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Location-Based Mobile Application for Flexible Usage

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Abstract

Location-based activities have ever since been popular among people and have already been implemented into mobile applications for years. Those location-based applications have contributed to facilitating the accomplishment of not solely daily activities by using GPS but also other activities in sectors such as sports, education, entertainment or tourism. Famous games such as *Geocaching* or *Pokémon Go* or applications like *Runtastic* are used by millions of people. The main purpose of this work is to investigate the current situation of location-based mobile applications and to further combine features of those in one application. By developing an application covering a wide range of usage fields as well as functionalities, users can be equipped with an application for various purposes. It aims at combining education with fun activities and spending time outdoors. Moreover, it should also provide the possibility of creating own content and this should not display huge technical challenges. Therefore, a focus is set on easy usage and reaching out to different target groups. The application of this thesis is called *x-plore.it* and is developed in the hybrid framework *Ionic 2* in order to support all major smartphones. On the server-side *Meteor* is used. In order to provide different functionalities, external services such as *OpenstreetMap*, *Youtube* or *Wikipedia* are used. With the mobile application *x-plore.it* it is possible to play and create *Tours*, a kind of scavenger hunt. Such *Tours* exist of one or more *Spots* that are positioned on a specific location and where various *Actions* have to be done. For the evaluation of *x-plore.it*, example *Tours* are provided for a field test. The participants highly agreed on the flexible usage of the application and rated the motivation and the usability with scores of 75 and 82 respectively out of a maximum of 100 points. Moreover, there was a general consensus on the motivational character of mobile games for becoming more active in various sectors. Besides that, results provided useful input for future developments, such as additional types of *Actions*, offline functionality, and the support of wearables.

Kurzfassung

Standortbezogene Aktivitäten sind seit jeher bei Menschen beliebt und werden bereits seit Jahren in mobile Anwendungen implementiert. Diese ortsbezogenen Anwendungen haben dazu beigetragen, nicht nur alltägliche Aktivitäten, sondern auch jene in Bereichen wie etwa Sport, Bildung, Unterhaltung oder Tourismus mithilfe von GPS zu unterstützen. Spiele wie *Geocaching* oder *Pokémon Go* oder Anwendungen wie *Runtastic* werden von Millionen von Menschen verwendet. Der Hauptzweck dieser Arbeit ist es, die aktuelle Situation von standortbezogenen mobilen Anwendungen zu untersuchen und deren Funktionen in einer Anwendung zu bündeln. Durch die Entwicklung einer solchen Applikation, die ein breites Spektrum an Anwendungsbereichen und Funktionen abdeckt, können Benutzer mit einer Anwendung für verschiedene Zwecke ausgestattet werden. Ziel ist es, Bildung mit lustigen Aktivitäten zu verbinden und Zeit im Freien zu verbringen. Darüber hinaus sollte es auch die Möglichkeit geben, eigene Inhalte zu erstellen, was keine großen technischen Herausforderungen mit sich bringen soll. Ein Schwerpunkt liegt daher auf der einfachen Bedienung durch unterschiedliche Zielgruppen. Die in dieser Arbeit entwickelte mobile Applikation *x-plore.it* wurde im hybriden Framework *Ionic 2* entwickelt, um alle gängigen Smartphones zu unterstützen. Serverseitig wird *Meteor* verwendet. Um unterschiedliche Funktionalitäten zur Verfügung zu stellen, werden externe Dienste wie *OpenstreetMap*, *Youtube* oder *Wikipedia* verwendet. Mit *x-plore.it* ist es möglich, *Touren* zu spielen und zu erstellen, wie in einer Schnitzeljagd. Diese *Touren* bestehen aus einem oder mehreren *Spots*, die an einem bestimmten Ort positioniert sind und an denen verschiedene *Aktionen* ausgeführt werden müssen. Für die Auswertung von *x-plore.it* werden *Touren* für einen Feldtest bereitgestellt. Die Teilnehmer waren sich über die flexible Nutzung der Anwendung einig und bewerteten die Motivation und die Bedienbarkeit mit 75 beziehungsweise 82 von maximal 100 Punkten. Darüber hinaus bestand ein allgemeiner Konsens über die Tatsache, dass Handyspiele motivierend sein können, in bestimmten Sektoren aktiver zu werden. Zudem lieferten die Ergebnisse nützliche Informationen für zukünftige Entwicklungen, wie etwa neue *Aktionen*, Offline-Funktionalität oder die Unterstützung von Wearables.

Contents

1 Introduction

1.1 Motivation and Problem Statement

Positioning and navigation have already been present for a very long time and began centuries ago in the age of sea-faring explorers (Lei & Yuanfei, 2012). When the U.S. Government removed the Selective Availability (SA) of the global positioning system (GPS) in 2000, it was made available for the public in a more accurate form and therefore introduced a new era of positioning. Since then, GPS has been used in various areas of daily life, such as for hiking, in navigation system for cars, and also for games. (Arikawa, Konomi, & Ohnishi, 2007) One of the first games for which GPS was used was Geocaching (Kettler, 2017b). With the development of smartphones a new market was created and more location based mobile applications were developed, such as Ingress, Pokémon Go, Runtastic or Google Maps (Hulsey & Reeves, 2014; Kharpal, 2016; Emrich, Theobalt, Werth, & Loos, 2013). Such applications are used in different areas and contribute to facilitating daily live in many different ways.

Today there is a variety of different location based mobile applications; however, what can be considered as a major drawback of the applications mentioned above is that they are focusing on a single topic and therefore multiple applications are needed in order to fulfill all needs of users. Furthermore, the data is often provided by companies themselves and users do not have the possibility to create their own content. Similarly, users are often restricted and not able to adapt the data according to their needs or to decide to keep data private or share it publicly. For applications where user input is possible, it is often limited to technical experienced ones or is not possible on mobile devices.

1.2 Goals and Scope

The goal of this thesis is to develop a location-based mobile application that can be used in many different areas. It would be a great benefit for users to provide them with an application that covers various fields of usage, for instance sports or tourism, to reduce the number of applications on their mobile phones. Moreover, an application focusing on different sectors asks for flexibility or, to put it in other words, that users are able to create and adapt data within the application according to their needs and to decide whether data is made public or to keep it for private use only. Therefore, flexibility is an important characteristic that the application should provide.

An additional purpose of the application developed in the course of this thesis is to support people by the use of location based technology in becoming more active and in participating in different activities. Additionally, it should make certain aspects, such as sightseeing, more interesting for them by providing them with additional information in a playful or gameful manner, which is called gamification. Moreover, one main aspect of the application is to make use of edutainment by combining education and entertainment; for example, by providing students with fun activities while visits in museums or during learning trails. Another characteristic of the application should be to support people in a wide range of activities, not focusing on one specific use field, and enabling them to use the application in various areas. Furthermore, the application also aims at helping people in realizing their creativity as it should provide functionalities to create own tours on their mobile phones without any programming skills. Those tours include assigned locations where specified tasks have to be accomplished.

1.3 Structure of Work

This thesis deals with the design and implementation of the location-based mobile application *x-plore.it*. It describes the used techniques and tools to fulfill the needs for development and evaluation of the application. The written part of the thesis starts with theoretical background in chapter 2, followed by the practical part of design and development in chapters 3 and 4. Finally, the application *x-plore.it* was presented to test users in a field test to evaluate their experience. The research methods and results are presented in chapter 5.

Firstly, chapter 2 gives an insight into the historical background of positioning and navigation. It provides an overview of different satellite-based navigation systems, which were initially only used by military and finally also used by civil people; the various fields of usage by them are also described in this chapter. One of those fields includes location-based mobile applications and, since *x-plore.it* also displays such an application, the chapter additionally focuses on possible frameworks used for development of such mobile applications.

Chapter 3 deals with requirements and design. More specifically, non-functional as well as functional requirements, and the target group of the application are defined. Due to this, a conceptual design is created leading to a decision on a specific design, used techniques, and tools.

The next chapter, chapter 4, describes the process of development. It gives a detailed insight into the architecture of the application and the used technologies. Furthermore it provides the features of the application and how they are implemented. Finally, it provides many screenshots of the application while using it in order to provide a better overall picture of the application and its functionalities.

Chapter 5 is about the evaluation of the application and whether it fulfils its main purposes during a field test by multiple test users. The research methods and processes are presented as well as a summery and a discussion of the results.

Finally, chapter 6 summarizes the lessons which were learned throughout the whole process of this thesis.

2 Background and Related Work

The aim of this chapter is to give an insight into former works and the history that is related to this master's thesis. The chapter will guide through the historical development of positioning and navigation, beginning with early explorers and seafarers leading to the usage of computer- and satellite-based techniques used by military in section 2.1. Additionally, in section 2.2, there will be shown how those techniques and the knowledge are finally used in the form of mobile applications by millions of people in daily life. At the end, a short overview of a selection of relevant frameworks for mobile application development will be given in section 2.4.

2.1 Overview of Positioning Techniques

This section will give a historical overview of selected positioning techniques throughout time. It demonstrates to which extent seafarers and explorers had been the pioneers in the field of positioning and navigation and which tools helped them to locate themselves. The section also explains the term dead reckoning and the difficulties that came along with it. Additionally, techniques based on radio waves and satellites will be discussed, such as GPS, Galileo, and BeiDou, and finally there will be information concerning the impact of GPS on daily life.

2.1.1 Early Beginnings of Positioning and Navigation

2.1.1.1 Astronomical Observation

The history of positioning and navigation began centuries ago in the age of sea-faring explorers such as the Phoenicians, the ancient Greeks, the Persians and the Arabians, naming only a few. In the 13th century, one of the most important contributions in the history of navigation was invented: the mariner's compass, a tool that contained a pivoting needle inside a box. Besides the compass, there were already available some other tools to aid ocean navigators on their voyages, such as maps or astronomical tools like astrolabes and calipers. (Lei & Yuanfei, 2012)

Those astronomical tools made use of stars and planets. Because stars are so far away from the earth, it appears as they do not move while the earth rotates on its axes during a full day. Additionally, the planets also appear to move on the steady sky because of their distance that is much closer to the earth. Therefore, considering the time and the position of the planets people navigating on the sea and on the land were able to determine their current position, naming those positions *datum points*. Nevertheless, the astronomical tools were dependent on the sky; therefore, fog or clouds often prevented people from using those techniques, leading to *dead reckoning* as a fall-back. (Getting, 1993) The invention of electronic and technological tools in the 20th century ultimately introduced a new era and led to the replacement of astronomical tools. For example, radio beacons, radar, the gyroscopic compass, and the *global positioning system* (GPS). (Lei & Yuanfei, 2012)

2.1.1.2 Dead Reckoning

Dead reckoning (DR) is understood as a form of relative positioning with respect to a previous fixed position. It requires to repeatedly determine the traveled distances as well as their respective directions. Drifts, which can be caused by wind and currents, are occasionally occurring and are leading to errors. Those drifts have to be considered in the calculation of the estimated position, as shown in figure 2.1. As those errors can sum up, the goal is to fix the position with other techniques as often as possible and use DR in between as fixing is not always possible. (Hofmann-Wellenhof, Legat, & Wieser, 2003)

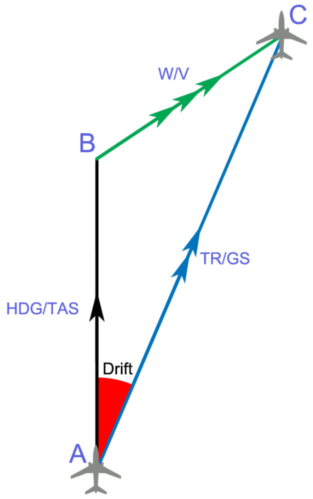


Figure 2.1: Drift is the angle between the heading of the airplane and the desired track. A is the last known position (fix, usually shown with a circle). B is the air position (usually shown with a plus sign). C is the DR position (usually shown with a triangle). (Sabuk, 2012)

One of the most accurate dead reckoning navigation tools was the *Inertial Navigation System*. This system used accelerometers and gyroscopes in order to measure changes in velocity and direction. With the aid of those tools it was much easier to calculate the current position in relation to the last known position. Examples of navigation tools are shown in figure 2.2. (Getting, 1993)

2.1.2 Radio-Based Techniques

Because astronomical observation was often negatively influence by poor visibility and only possible during nighttime, there was the need for better methods. One of the first attempt to accomplish better strategies was using electrotechnology for navigation by using radio waves. In the early period of the 20th century Reginald Fessenden tried to send radio waves synchronously with acoustic underwater signals from a lighthouse. Ships were by then able to calculate their distance to the lighthouse by measuring the differences between receiving those two signals traveling in different speed caused by different densities of the two mediums air and water. That technique did not function without any disadvantages. One major drawback was that this method was limited to traveling near the coastline and in the surrounding of civilization. (Getting, 1993) The same technique was also used for sonic depth finders and was also the start for commercial broadcasts, both invented by Reginald Fessenden. (Brittain, 1996)

2.1.3 Satellite-Based Techniques

This sections gives an overview of a selection of different satellite-based navigation techniques.

2.1.3.1 Global Positioning System (GPS)

The global positioning system (GPS) is a space-based radio navigation system which has its origin in the field of military and was originally designed by the United States Department of Defense. It was developed in order to serve the military as a tool which in order to function did not need any nearby civilization and was independent of weather circumstances. (Moore, 1994)

The fundamental principles of GPS are *Space Segment* and *Control Segment*, two segments with the aim of providing a tracking and timing tool in a consistent and

Figure 2.2: Left: Dead reckoning navigation tools in coastal navigation. Right: British P10 Magnetic Compass with dead reckoning navigation tools. (Bond, 2013)

reliable way. The Space Segment consists of currently twenty-four operational satellites, all of which are synchronized in time and are continuously transmitting time signals to the earth. The other segment of GPS, the Control Segment, is based on the ground and has its purpose in tracking and controlling the GPS satellites. (Mulla, Baviskar, Baviskar, & Bhovad, 2015)

A user of the GPS satellite tracking process is called *receiver* and represents the *User Segment*. In order to determine the user's own geographic position, one needs a connection to a minimum of four satellites. During this process, each satellite is transmitting a signal, named *Navigation Message*, which contains information for the receiver on earth. The content of this message consists of the name of the satellite as X, its current position as Y and its synchronized time Z. These three orbital parameters are called *Ephemeris* and *Almanac* data. (Mulla et al., 2015)

Considering the constant speed s of the radio signal sent by the satellite it is possible to determine the distance d to the satellites' positions by the time that passed between sending t_i and receiving t_0 ($\Delta t_i = t_0 - t_i$) with the simple formula $d_i = s \times \Delta t_i$. For this calculation it does not matter if the set time of the receiver t_r is not exactly synchronized with the satellites t_s, because the difference $t_r - t_s$ is the same for each satellite and will therefore be compensated in the equation.

Trilateration

In a two-dimensional (2D) model the given distance would be represented by a circle of possible positions with the satellite placed in the center of it. Given that fact, one single signal received will result in an infinite amount of possible positions, all located on a circle around the satellite as shown in figure 2.3. (GISgeography.com, 2018)

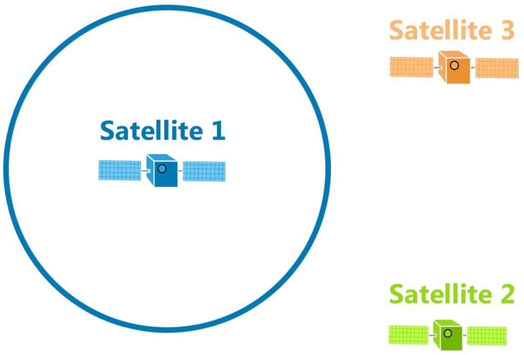


Figure 2.3: Distance to the satellite represented as circle in a 2D-model. (GISgeography.com, 2018)

When a second signal is received the distance to this satellite is represented by another circle. If all the measurements where correct, those two circles intersect, leading to only two possible positions for the receiver - exactly at their intersections as shown in figure 2.4. (GISgeography.com, 2018)

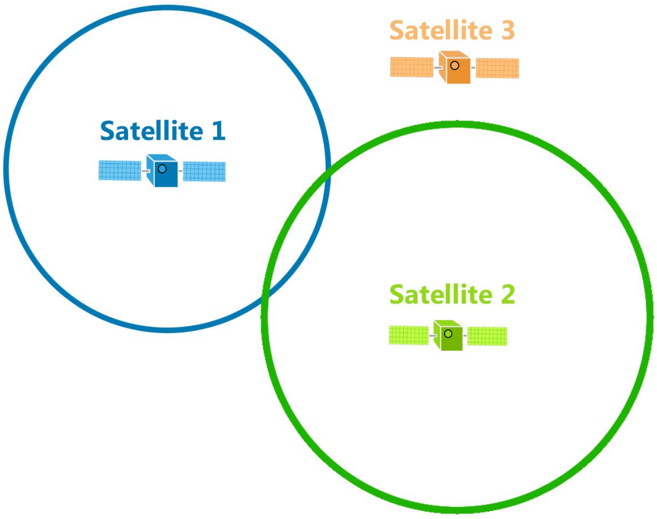


Figure 2.4: Possible positions are where the circles intersect. (GISgeography.com, 2018)

To finally receive the correct position, a minimum of three signals is needed in a 2D-model. At the position where all those circles intersect, the receiver is located. The method of determining the location by knowing the distance to three points is called *triateration*. This is shown in figure 2.5. (GISgeography.com, 2018)

As reality is three-dimensional, the signal of the satellites is being broadcast as a sphere and not as a circle. Therefore, there is the need of at least a forth signal to reveal the true receiver's position, which is located where all the spheres intersect. This is pictured in figure 2.6. (GISgeography.com, 2018)

In order to not depend on the navigational system GPS, having its origins in the United States of America, Europe and Asia started to introduce their own global navigation satellite systems (GNSS), namely *Galileo* and *BeiDou*. Those systems will be introduced in the following sections.

2.1.3.2 Galileo

The Galileo system as the European version of a global navigation satellite system (GNSS) is predicted to be fully used in the year 2020. The first satellite was launched in 2011. During the years, the system was steadily increasing in satellite numbers, growing to a total number of 18 satellites by 2018. In 2020, the full operational system will consist of 24 satellites and 6 additional spare satellites, moving in three circular medium earth orbit planes at an altitude of 23,222

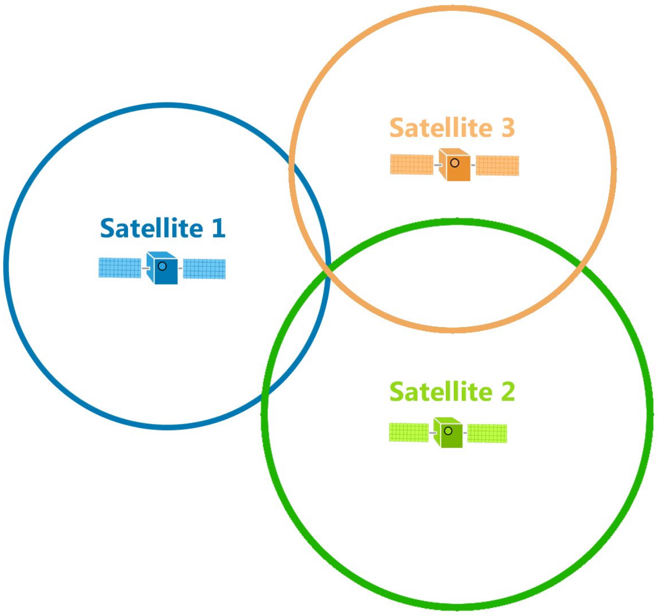


Figure 2.5: In a 2D-model three signals are needed to determine the position. (GISgeography.com, 2018)

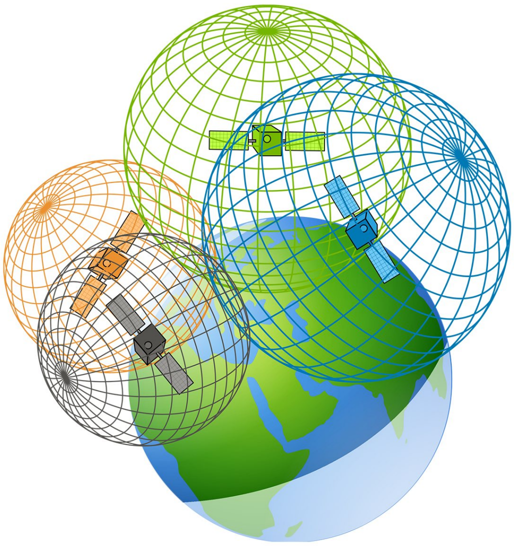


Figure 2.6: Satellites broadcast as a sphere. In order to determine the only true position at least four signals are needed. (GISgeography.com, 2018)

kilometers. Additionally, the Galileo system uses its own time, named Galileo System Time (GST), which does not consider leap seconds in contrast to the GPS time. The footprints of the Galileo satellites are shown in figure 2.7. (Lei & Yuanfei, 2012; Kwasniak, 2018)

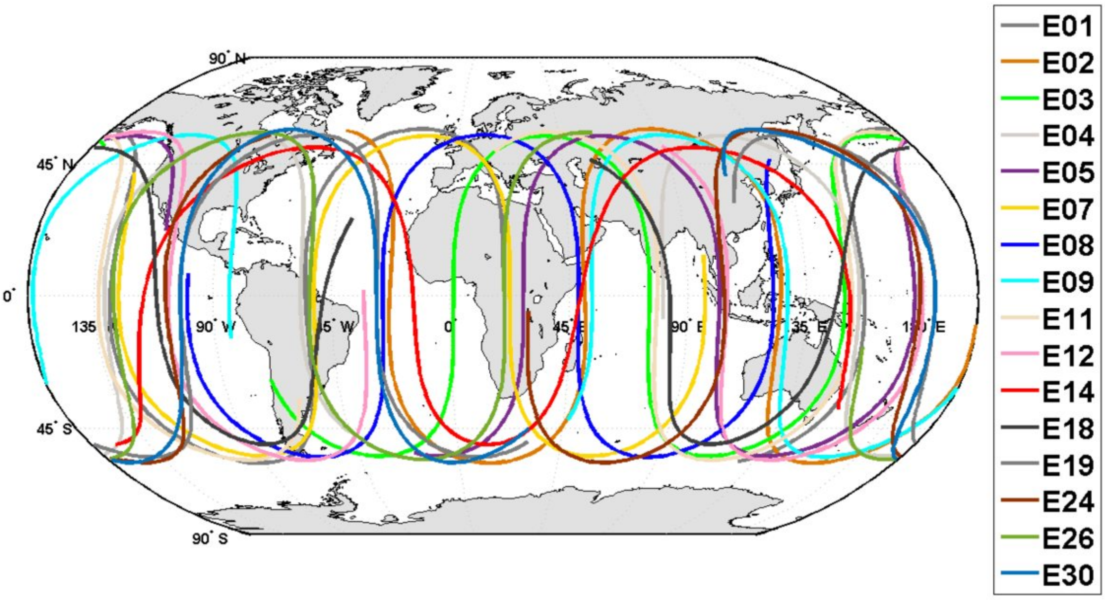


Figure 2.7: Galileo System satellite footprints. (Kwasniak, 2018)

2.1.3.3 BeiDou

The BeiDou System (BDS) - previously also known as *Compass* - is the Asian version of global navigation satellite systems. It consists of 35 satellites in total, 27 medium earth orbits (MEO), 5 geostationary satellites (GEO) and 3 inclined geosynchronous orbits (IGSO). It is predicted that BeiDou will be, as well as the Galileo system, in full operation in 2020. The BeiDou satellites are moving higher than those of the Galileo system, positioned at an altitude of 35,786 kilometers. The footprints of the satellites are shown in figure 2.8. (Lei & Yuanfei, 2012; Kwasniak, 2018)

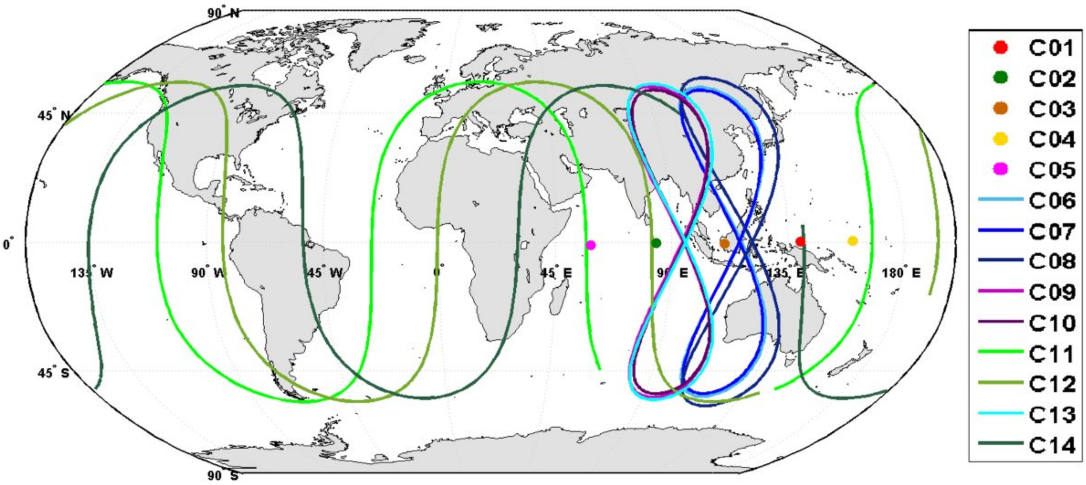


Figure 2.8: BeiDou System satellite footprints. (Kwasniak, 2018)

2.1.3.4 Others

GLONASS is the Russian version of a global navigation satellite system (GNSS), whose usage is not as widespread as *GPS* from the United States of America. Additionally, there are other existing systems functioning as regional navigation satellite systems (RNSS) such as the *QZSS* in Japan and *IRNSS* in India. (Lei & Yuanfei, 2012)

2.1.3.5 Influence on Daily Life

On May 2nd, 2000, the U.S. Government, at that time directed by Bill Clinton, stopped to use Selective Availability (SA), aiming to make GPS more responsive to civil and commercial users worldwide. Selective Availability was originally introduced to prevent others than the US military to use GPS and worked by adding artificial errors. By removing those errors GPS became available for the use by civil people worldwide with a notable accuracy. (President Clinton, 2000) In figure 2.9 the difference of GPS accuracy with and without the Selective Availability is shown. Turning SA off paved the way to global distribution of GPS, namely private GPS-devices for hiking, navigation systems in cars, or mobile phones and many others. (Arikawa et al., 2007)

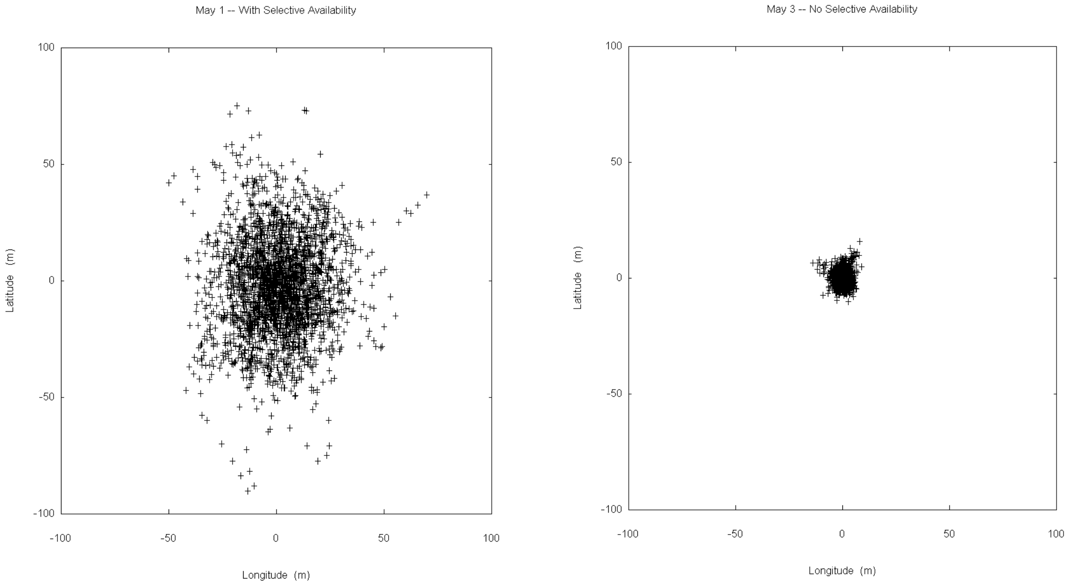


Figure 2.9: GPS accuracy before and after SA removal. (NGS, 2019)

On the 6th of April, 2019 the so-called *GPS Week Number Rollover Event* will take place. The native GPS signal contains a 10 bit parameter, which has a numeric maximum of $2^{10} = 1024$. This parameter represents the passed weeks since *0000Z January 6, 1980* as *Week Number* (WN). After the 1024th week, the WN counter will be set to zero, the so-called *Rollover*. This event happens approximately every 20 years and due to the wide spread of usage in the past years, many more devices may be affected this time compared to the year 1999. Tests showed that many devices are not well prepared for the Rollover, leading to malfunction of GPS. Owners of critical infrastructure depending on GPS are advised to become informed and subsequently prepare themselves, keeping the firmwares of the infrastructures' devices up-to-date. (Homeland Security, 2019)

2.1.4 Non-Satellite Indoor Navigation

Though GPS excels due to its global distribution and high accuracy it has a huge drawback, namely indoor navigation. The reason for this is that GPS needs a clear line of sight to the satellites in the sky. The more satellites are accessible for the GPS device, the better the location can be calculated by it. The ability depends on the material of the wall. Although GPS can work through windows, there is certain material which blocks it. For example, most buildings, especially at schools, have massive walls out of metal and bricks, where the GPS-device is not able to connect through them. Therefore, if someone needs to navigate within a certain building, there is the need of using another technology. A possible solution for positioning the user's device are *Indoor Positioning Systems*. (Varshney, Goel, & Qadeer, 2016) Those wireless systems use radio waves, magnetic fields, acoustic signals or other sensory information, which is collected by mobile devices, and can achieve to locate objects or people inside buildings. (Moreira & Mautz, 2012)

An example where indoor navigation can be very useful are high schools and universities, where you do not have a definite class room nowadays. Students have to change room for every lesson which can be complicated inside huge school complexes. In order to make navigation inside those buildings easier, it is possible to be navigated with the aid of a mobile application. Such an application can be connected to the student's timetable as well as the class rooms. Before the start of a class, the application is able to navigate to the next room. The same principle can also be used, for example, in airports, shopping centers or on campuses of huge companies. (Herrera et al., 2014)

In order to provide indoor navigation, most systems use either the technique of dead reckoning or trilateration or a combination of both. Dead reckoning, for example, was used by seafarer long before the usage of GPS and other techniques and was already introduced in section 2.1.1.2. Trilateration is a method to calculate the position by knowing its distance to three points and is also used by GPS. It was also already explained in section 2.1.3.1. When using dead reckoning for pedestrians, it is named *Pedestrian Dead Reckoning* (PDR). By the aid of PDR the current position of a pedestrian is calculated in relation to an already known position called *beacon*. The distance to those beacons is measured by different sensors of current mobile phone devices. (Herrera et al., 2014; Varshney et al., 2016)

Examples of Beacons and their Usage

There are different technical types of possible beacons. The following lines display some examples.

Wi-Fi
The already installed WiFi access points can easily be used as beacons for navigation. However, the distribution of those WiFi access points does not always satisfy the needs for navigation as those access points would need a different distribution for providing the Wi-Fi signal. Therefore, WiFi can provide bad scalability when used for navigational purpose. (Herrera et al., 2014)

An example of a mobile application that uses Wi-Fi to navigate on school campuses is *Anyplace*[1]. It won several prices regarding *indoor localization* such as the 2nd place in the *Microsoft Research Indoor Localization Competition at IEEE/ACM IPSN 2014, Berlin, Germany* or the 1st place for *Evaluation of RF-based Indoor Localization Solutions for the Future Internet (EVARILOS Open Challenge), European Union*. (AnyPlace, 2017) On their website the application is described as follows: *"Anyplace is a first-of-a-kind indoor information service offering GPS-less localization, navigation and search inside buildings using ordinary smartphones."* (AnyPlace, 2018)

For localizing the users inside of buildings and to show their location on indoor floor-maps several techniques like wireless, light and magnetic signals are used. (Zeinalipour-Yazti & Laoudias, 2017) The service architecture of the *Anyplace* application is shown in figure 2.10, the localizing techniques are shown in *Logger* and *Navigator*. (Georgiou et al., 2015)

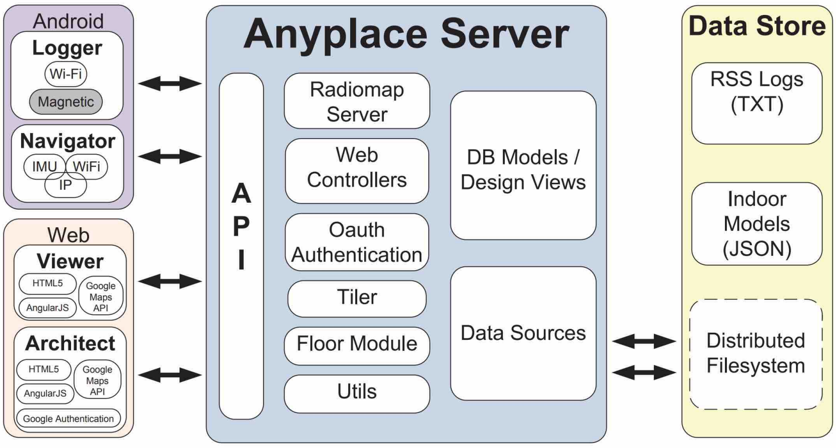


Figure 2.10: The Anyplace Internet-based Indoor Information (IIN) Service Architecture. (Zeinalipour-Yazti & Laoudias, 2017)

Bluetooth Low Energy
Bluetooth Low Energy (BLE) is a wireless personal area network technology used for transmission of data over short distances. If within the relatively small range of

[1] https://anyplace.cs.ucy.ac.cy/

such a BLE beacon the user's location can be determined easily and furthermore data such as advertisements can be transferred. Due to this, these techniques are suggesting themselves, for example, for the use within shopping malls. (Varshney et al., 2016)

QR codes
A QR ("Quick Response") code is understood as a 2D matrix code which provides high data storage capacity, fast scanning, omnidirectional readability. Because of those qualities, QR codes can be very useful for robot technology as they can provide location information by solely scanning a simple sticker displaying a QR code. (Tiwari, 2016) This technique is used by Amazon in their fully automated warehouses.[2] (Bogue, 2016)

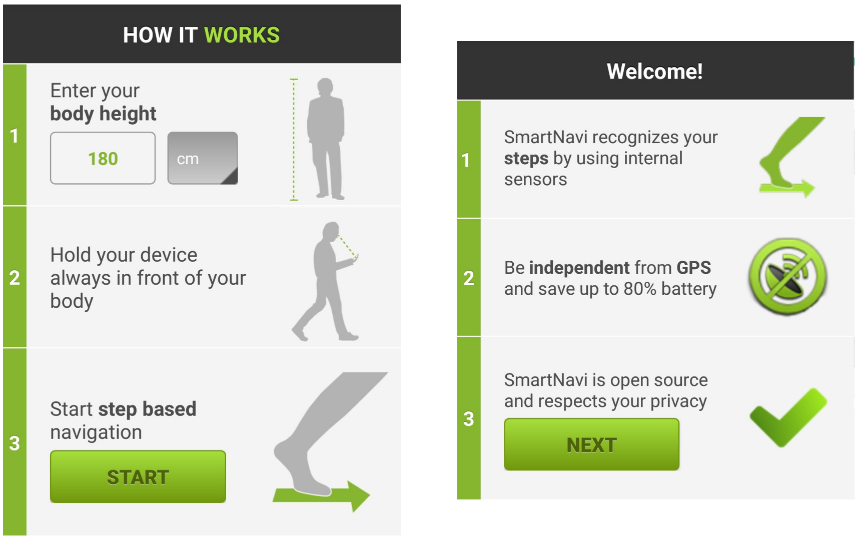
Computer Vision + Infrared
The project *Tango* by Google uses 3D sensing technologies such as computer vision and infrared to scan the surroundings and provide a 3D model in real time for navigation purposes. (Marques et al., 2018) This project was replaced in March 2018 by *ARCore*[3], a software development kit for creating augmented reality (AR) applications.

