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Remediation of Historical Photographs in Mobile Augmented Reality

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Being present at a location of historical significance, often demands imagination to understand the full scope of the area. An approach to spark one's imagination is to present a mediated simulation of a historic location in situ. As an application example, we used the sitsim AR platform to develop a simulation that conveys the history of fishermen in the historic fishing village of Storvågan in Lofoten, Norway. The study presents a rendition of the sitsim AR platform's functionality for engaging presentations of historical photographs. This functionality is enhanced from solely representing buildings in a historical photograph into also representing animated human characters. In Storvågan, a museum (Lofotmuseet) occupies historically significant buildings amid the historic surroundings. This museum exhibits a historical photograph of fishermen that also shows how the area once looked. This photograph is remediated into a 3D animation, presented as a real-time generated simulation, at the location where the photograph was originally photographed. The study documents a design experiment including the modelling and animation of a 3D representation depicting the photograph. The functionality is evaluated based on user feedback from a case study of a beta version on location in Lofoten. Users reported that the animated fishermen contribute to an engaging experience and a feeling of being "part of the history." The majority of users perceived the 3D representation as credible. An analysis of the modelled characters concludes that the 3D-models lack perceptual validity; hence, the case study's positive results were somewhat unexpected. Three theories are presented as conceivable explanations for the unexpected result. Ultimately, the study provides a method for modelling and animation of people from a historical photograph, and showcases how the animation of human characters in a sitsim may be applied to convey cultural heritage in an engaging way.

KEYWORDS

Sitsim, Situated simulations, Indirect Augmented Reality, Digital Cultural Heritage, Museum without walls, 3D-modelling, Animation, The Uncanny Valley, Remediation, Double Description.

INTRODUCTION AND BACKGROUND

This study represents part of a larger project initiated through «Connected Culture and Natural Heritage in a Northern Environment (CINE)» led by Museum Nord. The CINE project aims to maintain, develop and promote natural and cultural heritage, and enhance the identity of remote areas through knowledge transfer. As part of the CINE project, a situated simulation (sitsim) application (app) is under development. A sitsim app employs indirect augmented reality (AR) to present a historic site in 3D, combined with various multimodal texts, in order to present its history in a new way. Indirect AR utilizes the entire screen surface for virtual elements as opposed to AR where real and virtual elements mix

on screen (Wither, Tsai, Azuma, 2011). The development of the sitsim platform is based on media design, a synthetic-analytic methodology. As a scientific method, media design employs conventions from existing genres and media forms to develop new media forms, preferably by applying novel digital technology. In this sense, media design is a normative science, where humanistic informed developments of a media form are rigorously tested and analysed. The synthetic-analytic methodology is a circular process, where a new synthesis develops on the foundation of a previous one (Liestøl, 1999). This study presents such a synthesis, accompanied by an analysis of the rendition.

In situ presence in a location of cultural or historical significance is a crucial sitsim characteristic. Vågan in Lofoten, Norway, is an example of such a location. Vågan offers optimal climate and conditions that provide unique prerequisites for both the catching and conservation of fish. These natural resources made Lofoten a significant location in Norwegian fishing culture throughout the previous centuries. Storvågan was the most significant bay in the Vågan area. In Storvågan archaeological traces of settlements dates back to the era around 1000 CE. The archaeologist responsible for the excavations in Storvågan, Reidar Bertelsen, wrote about the area: "The traces are there, but they require your ability to imagine" (Bertelsen, 1995, author's translation). In this study, we have developed a sitsim for Storvågan that aims to spark this ability to imagine; specifically by increasing the visitor experience of presence in the historic surroundings by recreating a historical photograph as a digital 3D animation. This study aims to survey how a new media form can expand a visitor's understanding of an area's historical significance by remediating a historical photograph presented inside a museum as a digital 3D animation presented in situ outside the museum walls.

