Mixed reality and the Holy Ghost Church in Turku

Lauri Viinikkala, Timo Korkalainen, Juha-Pekka Arimaa, Teijo Lehtonen, Seppo Helle, Tuomas Mäkilä, Veijo Pönni and Olli Heimo, University of Turku, Finland

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Abstract: Our paper will deal with the creation process of a mixed reality based presentation and a 3D model of the Holy Ghost Church in Turku in Finland as a part of the Futuristic History research project. The focus of this case study was to research how experts from the fields of history, archaeology, economics, engineering and art can work together to produce attractive user oriented content for museums.

Mixed reality covers both virtual and augmented reality solutions. Augmented reality stands for technologies combining interactive virtual elements and information with reality in real time. The content can be presented using mobile or wearable equipment, like a smartphone, tablet or eyewear.

The building of the Holy Ghost Church began in 1588 but was never entirely completed. The church, however, was probably in use for a couple of years before it was severely damaged in a fire in 1593. Afterwards the church ruins were used as a cemetery. The last visible remains of the church were cleared in the 1650s to make way for the realization of the new street plan for the town. The ruins were revealed in archaeological excavations in the 1960s and 1980s.

The mixed reality experience of the Holy Ghost Church includes both an inside and outside presentation of the church. The experience consists of an accurate 3D model enriched with natural imagery, 3D scanned elements, live action video and realistic soundscape. Further information is presented in textual form and alternative historical interpretations are presented visually.

The main challenge was that no pictorial representations of the church have remained. With the help of the material from the excavations, archival research and comparisons with similar buildings in Finland and Sweden the presentation is made as historically reliable and accurate as possible. The viewer is however reminded that the model is only an interpretation of the past, and not the past in itself.

Keywords: augmented reality, mixed reality, Holy Ghost Church, Turku, 3D modeling

1. Introduction

The usage of augmented reality in historical sites is rising and several applications have already been made (www.armedia.it/tracker.php; www.vindolanda.com/). These applications may include features such as showing old photographs over modern day buildings or reconstructing the destroyed parts of a partly ruined building. On the other hand, virtual reality solutions such as virtual tours and recreations of historical sites with the help of computer aided modeling have existed for a long time (Masuch et al. 1999). Mixed reality solutions provide a wide range of possibilities, yet there are a lot of challenges including historical research and technical solutions.

In this paper we present the production of the mixed reality application of the Holy Ghost Church in Turku, Finland. The goal was to research the historical backgrounds, implement mixed reality applications, study usability requirements and analyze the business opportunities. In addition one of the most important research areas was to study the production process of creating a mixed reality application for a historical site. The model was done as part of the Futuristic History research project (Mäkilä et al. 2013).

This paper is organized in the following way: Section 2 describes the mixed reality concept. Section 3 introduces the history of the Holy Ghost Church. In Section 4 production goals and process details are discussed. Section 5 describes the process of recreating historical content and in Section 6, the technical aspects of production are discussed. Challenges and solutions are presented in Section 7. Finally, conclusions are described in Section 8.

2. Mixed reality

'Mixed reality' stands for the combination of reality, virtual reality, augmented reality and augmented virtuality. In this paper the focus is mainly on augmented and virtual reality. Augmented reality (AR) is a live view of real world with augmented elements such as audio, video or imagery. Augmented content can be shown with a variety of devices such as tablets, mobile phones or eyewear. Virtual

reality (VR) is a pure computer generated environment that can simulate a real or imagined world (Milgram & Kishino 1994). There are a great variety of virtual reality devices and new ones are in development (www.oculusvr.com).

Mixed reality solutions yield new possibilities for viewing historical content. Historical studies are always combinations of historical fact and interpretation. When a lack of research material is significant it may lead to several possible views. There is no need to hide all the alternative interpretations from the public. These diverging views and interpretations could rather easily be shown to the user, thus giving the user the possibility to evaluate them. In addition, the user may not even want straightforward information, but may come to understand the level of interpretation involved and may even get to know the research process. Furthermore, showing different eras could be clarified by giving the user a chance to choose the era to be presented.

