CASE STUDY: DEMONSTRATION OF A REAL SCALE HOLOGRAM OF A REMOTE LARGE SCALE OBJECT AT THE SPACE OF ANOTHER LARGE SCALE OBJECT VIA MIXED REALITY APPLICATION BY DEVICE MICROSOFT HOLOLENS 2

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Abstract: *The case study is a demonstration of the project for renovation of a remote large scale object (the municipal dormitory in Malko Tarnovo, Bulgaria, that is a demonstration site of H2020 project BIM-SPEED) into the space of another large scale object (the building of the Scientific and Technical Unions – Varna, where are the offices of the BIM-SPEED partner Architectural Spies) via the most powerful device for mixed reality Microsoft HoloLens 2.*

Key words: *MR, Mixed Reality, XR, Extended Reality, AR, Augmented Reality, VR, Virtual Reality, Microsoft HoloLens 2, HoloLens, BIM, Building Information Modeling, Building Information Modelling*

What is the best way to visualize a project for renovation of a building? In the past century it would be a physical mockup, after the 1990’s we would expect two-dimensional views and videos from virtual 3D models, and nowadays we have choice between the different types of extended reality. Each of them has their advantages and disadvantages. The relationship between the AR, AV, VR, MR, and XR as an umbrella on all of them, was explained in our other publication [1]. This case study relates to a specific method in demonstration by the means of MR, which the authors believe has not been resolved so far this way.

Till now the team of Architectural Spies has created VR and AR applications for demonstrating the variants of renovations of the two Bulgarian demonstration sites of the H2020 project BIM-SPEED, as well their BIM, photogrammetric, and thermo-photogrammetric models [2], [3], [4], [5].

Fig.1 Our device Microsoft HoloLens 2 [6]

The case study about exploring in scale 1:1 the projectfor renovation of the municipal dormitory of Malko Tarnovo (fig.2), (fig.3) via visualizing it into the space of the building of the Scientific and Technical Unions in Varna (NTS) (fig.4) is based on one developed by our team 3 methods for visualization of the architectural situation via the high-end MR device: Microsoft HoloLens 2 (fig.1), [7].

Fig.2 Dormitory in M.Tarnovo – S/E view

Fig.3 Dormitory in M.Tarnovo – S/W view

Fig.4 The building of the Scientific and Technical Unions – Varna (NTS), West view

a) Demonstrations of holograms in small scales

Our team tested holograms of different kinds of models (BIM (fig.5), photogrammetric, thermo- photogrammetric, CAD model textured with thermal scans (fig.6)) in small scale. The illustrations present views from HoloLens 2 of holograms of the dormitory, as tested in the office of Architectural Spies.

Fig.5 Hologram of the BIM of the renovation project of the dormitory

Fig.6 Hologram of CAD model, textured with thermal scans of the existing condition

b) On-site demonstration in scale 1:1

With a preselected starting position on both the virtual environment (hologram) and the physical building, our team works on the demonstration of the renovation project on-site, fitting it to the real building. During the walking in the real, but not yet renovated demonstration site, the user could observe and analyse the project for renovation. Observing the realistic 3D model outside and inside in scale 1:1 is impressive and effective with the opportunity to obtain realistic sense for the space and comparing the existing condition to the new design.

The on-site demonstrations in scale 1:1 also are possible to be used in reverse: after finalizing the renovation, while walking in the completely renovated building the user could observe the past condition of the building, its BIM model for the condition before the renovation and also its photogrammetric model (fig.7) and thermo- photogrammetric models in different seasons.

Fig.7 Photogrammetric model of the dining room of the dormitory before the renovation

c) Demonstration in scale 1:1 at another location

This example shows a MR demonstration of the project for renovation of the dormitory in Malko Tarnovo, using as a hosting place for demonstration the building of the Scientific and Technical Unions (NTS) in Varna, where the office of Architectural Spies is located. The two buildings are physically separated by about 300 km. What helped our team for this experiment, was the similar planning scheme of both buildings – the real one in Varna and the demonstrated hologram of the building in Malko Tarnovo. Both are based on corridor scheme (fig.16), both are on same planning axes 3.60 m (fig.16), the staircases of the both are on clockwise direction (fig. 12, 13, 14, 15).

