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Article

3D Laser Scanning representation in Architecture: the place of the record

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Abstract

In Architecture, representing the context is for both a technical need and an understanding process for the architectural discipline. The creation of drawings is not only to measure and represent reality to intervene in it but also to analyse it in a broader sense, and often for purposes beyond placing a future design. From a wide range of available 3D recording technologies, we have developed our work using 3D laser scanning, also known as LiDAR. This method can provide comprehensive, detailed and accurate datasets to create architectural visualisations that offer new technical capabilities and conceptual dimensions of site, context and place. This essay shows a series of explorations and applications selected from our last 13 years of research and practice, ranging from documenting built heritage at risk to using the record as a basis for design. These are grouped thematically to reflect on their challenges and possibilities for architectural design and representation.

Keywords

3D laser scanning; LiDAR; built heritage; architecture; representation; urban change; record

1. Introduction

The use of new technologies to record the environment is increasing as they become affordable and more accessible than ever before. Among them, 3D laser scanning is particularly relevant since it can document reality as a measurable coloured three-dimensional point cloud (Trossell & Shaw 2011), from which different outcomes can be generated and explored as a new form of representation. These are not just images but the visualisation of a measurable 3D model of reality—with a resolution of potentially billions of points—that allows for creating architectural visualisations otherwise impossible to obtain from reality other than trying to reproduce it through drawing. Aerial views, elevations, sections and perspectives can thus be made by editing, dissecting and exploring the captured three-dimensional data.

All methods of representation have specific aesthetic characteristics. 3D laser-scanning offers unprecedented comprehensiveness and accuracy in documenting physical reality yet rendering it as if it were immaterial. Each 3D scan has millions of points with XYZ coordinates and an RGB value. Each point can be expressed as text or rendered to be visualised. With an aura between digital reality and ghostly existence, the images and videos rendered from 3D laser scanning offer distinctive aesthetics, like something that does not exist in reality or is a fictional digital model. This contrasts with the millimetric precision with which the 3D laser scan data captures the as-built condition of the surveyed sites.

2. Digital preservation of heritage buildings

The increasing number of buildings listed as heritage worldwide poses a challenge regarding their physical conservation, bringing forward the idea of digital preservation, for which 3D laser scanning is widely used (Cyark, 2024). We have addressed the related need for technical skills, expensive equipment, and software, which are required for this method, through arranging knowledge exchange and training activities around the documentation of heritage buildings.

2.1. Documenting built heritage as teaching experiences

Figure 1 was created with data obtained involving architectural students in the complex workflows of capturing and postprocessing 3D data at the Bartlett School of Architecture, University College London (UCL), whilst delivering open classes covering general aspects to specific applications for built heritage, fabrication and virtual reality. The cases were selected in collaboration with the Survey of London, such as at St Boniface's church in London, to generate a complete set of survey outputs, including images and technical drawings using data obtained in just one day of capture on-site, allowing to discuss further the importance of this documentation method for built heritage surveying, representation and intervention.

2.2. Remote skills development: Heritage Houses in Ahmedabad

Figure 2 was created in the context of the COVID-19 global pandemic. Researchers at CEPT University in India were given access to 3D laser scanner equipment and software as part of an international collaboration project: 'Surveying heritage buildings in Ahmedabad, India: empowering local action and skills for heritage conservation'.[1] They were guided remotely to document two houses in the UNESCO World Heritage Site of the Walled City of Ahmedabad. This experience was vital for capacity-building towards a post-earthquake heritage *re-construction* research project in Gujarat, India (Devilat et al., 2021).[2]

2.3. Documenting built heritage at risk

Wooden heritage buildings are particularly at risk due to fires and weather effects, implying the need for constant maintenance, including replacing structural elements. This is especially true in a harsh climate, as it occurs with the heritage churches in Chiloé, Chile, some of which are part of a UNESCO World Heritage site. These fragile buildings are located in remote coastal settings throughout the Chiloé Archipelago, where the rising sea levels in the context of climate change pose a further threat. Figure 3 shows one example we have surveyed as part of the project: 'Documenting the Heritage Churches of Chiloé: the record as knowledge transfer for conservation', part of the Endangered Wooden Architecture Programme (EWAP)[3], which also includes a component of training and knowledge transfer to local institutions.

