

Master's Thesis

**Design and development of
a web application for mobile devices
promoting a healthy lifestyle**

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Graz, March 2011

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Masterarbeit

(Diese Arbeit ist in englischer Sprache verfasst)

Entwurf und Entwicklung einer Webapplikation für mobile Endgeräte zur Förderung eines gesunden Lebensstils

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Abstract

The decreasing general state of health caused by lack of health consciousness, sedentary lifestyles and demographic changes will have dramatic effects on our health care system in years to come. An unhealthy lifestyle will lead to an increase in chronic diseases and eventually to increased costs in health care. A preventive measure against such a development can be to reinforce health-awareness through the use of mobile applications supporting self-observation and behavior change. The aim of this project was the design and development of a mobile web application that assists people in changing their lifestyles by providing the means to manage their wellness related activities and health risks. The application not merely offers the means for wellness management but also attempts to create high motivation through the adaption of design goals created especially for supporting behavior change.

A user study on the final prototype including a questionnaire showed very good usability ratings with a SUS score of 83.75. The majority of our respondents stated that the functions offered by the system could be useful for them and they could image that using the application might motivate them to lead a healthier life. The goal-reward system and the summarizing feedback page were the most popular features among our test users. Usability issues discovered in the study included button size and spacing as well as the system reaction on tapping events. Neither age nor previous experience with computers or smartphones showed a significant influence on the users' perceived usability and on their motivation to use the application.

Keywords

Health Care, Mobile, Wellness Applications, Health Data Visualization, Usability Research

ÖSTAT-Topics (maximum 4)

1161	40 %	3927	30 %	1157	20 %	1150	10 %
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ACM Classification

H.4, H.5, H.5.1., J.3

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Zusammenfassung

Mangelndes Gesundheitsbewusstsein, eine bewegungsarme Lebensweise und demographische Veränderungen führen zu einer Verschlechterung des allgemeinen Gesundheitszustands und in weiterer Folge durch den Anstieg chronischer Krankheiten zu erhöhten Kosten für unser Gesundheitswesen. Ziel dieses Projektes waren Entwurf und Entwicklung einer Web-Applikation für mobile Endgeräte, die es ihren Benutzern ermöglicht, ihre Aktivitäten und Gesundheitsrisiken, die Einfluss auf ihr Wohlbefinden haben, zu verwalten, und die dadurch eine Änderung ihres Lebensstils unterstützt. Diese Anwendung ermöglicht nicht nur eine einfache Verwaltung dieser wichtigen Einflüsse auf das persönliche Wohlbefinden, sie versucht auch, ihre Benutzer durch den Einsatz von Design-Zielen, die besonders darauf zugeschnitten sind verhaltensändernde Maßnahmen zu unterstützen, in hohem Maß zu motivieren.

Eine Usability-Studie mit Befragung der Probanden wertete die Anwendung als sehr benutzerfreundlich mit einem SUS-Wert von 83,75. Viele Probanden gaben an, dass ihnen die Funktionen des Systems nützlich sein könnten, und dass sie sich vorstellen könnten, dass die Applikation sie zu einer gesünderen Lebensweise motiviert. Persönlichen Ziele und Belohnungen und die zusammenfassende Feedback-Seite waren die beliebtesten Funktionen. Benutzerfreundlichkeits-Probleme betrafen Größe und Abstand der Buttons und die Reaktionszeit des Systems auf Antippen des Touchscreens. Gefühlte Benutzerfreundlichkeit und Motivation der Benutzer wurden weder vom Alter noch von bisheriger Erfahrung mit Computern oder Smartphones beeinflusst.

Schlüsselwörter

Gesundheitsvorsorge, Mobil, Wellness Applikationen, Visualisierung von Gesundheitsdaten, Benutzerfreundlichkeit, Usability

ÖSTAT-Fachgebiete (Maximum 4)

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Abbreviations

ANOVA	Analysis of Variance
API	Application Programming Interface
BU	Bread Unit
DAO	Data Access Object
DDD	Domain Driven Design
DTO	Data Transfer Object
EHR	Electronic Health Record
GPRS	General Packet Radio Service
GPS	Global Positioning System
GUI	Graphical User Interface
HCI	Human–Computer Interaction
HL7	Health Level 7
HTTP	Hypertext Transfer Protocol
JSON	JavaScript Object Notation
MET	Metabolic Equivalent of Task
ORM	Object-Relational Mapping
PHR	Personal Health Record
RIA	Rich Internet Applications
SOA	Service Oriented Architecture
SUS	Systems Usability Scale
TTM	Transtheoretical Model of Health Behavior Change
UCD	User Centered Development
UMTS	Universal Mobile Telecommunication System
URL	Uniform Resource Locator
UX	User Experience
UXR	User Experience Research
W3C	World Wide Web Consortium
WLAN	Wireless Local Area Network
XML	Extensible Markup Language

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1 Introduction and Motivation for Research

1.1 Situation analysis

The decreasing general state of health caused by lack of health consciousness, sedentary lifestyles and demographic changes will have dramatic effects on our health care system in years to come. According to (Chini and Dorner, 2010) we will have to face additional costs of 1.6 billion Euros in 2030, increasing to 3.7 billion Euros in 2050. This will be due to the most common health risks, smoking, alcohol, obesity, lack of physical activity and insufficient consumption of fruit (Figure 1), leading to complications like diabetes mellitus, hypertension, cardiac infarction, apoplectic stroke, renal insufficiency, osteoporosis and chronic backache. “Today’s unhealthy living youths will be tomorrow’s chronically ill”, as Dr. Walter Dorner, president of the Austrian medical association (ÖÄK) puts it. This trend will not only lead to increased costs in health care, but it will also result in a lack of available manpower to be used in the job market. As suggested by Dr. Chini, these costs should better be reallocated to preventive costs. Through successful use of prevention, health care costs used for people from the age of 65 can be reduced significantly (Figure 2).

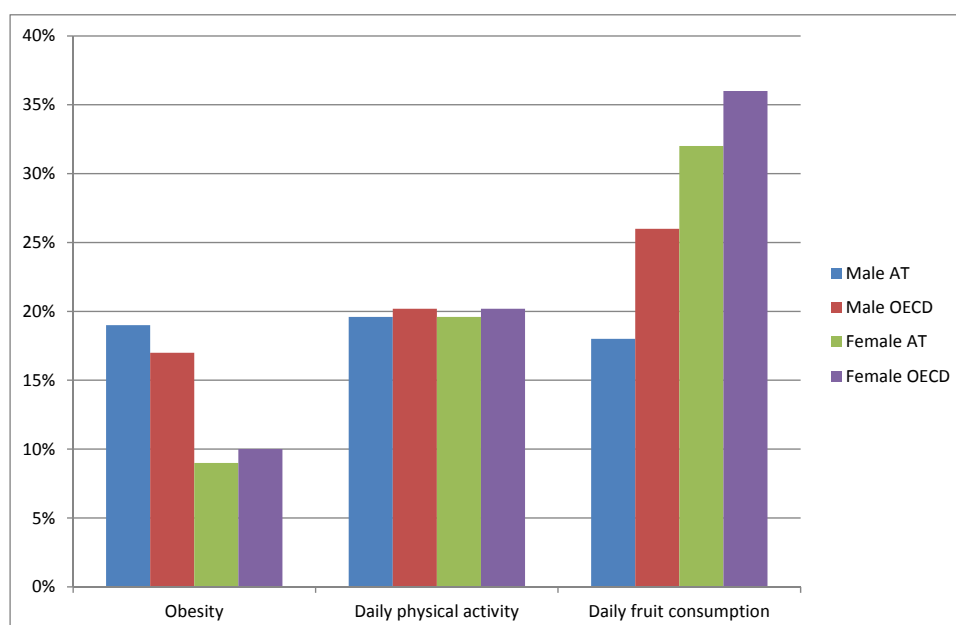


Figure 1: Health risks of youths aged 15 in the OECD, data from (OECD, 2009)

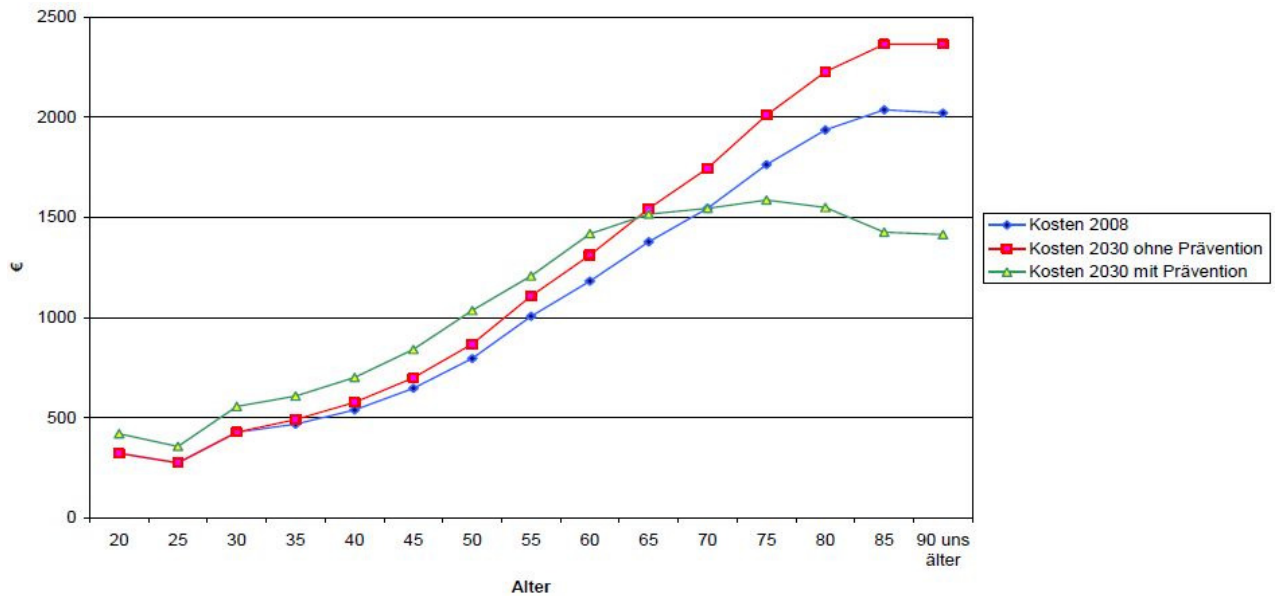


Figure 2: Age related costs through illness and prevention (Chini and Dorner, 2010)

1.2 Intended purpose of the project

Preventive care can be empowered by proper health education and motivating incitements (Saranummi, 2008). The aim of our research is to design and develop an application that is able to give these motivating factors to its users. In order to motivate people to start adapting to a healthier way of life it is important to give them proper knowledge about why and how they should do so. This can be achieved by giving them the means to get information about their current state of health and about how their current lifestyle will affect it. Combining this with comprehensible educational information about all involved physiological parameters and how they affect their personal health can serve as a good means for getting people more interested in their personal health and lifestyle and motivated in improving it. As a healthy lifestyle is only really useful in long terms, this motivation needs to be kept up. One way of achieving this can be to let the affected persons define personal goals (such as obtaining a certain weight or accomplishing a defined amount of physical exercise over a period) and offer rewards when the person reaches such a goal. Such rewards can be as simple as a virtual medal or more sophisticated as a virtual avatar of the user depicting him in a way as predicted by evaluating his current lifestyle.

In order to reach a broad audience it is important that such an application is easy to obtain, straightforward in its usage and widely accessible without impeding the user's everyday life. By taking the approach of a web application, there is no need for the user to obtain and install a program - he simply has to start a web browser and visit the appropriate web page. Since mobile devices are used ubiquitously, especially in our target group, a mobile web application will ensure a broad audience as well as easy accessibility in everyday life. Modern mobile devices already own adequate technologies supporting rich internet application (RIA) technologies that allow for web applications to be very straightforward in its usage and avoid the typical drawbacks of traditional web pages like full page reloads and high traffic needs.

1.3 Who will be using the application?

The target audience of the application will consist of people that are already acquainted with the use of mobile devices. Thereby the target group will not be restricted to certain age groups, but age will still have an influence on the proportion of younger and older people using the application. According to recent data from (The Nielsen Company, 2010) a majority of all smartphone users in the U.S. belong to the age group of 18-34. Depending on the operating system of the smartphone, the portion of people belonging to this group can account for about 40% to 50% of all users (Figure 3). The next higher age group already accounts for a significantly lower portion of the users, and the proportion declines more linearly from this group to the group of people aged 65+. So when we define our target group as people already using smartphones, we can assume that the majority of our users will be younger than 45 years.

Fifty percent of Android owners are under the age of 35

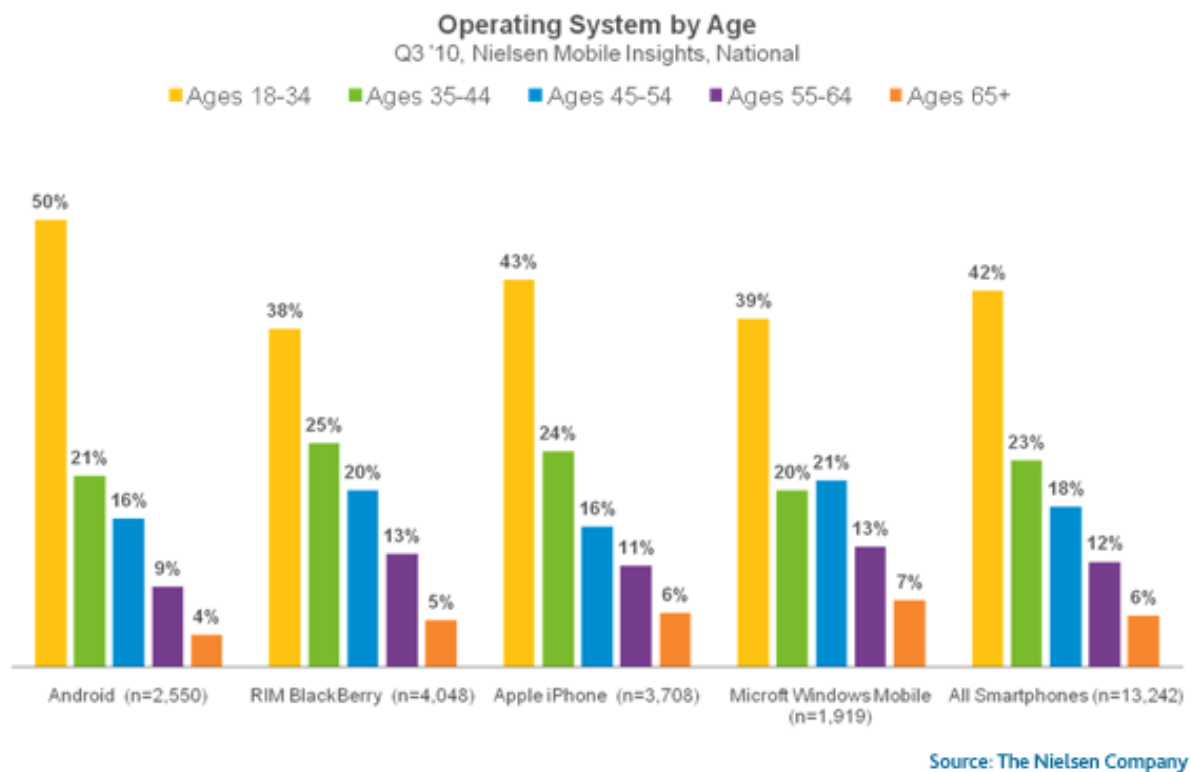


Figure 3: Smartphone operating system by age, (The Nielsen Company, 2010)

2 Theoretical Background and Related Work

2.1 Health and wellness data visualization

This section describes the development of research up to the current state-of-the-art on the field of visualization of personal health data. Most of this research has been conducted in order to improve the use of health records in medical care. Only recently the field of health data visualization for use by patients and persons outside the health-care business has also moved into the focus of research.

2.1.1 Graphical summary of patient status

(Powsner and Tufte, 1994) proposed a graphical summary of patient status as an additional source of information to the traditional medical record. The data was entered manually from the original record and prepared using commercially available hardware and software. It was then plotted using a non-linear timescale on the x-axis, compressing years of data into a smaller space, while giving more room to recent data. The y-axis, on which treatments and measured entities were plotted, was scaled individually and divided into five ranges that could be applied to every set of data: critically elevated, elevated, normal, reduced and critically reduced. Additional information, such as the name and units of measurement as well as the most recent values were shown outside the graph.

2.1.2 LifeLines

LifeLines (Plaisant et al., 1996), (Plaisant et al., 1998) extended the concept of timelines (Tufte, 1983), (Powsner and Tufte, 1994) as a visualization technique for displaying clinical data. LifeLines was originally developed in order to represent youth records (Plaisant et al., 1996), but being a very adaptable system, it was soon used for visualizing medical records as well. The key feature of LifeLines is to show multiple facets of a record in a screen overview. These aspects are shown as horizontal lines; discrete events are displayed by using icons. Relationships between aspects as well as

their significance can be encoded using color and line thickness. In order to focus on a certain period the user can rescale the time axis. When the number of timelines shown exceeds the available screen space, the lines can be brought closer together and the labels can be hidden from the view. Another distinguishing feature of LifeLines was its ability to provide access to all detail information from the overview with one or two mouse clicks.

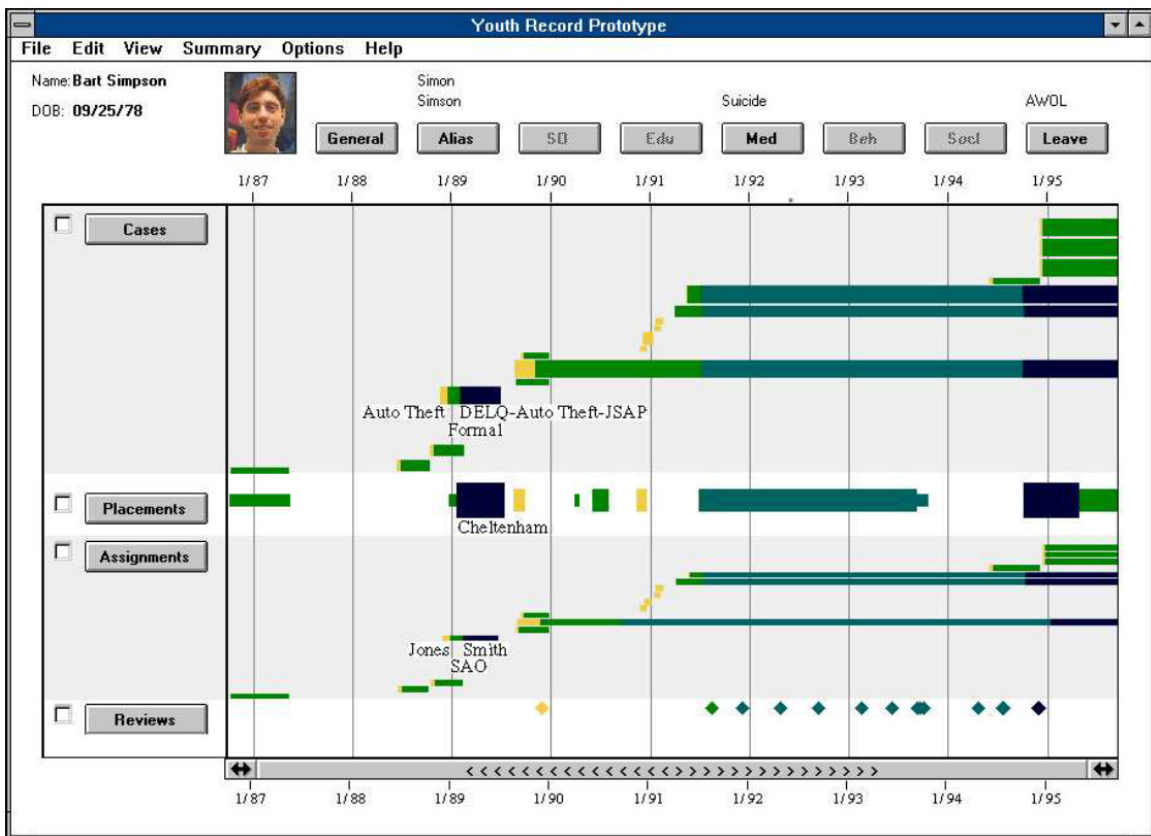


Figure 4: LifeLines (Plaisant et al., 1996)

These former approaches were developed further by (Bade et al., 2004). They introduced several improved visualization techniques providing increased information content and requiring different amounts of display space. The “color-coded timelines” use horizontal bars similar to those used in LifeLines, but additionally utilizing color as a means to mark regions of different qualitative characteristics. Another type of timelines developed was “height-coded timelines”. The horizontal bars used by this approach vary in their heights depending on the region’s respective qualitative level.

These “height-coded timelines” can be further enhanced by adding color as in the “color-coded timelines” thus making it easier to identify regions of interest at first glance. A qualitative-quantitative hybrid technique was shown enhancing a quantitative data stream with color-coded qualitative regions. Those regions do not necessarily have to be split into qualitative regions using color, vertical lines can also be used for separating those regions. Another method for marking different qualitative regions in a quantitative visualization is to add color horizontal lines marking points where the data switches to another qualitative level.

2.1.3 Interactive Visualization for intensive care units

(Bade et al., 2004) also described a way to visualize additional dimensions (occurrence time, valid time, measurement deviation tolerance and trustability) of a data point. The occurrence time can be shown as either a small mark or an extended mark, depending on its granularity. The valid time can be shown by using a horizontal line starting at the occurrence time. Trustability is represented by the fill level of a green bar (looking similar to a thermometer) while measurement deviations can be shown by extending the vertical size of the element.



Figure 5: Prototype for intensive care and long term treatment (Bade et al., 2004)

Another suggestion given in (Bade et al., 2004) covered the visualization of high-frequency data. Such data cannot be clearly represented by using connected data points and needs to be visualized using special techniques. They enhanced the visualization technique of Information Murals (Jerding and Stasko, 1998) by additionally displaying minima, maxima, the median and 25% and 75% percentile. They also created an even more abstract visualization by applying the system used in Tukey box plots to the high frequency data stream.

(Bade et al., 2004) also introduced several advanced user interaction techniques into the field of health data visualization. By using a system similar to zooming, the users can switch from a broad, qualitative overview of the data (“color-coded timelines”) to the most detailed, quantitative view, gradually stepping through the various visualization

modes. Exact individual data values can be seen by hovering the mouse cursor over the appropriate position in the visualization.

