

3D image and Augmented Reality: symbiosis for digital art

Mona TURKI, teacher-researcher at the Higher Institute of Computer science and Multimedia in
Sfax- Tunisia¹,

¹ Doctor in Sciences and Technology of Design - Tunis- Tunisia, monaturki2022@gmail.com,

Received: 17/09/2022

Accepted: 22/11/2022

Published: 28/12/2022

Abstract:

This research focuses on the improvement of Tunisian cultural heritage using digital art, namely augmented reality technologies and 3D computer graphics. Indeed, 3D image and artificial intelligence are the most important topics among new technologies, especially in the field of historical and cultural preservation.

This article target on the motivation of young UI / UX designers of the Higher Institute of Computer Science and Multimedia in Sfax to create new projects (3D Augmented Reality apps) during the academic year 2020-2021. The aim of this paper is to review the issue of digital art at the service of history and the value of cultural heritage. Indeed, "Tafrouira AR" is an innovative AR application designed with game engine (Unity 3D; Vuforia) and 3D software (3Ds Max).

Keywords: Augmented reality; 3D image; UI / UX Design; application; cultural patrimony;

1. INTRODUCTION

The most significant advancements in emerging technologies during the shift to the digital age are 3D computer graphics and Artificial Intelligence, particularly in the field of patrimony preservation and cultural heritage. While they have been present since the 20th century, Augmented Reality and 3D computer graphics have just recently gained popularity.

Better still, rapid development of new immersive technologies has contributed to preserve and improve patrimony and cultural heritage. In this respect, digital art (such as augmented

reality and 3D computer graphics) can significantly advance the field of heritage enhancement. In that, augmented reality (AR) makes a major contribution to the mediation and enhancement of cultural heritage, a field that is progressively seizing on these technologies in order to offer new entertaining and interactive devices. 3D computer graphics offer several possibilities for juxtaposing 3D reconstructions with the real environment (its appearance in previous years or its metamorphosis in the future, virtual guides, additional information, etc.).

In order to better understand how 3D images might be used to promote cultural heritage, this essay will look at the topic from two different angles. The first one examines how AR technology has progressed to benefit research, UI/UX designers, and the general public (both the design-production community and the reception-use community). The second perspective views 3D image as a source of information and education for the general audience (the reception-use community). In this context, the young UI/UX designers of Higher Institute of Computer Science and Multimedia in Sfax create mobile AR app pertaining towards the value addition of Tunisian patrimony (example: the reconstruction in 3D of the famous rampart and gates in Sfax city).

In this paper, we emphasis on mobile AR app that provide approaches for virtual information (like 3D sceneries and 3D animations) and its community in order to highlight the Tunisian culture and traditions heritage. This application go by the name "تفرورة RA".

In this regard, the purpose of this article is to provide answers to the following important questions:

- ✓ What relationship exists between 3D computer graphics and AR application?
- ✓ What reward does AR see in enhancing Tunisia's cultural heritage?
- ✓ What relevance do 3-dimensional sceneries play in augmented reality applications?

2. Three Dimensions image applied to Augmented Reality

The concept of augmented reality (AR) was originally introduced after Evan Sutherland developed the first HMD in the 1960s (Sutherland, 1968, p.758). Since the 1990s, Tom Caudell and David Mizell (1992) first used the concept of AR to mean Augmented Reality. Indeed, in 1992, Caudell and his research team invented the term "Augmented Reality" to describe the process of overlaying digital (computer-generated) information on the physical environment. Augmented Reality, in general, is a technology that bridges the gap between the digital and physical worlds (Manuri and Sanna, 2016, Uluyol and Sahin, 2016, p.19). In that, according to Olivier Hugues (2011), the goal of augmented reality is to increase perceptions of reality, either by conforming to reality's rules or by transforming reality using imagination.