Step-based
The mobile application *SmartNavi*[4] provides positioning by counting the steps of a user. After a first localization is done by using GPS, it derives the movements by the length of the steps related to the size of a user. The steps are recognized by the sensors of a smartphone, the walking direction by the built-in compass. With this information all further localization can be calculated without the need of GPS in relation to the original GPS-based localization. The amount of re-correction via GPS can be set in the configurations of the application. According to tests done by the developer, the SmartNavi application saves up to 80% of battery compared to other applications used for navigation, such as *Google Maps* or *OSMNavigation*. SmartNavi is part of the *Android Experiment*[5], by which *Google* wants to celebrate the creative, experimental Android work of developers. Screenshots of the application are shown in figure 2.11.

2.2 Overview of Location-Based Games

Location-based games are classified depending on the location of their players and consequently the gameplay can be adjusted to the player's location. Those games require the player to be at a specific location in the real world in order to fulfill the goals of the game. However, that does not mean that it has to be a virtual game which connects with the real physical world, so-called *Pervasive Games* (Benford, Magerkurth, & Ljungstrand, 2005). Location-based games had already

[2] https://www.handelsblatt.com/20057656.html
[3] https://developers.google.com/ar/
[4] https://smartnavi-app.com
[5] https://experiments.withgoogle.com/



HOW IT WORKS

1 Enter your **body height**

180 cm

2 Hold your device always in front of your body

3 Start **step based** navigation

START

Welcome!

1 SmartNavi recognizes your **steps** by using internal sensors

2 Be **independent** from **GPS** and save up to 80% battery

3 SmartNavi is open source and respects your privacy

NEXT

Figure 2.11: Description, configuration and welcome screen of *Smartnavi*. Screenshots taken from the mobile application.

existed long before mobile-phones and technologies like *global positioning systems* (GPS) were established, at a time when maps, rulers and mathematical algorithms were used to calculate coordinates (National Geographic, 2002). Examples will be given in the following subsections.

2.2.1 Selection of Non-Technical Location-Based Games

This section is used to show that location-based game were already present before computers and smartphones existed. There will be examples of a certain group of games that only required non-technical equipment.

Letterboxing

The first so called *Letterbox* was created by James Perrott in 1854 in Dartmoor, England. He built a little cairn and made visitors leave their calling cards in a glass bottle inside. Later, there was a visitor's book added and more cairns were placed throughout the Dartmoor National Park. In 1937, a permanent stone box replaced the original cairn. It contained a door with a written manual explaining how to play on it as well as a stamp and an ink pad inside. It enabled visitors to log their visit also in their own visitors' books. (Ihamäki, 2006; Dunlop, 2014) A photograph of the first *Letterbox* is shown in figure 2.12.

Something similar to Letterboxing is already existing on mountain trails. On mountain summits, there exist so-called *Summit Registers*, in which people can log their successful hikes by signing the registers with their name and the date of their visit. Additionally, the boxes or shrines holding such registers can contain stamps which can be collected in someone own's book. Such a shrine is shown in

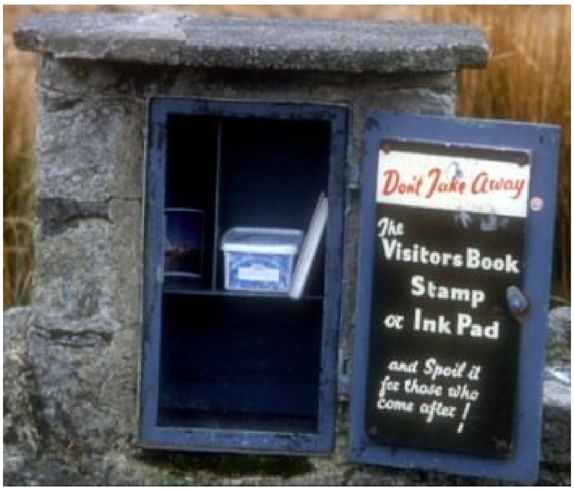


Figure 2.12: Photo of the first Cranmere Pool Letterbox. (Gueulle, 2000)

figure 2.13. However, much more important is information like the name of each hiker, the date and time of the visit as well as the route that hikers are planning to continue on, which should help the mountain rescuers to find hikers in a case of emergency. (Geyer, 2018)

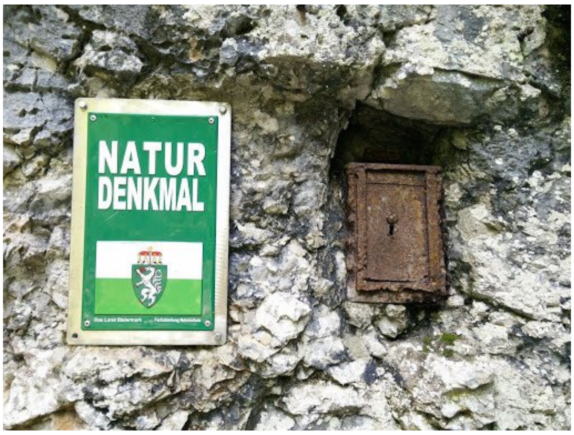


Figure 2.13: Old shrine on a Styrian mountain trail.

Nuuksion Metsäsissit

In the 1980s, a club called *Nuuksion Metsäsissit*, what translates to *"Nuuksio Forest Guerrillas"*, began hunting locations in the Nuuksio National Park and around Helsinki in Finland without electronic devices. They only used 1:20.000 maps and measurements with an accuracy of half-a-millimeter which resolved in a 10-meter accuracy for their coordinates. The coordinates were calculated by putting a grid over a map and counting the lines. Later on, the hunters group switched to GPS devices, but due to the inaccuracy at that time, they only used them to check their calculations for errors as their manually technique was more accurate. (Mesu, 2002; Ihamäki, 2006)

2.2.2 Selection of Technical Location-Based Games

In this section there will be a presentation of games which have the characteristics of already using electrical devices such as a GPS-receiver or others but not yet smartphones as they were not present at the time the games were developed.

Geocaching

On May 2nd, 2000, the U.S. Government removed *Selective Availability* from GPS. This made GPS available and usable for civil users worldwide (The National Coordination Office, 2000). On May 3rd, Dave Ulmer published a post in a newsgroup, suggesting to celebrate this circumstance with *"The Great American GPS Stash Hunt"*. Near Portland, he buried a container that he called *Stash* at the coordinates *N* 45°17′28″, *W* 122°24′48″ and filled it with some stuff. He told people to find it and set up simple rules for the hunt: *"Get some Stuff, Leave some Stuff!"*. (Ulmer, 2000)

On May 30th, the game's name was changed to *Geocaching* and on September 2nd, the domain *geocaching.com*[6] was registered by Jeremy Irish. He set up a website in order to be able to collect the steadily growing number of containers, which were by then called *Geocaches*. Geocaching.com is now the biggest collection of Geocaches with more than 3 Million container around the world. (Kettler, 2017b) It even includes one in the outer space on the *International Space Station* (ISS)[7] that was hidden by *Richard Garriott*, a space tourist, in the year 2008 and was first found 5 years later in 2013. (Garriott, 2008)

At the beginning, Geocaching was played mostly on GPS-devices. Subsequently, after smartphones got equipped with Internet access and GPS, the game-play became much easier, leading to a fast growing user base worldwide. Several mobile-applications, for example like *c:geo*[8], were published using the database of geocaching.com. This made it much more easier to play the game spontaneously.

Different types of Geocaches have been introduced throughout time, such as Multi- or Mystery-Caches. All of them have in common that a hidden physical container with a logbook inside has to be found at specific coordinates that are either public or have to be calculated solving a riddle or something similar. There are only two exceptions, namely Earth-Caches, which are natural monuments, and Virtual-Caches, which were available only for a short time. (Groundspeak, 2018)

Since the beginning in 2000, 3 million caches hidden by 360.000 cache owners in 191 different countries have been found for almost 590.000.000 times by 7 million

[6] https://www.geocaching.com/

[7] https://www.geocaching.com/geocache/GC1BE91_international-space-station

[8] https://www.cgeo.org/

active players. The busiest cache has approximately 6000 visitors per year. (Kettler, 2017a)

BotFighters

BotFighters was a game by *It's Alive* released in 2001. It was the first location-based game that was played on a cell phone taking advantage of the mobile positioning. There was an additional website where the players could upgrade their character; however, the game itself was played on the mobile phone outside on the streets. At this time, Internet was hardly available on mobile phones. Therefore, the game was played via SMS. The players were shooting by sending an SMS to the game-server aiming to hit surrounding players related to their actual real location. BotFighters is similar to the ego-shooter games such as *Quake* or *Counter-Strike*, though playable in the real-world. (Struppek & Willis, 2007)

Can You See Me Now?

The game *Can You See Me Now?*[9] was a game from *blast theory* from 2001. After registering on a web page, users had to answer the question *"Is there someone you haven't seen for a long time that you still think of?"*. Without knowing the purpose of this question, the users were then placed randomly on a virtual replica of their cities' street maps and were able to navigate through them with their cursor keys on their computers.

On the real streets, there were so-called *Runners* equipped with a GPS receiver as well as a radio transceiver and a mobile device. Those Runners were able to see the location of online players on a map and were trying to catch them by running to the players' positions while the online players tried to not get caught and get out of sight of the Runners.

As soon as a Runner caught an online player by getting close enough to the virtual position, the Runner called out a name through the radio transceiver being connected to the online game. It was the name of the person which the caught user mentioned during the registration. Additionally, a picture was taken by the Runner, permanently saved to that place where the long-not-seen person was caught and finally "met", generating an art gallery to remind the users to maybe reach out to their old friends. (Benford et al., 2006)

Pac-Manhattan

In 2004, the New York University wanted to take *Pac-Man* out on the streets and established *Pac-Manhattan*[10]. Five players, one dressed as Pac-Man and the others

[9] https://www.blasttheory.co.uk/cysmn/

[10] http://www.pacmanhattan.com/

as four ghosts, were running through the streets of Manhatten trying to eat the virtual dots or to catch each other. Due to problems with GPS in *"urban canyons"* and because they *"could not find an easy (read: cheap) way to send the geo-coordinate data from the GPS receiver back to the network"*, the creators of *Pac-Manhattan* could not use GPS for their game. WiFi was also not usable because they *"could not find an area of the city with consistent WiFi coverage over a large area"*. (New York University, 2004; Adamowsky, 2009)

Because of those problems five other players were sitting in a control room connected with their companion via phone to guide them through the streets and to send updates about the locations of other players. Modern smartphones would have made this game much more easier and more special, being able to conquer all those technical problems.

In the year 2015 and 2017, *Google Maps* did an April Fool and let users play *Pac-Man* on their smartphones within the Google-Maps application on the streets surrounding them. (Garun, 2017)

Sportinate

The application *sportinate* was developed by Gritsch in 2013. It gave the users the possibility to track their sport activities such as running tours with a GPS-device and made it possible to evaluate them on a website. Additionally, *sportinate* aimed at motivating its users to do more and longer runs by the use of achievements which could be collected in the form of virtual objects along the route. Another possibility was to start competitions where runners were able to compare their needed time for specific sections of their track. (Gritsch, 2013)

2.2.3 Selection Location-Based Mobile Application Games

With the development of smartphones a new possibility for location-based games was born. Small and affordable devices were by then able to connect to the Internet and receive GPS-signals, which paved the way for a new way of gaming experience. The games changed quickly in order to adapt to the new available features and the market of location-based games started to expand due to the increasing spread of usage of smartphones for people of all ages as shown in figure 2.14.

Parallel Kingdom

Parallel Kingdom[11] was a mobile game existing from 2008 until 2016. It was the first location-based role-playing game (RPG) and used *Google Maps* and the location of a user to create a virtual world called *"Parallel Kingdom"*. The users were able

[11] http://www.parallelkingdom.com/

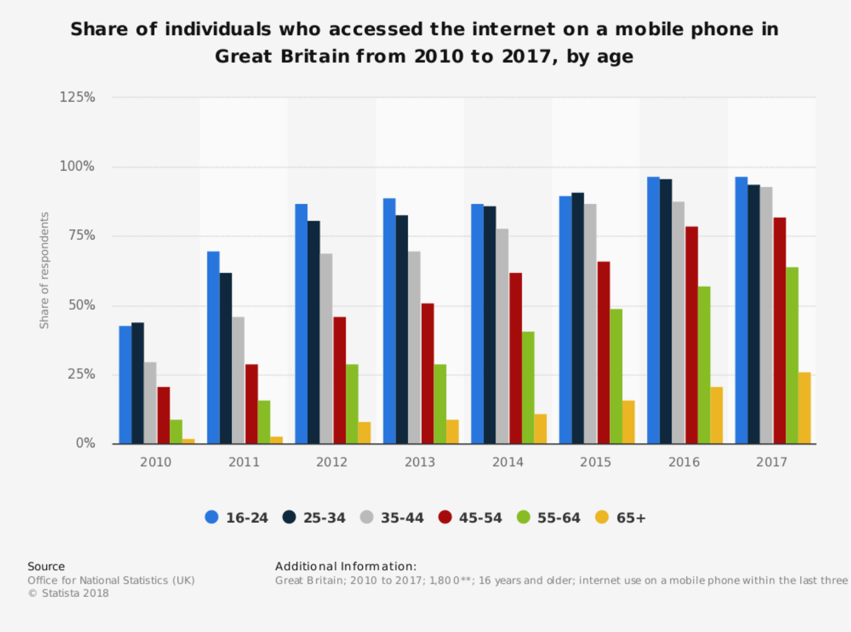


Figure 2.14: Internet usage on mobile phone by age in Great Britain. (Office for National Statistics (UK) & Statista, 2018)

to claim their territories based on their locations, building up a virtual kingdom. The needed goods for buildings or virtual monsters existed in Parallel Kingdom. To find and reach those goods, the players had to move through the virtual world to get the items and monsters into range. In order to accomplish this, the players had to walk in the real world so that their avatar could move in the game. (Verdejo et al., 2010)

Gbanga Zooh

Gbanga Zooh[12] is a good example for *Edutainment*[13], a game that educates its users while playing. In *Zooh*, the goal was to make players more aware of endangered species. In 2009, Gbanga released virtual animals and placed them all over the city of Zurich. The players then had to collect the endangered animals by walking to the places where the animals were located. Afterwards, the players should bring them back to the Zoo Zurich by walking their in real life. (Jirapanthong, Yampray, & Tancharoen, 2017)

Munzee

Munzee[14] started in 2011. The game's goal is to collect points by virtually collecting items hidden in the real world. Those items are called *Munzee* and can be stickers

[12] https://gbanga.com/de/gameography/gbanga-zooh/
[13] http://soziologie.soz.uni-linz.ac.at/sozthe/freitour/FreiTour-Wiki/Edutainment.htm
[14] https://www.playmunzee.com/

with an QR-code or an NFC-tag. They can be placed wherever a user wanted them to place. After the sticker is discovered, it has to be scanned with the application on a smartphone to log the find and earn points. (Gama, Wanderley, Maranhão, & Garcia, 2015)

The scanning of the QR-code prevents a common problem throughout all location-based mobile-games. On almost all phones it is possible to manipulate the location. There is often no way to detect if the user is really on the set location or if the location has been set manually by the user, cheating within the game. By scanning a sticker existing only at the specific location, it can be guaranteed that the user is at the correct location. (Zhao & Sui, 2017)

Earth Puzzle Project

Earth Puzzle Project[15] was created in 2011 by a group of students in Graz, Austria. Their plan was to split up the Earth into 500.000.000 puzzle pieces and get them replaced correctly by their users by carrying them to the specified location of each puzzle piece. (Earth Puzzle Project, 2011)

It was possible to exchange pieces with other users to make placing easier; however, the game never got out of the alpha-phase which was held in Graz. In the alpha-phase, which lasted over 4 months, 12.400 kilometers were travelled and 750 pieces were placed by the puzzlers. (Earth Puzzle Project, 2012)

Ingress

Ingress[16] is produced by *Niantic* and it is a game for mobile devices only, starting in 2012. The players are part of two teams, fighting in order to capture so called *Portals*. Those Portals represent *Points of Interests (POIs)* which can be linked together by the Portals' owners with a straight line, under the condition that no other connecting line is being crossed. If the set links build up a triangle, the inner area is called *Field*, marked in the color of the team, counting as their points. The game is played world-wide and some international operations managed to set up links and fields larger than continents. The POIs were selected, photographed and placed by users and afterwards checked by Niantic. They were re-used later for *Pokémon Go* as well. (Hulsey & Reeves, 2014)

LMAC

The Location-based Mobile Application Creator (LMAC) is a framework developed by Weiner in 2014. The goal of the framework was to provide an easy

[15] http://www.earthpuzzleproject.org/

[16] https://www.ingress.com/

solution for creating location-aware mobile applications. For example, the framework was used to create a mobile scavenger hunt. It was designed for children with the aim of being used for exploring the city of Graz and providing more information about dedicated locations. Especially teachers and their students were defined as the target group. (Pirker, Gütl, Weiner, Garcia-Barrios, & Tomintz, 2014)

MythHunter

Another approach was published 2017 by Hutzler. The so-called *MythHunter* was also a location-based scavenger hunt game which focused mainly on a playful and story-telling design, for example, by introducing virtual quests. Once more teachers and students were the defined target group.

MythHunter was separated into two parts. The first one was the editor, a web-application that was used to create the quests and challenges. In order to do so users were able to select locations on a map to place markers there. Those markers could then be linked to tasks, such as info or quiz tasks, or an invisible task which hid the location.

The second part was a mobile-game application which was developed with the Unity Game Engine in order to provide broad compatibility. The app was used to play the previously created quests. It gave the user a statistical overview about achievements and displayed the surrounding quests on an interactive map.

A study by Hutzler showed that such scavenger hunts can highly motivate people to learn more about their environment. (Hutzler, Wagner, Pirker, & Gütl, 2017)

Pokémon Go

A lot of people were waiting many years for *Pokémon Go*[17] because it would represent the first game where the player actually could step into the main character's position and walk through the original gameboy game of the 1990s, now being connected to the real world. When it finally was released by Niantic in 2016, all servers crashed because of the huge worldwide interest. For this reason, Pokémon Go was the fastest game to reach 10 million downloads. Within the first month, the creators could accomplish $200 million with in-game purchases. (Kharpal, 2016)

On smartphones users can see a comicized map of their surroundings. It shows *PokéStops* or *-arenas* where they can gain items like *PokéBalls* or fight other players. By walking around, users guide their virtual trainer through the virtual world of Pokémon, as they are bound to the same location. The in-game animals Pokémon (short for "Pocket Monsters") appear randomly and can be caught with a Pokéball if they are within users' reach. The PokéStops and PokéArenas are *Points of Interest*

[17] https://www.pokemongo.com/

(POIs) and are reused by Niantic from their former game Ingress, where users could recommend those POIs as in-game portals. (Tateno, Skokauskas, Kato, Teo, & Guerrero, 2016)

Studies show that *Pokémon Go* led to significant increases in physical activity, approximately up to 25 percent across men and women of all ages, weight status, and prior activity levels. Additionally, it was able to reach out to low activity populations as well. (Althoff, White, & Horvitz, 2016)

2.2.4 Comparison

As the table 2.1 displays a chronological order of selected location-based mobile games, it can be easily seen in which direction the development is moving. Recent developments generally require a mobile device such as a smartphone and are completely virtual; therefore, no other physical item is involved. It is important to note that the number of users for *Geocaching* is still stable after the boom between 2014 and 2016, as seen in figure 2.15, even though it is against the current trend of going completely virtual.

Table 2.1: Characteristics of selected location-based games.

Name	**Device**	**Virtual**	**Physical**	**Purpose**
Letterboxing	-	-	x	Outdoor
Nuuksion Metsäsissit	Maps	-	x	Outdoor
Geocaching	GPS / Mobile	-[1]	x	Outdoor, Game
BotFighters	3G Mobile	x	-	Game
Can you see me now?	PC / GPS	x	-	Game
Pac-Manhattan	PC / Mobile	x	-	Game
Sportinate	PC / GPS	x	-	Sport
Parallel Kingdom	Mobile	x	-	Game
Gbanga Zooh	Mobile	x	-	Education
Munzee	Mobile	x	∼[2]	Outdoor, Game
Earth Puzzle Project	Mobile	x	-	Outdoor, Game
Ingress	Mobile	x	-	Game
LMAC	Mobile	x	-	Game
MythHunter	Mobile	x	-	Game, Tourism
Pokémon Go	Mobile	x	-	Game

[1] Except the type ”virtual”, which is not available for new caches anymore.

[2] There is a QR-code sticker to proof presence at according location.

2.3 Location-Based Activities in diverse Areas

Activities in daily life can be location-based in a variety of ways. For example, such a location can be the specific target of a hike or it can be a *control point* of

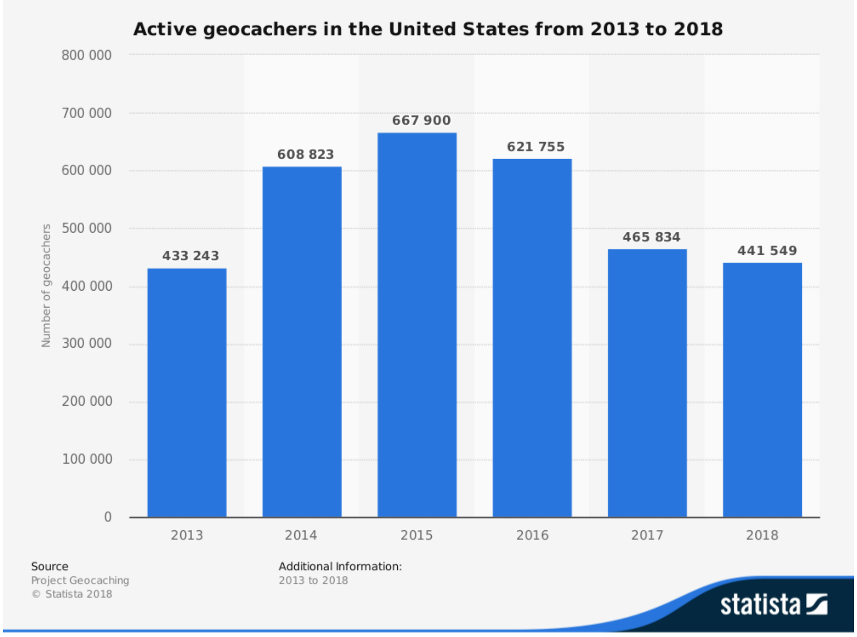


Figure 2.15: Active geocachers in the United States from 2013 to 2018. (Statista, 2019)

orienteering. Another example would be the definition of multiple specific locations where different tasks have to be accomplished, like it is done in a *scavenger hunt*, or where information has to be collected like for a *cloze text*. Location-based activities can also be performed in museums and could be used to encourage pupils to take part in the visit. For example, location-based information can be displayed at specific spots in an exhibition, similar to listening to audio information when walking through with *audio-guides*. In the following sections those different kinds of activities will be described in more detail, separated into different areas. A comparison between selected activities is shown in table 2.2. (International Orienteering Federation, 2018; Economou, Bouki, Kounenis, Mentzelopoulos, & Georgalas, 2015; Van Hage, Stash, Wang, & Aroyo, 2010)

2.3.1 Examples of Sport and Health Activities

This section will contain a selection of location-based activities that are related to sports and health. Those activities will be described in more detail.

Fitness Tracking

Runtastic is an example of a mobile application that intents to support physical training activities. While doing any kind of activity, a GPS tracker can be enabled in order to keep track of the running track and to get information about speed, distance, burned calories and various other information. By the possibility of managing training plans, goals and automatic reminders, Runtastic helps to motivate people to become active and do any kind of sports. Another important feature of the application is the social aspect. Equipping the users with the possibility to display or share their sport activities on platforms such as Facebook, Runtastic enables its users to take part in game-like competitions with friends, further increasing their motivation for sport. (Emrich et al., 2013) The Runtastic GmbH was founded in Austria in 2009 and was sold for 220 million Euro six years later to the adidas Group, making it to one of the most successful start-ups in Europe (Kleindessner, 2017; Pereira, 2018).

Activity Tracking

The mobile application *Google Fit* is another mobile fitness application similar to Runtastic and is supposed to track the user's activity in the background in a simple and effortless way. The users can set the goals they want to achieve and Google Fit keeps track of them. The application automatically detects several kinds of activities like walking, running or cycling and saves them accordingly. By receiving push notifications on the mobile phone, Google Fit users get informed about the progress to reach their goals set by themselves. (Menaspà, 2015)

Orienteering

Orienteering is understood as a sport that requires not only good running skills but also a good sense of orientation as well as navigation. The course of a competition consists of multiple so called *control points*, which have to be found and passed by the attendees in a given order and as fast as possible. In order to find the optimal path, a participant is only allowed to help himself using a map and a compass for navigation. (International Orienteering Federation, 2018)

The origin of Orienteering is in 19th century in Sweden and was called *"orientering"*, which meant *the crossing of unknown land with the help of a map and a compass*. It started as military training, to competitions of military officers and later then for civilians as well. (International Orienteering Federation, 2017)

Those Orienteering competitions often take place in forests or parks. The attendees normally do not know much about the area before and are getting the map at the beginning of their run. To reach good results in the competition, it is so required that the map has to be read during running. (Cych, 2007)

2.3.2 Examples of Tourist Activities

This section will give examples about location-based approaches in the area of tourism. It gives some insights into new inventions and improvements that helped to provide tourists and visitors with as much information as possible. Additionally, different aspects will be shown which contributed to increase the tourists' motivation.

Museums

While visiting museums, it may occur that children are lacking in interest for the contents displayed, especially when there is no active participation included in their visit. However, museums can be of great value for people, and in particular for children. Due to this, various museums are trying to establish new ways to catch the interest of their visitors by including the usage of mobile devices. The first attempt of this was the usage of audio-guides, already existing for a long period. Those big phone-like devices provide the museum's visitors with different kind of information about each point of interest. In order to get the information, visitors generally simply need to enter a specific number displayed on the location. A first step to modernize the concept of audio-guides can be to display further information on a mobile phone combined with QR-codes. Those QR-codes are already present in many museums. Some museums are already a step further and are bringing old paintings to live with virtual reality or providing personalized virtual tours like the *Virtual Museum* (of Canada)[18]. There is a wide range of possibilities to make museums more interesting to all classes of age, and often there is a second view needed, to fully understand a situation. (Van Hage et al., 2010)

In 2016, a picture shown in figure 2.16 went viral where a group of children was starring at their smart phones in front of a Rembrandt's painting. The children were widely criticized for not paying attention to the museum and it was argued that the picture represented what is wrong with today's youth jumping on the *kids these days!* bandwagon. However, in fact the children were using the museum's smartphone application. (Maria Guido, 2016)

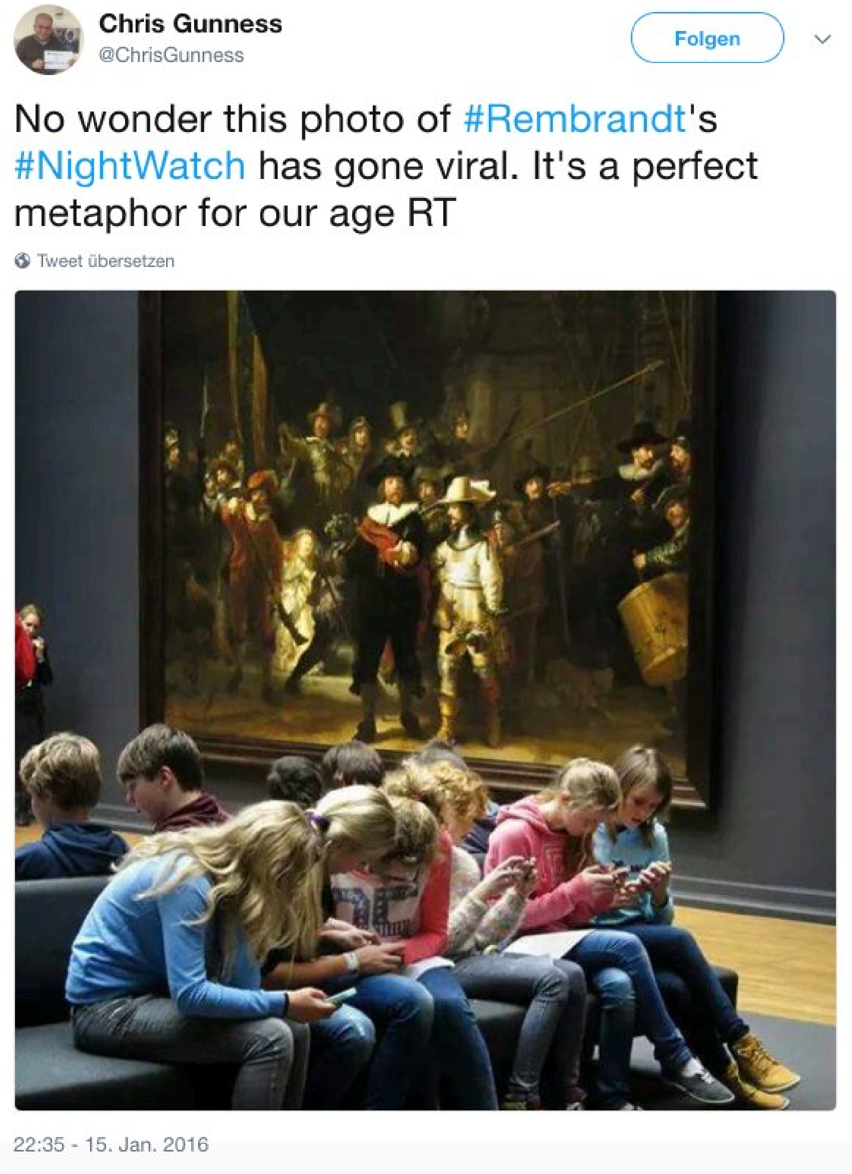
The *Rijksmuseum* in Amsterdam provides an application to their visitors that contains guided tours and further information about the exhibitions (Van Hage et al., 2010), and *"the students were instructed to complete an assignment by their school teachers, using the museum's excellent smartphone app"*, according to José Picardo (2016).

Another approach is to organize *Treasure Hunts* within museums as a new possibility to earn interest for the museums' contents. More information on that topic can be found in section 2.3.4. (Economou et al., 2015)

Sightseeing

Tourists traveling in foreign countries have to rely on travel guides and tourist maps for gaining information about the area they are visiting. Guides and maps are helpful to get knowledge about the most interesting sights in a designated area. Nonetheless, they are limited to an offline map to provide information about where they are placed. In order to take advantage of the whole potential of modern technologies such as GPS, additional applications can be used to navigate

[18] http://www.museevirtuel-virtualmuseum.ca/



Chris Gunness
@ChrisGunness

No wonder this photo of #Rembrandt's #NightWatch has gone viral. It's a perfect metaphor for our age RT

22:35 - 15. Jan. 2016

Figure 2.16: Screenshot of a tweet by *Chris Gunness* prejudicing children for using their smartphones in a museum.

through a foreign city. Apps such as *tripadvisor*[19] provide their users with sights, helpful ratings and GPS coordinates of tourist attractions. In combination with a navigation application, for example *Google Maps*[20], tourists can be guided directly to the sight, also including public transportation if needed. Another approach to combine tourist maps with GPS navigation is described by Hsu et al. (2018).

