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DIGITAL FORENSICS AS A TOOL FOR AUGMENTING HISTORICAL ARCHITECTURAL ANALYSIS

Case Study: The student work of James Stirling

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Abstract. Digital techniques in architecture have developed rapidly over the last 25 years. This has enabled digitally mediated visualisations to become increasingly complex, and potentially more beneficial to the user. In architectural critique this creates an opportunity to re-analyse and re-interpret paper and photographic records of architectural artefacts. The information available to construct models of lost or unbuilt designs is almost always incomplete; therefore interpretation of material requires parallel study into the architect, their influences and the contemporary context they operated within. This can prove to be a rich exercise in augmenting a critical architectural analysis of an architect, a built product or building type. The process of constructing a model and its subsequent analysis can be referred to as scenario building, or informed extrapolation. This paper uses the reconstruction of an unbuilt scheme by Sir James Stirling as a vehicle to explore and illustrate the techniques, implications and limitations of the process.

Keywords. Forensic analysis; digital modelling; scenario building; virtual reconstruction.

1. Introduction

The idea of digital recreation of unbuilt or lost architectural artefacts has been an area of interest since the time when reasonable quality digital visualisations of architectural models could be produced. In the 1990s and subsequently work such as that of Burry and Burry (2006) in relation to Temple Sagrada Familia in Barcelona has by necessity used techniques in which the digital representation has enabled appropriately informed construction of the unbuilt.

There are those who question the appropriateness of reconstruction, or construction of the unbuilt, such as Jarzombek (2004). But such debates are an inevitable part of the most engaging aspects of Architectural critique. When Architecture stops creating debate it stops being Architecture.

The study reported here is part of a larger research investigation into a series of architects and their work. The concern here is to help better understand the early formative years in James Stirling's career, from the time when he was a student at the Liverpool School of Architecture.

2. Case study overview

In 2008, Liverpool celebrated its year as European Capital of Culture and as part of the events held across the city, the Liverpool School of Architecture launched an exhibition and catalogue entitled 'The World in One School'. The catalogue focuses on outstanding alumni from the school and notes the six Royal Gold Medallists for architecture amongst the former staff and students (Dunne and Richmond 2008). One of the former students to achieve this outstanding recognition was Sir James Stirling (1926-1992).

Stirling is one of the school's most successful graduates and his work holds significant influence and admiration amongst the architectural community (Jacobus 1975; Rowe 1984). In order to enhance our understanding of Stirling's architecture the decision was taken to reconstruct the lost model of his final thesis project of a community centre at Newton Aycliffe designed in 1950. All that remained in the University of Liverpool archives were photographs of the original model constructed at a small scale and an incomplete set of drawings. However, it soon became apparent that the information available to build the model was fragmented. Therefore, the task involved piecing together the available information and working out how to interpolate and extrapolate to fill in the missing elements of the design. Stirling's education and early work as an architect was studied in order to understand his design principles and realise the context the thesis project was set in. This paper describes the process of investigating fragmented primary evidence and creating a model in order to support a rigorous analysis of a building that is lost, damaged or unbuilt. The reconstruction of the lost model of Stirling's design is used as a vehicle to explore and describe the techniques, implications, limitations and outcomes of the process. The forensic techniques adopted mean that we can go beyond simple reconstruction and interrogate the design decisions through a systematic computer mediated process.

3. Precedents and parallels

Beyond the use of modelling to produce reports of existing buildings or predicted appearances and functions of buildings that may be built, digital techniques can also be used to investigate the past in the form of reconstructions. From this, propositions can be made, and these are referred to as *counterfactuals* (Ferguson 1997; Mitchell 1998). A *reconstruction* is a model of a design that has been lost, destroyed or never built. The primary information is almost always incomplete meaning that investigation is needed as of how to fill in the missing parts. A counterfactual involves the development of an argument from this construction, usually a 'what if?' scenario. Questions can be raised such as 'how would this design scheme have influenced the design of subsequent buildings near the site?' Such enquiries can take advantage of what can be called *digital forensics*; a process which aims to provide rigorous investigation in the construction of a model (Harfmann and Akins 2000).