2.1.4 TimeLine

TimeLine (Bui et al., 2007) aims to be a comprehensive framework for accessing an electronic health record as a chronological, problem-oriented display. It consists of three main modules: data access, data mapping and visualization. One of the main goals of the project is to provide a flexible way of data visualization in order to allow users to tailor the view to their specific requirements. The patient data displayed in the view is collected from multiple distributed and heterogeneous data sources and gets classified using a knowledge base. The visualization engine uses a knowledge base to decide how a timeline and its associated data should be rendered and then outputs the rendering to the required target platform. It uses a “TimeLine Visualization Dictionary” which combines information about the data type or source and the medical problem using complex sets of rules and thereby decides what data should be rendered and how it should be displayed. In order to avoid dense clustering of icons, TimeLine uses a nonlinear time axis to remove gaps and increase the available space for dense periods. By using a model-view-controller architecture, TimeLine can support multiple display platforms. The currently supported platforms are Java Swing and HTML.

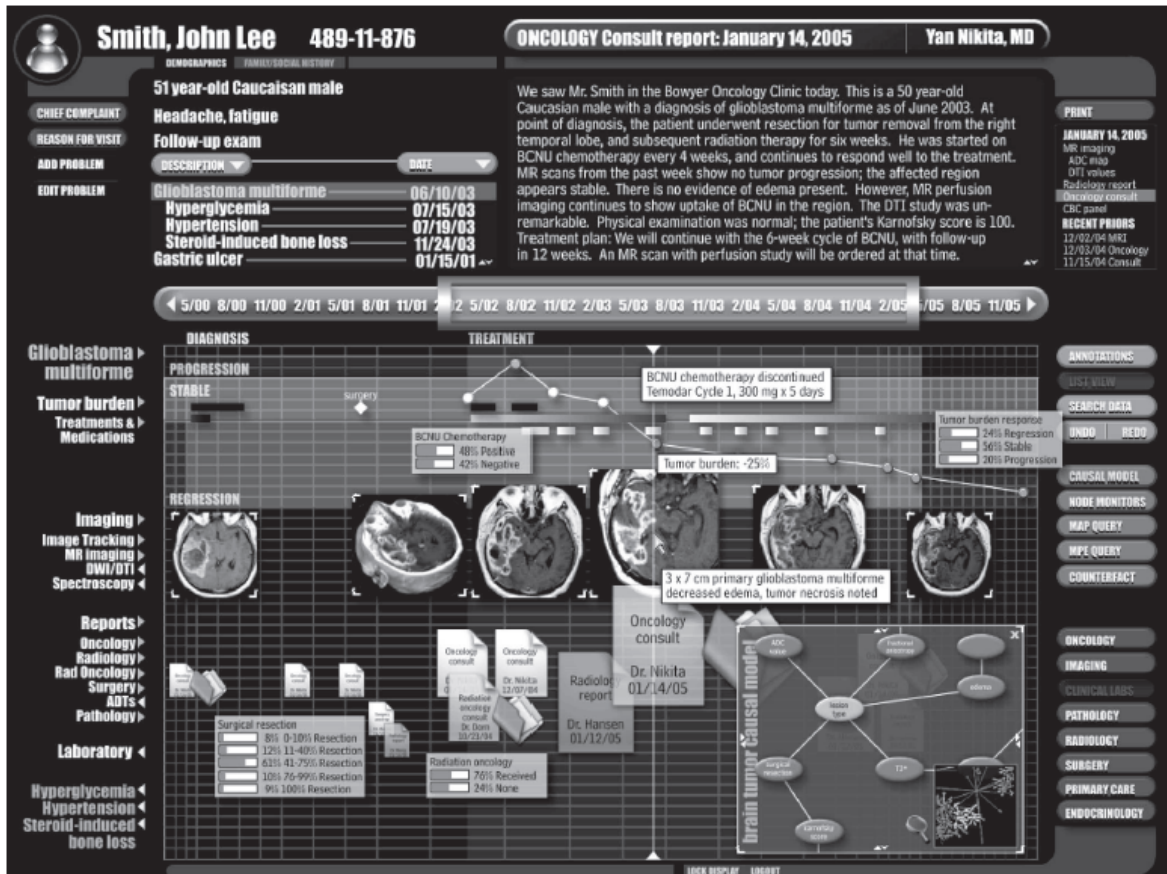


Figure 6: TimeLine (Bui et al., 2007)

Further work in the field of patient data visualization has been conducted by (Jiye et al., 2008) who visualized information contained in electronic health records (EHR) using the Health Level 7 (HL7) data representation and by (Hallett et al., 2006) who described a system providing a combination of generated textual reports and interactive, visual timelines.

So far research in the field of patient data visualization has concentrated mostly on applications used by health care professionals and trained personal. Work on visualization techniques that can be used to convey information to patients themselves was outside the scope of most research done. Development targeting this kind of end user has become more intense during the last years.

2.2 Simulation and visualization of patient status

2.2.1 Visual Fitness Planner

The “Visual Fitness Planner”, patented by (Bravomalo) uses image morphing technology to modify a current image of the user based on entered user data and a generated fitness program thereby predicting an image of how the user will look like if he follows this fitness program for a certain amount of time. The user image is sectionalized into body components which can then be individually morphed into predicted visuals based on physiological formulae and data tables. The main aim of this system is to enable the users to visualize their future appearance and thus increasing their motivation and satisfaction levels. The invention primarily aims to be used by commercial organizations like health clubs, diet centers and exercise equipment manufacturers by creating a motivated, satisfied and loyal clientele for them.

2.2.2 Personalized Body Image

A patent by (Brown) in 2007 described a way to display health conditions of a patient on a personalized image model of the patient. The patient should identify himself with the display. This can either be achieved by using an image reproduction of the patient (e.g. a photograph) or by modifying a more generic body image matching physical characteristics of the patient, such as age, height, gender, weight, skin color and hair color. The input data, as for example the condition of a body part or organ, blood pressure or the cholesterol level makes up a personalized health model of the patient. This health model affects the display of the body image. Therefore the body image should comprise body sections, parts and organs, and the rendering of these sections reflects the appropriate health conditions. The body image should be created as an image map, so by interacting with a section of it appropriate information about the body part can be returned. Body parts requiring particular attention can be highlighted in order to bring this to the user’s attention.

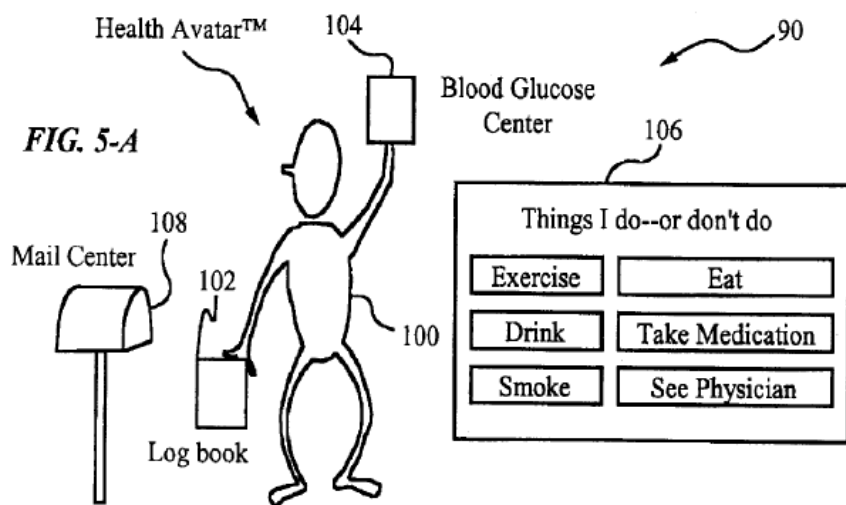


Figure 7: Health Avatar by (Brown)

2.3 Wellness-supporting applications

Research in the field of health informatics has been very prominent during recent years. While patients are generally seen as a source of data and the healthcare systems as end users of applications in this area, we can now see a new area of informatics that tries to reverse this flow (Grinter et al., 2010).

Personal Health Applications allow their users to store a wide variety of personal health information and data ranging from medical conditions and test results to medications and allergies (Alagöz et al., 2010). Among the most prominent of these applications are Google Health and Microsoft HealthVault. The increasing availability of smartphones and the accompanying popularity of online software stores including Apple's App Store and Google's Android Market have made mobile devices a popular platform for personal wellness applications. Diary applications support the management of health related, dietary and exercise data. Some applications utilize sensory data like pedometers or GPS receivers to track outdoor sports activities. Gesture-based technologies and the integration of Web 2.0 features like social networking or social gaming still offer very interesting possibilities for the further development of wellness applications (Ziefle and Jakobs, 2010).

2.3.1 Patents

In a patent from (Arai) dating to 2000, a device was introduced which uses the results of an intake calorie calculation based on entered diet data combined with a consumption calorie calculation based on a measured quantity of physical activity in order to create a calorie balance analysis. The results of this analysis can then be represented as a change in a displayed character image, as in a game. The patent suggests a number of slim, fat and muscular comic-like figures that can be used for this representation.

(Suzansky) describes a system that consists of several modules aiming to motivate and support users to achieve a healthier lifestyle through a combination of monitoring, education and gaming. The main parts of the system are

1. an education module providing information about health related issues
2. a monitoring module tracking the user's health status (through manual data input)
3. an alerting module keeping track of potential health risks that can be deduced from the entered data
4. a gaming module consisting of a set of games that provide health related education
5. a module linking the system to websites that contain further information on related topics
6. an information recording module gathering and summarizing information and user interaction from the other modules

A patent by (Kil) from 2008 describes a computer system and methods with the aim of supporting lifestyle-reward health games. Such a game relies on information about the user's health behavior and predicted health condition which is converted into a gaming parameter thereby altering the execution of the game itself. The game also visualizes the predicted health condition by using an in-game avatar.

(Kurple) introduces a system which can be used for monitoring the diet a user takes over time. By employing a database that contains information about a variety of

nutrition data, the diet's effect on health, weight and budget as well as effects on blood glucose level and nutritional value can be estimated. The system can also be used to plan diet modifications in order to reach health related goals such as weight loss.

2.3.2 Fish'n'Steps

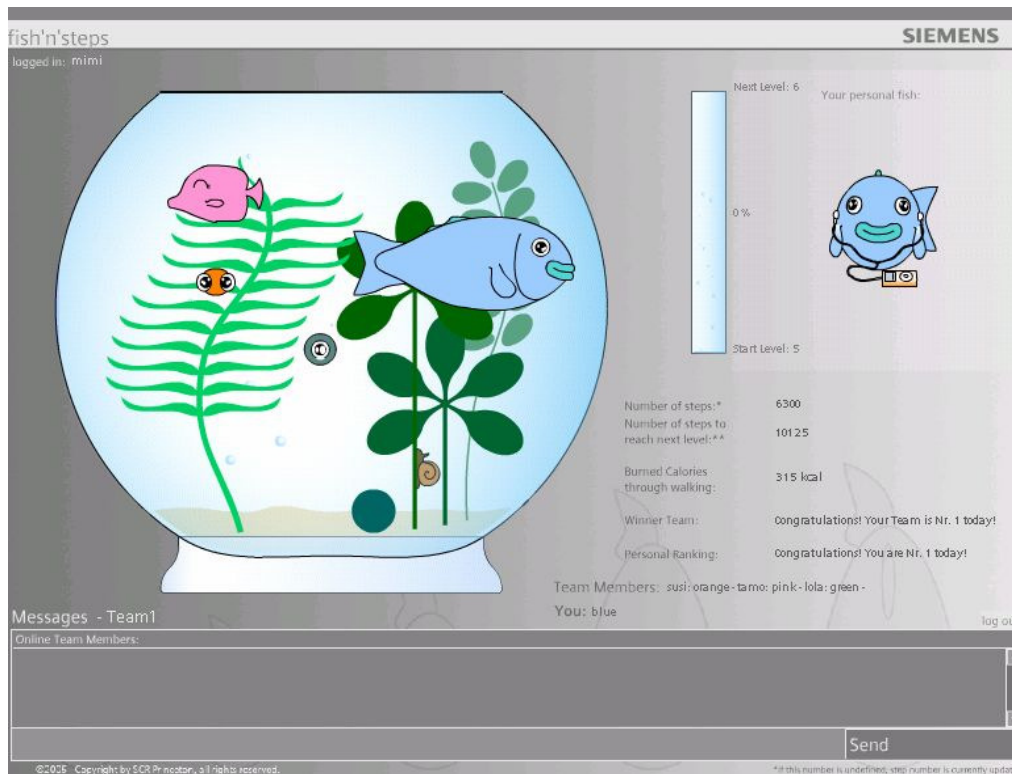


Figure 8: Fish'n'Steps, (Lin et al., 2006)

Fish'n'Steps is a mobile application aiming to promote physical activity with its users. The level of activity is measured by using a pedometer device the users are carrying with them. Every user gets a goal defining the number of steps he should do every day. In order to motivate the users to reach these goals, Fish'n'Steps uses a game-like approach. Every user owns a virtual fish tank and the size and number of fish increases when the user's step count reaches certain targets. Additionally, the fish get a happy facial expression if the user reaches his personal goal and a sad expression if he fails to do so. The application also adds a social aspect by allowing the users to form teams that can compete with each other and within the team. According to a user study conducted

by (Lin et al., 2006), the application managed to increase its users' awareness of their physical activity and motivated them to engage in such activity.

2.3.3 UbiFit Garden

A similar approach to that of Fish'n'Steps was taken by UbiFit Garden (Consolvo et al., 2008), another wellness application for mobile devices. The application is able to monitor several types of physical activity like walking, running or cycling through a set of sensors worn by the user, and stores them on a mobile device. The information gathered this way is stored in a journal where it can be edited at a later time. Like Fish'n'Steps, UbiFit Garden also allows its users to set personal goals and monitor their progress towards those. Similar to the virtual fish tank in Fish'n'Steps, a virtual garden is displayed in UbiFit Garden containing flowers representing types of physical activity and butterflies representing achieved goals. Because (Lin et al., 2006) found out that negative feedback like the sad facial expression of the fish can in some cases rather discourage the users from using the application, UbiFit Garden avoids the use of negative reinforcement. (Consolvo et al., 2008) also conducted a user study which emphasized the need of such a sensor based system to be able to identify a broad range of different physical activities and to allow its users to manually modify the recorded data.



Figure 9: UbiFit Garden, (Consolvo et al., 2008)

2.3.4 BALANCE

The BALANCE application which is described by (Denning et al., 2009) runs on Nokia mobile devices and additionally uses a Mobile Sensing Platform (MSP) which combines several sensors like an accelerometer, a barometer or GPS. By combining the information gathered by these sensors with manual input of consumed foods and undetected physical activities the system is able to measure caloric intake as well as caloric expenditure which together allow the application to measure the user's caloric balance.

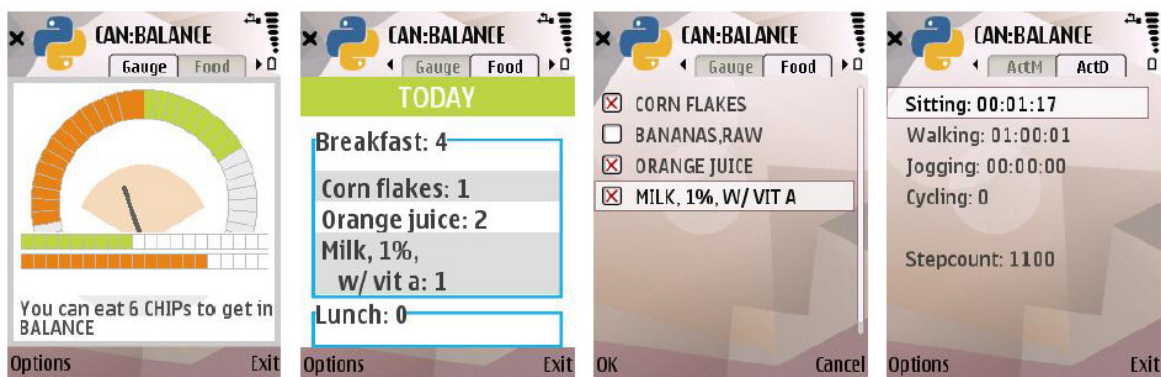


Figure 10: BALANCE (Denning et al., 2009)

2.3.5 Wellness Diary

The *Wellness Diary* described by (Mattila et al., 2010) is a mobile application that can be used for recording and managing personal health information and returns feedback based on this information. The system is able to monitor weight, exercise, diet, alcohol usage, sleep, smoking, stress and step data per default, but it is also customizable, so users are able to adapt the data model to their needs and preferences. The mobile application is a standalone app running on Nokia devices. The relevant data needs to be entered manually by the user and is then stored locally on the mobile device. The developers also created a web service counterpart to the mobile application which allows for data synchronization between the mobile device and a central server.

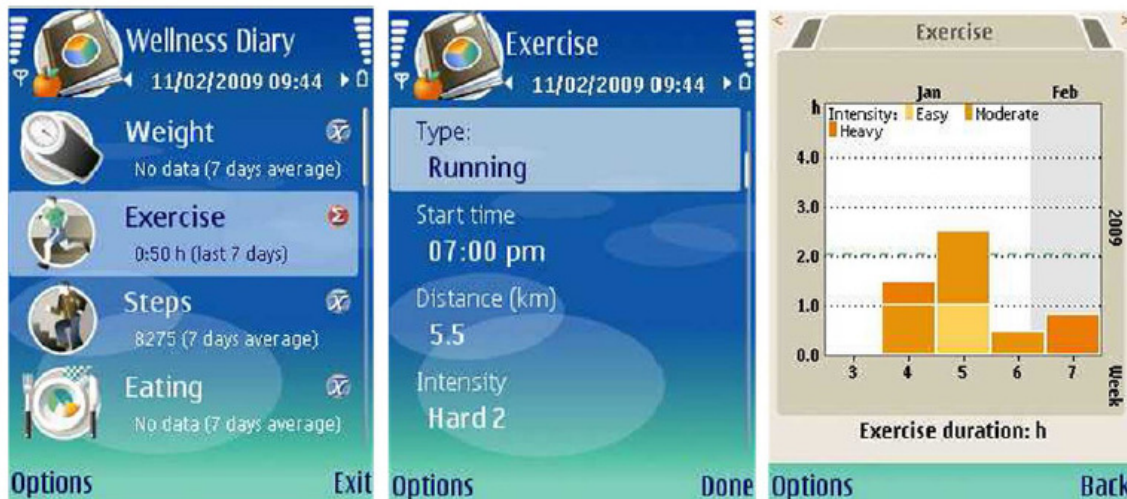


Figure 11: Wellness Diary (Mattila et al., 2010)

Several studies have been published regarding *Wellness Diary*. (Ahtinen et al., 2008) studied the differences in needs and usage of wellness applications when comparing users from Finland and from India. One of the most interesting results of their study was the fact that the concept of wellness is seen very differently by people from these two cultures. While physical activity, leisure activities and a healthy diet were the most important wellness factors for Finnish people, mental and emotional aspects of wellness were very important for Indian participants. The authors suggested that wellness applications, which currently focus on the former, more rational aspects, should also try to include those latter mental and spiritual aspects, especially if their aim was to be used in regions with a spiritual tradition of Hinduism or Buddhism. Another difference between the two user groups was that Finnish users appreciated the possibilities for setting personal wellness goals more than the Indian users did.

(Ahtinen et al., 2009) conducted a user study on three mobile wellness applications, *Wellness Diary*, *Mobile Coach* and *SelfRelax*. Their research questions regarded user perception of the applications, changes in usage habits, motivating elements of the applications and approaches towards creating more long-term motivating applications. Among the key motivational factors for using wellness applications this study identified were ease-of-use and a low threshold to start using the application. Graphical feedback, giving the users information about their long-term progress, was a very popular feature

giving high motivation. One of the main problems identified was the manual form of entering data which soon becomes a monotonous activity for the users. Other motivating features among the studied applications included adaptable training programs and goals.

2.3.6 LifeSensor Diabetes

(Andry et al., 2008) created LifeSensor Diabetes, which is built atop the LifeSensor Personal Health Record (PHR) and the ICW eHealth Framework (also see chapter “eHealth Development Frameworks”). Users can start using the application by filling in basic profile information (gender, age, height, weight). They can also specify personal targets for specific diabetes markers. Data that already exists in the user’s PHR on LifeSensor can be imported, new data is entered regularly. Since the ICW eHealth Framework supports device integration, the project is working on implemented automatic data gathering from glucometers. Since the application aims to motivate its users to access the system regularly, much effort is put into high interactivity und good usability features. In order to achieve this, modern web technologies like AJAX and FLEX were used for implementing the client application. Another motivating feature is the possibility for users to define action plans that give them the possibility to plan and track their progress towards achieving defined personal goals.

