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Using Mobile Computing to Enhance Skiing

An investigation into how mobile computing can be used to enhance the skiing experience

Master of Science Thesis in Interaction Design and Technologies

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Abstract

Skiing is a popular activity in Sweden and about 24% of the population between the age 0 and 74 ski each year. Of these skiers 42% are between the ages of 15 to 45 and around 75% of them have a smartphone. Smartphones are becoming more popular each day and represents the majority of the mobile phone market. With the increase in smartphone usage along with the interest in winter sports, there exist a general interest in how these can be combined, both to benefit the skiers and also the resorts as a way to engage more people into skiing.

The aim of this report was to investigate how smartphones can be used to enhance the downhill skiing experience, especially looking into if and how sound can be used as a design parameter. The presented ideas and concepts have been acquired by using established methods to both understand the potential users and evaluate prototypes based on some of the ideas. The report will go trough the process behind the achieved results outlining what has been done in each step of the way.

Some of the presented ideas are: a functionality to know where people that you ski with are, an audio feedback system that informs the user about their performance and an algorithm that can be used to detect if a user is in a slope or a lift. Additionally, a new way to interact with a mobile device is presented that do not require the user to take the device out of the pocket.

Contents

Chapter 1

Introduction

Mobile computing is a massive market and it is estimated that the number of shipped smartphones will increase by more than 50% in the coming years leading up to 2015 were it is estimated that around 1 billion devices will be shipped [1]. Just in Sweden approximately 3 million smartphones were sold in 2012, 80% of the total mobile phone market and an increase with 25% compared to the previous year. It is estimated that the number of sold smartphones in Sweden will grow to 90% in 2013 [2]. Even though these devices are quite powerful they are often used for a quite limited selection of tasks. With the use of the different inputs that are available on them like GPS, sensors and constant connectivity it is possible to create a wide range of applications not possible in any other context than for smartphones.

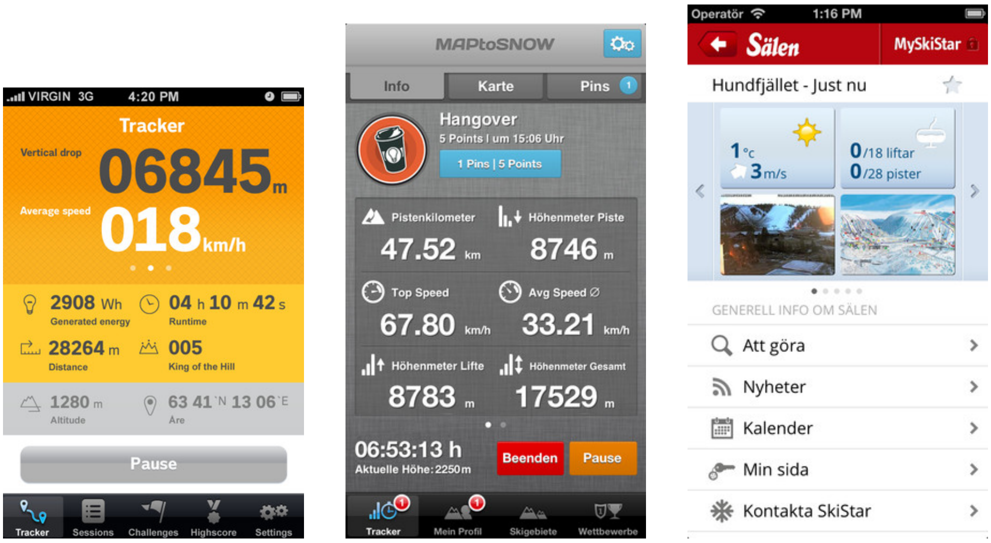
Skiing is a popular activity in Sweden, in 2011 2.1 million Swedes went downhill skiing which results in 24% of all Swedish citizens between the age of 0 and 74 [3]. Of these skiers 42% are between the age 15 and 45 and in these groups around 75% have a smartphone [4][5].

With the increase in smartphone usage along with the interest for winter sport, there exist a general interest into how these can be combined, both to benefit the skiers but also the resorts as a way to engage more people into skiing. The focus of this thesis is to investigate how smartphones can be used to enhance the downhill skiing experience. The work will be performed together with the Interactive Institute [6] and Experimedia [7] and especially look into if and how sound can be used as a design parameter.

The final concept presented shows how sound can be used to enhance the skiing experience, what information that is important to skiers, what ski resorts are looking for along with a new concept for input handling that does require the user to take the smartphone out of her pocket that can have use-cases outside of the skiing domain.

1.1 Background

Applications for smartphones to be used while skiing are nothing new and several products exist on the market; many of which were investigated for this thesis. In the following paragraphs some of the more popular ones will be presented, outlining some of their functionality, to give a perspective on what exists today. Something that all of the presented applications have in common is some sort of achievements together with global high score lists.



(a) King of the Slope **(b)** MaptoSnow **(c)** MySkiStar

Figure 1.1: Existing skiing applications for iOS.

King of the Slope, figure 1.1a, is an application by Vattenfall that is available on both Android and iOS [8]. The application uses GPS to track the user and provides some statistics like distance traveled, average speed, vertical drop and running time. It is also possible to challenge Facebook friends in most vertical meters during a specific time period. The application is not locked to any particular ski resort and can be used everywhere.

MaptoSnow, figure 1.1b, is an application by Mapcase and is available for both Android and iOS [9]. Similar to King of the Slope the application provide statistics about the user's skiing using the GPS on the device. *MaptoSnow* features however more data and statistics like number of lifts taken, the distance traveled by lifts and top speed. The application has support for several ski resorts in mainly Austria, Switzerland and Germany but it is possible to use it everywhere with limited functionality.

MySkiStar, figure 1.1c, is an application by Skistar and is mainly a web-based application although applications for Android, iOS and Windows Phone exists with limited functionality [10]. Different from the others this application does not use GPS to track the user but instead connects an account with a ski ticket and based on that knows which lifts that the user has taken and from that calculates the vertical meters traveled. As with King of the Slope it is possible to compete against others in most vertical meters and it is also possible to compete in first to a specific number of vertical meters, most rides and first to a specific amount of rides. Uniquely for *MySkiStar* is the ability to see where your friends are in the slope limited to the basic information that exists in the application, namely what lift they used last.

1.2 Aim

The aim of the thesis is to investigate how mobile computing can be used to enhance the skiing experience. That includes understanding the skiers and based on that create a concept for a potential application that provides something new to the market and solves the goals of the skiers. As a request from the Interactive Institute, that the thesis was done together with, an investigation into if and how sound can be used while skiing will be performed.

1.3 Delimitations

Since the aim of the thesis is to investigate and present a concept based on the data that is collected a final application will not be created for release in public, as such work will not be allocated towards the look and appearance of the application but the core functionality. To limit the needed research the iOS platform [11] has been chosen as the technical platform, although many of the concepts presented are applicable on other existing platforms. The reasoning for selecting iOS is that it is a popular platform [12] and something that the author could easily develop for since it was the platform that he had easy access to and prior knowledge about.

Chapter 2

Methodology

Several different methods were used during the thesis each contributing to the end result. The following section will go through each of them and describe them in detail.

2.1 Goal-Directed Design

Goal-Directed Design is a user centered design approach that is about designing products that people can use to achieve the goals that they have which will result in satisfied users that enjoy the end product. This is about understanding the users' desires, needs, motivations and contexts as well as understanding the business aspects, technical and domain opportunities, requirements and constraints [13]. Goal-Directed Design involves the users early in the design phase and based on their feedback the designers can deliver specifications for the developers to build prototypes that later can be tested with users. The feedback that is acquired from the tests is then given back to the programmers and designers for continued iteration. See figure 2.1 for a visual representation of the Goal-Directed Design approach [13].

The Goal-Directed Design approach was used as framework for the thesis, consisting in an iterative approach were information was gathered and a design was drafted, a prototype was developed and then tested. Based on the results from the test the process repeated itself with more information gathering and analysis of the data from the test, a new prototype was developed and a new test was done. Interviews were performed during the design phase to get information about the users as well as the test phase to evaluate the prototype. Observations

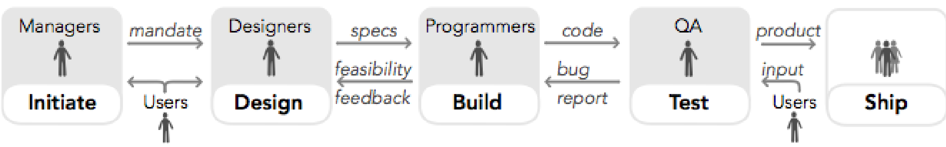


Figure 2.1: The Goal-Directed Design approach to software development. [13]

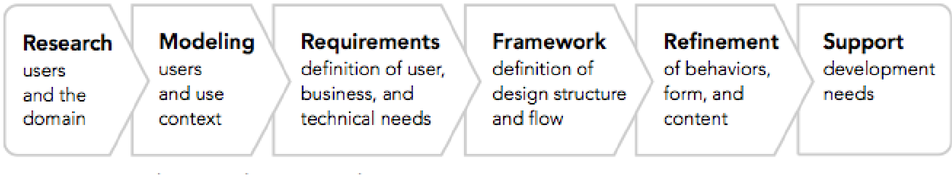


Figure 2.2: The Goal-Directed process. [13]

were performed during the test phase and focus groups together with participatory design were used in the design phase.

An important part to succeed with Goal-Directed Design is to involve the designers in the research phase of the project; designers need to be the researchers [13]. From this the Goal-Directed Design process comes with its six phases, figure 2.2 [13].

In the research phase data gathering techniques are used to provide qualitative data about potential users of the product as well as research about the market, technology, papers, and similar. This information is then used in the next phase, modeling, were the data is analyzed to create domain and user models. This is about understanding who the potential users are, what their goals are, what motivates them and more. Using these models as base more detailed requirements are defined in the requirements phase. This is about understanding what the users want to achieve and what they would do with the application to fulfill their goals. Then in the next phase, the framework phase, the product's concept are developed by defining the product's behavior and visual design. Following that is the refinement phase that is similar to the previous one but with a greater focus on details and implementation. Lastly is the support phase were the designers aid the developers by answering their questions as they arise during development [13].

Since the scope of this research is smaller than what Goal-Directed Design is aimed to be used for some phases will be slightly altered to work better. For example as the researcher and designer will be the same as the developer the last step in the process isn't needed and additionally the focus of the thesis is not to build a complete product but rather make an investigation into the chosen subject and therefore some of the later phases will not be as important.

2.2 Interviews

Throughout the thesis several interviews were performed as a way acquire qualitative data from different stakeholders. Mainly two types of interviews were used: unstructured and semi-structured.

Unstructured interviews are interviews that are performed similarly to an ordinary conversation focused around a specific topic. The questions that the interviewer has are open and as such the answers are not limited in any way and can be as long or as short as the interviewee desires. As an effect this also results in that both parties can steer the interview making it important for the interviewer to make sure that the relevant questions are covered and answered. One benefit of unstructured interviews are that they generate rich data that can not be as easily obtained using an alternative interview method, things can be mentioned that were never considered when starting the interview. However this type can be time consuming and the results from the interview can be difficult to analyze. Another drawback is that it is impossible to replicate the process with another interviewee [14]. This method has only been used in the thesis when interviewing a single subject meaning that the interview does not have to be repeated and the data that needs to be analyzed is limited.

