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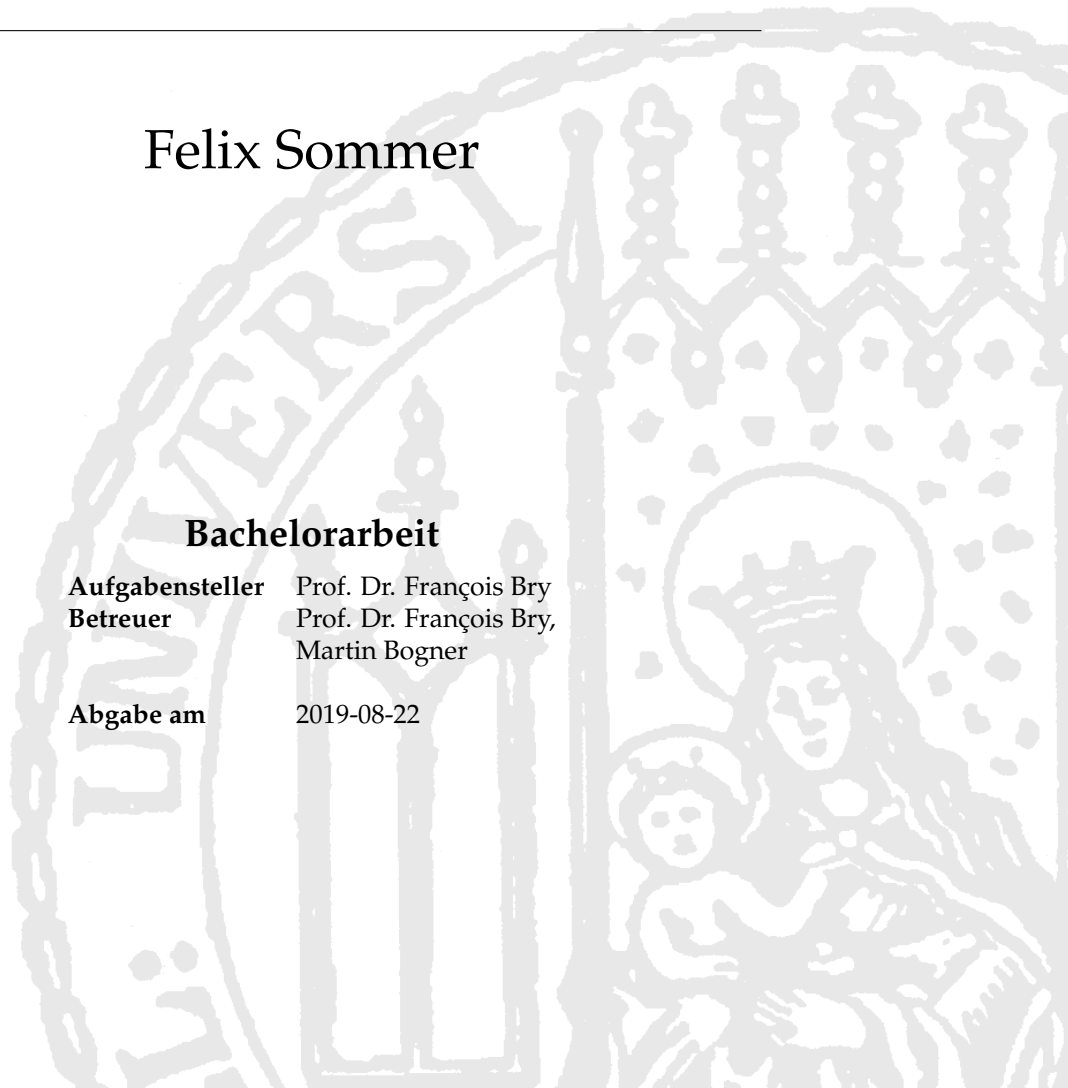
# A SMARTPHONE APPLICATION FOR LOCATING VIEWPOINTS OF ARTWORK SCENES

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Felix Sommer

## Bachelorarbeit

<b>Aufgabensteller</b>	Prof. Dr. François Bry
<b>Betreuer</b>	Prof. Dr. François Bry, Martin Bogner
<b>Abgabe am</b>	2019-08-22





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## Erklärung

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Hiermit versichere ich, dass ich die vorliegende Arbeit selbständig verfasst habe und keine anderen als die angegebenen Hilfsmittel verwendet habe.

München, den 2019-08-22

Felix Sommer



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*Felix Sommer*



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## Abstract

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The Artigo Project collects annotations on artworks in order to generate a semantic artwork search engine and to enable data-driven art history. Currently, location information is largely missing from the data set, thus the location of the viewpoint could be a valuable addition. The viewpoint of an artwork (VipA) is defined as the narrative point of view of the artwork. This thesis reports on the smartphone application ArtSight. Through the use of which, one can learn about art and take part in collecting location data for further research. While searching these VipAs, users are assisted by the application through a graphical interface which offers some guiding features. Tours can be composed to provide a trip through the city or landscape for tourists and locals. For further research, implementation of additional gamification elements, machine learning, augmented reality or community features could be added.





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## Zusammenfassung

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Das Artigo-Projekt sammelt Anmerkungen zu Kunstwerken, um eine semantische Kunstwerk Suchmaschine zu generieren und datengesteuerte Kunstgeschichte zu ermöglichen. Derzeit fehlen im Datensatz weitgehend Standortinformationen, sodass die Lage des Standpunktes eine wertvolle Ergänzung sein könnte. Der Standpunkt eines Kunstwerks (VipA) ist definiert als die Erzählperspektive oder der erzählerische Blickwinkel des Kunstwerks. Diese Arbeit berichtet über die Smartphone-Anwendung ArtSight. Durch dessen Nutzung, man sich über Kunst informieren und an der Erhebung von Standortdaten für die weitere Forschung teilnehmen kann. Bei der Suche von diesen Standpunkten von Kunstwerken werden die Benutzer der Anwendung durch eine grafische Oberfläche unterstützt, die einige Leitfunktionen bietet. Die Touren können so zusammengestellt werden, dass sie eine Reise durch die Stadt oder Landschaft für Touristen oder Bürger anbieten. Für zukünftige Weiterentwicklung werden schließlich mögliche Erweiterungen der Anwendung mit zusätzlichen Spielelementen, maschinellem Lernen, Augmented Reality oder Community-Features skizziert.



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# CHAPTER 1

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## Introduction

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People like to spend their spare time and holidays travelling the world to experience other cultures and live the adventure. There are many resources available like books, websites or smartphone applications which can help tourists or locals to plan a sightseeing trip through a city. Many of these tools and resources are free to use, others can be quite expensive. But all of them have a similar approach. Users choose a number of sights, which are then displayed with useful details and location information. Smartphone applications are also able to navigate the user from any location to the selected museum, statue or park. These details and information might be useful for users who only want to see the sights. But people who want to get to know the city can not learn and appreciate a place by rushing from one sight to another. There is no adventure, there is no exploring the city on your own. Many opportunities to get to know the city or place are missed by spending too much time at places that are build or prepared especially for tourists.

A similar behaviour can be observed, if someone pays a tour guide for a day. The guide talks about all the interesting parts in a city and explains historical, art and cultural details. This can be seen as a top-down guide who explains complex and abstract art or history in an easier and more practical way. The guide has all the information and teaches all the tour members.

Through these available resources, it is often suggested that most of the art can only be experienced in museums, exhibitions or through tour guides. But art and history may be better encountered in the city itself, where the places of historic events can be visited. Therefore, a new way of exploring art, history and overall the city, has to be proposed. Not only tourists but also locals can profit from a new resource that lets them expand the knowledge of their city and surroundings by exploring art, history and places, they have never seen. These people are not likely to use tourist tours or pay for a guide to get to know their own city better.

Thanks to mobile games like Pokémon GO, Ingress or the recently released game Harry Potter: Wizards Unite, location-based games have seen an upsurge in awareness and popularity. This kind of games can also be combined with a purpose that is not centred on entertaining players, but also to collect data or educate users. One possible application of these games is art and history, which is already well researched and discussed.

A lot of details to artworks and artists are already known and documented. However, there are still open questions to be answered in research. One of the question deals with the location of the viewpoint of an artwork (VipA), which can be defined as the current

location that shows the scene of an artwork at the time of creation. Or in other words, the location from where the artist could have painted the scene of the artwork, not meaning the studio in which the artist painted the artwork but rather the location from where the inspiration of the artwork could have come. Similar to the narrative point of view in poetry, the viewpoint of an artwork takes this role in artworks. The only artworks which fit this utilization, have a geographical context or a specific location connected to it. But also artworks displaying indoor scenes of famous halls or houses may fulfil this requirement. Collecting this new kind of location data could enable research to find new conclusions or insights on the life of artists or changes in cities. More participants could be attracted to join art research using the combination of a geo-location based game and by comparing famous places through their representation in artworks to their present appearance. There are many, yet unknown purposes that will be found in the future; therefore, gathering the data now makes research in the future more accessible. The goal of this thesis is to present a location-based game which combines sightseeing of cities, educating about art and history, and collecting location data. The resulting game with a purpose uses mechanisms known from citizen science projects to involve users in gathering location data of viewpoints of artworks.

This thesis starts with an introduction of related work that has already been done in this field. Then the concept of the smartphone application is elaborated and its implementation is described. After some additional technical aspects of implementation, suggestions for further research or extensions and enhancements of the application are provided.

## 2.1 Gamification

The term *gamification* has been around for more than a decade. But the first known written mention and definition was stated by Bret Terrill, who defined the concept of gamification as "taking game mechanics and applying to other web properties to increase engagement" [68]. This word relates to many other concepts like *ludification* which describes the process of society's central core and focus becoming playful [10]. *Games with a purpose* where games are used to collect data or fulfil other tasks, can also be associated with gamification [71]. Jane McGonigal described the role of games in our world and how it can be connected to activities with a serious purpose. Thereby she implicitly used gamification as a central concept [33]. There have been multiple other attempts of finding a widely accepted definition to this term [29]. Detering et al. defined gamification as "Gamification is the use of game design elements in non-game contexts" [18]. This has become one of the most commonly used understandings of gamification. Therefore, these elements must be carefully selected. Some of these elements can be leader-boards, scores, achievements, levels or rewards [75]. By linking these elements to the definition presented by Gabe Zichermann, "Gamification is: the process of using game thinking and game mechanics to solve problems and engage users", gamification has the power to engage people in doing, learning and achieving things they wouldn't have done on their own. In contrast to the mentioned technical definitions, Nicholson described a recipe for meaningful gamification. The "ingredients" for the recipe are play, choice, exposition, information, engagement and reflection [38]. These concepts are explained and discussed in the following paragraphs.

**Play** The concept of *Play* focuses on attracting the user through activities that create fun. Therefore, fun should not be induced by rewards, it is rather the activity itself that makes the user happy and willing to spend more time with it. This principle can be used to teach a variety of lessons. A good real life example are science museums, where children can experiment and play while learning basic principles about physics, biology or geography. Usually those activities have some constraints or rules, but the players are given the freedom to change rules to some extend. An important concept of play in gamification is, that it has to be optional and the user is not forced to do the activity. Therefore, the participant can choose and explore for himself what he enjoys and where he learns the most [12].