The recreation of an analogue historical photograph as a digital 3D animation is a form of remediation. Bolter and Grusin define remediation as "the formal logic by which new media refashion prior media forms" (1999). Remediation occurs in an interplay between immediacy and hypermediacy, which are styles of visual representation, whose objectives are respectively either to make the viewer forget the presence of the medium or to remind the viewer of the medium. All forms of mediation are remediation in the sense that mediation refashions prior media forms. Media forms sustain constant remediation because of continuous evolvement. The historical photograph on the museum wall for instance, provides more immediacy than a painting of the same scene, and refashions conventions such as posture and mise en scène. Remediation of the photograph into a digital 3D animation prerequisites the same need to refashion old media forms, by deriving from film, computer games, photography etc. In order to expand the visitor's understanding of the area's historical significance, the ambition of the remediated 3D animation is to provide increased immediacy. Increased immediacy is accomplished by means of the sitsim AR platform, which provides immediacy through double description. Double description is a term coined by Gregory Bateson to describe "cases in which two or more information sources come together to give information of a sort different from what was in either source separately." (Bateson, 1979; Hui, Cashman, & Deacon, 2008). The mediated simulation presented on the screen surface, accompanied by the unmediated reality offers a double description, which subsequently delivers increased immediacy.

The recreated 3D model is displayed in situ using the sitsim AR platform. AR is an example of a technology that continually evolves through remediation from previous and simultaneous media forms. AR technology can be traced back as far as experiments performed by Ivan Sutherland in 1963 (Billinghurst et al., 2015). Azuma and Milgram & Kishino provide the two most prominent definitions of AR in research literature. Azuma defines AR as a combination of real and virtual content that is interactive, real-time generated and recorded in 3D (2001).

Milgram & Kishino define AR as a taxonomy, in the form of a spectrum that extends from real to virtual environments (VR), where everything that is a mixture of these is "mixed reality" (MR) (1994). In the sitsim AR platform, this mix occurs when the parallel virtual environment on a screen surface appears relative to the in situ unmediated reality of the user (Liestøl, 2011).

The sitsim platform enables multiple applications, yet the platform's primary use is as a learning aid to present cultural heritage and historical surroundings in a remediated way to the general public. One of the platform's recent developments is a solution for creating engaging applications for historical photographs by combining mobile augmented reality and gamification. The solution provides the user with multiple historical photographs. The user's task is to determine where in a historic location the photographer was standing in a three-dimensional jigsaw puzzle. The gamification component utilizes conventions from the "hot and cold" game. The app provides feedback for the user in terms of increased model-opacity when the user gets close to the intended location. When all the jigsaw puzzle pieces are in place, the historical surroundings appear for the user. After testing the functionality in situ in Narva, Estonia, the functionality showed promising results for engaging user experiences (Liestøl, 2018).

Figure 1: Photograph depicting fishermen in Storvågan, Lofoten. The photograph is the basis for 3D-modelling and animation in this study. Photo: Jørgen E. Wickstrøm 1870-1895 (Nordlandsmuseet, 2015).

This study presents a new synthesis based on the photo puzzle functionality, where the Narva application's features are expanded. This synthesis explores whether a historical photograph containing people, remediated into a situated 3D-animation, can enhance the overall user-experience of a sitsim, and whether realism is key to such an enhancement.

DEVELOPMENT OF VIRTUAL ELEMENTS FOR THE SIMULATION

To investigate whether a historic photograph containing people, remediated into a situated 3D-animation, provides increased immediacy, we have developed a 3D-model and surveyed user-experience through a user test on location. In the following, we present the work with the 3D model, including the work with historical accuracy based on written sources, implementation of gathered data in the model, and description of the actual modelling and animation process. Thereafter, we describe the user test, together with an analysis of user experiences.

The study is based on a photograph in the exhibition at the Lofotmuseum photographed by Jørgen E. Wickstrøm between 1870-1895[1] (Nordlandsmuseet, 2015; Figure 1). The photograph is black & white and shot with a long shutter speed, which was a limitation of contemporary camera technology. Several people in the photograph are far from the camera, making precise 3D recreation a problem. The photograph depicts 15 people, where only seven are sufficiently distinct to identify some of the facial features. The fishermen are wearing variations of five different outfits. The fishermen's figures vary mainly by height. The middle ground and background of the photograph contain, respectively, "væreierbygningen" (innkeeper's main building, currently hosting the Lofoten Museum in Storvågan), and Tjeldbergtind (the mountaintop in the background). The photo provides excellent means to determine the location of where in the area the photographer was standing. In the foreground of the photograph, apart from the fishermen, multiple boats, huts, and fishermen's cottages (rorbuer) can be seen.

