the most important part before beginning the implementation step was to define the problems and the areas that the prototypes created had to focus on. Given this decision, each problem of interest identified was investigated deeper and individually.

3.1.1 Method

The initial step for the investigation of different problematic areas in the camera UI was to investigate the usability issues found in the existing camera devices. This step was also important in order to acquire a certain experience with the IR data and get accustomed with the functionalities and the applications in which they are used.

Searching for a quick and effective way of evaluation of the IR camera UI, the one found as most appropriate is the heuristic evaluation, (Nielsen and Molich, 1990; Molich and Nielsen, 1990). In this kind of evaluation the whole interface is browsed gradually given some specific usability questions and guidelines, (Nielsen, 1994a,b).

Given this set of guidelines, see table 3.1, the UI of two IR cameras, the FLIR SC660 and the FLIR I7, was investigated to identify specific problem areas, (FlirSystems, 2010b), (FlirSystems, 2010a). A list of possible issues was created, out of which the candidate problem areas were defined. Those areas and ideas regarding the specification of the prototypes are presented in table 3.2. Out of those, only one area of interest was chosen, and then three specific user tasks were extracted, as the most interesting and valuable for this thesis.
### Table 3.1: Heuristic Evaluation Guidelines (Nielsen, 2010)

<table>
<thead>
<tr>
<th>Visibility of system status</th>
<th>The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match between system and the real world</td>
<td>The system should speak the users’ language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.</td>
</tr>
<tr>
<td>User control and freedom</td>
<td>Users often choose system functions by mistake and will need a clearly marked ’emergency exit’ to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.</td>
</tr>
<tr>
<td>Consistency and standards</td>
<td>Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.</td>
</tr>
<tr>
<td>Error prevention</td>
<td>Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.</td>
</tr>
<tr>
<td>Recognition rather than recall</td>
<td>Minimize the user’s memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.</td>
</tr>
<tr>
<td>Flexibility and efficiency of use</td>
<td>Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.</td>
</tr>
<tr>
<td>Aesthetic and minimalist design</td>
<td>Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.</td>
</tr>
<tr>
<td>Help users recognize, diagnose, and recover from errors</td>
<td>Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.</td>
</tr>
<tr>
<td>Help and documentation</td>
<td>Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user’s task, list concrete steps to be carried out, and not be too large.</td>
</tr>
</tbody>
</table>
3.1. PROBLEM IDENTIFICATION AND SPECIFICATION

Table 3.2: Problem areas identified with the heuristic evaluation guidelines

<table>
<thead>
<tr>
<th>Problem area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combining multiple data sources (video, still images, digital images)</td>
<td>How to aid the user’s understanding and efficiency in cases where the combination of various data is required (IR video data, IR image, digital image, documents, e.t.c.). In this case, the zoom case with an overview of the whole IR scene can be categorized, as well as the case of comparison with a reference image.</td>
</tr>
<tr>
<td>Optimization of the saving procedure</td>
<td>How to communicate to the user what exactly is being saved and when in the saving procedure. How to make understandable the freezed preview of the image to the user.</td>
</tr>
<tr>
<td>Visualization of the changes of the system’s state and changes in the IR flow</td>
<td>How to give understandable feedback to the user for changing the scope of the IR data (changing level/span and max/min) and for changing between different modes (IR/digital/Picture In Picture/Fusion).</td>
</tr>
<tr>
<td>Informative delays</td>
<td>How to take advantage of delays happening because of the hardware, in order to provide a better understanding for the system’s state to the user.</td>
</tr>
<tr>
<td>Archive view</td>
<td>How to create usable and understandable data collections which contain information for the groups of data and the chronological sequence with which they were acquired.</td>
</tr>
<tr>
<td>Small displays in relation to large group of data</td>
<td>How to visualize all the available information and camera functionalities in the given display space of the camera screen, always keeping the maximum possible space for the live IR data.</td>
</tr>
<tr>
<td>Help and Documentation</td>
<td>How to integrate help functionalities and information for specific camera features in the camera UI without affecting available UI space significantly.</td>
</tr>
<tr>
<td>Documentation of a IR problem</td>
<td>How to help the users create adequate documentation of an IR finding in the work field, by saving various and correct kind of data.</td>
</tr>
</tbody>
</table>

Reference to the site.

3.1.2 Specification areas

The problem area selected was that of Combining multiple data sources, in order to aid the user’s understanding and efficiency during specific tasks that require or could be enriched by this combination. The heuristic evaluation, revealed certain user tasks that could be more problematic than others and which could be enriched and facilitated, if further data sources were integrated. Those tasks were found the
most suitable for the application of different animation, direct manipulation and other innovative HCI techniques. The thought was that each data entity created in the UI (IR video, IR image, digital image, second IR image) should be an independent, solid and easily distinguishable entity, manipulable by the use of animation techniques, as those proposed in the bibliography. By designing specific ways of behavior for each data entity, the user is able to control the UI better and expect the results of the actions performed.

Therefore the areas/tasks of interest selected for this thesis can be divided and explained as:

A The reference image case: Use of graphic effects, animation, direct manipulation and other interaction techniques, in order to ease the identification and recreation of a specific scene of IR data, given a reference image.

This area of interest is connected with the ability of users to navigate into physical space, identify possible problem areas and to compare them with previously acquired images to the current system state. It is also connected with the ability of recreating a given scene. The UI features that might be helpful in terms of those goals are investigated.

B The zoom case: Use of graphic effects, animation, direct manipulation and other interaction techniques, in order to ease the navigation and the user’s perception of the zoomed in position in relation to the whole space.

This design area concerns the spatial navigation of a user in the context of IR data with different points of interest. The design in this case aims to help the user to perform zoom in/out tasks by preserving the track of his position inside the initial context and in relation to different data.

C The group navigation case: Use of graphic effects and animation techniques to investigate new ways of navigation inside a group of IR related data.

The above goal concerns the cases of navigation from one type of data to another and the combination of different still forms of data in a useful way. The design proposed will aim to aid the user follow the spatial and relative context between different data sources and ease the understanding of the IR image.

Given those areas the design procedure is going to be analyzed for each of the cases in the following chapters.

3.2 Scenarios and Sketches

The definition of the design goals and problem areas lead to a new step of the design procedure, the creation of sketches and scenarios. Those two design techniques are known and commonly used in the design procedure, so as designers to
be able to express and visualize design ideas in an effective and not time consuming way. Both techniques are presented in the next chapters.

3.2.1 Sketches

Different sketches were made for each of the design goals. The sketches were simple drawings made on paper aiming to visualize different forms that each of the prototypes proposed could have, (see Löwgren and Stolterman, 2007, p. 82). The drawings did not include any kind of interaction description, but instead they were single and independent representations of the UI. The goal of those sketches was to initiate a discussion, together with the supervisor in FLIR Systems, regarding the design of each prototype. This discussion, partly used as a brainstorming session as well, was the one that defined the guidelines for the creation of the scenarios. During the implementation of the prototypes, an attempt was made for different ideas to become functional, but some of them were gradually abandoned, given the possibilities of the tool used for the implementation or the final result.

3.2.2 Scenarios

Based on the first sketches made, some scenarios were developed in order to specify further the implementation made, (see Löwgren and Stolterman, 2007, p. 80). Another decisive factor for the creation of the scenarios, were the personas developed independently from this thesis by the usability team of FLIR Systems, (Blomquist and Arvola, 2002). Those personas, together with user cases and observations that came out of multiple usability testings on the FLIR cameras, were discussed in some supervising session. These information and relative user experience that was discussed inside the design team and were communicated orally have been very helpful for the formation of the scenarios.

Finally, one scenario was designed for each of the problem areas, focusing a bit more on the way that the interaction should take place in the UI. Those scenarios were discussed as simple Powerpoint presentations, since their value was clearly communicative and descriptive and there was no reason for further time to be spent on them.
Chapter 4

Implementation of the Prototypes

4.1 Implementation details

There are different categorizations and discriminations for the prototypes that are implemented in a design procedure. In (Rettig, 1994), the prototypes are divided into Lo-fi and Hi-fi prototypes, given the technical means used for their creation and the amount of detail contained. In (Houde and Hill, 1997), prototypes are placed according to their role in a triangle space whose corners represent the role, the look and feel and the implementation prototypes.

The prototypes made during this thesis could be categorized as HiFi prototypes based on their form and could be placed somewhere between the look and feel and implementation side of the triangle according to their focus. Their goal was twofold, firstly to explore the way that the users feel for the design proposed and then to explore how this design could be implemented with the software tool available, see figure 4.1.

Figure 4.1: Categorization of UI prototypes
4.1.1 Software

The software used for the implementation of the prototypes is a xml-based framework used internally by FLIR Systems for the camera UI. The main concept behind this framework is the model-view-controller or model-visual-control (MVC) software architecture, which is used to differentiate between different roles and parts of the applications. The term model is connected to data management and is responsible for the notification of the other application parts whenever a change is taking place in the data. The term view or visual is connected to the UI elements and the interactive part of the application. The same model can have multiple views in the same application. Finally, the controller or control is the level that handles the events that arise from the interaction and alternates the models accordingly. It is also responsible for the initiation of feedback given in the view/visual level. From now on the terminology model-visual-control will be used for the description of those components.

In the framework used for the specific implementation there were two forms of data used according to the flexibility wanted. There were data that were defined as static models in the model level and there were other kind of data that alternated continuously which were provided to the model level repeatedly through notifications send from the C code running in the background. The whole framework used was already available and used by FLIR Systems and different functionalities of it were adapted to the fit the prototypes' demands.

4.1.2 Common Frame

Before beginning to analyze the implementation of the prototypes made one by one, an overview should be made regarding the general design for the implementation.

As explained in the introduction in the limitations section, a common problem for the implementation of such prototype solutions is the hardware available. The design ideas that came out of the sketching and brainstorming sessions did not take into account the processing power and the hardware specification of the IR cameras. Specifically, in the case of this thesis, there was a further problem since there was no camera working and having integrated the software used for the implementation, when this thesis was developed.

Given this problem, it was decided to implement all the prototypes in a common laptop computer, Windows Vista, 2.33GHz Intel Core 2 Duo with 2GB RAM, which included touch based interaction as well. In that way the touch interaction that would take place in the camera screen, was simulated by touch events on a simple window environment in the laptop screen. The events that concerned specific buttons on the camera (zoom in/out, save, etc) were initially executed by events on the keyboard. However, while approaching the evaluation procedure, this solution was abandoned and a simple menu, manipulated by touch next to the camera window, was added.
4.1. IMPLEMENTATION DETAILS

As shown in figure 4.2, the main application window was 660 × 340 pixels and in there two other components are drawn. The camera window, representing the camera screen, is the one where the live IR image acquired from the camera is shown and its resolution is 320 × 240 pixels. The menu component is the one placed 10 pixels away, on the right of the camera window and contains buttons representing the physical buttons on the camera. The quantity and the context of those buttons is changing according to the prototype.

![Figure 4.2: Common window view for all the prototypes created](image)

**Model-Visual-Controls**

As mentioned earlier, this window frame was common, to a certain extend, for all the prototypes created. Therefore, the main controls and models used, remain the same for all the prototypes and it was only the visuals that differentiated for each prototype. Of course, if there was a need for further functionality to be added, more controls were added as well. The software framework used for the implementation, contains some ready made controls and visuals that could be used according to the case.

The basic controls that were common for all the prototypes are going to be presented in detail, as a base for the demonstration of the elements added further for each case. To begin with, the basic controls, used to create the common window view presented above, figure 4.2, are going to be presented one by one. Those controls were six and more than one instances of them were used in some cases. Here they are presented in an hierarchical order, starting from the most important in the implementation tree, going to the less important and more flexible controls.

1. **uiRoot control**

   It is the most basic control that should exist in every application and initiates the implementation tree. It is always the starting point and it must contain
the visuals for the top control contained by it, which is usually a frame.

2 **frame control**

The frame control is usually the top control in an application. It allows for grouping of other controls but in the same time it has the role of a browser. Therefore it has the ability to invoke navigation through history (e.g. next, previous) and through other controls.

3 **list control**

The list control is a pretty much independent control with multiple functionality, able to stand alone and inside other controls. It is usually used to visualize large data spaces that might be out of the screen. It also needs to be connected to its own model which makes it flexible and easily changeable according to the state of the program.