**Choice** A strongly connected concept of Play is *Choice*. Hereby the player is set in control of interactions with the system. The gamified system gives the player freedom of learning and doing what he feels like. This helps the user to express his inner abilities and motivations. Through this path of design, a choice is being offered on how the real world tasks are being engaged and how success is measured [57].

**Exposition** The main purpose of *Exposition* in gamification is to provide players with additional ways to feel connected to a real world setting. This can be established by introducing a narrative element to the user. A story or an allegory may be applied which uses its analogies with the real world to help the user to engage with the gamified system. One must be careful to implement a narrative if the story line causes a distraction of the real world task.

**Information** Deci and Ryan are the developers and founders of the *Self-Determination Theory*, which got published in 2004. This theory explains what raises or lowers human motivation [17]. Three elements were defined which are necessary to develop self-determination. The element of Mastery corresponds to the gamification concept of *Information*. The user does not want to feel abused for playing and interacting with the system but he rather wants to be informed of the purpose and background of his actions. An intrinsic motivation is hard to promote if the ulterior motives of the system are not clear. Through the information about the 'why' and 'how', a connection of trust can be created where the user likes to interact with the system rather than backing away from it.

**Engagement** *Engagement* can be split up in two different parts. Social engagement creates opportunities for users to get in touch with other players. This interaction with other participants creates a feeling of relatedness and connection [17]. The second part is to increase the difficulty of the activity. This challenges the user again and again as his skill increases. Such an implementation keeps the player from feeling bored of solving similar tasks although new assignments are not demanding more innovation.

**Reflection** The concept of *Reflection* creates opportunities for a player to look back at what he has done and think about the experiences he made. A user can therefore explore and learn about himself and find actual meaning in what he is doing [56]. It is similar to any debriefings that occur on a regular basis in companies when they speak about their projects they successfully or improperly finished. Speaking and reflecting about problems or new ideas they had, helps them to improve and progress. Systems that implement the concept of reflection should make the player think about his way and help him to improve. Thereby, users can find meaning in the gamified system [31].

There are multiple examples and domains in today's industry and research, in which gamification is being applied. In the following section some examples are discussed.

### 2.1.1 Serious games

*Serious Games* usually refer to games which are used for training or education purposes [66]. Zyda defines "Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." [76]. Serious games and gamification are not easily differentiated on first sight. Gamification only aims to implement game elements in non-game environments. Serious games on the other hand implements an entire game that teaches one or multiple lessons and skills [44]. Although



serious games are only a small branch in the universe of gaming, more and more enterprises are finding applications for it [64]. Major industries and institutions like the military are using games already for a long time to provide educational opportunities. But it is not only used in educational purposes, entertainment is also an important application reason [54, 18]. Often entertainment is the main focus and is used to keep the player interested and patient while learning alongside hard or soft skills.

### 2.1.2 Citizen science

The world is full of unexplored questions and topics we don't understand yet. Commercial and academic research is working on elucidating these questions. Significant data is the most important resource, but gathering the needed information is the biggest expense in research [73]. There are many people interested and willing to contribute to research and discover parts of the world on their own. When those people work together and engage in these public scientific research projects, it is called *Citizen Science*.

Citizen science is often used in biological or geological areas of studies, since the data that is being gathered can usually be found in many places around the globe. Thanks to the participants, expensive data collecting methods can be avoided. Everyone can integrate their data and contribute to the projects progress. For most of the projects, like bird monitoring, it is a necessity to get as many people as possible involved, or else not enough crucial data can be gathered [11, 9]. Most citizen science projects are organized by professional scientists. The roles are predefined, individuals that are enrolled in the citizen science project share their gathered data, which is then used by scientists to evaluate and improve their algorithms or results [2]. A big community of people from everywhere around the globe, with an enormous diverse background, participates in these projects [35]. Some are professionals who enjoy researching new projects in their free time. Others want to contribute to a community which likes to share and help the general public interest. Scientific projects can be tedious and exhausting until a progress or any conclusion can be seen. Not every user and contributor has the patience to stay motivated. To ease this issue, gamification may be used to keep participants interested in the project and add more data. The use of game elements can have the effect of creating interest in the subject and introducing the user slowly towards the actual task [69].

In the research on motivation, *extrinsic motivation* and *intrinsic motivation* are often differentiated. Extrinsic motivation resolves from contingent rewards, whereas intrinsic motivation originates from the individual's desire to perform a task for its own sake [7]. At early stages of participation, gamification is able to motivate extrinsically. But at some point, rather sooner than later, this extrinsic motivation has to be replaced by intrinsic motivation. Without this, the user may lose interest and will not continue his participation [38, 58]. Gamification is only one approach to evolve the first banal interests into long-living intrinsic motivation, but there is no guarantee for this effect [21]. Therefore, new volunteers are also easier acquired through the addition of playful elements. A user is more likely to share the application or website with his friends and acquaintances, when he genuinely enjoys using it or is even convinced of the idea behind it. Even though the first steps of data collecting can be simplified and motivated through game-like components, the risk exists of these elements becoming very repetitive. Therefore, designers of these projects have to find ways to provide multiple paths of solving these repetitious activities, using new and innovative ideas and approaches, else these tasks are deemed tedious very quickly [25].

Nowadays game designers face this crucial task in every game they create. In role-playing games like World of Warcraft, multiplayer-shooters like Destiny or action-adventure games like Grand Theft Auto, the player is confronted with basically always the same tasks. But through different abilities or tactics the outcome can be reached in many compelling ways [52]. With the experience of game designers citizen science can evolve to the next

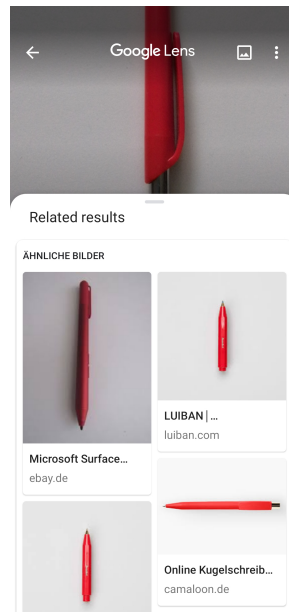


Figure 2.1: A red pen being recognized by Google Lens

step of not just collecting data or gathering knowledge, but to foster interest in science in anybody who is willing to participate in the journey to great discoveries [11].

## 2.2 Human computation

The goal of modern computation sciences is the complete automation of any reasonable tasks [34]. Through the recent advance in machine learning, this goal seemed very close. But the more research was invested, the more borders of artificial intelligence (AI) were reached. There are still a couple of tasks that are very hard or almost impossible to solve for computers, but are fairly easy for humans. Those cases include the use of natural language and visual object recognition. Thanks to modern and continuously evolving machine learning algorithms, object detection and image recognition has advanced in many aspects. But the task of solving correspondence between two shapes, which is seemingly easy for humans, causes many problems for artificial intelligence [6].

At the end of 2017, Google announced its newest feature, Google Lens, an AI assistant, that can detect objects, recognize written words and much more. It can be seen as the fulfilment of many dreams come true. Not much is known about the algorithms or techniques used, as they are not disclosed by Google. TensorFlow, Google's open source machine learning framework, is for example used to connect images of a pen to the pen that is presented to Google Lens as shown in figure 2.1. To recognize text, optical character recognition in combination with spell-correction is applied. It requires a lot of data to sufficiently train an AI, which should be easily acquired by all the data that can be gathered through the many people using Google's search engine, but is rather difficult for smaller companies or fields where existing data is sparse [13].

It is surprising how helpful this application can be and how easily it can identify someone's shoes and recommend shops where you can buy exactly the same ones. Even though Google Lens has set a new state of art in object detection, it is not infallible. Google's AI is very advanced concerning text, object and face recognition, but it is still some steps away

from being perfect. Because there is no strong AI known that can easily solve all the problems like natural language understanding, visual object recognition or dealing with unexpected circumstances, humans are still necessary for many of these tasks where computers are not good enough (yet?!), or to create the training data needed. For these purposes human-based computation is used to solve tasks that are hard or impossible for computers [65].

A well known example is CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart), which serves as a popular security measurement for web sites. Two snippets of text are shown, one is already computer readable or at least known to the computer and the other one is not. Through the user's input of the first snippet, the website can validate if the user is a real human. The by-product, the input of the second snippet, contributes to completing a text where automated text recognition methods failed [3]. Many other applications or games use a similar principle of useful by-products.

Seeing the potential of artificial intelligence, emphasizes the importance for human computation even more. The data has to be generated or created through human interaction with games or other interaction forms like CAPTCHAs. Once the data is collected and analysed by AI, the results of the machine learning algorithms have to be validated to ensure the quality of the outcome. This validation can and has to be done again by human computation, which therefore serves many purposes and is inevitable for developing strong AIs [70].

Thanks to human computation, new types of data can be made accessible that could help researchers and governments or assist other human beings in their daily activities.

## 2.3 Augmented reality

The basic principle of augmented reality is to supplement the real world with virtual objects. Users can interact with these objects in real time and in a real environment. This supplemented reality can address many senses like sight, hearing, touch and smell [4].

### 2.3.1 Augmented reality used in research and teaching

Augmented reality leaves a vast field of innovation and creativity to design new products and software, that enable people to provide additional interactivities with the environment. Not only companies and the commercial industries engage in augmented reality but also governments or institutions like museums. Already known products of the game industry are often connected with museums to create a new way of learning and approaching science or art [61]. Purpose of these games and applications is usually to raise awareness of the local environment [37]. This can help to teach children and adults in a playful manner, subjects they would usually not be interested in.

But this is not the only place augmented reality in connection with learning is encountered. A number of applications aimed to encourage peoples interest in cultural education can be found. Many of these projects serve as possibilities to gather data of users, artworks, museums and cities. Every project approaches the task of cultural education in a different manner. Čopič et al. tried to involve especially children in galleries and art [50]. They managed to develop an augmented reality application that required the participating children to colourize different contours of paintings without the context of the artwork. Then they could search the museum for paintings or statues that resembled the contours they've coloured. Once they found the matching painting, their own created contours wrapped onto the artwork creating their unique version of the artwork. In this way a possibility for research through art and design was created, which is characterized by reflecting upon the process of its creation [22].



Figure 2.2: In game view of a house created with photogrammetry [49]

Therefore, augmented reality can be used as a teaching tool for young and old. It provides an easily approachable and interesting base for newcomers which have a hard time getting into these kind of subjects.

## 2.4 Photogrammetry

Through the ages, the quality of photos and video has consistently improved. Photo filters and other tools are widely used to increase the quality or the looks of self-made photos even more. This process is additionally fuelled by the gaming industry, which sets new standards for more realistic looking graphics and 3D models. Every few years a new milestone is reached for visual presentation of a game due to graphic updates for the most commonly used game engines like Unity or the Unreal Engine [48]. This pressures the companies to invest more and more into photo-realistic graphics of humans, buildings and whole landscape sceneries [72]. Only the newest graphics software and techniques make it possible to keep up with those challenging standards. One of the newest designing technique is called *Photogrammetry* where many 2D photos of an object, from different angles, are analysed by a specialized software to render a 3D model of the object. A big amount of pictures, shot under special conditions, e.g. low contrast lighting, are needed to create a satisfying realistic model [51]. Although much work and money is needed to realize this procedure, players of the game "The vanishing Ethan Carter" benefit from the realistic looking 3D models of an old church or cemetery. In figure 2.2, the synergy of conventional graphics design and models that have been created through photogrammetry is visible. An old house can be seen, with a facade as vivid as one in reality, no perfectly smooth walls or symmetric bricks, that would make the player conspicuous about the reality of this house. It looks like the nature and physics of the game carved the cracks into the wood as realistic as someone would expect it to happen in the real world [49].