1 - Funded with an internal grant obtained at NTU. Research team: NTU: B. Devilat (PI) & G. Abdelmonem (Co-I); CHC CRDF: J. Desai (Co-I) and M. Mane (Research Assistant, RA)

2 - More information on Fig. 7.

3 - Supported by EWAP, Oxford Brookes University and funded by Arcadia, a charitable foundation that works to protect nature, preserve cultural heritage and promote open access to knowledge, in collaboration with Cyark. Research team: UoN: B. Devilat (PI) & F. Lanuza (RF); Centre for Cultural Heritage, P. Catholic University of Chile (PUC): U. Bonomo (collaborator) & S. Bernales (RA); University of Chile: L. Berg (collaborator); Churches of Chiloe Foundation: N. Cruz (collaborator).

Figure 1. St Peter's Church in Walworth, in London, 2018. Source: B. Devilat with data captured on-site by her as a tutor, H. Williams (tutor) and the MA Situated Practice students: N. Beesley, D. Cappaert, L. Dong, S. Hardcastle, M. Guttierrez, E. Malano, A. Perahia, J. Rebernak, I. Rivas, I. Saavedra and S. Shah. The Bartlett School of Architecture, UCL. More information at: https://bartlett3dscanlibrary.wordpress.com/

Figure 2. Elevation of a house in the historical centre of Ahmedabad, 2021. Source: B. Devilat using the data captured on-site by M. Mane (tutor) with the MA Architectural Conservation students: A. Mital, K. Chaudhari, N. Chandel, S. Chavan, A. L., B. V., S. Anand, and the teaching assistants: J. Bafna & Z. Pithawala. Center for Heritage Conservation (CHC), CEPT Research and Development Foundation (CRDF) and Nottingham Trent University (NTU), in the context of the research project: https://ntu3dscanlibrary.wordpress.com/

Figure 3. Church of Vilupulli in Chiloé, Chile, 2023. Source: B. Devilat using data captured on-site by her, F. Lanuza and A. Morales, in the context of the research project: www.churcheschiloe.wordpress.com