3. The Holy Ghost Church

At the end of the 16th century, Turku (Åbo) was the most important city in Finland, then a province of the Swedish realm, and the second largest city in the kingdom. Its population was between 4000 and 6000. The city was also the capital of the diocese of Turku. The Turku Cathedral consecrated in 1300 was the only church still in use in the city after the reformation (Laitinen 2012, pp.312-314).

The construction of the Holy Ghost Church began in 1588 by King Johan III. The purpose was to build a church for the Finnish speaking residents of Turku, because at that time Swedish was the language used by the ruling classes and thus the language of the service in the Cathedral (Gardberg 1966, pp. 8-16). The Holy Ghost Church may never have been entirely completed but it probably was consecrated before it was severely damaged in a fire in 1593. The ruins of the church were still used as a cemetery. The last visible remains of the church were cleared in the 1650s to make way for the realization of the new street plan for the city (Kalpa, Junttila & Moberg 2011, pp.13-16).

In the archaeological excavations of the 1960s and 1980s the foundations were unearthed. Later, it was decided that the foundations shall be left visible for visitors. In addition, the Holy Ghost Chapel was established on the remnants of the foundations (Kalpa, Junttila & Moberg 2011, pp.12-16 and 70-80).

4. Production goals and process

Not every historical building or event is suitable for an augmented reality application. The major criteria used in this project were historical knowledge, public interest, business opportunities and usability. All these facets are also in relation technical challenges.

Without suitable quantity and quality of historical knowledge, the recreation process becomes a difficult task and the historians are forced into interpretation, make decisions based on guesswork. Naturally, public interest has to be taken into consideration if the end product is designed for consumers instead of professionals or just to be a mere showroom toy.

Therefore, business opportunities need to be analyzed as well. Important aspects include the needs of different customer segments, sales and marketing, payment method, device management and platform decisions. Also the accessibility of the attraction has its' effect on the business model applied. Without proper business model or best practices from the field business solutions are only educated guesses.

In addition, the usability of augmented reality applications requires a lot of attention since the area is rather new and there are no standard usability solutions. AR glasses for example require additional study. Concerning usability, AR devices are usually intended to be mobile and to be used while moving around the scene, thus requiring a lot of attention from the user. Therefore, safety issues such as staircases and other changes in land or floor must be taken seriously.

While developing emerging technologies, an information ethics analysis can prevent some of the negative impacts created by new technology (Floridi 1999; Moor 2005). While other analyses prevent mistakes being made in the creation of bad or poorly selling software and hardware, information ethics concerns functioning, but ethically questionable solutions, thus preventing the loss of reputation and - in the end - capital. In AR solutions these concerns include, but are not limited to, privacy, data ownership and equality (Heimo et al. 2014).

After the analysis of the historical knowledge, public interest, business opportunities, and usability the aforementioned relation to the technical solutions must be emphasized with cost-benefit analysis. Many of the technical possibilities play a key role in the final product. With proper knowledge of the solutions at hand both the required and the most beneficial solutions can be located and implemented in the system. When conducting pre-production analysis, it is important to realize that the area of AR is under continuous research and new challenges and opportunities arise frequently.

Once the target was determined it was considered important to define common goals and discuss application possibilities. Since AR applications are a rather new, cross-disciplinary concept, it was thought that the research team should include personnel from different educational and professional backgrounds. Thus, there lies a risk for various misunderstandings to occur.

To negate the aforementioned misunderstandings, an iterative approach was found to be suitable to constantly build and show a demonstrative application to the research team. This approach merged visions and emphasized the common terminology of the project team members, making it easier to discuss further development. In the project, the research on historical matters was continuous and the search for new material and references was found to be helpful to gain a common vision between historians, economists, engineers and other professionals.

