AUGMENTED ENVIRONMENTS

The Architecture for the Augmented Era

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Abstract. Human imagination has played with the idea of an alternative technological world for years. From dystopian proposals like Neuromancer or The Matrix to more positive views like the recent Upload series, the exploration of the friction between the digital world and the physical world has entertained the imagination of our society for decades. Outside the fictional environments, the omnipresence of the internet and the development of "the cloud" are showing that the virtual world is possible and that the idea of a Metaverse is no longer part of science fiction but a very real future for human relations (Winters 2021). In line with the idea of the Metaverse, the intersection of the virtual and the physical world is being explored through the idea of Extended Realities. Technology is allowing humans to enhance their capabilities more than ever, and in fact, it has been proposed that we are entering the Augmented era (King 2014). This paper explores the opportunities and possible challenges that "Extended Architecture" has by analyzing a research project based on augmented reality as the media to explore these ideas. This project will propose a speculative approach to how the fact that in the recent future, everyone will have access to an AR device will change the way we perceive and understand our architectural environment.

Keywords. Work in progress, Virtual and Augmented Environments, Disruptive Modes of Practice and Pedagogy, Extended Realities, Machine Learning.

1. Introduction

Although accurate, Baudrillard's idea of Hyper-Reality, in fact, can seem naive today if we analyze the evolution of society influenced by the current state of Mass Media, Social Networks, and the Internet (Baudrillard 1981). Simulation in our society is more prevalent than ever, and concepts like Instagram filters and "fake news" are making it almost impossible to separate reality and the "simulation" anymore. The shift toward a dystopian Hyper-Real future seems like a real possibility, whereas Keiichi's Matsuda Hyperreality (Matsuda 2016) seems even a positive approach (Figure 1).

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Figure 1. Hyperreality by Keiichi Matsuda. 2016.

In fact, a major issue we are facing is not that what we see is altered or edited to look different or more attractive; the real risk is who or what is driving the simulation. In its origins, the internet was born for freedom and communication (Outside the military origins). The original Hackers, which was an early self-named group of programmers, envisioned the internet as a place outside the system that was not controlled by big corporations like IBM (Levy 1984). This scenario of freedom now seems all but a long-lost dream. The reality is that the newer internet platforms have conquered the Internet, and in fact, they have doubled their influence and size if we compare them with the previous generation. They are far more influential in our lives and poised to control the future of communications (Lainer 2013).

The omnipresence of smartphones and other portable devices with Augmented Reality capabilities is slowly blurring the barrier between the digital world and the analogue world. From early experiments like the Archeoguide Project (Vassillios et al. 2001) that overlapped virtual models of classic Greek buildings on top of the ruins for the visitors to experience the feeling of walking in ancient times (Figure 2), there is a will to enhance and mixing our world with the virtual one. More accessible and capable hardware has been released, and now any average user can access Augmented Reality (Coppens 2017). A good example of this is the Medusa Installation at the V&A Museum (2021), where an animated digital sculpture was showcased using Augmented Reality goggles (Figure 3).

The evolution of visualization is not the only driver for the change. Together with the visual capabilities of the AR goggles, most of the new devices like HoloLens© are incorporating a series of sensors that can read and interact with the analogue world. This idea is very relevant since that means humans can interact with the virtual world and the analogue world. Many professions and workers are now using these devices to guide and enhance their performance. Soon, these technologies will be mainstream in many areas like medicine or the manufacturing industry (Coppens 2017).

In this scenario, it seems paramount to really analyze and criticize how we use the Mixed Realities and how we will relate to them in the future. How the Augmented Human will perceive and interact with the urban environment and the architecture, and how this will change our creative view. In essence, what will it mean for architecture to enter the Augmented Era.

Figure 2. Medusa Project, V&A Museum. 2021.