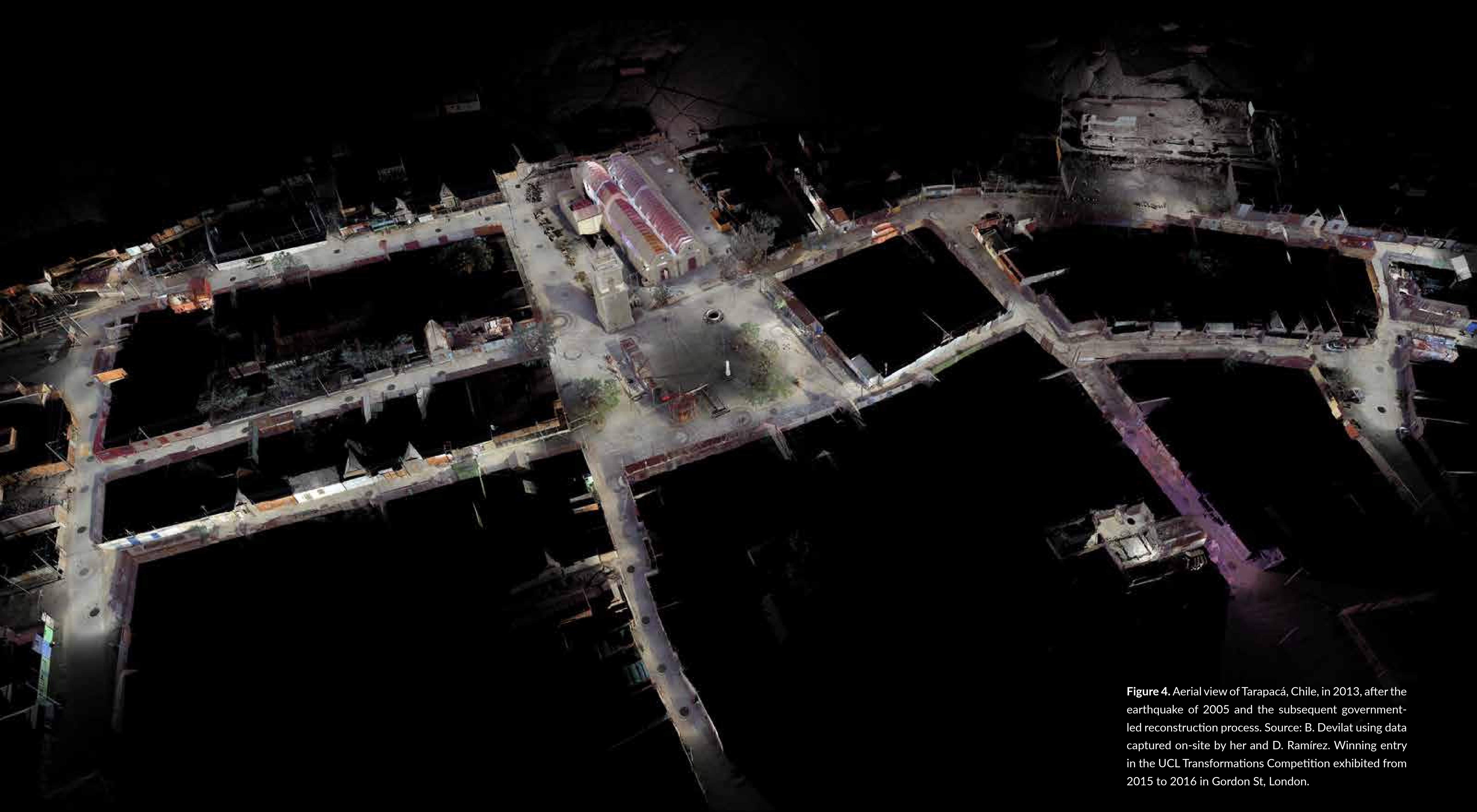

Figure 4. Aerial view of Tarapacá, Chile, in 2013, after the earthquake of 2005 and the subsequent government-led reconstruction process. Source: B. Devilat using data captured on-site by her and D. Ramírez. Winning entry in the UCL Transformations Competition exhibited from 2015 to 2016 in Gordon St, London.

Figure 5. A house in the heritage village of Zúñiga in 2013, still damaged by the 2010 earthquake. The inherent transparency of the 3D point cloud renders domesticity from an outside perspective, with the house partially damaged by the earthquake yet still inhabited. This image obtained the first Prize in the UCL Research Images as Art / Art Images as Research Competition at UCL Doctoral School, 2016. Source: B. Devilat, using data captured on-site by her, F. Carter and F. Vargas.

Figure 6. A damaged house in the heritage village of Lolol, 2013. It represents a ruined condition that will never exist again, as the structure has continued deteriorating since then, becoming a digital record of the 2010 earthquake's destruction. Source: B. Devilat using data captured on-site by her and F. Lanuza.