The photograph's recreation in 3D consists of three main elements besides the natural scenery (Figure 2). "Spissbåt", an area-specific fishing boat made for 2-3 people (panel a), "rorbu", which is a fisherman's cottage commonly used in the Lofoten area (panel b) and fishermen (panel c). Apart from the photograph, several different sources form the basis of the historical accuracy of the elements in the 3D-recreation. We identified the boats with their keels up (located to the right of the photograph) in collaboration with Museum Nord. Gunnar Eldjarn, boatbuilder and author of several books about «Nordlandsbåter» (an umbrella term for boats from this region), identified the boats as "spissbåter". Eldjarn judged that the boats originated from either Rana or Hemnes. Based on this information, we conducted an extensive literature search to gather data for historically accurate reproductions. For example, sketches showing the cross-section of the boats' structural ele-

2 A.Spissbåt

2B. Rorbu

2C. Fishermen

Figure 2: The elements of the 3D model.

1 The origin of the photograph is uncertain. It is attributed to different photographers.

ments from bow to stern were essential to building the boat-model. We discovered photographs of the boats from multiple sources, including digitaltmuseum.no. These images were used to generate textures and to determine the natural ageing to add to the textures. The spissbåt was a new boat model in the time period of the photograph; this affects the level of wear that we added to the texturing. The sources describe many objects that would have been in a spissbåt (so-called: "tilfar"). These details are essential to provide a higher level of realism for the end user, but we left out these details in the beta testing due to time limitations. We found details concerning the fishermen's clothing accurately described in books written by Gunnar Eldjarn (Eldjarn, 1988). These sources provide information about a common style of clothing for fishermen, which included five clothing layers. This information affected the movement so that it would appear natural in the animation. At the same time, this explained why the fishermen appear bulky in the photograph.

The fishermen's cottages in Storvågan are unfortunately gone. In connection with the museum, a fisherman's cottage was brought in from an old fishing village on Skrova, an island a few kilometres northeast from Storvågan. We based the "rorbu" model and its textures on photographs and measurements from this cottage. Thus, the modelled cottage probably has more patination than was the case at the end of the 19th century. However, the fisherman's cottage probably appeared worn already in the time the sitsim represents. Contemporary photographs also confirm this.

The 3D elements needed for this study (figure 2) were modelled using the open-source software Blender. 3D modelling is the process of forming a digital representation of an object's surface. A vertex (point) is placed on a coordinate on the X, Y and Z-axes in a digital coordinate system; multiple vertices are connected into polygons and the assemblage of these polygons forms a mesh (figure 3). The mesh is a representation of an object's surface. For the fishermen, we developed one mesh, which was adapted to each of the five clothing styles from the photograph. We subsequently varied the five models in facial features and size.

Character animation (movement) requires rigging of the mesh with a virtual skeleton (armature). After finishing all models, they were exported from Blender as pure mesh files (in .OBJ format) and imported into Adobe Mixamo. Mixamo is a tool for automatic rigging of human (humanoid) 3D models. Rigging a humanoid 3D model means placing an armature inside the model's mesh (Figure 4). The armature controls the animation of different parts of the mesh, enabling character animation. Mixamo has a large selection of ready-made animations that were

Figure 3. Fisherman 3D mesh highlighted in white

Figure 4. Fisherman armature highlighted in orange

used for most of the tasks the fishermen perform. After modelling and animation, the models have a surface and movement. In order to resemble the characters in the photograph, the models also need a texture that provides colour to the mesh. 3D soft-