In this light, writers frequently adopt the strategy of Azuna et al. (1997, 2001) to define the Augmented Reality system. Indeed, Ronald T. Azuna (1997) proposed to define AR as applications verifying the following three properties:

- ✓ The combination of the real and the virtual;
- ✓ Real-time user interaction;
- ✓ The recording of information in three dimensions (3D);

In the light of this study, the definition of the 3D image is understood as a part of the general context of the key ideas relating to the advancements of augmented reality technology. In fact, the many methods and tools of digital art include the immersive technologies of VR, AR, Interactive Art, and Artificial Intelligence. Consequently, digital art refers to any type of art that uses the specificities of digital software's and devices (computers, interfaces and networks, etc.). In this context, the related inventions and innovations are constantly multiplying, as are the possibilities offered by these emerging technologies. The particularity of these 3D computer-generated images is that they allow immersion in virtual worlds of

striking realism. Indeed, the 3D image, which is significant to the three-dimensional image or the 3D computer-generated images, is defined as a synthetic (digital) image represented on the screen in a three-coordinate reference frame (X, Y, Z) giving an illusion of depth and realism.

This 3D image synthesis (three-dimensional computer graphics) is currently used in digital art as much in the film industry (Pixar Studios, Disney, Dreamworks, Blue Sky, Illumination and ILM creation) as in the video game industry (Nintendo, Play Station, etc.) and in the immersive applications industry (AR/VR and Mixed Reality). Indeed, AR is built on an artificial supplement of contextual information that allows the user to perceive their surroundings. The constant development of this AR technology is due to the rapid evolution of technological supports. Indeed, the boom in the market for "smart" objects (smartphones, "smart" tablets, "smart" glasses, etc.), the development of the telecommunications sector and social networks have legitimized the existence of a new reality: Augmented Reality.

Thus, three-dimensional models (figure, image or scene) require a GPU processor and software to reconstitute objects in 3D by modelling (3Ds Max, SolidWorks, SketchUp, Blender, Catia, Cinema 4D, Maya, SolidEdge, Zbrush, Inventor, etc.).

Better still, the last few years have seen the development of new technological hardware at very low cost and with very good performance (smartphone, tablet, video headset, PC with GPU graphics processor, etc.) and the development of software equipment from the new immersive applications and video game industries (3Dsmax, Unity 3D and Vuforia).

3. Preserving Tunisian cultural heritage through AR and 3D images

In recent years, humanity seems to have been experienced the unceasing expansion of Augmented Reality technology and its fields of application. In this sense, the research, sectors and fields of application are infinitely variable. Indeed, the literature on augmented reality

covers a vast field of multidisciplinary research in various domains (architecture, medicine, education, entertainment, tourism, online commerce, industry, marketing, etc.). In this sense, The main mobile AR applications studies that this survey cover is cultural and heritage preservation. In fact, Mobile AR systems are increasingly being tested in rich content environments, as they can enable visualization of unseen valuable and complexed content as well as provide added edutainment-value in today cultural heritage sites. The shift in the traditional economic paradigm that the cultural heritage sector is currently experiencing, along with the increased digitization efforts, make AR interfaces an innovative and ideal way to display both tangible (i.e., objects, static buildings) and intangible (i.e., ceremonies, customs, myths) cultural artifacts.

The field of cultural and heritage preservation soon recognized how Augmented Reality may improve its procedures and is attempting to make benefit of it:

- ✓ Visualization of monuments, objects, coins, sculpture, mosaics partially lost thanks to AR technology;
- ✓ Restitution of an archaeological site (castle, ramparts, troglodyte house, library, etc.);
- ✓ Accompaniment of a subset of museum artwork during programmed visits and engagement with it through the activation of multimedia elements (3D, video, music, etc.);
- ✓ Accompanying a visit with a virtual guide who provides commentary in different languages;

Augmented reality as well as 3D scenes can play an important role in developing a community identity. In this, the young UI / UX designers of the High Institute of Computer Science and Multimedia of Sfax create 3D applications of augmented reality on the enhancement of cultural and heritage preservation under different themes. Indeed, these 3D applications are innovative applications with the Unity 3D software. In That, the designers

learn the principles of this famous software for creating games and applications (design, modelling and implementation) in order to create their own AR projects on PC or mobile. Also, these designers carry out the conception of 3D scenes (modelling, texturing and lighting) on 3D software such as 3ds Max, Blender, Vray, ... etc.

