

IMMERSIVE PRESENTATION TECHNOLOGIES: XR (AR, VR, MR) OF CULTURAL HERITAGE IN THE CITY OF VARNA, BULGARIA

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Abstract: *The presented 3 case studies for XR (Extended Reality) solutions were developed by Architectural Spies EOOD in 2021 for visualization the condition before and after the renovation of the cultural heritage building at 28, Dragoman Str., Varna, Bulgaria. The solutions include mobile AR (Augmented Reality) for Android smartphone, VR (Virtual Reality) for VR boxes with Android smartphone, and MR (Mixed Reality) holograms with Microsoft HoloLens 2. They are preparations for XR demonstrations in the frames of the H2020 project BIM-SPEED, scheduled for the autumn of 2022 in Varna.*

Key words: XR,AR,VR,MR, Extended Reality, Augmented Reality, Virtual Reality, Mixed Reality, Unity, CAD, BIM, FLIR, CH, Cultural Heritage, Photogrammetry, Thermo-photogrammetry

The cultural heritage building at the corner of the Dragoman and Bdin streets in the center of the city of Varna is one of the two Bulgarian demo sites, included in the H2020 project BIM-SPEED (Harmonized Building Information Speedway for Energy-Efficient Renovation) for AR/VR demonstrations [5],[10].

The building, cultural heritage, was designed in 1912 by the architect-engineer Joseph Hadzhistoyanov for the wholesaler Vasil Kojuharov [6], [9].

The XR visualizations could be used for presenting surveys, done in different time periods, variants of the projects for renovation, as well during or after the renovation activities could be shown retrospectively the past condition of the same buildings.

The illustration at (Fig.1) is a collage, an example from the GDD (Game Design Document), planning the mobile AR before developing the application. There are two variants of this cadre: the primary cadre showing on the screen the planned renovation at the real background of the building before the renovation, and the secondary with the old view, shown by the smartphone at the real background of the renovated building. Other planned features that could be shown, are different details from the renovation (Fig.2), or different types of models (BIM [5]; photogrammetric [6],[7],[8]; 3D CAD with thermal texturing, using the 2D thermal scans [1],[2],[3]; thermo-photogrammetric, produced from the both components of a thermo-visual FLIR camera [1],[2],[4]).



Fig.1 Showing the past condition by mobile AR

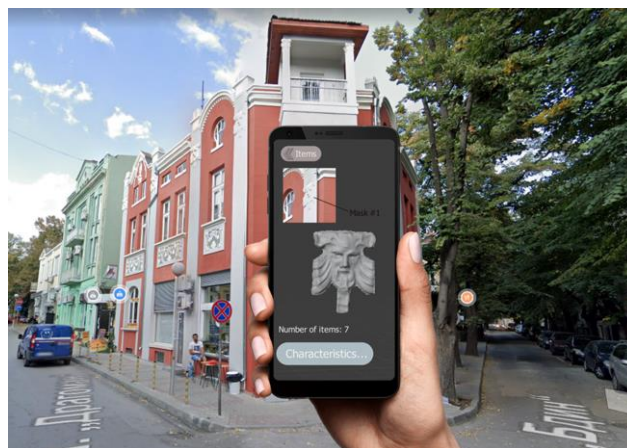


Fig.2 Showing a detail from the renovation by mobile AR

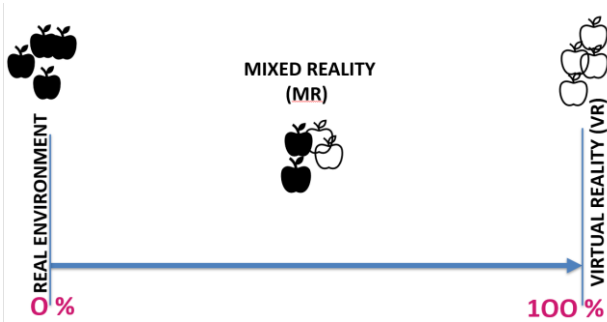


Fig.3 Reality, Virtual Reality (VR), and Mixed Reality (MR)

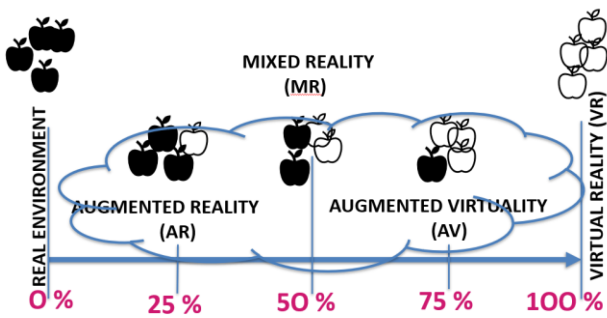


Fig.4 Augmented Reality (AR) and Augmented Virtuality (AV)

