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3D digital modelling, fabrication and installation for understanding space and place

3D DIGITAL MODELING, FABRICATION AND INSTALLATION FOR UNDERSTANDING SPACE & PLACE

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Traditionally the teaching of history or theory on art and design courses often takes place in a lecture theatre. Space and place theory is integral to informing the practice led and practice-based experiences in architecture, interior and the built environment. The research team has investigated how digital modeling, fabrication and population tools can enhance the understanding of current theoretical debates surrounding space and place. The aim is to integrate inter-disciplinary practice allowing us to address key research questions relating to the emergence of digital fabrication and its potential impact upon art and design education.

The purpose is to provide an engaging and informative situated display, offering an experiential and intuitive frame of reference for constructing and placing objects, activities or events into their spatial context. The research has potential to act as an integrative experiential framework through which we can learn more about different contexts or connections between themes or theories which provides a deeper understanding of space or place.

In this new work with Taylor, Benincasa, and Unver evolve their practice through translating 3D research data for a series of new digital and physical experiments intended for enhancing or informing teaching and learning in art, design & architecture. The researchers experimented with a range of 3D software and the functionality of different tool parameters. Fabrication apps and 3D crowd simulation animation tools were used for the first time in this research to explore digital fabrication using cardboard in order to compose and construct 2D and 3D physical simulations of this well-known built environment in the landscape. The fabricated physical cardboard models we produced were located in studio spaces and 3D visual projection live drawing experiences were tested with students and staff working together. The 2D and 3D simulations that the team envisioned are both digital and real; and when installed facilitate a more kinesthetic experience of learning as students are able to create together, and interact with fabricated structures. This evolving research demonstrates how these 3D models, animations and fabrications have the potential to be used together as a catalyst to explore multiple projections of space, place identities, historical and cultural built environment concepts for art, design and architecture students at undergraduate and postgraduate level.

Keywords: Interdisciplinary, 3D, projection, fabrication, space, place, theory, architecture

1 INTRODUCTION

We are an inter-disciplinary design academic research group from the University of Huddersfield, Yorkshire, UK. Our research dynamic emerged from an openness to connect and share research and teaching experiences. The focus is to innovate, integrate, design, make and communicate things across and through theory and practice in art and design architecture, and historical and theoretical studies. As lecturers in HE A&D we strive to evolve; and where possible we experiment with and augment conventional lecture formats - Activating the imagination, creative thinking, enhancing tacit abilities, senses and emotions and basically being more hands-on; we feel, can draw everyone more deeply into the materials of the subject generating a more enjoyable and meaningful learning and teaching experience for both student, researcher and academic.

Since 2009, Taylor, Unver, and Benincasa have worked on various phases concerned with simulations of Stonehenge. Previous research on acoustics analysis and 3D visualization explored how pre-modern communities may have used Stonehenge for music making and ritual practice [1]. Unver and Taylor sourced photogrammetric 3D point cloud data files from English Heritage National Monuments Record Archive. The fragmented scanned surfaces were cleaned, filled in and merged using 3D scan data editing software, to generate exact models of each individual stone. These models of the stones were then imported into 3D Studio Max software. The authentic polygonal data of each stone was positioned in the correct location using sourced archive survey plans and satellite maps. The addition of 3D renderings and animations incorporating sun alignments, environmental effects such rain and fire, and a LIDAR landscape produced high quality digital realistic simulations.

For this conference paper; the research group presents their experimental practice led research collaboration with the aim to share this new work that explores how digital modeling, fabrication and population tools can be applied to inform the understanding of current theoretical debates surrounding space and place. The research also has innovated new methods through questioning how combining different technologies could be used for cultural heritage, educational experiences and archaeology research. For example; physical re-constructions of artefacts that are sustainable, or recording population behaviours and crowd visualisations will open up far-reaching new opportunities for collective creative human activities.

2 BACKGROUND

In recent years, the use of approaches based on 3D models has seen rapid progress in many different areas from digital factories of the future to car, flight- and surgical training simulators to 3D maps, 3D TV/Cinema, 3D smart mobile devices and games but also in cultural heritage applications. In general, the handling of 3D data poses different challenges but also provides new, exciting and innovative opportunities compared to more established media like texts, images or sound.

