Spatial Augmented Reality for Collective and Immersive Experiences In Museums

Ronan German, PhD, Benjamin Hervy, PhD, Vincent Roirand

Mazedia, France
ronan.german@mazedia.fr
benjamin.hervy@mazedia.fr

ABSTRACT: Digital technologies such as Virtual Reality and Augmented Reality are often seen as not conducive for sharing quality time between family members or a school group,given the more individualistic experiences they allow (especially when headsets are required). On the contrary, our project examines how Spatial Augmented Reality (SAR) technologies can address a more socially and bodily engaging experience for the group members. The SAR apparatus we are working on relies on 3D animation triggering based on facial expression, gesture recognition and (group) behaviour analysis. The experimentation, which will involve 3D animals and provide a live immersive family experience, will take place in the aquarium of Le Croisic, France.

1. INTRODUCTION

In Spring 2018, Mazedia [https://www.mazedia.fr/] - a communication agency working in the heritage and tourism sectors - started working with the aquarium of Le Croisic, France [https://www.ocearium-croisic.fr/]. The project aimed at offering a new experience for the aquarium's visitors in order to give them a more immersive and engaging experience with the aquarium's specimens.
Mazedia, together with the aquarium team, designed an apparatus that gave visitors the impression of interacting with 3D animated models of a shark and a group of penguins.
That apparatus operates by integrating augmented reality elements within a specific area of the aquarium, dedicated to families and pupils with their teachers.

The group members take place in front of a monumental projection (5 meters wide and 2,5 meters high) in which they see themselves thanks to a central camera. On the ground is symbolized a line they cannot cross for the apparatus to work properly. Once they are in place, the animation is triggered and the virtual 3D animal appears in the projected scene. This projection gives the impression that the animal is in the space with the group members.

The first few months of exploitation have shown a real interest and great success of the apparatus on the visitors' side but also with the aquarium's staff.

To make it an even more immersive experience, we have partnered with Dynamixyz [http://www.dynamixyz.com/] (a world leader in markerless facial motion capture, based in Rennes) and two research teams: the CRENAU team of the AAU lab (UMR CNRS 1563) [https://aau.archi.fr/crenau/] - experts in augmented and virtual reality based at the Ecole Centrale de Nantes - and the PACCE team of the LS2N lab (UMR CNRS 6004) [https://www.ls2n.fr/equipe/pacce/] - specialized in human-machine interaction and cognition (based at the Institut Mines Télécoms of Nantes).

This partnership aims at building upon the existing experience to improve the different interactions between the group members and the 3D animated specimens.

Thus, the main aim of the article is to give an overview of the project's objectives and means and focus on a few outlines.

First, we present the details of the existing system and the limits. Then, we identify the

three main goals the project has to achieve. Finally, we focus on the scientific, technical and experiential issues the consortium will have to tackle.

2. ACHIEVEMENTS AND LIMITS OF THE EXISTING APPARATUS

As noted in the introduction, the existing spatial augmented reality system encourages group members to move within a designated space and look at a giant projection on the wall in front of them (cf. figure 1)

***Figure 1**. A group of children trying to touch the 3D model of the shark appearing in the projection*

The system is composed of a camera, a video projector, a series of pre-processed 3D animations of animals (a shark and a group of penguins) and a special setting that allows a deeper sense of immersion.

***Figure 2**. The setting of the experience: a printed background and floor representing the seaside, enhancing the feeling of immersion*

The system relies on two scenarios: the shark and the group of penguins. The two animations launch periodically and have a duration of 40 seconds with about 10 seconds between each.
The visitors take place in front of the projection and see themselves. A first animal appears in the projection and gives the impression of getting closer and closer to the visitor. The 3D animations were designed to be as realistic as possible, according to the animals' behaviour in a natural setting (thus, coherent with scientific knowledge).

