VIRTUAL REALITY FOR IMPROVING WALKABILITY

DOI: https://doi.org/10.18485/arh_pt.2024.8.ch35

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ABSTRACT

UDIHiG stands for 'Urban Design for Improving Health in Groningen'. This paper describes the application of Virtual Reality as a tool for supporting design and participation for a Walkable Neighbourhood in Groningen (NL). Health and well-being are highly related to access to healthy food, social interaction, and physical activity. The objective of the UDIHiG project is to improve Health in this specific area. Virtual Reality (VR) was used to test design scenarios of public space in a 3D Virtual environment. This way, participants experience the design at scale 1:1 from eye-level perspective. VR was used in multiple stages: (1) for the problem definition by experts and residents, (2) for designing the scenarios by experts, (3) for evaluating and assessing the scenarios by residents and (4) finally for demonstrating the concluding design strategies. The paper results in four conclusions: the potential of VR as a design tool, the use of VR as an evaluation tool, the role of the Level of Detail (LoD) and the Requirements for optimal use of VR.

KEYWORDS _ *Urban Design (UD), Public Health, Participation, (Active) Lifestyles, Post-war neighbourhood*

INTRODUCTION

UDIHiG stands for Urban Design for Improving Health in Groningen. This paper describes the application of Virtual Reality as tool for supporting design and participation for a Walkable Neighbourhood in Groningen (NL). Health and well-being is highly related to access to healthy food, social interaction and physical activity (Cohen et al, 2009, Saelens, 2003, Frank. 2001). The objective of the UDIHiG project is to improve Health in this specific area. Virtual Reality (VR) was used to test design scenarios of public space in a 3D Virtual environment. This way, participants experience the design at scale 1:1 from eye-level perspective. VR was used in multiple stages: (1) for the problem definition by experts and residents, (2) for designing the scenarios by experts, (3) for evaluating and assessing the scenarios by residents and (4) finally for demonstrating the concluding design strategies. The UDIHiG project started in 2018 with a pilot. The first VR workshops were held in 2019 on the accessibility of the neighbourhood facilities by elderly. In 2021 a second project was run on three typologically different locations.

This paper on the use of Virtual Reality (VR) in Urban Design is based on the premises that VR will have great impact on the design process. We expect it to do so in four ways in particular: Firstly, VR will be a powerful tool for developing and proofing of spatial design concepts (Araby, 2002; Bellini, 2016; Chen, 2011; Milovanovic, 2017); Secondly, VR will enable collaborative 3D design at a distance (Portman, 2015); Thirdly, VR will improve citizen participation (Heydarian, 2015; Schubert, 2012; Van Leeuwen, 2018 & 2019); Finally, VR will increase the comprehension of spatial data (Chen, 2011; Portman, 2015). This paper describes the application of VR in the first (pilot) phase of the research project and how lessons learned will be applied in the second phase (2021-2022). Firstly, we introduce the technology. In the second chapter we describe the application in the UDIHiG project – Urban Design for Improving Health in Groningen. Finally, we sum-up the experiences of the application of VR in UDIHiG.

Why Virtual Reality?

Today, VR-technologies are core products in (serious-) gaming environments. Besides, large companies, like IKEA, car manufacturers and the aerial industry use VR technologies to promote or test their products. Nevertheless, in architecture and urban design practice these technologies are rarely used (Hanssen, 2017). If used, these technologies only play a part in visualisation of the final design. The products that architects, urban designers or landscape architects design are too large to discuss with clients using 1:1 mock-ups or 3D prints. Up to now 2.5D representations (print or screen) or 3D scale models are being used together with video. These representations lack the actual experience of scale. Designers, potential users or clients are not able to immerse in an experience that comes close to the impact of the real object when it is built (Schubert, 2012; Araby, 2002). VR reality offers exactly that quality and becomes potentially an important method in the design process of architects, urban designers and landscape architects (Hannah, Huber & Matei, 2019, Liu, 2018). In our strategy we aim to use VR for design, evaluation, assessment, visualisation and communication. From this perspective VR technologies are an effective means to provide inside in the design for practitioners and students and to communicate design proposals with layman.

What is VR? A short definition.

Virtual Reality (VR). VR provides a fully artificial digital world. People use a headset to fully immerse into an artificial environment and walk or move around that environment by themselves (Wikipedia). Hardware: HTC Vive, Valve Index, HP Omnicept, Oculus Go/Rift/Quest (Bellini: Goldman Sacks, 2016).