2. The Augmented Environment

The idea of an augmented interaction with the environment is nothing new at this point. From its early development at the beginning of the XX century, the concept of an Augmented Reality that would enhance our view of the world has been a technological goal for the last 120 years (Sünger, & Çankaya 2019). During the past 25 years, AR technology has accelerated its development and is becoming common in all sorts of devices (Clemens et al. 2015). In that sense, if the evolution continues at the same pace, it is expected that soon, many more objects like shop screens, cars (some like the new Mercedes Benz S Series already have it) or sunglasses will adopt this technology. In fact, it is expected that AR will be a ubiquitous thing in the near future (King 2014).

In this scenario, the speculation on how this augmented environment will be, brings two important questions to the discussion, what are we augmenting, and who is augmenting it? Several levels can be explored on what can be augmented. The first would be purely technical information, such as GPS guidance, weather conditions, safety alerts, or language translation. This augmentation could be helpful and seems innocuous, lacking any specific intention apart from real-time information. The second level is Practical Augmentation, such as general commercial advertisement, events guidance, historical facts or social interactions. These can be a bit more complex since they, by definition, have third-party influence, and their existence should require some control. The third level of augmentation would then be Perceptive Augmentation. This level touches on a deeper impact since it is the augmentation that would not only add information to the user but change the reality perceived by them in real-time. This could mean simple things like street decorations or styles to more controversial censorship or modifications. This situation makes this level the one that would need closer monitoring since it could mean a tangible risk (i.e. censorship).

Regarding the second question about who is augmenting the environment, a very intense discussion connects with current controversies about the ownership of the data, the internet, and the media (Lanier 2013). Again, to synthesize this, we could expect three possible scenarios according to the implication of the control and ownership the augmentation can have (Srnicek 2016). In the Open Source Scenario, in this case, the augmented content is produced by users for users in an open-source ownership state, avoiding control and management from big corporations or governments. The Centralized scenario. This scenario proposes the idea that a government/central neutral

entity will manage the data flow and the augmentation so that the user can have access to the augmented content, ideally free and democratic, but with a certain bias based on the control entity. The Corporativist scenario. This scenario is the opposite of the first, where the tech corporations manage all the content with no or few regulations, so the users only have access to a completely brand-biased augmentation based on ownership and commercial transactions. Again, it is important to clarify that those three are ideal scenarios and are not exclusive to each other. Like the current state of the internet, we can find different levels of ownership and management models coexisting at the same time (Assange 2026).

3. Methods

Once the frame for the study is settled, this paper will introduce and analyze two speculative projects on how the challenges described before can be faced. The projects aim to propose specific scenarios where levels of augmentation and ownership are part of the discussion and the possible uses that such AR apps could have in the near or even the present. It is important to note that the projects experiment with existing AR technology and theorise about future technology. The main computing frame is based on Unity© and MRTK-Unity© tools to create the testing apps and functionalities.

3.1. THE MIXR PROJECT

The idea of a personalized augmentation for the urban environment is the starting point for the project. Trying to speculate with the proposal of a future where the Extended Realities can affect several aspects of our day-to-day life, this research explores the idea of an app that can change and configure the entire perception of the city according to the user control proposing at the same time three possible scenarios for its use, Positive, Neutral and Negative. To achieve this. The app would read the environment and detect the architectural elements around to replace them with themes chosen by the user. This ideally would give the opportunity to experience the city according to the user's taste, promoting an individualistic vision of the urban space in contraposition with the amalgamated noise we usually perceive.

Technologically speaking, the project uses an already existing technology called Image Segmentation to read and differentiate the surrounding environment and the features contained within (Zhang & Jinglu 2008). This type of computer vision allows for isolating urban features like façades or trees and then performing a change on them (Figure 4). Two actions were tested through this method, Remove and Replace. For the Remove, just an image deleting logic was used, so, for example, the user could get rid of small objects like street lamps or garbage bins. This action was limited by the technical development of the app during the research and was based on Image blur and layer segmentation.

Figure 3. Image Segmentation training.

For the Replace action, several algorithms from Pix2Pix (Isola et al. 2016) or Style Transfer (Gatys et al. 2016), were tested to give the user a wide catalogue of options to choose from. The option chosen for the prototype app was the Style Transfer. The model was trained with a collection of architectural images to create different styles, pre-classified per architectural style. As a result, the user could choose between several Machine Learning generated skins to replace the existing architecture in the environment.