The gaming industry is not the only one that uses photogrammetry. Archaeologists and historians analyse antique buildings already for a long time. This analysis takes time and requires the researchers to be on site. More and more historic sites are being examined. To allow cultural heritage research new technologies like photogrammetry are necessary to

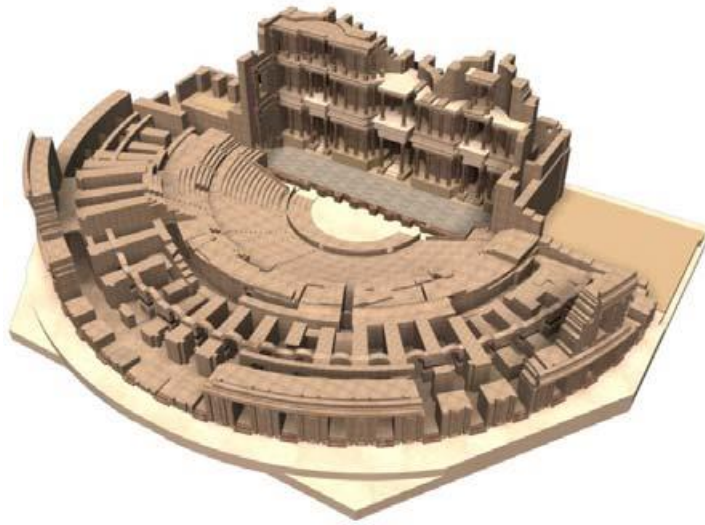


Figure 2.3: 3D model of a Roman theatre created with photogrammetry [41]

make this investigation more scalable and accessible for more people [20]. Especially big areas or sites that are difficultly accessible are predestined to call upon photogrammetry. Like Pádua et al. or Pisa et al. [41, 59] showed how photogrammetry can be applied to sites like a Roman theatre or a chapel in Portugal. A new era of cultural heritage site research is reached, where scientists from all around the globe can study those sites and contribute together to a more enlightened history. Like unmanned aerial systems or spherical panoramas, possible methods of photogrammetry are constantly being refined and can offer more and more realistic 3D models. In figure 2.3, a model of a Roman theatre has been created that shows how powerful the use of spherical panoramas in photogrammetry can be.

Through these techniques many more sites may be transferred to this kind of model and researched by a greater amount of scientists.

## 2.5 Location-based games

During a lifetime, a person encounters many people, many cultures and visits many locations. Some of which are visited more frequently than others. Sifonis showed through her work, that places and locations which are associated with fun, socializing or competition are more likely to build a sense of closeness or fondness than places not associated with these qualities. Places like these are especially formed through games. Children are therefore more likely to remember and feel a connection to their playground or football stadium, rather than their school or dentist [63].

To understand what kind of games can create these memories connected to neighbourhoods, examples of location-based games are described first. Then the benefits and dangers which are faced by this genre of games are discussed.

### 2.5.1 Examples of location-based games

There are many examples for location-based games, nevertheless the origin of this genre goes back to the game BotFighters [36]. But since then, there have been many more games which are based on geo-locations. McGonigal herself created multiple games, like Cruel

2 B Kind or Tombstone Hold 'Em [33]. Especially through the games Pokémon GO and Geocaching, location-based games started to become popular in recent years.

**Geocaching** Geocaching is an outdoor activity, that consists of hiding containers, filled with a log book, pencil and other small free to take objects. These containers can then be searched by other players called geocachers. The containers are marked by coordinates and shared online for geocachers to find them through the use of a GPS receiver. This concept can be summarized as a technology-enabled treasure-hunt [24]. In a study from O'Hara [40], the motivation of geocachers was examined. First of all, the social motivation in hunting or searching for the geocaches plays a big role. It can be seen as taking a walk with family and friends with a purpose or providing a motivation, which can be particularly important for children. Another aspect shows, that there is a whole community behind this activity and interaction with it can have an important influence on behaviour.

**EyeSpy** Another good example is the game EyeSpy [5], where players take photos of locations like buildings, statues or any other kind of place. These photographs are then shared with other players, who then have to find the place or viewpoint from where those photos were taken to validate them. Through this validation any possibilities of cheating are being ruled out. Points are scored by either confirming other's photographs or uploading photos of their own. This game was designed to generate geo-referenced photographs and accompanied tags to create a map with labels and annotations that help people orientating in their environment. As a result or by-product, images and their location tags can be identified.

**Pokémon GO and Ingress** Games like Ingress or Pokémon GO are based on real geolocations that can be virtually captured and defended. Other players or factions attack opposing locations to increase their influence on the game landscape. Pokémon GO expands the basic functionalities of Ingress through the addition of Pokémon, pocket monsters, which can appear at any place and be caught by anyone who is close enough. This principle leads to players visiting many places in their surrounding neighbourhoods, communities and cities [43]. PokéStops are also geolocations that can be visited but players do not compete over them, they dispense items or serve other useful purposes. By applying special modules these PokéStops attract more Pokémon and are therefore another vital part of the game play [14].

**Related projects at the Ludwig Maximilian University of Munich** Three different groups of students at the Ludwig Maximilian University of Munich worked on a project of creating a location-based game, which included connecting artworks with geo-locations [47]. Based on artworks displaying scenes of Munich, the game offered the composition of tours or extra information on the artwork and artist. The games focused more on finding sights of Munich and taking pictures of them. A quiz about the sights and the city engages and educates the users. Gathering location data of artworks is only a small part of the application. This purpose is implemented but not emphasized. Through different gamification elements the games are suited for tourists and citizen. This idea gives much room for improvements and adaptations.

### 2.5.2 Benefits

Ingress and Pokémon GO belong to the geo-augmented reality applications which is a growing branch for many purposes. Marketing, tourism or serious games are just some



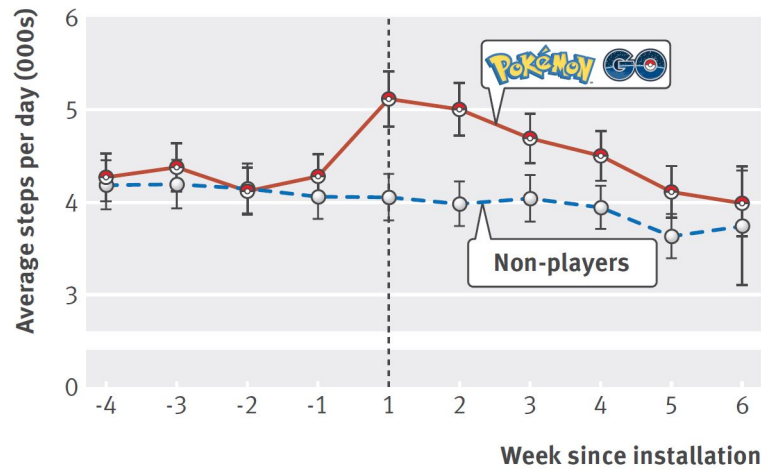


Figure 2.4: Statistics on average walking distance for Pokémon GO players and non-players [28]

of many application areas [23]. In combination with these video games new places of public interest can form. Using the relationship of players to certain locations, new tourism and marketing chances are provided. Pamuru et al. showed in their study on the impact of augmented reality games on local businesses, that restaurants profit from these genre of games. Restaurants that had a PokéStop nearby, achieved higher visitor rates than before the time Pokémon GO was released [42].

Location-based games do not only profit the resident economy but also each individual player because they are motivated to go outside, walk and practice physical activity more often. One might think, that the impact of these games on public health is great. But a study on differences of physical activity of Pokémon GO players and non-players showed, that the motivation to walk more decreases already after the first week of playing as shown in figure 2.4. Reasons are not mentioned but negative effects, like injuries and road traffic incidents that result from playing, lower the hope of a positive influence on public health even more [28]. Although an increase of physical health could not be assessed, interactive games have an effect on psychological health and social behaviour. In Japan, many teenagers and adults withdraw themselves from society because of refusal anxieties. Pokémon GO achieved, to get these people to socialize and leave their apartments, something psychologists were not able to do. Therefore, the conclusion can be made, that location-based games could have a positive impact on the society [67].

Furthermore, Geocaching has also an influence on the social life and mental health. Creating caches and sharing them online in a forum or on a website, gives users the opportunity of letting others experience places that are important to them. This interaction can create friendly rivalry between participants or a social accountability. The combination of these online and offline social aspects can be a good basis for developers of location-based games and activities [40].

### 2.5.3 Problems and dangers

On the other hand, there are also some problems locals and the game publishers have to face. Depending on important spots in the game, crowds of people gather at places that may not be fitted for these purposes. Cities have to know about this to provide security and other logistic services like garbage disposals. This requires a lot of communication

with cities and municipalities. If this is not done, neighbourhoods or the natural environment may be damaged [53]. Another new problem that emerges through this kind of games is the matter of jurisdiction. These games play in a virtual world which is connected to the real world and requires players to interact with both. Private places that contain a PokéStop or even just normal Pokémon attract players without the property owners knowledge and consent. Through the complexity of this subject, publishers of this game genre and legislature have to agree upon laws that give players the freedom of action they seek for, without breaking property laws or the traffic code [62].

Therefore, geo-augmented reality applications may be used and deployed with caution and a lot of communication with local and global offices.



### 3.1 Idea

The idea is to open a new way of experiencing a city by viewing artworks and finding their viewpoint in the city by oneself or in a group. This idea also applies to landscapes, other non rural areas or inside of buildings. But this work focuses particularly on cities because these are the places where most tourists go and citizens live and is therefore most likely to be used. Therefore, users can explore the city, its culture and history on their own. They learn and experience at their own speed and interest. To realize this idea, a smartphone application would provide the best ecosystem and base. The application is made to support the user in this new experience by providing the necessary information and guidance. If using traditional tour guides is seen as a top-down method of knowledge transfer, the presented approach offers a tour which is bottom-up or on a same level. This is caused by the idea of letting a user get to know the city by him self with only some minor guiding tools. Through the gathered knowledge of the user, some information is passed on to the system and research. It serves the purpose of finding locations of viewpoints which are not known yet to the system or the broad audience. This knowledge is being created and other people can profit. It can also be seen, as the system or application assists the user by giving hints and showing the artwork, but he has to explore and discover the city on his own.

Users would profit from this idea in many ways, one of them is seeing the difference of the past and comparing it to today's reality, which offers a new sight on how cities or landscapes changed over time. Through the contact of history and art in a location-based setting, the user can learn and improve his knowledge. Research profits through the generation of new location data for VipAs.

