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Design considerations for the transformative reuse of a Japanese temple

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Abstract: This paper concerns the transformative reuse of materials from a derelict Japanese Buddhist temple in a transcultural context. The process of 3D scanning and photogrammetry modelling for a virtual experience of the building and its furnishings is described in reference to the development of a later study: the proposal to test the reuse of materials by international team of designers working remotely with digital models. The capacity for designers using digital data and metadata to inform transformative reuse applied locally in Japan, via either handcraft or robotic fabrication, is discussed as a challenge for virtual embodiment and craft knowledge. The steps required to progress the research are discussed. Framed by theories of cosmopolitan-localism, the ongoing project proposes new methods for design-led transformative reuse that address the globalised problem of waste flows and test the use of emerging technologies to innovate cultures of repair, reuse and circular economy.

Keywords: reuse; repair; waste; virtual reality

1. Introduction

The global flows of resources, materials and products means waste is a global problem. Waste is also a political problem, as illustrated in 2018 when China stopped accepting foreign recycling waste. Repair and reuse are first responders to the emergency of waste: they use less energy than recycling, and conserve material and the embodied energy used to extract and craft that material.

However, both reuse and repair are marginalized by dominant paradigms that privilege the creation of new products from newly extracted resources (Shultz, 2017). At the economic and community level, repair industries are in global decline as more and more nations embrace a hyper-consumerist 'break and replace' model of material use that developed within capitalist economies in the 20th century (Slade, 2006). The break and replace

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mentality departs from earlier traditions of repair in global cultures and an intriguing problem to consider is whether the cultural knowledge that is materialised and embedded in designed products and structures becomes lost when repair traditions disappear and materials are increasingly sent to waste. This problem would persist with recycling, a process that by industrial convention destroys the formal and contextual knowledge of objects in the process of their conversion into feedstock for the manufacturing of new products. Recycling has the additional problem that it is industrial. It cannot be done easily at home or in the community, so requires collection and sorting. But waste in the consumer landscape is assorted. Product-material marriages are not standardised, and neither is collection, sorting and recycling capacity, even in the one city or suburb (Norman, 2020). However, between conventional forms of repair and the reuse of materials by recycling, there exists a spectrum of object-material transformations variously known by terms such as transformative repair, adaptive reuse, transformative reuse, upcycling and visible mending etc. As discussed in a number of special volumes on repair published in the last few years, these practices occur across a range of design disciplines including product design, textiles, craft, architecture and jewellery (Graziano & Trogal, 2019; Strebel, Bovet & Sormani, 2019; Reeves-Evison & Rainey, 2018; Houston et al., 2017). These practices occur in a range of cultures, traditional and industrialised, around the world and together comprise one aspect of circular economy design, a framework for conserving material and embodied energy in recognition of the expanding needs of a global population on a planet with finite resources and an environmental and climate change crisis.

Emerging technologies such as 3D scanning and robotic fabrication appear to have potential to innovate circular economy cultures of repair and reuse – just as they have for linear economy design and production. The capacity to attach metadata to digital models of real world materials and objects, such as in Building Information Management (BIM), is well understood for linear economy design methods in architecture, including those that attempt to reduce construction waste and produce more energy efficient buildings (Wong & Fan, 2013). The use of BIM explicitly for circular economy mostly lacks real-world applications and has recently been described in aspirational terms (Krygiel et al., 2017: 201) though Cheng and Ma (2013) have developed a system to estimate waste from building demolition that works with BIM datasets (which they believe will soon exist for “most buildings, including historical buildings”). There is also a proposal for the use of BIM to facilitate design for deconstruction (Akbarnezhad et al., 2014). But beyond the use of BIM for building material reuse, the impact of 3D scanning and related technologies, such as virtual reality (VR) or augmented reality (AR), on reuse practices in design more broadly appears under-researched. Generally, use of emergent technology in the scholarly discourse for repair and reuse is lacking. For example, within three journal special issues on repair published in the last few years (Strebel, Bovet & Sormani, 2019; Reeves-Evison & Rainey, 2018; Houston et al., 2017) repair-based applications of 3D scanning or robotic fabrication processes are barely mentioned.