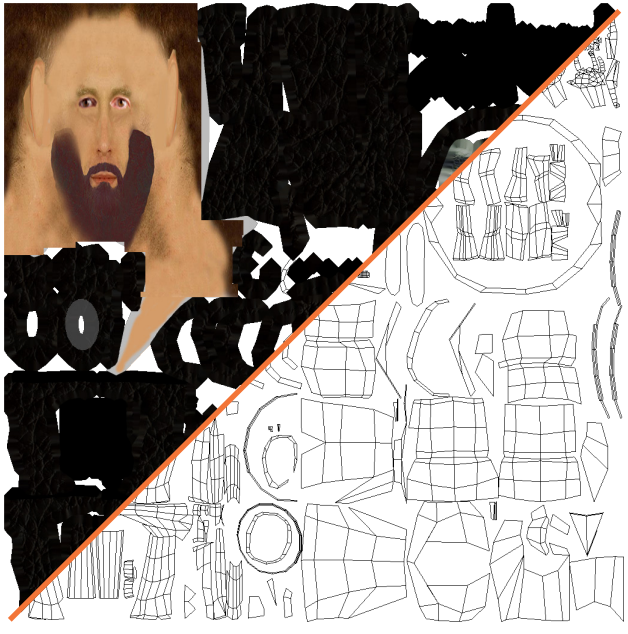

Figure 5. Montage of UV map (Lines in the bottom right corner) and diffuse texture map (top left) for one of the fishermen. The diffuse texture map wraps around the 3D mesh using coordinate mapping on the U and V axes.

ware uses UV-maps to texture 3D-models (Figure 5). A UV map has coordinates on U- and V-axes that the 3D software uses to determine how a 2D image should wrap around a 3D mesh. Texturing is based on contemporary photographs of fishermen, and images of materials (e.g. leather) that would have been used for their clothing. These images were added to the texture map using Blender and Photoshop. All fishermen models received a unique texture map, which made the characters stand apart (Figure 5).

The sitsim AR platform is an indirect AR platform, meaning the entire simulated world is modelled in 3D. The terrain developed for this sitsim is developed using photogrammetry. Photogrammetry is a technique for determining an object's geometric shape based on a collection of photographs (Dick & Mæhlum, 2020). This means that the mesh and texture of the terrain is automatically generated using computer software. The photographs that formed the basis for the terrain models and textures, were captured using a drone.

Using the game engine Unity3D, the 3D characters were placed in the terrain relative to how they appear in the photograph. In Unity3D, all characters received gravity, which controls their movement on the Y-axis. A timeline was programmed to control how the fishermen act in the simulation. Two of the fishermen push a boat down to the shore, while the others walk around doing everyday activities such as sitting down on a fishing barrel. The alpha version of the simulation was submitted to the developers at Tag of Joy for implementation and optimization against the other components of the sitsim.

Figure 6: Sample images from sitsim testing in Storvågan. Photo: Gunnar Liestøl

CASE STUDY AND SURVEY

The case study was carried out starting from the museum building at Storvågan in Lofoten on 11 June 2020. The experiment consisted of two rounds with two different user groups; schoolchildren and staff at the museum (this group also included the student`s teacher). The participants were introduced to the project's background and app prior to the testing. The school class also had an introductory tour of the museum. The test app began with a new instalment of the photo positioning puzzle. The app shows multiple historical photographs (four photographs in the app), with the task of finding the location where the photograph was taken (functionality from the Narva application). The users went together in pairs, each pair with an iPad and accompanying headphones. When users were at the last historical photograph's location, the iPad showed a transition from photography to 3D animation of the people in the image (Figure 6).

The users moved around the landscape without guidance from the researchers. However, the researchers were on hand to demonstrate the app's essential features, to ensure proper use and to avoid technical problems. After completing the test, the users were provided with a questionnaire in paper format which they completed individually. The questionnaire contained 23 open-ended questions (free text answers). Two of which, relate to this study.

> Question 11: (shown in questionnaire with a picture of the historical photograph). The last photograph in the photo puzzle contained people. Once you found the last photo's position, the 3D environment around the photo was transformed into colors, and people began to move. How did you experience this transition from the historical still image to the reconstructed movements? Did it seem credible? Was it a kind of revival of the photograph and what it represents (Storvågan in the 1880s)?
>
> Question 12: The photo puzzle's last location is in the same place as the photographer was at the end of the 19th century when the picture was taken. What experience did the combination of photography and 3D animation bring to the site, compared to if you had seen the photograph alone, e.g., in a book? Did you find that the animation added a new or different experience to the photograph?