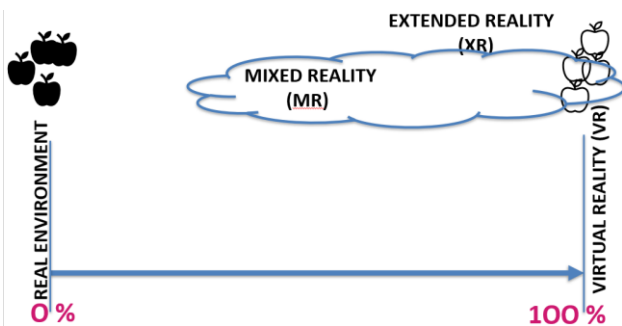


Fig.5 Mixed Reality (MR) and Extended Reality (XR)

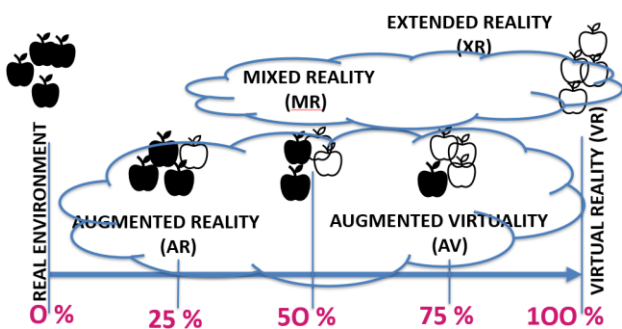


Fig.6 Full scheme of the Extended Reality (XR)



Fig.7 Comparison of the facades of the building before and after renovation (cultural heritage project nomination 2019)

There are different ways for demonstrate the differences before and after the renovation. For example (Fig.7) shows the panels from the exhibition at the biennial in Constanta (Romania) of projects from Romania, Bulgaria, and Moldova, where the Bulgarian project of N.Stamatova and M.Hlebarova was nominated for a renovation of cultural heritage. (Fig.1), (Fig.8), and (Fig.10) provide the same information, comparing the old and the new facades by the means of the Augmented Reality.

What is behind the abbreviations AR, AV, MR, VR, and XR ? The scheme on (Fig.3) visually explains the place of the Mixed Reality (MR) between the real world and the fully virtual world. The scheme at (Fig.4) shows the “slider” from 0% to 100% and the fields of the Augmented Reality (AR) and the Augmented Virtuality (AV). The meaning of the Extended Reality (XR) as an umbrella covering the Mixed Reality (MR) and the Virtual Reality (VR), is illustrated on (Fig.5). The full picture of the interconnections between the AR, AV, VR, MR, and XR could be seen at the scheme on (Fig.6). The work of Architectural Spies in 2021 on the BIM-SPEED demonstration site in Varna was testing three XR technologies. The first case study was a mobile AR, the second one was a VR with an Android smartphone in a VR box, and the third one was MR holograms.



Fig.8 Mobile AR of 3D photogrammetric model of the building before the renovation



Fig.10 Mobile AR of 3D photogrammetric model of the building before the renovation



Fig.9 Mobile AR of the BIM model, textured by the 2D thermal scans from the thermal surveys



Fig.11 Mobile AR of a section of the BIM model of the building (virtually removed façade)