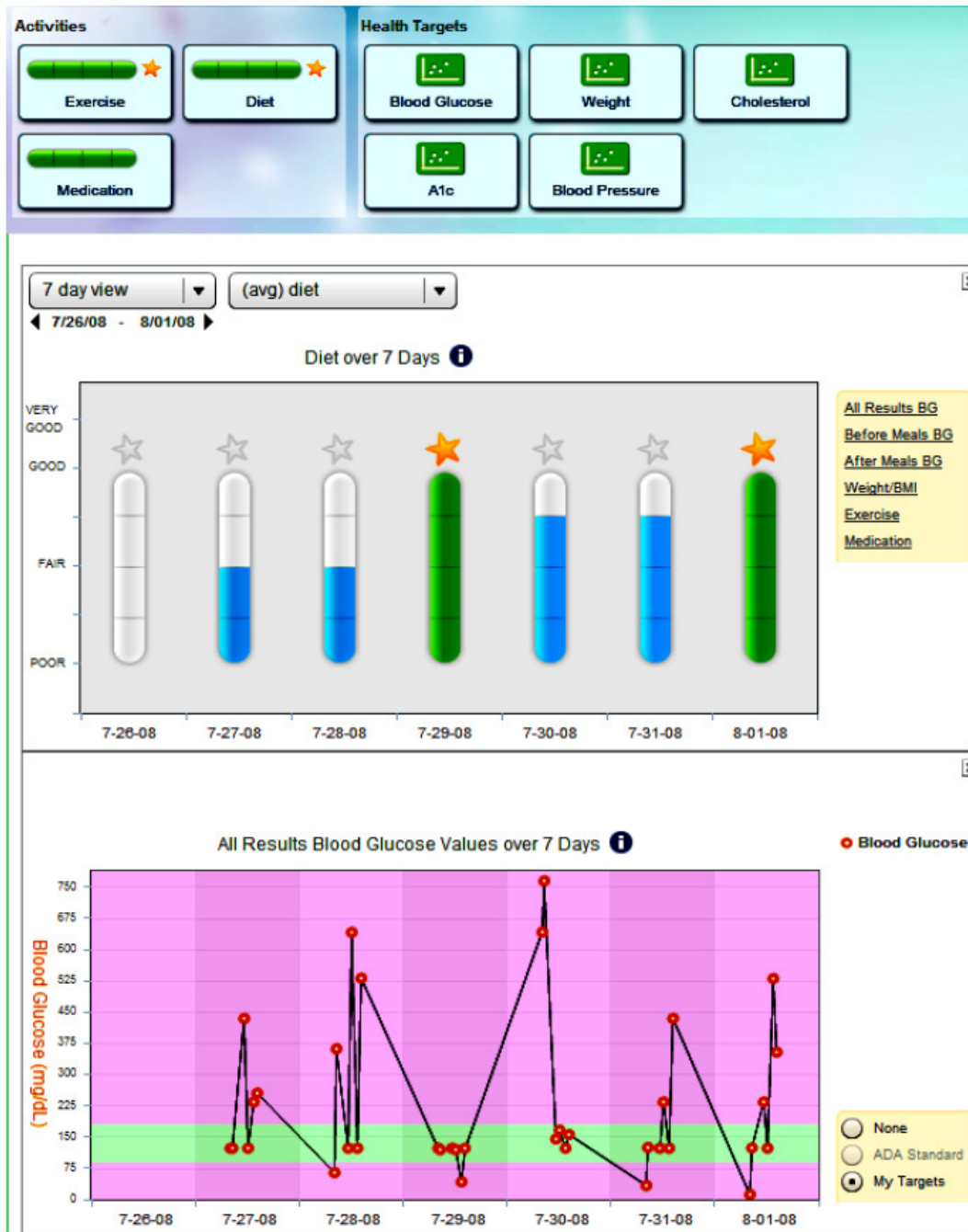


Figure 12: LifeSensor Diabetes (Andry et al., 2009)

Analyzing the granularity of the visualized observations (Andry et al., 2009) showed that data differed in both the frequency of measurement and the types of values. Some data has to be measured several times a day, while other data will be measured on a yearly basis. The different types of values were assigned to two different types of graphs: health targets (e.g. blood glucose or cholesterol) can be represented using 2D

line charts and candle-like charts, activities (e.g. exercise, diet or medication) were assigned ordinal values (poor, fair, good, very good) and displayed using histograms. The visualization itself is handled by a generic graph container which can display one or two modules out of eight currently implemented modules (exercise, diet, medication, blood glucose, weight, cholesterol, HbA1c, blood pressure / heart rate. By displaying two modules inside the same container and synchronizing their time axis, data correlations can be discovered visually.

2.3.7 Diabetes Living Assistant

Applications offering support for people with diabetes are a very popular area of research in the field of personal health applications.

The Diabetes Living Assistant (Calero Valdez et al., 2009) is a mobile application allowing persons with diabetes to manage information relevant to this metabolic disease (Figure 13). The application consists of a diabetes diary, a tracking tool for relevant health parameters, an application for calculating bread units (BUs) and a medicine intake reminder tool.

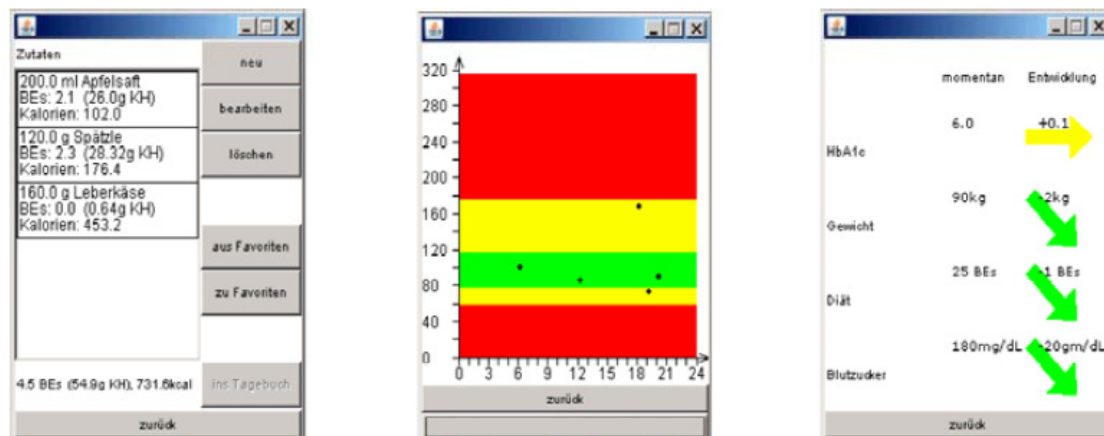


Figure 13: Diabetes Living Assistant (Calero Valdez et al., 2009)

Taking the entered information about glucose level, activity and eating into account, the Diabetes Living assistant is also able to do the calculations for daily insulin dosages for

the user. By creating a user interface that is based on common paper-based diabetes diaries, the application achieved high acceptance rates among its test users.

As applications offering support for people with diabetes are a very active field of research in the area of health supporting applications, several other applications among the two mentioned above were found during our research. (Katz and Nordwall, 2008) describe Self-care, a mobile application for chronic disease management. (Arsand et al., 2010) introduce the Few Touch application, which consists of a blood glucose meter, a step counter and software for recording food habits and providing feedback for patients suffering from type 2 diabetes.

2.3.8 MyMobileDoc

MyMobileDoc (Nischelwitzer et al., 2007) is a mobile medical application designed to assist people with chronic diseases in a home environment. Special focus was laid on the usability of the application for the elderly. The application offers a graphical user interface for entering medical data including blood glucose level, blood pressure, peak-flow, paint intensity and contentment level. This data is sent to a medical data center where will be evaluated and feedback can be given back to the user.

A user study including 15 patients aged from 36 to 84 years with a mean age of 65 years and 4 nurses aged from 20 to 33 with a mean age of 26 years was conducted with a working prototype. Among the evaluated elements of the prototype were various different input widgets for entering numeric input data, calculator, cursor or slider style (Figure 14), as well as the preferred display of longer text chunks. The by far most favored way of entering numeric input data was using the calculator styled widget (13 out of 15 patients preferred this way). Navigation through longer texts was rather done through scrolling than through paging. The maximum amount of information blocks still manageable by the users was found out to be 5 chunks.

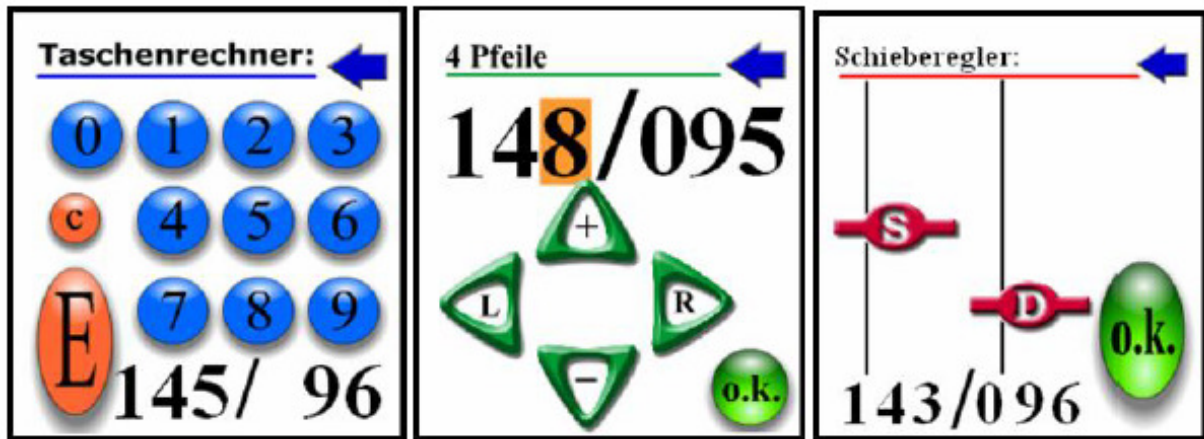


Figure 14: Numeric input widgets in My Mobile Doc (Nischelwitzer et al., 2007)

2.4 Designing for mobile web applications

2.4.1 Research based guidelines

There are considerable differences in designing web applications for mobile devices compared to designing for desktop computers. Based on their experiences in this field, (Holzinger and Errath, 2007) compiled a comprehensive list of design guidelines for creating mobile web applications. The following list shows some of these design guidelines that were most important for our current project. The items are categorized into several problem areas.

Information output

- Chunking information
 - The most relevant information should be displayed first.
 - Information should be represented in a way that is familiar to the users.
 - Common information goes to common locations on the screen.
 - Frequent information goes to obvious locations.
 - General items come before specific items.
- Textual information
 - The amount of text should be kept as low as possible.
 - Most important content comes first.

- Good contrast between text and background is essential.
- Icons
 - The meaning of an icon results from a combination of the icon itself, the context in which it is displayed and the user interpreting it.
 - Icons should be favored to textual information when possible.
 - Use familiar icons.
 - Good contrast between icons and background is important.
- Colors
 - Colors should only be used with purpose (orientation, navigation).
 - The color scheme should be consistent.
 - Do not use too many colors together.
- Errors
 - Always display a back button.
 - Actions causing a change should require confirmation by the user.
 - Error messages should be meaningful and in plain language.

Information input

- Select-controls should be preferred to text inputs
- The user should only be required to enter text when it is necessary for the application and for him.
- Provide default values for input fields.

Interaction and navigation

- The applications core features should be accessible from the main menu.
- Navigation interaction should always be comprehensible for the user.
- Term should be used consistently.

Specific importance is given to the following design goals

- The interface should be kept as simple as possible.

- The limited resources of mobile devices (screen size, difficulty of textual input, connection bandwidth) should always be considered when designing web applications.
- Support dynamic resizing
- Avoid horizontal scrolling

2.4.2 Mobile web best practices

The World Wide Web Consortium (W3C) has released a document containing guidelines and best practices for delivering web content to mobile devices (Rabin and McCathieNevile, 2008). Compared to the design guidelines for mobile web applications by (Holzinger and Errath, 2007) these many of best practices described here are of a more technical and less usability based nature. The following list gives an overview of the guidelines and best practices they proposed that were most important for designing and developing our wellness application.

Design for One Web

- Content reached by one URI should provide a thematically coherent experience, independent of the devices used for accessing it.
- The capabilities of the devices used to access the application should be exploited, if useful.
- Deficiencies of various devices used for accessing the application should be avoided by using workarounds.
- Use actual devices and emulators for testing.

Rely on Web Standards

- Use valid markup.
- Content format must be understood by the device.
- Use character encoding known by the device.
- Whenever possible do layout using style sheets
- Error messages should be informative.

Be cautious of device limitations

- Colored information should also be identifiable without colors

Optimize navigation

- Navigation should be consistent.
- Link targets should be clearly identified.
- Balance the amount of links at one page with the amount of clicks needed to access the desired content.

Check graphics & colors

- Images with intrinsic sizes should be resized on the server.
- Avoid graphics too large for the device where possible.
- Provide good contrast between foreground and background.
- Avoid pixel measures and absolute units.

Help & guide user input

- Avoid requiring the user to enter free text where possible.
- Offer default values for input elements.
- All input elements should be labeled.

Think of users on the go

- Offer a descriptive page title.
- Use clear and simple language.
- Information central to the page's intent should be shown first.
- Content should be limited to the scope requested and intended by the user.

2.5 Usability engineering methods

A comprehensive set of usability inspection methods and usability test methods was presented by (Holzinger, 2005). In this work five essential usability characteristics for every software project are listed

- Learnability, allowing the user to start working with the system as quickly as possible
- Efficiency, making a high level of productivity possible
- Memorability, making it easy to start working with the system again after a period without using it
- Low error rate, minimizing the chance of users making errors
- Satisfaction, motivating to users to use the system

Figure 15 gives an extensive overview of all usability inspection methods and usability test methods explained in the paper.

	Inspection Methods			Test Methods		
	Heuristic Evaluation	Cognitive Walkthrough	Action Analysis	Thinking Aloud	Field Observation	Questionnaires
Applicably in Phase	all	all	design	design	final testing	all
Required Time	low	medium	high	high	medium	low
Needed Users	none	none	none	3+	20+	30+
Required Evaluators	3+	3+	1-2	1	1+	1
Required Equipment	low	low	low	high	medium	low
Required Expertise	medium	high	high	medium	high	low
Intrusive	no	no	no	yes	yes	no
Comparison of Usability Evaluation Techniques						

Figure 15: Comparison of usability evaluation techniques (Holzinger, 2005)

2.6 Behavioral and social psychological theories

2.6.1 Transtheoretical Model of Health Behavior Change

The Transtheoretical Model of Behavior Change (TTM) describes health behavior change as a “progress through six stages of change”. This progress is achieved through a set of “processes of change” (Prochaska and Velicer, 1997).

The TTM can be applied to a broad set of health behaviors, among which can be found smoking cessation, weight control, dietary change or physical exercise. While the states of change are quite consistent over different types of health behavior, the processes of change can vary in their number by a small amount.

The states of change as described by (Prochaska and Velicer, 1997) and their role in a wellness promoting application are:

Precontemplation: In this stage, people are not yet aware about the consequences of their risk behavior, or at least they don't plan on taking any action against it.

Contemplation: People, who are in this stage, are aware of impacts of their current behavior and intend to do something against it within the following 6 months. Many people will stay in this stage for a long time, depending on the perceived balance of pros and cons of the intended change.

Preparation: This stage consists of people intending to take action, which has already been planned, within the next month.

Action: At this stage, people have already started taking action and have changed their behavior accordingly. These changes have happened within the last 6 months.

Maintenance: People who have reached this stage still take change action, although not as often as those in the action stage. The peril of falling back into an earlier stage is not as high as it used to be.

Termination: This stage represents the state when the risk of falling back into previous risk behavior is non-existent.

The processes of change, through which progress between the stages is achieved, and which are also described in (Prochaska and Velicer, 1997), and the possibilities of using them in a wellness promoting application are :

Consciousness Raising: Increased awareness about the risk behavior

Dramatic Relief: Increased emotional experience and reduction through introduction of possible ways of action

Self-re-evaluation: Evaluation of self-image, with and without behavior

Environmental Re-evaluation: Evaluating the effects of one's behavior on the direct environment

Self-liberation: Belief in possibility of change and commitment to change

Social liberation: Identification and creating of opportunities and alternatives

Counterconditioning: Acquisition of alternative, substitutional behaviors for risk behavior

Stimulus Control: Removal of incitements for unhealthy and introduction of incitements for healthy behavior

Contingency Management: Consequences as a reaction to actions, punishments should be avoided while rewards offer good results.

Helping Relationships: Social support and an open and trusting relationship with a trusted person

2.6.2 Goal Setting Theory

The Goal-Setting Theory (Locke and Latham, 2002) describes how different kinds of goals are able to motivate people and which core properties are needed for a goal to be effective. Challenging goals lead to higher levels of effort and performance than rather easy to achieve goals. Goals with higher specificity also lead to better performance when compared to more general goals ("do your best"). Individuals must be aware of their personal importance of a goal and they should be able to set the goal themselves or with the help of an expert, instead of just being assigned a goal. Feedback and information about progress towards achieving a goal should be available all time instead of just at the time of completing the goal.

The high-performance cycle (Figure 16) describes how challenging goals will lead to high performance. High performance leads to rewards (recognition, promotion) resulting in satisfaction and further willingness to commit to new challenges. While high satisfaction is often regarded as an important factor for high performance, the high-performance cycle reverses this dependency, showing that high performance rather leads to high satisfaction.

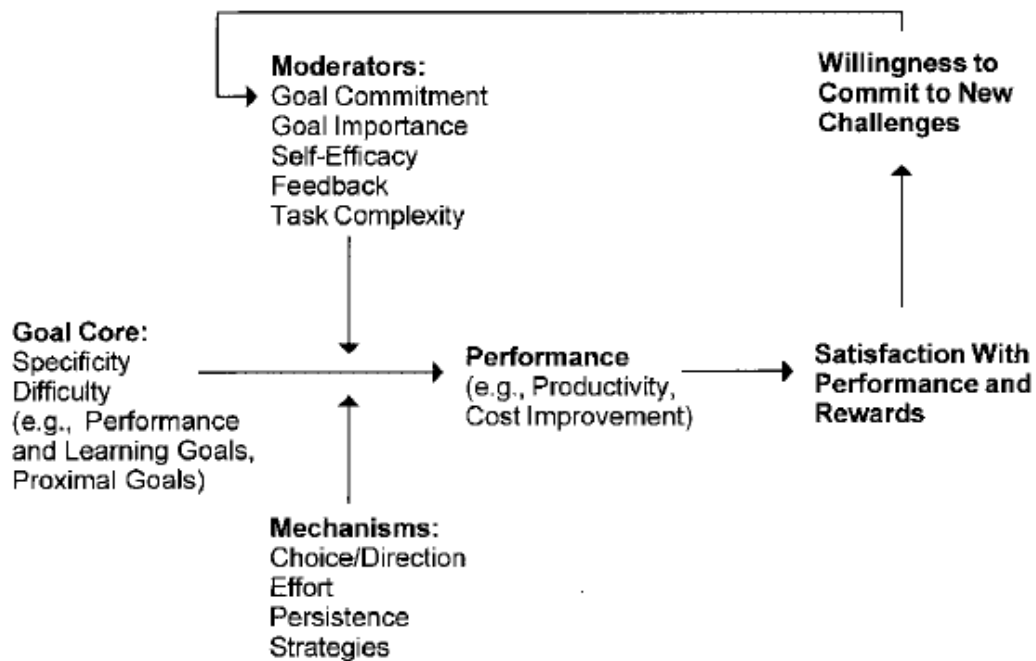


Figure 16: The high-performance cycle (Locke and Latham, 2002)

2.7 The Metabolic equivalent of task

Metabolic equivalents (MET) are a well-researched way of estimating the energy consumption of physical activities. Per definition one MET is set to $3.5 \text{ ml O}_2 \cdot \text{kg}^{-1} \cdot \text{h}^{-1}$ which amounts to $1 \text{ kcal kg}^{-1} \cdot \text{h}^{-1}$ and is considered the metabolic rate for a person sitting quietly (Ainsworth et al., 1993), (Ainsworth et al., 2000). A person conducting an activity whose MET is at 8.0 will consume 8 times the person's bodyweight in calories per hour. It must be emphasized that calculating calorie consumption using MET values is only a raw estimation and these values can vary strongly between different individuals.

The concept of MET values was implemented in our application in order to estimate the calorie consumption of the users' exercise entries based on their weight and the type and duration of their exercise. Using the MET values from (Ainsworth et al., 1993) and (Ainsworth et al., 2000), combined with the activity goals recommended by (Haskell et al., 2007), we were able to create a basic evaluation system for our users' activity entries. The minimum goal of weekly activity proposed by Haskell should be in the range of 450 to 750 MET·min·wk⁻¹ which means about 150 minutes of moderate activity (3 to 6 MET) per week.

3 Materials and Methods

3.1 Definition of user requirements

3.1.1 Functional user requirements

The basic functional user requirements for our wellness promoting application are:

- The user can manage personal wellness data.
 - The first version of the application should be able to manage height, weight, waist-hip ratio, body fat, blood pressure and heart rate.
 - Each data entry comprises the type of the entry, its unit and value as well as the date it was measured
 - Existing data entries can be viewed in tabular and graphical form

- The user can manage his personal exercise information
 - Initially the application will be able to handle a defined list of sports which can be extended by an administrator
 - Each exercise entry comprises the type of activity, its duration and the date it was performed on
 - Based on its knowledge about the user's weight the application will calculate the approximate calorie consumption for each exercise entry
 - Exercise entries can be viewed in tabular form
 - Daily energy consumption as calculated by the application can be viewed in graphical form as well

- The user can enter basic information about his dietary behavior
 - Each data entry comprises the daily portions of fruits and vegetables he eats, the amount of water (and diluted fruit juice and teas) he drinks every day as well as the date this entry represents

- The user can choose wellness related goals
 - The application will suggest a number from which the user can choose, and the user can also create a goal by himself
 - The suggested goals will be based on the user's currently entered information and will be suggested in several levels of difficulty
 - Each goal comprises the type of the goal (e.g. weight, amount of exercise, healthy nutrition), a threshold value he must reach and a date until he must reach this value
 - Completed goals will result in a virtual medal as a reward for the user
 - The user can view all of his virtual medals on a rewards overview page

The aforementioned functional user requirements make up the basic functionality of the application. Since the success of wellness applications strongly depends on the consideration of human properties, namely cognitive affective and motivational aspects (Alagöz et al., 2010), the demands and cognitive abilities of a broad and diverse user group should be met and supported by intuitively usable interfaces. As the main goal of wellness applications, promoting a healthy lifestyle, depends on continuous and long-term usage, wellness applications should be developed in a way that users want to use it and should include emotional or affective designs. Thus good interface design should not only focus on mere functional aspects, but should also include hedonic aspects aiming at the user's well-being, pleasure and fun (Holzinger et al., 2010), (Ziefle and Jakobs, 2010).

In order to make the application more fun to use, the already existing requirements are extended by a set of requirements specifically aiming to improve long term user motivation. (Consolvo et al., 2009) proposed a set of design goals for technologies that aim to support behavior change. Starting with four design goals that were suggested by (Jafarainimi et al., 2005) in their Breakaway project, they added four additional goals based on behavioral theories and social psychological theories. They called these design goals "Abstract & Reflective", "Unobtrusive", "Public", "Aesthetic", "Positive", "Controllable", "Trending / Historical" and "Comprehensive". Based on these design

goals we defined at set of additional functional requirements that aim to make the application motivating and fun to use.

Abstract & Reflective: Wellness data and information about the user will have visual effects that can be interpreted by the user in a very intuitive way. The following functions will provide easily interpretable views of the user's wellness data:

- Data displayed in tables will be color coded (green, yellow, red) to show how well it corresponds to desired target values. Information icons allow access to health information regarding the according data.
- Longitudinal data can be viewed using diagrams that show the course of the data during defined timespans. Buttons should allow for backward and forward navigation in time as well as changing the amount of days shown in one diagram.
- An overview page will provide an “at a glance” view on the most important wellness information about the user. This information should be given using colored icons, where the icon defines the type of health parameter and the color shows an evaluation of the desirability of the user's current values.