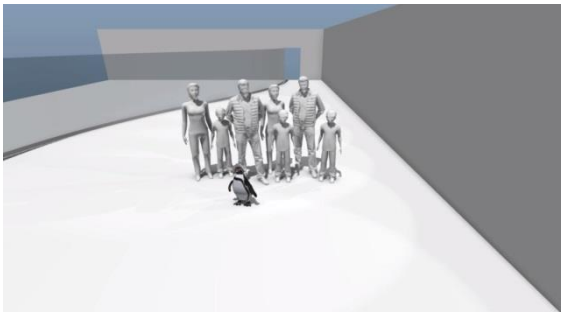

***Figure 3**. A mockup of the penguin's animation*

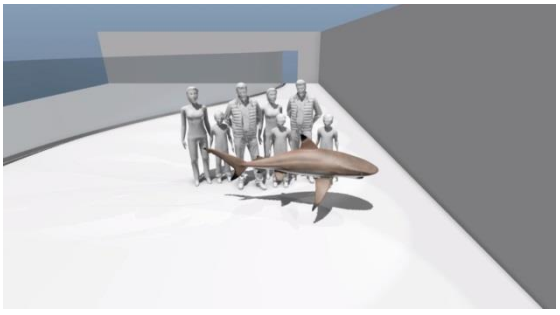

***Figure 4**. A mockup of the shark's animation*

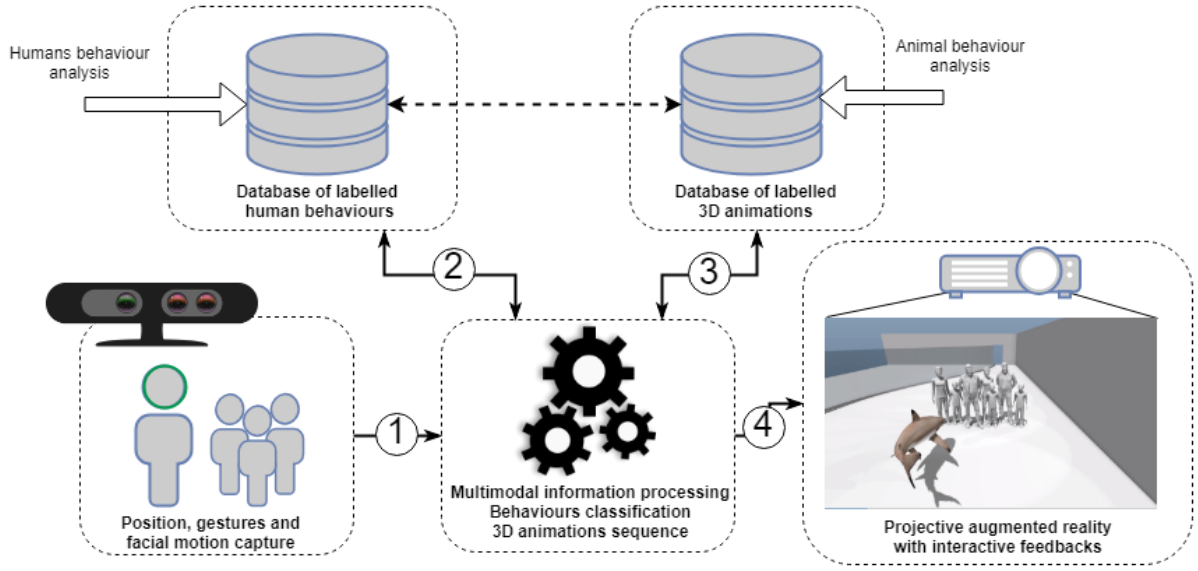

***Figure 5**. Simplified overview of the SAR proposal*

Also, the projective augmented reality system (according to the taxonomy of [1]) is quite simple technology-wise, it relies on the combination of high-quality 3D animations of the animals and the immersive aspect of the setting. The visitor experience benefits from this very combination.
As shown in figure 1, the children are very sensitive to the presence of the virtual animals and try to touch the 3D animations even though there is no real interaction between them and the animal. This gives us a good idea of the evocative power of this kind of setting. Interestingly enough, we notice, in that phase of the project, that it was the visitors who adjusted and adapted their own behaviour and gestures to the 3D animated animals (for instance, following the penguin's predetermined path to pad it on the head). The very aim of the future project is precisely to meet visitors' existing expectations when trying to interact in a meaningful way with the animals. Evaluation has shown that the children are not the only one fascinated with this evocative power of the system, adults are too (parents have been seen mimicking swimming with the shark).