### 3.2 Target group

This application is targeted at tourists of any age with interest in history and art. Citizens who want to learn more about their city and its cultural past and present may also profit. Many books already address the topic of comparing old photographs of popular areas with pictures of today [19]. People that are interested in these kinds of books fit perfectly the

profile of people who are targeted through this application. Specialists of certain eras of art may also experience new angles of viewing parts of cities they have only known through artworks. To use the application it is necessary to possess a smartphone with the Android operating system.

### 3.3 Concept

The purpose of the concept of this application (app) is to describe the basic features which are necessary to implement the idea in the best way. There are multiple approaches to realize this idea and here described blueprint.

#### 3.3.1 Start

Starting the app, the user could see a starting screen in form of a start menu which is easily understandable. All features, offered by the app, should be visible and accessible through this menu to give especially new users a good overview. Since the game does not really tell a story or has a lot of on screen interactivity, the configuration of the game can therefore happen before the game starts without negative influence on the user experience [15]. Conway also mentions the importance of presenting an option to dive directly into the game without the need of much configuration. Therefore, a button in the start menu should exist, where players can start a game by just clicking this one button. To make players feel more attracted towards playing the game, the visual design of the start menu should already suggest, that they can learn about art. Implementing this aspect consists of having a significant icon that already gives a hint what the game is about.

Furthermore, the start menu should have some more setting and configuration options for players who want to plan or start an individually adjusted tour. An option to resume an already started game is especially important, since it is a smartphone game, where players are expected to stop and continue the game while walking through the city. This would make it easy to handle even if the user does not use the application for a long time.

#### 3.3.2 Plan and start a tour

Even though many players may want to start the game straight away and play, other users may want to plan ahead of time and plan a tour with multiple artworks for later. To satisfy this need, a dedicated place in the app has to be created where players can preselect artworks, whose viewpoints they want to find. More settings should be made configurable, e.g. where the game should take place. This feature is especially important for users who are not in the city in which they want to play, at the moment of tour creation, e.g. a user from Stuttgart plans to come to Munich the next day and wants to plan a tour which he can do during the visit of the city. Therefore this feature is essential to make the trip as enjoyable as the player desires it to be. After the creation of the tour, the player should be able to select from multiple saved tours and start a selected tour with just one click.

#### 3.3.3 Select artworks

Like mentioned before, players select artworks to find their viewpoints. During this selection, the user should be provided information that may be important for the selection process, like title of the artwork or artist. Additional information could consist of the era of art, or the year the artwork was painted. An interesting and crucial fact is the distance or how far the location of the viewpoint approximately is, from where the user wants to start the tour. This helps to keep the frustration low when users want to find the VipA,

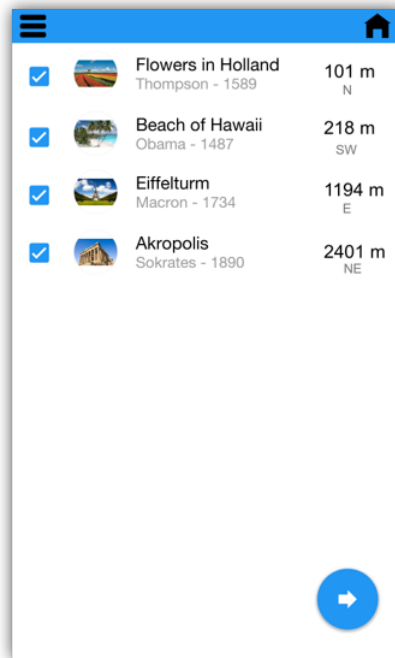


Figure 3.1: Blueprint of how artworks could be selected in the application

but it is really far away or not on the route they want to take through the city. A possible implementation could look like the screen visible in figure 3.1.

### 3.3.4 Additional information

Players want to know more about the artworks they selected for their tour. An opportunity has to be given where the user can look at the artwork and see information about the artist, the artwork, the era of art or other interesting details which might help to find the viewpoint. This is most likely the best instance to educate users and to give hints. Therefore, it is essential to be careful what information is given without spoiling the game with hints which are too good or maybe lead the player in a wrong direction. A good way has to be found to present this information to the user, without blocking other important data. The user should be able to display and to dismiss the description of the artwork easily without much effort. All these requirements could be fulfilled by implementing the blueprint in figure 3.2.

### 3.3.5 The game

The goal of the game consists of finding VipAs, which requires the user to be able to view all the artworks he added to the tour. In addition to the artworks, a map or some other navigation tool has to be given, so that the player can always see his current location and surroundings. Considering, that the player will memorize the selected artwork quickly and that most of the artworks have a horizontal orientation, the map should be more present than the artworks. Therefore, the screen of the smartphone is filled with only the most important information. The map can not only be used to see where the user is currently located but also to give hints and additional information about the city. Markers or circles could be used, to indicate an area of possible locations for the viewpoint. It is not necessary,

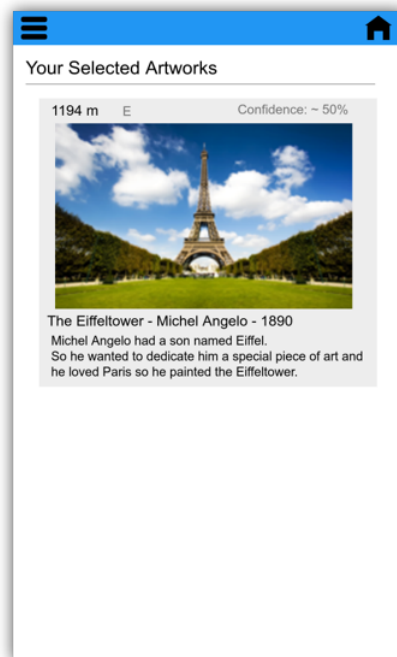


Figure 3.2: Blueprint of how additional information of the artwork could be shown in the application

that the area has to contain the actual location of the viewpoint, but it is supposed to give a clue, so that the players do not have to walk through the whole city without any indication where the viewpoint could be found. This can be compared to a treasure map where hints are marked on the map. It is the purpose of the players to find the exact location. More help and tools could be given especially for tourists who do not know their way around the city. Users should be able to get navigated from where they are to a certain point on the map, maybe where they believe the VipA could be. The actual screen could look as in figure 3.3 displayed.

### 3.3.6 Found artworks

After some successful tours, the player might want to see all the pictures he took and compare them again with the artwork. This would apply the gamification element of reflection and could be the first step of implementing achievements or trophies that players could show other people. Therefore, a list with all found VipAs in form of a gallery should be provided, where all information of the artwork is given. If a player wants to show the application to other people, this should be one of the main features that are presented. Consequently this should be a very handy and clear view, so that people become interested in the application and might want to try it out. This would provide users a good tool to advertise the application. The gallery could look like the blueprint shown in figure 3.4.

### 3.3.7 Various game modes

Not every player is the same, some may already have experience in art and history or know the city very well. Others may visit the city for the first time and have no art background. To make the experience for all players enjoyable, a variation of levels or difficulties should

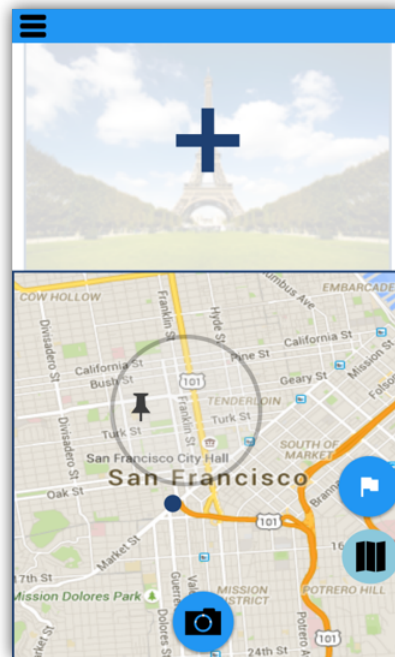


Figure 3.3: Blueprint of how the game is shown in the application

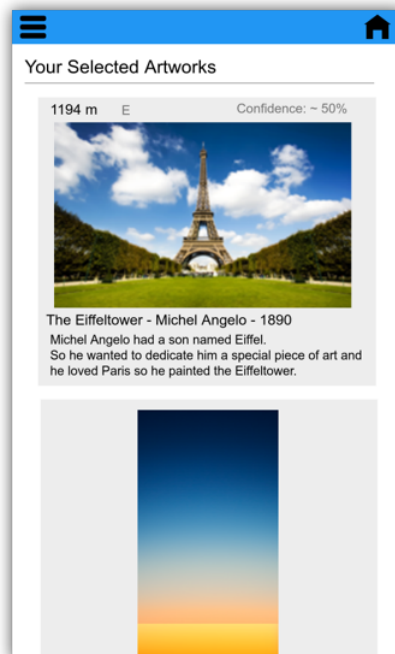


Figure 3.4: Blueprint of how the found artworks are shown in the application

be made available. This will enable users to choose how challenging the game is going to be. The various modes or difficulties could show different hints. In the more challenging mode, the user can only select artworks where further information of the actual location of the VipA is not available or not known yet. Feeling ready to use the harder mode will also give experienced players a sense of progress and improvement of their knowledge in art, history and the city overall.

### **3.3.8 User input validation**

To fully execute the purpose of collecting location data of artworks, the user input has to be validated. It is expected, that players might register wrong pictures and data by accident, maliciously or simply by misinterpretation of the artwork. All of these events must be caught to ensure the quality of the data. GPS data is not always the most accurate data. The quality can therefore vary especially within different altitudes [1]. The problem is, that not only the GPS data is wrong but the image which is gathered by the user does not fit to the location data. This is a major problem while trying to find the most accurate location data combined with the image of the viewpoint. All of these errors which occur through natural physics or human mistakes have to be considered and a solution has to be found. Eventually it should be possible to calculate the actual location of the VipA. Therefore, incorrect data could be filtered out when the user input is registered or when the best result of the location is calculated. Additionally players could validate the picture of other users, which would ensure the data quality even more, although this only solves data issues concerning human mistakes but not errors caused by laws of nature.

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### Smartphone application implementation

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#### 4.1 Activities

The application is structured into activities which can be described as different screens or entry points of the app with a user interface and other interaction possibilities [46]. Each of them serves an organizational or game-play purpose. The structure of the activities is shown in figure 4.1. In the following sections the actually implemented application is elaborated and the mentioned activities are explained.

##### 4.1.1 Start Activity

Opening the application for the first time a dialogue opens to ask for permission to use the GPS position of the smartphone. The GPS signal has to be turned on at all time during the use because the whole app is based on location services. This is quite important because if these are not continually updated the user experience may suffer.

After the permission is granted, the starting activity is visible as shown in figure 4.2. Five buttons are shown to the user, which are Resume Game, Quick Start, Plan Tour, Start Tour and Gallery. If a user has already played a game and closed the application for some reason, he can continue the tour he started, from where he left off by clicking the Resume Game button. The button Quick Start is made for players who use the app for the first time or want to get into the game as fast as possible. Therefore, the user is redirected to the *Main Game Activity* to start the game right away. Moreover, a possibility to plan a tour ahead of time is given. The button Plan Tour redirects the user to the *Plan Tour Activity*. Once the player is ready to play he can click on the button Start Tour, where he can choose one from his created tours. The button Gallery leads to all taken pictures of viewpoints combined with the artwork and additional information.