Semi-structured interviews combine aspects of structured interviews, were all the questions are closed and the interview is similar to a spoken questionnaire, and unstructured interviews resulting in both open an closed questions. The interviewer relies on a basic script that is used as a base for the interview, this makes sure that the same things can be brought up during each interview. Probing is a common concept in semi-structured interviews where a predetermined question is asked and then followed up with additional questions with the goal to get an even more detailed answer. A benefit with this style is that it is possible to replicate the interview to a large extent, making it a good candidate to be used when interviewing several users, while still being able to have some freedom during the interviews [14].

In both cases it is important that the interview is well structured and performed in a good manner. This includes avoiding long questions, using easy to understand language, avoiding leading questions and trying to be as neutral as possible. An interview should be started with an introduction were the interviewer presents himself and explains the purpose of the interview. As the interview begins easy and non-threatening questions should be asked first as a way to ease the interviewee into the session before the main subject is touch upon with the most difficult questions last. When the interview is starting to come to an end it is suggested to end with some easy questions and finally finish up by thanking the interviewee for his or her participation [15].

2.3 Observations

Observations are often used to get a better understanding about the user and something specific, like the effectiveness of a prototype or just how the user performs a task. There exists several different ways to perform an observation, mainly in a controlled environment like a lab or in the users' ordinary environment often called the field [14]. Doing observations in the field can be of great benefit since it is possible to observe things that the user might not recognize as a problem or do not think is solvable and therefore do not bring it up [16]. No matter how an observation is performed it is important that the results are recorded in some way. This can be done by taking notes, taking pictures, record audio or use video recording. Another important aspect when doing an observation is to have a goal with it, knowing what questions that needs to be answered. Especially during field observations it is important to keep track on what is happening and to aid in that the observer can use a framework. This framework outlines what needs to be considered so that nothing important is missed when performing the observation [14]. A simple framework consisting of only three items is defined by Sharp et al. [14]:

- **The person** – Who is using the technology at any particular time?
- **The place** – Where are they using it?
- **The thing** – What are they doing with it?

More detailed frameworks exist but are similar to the extent that they all are used as an aid for the observer to remember the goals and questions when observing [14].

Field observations are what have been used during the thesis to both understand how users used a prototype and understand their behavior when skiing. This helped in both understanding the users needs and to some extent if the developed prototype meet those needs. During the observations the observer operated as a participant observer meaning that the observer took part in the activities that users performed to get a better understanding about the problems and needs they have. All of the observations were either recorded by taking notes or using a video recorder and additionally all of the recorded material was evaluated each day to structure the data and find the important details in it as suggested by Sharp et. al [14].

2.4 Focus Groups

Focus group is a form of group interview where a group of participants are interviewed at the same time [14] and is particularly useful for exploring participants knowledge and experience as well as not only what people think but also how they think and why they think in that way [17]. The group normally consists of around three to ten people [14]. The group composition should if possible according to Sharp et. al represent a representative sample of the typical user [14] while Kitzinger highlights the benefits of homogeneity between the group members to capitalize on shared experiences [17]. The goal of the focus group is to create a discussion among the participants about the questions that the facilitator has, which can bring the research in a new and often unexpected direction. This means that the facilitator asks the group as a whole a question that they then can discus among themselves instead of addressing each participant individually in sequence. Another benefit with focus groups over other forms of data gathering techniques is that it lets the researcher tap into the many different form of communication that people use in their ordinary day to day interactions like jokes, anecdotes, teasing and arguing which could grant access to more information that would otherwise be unobtainable [17].

The structure is quite flexible but it is important for the facilitator to keep the discussion on point and not let it drift too much from the subject as well as making sure that everybody gets a chance to state their opinion. Most often the discussion is recorded to make it easier to analyze it afterwards [17] [14]. The focus group should take place in a comfortable setting, be relaxed, refreshments could be offered and participants should be sitting in a circle if possible to establish the right atmosphere [17]. One disadvantage however with focus groups is that it can be hard to find a time and a place which works for all of the participants [14].

2.5 Participatory Design

Participatory design is when users are involved in the design process and is a powerful method when users are available and interested in becoming an active part of the design. There exists many different approaches to participatory design, each with their own take on the concept of how to involve users in the design process. All of them share however the importance of giving the participants the necessary tools and information to make it possible for the them to deliver a good result. One of the drawbacks with participatory design is that the users thinking can be constrained based on the information that they have about the topic. Another problem that needs to be avoided is to involve the users too much in the process which can result in them being bored and in the end being counterproductive for the study [14].

One of the core methods of participatory design is workshops and that is what have been used in this thesis. Workshops are when the users and the designers are collaborating in creating a design, vision, policy or understanding about the selected topic together [18].

Chapter 3

Research Phase

The thesis was done in three major phases, each consisting of several steps that all built on the knowledge from the previous. The following sections will go through the first phase in which the majority of the research was done in the same order as the steps were performed.

3.1 Literature Research

The thesis began with a literature study into both application development and into literature that relates to the subject, using technology to enhance an experience. This step relates to the research phase of the Goal-Directed process.

3.1.1 Application Development

Since iOS had been selected as the target platform for the thesis it was deemed important to get a good understanding about the platform to know what was possible to do before any work began. This information was acquired from Apples developer portal for iOS featuring everything from technical documentation to videos and example code [19]. This work continued throughout the entire thesis, reading up on technical aspects as more information was needed and new challenges was encountered.

3.1.2 Related Work

Time was allocated to get a better understanding about what already had been done on the subject, using mobile computing to enhance an activity and use sound as a design parameter. The following sections will go through some of the literature that was examined and present why they are interesting for this thesis.

Kurdyukova et al. [20] has done an evaluation into the design of auditory feedback for a mobile outdoor training assistant. In their paper they outline four essential functions that sound should be used for in an outdoor sport application: performance feedback, navigation, competition support and entertainment. All of these serves a function and is something that need to be considered while designing an application that is aimed for this area, outdoor sports. They then go on to identify a number of moments where sound was important: time unit is over, distance is covered, additional information about objects on the track, wrong way scenario, race information like who is first and when the user has reached the finish. In relation to these moments Kurdyukova et al. also investigated whether to use spoken voice feedback or a signal to convey the message. They found that voice feedback was primarily the best alternative to use but signal feedback could be mixed in with the voice for even better results in the additional information moment, the wrong way moment and when the user has reached the finish. The results presented in the paper might not be strictly applicable onto skiing as this study was done for running, e.g. skiers might be more interested to know how long a slope were and what time it took than an update every minute or similar, but inspiration can definitely be taken.

Haid et al. [21] did an evaluation on a mobile ski touring application. Their application featured avalanche conditions, weather information, maps among other things and used text, audio and visual feedback to direct the user to her chosen destination. From their evaluation they observed that the participants preferred to not use headphones but rather the built-in speaker of the phone, however they complained that the sound was too low. In general all of their test persons liked the audio feedback, giving the reason that it made it possible for them to focus on the tour and not having to look at the display of the phone. Another reason stated was that they did not have to put on and off their gloves to use the application. Even though this is not for the same type of activity, touring verses downhill, it still has a lot of relevant insights in how mobile computing can be used to enhance the skiing experience and the benefit of using audio.

As stated by Kurdyukova et al. [20] it is possible to use sounds other than voice as feedback. One such thing is to use spatial audio, stereo sound, giving the user a sense of direction among other things. Such a system is discussed in the paper by Lijedahl and Papworth [22]. The presented system aimed to make on foot navigation simpler and provide an eyes-free interaction based experience. In the paper they evaluated the system by creating two separate applications, one used for navigating a city on foot and one pervasive game.

The city navigation application used a multimodal interface, graphics along with audio, and the electronic compass in the phone together with GPS information to find points of interest (POI) by letting the user sweep the phone in front of her. The application also had a mode where the user could select a specific location and a virtual sound would be played based on where the selected location was in relation to the direction of the device, resulting in the sound moving between the left and the right ear depending on the direction. The audio would also change volume and increase as the user got closer to the target or decrease when moving away. Additionally three different sound effects were used to indicate one third of the distance each. This meaning that when the user had traveled one third of the distance the sound would change to indicate that and so forth. The game worked in a similar way but instead of locating POI the users could locate each other with the goal to destroy them virtually in a game where half of the players played submarines and the other half corvettes. Each team featured unique game mechanics around the use of spatial audio. Based on their results from the tests they found that the users found the applications effective, easy to use as well as fun. If and how this can be used in this thesis is something that needs to be evaluated. In the presented implementation it has only been used while navigating on foot, which is quite different from skiing, and it also used both audio in conjunction with a more traditional interface, which will be hard for a skier to look at while going downhill.

In *Hummingbirds Go Skiing* by Weilenmann and Holmquist [23] they present a concept for a wearable computer system, Hummingbird, aimed to be used while skiing to help the users know where other skiers are. The system worked in the following way; when two users were close to each other (around 100 meters) the device that the users were equipped with would give an auditory feedback in the form of an *"hum"*. Together with the sound a screen was used for informing the user about who were near her. From their test with ski instructors they observed that the devices was mostly used for finding others to have lunch with and see who had left the cabin in the morning. They also observed that the Hummingbird was not really used while skiing because of their limited range that was an effect based on the technology used, the sound being too low as well as problematic to take the device out of the pocket to look at the display. Instead users looked at the devices when taking a break or being in the lift. A focus group were also performed with the users that had tested the device and some suggestions was purposed like better range, knowing the direction of others, not only that they were in the vicinity and a smaller design of the actual device. An interesting observation that they made were when they performed a focus group with ski instructors that had not used the device previously. The ski instructors had a hard time understanding what it could be used for and how it could be improved, making the argument that it is important for the participants in a focus group to have a good understanding about the concept to be able to discuss it successfully. This correlates with what was brought up in section 2.5 about participatory design, that it is crucial that the participants have a good understanding about the topic to be able to contribute. The presented concept gives interesting insight in the power of being able to know where others are when skiing and is something that should be investigated further. Some of the problems and suggestions that they got in their study should be relatively easy to address as technology has advanced since the paper was published in 1999 resulting in smaller devices with better range among other things.

3.2 Initial Interviews

Using the knowledge acquired from the literature studies interviews were performed with potential users of an application for skiing with a selected number of people to acquire qualitative data. The interviews were performed in a semi-structured approach, see section 2.2, with questions about their skiing habits with the goal to understand how they skied, some questions about music as sound use was one of the aims of the thesis, and what they thought was missing today. For a complete summary of the questions see Appendix A.

The number of participants was not determined from the beginning, instead the following approach were used: *"An appropriate sample size for a qualitative study is one that adequately answers the research question"* [24]. This would in the end result in a total of eight participants since the same answers started to be repeated and the amount was deemed sufficient. The participants where selected based on a combination between convenience sampling and judgment sampling [24], meaning that people where selected that were deemed to be well suited to answer the questions and that were easily accessible for the study. Although this type of sampling has flaws such as *"If the subject are known to the researcher, they may be stratified according to known public attitudes or beliefs"* [24], it was deemed as a good alternative over other methods to quickly answer the questions.