The researchers transcribed the responses (in Norwegian) from the questionnaires. We analysed the responses qualitatively by reviewing the responses' breadth and common features. We coded the responses into the following four categories to enable quantitative analysis: positive answer, negative answer, technical problems, or missing answers.

RESULTS

In total, 30 users tested the app. We received 29 response forms, as two users completed one of the forms in collaboration. Most respondents answered all the questions. One respondent submitted a blank form because the user did not feel qualified to respond. The first user group consisted of a school class with 16 students aged 15-16 years in the tenth grade of secondary school. The other user group consisted of 14 adults; some with connections to Museum Nord and others who were the students' teachers. The average age for this group was 52 years.

Credibility and revival using 3D animation (Q. 11)

Most users (20 of 29 respondents) perceived the 3D animation as credible and contributing to the revival of the photograph (Table 2).

Table 2: Assessment of the credibility of the 3D-modeled people.

	Positive answer	Negative answer	Technical problems	Not answered	Total
Number of respondents	21	2	4	2	29
Percentage	70%	9%	14%	7%	100%

Most respondents with a positive answer stated that they experienced the 3D animation as good, that it seemed credible and contributed to bringing the photograph to life, although most respondents did not provide further details about their experience. Questions were formed as free text answers and among the students who elaborated further, a couple stated that the animation contributed to a fun experience, and some stated that the experience startled them. The students described it like this:

> I was completely shocked because it was so incredibly good. The sound and everything, 6+.

> I was startled, so I'm very impressed! Everything was realistic. So good.

> I think it was a lot of fun, it gave an extra element that was very engaging. The only thing was that the transition was a bit abrupt, and I jumped a little.

In-depth feedback from a couple of the museum staff was that it made them feel like a part of history. Two unique respondents described the transition as something that gave the impression of taking part in the history.

> [The history] Became credible. Element with people made it feel alive, and you became almost a part of the history.
>
> Student Affiliated With Museum Nord 23

Two of the respondents gave exclusively negative feedback. Of these, one perceived the modelled people as too stylized for it to come to life. The other underwent no memorable experience related to the transition from the historical still image to the reconstructed movements. Another mainly positive respondent recommended that the degree of credibility should be improved in a finished version of the app. The other respondents either had technical problems (4 of 29 respondents) or did not respond (2 of 29 respondents). Technical problems included challenges with seeing the screen on the iPad due to strong sunlight, that the animations did not start, and that the iPad had problems with location determination.

The benefit of 3D-animation (Q. 12)

The response to question 12 is exclusively positive, except for those who had technical problems.

All respondents stated that they received a different or new experience related to the animation sequence. They generally described the combination of photography and 3D animation as something that made the image come alive. An excerpt of the response is provided in the following, one of the respondents describes it as follows:

> You feel more like you are part of the history, something you may not otherwise do in an exhibition.
>
> Student Affiliated With Museum Nord 23

In particular, the experience of entering the picture is described as something that contributes to this new experience:

> Exciting that you can change the angle. (and look around) You cannot do that in a picture.
>
> Teacher 59

Another respondent described that the recreation contributes to the understanding that this has actually happened:

> I got a better feeling that this was a scene from a long time ago. The fact that I was in the same place, and saw a recreation of what could have happened when the picture was taken, makes the experience more real, and contributes to the understanding that this has actually happened.
>
> Student 16

DISCUSSION

This study presents an enhancement of functionality from a previous sitsim AR app. The photo puzzle functionality based on historical photographs is adapted from representing primarily buildings into also representing people. The study examines whether this adaptation contributes to the feeling of being a part of the conveyed history, with an enhanced experience of immediacy. The users' feedback was generally positive. Most who tested the app, experienced the animation as credible, and some respondents expressed an enhanced historical experience. The positive feedback of the animated characters could be interpreted as a form of enhanced user experience. It is nevertheless complicated to draw unambiguous conclusions about what leads to this; the photo puzzle functionality combined with 3D-models or animation of people in isolation. Most users described the transition from the photography to the 3D-model as credible, but is this a result of the 3D-models themselves being credible? Our initial hypothesis was that we would receive negative feedback on character realism; but such response was sparse – how may this be explained? Could the cause of the user experience of credibility be that the media form was new to them, and more realistic than media forms to which they compare? We discuss these questions in the following.