As a doctorate researcher at ISIMS, I am associated with the professional master UI / UX design program, especially the courses and workshops of immersive technologies. So, I am having issues concerning the preservation of Tunisian patrimony and culture heritage through digital art. In this light, young UI/UX designers provide a new dynamic and interactive approach to Tunisian cultural patrimony.

The valorization of Tunisian cultural heritage using digital art technologies (AR and 3D) from the perspective of young Tunisian UI/UX designers is at the center of this research problematic. In that, we find ourselves facing the following problematic questions:

- ✓ What is the connection between augmented reality and 3D images?
- ✓ What is AR's aim towards enhancing Tunisian cultural heritage?
- ✓ What is the significance of 3D sceneries in AR applications?
- ✓ What is the link between 3D reconstruction scenes of Tunisian cultural heritage and augmented reality applications?

In other words, the purpose of this research is to consider the following two hypotheses:

Hypothesis 1: The symbiosis between 3D images of Tunisian cultural heritage and AR technology as demonstrated by the application "تفرورة AR";

Hypothesis 2: The main value of digital art is based on three-dimensional (3D) computer graphics and AR application;

4. "تفرورة AR" : Value of 3D scenes in AR application

The fundamental purpose of Tunisian heritage AR application "تفرورة RA" is to engage the audience with persuasive, innovative and entertaining experiences. Indeed, it is to lead the

spect-actors into numerous vectors of immersive interactions and gripping emotions. In this sense, each application offers, in real time, the possibility to capture cultural knowledge by adding virtual digital content in 3D.

In other words, the aim is to make immersive AR applications more attractive. Better still, it is to be guided towards a sensory approach to the various heritage elements. Consequently, all these elements are taken into consideration in the design of projects to enhance the ramparts of medina of Sfax, the old city. In this respect, we propose an analytical study of mobile AR app : "تفرورة RA". This is to determine the value of 3D scenes in the preservation and enhancement of cultural patrimony.

AR technology brings real added value to the various elements of Tunisian culture and heritage (archaeological site: ramparts and gates of old city of Sfax). The main purpose of AR mobile app "تفرورة RA" is to allow reception-usage community to enrich the common knowledge about the culture of Tunisia. Also, it may bring this community to live a persuasive and engaging experience.



Fig.1. 3D application host interfaces of تفرورة RA , ISIMS, 2021.

In order to create 3D Augmented Reality scenes, young UI/UX designer have to start with the 3D reconstruction of archeological site of old city in Sfax: the rampart and each of the different 8 gates). Each 3D model depends on the original element: an architectural

monument, an object or a human being. In this step, the 3D designer creates the modelling of each element according to the archeological site in Sfax, and then proceed to color, texture and edit in order to obtain a photo-realistic 3D rendering scenes. Thus, this mobile AR app consider these 3D scenes:

- The ramparts of the ancient medina of the Tunisian city Sfax;
- The different doors of Sfax's ramparts;
- Virtual Sfaxien guide;

The modelling is based on two methods: either spline editable and/or poly editable. In the first method, the designer starts by drawing a 2D primitive design, converting it to spline editable in order to draw the overall shape in a second step. Then, he uses the extrude in the edit list to make the 2D shape evolve into a 3D volume. As for the second method, the designer starts by adding 3D primitives, converting them into editable poly in order to draw the global shape (door, stairs, archway, façade, etc.). Then, she uses the different editing panels (edit vertices, edit poly, edit geometry) to obtain the final model. Then, she employs the Material Editor and the Material / Map Browser to add faithful materials to each 3D object (gold, silver, pearl, precious stones, stone, wood, copper, etc.). Finally, she switches to the realistic 3D synthesis technique of virtual images to get a final rendering preview.