All of the participants that were selected had previous experience from skiing with ranging levels of expertise, going from beginner to intermediate and advanced. In total the participants consisted of four male and four female subjects with two being around 45, four being around 25 and two being around 20 years of age. All of them were also smartphone users and altogether the selected participants matched well against the group that was mentioned in the section 1, the majority of skiers that use a smartphone and also possible potential users of a skiing application.

3.2.1 Results

From the interviews several things were observed that were used as a basis for the continued work performed in the thesis. Firstly all of the participants said that they ski together with others, be that colleagues, friends or family. Most often these groups stay together but sometimes they will break into smaller ones. Reasons for this that were mentioned were different skill levels, interests (some want to jump in the ski park, other wants to go fast) and that sometimes the group can become too large to function at the ski resort.

When asked about how they use their phones while skiing the answers differed somewhat between the participants, some mentioning that they never gave the phone any attention during the day others said that they check their smartphone whenever it was possible, mostly in the lift and when taking a break. This is similar to what was mentioned in *Hummingbirds Go Skiing* [23]. They all however stated that the main problem with using their phones while skiing was that they didn't want to take off their gloves, the same observation that had been done by Haid et al. [21]. When asked about their use of music when skiing the answer was almost unanimously, they tended not to listen to music saying that the main reason being that it blocks out to much sound being both a problem to be able to talk friends and also hearing what is going on in the slope.

None of the participants had previously used any application aimed to be used while skiing, some had however heard about *King of the Slope* and *MySkiStar* before. When asked about similar applications that are used while exercising most had at least tried some running application, like *RunKeeper* [25], and had mostly only good things to say about them. Something that was brought up was the usefulness of the voice feedback these applications provide. In regards to what they would like in an application aimed for skiing they mentioned distance, speed and what slopes they had ridden primarily. In regards to the fact that almost all of the existing applications have some sort of achievement system or high score the participates were asked about what they thought about it, they were given a short presentation of some of the existing applications. Nobody found it fun to be far down on a high score, saying that they thought them to be pointless and bring little to no value. The same was said about achievements which from the users point of view bring little value, at least in the present form where the achievements revolves around number of slopes taken for example.

3.3 Conclusions

Using the results from the interviews together with the information acquired from the literature study some goals for the continued thesis were decided. A rough user archetype to be used in the next phase was firstly formed; a smartphone user with intermediate skiing level around 25 years of age, skiing together with others in a group and dislikes to interact with the phone directly if not needed. The user enjoys being able to get feedback and statistics based on her skiing but do not have any interest in achievements or global high score lists. Additionally the user wants to be able to talk to others and do not like to use earphones while skiing. The reasoning behind selecting the user to be around 25 years with an intermediate skiing level was that the majority of the participants were of that age and most of them being intermediately skilled at skiing.

Areas that will be further investigated is audio feedback as this seems to be an promising area and as requested by the Interactive Institute. This includes both the form of something similar to what can be found in running applications and the use of spatial audio. This to avoid direct interaction with the application that requires the user to take of their gloves, but other possible solutions for this problem will also be investigated. Additionally a way to find and locate friends in a group will be investigated similar to what was done in *Hummingbirds Go Skiing*.

Chapter 4

Development Phase

The following sections will go through the second phase of the thesis in which ideas were evaluated using prototypes and user tests. Several prototypes were developed as an incremental approach where new functionality was added in each version.

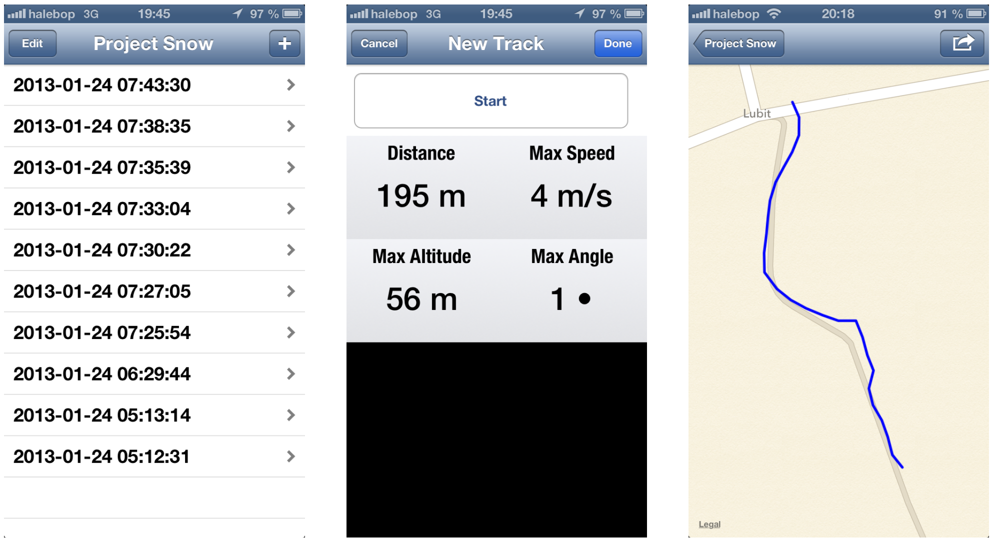
4.1 First Prototype

At the same time as the first interviews were performed, work began on a prototype with three main goals. The first of them was to create a base to build on for the continued work in the thesis. The second was to test what was possible to do on the technical platform, iOS. The third and final one was to acquire data from a real skiing session, getting feedback from a user about the experience and possible bugs as well as data to be used in simulations for further development. During this time the prototype was referred to as *Project Snow* as can be seen in figure 4.1a.

The prototype featured a simple interface along with basic functionality aimed to reach the three mentioned goals. The app's three views can be seen in figure 4.1. The first view, figure 4.1a, uses a table view [26] to show previous recorded sessions that the user has done. To start a session the user hit the plus-button found in the upper right corner. By doing so a new view will be presented, figure 4.1b, where the user can start, stop and pause the recording of data. Also visible in this view are four values displaying distance traveled, maximum speed, maximum altitude, and the maximal downhill angle.

A core part of the application is being able to track the user, making it possible to get information like maximum speed and total distance traveled. To achieve this the GPS in the device is used. Utilizing the background functionality of iOS it is possible for the application to track the user even if the application is not in focus or the device is put to sleep [27]. During each update that the application receives from the GPS the data is analyzed and saved in a Core Data database [28] for easy access after the session has been completed making further analysis possible.

In figure 4.1c a map is displayed for the user that shows how she has traveled while being tracked by the application. This view is presented after the user has selected one of the saved sessions seen in figure 4.1a. The default map of iOS, Apple Maps, is used as a way to speed up development since it can easily be implemented into an application. Apple Maps were introduced in iOS 6



(a) Recorded sessions view. (b) Tracking view. (c) Map view.

Figure 4.1: Screenshots of the first prototype.

[29], the same version as the prototype was developed for. Also possible from this view is the option to export the recorded data as GPX (GPS Exchange Format) [30] either via email or by opening it in another application on the same phone that support the format. The reason for this was that it provided an easy way to access the recorded data making it possible to analyze the data further outside of the application as well as using the data in future simulations.

Additionally the prototype featured several settings related primarily to the GPS, see figure 4.2, as a way to easily test different levels of precision to see what effects it had on both the data that is recorded as well as battery consumption. The first setting, *The accuracy to use*, is related to iOS location accuracy settings and is used to tell the system how many resources it needs to allocate to find a position update [31]. The next setting, *Ignore small movements*, is used to ignore an update from the GPS if the distance between the new and previous locations is small, this saves battery as the application never has to process the new information. The last settings, *Accuracy Limits*, is used by the application when receiving an position update from the GPS and ignoring it if the reported accuracy is higher than the selected values, this to avoid imprecise updates. In regards to battery consumption, a safe guard was also implemented that turned off the tracking if the battery dropped below a certain limit, see *Stop tracking when the battery is low*.

4.1.1 Evaluation & Results

Using the finished prototype several tests were performed around the precision of the GPS and the battery consumption associated with different settings inside the application. Based on the results from the tests, a set of settings were selected to be tested in a real setting by running the application on an iPhone 5 while skiing during two days. The chosen settings can be seen in figure 4.2. All data that the application recorded was saved and analyzed and an interview was performed with the test person after the completion of the test about the application and the

Figure 4.2: Settings view

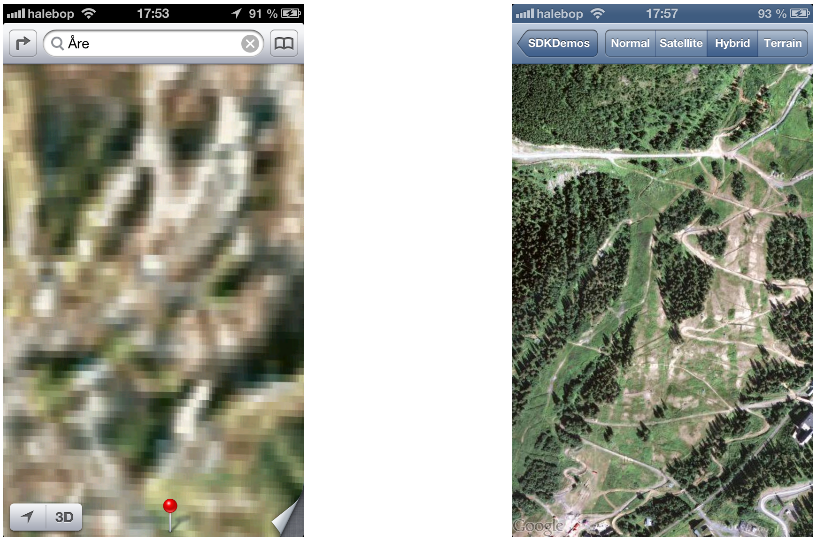
test in general using an unstructured interview approach as described in section 2.2.

Several interesting things were brought forward during the interview. The first thing that was mentioned were the poor maps, this referring to Apple Maps, complaining about the level of detail in them. No problems were reported about the battery consumption, the user stated that it was possible to use the application during an entire ski day and only loosing about 50% of the battery on average and this including normal use of the phone in general while skiing. One thing that was requested was more data about the ski performance similar to speed and distance. The user also stated that he found it particularly fun to be able to see his maximum speed in the application.

As stated previously, all the data that was recorded by the application was analyzed and mainly one thing was observed from this. Given that the application received all GPS updates, the application did not ignore small movements, it was actually possible to receive several positions during same time period from the application's point of view. This resulted in unexpected speed spikes as the user from the application's point of view could move a significant distance in no time at all. Another observation was that the level of detail was unnecessary and no extra information was gained in having this level of precision. It would therefore be beneficial from two perspectives, battery consumption and incorrect readings, to ignore moves under a certain threshold and based on the analysis of the data, 5 meters seemed like a good candidate.

4.2 Second Prototype

Based on the feedback and the data acquired from the first prototype together with the results from the research phase a new prototype was built with a larger scope. The goal was to correct the problems that existed in the first prototype, aiming it towards the user archetype that was defined previously and investigate the decided areas; audio feedback, hands-free interaction and a way to locate friends while skiing.



(a) Åre - Satellite, Apple Maps.