[19] https://www.tripadvisor.com/

[20] https://www.google.com/maps

Hiking

When going on a hike, one challenge can be to avoid getting lost in alpine areas which can display dangers due to their wide ranges and their weather conditions. Therefore, following marked tours is essential, especially for non experienced hikers. Many apps like *Ortovox*[21] provide a huge collection of alpine tours. Combining them with the technology of GPS, it is significantly easier for hikers to keep track on alpine tours. Moreover, an important fact is that those maps and tracks are additionally available offline, due to often lacking mobile signal in alpine areas. Additionally, various other useful features are available such as a compass, an altimeter, tour tracking or a summit finder. Summit finders, for example, can identify summits by combining information gathered through GPS, compass and augmented reality (AR), which can add a whole new experience to a hike. (Fischer, 2011)

2.3.3 Examples of Educational Activities

Schools use to combine their class outings or field trips with hiking in order to bring children out into the nature and teach them about different aspects of the environment. While trekking through, for example, forests, information about the environment like trees with their unique leafs, berries, or animals are provided and taught to the children. To get them even more interested, pupils can be encouraged to fill out cloze tests about the things they are currently learning. If the class outing is not taking place in the nature but in a city, those cloze tests can help children to get a better understanding concerning facts about the city itself, such as the number of its inhabitants, the year of the foundation, the city's famous people or historical impacts. The cloze tests can be as well perfectly combined with the sights, attractions and points of interests of a city. (Pearce, 2015)

To make those school trips even more appealing to children, the trip can be easily turned into a game. Studies show that the majority of teachers and students claim that using games to teach is a great motivation to learn (Sandford, Ulicsak, Facer, & Rudd, 2009). One possibility of modifying those trips with the help of games would be the usage of mobile devices. With the aid of mobile devices, each child could be asked to find the next sight. This can be done by simply providing hints about the sight or by giving its GPS-coordinates for navigation. (Donadelli et al., 2017)

2.3.4 Examples of Game Activities

This section is about game activities and gives a short overview about different games which require the players to go to specific locations while performing the game.

[21] https://www.ortovox.com/de/safety-academy/tourenplanung/bergtouren-app/

Treasure Hunt

The game *Treasure Hunt* is a very famous game where the participants have to find hidden objects or places by following hints or solving riddles. It normally consists of multiple stations where a hidden objects with a clue or a hint has to be found at each station in order to get to the next station. For reaching the hint, participants generally have to solve a riddle first. Although Treasure Hunt is mostly played outside due to better possibilities of hiding objects, it is also playable indoors. Moreover, the game is popular at birthday parties as it is perfectly suited for being played by multiple players in a team but as well in separated teams with the purpose of racing each other. An additional approach is to use Treasure Hunts for educational purposes at cultural organizations, such as museums and archaeological sites where the game aims to enhance the experience of their visitors. (Economou et al., 2015)

As previously described, a Treasure Hunt actually needs some preparation. It normally consists of multiple stations where hidden objects containing a hint are located. Those objects have to be hidden at the correct location filled with the previously prepared hints or riddles. Those riddles can be of a great variety. For example, they can consist of navigational information like directions and distances, so that the next location has to be found like in *Orienteering*. The riddles can also be questions of a certain topic where the solution directs you to the next stage. Moreover, the riddles can display letters which have to be marked like in a crossword puzzle whose combination will then provide the hint. Finally, the participants can also be asked to solve an *anagram* or to calculate letters regarding their position in the alphabet in order to receive coordinates as a result. There is a wide range of possibilities (some examples[22]) and people are very creative in establishing such hunts. (Economou et al., 2015)

The Guinness World Record for *"most participants in a treasure hunt game"* is currently held by 466 participants, who where all Ambassadors of the 2012 Summer Olympics in London. They played in 93 teams of 5 and had to solve 12 riddles along the River Thames. (London & Partners, 2012)

Scavenger Hunt

The game *Scavenger Hunt* is a more flexible variety of the game *Treasure Hunt* usually played in small teams. There are defined but mostly useless objects which have to be gathered by the participants. The difference with Scavenger Hunt is that there is no given order in which the list has to be accomplished. Those objects on the list are mostly useless or cheap, so they can for example be get from pedestrians or be found somewhere in the city. Within the game the winner is that participant who was able to get most items done or who is the first in finishing the list. (Master Scavenger, scavengerhuntideas.com, 2015; Economou et al., 2015)

[22] http://www.treasure-hunt-ideas.co.uk/all-ideas

Scavenger Hunts are also used as advertisement as it is an original way to include people to participate and get to know a specific product. One of the most famous examples is the novel *The Da Vinci Code*. In 2006 a Scavenger Hunt called *The Da Vinci Code Quest on Google* was organized in a cooperation of *Google* and *Sony Pictures* to promote the release of the upcoming movie version of *The Da Vinci Code*. Participants could solve up to 12,358 original puzzles and where able to win prices. The first price was a round trip to all of the main locations of the novel: New York City, Paris, Rome and London. (Wei-Hwa Huang, Google, 2006)

The Guinness World Record for *"Largest scavenger hunt"* was achieved by 2732 people joining a Scavenger Hunt organized in Otawa, Canada, as part of Canada's 150th anniversary in the year 2017. (Guinness World Records, 2017)

Mobile applications like *LMAC* or *MythHunter* are providing possibilities for creating mobile Scavenger Hunts, introducing them to the digital era. More details about them and other games can be found in section 2.2.3.

Table 2.2: Characteristics of selected location-based activities.

Activity	Sector	Participants	Application Example
Fitness Tracking	Sport, Health	single	Runtastic[1]
Activity Tracking	Sport, Health	single	Google Fit[2]
Orienteering	Sport, Health	multi	-
Museums	Tourism, Education	single/multi	Rijksmuseum's App[3]
Sightseeing	Tourism	multi	Tripadvisor[4]
Hiking	Sport, Tourism	single/multi	Ortovox[5]
Field Trips	Education	multi	-
Treasure Hunt	Game	multi	LMAC
Scavenger Hunt	Game	multi	MythHunter

[1] https://www.runtastic.com/
[2] https://www.google.com/fit/
[3] https://www.rijksmuseum.nl/en/app
[4] https://www.tripadvisor.com/apps
[5] https://www.ortovox.com/de/safety-academy/tourenplanung/bergtouren-app/

2.4 Frameworks for Mobile Applications

The mobile phone market is mostly occupied by two leading operating systems, namely *Android*[23] by *Google* with a market share of approximately 75 percent and *iOS*[24] by *Apple* with a market share of approximately 23 percent (StatCounter, 2019). To cover the whole market, mobile applications (*apps*) for at least those two operating systems should be provided by their developers. This can be achieved

[23] https://www.android.com/
[24] https://www.apple.com/at/ios/

by different approaches, which will be shortly described in this section and are visually shown in figure 2.17.

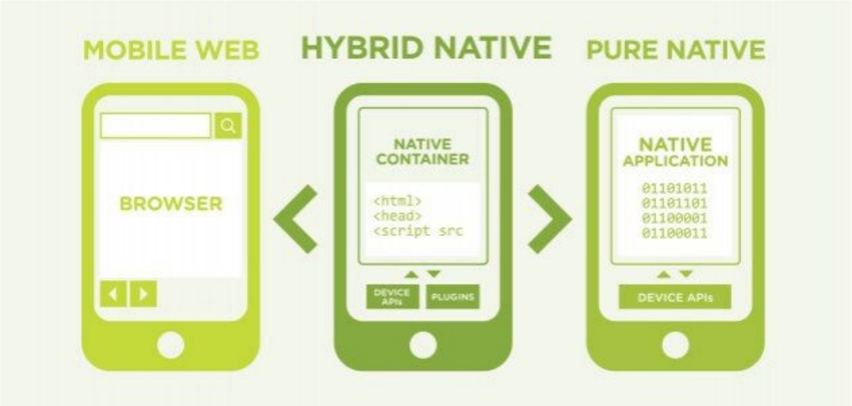


Figure 2.17: The architectural difference between Native, Hybrid and Mobile Web apps. (altitude-labs.com, 2019)

2.4.1 Native Applications

Targeting multiple operating systems with *native applications* is normally resulting in significantly more work, because the time and effort needed is multiplied as two independent applications have to be developed. Additionally, constructing native applications also leads to more costs as well. The reason for this is that separate teams frequently need to develop each functionality independently given that the code is not re-usable for different platforms. (Majchrzak & Grønli, 2017)

In order to develop a native app for **iOS**, a computer with *macOS* is needed to run the *Apple* Software Development Kit (*SDK)*[25], which contains the necessary framework **XCode-Tools**[26]. The code itself has to be written in *Objective-C*, *C++* or *C*.

For the creation of a native **Android** application, one needs to have the *Android* Software Development Kit[27] installed, which runs on various platforms such as *Windows*, *macOS* or *Linux*. It contains the necessary **SDK Tools**, needed for the compilation of the code that is written in *Java*.

2.4.2 Pure Web Applications

Pure Web Applications are basically a website based on HTML5, CSS and JavaScript. They are supposed to be viewed within a mobile web browser like *Chrome* or *Firefox*, but are lacking the user-experience (UX) of a real native app. Besides,

[25] https://developer.apple.com/
[26] https://developer.apple.com/xcode/
[27] https://developer.android.com/studio/

the access to functionality of the phone is frequently limited. (Majchrzak & Grønli, 2017) Examples for such frameworks are **jQuery Mobile**[28], **React JS**[29] or **Onsen UI**[30].

2.4.3 Hybrid Applications

Hybrid Applications, known as well as *Cross-Platform Applications*, are developed in specific frameworks (i.e. Ionic Framework[31]). Using those frameworks, a mobile application can be deployed to multiple platforms by only programming it once. (Majchrzak & Grønli, 2017) Such applications are again websites like the pure web applications. However, they are not destined to be run in a web-browser on the mobile phone but in the native *WebViews* wrapped by a container. This allows the application to access the device's *application programming interfaces* (API) like a native application and attempts to simulate the native user interface (UI). This wrapping is done by tools such as **Cordova**[32] or **PhoneGap**[33], or with **Unity**[34] for 3D game development. (Andersson, 2018)

According to *appfigures.com*, the ratio between native and non-native apps is around 75 to 25 percent. Within the part of the non-native apps around 40 percent are using *Cordova* and 30 percent *Unity* as shown in figure 2.18. (Ariel, 2018)

2.4.4 React Native

Another new approach by *Facebook* is *React Native*[35]. By using React Native, their developers attempt to dispose of the simulation layer *WebView* used by for example *Cordova*. This layer is supposed to mimic the native UI. In order to achieve a real native feeling, the UI of Native React is directly accessing the native framework with JavaScript and is using native UI widgets rather than simulating them. Those different architecture stacks are visualized and compared in figure 2.19. (Ye, 2018)

2.4.5 Comparison

Frameworks for mobile applications can be separated in three main groups, namely those to develop native applications, those for pure web applications, and those for developing hybrid applications. There is no definitive best framework

[28] https://jquerymobile.com/
[29] https://reactjs.org/
[30] https://onsen.io/
[31] https://ionicframework.com/
[32] https://cordova.apache.org/
[33] https://phonegap.com/
[34] https://unity3d.com/
[35] https://facebook.github.io/react-native/

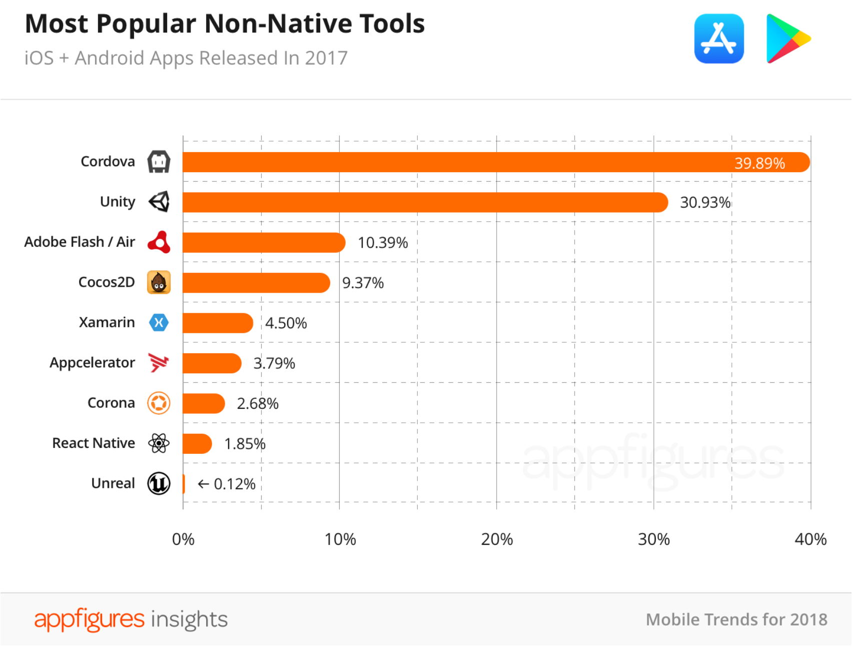


Figure 2.18: Most popular non-native tools. (Ariel, 2018)

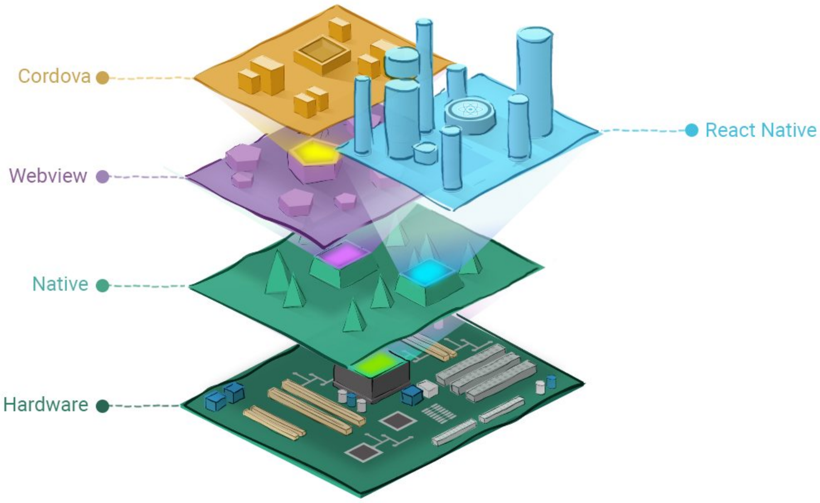


Figure 2.19: React Native strives to discard the simulation layer by directly accessing native UI widgets. (Ye, 2018)

as each has their pros and cons. Therefore, the correct decision highly depends on the objectives of the development. This comparison is focused on seven main features which are described in the following paragraphs, and should help developers in finding the framework which best fits their needs. Figure 2.20 is a visual presentation of the focus of each framework type.

Native Applications are developed to be used in only one specific operating system and are therefore optimized in performance, look, and feeling. That provides a behavior which the user already knows and expects of a mobile application. However, the specialization also leads to certain drawbacks, namely the higher effort in developing the application for all major operating systems like Android and iOS. Another big drawback is that specific hardware could be required for development.

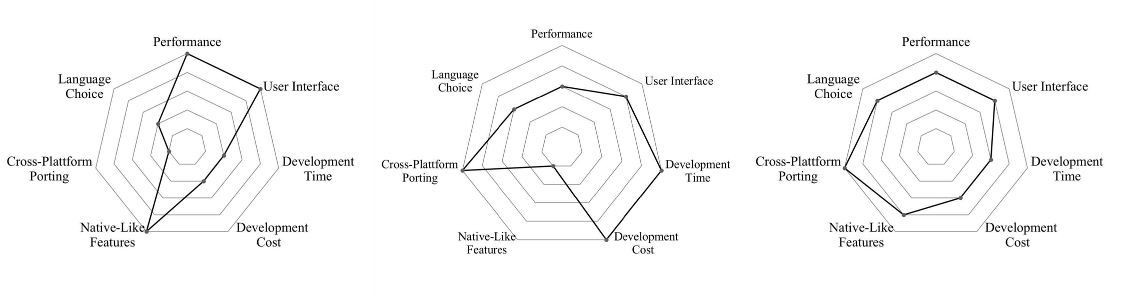
In general, native applications are recommended for projects with a focus on performance and a user-known UI and UX.

Pure Web Applications are basically just a HTML5-based website and are highly cross-platform compatible, because the only requirement is a web-browser. Therefore, development-time and -costs are kept low. A huge drawback is the dependency on the browser's support of mobile functionalities which is often limited. Additionally, the user-interface as well as the user experience are only simulated with CSS and JavaScript to behave in a way as native as possible.

Pure web applications are recommended for projects with a focus on cross-platform compatibility, but with limited budget and time, or for a quick prototype.

Hybrid Applications are developed for multiple platforms at once, which keeps the afford lower. Specific frameworks can be used for development, such as *Ionic*, which helps to maintain huge projects as well. Additionally, by selecting the framework the programming-language can also be chosen, such as *TypeScript* or *Java* for example. The code then is wrapped by tools like *Cordova* to access the device's API for a better simulation of the user-interface.

Generally, hybrid applications are recommended for bigger projects with a focus on cross-platform compatibility, native-like behaviour, or a specific programming-language.



(a) Native Applications (b) Pure Web Applications (c) Hybrid Applications

Figure 2.20: Comparison of the main features for three different framework-types. The recommendation for a framework depends highly on the focus and needs of the development. However, hybrid applications (c) present the most balanced ones.

2.5 Summary

This chapter gave an insight into the early beginnings of navigation technologies such as radio-based and satellite-based navigation and their development to latest technologies like indoor navigation. In order to become independent of GPS, being provided by the United States of America, other countries are starting their own satellite-based navigation systems, some of them being Galileo or BeiDou.

Over the time and especially after removing the artificial errors called Selective Availability, GPS became available to civil people who progressively started to use it in their daily life, for example in cars as navigation system. Additionally, smartphones became widely available and subsequently their usage and functionalities such as providing mobile internet or GPS navigation made the usage of GPS much easier and affordable for everyone.

Those changes in navigation and the market of mobile devices also affected the development of location-based activities in many different areas, paving the way for the creation of a variety of applications. Inspired by those activities and the availability of new technologies, new games such as Geocaching were developed and lead to modern virtual mobile games like Ingress or Pokémon Go.

This chapter also provided an overview about frameworks which are available for developing such mobile applications and, finally, there was also an explanation about the advantages of cross-platform applications.

3 Requirements and Design

The research and findings in chapter 2 display an overview about the development in the field of location-based games and activities and provided information about the current market situation. In this chapter the conclusions are used to define the requirements and objectives to improve former work. Those requirements will determine the first conceptional architecture and design.

3.1 Requirements and Objectives

After the research in the last chapter was done, it could be concluded that people are willing to spend time outdoors and do some activities but are likely to use technologies that support them in doing those activities and even motivate them to go out and be active. Another conclusion was that location-based activities are a useful tool in the field of tourism, supporting tourists while sightseeing and providing them with more information than available on the streets. In the area of education technology is used to provide a playful way of learning, so-called edutainment, to motivate students and improve their learning success.

Therefore, several areas of activities, such as the examples given in section 2.3, could be defined, where people are using location based technologies, such as sport, tourism, games, education. One major requirement is to provide an application that can be used for activities in all of those areas. Although there are already existing applications that can be used in each area, an application which combines all the different fields of usage is still lacking. By providing the possibility to save a collection of geolocation points and linking different kinds of activities to them, a functionality is given to the users that can be used in many ways and opens many creative possibilities. Additional features should make the usage easier and funnier and consequently motivate people to go outside, leading to the name of the application which should be called *x-plore.it* (spelled *"explore it"*. More details are given in the following subsections.

3.1.1 Target Group

In relation to the application's target group, the aim is to establish an application which provides as much diversity as possible. In section 2.3 there was a list of various location-based activities described in detail. Those activities were separated into four categories, also defining the different target groups for the application.

The first category is **Sport and Health**; therefore, that category is especially appealing to sporty people. The second category is **Tourism**, primarily obviously focusing on tourists as players, but also on tourist boards and museums for creating and promoting their tours and exhibitions. Additionally, **Education** displays the third field, aiming to attract teachers as well as rangers which may be able to use the application for creating learning trails for their students. The fourth category is **Entertainment**, being interesting for people which already are playing location based games such as Geocaching or Pokémon Go. Additionally to the categories mentioned in section 2.3, **Marketing** was defined as another purpose of the application. The range of this group covers companies that want to promote their local branches or products.

To sum up, as different the areas of the provided activities are, as different are the target groups. However, the union of all those target groups represents a diversity of all kinds of people with no limitation to interests, age, or gender. For example, in order to use the application, it is not necessary to have knowledge in the field of technology. On the contrary, the application can also be appealing for computer geeks. Equally, the same applies to sporty people as well as to people not actively practicing sport. The only requirement in order to use it is owning a smartphone and due to this the usage should be as simple as possible for all kind of people.

The diversity of the target group and the purpose of the application determined the requirements described in detail in the following sections.

3.1.2 Non-Functional Requirements

Mobility

For using this application there should be no other device needed than a smartphone. This guarantees a high level of mobility for the user, as smartphones can be used almost everywhere. The only limitations are the signal and the battery. This requirement also offers the user the possibility to create new data on the fly while being at the location.

Usability

The app should be easy to use for all kind of people and should not be limited to the technically experienced ones. A good user-interface (UI) is essential to make the usage of features as intuitive as possible. Additionally, the app should provide the feeling of a native application.

Flexibility

One specific aim of the application which is important to consider during the process of programming is to create an application that can provide as much flexibility as possible for creating tours. This function should motivate users to activate their own creativity and use the application for many different purposes. Moreover, the application should be usable in different areas of daily life.

Availability

The application should be always and everywhere fully available. The user's progress should be available throughout multiple devices.

Performance

The application should run smoothly, which means without any long lasting loading phases that could become irritating for the users. In other words, the application should function in a proper way even though there is a huge amount of data available.

Scalability

The application should be flexible to the amount of users and data such as *Tours* and *Spots* without an impact to the performance.

Compatibility

The application should run on Android and iOS and is required to be compatible to older phones and OS versions. The users should be able to cross-platform play.

3.1.3 Functional Requirements

The general functional requirement of the mobile application is that a user can create a *Tour* that consists of multiple locations, called *Spots*, and play it afterwards. Those *Spots* are located at specific coordinates which are also defined by the user. Such *Spots* can have multiple *Actions* such as videos, questions, fitness activities or just simple information that is shown in the form of a text. After such a *Tour* has been created completely, it can be played privately or it can be officially published in order to be playable by other users as well. To play a *Tour*, a user has to finish all *Spots*. Due to this, the user has to go to the specified location of the *Spot* and finish all the assigned *Actions*. If all *Actions* of all *Spots* are finished, the *Tour* is accomplished successfully and can be rated. The *Tour* progress of the user can be reset so that the *Tour* can be accomplished multiple times what is displayed by a counter in the details of the *Tour*.

To get an overview about the functional requirements they are listed in the following lines. A more detailed explanation follows afterwards.

- *Tours*
  - are created by users,
  - consist of one or multiple *Spots*,
  - can be private or public,
  - can be played by users multiple times,
  - can be rated by users,
  - are finished when all *Spots* have been finished.
- *Spots*
  - are created by users,
  - are assigned to one *Tour*,
  - are virtually located at their GPS-coordinates,
  - can be visible or hidden,
  - are sorted or in random order,
  - can be navigated to,
  - can be found by getting close to their locations,
  - can require one or multiple user-*Actions*,
  - are finished when all *Actions* have been accomplished.
- *Actions*
  - are created by users,
  - are assigned to a *Spot*,
  - are requiring user-interactions,
  - can be of the following types, such as
    - Information,
    - Question, such as
      - Free text,
      - Yes / No,
      - Multiple choice
    - Website,
    - Video,
    - Sport.
- Users as Creators are able to
  - create, edit, and delete *Tours*,
  - create, edit, delete, and assign *Spots*,
  - create, edit, delete, and assign *Actions*,
  - upload, delete, and assign images,
  - publish and unpublish *Tours*,

  - request location-based information from *Wikipedia*[36],
  - request location-based videos from *Youtube*[37].
- Users as Players are able to
  - search *Tours* on a map,
  - search and navigate to *Spots* on a map,
  - play *Tours*,
  - play *Spots*,
  - accomplish *Actions* to finish a *Spot*,
  - finish a *Tour* by finishing all assigned *Spots*,
  - rate finished *Tours*,
  - redo finished *Tours*.

To sum up, *Tours* are created by users in order to be played by themselves or by other users. Those tours can consist of one or multiple locations called *Spots* where one or multiple *Actions* have to be done. If all *Actions* are successfully completed by the user, the specific *Spot* is finished. If all *Spots* of a *Tour* are finished, the *Tour* is completed as well. Those main functionalities are described conceptually in the next lines. Implementation details and screenshots about those and other useful features are provided in chapter 4.

Creating a Tour

A user can create an unlimited amount of *Tours*. Such a *Tour* is a collection of *Spots*. A *Tour* has a description and an image gallery, both set by the creator. A *Tour* itself has a calculated location at the geographical center of all its *Spots*. When the *Tour* is finished it can be played by the creator or it can be played by anyone else if the *Tour* is published as well.

Creating a Spot

A user can create an unlimited amount of *Spots*. A *Spot* is virtually located at a geolocation, which can be automatically set to the creator's current location or manually edited. A *Spot* has a description and an image gallery, both set by the creator. Additionally, it holds a collection of *Actions*. If the *Spot* is saved, it can be assigned to one *Tour*.

Creating an Action

A user can create an unlimited amount of *Actions* as part of a *Spot*. An *Action* can be of different types like information, questions, videos, fitness, or a link to a

[36] https://www.wikipedia.org/

[37] https://www.youtube.com/

website and has to be configured accordingly. When created it is automatically added to the current *Spot*.

Playing a Tour

A user can play his own *Tours* or those which are published by their creators. To play a *Tour*, the user has to finish all containing *Spots*. To do so, the user has to go to the location of the chosen *Spot*. If the location is confirmed by the application, all *Actions* are shown after each other and have to be done by the user. If all *Actions* are done successfully, the *Spot* is done. If all *Spots* of a *Tour* are done, the *Tour* itself is accomplished. After that the user has the option to rate the tour. Additionally, there is the option to reset the user's progress of the tour to redo it. Multiple successfully accomplishments are shown by a counter.

Doing an Action

A user has to do some *Actions* to finish a *Spot*. In which way the *Actions* are done depends on the type of them. An *Action* can be a simple information that is shown or a question that has to be answered. It can also be a video that has to be watched or a link that has to be followed. It can also be a fitness exercise that has to be done.

Rating a Tour

After a *Tour* is finished successfully the user has the possibility to rate this *Tour* with stars form 1 to 5 with 5 being the best. A *Tour*-rating is shown as the average of all votes with an accuracy of half a star.

Redoing a Tour

A user has the possibility to reset a *Tour* to redo it again. This is practical, for example, when doing daily routines like running parcours. A counter helps to keep track of the amount of completions.

World Map

All the published *Tours* are displayed on a map together with the current location of the user. This gives the user the possibility to see all surrounding *Tours*. By clicking on a *Tour*, the details and *Spots* are shown.

Automated Functionality

Wikipedia During the creation of a *Spot* the user has the possibility to automatically add a description selected from a Wikipedia[38] page. The coordinates of the *Spot* are used in order to find Wikipedia articles about topics located close to them. After triggering the search, a list of the closest articles are presented which are sorted by distance, using the public application programming interface (API) provided by Wikipedia. After the selection of the correct article, the introduction of it is used and automatically set as description for the *Spot* and a link to the dedicated Wikipedia page is automatically added as link-*Action* as well.

YouTube For adding a video-*Action* to a *Spot* the user can select a video from YouTube[39] either by defining it via a known YouTube-UID, or the video can be selected out of a provided list of videos. The list is generated by using the API of YouTube and by searching for videos related to the known information given by the *Spot*, like its title and location. After selecting a video from the list, the ID and title is used to create a video-*Action* and is added automatically to the *Spot*.

3.2 Conceptual Design

One purpose of the application is to create and share data with other users. To make this possible, all those data has to be stored in a global database on a server which is made accessible through the internet. This architecture is drafted in figure 3.1 as block *Server*. By saving the user's progress not only locally but also in the database, it is guaranteed that the user can play on any device with the data always up to date and synchronized. By the integrated *User Management* it is assured that user's can only access the data which they are allowed to access.

Additionally, the application requires the user to go to specific locations, making it necessary for the application to be run on a mobile device, which is represented by the block *Client* in figure 3.1. To create a native feeling as good as possible and to use native features such as GPS, navigation, or the camera, the decision was made to provide a mobile application instead of solely a website. In order to make the mobile application available to as many people as possible, it should be provided for *Android* and *iOS*. To prevent increasing the development time by developing two applications, a hybrid framework should be used for creating only one application.

To keep the application for playing and especially for the creation of *Tours* as simple as possible, all available options should be self-explanatory, visible, and structured. As a consequence, the user-interface is essential for a good

[38] https://www.wikipedia.org/

[39] https://www.youtube.com/

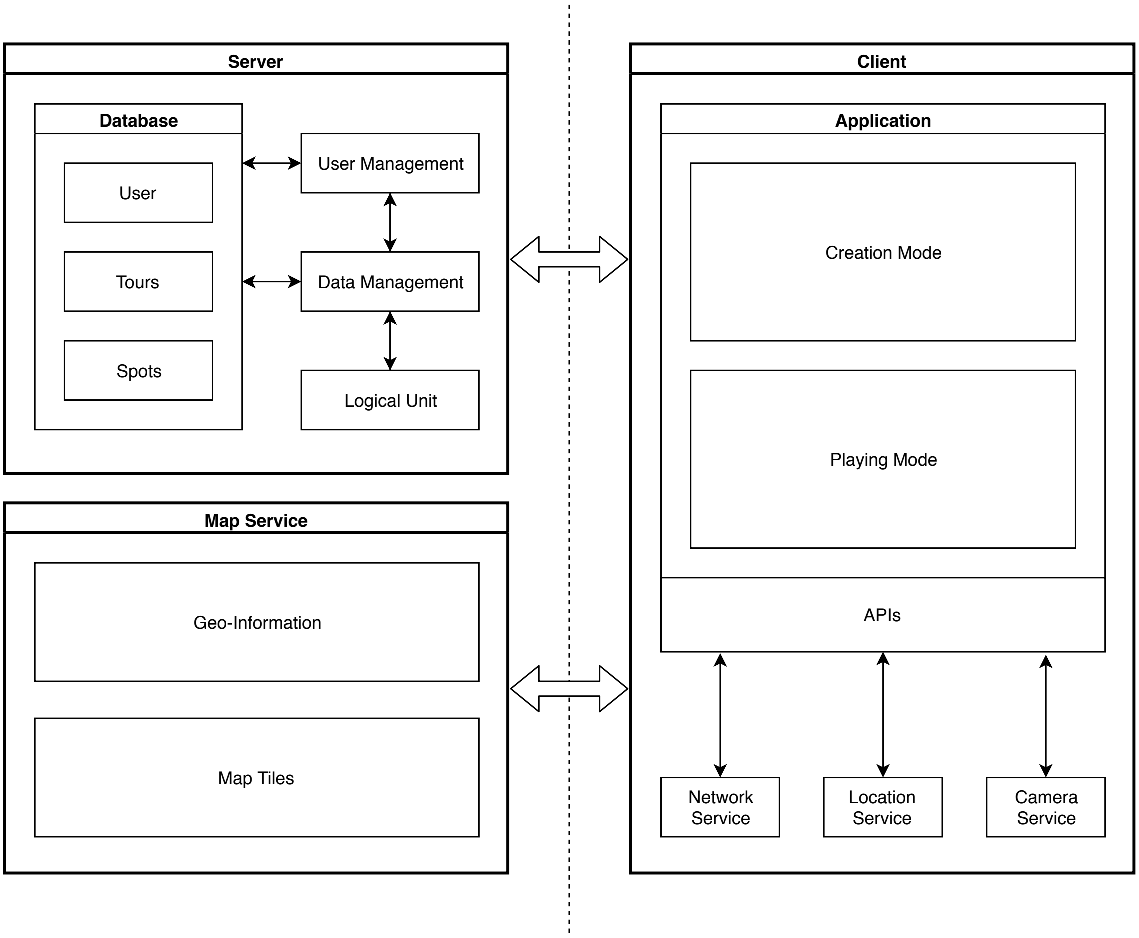


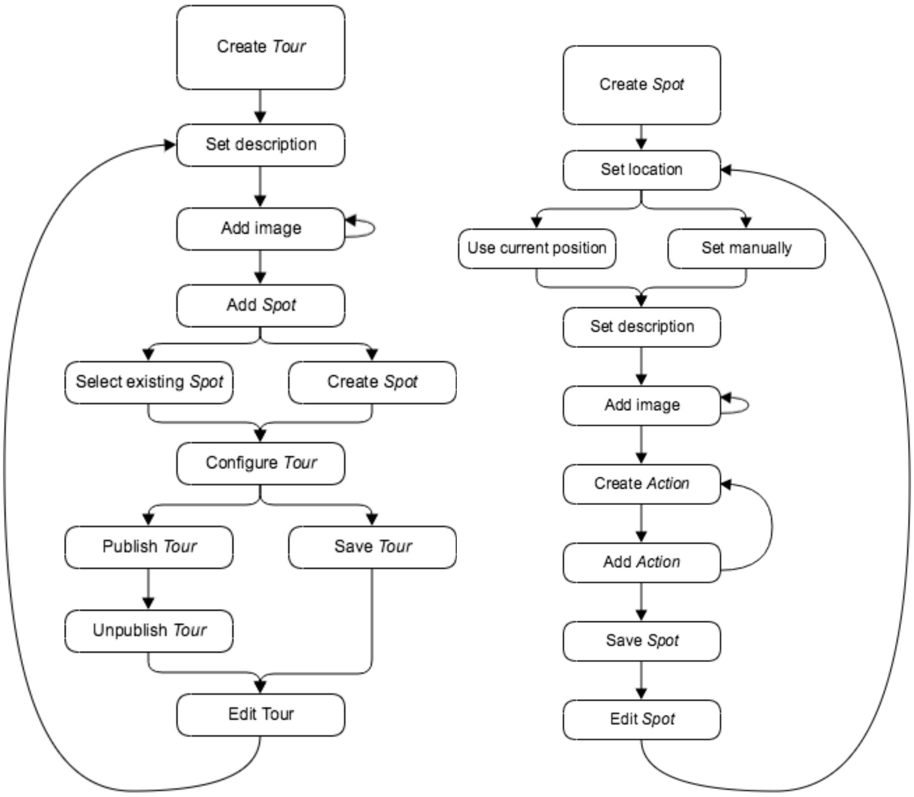
Figure 3.1: Conceptual client-server architecture of the application.

user-experience. Keeping up the native feeling as good as possible must be a requirement to the chosen hybrid framework.