Once the models have been built they can then form the basis of analysis through *scenario building* by developing these 'what if?' questions to suggest an alternative truth which forms 'the start of a trajectory along a postulated historical path and associated circumstances' (Brown 2001). The process of scenario building aims to enhance and augment understanding of a piece of architecture, or an architect's work. The authors creating the scenario are aiming to generate instructive new material. When these concepts are used, they have the ability to form the basis of a much more critical investigation into a design than reviewing two dimensional sources alone. Therefore, by employing these techniques, the advantages from a research perspective are considerable.

4. Case study: Piecing together the Stirling information

One major difference between the studies discussed above, and the Stirling Newton Aycliffe Community Centre model was that the artefact to be recreated primarily took the form of a physical scale model. This enables a unique take on investigating digital forensics and reconstruction that uses both manual and digital techniques.

Various primary and secondary sources were studied to gather enough information to construct the model of Stirling's design. The first of these was to investigate the history of the Liverpool School of Architecture in the period leading up to his thesis project in 1950; when the school was undergoing a period of transition. In the years before the Second World War it had been associated with traditional styles such as the Beaux Arts and Neo Classicism under Sir Charles Reilly. The arrival of the Modern Movement in mainland

Europe began to filter through to the students in the 1930s which was assisted by the arrival of the Polish School of Architecture who took sanctuary in Liverpool in 1942-43 (Rowe 1984).

The writings of Rowe, Stirling's tutor, also formed key sources in understanding the community centre thesis. Rowe commented on the precedent studies Stirling used for the design including the unbuilt Illinois Institute of Technology Library and Administration building by Mies van der Rohe as well as the St Dié factory in France by Le Corbusier (Jacobus 1975). With this knowledge an investigation into those designs was carried out to look for similarities as to what Stirling's intentions could have been in the missing elements of the design. Corbusier's St Dié factory bears a strong resemblance to Stirling's thesis design; the core defining element being a concrete grid structure on pilotis. The fenestration is also likely to have been an inspiration to Stirling; prefabricated timber frames that are mirrored and paired to create a facade that links to the modular nature of the grid, yet retaining variety relating to the various functions of the building (Gans 2006). The scheme provides vital clues of materiality and space as to how the community centre design may have looked if it had been built. Mies van der Rohe's unbuilt library scheme at IIT also forms a good source of extrapolation for the model offering insights into the possible materiality of the design, such as the use of brickwork between the floor level and window sill.

5. Interpolation based on the contemporary context of the model

Inspection of the original drawings for constructing the model revealed that the missing information included the second floor plan, roof plan, both short elevations as well as several courtyard elevations. The problem of the short elevations was in part solved by manipulating a perspective image that included one of these elevations (see figure 1).

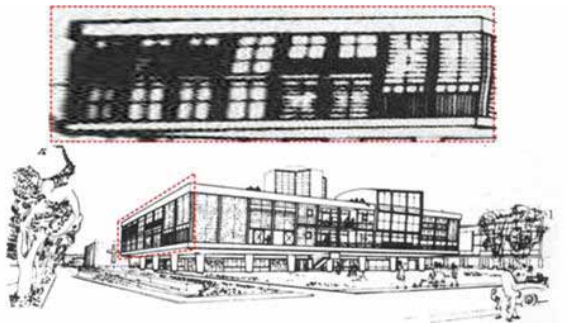

Figure 1. Stirling perspective (above) was digitally orthorectified to gain a clearer indication of the facade pattern (below).

This formed a reasonably clear indication of Stirling's original intentions in relation to the short elevation. The remaining short elevation proved a more difficult issue to resolve; an original section drawn through that part of the design revealed that the internal floor levels changed from being equidistant to a lower floor to ceiling height on the first floor, consequently making the second floor higher. At this point a detailed study of the existing drawings was required in order to work out where this change in level appeared on the external elevation. This change was already visible on the rear elevation of the scheme, of which drawings were available, and ended somewhere along the missing short elevation. As the design was based on a formal grid, it was feasible to interpolate based on examining the rear elevation and section. By studying these it became clear that the change in level took place in the library. Therefore by looking at the first floor plan, and locating the library, it was possible to determine to a relative degree of certainty whereabouts the change in grid pattern ended along the missing elevation (see figure 2). Without this line of enquiry to follow, it is unlikely that someone inspecting the drawings would realise that a change of level occurred in the design.