(b) Åre - Satellite, Google Maps.

Figure 4.3: Comparison between different map providers.

Work began by looking closer at the map that was presented to the users in the application since feedback was given about the quality of it. Comparisons were made between Apple Maps that is a part of the iOS operative system and Google Maps [32] a free alternative that is possible to integrate into ones application, the previous standard on iOS before iOS 6. Based on this evaluation Google Maps was deemed as the superior alternative with the only drawback that it would require a bit more programming to get it working. An example for why Google Maps was superior over Apple Maps can be seen in figure 4.3 where the ski resort Åre is shown using the satellite view for respective version. The same difference could be found in general in all of the different map modes over several locations. Another advantage that Google Maps also provided over Apple Maps was a Terrain view, which featured altitude lines something that can be quite powerful for skiing as it becomes easier to see where the peeks and valleys are.

As stated in the research phase it was decided that audio feedback would be one area for further research based on what Haid et al. [21] and Kurdyukova et al. [20] brought up in their papers together with the request from the Interactive Institute. Work began with integration audio feedback into the application to make it possible to provide the user with all of the four types of feedback that Kurdyukova et al. brought up and also serve as a way to deliver information to the user without requiring him or her to take of their gloves, something that users prefer not to do if not absolutely needed as seen in the interviews.

To deliver voice feedback from the application, a small investigation into text-to-speech engines was performed with the aim to find a suitable alternative. While text-to-speech engines voice feedback can be a little robotic it allows for easy and fast prototyping, in a final application a better alternative would be to use prerecorded phrases when possible for a better user experience. Since the application only was aimed to be a prototype the engine chosen needed to be simple to implement and additionally not require an Internet connection, it is possible that there is no connection available when skiing, and a relatively good quality in the voice feedback. Two possible candidates were selected: OpenEars [33] and eSpeak [34] (more specifically a wrapper for iOS called ESpeakEngine [35]). ESpeakEngine was selected to be used in the prototype because it was more straightforward to implement and additionally supported Swedish as well as multitude of other languages while OpenEars only supported English.

During the investigation of text-to-speech engines some work was also allocated into speech recognition and the possibility to use it in the application as a means for easy input for the user, something that could provide a hands-free experience. The engine that was tested was OpenEars [33] which featured offline speech recognition. While the results were quite promising, it was not flawless and sometimes picked up the wrong commands. The decision was made to not use speech recognition in the prototype due to its inconsistency, which would result in a bad user experience. Additionally it would require the user to have a microphone available that would be able to pick up what the user was saying while skiing, something that probably would make it even harder to get the commands right than in the controlled environment that the technology was tested in.

With voice feedback implemented into the prototype the question was now when it should be used and what it should say. Kurdyukova et al. [20] identified a number of moments where sound was important for outdoor training, like ”time unit is over” and ”distance is covered”. They mainly focused on running, cycling and similar where the user’s goal is to cover a distance or keep within a time limit. This does not apply to skiing. Instead here the users goal is to go down a slope and then eventually take a lift up and go down again. Based on this it was decided that an interesting point to get feedback at would be at the end of a slope, as the user was waiting for the lift or alternatively was in it. This matches well with the fact that this is a moment, in the lift, where users say that they normally interact with their devices as seen in the interviews as well stated by Weilenmann and Holmquist [23].

Some basic information was decided to be given to the user while in the lift after a slope had ended. Mainly the distance of the slope, the time it took and the maximum speed achieved during the ride. The first two correlates to the moments Kurdyukova et al. [20] mentions but adopted to a skiing setting and maximum speed as that was something that was mentioned for being particularly interesting by the test user of the first prototype. With the moment to present feedback decided and what that information should be a new problem presented itself, how to know when the user actually has stopped going down the slope and is in the lift and when the slope begins to be able to measure distance and time. Using the data that was collected using the first prototype for simulations an algorithm was created that was able to detect when the user starts going in a lift and where it ends and when the user starts going down a slope and where it ends.

A pseudo code representation of the algorithm can be seen in figure 4.4. The algorithm firstly uses a distance limit meaning that it only proceeds if the user has moved a certain distance, this to avoid problems associated with the precision of GPS, see row 2. The algorithm then consists of two blocks, one for detecting if the user is going down a slope (row 3 - 9) and the other to detect if the user is going up with a lift (row 10 - 16). Both of the blocks uses an angle check to detect which direction the user is traveling; a positive angle value that is larger than the threshold means that the users is moving downwards (row 3) and a negative value that is smaller than the negative threshold value indicates that the user is going upwards (row 10). The threshold is used to make sure that only large enough angles are considered since the GPS as mentioned is not perfect. Both blocks then continue with a similar case where the algorithm checks if the user is not in a slope and not in a lift. If this is the case the algorithm will return that the user has either started going down a slope (row 4) or up a lift (row 11). If the previous case was false the algorithm will continue with checking if the user was in a lift (row 6) or a slope (row 13) and if

```
Input: angle: Angle between previous and current location where a positive value
       represents that the user is going down.
Input: distance: Distance between previous and current location.
Input: thresholdAngle: Threshold angle to detect a change in position.
Input: liftDistance: The length of the currently active lift.
Input: slopeDistance: The length of the currently active slope.
Input: minLiftDistance: The minimum length a lift needs to be.
Input: minSlopeDistance: The minimum length a slope needs to be.
Output: Slope Started, Slope Ended, Lift Started, Lift Ended, Ignore Last Slope or Ignore
        Last Lift
1  Function GetCurrentStatus() begin
2      if (distance > minDistance) then
3          if (angle > thresholdAngle) then
4              if (not Slope Started and not Lift Started) then
5                  return Slope Started;
6              if (Lift Started) then
7                  if (liftDistance > minLiftDistance) then
8                      return Lift Ended + Slope Started ;
9                  else return Ignore Last Lift + Slope Started ;
10         else if (angle < -thresholdAngle) then
11             if (not Slope Started and not Lift Started) then
12                 return Lift Started;
13             if (Slope Started) then
14                 if (slopeDistance > minSlopeDistance) then
15                     return Slope Ended + Lift Started;
16                 else return Ignore Last Slope + Lift Started;
```

Figure 4.4: The basis of the algorithm that is used to know if the user is in a slope or a lift.

true it will validate that the minimum distance of either the lift (row 7) or the slope (row 14) has been reached. If the minimum distance has been reached the algorithm will return that the user has either left the lift and started going down a slope (row 7) or left the slope and started going up with a lift (row 14). If the minimum distance was not reached the algorithm will return that the user actually never was in a lift and now is in a slope (row 9) or never was in a slope and now is in a lift (row 16). As can be seen the algorithm makes assumptions based on the information that is available and reevaluates previous assumptions with the goal to minimize errors that can occur because of either incorrect values from the GPS or unexpected geographic properties (like a lift that goes downwards or a slope that has a segment that goes upwards).

Knowing when the user is in lift or slope gives additional benefits than just being able to give the user feedback at appropriate moments. For instance a more visual representation of the user's ski day was added to the map to give a better experience as comments were given about the poor quality of it, figure 4.5. The new map view shows the users track encoded with a color that goes from red to green where red represents high points and green low points. To this the track also has annotations that show where and when the user started to go up or down in either a lift

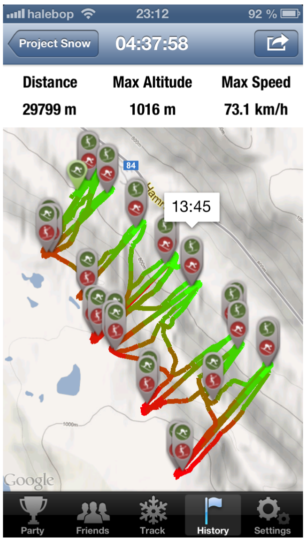


Figure 4.5: Map view, showing the new maps and the visualization of the user's ski day.

or a slope and where they ended using the algorithm.

Another thing that was decided to be investigated in the research phase was the possibility to use a smartphone to know where others were in the slope, similarly to the concept presented in *Hummingbirds Go Skiing* by Weilenmann and Holmquist [23]. This would be beneficial for users since they do not always stick together when skiing in groups as seen in the interviews. To support this type of functionality a *Party* system was added to the prototype based on the information gathered from the interviews, that people ski with others. People that belong to the same party share information between each other, mainly the functionality to know where others are by using their position that is acquired from the GPS. Additionally with the aid of the algorithm presented earlier the functionality to know the status of the party members were also added, knowing if they where in a lift or a slope at the moment. This was achieved technically by sending the GPS position of the user combined with the result from the algorithm to a custom server. The server then relayed the data that it received to all of the users that belonged to the same party keeping everyone up to date.

Additionally other small improvements were made to the prototype based on feedback from the initial test. This included a slightly altered interface, however this was not the main focus of the prototype, and more data that is recorded and presented to the user, figure 4.7. The application was also altered in such a way that it saved both the calculated speed of the user based on the user's two previous locations and the reported speed of the user from the GPS. This to make it possible to evaluate which of them gave the most accurate readings since the GPS value is based on the current moment when the GPS got an update while the other is an average over the distance the user has traveled, something that might give more normalized values if the distance between updates are long. An extra voice feedback event was also added to the prototype, giving the user direct feedback when the maximum speed was beaten for that day. This as a reaction to feedback received about the interest for knowing the speed, relating to performance feedback as defined by Kurdyukova et al. [20].

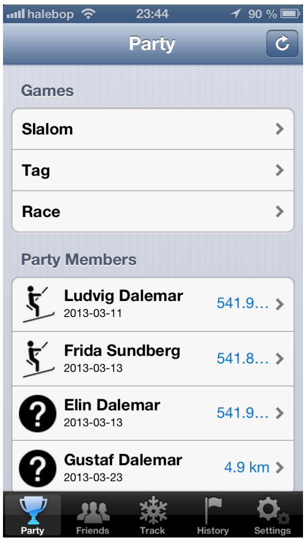


Figure 4.6: Party view.

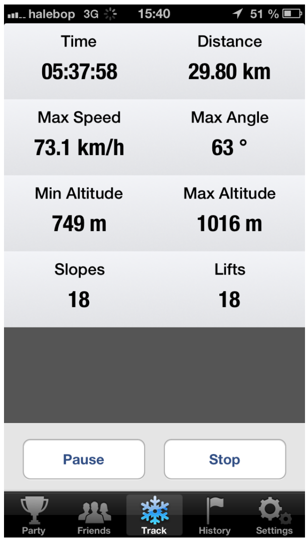


Figure 4.7: Main view.

4.2.1 Ping

It was decided early in the thesis that the potential of using a spatial audio system while skiing would be investigated, something that matched the request from the Interactive Institute about looking into how sound can be used while skiing. A contact was made with Mats Liljedahl, one of the creators behind Ping [22] that was reviewed in the literature study. Potential concepts were discussed, how the system worked was gone through and eventually the source code behind Ping was received. Several different possibilities were discussed for how Ping could be used while skiing, some being more practical like finding the nearest lift and some more game oriented with the aim to create a new type of experience not possible before. The concept that was decided to be evaluated was to recreate the experience of slalom without actual ports or other physical markers in the environment.