In every civilization there are consecrated sites and sacred places that are heavy with geometric and spiritual significance. Temples, caves, sanctuaries, or features such as rocks serve as vital points of alignments, contact and centres of accumulated energy [3]. Ceccato C., et al [2] states that;

“Geometry lies at the core of the architectural design process. It is omnipresent, from the initial form-finding to the final construction. Modern geometric computing provides a variety of tools for the efficient design, analysis, and manufacturing of complex shapes…Geometry lies at the core of the architectural design process. It is omnipresent, from the initial form-finding to the final construction.”

Stonehenge is a ritual site of convergent significance designed and built around 5000 years ago in Wiltshire, England in the British Isles. The Stones are visited by over a million people every year and the wider site remains a mysterious and mystical destination place for a multitude of experiences. Many visit as members of English Heritage, others as international or national tourists. People seeking a humanist spiritual connection are drawn to the stones particularly at the times of Solstice.

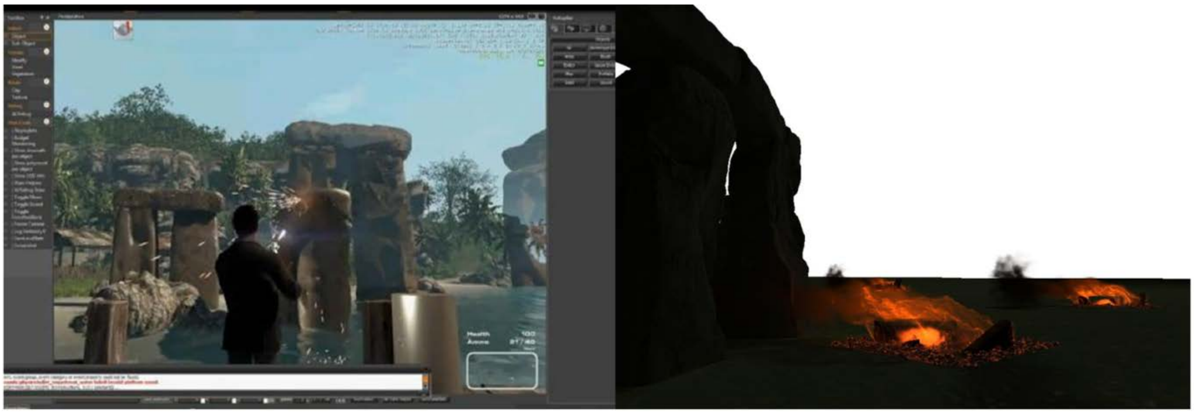

Figure 1. Earlier phases of interactive virtual environment

Stonehenge is both architecture and built environment and its making and use spanning 1000s of years in pre-history undoubtedly still captures the imagination. Stonehenge was built as a social instrument; intended for multi-purpose social gatherings, performances and rituals and as a known place where collectively people travelled and came together to transform ideas, perceptions, beliefs through physical and other dimensional acts. Omnipotent in contemporary life it and reminds us of the immensity of human creativity, art, design, craftsmanship, sculpture, communication and collaboration – social, political, and religious.

Art, design and architecture students need to evolve and develop an awareness and understanding of how to interpret multiple spatial and political contexts of the places and spaces in which they are working or designing and producing artefacts. As-Safi believes that, ‘The task of a translator is multiple: as a decoder, appreciator, critic, encoder and creator’ [4]. Because Stonehenge’s creators or encoders are largely unknown, the ‘text’ that is the stones, does not have a single recognised author, or designer, it can be argued that they have multiple authors who take the guise of visitor, curator, security guard or druid to name just a few.

Our interpretation for this project was felt to be appropriate for the disciplines of the academics in the team and our students. You may watch our presentation and see things that we had never imagined for these tools: theories and practices in your own teaching and Learning.