4 **page control**

The page control is mostly a grouping control, representing different views of the same application. It is usually placed in a frame control which allows the application to navigate from page to page.

5 **form control**

The form control is a very powerful control that can be used not only to group other controls but to navigate through them. It can keep information for the id of the control that is active any current moment and it is suitable when multiple functionality should be added in different levels.

6 **control control**

The control control is the most basic simple control. It cannot group other controls and it is always a bottom entity in the implementation tree.

![Diagram of the controls used](image)

**Figure 4.3:** Diagram of the controls used
For each one of the controls a related visual was used as well. The visuals included in the software framework used, are different kind of entities, which, according to their form, bare different functionalities. The role of the visual components is, as explained before, to define the UI of the application. Therefore, they are useful to define margins, to draw specific schemas, to align elements e.t.c. and to declare which of the parts of the UI can produce events. Roughly, the visuals used can be categorized in two groups, the first group of visuals are those that are not visible to the user and their role is strictly organizational, while the second group of visuals are those that are visible to the user. Both of them can identify the existence of events in most of the cases, if requested by the application. There is a third group of visuals equally important that has to do with the initiation of animation effects on the other visual components.

Some of the visuals used for the prototypes are going to be presented very shortly here.

1 Graphical Components
   a) Image: Used to load images from a specific folder to the UI
   b) Text: Used to produce specific text entries
   c) Rect: User to draw rectangle areas

2 Layouts
   a) Container: Used to group other components which are cropped at its borders.
   b) DockLayout: Used as a container, but can also align the components in it.
   c) ScrollBar: Represents a value interval graphically.

3 Scrollable Layouts
   a) ListView: Used to visualize list controls and large data spaces that might need scrolling

4 Animations
   a) Action: Defines a group of actions that are initiated by a specific event
   b) Animate: Defines a single component animation
   c) setString: It is not really an animation but mostly an action to change the value of strings for different attributes.

Together with the visuals and the controls there are also a number of models used in the implementation. The list model contains the buttons presented in the menu on the right of the camera view window and it is defined as a simple xml file. The values model is defined in the page control and contains a set of variables with information about the size of the different components of each prototype and boolean variables describing the state of the system. A simple organizational project tree containing the controls and model used can be viewed in the figure 4.4.
CHAPTER 4. IMPLEMENTATION OF THE PROTOTYPES

Figure 4.4: Example of a project tree with controls and models

Camera Video Stream

Another common component used in two out of three prototypes, was the camera IR video stream that fetched a live video image from an IR camera into the laptop application. Initially, the idea was that a prerecorded video could be used as a background for the prototype, but it was abandoned due to the low quality of the video. It was also found that a real look and feel for the users, who would have been unable to control the live image flow. Therefore, the live video stream was used since the drivers for the camera and the code for the frame grabbing were already available from FLIR Systems.

The available code used and adapted for the purpose of this thesis is based in the DirectShow API, which is suitable for creating media streams on Windows, (DirectShow, 2010). The code used could identify the specific camera model and drivers, and create a suitable graph for the stream. The graph built contained a sequence of filters used to decompress the stream acquired (e.g. Sample Grabber, AVI decompressor, etc.). The frames grabbed from the stream were in the YUV colorspace and had to be transformed to simple ARGB format to be integrated in the code. For all the transformations made and the inner use of the frames grabbed, a common open source library was used, OpenCV (2010). Then the frames grabbed were provided to the integration layer of the C code to the UI, which was responsible for the rendering. The framework used could notify for the arrival of a each new frame through a callback function, so as the UI scene to be rendered continuously. Since the IR video data contained a large amount of slightly compressed information, a firewire connection was used in order to achieve the a good frame rate, around 20–25fps.

Having explained the common elements behind the implementation of the prototypes, each case can be viewed separately according to the problem posed.
4.2. THE REFERENCE IMAGE CASE: PROTOTYPE A

4.2 The reference image case: Prototype A

Use of graphic effects, animation, direct manipulation and other interaction techniques, in order to ease the identification and recreation of a specific scene of IR data given a reference image.

As explained above, for this case, the design proposed had to facilitate the user in multiple ways. Firstly, the prototype created had to allow the user to browse the IR space, by moving the camera and be able to identify some objects of interest. Having identified those objects the user should be able to bring a similar image from the archive and compare it with the current situation. The prototype should also allow capturing images and permit the user to be in control of this procedure continuously.

4.2.1 Functionality and Interactivity

Based on those goals the design of the prototype is going to be presented gradually. The initial view that the user had was the camera view window, which contained the live IR video stream, and the menu next to it with four different buttons; a) Freeze b) Image Archive c) Change View d) Save, figure 4.6a. When moving the IR camera the user could see the video stream changing in the live IR camera space of the UI and he could use it as a real camera screen. Then he could navigate through the IR space, identify different objects and focus on a specific scene.

The actions available in this state was either to freeze and then save, or bring up the image archive. When pressing the image archive button, a list with five thumbnails appeared on the upper part of the live IR view. The user could choose any of the five thumbnails available. From this point the user could either click in one of the thumbnails and bring it to an initial position, figure 4.6c, or grab a thumbnail and drop it to the live IR space, figures 4.6d–4.6e.

As soon as the user brought the image to the live IR view with the first or second way, the archive list was hidden again. In case the user has brought a wrong thumbnail or just wanted to change the current one, he could either bring out the image archive again, by pressing the relevant button, and make the change, or double click on the current thumbnail and make it go back to the image archive. The image archive remained visible after that for the user to choose a new thumbnail. If he did not want to choose a new thumbnail he could just hide the archive again.
CHAPTER 4. IMPLEMENTATION OF THE PROTOTYPES

Figure 4.6: Bringing an image from the archive in prototype A: (a) Initial view of the prototype (b) After pressing the archive button (c) Clicking the thumbnail on the archive brings it to an initial position (d) Also, the user could grab a thumbnail from the archive and, (e) Move it and drop it in the live IR view.

by pressing the image archive button. Those were the possible sequences of events followed in order to bring an reference image from the archive.

Having brought the wanted reference image from the archive the user could then try to manipulate the UI, in order to get it to a preferable form. This could happen by directly manipulating the thumbnail which was in the live IR video view. The user could either move the image around, figure 4.7a, either resize it; maximize it, figure 4.7b, or minimize it, figure 4.7c, by dragging one of its corners. There was a maximum and a minimum size that the thumbnail could reach, so as to avoid hiding the whole live IR view or become so small that the user would not be able to manipulate it. The feedback when the user tried to move the thumbnail was
4.2. THE REFERENCE IMAGE CASE: PROTOTYPE A

Figure 4.7: Direct manipulation in prototype A: (a) The user could move the image in the live IR space, (b) Make it bigger by dragging one of the corners, (c) Make it smaller by dragging another corner, (d) Resize it and position it wherever in the live space.

that its border became green and when trying to drag one of the corners a green square appeared that defined the active dragging area. The user could apply as many actions as wanted until he reached a satisfactory state, figure 4.7d.

As explained before, in the state of sketching, more than one solutions and proposals were identified for some of the prototypes. For this specific case, except from the solution proposed already, another view was considered descriptive and useful for the users. Therefore, the change view button in the menu, could bring the user to a side−by−side view, where the reference image and the live IR view were placed the one next to the other, to ease the comparison, figures 4.8a−4.8b. From this point, the user could either click the reference image or the live IR space to enlarge them, in case their size was too small to identify specific details. Each of the components in the side−by−side view, the live IR and the reference image, had two states. their initial state was to have both the same size, and if one of them was clicked it became bigger and the other one smaller. The user could not manipulate the size of the components by direct manipulation in this view. Clicking the change view button again could directly bring the user to the initial state of the system, where the thumbnail is placed on the live IR space and not next to it.

Finally, when the user has achieved a satisfactory result by manipulating the camera and with the help of the UI, he could freeze and save the view created. The step of freezing was added in the saving procedure, in order to allow the user to
easily control the saving sequence and recover from possible errors. The user could freeze and unfreeze the view as many times as he wanted, without saving and if being unsatisfied from the result produced, he could just unfreeze and recreate the scene without having to produce a saved result. The user was informed for the act of freezing by the appearance of a semi-transparent rectangle above the data, figures 4.9a–4.9b. The user could also directly manipulate the reference image in the freezed state, in case it was affecting the view somehow. Freezing either in the normal view or in the side–by–side view would keep the state of the system as it is, but saving the image would initiate an informative message, return the system to the normal view, bring out the archive and place the reference image back to it, through a series of animation effects, figure 4.9c.

It has to be mentioned also, that two specific design choices were abandoned during the implementation. The first one, has to do with the direct manipulation of the thumbnail in the normal view, where the user could drag the corners and resize it.

At the initial state of the design, the idea was that the user should be able to drag a thin slice in each side of the rectangle, figure 4.10. However, this idea was abandoned, because it affected the ratio of the thumbnail, that should be kept stable and also because it needed some extra steps of interaction by the part of the user to reach a satisfactory state. Then, the corners of the reference image were chosen as active spaces for the direct manipulation, affecting simultaneously the

Figure 4.8: side-by-side for the Prototype A: (a) The user could change to Side-by-Side view, (b) and the see the live IR data Side-by-Side to the reference image, (c) make the live IR data bigger, (d) or make the reference image bigger.
4.2. THE REFERENCE IMAGE CASE: PROTOTYPE A

Figure 4.9: Saving sequence for the prototype A: (a) The user could freeze either in the normal view, (b) or the side-by-side view and (c) pressing save returned to the initial view.

width and height of the reference image. In that way the user could easily resize the whole thumbnail and an invisible extra space of manipulation was added out of the corners of the thumbnail. This space remained the same no matter the scale of the thumbnail, so as to be a sufficient space for touch in the screen.

Figure 4.10: Description of the evolution of the areas of interaction for the thumbnail. 1–4: resizing and 5: moving

The second type of interactivity that was abandoned, has to do with the side–by–side view. At the beginning, the idea was that the two components in this view would also bear direct manipulation and the user could move and resize them as wanted. However, although this interactivity was implemented, it was decided not to include it in the final version. Changing place and resizing those components was causing a certain frustration, since the actions applied to one of the components
affected the other. There was also no consistency in the scene, regarding which was the reference image and the which image was live IR view, since the sequence of them could be alternated and confuse the user. Therefore, to conclude, users were only allowed to maximize to a stable size the components, as it was explained before.

4.2.2 Implementation

Some more details regarding the implementation are going to be presented in this section as well.

As mentioned at the beginning of this chapter, the controls used for the prototypes are almost the same, for the majority of the cases. Therefore, in this case as well, the most basic, initial control was the `uiRoot control`, including a `frame control` and a `list control` for the button menu. The frame control included a `page control` and the `page control` included a `form control` and three `models`. The `form control` included a series of `control controls` for each one of the distinctive components in the UI. Those are:

- `video_control`
- `ref_control`
- `ref_title_control`
- `video_title_control`
- `copy_video_control`
- `copy_ref_control`
- `save_control`
- `list_archive_control`

In detail, one `control control` is used for the live IR video component which is communicated by the visual of an image, `video_control`. This image is continuously alternated according to the data of the IR stream that arrive, which also notify the
4.2. THE REFERENCE IMAGE CASE: PROTOTYPE A

application to rerender the whole scene. Then, another control control is used for
the reference image brought from the archive, ref_control. At the beginning, before
the user chooses an image from the archive, the image of the visual contained in
this control is empty and invisible, but as soon as an image is brought in the live
IR view, this component becomes visible. There are also two controls for the titles
that appear in the side–by–side view, the ref_title_control and the video_title_-
control, and one control control for the semi-transparent rectangle that is used for
the saving procedure, save_control. An independent control is also used for the list
of the archive appearing from the top of the UI, the list_archive_control. Finally,
two control controls, entitled copy_video_control and copy_ref_control, are used
to create the animation effects, when changing from the normal to the side–by-
side and vice-versa, so as to show the progress of change between the views. The
difference of those copy controls is that their size and position is only manipulated
by the xml-like environment, the higher part of the application, and that makes
them less flexible to immediate changes, initiated by specific events, but suitable
for a series of organized and foreknown animations. On the other hand, the main
control controls, video_control and ref_control, since they must be quite flexible
and easily alternated by touch events, are based in the specifications given by the
values model.