In the UDIHiG project VR was chosen as the core interface providing full immersive experience to project partners and local respondents. Here VR was used as a tool to communicate design locations with project partners and to assess different design scenarios for public space by inhabitants, so called participation. The hypothesis was that VR technology would inform laymen easier and better. The aim of this paper is to report on a pilot of use of VR in the setting of urban design of a post-war neighbourhood making use of resident participation and aiming to create a more health promoting environment.

RESEARCH

The Project : UDIHiG

In this multidisciplinary project on "Public Space, Health and Well-being" VR was foreseen as an experimental platform for citizens engagement and collaboration with practice. The objective of the UDIHiG project is to improve health and well-being by spatial design . The project is initiated by the Expertise Center Architecture Urbanism and Health of the University of Groningen, and realized by a consortium that incorporates the inhabitants of the case study neighbourhood, the local health services, the municipality of Groningen and the team of the City Architect. In the first phase of the project a pilot location was selected: Paddepoel. A huge issue is that the central shopping mall is surrounded by a circuit of roads with high intensity of motorised traffic. Objective of the first phase was to investigate how to improve accessibility of the shopping mall for elderly in order to stimulate active behaviour, provide better access to healthier food and increase social interaction.

The role of VR

In this project the role of VR was to provide a novel platform to better engage citizens in the development of their surroundings. The idea to include VR was triggered by the assumption that it may help to solve the principal barrier for the assessment of the possible effects: the fact that the spatial interventions themselves cannot be tested since they only exist in the form of plans. The starting point was that 2D maps and 3D images do not provide enough insight to laymen to assess design scenarios adequately (Schubert, 2012; Stauskis, 2014). VR provides a full immersive environment which can be experienced at scale 1:1 from eye-level perspective. During the pilot phase VR was used in several meetings to present the current built environment, to assess the accessibility and to collect feedback on different urban design scenarios for public space.

A requirement from the participating Institutes was an approval by the Human Research Ethics Committee (HREC). In the application a data-management plan, a privacy protection strategy and a risk analysis plan have to be written. The risk of using VR is limited to nausea and motion sickness (Heydarian, 2015). To limited the risks for the elderly participants in this research, TU Delft took several measurements in the experiments: (1) motion was limited to 360° viewing from predefined viewing points, (2) limiting time to 15-20", (3) if necessary, people can sit and (4) participants are always assisted and monitored by staff. The HREC was approved.

The pilot (application/process)

The project started in Fall 2018 with an analysis and definition phase. As a result, four problematic locations were selected by the project team. These four locations were converted into 3D and evaluated in VR by a selection of elderly residents in the first workshop. This first workshop, organised in a community building in the neighbourhood, consisted of: (1) a general introduction presentation covering the project, aims and setup of the workshop; (2) a personal questionnaire investigating health and well-being conditions of the participant; (3a) evaluation of the four selected locations in VR and (3b) experience of the VR. Based on the feedback of the first workshop, the City Architect prioritised two locations and developed design scenarios for these locations. In Spring 2019 a second workshop was organised. In this workshop, (0) the current situation, (1) a minimalistic design and (2/3) two strategic design scenarios were tested by the participants using VR. For both locations the respondents answered standard questions regarding the design, physical safety and social security for all three design variants. In Fall 2019 a third workshop was be organised to communicate the results of the pilot to the participants and residents. The results from the first two workshops will be used by the City Architect (1) to adapt the minimalistic design and (2) to develop a new design scenario which will be presented in VR. In the final workshop, VR will be used to communicate an extended version of the design scenario.

RESULTS

In the initial workshop 13 elderly residents with an average age of 65 years participated. From the four locations which were evaluated, two locations were prioritised based on the feedback on physical (un)safety, the frequency of use and the intensity of motorised or bike traffic. Both locations are informal crossings at the moment and are therefore not (well) supporting crossing the busy roads for pedestrians. A significant aspect is that many elderly have either visual or physical limitations.

In the second workshop 9 original respondents participated and 22 new respondents. This workshop was spread over two days. The sessions were carried out in smaller groups and three VR systems were applied parallel. The respondents answered specific question on experience, barriers, attractivity, visibility, social- and physical safety for three variants: (1) a minimalistic in which only zebra-crossings were added, (2) a scenario reducing traffic by introducing shared space and (3) a scenario limiting traffic and adding more green. Based on both the quantitative technical questions and qualitative responses, scenario 2 scored the best. After finishing the VR respondents were asked their general preference. This outcome contradicted the earlier responses, as respondents here preferred the last scenario (3). A possible explanation is that at the end respondents firstly prefer a greener environment and secondly hesitate the uncertain implications of shared-space.