A standalone prototype was developed to test the concept with easy access to all of the data that Ping used. This early prototype required the user to manually set out the positions, waypoints, that the user had to get to in sequence and when done Ping would be used for guiding the user from one position to the next using sound. When the user was within a given radius of the current waypoint it was considered to been reached and the next one was activated until all of them where reached.

Initially the default sound behavior of Ping was used, where three different sounds are used based on the distance to the location and with increasing volume as the user gets closer. After further discussion with Mats Liljedahl, an alternative sound model were decided to be implemented and evaluated along side the original one that might suit skiing better. This new mode used a single sound where the frequency of the sound was determined by the distance to the waypoint. This meaning that the sound was repeated quicker and quicker the closer the user got to the position. Both of these two sound models used the original behavior where the sound would be balanced between the left and right speaker based on the users direction relative to the waypoint. Additionally the system could calculate the direction using either the last and current location from the GPS or the magnetic compass. The reason for supporting these two modes was to be

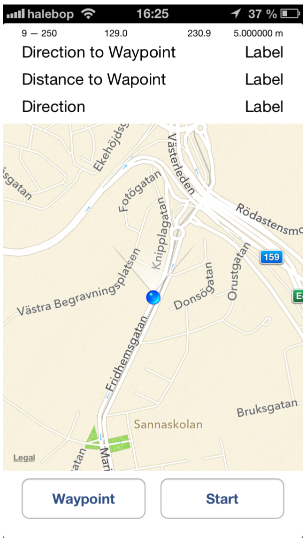


Figure 4.8: Ping prototype

able to evaluate the difference between them and see how well they performed.

Using the Ping prototype several small tests were performed on foot testing the different audio models, needed radius for the waypoints and different modes for deciding the direction. See figure 4.8 for an image of the prototype. Based on the results from the tests a radius of 10 meters around a position was decided to be used as a starting value when testing the application in a real setting. The built-in compass were also selected as the default method for deciding the users direction, however the question that still remained to be answered was if the phone would be stationary enough while skiing to use the compass.

Based on the tests that were performed, a new functionality was added to the prototype to solve the problem when the user missed a waypoint. The prototype considers a waypoint missed when the user has traveled outside the radius for the waypoint and having it behind her, that is having a direction which is 120 degrees from the waypoint. Several different values were evaluated and 120 degrees worked best when testing the prototype. When the user has missed a waypoint a sound feedback is given to indicate this and the next waypoint is selected by the prototype.

After evaluation of the stand-alone prototype the functionality was implemented into the main application. Instead of only having the created waypoints saved on the local device the same server used for the party functionality mentioned earlier was used and the positions were uploaded so that everybody in the same party could access them. This meant that one user in the party could ski before the rest and create a course that the others could compete in. When all of the users had completed the course it was possible to see how many waypoints they had taken and what their time was making it possible to compare each other's results.

During the evaluation of the prototype while skiing, another sound feedback mode was added to the slalom game based on feedback from the testers. Instead of using a balanced sound between the left and the right ear this new system instead played a sound on only left if the user needed to go to the left and only on the right if the user needed to go the right. If the users was on track and just needed to go straight a special sound would be played in both left and right speaker. An small equation was used to determine when the user was on course for the waypoint and

$$angle = \max(\tan^{-1} \frac{radiusOfWaypoint}{distanceToWaypoint}, 3)$$

Figure 4.9: Equation to determine the needed angle that indicates that the user is heading forwards the current waypoint.

when not, see figure 4.9. As can be seen in the figure the radius of the waypoint is divided by the distance to the waypoint and then tangents inverse is used to get maximum angle that the user need to be within to hit the waypoint. Then a maximum function is used to make sure that the angle is at least three degrees meaning that the user needs to be at least within the waypoints direction by three degrees, a smaller value would make it next to impossible to aim for the waypoint using only sound. The design reasoning behind the new sound model was that the distance to waypoints is much smaller than what Ping was designed for and the speed that the user is traveling in is much higher compared to walking. Because of this it was deemed that a binary model might work better, giving clearer feedback to the user that should be faster to interpret.

4.2.2 Evaluation

Using the second prototype a large-scale test was performed during five days of skiing with a group of four people from the initial interviews. The participants where two females and two males and all around 25 with two being more advanced skiers and two on the intermediate skill level. All of the participants used their own phone with the application preloaded on them, this included iPhone 3GS, iPhone 4, iPhone 4S and iPhone 5. All of the devices were running the latest version of iOS 6 at the time and using the standard earphones for each device. As with the initial interviews the participants were selected based on convenience sampling and judgment sampling [24], matching the user archetype defined in the first phase.

During the test the participants were observed in the field, see section 2.3, both in regards to their use of the application and their behavior while skiing in general. The observer operated as a participant observer being part of the activity and all of the observations was either video recorded by using an GoPro HERO3 video camera [36] that was used in a non disruptive manner or by taking notes.

All of the users were also given the opportunity to test a pair of ski-goggles with a built-in heads-up display (HUD) from Recon Instruments [37], see figure 4.10. The functionality of the goggles is to some extent similar to the prototype that was being evaluated since they both track data about the users skiing and try to provide the user with information without requiring them to interact with any device. The goggles featured several different modes and the possibility to provide a lot of different information. During the test mainly three screens were used as can be seen in figure 4.11.

A small scaled test was also performed using two of the already existing applications for iOS that are to be used while skiing, *King of the Slope* [8] and *MaptoSnow* [9], with the goal to compare the data that the different applications record and detect possible differences between them. Several tests were also performed around Ping and the implemented slalom game. All of the three models described earlier where evaluated using all of the different settings mentioned.

After the five ski days all participants where interviewed about their experience using the application and the goggles using a semi-structured approach, see section 2.2. Additionally all of

Figure 4.10: Recon Goggles - The HUD can be seen at the right lower corner of the glasses. [37]

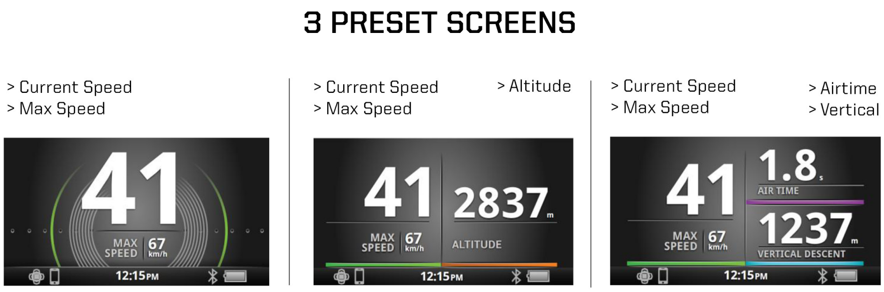


Figure 4.11: Recon Goggles - The three main used views that where used on the glasses. [38]

the data that were recorded through the prototype during the test were collected and analyzed afterwards.

4.2.3 Results

The following four sections will go through what information that was acquired from the test divided up in observations, interviews, things related to Ping and the slalom game as well as technical aspects.

Observations

An interesting thing was observed during the test. When designing the prototype and implementing the voice feedback system it was at all times envisioned that the user would use earphones to receive the feedback. What happened was that one of the users forgot to plugin her earphones and because of that the feedback was played through the built-in speaker instead. This was so popular that eventually everybody used the built-in speaker over the use of earphones. The feedback was easy to hear when being in the lift but the feedback event for reaching a new maximum speed was lost due to too much background noise from skiing. This was however something that all of the participants were prepared to sacrifice to being able to skip the earphones and still get most of the feedback. This new way of using the prototype also created some new problems not considered while designing the application. Mainly that the algorithm used for invoking the feedback while in the lift started the feedback on all of the devices at almost the same time, making it harder to hear what was said since all of the devices canceled each others out to some extent.

As stated during the interviews people do not have the same skill level and therefore sometimes split-up and go down different slopes and ski in different parts of the same resort. This was not just observed with the four participants but was also observed with other skiers visiting the same resort. Another interesting observation was that looking at a piste map is a social activity that the group does together and often a discussion start about where to go next. This suggests that Ping might not be suited to be used for navigating to a specific location since it would eliminate the existing social aspect of it. Something that was expected to be observed was the use of smartphones while in the lift since it was something that was brought up during the interviews but none of the participants did this. There can be several explanations for this contradicting behavior. One explanation could be because of the temperature and the participates deeming it to cold to use their smartphones. Another explanation could be that none of the lifts was a closed cabin lift and that could have been something that they were thinking about in the interviews when talking about lifts. Instead the main use of the smartphones were when taking a break (coffee, lunch) or when back at the cabin at the end of the day.

Finally since some part of the test required the participants to wear earphones and it was observed that it was quite hard to actually put them on when in the slope given that all of the participants were wearing a helmet and some also a cap. This would suggest that if earphones needs to be used for some part of an application it should give the user an incentive to wear them during the entire day or else the user might avoid using the feature all together because it is to complicated to apply the earphones when needed. Other observations that were made while comparing the different applications against each other were that the battery consumption, distance and speed measured were similar to the extent that the small difference that existed had little significance.

It was also observed that the participants did not like to take of their gloves if not needed, matching what was said in the interviews.

Interviews

After the five days when all of the participants had tested the prototype interviews were performed using an semi-structured approach asking about the prototype and the goggles. See Appendix B for the questions that were asked.

All of the participants stated that they thought it was really useful and fun to be able to hear the statistics from the last slope when in the lift and especially when they did not need to wear earphones. They also stated that it made it possible to easy and fast compare mainly speeds between each other and see who was the fastest. Both of the advanced skiers said that they liked the possibility to hear when they reached a new maximum speed but thought it was not worth it since it required them to wear earphones to be able to hear the feedback. Similar to what was said in the initial interviews where all of the participants stated their dislike for earphones bringing up that it made it hard to hear what others said and what happened in the slope . One user requested the possibility to invoke the sound feedback at will and brought up the running application *RunKeeper* [25] where something similar is possible.

When asked about the data that was collected using the prototype all of the participants said that they liked being able to see the information that were provided to them. They stated that they especially enjoyed to compare the results between each other at the end of the day to see who had traveled fastest, longest, went down the most slopes or being at the highest location for example. In regards to this some users requested better support for comparing data between users in the same party, like high score list, and also for friends outside of the party like people on Facebook. One participant requested a more detailed analysis of his ski day at the end of the day, wanting to see things like data for each individual ride. The *Party* functionality was something that was well received, stating that it felt natural to be in a group with the people they where skiing with. The participants also stated that is was fun and useful to be able to see where others were and what they were doing while using the prototype, saying that it was a functionality that they could see themselves using in the future.

When asking the participants about the goggles a lot of interesting feedback was received. One user stated that the display caused the user to get nauseous if looking at it while skiing and instead only looked at it when sitting in the lift. Only one user stated that he looked at the screen when skiing and said that he enjoyed being able to see his current speed. An interesting thing when discussing what was best with the goggles were that all of the participants said that the clock was the most valuable of all the features; being able to see what the time was. Both of the intermediate skiers stated it was hard to look at the screen while skiing since they felt that they needed to keep an eye on the slope at all times. The participants also mentioned that it was really hard to see what it said on the screen when being in bright sunshine. Some complaints was also addressed towards the small screen and that the information could at times be hard to see. Before testing the goggles all participants stated that they expected the HUD to cover the entirety of the goggles, something that is not the case. Additionally only one of the participants observed that the glasses showed the user information about their latest slope and if they broke any of their records, similarly to what the prototype did using voice feedback. One feature that the goggles had that peeked an interest in the advanced skiers was the functionality to measure airtime when jumping. All of the participants stated that the prototype provided them with an as good experience as the goggles did when considering that they already owned a smartphone and the goggles are quite expensive. Some even went as far as stating that the prototype was superior in some regards since the audio feedback did not require them to take their eyes of the slope when skiing.