Figure 4. Pix2Pix VS Style Transfer

In addition to the visualization functionality, The Add action was also added, so users could overlap new elements and information within the environment to complete the augmented visualization. A catalogue of features to add was created, and it used the same Image Segmentation technology to implement the selected components. The app also proposes the idea of a social interaction capacity based on creating communities of friends. This functionality would then add a chat and share geolocation information that the two users could visualise in real-time. An important option that the social interaction would also give is the possibility of sharing and combining views together, so a group of friends could share their own view of the city and experiment with it altogether (Figure 6).

Figure 5. App Visualization for smartphones.

The augmented environment proposal of the project positions itself into a hybrid level of augmentation (Cetralized/Corporativist). The app allows us to visualize practical information like events or communications with friends and modifies and changes the reality we perceive. The result is that Level Two and Three augmentations being the third most prevalent. Due to this fact, there was an interesting discussion within the project on how the app could be managed. The project then proposed that the app could look at three scenarios, Utopian, Neutral and Dystopian. In all three scenarios, the augmentation would be managed by a third party and for commercial use of the app. The Utopian scenario proposes a use with positive social impact, so styles and augmentation will be not only for improving the user´s perception of the city but to promote integrative values events. The Neutral scenario establishes that the central authority would manage the augmentation and would be only based on the user's taste and basic practical, unbiased information with it. The Dystopian will be a scenario where the central entity/corporation would allow the user a certain configuration but full of third-party content for commercial or political uses(figure 5).

3.2. THE XREF PROJECT

Dynamic spaces for changing uses are a concept that architecture has been speculating about for years. From the Archigram's Instant City (Cook et.al. 1961) to the Event Space proposed by Tschumi (Tschumi 1994) up to the Hyperreality (Matsuda 2014), there have been examples of this concept that shows the potential that this idea has. Opposite to the traditional immobile architecture, these projects explore how an ever-changing and mobile space can change our understanding proposing a user-based space that changes and adapts to the environment.

To create the Augmented Architecture, this project focuses on three main technical concepts to achieve the proposed goals. The first technical idea is environment recognition. To achieve this, A mix of two technologies is used to survey the environment and generate a base geometry to fixate the augmented space. For environment sensing, a ZED® camera is used, and for interaction tracking, a Leap

Motion® camera is combined. The ZED® Camera senses the environment by using a stereo camera system enhanced by AI to produce an accurate 3D model of the area recorded. This information was used to generate a digital twin of the environment to locate the Augmented Architecture (Liu, Zhao & Li 2012). The Leap Motion is a tracking device that uses two infra-red monochromatic cameras to locate and track objects on a spherical projection in a short distance. This capability allows for hand and gesture tracking to allow for human interaction. These two sensors were installed into an Oculus Quest VR device to upgrade it into an XR device. Combining the three technologies, it is possible to produce a precise and low-lag XR environment for an interactive and immersive experience.

Figure 6. Experimental XR Device.

The augmented space is generated digitally by using a series of geometry block collections and a Wave Function Collapse Algorithm (Kim et.al., 2019). Based on the mesh border generated by the 3D scanning, the WFC distributes the blocks and generates the space based on predefined premises established by the user. As a result, every space is different for every user and can be modified easily, just changing the rules or the seed for the generation process. The option of choosing different block catalogues also gives the space a more bespoke feeling to the user creating a dynamic personal augmented space that is connected and can be experimented with in conjunction with the physical space. (Figure 7)

Figure 7. WCF Model.

In order to connect both technological approaches and give the user easy access to

the augmented space configuration and experimentation, a digital platform app is also proposed. This app, which could work either with smartphones or goggles, allows the user, through a simple interface, to scan the surroundings, choose from the catalogue, configure the space option and generate it automatically.