- The ramparts of old city in Sfax;

Sfax's ramparts are 2 kilometres long and enclose the rectangular Medina 600 metres east to west and 400 metres north to south. They were built from quarry stones secured with lime mortar and funded by "Ali ibn Aslam al-Bakri", the qadi of Sfax at the time. Shelly sandstone ashlar create the corners and vertical ties, with the stones alternately placed horizontally and against the grain. Round billets of olive, grape, and Thuya wood are embedded in the brickwork between the stone links. There are 69 towers flanking the ramparts. The semi-

circular towers are among the most ancient. In addition, there are oblong and hexagonal towers (with cut-off corners).

The oblong towers' sides are not equilateral, generating irregular hexagons or octagons. The four corner towers are so big because they function as buttresses and control points. The “Burj al-Qsar” is located to the northwest, the “Kasbah” is located to the southwest, the “Burj al-Nar” is located to the southeast, the “Burj al-Qsar” is located to the northwest, and the “Burj Mas'uda” is located to the northeast. The parapets of the towers and the walls in between are topped with split, pointed crenellations formed like gothic arches.

The interior was accessed by two gates: “Bab Diwan” to the south, which overlooked the sea, and “Bab al-Jebli” to the north, which opened onto the hinterland. The settlement was defended by double doors in each.

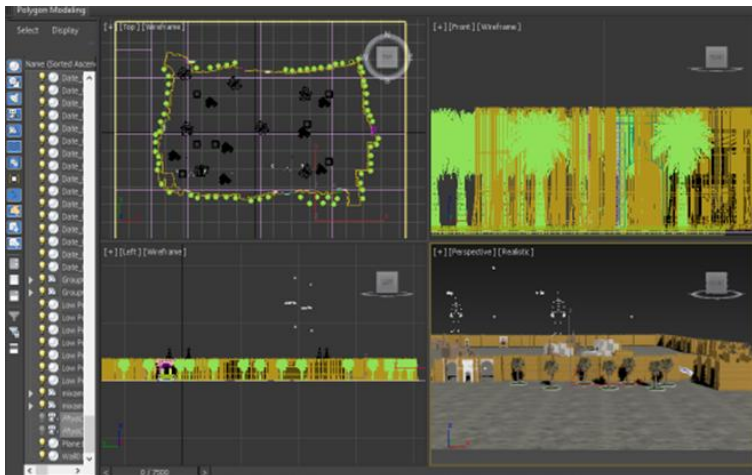


Fig.2. Modelling and texturing of the ramparts of the medina of Sfax (3ds Max), Mabrouk, 2021.

- **Sfax's ramparts gate : Bab al-Jebli**

“Bab al-Jebli” is the second gate to the old city of Sfax, and is located in the middle of the northern wall between “Bab Nahj El Bey” and “Bab El Jadid”. This gate was built with the construction of the old city towers of Sfax in the middle of the 9th century AD. “Bab al-Jebli” and part of the wall were damaged as a result of the war waged by his brother, “Sultan Abu

Faris Abdelaziz Ali”, who was the governor of Sfax at that time. “Sultan Abu Faris” besieged the city and arrested his brother. The gate knew of his most important reforms at the beginning of Muharram in the year 823 A.H. during the reign of “Sultan Abu Faris Abd al-Aziz”, nicknamed “Abd al-Aziz al-Hafsi”. It was also renovated in 1170 AH during the reign of Prince “Muhammad bin Hussein Bey”, and the door was rebuilt in its old place during the reign of Prince “Husseini Hamouda Pasha” in 1224 AH.