They stated that they liked the updated map view thinking the quality of the maps was sufficient for their needs and thought it was fun being able to see where they had skied and where they had taken a lift and at what time. Some comments where also given around the visualization that was used. They thought it was interesting being able to see the height as a visual representation and requested more similar modes like being able to see their speed encoded into the track.

Ping and Slalom

As mentioned earlier all three different sound models were tested and their associated settings. It was found that using spatial audio for doing slalom was quite hard and something that all users had problems with. The biggest complaint was that it was hard to interpret the sound and understand where the system wanted the user to go. Saying that it was hard to both focus on the slope, avoid other skiers, watch the terrain, and understanding the feedback. All however stated that hearing the audio using their earphones while skiing was of no problem.

Out of the three models the original from Ping was the one that the users thought was the worst of them, giving to little information about how the user should ski. Better but still bad was the second model, using the frequency of the sound as an indicator for the distance to the waypoint. Because of this a new model was developed, as stated earlier, with the aim to make it easier and faster to understand the message that the user was given. This model work much better and was according to the users the best of the three. However the user still had to travel quite slowly to be able to successfully take all of the waypoints, something that eliminated all of the fun according to the users.

In the prototype that was evaluated the users created the courses themselves and some feedback was received about this. Some thought it was fun and easy to think out interesting courses while others stated it was hard to do. Something that all however wanted to see was an automated system that would create a course without the need for someone in the party to ski before the others and better feedback for how the course that was created looked like. Another point that was made was that it was hard to create an interesting course that worked with the precision of the GPS without covering the entire slope.

In regards to the concept in general the users really had a hard time getting a grip around it and all mentioned that they missed a physical marker to aim for when going down. All in all none of the participants thought it was really fun and all of them had a hard time to see the concept work in any form, because of the problems with understanding the sound. One participant commented that it would be better to just use the ski poles as ports if anyone in the party wanted to do slalom. When asked about Ping in general and the potential use of spatial audio while skiing all of the participants had a hard time to see any use for it. One user mentioned that it might be useful as a navigation tool, finding a selected location similar to what it was originally designed for, but only then for larger ski resorts like what can be found in the Alps and not in Sweden.

Technical aspects

The algorithm that was used for detecting when a slope and a lift starts and ends worked mostly correct. Some small errors where observed when a lift would be assumed to have ended and directly there after a new lift started again. Another observation that was made in relation to the algorithm was where it determined that a slope started, sometimes it was a couple of 100 meters after where the slope actually started due to the slant being too small to be detected. Observed however from the data was that the speed always changed when the user got off the lift and most often turned 90 degrees. The problem with changing the algorithm to look for that however is that the users might stop to look at a ski map after getting off the lift or waiting for the rest of the members of the party, something that was observed during the test.

Using the data that were collected a comparison between the two different ways to get the user's speed as mentioned earlier was also performed. Looking at the data it was clear that the speed that was reported from the GPS would be the best alternative to use since it didn't contain any incorrect readings, something that existed with the calculated speed since some of the positions that were used was incorrect and by an extension the speed calculations became wrong.

4.3 Third Prototype

With the results from the second prototype work began on a third version with the aim to address one specific request. One user requested a way to get voice feedback when he wanted to and not only when going up with a lift. This also relates to one of the areas that was decided to be investigated in the research phase: hands-free interaction.

With the aim to solve this problem work began with looking into the iOS platform and what was possible to do with it. The use of speech recognition had already been looked at and dismissed. Another approach that was considered was using the built-in button that exists on all default iPhone earphones. This however was not possible to do since it would require the application to be playing music as stated in Apples developer documentation [39]. Another approach was needed and attention was moved to the use of motion events, events generated by the device accelerometer and gyroscope [40]. Preliminary test showed promising results but the application stopped receiving data as soon as the screen on the device was locked. However thanks to the fact that GPS is one of the allowed background modes by Apple [27] it was possible to modify the code to also work when the device was put into sleep mode or when the user went out of the program.

Using the data from the accelerometer it was possible to detect when the user hit the phone while being located inside a pocket. This would allow the user to interact with the device without having to pick it up or taking of any gloves. Further optimization was done to make the detection work better and support was added to distinguish between a single *tap* or a *double tap* on the device while still being in the pocket.

4.3.1 Evaluation & Results

Tests were performed with the prototype by letting users have the application active while doing their ordinary business like walking outside, going up and down stairs as well as just sitting by a computer. Unfortunately it was not possible to test this functionality while skiing due to limited access to ski resorts and snow. Based on the results from the tests that was gathered by performing small semi-structured interviews it seemed like the approach taken worked well with users stating that the interaction felt natural and easy to understand and only mentioning a few incorrect readings.

Chapter 5

Evaluation Phase

The last phase in the thesis was the evaluation phase and was performed after the completion of the development phase. During this phase results from the first two phases were presented to different parties as a way to receive feedback on it and create further discussion. The following sections will go through what was done during this phase.

5.1 Meeting with Ski Resort

So far the thesis has only been focused on the skiers, the users of the ski resorts. Another perspective is the actual resort owners and what interests they have in regards to the use of mobile computing while skiing and how they understand their customers. A meeting was setup with Mikael Elfrod, the sales manager for Branäsgruppen AB [41], as well as Mats Liljedahl and Jakob Rubenson at the Interactive Institute.

During the meeting the results that so far had been acquired during the thesis was presented and used as a basis for a continued discussion. The ideas and results that were presented was well received and even to some extent confirmed from a ski resorts point of view. An example of this is that children prefer to ski by themselves while the parents will be somewhere else, going back to the fact that people ski in groups and often split up. The idea to use mobile computing to be able to see where everybody is and to some extent what they are doing received positive feedback and was seen as something that could be really beneficial for their customers. The idea to let the users interact with their devices without needing to take them out of their pockets really sparked an interest and other areas where a hands-free approach is desirable were shortly discussed.

Mikael also provided some information about skiers from their point of view and their interests. He stated that people like to keep themselves entertained while skiing and because of that thought that being able to compare statistics and compete against other that you ski with was a great idea. A possibility he saw was that one could give users of an application some form of cash price to encourage the use of the application and also create a stronger brand. From their point of view they would like an application to generate more sells of ski cards and make people revisit the resort the next year, around 60% of their customers are returning each year today. Another thing that he would like the application to be able to do was give the users tips about where

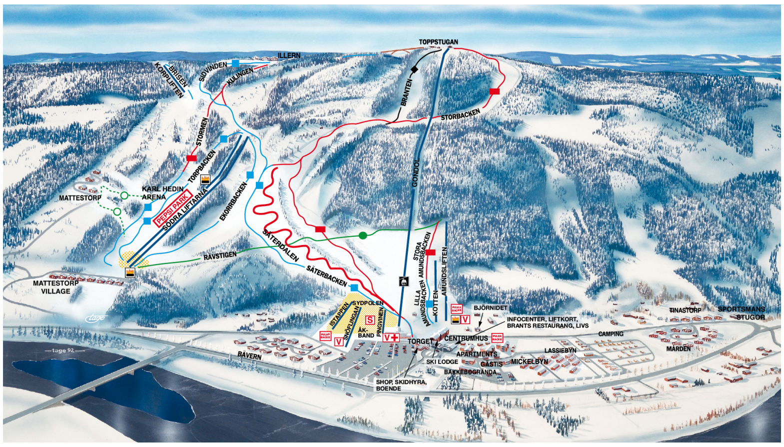


Figure 5.1: Ski map over Branäs By. [41]

to ski using voice feedback, informing the users where the queue time for a lift is the shortest and thanks to that can spread the visitors more evenly over the resort. Another possibility that were discussed was to use the application for some sort of guided tour where the user would be directed on a preselected path with the same goal as mentioned before, to more evenly spread the customers over the resort.

Some new ideas were also discussed during the meeting. One of them was a game where the user needed to go down the same slope first once and then again with the aim to get the same time as the first run. This would encourage the user to ski more and possibly some sort of cash price could be connected to it as a motivation. Another idea that was discussed where that everybody in the group was running the application and then by the end of the day all of the statistics that would have been gathered could be reviewed together on a large screen, like a tablet or a computer. This would make it social to look at the data that has been collected and a winner could be declared based on the data. In the prototype it was possible for the user to see how he had skied on a ordinary Google Maps view as described earlier. Something that was suggested was to use a map that is more similar to the style that is used in ski maps today, see figure 5.1, as this would be easier for the user to relate to.

5.2 Meeting with Skiers

To get additional feedback on the work performed in the thesis a focus group together with a workshop were performed with four participants. The participants were selected based on convenience sampling and judgment sampling [24] matching the user archetype and using the homogeneity concept, see section 2.4. All of the participants were males, around 25 years old and all currently studying at Chalmers in Computer Science. None of the participants had previously been involved in the thesis, giving the study a fresh perspective. The entire session was recorded with a video camera, the participants were sitting in a circle and food was offered in the beginning of the session. The participants were also involved in selecting the place and the time as a way to increase the possibility that people could attend.

The session was divided into three parts, the outline used can be found in appendix C. First was the focus group where questions similar to those asked during the initial interviews were discussed. After that a presentation was performed around the results and work performed so far in the thesis as a way to give the participants as much information as possible for the following workshop. This to make sure that the problems mentioned in *Hummingbirds Go Skiing* by Weilenmann and Holmquist [23], that the participants did not understand their work and therefor could not contribute, does not occur. This also relates to what was mentioned in section 2.5 about Participatory Design and the importance of informing the participants and give them the necessary tools. Lastly the workshop was performed where the participants were tasked with improving and finding new uses for the presented concepts. To their help they had access to posts-its, papers and pens as well as printed ski maps featuring some different ski resorts as an aid to remind them about skiing.

5.2.1 Focus Group

Most of the same things that were brought up during the initial interviews were said during the focus group. Everybody skied together with others and sometimes those groups broke apart for a variable amount of time. All of the participants were existing smartphone users and mentioned that they primarily use their devices when taking a short break from skiing, when being back at the cabin, taking pictures and when needing to contact someone in the group. When talking about this they discussed the problems with being able to hear when the phone rings or that an SMS has been received resulting in that it can be quite hard to get in contact with someone, not knowing where he or she is. None of the participants listen to music while skiing, even though some of them did it when they for example were running. They stated that they thought it was too big of a safety risk and it was fun to ski without the need of music.

When talking about existing applications no one of the participants had any previous experience with them, some had however heard about their existence. They thought that they mainly were aimed towards people that ski a lot and not a couple of times a year which they all did. One of the participants stated that he was not that interested in them as he did not want to know how bad he was, referring to the often used high score lists existing in them. If they would use an application they where interested in seeing mainly the distance that they have skied and their top speed. The participants themselves did not like the ideas of achievements considering them as pointless. They did however note that they are quite popular in general and some of them stated that if they were available they most often at least looked at them and possibly tried to get some of them. If they would be interested in achievements for skiing they would like to see more specialized achievements that are aimed for a specific ski resort, like going a certain speed in a slope and not general ones like going a predetermined distance.