This paper discusses a pilot case study comprising the first phase of an ongoing project testing the hypothesis that *3D scanning can innovate circular economy cultures of transformative reuse for product designers and craftspeople primarily in ways that are locally sensitive and globally relevant*. This paper thus serves to:

1. report on preliminary research comprising non-destructive 3D scanning and virtual modelling of its case study, including review of human research conducted in the case study's locality, and
2. discuss the ethical, theoretical and methodological considerations needed to proceed with transformative reuse of the case study's materials, components and objects in subsequent research investigating the above hypothesis.

2. Case Study Background

Figure 1 Anyoji Temple, Shinano, Nagano, Japan, dating from the Edo period. Photographed May 2019.

Anyōji (安養寺) is a Buddhist temple in Shinano, Nagano prefecture, Japan, that, absent of community funds needed to restore the temple, has been scheduled for demolition by the local council for health and safety reasons (figs.1–3) Due to increased secularism and urbanisation, temples throughout rural Japan struggle to maintain the patriarchal lineage of caretaker monks (McCurry, 2015). This temple is a rich example of Edo period Japanese temple architecture and operated for more than 300 years (Watanabe, 2019) (fig. 6 & 7).

Without a caretaker monk for more than 20 years, the temple has fallen into disrepair from snow and storm damage. AIR Myoko, a nearby ski lodge in the neighbouring Niigata prefecture, has planned to purchase the building's material and objects with the intention of reuse to prevent the materials from going to waste. This intends to be a 'transformative reuse' (Keulemans 2018; Keulemans, Rubenis & Marks, 2017). Though the largely timber components of the building potentialise a variety of reuses, including architectural reuse at a new site or transformation into timbercraft products such as furniture or homewares, the perception and appeal of such possibilities is only partially known within the local cultural context. The temple's interior objects appear largely untouched since the temple ceased operations, with a few key exceptions including the relocation of a significant buddha statue and some other items to nearby temples (Fujiki, 2019). The remaining objects potentialize a range of reparative approaches including simple restoration and sale, or more design-intensive forms of repair, transformative repair or reuse. The large number of interior objects that remain, comprising ceramics, furniture, ritual objects and books among many other things, would be well served by some form of inventory.

Figures 2, 3 Interiors, debris and roof structure within the temple. Storm damage is exacerbated by snow build-up during the winter months.

Preliminary research undertaken in May 2019 included photographing the temple and its objects (figs 1–5) for later reconstruction in photogrammetry models, plus a small scoping human research study, comprising short semi-structured interviews with local people to gather cultural and contextual information, and gauge community support and perception (undertaken with ethics approval).

Figures 4, 5 Temple objects: carved wooden debris and Showa era (1926–89) Buddhist Women's Association flag.

3. Theoretical Framework

This project is firstly framed by known problems and theoretical solutions within the field of design. Over-production and excessive exploitation of planetary resources presents an existential threat of climate change caused by greenhouse gas emissions from extraction, manufacturing and shipping. Waste and waste-related pollution, both local and global, are key topics of concern to sustainable designers. Material reuse is a key means to preserve embodied energy, avoid unnecessary production of materials from raw resources and form a closed loop material flow; as such it forms part of the xR (reduce, reuse, recycle etc) principles within Design for Sustainability frameworks (Ceschin & Gaziulusoy, 2017: 126).

Within the Design of Sustainability framework, transformative repair and reuse are designed forms of visual arts and craft practice that transform an object or material's form, function or cultural value (Keulemans, 2018). It has been recognised there is a need for transformative practices in design and craft to shift paradigmatic, harmful practices of design, consumption and waste towards sustainable making cultures (Kiem, 2011). Schultz (2017) has argued that the “transferability” or repair and reuse cultures should be investigated, but that transnational or transcultural studies should be done with a concern for decolonial imperatives, as will be shortly discussed.