The respondents spend more time in the VR than expected based on dry runs in the lab. A key cause is that local participants intent to answer much broader, give extended context to answers and like to tell stories and anecdotes. The durations did not affect their responses. An important success was that 100% of the participants was willing to join a follow-up workshop.

Discussion

As a result of the application in phase 1, four topics will be discussed in relation to the use of VR for participation in research projects: the representativeness of the respondents, the Level of Detail, the Representativeness of VR as a method and the scalability.

Participants. The initial phase of the project focused on a limited area/assignment and also limited user group: only the accessibility of the central shopping mall by elderly, less mobile residents. An important characteristic of this user group is that they do not only move on foot, but also use rollators or motorised scooters. On the other hand, they move far less by bike. This group does not represent the community in the area. The proposed interventions will never be a one-to-one translation of this research based on this group only. Therefore, also general knowledge from literature and practice is used to define the issues and develop design interventions. An essential question is how to incorporate multiple user perspective, satisfy the weakest group, but balance the interventions for all users.

Level of Detail. A main response from the participants is the Level of Detail (LOD) (Biljecki, 2014; Chen(R), 2011): which level is appropriate for which (research) question? How far does VR have to go in mimicking the real-world (Bouwman, 2007; Paes, 2017)? For our project we had two main questions: what LOD to deliver at what stage and adding animations of other users, i.e. pedestrians, bikes, cars and buses or not. For this project it was concluded that too much detail in the beginning is not necessary. The key is the experience of public space and the performance of the overall model, not details of buildings. Nevertheless, a too abstract environment is difficult in scale to interpret for laymen. Adding simulated people and cars improves the reality, but also disturbs the experience of public space. If interactions are not part of the research, these features should be left out to reduce interference. In a final design communication, these features can be added to show changing use of space by different modalities and the implications of the spatial design.

Validity of responses. What is the value of the answers of the respondents in VR? How are the results compared to the real world? The conclusion was that this project cannot provide answers for this. More insight is absolutely necessary, e.g. by experimenting with control groups: Future research should cover parallel experiments in VR and with other methods, to define a ground truth on the impact of VR hardware, LOD, way of moving (free versus pre-defined), other simulated traffic in relation to the characteristics of the respondent (Paes, 2017). This will be a key topic in our future research agenda.

Scalability. Using VR the user group is able to provide very detailed and accurate feedback on the problem analysis and design solutions. Nevertheless, this way of working is labour-intensive. With four VR stations (three operational, one backup), it takes in average an hour per respondent for the general introduction, the questionnaire and the VR session. In one hour, six respondents can be taken through the whole process. A crucial question is how scalable the method is as research instrument, both in spatial area covered, topics covered and number of participants. From our perspective, here the multiplayer as well as an integrated questionnaire can play an important role to provide digital aids to have more parallel VR sessions. Now a respondent is monitored and questioned by staff. In the ideal situation the questionnaire is provided by a digital tablet in VR. Besides, more measurements will be carried out. In the next chapter 'Practice' tools are developed which will provide automated data collection in VR, providing more tools and underpinning of experiences.

CONCLUSION & DISCUSSION

The most important observation is that VR/AR can provide 1:1 simulations of virtual futures, providing insight in design alternatives in architecture and urban design for designers, students, stakeholders, citizens or other participants: Both VR/AR provide freedom to walk through virtual objects, choose your own route and choose your own viewpoint. The technology was applied in education, research and practice. All fields can benefit from VR/AR, but for each field several research questions emerge as well. Based on the exploration in this paper, we will address the following topics in this final section: (1) VR as design tool; (2) VR as evaluation tool; (3) Level-of-Detail; And (4) the requirements to optimally make use of VR.

VR as design tool.

The use of VR as a design tool has obvious benefits for the quality of design, but also requirements: without the ability to validate in VR and without quick workflows for preparing 3D or interacting with VR, the benefit is limited. Understanding how and what to evaluate in VR is crucial. A framework to research this will be setup in the future VRDMA lab. An example from the research project UDIHiG: Urban Design for Improving Health in Groningen: Here VR was originally only used for evaluation by the residents, but during the project the added value of VR was acknowledged for the design team itself as well. In the initial process the design team from the City Architect delivered 2D drawings which were translated to 3D and prepared for VR by the academic team. In the last stage the design team will participate in the conversion and interact with the design, before it is communicated to the community during the final event. *The main question is what makes VR a design tool and how can this be arranged in an optimal way? How can we scale up VR in the classroom to cover full curricula with VR?*

VR as evaluation tool.