The values model is the one contained in the page control, that has information
regarding the sizes of some controls and regarding some booleans showing the state
of the system. The main advantage of this model, is that it can be manipulated and
alternated both by the xml-like environment and the C code at the background.
For example, when the user drags the corners of the reference image to resize it,
a function is called in the C code, that catches the pointer, mouse or touch, and
alternates the values in the model. Then, since the values are alternated, a notifi-
cation is send immediately in the xml-like layer and the UI is rerendered. If this
alternation took place in the xml-like layer, the notification for the change of the
values would be send with a certain latency, after all the events were handled, and
the feedback of resizing would be obvious only after the user had finished the action
of dragging.

Two more models are included in the same page as well, one pointing to the
names of the files of the images shown in the archive and one pointing to the name
of the file shown in the reference image. Therefore, when the user brings an image
to the live IR space, the name of the file corresponding to the thumbnail chosen is
deleted from the first model and copied to the other, from the C code. Another,
model is used for the names of the components (buttons) presented in the menu on
the right.

The visuals used for each one of the controls are not going to be presented in
detail as they are not considered important for the understanding of the function-
ality of the application. What is important to stress however, is the animation
effects included in the design, which aimed to ease the users’ understanding re-
garding the sequence of the actions taking place and the changes of the states of
the system. Therefore, one animation sequence, as mentioned before, exists when
changing between the two views, which gradually resizes the \texttt{copy_video\_control} and the \texttt{copy\_ref\_control} from their initial position to the final state, in order the user to follow gradually the change of the form of the components. Another animation sequence is used in the saving procedure, when the archive becomes visible and the reference image is gradually resized and positioned again in it. This is happening again in order to narrate the sequence of actions that take place to the user and not present a sudden, difficult to understand change.

4.3 The zoom case: Prototype B

Use of graphic effects, animation, direct manipulation and other interaction techniques, in order to ease the navigation and the user’s perception of the zoomed in position in relation to the whole space.

As explained above, this case is about easing the perception of the user in the IR space, especially if being in a zoomed in state, when the data space is very limited and its relation to the environment is not clear. Therefore, the goal of the design proposed is to facilitate the user zooming in to specific details and navigate in the IR space effectively from one point to another. For example, when IR cameras are used in industry, there are many cases where the users have to focus on details placed far away from them and which are not approached easily. Then, because of this, the users need to able efficiently navigate in the IR space while in the same time, do not loose their understanding of the environment, figure 4.12.

4.3.1 Functionality and Interactivity

Those goals defined the final design proposed. As before, the initial view that the user had was the camera view window, containing the live IR data and a menu placed next to it with four buttons; a) Freeze b) Zoom In c) Zoom Out d) Save, figure 4.13a. Moving the IR camera, directly renewed the image rendered in the camera view window, as if it was the real camera window. Then, the user could navigate in the IR space and identify objects of interest.
4.3. THE ZOOM CASE: PROTOTYPE B

Figure 4.13: Zoom in functionality for the prototype B: (a) The initial state of the prototype, (b) when the user pressed the Zoom In button for the first time the overview window appeared (c) as the user kept pressing the button continuously the image was zoomed in and the white rectangular border in the overview window became smaller (d) the user could keep zooming until a maximum point.

As in the prototype A, the user was able to freeze and save whenever a satisfactory view was created in the camera view window. In this case however, the thought was that the user should be able to save instantly an image, without having to freeze first, since he might need to take several quick shots of the same problem, without losing the view created and the focus on details.

Except freezing and saving, the user could also zoom in and out to specific details. The first time the user pressed the Zoom In button the overview window appeared, which contained the initial view of the image at zero zoom level. It also contained an inner rectangular border, which represented the amount of the initial image that was rendered in the camera view window; the part of the image that the user was seeing after zooming in. Each time the Zoom In button was pressed, the image was zoomed in from its centered by a stable factor, and the rectangular border alternated correspondingly. There was a maximum zoom level that the user could reach and the minimum was zero, when the overview window disappeared again, figure 4.13.

As in the first case of the prototype, the design proposed, aimed at giving as much as possible freedom and control to the user, so as to manipulate the UI in a comfortable way. The components in the UI were designed to bear direct manipulation by touch, and in that way the user was able to place them in a
CHAPTER 4. IMPLEMENTATION OF THE PROTOTYPES

Figure 4.14: Direct manipulation of the overview window in the prototype B: (a) The user could move the overview window wherever in the live IR space, (b) make it larger by dragging one of its corners, (c) or make it smaller by dragging one of its corners, (d) by double clicking on the overview window made it disappear on the upper left corner.

preferred position and readjust them according to the case. Therefore, the overview window, which appeared when zooming in, was changeable and manipulable in the same way as the reference image in the previous prototype. The user could move it wherever in the IR data space and resize it by dragging one of its corners. Another interactivity feature was also added in this case, where the user could double click in the overview window and make it minimize in the upper left corner in the form of a semi-transparent square. This choice was given to the user in case the overview window was perceived as distracting.

Another part of the prototype, that alternated in relation to the case A, was the freezed state of the image. When the user was freezing the image, except from being able to manipulate the overview window as before, he was also able to pan the freezed image in every direction. The rectangular border drawn in the overview window was following the panning interaction and showing at each case the part of the image available in the camera view window, figure 4.15. This feature was added in case the user has failed to lock the target in the image effectively, while in the zoomed in view. It is a known problem that small movements can alternate significantly the zoomed view of the camera. Then, by adding the panning interaction, in the freezed, zoomed version of the image, an extra amount of data was presented and manipulated by the user, allowing him to target better the object of
4.3. THE ZOOM CASE: PROTOTYPE B

![Figure 4.15](image)

**Figure 4.15:** Panning functionality of the freezed image in the prototype B: (a) The user could freeze the image in a satisfactory state (b) and pan it by touch in different directions (c) while following the changes of the overview window (d) until reaching a satisfactory point and save.

...interest. The idea was that if the user has been able to freeze an image somewhere near the object of interest, then he could, even after freezing, choose and create an optimal scene, targeting the problem identified, without having to repeat the procedure from the beginning. Then the user could save the result, as in the case A.

Finally, at the beginning of the design process, panning was also allowed even if not being on the freezed state. However, this feature was abandoned, thinking that it would have caused a certain frustration and that the user is better in control of the image acquired by physically moving the camera.

### 4.3.2 Implementation

The implementation of the prototype is going to be described shortly in this section, as it is closely connected to the design goals followed.

The controls are very similar to the cases that were mentioned before. The most basic control is the `uiRoot control`, including a `frame control` and a `list control` for the button menu. Further inside the implementation tree, the frame control owns a `page control` and the `page control` owns a `form control`, some independent `control controls` and one `model`. The `form control` owns a series of `control controls` for each one of the distinctive components in the UI. The `control controls` in the `form control`
are:

- `video_control`
- `full_view_control`
- `full_view_control_copy`

while the ones owned directly by the `page_control` are

- `min_control`
- `save_control`

As before, one `control` is used to handle the live IR stream, accepting notifications from the integration layer and rerendering from each new frame grabbed. It is also important to stress out in this case that the zoom in functionality is not handled by the hardware level of the application, the camera, but is taking place through image processing, in the software layer. This solution was preferred, although obviously lacking in terms of the quality of the image, because it would have been too time consuming to implement a prototype, that would send events to the camera hardware and handle the zooming there. Another `control`, entitled as `full_view_control`, is used for the drawing of the overview window. It is also handling the IR stream and being notified by the integration layer for the arrival of new frames. This is a major advantage of the framework used, which gives the ability of simultaneously and without latency handling streams of images and overlay the one above the other. The `full_view_control_copy` is used as before to create the illusion of animation effects, which would have been problematic and irreversible if the normal control was used.

On the other hand, in this case, there is a differentiation in the design of the implementation, since two `control` are not grouped in the `form control`, but are placed directly under the `page control`. This is happening mostly because of functionality reasons, partly having to do with the rules of the xml-like environment used. One of those reasons, was the panning effect achieved in the freezed version of the IR image, which could not be addressed only in the `video_control`, if the `save_control` was placed in the `form group`. The `min_control` corresponds to the visual semi transparent rectangle appearing when the user double clicks on the overview window to make it disappear.

The `values model` is used to define alternating variables for the size of the change---
able components on the screen and state variables. As explained before, whenever an interaction is taking place, a function in the C code identifies the position of the touch event and alternates the model, to give an instant feedback to the user.

Another point important to mention, are the animation sequences included in this prototype, in order to express changes on the state of the system and on different components. As in the previous case, an animation was added to narrate the saving sequence, containing an informative message and a gradual transition from the freeze to the live state of the camera. Then, an animation was used also, to describe the event of double clicking the overview window and making it disappear in the form of a semi transparent square, at the upper left corner. The thought was that such a change should not happen instantly, but the route from the initial to the final position should be also visible to the user, so as to follow the change of the position and the form of the component.

4.4 The group navigation case: Prototype C

Use of graphic effects and animation techniques to investigate new ways of navigation inside a group of IR related data.

In this case, the goal was to find an effective way to denote relationships between a group of data with different forms, and allow the user easily navigate through such entities. The case on which this design focused was a very small specified group, that contained one IR image, a relative digital image and a form, containing both the IR and digital image. This form, is used by many kind of users of IR cameras in order to create a written documentation of the problem detected. It usually includes both the IR and digital data as well as information extracted by those. This grouped representation of data is used before the user finishes a specific sequence of interaction with the camera, usually focusing on identifying a specific problem. Then, the user is brought to this state of the system, in order to be able to see if he have collected all the data he wanted and if the set of data to be saved is correct and adequate.

4.4.1 Functionality and Interactivity

The functionality included in this case if much simpler than in the previous cases.

The initial view that the user has of the system is that of an IR image in full view and a vertical list of different data placed on the left next to it. This list contains the thumbnails of the elements contained in the group, together with a blue group icon, similar to a folder icon, placed above the thumbnails. Then, the data can be browsed one by one and by clicking on their thumbnails, they are brought to the full view. There is an animation sequence taking place each time a navigation is initiated. This animation is responsible for bringing the element currently in the full view to the back level and bringing the element to be shown in the full view to the front level. It is also responsible for gradually alternating the sizes of those elements.
Figure 4.17: Browsing a group of data in prototype C: (a) The initial view of the group of data, (b) where the user could initiate an animation effect by clicking a new element in the vertical list, (c) and navigate to the new element, (d) the animation was differentiated according to the initial state of the system, (e) and always ended in the selected element.
4.4. THE GROUP NAVIGATION CASE: PROTOTYPE C

Figure 4.18: Overview of the group in prototype C: (a) Pressing the blue folder button revealed the overview of the group, (b) and pressing any element of the overview, (c) returned to the previous view.

from their initial state to the final, figure 4.17. Then the user can easily alternate from one form of data to the other and be able to identify details of interest to the data acquired and saved.

The blue group icon, placed at the top of the thumbnails, is actually a button initiating a series of events as well. When the user presses it, an overview of all the components of the group is presented, with magnified versions of the elements, while the vertical list with the thumbnails is hidden. The user can go back to the previous state of the system, and make the vertical thumbnail list visible again, by pressing either the blue icon again or any of the magnified versions of the icons. This view of the system was added to allow the user, compare between the data acquired and to propose a possible overview of different form of data. An animation sequence was used in this case also, so as to allow the user follow the effects of the actions made.

There are also two more buttons placed under the thumbnails with labels Save and Exit, which are connected with the general purpose of this view of the prototype. Those buttons are partly functional, the Save button initializes an animation as in the previous cases while the Exit button does not have any effect. Those are only placed there, to add up to the understanding of the situation for which this view could have been used in the camera.
4.4.2 Implementation

The implementation details used for this prototype are partly different from the two previous cases described. Initially, the IR data stream is not used in this case and the components used, do not need to be notified continuously by the integration level for changes taking place in their context.

Therefore, by simplifying the relationship between the C code and the UI, there is a greater freedom regarding the design components used for this case and the animations included. As before, there is the `uiRoot` control, followed by a `frame` and a `page control`, which includes a `form control`. In this `form` a series of other controls are included, such as five `control controls`, one `dataform control` and one `list control`. The `dataform control` then, includes four more controls.