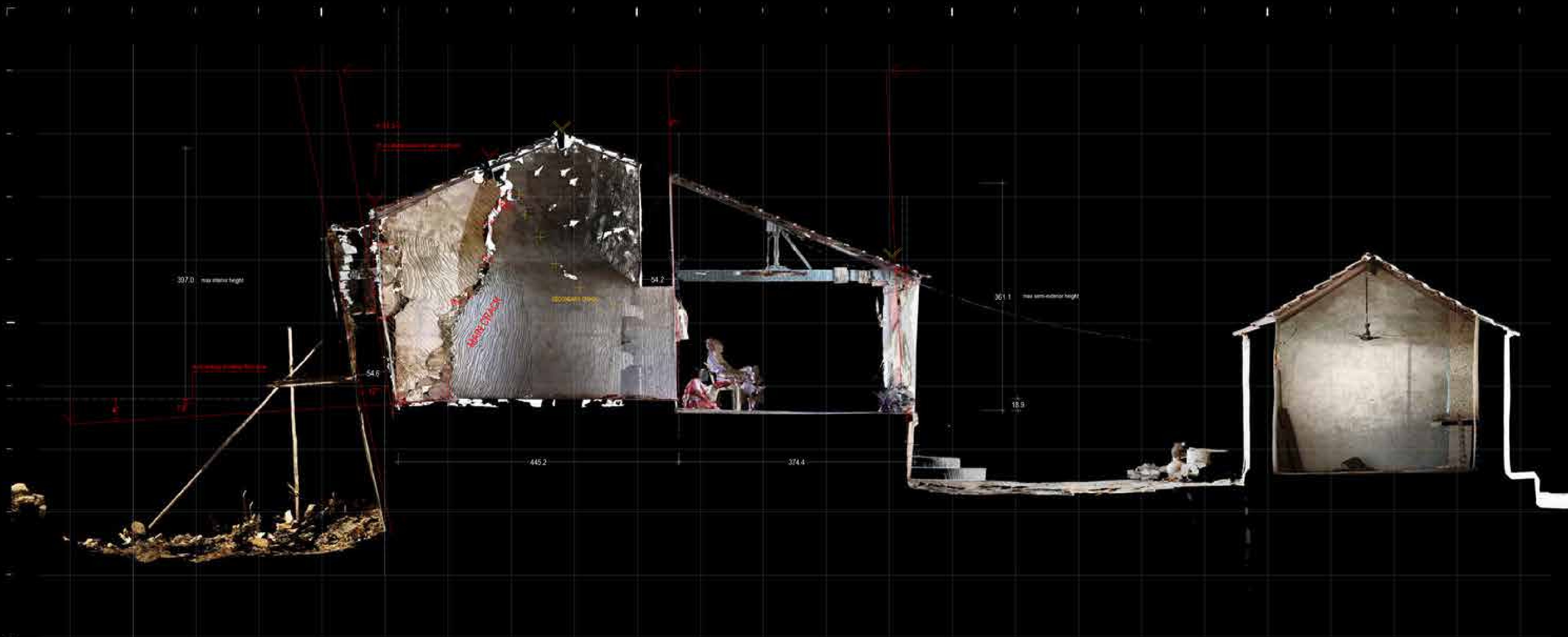

Figure 7. Geometrical analysis of damage in a family temple in the historical village of Bela, located in Gujarat, India, in 2021. Source: F. Lanuza using data processed by him and B. Devilat, based on the capture on-site by M. Mane and Z. Pithawalla, in the context of the research project: www.3D4heritageindia.wordpress.com [4]

3. *Re-construction* and record

3.1. The role of the record for heritage intervention

Figures 4, 5 and 6 explore the role of 3D laser scanning as a documenting tool for historical settlements affected by earthquakes in Chile via three case studies: Tarapacá (Figure 4), Zúñiga (Figure 5) and Lolol (Figure 6). Whilst current digital technologies offer unprecedented capabilities for creating replicas if destroyed, this work proposes *re-construction* as an alternative way of understanding heritage intervention, building traditions and sustainability in post-earthquake recovery processes (Devilat 2016). The images show the domestic scale of homes along with the damage produced by the earthquake, where the aesthetics of the 3D-laser-scan record conveys the fragility of life and its material support whilst showing destruction in a seemingly immaterial way, strangely contrasting with its physical effect.[5]

3.2. 3D laser scanning as a post-earthquake surveying tool

The 3D documentation allows for rendering architectural projections showing the actual state of the documented structure, offering the possibility for damage assessment, detailed measurements, and insights into how people use the interior spaces depending on their cultural contexts, as shown in Figure 7.