Unobtrusive: The user should be able to manage his wellness information in an easy to use way, at any time and place during his daily life. Using the application should not be complicated or take too much time, and it should at any time be possible to stop using it and continue later. By creating a web application that is optimized for usage with mobile devices no special technologies will be needed by the users. Nowadays mobile phones are a part of their daily life for many people, and our target group is especially used to handling smartphones and not only using them as a phone but also for additional activities. The following functional requirements were created from these design goals:

- Though the application should only be used by authorized users (see design goal “Public”), the user should be able to continue using it without losing data due to

a new login process. This can be done using cookies that remember the logged in user which will be deleted when the user explicitly logs out.

- No download, installation and update procedures should be required from the user. The only activity needed to start the application should be navigating to a website.

Public: Wellness related data is often regarded as very personal data. Mobile devices are not only available to their owners most of the time, it is also very easy for other people to access devices that are not their own. Users of the application should be able to store their personal data without needing to worry about other people accessing data they should not see. These design goals lead to the following functional requirements:

- Only authorized users should be able to see personal wellness data
- Authentication will be done using a username/password login form
- The password must be stored in a way that no one can read it, even if he has access to the server
- While a “remember me” cookie will allow the user to stay logged in, even after a server timeout, the user can explicitly log out from the application

Aesthetic: One of the main goals of the application is to motivate its users to access it regularly and over a long time. Visual attractiveness of the application can make it more fun to use and adaptiveness to different aesthetic preferences emphasizes the personal character of the application. The following functional requirement will support these points:

- The application should be created using a combination of rich internet application (RIA) technologies
- and an easily customizable look & feel through the use of Cascading Style Sheets (CSS)

Positive: Positive reinforcement can be a powerful driving for user motivation (Consolvo et al., 2009). Negative reinforcement can lead to discouraging effects on the user (Lin et al., 2006), (Prochaska and Velicer, 1997) and should be used cautiously, if at all. The following functional requirement will try to make use of this:

- Raw data views should show their numbers color coded, using either only green for good values or a traffic light coloring system (green, yellow, red) marking good, not so good and bad values. The results from a user study should tell us whether using yellow and red colors can also have the same discouraging effects as the negative reinforcement in (Lin et al., 2006).
- The user can choose personal goals from a list of goals suggested by the system. These suggested goals should cover the whole set of wellness information that can be managed with the application. If the user manages to successfully achieve these goals within a defined timespan, he will be rewarded with a virtual medal.

Controllable: The users should be able to add, modify and delete their personal data as they seem fit. If they get reminded of personal wellness conditions that make them feel bad, they should rather be able to delete this data than stop using the application at all. As the application will not rely on sensory data but rather let the user input their activity and wellness information manually, adding, modifying and deleting data will among the most time consuming actions the user will perform and should be very easy and quick to use. This leads us to the following functional requirements:

- Every type of personal data that can be added can also get modified or deleted.

Trending/Historical: The users should be able access their past wellness information in an easy to use way. Seeing how personal health parameters have increased over time and having access to a list of goals they have already achieved may help them to see, how small improvements can add up over time. In order for long term motivation to

work, the user should also be able to view his data over long terms. This design goal will be implemented by adhering to the following functional requirements:

- Tabular and graphical display of wellness information must be able to show current and historic data.
- The user should be able to see all the goals he has achieved over time
- Wellness information types that allow trending will show a trend over the currently viewed timespan in their graphical display

Comprehensive: Since wellness information is much more useful if it can be entered as exhaustively as possible, the list of activities and wellness data provided by the application should be easily extensible according to the users' wishes. In a first version of the application, additional wellness data and exercise types can be added by an administrator as flat database entries. A later version of the application might also allow the users to add their own, personal wellness data and exercise types.

- All forms and graph should exist in a generic version that can easily be used for managing new exercise types and wellness data types.

3.1.2 Non-functional user requirements

The aforementioned design goals also have an impact on the non-functional user requirements of the application.

- The application should be compatible with the majority of modern smartphones, so it should at least support web browsers based on Google's Chrome engine and Apple's WebKit (**unobtrusive**).
- The application as a whole, but especially the input elements used for adding, editing and deleting actions should conform to the suggestions about user input given by (Holzinger and Errath, 2007) and in the W3C Mobile Web Best Practices (Rabin and McCathieNevile, 2008) (**controllable**).

- Scalability – after the initial user study phase, the application should be able to support an increasing number of users simultaneously without any changes to the code.
- The application should run with an acceptable performance for the users, this will be tested in the user study.
- Maintainability and extensibility – good documentation and modular software architecture must ensure that the application can be easily maintained and extended by developers that were not part of the initial development phase.
- Administrators of the application must be able to add new exercise types and wellness data types by adding new types to a configuration file or a database table (**comprehensive**).

3.2 Use cases

Based on the defined functional requirements the desired behavior of the system was modeled in UML use cases.

Table 1: Use case "Authentication"

Name	Authentication
Purpose	Users must identify themselves before using the application
Summary	An unauthenticated user must fill out a login form with their personal username and password. The entered data is compared with existing users in the database. After a successful login, the login form is closed and the user is able to work with the application.
Preconditions	Username and password exist in the database.
Postconditions	The user session is authenticated and the user is able to manage data belonging to his user entry.

Table 2: Use case "Managing personal data"

Name	Managing personal data
Purpose	Users can enter and edit basic information about themselves
Summary	Every user has an entry containing basic personal information (first name, last name, gender, date of birth, height). An input form, accessible from the main menu allows the user to enter and edit this information and store it on the server. None of the information is compulsory. After storing the information on the server, an info message tells about success or possible failure.
Preconditions	The user is authenticated.
Postconditions	The basic personal information is stored in the database. Gender, date of birth and height can be used as parameters for evaluating the user's additional wellness information.

Table 3: Use case "List wellness data entries"

Name	List wellness data entries
Purpose	The user gets a list containing all previously entered wellness data for a selected data type
Summary	<p>After accessing the main menu entry "My Wellness Data" a list of all wellness data types (weight, tail-hip-ratio, body fat, blood pressure, heart rate) is shown. When the user chooses one of these types, a tabular view containing all existing data entries of this type for the user is shown. The data is initially sorted by the entries date, but clicking the header cells of the table allows the user to change the sorting.</p> <p>The columns shown in this view are the date of the entry, an info-icon through which additional information about an entry can be accessed and, depending on the type of data one or more value columns. Generic wellness data types show one</p>

	<p>column containing the value and its unit. Blood pressure entries show systolic and diastolic values. Waist-hip-ratio entries show hip size, waist size and the ratio of these two.</p> <p>Sample evaluations for defined wellness data types (weight and blood pressure) are implemented on the server and can be easily replaced by more advanced evaluation methods.</p>
Preconditions	<p>The user is authenticated.</p> <p>The user has chosen a wellness data type.</p>

Table 4: Use case "Create a new wellness data entry"

Name	Create a new wellness data entry
Purpose	The user creates and stores a new wellness data entry
Summary	Clicking on a "new entry" button opens an input form allowing the user to enter the date and value(s) of a new wellness data entry. After storing the entry on the server, an info message tells about success or possible failure.
Preconditions	<p>The user is authenticated.</p> <p>The user has chosen a wellness data type.</p>
Postconditions	A new wellness data entry is stored on the server.

Table 5: Use case "Modify a wellness data entry"

Name	Modify a wellness data entry
Purpose	The user edits the value of an existing wellness data entry
Summary	Clicking on an entry's row in the list of all wellness entries (except clicking on the info-icon) opens an input form allowing the user to modify and store the selected entry. After storing the entry on the server, an info message tells about success or possible failure. Instead of modifying the data, the

	user can also delete the entry using a button in this form.
Preconditions	The user is authenticated. The user has chosen an existing wellness data entry.
Postconditions	The entry is updated or deleted on the server.

Table 6: Use case "Show wellness data chart"

Name	Show wellness data chart
Purpose	A line chart including a trend line shows the user's wellness data
Summary	<p>Clicking on a special chart icon in the wellness data list opens a graphical summary of the user's data entries for the chosen data type. The chart is rendered as a line chart spanning a defined period of time. Data points are only drawn on days for which data exists. These data points are the connected, so that the value on days between can be evaluated from the connection line. The user can increase or decrease the amount of days the chart shows (choosing between 2 weeks, 4 weeks, 10 weeks, 20 weeks and one year), and he can also navigate to later or earlier dates.</p> <p>The range of values shown on the y-axis is calculated dynamically from the range spanned by the currently shown values, so that the available screen space is utilized to its full extend. A trend line will be calculated from the values inside the chosen timespan and also be shown on the graph.</p> <p>Special charts are generated for the wellness data types blood pressure and waist-hip-ratio. The blood pressure graph shows a combined chart of systolic and diastolic values with separate trend lines for each of them. The waist-hip-ratio</p>

	graph shows a combined graph of the waist and the hip circumference as well as an additional chart showing their ratio. A trend line is only shown for the ratio.
Preconditions	The user is authenticated. The user has chosen a wellness data type. Data entries of the given type exist for the user.

The following use case diagram shows an overview of the functionalities for managing wellness data.

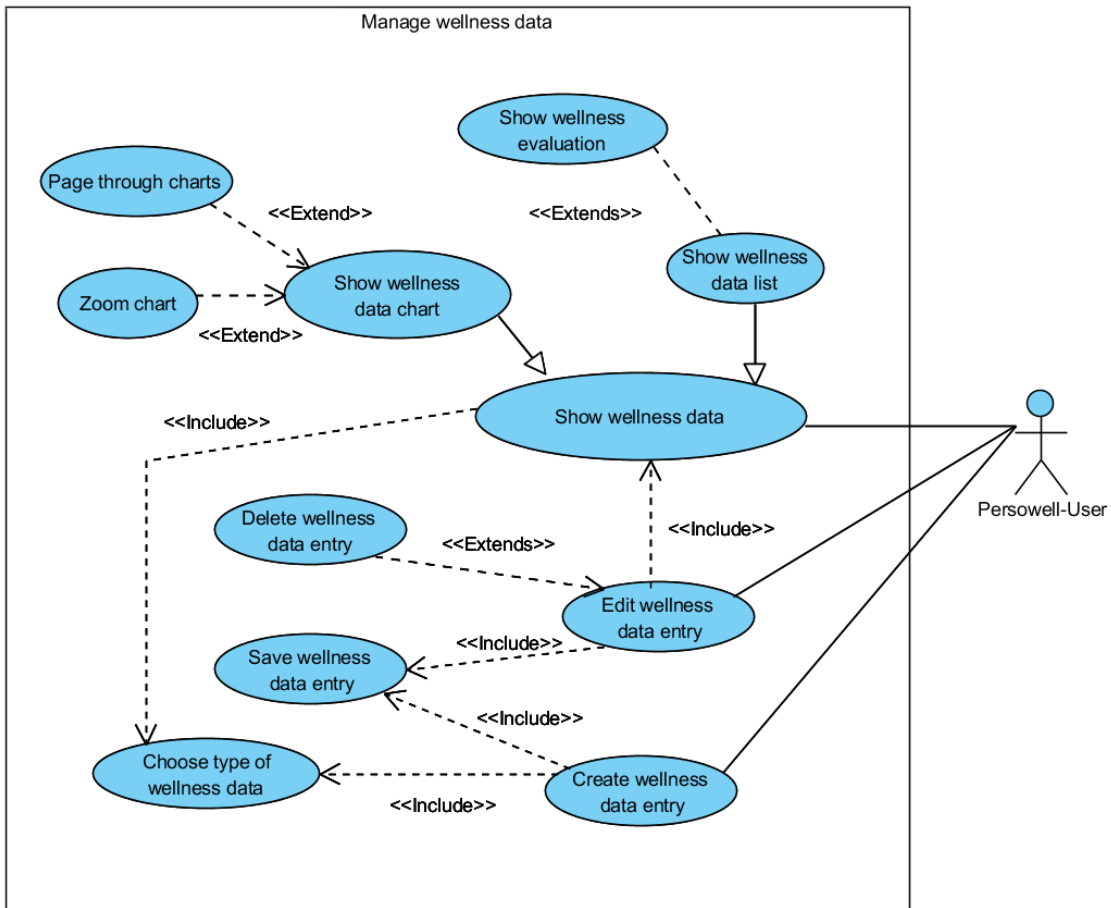


Figure 17: Use case diagram "Manage wellness data"

Table 7: Use case "List exercise entries"

Name	List exercise entries
Purpose	The user gets a list containing all previously entered exercise activities. The entries are ordered by their date column, but clicking on a header cell can change the sorting. The values shown are the type of exercise, the date the activity was conducted, the duration of the activity and the estimated amount of calories consumed through the activity. The amount of calories is estimated by the application and depends on the user's entered body weight, the type of activity and its duration.
Summary	The exercise data is shown in a tabular view
Preconditions	The user is authenticated.

Table 8: Use case "Create a new exercise entry"

Name	Create a new exercise entry
Purpose	The user creates and stores an new exercise entry
Summary	Inserting new exercise entries works similar to wellness entries. The data entered consists of type of sport, duration and date of the activity.
Preconditions	The user is authenticated.
Postconditions	A new exercise entry is stored on the server.

Table 9: Use case "Modify an exercise entry"

Name	Modify an exercise entry
Purpose	The user edits the value of an existing exercise entry
Summary	Editing and deleting exercise entries works similar to modifying wellness entries.
Preconditions	The user is authenticated.

	The user has chosen an existing exercise entry.
Postconditions	The entry is updated or deleted on the server.

Table 10: Use case "Show exercise chart"

Name	Show exercise chart
Purpose	A line chart show the user's calorie consumption per day
Summary	<p>Clicking on a chart icon in the exercise entry list opens a graphical summary of the user's estimated calorie consumption per day. The amount of calories is estimated by the server based on the user's weight and the type of activities and their durations for each day. In contrast to the charts show for wellness data, days for which no entries exist are shown as data points with a calorie consumption of 0. If such days exist the chart will be similar to a zigzag line compared to the more continuous line of a wellness data chart.</p> <p>Similar to the wellness data chart the user can zoom in and out and can navigate to earlier and later dates. The range of calories show on the y-axis ranges from 0 to the highest value of the shown timespan.</p>
Preconditions	<p>The user is authenticated.</p> <p>Exercise entries exist for the user.</p>

A summary of the functions provided by the exercise management module of the application can be seen in the following figure.

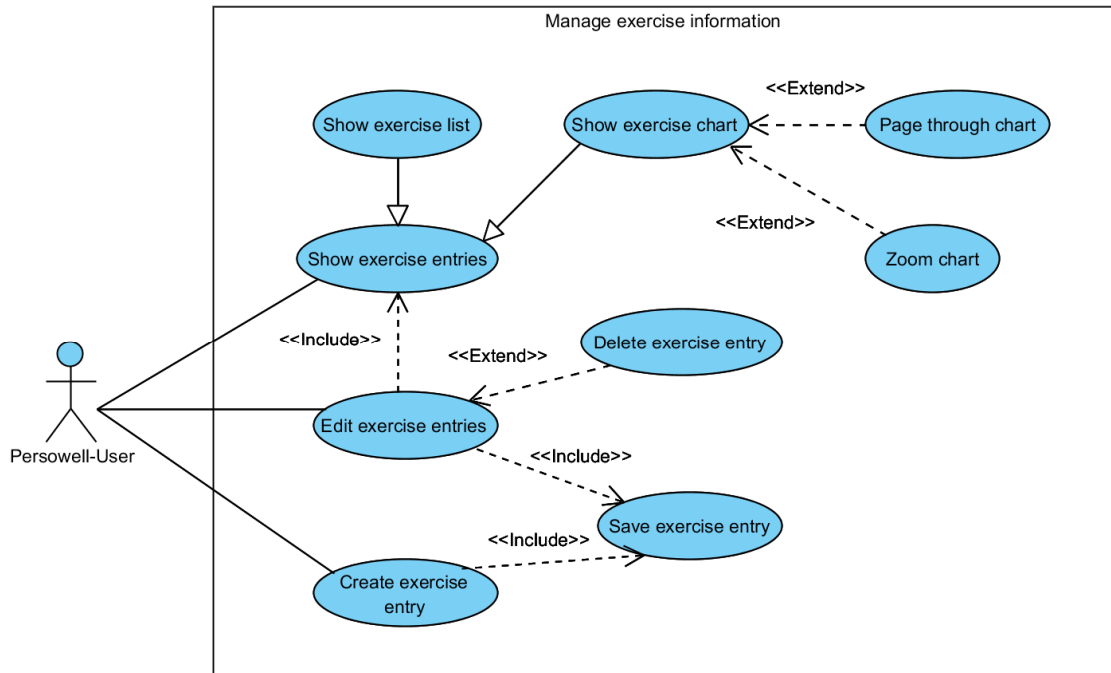


Figure 18: Use case diagram "Manage exercise information"

Table 11: Use case "List nutrition entries"

Name	List nutrition entries
Purpose	The nutrition data is shown in a tabular view.
Summary	<p>A nutrition entry consist of the amount of liquid (water, diluted fruit juice and tea) and the number of portions of fruit and vegetables the user hat consumed on a given day. These also make up the entries of the tabular view of nutrition entries together with an information column through which an individual evaluation of each entry can be accessed. Sorting works similar to the other entry lists.</p> <p>The evaluation of each entry is implemented as a simple example method and can be easily replaced by more advanced methods on the server.</p>
Preconditions	The user is authenticated.

Table 12: Use case "Create a new nutrition entry"

Name	Create a new nutrition entry
Purpose	The user creates and stores an new nutrition entry
Summary	Inserting new exercise entries works similar to wellness entries. The data entered consists of type of the number of portions of fruit and vegetables and the amount of water, diluted juice and tea consumed for a given date.
Preconditions	The user is authenticated.
Postconditions	A new nutrition entry is stored on the server.

The following use case diagram shows the functionalities provided for the nutrition module of the application.

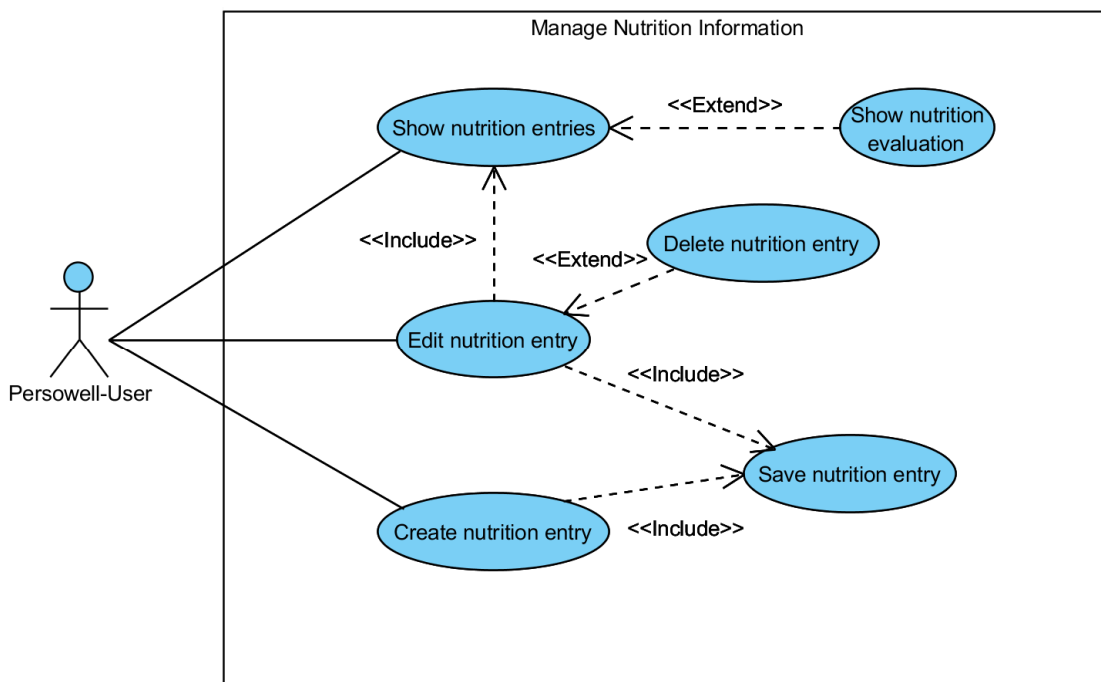


Figure 19: Use case diagram "Manage nutrition information"

Table 13: Use case "List goals"

Name	List goals
-------------	------------

Purpose	A list of active and already achieved goals is shown
Summary	<p>There are different types of goal types. Wellness data goals require the user to reach a certain value threshold (e.g. get below a defined body weight or waist-hip-ratio) within a certain timespan. Exercise goal demand a defined number of calories consumed through sports activities within a timespan. Nutrition goals either want the user to consume a healthy amount of water or of fruit and vegetables on a daily basis for a given timespan.</p> <p>The “list goals” view shows the user two lists. The first list contains all goals that are currently active for the user. The second list shows all goals that the user has already achieved. This second list also shows a virtual medal for each achieved goal.</p>
Preconditions	The user is authenticated.

Table 14: Use case "Acquire new goal"

Name	Acquire new goal
Purpose	The user chooses a new goal from a list of recommended goals
Summary	Starting at the list of active and achieved goals the user can navigate to a form for acquiring a new goal. In this form the application suggests a number of goals suited for the user’s current status. The goals cover the range of goals defined in Table 13: Use case "List goals" and offer multiple goals of each kind providing different levels of challenge. The virtual medal of the goal depends on the type of goal and on the difficulty (gold, silver, bronze).

Preconditions	The user is authenticated.
Postconditions	A new active goal is created for the user.

The following figure shows an overview of the functionalities provided by the application for managing goals.