To show the user's location and the data-points of the application such as *Tours* and *Spots*, an interactive map is needed. A map-service should be used which provides tiles of the current user's visible area of a map, the so-called viewport. This service is represented as *Map Service* in figure 3.1.

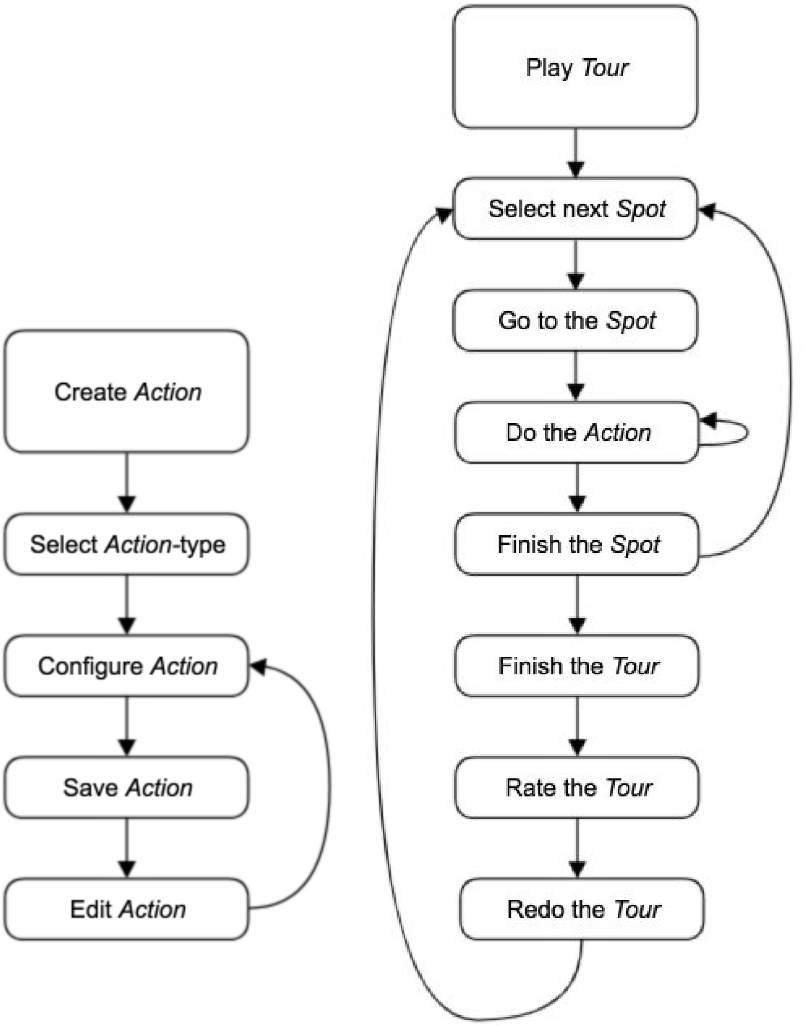
Workflows

The conceptional workflows of the main functions are shown in the following figures 3.2, 3.3 and 3.4.



(a) (b)

Figure 3.2: Workflows of creating a *Tour* (a) and of creating a *Spot* (b).



(a) (b)

Figure 3.3: Workflows of creating an *Action* (a) and of playing a *Tour* (b).

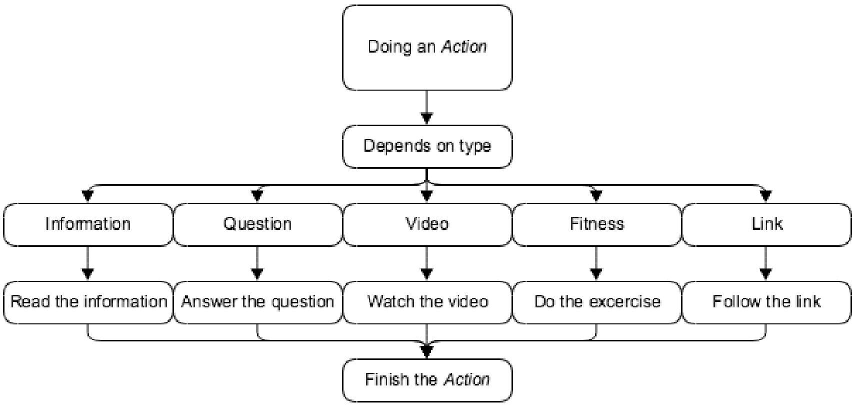


Figure 3.4: Workflow of doing an *Action*.

3.3 Design Decisions

Actually, there were two design decisions about which framework should be used. The first prototype of the application was a pure web application, developed in *jQuery Mobile*[40] together with a *MySQL*-database. However, as the project was growing, it quickly got too complex for maintaining the source code easily and the feeling of the user interface was far from being as native as expected. As a result, the first prototype was discarded and a new framework had to be selected, one that should be suitable for creating hybrid applications.

At the time of the restart of the development of the mobile application the hybrid framework *Ionic 2*[41] was released. As it met all the mentioned requirements of section 3.2 and because it was interesting to try out a new framework, it was chosen as a possible candidate. In the tutorial[42] of *Ionic 2*, which was a *WhatsApp*[43]-clone, a server-client architecture was used together with *Meteor*[44] as a web-framework and *MongoDB*[45] as a database. Because of the good tutorial and the good documentation, *Ionic 2* was finally chosen as the hybrid framework and the setup of this working tutorial should be used as a basis for the mobile application of this thesis.

Meteor together with *MongoDB* already provides a build-in user management and supports geometrical methods such as *near*, which can be used for location based searching. Additionally, in contrast to tabular database models like *MySQL*, where all the data has to be collected from several tables, MongoDB uses a document data model. Those documents are closely aligned to the structure of objects in the programming language with all related data already embedded as sub-documents or arrays. This makes it much easier to map the data in the application to the data stored in the database. In MongoDB the data is stored as JSON documents in their binary representation called BSON in order to support further datatypes such as *int*, *float* and others. (mongoDB, 2018) All of those benefits of MongoDB as well as having an already working server-client example led to the final decision to use Meteor in combination with MongoDB.

Additionally, for the interactive map which is necessary to show the user's current location and the data-points of the application, *OpenStreetMap*[46] (OSM) should be used as it is the free alternative of choice to *Google Maps*[47]. For the integration of OSM to an *Ionic* application, the JavaScript-library *Leaflet*[48] is recommended.

[40] https://jquerymobile.com/
[41] https://ionicframework.com/
[42] https://angular-meteor.com/tutorials/whatsapp2/ionic/setup
[43] https://www.whatsapp.com/
[44] https://www.meteor.com/
[45] https://www.mongodb.com/
[46] https://www.openstreetmap.org/
[47] https://www.google.com/maps
[48] https://leafletjs.com/

3.4 Summary

This chapter gave an overview about the main functionality of the application. This functionality is that users can create *Tours* which display a collection of geolocations, so-called *Spots*. Various *Actions* can be linked to those *Spots* and can be modified depending on the creativity of the users.

One of the major contents of this chapter was the definition of the target group. The target groups include people actively practicing sports, people that are already playing location-based games such as *Geocaching* or *Pokémon Go*, people of the education sector, people of the tourism sector, and people of the marketing sector. The union of all those groups is leading to an overall target group, representing various people in the possession of smartphones but independent from age and gender.

Furthermore, this chapter was used to define and describe the requirements and objectives out of which a conceptual design should be developed. The requirements were separated into non-functional and functional requirements and were first described in a bullet point list and further explained in more detail in the form of a text and in workflow diagrams.

Non-functional requirements such as availability and mobility led to the first decision to develop a mobile application and finally to the conceptual architecture of a client-server application.

Finally, a design decision was made and the technologies which should be used were defined. On the server side *Meteor* together with *MongoDB* will be used and on the client side the mobile application should be developed with the hybrid framework *Ionic 2*.

For the functional requirements the native features such as GPS, navigation, and camera should be used. For the interactive map *Leaflet* together with *OpenStreetMap* were chosen. Those and other functional requirements will be explained in more detail and displayed by the help of screenshots in the following chapter.

4 Development

This chapter describes the designed architecture and gives information about the technologies that were used to accomplish this. Furthermore, there will be an insight into different features and how they were implemented. Additionally, this section gives an insight into the mobile application and its features, how they look like and how they are used by the different user-roles. In order to get a better picture of the application, screenshots will be included.

4.1 Architecture

In chapter 3 all the requirements were defined, leading to a conceptual design of a client-server architecture. Additionally, the design decisions were made and the used technologies were defined, leading to the usage of *Meteor* as a web-framework together with *MongoDB* as a database. The database should hold all the data about users, *Tours*, *Spots*, user-progresses, ratings, and others.

For the mobile application on the client-side the front-end software development kit (SDK) *Ionic 2* is chosen, which uses *Angular 2* and *TypeScript*. For compiling the applications for *iOS* and *Android Cordova* is used.

For the presentation of all data-points like *Tours* and *Spots* and additionally the current user's position an interactive map is needed. Therefore, the decision was made to use *OpenStreetMap* which is included to the application with the JavaScript library *Leaflet*.

The user's location is determined by the native locating functionality of the mobile device. Almost all modern devices provide at least one system which is generally *GPS*. The phone reaches out to the signal of GPS satellites to determine the user's current location.

A visual presentation of the architecture can be found in figure 4.1.

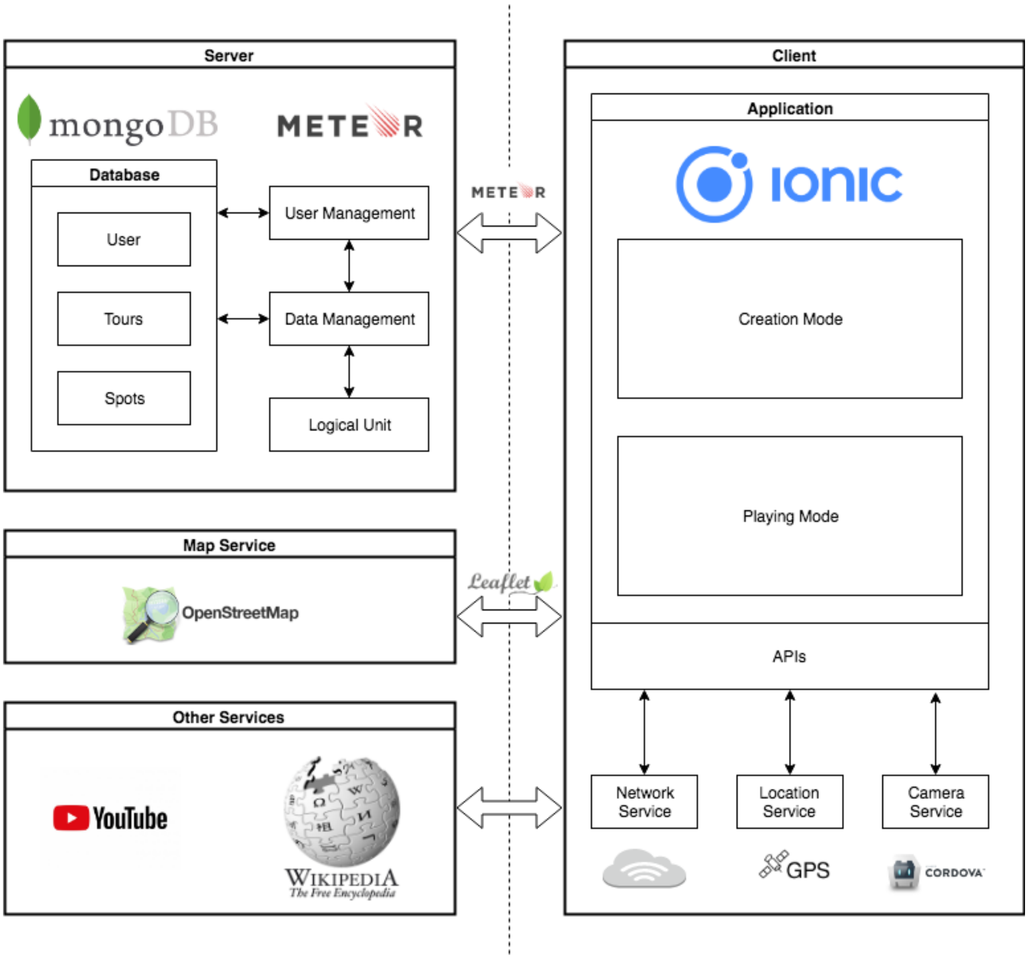


Figure 4.1: Architecture of the client-server application.

4.2 Technology

For the process of developing the mobile application the *Ionic 2*[49] framework was used, which works with *Angular 2*[50] and *Typescript*[51]. In order to compile the application for *Android* and *iOS*, the compiler *Cordova*[52] was considered.

Used Technologies

Ionic was founded in 2012 and first released at the end of 2013. The goal of the founders was to *create a better way for web developers to use their existing skillsets to build apps for the app stores*. Therefore, when using this framework it was possible to do the programming of mobile applications in *JavaScript*. At the beginning of 2017, version 2 of the *Ionic Framework* was announced and published. There

[49] https://ionicframework.com/
[50] https://angular.io/
[51] https://www.typescriptlang.org/
[52] https://cordova.apache.org/

was a major change from *AngularJS* to *Angular 2* and therefore from *JavaScript* to *TypeScript*, which offered great features such as object orientation, type safety and auto-completion, consequently making programming of bigger projects much more consistent, cleaner and reusable. The announcement of version 2 took place while the restart of the programming part of this thesis. After discarding the previous work that was done with *jQuery Mobile*, the switch to *Ionic 2* was performed and it finally was the correct choice due to the earlier mentioned advantages of typescript and the provided cross-platform mobile development technology stack.

Ionic 2 is a front-end SDK and therefore focuses mostly on the look and feel (LAF) or the user interface interactions of an application. In order to do so, the framework provides major functionalities, such as the navigation behaviour within the application, modals, alerts or simple selectors in forms which should behave like native applications would do. For the navigation, for example, a navigation-stack is used. To navigate to another page, it is pushed to the stack and in order to go back to the previous one the page is popped again. The same is valid for modals. *Ionics* takes care of the corresponding animation.

Each page of an application consists of components. Those components can be re-used all over the application and are defined in *TypeScript*-files. Those files contain the functional and logical part whereas the look of the components is defined with *Angular* and *CSS* in HTML-files. The HTML-structure is filled with data provided by the corresponding *TypeScript*-files. Those data, for example, can be received from a database. (ionicframework.com, 2019)

Meteor[53] was used as a web-framework together with *MongoDB*[54] as a database. Meteor would provide a full-stack JavaScript platform for developing mobile applications; however, because of the usage of *Ionic 2* on the client-side, only the server-part of *Meteor* was used. It offers full-stack reactivity which means that all the data is updated immediately to all devices that are connected via *WebSockets*. Those data is not sent as HTML but rather as actual data that will be rendered on the client side. (meteor.com, 2019)

MongoDB was used as a database for the server-application. Compared to MySQL, which uses tabular database model schemas to define the structure of the database where all rows and columns have to have values of a specific type, MongoDB uses a document data model with documents closely aligned to the programming language's object structure. What is more, MongoDB stores its data in JSON-like documents with the possibility to have a varied structure. (mongoDB, 2018)

[53] https://www.meteor.com/

[54] https://www.mongodb.com/

Other features within the application are using many additional 3rd-party technologies, such as *Leaflet*[55] together with *OpenStreetMap*[56] or public application programming interfaces (API) of *Wikipedia*[57] and *Youtube*[58].

For the package-management *NPM*[59] was used and for version-controlling *GIT*[60] was used via *Github*[61]. Finally, for the written part of this thesis, *LaTeX*[62] via *Overleaf*[63] was chosen.

Discarded Technologies

At the beginning of the implementation some technologies were tested but discarded as they did not fully meet the requirements. Some of the various reasons for the discard were, for example, the limitation of the mobile operation system, the lack of the native application feeling such as with *pure HTML5*[64], or the bad usability and overview during development of big projects such as with *jQuery Mobile*[65].

4.3 Development Details

The application *x-plore.it* is a mobile application developed as part of this thesis. The goal was to provide a tool that can easily combine a specific location with a task or information without any detailed technical knowledge. It can naturally be used by anyone for spare time activities as well.

The name *x-plore.it* (spelled *"explore it"*) describes the main purpose of the application: to explore the environment, especially to gather information about the surroundings, the nature, the city, or the museum.

In the next subsections, the definitions of the major types of the application will be shown at first and afterwards some main features will be presented with some insight of how it was implemented.

[55] https://leafletjs.com/
[56] https://www.openstreetmap.org/
[57] https://www.wikipedia.org/
[58] https://www.youtube.com/
[59] https://www.npmjs.com/
[60] https://git-scm.com/
[61] https://github.com/
[62] https://www.latex-project.org/
[63] https://www.overleaf.com/
[64] https://mobilehtml5.org/
[65] https://jquerymobile.com/

4.3.1 Object Types

Due to the usage of *MongoDB* all object types were defined in the document data model of the database. This model was also used in the application and made it possible that the objects are easily mapped to the data stored in the database. In the following subsections the major types are explained and their data model is presented.

User

A *User* is created upon registration and consists of an `_id`, a `username` and a `password`. It extends the already provided `Meteor.User`. The interface is presented in listing 4.1.

```
interface User extends Meteor.User {
  _id: string;
  username: string;
  password: string;
}
```

Listing 4.1: Interface of a *User*.

Tour

A *Tour* is a collection of *Spots*. If all *Spots* of a *Tour* are accomplished, the *Tour* will be accomplished as well. The position of a *Tour* is calculated automatically on creation and is located in the geographical center of all its containing *Spots*. The location is used to calculate the distance to a user or to show the *Tour* on the *World Map*.

```
interface Tour {
  _id?: string;
  ownerId?: string;
  approved?: Approval;

  title?: string;
  description?: string;
  images?: Image[];

  hide?: boolean;
  random?: boolean;

  //center of spots
  lat?: number;
  lng?: number;

  //user-specific / calculated - don't save in database
  rating?: number;
  status?: Status;
```

```
    iteration?: number;
  }
```

Listing 4.2: Interface of a *Tour*.

As shown in listing 4.2, the object `Tour` is separated into several parts. The first one contains the status of the *Tour* itself. Its ID `_id`, the owner `onwerID` and its approval status `approved`.

The next part is the visual front-end part that is shown to the user, namely the title `title`, the description `description` and the image-gallery `images` as an array of images.

In the following part, the global configurations for the assigned *Spots* of the *Tour* are saved. The first one, `hide`, defines if the *Spots* should be hidden or visible to the user, and the second one, `random`, if the next hidden *Spot* should be selected in order or randomly.

The next part is not entered by the creator but calculated during the process of saving the *Tour*. It represents the geographical center of all assigned *Spots* and is saved as coordinates in `lat` and `lng`. Listing 4.3 shows how the center is calculated.

```
let center = L.latLngBounds(
        tourSpots.map(s => [s.lat, s.lng] as [number, number])
    ).getCenter();

tour.lat = center.lat;
tour.lng = center.lng;
```

Listing 4.3: Code snippet of calculating the geographical center.

The final part defines fields that are not saved on the *Tour* itself in the database, because they are user-specific and need to be added or calculated on-the-fly, namely the average of all ratings `rating`, and the current user status `status` and the amount of the user's iterations `iteration`.

Spot

A *Spot* is a specific location defined by its coordinates. The owner of the *Spot* can add images and bind one or more *Actions* to it. The user then has to physically go to that *Spot*. When being in range of the *Spot*, a check can be triggered to prove the user's current position. When the position is confirmed, the *Actions* will be presented to the user one by one. In order to achieve the *Spot*, those actions have to be accomplished successfully.

```
interface Spot {
  _id?: string;
  ownerId?: string;
  tourId?: string;
  tourOrder: number;
  approved?: Approval;

  title?: string;
  images?: Image[];
  description?: string;

  actionSettings?: ActionSettings;
  hidden?: boolean;
  lat?: number;
  lng?: number;

  //user-specific / calculated - don't save in database
  status?: Status;
}
```

Listing 4.4: Interface of a *Spot*.

The object `Spot` can also be separated into several parts, shown in listing 4.4. The first one again contains the status of the *Spot*, namely its ID `_id`, the owner `ownerId` and its approval status `approved`. Additionally, it holds to which *Tour* it is assigned in `tourId` and at which position it should be shown in `tourOrder`.

The next part is the visual front-end part that is shown to the user, namely the title `title`, the description `description` and the image-gallery `images` as an array of images.

As mentioned above, a *Spot* can have multiple *Actions* assigned, and those are saved as `actionSettings`. Additionally, the *Spot* is placed at a specific location represented as `lat` and `lng`. The option `hidden` defines if the *Spot* initially should be visible or hidden to the user.

The user-specific status `status` is again not saved in the database to the *Spot*, but joined when receiving the *Spot*.

Action

An *Action* is bound to a *Spot* and has to be done in order to accomplish the *Spot* and *Tour*. Currently, following *Actions* are existing.

- Information
  A simple text is shown as a pop-up. It is usually an information about the current location but can also be an instruction to the oncoming *Actions* as multiple ones can be assigned to a *Spot*. To accomplish this *Action*, only an OK-button has to be pressed.

- Question
  This is usually a question about a specific topic or a question that can only be answered at the current location. To accomplish this *Action*, the correct answer has to be entered or selected. There are 3 types available:
  - Free Text
    A simple text-box is shown where the user has to enter the correct answer.
  - Yes / No
    The user can answer the question by selecting Yes or No.
  - Multiple Choice
    The user can select the correct answer out of a maximum of 4 answers.
- Video
  A defined *Youtube*-video is displayed in an overlay and can be seen by the user. To accomplish this action, the video has to be watched completely.
- Fitness
  A fitness exercise is described and has to be done by the user. During the process of creation a list of exercises is provided out of which a specific exercise can be chosen.
- Link
  A link to a web-page is provided. For safety reasons the user is asked before whether he wants to follow the link and open it in the local browser. No special interaction is needed to accomplish this *Action*.

All *Actions* are saved as `ActionSetting` to their *Spots*. If they need to be executed, they are converted to the correct type of *Action* with `createAction()` . To do so, all *ActionSettings* have their supposed type saved and are used in the constructor of the corresponding *Action*. Those *Actions* are extending a super-class, which requires to implement a `do()` -method. This method is called to actually start the specific *Action*-routine and requests a user-interaction. The result of this interaction is returned in a `Promise` , that can be successfully or not, depending on the result of the *Action*.

To accomplish a *Spot*, all its *Actions* have to be done. Therefore, all assigned *Actions* are looped and only if all *Actions* are finished successfully, the *Spot* is marked as done. This method is shown in listing 4.5.

```
loop(actionSettings: ActionSettings): Promise<any> {

  let ctrlService = this.ctrlService;
  let _this = this;

  return new Promise((resolve, reject) => {

    function loop(n): any {
      if (!actionSettings || n >= actionSettings.length)
        resolve();

      _this.createAction(actionSettings[n])
        .do()
        .then(() => { loop(++n) })
        .catch(() => { reject(); });
    };

    loop(0);
  });
}
```

Listing 4.5: Method for looping all *Actions*.

More details about the creation and the look of *Actions* will follow in the section 4.4 including screenshots from the user's point of view.

4.3.2 Server Side Implementation

On the server *Meteor* together with *MongoDB* is running. After the client is connected to the server, not only the sets of published database records but also methods are provided. Those methods are remotely callable functions that are invoked by the client by calling `Meteor.call()`. This triggers an asynchronous call to the server requesting data in response or to perform some specified actions.

Methods

Those methods are, for example, representing the four basic functions for persistent storage, such as *create*, *read*, *update* or *delete* (CRUD). Using the object type *Tour* as an example, those functions are represented by the following methods shown in listing 4.6.

```
    newTour(tour: Tour): Tour {}

    getTourById(tourId: string): Tour {}
    getTourIdBySpotId(spotId: string): Tour {}
    getAreaTours(bounds): Tour[] {}

    updateTour(tour: Tour): void {}
    updateTourStatus(tourId: string, status: Status): void {}

    deleteTour(tour: Tour): void {}
```

Listing 4.6: Server-side methods providing the *CRUD*-functionality.

Obviously, additional methods are needed to provide functionality for the offered features. Those methods are shown in listing 4.7.

```
    rateTourById(tourId: string, rating: number) {}
    getTourRating(tourId: string) : number {}

    redoTourById(tourId: string) {}
    unapproveTour(tour: Tour) {}
```

Listing 4.7: Server-side methods providing feature-functionality.

Most of the logic is done on server-side. Therefore, various helper methods are provided as well, shown in listing 4.8.

```
    unhideNextSpot(tourId: string): void {}
    calculateTourStatus(tourId: string): void {}
    resetTourIterationById(tourId: string) {}

    getWikipediaByCoords(lng: number, lat: number) {}
    getYoutube(search: string) {}
```

Listing 4.8: Server-side helper methods.

4.3.3 Client Side Implementation

On client side *Ionic 2* was used, which is based on *Angular 2* and *Typescript*. The project structure of a new *Ionic 2* application looks as shown in listing 4.9.

```
|-- config.xml
|-- hooks
|-- ionic.config.json
|-- node_modules
|-- package.json
|-- platforms
|-- plugins
|-- resources
|-- src
|-- tsconfig.json
|-- tslint.json
```

Listing 4.9: Folder structure of an *Ionic 2* project.

Most of the application's logic is located in the `src` folder, where also the `index.html` file is located. This file basically loads the whole app via the entry point `<ion-app></ion-app>`.

Component

An application written in *Ionic 2* is based on page components. Such a page component represents a single page that is viewable on the mobile screen - similar to what is known as *Activity* for Android developers. Those page components are put into a stack, so navigation between pages - back and forth - is just a simple push or pop on the page stack. (Ganga, 2016)

A page component consists of three parts, namely decorator, class, and template - as shown in listing 4.10

Decorator To define a class as a *Component* it is necessary to annotate it with a *Component* decorator. Therefore, it is required to import the *Component* package from `@angular/core`. The decorator provides configuration metadata that determine how the component should be processed at runtime. For example, that metadata can be the `templateUrl`, where the template file of this component is defined, or the `selector`, which defines a CSS-selector for easily re-using and including the component in any other component. (Tomes, 2019)

Class The logical part of the component class defines all the properties and functionalities. Depending on the complexity of the class this can be as simple as just having some user data to display or more complex like creating or manipulating some *Tour*-data. The properties and methods can also be accessed from the *View*, either for displaying the content of a variable or for calling a method by clicking a button.

Template The view of a page component is defined by a specified HTML/CSS-template. In this template, defined variables of the class can be used in different ways, like one- or two-way bindings or by simple interpolation `{ ... }`. Other useful features are `*ngIf="condition"` for displaying elements only depending on a given condition, or `*ngFor="let i of iterable"` for easily looping through an iterable, printing all its content such as a list of users. Calling a method by clicking a button is as simple as `<button ion-button (click)="buttonClicked()">Click</button>`.

```
import { Component } from ’angular/core’;

Component({
  selector: ’myClass’,
  templateUrl: ’myClass.html’,
})

export class MyClass {

}
```

Listing 4.10: Code example of an *Ionic 2* page component.

4.3.4 Features

This section will give an overview about selected main features to be pointed out besides many other functionalities. Screenshots of the viewpoints will be provided in section 4.4.

Private Usage

Due to the provided settings it is possible to use the application for private purposes. If the *Tour* is not published, only the creator can see as well as play it. This can be used, for example, for daily training.

World Map

On a *World Map* all published *Tours* are shown to the user. With a click on a *Tour* more details are shown about the containing *Spots* (if not hidden), the current distance or about the owner. The *Tour* is located in the geographical center of all its containing *Spots*.

The map offers features such as to center the current user's position and to follow while the user is moving. Additionally, a new *Spot* can be created at the current position, or the user's profile can be opened.

Location based Spot recommendations

When creating a *Spot*, it is recommended to provide some detailed information about the location. This can automatically be done by fetching information from *Wikipedia.org*. A location-based request is sent to the API and the user can select the correct result to be entered as a description of his spot. Additionally, the user is asked whether a link to the chosen *Wikipedia* article should be added as *Link* as well.

An example for such an API-call is shown in listing 4.11.

```
https://en.wikipedia.org/w/api.php?
    format=json&
    action=query&
    prop=extracts%7Cpageimages%7Cinfo&
    inprop=url&
    piprop=thumbnail&
    pithumbsize=144&
    pilimit=20&
    exintro&
    explaintext&
    redirects=1n&
    generator=geosearch&
    ggscoord=47.0582022%7C15.4440016&
    ggsradius=1000&
    ggslimit=20&
    origin=*
```

Listing 4.11: Example for an API-call to *Wikipedia*.

Location based Video recommendations

A *YouTube* video represents a possible *Action*. If the user does not yet know which video to include, it is possible to get location based recommendations using the YouTube-API. The user can select a video from the results and the video is then added to the spot as *Action*.

One possible API-call is given in listing 4.12.

```
https://www.googleapis.com/youtube/v3/search?
   location=47.0582022%2C%2015.4440016&
   locationRadius=5km&
   maxResults=50&
   order=relevance&
   part=snippet&
   type=video&
   q=Graz&
   key={key}
```

Listing 4.12: Example for an API-call to *YouTube*.

The location-based results of the YouTube-API are not as good as from Wikipedia. Therefore, the possibility to add search-terms was provided.

Navigating to a Spot

A user can use any installed navigation application to navigate to a selected *Spot* by pressing the compass-icon in the top-right corner. This triggers an external call pointing to an address written in the *Geo URI scheme*[66], defining the supposed coordinates. An example of the *Geo URI scheme* looks like this: `geo:37.786971,-122.399677`. The implementation is shown in listing 4.13.

```
callExternalNavigator() {
    let label = this.spot.title;
    let coords = this.spot.lat + ',' + this.spot.lng;
    window.open(encodeURI('geo:?q=' + coords + '(' + label + ')&
       mode=w'), '_system');
}
```

Listing 4.13: Method using the *Geo URI scheme* for navigating.

[66] http://geouri.org/

Protection of User data

With children being part of the target-groups, protecting their data is very important. For this reason all the saved user-data is anonymous. The best protection of private data is not using it, so during registration for *x-plore.it* no email-address or phone-number is required, only a username and a password is needed. Furthermore, the user's progress is not visible to anyone else within the game as it could provide sensible data about the user's home location.

Rating

After successfully finishing a *Tour* the user can rate how much the *Tour* was enjoyed with up to five stars. The overall rating that is shown on the *Tour* is the average of all votes.

Iterations

There is the possibility to do a *Tour* multiple times. Therefore, a counter which counts the successfully finished iterations of a *Tour* is added. This can be useful if the application is used for a regular training.

User Management

Meteor is providing a user management, named *Meteor Accounts*[67] system, that was used and extended by this application by including the `accounts-password`-package. Methods are provided for authentication and authorization of users to verify the reading or writing rights for the requested data.

Creating, Editing and Publishing

Tours, *Spots* and *Actions* can be created by any user. During creation users are able to use their own creative thinking in order to fill out details and descriptions. By doing so, users are able to enhance *Spots* and *Actions* by their own ideas and images. Those texts and images can also be edited by users multiple times until the *Tour* is published for others. When published, other users can play the *Tour* as well. The *Tour* can also be unpublished and then edited again. More details and screenshots are found in section 4.4.2.

[67] https://docs.meteor.com/api/accounts.html

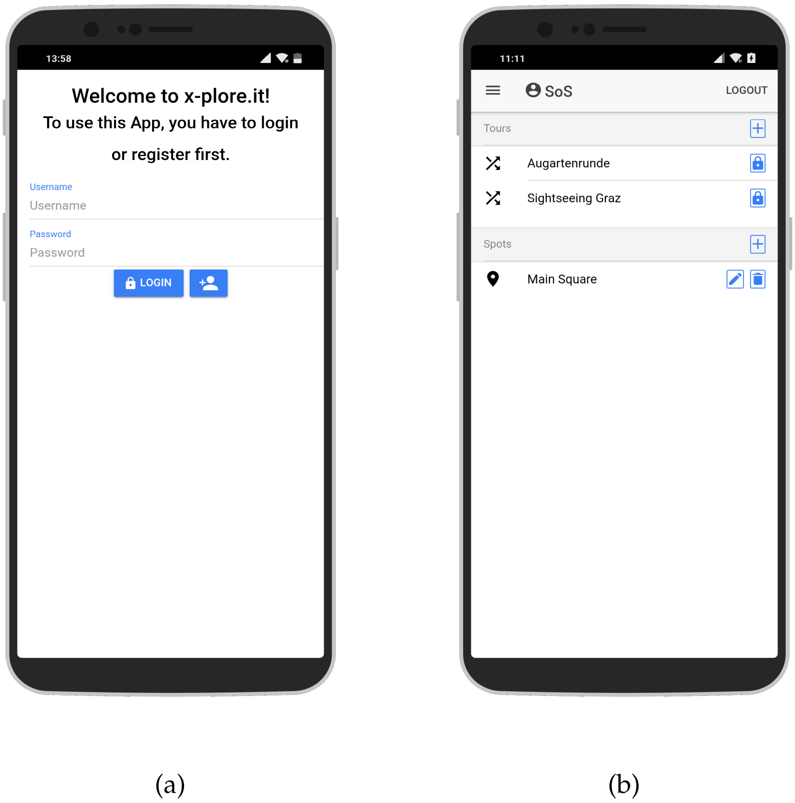
4.4 Usage and Viewpoint

This section will provide an insight into the mobile application *x-plore.it*. For this reason, several screenshots will be provided showing the possibilities of the usage and the features.