3 SPACE AND PLACE

> "The only thing that struck me is you can't go up and touch it," said fourth-time visitor Keith Foskett, of West Sussex, England. "I think that's a real shame. English Heritage might own it, but it really belongs to the people. You should be allowed to go up and hug the stones" [5].

Experiencing relationships between space and place and the efficacy of the image is felt to be of great importance to the work created and produced. Space and place can best be understood in relation to each other [6]. Place simply cannot exist without space, so in order to get close to what is meant by identity of place, firstly one has to consider what space is. Geographers, cultural theorists and historians such as Le Fevebre [7] and Paccione [8] agree that space is an abstract concept. They understand that space is the realm inhabited by the likes of planners, surveyors, archaeologists and architects, so one quality of space is that it can be marked, mapped and measured. The architect Inigo Jones surveyed Stonehenge in the 17th century for King James I [9] and our topographical mapping of the site located through processing of new materials sourced in pre-existent phases such as transforming cloud and LIDAR data [10] data can be seen, (figure 2) to be an example of sculpting *space*, rather than place. So how does space becomes place?

English Heritage granted the researchers permission to access the Stone Circle and to record the stones using photography and video. The inner circle site visit enabled the accuracy of cloud data cleaning, polygonal 3D surfacing and modelling and texture mapping. To assure the correct location of the stones within a topographically accurate one km square site there was a triad of approaches; historical drawings and survey plans were sourced from the English Heritage Monuments Archive database, satellite maps from Google were utilised and LIDAR data was obtained [11].

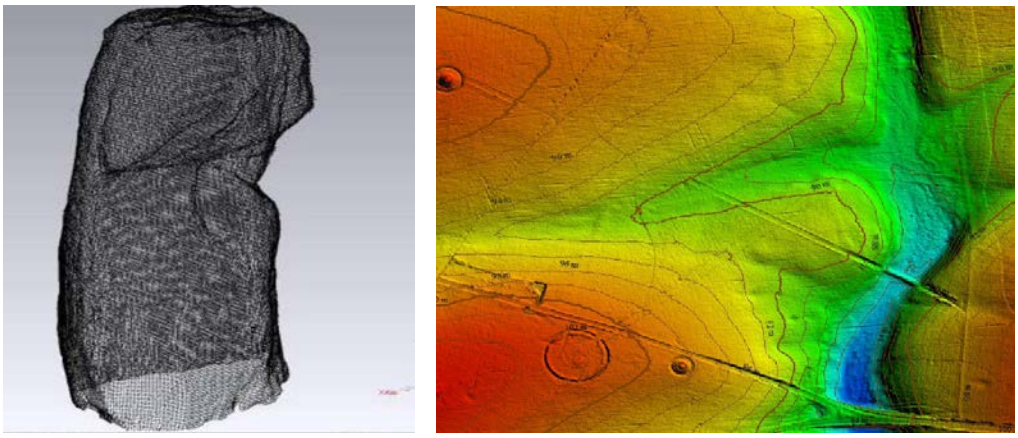

Figure 2. Point Cloud & LIDAR Data

Topography can help frame an objective space, but spaces lack purpose and interest without what Relph, calls 'insideness' [12]. Identifying with a space bridges the gap and marks the transition for an individual or group of people towards a sense of *place*. Spaces become places then, through familiarity and emotional engagement which can be enabling and positive [13] or negative and oppressing [14]. For Hayllar, Griffin & Edwards spaces are created by people as 'places for civil interaction – to meet, eat, amble, spectate, shop, view or simply pass time' [15].

The team are exploring digitally, textually, physically and experientially questions that have interested writers, spectators and makers for decades about the efficacy of experiencing artefacts first hand [16] in time and space. Walter Benjamin, in his seminal paper *Art in the Age of Mechanical Reproduction,* worried about the destruction of authenticity and aura that reproductions of the real create for the viewer, whilst acknowledging that this reproduction allowed artefacts to be made available to those who may never have the chance to experience the original objects or places depicted [17]. It is possible therefore, for a person to have a strong sense of place even if they have never visited a location.