##### 4.1.2 Main Game Activity

The display of this activity is very similar to the blueprint as seen as in figure 4.3 and is separated into two parts. In the top part an image view is placed, which shows the selected artworks for the tour. The bottom part is dedicated to a map, provided by Google Maps. On the map the players position is indicated and shows circles as soon as artworks are

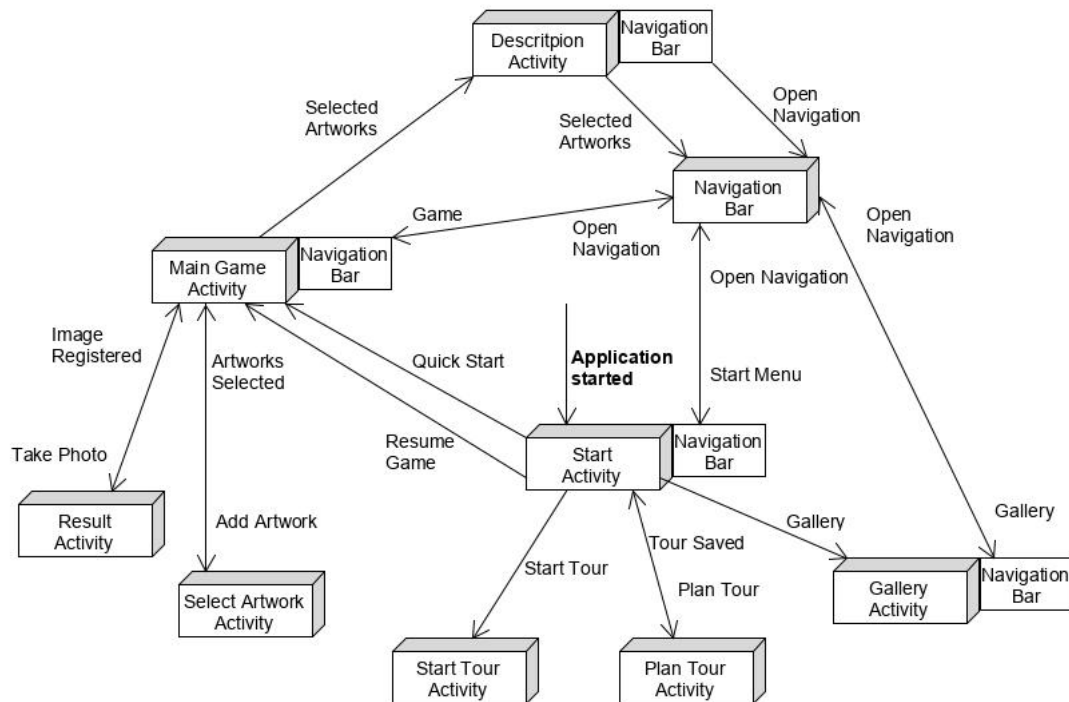


Figure 4.1: Diagram of how the different activities are connected to each other

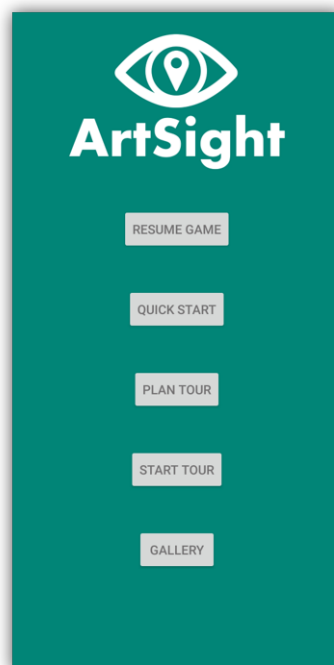


Figure 4.2: The *Start Activity*, which is displayed when opening the application



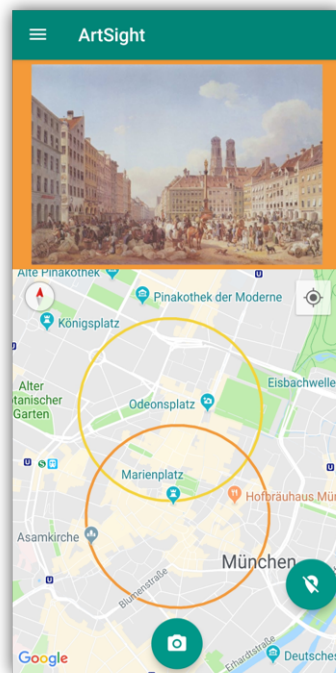


Figure 4.3: The *Main Game Activity*, which displays all functions needed for playing the game

selected. These imply, that the viewpoint to the corresponding artwork might be located in the area of the circle. The circles are in the same colour as the background of the artwork on the top. Therefore, it can be easily distinguished which circle is related to which artwork. But to specify, the circles are no guarantee, that the viewpoint is located inside of it. They are just hints for the player, so he knows a rough direction where the viewpoint is to be found. On the right side of the map a button is visible which can be clicked to set markers on the map. Is the button pushed again, markers can be deleted by clicking on the marker. Another click on the button disables adding and deleting markers. Markers may be used by players to set way points for themselves to mark, where the viewpoint might be located. If a marker is clicked, a Google Maps button appears on the bottom right. This button opens up Google Maps and can navigate the user to the chosen location. This is a powerful tool especially made for tourists who don't know the city very well. It enables them to get faster from one point to another without losing interest in the game by feeling lost in a big city. But this tool should be used rarely, since the point of the application is to get to know the city and learn more about the history and art. If the Google Maps navigation is used only to rush through the tour, this goal may not be accomplished.

As soon as the player has found the viewpoint of an artwork, he can click the button at the bottom centre. This lets the player take a picture of the viewpoint he is looking at. A separate activity, the *Result Photo Activity* is being opened. At the start, the image view on the top part of the screen shows a plus sign on top of an image icon. This is supposed to indicate, that by clicking on this image new artworks can be added to the tour. The image view allows the player to swipe left or right to see all of the selected artworks. When the image with the plus sign is being clicked on, the *Select Artwork Activity* is visible. If a selected artwork is being clicked on, the *Description Activity* is opened.

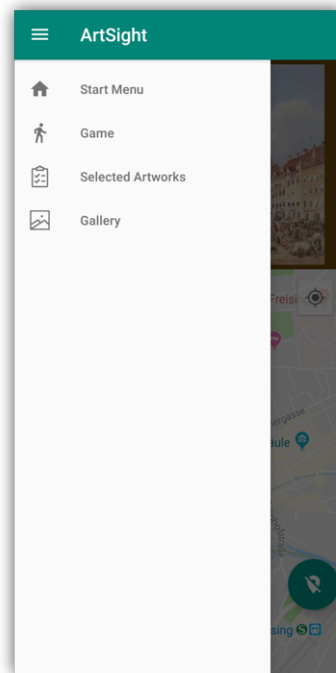


Figure 4.4: The *Navigation Bar*, which is an additional tool to navigate through the application

### 4.1.3 Select Artwork Activity

This activity serves the purpose of selecting all the artworks, the user wants in his tour included. How the activity is structured depends on the game mode. Entering this activity with the normal mode, a normal list appears with artworks that can be selected by clicking on them. In the explorer mode, the list is replaced by a map with markers indicating the location of the artworks. By clicking the button on the bottom right, the selected artworks or list items with the checked checkbox are added to the tour. This is further explained in the section 4.2.

### 4.1.4 Navigation Bar

As an additional way to navigate through the application, a navigation bar is provided. It can be opened in the most activities which fulfil more purposes than just selecting artworks. This navigation bar, shown in figure 4.4, is opened by clicking on the menu icon at the top of the screen. The tool enables quick switching between the activities to the *Start Activity*, the *Main Game Activity*, the *Description Activity* and the *Gallery Activity*.

### 4.1.5 Result Photo Activity

If a player eventually finds the viewpoint of an artwork, he takes a picture by clicking the bottom centre button in the *Main Game Activity*. The camera opens up and enables the user to take a picture of the scenery. After the user is satisfied with the taken picture the *Result Photo Activity* is opened and shows his picture on the bottom and the available artworks at the top, like shown in Figure 4.5. Now he can swipe the artworks to choose whose corresponding viewpoint he found. Underneath the artwork, an input field is displayed

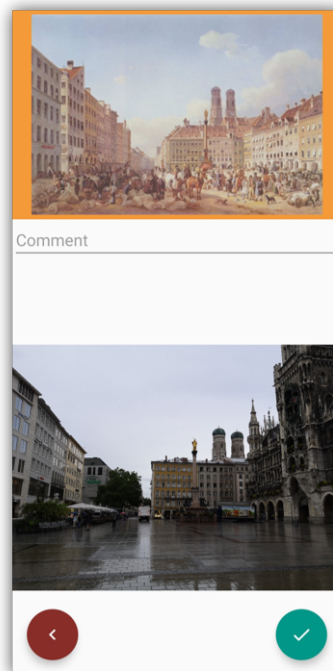


Figure 4.5: The *Result Photo Activity*, which displays the artwork and the photo taken by the user

where users can comment on their taken picture. This enables them to give feedback about the artwork or the viewpoint, if it was very hard to find, if the hints were not very good or if there is anything else to mention. He then can either cancel the operation or click the green button to register the photo. The photo is then send to the server where it is saved for later use.

#### 4.1.6 Description Activity

This activity may be opened after artworks may have already been selected and the tour has started. A list of all the selected artworks is shown as seen as in figure 4.6. Each item of the list shows the title of the artwork, a bigger picture of the artwork and additional information. The information consists of a description of the artwork together with a notice about the approximate distance to the viewpoint on the bottom left. The shown details could explain the history of the artwork, its origin story or some details about the artist. This view is supposed to present additional information to the user if he wants to learn and know more about the artwork, whose viewpoint he is searching. The description may also give additional hints for finding the viewpoint. This tool serves the purpose of replacing information panels which users may be used to from museums or expositions.

#### 4.1.7 Plan Tour Activity

Players can create a tour ahead of time to start it at any given moment. The *Plan Tour Activity* shows all necessary information and options a player could need while planing a tour as shown in figure 4.7. At the top an input field is shown to enter the name of the tour. Underneath, the game mode can be configured, and the user can click on either the normal

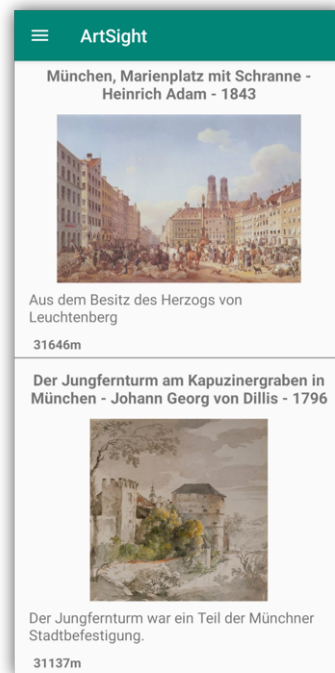


Figure 4.6: The *Description Activity*, which displays additional information about the selected artworks

or the explorer mode radio button. Players can also plan for a location which is not their current one; therefore, a map is shown and players can set a marker to indicate where the tour should take place. Then the player has to choose if he wants to take his current location or the one selected on the map by clicking on the radio buttons of the displayed options. Once the basic settings have been made, the user can click on a button at the bottom left to add artworks to the tour. The *Select Artwork Activity*, depending on the choice of the game mode, is opened. Are all artworks selected, the user returns to the *Plan Tour Activity* and can see a text indicating the amount of artworks selected. By clicking on the button on the bottom right, the tour is saved and the user is returned to the *Start Activity*.