Generally, the idea behind this design is to have one independent control for each one of the components of the group and one independent for the blue group icon. On those controls different animation effects, foreknown by the designer, can be applied. The list containing the thumbnails of those components, since it is stable in the sense that it always covers a specific part of space, is represented by a `dataform control`, which is quite similar to a list and more flexible, and which encapsulates the thumbnail version of the group components. Then, the buttons `save` and `exit` are implemented by a `list control`, since no flexibility is needed.

The animation effects are different in this case, since there is no random position for the components included, and therefore there can be pre-specified. The illusion of animation is created by alternating the size and position of the independent controls for each of the entities of the group (IR image, digital image, form) and by overlaying them to different rendering depths. The rendering depth can be a very useful feature of the implementation since it allows the user to follow one important component.
4.5 Comparison Cases and Introductory Prototype

The prototypes presented previously are solutions proposed regarding each one of the problems areas posed, which came out of the design and specification procedure. However, there was a need to evaluate the efficiency and usability of those solutions as well. Evaluating those prototypes, in relation with the existing camera interface, would be at least unfair and ineffective for various reasons.

Firstly, the prototypes proposed in this thesis are implemented on a laptop computer, as explained before, and it would not have been fair to compare them with the solution already integrated in the camera. Then, the implementation framework used by FLIR Systems until recently, was a different one and allowed for different functionality and for different kind of interactivity. Finally, the interface existing on the camera, contains a large amount of functionalities and possibilities, out of the range of this thesis, that could frustrate the user.

Therefore, the thought was that the solutions proposed, since they are related to our initial question, as mentioned in section 1.1 on page 2,

"investigate the efficiency of use of animation techniques, graphic elements, direct manipulation and other contemporary UI techniques in order to enhance the users’ understanding and improve the user experience for specific tasks when using IR cameras"

should be compared to simpler solutions, which do not include such elements. Then, for each one of the prototypes that were created, a comparison case was created as well, from which the animated elements, the direct manipulation and other more advanced UI techniques were excluded. A training prototype was also created, which was used in the evaluation, to help the users train before the experiment, both in terms of the IR data and of the interaction.

Those comparison cases and the training prototype are going to be presented very shortly in this section.

4.5.1 Training Prototype

As mentioned before the introductory prototype was only used to allow the users get in touch with the idea of IR data and the interaction techniques used. An overview of this introductory prototype used can be seen in figure 4.20. The user could see the live IR stream and interact with the camera to navigate to the space, could also move and resize a semi-transparent component, freeze and save. Therefore, it was mostly an introduction to the prototype cases A and B, and not so much for the case C, which was thought to be more understandable and easy to use.
CHAPTER 4. IMPLEMENTATION OF THE PROTOTYPES

Figure 4.20: Training Prototype: (a) In the initial view the user could see the live stream IR data and a semi-transparent entity, (b) the user could move around this entity, (c) and resize it (d) freeze and save.

4.5.2 Comparison Case for Prototype A

The comparison case for the prototype A, was very similar to the proposed solution and differed only to the interactivity possibilities. As seen in figure 4.21b, the comparison case did not include the side-by-side view in the menu or as a possible choice. In the comparison case, the user could only bring the reference image from the archive, the procedure was the same as described in figure 4.6b, but instead the reference image was always presented in the default upper left position, figure 4.6d and was not moveable or resizable. Therefore, the user was restricted to one UI view, which contained stable and unchangeable entities, with little direct manipulation techniques.

4.5.3 Comparison Case for Prototype B

The comparison case for the prototype B, was following the same concept of interactivity as the proposed prototype. The menu presented to the user was exactly the same and the only differentiation was the visualization of the zoom in/out procedure. Instead of having an overview window, the zoom in/out action was visualized by the use of a scrollbar which alternated as the zoom level was increasing or decreasing, figure 4.22. Therefore the user could have a feeling regarding the zoom level he was using but no feedback regarding his position in relation to the rest of
4.5. COMPARISON CASES AND INTRODUCTORY PROTOTYPE

Figure 4.21: Compared prototypes for the case A: (a) Initial view of the proposed prototype (b) Initial view for the comparison prototype

Figure 4.22: Compared prototypes for the case B: (a) Initial view of the proposed prototype (b) Initial view for the comparison prototype (c) Screenshot of the use the proposed prototype (d) Screenshot of the use the comparison prototype

The comparison case for the prototype C, was also quite similar to the proposed solution. What was excluded in this case, was the animation effects for the navigation between the different data of the group and the blue icon navigating to the magnified overview of the group data. Instead of animation effects, the navigation between the data was happening in a sudden and quick way, without size, depth...
and position changes for the components. The images used to represent the different form of data were also different. The concept was to investigate if the user would notice the lack of animation effects in the second case. The blue icon was also missing in order to find out whether the users would seek this view.

4.6 Overview of the evaluated system

Therefore, all the prototypes created in this chapter, defined the evaluated system and the evaluation procedure. Although, this is going to be presented in detail in the following chapter an overview can be given at this point as well, covering the evaluation features that depended on the implementation made.

As explained, the evaluated system involved a laptop computer, bearing touch manipulation, where the UI was presented and which was used as a touch screen. This laptop was connected through a firewire cable with an IR camera, which the user could move physically and see the feedback on the laptop screen. The laptop was also connected with a keyboard that allowed the evaluator to navigate between the prototypes tested, figure 4.24.

The prototypes were separated as explained to the proposed and the comparison solutions made. A different code name was given to each one them to aid their differentiation, the design of the experiment and the analysis of the results. Those prototypes id’s are going to be explained so that the evaluation and analysis section can be easily followed.

1 The Reference Image Case : Prototype A

Use of graphic effects, animation, direct manipulation and other interaction techniques to ease the identification and recreation of a specific scene of IR data given a reference image.

a) Prototype Case A1 (resizable and movable ref. image): This is the case where the user can bring the reference image from the archive and
4.6. OVERVIEW OF THE EVALUATED SYSTEM

Figure 4.24: The evaluation system

manipulate it, resize it and move it, in order to create a satisfactory view of the UI and create a similar image, figures 4.6–4.7.

b) Prototype Case A2 (side–by–side view): This is the case where the user can bring the reference image from the archive and switch to the side-by-side view, in order to create a similar image, figure 4.8.

c) Prototype Case A3: This is the case where the user can bring the reference image from the archive but cannot move or resize it. He has to create a similar image using the given form of the UI, figure 4.21.

2 THE ZOOM CASE: PROTOTYPE B

Use of graphic effects, animation, direct manipulation and other interaction techniques to ease the navigation and the user’s conception of the zoomed in position in relation to the whole space.

a) Prototype Case B1 (zoom with overview): This is the case that the user can zoom in and navigate to space using the overview window available in the UI, which can be resized, repositioned and hidden, figures 4.13–4.15.

b) Prototype Case B2: This is the case that the user can zoom in and navigate to space without an overview window but only with the help of a slider, visualizing the zoom level, figure 4.22.

3 THE GROUP NAVIGATION CASE: PROTOTYPE C

Use of graphic effects and animation techniques to investigate new ways of navigation inside a group of IR related data.
a) Prototype Case **C1** (animated navigation): This is the case where the navigation in a group of data is enriched by the use of animation effects, while a magnified overview of the elements of the group is also available, figures 4.17–4.18.

b) Prototype Case **C2**: This is the case where the navigation in a group of data is straightforward and without animations, while a magnified overview of the group is not provided, figure 4.23.
Chapter 5

Evaluation

5.1 Evaluation Method

Generally, various ways for the evaluation of HCI problems could be found according to the purpose of the evaluation and the object evaluated. In Nielsen (1994b) a categorization between different types of evaluations is made into four groups, automatic, empirical, formal and informal. The automatic evaluations are based on measurements made in a automatical way by programs given a set of UI specifications. The evaluations which are categorized as formal are the ones based on the existence of specific models and functions which measure usability according to the features of the UI. On the other hand, informal evaluations are those that derive from the experience and skills of expert evaluators. Finally, empirical evaluations are those that are made on real users. During the previous years multiple methods of evaluations were proposed on different studies, mostly categorized as informal or empirical. Some of the most known and most commonly used methods until today are those of Cognitive Walkthrough, Heuristic Evaluation, Expert Reviews, GOMS, interviews, observations and questionnaires.

In this thesis the objects evaluated are the prototypes created and the purpose of this evaluation is to argue regarding the initial purpose of the thesis. The method for the evaluation chosen is empirical evaluation and the "think aloud" test as proposed in (Clayton, John and Amended, 1993; Dumas and Redish, 1993). This kind of user testing supports that real users should be brought in a protected environment, in order to test the prototypes created. They are asked to "think aloud", while performing a number of tasks on the prototype tested and the evaluation procedure is usually video recorded. Before the actual test, users usually perform an introductory task, in order to get used to the prototype and the context of testing. During the whole procedure the evaluator can also take the role of the facilitator, if users encounter any kind of problems. At the end of the evaluation phase the user is given the opportunity to express opinions and ideas regarding the prototype tested in different ways (questionnaires, interviews, etc).

Together with the qualitative results that were expected as an outcome of the
above method, some quantitative measurements were also considered helpful for the evaluation. In order to acquire those quantitative results in a meaningful context, a certain experiment had to be designed. More detailed hypotheses were created, relevant to the features of the prototypes implemented, that could be approved or disapproved through the evaluation procedure. In advance, as explained above, the experiment included some tasks that each user had to perform during the evaluation. The next step was to find a way to compare the behavior of the users while performing the tasks with the prototypes proposed in comparison to performing the same tasks with simpler solutions of UIs, that do not included animated features and innovative interaction techniques. Therefore, based on the evaluation procedure followed by a number of relevant publications for UIs, the implemented comparison prototypes were used in order to perform a within subjects experiment. The quantitative results acquired, had to do with the effort put by the users in different levels, when completing the tasks with different prototypes. At the end of the experiment, each user was also asked to fill a questionnaire designed especially for this case.

The evaluation experiment as well as the design chosen is analyzed and elaborated in the following sections in detail, together with the results acquired.

5.1.1 Experiment Design

The experiment conducted for the evaluation was a within subjects (repeated measures) experiment. Each user was asked to perform a task three times, under different conditions and the same kind of measurements were acquired each time the user performed the task. The dependent variables of the experiment were also the quantitative measurements acquired for each hypotheses. The independent variables were the different environment (prototypes), where the tasks were performed by each user. For the prototypes of the group A, the independent variables were the set of A1, A2 and A3 prototypes. For the prototypes of the group B the independent variables were the set of B1 and B2 prototypes, while for the group C it was the set of C1 and C2 prototypes.

It is also generally proposed that the users should complete an introductory task before the experimental procedure begins. In the experiment designed for this evaluation, there was a small introductory/training task used, that the users were asked to perform, in order to minimize learning effects. It was also the case of introducing users to the IR data, since they did not have such an experience in the past. A short explanation of the tasks performed in this experiment will be made further and a more detailed version of those can also be viewed in the appendix.

5.1.2 Tasks

As mentioned above, users had to perform one specific task for each group of prototypes (A, B or C). The tasks were only differentiated between the groups, the same task was performed for the prototypes of the group A, a different one was
5.1. EVALUATION METHOD

The order of the prototypes tested for the same task was alternated in a structured way, to further minimize the learning effects, figure 5.1. In that way, learning effects that might appear only the first time that users perform one task could be minimized and not misinterpreted as measurement data caused by a specific prototype.

Task for the training prototype

In the introductory prototype the goal was to allow the users familiarize with the IR data and the way of interaction proposed in the UI. Therefore, firstly the users were asked to look around the space and try to identify certain objects with different temperatures. Some examples of objects that could be found were a radiator, a water boiler, coffee maker etc. As soon as the users familiarized with this idea, they were asked to move a semi transparent square at the upper right corner of the IR data stream, to different positions on the screen. They were also asked to maximize and minimize it and bring it to the center of the image. In that way they became accustomed, to some extend, with the touch based interaction that they would need to use in the rest evaluation cases.

Task for the Reference Image Case: Group A Prototypes

The goal for the task performed for the prototypes belonging to the group A, was to investigate the ease of creating and setting up a scene with IR data, given a specific problem or situation, that would require an image to be saved. Therefore, the users were asked to bring an image from the image archive (reference image) and try to create and save a similar version of it in the live flow. The image that the users were asked to bring from the archive contained two cups, one filled with cold water and one filled with hot, which were placed the one next to the other, figure 5.4.