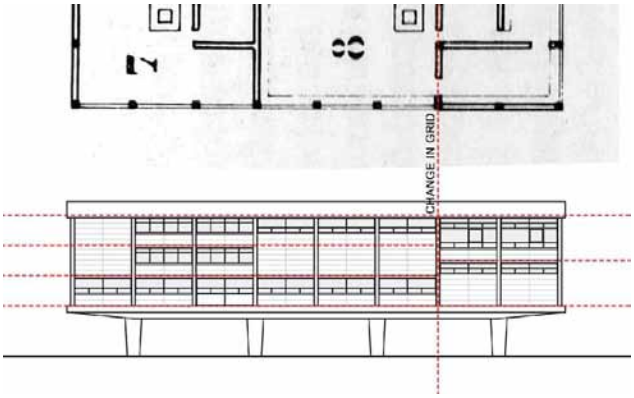

Figure 2. The interpolated short section: the change in grid pattern was discovered by studying the original plan to see where the library was situated.

The centre of the design features two courtyards which are separated by a promenade deck and games deck (see figure 3). The process of constructing the model revealed an inconsistency with the internal columns supporting this element that is not apparent from looking at the existing drawings alone. Two versions of the ground floor plan were available for Stirling's design; the first being less detailed than the second that suggests it was an earlier version. The first plan shows the columns positioned centrally in the internal courtyard which were of the same design as the majority of the columns (circular in section with their diameter increasing as they rise). The second, later plan

employs a different column design altogether; rounded extruded rectangles. When this information was applied to the digital model used to create the physical model, the structural grid informed the position of the columns based on their location on the ground floor plan as described above. Once they were drawn in three dimensions it became apparent that their positioning meant they would protrude past the facade they were supporting above, which is almost certainly an error on Stirling's part. This is especially true as the earlier plan with centrally placed columns suggests the change in column design was last minute.

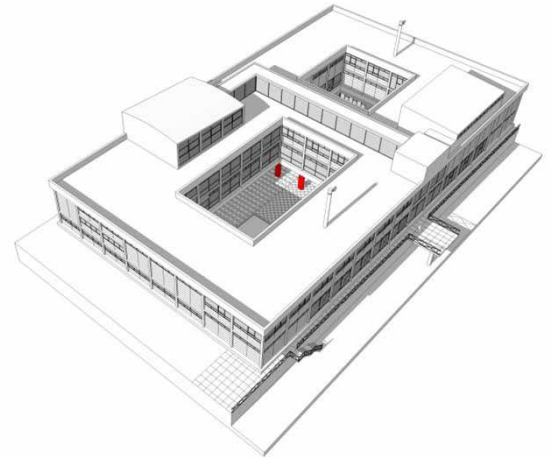

Figure 3. Digital model of Stirling's design showing the repositioned columns highlighted.

After the model was completed, further study of the original drawings revealed that the columns shift away from the structural grid slightly on the section but remained in line with the grid in plan (see figure 5). This indicates that the section was drawn after the plan once Stirling had realised the problem. One can imagine with the deadline approaching, the thought of moving the columns in plan by a barely noticeable amount would have been low on Stirling's list of priorities. However, this inconsistency meant that a decision had to be made as to where the columns should be positioned in the reconstructed model, bearing in mind that at this point their amendment in section was not realised. It was decided to keep the columns in line with the structural grid and rotate them by ninety degrees (see figure 4). This seemed like the most appropriate course of action seeing as the rigorous structural grid underpinned the whole scheme. This highlights a problem with constructing models based on partial information in that it is almost impossible to gain certainty of their accuracy. The practice has been regarded as 'slippery' as the distinction between what is fact and what is supposition or interpolated can be blurred (Mitchell 1998).

This issue can be addressed in the way the reconstructed model is presented; for instance elements of the design that are unknown or based on educated guesses could, for example, be presented in a different manner, by being left empty or shown with less detail than the known elements (Kensek 2005).