#### 4.1.8 Start Tour Activity

Once the player is ready to start the tour through the city, the *Start Tour Activity* can be opened as shown in figure 4.8. In this activity a list of all saved tours is displayed. Each list item consists of the title of the tour, selected game mode, date of tour creation and the amount of artworks added to the tour. By clicking on the item, the tour is selected and the game starts with the *Main Game Activity* already containing all selected artworks and hints. If the item is swiped to the left, the saved tour is deleted.

#### 4.1.9 Gallery Activity

Entering this activity, visible in figure 4.9, the user can see a list of all pictures of viewpoints the user took. Each list element shows the title of the artwork, the artist and the creation year. Then the artwork is displayed with its description underneath. Following the part of the artwork, the user's picture is shown. This enables the user to compare the past and the

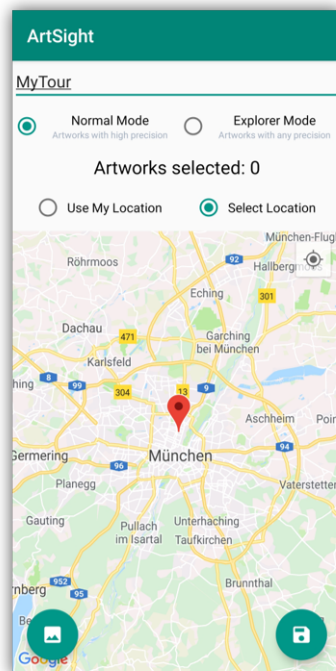


Figure 4.7: The *Plan Tour Activity*, where players can plan a tour and save it for later use

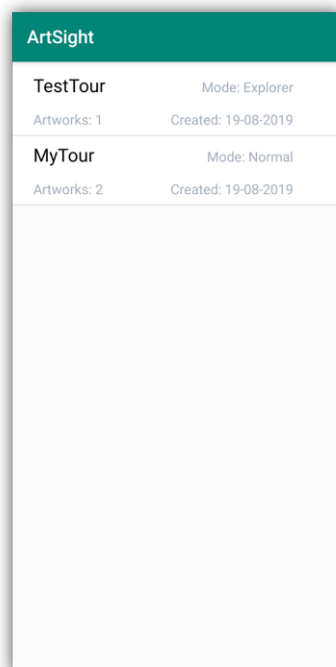


Figure 4.8: The *Start Tour Activity*, where players can start a saved tour

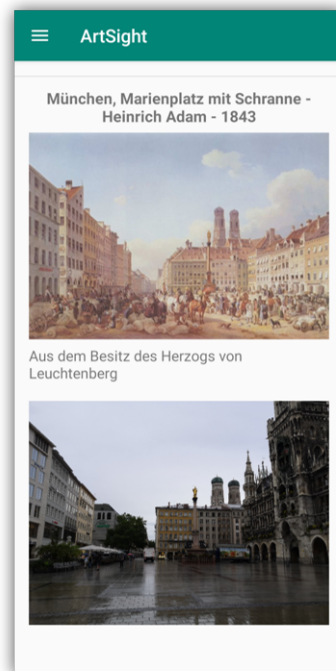


Figure 4.9: The *Gallery Activity*, where players can see all taken pictures and the corresponding artwork

present of the viewpoint even after the tour is finished.

## 4.2 Normal and explorer mode

Like described in the concept two game modes exist, the normal and the explorer mode. These modes can be chosen in the *Plan Tour Activity* while the user creates a tour. If the game is started through hitting the Quick Start button in the *Start Activity*, the normal mode is active for the current game. The idea is to offer two difficulty levels, the normal mode is most likely used by tourists or users that do not know the city very well. It is also suggested that any player who is not too familiar with art and history uses this mode. The explorer mode gives experienced users the opportunity to discover the city even more and get to know parts that are not very popular. At the current state, these two modes are only distinguished by a different *Select Artwork Activity*. In the *Select Artwork Activity* of the normal mode as shown in Figure 4.10, a list of all viewpoints in an area of 20 kilometres of the selected position is shown. Each item is displaying the title and the artist together with the approximate distance to the viewpoint. Clicking on one of the list items, checks off the checkbox and the artwork is selected.

Therefore, users who choose the normal mode can select artworks based on the relative distance to their viewpoints. Since it is assumed, that these users do not know the city very well, it does not matter where exactly the viewpoints might be located. This helps to get to explore the city without the need of knowing the specific districts or areas. The *Select Artwork Activity* of the explorer mode, shown in figure 4.11, displays a map of Munich. In this map, some markers are placed, where VipAs could be located. By clicking on the marker, the image and title of the artwork are shown. Is the additional information of the

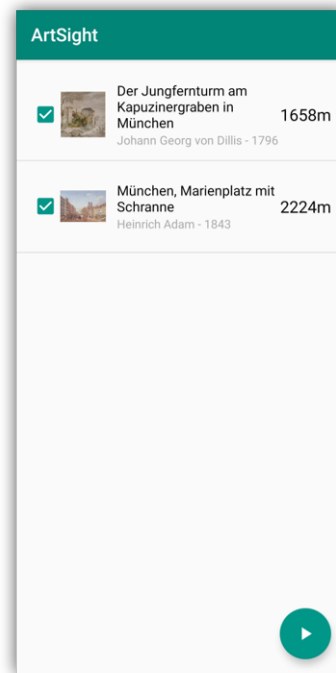


Figure 4.10: The *Select Artwork Activity*, when the normal mode is used

artwork being clicked on, the artwork is selected. This method helps experienced users to determine where a viewpoint could be located and to help plan a tour that is concentrated on specific districts of the city.

Without a doubt, the application and implementation of the different modes can be discussed and more functions could be added. These aspects are further elaborated in the subsection 6.1.6.

### 4.3 Implementation of gamification elements

One of the purposes of this application is to gather location data of VipAs, but to make sure this is a fun activity, gamification elements are added to make out of tedious to-do lists an enjoyable game. No traditional gamification elements like achievements or score system are implemented because the motivation to play and use ArtSight should be of an intrinsic nature. This motivation comes from our curiosity to learn about art and history and to get to know a city. But even though ArtSight does not focus on implementing many gamification principles, there are still some naturally applied. To analyse the used gamification elements in the application, the six elements of gamification by Nicholson [38] are discussed. More possible implementations of gamification elements are examined in the subsection 6.1.4.

#### 4.3.1 Play

The concept of the game is to search the city to find the viewpoint. By doing this, the player experiences and learns about the city on his own. This application is especially build for tourists or citizen who want to discover their own city more. These people genuinely enjoy

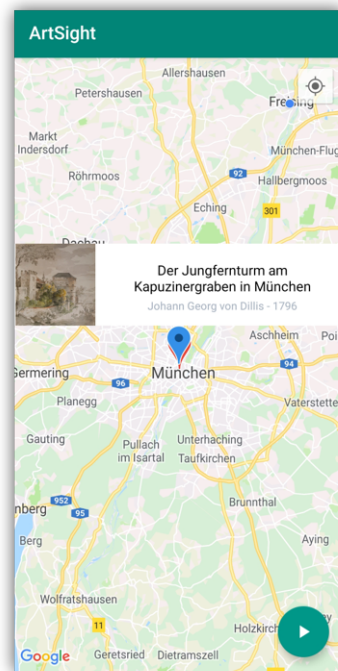


Figure 4.11: The *Select Artwork Activity*, when the explorer mode is used

wandering through the city and discovering new and unseen places or districts. The game is only helping and assisting the player in learning about the city, art and history. Therefore, the element of Play is partially fulfilled in the sense that players can have fun, but the game or app has only a small effect on it. A basic motivation has to be present, or else the players will not profit from the game.

### 4.3.2 Choice

This element is very well implemented in ArtSight. Every player can choose when, where and how long he wants to play. There are no time limits or other boundaries that take away the agency of the user. The game acts even contrary to this, it gives many choices to the player only helping him to have the best game experience he can have. Artworks can be selected and unselected at will. The viewpoints do not have to be found in a special order. Every feature of the application is available to any player without restrictive level or made up borders.

### 4.3.3 Exposition

ArtSight does not have a narrative element to make the player connect to the real world. This not necessary, since the whole location-based game is taking place in the real world. The player may even know some of the artworks that are shown and know their places. Therefore, the element of exposition is fulfilled in multiple ways.



#### **4.3.4 Information**

In terms of information, the user is not notified or instructed, that one of the purposes of the application is to gather location data which is collected through the users input. Therefore, the player does not know about the citizen science aspects behind the game. This is a crucial point which should be adapted.

#### **4.3.5 Engagement**

Players can add social engagement on their own by inviting friends to play the game together. Not every participant needs the smartphone application. Like Geocaching, players can go with their friends and families through the city and play the game while the others enjoy the walk with their relatives [40]. ArtSight engages its players as well through the different game modes. If players already know the city very well and need an additional challenge, the explorer mode can be selected to enable some additional difficulty. But even without the game modes each artwork can be differently challenging depending on background knowledge and experience. Therefore, the difficulty can not be completely divided into distinct levels or degrees.

#### **4.3.6 Reflection**

Once the game is played and the user finds VipAs, he takes a pictures of them. These pictures can be later examined in the Gallery which enables the player to think back and reflect upon the tour he has experienced. It also helps the player to see mistakes he has made while taking the picture or not hitting the right angle. This encourages and motivates the user again to find other viewpoints or to bring the picture to perfection. Through the physical interaction with the environment of the city, these experiences are even longer memorized.



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### Technical implementation

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In this chapter, the approach of the technical implementation is discussed to show the software structure and architecture. In figure 5.1, it is displayed how the communication between client or smartphone application, the server and the Artigo database is structured.

#### 5.1 REST API

Because of the statelessness of the application a REST API is used to connect server and Android client. It is not necessary for the server to save any session or state of the user in order to provide all necessary information. Furthermore, there are not many different client requests, therefore a REST API simplifies the structure and handling of these requests. For future additions of website features or API services, the REST API is a good base to be easily extended.

#### 5.2 Server

The server is written in the programming language *JavaScript*, and uses more specifically the *NodeJS* server framework. NodeJS is very popular for its scalability of REST APIs, therefore this framework was chosen.

##### 5.2.1 Limitations of selectable artworks

To confront the user with only 20 artworks to choose from, Williams aviation formula [74] is used to calculate the outer bounds for the database query. This formula provides coordinates which act as borders, so no artworks whose hint location lies outside these borders are shown to the user. The formula needs a location where the user demands to get artworks from and a distance, how far away artworks can be to be suggested to the user. It is proposed to limit the maximal distance to five or less kilometres to reduce the amount the player has to walk. The server could also just provide the user with the closest 20 artwork without limiting the distance.