Starting with Sutherland's pioneering work with CG in the early '60s, advances in the credibility of CG measures against a goal of photorealism (Bolter et al., 2020, pp. 48-49). Photorealism, especially in 3D representations of people, is very complex; there are small nuances in everything from facial expressions to micro-movements, which affect the end result. The modelling of the characters in this study aspires towards photorealism, but it has limitations that leave no doubt that the characters are merely graphic representations. We discuss the most prominent limitations based on human motion studies.

Human motion studies is a vast research field. In order to analyse the credibility of the models built for this study, a delimitation is necessary. Hence, the models were analysed using Etemad and colleague's model for analysing Perceptual Validity (PV) in human motion (Etemad, Arya, Parush, & DiPaola, 2016). To achieve perceptual validity in human motion, Etemad et.al. present a model for analysing Body Motion (BM) and Facial Motion (FM). The model divides human motion into two themes, Primary Themes (PT) and Secondary Themes (ST). PT specify primary actions, like walking or running. ST specify "affect, style or individual characteristics in those actions which are performed". When modelling characters for this study, PT received all the attention, meaning it was more important that characters performed assigned actions (PT), than the style of those actions (ST). This means that if you were to analyse characters side by side, you would see that all characters move in the same way, without any deviations or individual characteristics. The PV model provides ways to analyse consistency in both FM and BM. An example of a fallacy in the consistency of the animated characters is at the instance where the fishermen push the boat down to the shore; the BM indicates muscle strain, yet the FM of the characters indicates no effect. This represent an inconsistency that reduces character credibility. Although not extensive, this analysis proves that our models lack full perceptual validity.

The PV analysis of the modelled characters reveals limitations in the models, hence we presumed a degree of negative response from the users. The test users are experienced media users, with a frame of reference defined by familiarity with similar media forms, like animated feature films such as Toy Story, and computer games on hand-held devices (50% of test users state they have tried Pokemon Go, or similar apps). The development of Toy Story 4 spanned over five years, with a large team of creatives. For our study, a single modeller was responsible for modelling and animating all the resources (figure 2). When grounds (respondent's frame of reference) and causes (limitations in the model) for constructive criticism is apparent, the absence of negative response is an

interesting result. In the following, we present three theories that provide possible explanations for this result: 1) Bateson's theory of double description; 2) Bolter & Grusin`s theories on remediation; and 3) Miro's theory of "the uncanny valley". Although none of the theories provides fully-fledged explanations, the theories explain interesting aspects that all deserve further investigation.

Bateson's theory of double description was foundational for the experiments with the sitsim AR platform (Liestøl, 2013). The sitsim platform is showcased in promotional videos, but these videos lack the double description that sitsim offers on location. The double description experience, where two sources of information completes and extends one another, is an experience that is impossible to reproduce without presence on location. Hence, the showcase videos lack the immediacy of the the sitsim in situ. The double description experience provided on location may be one of the reasons why users fail to report the limitations of the modelled characters. The scene with transition from the historical photograph to animation, supplements many elements of information. The modelled surroundings shift from black and white to colour, a voiceover gives background information and the characters start moving. The scene alone provides much information to process and many details to register. Combined with the double description of unmediated reality and simulated reality, users may experience an information overload, where users are at the limits of their cognitive capacity. If this is the case, the character animation may be successful because users are attentive to other aspects of the experience rather than its flaws. John Lasseter of Pixar said that "character animation is successful when the story becomes more important and apparent than the technique that went into the animation" (Lasseter, 1987). Hence, the positive aspects of the sitsim experience could be the cause of a user's failure to notice flaws in the animated characters. If information overload is the cause of users failing to recognize flaws, there is simultaneously a risk that vital information lacks attention as well. Another aspect that could cause failure to notice flaws is that users are preoccupied with comprehending a new media form.