One important characteristic of the reference image used, was that the view angle was sightly shifted. It was an interesting question to investigate whether and when the users will notice this fact and in what way they are going to interact with the camera and the UI in order to solve it. Another fact about the reference image

![Figure 5.1: The order with which the prototypes were evaluated on each user](image-url)
was that the cups pictured in it were slightly different than the ones that the user had in front of him. This fact raised another question regarding the time and way that the users might perceive this difference between the cups in the two cases, figure 5.4. Finally, the object of interest for the task, the cold (blue) cup, was at the right part of the reference image.

**Task for the group B prototypes**

The goal of the task performed for the prototypes belonging to the group B, was for the users to navigate efficiently into space while in a zoomed in view. Two cups, one filled with hot water and one filled with cold, were placed far away from the user in different positions inside the same room. Then the user was asked to firstly zoom in to one of those cups, the cold for example, and then navigate with the camera and find the other one, the hot one, and zoom in to it as well. The most important question was to examine the ease of navigation through space, while keeping an overview of it as well.

**Task for the group C prototypes**

The goal of the task performed for the prototypes belonging to the group C was to investigate the users’ feelings and reactions towards the existence of animations and additional interaction, while navigating into a group of data. This group of data, which was relevant to the previous tasks, included an IR image, a digital image and a form containing both the IR and digital image with some notes. Then the user was asked to browse the items one by one and search for the overview of the group data (only in the C1 prototype) and interact with it. The question was whether the users would express any kind of different feelings for the compared prototypes and differentiate them in terms of the existence of animation for the navigation between the data and the existence of the overview.
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5.1.3 Hypotheses

Based on the tasks presented, specific hypotheses were made and examined for each group of prototypes.

Hypotheses for the prototypes of the group A

Three hypotheses were made for the differentiation between the three prototypes belonging to the group A.

Hypothesis 1. The images that will be created and saved by the users in the completion of the task, will be more similar to the reference image used for the evaluation, when using the A1 (resizable and movable ref. image) and A2 (side–by–side) prototypes instead of the A3 (comparison) prototype.

With this initial hypothesis, it is argued that the prototypes created (A1 and A2), will aid the users to achieve better results, when the goal is to create an as much similar picture to the reference image as possible. Although the A1 and A2 cases are quite different to each other, both of them combine animation techniques and different kind of interaction, in relation to the A3 case. Therefore, the purpose of this hypothesis is to investigate the way that those extra elements can affect the final result.

Hypothesis 2. The work load and the mental effort that the user needs to apply in order to make the comparison between the reference image and the live flow, will be less when using the A1 (resizable and movable ref. image) and A2 (side–by–side) prototypes and especially in the A2 (side–by–side) case.

The second hypothesis aims to investigate the amount of effort used for the completion of the task by the users. The effort is usually connected with the notion of mental effort, as the energy acquired from the users mentally, in order to complete a task which is related to terms as working memory, memory load, etc.

Hypothesis 3. The interaction with the UI in A1 (resizable and movable ref. image) and A2 (side–by–side) prototypes, for the completion of the given task, will be more time consuming and more flexible than in the A3 (comparison) case because of the variety of the features included in the design.

This last hypothesis regarding the prototypes of the group A refers to the amount of physical interaction with the camera and with the interface, that each user needs in order to complete the task. The thought is that A1 and A2 prototypes, either because they are enriched with more features, either because of their design, will require from the users more time and but will allow them be more flexible in their actions.
Hypotheses for the prototypes of the group B

Two hypotheses were made for the differentiation between the two prototypes belonging to the group B.

**Hypothesis 4.** The time and mental effort required from the user to navigate from one point of interest to another, will be less with the B1 (zoom with overview) prototype than in the B2 (comparison) prototype.

This hypothesis argues that the users will be facilitated with the B1 prototype when asked to navigate in space, in relation to the time of navigation needed with the B2 case.

**Hypothesis 5.** The interaction with the UI in the B1 (zoom with overview) prototype, for the creation of a satisfactory view of an image to be saved, will be more time consuming and more flexible, because of the variety of the features included in the design than in B2 (comparison).

This hypothesis is again about the effect of the added animation and interaction features on the entire interaction and relation of the user to the UI. The prototype B1 is expected to require more time and interaction from the user, but to be considered more flexible as well.

Hypothesis for the prototypes of the group C

One hypothesis was made for the differentiation between the two prototypes belonging to the group C.

**Hypothesis 6.** The feelings and the opinions expressed by the users are expected to be more positive towards the C1 (animated navigation) in relation to the C2 (comparison) prototype.

This is a hypothesis regarding the preferences of the users when interacting with C1 and C2 prototypes. This hypothesis is posed in order to investigate the way that users feel towards the animation effects and the existence of an overview for the group entity.

5.1.4 Questionnaires

After the evaluation procedure was finished, the users were asked to express further comments and feelings about the different prototypes, in the form of a questionnaire. There are different kind of questionnaires, depending on the tasks performed for the evaluation and the type of facts that the evaluators need to focus on. Some of the most known and usually preferred questionnaires are proposed in Chin, Diehl and Norman (1988); Davis (1989); Hart and Stavenland (1988); Brooke (1996). While choosing and designing a questionnaire for a specific evaluation, it is important to try to keep the amount of questions limited and understandable, so
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as not to confuse the user. Therefore, it is important to try to choose correct and relevant questions to the goals of the evaluation.

In this case, the questions used were a combination of data found in different questionnaires, which were alternated to fit the evaluation. The questions posed were the same for each one of the tasks belonging to the same group, so as to be able to compare the answers given (between subjects experiment). The form of the questions used was mostly close-ended questions, where the user had to choose only one possible answer in a climate from 1 to 5, as proposed in the Likert scale (Likert, 1932). Some of the close-ended questions regarding the mental demand, the performance, the effort and the frustration caused by the completion of the task in each prototype were taken from the Nasa TLX questionnaire (Hart and Stavenland, 1988). Other close-ended questions having to do with the feelings and the user experience for each prototype were taken from the QUIS questionnaire (Chin et al., 1988). For each prototype the users could also answer freely in a open-ended question regarding the most negative or positive aspects and feelings that they had in terms of the interface.

5.2 Analysis of the Results

In this section, the analysis of the results acquired, both qualitative and quantitative, is going to be presented according to the hypotheses made. The evaluation was conducted in a set of seven users, four male and three female, and none of them had any previous experience with IR data, but all of them had previous experience into using touch devices. All the users had a higher educational level, master students or PHD candidates, and their ages were in the range of 24-31 years old. They all volunteered for this evaluation and an agreement was signed before the evaluation, regarding the confidentiality and the use of the data acquired. Most of the measurements presented were either acquired from the video recordings made during the evaluation test or from the questionnaires filled at the end of the testing.

In the case of one user, user number 4, due to some technical problems, there was no video recording available, therefore there are no quantitative results available, regarding some hypotheses. However, in most of the part of the analysis, user 4, is also mentioned, whenever available, since his answers to the questionnaire were proven useful and some other data were also recorded during his evaluation. For the cases, that there are no results available, user 4 is excluded from the graphs and the analysis takes place only for the set of six users.

5.2.1 The Reference Image Case: Prototypes of group A

Hypothesis 1. The images that will be created and saved by the users in the completion of the task, will be more similar to the reference image used for the evaluation, when using the A1 (resizable and movable ref. image) and A2 (side-by-side) prototypes instead of the A3 (comparison) prototype.
For this hypothesis, the images acquired from each iteration of the experiment were evaluated in a scale from 1 to 3. The one considered as the least similar to the reference image of the three was graded with 1 while the best was graded with 3. For the cases that there was no clear differentiation between the images, all the similar images received an identical grade. This technique was applied for the data acquired only from 6 users, since as mentioned above there was no video recording for the one of the users (user 4).

Given the above grading system, graphs were created to represent the acquired results. The first graph, graph 5.3a, represents the grades that each image took for each prototype. It is shown that images captured with the A2 (side–by–side) prototype, are considered in general more similar to the reference image for 4 out of 6 users. However, there is no clear differentiation between the images acquired from the prototypes A1 (resizable and movable ref.image) and A3 (comparison). The strongest observation coming out of this graph is that in four cases the images acquired by the prototype A2 (side–by–side) are rated with a grade 3, when none of the other prototypes receives the highest grade in any case. This indicates that the comparison between images was easiest in the side–by–side view. An example of the differences between the images acquired with each prototype is presented in figure 5.4, from the recording acquired by the evaluation on user 1.

However those results do not coincide with the feeling that the users had regarding the quality of the pictures acquired. In the second question of the questionnaire, when the users were asked how successful they thought they were into accomplishing what they were asked to do, the answers given are not very engaging.

In the first figure concerning this question, graph 5.5a, 4 out of 7 users grade their effort with the same points, while for the rest 3 users the grades given pretty much vary. Observing this graph as a whole, one can notice the existence of a ceiling effect. In this kind of effect, one cannot argue for the superiority of one case over the other, since in the majority of the cases the results are graded all with the maximum possible grade. Therefore, the perceived accomplished image quality
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(a) Image captured with prototype A1  
(b) Image captured with prototype A2  
(c) Image captured with prototype A3

Figure 5.4: Example of the instance of image capturing with each of the prototypes

does not differentiate between the prototypes.

Some observations made, regarding the quality that is anticipated by the users, as they repeat the task for the second or third time, are relative to all the above. User 1, at the end of the evaluation of all the three prototypes of group A, mentions that he is not satisfied with the quality of the focus of the image saved, although the focus was optimized at the beginning. User 2, while performing the task for the third time, points out that she starts becoming more and more critical about the result. User 3, again while performing the task for the third time, mentions for the first time that he notices that the cups between the two situations are not the same. User 6 becomes more secure about the purpose of the task at the end of the second time repeating it and then he notices that he must try to change the angle of the camera.

Therefore, although the understanding and expectations of the users change as they perform the task more and more, still it is quite interesting that there is a quite clear differentiation in favor of the quality of the images acquired with the A2(side–by–side) prototype.

Hypothesis 2. The work load and the mental effort that the user needs to apply in order to make the comparison between the reference image and the live flow, will be less when using the A1 (resizable and movable ref. image) and A2 (side–by–side) prototypes and especially in the A2 (side–by–side) case.

The majority of users do not seem to differentiate in terms of mental effort used for the different prototypes. The answers acquired in the question: "How mentally demanding was the task?" are shown in the graph 5.5a. 4 out of 7 users have graded all the prototypes with equal points. Different kind of variability is
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(a) Q1: How mentally demanding was the task? (1: Very Low – 5: Very High)

(b) Q3: How hard did you have to work to accomplish your level of performance? (1: Very Low – 5: Very High)

Figure 5.5: Results for Hypothesis 2

presented between the prototypes, for the rest of the users. User 3 rates A2 (side-by-side) as more mentally demanding, while user 4 rates A1 (resizable and movable ref. image) as the most mentally demanding. The last user rates A3 (comparison) as the less mentally demanding compared to the other two. Therefore no clear differentiation can be mentioned for this question.

In terms of effort, the question was "How hard did you have to work to accomplish your level of performance?", graph 5.5b. Prototype A1 (resizable and movable ref. image) receives the higher rates, considered as one of the most hard, by 5 out of 7 users. The prototypes A2 (side-by-side) and A3 (comparison) generally receive the similar grades if the experiment is viewed as a whole. Therefore, the only observation that can be made according to this question is that the comparison and the side-by-side prototypes are considered both less hard than A1 (resizable and movable ref. image) in general, without differentiating significantly from each other.

Similar remarks can be made by the answers acquired in the fourth question posed in the questionnaire asking the users to grade from 1 to 5 how insecure, discouraged, irritated, stressed and annoyed they were, graph 5.6a. 5 out of 7 users give the same grade to all the tasks, while the rest of the answers vary and do not lead to any valuable conclusions.

Together with the quantitative results acquired, some observations made throughout the experiment and which are relevant to this hypothesis worth to be mentioned.