From the scenario perspective, XRef focuses on an "All Out" situation where a third party defines the app, the augmentation and the content for a mainly commercial and advertising product (Corporativist scenario). The result is a virtual space that gives access to the user to virtual shops that overlap and complement the urban environment and caters to the user's likes as well. The space, therefore, constitutes a series of different event spaces where the user can mix visual experiences like art exhibitions with direct shipping for products. Depending on the user's will, the augmented space will show different configurations, from purely augmented space proposals that can interact with the user in a playful manner, more informative spaces like galleries and multiplayer experiences, or full-on virtual shop street that adverts and sales a product based on the users collected data. (Figure 8)

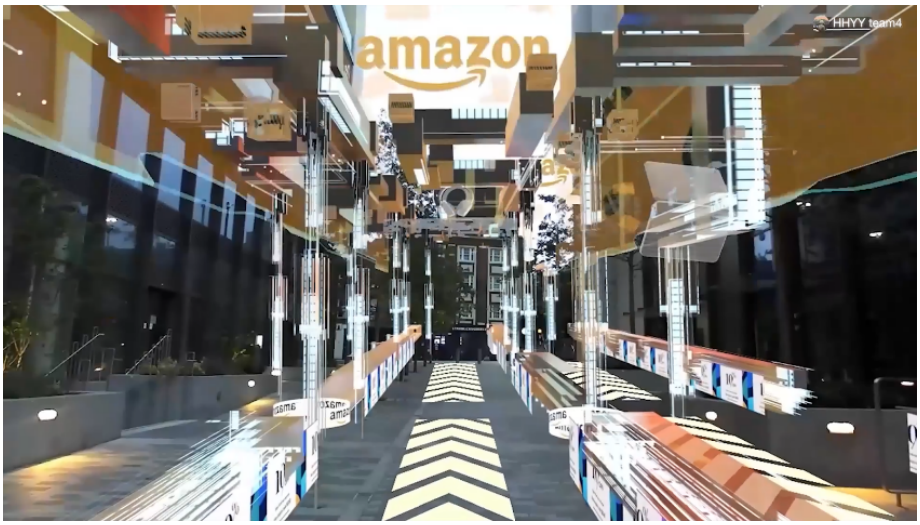

Figure 8. Augmented Space.

4. Results and Discussion

The exploration of the boundaries for Augmented Architecture is a long but paramount process. The future of architecture will be linked to the idea of the Metaverse, and the intersection between the two worlds is a relevant area to study. The projects described a speculative approach to how this interaction could be in the near future.

From the pure technological perspective, even though the capabilities of Augmented Reality hardware have rapidly increased during the past years, it is true that for now, its real impact is limited and mainly niche to the research world. The projects were primarily tested using a series of smartphones which allowed us to see a

hint of the potential, but at the same time, they were limited in sensors and computing power. Regarding the software area, the technology seems to be ahead, being able to perform the actions explored with sufficient results. It is expected that in the near future, the software algorithms used for the project will improve and gain capabilities for more precise and agile results and interactions (Jordan & Mitchell 2015).

The proposed apps and scenarios show two of the possible uses that Augmented Architecture could have soon. From the functionalities to the ownership, the projects develop a case study on how this technology could affect and interact with us as users. In that sense, the Apps showcase a pretty realistic approach for the possible ownership of the augmentation and its possible scenarios of use.

From a comparative perspective, the two projects show different positions. While MiXR proposes more of an open case where the possible uses of the app, whether positive, neutral or negative, are tested. Problems like the ownership of the augmentation and what that would mean regarding social censorship are questioned and explored with the three scenarios. On the other hand, XRef explores a more commercial and, in that sense, realistic approach where this technology can be used for mixed situations benefiting the user (with a new and configurable experience) and the private sector (by promoting shopping). What is interesting to point out from both cases is the fact that because this technology is based on simple mobile phone apps, access to it will be quickly mainstream and has the potential to reach a wide public.

The use of Augmented Architecture presents a number of challenges. Although some of them, like third-party ownership or urban editing, are explored here, more research will be needed to understand the real potential as well as the risks of this future area of architecture. It will be essential to understand not only how it works but the social impact it could have in the very likely near future.