5. Recreating historical content

In the Futuristic History project, previous archeological and historical research was carried forward. For the creation of a 3D model of the Holy Ghost Church, the interior and exterior looks and the possible furnishings were studied. Based on these studies, interpretations of the designs were made. One of the main challenges in the reconstruction process was that there were no pictures and only a little archaeological and archival material left of the church. The challenge was approached by comparing designs to other similar buildings that existed in the same era.

The extensive publications Suomen Kirkot (Churches of Finland) and Sveriges Kyrkor (Churches of Sweden) yielded valuable information about the appearance and furnishing of the contemporary churches. An earlier interpretation suggested that the Holy Ghost Church was much like the St. Jacob's Church in Stockholm. Further investigation of the literature (Quensel, Lundmark, & Hedlund 1928 and 1934) and material from the excavations of the Holy Ghost Church revealed that the architecture of the church differed considerably from St. Jacob's Church. The Askainen Church from the first half of the 17th century (Riska 1961) was revealed as a better example on how the Holy Ghost Church might have looked. The medieval Holy Cross Church in Hattula and its 16th century furnishings (Knapas 1997; Hiekkanen 2007, pp. 282-291) were also used as references.

Even though the reformation and conversion from Catholicism to Lutheranism in Sweden began in 1527, some features in church furnishings, such as the lack of benches, remained throughout the 16th and the beginning of the 17th centuries (Laitinen, 2012, pp.312-317 and pp.329-330). The choir screen was considered even more important during the 17th century than it was before the reformation (Pirinen 1996, pp. 49-53 and 177-178). On the other hand, new elements appeared in the church space. Before the reformation the pulpit had been rare in Finnish churches (Laitinen 2012, p. 327; Hiekkanen 2003, pp.111-112).

The floor, baptismal font, chandeliers, candlesticks, wall plaster, doors and pulpit in the 3D model are all influenced by the design of Holy Cross Church. The windows are considered to be very dark and rather opaque, allowing only a dim green light to pass through. The windows in the Askainen Church were used as a reference. The examples of the sconces (used for light dispersion), the crucifixes and the choir screen are also taken from the Askainen Church. The choir screen is depicted as green, a common color at the time. Besides the Askainen Church, a 3D model of Petäjävesi Old Church was also used as a reference for the choir screen. The ceiling is still under discussion, it may have been level or barrel vaulted. The reference for the level ceiling is from the Louhisaari Mansion.

Thus the created model combines historical knowledge of the Holy Ghost Church and general knowledge of Finnish and Swedish churches, their furnishing and the services within them in the 16th and 17th centuries. This is how the model was made historically as accurate and reliable as possible.

There is music used in the application, in form of 16th century Finnish chant. The music was recorded in the atrium of Martin's Church in Turku and the particular track used is "Jeesus Kristus Uhrix Meille". In the application there is also a priest giving a short introduction about the Holy Ghost Church. A priest's clothing at the end of the 16th century included a long black robe and a white ruff.

6. Technical aspects of the production

The technical aspects of production include 3D modeling, application development and acquiring the specious visual look. 3D modeling includes various methods such as 3D scanning, manual modeling and reference based modeling. Application development refers to the actual building and deployment of the software. Together, modeling and development form the resulting visual look by taking advantage of different techniques, discussed in this section.

6.1 3D scanning techniques

Many different techniques exist to create virtual 3D models. One method that has gained popularity in the last few years is 3D scanning, which in some cases results in extremely accurate models. Unfortunately, models created for use in professional museums are rarely suitable for consumer grade products. One of the key factors here lies in the wide range of hardware and software that is used to run such applications. An average consumer tablet computer for example cannot draw the complex point clouds produced by 3D scanning fast enough to achieve real time performance. Thus in most cases the material needs to be created, especially for real time use. On the other hand, the ever growing amount of processing power allows for more and more visually attractive games, resulting in the target audience's demanding the same quality from all the content they consume. This sets high demands on cost efficiency.