4.4.1 General Viewpoints

Welcome Screen

After starting the application, the welcome screen as in figure 4.2 is shown, where the username and the password have to be filled in. By providing those data the user can register a new user and login the next time.



13:58

Welcome to x-plore.it!
To use this App, you have to login or register first.

Username
Username

Password
Password

LOGIN

11:11

SoS LOGOUT

Tours

Augartenrunde

Sightseeing Graz

Spots

Main Square

(a) (b)

Figure 4.2: Screenshots of the login-screen of the application *x-plore.it* (a) and of the profile page (b). The public profile page of another user lists all public *Tours* of this user. The own profile page additional shows the unpublished *Tours* and the unused *Spots* and offers the option for editing, deleting and creating new ones.

Profile Page

When logged in, the user is able to enter several views. The first one that shows up after the login is the personal profile page. The profile pages shows the *Tours* of the selected user. If it is the own profile, it additional shows the unused *Spots* and offers the option to edit or delete those data, or to create new ones. More details about creating *Tours* and *Spots* will be shown in section 4.4.2. And the viewpoints of a player's perspective will be offered in section 4.4.3.

World Map

Another view is the World Map where the user's current position is shown. Users can scroll and zoom around as they want or they can enable to be centered and followed automatically while he moves. Additionally to the user's position, the surrounding *Tours* are displayed. They are located at the geographical center of all assigned *Spots*. In the corners of the maps users have a button with options to zoom in and out, go to personal profile pages, create a new *Spot* at the current position, or to configure the automatic centering and following of the position or to zoom out to show all surrounding *Tours* as shown in figure 4.3.

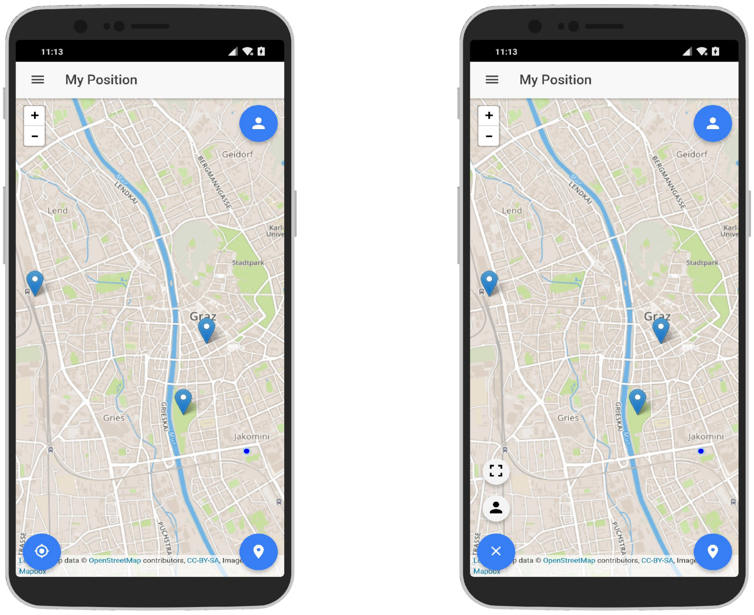


Figure 4.3: Screenshot of the World Map. It shows the current position of the user and the surrounding *Tours*. The buttons in the corners offer different functionalities.

4.4.2 Viewpoint as Creator

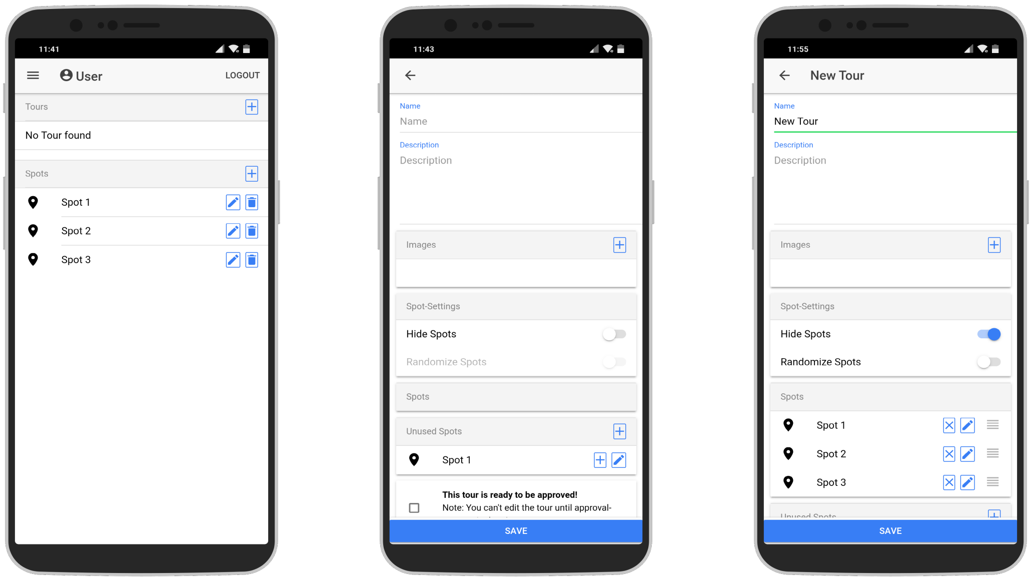
Creation of a Tour

Creating a *Tour* is simple. In the user profile an overview of the user's *Tours* and *Spots* is shown. To create a new *Tour*, the [+]-button next to the *Tours*-headline has to be pressed. This creates a new empty *Tour*, that can be configured by the user. Those steps are visually shown in figure 4.4.

Besides entering a name or description, the user can additionally add images that are shown in a gallery. Moreover, settings can be made to hide all assigned *Spots* or whether the hidden *Spots* should be made visible in sorted or random order.

As a next step, the user has to assign *Spots* to the *Tour*. If unused *Spots* exist, they can be selected by clicking the [+]-button next to the *Spot*. Otherwise, if no *Spot* is available, a new *Spot* can be created by pressing the [+]-button next to the headline. The order of the assigned *Spots* can be changed using drag and drop with the horizontal lines on the right. Assigned *Spots* can be removed by clicking the [x]-button or they can be edited by clicking on the pencil.

The *Tour* can be edited until it is marked to be published. To do so, the checkbox at the bottom has to be checked. After that, the *Tour* is marked to be approved by an administrator; however, currently, all *Tours* are automatically approved.



□ **This tour is ready to be approved!**
Note: You can't edit the tour until approval-

(a) User profile (b) Empty *Tour* (c) Filled *Tour*

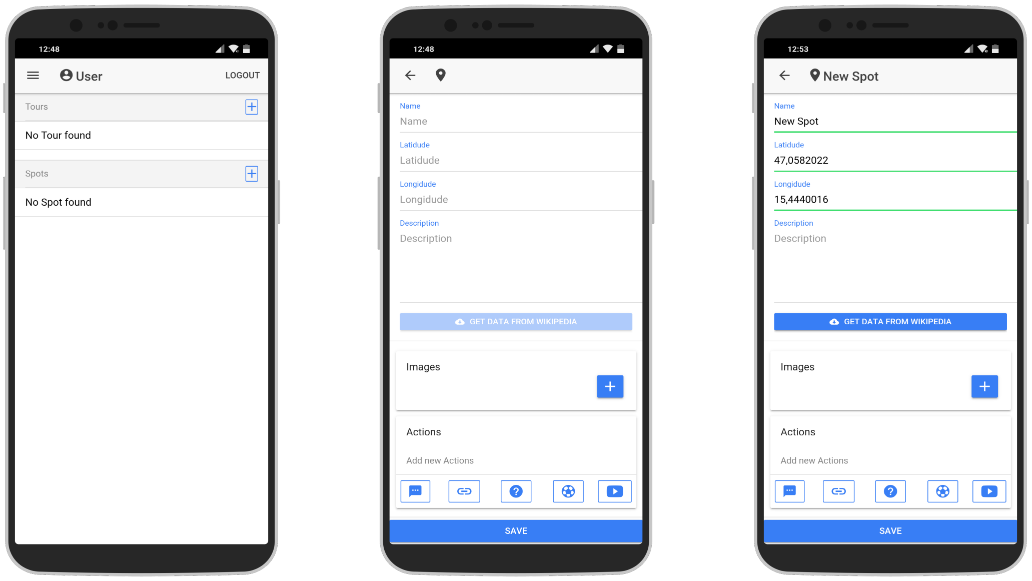
Figure 4.4: Screenshots of the creation-process of a *Tour*. It starts in the user profile (a) by pressing the [+]-button, which leads to an new empty *Tour* (b), where the data can be entered and images and *Spots* can be assigned (c).

Editing of a Tour A *Tour* can be edited by pressing the pencil next to it or in its header. If the *Tour* is published, a lock is shown instead of the pencil. By clicking the lock, the publication of the *Tour* can be revoked anytime and the *Tour* can be edited again. The editing of the *Tour* is the same procedure as the creation of the *Tour*, but the fields and data are already pre-filled.

Creation of a Spot

A *Spot* can be created in several ways. The first one is via the user-profile, by pressing the [+]-button next to the *Spots*-headline. This process is shown in figure 4.5. The second one is during the creation of a *Tour*, where again the [+]-button next to the *Unused Spots*-headline has to be pressed. The third one is via the *WorldMap*, by pressing the marker in the bottom-right corner. All three possibilities create a new empty *Spot*; though the coordinates are already pre-set to the current location of the user if created via the *WorldMap*. Therefore, this way is the recommended one, if the user is currently at a specific location of choice.

Besides entering the name, a *Spot* needs coordinates. They can be entered manually, or as already mentioned, by creating the *Spot* via the *WorldMap*.

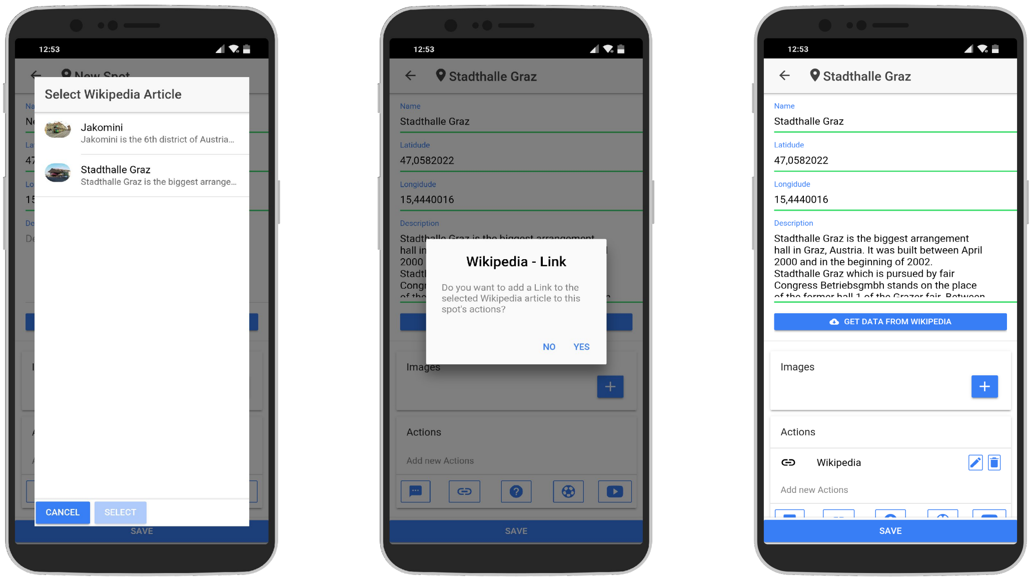


Name
New Spot
Latidude
47,0582022
Longidude
15,4440016
Description
Description

(a) (b) (c)

Figure 4.5: Screenshots of the creation-process of a *Spot*. It starts in the user profile (a) by pressing the [+]-button, which leads to an new empty *Spot* (b), where the data can be entered and images and *Spots* can be assigned (c).

The description can be entered manually as well, or it can be automatically filled with data from *Wikipedia*. By pressing the button below, the description-field, the current location of the *Spot* is used to find *Wikipedia* articles about topics located nearby. A list of articles is then presented to the user. After the selection of the correct article, the title and introduction of it are used and automatically set as name and description of the *Spot* and a link to the dedicated Wikipedia page is automatically added as link-*Action* as well. This process is shown in figure 4.6.



12:53

New Spot

Select Wikipedia Article

Jakomini
Jakomini is the 6th district of Austria...

Stadthalle Graz
Stadthalle Graz is the biggest arrange...

CANCEL SELECT

SAVE

12:53

Stadthalle Graz

Name
Stadthalle Graz

Latidude
47,0582022

Longidude
15,4440016

Description

Wikipedia - Link

Do you want to add a Link to the selected Wikipedia article to this spot's actions?

NO YES

Images

Actions

Add new Actions

SAVE

12:53

Stadthalle Graz

Name
Stadthalle Graz

Latidude
47,0582022

Longidude
15,4440016

Description
Stadthalle Graz is the biggest arrangement hall in Graz, Austria. It was built between April 2000 and in the beginning of 2002. Stadthalle Graz which is pursued by fair Congress Betriebsgmbh stands on the place of the former hall 1 of the Grazer fair. Between

GET DATA FROM WIKIPEDIA

Images

Actions

Wikipedia

Add new Actions

SAVE

(a) (b) (c)

Figure 4.6: Screenshots of automatically using data from *Wikipedia* for creating a *Spot*. First, a list of nearby articles is shown to the user (a). By selecting one, the user gets the option of adding a link-*Action* (b) and the *Spot* gets filled with data (c).

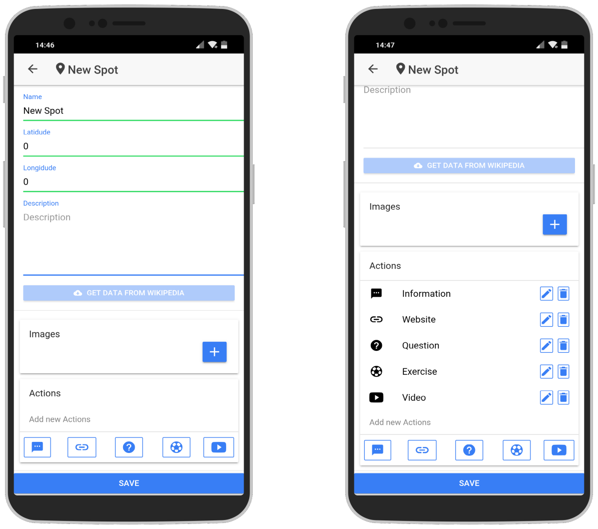
Similarly as for the *Tour*, images can be added to the *Spot* that are shown in a gallery.

As the next step, so-called *Actions* can be added to a *Spot*. Several types are available, such as information, links to websites, questions, videos, or fitness exercises. Those *Actions* require the user to do something in order to finish that *Spot*. The user's creativity defines what is possible. More details about the creation of *Actions* will be explained in the next subsection.

Editing of a Spot A *Spot* can be edited by pressing the pencil next to it when shown in a list or on the pencil in the header, when the *Spot* is displayed in detail by the owner. If the *Spot* is already assigned to a *Tour* that is published, it has to be unpublished before editing is possible again. The editing of a *Spot* is the same procedure as the creation of the *Spot*, but the fields and data are already pre-filled.

Creation of an Action

An *Action* is bound to a *Spot* and is created during the creation or editing of the *Spot* itself by clicking on one of the five offered *Action*-types at the bottom as shown in figure 4.7. By pressing the pencil next the *Action* it can be edited again and by pressing the trashcan it can be removed from the *Spot*. By pressing on the *Action* itself it can be simulated and tested.



Name
New Spot
Latidude
0
Longidude
0

(a) (b)

Figure 4.7: Screenshot of editing a *Spot* with all offered types of *Actions* at the bottom (a) and all kind of *Actions* already added to the *Spot* (b).

All the *Actions* have a title, still the rest of the creation is different and depends on the selected type.

Combination of multiple Actions An example of the combination of multiple *Actions* in the player's perspective of a *Spot* is given in figure 4.8. The player's perspective of the different *Actions* in use are shown in figures 4.23 and 4.24.

Information To create an *Action* of the type information, the first button has to be clicked and a title and a text must be set by the creator as shown in figure 4.9. While performing this action, a modal window is shown that contains the title and text which the creator has entered.

Website By pressing the second button, a link to a website can be offered within a *Spot*. The specific link to the website together with a title has to be entered by

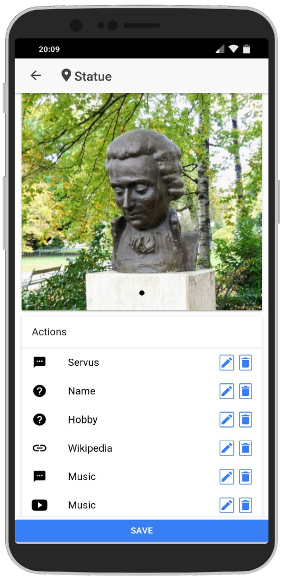
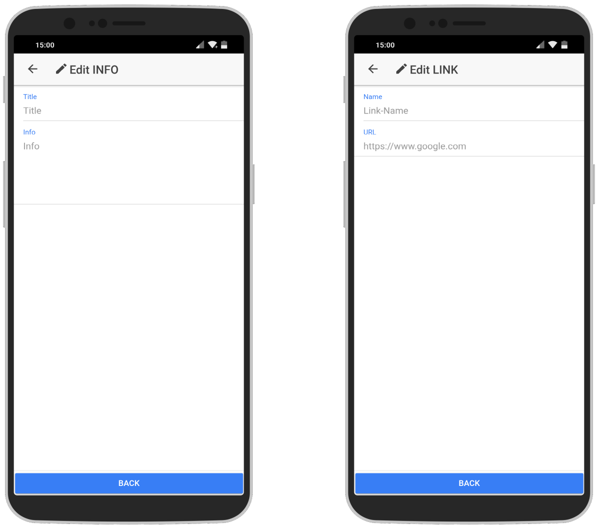


Figure 4.8: Combination of multiple *Actions*.



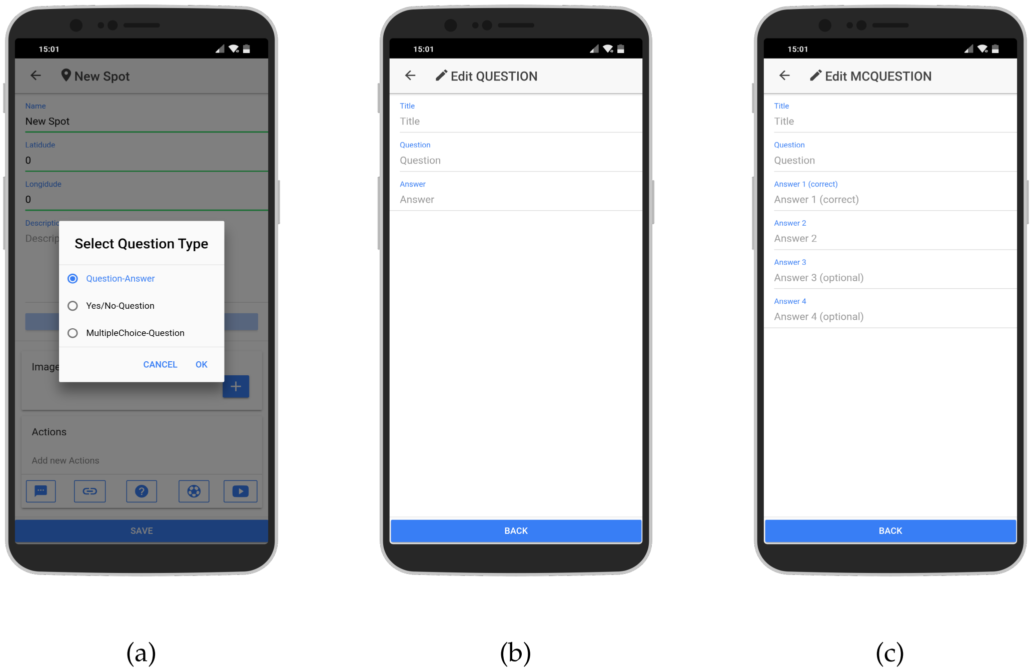
(a) (b)

Figure 4.9: Screenshots of creating an *Action* of the type information (a) or of the type website (b).

the creator as shown in figure 4.9. While performing this action, the user has to confirm opening the website in the browser due to security reasons.

Question When pressing the third button, a question can be created as shown in figure 4.10. There are three types of possible questions out of which the user can select.

- Free Text
  A question with a corresponding answer is provided by the creator. This question has to be answered by entering the correct answer in a textbox.
- Multiple Choice
  A question is entered by the creator with up to four possible answers. The first one to enter is the correct one, they will be shuffled when shown to the user anyway.
- Yes / No
  Basically the same as the multiple choice question, but with the answers Yes and No pre-filled as answer 1 and 2.


New Spot

Name: New Spot

Latidude: 0

Longidude: 0

Select Question Type

● Question-Answer

○ Yes/No-Question

○ MultipleChoice-Question

Edit QUESTION

Title

Question

Answer

Edit MCQUESTION

Title

Question

Answer 1 (correct)

Answer 2

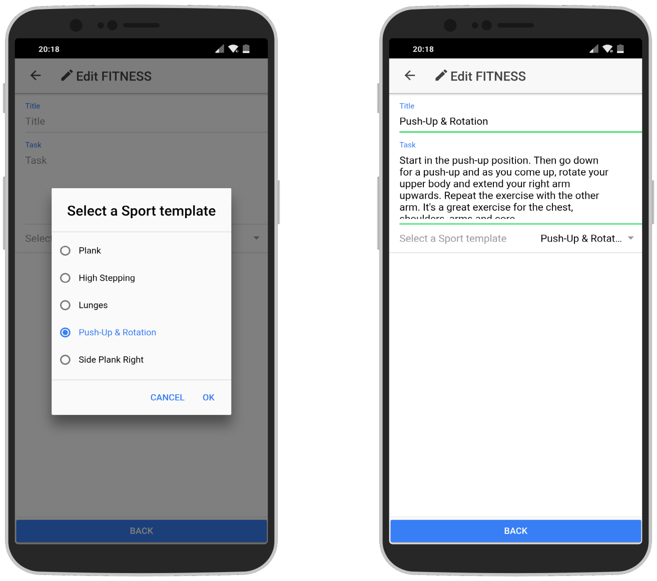
Answer 3 (optional)

Answer 4 (optional)

(a) (b) (c)

Figure 4.10: Screenshot of creating an *Action* of the type question. After selecting the type of question (a) depending of the type one (b) or up to four answers (c) can be provided.

Fitness Exercise The fourth button, represented as little ball, can be used to create a fitness exercise as shown in figure 4.11. The user can enter an own exercise, or a provided exercise can be selected from a list of 13. After selecting an exercise the title and task is set automatically to the fitness-*Action*.



Select a Sport template

○ Plank
○ High Stepping
○ Lunges
● Push-Up & Rotation
○ Side Plank Right

Title: Push-Up & Rotation

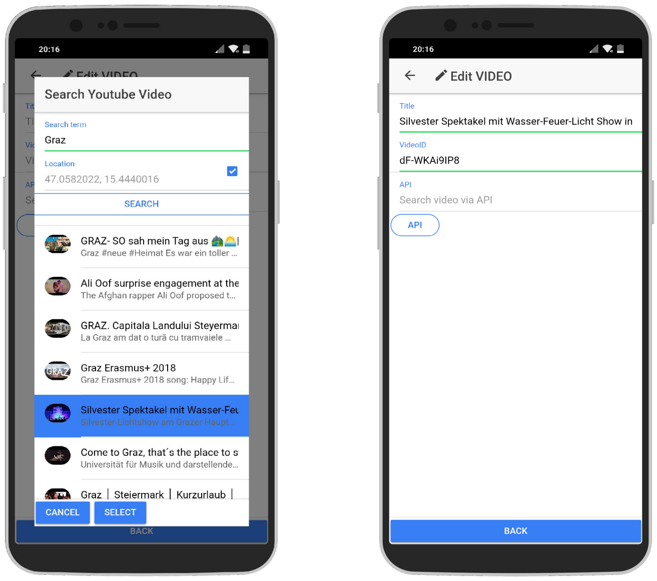
Task: Start in the push-up position. Then go down for a push-up and as you come up, rotate your upper body and extend your right arm upwards. Repeat the exercise with the other arm. It's a great exercise for the chest, shoulders, arms and core

Select a Sport template: Push-Up & Rotat...

(a) (b)

Figure 4.11: Screenshots of creating an *Action* of the type fitness exercise. It can be chosen out of a list of 13 provided exercises (a) which are filling the title ans task automatically after selection (b). Or it can be filles with a personal exercise of choice.

Video By pressing the fifth button a video-*Action* can be created as shown in figure 4.12. Therefore the YouTube-ID is needed. If not known, the YouTube-API can be used to search for a fitting video. The search is using a provided search-term and the location of the spot if wanted. After selecting a video, the YouTube-ID and the title is automatically set to the data of the selected video.



Search term: Graz

Location: 47.0582022, 15.4440016 ☑

GRAZ- SO sah mein Tag aus 🏞🌅|
Graz #neue #Heimat Es war ein toller ...

Ali Oof surprise engagement at the
The Afghan rapper Ali Oof proposed t...

GRAZ. Capitala Landului Steyermaı
La Graz am dat o tură cu tramvaiele ...

Graz Erasmus+ 2018
Graz Erasmus+ 2018 song: Happy Lif...

Silvester Spektakel mit Wasser-Feu
Silvester-Lichtshow am Grazer Haupt...

Come to Graz, that´s the place to s
Universität für Musik und darstellende...

Graz | Steiermark | Kurzurlaub |

(a)

Title: Silvester Spektakel mit Wasser-Feuer-Licht Show in

VideoID: dF-WKAi9IP8

API: Search video via API

(b)

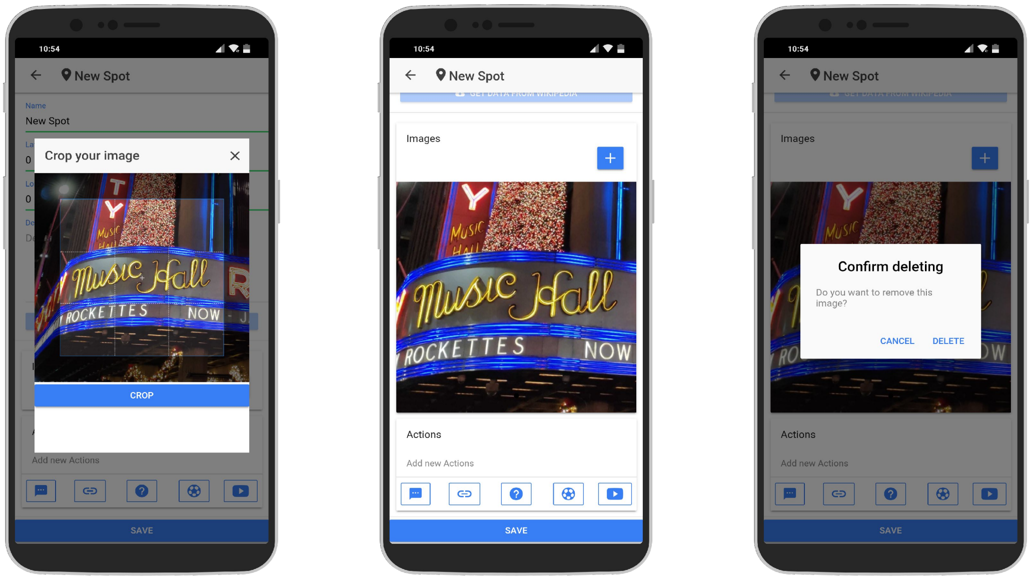
Figure 4.12: Screenshots of creating a video-*Action*. If the YouTube-ID is not known it can be searched for by using the YouTube-API (a). After selecting a video the title and the ID automatically filled (b).

Image Gallery

Each *Tour* and each *Spot* offers an image-gallery. During the creation or editing of them, users can add and remove images. To add one, they have to press the [+]-button. As a next step, users have to take a photo of the object which they want to add. This should guarantee the usage of self-made pictures which are necessary due to copyright issues. After taking a picture, users can crop it to a square format and only show the object of choice.

For deleting an image, users have to long-press on the image. After confirming the deletion, the image is removed from the gallery.

These steps are shown in figure 4.13.



Do you want to remove this image?

(a) (b) (c)

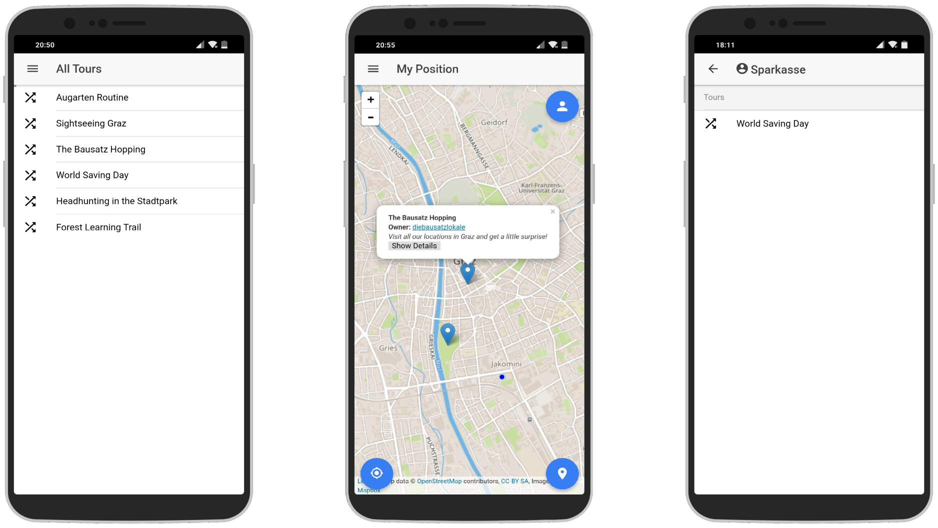
Figure 4.13: Adding and cropping of an image (a), to add it to the image-gallery (b). By long-pressing the image it can be removed again (c).

4.4.3 Viewpoint as Player

Playing a Tour

In this section all steps of playing a *Tour* will be explained and demonstrated with screenshots to get a better idea of the functionalities the application *x-plore.it* provides.

Selecting a Tour To select a *Tour* for playing, a user can either select it from the *All Tours* list, where all public *Tours* are listed and sorted by distance to the user's current position, or the user can go to the *World Map* and select the *Tour* from the ones in the surroundings. A third option is to go to a specific user profile and select a *Tour* out of the user's repository. Those three possibilities are shown in figure 4.14.



20:50

All Tours

Augarten Routine

Sightseeing Graz

The Bausatz Hopping

World Saving Day

Headhunting in the Stadtpark

Forest Learning Trail

20:55

My Position

The Bausatz Hopping

Owner: diebausatzlokale

Visit all our locations in Graz and get a little surprise!

Show Details

18:11

Sparkasse

Tours

World Saving Day

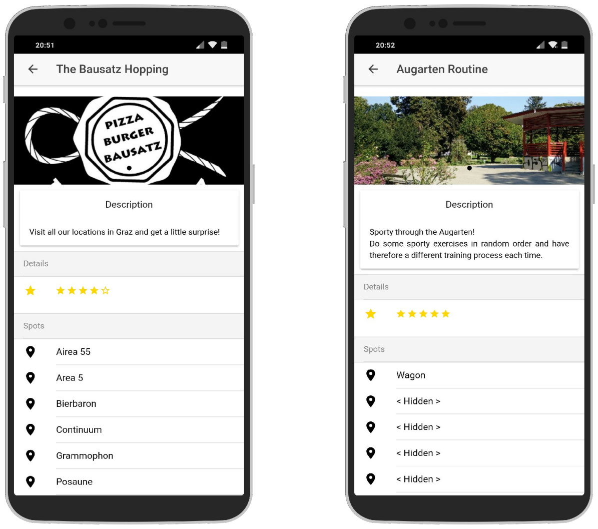
Geidorf
Bergmanngasse
Lendkai
Karl-Franzens-Universität Graz
Gries
Grieskai
Jakomini
Puchstrasse
p data © OpenStreetMap contributors, CC BY SA, Image
Mapbox
+
-

(a) "All Tours"-list (b) On the WorldMap (c) By a specific user

Figure 4.14: Screenshots of the three possibilities to select a *Tour*.

Displaying a Tour After selecting a *Tour*, its page is presented, showing the details, the image-gallery and the *Spots*. The *Spots* can be either visible or hidden. An example is given in figure 4.15.

Doing its Spots To accomplish a *Tour*, its *Spots* have to be finished one by one. Therefore, one of them has to be selected. By clicking on a *Spot*, the *Spot*-page is opened, showing its description, an image-gallery and the *Spot*'s location. The user has now to get closer to the *Spot*. It is possible to use a navigation



20:51

The Bausatz Hopping

Description

Visit all our locations in Graz and get a little surprise!

Details

★ ★★★★☆

Spots

Airea 55

Area 5

Bierbaron

Continuum

Grammophon

Posaune

20:52

Augarten Routine

Description

Sporty through the Augarten!
Do some sporty exercises in random order and have therefore a different training process each time.

Details

★ ★★★★★

Spots

Wagon

< Hidden >

< Hidden >

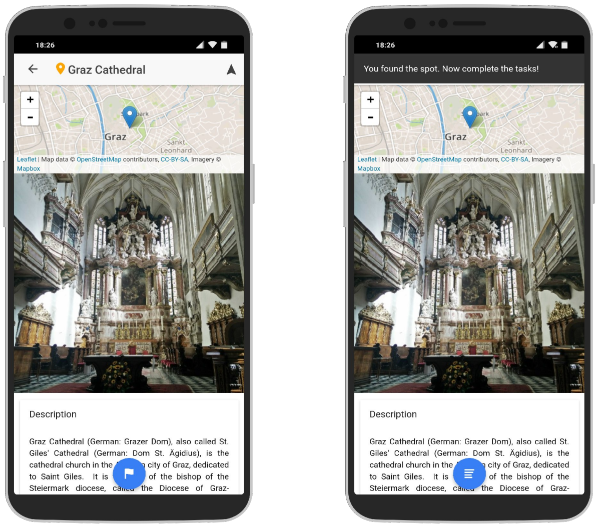
< Hidden >

< Hidden >

(a) (b)

Figure 4.15: Screenshots of example *Tours* with all *Spots* visible (a) or with hidden ones (b).

functionality by pressing the compass-icon on the top-right corned. If the user believes himself to be close enough, the current position can be checked by clicking the little flag-button at the bottom. If confirmed, the *Spot* is marked as found. This process is shown in figure 4.16.