The door consists of two opposite openings connected to a shed used to house the guards, and directly above it is a military fortress called “Bab al-Jebli tower”. Each opening is closed by thick wooden doors armored with iron, which is the inner door overlooking the painters market and the outer door overlooking the markets of “Bab al-Jebli”.

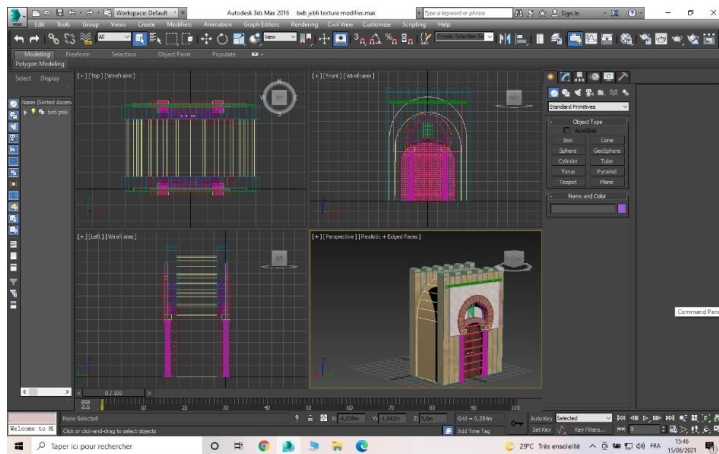


Fig.3. Modelling and texturing of Bab al-Jebli, Mabrouk, 2021.

- **Sfax’s ramparts gate : Bab al-Diwan**

“Bab al-Diwan” or “Bab al-Bahr” is considered the first gate of the ancient city of Sfax. It is located in the middle of the southern wall, dating back to the era of building the wall (between 234 AH and 236 AH). The current appearance of “Bab Al-Bahr” dates back to the seventies of the twentieth century. “Bab al-Bahr” is also called “Bab al-Diwan”, and it is more likely that it was called by this name in the Hafsid era.

"Bab al-Bahr" consisted of two doors: An external door, which is the last door to the west. An inner door, which is facing the old mosque inside the old city. To get inside the city, you must enter through the outer door and pass through two sheds, the first extending from the east and the second. It seems that the shops that are now inside the two sheds were originally strongholds of soldiers.

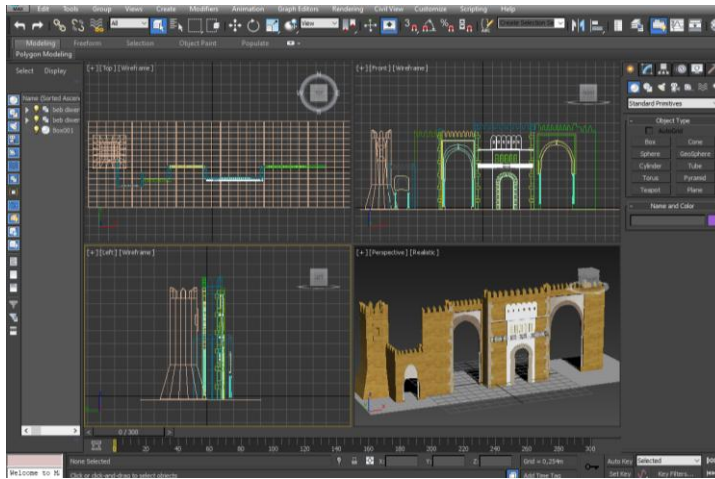


Fig.4. Modelling and texturing of Bab al- Diwan, Mabrouk, 2021.

- Virtual Sfaxien guide;

To realize an interactive visit in 3D, the UI/ UX designer must create the modelling of the virtual guide.

She chooses 3Ds Max to carry out the ringing or "skeletonization" of the character "عم منصور", the coloring, the texturing, the addition of hair and the animation in order to obtain the photo-realistic 3D rendering. In this case, the designer may opt for animated characters on the Free 3D platform, then proceeds to the modification according to the needs. So, when it comes to the Sfaxien character "عم منصور", he wears traditional male clothes ("chachya", "jebba" and "sarouel"). Then, to make the animation of the 3D character, the designer chooses Mixamo to simulate the gesture of greeting according to the customs of Sfax city.