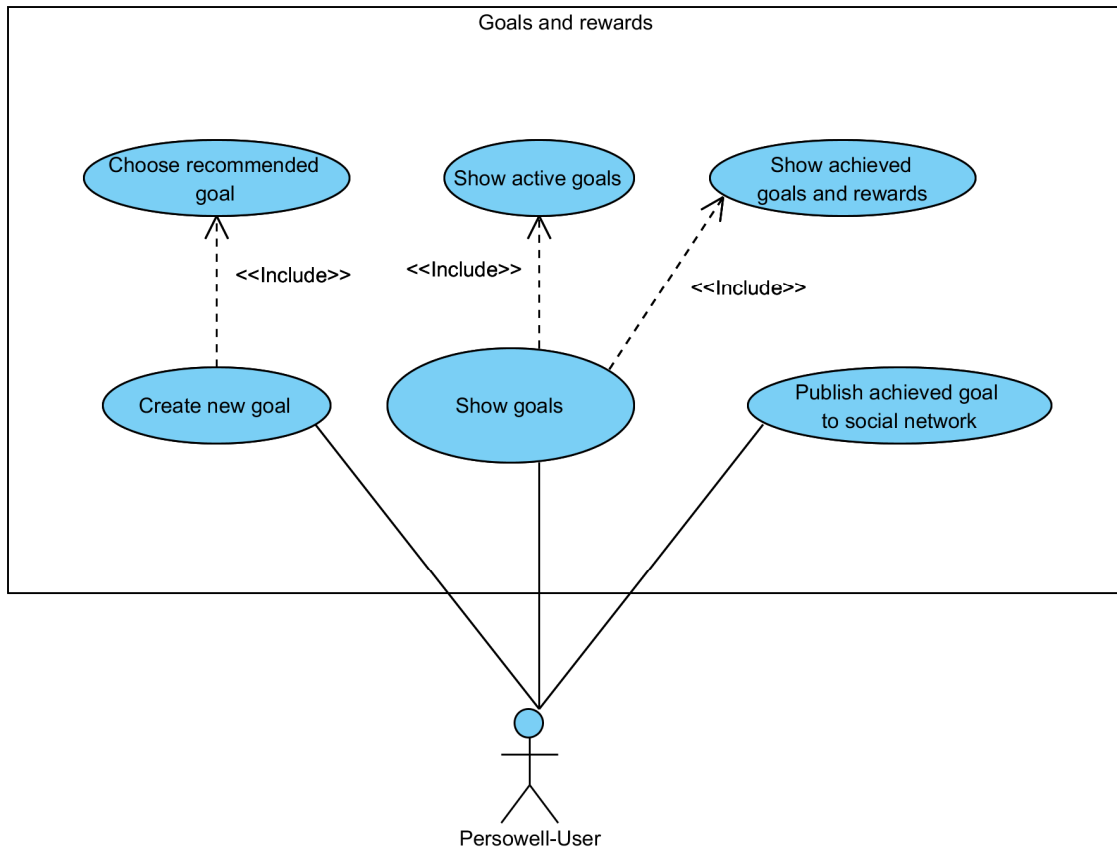


Figure 20: Use case diagram "Goals and rewards"

Table 15: Use case "Wellness summary"

Name	Wellness summary
Purpose	An overview of an evaluation of the user's wellness, exercise and nutritional behavior is shown
Summary	An image showing icons representing the users sports exercise activity, essential wellness data (weight, waist-hip-ratio, blood pressure) and his behavior regarding daily liquid,

	<p>fruit and vegetable consumption is shown. The target each icon represents should be easily identifiable. The icons are colored using a traffic signal scheme (green, yellow, red), where green coloring means the user's values are estimated as good, yellow as moderate and red as bad.</p> <p>Additionally, evaluation results for each of these items are summarized in a few short, meaningful sentences.</p>
Preconditions	<p>The user is authenticated.</p> <p>Valid data entries for the items that will be summarized exist.</p>

3.3 Application architecture

The implementation of functionalities on the server side is based on the concepts of a layered architecture as described by (Fowler, 2002). The main layers of this architecture are the presentation logic, the domain logic and the data source. These can be extended by additional layers in order to achieve a higher level of granularity. The advantages of a layered architecture according to Fowler are:

- The contents of one layer (and the developers working on it) do not need to have additional knowledge about other layers.
- The implementation of a layer can easily be substituted with an alternative version providing the same services.
- Layers can be reused in a different context
- Dependencies stay local and are not distributed among different layers.

Based on this design pattern, our application consists of the following layers on the server side (Figure 21):

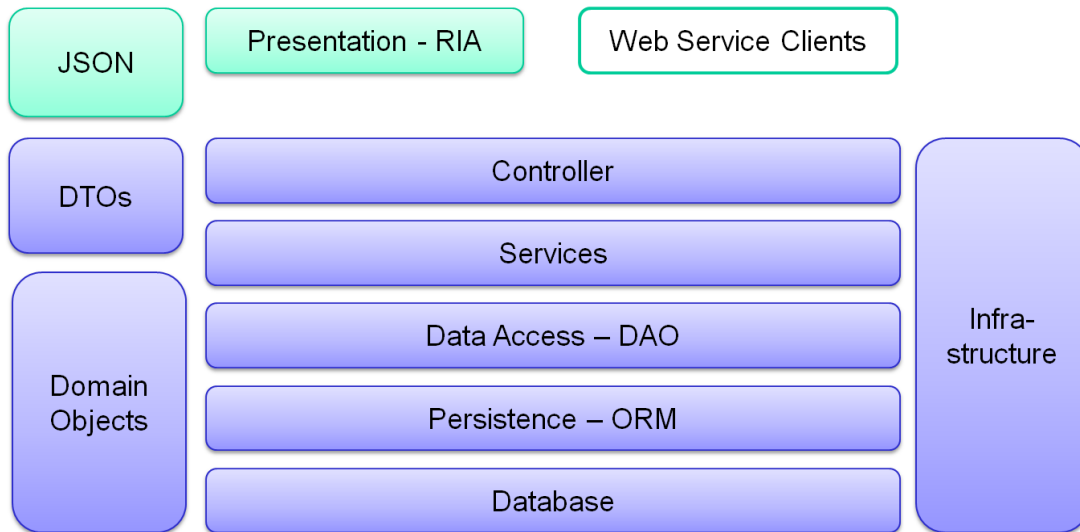


Figure 21: Server side architecture

Starting at the highest layer, the task of the application layers are as follows:

The presentation layer is responsible for interaction with the user. It provides all graphical user interface (GUI) elements that are offered on the client, their interactions and the client side communication part with the server. In our application this layer is executed in the client's web browser, the server is only responsible for delivering the code to the client at the first request. As this layer runs in a web browser, it is implemented using the JavaScript programming language. The data transferred from and to the server is described in the JavaScript Object Notation (JSON), a language-independent, text-based data interchange format, related to JavaScript. For further details on the implementation see the description of technologies.

Requests from the presentation layer containing JSON objects are received by the controller layer. The layer maps the URLs of HTTP requests to methods in specialized controller classes. URL parameters and transferred JSON objects get converted to Java objects automatically and are passed as parameters to these methods. These Java objects are implemented as data transfer objects (DTOs). In contrast to domain objects, which will be used by the lower layers, these DTOs only contain each object's member variables as well as getter and setter methods but no additional domain specific

functionality or information. The controller layer implemented in our application is intended to work with HTTP requests from a client application containing JSON objects, but creating a different layer implementation that can work with other clients (web service calls, remote procedure calls) can easily replace or extend this existing layer. After the controller has taken the request from the client it forwards them to the next layer, the service layer, and again transforms the results it receives into JSON and returns them to the client.

The next layer, the service layer, defines the functionality of the application, the methods and services it provides. All functionality offered by this layer, as well as by the subjacent data access layer consists of interfaces and of implementing classes. This makes it easy to create alternative implementations of the layers without changing the neighboring layers. The service layer takes lightweight DTO objects as parameters and transforms them into heavyweight domain objects for further processing. These domain objects can have additional domain specific functionality and information and can also contain additional information about their storage. Domain specific functionality is also implemented in this layer. The classes of this service layer can call each other's functionalities and also have access to the next lower layer.

The next layer, the data access layer, is implemented using data access objects (DAOs). This layer acts as a mediator between the application and its data storage. Similar to the service layer, it also consists of interfaces and implementing classes. Thus new implementations for different types of data storage can easily be exchanged with the existing ones. In our project, all data storage was at first implemented using mock objects, which were defined in a configuration XML file, read at server startup and held in memory. This was ideal for testing purposes in the early phases of development. At a later stage, the mock implementations of the data access interfaces were exchanged by implementations using the Hibernate Frame, which was also used to create the next layer.

The persistence layer defines how Java objects will be serialized for storage. This layer was also implemented using the above-mentioned Hibernate Framework, which enable

us to define the mapping of our Java objects to database tables, which make up the final layer of our architecture, database layer.

Logging, exception handling and security mechanisms which were used through all layers of the applications are shown as an infrastructure block in Figure 21.

3.4 Class diagrams

The server side architecture discussed in the previous paragraphs can also be seen in the class architecture for the server side classes as shown in Figure 22. Moving in the diagram from the top to the bottom, the classes making up the controller layer, the service layer and the data access layer can be seen. Some classes defining domain functionality from the service layer vary in their vertical positioning on order to make the diagram more compact.

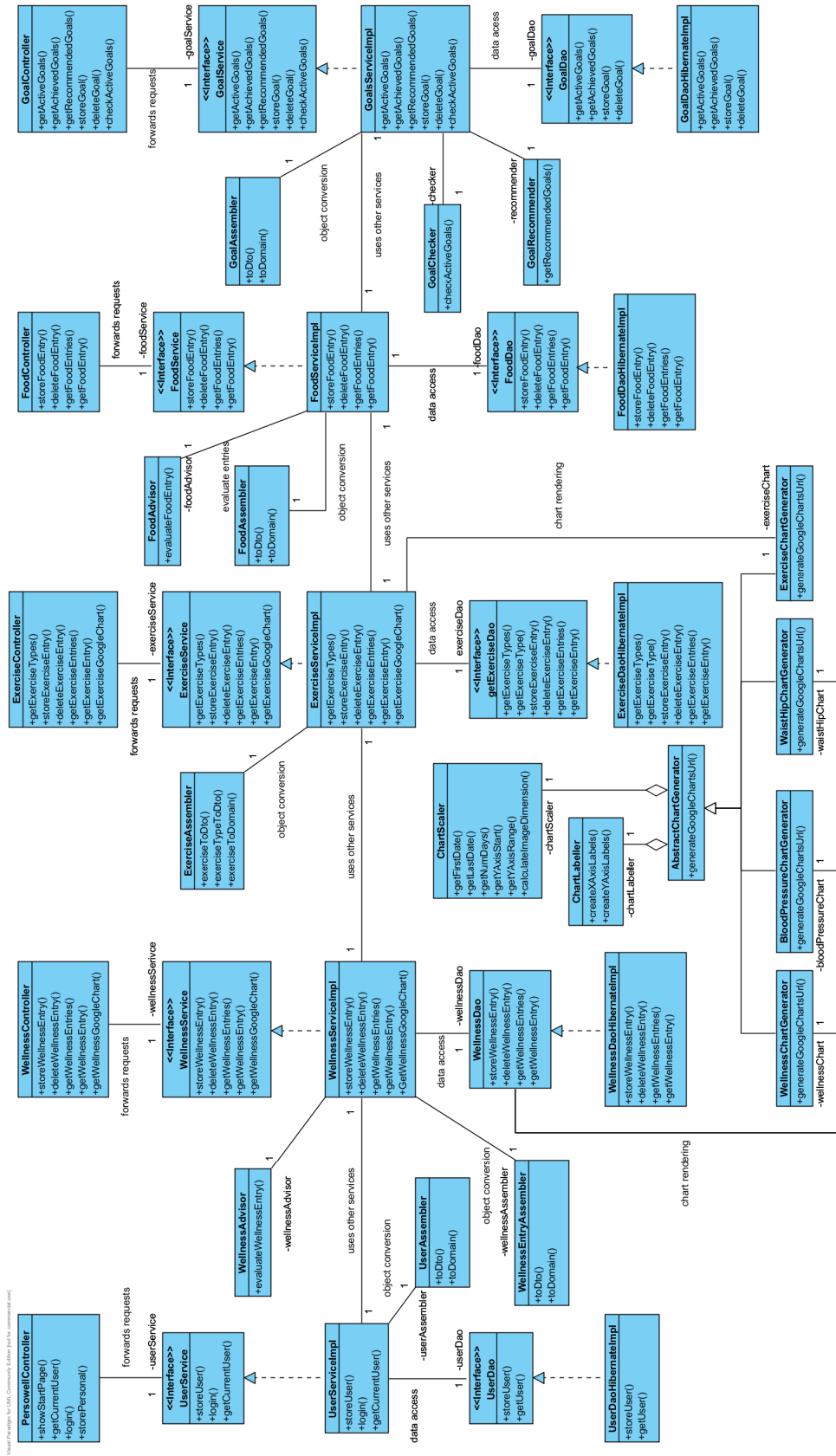


Figure 22: Class diagram service architecture

The class diagram shown in Figure 23 shows the structure of the domain objects, which is also mirrored by the DTO objects.

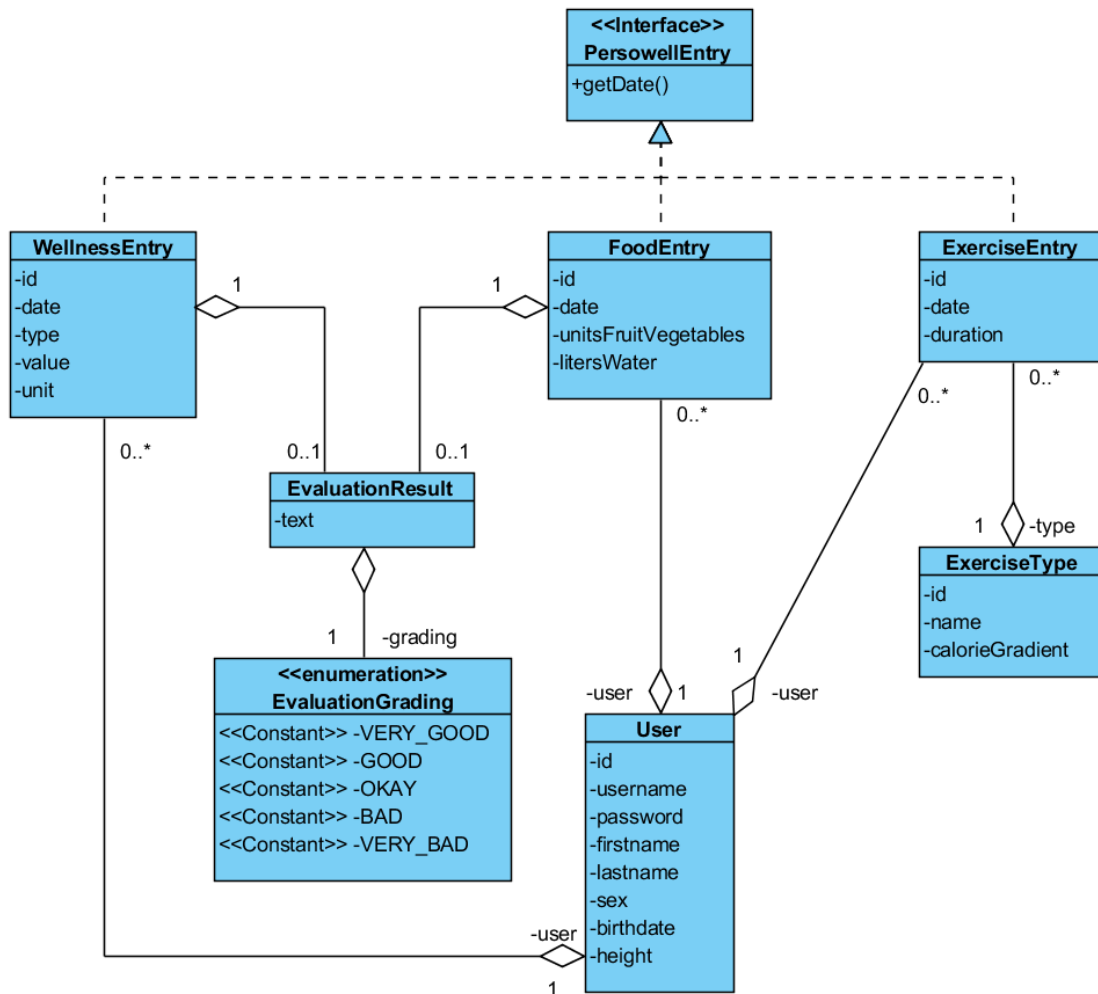


Figure 23: Class diagram data structure

3.5 Usability Study

3.5.1 Field observation

Since our users have no definite workplace where they will be using the application, the field study was conducted in several different locations of daily life, where users have the free time to invest some minutes to enter their latest wellness related information. These locations include a bus station, a café, and the living room at home or just standing in the city having a few minutes time. The users were given an iPhone 3GS to conduct the test and were asked to hold it in landscape format.



Figure 24: Users testing the application in daily life situations

Users with no prior knowledge on how to use smartphones got a short introduction on how to use the device's web browser but without showing them the application yet. After a short introduction on the aims of the application the users were given the following list of tasks they should try to solve. The time needed to complete single tasks as well as the time needed to do the complete list of tasks was measured for every user.

Table 16: User tasks for the usability study

#	Task
1	Get an overview over what the program is about and how the menu works.
2	Take some time to examine different parts of the program and its controls by trying out various main menu entries until you think you know what the application is about.

3	Check if your personal data (actually that of the test user) is entered correctly.
4	Your year of birth seems to be wrong, correct it to 1980.
5	You have measured your body weight (75 kg) and your blood pressure (120/79) this morning. Now you have some time to enter these measurements.
6	Verify that your newly entered measurements have been stored correctly.
7	You have been told that the program can also show you a chart displaying trends about your body weight. Have a look at it.
8	You want to see how your body weight changed during the last 4 weeks, try to get this information from the chart.
9	Now you're also interested in your body weight during the recent months.
10	You did some swimming for 1 hour yesterday evening. Enter this information into the application.
11	How many calories did you consume during that hour?
12	On approximately how many days did you do some physical activity during the last 4 weeks?
13	You know it's healthy to eat several portions of fruit and vegetable and to drink at least 2 liters of water or diluted fruit juice and tea every day. Since you're trying to live a healthy live, you try to do so consciously. Still you only ate 1 apple and 1 tomato yesterday and drank about 1.5 liters of mineral water. Enter this information into the program.
14	Does the application tell you, whether this good or bad?
15	In order to motivate yourself to a healthier lifestyle you have set yourself some goals using this application. Review them now.
16	You think it's time for a new goal, add one.
17	Try to get an overview of all your information you have told the program about.

The mobile network bandwidth used for the test depended on the current test location. The tests were done using different types of mobile connection speeds, which were WLAN (tests in private apartments), UMTS (tests in urban areas) and GPRS (tests done in rural areas). Rich internet applications generally tend to be larger when initially

loaded but require less network traffic while working with them. In accordance to this fact, the time needed for initially starting the application differed largely depending on the network speed, ranging from about 3 seconds when using WLAN and 15 seconds when using UMTS to up to 40 seconds when using GPRS in combination with a weak signal from the mobile provider. After the initial loading of the application only minor amounts of network traffic were created by the application. The lag times created by these communication actions between the application and the server ranged from hardly observable amounts of time when using faster networks to about a second when using very slow mobile networks.

3.5.2 Questionnaire

After trying to solve their tasks in the field study, the users were asked to fill out a questionnaire.

The first part of the usability survey is used to determine the respondents' previous experience in using technologies that may affect their usage behavior when testing the application. These technologies include using computers, web pages, mobile phones, smartphones and other mobile devices.

Part two of the survey aims to determine the interviewee's attitude towards a healthy lifestyle. The respondents are asked how important leading a healthy life is to them and in what extend this affects their daily behavior.

The following part of the usability survey implements the Systems Usability Scale (SUS) by (Brooke, 1996). The SUS is a simple set of survey questions used for usability measurements which can be applied to any type of software system. It consists of 10 questions requiring the respondents to rate statements on a five point Likert-scale. These questions were originally selected from a pool of 50 usability questions which were used in a study rating two exemplary software applications. The 10 questions leading to the most extreme ratings on the Likert-scale, either agreeing or disagreeing, were then selected to be used in the SUS. Analyzing the results of a SUS test leads to a single

numeric score ranging from 0 to 100, higher scores meaning better usability. This resulting score can be used to estimate the tested application's level of usability. The score is calculated by alternately subtracting 1 from the Likert-scale value (1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree) or subtracting the Likert-scale score from 5 and summing up the values achieved by doing this. This alteration is needed because agreeing to statements 1, 3, 5, 7 and 9 generally stands for good usability of the tested software, while agreeing to statements 2, 4, 6, 8 and 10 means that the respondent didn't feel that the software had good usability.

(Bangor et al., 2008) have collected data from more than 2324 surveys using the SUS and created a benchmark which allows to easily compare the usability of software tested using the SUS to that of other applications. The mean SUS score of all surveys analyzed by them was 70.14 with a standard deviation of 21.71 (Figure 25).

(Lewis and Sauro, 2009) suggested that the SUS contains two different factors, "usable", derived from items 1, 2, 3, 5, 6, 7, 8 and 9 and "learnable", derived from items 4 and 10.

Analysis of variance (ANOVA) was applied to show whether gender, education, previous experience with various technologies or attitude towards a healthy life influenced the SUS score of our test users.