VR as an evaluation tool is an objective in itself and a prerequisite for being a design tool. VR can be seen as a 3D evaluation tool in case citizens participate in the evaluation of design proposals in VR. Another example is in case a stakeholder, municipality or teacher evaluates a design made by a design firm, project developer or student. This requires not only technical knowledge about workflows, but also requires experience and insight how to evaluate these designs in VR. Experiments with control groups are key aspects of the future research agenda. *The question is what the influence/bias of VR is on the evaluation (Jones, 2008)? How reliable is it? Does it cover all (essential) aspects of the design or does it emphasize on a limited set? Does this method of analyzing replace existing tools like models and drawings or is it an additional tool? Do evaluators using VR make different, better decisions?*

Level of Detail (LOD) and Level of Realism (LoR)

LOD is a term which popups in 3D and VR/AR like privacy does in data science. LOD is highly related to the performance and experience of VR/AR. The LOD can be arranged by extended geometry and by sophisticated imaging (ref). Both ways have advantages and disadvantages. LOD is seen as a research field on its own. The choice for LOD depends on the project, the research questions and the objective of visualization: The more detail, elements, or materials, the more time-consuming, expensive, complex and slower the model becomes. LOD is not an average for a whole project but can be differentiated within the model: A general rule used in the 3D projects is to limit details on parts which will not be visible and only to extent materials and details for the key places of the design. Another lesson learned is to limit the use of beautiful libraries, but build 3D objectives yourselves, eventually in a multiscale approach. *Returning questions in practice and research were: which LOD is expected? What is the influence of LOD on the experience? How can performance and LOD be balanced? How much emersion is enough (Bowman, 2007)?*

Requirements for optimal use of VR

A base requirement for all projects in education, research and practice is a clear workflow, aligning the capabilities of the hardware, performance of the software and the requirements from the project. Besides the way the model is organized, the Level of Detail and the scale/size influence the performance. An important aspect for using VR is the complexity and duration of the workflow between CAD/BIM application and VR application (Yan, 2011). Expertise in several specialistic programmes is essential to build high quality VR applications. Originally, gaming engines like Unity and Unreal Engine were essential (Johns, 2006), but time-consuming stages in this process. In 2016 students who wanted to deliver a high-performance VR had to deliver their final project one week earlier to process the application. Today, smart plugins can provide a live connection the CAD/BIM and the VR application. Of course, platforms like Unity and Unreal Engine provide far more powerful features for visualization (Johns, 2006). On the one hand changing hardware and new plugin software offers opportunities for improving the workflows in VR, making VR more accessible for everyone, on the other hand the weekly updates destabilize workflows. *The question is where we are in five years? What dot can we put on the horizon for the use of VR in education, research and practice? Can we already roll out the use of VR to a whole curriculum? Is that a valuable method? What is necessary in hardware, software, support and facilities to achieve that? What research questions do we have to formulate to reach this objective?*

ACKNOWLEDGMENTS

The UDIHiG project is funded by ZonMW and carried out by the following partners: University of Groningen (RUG), University Medical Centre Groningen (UMCG), City of Groningen, City Architect of Groningen, GGD Groningen, Wijkraad Paddepoel, Platform GRAS and Delft University of Technology.