4. The record as a basis for design

4.1. Designing from the context

We explored the potential of 3D laser scanning for the remote design, from London, of a second house in a rural plot in the outskirts of Talagante, Chile. Resonating with speculations by Sheil (2014) about the impact of this technology on a zero-tolerance design, we tested the concept of inserting a proposal within existing vegetation, flower beds, pavings and a barbecue area in the corner of the site, as shown in Figure 9, accurately measured in the 3D point cloud (Devilat & Lanuza, 2020). The new construction was carefully positioned within the existing elements, which determined its geometry and vistas (Figures 10 and 11). The construction process revealed the design changing from its initial precision to a more dynamic condition, to accommodate contingencies and technical gaps (Figure 12).

4.2. Damage assessment, retrofitting and reinforcing buildings

Following a similar principle, the 3D data was used for damage assessment of an existing structure, as shown in Figure 13, that was affected by the 2001 Bhuj earthquake, supporting the design of retrofitting and reinforcing measures. These structural interventions were left exposed as examples of strategies to address damage and mitigate risks in other constructions in the village.

5. The record *in absentia*

Beyond capturing and representing architecture as a form of preservation or to inform intervention, 3D laser scanning documentation can inform wider accounts of urban change. Due to its capacity to provide a precise record of the built environment, but also given the immaterial nature of its visualisations, it can speak of the fragility of buildings and places now absent or set to disappear. For example, the Eastman Dental Hospital (EDH) in London (Figure 8) and the Royal National Throat, Nose and Ear Hospital (RNTNEH shown in Figure 14), before moving to new facilities nearby. The sections of the EDH obtained from the data offer otherwise impossible architectural sections, as if the facades of the buildings were removed, like in a doll's house. Interiors featuring furniture, objects, and decorations as traces of life could be seen under a new light, suggesting the possibility for an alternative form of 'architectural ethnography' (Kaijima, 2018), drawing from the comprehensive and detailed 3D laser capture of the material culture embedded in buildings.

4 - Funded by AHRC and DCMS. Image done in Phase 3 of this research project. Research team: UoN: B. Devilat (PI) & F. Lanuza (Co-I); NTU: G. Abdelmonem (Co-I); CHC CRDF: J. Desai (Co-I), M. Mane & N. Shaikh (Research Associates), S. Pancholi & Z. Pithawalla (RA); Gujarat Institute of Disaster Risk Managament (GIDM): S. Daberao (project partner); Hunnarsa-hala Foundation: A. Singh & M. Acharya (project partners IC-CROM: R. Jigyasu (Co-I) & S. Sen (RA).). More information at: www.3D4heritageindia.com

5 - The 3D laser scanning survey of these three heritage villages was carried out as part of Bernadette's PhD, funded by the National Agency for Research and Development (ANID), Scholarship Program / DOCTORADO BECAS CHILE/2009-72100578. The fieldwork was partially funded by the Graduate School, UCL, in 2012, with equipment lent by Diego Ramírez from www.getarq.cl.

Figure 8. Section of the EDH in Greys Inn Road, London (zoom-in). This artwork is part of the permanent exhibition 'The Texture of Air'. Source: B. Devilat, in collaboration with L. Mitchison, using the on-site data captured by B. Devilat (tutor), L. Jiang, S. Shah & V. Wu, as part of the Bartlett School of Architecture UCL training activities. More information here: https://www.thetextureofair.uk/

Figure 9. Aerial view of the design placed within the 3D laser scanning point-cloud, 2017. Source: B. Devilat & F. Lanuza.