6.2 Manual modeling pipeline

To research the best ways to create material for the project, many separate practices were tried out. Based on archeological research done in the 1980s and additional work carried out for this project, archaeologists created a rough 3D model of the church (Image 6.1). This model was then used as a reference for the shape and size of the actual model appearing in the application. An important element in enlivening game graphics is the use of materials and textures to make models appear more detailed and lively than their basic geometric form. To achieve the best possible results most of the textures in the application were created from photographs shot at real locations appointed by the historians. The use of textures was also applied to certain objects decorating the interior. The sconces and the chandeliers were modeled extremely roughly and all the visible details were achieved by using transparent textures defining the visual shape (Image 6.2). Other commonly used feature in modern game graphics are different kind of shaders, further modifying the look of the materials (Akenine-Möller et al. 2008).

Image 6.1: Original 3D model

A rough 3D model of the church based on the archaeological research.

Image 6.2: Sconces

Geometry and texture used for the sconces.

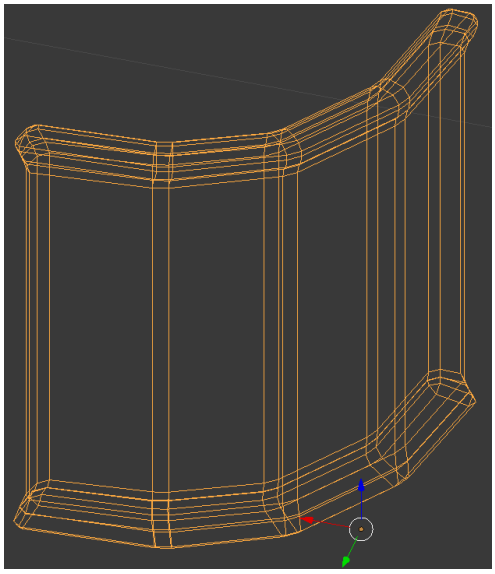
6.3 Modeling the interiors

According to our knowledge and interpretations, the design was very ascetic and minimal. This meant a lack of decoration and only very few items inside the building. The challenge was to make the interior seem lively despite this minimal look, so that it did not appear as an empty, and perhaps even unfinished, shell. This challenge became a starting point to establishing communication habits between content creators and historians. Conveying the very ascetic nature of the site was of crucial importance as it would define the look and feel of the whole scene.

The arches at the doorways and at the entry to the choir serve as a good example of the difficulties our artist had in getting to the right mindset. The lack of decoration and small details could be seen as a lack of information rather than the actual desired look. Questions were thus asked about whether there were any paintings or small carvings surrounding them. Especially important in the process were the reasons behind the answers: the rather poor Finnish population had no interest in spending vast sums of money building the church.

The seemingly simple dialogue also helped the historians to understand what kind of information the content creators needed - not just what existed but also what definitely did not exist - and the reasons behind this information. Once the right mindset was achieved the content production took on a much faster pace as the vision of the final look was shared to a greater extent. Sharing the vision of what was needed also helped our historians find reference materials needed for the final production. For example a lot of photographs were shot and some of them ended up in the final application, integrated into textures. A clear example is the pulpit which only has a very crude geometry (Image 6.3) but is highly detailed due to real world textures.

Image 6.3: Pulpit



Geometry of the pulpit.

Understanding the requirements of the content production made it possible for historians to suggest the most feasible references when multiple historically accurate choices were available. For example the material of the font has little effect on the content production but the shape does. Therefore it was possible to suggest a version that was both easy to create and still historically accurate even if in the reference photographs the material was not desired.

To increase the vibrancy of the interior, two wooden sculptures were added. Most likely, these would have been donated from churches nearby and thus would not be in ideal condition. Therefore it was possible to use real sculptures existing today as reference material and they did not have to be reconstructed to their original form. As two fitting sculptures were available at the Museum Centre of Turku it was decided to test out the viability of 3D scanning.