Firstly, user 2, while evaluating the A2 (side-by-side) prototype, which was the first one evaluated, deals with a problem of understanding. Although asked to create an identical image, the user is at the beginning pointing to a reverse group of cups (red mug on the right and blue mug on the left of the image, figure 5.4). It is only after the persistence of the evaluator that understands that it is important for the sequence of the colors to be identical as well. Although, this incident cannot be used as evidence towards a general understanding, it can give some hints regarding the mental effort required by the user. One might consider that since the user was almost at once asked to change to the side-by-side view, she lost the part of the
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(a) Q4: How insecure, discouraged, irritated, stressed and annoyed were you? (1: Very Low – 5: Very High)

(b) Time that the user needs to understand and finish the task for each prototype

Figure 5.6: Results for Hypothesis 2

spatial understanding provided by the wider view of the live camera flow and that’s why she was confused. Even if this is not the case, the frustration of the user points towards an extra effort regarding the understanding of the situation.

Moreover, user 5, when the evaluation again begins with the A2 (side–by–side) prototype, she is asking which one of the windows is the reference image. This again points towards an extra amount of mental effort used for this task.

In addition, the fact that the user is asked to interact with the UI only in the case of the A1 (resizable and movable ref. image) prototype, is also considered quite important. When the A1 prototype is evaluated, the users need to shift their attention between the manipulation of the camera and the interaction with the UI, in order to follow the evaluator’s instructions. This alternation of interaction between physical interaction with the camera and interaction with the UI requires a greater effort than usual.

On the other hand, based on further observations, there are some clues, that there is a learning effect present throughout the experiment.

If one looks at the whole time that each user needs for each prototype, measuring the dialogues made and the further explanations given by the part of the evaluator, in 4 out of 6 users, the first time that the task is performed requires more time. As shown in the table 5.6b, where the tasks performed first are highlighted with green and the maximum time values are red, in every case, except user 3 and 6, the task where the user took more time, was the first one performed. As user 1 mentions in the open–end question for the last prototype evaluated, A3 (comparison) in his case, "this time it got a bit easier to accomplish the task due to repetition".

Therefore, by combining the information acquired but those different sources, it can be seen that, perhaps users need to put some extra effort when dealing with the side–by–side prototype for the first time, to understand this new view, but this can be considered as part of the learning effect as well. After all, the A1 (resizable and movable ref. image) and the A3 (comparison) prototypes, use a common camera view to which users are accustomed. A1 (resizable and movable
The ref. image prototype might need some extra effort as well, since it involves more interaction with the UI, and users need to shift their attention between the camera and the UI more often.

**Hypothesis 3.** The interaction with the UI in A1 (resizable and movable ref. image) and A2 (side-by-side) prototypes, for the completion of the given task, will be more time consuming and more flexible than in the A3 (comparison) case because of the variety of the features included in the design.

In order to examine this hypothesis, two kind of time segments were measured for each prototype and each user. The first one, mentioned as camera manipulation time has to do with the time that each user spends to move the camera in order to create the wanted result. The second one, defined as the sum of the camera manipulation time and the time used by the users to interact with the UI, has to do with the whole amount of time used by the users in order to complete the task.

Those times were acquired from the video recordings available only for 6 out of 7 users, user 4 is not included. For the measurement of those time segments the dialogues (explanation of the tasks, help etc) or further actions performed by the evaluator during the task (like changing the focus of the camera) were extracted, graphs 5.7a, 5.7b.

Given those measurements, it can be noticed from the graph 5.7a, that 4 out of 6 users spend more time manipulating the camera for the A2 (side-by-side) prototype. Therefore, there is a clear differentiation in terms of the camera manipulation time between the prototypes A1 (resizable and movable ref. image) and A3 (comparison) compared with the prototype A2 (side-by-side). On the other hand, the camera manipulation time between the prototypes A1 and A3, does not present such an obvious difference.

However, the discrimination between the prototypes A1 (resizable and movable ref. image) and A3 (comparison), becomes more obvious in the second graph 5.7b, where the task performed with the prototype A1 (resizable and movable ref. image)
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is in every case, 6 out of 6 users, more time consuming than with the prototype A3 (comparison), since the users take some time to interact with the UI as well.

The flexibility of the UI and the way that this is perceived by the users is evaluated by qualitative observations made throughout the evaluations.

To begin with, in 3 out of 4 cases in total, when the users were asked to evaluate the A1 (resizable and movable ref. image) prototype first and the A3 (comparison) prototype later, they complained for the absence of the interaction. User 1 tries to move the thumb-nail version of the reference image and when the evaluator explains that this is not possible in the A3 (comparison) case, he expresses dissatisfaction. User 5 as well tries in the comparison prototype to move the thumbnail version of the reference image and when she realizes it cannot be moved she express disappointment. User 4 makes a movement showing his intention to move the thumbnail while performing the evaluation for the A3 (comparison) prototype. However, user 7, although being introduced to the prototype containing interaction first, does not try to move the thumbnail. There is also one case of a user, who being introduced to the A1 (resizable and movable ref. image) prototype first believes that the UI is as flexible and interactive as that he will be able to manipulate the change of the angle on the picture not by moving the camera but by interacting with the UI.

It is also noticeable that although the users do not notice the presence of the interaction on their own they express satisfaction when they are told they can move the reference image. User 3, when informed from the evaluator for the interaction says 'Aaah, I can?' expressing content together with surprise. User 6 as well, when informed for the existence of the interaction seems surprised and thrilled, and spends quite a lot of time playing around. A quite important amount of time is also used by the first user to interact with the UI and bring the reference image to a satisfactory position, graph 5.8.

Some of the answers acquired in the open–end question are also worth mentioning. User 2, writes for the A2 (side–by–side) prototype that it is "user friendly", while user 1 writes that "the touch screen did not feel very responsive" as a negative aspect of the A1 (resizable and movable ref. image) prototype and "easiness of understanding and interaction" for the A2 (side–by–side) prototype. User 3 writes that the "resizable saved image frame" for the A1 (resizable and movable ref. image) prototype is a positive feature. User 4 points out for the A2 (side–by–side) prototype that "I enjoyed playing with the interface'. Finally, user 6 writes for the task A2 (side–by–side) that it was "easier to recreate than before". However, for the prototype A1 (resizable and movable ref. image) the same user writes that "I knew I can move the ref. image but it was not very helpful" as a negative point and "I
scaled it down a lot when it was becoming annoying as a positive feature.

Therefore, the above data show that users generally needed more time for physical interaction with the camera and interaction with the UI, with prototypes A2 (side-by-side) and A1 (resizable and movable ref. image), but that resulted either in better results as seen in first hypothesis, or it was because of the existence of more flexible interaction.

5.2.2 The Zoom Case: Prototypes of group B

**Hypothesis 4.** The time and mental effort required from the user to navigate from one point of interest to another, will be less with the B1 (zoom with overview) prototype than in the B2 (comparison) prototype

The completion times for the task performed with each of the prototypes of the group B that were acquired by the experiments, are not as descriptive as expected. As shown in the figure 5.9a, 3 out of 7 users needed less time to complete the task with the prototype B1 (zoom with overview), as it was expected, for 2 users the measured time segments are almost equal and for the other 2 out of 7, there is a clear differentiation in favor of the prototype B2 (comparison), graph 5.9a.

Those results can be analyzed and viewed under many different factors. Firstly, the observations made, indicate the existence of an ordering effect during the experiment. In table 5.9b, each task performed first by the users is highlighted with green and the one with the maximum value is red. Then, it can be noticed that 6 out of 7 users need more time for the task performed first and for 5 of them the differentiation is quite large.

In advance, following the videos acquired from all the users, it is noticeable that there are certain facts on the description and the completion of the task that affect significantly the users understanding when performing it for the first time. The first observation has to do with users losing their spatial understanding when dealing with IR data and having too many difficulties orienting themselves in the
space even without zooming in. Those users that had the chance to navigate in the space before starting performing the task, either because the pointed towards the wrong cup initially, either because they did it on their own, handle the task much more easily than the ones that did not. The two extreme time segments presented for users 4 and 5 are related to the fact that users did not have the chance to view the space and perform the wanted route, from one cup to another, before the experiment started. Especially in the case of the user 4, for the most of time, she was trying to point the camera to the opposite direction, left instead of right, since she had a wrong understanding of the space viewed in the IR picture. Another similar case is that of the user 1, who when asked to move towards the blue cup spotted another cup present in the space and claimed for a long time that this was the cup he was searching for, since he had not visually seen the existence of the cold cup.

Another important drawback presented during the experiment was the misunderstanding of the users regarding the association of hot and cold attributes to the representative colors, red and blue. In a two cases, user 1, 2, there is a misunderstanding regarding which cup is being viewed and the evaluator has to stress out the differentiation of the colors.

Another important observation made regarding the time and the effort used by the users while performing the task with the B2 (comparison), is that most of the
users (3, 4, 5, 6, 7), when they are asked to move the camera to the cup with the opposite temperature, first they zoom out to have again a full view of the space and then they zoom in again to lock their target. That leads to the conclusion that users feel and need a full view of the space in order navigate better.

By viewing the answers to the questionnaires filled, it becomes obvious that the users do not differentiate in terms of mental effort between the two tasks nor do they claim to feel significantly more stressed with one of the two, graphs 5.10a and 5.10b. In terms of difficulty, the majority of users, 4 out 7, give similar points to both tasks, graph 5.10c.

The analysis made above is also supported by the answers given in the open–end question of the questionnaire. User 6 mentions for the prototype B2 (comparison) that "I did not have a good perception of space and I only knew I was looking for a blue dot". He also mentions for the B1 (zoom with overview) prototype that "It took me some time to understand the role of the thumbnail" but "when I realized how it works, it was much easier to find the second cup than before". User 3 also while looking for the cold cup says 'I don't know if it is a cold cup or whatever... It's something that’s cold...'. User 1 writes in the open end question "Nice feature is the small overview window" and then for the B2 (comparison) prototype "I missed the overview window". Finally, user 4 fails to notice the existence of the overview window in order to use it while completing the task with the B1 prototype.

The data analyzed for this hypothesis show that the existence of an ordering effect in this case is so strong that affects the rest of the results. There can be no differentiation in terms of completion time for the prototypes, but the feeling created by the impressions of the users is that they prefer the zoom with overview (B1) prototype. However, difficulties in the understanding of IR data and generally in the navigation on space, even without zoom, affect the whole task and hide other possible conclusions regarding the design of the UI.

Hypothesis 5. The interaction with the UI in the B1 (zoom with overview) prototype, for the creation of a satisfactory view of an image to be saved, will be more time consuming and more flexible because of the variety of the features included in the design than in B2 (comparison).

The data acquired from the evaluation videos reveal a new perspective for the specific hypothesis. As it seems from the graph, 5.11a, the majority of users, 5 out of 6 users, spend slightly more time to interact with the UI in the case of the B2 (comparison) compared with B1 (zoom with overview). This can be explained by two kind of observations made on the users behavior.

Firstly, most users do not seek to interact with the overview window as it was expected. There can be various explanations for that. It could be either because the overview does not affect their view of the object of interest, as in the prototypes of the group A. Another explanation could be that users do not feel the need to interact with the UI. Finally, it could either be, because this task is much more physically demanding than the one for the prototypes of the group A, the users have to move the camera around more time, and therefore their attention shifts from the UI to the
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(a) Duration of the interaction with the UI for the prototypes of group B

(b) Duration of the interaction with the UI for the prototypes B1

Figure 5.11: Results for Hypothesis 5

physical interaction. Whatever the case, the important observation is that, unless they are reminded or encouraged from the evaluator they do not attempt to move the overview on their own except for the case of user 3.

Moreover, another relevant observation is that although it was not expected in the case of the prototype B2 (comparison), where there is no overview, the majority of users need to zoom out in order to navigate in the space, and that adds some time of interaction. Therefore, 5 out of 7 users, zoom out and then zoom in again in order to complete the task with the prototype B2. However, 2 out of these 5 users also zoom out slightly in the B1 prototype as well. In the case of user 4 this is happening because he did not notice the overview window at all and in the case of the user 7 it seems like the user is trying to manipulate the image of the camera thought the interface, trying to bring the cold cup in the center of the picture and zooms out to succeed that.

As mentioned again, the users attitude towards the interaction with the overview window, varies, graph 5.11b. User 3, 6 and 7 move the overview window but user 7 does it after being encouraged from the evaluator.

Consequently, it is quite obvious that B2 prototype needs more UI interaction time from the part of the users so as the task to be completed. This is because the users zoom out in order to have a more wide view of the environment, a fact that supports the users’ need of an overview.