REFERENCES

- Proceedings: Araby, M. El., 'Possibilities and constraints of using virtual reality in urban design', Proceedings of the 7Th International CORP (2002), 457–463.
- Book: Bellini, H. et al., 'Virtual & Augmented Reality: Understanding the race for the next computing platform', Profiles in Innovation, (Goldman Sacks, 2016).
- Journal article: Biljecki, F. et al., 'Formalisation of the level of detail in 3D city modelling', Computers, Environment and Urban Systems, 48, (2014), 1–15.
- Journal article: Bowman, D., McMahan, R.P. & Tech, V., 'Virtual Reality: How Much Immersion Is Enough?' Computer, 40, 7, (2007), 36–43.
- Journal article: Chen, B., Huang, F. & Fang, Y., 'Integrating virtual environment and GIS for 3D virtual city development and urban planning', 2011 IEEE International Geoscience and Remote Sensing Symposium, (2011a), 4200–4203.
- Journal article: Chen, R., 'The development of 3D city model and its applications in urban planning', Proceedings of the 19th International Conference on Geoinformatics, (2011b), 1–5.
- Journal article: Chowdhury, S., & Schnabel, M. A. (2018). Communication and Participation in Virtual Environments. International Conference of the Architectural Science Association, 727–734.
- Journal article: Cohen DA, Marsh T, Williamson S, Derose KP, Martinez H, Setodji C, McKenzie TL. Parks and physical activity: why are some parks used more than others? Prev Med. 2010 Jan;50 Suppl 1(Suppl 1):S9-12. doi: 10.1016/j.ypmed.2009.08.020. Epub 2009 Oct 19. PMID: 19850067; PMCID: PMC2821457.
- Journal article: Foth, M. (2017). Participation, Co-Creation, and Public Space. The Journal of Public Space, 2(4), 21. https://doi.org/10.5204/jps.v2i4.139
- Journal article: Frank LD, Engelke PO. The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health. Journal of Planning Literature. 2001;16(2):202-218. doi:10.1177/08854120122093339
- Journal article: Matthew Hannah, Sarah Huber & Sorin Adam Matei (2019) Collecting Virtual and Augmented Reality in the Twenty-First Century Library, Collection Management, 44:2-4, 277-295, DOI: 10.1080/01462679.2019.1587673
- Journal article: Hanssen, R., The State of the Art of Virtual Reality in Urban design, (TU Delft, 2017).
- Journal article: Heydarian, A. et al., 'Immersive virtual environments versus physical built environments: A benchmarking study for building design and user-built environment explorations', Automation in Construction, 54, (2015), 116–126.
- Journal article: Hofland, A. C. L., Devilee, J., Van Kempen, E., & Den Broeder, L. (2018). Resident participation in neighbourhood audit tools - A scoping review. European Journal of Public Health, 28(1), 23–29. https://doi.org/10.1093/eurpub/ckx075
- Proceedings: Johns, R. & Lowe, R., 'Unreal Editor as a Virtual Design Instrument in Landscape Architecture Studio', Proceedings Digital Landscape Architecture Conference, (2006), 1–7.
- Proceedings: Jones, A. et al., 'The Effects of Virtual Reality, Augmented Reality, and Motion Parallax on Egocentric Depth Perception', 2008 IEEE Virtual Reality Conference, 1(212), (2008), 267–268.
- Proceedings: Liu, B. Y., Mateo-babiano, I., & Darchen, S. (2018). How virtual 3D modelling and simulation can help us create better cities. July, 1–3.
- Proceedings: Milovanovic, J., Moreau, G., Siret, D., and Miguet, F., 'Virtual and Augmented Reality in Architectural Design and Education : An Immersive Multimodal Platform to Support Architectural Pedagogy', 17th International Conference, CAAD Futures 2017, Jul 2017, Istanbul, Turkey (2017).
- Journal article: Paes, D., Arantes, E., Irizarry, J. 'Immersive environment for improving the understanding of architectural 3Dmodels: Comparing user spatial perception between immersive and traditional virtual reality systems' Automation in Construction, 84, (2017), 292-303.

- Journal article: Portman, M.E., Natapov, A. and Fischer-Gewirtzman, D., 'To go where no man has gone before: Virtual Reality in Architecture, Landscape architecture, and Environmental planning', Computers, Environment and Urban Systems (CEUS), 54, (2015), 376-384
- Proceedings: Schubert, G. et al., 'From Physical to Virtual: Real-Time Immersive Visualisations from an Architect's Working Model', 12th International Conference on Construction Applications of Virtual Reality (CONVR '12), (2012), 417–426.
- Journal article: Stauskis, G. (2014). Development of methods and practices of virtual reality as a tool for participatory urban planning: a case study of Vilnius City as an example for improving environmental, social and energy sustainability. Energy, Sustainability and Society, 4(1), 1–13. https://doi.org/10.1186/2192-0567-4-7
- Proceedings: Van Leeuwen, J. P., Hermans, K., Jylhä, A., Quanjer, A. J., & Nijman, H. (2018). Effectiveness of virtual reality in participatory urban planning. ACM International Conference Proceeding Series, February 2019, 128–136. https://doi.org/10.1145/3284389.3284491
- Proceedings: Van Leeuwen, J., Hermans, K., Jan Quanjer, A., Jylhä, A., & Nijman, H. (2018). Using virtual reality to increase civic participation in designing public spaces. Proceedings of the European Conference on E-Government, ECEG, 2018-Octob(February), 230–239.
- Journal article: Yan, W., Culp, C. & Graf, R., 'Integrating BIM and gaming for real-time interactive architectural visualization', Automation in Construction, 20, 4, (2011), 446–458.