VIRTUAL REALITY APPLICATIONS IN HOUSING INSECURITY RESEARCH

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Abstract. Virtual Reality technology has been widely explored to simulate environment and spaces in architectural and urban design. However, there is a gap of knowledge on real-world applications of Virtual Reality to conduct architectural research of social impact on existing architecture and domestic interior spaces. This paper focuses on the application of VR within a case study research project entitled Housing Insecurity in Mississippi and the resulting exhibition. By using immersive 360º video to place exhibition attendees inside virtual representations of these residential environments, interviewees' stories are communicated in a rich and immediate way that other methods cannot offer. The VR presentation of the oral histories information asks how the added richness and detail can help convey their stories more effectively with the goal to increasing empathy for the interviewees, increasing public awareness of the conditions of housing insecurity, and motivating public discussions of solutions. This paper explores the process of implementation and reviews the project's potential, results, challenges, and future directions.

Keywords. Architecture Survey, Community Engaged Learning, Empathy, Housing Insecurity, Immersive Environments, Oral History, Public History, Virtual Reality.

1. Introduction

This paper explores the use of immersive 360º video as a component of an oral history and architecture survey research project on housing insecurity in Mississippi. We seek to answer whether presenting this data in Virtual Reality can help convey interviewee stories more effectively than traditional media. Effectiveness is defined as an increase of empathy for the interviewees, which is central to the ultimate goals of increasing public awareness of the conditions of housing insecurity and motivating public discussions of possible solutions.

To date this and other media have been gathered through field work and exhibited publicly. Currently, a controlled study to provide quantitative measurement of the impact of the presentation methods is under design and will be discussed below. This

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results, challenges, and future directions.

For this project, Kateryna Malaia and Silvina Lopez Barrera - researchers in architectural humanities - have teamed with Duane McLemore, a researcher in advanced visualization methods. Each has brought a previously unrealized aspect to the work of the other. Through this partnership, social and technological challenges which complicate this work have been encountered. This paper endeavours to identify and address these more generally in hope these lessons will be of use to future researchers bridging this same methodological divide.

1.1. RESEARCH BACKGROUND

Housing Insecurity in Mississippi is primarily an oral history project which creates a narrative of the problem. In addition to the oral histories, the lived spaces of individuals and communities that have experienced or are experiencing housing insecurity and evictions in the state of Mississippi are documented and presented to the public. Oral history entails not only the collection of interviews, but also archiving these publicly for open access and use by anyone interested in the subject. To date, oral history has been effectively used by architectural historians to not only pursue traditional histories, such as personal interviews with famous architects, but also "expand the map of architectural history and its historiography." (Gosseye, Stead, Van der Plaat, 19). In particular it has been essential to understanding the role and the work of those "who use, occupy, and construct buildings," which in our case are the building residents.

Like other forms of socio-economic pressure and inequality, housing insecurity is a *lived experience* that permeates all aspects of life. It is not just a statistical number of evictions and foreclosures. Housing insecurity dictates the ways in which people inhabit their residential spaces: the way they rest, socialize, work, build families, all the ways they live every day. Housing insecurity is not just a negative bank balance, collections notice, or missed rent check, it has long-lasting effects on the space, possessions, and conditions of those experiencing it.

Housing Insecurity in Mississippi aims to create a portrait of lived experiences and domestic environments constructed under the pressure of housing insecurity. While historically an ill-defined term, currently there is a push towards developing a universal definition of housing insecurity. This definition should include interrupted housing stability, unsatisfactory housing quality, including state of disrepair, structural, mechanical, electrical and other forms of hazards, lack of thermal comfort, lack of access to drinking water, and unsafe neighbourhoods. (Cox, Henwood, Rodnyansky, Rice, Wenzel, 100) Through adding to the oral history collections of Mississippi State University, Jackson State University, and the University of Southern Mississippi and designing a companion exhibit and website, the project aims to flesh out an otherwise difficult to obtain view of this problem in Mississippi and beyond, and add to the discourse on the nature of housing insecurity in the United States. By letting those effected speak in their own voices and words and documenting the domestic spaces which bear witness to the consequences of housing insecurity, the project facilitates public awareness while still maintaining respect for privacy of the interviewees. In this context, the use of immersive video is a powerful tool, but one which must be carefully engaged (as discussed below).