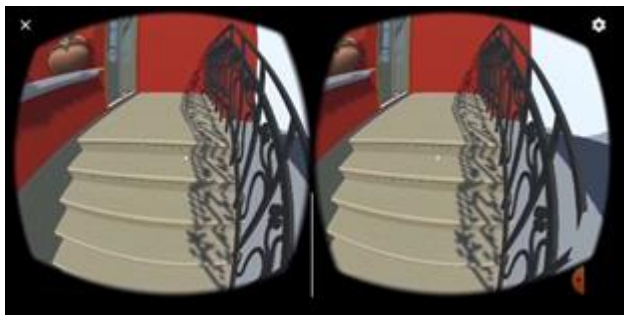


Fig.10 VR with an Android smartphone in a VR box



Fig.14 VR with an Android smartphone in a VR box

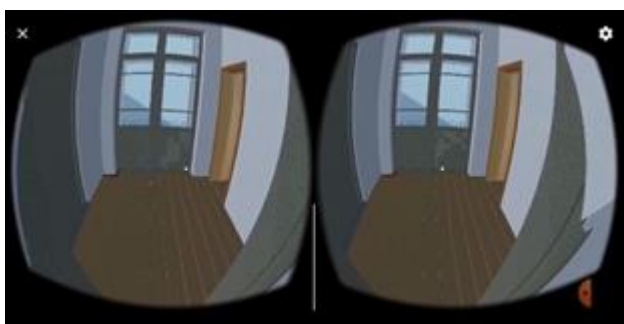


Fig.11 VR with an Android smartphone in a VR box



Fig.15 VR with an Android smartphone in a VR box

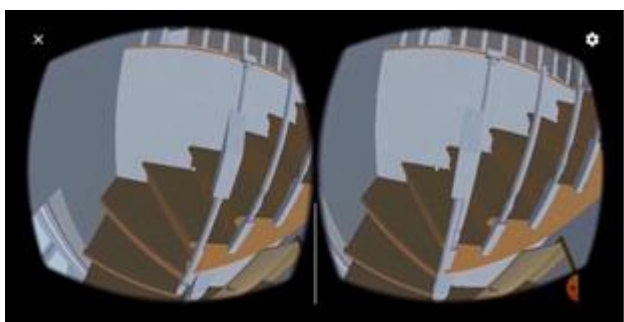


Fig.12 VR with an Android smartphone in a VR box

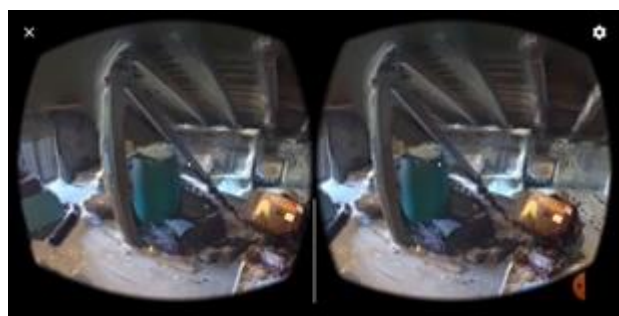


Fig.16 VR with an Android smartphone in a VR box

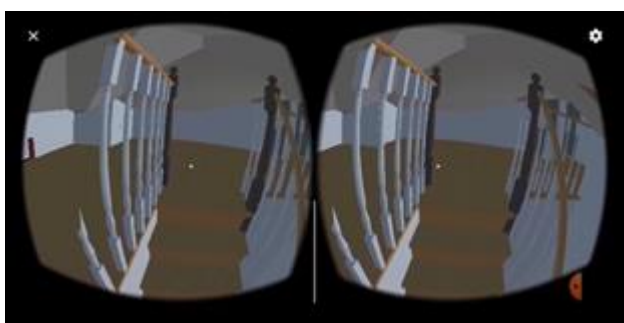


Fig.13 VR with an Android smartphone in a VR box



Fig.17 VR with an Android smartphone in a VR box



Fig.18 MR hologram of a scaled photogrammetric model of the building before the renovation



Fig.19 MR hologram of a scaled BIM model of the building after the renovation



Fig.20 MR hologram of a scaled BIM model, textured with the 2D thermal scans from a survey with a thermo-visional FLIR camera

The tests, shown in the first case study (mobile AR at (Fig.8)-(Fig.11)) and the second case study (VR with a smartphone in a VR box at (Fig.10)-(Fig.17)) were done by a comparatively cheap Android device model Samsung A20. The BIM models of the building before and after the renovation [5], as well the 3D models produced by photogrammetry from terrestrial and aerial photos and videos [6],[7],[8],[9], and the 3D models, textured with the 2D thermal scans [1],[2],[3], were imported to the game engine Unity. For the recognition of the AR target (the existing building on-site) was used Vuforia. An interesting solution for the produced application for smartphones in VR boxes was the especially written for this case study C# script for Unity, giving the opportunity of changing the variants for observing. The view changes automatically after focusing the sight for some seconds. It was necessary because of the lack of controllers for the cheapest VR boxes.

The above shown models were used for the case study of producing holograms for Mixed Reality device Microsoft HoloLens 2. (Fig.18) shows a scaled hologram of the photogrammetric model of the building before the renovation, and (Fig. 19) the BIM model after the renovation. (Fig.20) shows a scaled BIM model, textured with the 2D thermal scans from a survey with a thermo-visional FLIR camera.

Here is the place to mention the most important of the specific technological features of the Mixed Reality. In spite that this term theoretically relates to the all XR production, shown between the 0% and 100% of the “slider”, illustrated at (Fig.3), in the practical work it is used when the technology permits the so called “occlusion”, i.e. when the hologram could be placed on a position between the really existing objects. The AR technology is simpler, and the activated images always appear on the screen of the device at front of the real environment. Microsoft HoloLens 2 permits parallel monitoring of the MR demonstration from another device (Fig.21), (Fig.22).



