TrilateStation: An Interactive Spatial Framework for Science Center Experiences*

Extended Abstract†

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ABSTRACT

This paper covers the initial attempt to design a spatially based interactive framework, TrilateStation. It is intended to be implemented by science centers to allow visitors to access virtual material within the physical science center, as well as after the visit is over. The result is a map-based application - TrilateStation, that utilizes indoor positioning technology and bluetooth beacons to allow the visitors to walk up to digital points of interest. The project was presented at the 2020 Interaction Design Expo (IDXPO) and highlights many interesting opportunities for physical-virtual transitions in science center design.

KEYWORDS

Interaction Design, Science Center, Teens, Education, Information Technology, Indoor Positioning, Bluetooth Low Energy, Android

1 INTRODUCTION

During the latest years, several reports have raised concerns about the fact that children in Sweden are losing interest in Science-Technology-Engineering-Mathematics (STEM) subjects as they become older [1,2]. During years 5-9 of junior high school, children's interest in pursuing STEM careers gradually decreases, resulting in them picking non-STEM fields for their upper secondary education [3,4] and future field of work. The lack of interest in technology will have real life consequences in the near future: By 2022, it is estimated that the Swedish workforce will be missing 70 000 employees with IT-competency [1].

Research suggests that science centers can help increase the amount of people picking STEM-related subjects for their higher education [5,6]. The Gothenburg Science Center, Universeum, is currently developing a digital learning platform, Digitala Universeum. The portal is intended to be used by both visitors that want to keep exploring the exhibits from home, and by schools, as an educational tool with content from the Swedish curriculum [7]. The purpose of this project is to raise the interest in science as well as strengthen the goals of life long learning [8].

1.1 The Challenge

Through a project course at the master program in Interaction Design at Chalmers, we were tasked by the Science Center Universeum, to present a design that utilizes their digital platform and targets 12-16 year olds' scientific education.

1.2 Suggested Solution

TrilateStation: An interactive framework that utilizes indoor positioning to bring Universeum's digital platform into the physical building. For the specific target group of 12-16 year olds, a slightly gamified approach is suggested, that allows them to cultivate an interest in STEM based on their personal interests.

2 THEORETICAL FRAMEWORK

2.1 Physical and Virtual Space

In the science center design framework provided by Wideström (2020) [9], differences between physical and virtual interactive space within the science center is discussed. Three aspects of spatiality are identified:

- Physical: Interaction between users and content happens in the actual physical space.
- Virtual: Interaction between users and content happens in the potential virtual space.
- Physical-Virtual: The interaction takes place in a physical-virtual space.

Science center installations focused on the physical space are typically centered around hands-on interaction with tangible objects, such as levers, building blocks or wheels. The virtual space contains installations digitized to a greater extent: Visualizations, VR, AR and web pages.

The project described in this report strives to augment the physical space by providing spatially dependent virtual experiences within the physical framework. This challenge is not a new one; Transitions between the digital and physical aspects of museum exhibits have previously been explored in the shape of QR codes [10] and tangible artefacts [11]. The topic has been rigorously discussed to find methods that can make the transitions as coherent as possible [12]. Here, the transitions are achieved through a map-based application, where digital content can be accessed based on the user's position in the physical exhibit.

2.2 Quantified Self for Teenagers

The Quantified Self (QS) philosophy is centered around self-tracking and gathering numerical data about one self to gain new insights about one's health and habits [13]. The idea is that by learning about one self, one will l about how the world works on a greater scale as well.

The recommended content for QS-like products is typically used for ad revenue and personalization [14]. Within this project, the QS concept is utilized to give the teenagers insight into their own learning processes and interests, to personalize their learning journey based on their preferred topics. Hopefully, this will allow teenagers to keep cultivating an interest in STEM and their own learning goals.

2.3 Trilateration and Indoor Positioning

Trilateration is a positioning method where a receiver is able to determine its location based on the signals from at least three transmitters whose positions are known. The distance to each transmitter is determined with some signal measurement technique [15], e.g. received signal strength (RSS). By letting this distance to a known transmitter form the radius of a circle or sphere, it is possible to geometrically determine the receiver's location, see fig. 1. While at least three transmitters are required, typically, it is done with many more as is the case with GPS [16].