The lack of visibility of housing insecurity in small towns and rural areas is worsened by the "out of sight, out of mind" approach to the problem. The trade-off for only being able to afford rent on the cheapest apartment complexes and mobile homes is grossly inadequate or non-existent maintenance. This results in substandard housing conditions existing on dead-end streets, cul-de-sacs, and remote country roads across the region. While busy car and pedestrian routes to nearby shopping and entertainment districts may pass right by them, the region's car-first culture renders housing insecurity invisible to the public unless you are caught in it.

In Starkville, the university town of 40,000 where this research is conducted, housing insecurity is a daily lived experience and evictions - even mass evictions - are a common occurrence yet there is not even one homeless shelter. The impetus for a project focusing on housing insecurity was a mass eviction in fall 2021, when the residents of a 60-unit apartment complex were displaced due to a change in ownership. The eviction notices were handed just a day ahead of a hurricane that was supposed to hit Starkville with heavy rain and wind gusts.

Local non-profit Starkville Strong advocates for and provides assistance to those facing housing insecurity in the area. They took a mission of helping resettle the displaced residents, as well as advocating for the construction of a homeless shelter in or near Starkville. The shelter was not built but in the public debate around the topic the opinions expressed by the housed population were illuminating of a lack of understanding that the systemic causes of housing insecurity are outside the control of the individuals experiencing it (Jones, 2021). This evidences the need for a project of this nature. As a result, Housing Insecurity in Mississippi partnered with Starkville Strong to increase the visibility of the issue of housing insecurity and amplify the stories of those experiencing it.

The wider Project seeks to: deconstruct misconceptions about small town homelessness, create a public archive that will serve as an advocacy tool for organizations and individuals fighting housing insecurity, and educate university students on the problem through using architectural survey methods in field work on everyday residential spaces. All of these will be covered in more detail in subsequent scholarship.

The narratives and data collected in this project show that housing insecurity is a structural problem that effects even individuals who do everything “by the book,” yet are still unable to afford safe and secure housing. Housing insecurity in a university town in the South is rooted in many factors, among them: income inequality, the cyclical nature of the university town economy, structural racism, flawed rental laws, lack of support for affordable housing construction, lack of workers skilled in the building trades, housing shortages due to a booming student population, and surprisingly but possibly most importantly - removal of long-term rentals from the market for use as short-term “game day” rentals, which has increased housing prices drastically in recent years. (Solomon. 2021)

The wider research project involves two particularly novel aspects - partnerships with community organizations championing more humane housing solutions and research conducted by undergraduate architecture students. While the oral histories and architectural survey are the primary output, this research project has also generated an exhibition showcasing these interviews alongside drawings, a full-scale

2d recreation of the floor plan of an interviewee apartment, photographic documentation, and the VR video discussed here.

From the collected data, an exhibit dedicated to the problem of housing insecurity with oral histories hosted by Jackson State University has been created (*Figure 1*), along with a companion website. This public display and archive are perhaps the most important aspects of this work: writing history from below is not new, nor are oral history and architectural documentation; but the lack of public awareness about housing insecurity in the Southern United States is tremendous. Without these publicly available advocacy resources, small towns like Starkville can continue ignoring and concealing the problem and perpetuating problematic landlord-tenant laws and code violations.

Figure 1. Housing Insecurity in Mississippi Exhibition at Jackson State University

1.2. PROJECT FRAMING

New visual media have been used to advocate for social reform throughout the modern era. In the 20th Century, the moving image was widely responsible for building public awareness of social movements, such as in the broadcast of footage from the Civil Rights Movement on the burgeoning medium of television in the 1950's. In the 19th Century photography was widely used in a similar way--for example by Jacob Riis in documenting tenement housing conditions in New York City. In 1991, a video recorded by George Holliday on a relatively new consumer product - a Sony camcorder - captured and widely exposed the beating of Rodney King by Los Angeles police. Arguably, this single event of racist violence captured using progressive technology and then disseminated via an established technology of television networks, made police brutality more visible than endless reports of victims and witness in the decades prior. In these and a variety of other cases, the use of the novel communicative facility of a technology helped knowledge reach and produce a strong response in a wider audience.

Today, Virtual Reality is widely used to simulate environment and spaces in architectural and urban design. However, there is a gap of knowledge on real-world applications of Virtual Reality within research of social impact on existing architecture and domestic interior spaces. By bringing the public into immersive virtual representations of these environments, the hope is that interviewees' stories are

communicated in a rich and immediate way that other methods cannot offer.