18:26

Graz Cathedral

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Description

Graz Cathedral (German: Grazer Dom), also called St. Giles' Cathedral (German: Dom St. Ägidius), is the cathedral church in the city of Graz, dedicated to Saint Giles. It is of the bishop of the Steiermark diocese, ca the Diocese of Graz-

18:26

You found the spot. Now complete the tasks!

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

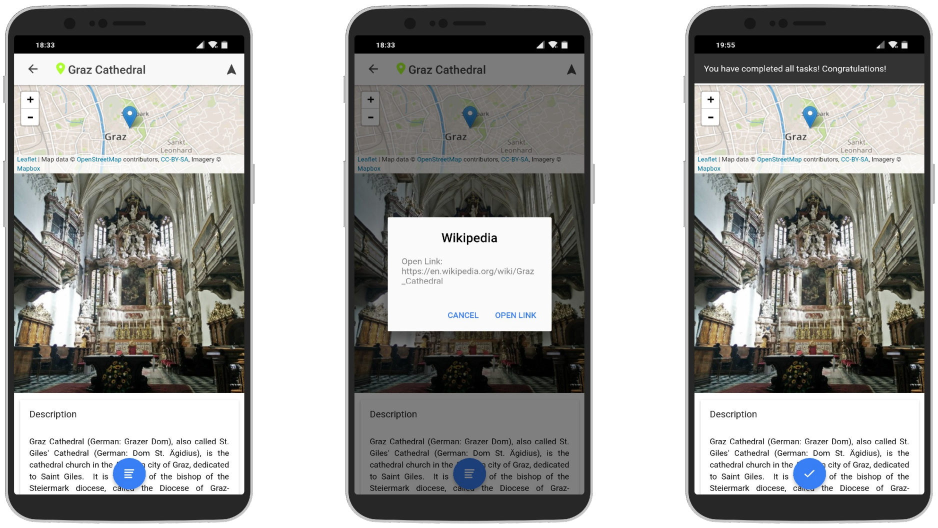
Description

Graz Cathedral (German: Grazer Dom), also called St. Giles' Cathedral (German: Dom St. Ägidius), is the cathedral church in the city of Graz, dedicated to Saint Giles. It is of the bishop of the Steiermark diocese, ca the Diocese of Graz-

(a) (b)

Figure 4.16: Screenshots of an example *Spot* before (a) and during it has been found (b).

Doing Actions As the next step, the *Spot*'s *Actions* have to be done. There is a individual number of *Actions* possible, even zero. By pressing the button at the bottom each *Action* is presented to the user one by one. After successfully finishing an *Action*, the next one is shown until all are done. This process is shown in figure 4.17.



18:33

Graz Cathedral

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Description

Graz Cathedral (German: Grazer Dom), also called St. Giles' Cathedral (German: Dom St. Ägidius), is the cathedral church in the city of Graz, dedicated to Saint Giles. It is of the bishop of the Steiermark diocese, the Diocese of Graz-

18:33

Graz Cathedral

Wikipedia

Open Link: https://en.wikipedia.org/wiki/Graz_Cathedral

CANCEL OPEN LINK

19:55

You have completed all tasks! Congratulations!

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Description

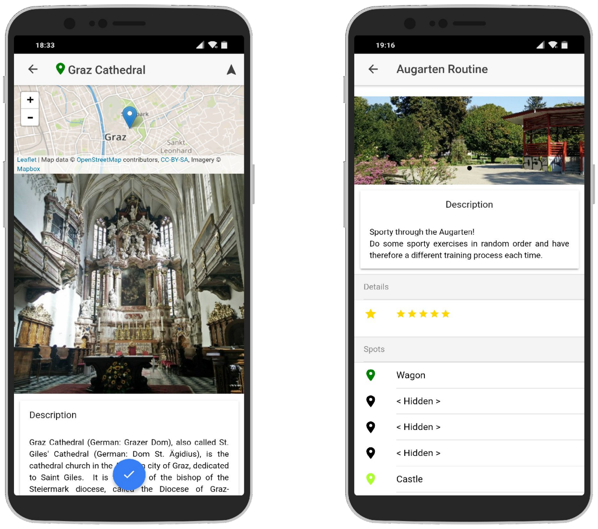
Graz Cathedral (German: Grazer Dom), also called St. Giles' Cathedral (German: Dom St. Ägidius), is the cathedral church in the city of Graz, dedicated to Saint Giles. It is of the bishop of the Steiermark diocese, the Diocese of Graz-

(a) *Spot* found. (b) *Action* is shown. (c) All *Actions* done.

Figure 4.17: If a *Spot* is found (a), the *Actions* have to be done (b) until all are finished (c).

Finishing a Spot If all *Actions* are done, the *Spot* is marked as accomplished. If the *Spots* are hidden, the next or a random one is being changed to visible, depending on the *Tour*'s settings. This is shown in figure 4.18.

Finishing a Tour After finishing a *Spot*, the next one can be selected. If all *Spots* of a *Tour* are finished, the *Tour* itself is marked as finished and the user has the possibility to rate how much the *Tour* was enjoyed with stars from one to five. The rating shown for a *Tour* is the average of all given ratings. Additionally, when finishing a *Tour* a counter is incremented and the user has the possibility to re-do a *Tour*. By clicking the redo-button, all the progress of the *Spots* is being reset to the start and everything can be done again. This can be useful for daily routines for example. The amount of all successful accomplishments is displayed by a counter. All those steps are shown in figure 4.19.

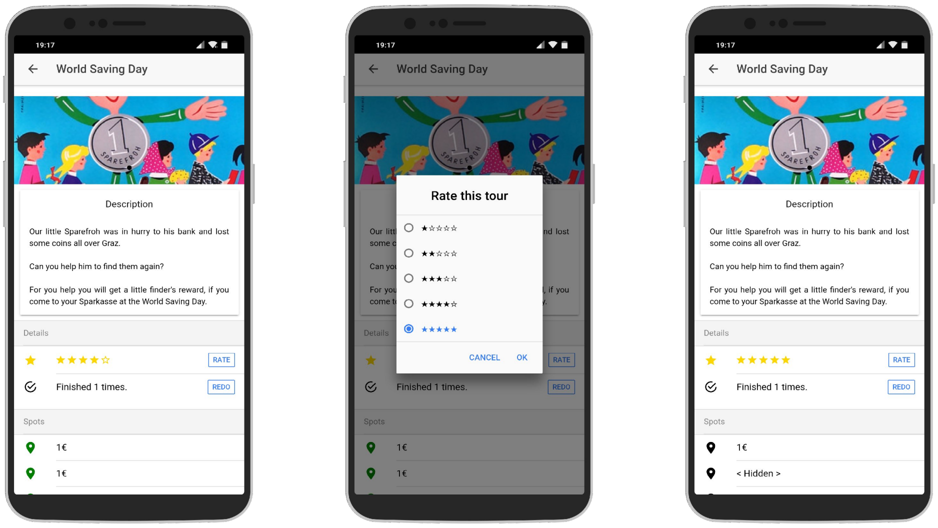


Graz Cathedral (German: Grazer Dom), also called St. Giles' Cathedral (German: Dom St. Ägidius), is the cathedral church in the city of Graz, dedicated to Saint Giles. It is of the bishop of the Steiermark diocese, the Diocese of Graz-

Sporty through the Augarten!
Do some sporty exercises in random order and have therefore a different training process each time.

(a) (b)

Figure 4.18: If one *Spot* is finished (a), the next one can be selected. If the *Spots* are hidden, one was made visible (b).



Our little Sparefroh was in hurry to his bank and lost some coins all over Graz.

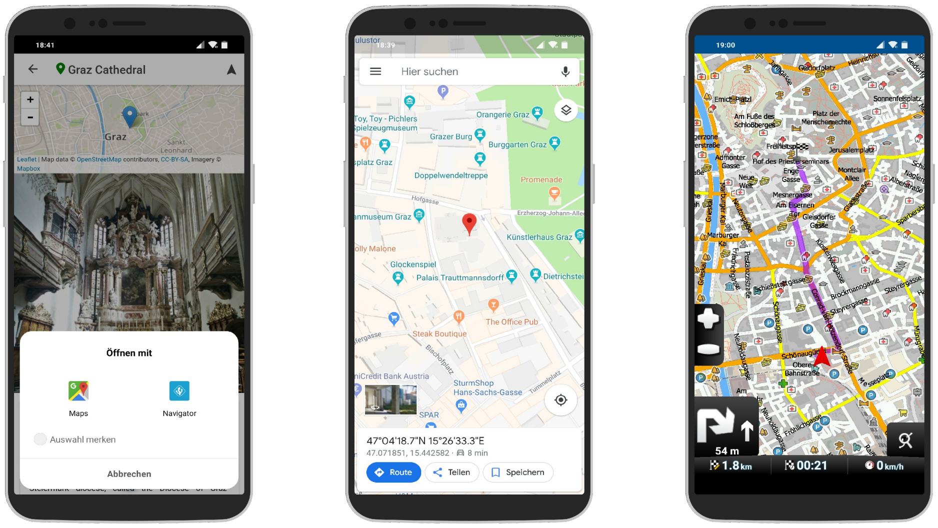
Can you help him to find them again?

For you help you will get a little finder's reward, if you come to your Sparkasse at the World Saving Day.

(a) Finished *Tour* (b) Rating a *Tour* (c) Reset *Tour*.

Figure 4.19: Screenshots of a finished *Tour* (a), with the possibility to rate it (b) or to reset the progress (c).

Navigating to a Spot To find a *Spot*, the user can try to find it by himself or an additional navigation application can be used to be navigated to the *Spot*. By pressing the compass-icon in the top-right corner, the user is asked which application should be used as shown in figure 4.20. After selecting an application, the coordinates of the *Spot* are forwarded and the navigation can be started. When reaching the *Spot* the user has to return to *x-plore.it* to confirm the current position and to continue with the assigned *Actions*.



(a) Choice of navigation applications

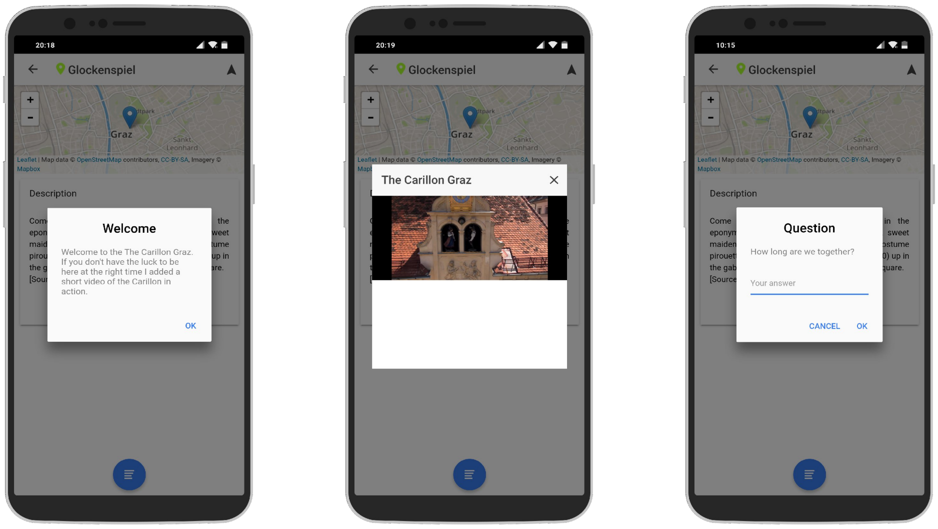
(b) *Google Maps*

(c) *Navigator*

Figure 4.20: Screenshot of using the navigation function. The user is asked which application should be used (a). After selecting, the navigation to the *Spot* is started. In that case *Google Maps* (b) and *Navigator* (c) were used.

Examples of Action Types

An example of all kinds of *Actions* are shown in figure 4.21 and 4.22.



Welcome

Welcome to the The Carillon Graz. If you don't have the luck to be here at the right time I added a short video of the Carillon in action.

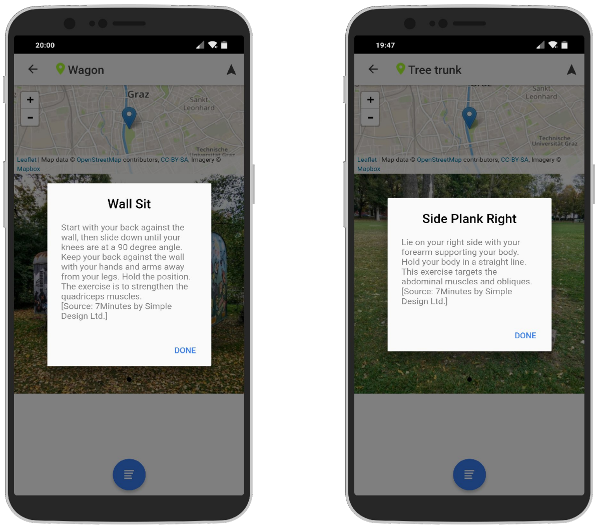
OK

Question

How long are we together?

(a) Information (b) Video (c) Question

Figure 4.21: *Actions* can be combined for more information. First, in figure (a) an information-*Action* is shown to explain and introduce the following video-*Action* in (b). As the last step, a question is asked about the video (c).


20:00
Wagon
Graz
Sankt Leonhard
Technische Universität Graz
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox
19:47
Tree trunk
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Wall Sit

Start with your back against the wall, then slide down until your knees are at a 90 degree angle. Keep your back against the wall with your hands and arms away from your legs. Hold the position. The exercise is to strengthen the quadriceps muscles. [Source: 7Minutes by Simple Design Ltd.]

DONE

Side Plank Right

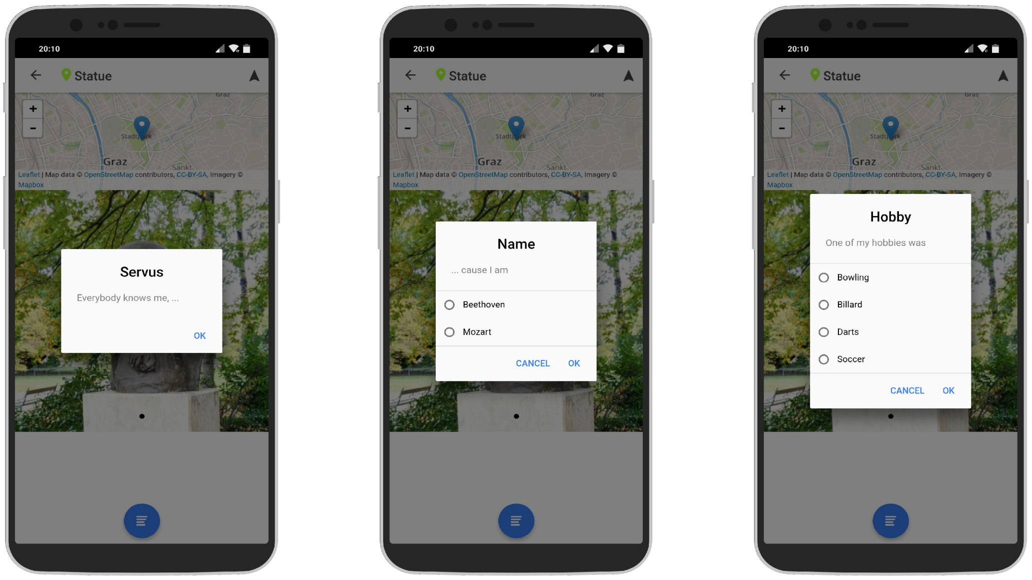
Lie on your right side with your forearm supporting your body. Hold your body in a straight line. This exercise targets the abdominal muscles and obliques. [Source: 7Minutes by Simple Design Ltd.]

DONE

(a) ”Wall Sit”-exercise (b) ”Side Plank”-exercise

Figure 4.22: Fitness exercises are instructing the player what to do. Screenshots of two examples of exercises are shown.

Combination of multiple Actions Figure 4.23 and 4.24 are presenting a combination of multiple *Actions*. The creator's perspective is shown in figure 4.8.


20:10
Statue
Graz
Stadtpark
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox
OK
CANCEL
OK
CANCEL
OK

Servus

Everybody knows me, ...

Name

... cause I am

○ Beethoven

○ Mozart

Hobby

One of my hobbies was

○ Bowling

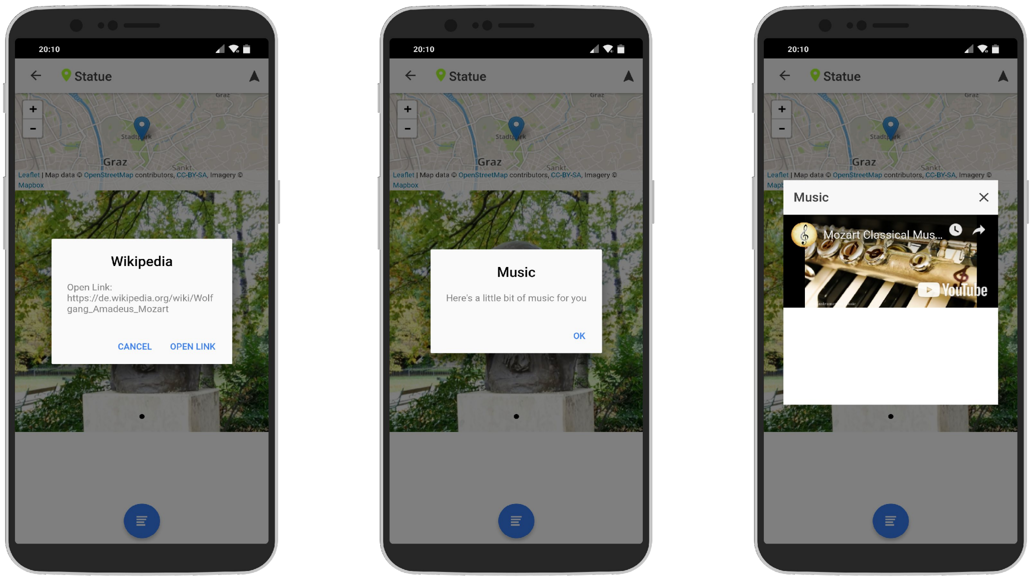
○ Billard

○ Darts

○ Soccer

(a) Information (b) Question (c) Question

Figure 4.23: Combination of 6 *Actions* - part 1.


20:10
Statue
Graz
Stadtpark
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox
CANCEL
OPEN LINK
OK
✕
Mozart Classical Mus...
YouTube

Wikipedia

Open Link: https://de.wikipedia.org/wiki/Wolfgang_Amadeus_Mozart

Music

Here's a little bit of music for you

Music

(a) Website (b) Information (c) Video

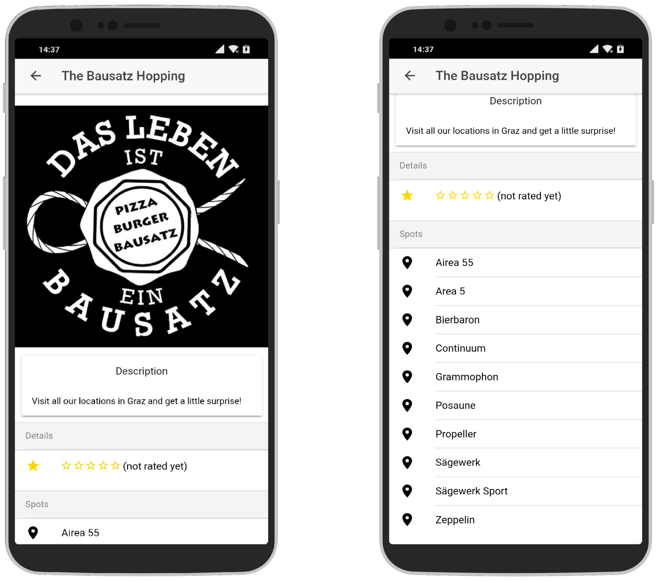
Figure 4.24: Combination of 6 *Actions* - part 2.

4.4.4 Example Tours

For providing an overview about possible usecases, some fictitious tours were created. It was focused on covering different areas of usage in order to show the flexibility of the application *x-plore.it*. Those tours are publicly available and can be played by everyone who has an account.

The Bausatz Hopping

A local chain of restaurant offers so called *Bausätze*, where the ingredients of the meal can be chosen from a list. To promote all their locations in the city of Graz, a campaign is started using *x-plore.it*. The users have to visit all locations of their restaurants which are represented as *Spots* in the *Tour* "The Bausatz Hopping", shown in figure 4.25. When the user visits one restaurant and the location is confirmed by the application, it shows a list of different kinds of Bausätze that are offered at that specific restaurant, displaying the first *Action*, shown in figure 4.26. To double-proof the current location and to finish the *Spot*, a password has to be entered as second *Action* which can be requested from the bartender. Logos of the restaurants are from SPZG GmbH and their usage in this thesis was granted.



The Bausatz Hopping

Description

Visit all our locations in Graz and get a little surprise!

Details

★ ☆☆☆☆☆ (not rated yet)

Spots

- Airea 55

The Bausatz Hopping

Description

Visit all our locations in Graz and get a little surprise!

Details

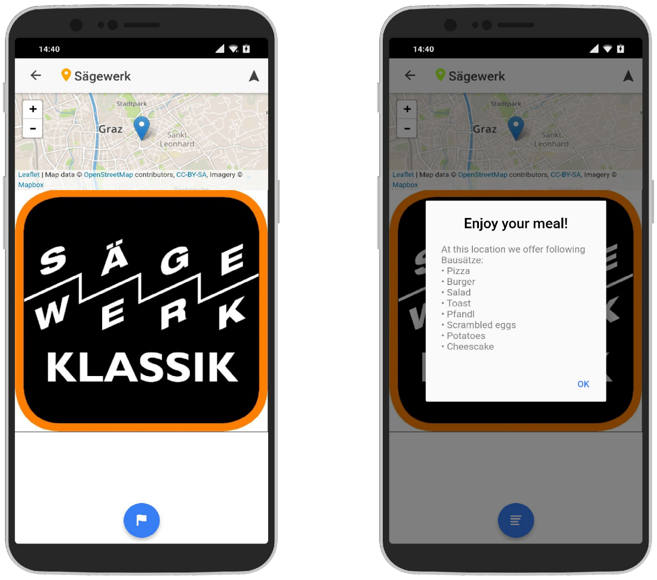
★ ☆☆☆☆☆ (not rated yet)

Spots

- Airea 55
- Area 5
- Bierbaron
- Continuum
- Grammophon
- Posaune
- Propeller
- Sägewerk
- Sägewerk Sport
- Zeppelin

(a) (b)

Figure 4.25: Screenshots of the *Tour* "The Bausatz Hopping" (a) with all the locations of the restaurant chain represented as *Spots* (b).


14:40
Sägewerk
+
-
Stadtpark
Graz
Sankt Leonhard
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox
SÄGE WERK
KLASSIK
14:40
Sägewerk
Stadtpark
Graz
Sankt Leonhard
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Enjoy your meal!

At this location we offer following Bausätze:
- Pizza
- Burger
- Salad
- Toast
- Pfandl
- Scrambled eggs
- Potatoes
- Cheescake

OK

(a)

(b)

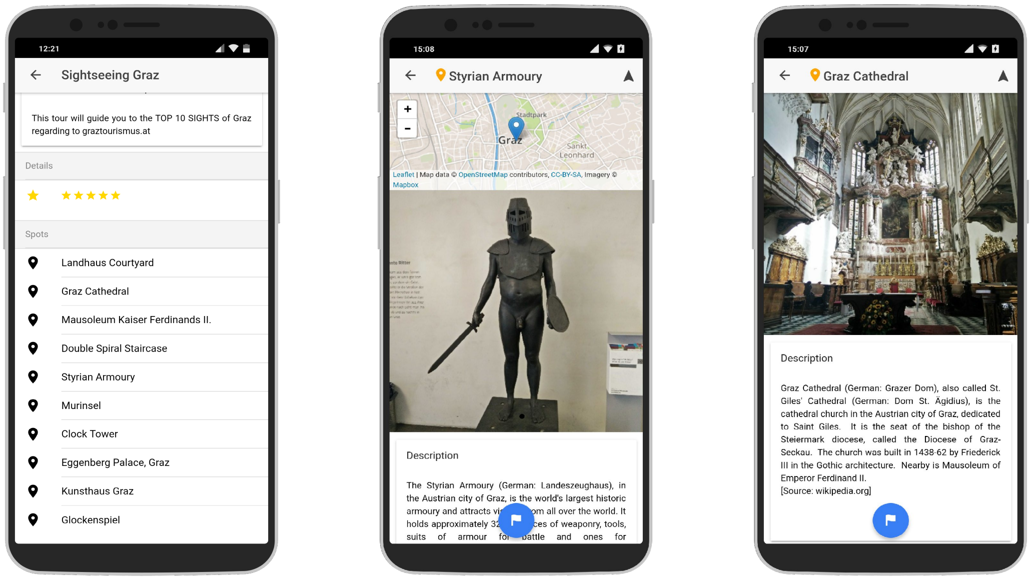
Figure 4.26: Screenshots of the *Spot* "Sägewerk" (a) and the offered meals at this location shown as textual *Action* (b).

Sightseeing Graz

Due to the rise of Geocaching, Pokémon Go and other location-based games, the Tourist Board Graz wants to try a newer and modern way to guide tourists to the sights of Graz. After doing some research, they want to realize their new idea with *x-plore.it*. A *Tour* is created and all the sights are represented as a *Spot*, as shown in figure 4.27. During creation of the *Spots*, features like automatically adding location-based information from Wikipedia or the simple linking of videos from Youtube via integrated search helped tremendously.

The tourist can now decide which of the sights should be the next one and can be navigated to by the application. At the sight, useful information or nice pictures are shown and links to Wikipedia for further reading or a little quiz can be provided.

One sight is a carillon that plays music only at specific times. If the tourist does not have the luck to be there at the right time, a Youtube video is provided that shows the carillon in action and also gives a little background information about the used techniques. This is shown in figure 4.28.



Sightseeing Graz

This tour will guide you to the TOP 10 SIGHTS of Graz regarding to graztourismus.at

Details

★ ★★★★★

Spots

- Landhaus Courtyard
- Graz Cathedral
- Mausoleum Kaiser Ferdinands II.
- Double Spiral Staircase
- Styrian Armoury
- Murinsel
- Clock Tower
- Eggenberg Palace, Graz
- Kunsthaus Graz
- Glockenspiel

Styrian Armoury

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Description

The Styrian Armoury (German: Landeszeughaus), in the Austrian city of Graz, is the world's largest historic armoury and attracts vi om all over the world. It holds approximately 32 ces of weaponry, tools, suits of armour fo battle and ones for

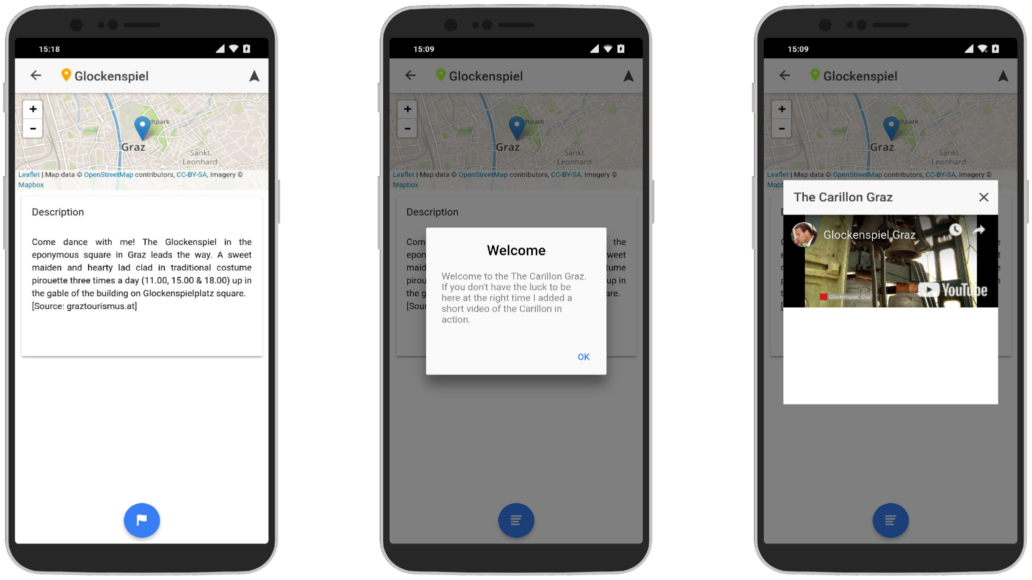
Graz Cathedral

Description

Graz Cathedral (German: Grazer Dom), also called St. Giles' Cathedral (German: Dom St. Ägidius), is the cathedral church in the Austrian city of Graz, dedicated to Saint Giles. It is the seat of the bishop of the Steiermark diocese, called the Diocese of Graz-Seckau. The church was built in 1438-62 by Friederick III in the Gothic architecture. Nearby is Mausoleum of Emperor Ferdinand II.
[Source: wikipedia.org]

(a) (b) (c)

Figure 4.27: Screenshots of two sights represented as *Spot* (b, c) in the *Tour* "Sightseeing Graz" (a).



Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Description

Come dance with me! The Glockenspiel in the eponymous square in Graz leads the way. A sweet maiden and hearty lad clad in traditional costume pirouette three times a day (11.00, 15.00 & 18.00) up in the gable of the building on Glockenspielplatz square.
[Source: graztourismus.at]

Welcome

Welcome to the The Carillon Graz. If you don't have the luck to be here at the right time I added a short video of the Carillon in action.

OK

The Carillon Graz ✕

(a) *Spot* description (b) Info-*Action* (c) Video-*Action*

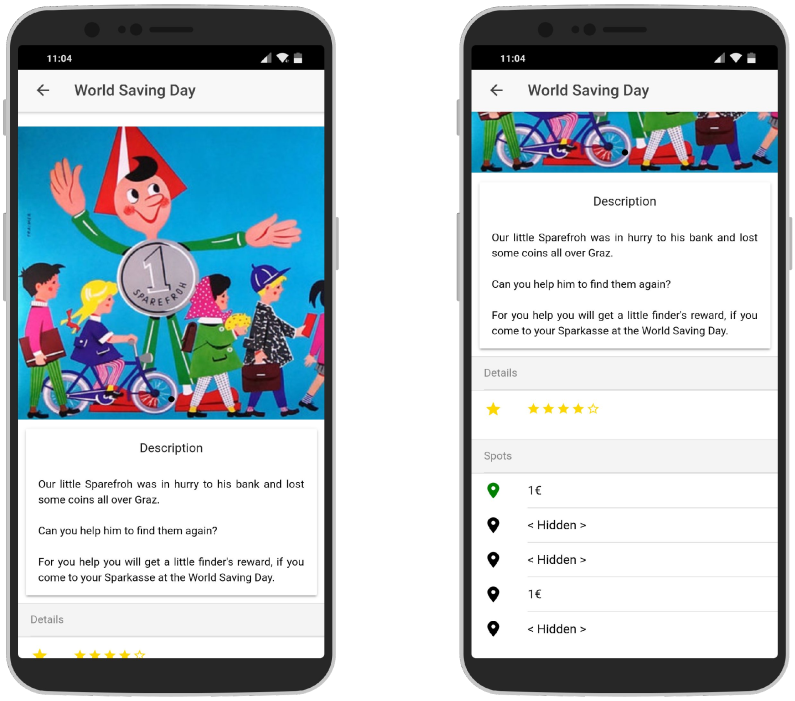
Figure 4.28: Screenshots of the *Spot* "Glockenspiel" itself (a), the info text about the location and the following video (b), and the YouTube video-*Action* (c).

World Saving Day

For the next World Savings Day the Sparkasse Graz wants to offer a little game. Usually, children get a little present if they bring their hard saved money to the bank at the end of October[68]. This year, if they have successfully finished a game, they will get additional 5€ to their saving account.

To accomplish this, the Sparkasse is using the application *x-plore.it*. A *Tour* shown in figure 4.29 is created that tells a little story about their mascot Sparefroh who lost five pieces of 1€-coins all over the city of Graz. Those virtual coins are represented by *Spots* with the hidden- and random-functionality switched on. Consequently, the user does not know where all virtual coins are placed and has to find them one by one in given but random order.

If all virtual coins have been collected, the *Tour* ”World Saving Day” is accomplished and can be shown at the Sparkasse to get the promised 5€.



Description

Our little Sparefroh was in hurry to his bank and lost some coins all over Graz.

Can you help him to find them again?

For you help you will get a little finder's reward, if you come to your Sparkasse at the World Saving Day.

Description

Our little Sparefroh was in hurry to his bank and lost some coins all over Graz.

Can you help him to find them again?

For you help you will get a little finder's reward, if you come to your Sparkasse at the World Saving Day.

★ ★★★★☆

1€
< Hidden >
< Hidden >
1€
< Hidden >

(a) *Tour* overview.

(b) List of *Spots*.