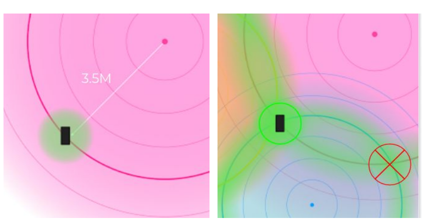

Figure. 1: Radio signal strength can be used to determine the radius of a circle where the transmitter is the center. With three signals the intersection of the three resulting circles can be calculated to determine the receiver's location.

While GPS works well outside, the line-of-sight required for useful readings is usually lost indoors [17,18]. Consequently, indoor positioning systems require local transmitters. These commonly broadcast with Wi-Fi or Bluetooth radio signals [17]. Since the release of Bluetooth 4.0, which introduced Bluetooth Low Energy (BLE), BLE beacons have received attention as transmitters for indoor positioning due their cost and their power efficiency [18].

Indoor positioning systems are commercially available from several companies such as sewio, elico and proximi.io.

3 DESIGN PROCESS

3.1 Ideation

We began our project in ideation about different ways to teach teenagers about the technology they use every day. Ideation methods such as Affinity Clustering and Crazy 8 [19,20] were applied. We decided to proceed with a concept that would teach teenagers about tracking technology.

After deciding to work with an application and use indoor tracking data, the idea was further refined to focus more on the interactive benefits that could be derived from this concept; a phone application that utilizes indoor tracking could be used as the official exhibit map, and be used to enhance the physical science center with additional content.

3.2 Storyboarding

The *Golden Path* [21] method was used to visualize the user journey and pain points that would need further work. This journey was later translated to the storyboard used during initial evaluations, see [29].

Later on in the project, a more detailed storyboard was created to complement the application prototype. This way, it would be possible to explain the parts of the project that we would not have enough time to implement. Teenagers have less sufficient reading skills, less sophisticated research strategies, and dramatically lower levels of patience [22]. A video prototype could help both the teenage target group, and additional stakeholders understand the concept in more detail. For the final, animated version of the storyboard see [29].

3.3 Evaluation with Universeum Professionals

An initial exploratory evaluation was performed with universeum experts who work closely with our target group. As guides at a science centre, the staff at Universeum regularly gets a first hand glimpse of what reactions teens have towards different exhibits - making their viewpoints invaluable to us as designers of such exhibits. While the guides are not teenagers themselves, they do have a wealth of experience on what pitfalls to avoid, what alterations has had what effects in the past etc. - making them a kind of self-taught expert on design guidelines for science center exhibits.

The guides were shown the initial storyboard sketch and got an introduction to the idea, after which they expressed their opinions in a 45 minute long discussion. Some of our main takeaways moving forward in this project are presented below.

- Content: The actual content that will later fill this framework is incredibly important. A "fancy" framework for virtual content means nothing if the content is uninteresting, badly presented or lacks functionality.

- Technology: To actually explain the tech behind the installation is a very good idea, that should be explored in detail. A common approach of science centers is to aspire to create curiosity about technology by presenting interesting installations. A proper explanation of the technology behind the installations helps satisfy this curiosity.
- Teenagers and Quantified Self: Teenagers usually come to Universeum with friends and younger siblings. They seldom get the chance to stay at installations they themselves are interested in because they get dragged around by the whims of their company. Perhaps their learning would be strengthened if they can continue learning at home.

3.4 Animation

The Universeum experts highlighted the importance of explaining the trilateration concept and the technology behind the application. As the nature of tracking is strongly tied to dynamic, real time-updating positions of users, a dynamic medium was deemed to be the best way to present the concept. The technology was thus presented in the form of a graphic visualization: an animated video.

The animation was made using Keynote's Magic Move feature [23], creating the start and end point as stills, and letting the software create the smooth transition. See final animation in [29].

3.5 UI mockups

To tie into the Universeum experience more seamlessly we decided to base the UI for our mockups on Universeum's native design system see [29]. To this effect, all the colors, iconography, illustrations and images were borrowed from Universeum's brand identity, created by the design studio milk [24].