1.3. TECHNOLOGICAL BACKGROUND

As shown above, the social and scholarly context into which this visualization research has been added are loaded with both potential and challenges.

One important aspect is the relationship of technologically driven research to the context and the locale. Due to the factors described above, opportunities for advanced technology research abstracted from potential real-world applications are often hard to come by. Mississippi State University is a Land Grant University, founded with a mission to materially improve the lives and livelihoods of the people of the state. As a small School of Architecture and faculty, most collaborative research is conducted in partnership with experts in other diverse areas. The result is interdisciplinary projects such as this one, which don't test the cutting edge of technology but have the potential to address real societal needs through application.

Presenting the lived spaces of those who have experienced housing insecurity in 360º video augments the wider project's goals. The first impacts of using 360º video to enhance the exhibition with affective immersive experiences are outlined below. Critical to this documentation are the ethical considerations, and as such this aspect of the project has been evaluated by the IRB staff of Mississippi State University for compliance with the project's Human Subject Research protocol.

2. Methodology

The typical data gathering process is as follows: the *Housing Insecurity* team solicits a referral to a potential interviewee from community partner organizations. The project team leaders contact potential interviewees to schedule an in-person meeting at their residence. Once a time and date are set, the researchers accompany a student interview team of 3-4 students (all enrolled in the class on the subject) to the residence for the field work. For the interviewee's privacy, most interviews occur outside. This is possible most of the year, owing to the mild weather of the Southern USA.

After a faculty researcher reviews the consent form with the interviewee, they step back and allow the students to conduct the interview with high-quality wireless audio equipment. One student (selected in advance) conducts the interview and asks any follow-up questions. The other students take notes and are welcome to ask questions and follow-ups when appropriate.

At the end of the recording, a faculty researcher finishes the paperwork with the interviewee and the students tear down. Once this is complete, the team documents the exterior and interior of the dwelling. For privacy, the interviewee leads the team through the dwelling where they use conventional architectural site documentation techniques to quickly complete the documentation.

While the team conducts their documentation, the faculty researcher operating the VR prepares it for use. This consists of mounting it on the tripod, establishing connection to the phone app to control it remotely, and positioning it in the chosen space. As the conventional documentation is concluding, the researcher reviews the space with the interviewee. The *Vuze Camera App* allows for real-time streaming

from the camera's eight lenses. The researcher reviews what is in frame with the interviewee to ensure that they are comfortable with everything being documented.

The goal of this documentation is to show the space itself and how it is used, not to violate the privacy of someone who has already experienced hardship. Objects or information that could disrupt the interviewee's privacy are moved, as are any items the interviewee doesn't want to be shared publicly.

Once this most crucial step is complete, VR documentation begins. For privacy, the room is cleared of human activity. Movement such as ceiling fans or screensavers that can help break the uncanny feeling of video of an empty room are left running. The ideal camera placement is roughly eye height (+/-165cm) in the centre of the room. However, the distorted parallax of moving objects near the camera can disorient VR viewers and placing the camera directly under the moving object mitigates this.

The current field work uses the *Vuze+ 3d 360º VR Camera* to capture video. In the two videos recorded to date, approximately 2.5 minutes of footage is taken. This allows a substantial voiceover yet is still short enough to maintain viewer interest.

After the field work is completed, the 3D video data processed in Vuze's proprietary VR Studio. This program allows the post-processing and refinement of the video. When the desired settings are achieved, the video is rendered out from VR Studio into the two formats used in the exhibition - monoscopic and stereoscopic 360º video.

The chosen audio clip from the interview are is added as a voiceover to the video using Adobe AfterEffects. To date no post-processing redactions have been necessary, but in future videos these would also be applied in AfterEffects. Once post-processing is complete, the files are rendered to standalone video files. These are tested on both a VR headset and iPad when any substantial change is made to render settings to ensure usability of the file. The last two steps have crucial influence on the final product, as described in **Results**.

In the Exhibition, iPads are used to play the monoscopic video, and Virtual Reality headsets to play the stereoscopic videos.