Some spontaneous comments that was made were that they most often do not go back to the same ski resort several years in a row and that a future application should be able to work without the need for an Internet connection while being in the slope since it should be possible to use it abroad.

5.2.2 Workshop

During the workshop the participants discussed a lot of ideas about how to use mobile computing in general while skiing and how the techniques and concepts that were presented could be used. Some of the ideas revolved around how Ping best could be used. One suggestion was to use it as a navigation tool when doing backcountry skiing to get a suggested path down the mountain. Another was to use the ambiguity of Ping for a treasure hunt game. The idea was that when the user was going down a slope she would hear a sound indicating that there was something near but as she was going downhill she would quickly miss it and would then have to go back to explore it more and eventually find the treasure with the aid of Ping. They drew parallels to geocaching and envisioned that it would mainly be interesting for families with children and would encourage exploration of the ski resort and potentially more rides taken.

Quite some time was allocated towards the problem with knowing where others were in the slope as well as communicating with them. They stated that they today made agreements before splitting up or calling each other when needed. The problem was however that most often people cannot hear their phones and because of that it is hard to get hold of people. They also stated that they generally do not check their phones for missed calls when skiing. The presented concept that showed where the users in the same party are located was something they really liked and had some suggestions for how to improve. Instead of only knowing the status of the users they would like to see what slope they were currently in or lift by name. Another suggestion was that this system could be used to know where other members of the party are by using the *tap* system, like *tapping* twice on the device and getting information about a specific user's position using voice feedback. Another suggestion was to use the application to record short audio messages, preferably using a sequence of *taps* and a hands-free microphone, that would be sent to the members of the party. The application could then notify the user that they have a new message allowing her to confirm the message and listen to it by *tapping* on the phone. If the user miss the first notification the application could remind her at appropriate moments, when standing still for example. They also would like a feature that could predict where a user would be in the future allowing someone to understand when a user would reach the end of the slope for instance.

A lot of discussion were also had around what the application should track and what information that could be presented to the user. Notable things mentioned were calories burned, g-force when skiing and number of carving turns. They also had a concept for how the data could be used to create a more interesting social experience, using a quiz based on all of the recorded data by the party members. Everybody would get the same questions that were all based on their ski day together with the goal to crown a winner. This would be used as a fun way to present the data that the application tracks and for the users to interact when not skiing. Some other ideas were also discussed around competing against others like a way to race against another skier, getting voice feedback about who is in the lead and the difference between the competitors. The same system was also suggested to be used for competing against oneself by hearing results from the previous ride and would give an incentive to try to become better.

Other things that were mentioned was a possible tie-in with a ski resort by offering small prices, like 5% off the next visit, by completing a challenge inside the application. Avalanche reports and weather information were also suggested to be included inside the application as a way for the user to plan the next day and give more value.

The participants were also tasked with trying to apply what they had come up with during the workshop to a summer setting, when the snow has disappeared from the slopes. The treasure hunt was mentioned as something that they thought should work on the summer as well. The functionality to find out where others are were also mentioned, however the cold would not be a problem and therefore it would be easier to use phones as normal limiting the need for it. Additionally they thought that the competition functionality against other or oneself could be used for downhill biking in the summer time.

Chapter 6

Results

The aim of the thesis was to understand the skiers and based on that create a concept for a potential application that provides something new and gives the users what they want. This chapter will summarize the knowledge acquired from the different phases of the project, delivering a final concept as well as a number of guidelines that highlights what is important when using mobile computing to enhance skiing.

6.1 Concept

Based on the work that has been performed in the thesis a concept has been created for a potential application. The following section will go through the concept, outlining the core functionality, keeping in mind that only a feature concept will be presented and no details about the appearance of a potential application will be shown.

At its core the application should feature statistics tracking that records data about a user's skiing. This includes data about the distance traveled in total, distance traveled in a lift, distance traveled in a slope, number of slopes, number of lifts, maximum altitude, maximum speed, average speed, minimum altitude, maximum downhill angle, session duration, jump time, jump distance, jump height, number of carving turns, maximum g-forces, average g-forces and possibly more. To this the application should also save the position of the user making it possible to display the path that she has skied on a map. All of this data, the statistics and the map, should be possible to access both during the ongoing session and after it. The statistics should be sortable by the user in the interface making it possible for the user to decide what is important and by tapping on one of them a more detailed view should be presented that can use graphs among other things to deliver more information to the user. The application should give the user the option to select if the map used should be displayed as a classical ski map or a more traditional map.

The recored data from the sessions should be grouped based on day, ski trip and season creating an easy to understand structure that also presents the user with a summarization of the data available for those time periods. By selecting them the user will then be presented with the data grouped in the smaller part, for instance if the user taps on a season the user will be presented with a number of ski trips and by selecting one of them a number of ski days will be presented.

When selecting a ski day the user will have direct access to all of the data that was recored by the application during that day, as mentioned earlier. When looking at the data after a completed session it should be possible to play back the recored data giving the user a chance to relive that ski day making it easier to remember what she did.

The application should feature voice feedback as a way to deliver information to the user without requiring that she look at the display of the device. The user should have the power to select when feedback should be delivered like; when in a slope, when in a lift, when standing still etc. and what information that should be delivered like; distance traveled, maximum speed, what the time is, what the weather will be like in a couple of hours etc. All of this should be configurable by the user allowing for the creation of rules that can connect an event with a specific feedback and allowing for selection of a multiple of information. The application should also support an external input from the user as a way to invoke the feedback, this being when the user *tap* the device when it is still in the pocket. This should also be connected with the users current context, that is that a *tap* might mean one thing when standing still and another when being in a lift. Also important is to not force the user to wear earphones to receive the feedback when possible, but rather use the built-in speaker of the device to deliver the message.

Another important part of the application is to support that people ski with others. It should be possible to create groups, a party, with the people that the user is skiing with by sending out invitations to their phone numbers, emails or using a social network service like Facebook. When the users are in the same party they can see where all of the members of the party are from a special party section of the application, showing the distance, direction, what they are doing (being in a lift or a slope) and exactly where they are on a map. It is also suggestible to show what slope or lift they currently are in if that data is available, for instance when creating the application together with a ski resort. From this party section it should also be possible to look at the statistics of the other skiers allowing for easy comparison and showing who is the best in the party using a high score list. Games is another thing that the party system can and should be used for. One such game is a quiz between the party members at the end of the day using questions that are based on the data that have been collected during that ski day, like who in the party had the highest speed, longest single slope and similar. The members of the party will get a final score after answering the questions and a winner will be declared. Another game is to use the application to compete against others, like a way to race against another skier, getting voice feedback about who is in the lead and the difference between the competitors. The same system can also be used for competing against oneself by hearing results from the previous ride making it possible to aim for a better time. Since communication can be difficult when skiing the application should have support for a system that can be used to record short audio messages that can be sent to the party members. The user will either do this by using the interface of the application or by using the mentioned *tap* interaction resulting in that the user do not need to take the device out of the pocket. The recored message will then be sent to the members of the party that will have the option to listen to it by either using the interface or using the *tap* interaction. A notification of the messages arrival should be give to the users directly when the message is sent and if they miss it or ignore it they will be reminded when standing still, like when being in the lift. Using this *tap* interaction it should also be possible to get the position of the party members when the device is still in pocket, this could be done by using a double *tap* for instance. When the ski trip is over the user can leave the party to remove the possibility for others to see where they are but it should still be possible to see the high score results in the previous recorded sessions, for that ski trip as mentioned earlier. The application should also feature a friends section where the user can add people that they would like to share information about their skiing with, making it possible to compare who is the best. From this section it is also possible to invite people to a party to share more information while skiing together.

If the application is made together with a ski resort a lot of things should be considered and included into the application. Examples of this is providing the user with the names of the slopes and lift in the system, competitions that the user can participate in and win cash prizes from, and a system that can be used together with the voice feedback system to inform the user about the queue time of different lifts making it possible for the resort to spread the costumers more evenly over it.

6.2 Guidelines

Use the built-in speaker over earphones when possible
If sound is needed in the application try to use the built-in speaker of the device since users do not want to wear earphones while skiing.

Avoid the use of spatial audio if possible
Spatial Audio should be avoided when building an application to be used for skiing. This as it is hard for users to understand the feedback when skiing and that it requirers earphones, see the previous guideline.

Make the application social, use the fact that people ski together
This can be achieved by introducing games that can be played with other that the user ski with, both to be played while skiing and after. Additionally the experience can be made more social by making it possible to see where others are, making it easy and fun to compare statistics and make communication easier with others.

Minimize the input needed from the user
Using voice feedback together with smart forms of input handling, like the *tap* interaction that has been presented in this thesis, the needed input from the user can be kept to a minimum, not forcing the users to take of their gloves.

Avoid focusing on achievements and global high score lists
This is something that users do not find that big of a value in and instead resources should be allocated forwards other features.

Give additional value
The use of sensors like the accelerometer of the device can be used to deliver many interesting statistics to the user like jump time and g-forces while turning.

Chapter 7

Discussion

The following sections will first discuss the presented results from the previous chapter, going into more detail about them, and additionally the process used will be discussed along with some thoughts about generalizability and possible future work.

7.1 Results Discussion

Several things have been evaluated during the course of this thesis, trying to identify what works and not in regards to the use of mobile computing while skiing. In the beginning a user archetype was decided based on data acquired from initial research together with interviews. Because of this the presented ideas and concepts will be aimed towards that user type, but that does not imply that everything discussed will not be of interest for other users.

A main observation that was made during the thesis was that people ski in groups and that communication can be quite hard. This is an important factor that should be considered when designing an application to be used while skiing. The potential of being able to see where other skiers are and grouping the people that ski together in a common party have has evaluated, proven useful and possible to do. Additionally suggestions have been made for a system that can be used to deliver voice messages to the members of the party as a way to make communication easier and faster.

Another important thing that has been observed is the way that skiers want to interact with their devices, requiring as little direct interaction as possible with the mobile device, not wanting to take of their gloves. A solution to this has been evaluated, tested and proven powerful; using *taps* on the device while still being located inside the users pocket. Also the power of using voice feedback has been evaluated and proven useful for a multitude of things. In this thesis mainly statistics have been given to the user using this type of feedback but other areas have been discussed. For example voice feedback has been suggested to be used to get information about where other members of the group are. This could for instance be done by using the *tap* interaction and giving an input that present the user with an option to select one member to get the position of. Similarly this *tap* interaction could be used as a way to create a message as mentioned earlier without requiring the user to take the device out of the pocket.

When comparing the second prototype against the already existing goggles several interesting things were observed. Firstly the user found it quite hard to actually look at the display inside them when skiing and stating that they liked the voice feedback more, keeping in mind that the retail price for the goggles are around US$500 [37] and the prototype was nothing more than a prototype. This statement matches the concept behind multiple resource theory [42] which states that two tasks that demand the same resource, in this case visual perception for both looking at the slope and the screen, will interfere with each other more than two tasks that uses different resources like a visual component (for looking at the slope) and a auditory component (for hearing the information from the application). Based on this theory the goggles is actually worse with its visual feedback already from the beginning compared to the audio feedback that the prototype features. However something that users really liked about the goggles was being able to see what the time was. In a potential application it is therefore advisable to include the functionality to get the current time using voice feedback invoked by a *tap* potentially.