Humanistic geographers believe that people's relationship to space changes when they start to attach a much greater value on the *representations* of place rather than its physical attributes. In fact, the representations themselves can become the authentic [13]. Visitors can freely celebrate this imaginary re-interpretation through their collective translations of place. The soundtracks, mappings, modelling, animations, and fabrications we project in this work may be considered as a way of representing the place-making that occurs when participants come in to contact with Stonehenge. The contact we make between both the virtual and physicality of our everyday lives both for people past and present is a reflection of both the interchangeable virtual and real projected experiences of time and space.

4 CROWD POPULATION SIMULATION

The earlier phases in the research have developed experimental interactive game environments and animations with environmental physical effects such as fire that have informed technical developments in teaching 3D Design and research as seen in Figure 1.

Human animations are an important and challenging problem in computer graphics. A number of characters need to be acquired or modelled to populate Stonehenge. The behaviours of people will ideally be appropriate including movements and function for the intended visualisation. Populating environments was previously a complex, time and processing heavy, requiring either advance 3D animations or programming skills and a team of games designers and visualizers. These characters needed to be interactive and move around the environment to simulate the work/life/tourist conditions and behaviour.

During the processing of populating the site the team have generated over three thousand frames of which a relevant number have been selected and can seen illustrated in Figure 3.

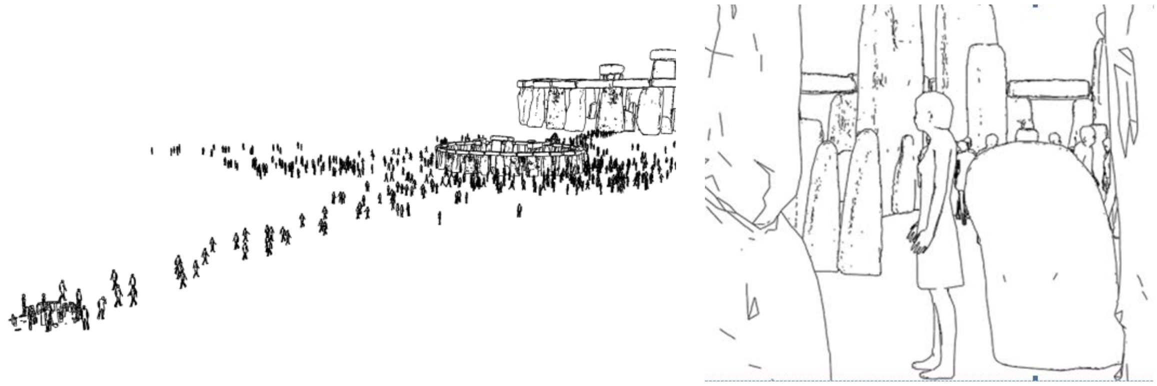

Figure 3. Still frames of 3D animated population.

The decision to render the virtual humans as figurative and abstract projections in hand drawn ink and paint silhouette style was chosen to make reference to historical art and architecture engravings often created and purchased during 18th century on Grand Tours. The colour and engraved style is achieved through experimenting with texturing and rendering parameters in 3D Studio Max. This minimalist styling shares characteristics' of cartoons. Traditionally a 'cartoon' was the pre-sketch stage of a finished piece of work or a depiction real life. The monochromatic abstracted shapes you can see in the figures and the stones were intended by the team to mutate reality and transcend the viewers/participants ability to imagine themselves within the space and 'fill in the gaps' through their imagination much like an optical illusion or a Rorschach test.

Through our processing, sifting and selection we feel these frames are archaeological finds or artefacts to be presented to participants in the installation. The opportunity for these unique drawings or snapshots to be experienced by the learners alongside the virtual crowd populace collectively en-acting in ritual virtual physical space – become more than digital images and could be seen as historic sketches or reflective recordings that learners or participants can consider, theorise about or reflect on in their praxis.

5 FABRICATION

Digital fabrication covers a broad range of technologies and the increasing popularity of on-demand, mass personalisation, flexible and sustainable production methods appealed to practicality of this project. It is therefore very timely that this research has been undertaken that considers the interconnected technological, commercial and theoretical historical contexts that can encourage new or different thinking around the emergence of digital fabrication.