Fig.8 The building in Varna, East view

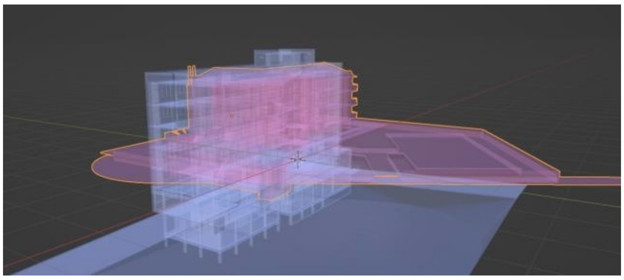

Fig.9 Intersection of the real building (in blue) and the demonstrated building (in pink)

Fig.10 Starting point on 5th floor in the real building

Fig. 11 Preliminary test with not fitted starting point and 100% transparency

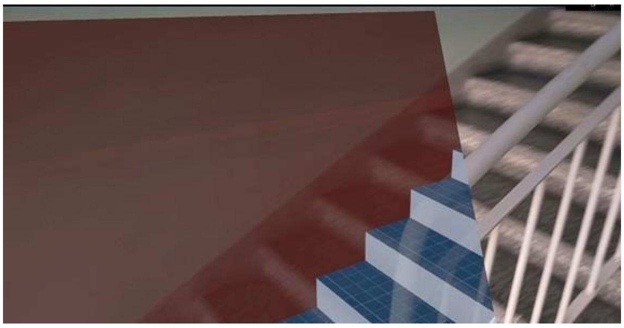

Fig.12 First MR test for fitting the staircases

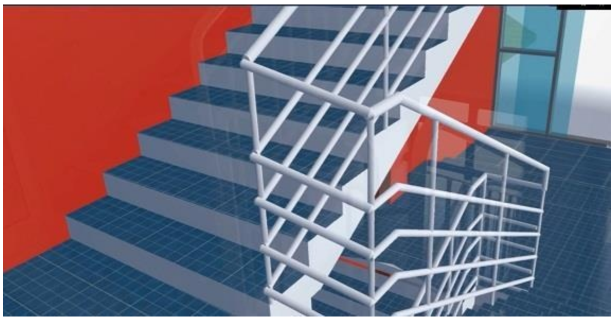

Fig.13 Hologram of the staircase hosted by the real staircase, with low transparency

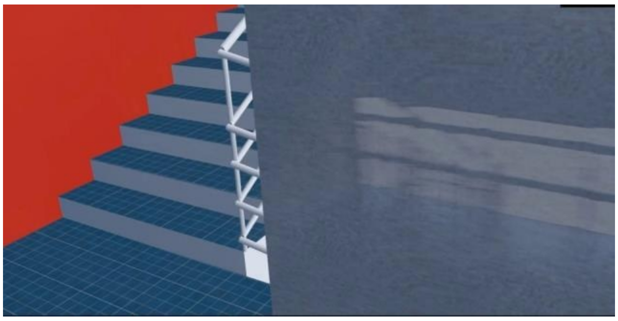

Fig.14 Regulating the transparency (right: real landing, left hologram)