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Figures

Figure 1: Hyperreality. 2016. http://hyper-reality.co/assets/HQ_images/hyper-reality_03.jpg
Figure 2: Medusa Project. 2021. https://www.tindrum.io/

References

Assange, J., Appelbaum, J., Müller-Maguhn A., & Zimmermann J. (2016). Cypherpunks: Freedom and the future of the internet. OR Books.

Baudrillard, J., (1981). Simulacres et Simulation. Paris. Galilée

Cook, P., Crompton, D., Greene, D., Herron, R., & Webb, M. (1971). Archigram: Instant City, 1961-1971. London.

Coppens, A. (2017). Merging real and virtual worlds: An analysis of state of the art and practical evaluation of Microsoft Hololens, Master's Thesis, University of Mons.

Gatys, L.A., Ecker, A.S., Bethge, M. (2016). "Image Style Transfer Using Convolutional Neural Networks," 2016 IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2016, pp. 2414-2423, https://doi.org/10.1109/CVPR.2016.265.

Jordan, M., & Mitchell, T.M. (2015). Machine Learning: Trends, Perspectives, and Prospects. Science (New York, N.Y.). 349. 255-60. https://doi.org/10.1126/science.aaa8415.

King, B. (2016). Augmented: Life in the Smart Lane. Singapore: Marshall Cavendish International.

Kim, H., Lee, S., Lee, H., Hahn, T.,& Kang, S.(2019). Automatic Generation of Game Content using a Graph-based Wave Function Collapse Algorithm. 1-4. https://doi.org/10.1109/CIG.2019.8848019.

Matsuda, K. (2016). Hyperreality. Accessed May 16, 2016. http://km.cx/projects/hyper-reality

Milgram, P. & Kishino, F. (1994). A taxonomy of mixed Reality visual displays. IEICE Transactions on Information Systems, E77 (12).

Merrell, P. (2007). Example-based model synthesis. I3D '07: Symposium on Interactive 3D graphics and games. 105-112. https://doi.org/10.1145/1230100.1230119.

Lanier, J. (2013). Who Owns the Future? New York: Simon & Schuster

Levy, S. (1984). Hackers: Heroes of the Computing Revolution. New York. Doubleday.

Liu, S., Zhao L., & Li, J. (2012). "The Applications and Summary of Three Dimensional Reconstruction Based on Stereo Vision," International Conference on Industrial Control and Electronics Engineering, pp. 620-623, https://doi.org/10.1109/ICICEE.2012.168.

Srnicek, N., & Williams, A. (2016). Inventing the Future: Postcapitalism and a World Without Work. London & New York: Verso Books.

Unity Technologies. (2019). Unity engine. Version 2019.3.5f. http:// www.unity.com.

Vlahakis, V., Karigiannis, J., Tsotros, M., Gounaris, M., Almeida, L., Stricker, D., Gleue, T., Christou, I. T., Carlucci, R., & Ioannidis, N. (2001). Archeoguide. Proceedings of the 2001 Conference on Virtual Reality, Archeology, and Cultural Heritage. https://doi.org/10.1145/584993.585015

Winters, T. (2021). The Metaverse: Buying Virtual Land, NFTs, VR, Web3 & Preparing For the Next Big Thing! Self-Published.

Arth, C., Grasset, R., Gruber, L., Langlotz, T., Mulloni, A., & Wagner, D. (2015). The History of Mobile Augmented Reality. Inst. for Computer Graphics and Vision. Graz University of Technology, Austria

Sunger, İ., & Çankaya, S. (2019). Augmented Reality: Historical Development and Area of Usage. Journal of Educational Technology and Online Learning. 2. 118-133. https://doi.org/10.31681/jetol.615499.

Isola, P., Zhu, J-Y., Zhou, T., & Efros, A.A. (2016), Image-to-Image Translation with Conditional Adversarial Networks,arXiv, https://arxiv.org/abs/1611.07004

Tschumi, B. (1994). Architecture and Disjunction, The MIT Press, Cambridge MA & London Uk.

Zhang, J., & Hu, J. (2008). “Image Segmentation Based on 2D Otsu Method with Histogram Analysis.” 2008 International Conference on Computer Science and Software Engineering 6 (2008): 105-108.