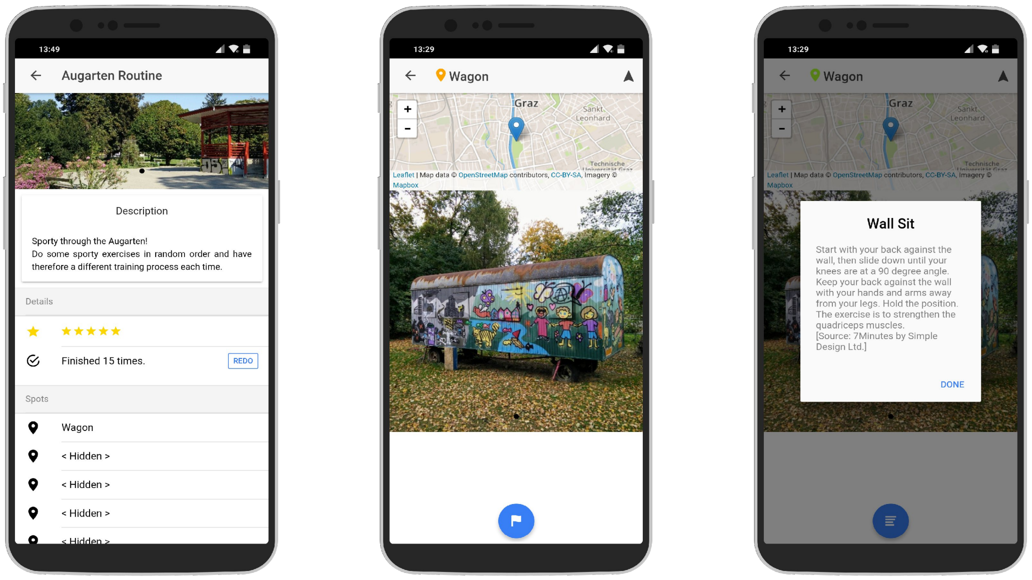
Figure 4.29: Screenshots of the *Tour* ”World Saving Day” (a) and its hidden coins as *Spots* (b). The green one had been found already. (Traimer, 1960; Bechtle, 2011)

[68] https://www.sparkasse.at/sgruppe/wir-ueber-uns

Augarten Routine

Marco is a sporty guy and wants to keep track of his daily routines. He therefore creates a *Tour* with *x-plore.it* and adds some landmarks as *Spots* located throughout the park. At each *Spot*, he adds a different exercise as a fitness-*Action*, which are already provided by *x-plore.it* and can be selected out of a list of templates. For having a different training everyday he enables the random-functionality. This guarantees that he is not getting bored by doing the same routines everyday.

Because it should only be for his personal training, he decides not to publish the *Tour* and to use it only privately. To keep track of the amount of his completions, he is using the in-build counter together with the reset-functionality of his *Tour*. Screenshots of that *Tour* are shown in figure 4.30.



Augarten Routine

Description

Sporty through the Augarten!
Do some sporty exercises in random order and have therefore a different training process each time.

Details

★★★★★

Finished 15 times. REDO

Spots

Wagon

< Hidden >

< Hidden >

< Hidden >

< Hidden >

Wall Sit

Start with your back against the wall, then slide down until your knees are at a 90 degree angle. Keep your back against the wall with your hands and arms away from your legs. Hold the position. The exercise is to strengthen the quadriceps muscles.
[Source: 7Minutes by Simple Design Ltd.]

DONE

13:49
13:29
Wagon
Graz
Sankt Leonhard
Technische Universität Graz
Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

(a)

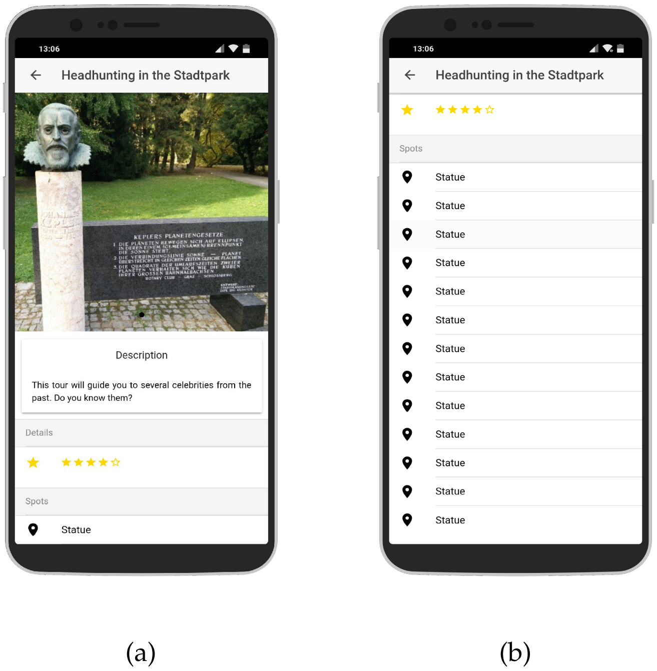
(b)

(c) Fitness-*Action*

Figure 4.30: Screenshots of the *Tour* "Augarten Routine" (a), one landmark (b) and the related fitness-*Action* (c).

Headhunting in the Stadtpark

For her 30th birthday Sabrina plans to meet some friends in the Stadtpark Graz. As a party game she decides to do a little scavenger hunt and calls it "Headhunting in the Stadtpark". To create the hunt, she is using *x-plore.it*, shown in figure 4.31. She is adding several statues placed all over the Stadtpark as *Spots*, adding several questions about their representatives and some fun facts as presented in figure 4.32. To have more fun together, the game is played in a team and not as a competition.



13:06

Headhunting in the Stadtpark

Description

This tour will guide you to several celebrities from the past. Do you know them?

Details

★★★★☆

Spots

Statue

(a)

13:06

Headhunting in the Stadtpark

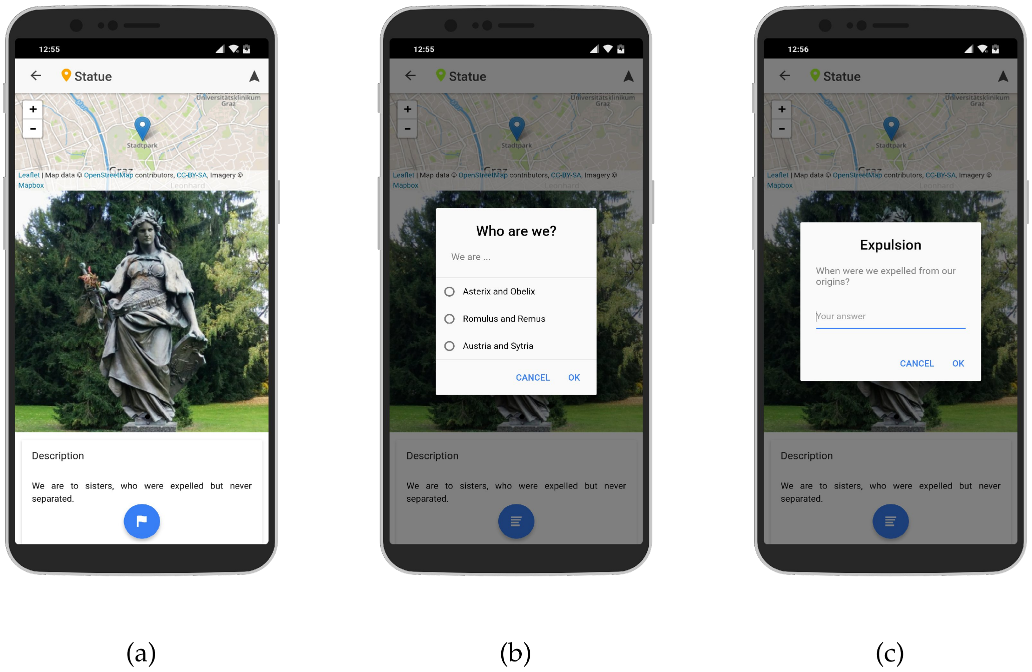
★★★★☆

Spots

Statue
Statue
Statue
Statue
Statue
Statue
Statue
Statue
Statue
Statue
Statue
Statue
Statue

(b)

Figure 4.31: Screenshots of the *Tour* "Headhunting in the Stadtpark" (a) and a list of statues represented as *Spots* (b).



12:55

Statue

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

Description

We are to sisters, who were expelled but never separated.

(a)

12:55

Statue

Who are we?

We are ...

○ Asterix and Obelix

○ Romulus and Remus

○ Austria and Sytria

CANCEL OK

(b)

12:56

Statue

Expulsion

When were we expelled from our origins?

Your answer

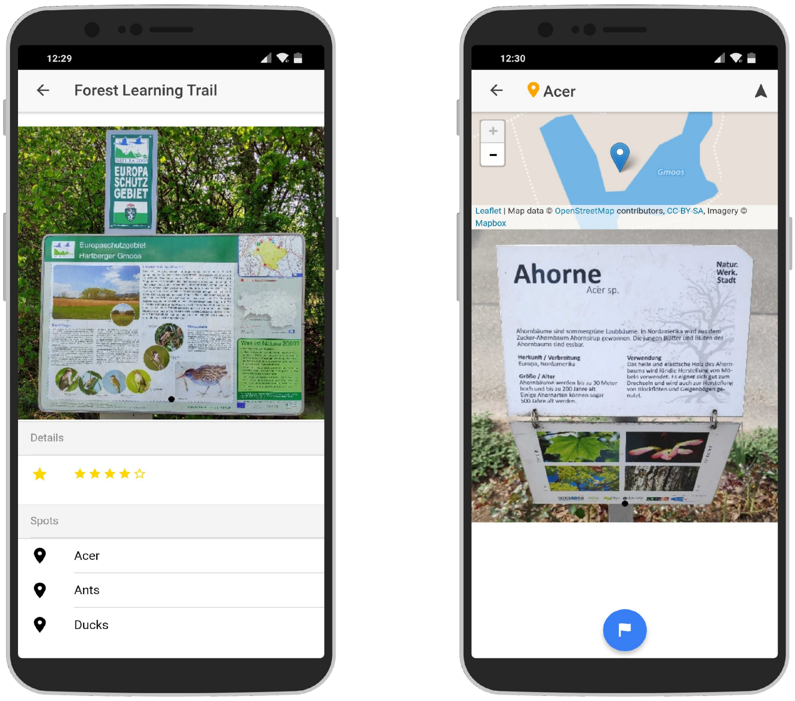
CANCEL OK

(c)

Figure 4.32: Screenshots of one statue represented as *Spot* with its description (a) and two question-*Actions*, one question in the form of multiple choice questions (b) and one as free text (c).

Forest Learning Trail

To make the students become more interested in forests and to teach them about the local fauna and flora, ranger Del Bosque plans to create a learning trail in his forest. Instead of only providing the information on plaques he uses *x-plore.it* to add more interactions to each location. He creates the *Tour* ”Forest Learning Trail” shown in figure 4.33 and adds a *Spot* to each planned plaque. There he can offer additional videos, ask questions or link to related websites easily. With a little quiz he can also make sure the students are participating actively.



(a)

(b)

Figure 4.33: Screenshots of the *Tour* ”Forest Learning Trail” (a) and of one *Spot* located next to an acer.

4.5 Summary

This chapter gave an overview about the used technologies and how the application was implemented and all the provided features were described in detail.

Furthermore, many screenshots were provided to give an insight into the viewpoints of the user and the viewpoint was separated into two parts. Those parts are the viewpoint of a user as a creator and as a player. In the first section, the creation of a *Tour* was shown step by step, including all the possible configurations including *Spots* and *Actions*.

Those *Tours* were then shown in the second part from the viewpoint of a user as a player. It was presented how a *Tour* can be selected and how it is played *Spot* by *Spot* and *Action* by *Action*.

In the next section of this chapter, some examples of *Tours* were presented to give an idea about the possibilities of the application *x-plore.it*. They tell a fictitious story and are placed in different areas, like marketing, education, tourism, and sports. Those *Tours* will be used for the evaluation in chapter 5 as well.

At the end there was information provided about the configuration of the environments and how to get the code of the server and the client running.

5 Evaluation

This chapter is about the evaluation of the application *x-plore.it*. It will be evaluated whether the application meets its supposed goals and reaches out to the expected target group. Therefore, several people will be selected to try out the application under previously defined conditions in a field test. The results will be gathered by surveys using standardized scales to measure to which extent objectives and goals are reached.

5.1 Research Focus

This section represents the main aspects on which the evaluation especially focuses on. Those aspects are determined by the motivation for and goals of the application, as defined in sections 1.1 and 1.2, resulting in three research questions, described in the following lines:

- The flexibility of the application to be used in a wide range of areas.
- The motivation of users to become active in specific areas by using this application, such as the motivation to participate in sport activities, or to visit specific places, such as museums or restaurants.
- The usability of the application by all kind of people not limited to technically experienced ones and if they would use it in practice.

For gathering data on these topics, a set of standardized questions together with self-defined ones are used for the survey. After the users accomplish their tasks, the questions are presented to them within the post-questionnaire.

5.2 Research Methodology

The application *x-plore.it* will be tested in a field test, where twelve participants will be taking part. Regarding the type of participants, it is necessary to cover a wide range of the participant's hobbies and regular activities leading to more meaningful results regarding the testing of flexibility and of user motivation for as much diverse areas as possible. Additionally, participants will be of different educational levels and with different technical experiences.

The participants will test the application in groups of two, accomplishing defined tasks on provided smartphones with the application already installed. After finishing all tasks the participants have to fill out a post-questionnaire with different questions including Likert-scale questions, polar questions, or open-ended questions. Likert-scale questions can be rated with a rate of 1 representing a strong disagreement while a rate of 5 represents a strong agreement.

Flexibility

The questions in this section are self-defined and were created in order to figure out in what fields the application can be used according to the participants' opinions. Additionally, this section tests whether *x-plore.it* can combine functionalities of other applications.

Motivation

The questions evaluating user motivation were taken from *The Flow State Scale* (FSS), developed by Jackson and Marsh (1996). According to them, user motivation regarding activities can be defined by the *Flow*, which is measured by the aid of the following nine dimensions:

- Challenge-skill
- Action-awareness
- Clear goals
- Unambiguous feedback
- Concentration
- Sense of control
- Loss of self-consciousness
- Transformation of time
- Autoletic experience

The original FSS contains 36 questions, four per dimension. However, for this questionnaire, the questions associated with *action-awareness, sense of control*, and *loss of self-consciousness* were excluded, since those dimensions are not primarily important for the evaluation of *x-plore.it*, leading to a total number of 24 questions. For each dimension a score between 0 and 1 is calculated; multiplied by 100 the results are between 0 and 100 for a better comparison with the other scales. By summing up all dimensions an overall score is calculated, representing the level of motivation.

Usability

This questionnaire is using the *System Usability Scale* (SUS) developed by Brooke et al. (1996). According to him, it is *"a simple, ten-item scale giving a global view of subjective assessments of usability"*. By using the provided weights for each question, the results lead to a final score between 0 and 100.

5.3 Participants

Overall, twelve people took part in the evaluation, with an age range between 24 and 38 years. In that group men and women were equally distributed. Regarding the educational level, participants ranged from a completed apprenticeship to university degree. The technical knowledge of the participants was additionally of a broad range, as five of them are working in a non-technical job, while seven are working in a technical one and four had a degree of a technical university. Two are from the fields of education and three are working in a medical job. No payment was provided for participating in the study.

5.4 Procedure

The twelve participants were separated into groups of two, leading to a total of six test sessions. Before starting with the field test of the application each participant will be asked to fill out the pre-questionnaire. After that, the teams will receive instructions of what they should do, provided as a task list. Additionally, smartphones with the already installed application *x-plore.it* will be handed over to them.

The teams have to accomplish three main tasks, covering the solving and creation of a *Tour* of their choice. More specifically, example *Tours* are already provided and for the creation of own *Tours*, the teams are asked to select a topic and an area that matches their hobbies and preferences. At the end they will be asked to fill out the post-questionnaire.

Tasks

- **Task 1**
  Open the application *x-plore.it* and register a new user. Get used to the application by exploring the different views.

- **Task 2.1**
  Select one *Tour* of your choice out of the provided example *Tours*. Read through its description and check out its *Spots*.

- **Task 2.2**
  Select a first *Spot* of your choice and try to find it. Either by using the map or a navigation application.

- **Task 2.3**
  After finding the first *Spot*, try to accomplish all its *Actions*, if assigned.

- **Task 2.4**
  Try to find and accomplish all remaining *Spots* of the selected *Tour* to finish it.

- **Task 3**
  Think about a use case of your own and create a simple *Tour* with a minimum of one *Spot*, that can be used for that case.

As the teams have to physically move to the different *Spots*, the administrator has to follow them in order to be able to monitor all their interactions.

5.5 Instruments and Settings

For the field tests the server-side application *Meteor* is running on a server in a private home network, but with an opened port for providing a connection for the mobile application *x-plore.it*. Thus, the mobile application can also connect via the mobile internet and can therefore be used outside. The participants are using mobile phones with the application *x-plore.it* already installed and GPS and mobile internet enabled.

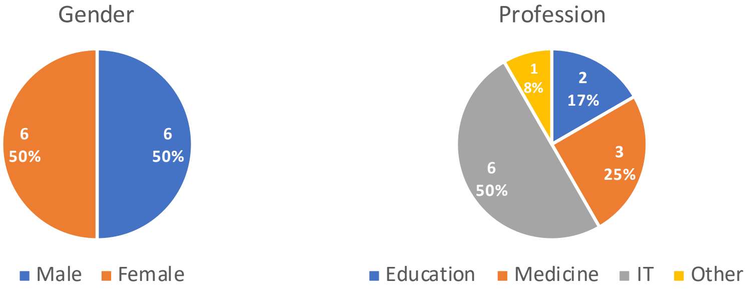
During evaluation, two questionnaires are used, both attached in the Appendix. The pre-questionnaire has to be answered before testing the application, while the post-questionnaire is handed to the participants afterwards. The pre-questionnaire is focusing on the participant's characteristics and hobbies, while the post-questionnaire focuses on the mobile application *x-plore.it*. Both are using different types of questions including Likert-scale questions, polar questions, or open-ended questions, while the pre-questionnaire additionally uses standardized scales like the *The Flow State Scale*, developed by Jackson and Marsh (1996), for measuring motivation and the *System Usability Scale*, by Brooke et al. (1996) to measure usability.

The participants are assigned to groups of two. To guide them through the field test, they get a list of tasks they have to accomplish one after each other. This list is attached in the Appendix as well. The users are asked to do three main tasks, mainly playing and creating a *Tour* with all its additions. Additionally, the administrator is following the groups, as they have to move to different locations physically. Notes are taken by the administrator in the case of occurring problems.

After all test sessions are accomplished, the results of the questionnaires are digitized for better evaluation and calculation of the final results.

5.6 Results

To start with, this section provides results gathered by the pre-questionnaire and gives insights into the participants characteristics and beliefs. In total, there were twelve participants taking part in the evaluation. Regarding gender, as mentioned in section 5.3, there was an equal distribution between both sexes (6 males, 6 females). The professions of the participants can be divided into four main groups, which are, in descending order of frequency, IT, medicine, education and others. Gender as well as profession are visually presented in figure 5.1.



(a)

(b)

Figure 5.1: Gender (a) and profession (b) of the participants of the evaluation.

Continuing, the participants were also interviewed regarding their previous knowledge about and experience with location-based activities and applications. This was done by three questions which had to be answered either with yes or no regarding each sector. Figure 5.2 shows the positive answers and clearly points out that the sectors *Sport and Health* as well as *Tourism* are widely known among the participants of the evaluation while *Entertainment* is placed in the middle field and finally, *Education* is still lacking in awareness.

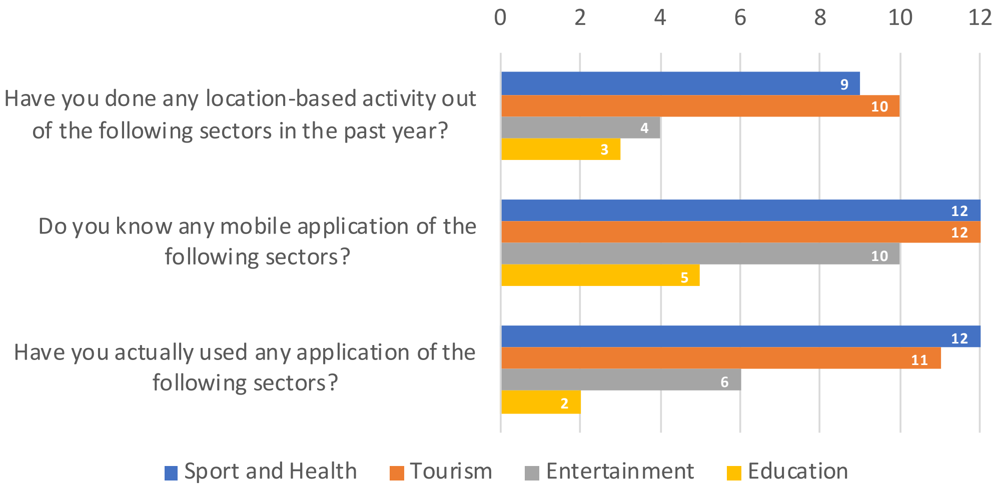


Figure 5.2: Previous knowledge and experience with location-based activities and applications.

As can be seen in figure 5.3, all participants have in common that they do not know any application that covers all purposes previously mentioned in the questionnaire, namely *Sport and Health*, *Tourism*, *Entertainment*, and *Education*. However, 9 participants (75%) of participants would indeed prefer a mobile application for various purposes.

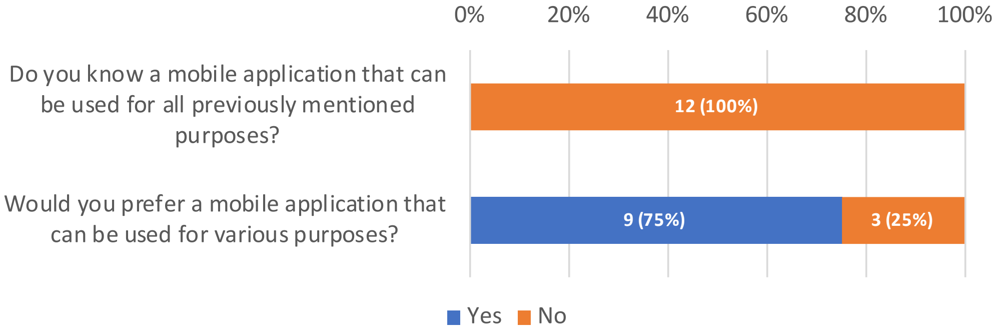


Figure 5.3: Opinion regarding mobile applications for various purposes.

The flexibility of the application *x-plore.it* was evaluated and examined in detail. The participants were asked to answer to which extent they believed the application could be used for various sectors and had to rate each sector on a Likert-scale between 1 and 5. Overall, all participants stated that the application can be used in all defined sectors. More specifically, the sectors *Tourism* and *Entertainment* score a mean of around 4.8 while the sectors *Advertisement*, *Education*, and *Sport Activities* are rated 4.42 and 4.33 respectively, as displayed in figure 5.4.

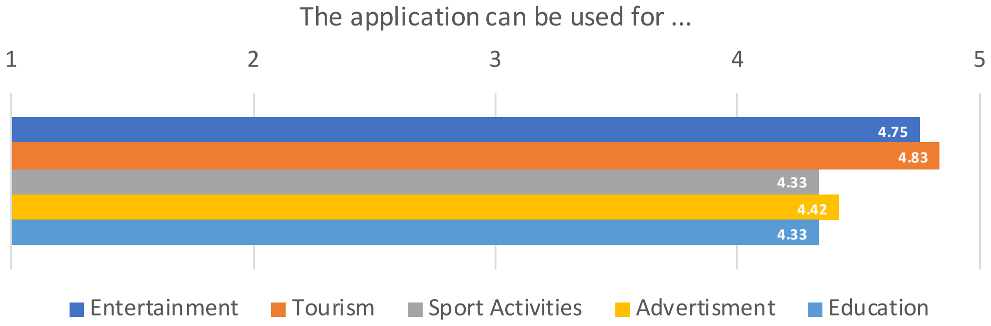


Figure 5.4: Flexible usage of the application *x-plore.it*.

Moreover, the testers were asked about the flexibility of the application *x-plore.it* itself and its functionalities in detail. For this purpose they had to rate three statements on a Likert-scale between 1 and 5 and the average results are presented in figure 5.5.

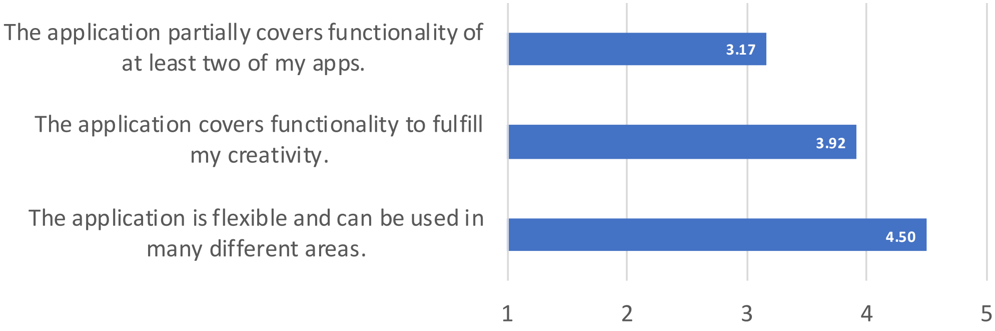


Figure 5.5: Coverage of the application *x-plore.it*.

Furthermore, the usability of the application and the motivation regarding its usage were evaluated by using standardized scales. The results of the *System Usability Scale* (SUS) and *The Flow State Scale* (FSS) are visually represented in figure 5.6 by the help of box-and-whisker diagrams. The motivation was rated with an average of 75 while the usability scored 82 out of a maximum of 100 possible points.

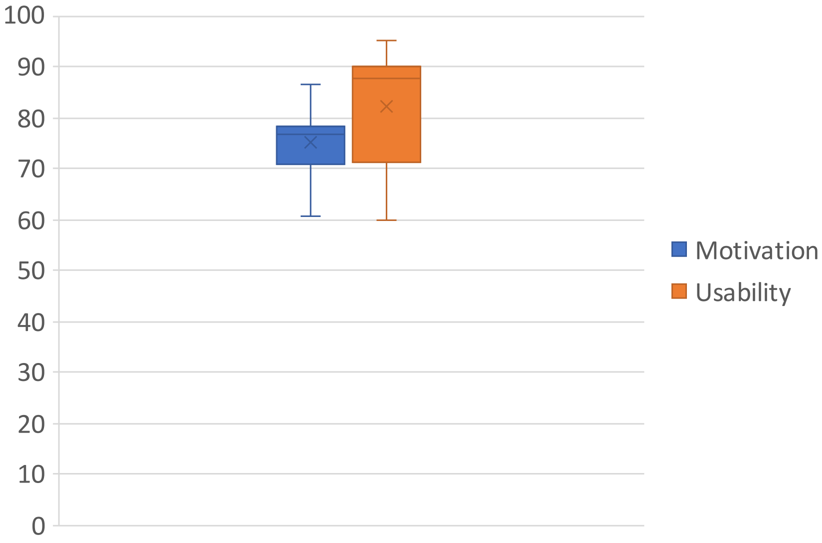


Figure 5.6: Box-and-whisker diagrams for the *System Usability Scale* and *The Flow State Scale*.

For more detailed results on the motivation, the several dimensions are displayed in figure 5.7. All dimensions are placed in the top quarter, with the exception of *Transformation of time*, which can be found in the middle.

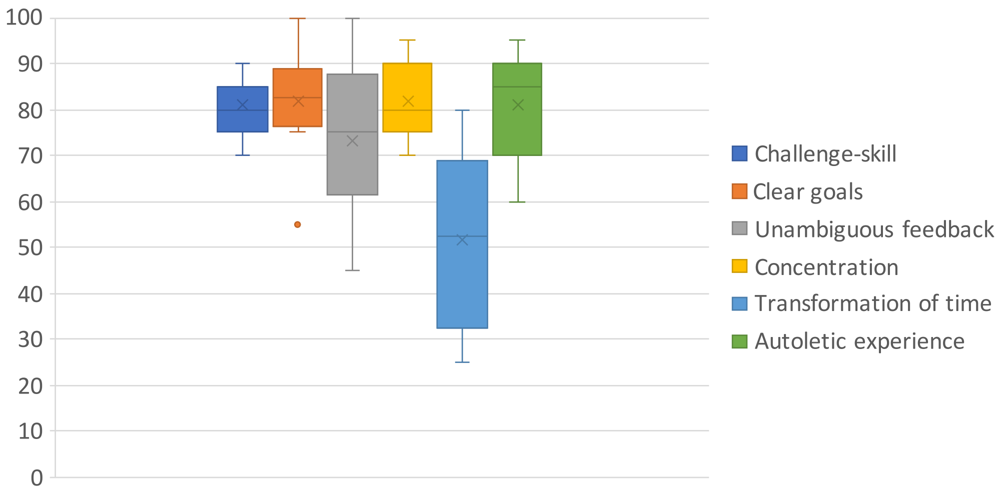


Figure 5.7: Box-and-whisker diagrams for different dimensions of *The Flow State Scale*.

Participants had to indicate whether mobile games can be motivating to become active in different sectors. For this, each sector had to be rated on a Likert-scale from 1 to 5. All participants generally agreed that overall mobile games can be motivating for people to become more active in all mentioned sectors. Figure 5.8 shows that all sectors were rated with average scores between 4 and 4.5.

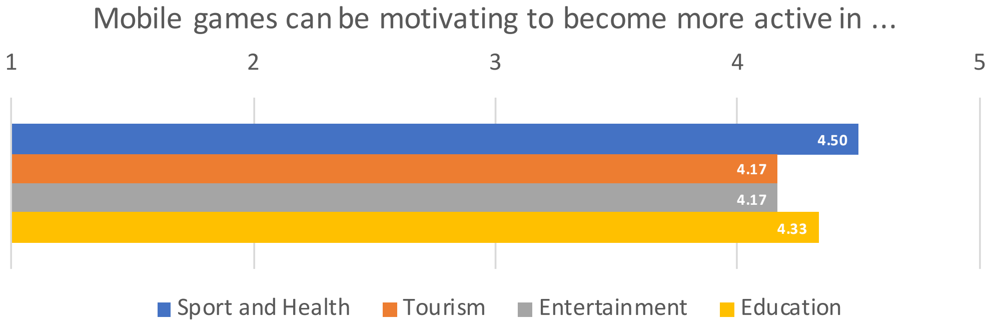


Figure 5.8: Potential of mobile games to motivate people to become more active in various fields.

In the last section of the questionnaire the person's experience with the game *x-plore.it* while playing and creating *Tours* was investigated in the form of various questions. One major part of it was to ask whether there were any problems occurring, and if so, participants were asked to specify those problems. Figure 5.9 shows the number of participants having problems during specific steps of the field test, while multiple selections where possible as the same participant could face problems at several steps.

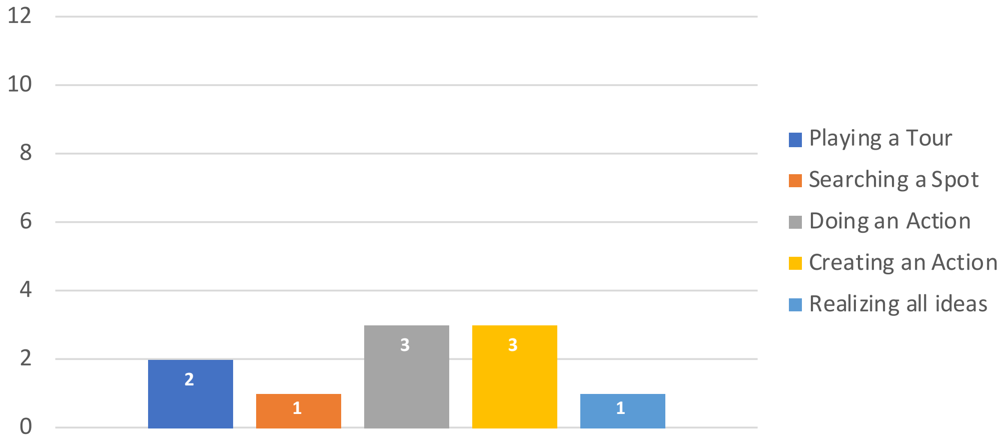


Figure 5.9: Number of participants encountering problems during the field test.

Furthermore, there were several open-ended questions, for instance, asking the participants about their likes and dislikes regarding the application. Concerning the interface, it was mentioned that the size of some buttons and the notifications are too small and two participants were confused while creating a *Tour*. The link-*Action* was often annoying and it was asked for a possibility to skip it. Regarding the image gallery it was suggested to make the images zoomable and scale them accordingly instead of cropping them when collapsed. While editing a *Spot* it was suggested to provide a possibility to edit the position of a *Spot* directly on a map instead of changing the coordinates itself in a textbox. It was also observed during the field test that the participants were clicking the button with a tick-icon after finishing all *Actions* in order to return back to the overview of the *Tour*. However, in that final state this button is by then without function, simply indicating that the *Spot* is accomplished.

When being asked about suggestions for possible improvement, participants indicated that they would like to enhance their user profiles by, firstly, being able to include a profile picture of themselves in order to individualize their account and, secondly, they asked for statistics for being able to compare their achievements with friends. Additionally, regarding *Actions*, participants believed that some improvements could be made. In detail, it was asked for the possibility to draw and take pictures and to scan QR-codes. Moreover, during evaluation it was also stated that after finishing a tour vouchers or goodies could be provided as a kind of promotion. On the technical perspective, participants suggested that the application should support wearables such as smartwatches or glasses. Furthermore, another suggestion was that the application should use sensors of smart phones to track the motion during sport *Actions*.

As an important part of the questionnaire, people were asked in which sectors they believed *x-plore.it* would be useful in. Answers included commerce, advertisement, and orientation. For orientation, participants mentioned that they could imagine the application being useful in huge complexes such as hospitals, schools, universities, or fares. Regarding commerce, it was suggested to promote stores, restaurants, and bars. Moreover, it was suggested that companies could use the application for advertisement by sponsoring tours and offering vouchers for the accomplishment of them.

When being asked about positive aspects of the application and what they especially liked about it, participants stated that the application was easy and fast to use, that it provided flexibility and fun, and that they learned how to handle it quickly due to its self-explanatory character. Moreover, various participants indicated that they appreciated creating their own tours in many different fields. Furthermore, it was mentioned by testers that they liked the idea of doing and learning things with activities outside, representing the major idea of edutainment, a main characteristic of the application *x-plore.it*.

After having completed the field test 100 percent of participants expressed their wish to play the other example tours as well and 89 percent asked for more offers of applications like *x-plore.it*.