This first experimentation taught us a lot about how visitors reacted to the virtual presence of the 3D modelled animals and how the system could be improved for further experimentation.

3. SPATIAL AUGMENTED REALITY WITH ADVANCED INTERACTIONS: A PROPOSAL

Our proposal is to build upon the past experiment results to improve the different interactions between the group members and the 3D animated specimens.
To do so, three challenges have to be met.

First, we want to offer a more engaging experience for the visitors, in order to meet their expectations. We then need to **provide real interactions**, meaning that visitors will have real time feedback and impact on the 3D model of the animal. For instance, if they try to get really close to the animal, it may want to flee, depending on the species' real behaviour and habits towards humans. In addition to this kind of reaction, the position and the number of visitors in the scene will have a crucial importance in the unfolding of the animation. The goal is to have a mutual influence on the virtual and real worlds (the behaviour of the 3D animal has an impact on the visitors' behaviour and *vice versa*).

The second challenge is to create a conducive environment for visitors to **share a common experience** where interactions between visitors have a direct impact on the scenario of the animation. For instance, the system can identify clusters and behavioural patterns within the group (adults with children, children interacting with each other, an isolated adult or child, a group of pupils with their teacher, etc.) and launch animations accordingly. The definition

and the relevance of these clusters and patterns will constitute a work package in and of itself.
In order to encourage collaboration amongst the group members (school groups or family groups), gamification elements could be integrated as a specific (but not the only) modality of interaction between the visitors and the virtual animations.

The third challenge is to keep in mind that, even though the experimentation will take place in an aquarium, the principles can be **relevant for other types of institutions and organisations** (arts museums, history museums, science centres, heritage sites, parks, etc.). The aim of this project is to provide these kinds of actors in the cultural field with the same immersive and collective experiences.
For instance, in an art museum, the same technical system could allow visitors either to embody an existing character in a painting or to be part of the scene as a new character (thanks to an avatar).

In figure 5 (see above), the diagram gives an overview of how the system works.

4. SCIENTIFIC, TECHNICAL AND EXPERIENTIAL ISSUES

The proposed SAR (Spatial Augmented Reality) system is expected first, to detect group members' position in the physical space to trigger specific movements from virtual avatars (animals), and second, to adapt the 3D animation based on the group members' body and facial motion capture. This second part is significant to achieve the goal of an immersive experience.
This innovative approach yields the following issues.

First, we need to **capture the position and posture of visitors** in the physical space. Hence, it means that the designed SAR system is able to detect a group, its members, and their physical characteristics like size and joint positions. Depth cameras like Microsoft Kinect or Intel RealSense can provide this kind of information with dedicated algorithms [2].

Second, the **real-time detection of facial expression through their motion capture** (see figure 6) [3] along with the definition of heuristics brings the interactive experience to a next step. Dynamixyz has great experience in this domain of expertise and will embed their technology inside the technical apparatus. One of the technical issues in this process is to handle undesired and unexpected situations like face detection failures due to occlusion, latency or low video frame definition.

Figure 6. *Facial motion capture - Dynamixyz*

Third, the project aims at **defining and classifying interaction triggers between the behaviour analysis of group members and the 3D animated behaviours of animals**. This is one of the main scientific issues identified so far. Indeed, it means that on one hand, multimodal information from sensors can be classified as corresponding human behaviours in a database [4], and on the other hand, 3D animations are labelled as corresponding answers based on these human behaviours (see figure 5). These two classified databases include knowledge of domain experts, both in human-computer interaction and cognition, and in ethology [5].