This fact can be also considered in relation to the answers given to the questions 4 and 5 of the questionnaire. When the users are asked to grade in a scale from 1 to 5 regarding how dull or stimulating was the prototype, 1 stands for dull and 5 stands for stimulating, it is noticeable that 4 out of 7 users consider B1 (zoom with overview) more stimulating, graph 5.12a. The rest of the users, 3 out of 7, grade both prototypes with the same grade.

For a similar question that users have to grade between rigid and flexible in terms of interactivity, 1 for rigid 5 for flexible, 3 out of 7 users give the same grades to both, 3 out of 7 users grades B1 (zoom with overview) as more flexible than B2 (comparison) and user 6 grades B2 as more flexible, graph 5.12b.
In the open-end questions and in the comments made by the users during the evaluation, there are also some relevant remarks given. User 1 clearly states that he preferred the prototype B1 (zoom with overview) by saying "I preferred the one with the window". He is then writing that "moving the camera with one hand while interacting with the interface" was negative and troublesome, while he also mentioned that "the zoom button needs to be pressed many times to zoom in. Continuous pressing doesn’t do the trick". User 3 also complains for the multitasking of using both the camera and the interface simultaneously, while user 4 writes that "it would be nice to zoom in and out when pressing the corresponding buttons continuously". User 2 and 3 are also confused while performing the task whether they should try zooming in from the camera or the UI.

Those data, show that the interaction both with the UI and the camera in this task was considered quite hard. However, since for the B1 (zoom with overview case), there was no need to interact continuously with the UI, the users preferred it and also graded it as more stimulating and flexible. The fact that the users had to zoom in, zoom out and then zoom in again in order to complete the task B2 (comparison), was considered negative, together with the fact that the zoom buttons had to be pressed multiple times.

### 5.2.3 The Group Navigation Case: Prototypes of group C

**Hypothesis 6.** The feelings and the opinions expressed by the users are expected to be more positive towards the C1 (animated navigation) in relation to the C2 (comparison) prototype.

The results acquired regarding this hypothesis seem to be quite straightforward both from the answers given on the questionnaire and the observations made.

Initially, as shown in the figures created from the close end questions of the questionnaires, C1 (animated navigation) is considered more difficult than C2 (comparison), but in the same time more stimulating, graphs 5.13a, 5.13b.

4 out of 7 users claim that C1 (animated navigation) was more difficult than C2
5.2. ANALYSIS OF THE RESULTS

(a) Q1: Difficult (1) - Easy (5)

(b) Q2: Dull (1) - Stimulating (5)

Figure 5.13: Results for Hypothesis 6

The above results can also be discussed in relation to the answers given to the open end questions of the questionnaires. User 1 writes that it was a negative that "It didn’t scroll down through the pictures when I rolled my finger" and that "the overview button is not very obvious" but "nice that you can see thumbnails to the left". However, for the C2 (comparison) prototype he also complains that "the overview button went missing". User 2 characterizes C2 (comparison) prototype as "user friendly and gives a good overview" but mentions for C1 (animated navigation) prototype that "I prefer this one and also to get all the pictures into bigger scale".

User 3 writes for C1 (animated navigation) that he enjoyed that "all the info was there" but he did not like the representation of the folder/overview of the group as a "blue thing" and the "pic/pdf which was unexpected". He also then writes for the C2 (comparison) that he missed the "blue thing" although it was a negative. Finally, user 6 writes for the C1 (animated navigation) that "the overview was not clear. I would try to press it but I wouldn’t be sure of what it does" but "nice feedback from the animation". Then for the C2 (comparison) he writes that "It was easy to do after having done the previous. But I was seeking the "overview" button".
as before).

Another graph showing the time that each user took to interact with the interface in total can be quite descriptive for the differentiation between the two prototypes, graph 5.13c. The majority of users tend to use significantly more time to interact with the interface for the C1 (animated navigation) prototype in relation to the C2 (comparison) prototype.

This fact can be viewed under different factors relative to the complexity of the tasks and the flexibility of the features of the interface. Firstly, for the C1 (animated navigation) prototype the guidelines given to the users were more complex, they were asked to browse an overview of all the elements of the group as well. Therefore, it is quite normal that they needed more time to browse the interface. However, even though it is not possible to make a straight comparison between the completion time for the two tasks since the complexity of the first one was higher, one cannot help but notice that although users need more time for the interaction they felt more stimulated. For the last user where the time for C2 is greater than the time used for C1, it was only a matter of searching the overview window on the C2 prototype that caused the use of extra time.

The above data show that users had some trouble to identify the existence of the magnified group overview button, blue icon button, in the prototype C1 (animated navigation), but when it was found, they considered C1 (animated navigation) prototype as more stimulating. Most of the users also missed this magnified overview of the group in the C2 (comparison) prototype and therefore considered it as more dull.

5.2.4 Other observations

There were a number of qualitative observations made regarding the prototypes evaluated that are not relevant to any of the hypotheses made. However, they can be proved useful for the improvement of the interaction and the design of the prototypes. Some of them are shortly mentioned in the following subsections.

Task A

While performing the tasks with the prototypes A1 (resizable and movable ref. image) and A2 (side–by–side), a lot of users declare confused by the same fact in the completion of the tasks. The prototypes A1 and A2 where implemented in such a way so as as soon as one of the two tasks (A1 or A2) was completed and the image was saved, the reference image could be found at the end of the archive for the next task. This caused some sort of confusion and inconsistency between the prototypes. When the prototypes were implemented it was not at all anticipated that the change of the sequence of the images in the archive would cause such a confusion.

In advance, some users complained for not being able to see the result of the image they saved in the archive. There was again an inconsistency between the
5.2. ANALYSIS OF THE RESULTS

actions performed and the feedback given in the prototype.

Moreover, when opening the archive some of the users tried to slide through the images, expecting that there were more images to be shown. Then the evaluator had to explain that the archive consisted only by five available images. Another important observation was the reaction of the users to the change view button. Most of the users when explained that they should change the view did not understand that the evaluator was referring to the button and were confused regarding what they had to do. There was also the case of user 3 who asks 'what does change view do?'

Furthermore, there are some unsuccessful attempts by the part of the users to push some of the buttons of the menu. It is, as mentioned a couple of times, the case is that the buttons of the menu are quite small for touch interaction. Therefore, one can notice several times users who try to press the same button twice in order to succeed the wanted action.

Finally, some of the users complained for the responsiveness of the touch events in relation to the buttons of the menu and the movement of the reference image square. It was also noticed sometimes that users were loosing or not succeeded with their interaction in order to resize of move the reference image. User 3 also complained for the existence of a maximum limit for the size of the reference image.

Task B

Similar comments were also made for the tasks B1 (zoom with overview) and B2 (comparison). Firstly, except from the complaints of most of the users, for the fact that the zoom buttons had to be pressed repetitively, there were also noticed again some cases of unsuccessful and inaccurate attempts of pushing those buttons. Once again the menu buttons were considered too close to each another or quite small for touch interaction.

Another user expressed quite different criticism. He stressed out that using the same colors for the border and the zoom square in the overview window was not a wise thing to do and that he could not easily differentiate between the two visualizations. The same user proposes that the zoom in/out could also happen by actively manipulating by touch the inner zoom border of the overview window.

Task C

While performing task C, there were also a couple of observations made that seemed valuable. Most of the users had again problems with the size of the buttons included in the interface. One extremely problematic case was the button of the overview for the whole group, blue button, which some users tried to push but they were not accurate and since nothing happened they were a bit confused. Then again when this button was moved to the bottom position and it was partly hidden, some of the users had a problem to press it accurately again. Consequently, it was both a problem of the buttons size and the lack of feedback when the button was pressed.
or not. There were also similar problems of accuracy in relation to the rest of the buttons existing in the UI, such as the thumbnail versions and the save button.
Chapter 6

Conclusions

6.1 The Reference Image Case: Prototypes of group A

For the reference image case there were a number of interesting facts viewed in the evaluation and the analysis of each hypothesis.

Hypothesis 1 was partly validated, since the results acquired from the side–by–side prototype were better in quality than in the two rest prototype cases.

The results acquired for hypothesis 2 regarding the work load and the mental effort of the users while using different prototype cases, were not so strong as to approve or disapprove it. However, the existence of the learning effect lead to some valuable observations related to the users’ understanding of IR visualizations.

Hypothesis 3, was mostly correct since the proposed prototypes, the side–by–side view and the movable and resizable reference image, were proven more time consuming and more flexible from the comparison case.

Therefore, what can be concluded combing all the results acquired is that, new features and extra interaction in the UI require an amount of extra effort from the part of the user, possibly until becoming accustomed to their usage. Especially, in this case of interaction with the UI, the user had to shift his attention from the camera to the laptop and that could be considered as a drawback in terms of the effort used.

However, even in those circumstances, users performed better in the side–by–side view and clearly stated their preference for it. It was also seen that this view allowed users to focus on the physical interaction with the camera, and allow for the UI work as an aid tool, which is a desired result. Although, users might need some extra time to fully perceive this new side–by–side view, to which they were never introduced, the results and the feelings created by the evaluation compensated for this time.

Another important conclusion was that, although the prototype with the resizable and movable reference image might not have produced as good results as the side–by–side view, most of the users missed the interaction and complained when it was not present. This fact indicates that users are in favor of extra interaction
and even if they do not always use it, they prefer having the option of using extra features that allow them to control the system.

Finally, the observations during the evaluation indicated that during this task, the attention of the users shifted from the understanding of the IR data to a more simple level of recreating a similar visual scene, especially in the side–by–side view. The users, in most of the cases, tried to fix a correct angle or have a correct context in the created image and therefore, their mental effort was based on their visual perception, making the completion of the task more easy.

6.2 The Zoom Case: Prototypes of group B

The results acquired for this case introduced some unexpected and interesting observations and issues. Hypothesis 4, regarding the mental effort and the work load used, could not clearly be approved or disapproved due to strong learning effects and general problems of navigation in the IR space. However, hypothesis 5 was partly validated since users generally considered the zoom with overview case as more flexible and more stimulating to the comparison prototype proposed.

Therefore, the strongest observation made from this evaluation is that, users loose in a great extend the perception of space when looking at the IR image. Even without seeing a zoomed in version, users that are not accustomed to the IR view, need a lot of time to understand the context of what they are watching. Therefore, an effective way should be found, in order to allow the UI work as an aid for the navigation in the IR view generally and then, specifically address the problem of the zoomed in view. In any way the UI should not work as a distraction, like in the comparison case that the users had to zoom in and out several times.

Another important observation made is that, users seek and want to have an overview of the whole space, since they had to zoom out in most of the cases in order to navigate. Therefore, the overview feature presented can be considered as helpful and appropriate. However, its size and the way of interaction with it must be examined carefully.

Furthermore, a good amount of users found the prototype with the overview more stimulating and flexible in general, and that leads to a conclusion in favor of the new ways of interaction. Users seem to appreciate the existence of new features and interaction, and even if there is no need for them to use them, they are happy if those features are present and make them feel more in control of the system. In this specific case of evaluation, the task acquired a great effort in order to move the camera and manipulate the UI in the same time, and worked as a negative factor in order to effectively judge the UI design. The results would have been quite different if the UI was integrated in the camera device.
6.3 The Group Navigation Case: Prototypes of group C

For the group navigation case the results and the data gathered are quite straightforward, not affected by learning or ordering effects. The hypothesis 6 is approved, since users clearly find the C1 (animated navigation) prototype more stimulating.

This fact shows that users enjoy and seek more interaction and multiple views of data, like the magnified overview of the group data and they are more intrigued by new features. Users that are already accustomed to more complex ways of interaction with the UI, by their mobile phones for example, expect from every kind of UI to be as flexible, and are disappointed if this does not happen. However, every new feature in the UI should be shown and integrated in an obvious and clear way, so as users can distinguish it efficiently, without being trained. A question is also raised regarding the extent on which users are accustomed to specific ways of interaction by other devices and regarding the extent on which this fact affects the design decision for new UIs.

6.4 General Discussion

The implementation and evaluation of the prototypes presented for the three distinct user cases, have aided the formulation of some valuable conclusions and discussion points regarding how users perceive the IR image.