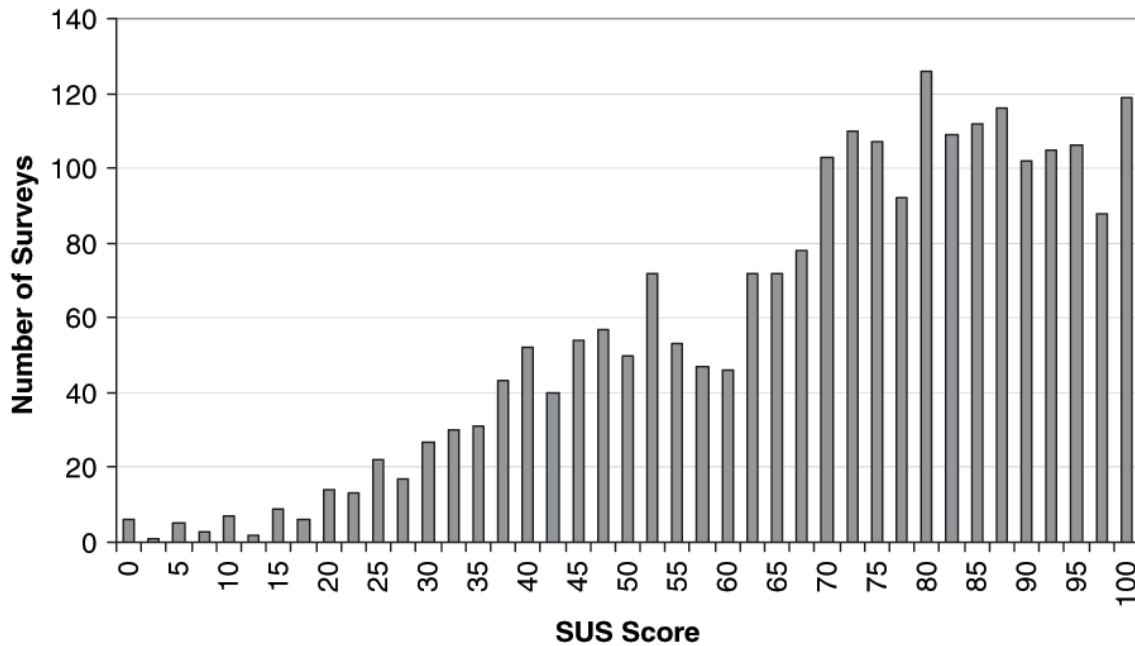


Figure 25: System Usability Scale scores for 2324 surveys (Bangor et al., 2008)

In order to make the score resulting from an SUS survey more meaningful, (Bangor et al., 2008) added an eleventh question to the existing 10 questions of the SUS, asking the interviewees to give an adjective rating to the question “Overall, I would rate the user-friendliness of this product as:” with the possible answers “worst imaginable, awful, poor, OK, good, excellent and best imaginable”. They also proposed a “university grade analog” meaning that an SUS score ranging from 90 to 100 was the equivalent of a university grade “A”, 80 to 89 corresponds to a “B”, etc.

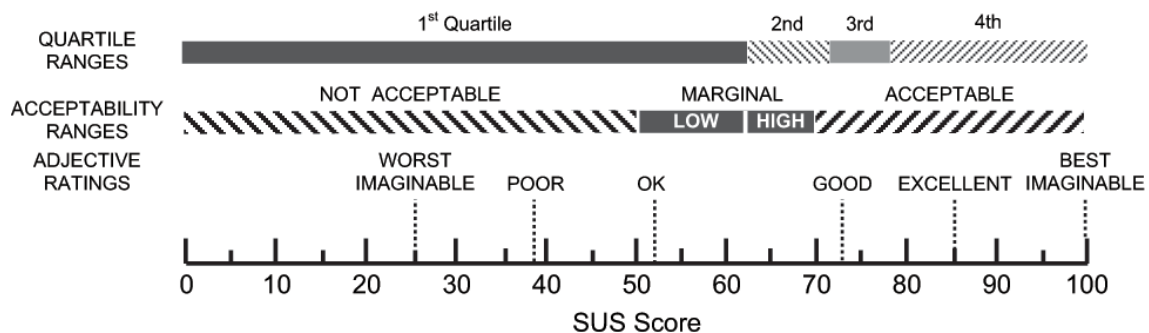


Figure 26: SUS scores, adjective rating and university grade analog (Bangor et al., 2008)

Other questions about the application also use statements the respondents can agree/disagree to on a Likert-scale and are partially based on the questions described in

(Lewis, 1995). These additional statements can be roughly grouped into the categories “ease of use”, “understandability” and “users’ interest in application features”. Correlation between gender and the results of these questions was tested using the Mann-Whitney-U-Test (Mann and Whitney, 1947). Age, education, previous experience in various technologies and attitude towards a healthy lifestyle was also tested against these questions using the Kruskal-Wallis-H-Test (Kruskal and Wallis, 1952).

The final part of the survey contains personal questions about the respondents including age, sex and level of education as well as parameters that may affect the interviewees capabilities of handling of small mobile devices.

Table 17: Questionnaire

The first questions about previous experiences ask for a school grading rating (excellent, good, satisfactory, fair, poor) for the following activities	
1	Using computers?
2	Using internet web pages in a web browser on a computer?
3	Using mobile phones?
4	Using smartphones?
5	Using other mobile devices?
6	Using internet web pages in a web browser on a mobile phone, a smartphone or on other mobile devices?
7	Using health or wellness related computer programs?
The next questions about the probands’ attitude towards health used a Likert-scale answer (strongly disagree to strongly agree)	
8	I try to lead a healthy life
9	I regularly do sports activities
10	Daily exercise is important to me
11	I am very diet-conscious
12	I regularly check body parameters important for my personal health and wellness

	(body weight, blood pressure, body fat)
13	I regularly attend preventive medical checkups
The following part of the survey uses the Systems Usability Scale (Brooke, 1996)	
14	I think that I would like to use this system frequently
15	I found the system unnecessarily complex
16	I thought the system was easy to use
17	I think that I would need the support of a technical person to be able to use this system
18	I found the various functions in this system were well integrated
19	I thought there was too much inconsistency in this system
20	I would imagine that most people would learn to use this system very quickly
21	I found the system very cumbersome to use
22	I felt very confident using the system
23	I needed to learn a lot of things before I could get going with this system
The second part of the usability questions focused on special aspects of the application	
24	If I was asked to do the same task again tomorrow, I could do it easily
25	It was hard to imagine what the entries in the main menu could mean
26	The meaning of the icons used throughout the system was easy to perceive
27	I used the information function a lot
28	I never felt lost when navigating through the system
29	The information contained in the charts was hard to interpret
30	Navigating the charts (zooming in and out, moving to earlier and later dates) was simple
31	The information contained in the data tables was hard to interpret
32	Entering new data felt cumbersome
33	The health-related feedback about my data provided by the system was useful
34	The functions the system offers can be useful for me
35	Using this system would probably motivate me to lead a healthier lifestyle

Three questions free text questions ask about personal opinions	
36	What did you like most about the application?
37	What didn't you like about the application?
38	Are there any additional features you would want the application to have?
39	If there is anything else you want to say about the application, do so here
Finally three personal questions are asked	
40	How old are you?
41	What's your gender?
42	Handedness
43	Do you use any optical aids?
44	Do you suffer from any form of color blindness?
45	What is your highest education?

4 Results

4.1 Frameworks and technologies

The server side part of the application was developed using the Java programming language¹ (Gosling et al., 2005) and runs under an Apache Tomcat application server.

Spring Framework

The Spring Framework² is an open source framework for the Java platform. It consists of an extensive set of modules providing useful services, especially for developers of mobile web applications. The modules used in the implementation of this project were:

- Inversion of Control Container, allowing advanced handling of the lifecycles of Java objects
- Aspect-oriented programming, a programming paradigm allowing the separation of support functions and business logic (Kiczales, 1996)
- Data access, for working with relational databases and object-relational mapping (ORM) tools
- Model-view-controller, providing an easy way to map incoming HTTP requests to our controller classes

Hibernate

The Hibernate Framework³ is a persistence and ORM tool for the Java platform. It allows mapping Java objects to the data structure of a relational database. This mapping can either be done using XML configuration files or, as we did it in our project, through the use of annotations directly in the code of the affected Java classes. This is the basis of the persistence layer of our server side architecture.

¹ <http://www.java.com>

² <http://www.springsource.org>

³ <http://www.hibernate.org/>

Accessing objects that are stored in the database can either be done using a special query language or by using the Hibernate Criteria-API. We used this API to create the data access layer of our architecture.

Sencha Touch

Sencha Touch⁴ is a HTML5 mobile JavaScript framework which aims at facilitating web applications for mobile devices that have the look and feel of native iPhone and Android applications. It uses object oriented JavaScript running directly in the client's web browser.

The current version is compatible with Apple iOS and Google Android, and applications implemented using Sencha Touch can also be run and tested on desktop PCs using Apple's Safari browser or Google's Chrome.

Google Charts

The Google Charts API⁵ is an easy to use tool for the online creation of charts. In order to create a chart using you need to encode all the parameters defining the chart in a URL and setting this the URL of an HTML image. Since the charts created this way are simple images, they do not support interactivity.

The parameters allowed for creating charts include the type of chart, the data itself, x- and y-axis labeling, legends, scaling, coloring, and chart title. The chart types supported by Google Charts include bar charts, box charts, candlestick charts, line charts, pie charts, and scatter charts.

⁴ <http://www.sencha.com/products/touch>

⁵ <http://code.google.com/apis/chart>

4.2 Prototype Application

4.2.1 Server hardware and software

The web application is running on an Apache Tomcat 6.0.29 web application server using a Java Runtime Environment version 1.6.0_22-b04. The database running on this server was MySQL version 5.0.51a.

The frameworks and Java libraries used by the project were deployed using the following versions:

Table 18: Versions of the deployed frameworks and libraries

Framework / library	Version
Hibernate	3.6.0.Final
Jackson JSON processor	1.6.2
Log4J	1.2.14
Sencha Touch	1.0.1a
Spring Framework	3.0.3

The user study was done using an Apple iPhone 3GS 16 GB running iOS 4.1.

4.2.2 Functionality of the Prototype

Authentication

If a user opens the application for the first time, or if his server session has timed out, a modal login window (Figure 27) will be floating above the main application window. After the user has entered his correct credentials, the login window will be closed and the application is available.

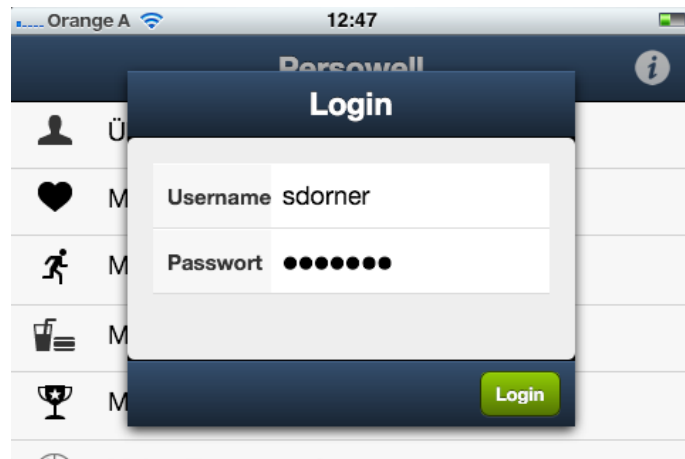


Figure 27: Login window for user authentication

Main menu

The first screen after successful authentication and the main screen for navigating through the application's function is the main menu (Figure 28). The main menu allows the user to access the different modules of the application. The menu consists of the following entries:

- About Myself
- My Wellness Data
- My Sports Activities
- My Nutrition
- My Goals
- My Personal Summary



Figure 28: The main menu

Though it is recommended to run the application in “landscape mode” (holding the mobile device in a way, that the screen’s width exceeds the screen’s height), the screenshot in Figure 28 was done using “portrait mode” in order to have all menu entries on one screen.

The functionality of the modules lying behind these menu entries will be described in the following subchapters.

Toolbar, info button and back button

On top of the screen, a toolbar containing the application name and an info button can be seen. The toolbar will be visible on every page of the application though the number and type of buttons will change depending on the context. The application title can only be seen in the main menu due to the amount of space needed for buttons on other pages. The info button, depicting the common symbol of an encircled letter “i”, is the only button available on all pages. When tapped, a floating window containing addition information about the currently active page will be shown (Figure 29).



Figure 29: The information window

On all pages except the main menu an additional “back” button is displayed in the toolbar. Tapping it will navigate the user back to the previously visited page.

About Myself

In this form the user can enter basic personal data (first name, last name, sex, birthdate, and height). Though all of this data is optional, it is recommended to enter at least birthdate and body height, as these can be used to make evaluations about the user’s wellness status better adapted to the user’s personal needs (Figure 30).

The screenshot shows the 'About Myself' input form in the Persowell app. At the top, the status bar displays 'Orange A', signal strength, Wi-Fi, and the time '12:48'. Below the status bar is a dark blue header with a 'Zurück' button and an information icon. The main content area is a form with the following fields:

Vorname	Stefan
Nachname	Dorner
Geschlecht	männlich
Geburtsdatum	08.11.1976

At the bottom right of the form is a green 'Speichern' button.

Figure 30: Input form "About Myself"

My Wellness Data

If the user navigates to this main menu entry he will be shown a menu prompting him to specify which type of wellness data (body weight, waist-hip ratio, body fat, blood pressure, heart rate) he wants to manage.

Selecting one of these will show a tabular view of all entries of this type the user has entered so far. Depending on the type of wellness data the user has chosen earlier, the type and number of columns shown can vary. Generic, single value data types, such as the currently available body weight, body fat and heart rate, will show three columns: date of entry, value and unit of entry and an optional info button, which will only be shown if evaluation data about an entry exists (Figure 31). Additional lists for showing waist-hip ratio entries (Figure 32) and blood pressure entries (Figure 33) have also been implemented.



Datum	Wert	Info
13.02.2011	75 kg	i
09.02.2011	75.4 kg	i
07.02.2011	75.3 kg	i
06.02.2011	75.7 kg	i
03.02.2011	75.8 kg	i

Figure 31: Generic wellness data table, showing body weight entries

Datum	Taillenum	Hüftumfang	Verhältnis	Info
01.01.201	90 cm	91 cm	0.99	i
15.12.201	89 cm	92 cm	0.97	i
01.12.201	90 cm	93 cm	0.97	i
15.11.201	90 cm	94 cm	0.96	i
01.11.201	91 cm	95 cm	0.96	i
15.10.201	90 cm	94 cm	0.96	i

Figure 32: Table showing waist-hip ratio entries

Datum	Diastolisch	Systolisch	Info
28.12.2010	79mmHg	123mmHg	
26.12.2010	81mmHg	121mmHg	
20.12.2010	80mmHg	127mmHg	
11.12.2010	83mmHg	125mmHg	
09.12.2010	76mmHg	126mmHg	
28.11.2010	80mmHg	127mmHg	

Figure 33: Table showing blood pressure entries

As can be seen in the blood pressure example, evaluation results for the entries from the server application can not only result in an info button showing information text, but can also contain grading information which will be shown using a color scheme based on traffic lights. The possible evaluation grading results “very good”, “good”, “okay”, “bad”, and “very bad” will be represented by the font colors green, light green, black, light red, and red.

New wellness entries can be created by tapping the “writing pencil” button in the toolbar. This will open an empty input form into which the user can enter value and date for the new entry. After successful storage of the new entry on the server, an information window will show a success message. Existing entries can be edited or

deleted by directly tapping on the entry's row. This will open a prefilled input form with a "save" and a "delete" button.



Figure 34: Input form for body weight



Figure 35: Message showing successful creation of an entry

The third button in the wellness entry list view, depicting a symbolized graph, will open a chart displaying the progress of the entered data values over time. The number of days shown in this chart can be chosen out of a set of defined time periods (2 weeks, 4 weeks, 10 weeks, 20 weeks, and 1 year) by zooming in and out of the graph through buttons depicting a plus- and a minus-sign. Buttons showing a left and a right arrow allow the user to move to earlier or later dates.

The range of the y-axis is calculated dynamically by analyzing the data entered for the current timespan. This allows the chart to make best use of the limited available space on mobile device screens. Since the user is not required to enter data for every day, there will probably be many days that will not contain a data points. So data points will only be shown for days containing data. Since these data points are connected by lines, any values between those days can be approximated by the value of the intersection line at the appropriate day. If no data exists for the first and the last day of the observed time period, data points will be calculated by extrapolating to the nearest data entries before and after the period. In addition to the line chart, a trend line, calculated from the data entries shown in the current zoom level is displayed as an additional thin red line. Figure 36 and Figure 37 show charts displaying entered body weight values over a period of 2 weeks respectively 10 weeks.

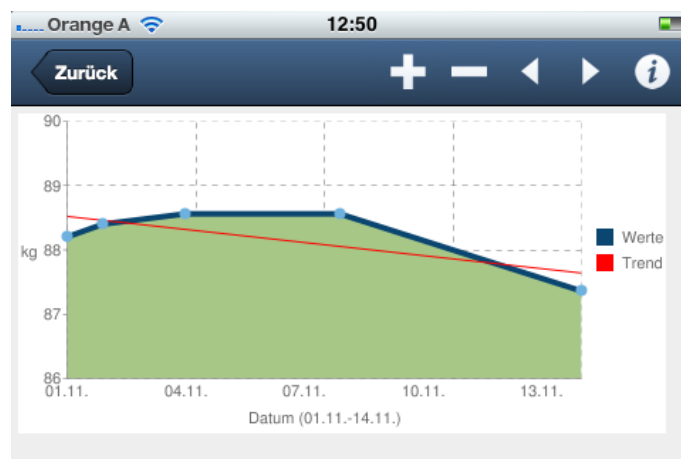


Figure 36: Chart of body weight over 2 weeks

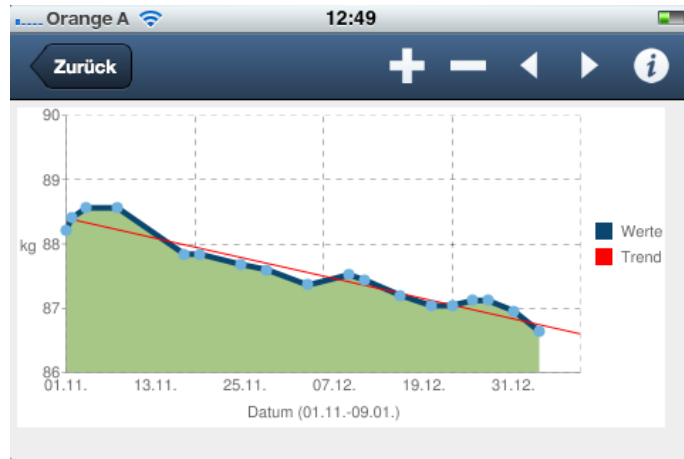


Figure 37: Chart of body weight over 10 weeks

In addition to this above mentioned generic wellness chart type, two additional charts have been implemented as well. The waist-hip ratio chart (Figure 38) shows combined line charts for 3 different values: waist circumference, hip circumference, and the ratio of these circumferences. The first two values are shown as dotted lines, the ratio is shown similar to the value chart for generic values. A trend line for the waist-hip ratio is also rendered. Since the ratio used a different scale than the two circumference values, a second y-axis has been added to the right side of the chart.

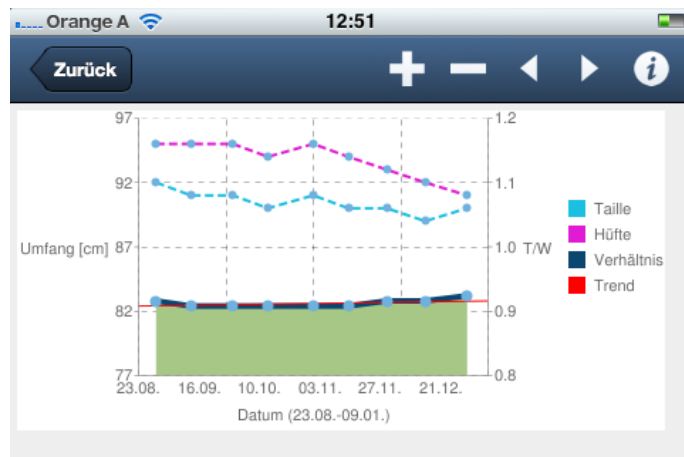


Figure 38: Chart of waist-hip ratio

The chart displaying blood pressure entries shows two combined line charts, one for systolic and one for diastolic blood pressure values. Each of these line charts also has a trend line for its respective values.

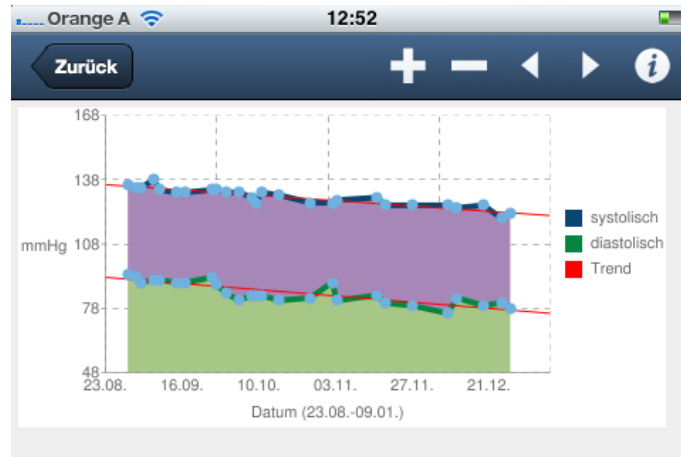


Figure 39: Chart of blood pressure

My Sports Activities

Selecting the main menu entry “My Sports Activities” will navigate to a tabular view showing all sports exercise entries already entered for the current user. This view works similar to the entries table in the wellness data module. The columns shown are the type of sports exercise, the date it was carried out, the duration of the exercise and an estimated calorie consumption value. These calorie values can be estimated using metabolic equivalents (METs), as described by (Haskell et al., 2007).

Sport	Datum	Dauer	Kalorien
Jogging	29.12.2010	60 min	999 kcal
Jogging	22.12.2010	45 min	749 kcal
Walken	18.12.2010	60 min	416 kcal
Jogging	15.12.2010	35 min	583 kcal
Schwimmen	10.12.2010	60 min	843 kcal
Walken	09.12.2010	30 min	208 kcal

Figure 40: Table showing sports exercise entries

Creating new entries and editing and deleting existing entries works similar to previously described wellness entries.

The history of sports activities can also be graphically displayed in a chart (Figure 41). Basically the chart works similar to the wellness charts, with the difference that no trend line is shown and that days, for which no exercise entries exist, are still shown as a data point in the chart having a calorie consumption value of 0. The y-axis ranges from 0 to the rounded up highest calorie value of the currently shown time period.

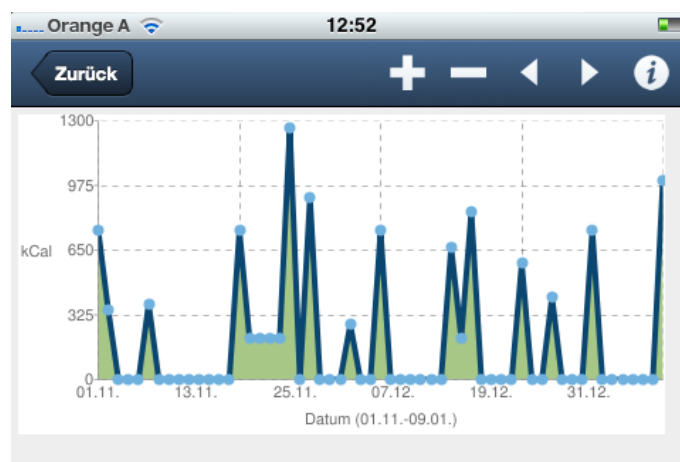


Figure 41: Chart of calorie consumption through sports

My Nutrition

The main menu entry “My Nutrition” takes the user to a tabular view showing information about the users habits regarding water (and diluted fruit juice and tea) and fruit and vegetable consumption. The table shown in this view contains all previously entered data by the user. Again, evaluation information is encoded in the display color of the individual values. Further evaluation information will also be shown, when the user taps the info button.