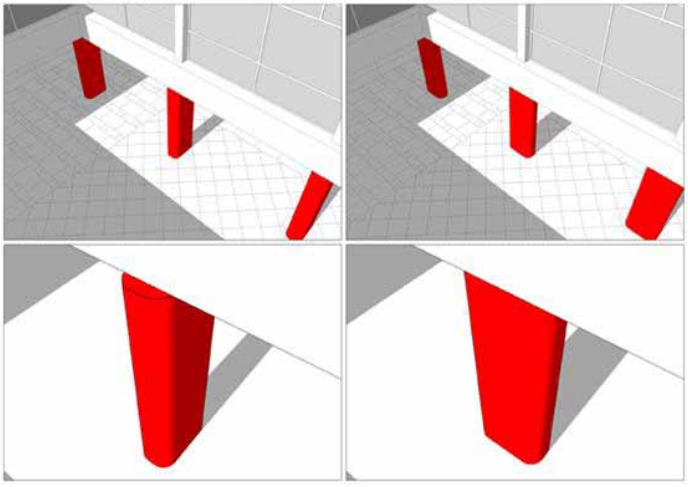

Figure 4. Digital model showing Stirling's final design with overhanging columns (left) and amended design (right).

One puzzling aspect of the design was the space Stirling created between the ground and first floor. At first glance of the drawings, it appeared that the vertical elements of the ground floor area meet the underside of the first floor slab (see figure 5). Upon closer inspection when preparing the drawings for the model, it became apparent that they do not meet; Stirling only connects the two levels where the circulation punches through the first floor slab. This is an example of how drawings alone can be deceptive; the construction of a model allows a more thorough analysis of the design in question and shows the advantages of it as a tool for augmenting architectural research.

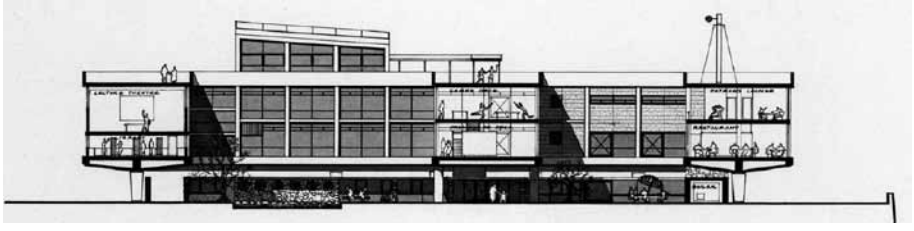

Figure 5. The original section showing the gap between ground and first floors as well as the columns below the deck appearing to sit correctly.

6. Constructing the Newton Aycliffe Community Centre model

Once all of the information was pieced together, the process of constructing the model could begin. Firstly all of the existing drawings were scanned onto a computer and scaled to size using a digital drafting package. The original drawings included a scale bar meaning that this was a simple process in ascertaining accurate dimensions. These sizes were checked by measuring people and door heights for clarity. The size of the grid pattern was established next, as it underpins the whole design. This was calculated at 9700mm (32 feet) between supporting columns and subsequently 4850mm (16 feet) between each window module on the facade. After these ruling factors were recognised, the rest of the drawings were traced over digitally as two dimensional vectors using the grid system as a guide. Once the existing known elements of the design were converted into digital line drawings, the process of filling in the missing elements could begin. This interpolation and extrapolation was carried out based on the research described previously.

After the vector based drawings were completed, they were reconfigured to prepare them for physical production on a CNC router. The process involved converting the drawings into the various layers that form the model. For instance, transparent acrylic was used for the glazed elements; therefore all of the drawings containing glazing were converted to this layer. In terms of representation, it was decided to allow the materiality of the design to be interpreted by the viewer as Stirling had not specified what each material was supposed to be (Knight et. al 2001; Kensek 2005).

Figure 6. Reconstruction of the lost physical model of Stirling's design for a community centre at Newton Aycliffe.

The construction of the model involved the use of both manual and digital techniques. Either alone would not have been enough to provide a satisfac-

tory result. The router cut the numerous pieces based on the digital line drawings and were finished manually by sanding and gluing them together. Some aspects of the design were highly sculptural, such as the weather vanes on the roof, and were consequently produced entirely by hand.

There were several lessons learned in constructing the model which could help with future exploration into digital modelling as a tool for augmenting our understanding. In terms of the missing elements of the design, primarily the missing elevation, a different approach could have been taken to ensure the viewer of the model does not believe it is an exact replica of Stirling's original design. Firstly, the elevation could have been left blank or to only show the grid pattern which runs through the whole scheme ensuring the viewer realises that this element of the design is unknown; however, this would have left the model disjointed and because of the research undertaken it was felt that an extrapolated design was sufficient. Another way of resolving this would have been to present several options of how the facade could have looked (Novitski 1998). This would have been an unhelpful complication when you consider that the model was intended for public viewing in the exhibition and was shown as one piece within the display to illustrate Stirling's Newton Aycliffe Community Centre design from Liverpool University rather than an investigation into what the missing elevation may have looked like. This issue could have been highlighted more clearly within the display though; with information showing which parts were unknown and which involved extrapolation from the known elements. This could also have included a brief description of the process of extrapolation to make the viewer fully aware of the nature of the model.