Figure 10. First floor plan, design within the 3D laser scanning point-cloud, 2017. Source: B. Devilat & F. Lanuza.

Figure 11. Section of the design within the 3D laser scanning point-cloud, 2017. Source: B. Devilat & F. Lanuza.

Figure 12. Photograph of the built house, 2017. Source: B. Devilat & F. Lanuza. More information at www.devilat-lanuza.com

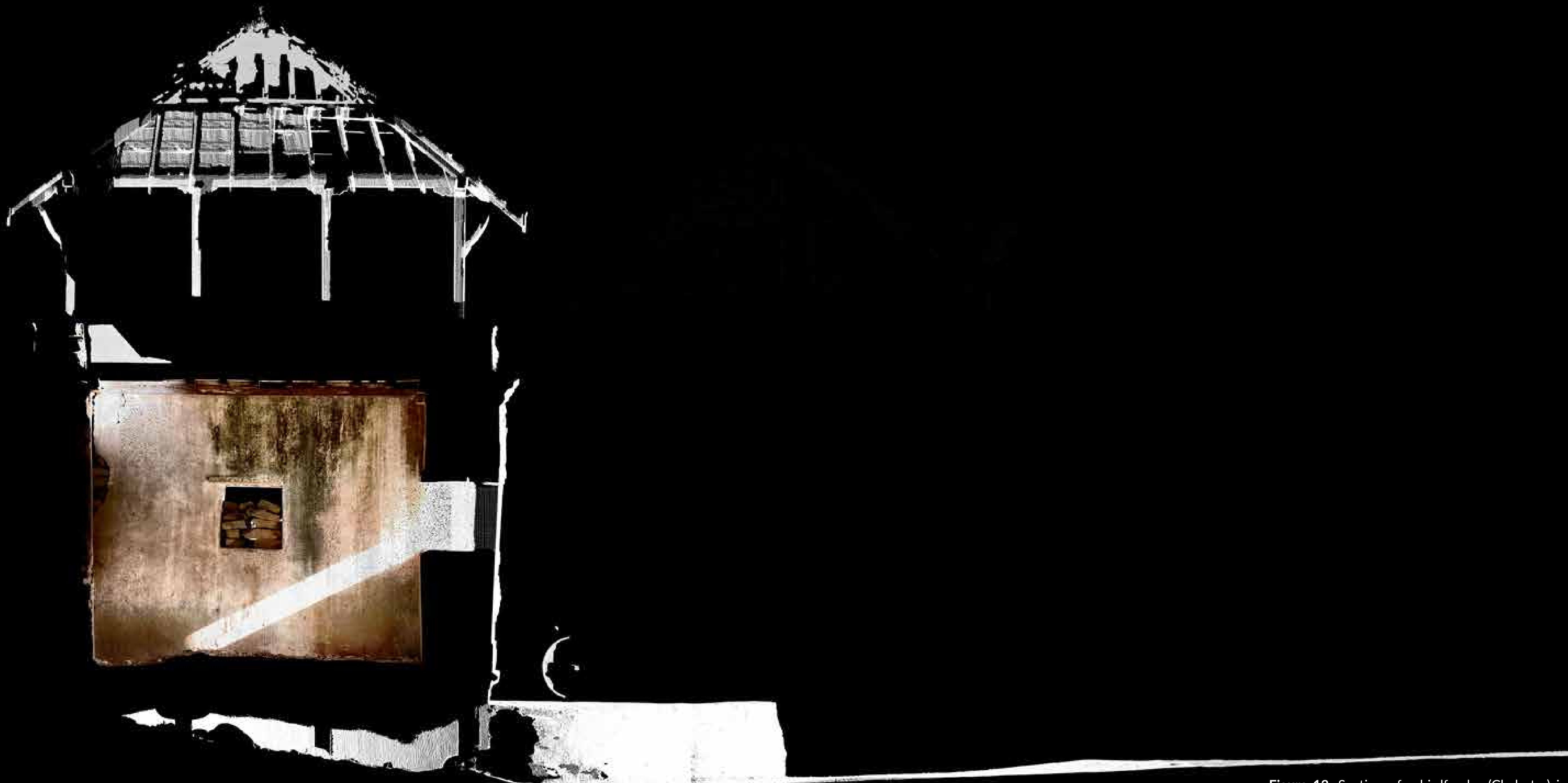

Figure 13. Section of a birdfeeder (Chabutra) in Bela, Gujarat, India, as documented in 2021. Source: F. Lanuza using data processed by him and B. Devilat, based on the capture on-site by M. Mane and Z. Pithawalla, in the context of the research project: www.3D4heritageindia.wordpress.com

Figure 14. Section of the RNTNEH in Greys Inn Road, London, where different cutting planes were overlapped in order to peek inside the rooms. This artwork is part of the permanent exhibition 'The Texture of Air'. Source: B. Devilat, in collaboration with L. Mitchison, with on-site data captured by B. Devilat (tutor), E. Ergin, F. Lanuza, F. Onsiper & M. C. Venegas, as part of the Bartlett School of Architecture UCL training activities. More information here: https://www.thetextureofair.uk/

Figure 15. Wendover building, Aylesbury Estate, 2023. Source: F. Lanuza. Data capture was conducted as part of the 'Research Talent Fund Award' at Nottingham Trent University (2022-23). Data processing and outputs were developed within the context of the project 'Conservation and Resistance: Documenting Urban Change in South London', funded by the University of Nottingham (2025).

replaced in the context of market-led urban regeneration, many areas of London are becoming unrecognisable and generic, very often implying the forced displacement of disadvantaged communities. The Aylesbury Estate in South London was one of the largest council housing schemes in the UK and is currently facing regeneration. With few buildings still standing and most of their flats emptied and concealed, the sense of absence in the context of this radical urban transformation is recreated in Figure 15. It shows an image of a vanishing Wendover building featuring a single, defiant flat in the middle of an otherwise empty, seemingly disappearing shell. There lived a council housing tenant who fiercely opposed the regeneration of the estate from the outset and was one of