Fourth, a time-consuming technical issue is the **creation of specific 3D animations**. These animations should be split into smallest units possible. Indeed, we need to reconstruct a 3D animation in the physical scene by combining many small animations in response to real-time events (humans' actions). In order to provide the best immersive interactive experience, the system should be flexible enough to answer group members behaviours, while delivering realistic 3D animations. Working with realistic, 3D animals is an additional challenge to provide an engaging interaction [6].

Finally, working with an aquarium implies **specific challenges in terms of interpretation**. For instance, the proposed SAR system has to deliver pedagogical messages under the form of specific animations. These messages should be triggered by specific detected behaviours, or, on the demand, by the aquarium staff. The final setting is pictured as both a pedagogical and playful medium. Thus, the

scenography of the physical setting will be of great importance to influence visitors' behaviour and improve the feeling and sense of immersion [7]. The use of sound design could also be an interesting lead to follow [8].

5. CONCLUSION

In this paper, we described a spatial augmented reality system to bring advanced interactions in the cultural sector.

Our main goal is to overcome the limitations of existing digital technologies as they are usually designed in museums as a whole. This proposal benefits from an existing setting in the aquarium of Le Croisic, France to bring the visitors to a further level of interaction with virtual specimens. By combining body and facial motion capture among the group members with databases of humans and animals' behaviour classification, we aim at providing real-time 3D animations based on the detected visitors' behaviour.

This project yields many scientific and technical issues that will be investigated by a consortium of researchers and industrials in the different fields of required expertise. In a long-term perspective, we plan to demonstrate how this approach could be applied in other contexts, such as art museums, history museums or heritage sites in general.

Finally, our work will investigate consequences of such system on interpretation strategies and collaborative experiences among groups (with a special focus on families [9]). This work-in-progress has been submitted to a call for proposals and is expected to start in June 2019 for a period of 24 months.

6. ACKNOWLEDGMENT

Special acknowledgements go to the Aquarium of Le Croisic, Ecole Centrale Nantes, Institut Mines Télécoms Atlantique and Dynamixyz.

7. REFERENCES

[1] Normand Jean-Marie, Servières Myriam and Moreau Guillaume: A new typology of augmented reality applications. 3rd Augmented Human International Conference, Megève, France, March 8-9 2012, ACM New York, NY, USA, 8 pages

[2] Jamie Shotton et al.: Real-Time Human Pose Recognition in Parts from a Single Depth Image. Computer Vision and Pattern Recognition (CVPR), Colorado Springs, CO, USA, USA, 20-25 June 2011, Institute of Electrical and Electronics Engineers (IEEE), 1297-1304

[3] Stoiber Nicolas, Aubault Olivier, Seguier Renaud, and Breton Gaspard: The mimic game: real-time recognition and imitation of emotional facial expressions. Conference: International Conference on Computer Graphics and Interactive Techniques, Los Angeles, California, USA, July 26-30, 2010, ACM, 1 page

[4] Durupinar, Funda et al.: PERFORM: Perceptual Approach for Adding OCEAN Personality to Human Motion Using Laban Movement Analysis. *ACM Transactions on Graphics*. vol. 36, no. 4, July 2017

[5] Gosling, Samuel D.: From mice to men: what can we learn about personality from animal research? *Psychology Bulletin*. vol. 127, no. 1, pp.45-86, January 2001

[6] Schwind, Valentin et al.: Is there an uncanny valley of virtual animals? A quantitative and qualitative investigation. *International Journal of Human-Computer Studies*. vol 111, pp.49-61, 2018

[7] Falk, John H.: *Identity and the Museum Visitor Experience*, Routledge, New York, 2012

[8] Vazquez-Alvarez Yolanda, Oakley Ian, and Brewster Stephen A.: Auditory display design for exploration in mobile audio-augmented reality. *Personal and Ubiquitous computing*, vol. 16, no. 8, pp.987-999, 2012

[9] Biraud Sophie, Jonchery Anne: *Visiter en famille. Socialisation et médiation des patrimoines*, Documentation Française, Paris, 2016