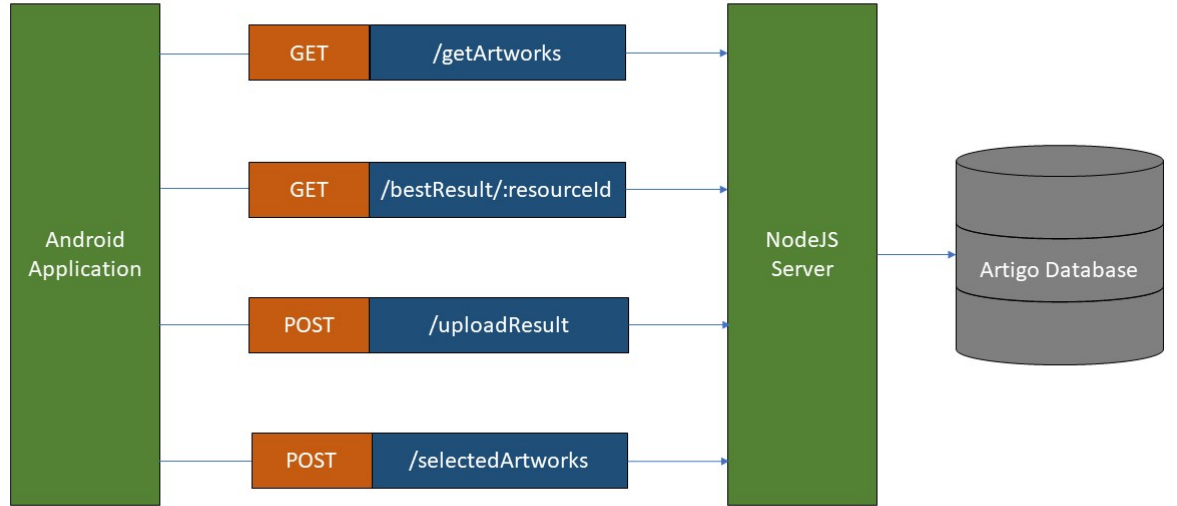


Figure 5.1: The structure of communication between client, server and database

### 5.2.2 Used frameworks

The *NodeJS* server runs on version 10.15.3 and uses the *NPM* package manager on version 6.4.1. To implement the REST API the framework *Express* is used. As database connection to the *PostgreSQL* database, the *Knex* framework helps with connection and query services, even though the standard *pg* client can also be used. *Winston* is used as a logging framework with the advantage of being able to log on the console and into extra log files with different levels. There are certain other smaller frameworks used like *fs* to save the images onto the server or computer, *cors* and *body-parser* help with parsing the incoming data from the REST requests and *path* handles path concatenation. For all mathematical and statistical calculations the server uses the framework *simple-statistics*. To facilitate the overview over the data model and database structure on Windows 10, *pgAdmin4* is used which is a database administration tool for *PostgreSQL*.

### 5.2.3 Calculation of the best result

The calculation of the best result consists of a few steps. In the first step, outliers are being removed. This is made through an unsophisticated but easily understandable method. The coordinates, latitude and longitude, of the data set are separated. This allows to calculate the mean and the variance of latitude and longitude separately. Now the z-score which indicates the distance of a point from the standard deviation [60], is calculated for each coordinate if the z-score is worse than three. Therefore, the point is removed from the data set. This is a very simple method which has some unwanted side effects like removing all points outside a rectangular shaped area, instead of a circular shaped cluster. Nonetheless, this method fulfils its purpose and dependably removes outliers. During the next step, the convex hull is being calculated using a well known formula [16], which is being calculated

in  $\mathcal{O}(n \log n)$  time. This formula only works if the used data set has at least three points. The data comes from all registered inputs of users for the artwork, whose best location of the viewpoint is being calculated. With the result of this function, the centre of the convex hull is calculated. The final result is calculated, using the centre of the convex hull and determining the nearest neighbour of the given data set. For this calculation, the Cosine-Haversine formula is applied which calculates the distance between two coordinates [55]. This way, only registered locations with images of the viewpoint are selected.

## 5.3 Smartphone application

The smartphone application is based on the Android OS version 9 which is equivalent to the API level 28. ArtSight is also compatible with the Android version 8.1, API level 27. The operating system was selected, due to the market share dominance of the operating system Android [27]. In the year 2018 Android achieved a market share of more than 80%, which makes the application available to more than 250 million users who are using the matching platform version [45]. To enable the REST API on client side, the *Android Spring* framework is used. *Google Maps API* provides all the map interfaces and location handling. For this to work, a Google Maps API key has to be generated through a Google developer account and implemented into the code of the application. Implementing the necessary features, some things had to be done to provide a good user experience. In the *Gallery Activity*, taken pictures from the smartphones gallery are used. By adding these pictures to the list items, the list behaves very slowly while scrolling through it. To resolve this problem, the pictures have to be resized to provide better performance.

## 5.4 Origin of the data

### 5.4.1 Artworks

The GWAP database is already used for many Artigo applications. The structure and data with all the artworks is therefore also used. Even though this database contains many artworks, the data set does not contain many useful artworks displaying scenes of Munich and surrounding areas. Therefore, other sources have to be found if more artworks need to be added to the application. The artworks consist of the actual image, the title in the original language and in some cases in French and English but only the original language, mostly German, is currently used. Artist and year of creation is also contained in the GWAP database.

### 5.4.2 Locations

For the first couple entries, the location is manually added by using Google Maps and some knowledge of the city to find the approximate location of the VipA. With the help of Google or any search engine and the title of the artwork, a lot of clues can be found, where the viewpoint could be located or what building or object is displayed. This information usually gives enough clues on the approximate location of the viewpoint to provide players with a hint good enough to find the viewpoint.

### 5.4.3 Description

By searching the web for title and artist, a lot of details to the artworks are available. These can be used as a description to inform the user more about the artwork and give hints, where the viewpoint could be found.

## 5.5 Database model

The database structure and schema of the GWAP database is adopted and three tables are added. One of them *artresources\_artsight*, which is the combination of all necessary information of the artworks containing id, language, title, date, url or path to the image, name of the image file, fore and surname of the artist, and the added columns description, latitude and longitude. The entries of the artwork details are taken from the table *artresourcetitle\_munich*, which contains all entries of the *artresourcetitle* table with the name *Munich* or *München* in the title. The table *artresources\_artsight\_userimage* is used to save all taken images and location data, users have uploaded. The fields are a unique id, resource\_id of the artwork, user\_id or unique smartphone id, name of the image, latitude, longitude, bearing and user comment.

This bachelor thesis does not cover all details and necessary information, which could lead to the best implementation of the location-based game ArtSight. There is much more, that can be done to improve and extend the application. What can be achieved with the gathered data is also elaborated here.

### 6.1 Additional application features

The field for applications of citizen science projects connected with gathering geo-location data is very wide. The presented concept of a smartphone application and its implementation can be extended with additional features and useful gadgets.

#### 6.1.1 Tutorial

The game ArtSight is for any kind of user, experienced or not. It contains functions that help players to get used to the game, like the differentiation of normal and explorer mode. But there is no real introduction into the game. Players do not know what to do, at the first time they use the application. Therefore, an on-boarding screen or tutorial is necessary which explains users what this game is about and how it can be played. To promote frequent use and intrinsic motivation, the purpose of the game, which is to collect location data of viewpoints, should be explained and elaborated. This helps people to understand and to feel more involved in the project. Applying this suggestion would be also an implementation of the gamification element of information.

#### 6.1.2 Community feature

Tourist groups are often viewed in cities. They come from many different places and visit many locations during their trip. These groups share a lot of attributes like passion or interest for art, history and culture. Even though they cross each others paths, they do not or rarely interact with each other. A lot of social, knowledge and cultural exchange is being missed out. Social networks like Facebook are primarily created to connect people with the same interests or status. ArtSight offers the same base for a social network of people that like to find or hunt viewpoints of photographs or artworks.

The proposed social network could offer many features. Some of them are here explained.

**Shareable artworks and pictures** The player can see all the taken pictures of the view-points and their corresponding artworks in the smartphone application. Through the social network the user could then share these pictures and recommend to find the same view-point to other users. Not only pictures can be shared, but also whole tours. Through this feature people could preselect artworks that represent the history of a city very well or create specialized tours for different periods of art. People can share their interest and encourage others to hunt the same or other viewpoints. This can also be combined with the gamification element of reflection. Users can view their work again and discuss them with other players. This helps users to learn and reflect about themselves and how they can become better in searching for viewpoints or art and history.

**Events and groups** Users may not want to go on a hunt on their own, therefore the social network gives an opportunity to meet people from the same city or tourists that are visiting the place during the same time and search viewpoints together. This combines the social contact online with the game in real life. It makes it possible for users who play the game for the first time to meet players who are already experienced and to learn from them about the game and the history or culture.

**Account management** The implementation of a social network would make it inevitable to realize account management functions. ArtSight does currently not offer this feature, since no account depending feature is implemented yet. But this would make it possible to save the tours, artworks and taken pictures not only on ones smartphone but to view them as well on other devices or services like a website. Another reason to provide account functionalities, would be the opportunity of saving user specific data, that helps monitor user interaction to improve the application services.

### 6.1.3 Tourism application

The presented application can provide a great help in sightseeing a city. Tourism centres and trip organizations can profit from this service. They know the interest of the tourists the best. Therefore, they know or get to know, which culture or art the users want to see and experience. This could lead to specialized tours which are offered by different trip organizations.

Art museums contain a great variety of artworks. Some of which show motifs that are located in the very same city. Visitors of these museums possibly do not just want to view the artwork but also the actual scene in reality to see the differences of the past and the present. The museum could suggest visitors to visit and find the exact same viewpoint, the artwork shows which they are viewing at this moment. This could be done by adding a QR-Code to the information panel of the artwork. Through scanning the code, users can install the application ArtSight, and the viewpoint of the artwork is added to a new tour, which can be started after the visit of the museum. This connects the visitors even more to the art and the history of the city.

The same process can be done the other way around. Players of the game could be given the hint, that the real artwork whose viewpoint they are hunting is exhibited at a museum in the players area. This offers an innovative way of connecting the isolation of museums with the reality to attract new visitors. Through this approach more people can be interested in seeing other places and artworks in the city. It is not just advertisement



for the application, but it also contributes even more to the goal of playfully educating and challenging people in an art environment.

#### 6.1.4 Gamification enhancements

The element of information is the only gamification principle that has not been implemented in ArtSight. This could be easily done by adding an on-boarding screen, which explains most of the features the application offers and the reason for collecting location data. Another way of doing this, would be a tutorial, like the one from Ingress [30], where every mechanic of the game is explained and directly used. On the one hand, this would make the introduction easier for users that are not familiar with location games, but on the other hand, first time users might lose interest through a long tutorial that clarifies the intentions of the game.

Social engagement is already possible, but the application does not offer any help in connecting players. They would have to do the organization on their own. Therefore, a community feature could be established which lets users contact other participants and gather in groups to make ArtSight tours through the city. The resulting events and groups would have the opportunity to exchange knowledge about art and history.