Fig.15 Staircase of the dormitory in Malko Tarnovo

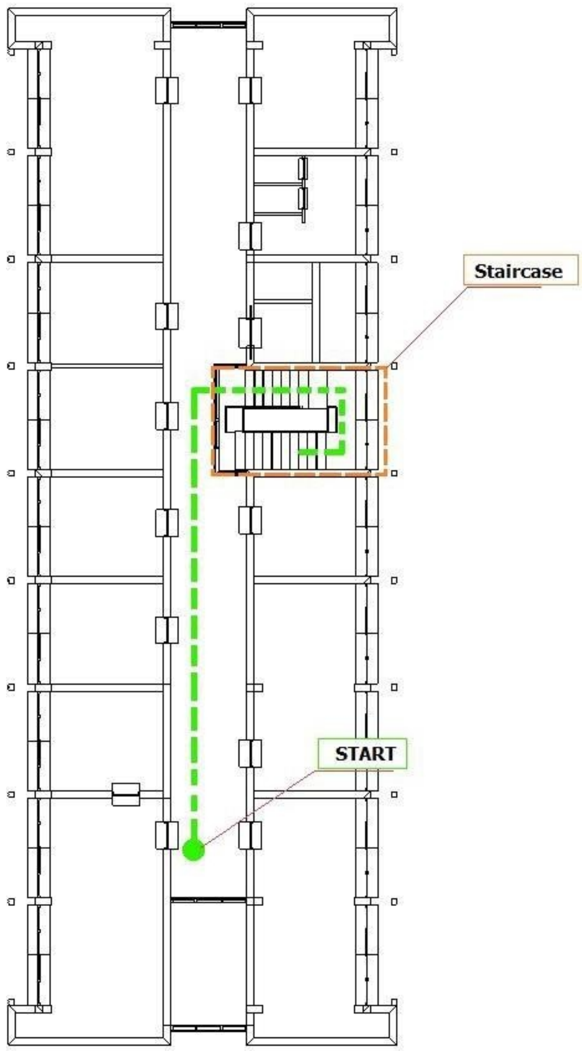

Fig.16 Route, starting on fl.5 in the real building, hosting the fl.1 of the hologram

There are some differences between both buildings, resulting in the hologram not perfectly fitting to the hosting space. The first one is the different height of the floors. The floors of the real building in Varna are higher than the floors of the dormitory in Malko Tarnovo. The result is the feeling of the user that that his body becomes higher after stepping on the landing of the upper floor due to the higher point of view (fig.17). This effect could be corrected via adding a regulating function in the application.

Another negative effect, coming from the imperfect fitting of both staircases, reflects on the distances of both corridors (the real one and the unreal one) from the staircase landings (the real one and the unreal one). In our case the user would be able to move in a pathway about 1 m wide, common for both corridors (the real one and the unreal one).

Fig.17 On left: 6th floor of the real building, on right: hologram of the 2nd floor of the demo building (both points of view don’t fit)

Fig.18 Hologram of the dining room of the dormitory at 1st floor, hosted at 5th floor of the real building

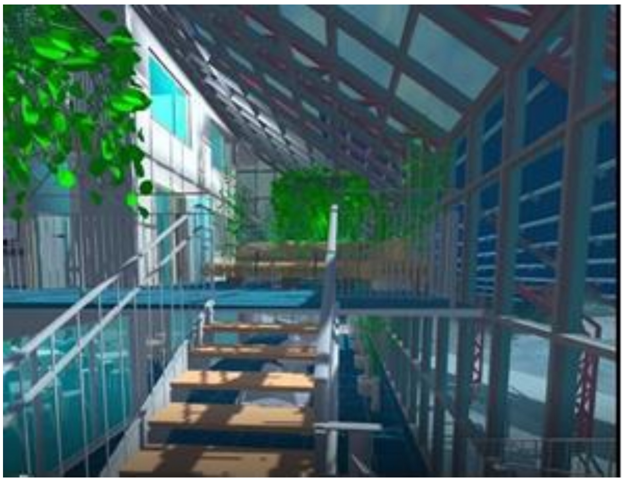

Fig.19 The sunspace (glassed lobby)

The route of the mixed reality walk started in the end of the corridor of the 5th floor of the real building in Varna (fig.16), hosting the hologram of the 1st floor of the dormitory. The walk of the user starts in the so called sunspace, designed on the 1st floor as a glassed lobby on the place of the former opened terrace of the not- renovated dormitory (fig.19), then passing through the renovated dining room (fig.18), passing through the corridor across the reception desk, climbing by the staircase (fig.12,13,14), turning back on the corridor of the 2nd floor (fig17), going across the pass way with vending machines (fig.20), and finalize the walk in the glassed lobby on its balcony (emporia) (fig.21,22,23,24). If he continues, the application offers 2 variants: with and without gravity. If use gravity variant, the user teleports to the first floor in the same glassed lobby. If he excludes the gravity, he could levitate and approach the details of the metal structure of the glassed roof or levitate outside and approach the exterior of the unreal building, from a distance that permits the space of the real building.