5.7 Discussion

Basically, it can be said that the participants of the field test generally enjoyed playing *x-plore.it* as a great part agreed that it provided fun, flexibility, easy usage and a good opportunity to combine mobile games with outdoor activities. According to the questionnaire results, they also agreed that mobile games can be motivating for people to become more active in sectors like *Sport and Health*, *Education*, *Tourism*, and *Entertainment*.

The drawbacks that were mentioned display minor adjustments that easily can be realized, such as skipping a link or adding a return functionality to a button. Furthermore, the basic interface was part of the criticism, a legitimate statement and a fact that results from limited experience in frontend-design, demanding future work.

Possible improvements suggested by the participants in the questionnaire, such as the functionality of editing the position of a *Spot* directly on the map, were initially planned but skipped for the first version of the application due to a focus on other main functionalities. Some suggestions for additional *Actions* are interesting and could be a great enhancement of the application, such as drawing or taking a picture. How those pictures could be handled needs to be discussed and requires further input from the tester. It was also mentioned that QR-codes should be added as an *Action*; however, this would make the creation of a *Tour* much more complicated as those codes have to be generated within the application, printed afterwards and physically located somewhere.

Regarding the results of the questionnaire, in particular results concerning the investigation of the flexible usage and coverage of *x-plore.it*, the average scores of 75 and 82 for motivation and usability respectively showed that the main objectives set at the beginning of the developmental process were finally met. Regarding the different dimensions of *The Flow State Scale*, the low results for *Transformation of time* can be explained by the fact that the participants generally were confused by related questions, not totally understanding the sense of those.

Overall, it was a great satisfaction observing people enjoying *x-plore.it* while playing the example *Tours*, especially since a great proportion of them did not encounter major problems and were able to realize their ideas while creating the *Tours*, highlighting the self-explanatory and flexible character of the application.

5.8 Summary

This chapter deals with the evaluation of the application *x-plore.it* and its results. In the beginning, the focus of research was defined as the flexibility, motivation, and usability of the application. In order to evaluate the application, a field test was performed, including twelve participants equipped witch a list of tasks that had to be performed by them using *x-plore.it*. Additionally, the participants were handed two questionnaires, a pre-questionnaire before testing and a post-questionnaire after all actions were done. Those questionnaires consisted of self-defined, as well as standardized questions from *The Flow State Scale* (FSS) and the *System Usability Scale* (SUS). Finally, results were presented and subsequently discussed and interpreted. In general, the previously defined goals and objectives of the application were met since results showed that the participants agreed on its flexible usage and confirmed the motivation and usability with average scores of 75 and 82 respectively.

6 Lessons Learned

This section gives an overview about the lessons that were learned during the different phases of this thesis, namely the theoretical part and background research, the development of the mobile application and finally, the evaluation of the final application.

6.1 Literature Survey

While researching papers for gaining knowledge about the background and the development of location-based games, diving through the history of navigation and localization and how GPS is working in detail was extremely expanding the knowledge in that special field. The history, starting with astronomical observation using stars and planets, continuing with helpful inventions like the compass and finally leading to satellite-based techniques like the global positioning system (GPS) was an interesting aspect during background research. It was interesting to get to know how exactly coordinates are calculated and how the position is determined by the help of satellites. Furthermore, it was novel to learn how live-changing the decision to remove the selective availability was to the public. By then, everyone was instantly able to determine their exact location and use that information in daily life. It was also the starting point for Geocaching, a game where coordinates are the core characteristics. Furthermore, it was also interesting to investigate location-based games that existed long time before all that technologies, like *Letterboxing*, which was invented back in 1854 in England, and to observe how it led to modern games like *Ingress* or *Pokémon Go*. Besides that, information was gained about alternative satellite-based navigation systems like *BeiDou* in Asia or *Galileo* in Europe and for alternative indoor-navigation systems working with WiFi, Bluetooth or even infrared.

Especially investigating older papers was interesting as they represent the knowledge of that time, not knowing how aspects would develop in the future. Additionally, all those papers also helped in getting knowledge about structuring and writing of academic papers and expanded the technical vocabulary used in this field.

Another interesting section for doing research was the market of mobile applications. Not only are there numerous different applications with many new ones published daily, but there are also many different types of programming languages used in that fast moving market. Mobile applications can be developed as three different types, namely native application, pure web applications or hybrid applications. While researching, many different kind of frameworks were analysed, discussed, and compared to each other.

6.2 Development

During the different phases of development a lot of new experiences were gained. For the development of huge projects it is crucial to define all requirements at the beginning of the working process instead of starting to program out of the blue such as it often happened during studying or in private projects. Moreover, at a specific point during development it had become necessary to discard the already written code and change the used framework due to complexity. This decision proved correct many times later since many functionalities would not have been able being realized without that design change, displaying the reason for the two mentioned design decisions in chapter 3.3.

The development of this thesis started with the release of *Ionic 2*. Due to the early state of the framework there was not a huge amount of work done before this thesis. In the provided tutorial some basic mistakes were found and reported to the developers of *Ionic*. Nevertheless, this tutorial displayed a good starting point and it was fascinating to observe how rapidly a simple application was running on a mobile phone already. This tutorial was then used as basis for the application *x-plore.it* because it already used the previously defined client-server architecture. Moreover, when posting questions about occurring problems to stackoverflow[69] almost none of them could be answered by other developers, making it necessary to find solutions by try-and-error. Although, this was a huge obstacle in this work, those questions and provided solutions finally helped others. Four of those questions received the badge *Notable Question* while four others received *Popular Question* with more than 24.000 views in total. For the solutions provided more than 600 points were given by other developers, increasing the rank on stackoverflow.

Furthermore, what can be considered as a huge disappointment was figuring out that even if a hybrid application is developed, a MacBook is needed to compile and create the final application file for iOS devices. Due to the lack of a MacBook, the application was only tested on Android devices so far.

Additionally, saving the code in a git repository to keep track of all changes and having a backup is already common practice. However, this work showed that this is not always enough and may pretend a false sense of security for the developer as not all required information can be restored when needed. The project uses many libraries which are managed by the node package manager npm. To reduce the used space in the repository only the versions of those packages are saved within the file package.json which is tracked by git. Unfortunately, those versions

[69] https://stackoverflow.com

are not always exactly defined but can be flexible, which is set with tilde or caret. For example, ~1.0.2 can also lead to the latest patch version like 1.0.4, while ˆ1.0.2 can resolve to the latest minor version like 1.1.0. Taking this into account, a thoughtlessly entered **npm update -a**, which updates all libraries to the latest available matching versions can create quite a chaos, if the dependencies between all those packages are not met anymore. Therefore, package-lock was introduced, keeping track of the exact versions of each used libraries, making changes comprehensible and reversible if something breaks. Unfortunately, this was not used at the beginning of this thesis and when the **npm update -a** was performed. After that update, the libraries were not compatible anymore and with more than 60 used libraries it was almost impossible to find the correct combination of versions. Luckily, a backup of the whole project folder was found and the node_modules folder, where all the used packages are located, could be restored.

At the end of the development it became clear that a lot of time and energy was invested in details caused by perfectionism and would not have been really necessary for developing a working prototype for a proof of concept. It was more focused on developing bug-free features than investing a little more time into front-end design, especially, knowing that the look of an application is what most average users see and rate first.

6.3 Evaluation

One of the main novel aspects during evaluation was that there are numerous standardized scales for different purposes that can be used in surveys. Although they were developed and published decades ago, they are still in use because they have proven their practical evidence for years. That given, the results of different tested applications can be compared easily if the same scales were used.

According to the answers from the questionnaire, it could be concluded that many improvement suggestions displayed minor functionality adjustments which can be fast and easily made but would result in a huge positive impact on the usability. This leads to the idea of having small testing phases in much earlier phases to get rid of those small issues much earlier. Furthermore, besides criticism on the application, various useful suggestions for additional functionalities came up by testers during the field test, providing a lot of ideas for future work.

During the testing phase it was interesting how the views and thoughts can differ among all participants. What can be complicated for one was easy for others and vice versa. That showed how hard it can be to satisfy all kind of users.

According to the type of data that should be displayed, different types of diagrams need to be used. In this thesis, mostly bar graphs were taken for presenting absolute values. For showing as much information as possible box-and-whisker diagrams were used as they display many values such as average, median, minimum and maximum, and the inner two quartiles within one diagram.

7 Conclusion and Outlook

Location-based activities have ever since been popular among people and have already been implemented into mobile applications for quite a long time. In order to avoid the necessity of having various applications installed on mobile phones, people would benefit from an application that can combine features of various types of applications. This work took that aspect as a main motivation. Within this thesis, an application, called *x-plore.it*, was developed with its major functionality of covering a wide range of usage fields and functionalities. Furthermore, the benefit of having such an application should not be limited to technically experienced people but also be available for everyone and therefore the application focuses on easy usage. What is more, everybody should be able to create their own content and share it with others who may play them as well.

Regarding the developmental process, the application was created in *Ionic 2*, a hybrid framework, in order to support all major mobile phone systems, more specifically, to support Android and iOS devices. On the server side *Meteor* together with *MongoDB* was used. For the interactive map *Leaflet* together with *OpenStreetMap* were chosen. The initial design decision on *jQuery Mobile* was discarded due to the rapidly increasing complexity of the project and its confusing structure. During the development new ideas came up and therefore new functionalities had to be added. Since the final project written in *Ionic 2* was good structured, it was easily extendable and adjustments could be made without encountering huge obstacles, highlighting that the decision to discard the first design decision was the right one.

The purpose of the application *x-plore.it* is to create *Tours* which consist of multiple *Spots* as it is the case in scavenger hunts. Those *Spots* are representing geological points defined by GPS coordinates. After finding those *Spots* by getting close to them, users have to accomplish different types of *Actions* in order to finish the *Spot*. Those *Actions* can be of several characters; for instance, they can consist of a sport activity, show a video or a website, provide users with additional information, or they can contain a quiz. Furthermore, the APIs from Wikipedia and YouTube were used in order to automatically contribute as a source of information to the creation of *Spots*. Moreover, *Tours* created by users themselves can be kept private or made public and shared with others.

According to the questionnaire, participants agreed that mobile games in general could be motivating for people to become more active in different sectors and they further agreed that *x-plore.it* was a useful application in that matter. As far as the evaluation of the application is concerned, one major general aspect that can be concluded from the results is that the application still exists in the form of a functional design. The reason for this is that due to limited knowledge in graphic design during development it was focused on a functional design, leading to the application having limitations in the frontend design. However, despite that criticism, the usability was rated with an average score of 82 out of a maximum of 100 possible points, highlighting that suggestions for improvement by participants represent minor flaws. Regarding results gathered by a motivational scale, an average of 75 out of a maximum of 100 points was found, aligning with the results of the questionnaire that 100 percent of participants expressed their wish to play the other example tours as well.

Future Work

Though the application *x-plore.it* already covers a wide range of usage fields and provides its users with various functionalities, there is still potential for improvement in specific areas for enhancing the game. During evaluation participants were interviewed about possible improvements and further areas of application regarding *x-plore.it*, which provide ideas as a basis for future work.

- **Optimizing the Frontend Design**
  Since there was limited experience in frontend design and due to a focus on a functional interface, there is a huge potential in improving the design. With the help of an expert in design huge steps could be easily achieved.

- **Editing the Position of a *Spot***
  Participants of the field test mentioned that it would be good to have the possibility to edit the position of a *Spot* not only by changing the coordinates in textboxes but also by moving the *Spot* to the correct location directly on a map.

- **Offline Usage of *x-plore.it***
  Tours can be located in areas without any internet access such as on mountain trails. It would be a great feature to save *Tours* offline in advance, to make them available everywhere and synchronize all progresses as soon as connection to the internet is back again.

- **Improvement of the Image Gallery**
  Possible improvements for the image gallery are the possibility to rotate images as well as to scale them accordingly instead of cropping them while the gallery is collapsed.

- **Enhancement of the User Profile**
  Players asked for an enhanced user profile. For example to add the possibility to upload user images for individualization or to add user statistics to compete with friends.

- **Additional Types of *Actions***
  During evaluation new kinds of *Actions* were suggested and their inclusion in the application could be the focus of future work. Possible new *Actions* include the drawing and taking of pictures as well as the possibility to scan QR-codes.

- **Support of Augmented Reality and Wearables**
  Since augmented reality has become more and more popular in recent years, supporting it within the application *x-plore.it* could be important in order to target more people. For example, there could be an animated character included that acts as a story teller, guiding users through *Tours*. Furthermore, a possible enhancement would be to support wearables such as smartwatches for navigation and other possibilities.

Although there are actually still certain aspects that can be improved, the current version of the application *x-plore.it* already reached the initially defined goals and objectives. Participants in the field test confirmed that the application can be used for various purposes and that its usage does not display a great technical challenge. It could be accomplished to develop an application that combines education with fun activities and spending time outdoors.

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Pre-Questionnaire

About yourself

Gender: ______________________________

Age: ______________________________

Profession / field of study: ______________________________

Personal characteristics

Please give an immediate answer that best matches your opinion.
1 … strongly disagree, 5 … strongly agree

I am an expert in computer usage.	1	2	3	4	5
I am an expert in internet usage.	1	2	3	4	5
I am an expert in playing mobile games.	1	2	3	4	5
I practice sport on a regular basis.	1	2	3	4	5
I regularly play computer or mobile games.	1	2	3	4	5
I am interested in culture and museums.	1	2	3	4	5
I like to spend time outdoors.	1	2	3	4	5
I frequently take use of promotions.	1	2	3	4	5

Have you done any location-based activity out of the following sectors in the past year?

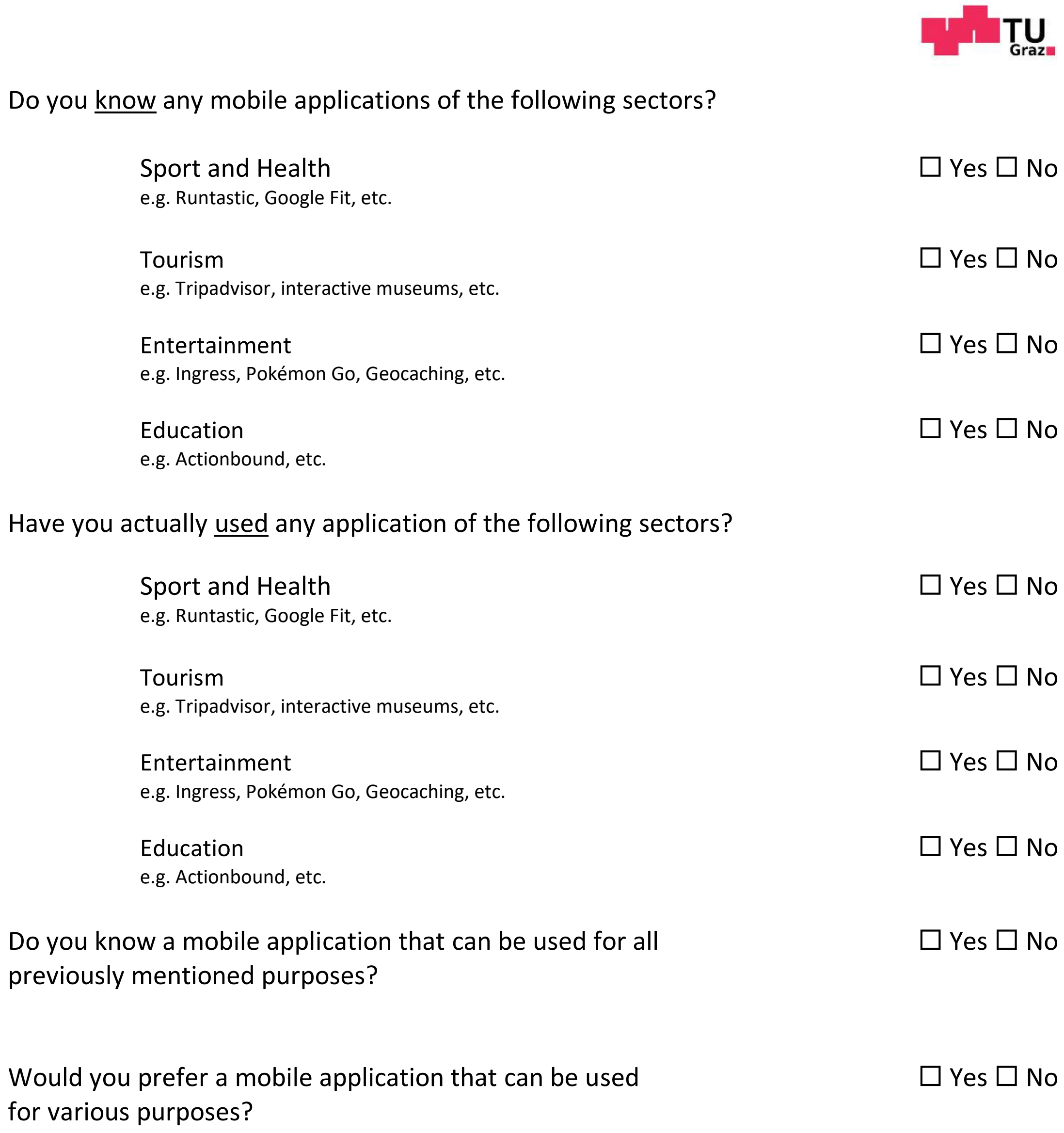
Sport and Health ☐ Yes ☐ No
e.g. fitness tracking, orienteering, hiking, etc.

Tourism ☐ Yes ☐ No
e.g. audio-guides in museums, sightseeing, hiking, etc.

Entertainment ☐ Yes ☐ No
e.g. treasure hunts, Geocaching, Pokémon Go, etc.

Education ☐ Yes ☐ No
e.g. field trips, learning trails, etc.

Appendix A - Pre-Questionnaire



Do you know any mobile applications of the following sectors?

Sport and Health ☐ Yes ☐ No
e.g. Runtastic, Google Fit, etc.

Tourism ☐ Yes ☐ No
e.g. Tripadvisor, interactive museums, etc.

Entertainment ☐ Yes ☐ No
e.g. Ingress, Pokémon Go, Geocaching, etc.

Education ☐ Yes ☐ No
e.g. Actionbound, etc.

Have you actually used any application of the following sectors?

Sport and Health ☐ Yes ☐ No
e.g. Runtastic, Google Fit, etc.

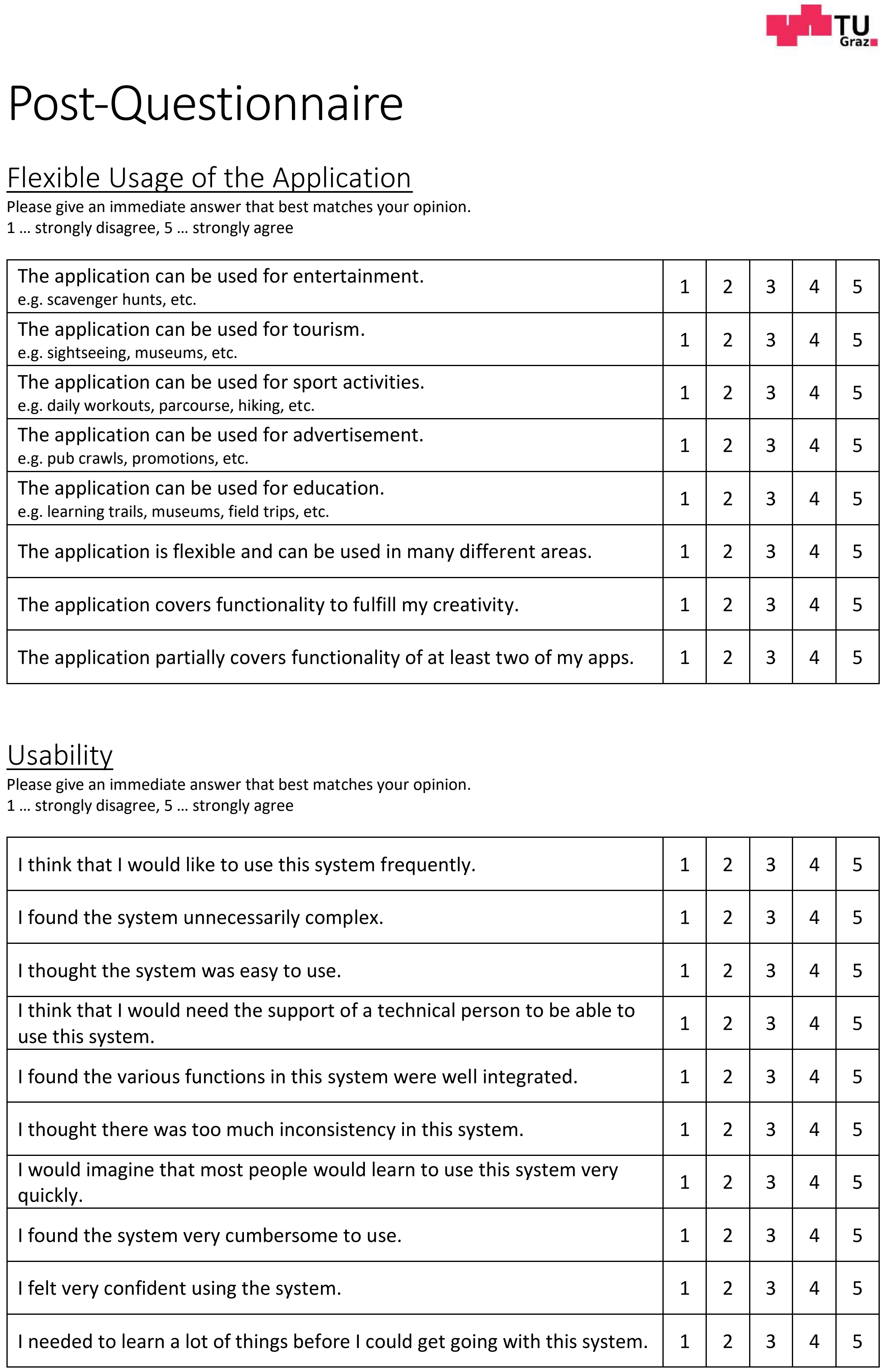
Tourism ☐ Yes ☐ No
e.g. Tripadvisor, interactive museums, etc.

Entertainment ☐ Yes ☐ No
e.g. Ingress, Pokémon Go, Geocaching, etc.

Education ☐ Yes ☐ No
e.g. Actionbound, etc.

Do you know a mobile application that can be used for all previously mentioned purposes? ☐ Yes ☐ No

Would you prefer a mobile application that can be used for various purposes? ☐ Yes ☐ No



Post-Questionnaire

Flexible Usage of the Application

Please give an immediate answer that best matches your opinion.
1 … strongly disagree, 5 … strongly agree

The application can be used for entertainment. e.g. scavenger hunts, etc.	1	2	3	4	5
The application can be used for tourism. e.g. sightseeing, museums, etc.	1	2	3	4	5
The application can be used for sport activities. e.g. daily workouts, parcourse, hiking, etc.	1	2	3	4	5
The application can be used for advertisement. e.g. pub crawls, promotions, etc.	1	2	3	4	5
The application can be used for education. e.g. learning trails, museums, field trips, etc.	1	2	3	4	5
The application is flexible and can be used in many different areas.	1	2	3	4	5
The application covers functionality to fulfill my creativity.	1	2	3	4	5
The application partially covers functionality of at least two of my apps.	1	2	3	4	5

Usability

Please give an immediate answer that best matches your opinion.
1 … strongly disagree, 5 … strongly agree

I think that I would like to use this system frequently.	1	2	3	4	5
I found the system unnecessarily complex.	1	2	3	4	5
I thought the system was easy to use.	1	2	3	4	5
I think that I would need the support of a technical person to be able to use this system.	1	2	3	4	5
I found the various functions in this system were well integrated.	1	2	3	4	5
I thought there was too much inconsistency in this system.	1	2	3	4	5
I would imagine that most people would learn to use this system very quickly.	1	2	3	4	5
I found the system very cumbersome to use.	1	2	3	4	5
I felt very confident using the system.	1	2	3	4	5
I needed to learn a lot of things before I could get going with this system.	1	2	3	4	5

Appendix B - Post-Questionnaire

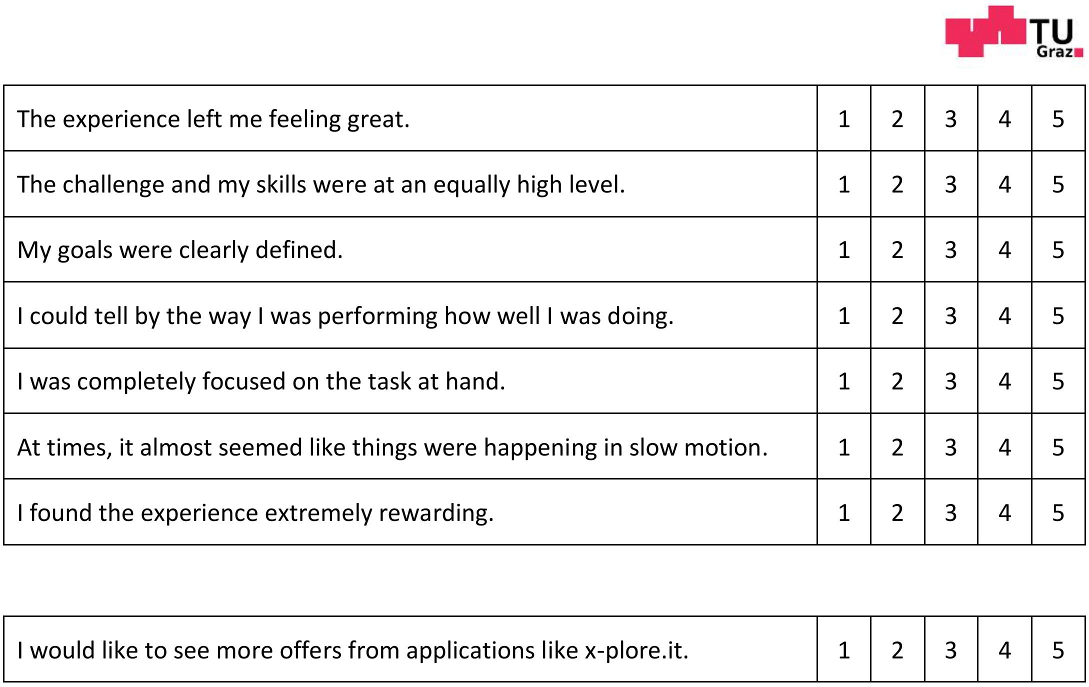
Motivation

Please give an immediate answer that best matches your opinion.
1 … strongly disagree, 5 … strongly agree

I think mobile games can be motivating for people to become more active in the sector of …

Sport and Health	1	2	3	4	5
Tourism	1	2	3	4	5
Entertainment	1	2	3	4	5
Education	1	2	3	4	5

I was challenged, but I believed my skills would allow me to meet the challenge.	1	2	3	4	5
I knew clearly what I wanted to do.	1	2	3	4	5
It was really clear to me that I was doing well.	1	2	3	4	5
My attention was focused entirely on what I was doing.	1	2	3	4	5
Time seemed to alter (either slowed down or speeded up).	1	2	3	4	5
I really enjoyed the experience.	1	2	3	4	5
My abilities matched the challenge of the situation.	1	2	3	4	5
I had a strong sense of what I wanted to do.	1	2	3	4	5
I was aware of how well I was performing.	1	2	3	4	5
It was no effort to keep my mind on what was happening.	1	2	3	4	5
The way time passed seemed to be different from normal.	1	2	3	4	5
I loved the feeling of that performance and want to capture it again.	1	2	3	4	5
I felt I was competent enough to meet the demands of the situation.	1	2	3	4	5
I knew what I wanted to achieve.	1	2	3	4	5
I had a good idea while I was performing about how well I was doing.	1	2	3	4	5
I had total concentration.	1	2	3	4	5
It felt like time stopped while I was performing.	1	2	3	4	5



The experience left me feeling great.	1	2	3	4	5
The challenge and my skills were at an equally high level.	1	2	3	4	5
My goals were clearly defined.	1	2	3	4	5
I could tell by the way I was performing how well I was doing.	1	2	3	4	5
I was completely focused on the task at hand.	1	2	3	4	5
At times, it almost seemed like things were happening in slow motion.	1	2	3	4	5
I found the experience extremely rewarding.	1	2	3	4	5

I would like to see more offers from applications like x-plore.it.	1	2	3	4	5

Appendix B - Post-Questionnaire

Experience with the Game *x-plore.it*

Playing a *Tour*

Which example *Tour* have you played during the field test?

Did you encounter any problems while …

… playing this *Tour*? ☐ Yes ☐ No

If Yes, please specify:

… searching a *Spot*? ☐ Yes ☐ No

If Yes, please specify:

… doing an *Action*? ☐ Yes ☐ No

If Yes, please specify:

Would you like to play the other *Tours* as well? ☐ Yes ☐ No

Creating a *Tour*

During evaluation you were asked to create your own *Tour*.

For which sector did you make it?

Where you able to realize all your ideas? ☐ Yes ☐ No

If No, which limitations did you encounter?

During evaluation you were asked to create *Actions*.

Are the icons of *Actions* self-explanatory? ☐ Yes ☐ No

Are there enough different types of *Actions*? ☐ Yes ☐ No

If No, which ones did you miss?

Did you encounter any problems while creating *Actions*? ☐ Yes ☐ No

If Yes, please specify:

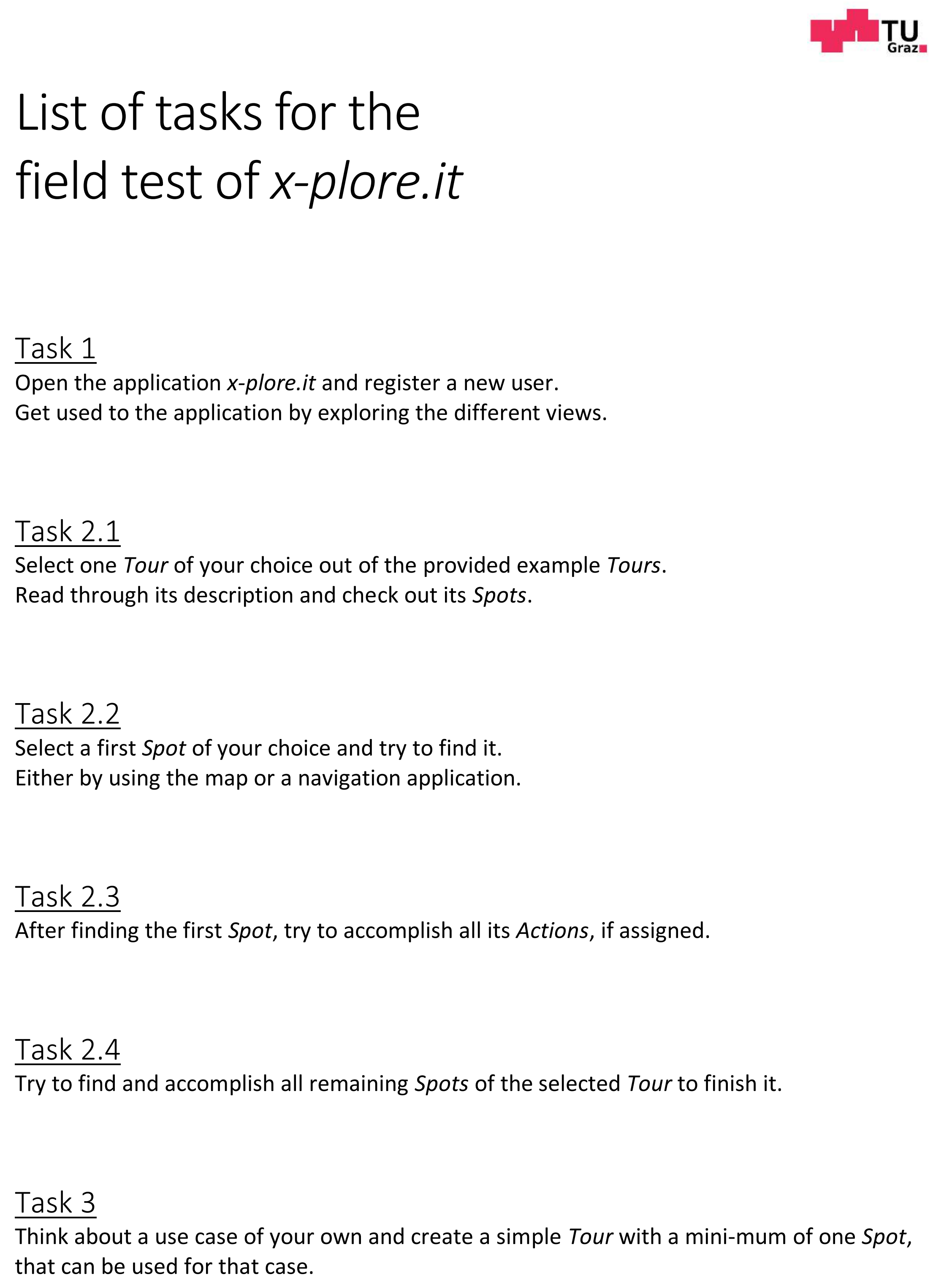
What did you like about *x-plore.it*?

What did you dislike about *x-plore.it*?

Which additional sectors do you imagine *x-plore.it* can be useful in?

Is there something missing in *x-plore.it*?

Appendix C - Task List



List of tasks for the field test of *x-plore.it*

Task 1

Open the application *x-plore.it* and register a new user.
Get used to the application by exploring the different views.

Task 2.1

Select one *Tour* of your choice out of the provided example *Tours*.
Read through its description and check out its *Spots*.

Task 2.2

Select a first *Spot* of your choice and try to find it.
Either by using the map or a navigation application.

Task 2.3

After finding the first *Spot*, try to accomplish all its *Actions*, if assigned.

Task 2.4

Try to find and accomplish all remaining *Spots* of the selected *Tour* to finish it.

Task 3

Think about a use case of your own and create a simple *Tour* with a mini-mum of one *Spot*, that can be used for that case.