Given this initial framing, this project has number of both complementary and competing considerations:

- The research team is transnational, based in both Japan and Australia, and there is scope to bring in more international designers, for example, transformative reuse practitioners from the UK, the Netherlands or Australia, as well as broader Japan (see Keulemans, 2016: 27–29 & Keulemans, Rubenis & Marks, 2017 for a discussion of the field).
- There is expected international interest in the outcomes of the temple's

transformative reuse, but a. there may be local objections to export of transformative reuse products, b. international shipping of materials comes at a carbon emissions cost and c. shipping to Australia in particular comes with biosecurity implications due to the preponderance of organic material.

- Preliminary interviewing (figs 6 & 7) has provided only a partial insight into local sensitivities regarding the temple's transformative reuse. Reuse would be appreciated (Watanabe, 2019), especially if the reuse maintained a link to the temple (Fujiki, 2019), and the quality of the temple materials is noted (Suzuki, 2019).
- So while there is a sustainability imperative to avert the temple's material going to waste, there are only partially known local capacities to fabricate transformative design, and unknown local needs and market viabilities for transformative reuse products.

Figures 6, 7 Archaeologist Tetsuya Watanabe discusses the significance of the temple for Edo period travellers.

Such considerations place local and global flows of information, material and capital into consequential relation. For example, how can an international team of designers work to solve local problems of waste without physically interacting with that waste material? While it is not a key aspect of this pilot study, financial viabilities are also an issue: what might motivate designers and fabricators (beyond the research team) to work on this project in respect of time, money and market? Crucially, in regards to the material encounters that craftspeople experience making physical objects (Ingold, 2013), this proposal presents a particular challenge of interest to the authors: what are the capacities of virtual embodiment for designers working remotely with digital captures of real world materials for locally applied repair and reuse? And, how can this challenge be theoretically framed?

'Cosmopolitan-localism' is a set of theoretical and practical concepts for the planet-wide networking of place-based communities to facilitate the exchange of knowledge, technologies and resources for sustainability transitions, and as such it appears to appropriately frame this challenge. It is a convergence of two developed traditions, cosmopolitanism and localism, that respectively attempt to realise a global humanity connected beyond borders, while preserving and protecting the freedom of local communities to manage their own affairs. Kossoff (2019) notes that this convergence,

through the work of Sach (1999), Manzini (2011) and others, is still nascent in the present day, but finds a pressing potential agency in the fight to prevent the destruction of local cultures and communities from dominant, homogenising forces of globalisation. Cosmopolitan-localism proposes that local cultures need not be undermined by trade and cultural exchange, but can develop with regard for interconnected global diversity and be enhanced by trade and cultural exchange that is carefully considered. A key insight is that place-based communities must develop in response to bio-regional conditions and resources, rather than rely precariously on ever-increasingly traded goods, transported at carbon cost, from mystified global supply chains with unethical labour conditions or negative environmental impacts. So, just for example, local building materials, might be prioritised over imported building materials. In complement, foreign knowledge and technologies that may be transferred informationally and digitally without high carbon cost can guide the use of local resources at many places, advancing global society while respecting the ecological limits of individual bio-regions (Kossoff, 2019). Bioregional design theorist John Thackara (2019) calls such scenarios “knowledge ecologies”.