the last to leave the building. With the support of artists, she turned her home into a manifesto for social justice in the form of an exhibition open to the public. If the building is demolished, its afterlife will be that of an archive: a dense enclave in the middle of a point cloud to raise awareness of the negative social effects of urban regeneration, using absence to reassert a vision critical to current forms of city-making (Lanuza 2020).

6. Conclusions

We believe that our built environment has its value in the aggregation over time of multiple histories that materialise in our cities and landscapes; some of them are present, and some others become absent. We tried to explore and bring them forward through new ways of architectural representation and design. As seen, 3D laser scanning documentation is not a straightforward process but rather one with different stages, thus implying a collaborative effort. The reality captured in a potentially permanent three-dimensional digital record, if carefully archived, holds almost infinite possibilities for further reimagining the surveyed sites. The data can be virtually explored, digitally translated into virtual reality, 3D printed and converted to formats we have not even invented yet, changing the way we think in the records we create for the future, presented here through these explorations. As with any other tool, however, there are possibilities as well as limitations to 3D laser scanning. From a technical perspective, it only captures visible surfaces, with missing data from misplacement and inaccessible areas on-site. There are hardware and software limits, given the large datasets implied, and specialist knowledge is required. From the perspective of a nuanced understanding of the surveyed places, its comprehensive and precise account of the space, its geometry and the objects contained in it, which contrasts with its limitations in capturing time. Therefore, it must be complemented with other methods, such as aerial photogrammetry and interviews, to effectively account for the social and cultural dimensions of architecture and any surveyed place.

Conflict of Interests and Ethics

This work used different Faro 3D scanner models. There is no association between Faro Technologies and the authors.

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