7. Conclusions and reflections

The production of digital or physical scale models to reinterpret lost or unbuilt designs is highly valuable as a research tool. It enabled a rigorous and thorough analysis of Stirling's Newton Aycliffe Community Centre design, resulting in new information being found. The process revealed that three dimensional modelling is particularly good at aiding the interpretation of a design, rather than relying on a set of two dimensional viewpoints. It also enabled the known and unknown elements to be easily distinguished from each other using the layer structure.

Virtual reconstruction allows an advanced level of understanding of lost architecture, giving an insight into a world that once was. This is valuable in gaining knowledge of our history and heritage in a way that engages the viewer on a much greater level than the study of two dimensional images and text alone. This can be said for reconstructions of models as well as three

dimensional modelling in general, either digital or physical. The World in One School exhibition is testimony to this as the Newton Aycliffe Community Centre model was commissioned for that reason; it enabled the attendees to experience and understand the design far better spatially. Without the use of digitally augmented techniques the model would have been incomplete, giving the viewer a disjointed vision of the design. Therefore its application was necessary and resulted in twofold benefits; a complete design for the viewer and a more thorough investigation into the building by the researcher.

The study demonstrates how thorough the exploration of a design has to be in order to produce satisfactory results, which consequently leads to a highly engaging research experience and augments the investigation into works of architecture. The resulting model, in the case of Stirling's design, creates a lively debate of what was and what could have been.

Acknowledgement

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References

Brown, A.: 2001, Architectural critique through digital scenario building, *Proceedings of the Ninth International Conference on Computer Aided Architectural Design Futures,* Eindhoven, Netherlands, 697–709.

Burry, J. and Burry M.: 2006, Sharing hidden power: Communicating latency in digital models, *Communicating Space(s), 24th eCAADe Conference Proceedings,* Volos, 786–793.

Dunne, J. and Richmond, P.: 2008, *The World in One School: The History and Influence of the Liverpool School of Architecture 1894-2008*, Liverpool University Press, Liverpool, UK

Ferguson, N. (ed.): 1997, *Virtual History: Alternatives and Counterfactuals*, Picador, UK.

Gans, D.: 2006, *The Le Corbusier Guid*e, Princeton Architectural Press, Princeton.

Harfmann, A. and Akins, P.: 2000, *The Composite Building Sketch, Eternity, Infinity and Virtuality in Architecture, Proceedings of the 22nd ACADIA,* Washington DC, 273–280.

Jacobus, J.: 1975, *James Stirling: buildings and projects 1950-1974,* Thames and Hudson, London.

Jarzombek, M.: 2004, Disguised Visibilities: Dresden/"Dresden," in Bastéa, E. (ed.): *Memory and Architecture,* University of New Mexico Press, New Mexico, 49–78.

Kensek, K.: 2005, Digital Reconstructions, *Confidence and Ambiguity, 9th SIGraDi Proceedings,* Lima, Peru, 640–644.

Knight, M.; Bandyopadhyay, S.; Berridge, P. and Brown, A.: 2001, Digital Hindcasting: Critical Analysis through Virtual Reconstruction, *Architectural Information Management, 19th eCAADe Conference Proceedings),* Helsinki, Finland, 529-533.

Mitchell, W.: 1998, Foreword, in Novitski, B.: *Rendering Real and Imagined Buildings; The Art of Computer Modeling from the Palace of Kublai Khan to Le Corbusier's Villas,* Rockport Publishers, Massachusetts, 8–13.

Novitski, B.: 1998, *Rendering Real and Imagined Buildings; The Art of Computer Modeling from the Palace of Kublai Khan to Le Corbusier's Villas,* Rockport Publishers, Massachusetts.

Rowe, C.: 1984, Introduction, in Arnell, P. and Bickford, T. (eds.): *James Stirling: buildings and projects,* Architectural Press, London, 12–13.