Remediation creates a basis for comparing a new media form, where the realism in the new media form is measured against the media technology from which it springs (Bolter et al., 2006). Bolter and colleagues argue that history's first film screening is an example of the effect of remediation (Bolter et al., 2020). In this screening, the Lumière brothers displayed a train en route to La Ciotat station. As the train moved towards the screen, the audience ran out of the theatre in horror. Judgement of realism in a new media form is measured against the realism in the media form from which it is remediated. Bolter and colleagues refer to this as the "La Ciotat effect." A possible explanation for the reported credibility of the animated characters is that users have fallen victim to the La Ciotat effect. It is conceivable that the characters appear credible because the sitsim experience is overall more credible than the media form the simulation remediates from (e.g. the historical photograph). The third possible explanation for users' experience of credibility may also be the opposite: the characters appear too stylized.

In the 1970s, Masahiro Miro wrote about the effect of of discomfort people experience when seeing human representations that do not appear fully human (Tinwell, 2015). Miro referred to robots in his article, but the term has proven particularly useful for describing CG. "The uncanny valley" denotes the point where a human-like character appears so human that it is mistaken for being a human being, but at the same time, lacks the last degree of realism that makes it believable. Studies show that when one is in this intermediate phase, the end user loses empathy for the characters, which harms the overall experience (Tinwell, 2015). In our study, users report that the characters appear credible. This credibility may stem from the 3D-representations appearing so stylized that users accept them as a stylized represen-

tation of people. The 3D-representations may appear so far from a human being that there was no doubt that it was a representation. In this way, the modelled people avoid ending up in "the uncanny valley," with the associated reduced degree of empathy and credibility for the characters.

The experiment indicates that the credibility of human character animation is dependent on the media form where the animation is presented. Simultaneously, further investigation should examine what an audience would say about the credibility of the characters presented off-location. An examination of character credibility off-location could be beneficial for better understanding of the level of realism one ought to aspire to when developing a sitsim.

A model is a simplified version of reality, and the small nuances and details make up the difference in the end product. 3D models are based on triangles, where all three sides have a location along the XYZ axes. The more triangles, the more detailed the 3D model becomes. At the same time, more triangles require increased hardware performance. The first fisherman developed for this study contained over 70,000 triangles. To run the real-time model on an iPad, this had to be reduced to about 5,000-10,000 triangles. This reduction resulted in a significantly reduced level of detail. As an alternative to a reduced level of detail, we considered producing a pre-cut animation sequence added as a video in the app. As this would be contrary to Azuma's definition of AR as real-time generated, we chose real-time animation with a reduced detail level. Although today's display technology entails limitations for 3D models, this will change in line with technological development in the coming years. In the end, only the modeller's artistic skills and available time, limit the photorealism and experience of immediacy in the sitsim AR platform.

CONCLUSION AND FURTHER WORK

The study contributes knowledge about how the animation of human characters in a sitsim AR app can convey cultural heritage. The study provides a method for modelling and animation of people from a historical photograph. Although the study is based on a case study from a beta version of the app, feedback from users shows that 3D animation of people can be a useful tool for presenting cultural heritage in an engaging way. The most significant result in the study is overwhelmingly positive feedback from users, despite the 3D models not being perceptually valid. Three theories that provide viable explanations for this result are presented: 1) the double description experience of two simultaneous information sources that contribute and add to one another, may cause an information overload for users, which reduces awareness of imperfections; 2) The sitsim media form appears more realistic than the media form from which it is remediated, hence the overall sitsim experience appears credible, reducing awareness of character flaws; 3) The 3D-characters appear too stylized and are therefore acknowledged as mere representations of people, hence avoiding the fallacy of "the uncanny valley".

The experiment indicates that the credibility of human character animation is dependent on the media form where the animation is displayed. Hence, an off-location case study is suggested to isolate the effect of immediacy provided by presence on-location. Such a study could present better answers to the degree of realism one ought to aspire towards in a sitsim.

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