Fig. 20 Hologram of the pass way with vending machines, 2nd floor

Fig.21 Hologram of the balcony in the sunspace

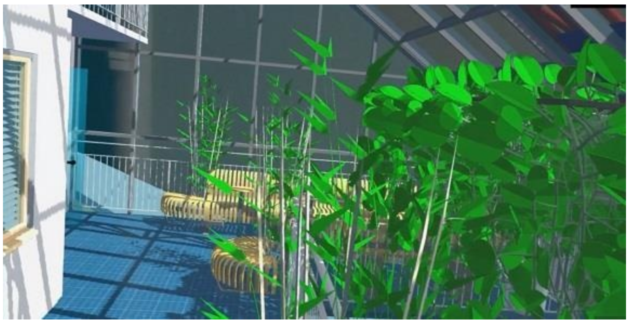

Fig. 22 Walk on the balcony (hologram)

Fig. 23 Walk on the balcony (hologram)

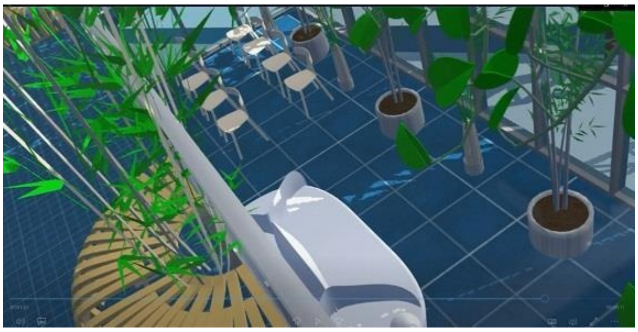

Fig.24 View from the balcony to the 1st level of the sunspace (hologram)

The conclusion is that if the interior spaces of two buildings are similar, the space of the real one could be used for hosting the hologram of the other in scale 1:1 and the user to walk inside the real building, obtaining visual information about the other building. In this case study the corridor is a match, and so is the staircase which allows us to explore two (or more) floors of the building, interact with the NPCs or avatars inside and explore the situation just as we would, when we are on site.

The real building is significantly larger than the demo site and thus we start at a measured distance from the staircase. The staircase which is almost identical in both buildings is our zeroing point and with that we are able to walk inside the next floors of our demo site. In this case study we did a test for 2 floors, but the method could be applied for many levels and used for buildings and other facilities to be spatially explored by the user. For example, a safe scaffolder at the construction site could be used for obtaining real impression about the future building or facility.

The holograms in MR are semi-transparent, and the transparency could be regulated by the user. Also, when the user moves his head around in a quick way he could get glimpse of what the real world is without the added hologram. That’s seen on (fig. 12,18). It’s also a good example as to how the corridor matches the path inside the virtual environment.

There are a few simple ways to zero the hologram onto the real world. One is with the use recognizable symbol (like QR code) that is static in the real world. Another variant is to mark the starting point (for example by a sticker) where to stand when starting the software. With that however inaccuracy may vary from session to session having a difference of half a step may not necessarily be that much of a factor. This of course only applies to the use of a substitute building or an open field to view the project. If we are at the site and we need to apply the former or future look on the interior, the accuracy needs to be much higher. There is a whole list of downsides when using MR on the actual demo site, starting with the need to travel to the location, higher accuracy demand, the higher accuracy can lead to higher level of trust into the virtual environment, which can lead to dismissing a real hole in the floor or wall and causing an accident and so on.

Using a different local site as a substitute removes the need for travel, can provide the same experience of walking up and down on stairs if correctly planned and can be sufficient for the immersion. What’s more by using our office building instead of the demo site any visual changes required by the client could be done much faster during his visit, while as on site the situation would be a lot more difficult.

The team of Architectural Spies doesn’t have information about any similar case study for using Microsoft HoloLens 2 in the AEC industry. It could be considered an original approach in the frames of the project Harmonised Building Information Speedway for Energy-Efficient Renovation - BIM-SPEED [8]. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.820553.

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