Fig.5. Modelling of the virtual guide and coloring on 3ds Max, Mabrouk, 2021.

The technology of our mobile AR application "تفروية RA" is marker – based Augmented Reality application. The operation is relatively simple, the application films the environment in order to detect image markers and locates the 3D positioning of 3D models (ramparts, gate, virtual guide, Pop Up text).

This type of AR technology, also known as recognition-based AR or image recognition, relies on identification of markers/user-defined images to function. An augmentation in marker-based AR must be activated by a marker. Markers are distinct patterns that cameras can easily recognize and process, and are visually independent of the environment around them; they can be paper-based or physical objects that exist in the real world. Marker-based AR operates by scanning a marker, which causes the emergence of an augmented experience (which might be an item, text, video, or animation) on the device. Generally, an app is required, which gives users the ability to scan markers from their device using the camera feed.



Fig.6. Graphical interfaces (image targets) of 3D AR applications “RA تفرورة”, 2021.

Indeed, image Targets refer to 2 D images which Vuforia Engine can easily recognize and track. In fact, we use full color images as image Targets. In that, it works in a similar way to QR codes: mention to the app where it should display a given virtual information (3D object, 3D animation, etc.). According to Vuforia Developer Library, the basic workflow for working with Image Targets is as follows: First, the UI/UX designer upload the image to the Vuforia Target Manager online. He can also use one of the sample Image Targets. Second step, he downloads the updated Target Manager Database. Third step, he Add the image target to your project in Unity : Add the Device Database then add and configure the Image Target as a GameObject (Add an ARCamera ; Add an ImageTarget ; Assign Content to the ImageTarget). In that, once the image Target is spotted by the camera, the visitor is able to instantiate the different 3D objects that offer information about archeological site (ramparts and gates of ancient medina in Sfax).

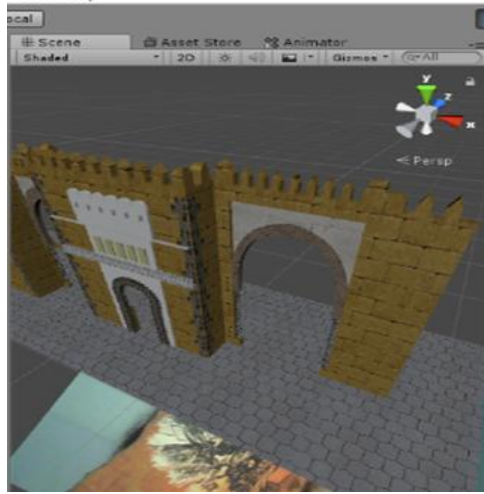


Fig.7. Examples of augmented reality scenes on Unity 3D software, 2021-2022

CONCLUSION

This study focuses on the two new technologies of augmented reality (AR) and 3D images in the context of enhancing the heritage of Tunisian cultural patrimony. Indeed, Tunisia is taking part of a universal trend of producing projects of new immersive technologies on all types of playful supports (PC, mobile, "smart" tablet, VR headset, AR headset, etc.). ISIMS participates in this new trend by teaching a variety of courses for various academic levels (professional master's degree or basic degree), including Augmented Reality and Virtual Reality, Immersive Environment, Virtual Sets, and Augmented Reality Workshop, as well as through national and international cooperation projects run by the Agency for the Enhancement of Heritage and Cultural Promotion in Tunisia. In this article, we have been able to answer the different hypotheses advocated by the study. In a first perspective, we note the value of the interrelation between 3D images specific to Tunisian cultural heritage and mobile AR app: "تفرورة RA". This is made possible through the specificities of digital art technologies (3D modelling and texturing, marker – based Augmented Reality, UI design of the application, UX design of mobile AR app, etc.).