Digital fabrication in this research uses extracted 3D cloud data converted by 123D app into sliced files for laser cutting in any cardboard materials. The cross-sections of a solid object are sliced along two orthogonal directions. Thin straight slots or slits of 5mm are laser cut as intersections were slotted together, and the intersections acted to stabilize the joints allowing the structures to stand as a solid structure or to be folded flat.

We aimed to build a larger scale at about 2m height at ¼ of real stones. The cutting for the large installation could potentially use the full width of the laser cutting bed 125 cm by 250 cm however the cardboard materials available were limited to 60 x 90cm. Because of the increased scale required, a greater amount of pieces needed to be cut and then joined together using duct tape. This also made the weight of the materials heavier when the model was constructed. For increased stability, the base had to be remodelled using 3DS Max.

The three-part structure was assembled in product design studio shown in Figure 4. The laser cutting of the card pieces was 4 hours and fabrication of the pieces into the trilithon structure with 4 people was 5 hours. This time could be reduced with additional prototypes and practice with software and understanding of material properties. The size of the structure and number of sliced panels and building was taken into consideration during design and fabrication. To move the model to exhibit in Textile Surface design studios across campus we transported the model by van.

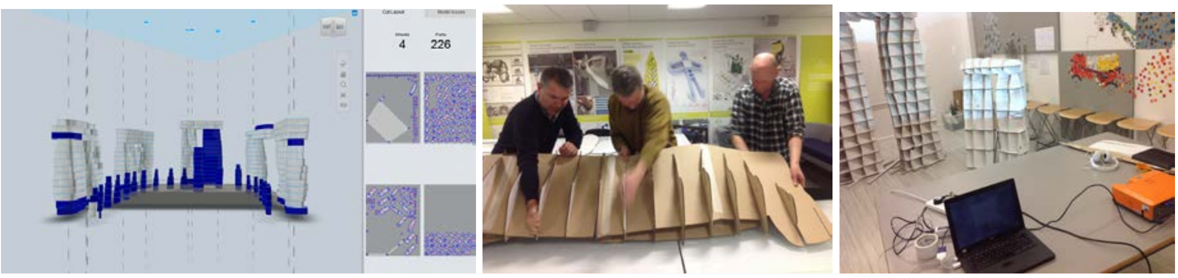

Figure 4. Evolving design and construction phases

6 INSTALLATION & EXHIBITIONS

The project was exhibited in two different studio exhibitions in the School of Art Design & Architecture. The first exhibition was setup in architectural lecture theatre with a projector. The 3D population animation was projected onto the cardboard trilithon as shown in Figure 5 sequence. Staff and students were invited to interact within the installation and were provided with marker pens and encouraged to move around and draw their thoughts about the work, the site, the environment. The duration of this exhibition phase was 45 minutes from initial setup of the model with 3D animation and human interaction and feedback collection.