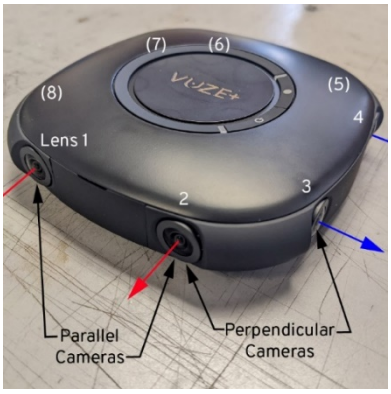

Figure 2. Vuze+ Lens Orientation

Figure 3. Lens Stitching Discontinuity

3. Results

These videos increase the realism in understanding the living conditions of those facing housing insecurity. This realism is a critical factor in driving "presence" in the VR environment (Jung, Lindeman, 2021), and thus empathy.

The VR captures spatial qualities which cannot be captured through conventional representations. However, to try to maintain neutrality of presentation, the camera is stationary and no particular aspects of the scene are highlighted or enriched. The viewer is allowed to simply exist in the space for a few minutes and observe what it would be like to be present there.

Challenges still exist in the realistic documentation of the spaces using current equipment. The Vuze+ camera uses eight separate lenses - one pair on each of the four sides of the camera body, whose fields of view overlap. The distance between any two coplanar lenses mimics the parallax of stereoscopic human vision (Figure 2).

Each lens only captures a portion of the environment, and the separate images are blended by software in post-production. In the monoscopic videos, data from only one camera of each pair is used, so the effect of parallax from adjacent corner lenses is minimized.

In stereo, blending between two lenses on the same face is seamless. However, between perpendicular lenses (2 and 3 in Figure 2), this zone can be visible. Parallax is less noticeable and forced perspective distortion is lessened for objects are further from the camera. Due to the small size of the interiors being documented, many objects are close enough to the camera that this parallax does not resolve cleanly. This requires careful use of the stitching and blending settings in VR Studio.

During testing it was observed that these are most disruptive when they coincide with a spatial boundary, especially vertical corners of rooms. While capturing data in the field, it is important to position the camera so that the stitching between perpendicular lenses occurs in an area with the least visual information such as a flat, featureless area of wall (Figure 3).

The centre of rotation for human eyes is in the neck while the centre of rotation of the fixed camera is at the centre of the lenses. This difference is mitigated by the small size of the interiors being captured, but this can result in the parallax issues described above so careful post-processing is necessary to minimize disorientation.

Proper video rendering is another crucial post-processing consideration. As documented in the existing literature on Virtual Reality implementation, fidelity and usability are non-trivial due to their impact on viewer comfort. Improper settings can destroy the sense of immersion and even cause motion sickness.

Many capture and output factors must be balanced against each other to ensure the video preserves the sense of presence and immersion. In capture, the scene must be well lit to avoid noise and artifacting and have a well framed field of view. In post-processing, resolution, framerate, and file size are important.

In previous studies, the viewer's "embodiment" within VR space has been shown to increase the sense of "see(ing) themselves as part of the VR environment" and thus feelings of empathy (Shin, 2018, 66). However, even with every precaution in post processing, some find VR physically disorienting, so the videos are also output to monoscopic 360º video for iPad viewing. Viewing this content through a frame rather

than through immersion does not have the same affective impact on feelings of empathy (Schutte, Stilinovic, 2017, 702), but as a measure to increase public dissemination, it was deemed necessary.

There are also challenges in the deployment of the viewing devices in an exhibition. The audio players used to listen to oral histories are inexpensive and have simple controls, but the iPads and VR headsets needed to view this media (Figure 4) are more expensive and are movable. The Gallery at Jackson State University where the exhibition recently concluded (February 2023) did not have full-time security, and the front-office staff were not trained to troubleshoot viewing issues or facilitate exhibition attendee use. As such, full inclusion into a physical exhibition will require more resources. Online display is easier, as the monoscopic 3d view can be played on the web natively. This aspect of the project is currently being implemented.

Figure 4. Use of Headset to View Stereoscopic 360º Video at Exhibition Opening

4. Discussion

> *"Representations are crucial in the field of humanitarian communication because aid and action are directly dependent on how spectators perceive the distant others who are subjects of the representations." (Irom, 2018)*

All 20 students that have been involved in this project to date have expressed that they did not have an accurate sense of the living conditions their fellow Starkville residents endure daily. Most of the town population has little understanding just how serious or widespread the problem is. Unlike the students, the average exhibition goer cannot experience these spaces in person. The VR component is an effort to increase the impact of the advocacy of this project by providing a more immersive experience to exhibition attendees.