In regards to the use of Ping when skiing some observations were made. Firstly was that the audio model that was developed during the thesis was the far superior one to be used for the slalom game since it allowed the users to more quickly understand where the sound was coming from and therefore navigate. However even with that model Ping was hard to use when skiing for the test users, at least in the game that it was tested with. A probable explanation for this is that Ping was originally designed to be used while on foot where it is possible to backtrack, stand still and hold the device in one hand making it possible to both scan the environment and being able to read information from the screen; none of this is possible to do while skiing. Some other possible uses for it was given during the workshop, like a treasure hunt game. However when using sound for an application in general that is to be used while skiing it is important to make the application work without the need for the user the wear earphones, and Ping requires them. This as it has been shown that users do not like to wear earphones while skiing stating that it blocks to much sound and that it is problematic to put them on while in the slope. Advisable is instead to use the built-in speaker whenever possible and potentially support extra features if the user wears earphones like when reaching a new maximum speed. As such Ping can not be recommended to be used for skiing as a main feature without further research into it, finding a use case that would make the use of earphones worth the trouble for the user. The problem with using the built-in speaker to give users feedback that was observed during the tests was that the information could be given at the same time on multiple devices making it hard to hear what was said. A solution for this would be to use the party system to make sure that no device that is in proximity to each other are talking at the same time by adding a delay.

If a possible application would use the accelerometer for detecting *taps* more functionality is possible to add using the same feature without effecting the battery consumption. This includes user suggestions for detecting the amount of g-forces that the user experiences and the number of carving turns. Another possibility is to use the data to get statistics about jumps like airtime, height and length similar to what the goggles could do and that users requested from them.

Several different statistics were available in the prototypes and more were requested by users like for example being able to see the number of calories burned. When creating an actual application it would be advisable to include as many values as possible and let the user decided what is important to her. For example a good approach when using audio feedback would be to let the user decide what information she wants and when. This being what the clock is every time he is in lift or his total distance whenever he is *tapping* on the device. In regards to statistics it would also be advisable to improve the algorithm used for detecting slopes and lifts as it was a powerful way to give the user feedback at appropriate moments as well as being able to track the numbers of slopes ridden for example and show it on a map. Speaking about maps, it was something that users would like to have more types of information on, being able to see not only the altitude of their track together with where they went up with a lift or down a slope. Another possibility that were discussed but never evaluated was to use maps that would be more similar to existing ski maps instead of ordinary maps to make it easier for users to relate.

Another thing that was observed was that none of the participants really cared for achievements and especially not global high scores. A better focus when wanting to add a game element to a potential application would be to focus on creating a more social experience between the group of people that ski together using easy ways to compare data, high scores within the group and as suggested from the workshop the potential of using all of the recorded data to create a game where the members of the group have to guess who got a certain statistic and similar.

7.2 Process Discussion

During the thesis Goal-Directed Design was used as a framework to structure the work done. While this worked well it was obvious that this approach is more aimed towards larger projects with the aim to deliver a product that is to be used by users and not a concept creation process, and that the developer is not the same person as the designer. It is however not believed that this affected the outcome of the result in any way and the iterative approach worked well together with the initial information gathering phase, but is something to keep in mind for the future.

In regards to the other methods used in the thesis to gather information they all worked well for their intended purposes. Notable however is that as stated when presenting focus groups is the problem with getting participants that can all participate at the same time. The focus group and workshop that were performed was the second attempt at doing so since the first failed due to too little participants.

As stated earlier the participants were often selected based on convenience sampling and judgment sampling. One could argue that convenience sampling should have been avoided since it can result in poor quality of the data, but as stated it was combined with judgment sampling and it was not always possible to select any participant during all phases. For example the second prototype evaluation was done together with people that already had planed on going skiing at the same time as the second prototype was completed. The natural choice was therefore to use their help when testing the prototype since it would not require setting up and finding other participants that could ski. The thesis also lacked large funds and easy access to skiing locations, which made it much harder to easily setup a test session with general participants.

Using iOS as the development platform worked well thanks to the great documentation and standardization that existed, allowing the prototype to be tested on several different devices. Some small problems were however encountered during the thesis that made some ideas and approaches impossible to achieve since the platform did not allow it; an example of this was the desire to use the button that exist on all default iPhone earphones.

7.3 Generalizability

Some of the concepts presented in this paper is nothing new in general but rather the context that they are used in. For example there already exists running applications that features voice feedback and statistics tracking about the activity. However the concept used for interacting with the device without the need to pick it out of the pocket has more uses than just skiing. As its current implementation, where an allowed background mode on iOS is needed like the GPS that was used in this thesis, it could be used with several applications where the user might not have any free hands or do not want to get the device out of the pocket. The most obvious example is maybe a running application since they share many similarities with the presented ideas. On a larger scale it is also possible to imagine the interaction to be used in applications without the background mode limitations. An example could be to use it for answering the phone and go directly to the speaker functionality without ever having to pick the device out of the pocket.

7.4 Future Work

As this study only focused on creating a concept for an application, there is a lot of interesting aspects that could be done in the future. One thing that would be interesting is to look more into the proposed uses of the *tap* interaction along with the audio feedback. This would include testing; giving feedback when the user so desires, leaving messages for the party members and getting information about where party members are through sound. Another thing that has not been tested is to use the data that the application records in a more game oriented way as suggested during the evaluation phase, like creating a quiz around the ski day or making an interesting visualization of the data that can be observed together with others.

It would of course also be interesting to create an actual application based on the ideas presented that could be released to the public using a well design graphical user interface. This does not only include iOS but other systems like Android and Windows Phone could be considered and adopting the ideas for those platforms. Additionally a dedicated web-service would probably benefit the application making it possible for users to look at their data when not having access to their phones and also look at it on bigger screen. Another advantage with using a web-service is the possibility to analyze all of the data that users record and from that build maps and statistics based on ski resorts. For example it would be possible to know which slope in a certain country that has the steepest angle, where the maximum average speed can be achieved, the longest jump and so on. It could also be possible for users of the application to help with naming slopes and resorts as a way to increase the user experience when using the application, a form of user generated content.

Another possible approach would be to collaborate with some ski resorts as a way to integrate a potential application into their systems that could lead to a richer application with potential rewards and information about the resorts. Additionally it could be interesting to look more at the possibility of applying the different concepts to a summer setting, similarly to what was done during the workshop.

Chapter 8

Conclusion

The goal of the thesis was to evaluate the use of mobile computing while skiing and present a concept for an application and investigating the potential of using audio feedback. It can be argued that all of this has been done using established methods following a Goal-Directed Design approach.

It was found that voice feedback is really powerful to use while skiing and that skiers often split-up from the groups that they ski in and therefor benefits greatly from a functionality that can be used to find where all of the members of the group are. A new way to interact with a mobile device was also presented allowing for easy and fast interaction while the device is still located inside the users pocket. This interaction could also be used in other areas than just for skiing applications. An algorithm was also presented that can be used to detect when a user is in either a slope or a lift, based on data from a GPS. One of the concepts presented also performed better than an commercially available product and additionally since all of the discussed solutions are possible to do with almost any smartphone it has a great chance of being heavily adopted, not requiring any additional hardware.

Hopefully some of the ideas and concepts that have been presented in this paper can lead to an actual application that brings something new and useful to the market and that users enjoy.

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Appendix A

Initial Interview Questions

Interview Questions

1. Inform the participant about the study that is performed and how the answers can help.
2. Take the participants basic personal information like gender and age.
3. Do you ski, and if so how often?
4. How would you rate your skill level and experience in regards to skiing?
5. A. Do you ski alone or together with a group of people?

   B. If skiing together with other; do you stick together or split up when skiing?
6. Do you use a smartphone today?
7. How do you use your phone while skiing, when if so?
8. Do you listen to music while skiing, why?
9. Do you know that their exists applications that can be used while skiing, do you use any?

   A. This applications features high-scores and achievements, what is your opinion about that?
10. Do you use any application in general that is aimed to be used for outdoor sports like running?
11. If you would have an application that is to be used while skiing what type of information is of interest to you?
12. Thank the participant for the help in taking part in the interview.

Appendix B

Second Prototype Evaluation Questions

Prototype Questions

1. What did you think of the voice feedback when being in the lift?
   A. What did you think of getting the feedback using the built-in speaker?
   B. What did you think of getting the feedback from the earphones?
2. What did you think of the voice feedback when reaching a new maximum speed?
3. What do you think about the data that the application tracks? Something that you feel is not needed or that you miss?
4. What did you think of the map view, how did you receive the quality of the maps?
5. What did you think of the party functionality?
6. Did you use the functionality to see where other where, what is your opinion about the feature?
7. What did you think about the goggles, where they useful, was something problematic, what did you use them for?
8. Did you use the goggles when skiing down a slope, looking at the display?
9. What was the best thing about the goggles?
10. Did you notice that the goggles showed information about the last ride when completing a slope?
11. If you would compare the functionality of the goggles against the prototype how would you rate them against each other?
12. What did you think about the slalom game?
13. What sound mode did you consider the easiest to understand?
14. What did you think about creating a course to be used for slalom?
15. Do you see any alternative uses for the system behind Ping for skiing?
16. Thank the participant for the help in taking part in the interview.

Appendix C

Focus Group & Workshop Outline

Focus Group & Workshop

18:00 Present myself and welcome them to the focus/workshop. Tell them a bit about my master thesis and what I'm looking at. Inform and ask if it's ok that I will record the session. Serve pizza.

18:10 Start the focus group part by discussing the questions below:

- Take everyones, gender and age.
- Do everyone ski?
  - Would you say that you are a experienced skier, novice?
- Who do you ski with?
  - Like friends, family, alone?
  - How many are you?
  - Do you stick together or spread out?
  - What do you think most people do?
- Do you use your smartphone while skiing, when if so?
  - If you do not use it, why not?
  - What do you think most people do?
- Do you listen to music while skiing, if not why?
  - What do you think most people do?
- Do you use an application currently when skiing?
  - Who do you think the target group is?
- What are you interested in knowing about your ski day that you don't know today?
  - Like speed, distance, drop meters, number of slopes.
  - What do you think most people are interested in?
- Do you think achievements and global high score lists are fun and engaging?
  - What do you think most people think about them?

18:50 Give the presentation.

19:05 Divide them into groups of 4-5 people and give them the task to design an application based on what was presented in the presentation and what have been discussed. Give them paper, pens, post-its, scissors to use.

- Audio feedback.
- PING!.
- Shake input .
- Think about all the stakeholders, e.i. how to make more people ski and have fun.

19:35 Present the results and have a discussion about them. Who is the application for, families/professional skiers etc?

19:50 Give them the twist to try to apply the concept they have created for a summer setting, for example hiking or cycling in the same region.

20:20 Have a final discussion about the concepts they have created.

20:30 Thank them for their participation and help.