In consideration of this framework, it is proposed that virtual capture of the temple materials, objects and architecture might be attached to metadata contextualising their local culture (e.g narratives obtained through human research in the temple’s area) and/or bio-regionally specific metadata for sustainability evaluations (e.g material ecology information and material life cycle analyses) in order to offer scope for remote repair and reuse by an international team of designers working with digital materials. Methodologically, some interesting hypotheses to test are:

- how can this be done technically, remotely, using only digital materials and with a level of virtual embodiment sufficiently analogous to that experienced by designers and craftspeople working with physical materials,
- how downstream workflows should be designed so that remote, virtual transformations can be manufactured locally, with
- the use of emerging manufacturing technologies such as robotic fabrication (e.g. CNC milling) that leverage production efficiencies from digital workflows, and/or
- engaging responsibly with traditional craft in the local community (in acknowledgement of Japan’s historical expertise in timbercraft and other craft practices).

To be clear, the development of studies that test these hypotheses is ongoing, so this paper only discusses the context in which these hypotheses emerge and how they are informed by preliminary research, including the results from an initial photogrammetry scan of the temple and some of its objects.

It should also be noted that the temple has been legally deconsecrated and, subject to an impending demolition/disassembly by order of council, has no heritage restrictions (Watanabe, 2019). There are still heritage implications though, and the transformative reuse of a religious building using Western-originating information capture technologies

such as photogrammetry raises ethical research considerations. The cosmopolitan localism framework can and should correspond with advancing imperatives from the broader Design for Sustainability cannon, but especially those from transition design (Irwin, Kossoff & Tonkinwise, 2015) and decolonial design (Schultz et al., 2018) that concern the consideration of Euro-centric biases, learning from “different modes of being-in-the-world” and amplification of plural and diverse migratory cultures in a global context (Schultz, 2017: 226 & 231). Euro/science-centric origins and practice of photogrammetry have been noted to be perpetuate Western biases concerning the extraction and isolation of knowledge out of social-cultural context (Harle, 2018). Likewise, it has been proposed that the reuse of heritage buildings should be undertaken within a wholistic framework assessing social and cultural dimensions alongside practical, economic and environmental aspects (Yung & Chan, 2012). These arguments highlight the need to give attention to Japanese cultural perceptions within a research project that involves the transformative reuse of a Japanese religious building by transnational designers.

4. Precedents

4.1 Japanese religious precedents

Figures 8, 9 The Shinto Ise Jingu is reconstructed every 20 years using wood from nearby managed forests. The old shrine is torn down and its wood sent around Japan to repair other shrines. Source: Agematsu Tourist Association, 2005.

Contextually, Japanese culture has a long engagement with repair and reuse. Care for material is expressed in the Japanese concept of ‘mottainai’ (Keulemans, 2016; Wallinger, 2012) and is notably apparent in Japanese craft traditions; such as those of ‘kintsugi’

(ceramic repair) (Keulemans, 2016) or ‘boro’ (textile reuse or upcycling) (Wada, 2004). Contemporary Japan has similar levels of industrial and municipal waste recycling as Germany, France and the UK, and while Japan has better systems for managing waste accumulation (a consequence of very high population densities), they nonetheless face similar problems with landfill and waste pollution (Amemiya, 2018). There is increased application of xR systems (e.g reduce, reuse, recycle etc) (JESC, 2014), but the dominant focus is on recycling systems that have little capacity to preserve material culture traces in the manner of traditional repair and reuse crafts. There is tradition of material reuse in the ritual rebuilding of the grand Shinto shrine Ise Jingu (Vallely, 2014) (figs. 8 & 9) (a significant example of how material traces are preserved for cultural enrichment), but there appears to be little evidence in the English language discourse for similar practices for Buddhist buildings. Triplett notes that redundant Buddhist objects of special significance are typically burnt – a tradition noted in one of our interviews (Fujiki, 2019) – but there is also a history of transformation practices for Buddhist objects that may categorise and substantiate the transformative reuse of the Anyoji Temple within a theological framework, termed “benevolent iconoclasm” (Triplett, 2017).