Even though a player of ArtSight already feels connected to the real world through the fact of the game being real world location-based, another aspect of the element of exposition could be implemented. The application could add a narrative element by creating a made up reason, why players should search this VipA. A possible story or setting can be focused around pirates and treasures which can be collected by the player through taking pictures of the viewpoint. Another setting could make the player slip into the role of a detective which wants to solve a crime by finding clues and taking pictures of the crime scene in the form of the viewpoint of the artwork [26]. The danger of implementing a narrative element, would be the departure of the game from its original purpose. This could discourage older players in playing and using the game. On the other hand children and younger players might feel more appealed by the game with the narrative element. Therefore, the story overlay could be optional to make the game fit for young and old.

Achievements or score boards are often used tools to create interest and competition in games. Even though explained in the subsection 2.1.2, achievements or rewards do not promote intrinsic motivation. It might add a competitive component to the game for people who want this challenge of becoming the best "viewpoint hunter". It can be used to reach a bigger target audience. Every user gets points for a number of actions he does playing the game. Finding a viewpoint rewards with a big number of points depending on a couple of variables like playing normal or explorer mode, duration of searching or the distance from the start. Other players could be involved in the validation process of the location and picture. They are as well rewarded with a small number of points, whereby the submitter gets additional points for good validation results. For all other social network interactions users are gifted some points.

The goal of all these gamification elements is to increase the amount of social interaction and to help users to create an intrinsic motivation.

#### 6.1.5 Confidence of viewpoint location

ArtSight gives the players some hints on where the viewpoint can be found through the description or the hint circle. The idea now is to give users an additional hint or indication with what confidence the VipA is located inside of the area that is surrounded by the hint circle. Through this clue, users know if it is necessary to search outside the area or not, which makes it easier to plan a tour through the city depending on the available time of the user.

This leaves the question open, how the confidence is determined. There are two scenarios, first of all the easier one, the actual location of the VipA has already been calculated. In this case, the actual confidence is 100%. Now it can be discussed, to encourage the player to see more of the city than the area inside the hint circle, so the confidence is artificially decreased.

In the other case, the location of the VipA has not been determined yet, it is more difficult to assign a location to the artwork to form the hint circle and to show the confidence. Selecting a first location for the hint, has to be done manually combined with the categorization of the artwork. This creates the problem, that the data is not objective if a human has to determine this value. Therefore, more sophisticated ideas have to be found in order to make this feature work as it is meant to work.

### 6.1.6 Further implementation of the normal and explorer modes

The feature, offering two game modes to target professionals and amateurs, can be expanded with various functions. First of all, artworks can be chosen whose confidence is comparably low. This could lead to frustrated players if too many VipAs can not be found, since the hints are suggesting a completely wrong location. Therefore, already validated artworks can be offered with a bigger area surrounded by the hint circle to make the player explore more of the city. Another method to challenge professional or experienced players even more would be the addition of a time limit. The amount of time, in which the player has to find the viewpoint, could be calculated by taking into account the confidence, the radius of the hint circle and the user's amount of already found viewpoints. The game could even be taken to a professional or competitive level by letting groups or single players race against each other by trying to find the viewpoint first. This would be a fun activity and encourages players to invest more time into the game to become an art and history expert of the city.

To help amateurs using the normal mode, who are searching an artwork that has already been found and validated by other users, the hint circle could get smaller and smaller around the viewpoint over time, to assist the users in finding the viewpoint more quickly. Additionally more hints in form of a text or a riddle could be given by clicking an extra hint button. The more hints the user needs, the smaller the hint circle is getting to facilitate the search. All these helping mechanism have to be applied with caution, so that the players do not get demotivated from offering too many hints. This could ruin the user experience and the interest in the application is quickly lost.

### 6.1.7 Validation of data

To support the calculation of the best result, pictures taken by users are validated. This can be done in two ways, through human or machine validation. If the machine compares picture and artwork, the results will be most likely bad because of the realism of the picture and the non-realistic painting style used by many artists. Therefore, users could be engaged in validating pictures of other players, showing them the artwork and the picture taken by the user. This could be an interesting task to see what pictures and viewpoints other players found. In addition, a machine learning algorithm could learn from the decisions of the users. Once a picture is found, through human validation and calculation of the best result, this image could be used as a reference for further inputs. The machine learning algorithm could then compare the best result with the newly submitted picture and calculate if the image really fits to the artwork or not. Thereby, users are used to validate until a point is reached, where artificial intelligence can take over. This process has to be done for every artwork and picture, therefore both methods of validation are needed.

### 6.1.8 Addition of more cities

In the current state only artworks which show scenes in the area of Munich are added to the database. This selection can be easily extended by adding more cities. But there are not only artworks from cities, there are plenty of landscapes and mountains. Therefore, this application could be used anywhere and from anyone, e.g. from hikers who want to find a special view an artist painted of the Alps. The more content and artworks of different cities or landscapes are added, the more users will join and play the game in multiple cities and places. This feature is the key to become a frequently used application for citizen and tourists.

### 6.1.9 Virtual reality

ArtSight extends the sight of players by adding the perspective of the past in form of an artwork or a photograph to the present viewpoint. This could be even more enhanced, by adding a third dimension to the artwork. If a 3D environment could be created out of an artwork, the newly generated environment can be used for *Virtual Reality*. Through an implementation of virtual reality the wanted effect of immersion is amplified. Players can now not only see the differences of past war scenes or landscapes but they can be in the scene and experience the differences better. This makes it easier to compare how the surroundings looked in the past and how they look now. Even small details are better visible and therefore being noticed. Humans live in a world of three dimensions, abstractions like artworks or photographs are useful to capture a certain event, but to comprehend the entire meaning, it is necessary to view the world in 3D. Therefore, even users that are normally not interested in art can get excited and be delighted by art which they can interact with.

### 6.1.10 Calculation of the best result

For now, the calculation of the best result consists of taking all user inputs, detecting and removing outliers, and then to calculate the convex hull. The centre of the data set, which represents the convex hull, is then calculated. With the centre the nearest neighbour is found and chosen to be the best result. This method can be refined by only considering the inputs which were successfully validated by human or machine validation. After the outliers have been removed, the calculation of the convex hull could be replaced by a clustering algorithm like robust information-theoretic clustering [8]. Then a weighted-centre could be found by the calculation of a heat-map [32]. Now the best results at the heart of the heat-map could be manually determined or by using again the nearest neighbour. There are many other ways to calculate the best result depending on the amount of inputs, it is proposed to do the last step manually to prevent unwanted behaviour.

## 6.2 Applications for the gathered data

ArtSight is designed as a game. It is supposed to help players to get to know the city and learn about art and history. Through the use of the application, data is generated. This data consists of location data of viewpoints which can be specified into bearing, latitude and longitude data. Additionally pictures are gathered which show the viewpoint of an associated artwork. All of the collected data could be analysed and evaluated to give information on artworks, sights, cities or user behaviour.

### 6.2.1 User profile

With the implementation of account management functions, every action and all gathered data can be unambiguously assigned to a specific user. Through this data mapping, users can be categorized in separate groups depending on their experience and previous results. Users that play ArtSight in multiple cities could be categorized as tourists. Therefore, it can be assumed, that they don't know the city very well which they are visiting next. This knowledge can be used to present these kinds of users viewpoints of artworks that are easier to find. By collecting additional timestamp data, it could be measured how long it takes the user to find the viewpoint. Depending on this value, the level of difficulty could be again modified.

Art and culture interested people usually tend to favour certain eras of art or architecture. Therefore, they might have extended knowledge about particular artworks or parts of a city. This expertise might be used to trust these players more when they find and commit a viewpoint. The trust is being applied by using less validation tools to validate if the data is correct. On the other hand, if users participate in validating images and data, these players could be trusted more and overrule validation results of others.

The knowledge, that people are interested in particular artists or motifs can also be used to recommend and predefine tours that fit very well to their past tours or found viewpoints. If a player for example likes the era of baroque, a specific tour of baroque artworks or artworks which show baroque architecture can be recommended. By implementing these user specific tours, ArtSight could differ from other smartphone applications used for sightseeing tours.

With all this data analysis, it must be carefully decided which conclusion is to be drawn, since the user behaviour might have other reasons than thought of. If this is the case, the user experience might suffer from getting bad artwork recommendations, e.g. if someone takes a long time to find a viewpoint, the conclusion could be drawn, that this viewpoint is too hard for this user. But the player could be also not playing to just find the viewpoints one after another but rather to enjoy the sights of the city and taking extra detours to get to know the city better. This misconception is very deceiving because the actual goal of the application is to educate and entertain the players but not to encourage the players to rapidly rush through the city and neglecting the culture and art that can be seen apart from the viewpoints.

### 6.2.2 Photogrammetry of sights

Thanks to photogrammetry, objects like buildings can be displayed as 3-dimensional models. Many artworks which display scenes in cities show buildings or statues. Through ArtSight many pictures of buildings can be collected. Even though they should show the same perspective of a building, the functionality of the application could be extended to motivate users to take a couple more pictures of the object from multiple angles. Photogrammetry requires the pictures that serve as an input of the rendering program special criteria like low shadow intensity. Users will not be able to take the perfect pictures of the objects, but the lack of quality may be compensated with a great quantity of decent pictures. The more people participate in the game, the better the result of the 3D model turns out and the quality rises by every photo that is being taken by players. In the future if enough buildings and objects of the city are modelled in 3D, a virtual tour through the city can be achieved.

### 6.2.3 Commercial purposes

Wherever data can be gathered, commercial purposes arise and analyse the information to draw conclusions about users behaviour. This could be used to sell special designed or composed tours to users. These tours could be offered by tourism agencies or private sellers. The resulting tours could be bought through in-game purchases. This would only be an effective business model if users can not share self created tours on their own. Else users will most likely choose free over payable content [39].

Apart from these in-game purchases, many co-operations could be made with local restaurants or hotels that are recommended to the user. The principle is simple, through connecting well-funded people and local businesses by the use of a service, revenue can be accomplished. Players could even get a coupon for certain places or get a discount on things they buy if they show, that they are ArtSight players.

This idea of commercially advertising restaurants or other local establishments to gain money does not comply with citizen science principles. By implementing these services or concluding contracts with businesses that only want more users to buy their goods, the thought of working together to collect data that could be useful for future art and history studies can not be combined without neglecting the personal interest of privacy.

### 6.2.4 Categorization of artworks and viewpoints

To correctly implement normal and explorer mode with all features, artworks have to be analysed and researched. Is the location of the VipA already known or not? Depending on the researched results, the artworks have to be categorized regarding the difficulty of recognizing the location that is visible in the artwork. If for example a famous statue is visible in the artwork, it is easier to determine where the viewpoint of the artwork could be located, than an artwork where a river is illustrated without any clue on the location of the viewpoint along the river. This evaluation has to be done for every single artwork to some extend. Machine learning or computational aid is limited in regards of knowing where places are and how easily people will find them. Therefore, categorization takes a lot of effort. To minimize the cost, a rough categorization is proposed, where artworks that illustrate a clear structured scene with buildings or recognizable objects are considered easy artworks. Whereas artworks which display just some generic environment are considered as hard artworks. Furthermore, the zoom of the artwork is important. If the scene of the artwork zoomed too far in or out, it is assigned to the hard group. If multiple buildings are clearly visible, the artwork is assigned to the easy group. These are very subjective criteria, therefore it has to be tested and refined, depending on feedback and results of users.



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