Since the app's primary focus is to enhance and augment the visit rather than deter from it, we conceptualized a simple, three tab application. Each of the three tabs represent the three main functions of the application which are : *Map*, *How it works* and *Profile*.

We also designed an additional onboarding experience [25] for first time users, wherein we guide the users through picking an avatar and accepting permissions required for the implemented indoor tracking.

1. Map View: This view consists of a basic floor plan view of the exhibit rooms with points of interests / "approachables" showing up as icons. The users' position on the map is indicated by their respective avatar icons. On approaching one of the points of interests (POI), the corresponding icon on the map, enlarges indicating pliancy for interaction. Tapping this POI icon, allows users to explore exhibit-relevant content on slide-up information cards.
2. How it Works: This view provides users with information on the underlying technology of Trilateration powering this indoor experience. Rather than merely presenting a "wall-of-text" explanation for the users to read through, we designed it as a series of slides with illustrations and information in a scrollable feed.
3. My Data: This view presents the user with insights on their visit based on the time they spent interacting or exploring exhibits and the subject matter of said exhibits. This view also provides the user with web links to read-up on the subjects of the exhibits that they spent the most amount interacting with. The idea behind this was to allow the users to take home, some part of their science centre experience and continue learning.

3.6 Evaluation with Teenagers

Three interview sessions with teenagers (two groups of four 15-year olds and one group with three 13-year olds) were conducted at the end of the project. The participants were shown an animation about indoor tracking technology, and were walked through the UI mockups together with the interview conductor. The teenagers were then asked questions about what they understood about the project, what expectations they had about using the app, and which types of activities they would like to find at the points of interest.

Our main takeaways from the evaluation concerned the comprehensibility of the animation, as well as input on graphics regarding map design and color choices in the application. We were also encouraged by the participants to add more gamified elements, such as high score lists, but were sadly not able to further explore this within the scope of the current project.

3.7 Development

An Android app was created using the Kotlin language and the positioning features utilized an open source indoor positioning library by neXenio [26]. The transmitter hardware was BLE beacons from Radbeacon and Estimote broadcasting with the iBeacon protocol.

Early on, different broadcasting technologies were briefly explored before BLE beacons were decided upon due to the benefits mentioned under 2.3. Following this, different open source indoor positioning libraries were considered, in search for one that would be suitable for the application in mind.

The UI was implemented firstly using the online design tool Figma, in parallel with the early software development, and was later continued directly in the Android Studio design tools.

3.8 The Physical Installation

TrilateStation is intended to be a framework to enhance the full science center experience that is used during the entire visit. As such, the design benefits immensely from being noticed by visitors when they first arrive at the science center. Within exhibits, the different exhibit objects are always competing for the visitors' attention [27]. To be noticed before other installations, two of the most important factors to consider are size and position.

Position wise, the installation should be located near the entrance of the exhibit area, as visitors tend to spend more time on installations they come upon early in their visit, compared to those at the end [27]. When it comes to size and what to display, the guideline is often “the bigger the better”, especially if the installation moves [27]. The physical TrilateStation should thus be placed close to the entrance of the exhibit space, preferably with two large screens that will draw attention to our content and inspire visitors to interact with our application.

4 RESULTS AND DISCUSSION

4.1 The Exhibit Setup

The exhibit was hosted physically at Visual Arena, Chalmers Lindholmen, and included live demos of the artifact, a poster and two displays: one with explanatory animation, one with an animated mockup of an expanded version of the map which displayed the movements of multiple fictional users (fig.2 & 3).

The framework was adapted to contain the project websites for the other installations. Visitors with an android phone could install the demo application and use it as they walked around the exhibit.

During the exhibit’s closed webinar hosted by IDXPO 2020, the group broadcasted a video presentation of the idea.

Figure. 2 & 3: The final exhibit at Visual Arena (left) and the active phone application (right).

4.2 Takeaways from Final Exhibit

Due to the COVID-19 restrictions, the final exhibit was hosted at Lindholmen’s *Visual Arena*. Visitors joined the exhibit primarily online, thus we did not get the opportunity to clearly test the design in a public setting. However, the online presentation was well received by those who partook.