4.2 Design-based / technological precedents

Regarding the proposal to develop digital workflows for transformative reuse via 3D scanning and robotic fabrication, Greg Lynn’s Toy Tables (2009) (figs. 10–13) is an interesting precedent. Mass-produced roto-moulded children’s toys were 3D scanned and their virtual models arranged together into a new structural design capable of supporting a table top. Model intersections were exported as tool paths for a 5-axis robotic router, which then cut the real world toys into their new forms for later assembly using a plastics welding gun (Lynn, 2009). Despite being developed more than a decade ago, this workflow does not seem to have been well taken up for adaptive reuse since.

Figure 10-13 Greg Lynn's Toy Tables. Toys are 3D scanned, reconfigured in Maya, toolpathing is exported to a CNC mill, and the parts reassembled into furniture. Source: Lynn, 2009.

The possibilities of such a digital workflow for designers working remotely can be considered in relation to what's already possible in the craft-led transformative reuse context. Liam Mugavin's *Gonbei* bench (2017) (fig. 14) was made in the Niigata region using waste wood from a farmhouse that fell after the 2011 Tohoku earthquake. Joinery details are visible in the design, conveying the character of the wood's prior purposes and suggesting an intent to conserve material. While this object was made using traditional craft processes, it's possible to imagine how this process could be replicated for remote, virtual design. For example, the virtual transformation of 3D scanned component models could generate tool-pathing commands that are subsequently exported for local, on-site robotic fabrication by a CNC router.

Figure 14 *Liam Mugavin's Gonbei bench (2017) made from waste material from a Japanese farmhouse destroyed by the 2011 Tohoku earthquake.*

However, there is a caveat that concerns the tactile and embodied practices in timbercraft. For example, the sensory information that allows the carpenter to habitually inspect the quality and structure of wood, make appropriate material selections and decide upon the placement of cuts and joins. Such knowledge is haptic, tacit and may develop incrementally across both the lifetime of the craftsperson and the time-span of the job. How such knowledge can be captured, embodied and instrumentalised in a virtual workflow requires research. Hybrid practices, for example in which a craftsperson might annotate virtual models with metadata obtained from physical inspection during or before 3D scanning may be a viable solution, though scope for later inspection during the design phase may be limited. Yet, the potential of solutions driven by emerging technologies are indicated in the following precedent, in which 3D scanning is used to capture structural details about tree forks for architectural purposes.

For repair and reuse within circular economy, it is considered important to preserve as much as possible of a material's embodied energy and structural capacity. The UK Architectural Association's *Woodchip Barn* (2016) (figs. 15 to 18) suggests how 3D scanning and robotic fabrication workflows may serve this need. 3D structured light scanning was used to create digital models of forked tree sections. Digitally arranged using a generative evolutionary algorithm to exploit their natural, 'anisotropic' qualities of wood grain and structured growth, the tree sections were then robotically cut for on-site glue-less joinery into a barn

structure (Mollica & Self, 2016). This capture of anisotropic information is important because Mollica and Self note it is a “wasteful redundancy” to over-process material to replicate structural properties that were extant in the original material before processing. (A common example of this redundancy is plywood or glue-lam composites that ‘cleverly’ cross-layer and glue wooden sheets to emulate the strength of the source timber). Such redundancy can be avoided by applying a similar design consideration to the Anyoji material in order to capture ‘thick’ data within a bioregional-cultural context. For example, the grain direction and age of wooden post and beam components, their internal and external condition (e.g. cracking, rotting, wood knots, structural tendencies, but also metadata resulting from an analysis of human design, craft or use, such as joinery style (method of construction, e.g. blade or saw marks), secondary uses (e.g. furnishing attachments) and decorative finishes, all with the potential to inform design-led transformative repair and reuse.

Figure 15-18 The Tree Fork Truss design process of the Woodchip Barn. Natural tree forks are 3D scanned, selected for structural and anisotropic properties, then CNC milled for glue-less on-site joinery. Source: Mollica & Self, 2016.