In this way, this process allows several objectives to be achieved: Reconstructing the past history of some elements of Tunisian patrimony; reinforcing the attractiveness of Tunisian archaeological site in Sfax; reinforcing the attractiveness of each object or element of old city of Sfax (historical specificities of the old rampart; material of the different gates); developing a pedagogical tool for the new generation to understand the particularities of Arab culture in Tunisia; improving the user experience of this mobile AR app, etc. Indeed, this mobile application concern the new approach of e-tourism, which specifically uses new immersive technologies (marker-based AR technology).

In a second perspective, we determine the main foundations of digital art (mobile AR app) based on three-dimensional (3D) computer graphics. Indeed, the particularity of these 3D computer graphics is that they allow an immersion in virtual worlds of a striking realism. In fact, the 3D designer builds a reconstruction in three-dimensional for the old ramparts as well as for the gates. More, she creates a virtual guide (Sfaxien character) like her imagination. Consequently, AR relies on an artificial complement of contextual information, especially 3D scenes. In that, user may apprehend the immersive environment that surrounds him. In this sense, "Tafroura AR" is based on the main 3D scenes of the ramparts and gates of the ancient medina in Sfax and the virtual Sfaxien guide. The intention is to enable the striking operation of the different scenes of Augmented Reality.

To conclude, "Tafroura AR", this mobile AR app is an ultimate example of symbiosis between technologies of digital art: 3D image and Augmented Reality.

5. Bibliography List :

1. Books :

Sutherland, Evan. (1968) A head-mounted three-dimensional display. In Proc. Fall Joint Computer Conf., pp. 757– 764, Washington, DC, Thompson Book;

2. Theses:

Hugues, Olivier. (2011), *Réalité augmentée pour l'aide à la navigation maritime*. PhD thesis. University of Bordeaux I. supervised by Pascal Guitton;

3. Journal article :

Caudell, Thomas P. & Mizell, David W. (1992). Augmented reality: an application of heads-up display technology to manual manufacturing processes. Material Science. System Sciences. Proceedings of the Twenty-Fifth Hawaii International Conference on. vol. II. Retrieved from <https://www.semanticscholar.org/paper/Augmented-reality%3A-an-application-of-heads-up-to-Caudell-Mizell> (Accessed March, 12 2022);

Milgram, P. Kishino , F. (1994) . A Taxonomy of Mixed Reality Visual Displays. (pp. 1321-1329). *IEICE Transactions on Information and Systems*. vol. E77-D. Retrieved from https://www.researchgate.net/publication/231514051_A_Taxonomy_of_Mixed_Reality_Visual_Displays (Accessed March, 5 2021);

Manuri, F., & Sanna, A. (2016). A survey on applications of augmented reality. (pp.18-27). *Advances in Computer Science: an International Journal*, 5(1). Retrieved from <http://www.acsij.org/acsij/article/view/400> (Accessed March, 10 2021);

Azuma, R.T. Baillot, Y. Behringer, R Feiner, S. Julier, S. and MacIntyre, B. (2001). "Recent advances in augmented reality," *IEEE Computer Graphics and Applications*, vol. 21, no. 6, (pp. 34-47) Retrieved from https://www.researchgate.net/publication/3208983_Recent_advances_in_augmented_reality_IEEE_Comput_Graphics_Appl (Accessed March, 15 2021);

4. Internet websites:

<https://www.mixamo.com/#/> (consulted on 30 May 2022);

[https://ms-kb.msdl.unimelb.edu.au/next-lab/augmented-reality/guides/unity-and-](https://ms-kb.msdl.unimelb.edu.au/next-lab/augmented-reality/guides/unity-and-vuforia-1/2d-targets)

[vuforia-1/2d-targets](https://ms-kb.msdl.unimelb.edu.au/next-lab/augmented-reality/guides/unity-and-vuforia-1/2d-targets) (consulted on 14 September 2022);