Datum	Obst/Gemüs	Flüssigkeit	Info
01.01.2011	2x am Tag	1.5 Liter	i
31.12.2010	2x am Tag	2.5 Liter	i
30.12.2010	4x am Tag	2.5 Liter	i
29.12.2010	2x am Tag	1.5 Liter	i
28.12.2010	3x am Tag	1 Liter	i
27.12.2010	3x am Tag	3 Liter	i

Figure 42: Table showing daily water as well as fruit and vegetable consumption

My Goals

This main menu entry opens a page containing a list of all currently active goals and a second list showing all already achieved goal for the user. Each goal consists of an icon depicting the type of goal (wellness, sports, nutrition) and a description of the goals target. Achieved goals also show a virtual medal awarding for the achievement. Tapping the “new goal” button, which shows the writing pencil again, will open a list of goals recommended by the application, from which the user can choose a new goal to add to his list. These recommended goals cover all types of goals (all adequate wellness types, calorie consumption through sports activities, daily water consumption, and daily fruit and vegetable consumption) and a range of goal difficulties for each type. Every recommended goal also shows a medal which will be awarded to the user after he has completed it. The medal chosen for these goals depends on the goal’s type and also reflects its difficulty.

Every time the user logs on and every time the user changes his wellness, sports or nutrition data, all currently active goals will be checked by the application, whether they have been completed. If this is the case, an info window will open, congratulating the user on his achievement.



Figure 43: Active and achieved goals



Figure 44: Recommended new goals

My Personal Summary

The last entry in the main menu opens a picture summing up evaluations on all of the users current wellness, sports, and nutrition entries. Each of the evaluated categories is represented by an icon. The color of this icon represents a grading result of the evaluation, similar to the color scheme of a traffic light (green for good results, yellow for okay results, and red for bad results). Additional information for each category is given in a few short below the image. This page aims to give the user an at a glance overview of his personal wellness status and efforts.



Figure 45: Personal summary page

4.3 Usability Study

4.3.1 Questionnaire

4.3.1.1 Description of the sample

20 persons were invited to carry out the usability test and answer the subsequent survey. The participants' age ranged from 14 to 43 years ($M=28.60$, $SD=14.804$), 8 were male 12 female. Table 19, Table 20 and Table 21 show their affiliation to age, education and gender groups. The attendees' estimated previous experience in using various technologies that may have an impact on their performance with our mobile wellness application is shown in Table 22.

Table 19: Test users' affiliation to age groups

Age group	Absolute frequency	Relative frequency
14 – 19 years	6	30%
20 – 29 years	5	25%
30 – 39 years	5	25%
40+ years	4	20%

Table 20: High education of the test users

Highest education	Absolute frequency	Relative frequency
Still attending school	5	25%
Apprenticeship	2	10%
Secondary school (Austrian AHS and BHS)	5	25%
Higher education	8	40%

Table 21: The users' gender

Gender	Absolute frequency	Relative frequency
Male	8	40
Female	12	60

Table 22: Previous experiences of the test users

Experience / grading	Excellent	Good	Satisfactory	Fair	Poor
Computers	40% (8)	40% (8)	20% (4)	0%	0%
Web pages	55% (11)	35% (7)	10% (2)	0%	0%
Mobile phones	35% (7)	40% (8)	15% (3)	5% (1)	5% (1)
Smartphones	10% (2)	15% (3)	30% (6)	25% (5)	20% (4)
Other mobile devices	5% (1)	40% (8)	20% (4)	15% (3)	20% (4)
Mobile web pages	10% (2)	35% (7)	10% (2)	15% (3)	30% (6)
Health software	5% (1)	5% (1)	25% (5)	25% (5)	40% (8)

Table 23: Probands' attitude towards a healthy lifestyle

Attitude / compliance	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Try to lead a healthy life	0%	15% (3)	15% (3)	65% (13)	5% (1)
Regularly do sports	25% (5)	20% (4)	15% (3)	20% (4)	20% (4)
Daily exercise is important to me	5% (1)	20% (4)	20% (4)	35% (7)	20% (4)
Diet-conscious	0%	15% (3)	25% (5)	60% (12)	0%
Regularly check body parameters	25% (5)	25% (5)	20% (4)	25% (5)	5% (1)
Regularly attend medical checkups	30% (6)	20% (4)	5% (1)	25% (5)	20% (4)

4.3.1.2 Time needed to complete the tasks

The average time needed to complete the tasks given to the users in the usability study was at 12 minutes 14 seconds (SD=03:08). Figure 46 shows the time in minutes for each of our test users.

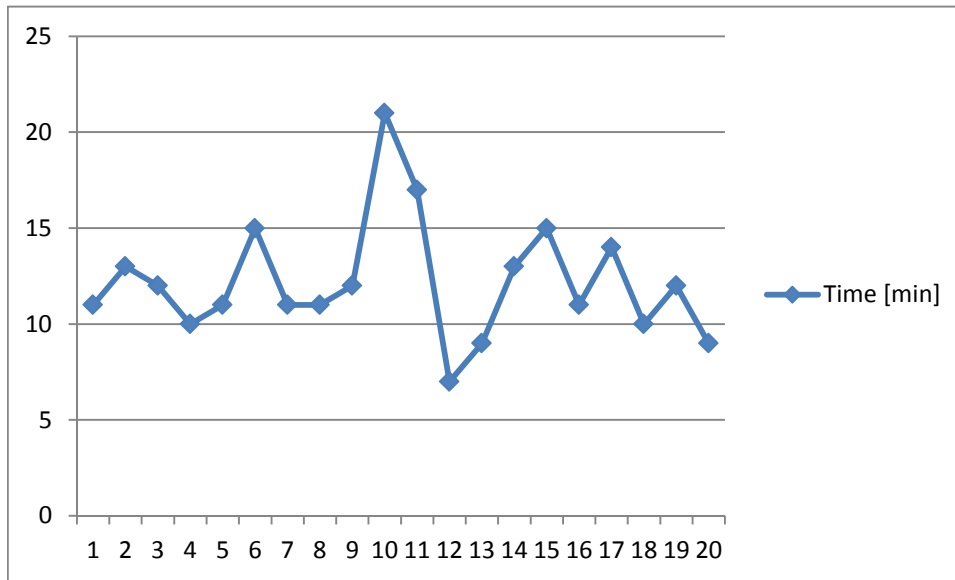


Figure 46: Time needed to complete the tasks per user

4.3.1.3 System Usability Scale

The mean SUS rating calculated from the individual ratings of the 20 respondents was at 83.75 with a standard deviation of 12.126 (Table 24). According to the SUS rating scale by (Bangor et al., 2008) this is a very good result, lying in the “acceptable” range of the acceptability ranges and just below the “excellent” adjective rating. The position of the SUS result within this scale is shown by the red line drawn over the SUS rating scale (Figure 47).

One-way analysis of variance (ANOVA) showed no statistically significant influence of age group, education, previous experience with various technologies or attitude towards a healthy life on the resulting score of the SUS. An independent sample T-test also showed no influence of gender on the SUS results.

Table 24: System Usability Scale ratings

	n	minimum	maximum	mean	standard deviation
SUS rating	20	57.5	97.5	83.75	12.126

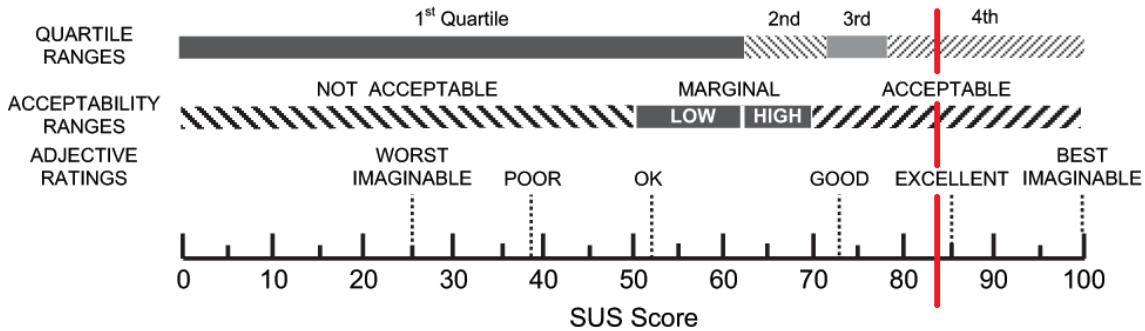


Figure 47: SUS rating of the application, drawn over the SUS rating scale by (Bangor et al., 2008)

4.3.1.4 Additional usability questions

In addition to the 10 questions from the SUS, 12 usability questions addressing application-specific topics were asked as well. These were also constructed using statements that could be rated using the same Likert-scale as in the SUS part. Table 25 shows the measures of central tendency and the measures of dispersion that were obtained through descriptive statistics of these questions. The relative and absolute frequencies of the different levels of agreement to the questions can be seen in Table 26.

Table 25: Descriptive statistics of the additional usability questions

Question / measure	Median	Mode	Range	Inter-quartile range
Could do it easily again tomorrow	5.0	5	1	0.00
Hard to interpret main menu items	1.0	1	2	0.00
Easy to see meaning of icons	4.0	4	2	1.00
Used info often	2.0	1	4	1.75
Never felt lost in navigation	4.0	4	2	1.00

Charts were hard to interpret	1.0	1	3	1.00
Chart navigation was simple	4.0	5	3	2.00
Data tables were hard to interpret	1.0	1	2	1.00
New data entry was cumbersome	1.0	1	3	1.00
Health-feedback was useful	4.5	5	3	1.00
System functions useful for me	4.5	5	4	1.00
System motivates to healthy lifestyle	3.0	4	4	2.00

Table 26: Relative and absolute frequencies of the additional usability questions

Question / Acceptance	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Could do it easily again tomorrow	0%	0%	0%	10% (2)	90% (18)
Hard to interpret main menu items	80% (16)	15% (3)	5% (1)	0%	0%
Easy to see meaning of icons	0%	0%	15% (3)	45% (9)	40% (8)
Used info often	45% (9)	30% (6)	10% (2)	10% (2)	5% (1)
Never felt lost in navigation	0%	0%	5% (1)	50% (10)	45% (9)
Charts were hard to interpret	60% (12)	30% (6)	5% (1)	5% (1)	0%
Chart navigation was simple	0%	10% (2)	25% (5)	20% (4)	45% (9)
Data tables were hard to interpret	55% (11)	40% (8)	5% (1)	0%	0%
New data entry was cumbersome	65% (13)	25% (5)	5% (1)	5% (1)	0%
Health-feedback was	0%	15% (3)	0%	35%	50% (10)

useful				(7)	
System functions useful for me	5% (1)	0%	15% (3)	30% (6)	50% (10)
System motivates to healthy lifestyle	5% (1)	25% (5)	10% (2)	40% (8)	20% (4)

These 12 usability questions (see Table 17 for a list of the questions) can be roughly grouped into three categories: ease-of-use, understandability and the user's interest in the application's features. Figure 48, Figure 49 and Figure 50 show grouped bar charts displaying the absolute frequencies of the different agreement levels the respondents showed on the questionnaire statements in the categories. When interpreting these charts the reader has to be aware that, in order to avoid acquiescence bias, the questions alternate between "usability positive" and "usability negative" statements. While one statement may say that a feature is difficult to use, the next statement may say that another feature is easy to use. Central tendency bias, which is the case when respondents tend to avoid either agreeing or disagreeing, was not a problem with these questions, in fact only 8.3% of all answers given to those 12 questions stated that the respondent "neither agreed nor disagreed" with the statement.

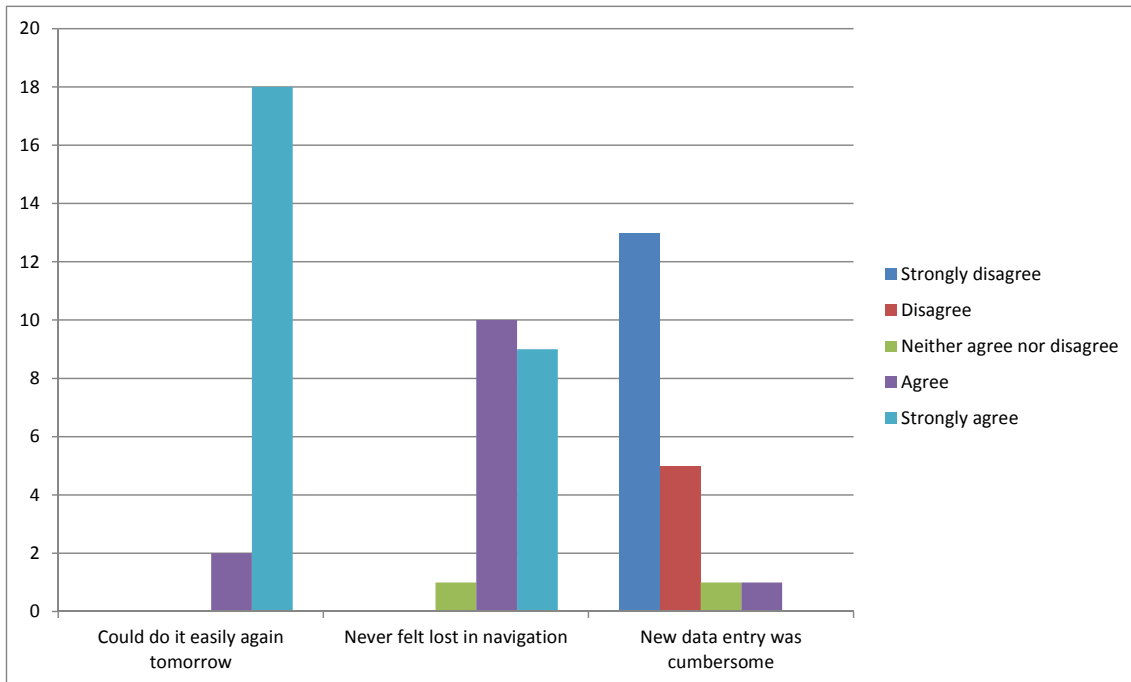


Figure 48: Absolute frequencies of agreement levels for ease-of-use statements

As can be seen in Table 26 and Figure 48, all of the users thought that they could easily complete the tasks given to them, if they were asked to do so again on the next day. The level of agreement to this statement was strong for 90% of the participants. This already indicates that the application was perceived as easy-to-use, which is further backed up by the number of times users stated “ease of use“ as a point in the free text question on what they liked about the application. Even though there were some elements some users had problems finding, their position and functionality seemed to be logical enough to be remembered for the next time.

Though chart navigation was seen as simple by a majority (65%) of the respondents, the results are not as clear as for the other ease of use statements. When asked to make the diagram show several months at once, the intended use of the zoom function was not conducted by all users. While some rather used the paging buttons instead, others interpreted the “+“ and “-“ buttons in a different way, namely that “+“ means “show more months“ instead of “zoom in“ and vice versa for “-“.

When asked whether entering new data felt cumbersome, 90% of the test users disagreed, the majority of them strongly. As has been stated in the free text questions, manually entering data every day can generally be an arduous task, and thus much emphasis has been placed in making the input form very simple. Some users still had issues with the select box input element which allows the user to scroll to the appropriate item and then choose it by pressing the “done“ button. Some users, who had no or small experience with smartphones, had to experiment with the widget until they found out that they could scroll to the desired item. Some users tried to tap the item in order to choose it, instead of pressing the done button.

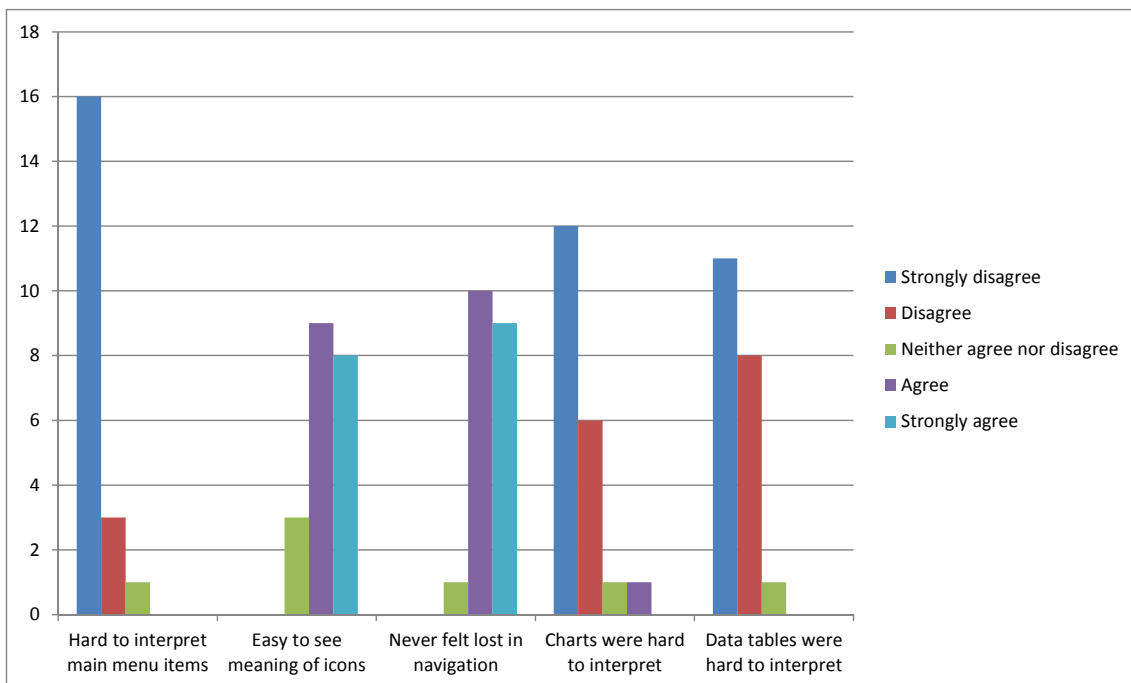


Figure 49: Absolute frequencies of agreement levels for understandability statements

The main menu items (also see Figure 28) were generally regarded as easy to interpret. As can be seen in Figure 49 90% of the respondents strongly disagreed to the statement saying that these were hard to interpret. The combination of icons and text allows the users to cross-check their interpretation of these two information types with each other. Once the users know about the structure and functionalities of the application, the icons allow for very quick navigation through the main menu. As one interviewee stated,

using the test device in landscape format demands the users to scroll down in order to reach the last item of the main menu.

When asked whether the meaning of the different icons in the application was easy to see, a majority of the users (85%) agreed. Still, when compared to other understandability items, the response was not that strong. While the icons shown in the main menu also had additional text next to them, the icons in the toolbar (as can be seen in Figure 31 and Figure 36) had to stand for themselves. While the info button “i” was easy to make out, several users had problems finding the “new entry” button, displaying a writing pen. Fewer users had problems finding the diagram button, which displays a simplified line chart. Two users suggested that a simplified bar chart might be easier to recognize as a diagram function. Overall the buttons in the toolbar were one of the main usability problems and should be reviewed in a next iteration of the application. One solution might be to show a small text, or rather a word, below each of these buttons, describing their functions.

When asked whether they felt lost at some time when navigating through the application, 95% of the respondents said that they did not feel so, though only half of them expressed their agreement level as strong. The “back“ button, which is available on every page except the starting main menu page allowed the users to quickly track back their steps, even if they misclicked or didn’t exactly know where they were. Due to this “way back“, which was always visible, a feeling of being lost did not come up often.

The charts were generally considered as easy to interpret (90% disagreement to negative statement). While the meaning of the weight chart was clear for all users, the informative value of the exercise chart was not seen by all users at first glance. After telling the users the information which was also given by the existing, though rarely used information window, the meaning of the exercise chart was also understood by all users. One user also thought that the width of the lines and the data points in the charts was too large.

The data tables were seen as easily interpretable as well (95% disagreement to negative statement). While the data displayed in the table cells themselves was understood by all users, several users had scrolled down or re-sorted the table when they explored the application at first, and had difficulties finding the most recent data afterwards.

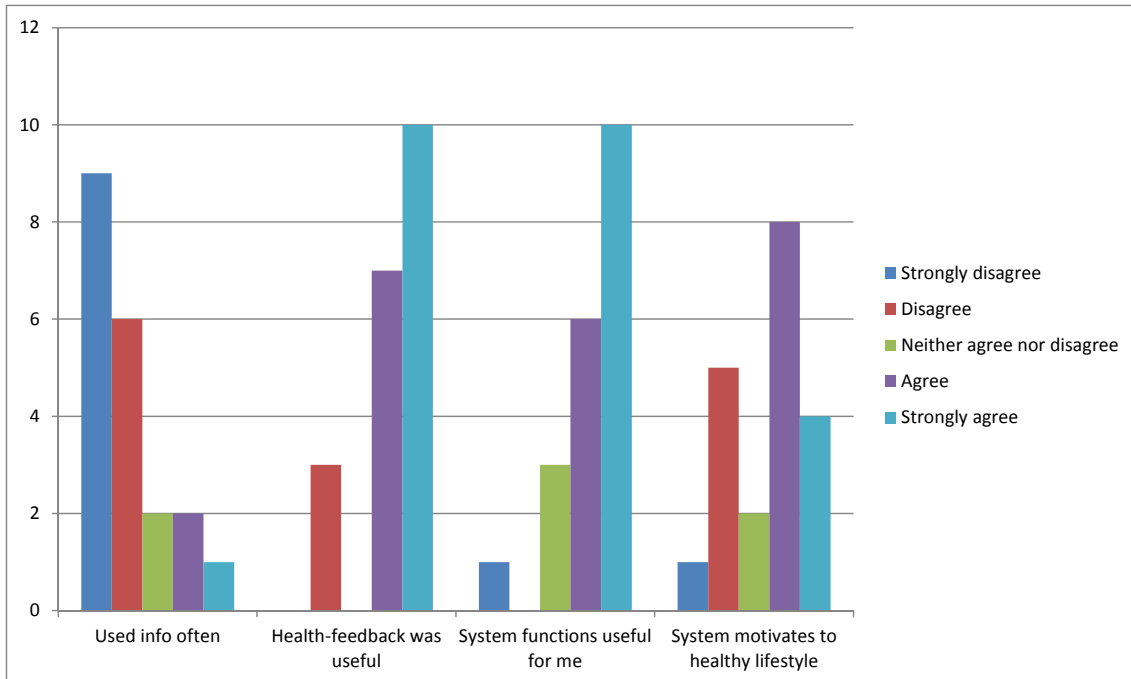


Figure 50: Absolute frequencies of agreement levels for user's interest in application features statements

When asked about their habits regarding usage of the information / help function, only 15% stated that they did use it, while 75% said they didn't. Several users accidentally opened the help window when trying to find the "new entry" button, but they did not read the information provided and closed the window again.