The sculptures were captured using the Artec Eva 3D scanner (www.artec3d.com). The resulting point cloud was then heavily processed with both hole-filling and point reduction algorithms and in the end finalized by hand to achieve a real time renderable version. The amount of work with this technique is less than modeling from scratch when the models in question are complex, such as human figures.

With a simple model as with more defined shapes such as furniture for example, it is much more efficient to create the models from the ground up. Most of the interior elements in the application were modeled in this manner with the help of photographic reference material.

6.4 Building the application

Once the models and the textures were created they were imported to Unity3D, a multiplatform game-engine (http://unity3d.com/). Unity3D takes care of real-time rendering along with the implementation of user interface and functionality. Lighting is done with pre-calculated light-maps, thus there is no real-time light calculation. The priest is implemented as a video texture with help of 3rd party plugins for mobile devices. The background in the video texture is made transparent with chroma key - technology. The application is implemented for iOS and Android; an Oculus Rift PC-version is also implemented with OculusVR Integration Kit (www.oculusvr.com/). For PC-version, additional post-processing shaders were used: blooming, screen space ambient occlusion and high dynamic range shading. Unity3D makes it possible to deploy the application to several different platforms and the application is currently deployable to iOS, Android, Windows Phone 8 and Windows devices.

Most of the software used in the content production was free and open sourced. This enabled the use of the same software without the need to fiddle around with license issues. Blender (www.blender.org/) was used as the main modeling and texturing tool with the help of Cloud Compare (www.danielgm.net/cc/) to process the 3D scanned point clouds. Inkscape (http://inkscape.org/) and Gimp (www.gimp.org/) were also used for creating the textures along with Photoshop as a commercial complement.

7. Challenges and solutions

One of the greatest challenges in the content production was the lack of any concrete source material. There exists no pictorial evidence of the church and even the textual sources are scarce. This left our historians and archeologists to work with only the research material from the excavations done at the site and what still was left of the samples taken at them. To counter the lack of actual reference material the project team members used other available sources - other similar sites from the era - in the end they drew conclusions about the most likely alternatives.

Another solution to the uncertainty about the actual look was to implement different views of the church. Since the ceiling is still under discussion, whether it was level or more like a barrel vault, it was made possible for the user to view both alternatives with a simple switch-button. This also conveys the idea that certain things are open to interpretation.

The lack of source material not only hindered possibilities relating to historical accuracy but also made it difficult for anyone but the historians and archaeologists, if even them, to grasp the actual look and feel of the church itself. Most importantly the artist needed to be able to share their vision but at first this proved to be difficult to enable. When this problem was identified, the project team sat down and discussed the matter thoroughly. This resulted in the sharing of information and the agreement that further communication was needed. The project team ended up passing around and discussing plans on non-finished content to constantly steer the end result towards the targeted look.

As if it had not been enough that most members of the project team did not have a clear picture of the actual target, the look and feel of the church, and the interpreted designs were under constant change due to the increasing historical knowledge. When new information came in from the research process the interior of the church would change from one design to the next. In the end the project team did what was thought to be based on the most stable information. Certain milestones were also set up when the project team would just have to go with the information available at the time and agree to have an amount of possible historical uncertainty in the design.