Fig.21 View from Microsoft HoloLens 2 on a MR hologram of a scaled BIM model, and the parallel monitoring on a desktop



Fig.22 View from Microsoft HoloLens on a MR hologram in the moment of opening the roof and the parallel monitoring on a desktop

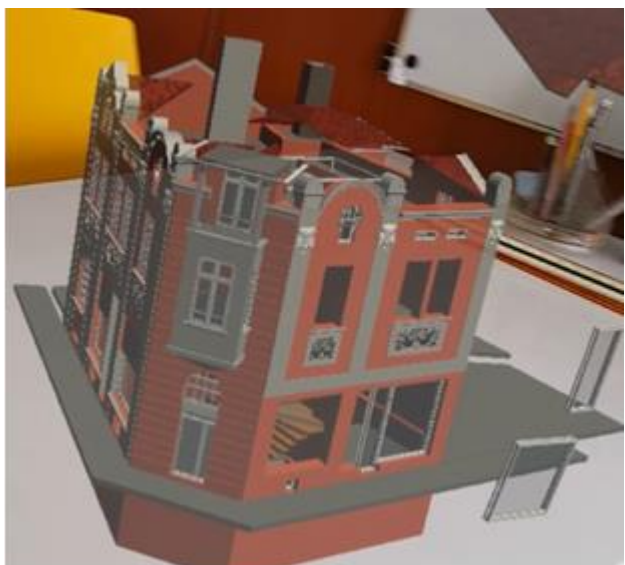


Fig.23 View from Microsoft HoloLens 2 on a MR hologram of a scaled BIM model

As it is shown on (Fig.22) - (Fig.26), the MR technology could show not only static holograms of 3D models, but different kinds of actions with them. In our third case study, was tested moving of different elements of the building, for example doors and windows (Fig.23), (Fig.25), walls, floors, or roof (Fig.22), (Fig.24).

Another interesting content was tested in the frames of the third case study: changing the scale from a scaled hologram (Fig.19), (Fig.21) – (Fig.25) to an interior view in real scale 1:1 (Fig.27),(Fig.28),(Fig.29). All these views from the interior of the attic's floor of the building on 28, Dragoman Str., were visible by Microsoft HoloLens 2. This is the same photogrammetric model of the interior, produced with iPhone 12 Pro, shown at the VR on (Fig.14) – (Fig.17). The feeling is a realistic presence in the space of the attic's floor, especially if the transparency of the device (Microsoft HoloLens 2) is regulated to its minimum level, i.e. like "teleporting" from our studio to the real building. It provoked a discussion on the XR terminology: the visual experience with HoloLens with minimum transparency is still Mixed Reality, or it should be considered a Virtual Reality, because all the view from the surrounding real environment is hidden. In other words, Microsoft HoloLens 2 could be used for showing the same objects, shown by VR devices without suffering by the dizziness, caused by most of the VR devices.



Fig.24 View from Microsoft HoloLens 2 on an action in the MR space



Fig.27 View of a photogrammetric model in scale 1:1 by Microsoft HoloLens 2

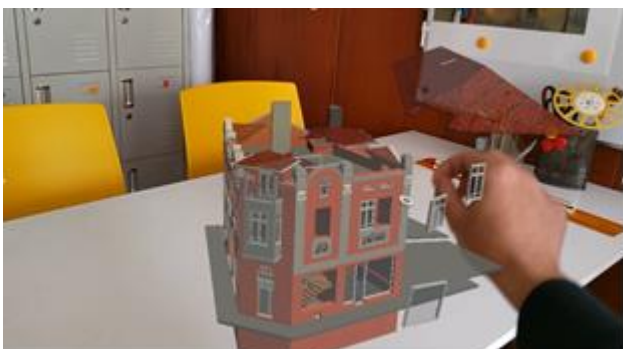


Fig.25 View from Microsoft HoloLens 2 on an action in the MR space

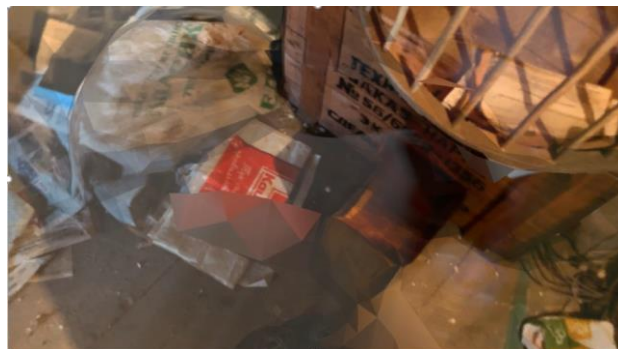


Fig.28 View of a photogrammetric model in scale 1:1 by Microsoft HoloLens 2



Fig.26 View from Microsoft HoloLens 2 on an action in the MR space



Fig.29 View of a photogrammetric model in scale 1:1 by Microsoft HoloLens 2

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