When asked whether the health-related feedback provided by the application was seen as useful, 85% of the users agreed while 15% disagreed. In their test tasks the users had to view and interpret several kinds of feedback. After entering their daily fruit and water consumption they were asked about the application's feedback. While the application offers two kinds of immediate feedback (color coding of the table row and an additional information button for each table row), the information button was generally seen as

providing the better information. One user stated that the color coding (green for good behavior, red for not so good behavior) seemed intuitive, but when he looked into the help window for assurance, the color codes were not explained. As several users stated in the open text questions section, the overall summary provided by the application, which includes color coded icons located around a large image of the human body and several short feedback statements (see Figure 45) was seen as a good feature of the application. One missing feature of this function was soon recognized as important, as many users tried to tap the color coded icons in order to receive additional feedback (which was located further down on the page). Future iterations of the development will have to add tap functionality to these icons, opening a popup window with the appropriate feedback text.

The functions and features provided by the wellness application were seen as potentially useful by 80% of the interviewees. Only one person disagreed to this statement, 3 remained neutral. Still 30% of the respondents thought that using the application would not motivate them to lead a healthier life. They stated that they did not think a computer program could change the way they lead their life by such an amount, that they would achieve a healthier lifestyle.

Gender showed no significant effect on the results of any of these 12 usability questions when tested using the Mann-Whitney-U-Test (Mann and Whitney, 1947). Affiliation to age group, education, previous experience with various technologies and attitude towards a healthy lifestyle also showed no significant effect on the results of the usability questions when tested using the Kruskal-Wallis-H-Test (Kruskal and Wallis, 1952).

4.3.1.5 Open questions

The interviewees also had the chance to comment on what they liked and what they didn't like about the application and also to suggest improvements and give any additional thoughts they had on the application.

Four interviewees regarded the general idea of the wellness application with favor. Two persons especially liked the general concept behind the application, that a healthy lifestyle can be attained using very simple means. Another respondent thought that the application's features covered the most important aspects of a healthy lifestyle.

The most frequently conveyed positive impression about the application was that it was easy to use. 12 respondents added this point to the question on what they liked about the application. This corresponds well to the high SUS score of 83.75. The clearly arranged layout and the clearness of the interface were also mentioned by 4 test users.

Three users liked the layout of the application well enough to add this to the points they especially liked about the application. This stands in contrast to the four users who weren't fully satisfied with the layout. While the positive statements about the layout were stated in a rather general way, the negative statements mentioned certain aspects of the design. Two users didn't like the look of the diagrams (confusing, lines and data points width was too large); one user would have preferred a more colorful design and one user didn't approve the fact that the layout tended to be very iPhone-centric. Two users criticized points they didn't like about the layout, namely that the main menu didn't fit on one screen and the last item had to be reached by scrolling down, and that the input form for entering blood pressure data didn't look good due to a line break inside the text labels of the input elements.

Two negative usability aspects were mentioned by several users. Seven users found the buttons in the toolbar too small and had problems tapping the correct ones. During the usability test they often tapped the button located to the right of the intended button unintentionally. Another negative aspect several users noticed was the tapping response of the application. As the wellness application was a web application, running in the mobile phone's internet browser, the application didn't react to tapping as reliably and as speedily as a native mobile app. This was amplified by the effect that some actions required the web application to load data from the server leading to a lag time after the tap.

Four users stated problems finding or understanding special features and functions of the application. One user understood the traffic light color coding of the application feedback, but when he wanted to look into the application help to make sure he was right, the color coding wasn't explained there. When tapping on items in the main- and submenus one user stated that he wasn't sure whether he could tap the whole row or whether he was required to tap at the text itself. Though only one user stated, that he didn't find the input form for entering new data easily, during the experiment several users were observed having the same problem. One user also stated that he didn't fully understand the summary graphics at first. Several users tried to tap the symbols in the summary graphics, but they were not linked to an action.

Various features of the application were mentioned as points the respondents liked especially about the application. Seven users mentioned the feedback summary page, two generally liked the various feedback provided by the application, three liked the idea of medals as rewards for achieved goals, two test users stated that the diagrams were a feature they liked especially well and one interviewee mentioned the automatic calculation of calories for exercise entries.

Many users also suggested additional features they would like such a wellness application to provide. The features suggested were manual creation of goals, medication monitoring, planning and managing the visits of physicians, injury management, cooking tips, additional information about healthy nutrition, appointments and reminder messages, an exercise planner, the possibility to enter several exercise activities at once, synchronization with sensor devices, and a printing function.

When asked about any further thoughts about the application they like to convey, three users stated that they liked the general idea of the application, two persons said that they found the application fun to use and two respondents liked the technical abilities of the application.

5 Discussion

The test results for our wellness promoting web application for mobile devices show very good usability regarding to its System Usability Scale (SUS) score. The score value of 83.75 can be seen as an “excellent” result when using the SUS scale provided by (Bangor et al., 2008). This good usability score is also supported by the acceptance levels for the 12 additional usability statements in our questionnaire.

Answers from the open questions show that the test users especially appreciated the ease-of-use of the application. Since we followed the design guidelines for mobile devices provided by (Holzinger and Errath, 2007) and by (Rabin and McCathieNevile, 2008) as well as the design goals for applications supporting behavior change by (Consolvo et al., 2009) right from the beginning of the project, it was possible to plan the features of the application in a way that conformed to these guidelines. This resulted in a very simple and easy to use interface. The good usability score also supports our decision to use modern rich internet application technologies for the implementation of the system. Since these technologies are just emerging for mobile devices (Sencha Touch version 1.0 was released by the end of 2010, the implementation of our application started when the framework was still in its beta phase), this shows that such technologies can be a good choice if you want to reach a broad audience through mobile devices.

Our results also show that such a wellness application has the potential to reach a broader audience, since 80% of our respondents thought that the application’s features might be useful for them and 60% of the test users believed that the application might help them in leading a healthier life.

We did not find any influence of age on either the perceived usability or on the willingness to use the application. Though initially aimed at a target group of adolescents, the application suits older people (within the age range of our sample) just as well. Neither did preceding knowledge about using computers, web applications or

smartphones influence the results nor did the attitude about the importance of leading a healthy life do so. This suggests that the possible target group for the application is a very broad one. Still, even though experience in using smartphones did not influence the results, people who do not own such a device can only access the application using special web browsers (Apple Safari, Google Chrome) on their home computer, a target device on which we have not tested the application yet. Furthermore, while people who don't estimate a healthy lifestyle as high as other still seemed to like the application just as well, they will still be a target group which is more difficult to reach, since they might lack the motivation to start using such an application in the first place.

While the usability was generally estimated as very good, there are still some important issues that came up during the tests and the open questions. The issue most annoying to many users was that the buttons in the toolbar and the gaps between them were too small. Also some users had problems identifying the meaning of those icons. While this is a very serious problem for the users, there are easy solutions to fix it. Future versions of the application will come with larger toolbar icons, larger gaps and a short textual description of the item's function below them.

Another important issue was the reaction time and sensitivity of tapping. While part of the longer reaction time comes from the underlying functionality of the browser and the performance difference to native apps, another part came from the time needed to send commands to and receive data from the server. As the users' main problem with the higher reaction time was that they did not know whether their tap was recognized by the application, a simple solution to this problem might be to add a "progress in work" image whenever communication with the server is required. Such images often show a rotating ring and are already quite common on mobile devices. It might also be beneficial to evaluate different client side libraries that can be used as an alternative to Sencha Touch and might offer better performance.

A feature several users wished for was an "on tap" reaction on the symbols offering immediate feedback on the summary image. Future versions of the application might

open a text popup showing the appropriate part of the information which is currently shown further down on the summary page.

Since the feedback regarding the design of the application was partially positive and partially negative, we will consider offering personalized designs in future versions of the application. Users might be allowed to switch between different styles, thereby changing color palettes, icons and images and the looks of the diagrams. We will also consider allowing users to modify some of these features themselves.

Several additional features were suggested by the users, though only one was suggested by two users, the others were only wished for by single users. This one feature was the possibility for users to manually create goals instead of selecting them from a list suggested by the application. An evaluation of the efforts and benefits of these features will be necessary before we can decide which ones will be implemented in future releases of the application.

The good response on the summary feedback and the medal rewards also shows us that motivating users through positive and informative feedback is a good way to go. Thus, motivational and information features should play a very important role in future versions of the application.

6 Conclusion

In this work we designed and developed a web application for mobile devices with the aim to promote a healthy lifestyle. The goal of such an application is to support early prevention of chronic diseases, which can be the result of unhealthy behavior. While several other health related applications already exist, we tried create a new experience by combining features from health, sports and nutrition applications with a motivating system of goals and rewards and the possibility of creating feedback that considers all these different sources of information as a whole. Technologically we also took a new approach by using rich internet application (RIA) technologies for mobile phones instead of implementing the system as a native application.

Our usability study produced several promising results. Applying the System Usability Scale showed us that the application received very good usability scores from the test users. The respondents especially mentioned the ease-of-use and the straightforwardness of the user interface as aspects they liked about the application. The most popular feature of the application was the summarizing feedback page, which takes all entered data and information (health parameters, exercise and nutrition information) into account and creates a short but meaningful graphical and textual summary of the users evaluated wellness status. Another feature that was well liked by the users was the goal-reward system, handing out virtual medals for achieved personal wellness goals.

Among several minor usability problems, including small buttons and button separation distances as well as on tap reactions in the graphical summary, which will be addressed in the next version of the application; one issue will need to be looked into more deeply. This regards the sensitivity of the system to user taps. In order to solve this issue we will need to evaluate several workarounds like local data storage and the addition of a “work in progress” icon, but we will also have to evaluate new browser technologies. Since mobile RIA technologies are an emerging field, we expect that much development will be conducted in this area within the next months and years.

While we concentrated at a target group of adolescents when developing the application, our user study showed that age had no significant influence on the motivation to use the application or on the perceived usability of the application. We will take this result into account when designing new features, by making them either optional or by making them suitable for all age groups.

7 Business Case

Development, maintenance, updating, support and user training require a good financial basis in order to successfully implement this project. This chapter explores possible business cases for our personal wellness web application for two different types of beneficiaries.

7.1 Private persons

Private persons are people who would use the application for themselves or for their families. Personal well-being for oneself and for one's family is one of the most important endeavors for many people. Still they often lack the initial motivation to change their lifestyle. As our user study showed, many people see the potential of our wellness application to motivate them to a healthier lifestyle and think that the features offered by it can be useful for them.

Since the fees private persons are ready to pay for a personal wellness application will probably be very limited, a large customer base will be needed in order to fund the project. Many people who might give the application a try will be discouraged to do so if they have to pay a fee for a product which doesn't give them an immediate merit, but rather does so in the long run. An interesting payment model for this target group would be a free version of the application, which offers access to a limited variety of features, but can be upgraded to a full version by paying a monthly fee. Asking for a monthly fee instead of a single payment decreases the initial financial impact and better suits the purpose of the application which is to accompany its users over a long term in order to promote a permanent change in one's lifestyle. Additional features that require the full version may include integration of data from various health data providers, professional feedback or personalized features.

Risks accompanying this strategy are that growing a large user base may be a difficult task, because people must first be convinced of the advantages of using the wellness application. Concerns regarding the passing of private health data may also be an issue in this case. Though monthly fees are better suited for a project that will continuously be improved, financial means in the initial phases after releasing the project will be lower than with a single payment model.

7.2 Health insurance companies

As stated by (Chini and Dorner, 2010) adopting preventive measures will save our health insurance companies a lot of money in the long run. These companies also have the means to finance the development of the application in a reliable way.

Health insurance companies can also leverage their influence on physicians so that these can convey information about the application to their patients and encourage their patients to use the application. While the financial advantages for the health insurance companies are easier to perceive, physicians will not see an immediate advantage for themselves. The physicians might be taken on board by offering them financial incentives for every patient convinced to use the wellness application.

Compared to the private persons option, trying to use health insurance companies as customers may have a higher risk of not being able to complete the project at all, because there are less nuances of success – either the health insurance companies will agree to finance the project or they will not compared to a higher or lower number of paying private customers.

8 Future Work

Since long-term motivation of users is one of the main goals of wellness promoting applications, long-term user studies with a functional application will lead to interesting insights into how motivating the current features of the application are in the long run. Another important aspect that can be examined is in what extend people using the wellness manager will be able to improve towards a healthier lifestyle.

Resolving the main usability issues discovered during our user study should have very high priority in our near future development work. These include positioning, size and labeling of the toolbar buttons, sensitivity to tapping events and the application's reaction to a tapping event in the summary graphics.

Our user study also resulted in a list of new features that the respondents desired. The features in this list will have to be evaluated regard their effort and benefits as well as their compliance with our future design goals and possible strategies for further development.

Additional features concentrating on hedonic aspects (Alagöz et al., 2010) and making the application more fun and enjoyable to use should also be examined. As the importance of social networking and social gaming is becoming increasingly important, especially for the younger generations, we can try to learn from these concepts and integrate promising features into the application. Such features can include creating individual groups in social networks, where networks of friends using the application together can share their goals and achievements. Other possibilities include linking goal achievement rewards to small rewards in massively multiplayer games, while at the same time keeping the main motivation of the users on improving themselves instead of just using the application in order to gain virtual rewards.

While exploring new possible features is an important goal, those features that are already implemented and were rated as the users' favorite ones should be carefully

improved in order to make them the application's figurehead and unique selling point. According to the results of our user study, these features should be the summarizing feedback page and the goal-reward system.

Already many web browsers installed on mobile devices support the Geolocation API⁶ drafted by the W3C allowing web applications to use global positioning system (GPS) data. Recently the new DeviceOrientation Event Specification⁷ has also been released by the W3C promising accelerometer and gyroscope support. This information can be utilized by the application to enable automatic tracking of many different kinds of sports, thus simplifying the input of exercise data.

Rich internet applications for mobile devices are still in their children's shoes. Sencha Touch, the framework for implementing the client part of the application has just recently been released as a stable 1.0 version. Most alternative frameworks haven't reached this stage yet. This area will progress very quickly within the next years, minimizing the differences between web applications and native apps. In order to further follow our design goal of creating an aesthetic application, we will have to adapt the application to the new possibilities which will rise from these developments.

While this application was developed mainly for smaller mobile devices, especially for mobile phones, larger mobile devices including the currently very popular tablet computers offer new possibilities for wellness applications. While keeping some of the advantages of mobile phones including increased mobility and highly developed touchscreens they also overcome some of their limitations, especially by offering a much larger screen. Adapting the application and its usability to these devices promises to be a very interesting task.

⁶ <http://dev.w3.org/geo/api/spec-source.html>

⁷ <http://dev.w3.org/geo/api/spec-source-orientation.html>

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Appendix A – German version of the task list for the usability study

1	Verschaffe dir einen Überblick über das Programm und die Funktionen des Hauptmenüs.
2	Nimm dir etwas Zeit, um dich im Programm und seinen Bedienelementen umzusehen bis du glaubst zu wissen, was man mit dem Programm machen kann.
3	Überprüfe ob deine korrekt eingetragen sind.
4	Dein Geburtsdatum scheint falsch eingetragen zu sein, ändere es in 1984.
5	Du hast heute Morgen dein Gewicht (75 kg) und deinen Blutdruck (120/79) gemessen. Da du jetzt etwas Zeit hast, trage diese Daten ein.
6	Überprüfe, ob die eingetragenen Daten korrekt gespeichert wurden.
7	Dir wurde gesagt, dass du dir dein Gewicht und dessen Trend auch grafisch in einem Diagramm anzeigen lassen kannst. Schau dir das an.
8	Du siehst hier den zeitlichen Verlauf deines Gewichtes. Wie groß ist der Zeitraum, den du hier siehst?
9	Nun interessiert dich noch dein Gewicht während der letzten Monate.
10	Gestern Abend warst du eine Stunde schwimmen. Trage diese Information ein.
11	Wie viele Kalorien hast du während dieser Stunde verbraucht?
12	An wie vielen Tagen hast du während des letzten Monats Sport betrieben?
13	Du weißt, das es gesund ist, täglich mehrere Portionen Obst und Gemüse zu essen, und dass man ebenfalls zumindest 2 Liter Wasser oder verdünnte Fruchtsäfte und Tees zu trinken. Da du dich bemühst, gesund zu leben, versucht du das auch bewusst so zu tun. Gestern hast du leider nur einen Apfel und eine Tomate gegessen und etwa 1.5 Liter Mineralwasser getrunken. Gib diese Information ein.
14	Sagt dir das Programm, ob das gut oder schlecht ist?
15	Um dich ein wenig zu motivieren, hast du dir bereits einige Ziele im Programm gesetzt. Sieh dir diese noch einmal an.
16	Du glaubst, es ist Zeit für ein weiteres Ziel. Leg dir eines zu.
17	Du hättest gerne eine zusammenfassende Bewertung über alle deine eingegebenen Daten. Was sagt das Programm dazu?

Appendix B – German version of the questionnaire

1. Wie schätzt du deine bisherige Erfahrung in folgenden Tätigkeiten ein?

(1=sehr gut, 2=gut, 3=befriedigend, 4=genügend, 5=nicht genügend)

	1	2	3	4	5
a. Benutzung von Computern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Benutzung von Internetseiten mit Webbrowsern	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Bedienung von Mobiltelefonen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Bedienung von Smartphones	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Bedienung anderer mobiler Geräte	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Benutzung von Internetseiten mit Webbrowsern auf Mobiltelefonen, Smartphones oder anderen mobilen Geräten	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g. Verwendung von Computerprogrammen, die mit Gesundheit oder persönlichem Wohlbefinden zu tun haben	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. Wie sehr treffen folgende Aussagen auf dich zu?

(trifft gar nicht zu, trifft eher zu, weder noch, trifft eher nicht zu, trifft völlig zu)

	Trifft gar nicht zu				Trifft völlig zu
a. Ich bemühe mich, ein gesundes Leben zu führen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Ich treibe regelmäßig Sport	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Tägliche Bewegung ist mir wichtig	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Ich achte auf eine gesunde Ernährung	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Ich überprüfe regelmäßig für meine Gesundheit wichtige körperliche Werte (Gewicht, Blutdruck, Körperfettanteil)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Ich gehe regelmäßig zur Vorsorgeuntersuchung	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Anschließend einige allgemeine Fragen zum Programm:

		Trifft gar nicht zu			Trifft völlig zu	
a.	Ich denke, dass ich dieses Programm gerne regelmäßig benutzen würde	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b.	Ich fand das Programm unnötig komplex	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c.	Ich empfand die Bedienung des Programms als einfach	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d.	Ich glaube, dass ich die Unterstützung eines Technikers benötige, um mit dem Programm zu arbeiten	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e.	Ich finde, dass die verschiedenen Funktionen des Programms gut aufeinander abgestimmt sind	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f.	Ich finde, es gibt zu viele Inkonsistenzen/Widersprüche im Programm	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
g.	Ich kann mir vorstellen, dass die meisten Leute die Bedienung des Programms sehr schnell erlernen würden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
h.	Ich empfand das Programm sehr umständlich zu bedienen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
i.	Ich fühlte mich sehr sicher in der Bedienung des Programms	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
j.	Ich musste sehr viele Sachen lernen, bevor ich beginnen konnte, das Programm zu verwenden	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
k.	Wenn ich die Aufgaben morgen noch einmal durchführen müsste, wäre das für mich sehr einfach	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
l.	Unter den Einträgen im Hauptmenü konnte ich mir nur sehr wenig vorstellen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
m.	Die Bedeutung der einzelnen Icons/Symbole im Programm war einfach zu erkennen	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
n.	Ich habe die Informations-Funktion oft benutzt	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
o.	Beim Navigieren durch das Programm habe ich mich nie verloren gefühlt	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
p.	Die aus den Diagrammen hervorgehenden Informationen waren schwierig zu interpretieren	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
q.	Die Navigation in den Diagrammen (zoomen, zu früheren und späteren Daten zu wechseln) war einfach	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

		Trifft gar nicht zu			Trifft völlig zu	
r.	Die aus den Daten-Tabellen hervorgehenden Informationen waren schwierig zu interpretieren	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
s.	Die Eingabe neuer Daten kam mir umständlich vor	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
t.	Ich fand das gesundheitsbezogene Feedback des Programms über meine Daten interessant	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
u.	Die Funktionen, die das Programm bietet, könnten mir nützlich sein	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
v.	Wenn ich dieses Programm verwende, würde mich das vermutlich zu einer gesünderen Lebensweise motivieren	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Was hat dir am Programm besonders gut gefallen?

1. _____
2. _____
3. _____

5. Was hat dir am Programm weniger gut gefallen?

1. _____
2. _____
3. _____

6. Was würdest du dir von diesem Programm noch wünschen?

1. _____
2. _____
3. _____

7. Alles was du sonst noch über das Programm sagen willst, kannst du hier festhalten.

Abschließend noch paar allgemeine Fragen zu deiner Person:

8. Wie alt bist du? _____

9. Was ist dein Geschlecht? männlich weiblich

10. Händigkeit? Rechtshänder Linkshänder

11. Benutzt du eine Sehhilfe?

Nein Ja, eine Brille Ja, Kontaktlinsen

12. Leidest du unter Farbenblindheit? Nein Ja

13. Deine abgeschlossene höchste Schulbildung ist

- | |
|---|
| <p><input type="radio"/> Gehe noch zur Schule</p> <p><input type="radio"/> Pflichtschule</p> <p><input type="radio"/> Lehre</p> <p><input type="radio"/> Berufsbildende mittlere Schule (BMS)</p> <p><input type="radio"/> Höhere Schule (AHS, BHS)</p> <p><input type="radio"/> Fachhochschule / Universität</p> <p><input type="radio"/> sonstige Ausbildung: _____</p> |
|---|

Vielen Dank für deine Mitarbeit!