8. Conclusions and further research

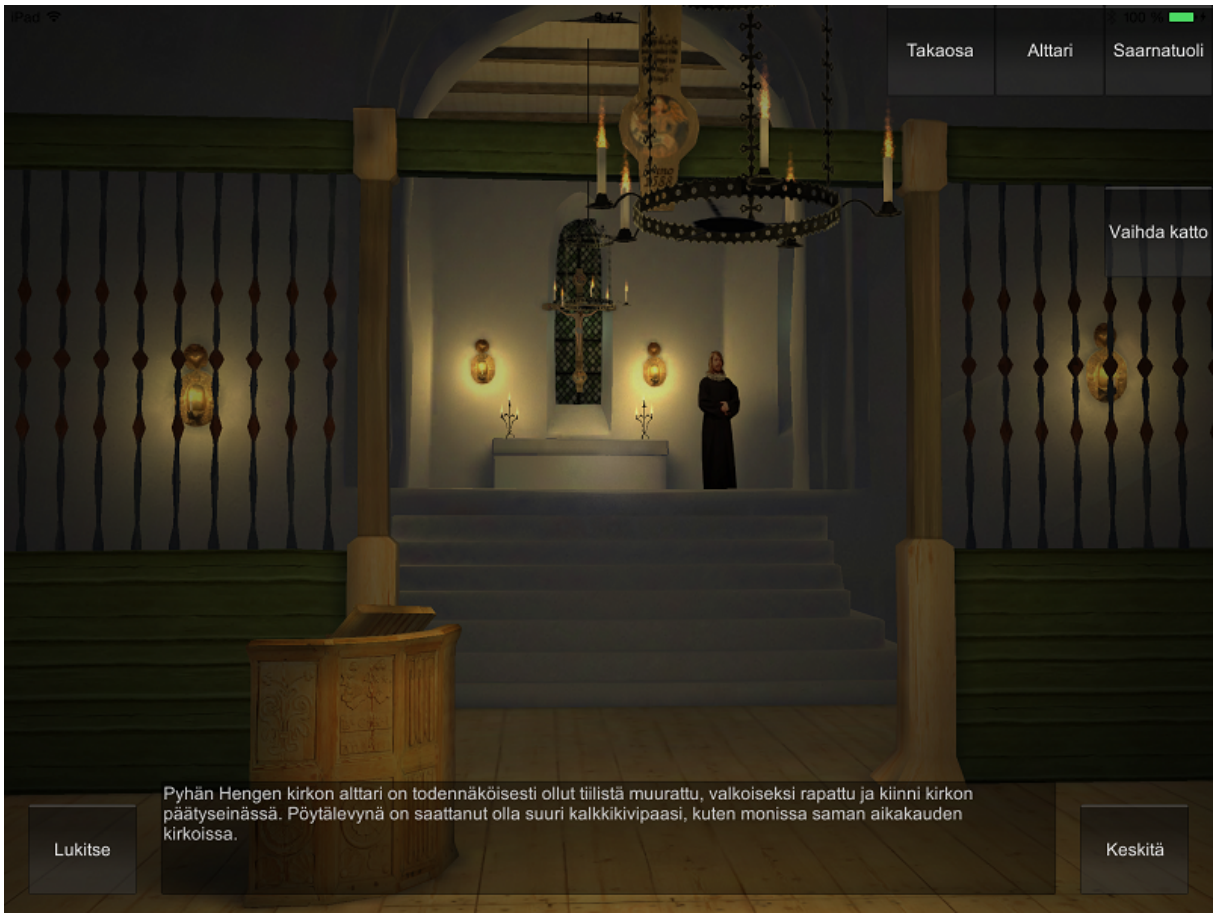
In this paper the history of the Holy Ghost Church in Turku was presented together with the process of recreating historical content. Production goals, process details and technical aspects were also discussed together with challenges and presented solutions.

A key point of this paper is the challenge of recreating historical content when there is only a minimal amount of historical knowledge available. Making the interpretations of the visual look, and conveying them to the artist was a major challenge. The solution was to find reference material and approach the desired look with continuous iteration. Despite the challenges, reasonable results were achieved (Image 8.1; Image 8.2).

Image 8.1: Model

Part of the model rendered with Blender.

Image 8.2: Application



Application running on iPad.

On the development side the challenges included the changing requirements. When new historical knowledge was acquired and the interpretation changed, the development team had to make the respective changes. 3D scanning was found to be a good solution for obtaining fast results without consuming much time.

The future research could include more study on the visualization process: how to bring the visual interpretation to digital form in a fast, accurate and cost-efficient way. If the applications were to be commercialized the business models and usability aspects should be studied further.

On the technical side 3D scanning and relevant algorithms would require further research. In addition, augmented reality technologies, such as eyewear and positioning, may play a remarkable role in the future.

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