Based on the fact that IR is a very abstract and quite difficult to perceive visualization, which causes problems of navigation for most of the users, innovative features were presented in this thesis, that might help towards an easier understanding and use of such data. By the use of multiple and different views of IR data under different circumstances, the users’ understanding and the task performance can be improved. Users were found positive towards these representations and significant problems regarding the use of multiple levels of data were not noticed. Instead they were satisfied for being able to interact with such components and found them intriguing.

However, any integration of such elements in the UI should happen very carefully, taking into consideration the screen resolution and the size and position of the components added. It is very important that users have as much screen space as possible for the IR view, since this is the most essential view.

Another question to be posed is if the interaction techniques used generally for other devices, like mobile phones, are suitable and should be used in the case of IR cameras. After all, it has been observed that users tend to repeat and use interaction techniques to which they are already accustomed. This fact could be considered and integrated in the design of the UI of IR cameras, but it should happen in a meaningful way for each task and each situation.

Above all, the most important conclusion drawn is that especially in the case of IR cameras, interaction and direct manipulation should be always present. Users
might not need to use it or can even choose to exclude it, but they should always be allowed, especially in the case of such an abstract context, to be in control of the system and the visualization, in the most efficient way as possible. After all, interaction techniques, animation effects and direct manipulation, are able to aid the users shift their attention and understanding from an abstract level such as temperatures, to the visual perception system which is more easily apprehended and used. They can only achieve that if the UI elements are flexible enough to allow each user create their own view of the interface, according to personal understanding and preferences.

6.5 Future work

The designs proposed and the conclusions drawn by this thesis can be used as a basis for future solutions and features presented in the field of IR.

As discussed before multiple views of data can be beneficial for the understanding of the IR. The content of those views is not predefined or fixed, but instead it can be alternated according to the task performed. Other forms of data can be used to enhance the users’ understanding such as visual images.

As mentioned in the bibliography section, fusion of IR and visual data has been a very strong feature troubling the research around IR technology. The latest work of Toet et al. (2010) proposes a shift towards cognitive image fusion, defined as a fusion of IR and digital data only in areas that are cognitively meaningful to the user. Inspired by this, the results of this work can argue a possible use of multiple independent views of data, that although not merged together, aid the users understanding. Their most powerful characteristic can be their autonomous nature, that allows the users be directly in control of them and manipulate them effectively. Those different views of data can contain different forms of representations and could even be applied only on specific components of the IR image.

Therefore, what has to be examined in the future is what other forms of data and what views can be helpful for the users’ understanding of the IR data. The existence and use of commonly used IR representations of data, such as fusion, should not be considered as the only and optimal solution for every user case. After all, new designs and innovative features integrated in the UI might help users overcome known problems.

Another fact to be considered is how those new features should be integrated in the UI, how they can be present without destructing users’ attention and without hiding a big part of the available screen of the cameras. Usability and multimodal interaction should be the basic notions for their design, in order to allow them to have a clear role in the IR representation. Therefore, the goal of future designs is to engage and shift users’ attention to the visual perception system, where the explanation and interpretation of IR imagery should happen almost automatically.
Bibliography


Appendix A

Evaluation Questionnaire
APPENDIX A. EVALUATION QUESTIONNAIRE

Evaluation

This evaluation is completely confidential and the answers provided will be used only as part of a master thesis conducted on behalf of KTH, taking place in FLIR A.B., and entitled “Evaluation of the usage of graphical effects within the graphical user interface of handheld IR cameras”. The data acquired during the evaluation either in the form of video or as written answers on the questionnaire are completely confidential and if quoted in the final text, the identity of the users will be kept hidden. The person evaluated has the right to withdraw from the evaluation whenever he/she wants. He/she also has the right to receive the results in case they want so. The participation on this evaluation is volunteering and no economical compensation will be given.

Participant
Evaluator

Gender: Male ___ Female ___
Age: ______
Educational Status: __________________
Previous Experience with touch based devices:
Yes___ (What kind? ____________) No___
Previous Experience with IR devices: Yes___ No___
Task A1

1. How mentally demanding was the task?

| Very Low | | | Very High |

2. How successful were you in accomplishing what you were asked to do?

| Very Low | | | Very High |

3. How hard did you have to work to accomplish your level of performance?

| Very Low | | | Very High |

4. How insecure, discouraged, irritated, stressed and annoyed were you?

| Very Low | | | Very High |

5. Rate your experience/impression of the interaction in terms of the following criteria.

| Easy | | | | | | | Difficult |
| Dull | | | | | | | Stimulating |
| Rigid | | | | | | | Flexible |

6. Which were the most positive and negatives aspects/feelings when using the interface?
APPENDIX A. EVALUATION QUESTIONNAIRE

Task A2

1. How mentally demanding was the task?

   Very Low  |  Very High

2. How successful were you in accomplishing what you were asked to do?

   Very Low  |  Very High

3. How hard did you have to work to accomplish your level of performance?

   Very Low  |  Very High

4. How insecure, discouraged, irritated, stressed and annoyed were you?

   Very Low  |  Very High

5. Rate your experience/impression of the interaction in terms of the following criteria.

   Easy  |  Difficult

   Dull  |  Stimulating

   Rigid  |  Flexible

6. Which were the most positive and negatives aspects/feelings when using the interface?
Task A3

1. How mentally demanding was the task?

<table>
<thead>
<tr>
<th></th>
<th>Very Low</th>
<th>Very High</th>
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</table>

2. How successful were you in accomplishing what you were asked to do?

<table>
<thead>
<tr>
<th></th>
<th>Very Low</th>
<th>Very High</th>
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</table>

3. How hard did you have to work to accomplish your level of performance?

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<tr>
<th></th>
<th>Very Low</th>
<th>Very High</th>
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</table>

4. How insecure, discouraged, irritated, stressed and annoyed were you?

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<th></th>
<th>Very Low</th>
<th>Very High</th>
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</table>

5. Rate your experience/impression of the interaction in terms of the following criteria.

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<th>Easy</th>
<th>Difficult</th>
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<td>Dull</td>
<td>Stimulating</td>
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<tr>
<td></td>
<td>Rigid</td>
<td>Flexible</td>
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</tbody>
</table>

6. Which were the most positive and negatives aspects/feelings when using the interface?
APPENDIX A. EVALUATION QUESTIONNAIRE

Task B1

1. How mentally demanding was the task?

<table>
<thead>
<tr>
<th>Very Low</th>
<th>Very High</th>
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2. How insecure, discouraged, irritated, stressed and annoyed were you?

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<th>Very Low</th>
<th>Very High</th>
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</table>

3. Rate your experience/impression of the interaction in terms of the following criteria.

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<th>Easy</th>
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<td>Dull</td>
<td>Stimulating</td>
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<tr>
<td>Rigid</td>
<td>Flexible</td>
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</table>

4. Which were the most positive and negatives aspects/feelings when using the interface?

   

88
Task B2

1. How mentally demanding was the task?
   
   | Very Low | | Very High |

2. How insecure, discouraged, irritated, stressed and annoyed were you?
   
   | Very Low | | Very High |

3. Rate your experience/impression of the interaction in terms of the following criteria
   
   | Easy | | Difficult |
   | Dull | | Stimulating |
   | Rigid | | Flexible |

4. Which were the most positive and negatives aspects/feelings when using the interface?

   

89
Task C1

1. Rate your reaction to the interface in terms of the following criteria.

<table>
<thead>
<tr>
<th></th>
<th>Easy</th>
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<th>Difficult</th>
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2. Which were the most positive and negatives aspects/feelings when using the interface?
Task C2

1. Rate your reaction to the interface in terms of the following criteria.

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<tbody>
<tr>
<td>Easy</td>
<td>Difficult</td>
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<tr>
<td>Dull</td>
<td>Stimulating</td>
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</table>

2. Which were the most positive and negative aspects/feelings when using the interface?

Thank you!
Appendix B

Description of the evaluation tasks
APPENDIX B. DESCRIPTION OF THE EVALUATION TASKS

Prototype Task Description

In this evaluation you will be asked to complete some small tasks. In order to complete them you can use the interface window appearing on the screen of the computer in front of you, which is manipulated by touch, and you can move the IR camera provided. You will not need to interact with the buttons on the camera or the keyboard. Keep in mind that in IR images, hot means red and cold means blue. In a specific point of the evaluation you will be informed that the duration of your actions is going to be measured, so it's for the best of the experiment to focus only on the given task. During the rest of the evaluation you are encouraged to "think aloud", describe what it's on your mind while performing actions, why you are performing each action, ask questions if you do not understand something and express your opinion for the interface.

Zero Case

(Make an introduction of what is what. Touch screen, Buttons, Camera etc)

1. Look at the space around you and identify the objects.

2. Find a specific object and try to focus the image on that.

3. Freeze the image when you have succeeded focusing on the object (if you are not satisfied just unfreeze and try again)

4. Move the white square first on each corner of the interface and then (left-top, right-top, right-bottom, left-bottom) and then on the spot in the middle of the image.

5. Save the image.

A. Reference Image Case

You were asked to heat all the mugs that are present but one of them has a problem and is not as warm as the rest. You remember that this has happened again in the past and you would like bring up an image from the image archive,
which is similar to the current situation (one with similar colors) and that would allow you to make an exact comparison. Your goal is to save an image that is identical to the reference image acquired in the past.

Task A1

1. Look at the mugs in the space in front of you and identify the problem (which is the cold mug).
2. Bring up the image archive and choose a reference image similar (same colors) to the given situation.
3. Fetch the image to the live video space.
4. Make sure that the reference image does not cover the object of interest (the cold mug).
5. Freeze the image when you are satisfied with the result. (If the freeze version does not satisfy you, unfreeze and start over).
6. Save the image when the result is satisfactory.

Task A2

1. Look at the mugs in the space in front of you and identify the problem (which is the cold mug).
2. Bring up the image archive and choose a reference image similar to the given situation (same colors).
3. Fetch the image to the live video space.
4. Before freezing switch the view mode.
5. Create the identical image and freeze (If not satisfied unfreeze and start over).
6. Save the image when the result is satisfactory.

Task A3

1. Look at the mugs in the space in front of you and identify the problem (which is the cold mug).
APPENDIX B. DESCRIPTION OF THE EVALUATION TASKS

2. Bring up the image archive and choose a reference image similar to the
given situation (same colors).
3. Fetch the image to the live video space.
4. Save the image.
5. Freeze the image when you are satisfied with the result (If not satisfied
unfreeze and start over)

Points of Interest

*Ease of creating and setting up a scene given a specific problem and situation
before saving an image.

B. Zoom Case

In the space around you there two mugs, one with hot and one with cold content.
The goal of this exercise is to zoom in to those mugs and place the measure spot
on the most intense temperature of those objects (the hottest spot for the hot
mug and the coldest spot for the cold mug).

Task B1

1. Look at the mugs in the space in front of you.
2. Zoom in to the hot mug.
3. Place the measure spot on what seems to be the hottest area (red-white) on the mug. No need to be precise. (start counting)
4. Find the cold mug.
5. Place the measure spot on what seems to be the coldest area on the
mug (blue). Make sure your image is zoomed in on that spot.
6. Freeze the image (If not satisfied unfreeze and start over).
7. If the zoom window covers the area of interest (coldest area) try moving
it, or taking it away or panning the background image.
8. Save the image.

Task B2

1. Look at the mugs in the space in front of you.
2. Zoom in to the hot mug.
3. Place the measure spot on what seems to be the hottest area (red-white) on the mug. (start counting)
4. Find the cold mug.
5. Place the measure spot on the coldest area on the mug (blue). Make sure that your image is zoomed in on that spot.
6. Freeze the image (if not satisfied unfreeze and start over).
7. Save the image.

Points of interest

*Ease of navigation through space (keeping an overview of the space)

*Ease of optimizing the result (the view of the image to be saved)

C. Archive Navigation Case

Each IR image you saved represents a group. The group consists of the IR image acquired together with a visual image which was saved automatically with the same characteristics. Based on the images and the measurement data acquired, a form was also generated automatically. You will be now looking at one of these groups.

Task C1

1. Browse each of the stored items one by one.
2. Can you look at the overview of the group?
3. Get back to the IR image
4. Save
APPENDIX B. DESCRIPTION OF THE EVALUATION TASKS

Task C2

1. Browse each of the stored items one by one.
2. Get back to the IR image.
3. Save.

Points of Interest

* Feeling of the animation
* Comments on the interaction
* Feeling of the overview