An important aspect is the use of the interview audio over the visual input. Hearing the interviewee describe the spaces they inhabit in their own words helps build "narrative transportation" and correlates the space with their lived experience. (van Laer, Feiereisen, Visconti, 2018, 136) This facilitates identification of the viewer with the interviewee and thus empathy for them. (Shin, 2018, 68)

To date the Oral History team has documented ten residences, and acquired the VR data for two (Figure 5 and Figure 6). Of these, both interviewees expressed in their oral history that their current situations are significantly better than their prior ones. While the differences in these spaces revealed by the VR data is a useful

counterpoint, a rigorous formal examination is outside the scope of the current examination. Regardless, transported to these dwellings by the virtual space of the 360º video, one can more clearly situate themselves within the spatial consequences of housing insecurity.

Figure 5. VR Capture 1 - Living Room

Figure 6. VR Capture 2 - Living Room

4.1. CONCLUDING DISCUSSION

The community partners of this project have expressed that the exhibition is a helpful advocacy tool, as it explains the problem of housing insecurity through the voices of the affected residents respectful of their agency even under onerous circumstance. VR component is used to continue this effort.

These first results from adding a Virtual Reality component to this oral history and architectural survey project are compelling and have inspired the researchers to explore future directions for this work. First, the VR documentation will continue along with the oral history project. The variety of spaces and the lived experiences they embody will expand. It is hoped that these can help further flesh out the gamut of living conditions and the challenges they present to the occupants.

Future plans of the travel exhibition include displays in different states across the U.S. The goal before the next viewing is to conduct a controlled study on MSU campus where the individuals' interactions with the media of the exhibition will be examined to measure different audience interactions with the exhibition artifacts (architectural drawings, audio, photographs, and VR). Results from this controlled

study will help inform future directions in the exhibition media and delivery method.

As the project garners more funding, the plan is to use 3d point cloud scanning or photogrammetry to create virtual representations of the spaces, not just 360º video from a fixed camera. This will increase detail and usability, with the hope of allowing viewers to feel more embodied within the space. This will be evaluated against the current techniques for effectiveness in communication.

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References

Cox, R., Henwood, B., Rodnyansky S., Rice, E., Wenzel, S. (2019). "Road Map to a Unified Measure of Housing Insecurity." Cityscape: A Journal of Policy Development and Research. Vol. 21, No. 2. 93-128.

Gosseye, J., Stead, N.,Van der Plaat, D. (2019). Speaking of Buildings: Oral Hisotry in Architectural Research. New York: Princeton Architectural Press.

Irom, B. (2018) Virtual Reality and the Syrian Refugee Camps: Humanitarian Communication and the Politics of Empathy. International Journal of Communication. 12, 4269-4291. 1932-8036/20180005

Jones, T. (2021). New group presses Oktibbeha County supes to fund homeless shelter. Dispatch. Retrieved December 9, 2022, from: https://cdispatch.com/news/2021-10-19/new-group-presses-oktibbeha-supes-to-fund-homeless-shelter/

Jung, S., Lindeman, RW. (2021) Perspective: Does Realism Improve Presence in VR? Suggesting a Model and Metric for VR Experience Evaluation. *Front. Virtual Real.* 2:693327. https://doi.org/10.3389/fvir.2021.693327

Schutte, N.S., Stilinović, E.J. Facilitating empathy through virtual reality. *Motiv Emot* 41, 708–712 (2017). https://doi.org/10.1007/s11031-017-9641-7

Shin, D. (2018). Empathy and embodied experience in the virtual environment: To what extent can virtual reality stimulate empathy and embodied experience? *Computers in Human Behavior,* 78, 64-73. https://doi.org/10.1016/j.chb.2017.09.012.

Solomon, A. (2021). Gameday Homes Increase Housing Prices in Southern College Towns. NextCity. Retrieved December 9, 2022 from: https://nextcity.org/urbanist-news/gameday-homes-increase-housing-prices-in-southern-college-towns

Van Laer, T., Feiereisen, S., Visconti, L. (2018). Storytelling in the digital era: A meta-analysis of relevant moderates of the narrative transporation effect. *Journal of Business Research,* 96, 135-146. https://doi.org/10.1016/j.jbusres.2018.10.053