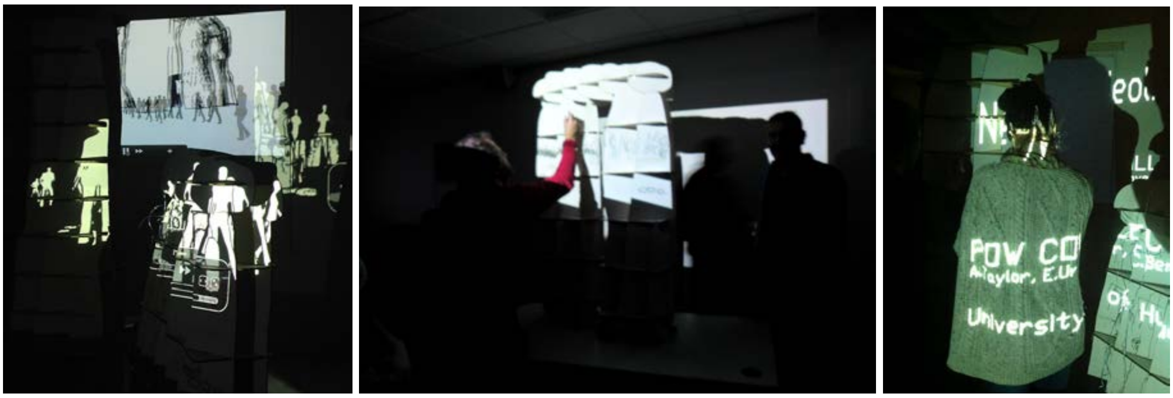

Figure 5 Drawing narrative experiences

The participants during the installed lecture theatre and studio experiences moved around, communicated and co-created drawings of un- specified subject or themes autonomously. Drawings were often figurative, included sun moon, clouds, animals, people, landscape and also abstract observations of the line and shapes of the projected images. The researchers and students used live video to record the live interaction responses. These can be viewed on www.huddersfield3D.co.uk/Digitalfabrication. During this phase of testing it was seen that participants enjoyed throwing shadows of themselves on to the 3D sculpture and the animation, melding their shadows with the animated projection. These multiplexed traces expressed spontaneously in the moment are an important aspect of the experience and aligns with human communication and connecting of space and place.

7 FINDINGS AND CONCLUSION

This paper documents an emergent interdisciplinary art and design practice based approach, for digital projection and fabrication of Stonehenge, UK. The researchers have outlined the technical methods involved in transforming digital models into physical fabrication using slice paneling methods to re-construct 3D model data for interactive installation for educational theory and practice experiences. The research combined digital fabrication with populated moving image projections and provided an engaging and informative situated display, offering an intuitive frame of reference for placing objects, activities or events into their spatial context. It investigated the advantages and difficulties of an art and design approach being carried out within a creative arts and design context rather than specifically or typically within archaeology, heritage or computer sciences.

The experiments became live kinaesthetic learning for both colleagues and students being active participants in their research practice – Drawing ‘live’ to scale and in space and place is surely an essential ingredient to real life thinking, design, making and building. An Audio soundtrack created from humans visiting the site authenticates the senses in this location. Also the virtual people in the crowd simulation moving over the human participants is a powerful interaction adding occlusion and encouraging sensory adjustments to happen in the physical world.

Further research could lead to using VR head mounted displays such as Occulus Rift to augment the physical and also to learn other new technologies for VR built environment or virtual tools linked to tablets and apps. A disadvantage of current VR head sets are limited to single user interaction and this focuses or restricts the participant in the virtual world. Our aim was to create low cost experiments and experiences with accessible technologies without high cost investment.

The easiness of the freeapp design making process may result in an increase of creative fabrication design and exhibition locally where before it was too difficult to produce large scale models due to cost and expertise required. These methods in this paper can be applied by artists, designer, architects or any creative person. Laser cutting is a common and low cost model making option for creative industry. Although 3D printing is becoming popular, the limitation of size that can be printed is key for not being a popular choice for art installation. A common laser cutter can cut and produce installation in size of few meters, 3D printing still very expensive and common 3D printer size is around A4 cube.

Social engagement is integral within thinking and making and occupying space and place and communities which is often lacking in today's disconnected society. Public engagement and exhibitions can help older, retired, lonely people to re-connect with local history, meeting, socialising and activities. The methods we have developed and presented can be adopted at any educational level especially pre-degree courses for shared experiences in design making, history, and communication to enhance and make learning fun, less daunting particularly for students with un-conventional learner styles. Students who are withdrawn, disruptive, dyslexic, dispraxic, aspergers or generally destructive all could benefit from learning through making about combining tech drawing, CAD, fabrication with theory and history simultaneously exhibited. School kids are active learners and are open minded. We built Stonehenge, although it would be just as easy to build a Egyptian pyramid and walk in and think about history.

This was academic practice led research which involved independent human collaboration across multi-disciplinary subject areas. The students and academics played and dis-played and interacted spontaneously with us and our test models. We designed and built this together – we found locations and installed it and projected on it and drew on it together. Further research being considered could include repeating this experimental learning installation in the curriculum with larger groups; and comparing conventional teaching methods with this integrated interactive learning style.

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