5. Methods

In May this year, most of the co-authors visited the temple and interviewed a small number of local residents, plus a local archaeologist, council representatives and relatives of the

temple's last monk. They discovered a sad story of a once grand temple and its community unable to afford its repair. The situation, left as it is, could mean the temple will be demolished and its remains go to landfill, but local residents were supportive of the general proposal to make use of the building materials via transformative reuse (as discussed in various interviews conducted May 2019 in Shinano).

As an initial step towards the goals outlined in the previous section, the temple was photographed and the data used to construct a preliminary photogrammetric model of the temple capturing some of the material quality and structure of the temple, its wooden posts and beams, ornate carvings, tatami floors and superabundance of sacred and non-sacred junk: discarded objects of ritual, worship and craft.

6. Discussion

Figure 19 Photogrammetry model of the Anyoji temple, front view.

Figure 20 Photogrammetry model of the Anyoji temple, top view showing internal roof structure.

Figures 19 to 23 show screenshots of a virtual model of the temple generated by first and second run of photographic data using the software RealityCapture. It should be noted that due to time constraints and inaccessibility, some areas of the temple were not well scanned. Additionally, work to develop the existing dataset into a more resolved model, experienceable in virtual reality, is planned for subsequent steps, so these images only illustrate an interim phase of the research. However, the images nonetheless provide visual material on which discussion can hinge.

It can be seen that broken and dishevelled materials in and around the temple are visually intermixed with areas of low image information. This visual confusion does not arise because disordered materials are harder to photogrammetrically process. Conversely, the lack of structural order and rich organic detail facilitates photogrammetry techniques (Harle, 2018). But, some of these dishevelled areas were hard to access and photograph. It was dangerous to walk in many places due to collapsed floors and visibly weakened overhead structures, so photographs from these perspectives are missing from the dataset. However, the photogrammetry method provides many possible viewing angles in the model that are difficult to obtain in the real world, including a 'see-through' capacity to view the complex design of the roof and ceiling structure (fig. 20).

Figure 21-23 Mesh reconstructions of the Anyoji photogrammetry model

The disordered appearance of some areas is in part a consequence of it being hard for the human eye and mind to ‘make sense’ of what is being seen in the model. This is especially true for the images of the model with a preliminary mesh construction in which visual qualities lack some physical world fidelities, such as realistic light and shadow. It was also true during the site visit, though, simply because ruinous areas of the temples are visually more complicated. Both aspects need to be considered for successful use of the model for virtual reality (VR).

The primary purpose of a future VR experience of the temple is conceived to contextualize the temple for designers working remotely on individual components. Preliminary 3D scans of a few temple objects were also conducted (figs. 24 & 25) and this is conceived as a conceptual start for an inventory design that links 3D models of individual objects to their viewable placement in situ within the temple VR model. Findings from this aspect of the study has potential to contribute to the discourse on human embodiment of digital objects (Munster, 2011). There are potential discoveries relevant to the field of digital heritage research (Kenderdine, 2015), and a VR experience of the temple for a local history museum could be a secondary application. The VR experience of the temple may also have value for architectural design, should funding be found to restore or renovate the temple itself.

Furthermore, an idea that arose through inspection of these images is the fragmented VR model can itself be repaired, conceptually and digitally using CAD modelling tools. This is, on the face of it, not surprising, because human interaction with digital workflows are typically reparative. For example, designers constantly repair mesh constructions and other errors or artefacts in 3D digital workflows. Innovation, however, may lay in the explicit use of transformative repair concepts – a creative remaking to improve appearance, role or cultural value – when applied to the temple model. That VR experiences can be time-based and animated expands the potential for virtual transformative repair. A time-based design might even reverse the decades of decay and entropy the temple has suffered as a virtual experience, in a way that transcends the limitations of the physical world. The potential of such ideas requires further research and studio experimentation, but importantly also community consultation. As with the proposed transformative reuse of the real world materials and components of the temple, the digital transformative repair of the temple may encounter unknown cultural sensitivities.

Figures 24,25 Comparison of photo and dense point cloud of a tool object found inside the temple.

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