The main interaction design challenge faced during this project was how to test whether a framework would work before the framework is filled with actual content. During the final exhibit, we filled the application with links to the web pages of other groups. This was successful, but the content was still not developed for the specific media. This, together with the fact that the final summary of the visit contained only mockup data, makes it difficult to do a full evaluation of the concept in its current state.

Another major constraint of the project is the accuracy of the tracking technology used. During the exhibit, the presence of other tech and many people revealed that there is much left to be done to improve positioning precision.

Still, the demo version presented during the exhibit was well received by participants and Universeum stakeholders, which bodes well for potential future work.

4.3 Concerning the Target Group

Due to the 2020 pandemic, and the difficulty of testing an unfilled framework, we had difficulty conducting real-life testing with teenagers from the target group. More time should be spent on adapting the framework to specifically fit the target group, for example by adding additional gamification elements within the main setup.

Still, the interviews conducted with teenagers did to an extent validate the project enough to motivate moving forward with the design. The participants were able to come up with multiple suggestions for content that could fill the framework and appeared excited to try it out.

An interesting aspect to explore further is the scenario presented by the interviewed Universeum guides: Teenagers that are visiting the science center rarely get to explore the things they are interested in thoroughly because they have to go along with the desires of their friends or families. If this is indeed the case, a framework that makes it easy for teenagers to continue exploring from home could be exactly what the target group needs.

The current solution focuses on personalizing the science center experience by providing recommendations for teenagers based on what they spent time on in the science center. Future work should focus more on how to determine what content to recommend to inspire the teenagers to keep learning. Perhaps the recommendations should not focus only on what they did during the visit, but also on what they wanted to do, but were not able to.

4.4 Map Precision

The precision during the exhibition was not high enough to limit access to content based on proximity, instead all content was accessible from anywhere by clicking. In the 16 by 12.5 meter room it was possible to tell which quadrant you were located in. While certainly acceptable for some use cases and for situations where content is separated with greater distances, it constituted a clear limitation for our use case. There are several potential approaches to increasing the precision.

Since RSSI values are sensitive to moving objects, and obstacles [28], the result could potentially have been improved by experimenting with the beacon placement and their settings for transmission power in the deployment setting.

Depending on the goal, indoor positioning might not be the best fit. If the primary goal is to track engagement time or to transfer a personalised experience between exhibits, providing the visitors with a beacon and letting them be the transmitter could be an option. If proximity alone is enough to deliver the appropriate content, a proximity based approach where each exhibit has its own beacon might work better.

4.5 Look and Feel

There is scope for visual refinements in the UI with respect to the color gradients, iconography, components (e.g. Avatars, points of interest) and illustrations. For instance, in the map view visibility of the icons could be improved with better contrast with other components, and the color scheme of the UI needs to be evaluated with the target user.

Another aspect to consider is that the current demo application is designed as a specific TrilateStation app. Ideally, this project could be adapted as part of an official Universeum-application, which would require a somewhat different main structure.

4.6 Filling the Framework

What ended up being created was mostly a framework ready to be filled, and many of our evaluations gave us insights into what ought to fill it. As the app combines the preexisting physical exhibitions with what Universeum aims to create online in Digitala Universeum, games and new exhibits utilizing both worlds could all be hosted within the same framework. Hosting content on one platform, our framework, could enable cross exhibit experiences such as collecting points from games and building spanning events/challenges.

Having a digital framework would also allow Universeum to fill it with non-exhibit content such as guided tours, language translations and accessibility features. This framework could also potentially be employed by science centers to track interests patterns from different users.

It is however very important to note that the framework itself does not guarantee success. The content within it should be detailed, well thought out and precisely designed to accommodate the target groups and their interest. Our initial interviews with Universeum guides warned us about trusting too much in frameworks and gamification; If the first thing that visitors interact with within the application does not match their standards and expectations, the entire experience could end before it has a chance to begin.

5 CONCLUSION AND FUTURE WORK

In its current form, TrilateStation offers a new take on virtual-physical transitions within science center- and museum exhibits. Future work could continue to explore the opportunities of the framework by development of framework-specific content. Further gamification of the interactions could make the application more appealing specifically to the teenage target group, but within the current framework, there is also a definite possibility to create material suitable for visitors of all ages.

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