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EXPERIMENTAL 3D DIGITAL TECHNIQUES IN DESIGN PRACTICE

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Abstract: Experimentation is central to creative practice. Artists throughout the ages have explored, adopted and adapted the use of tools and techniques for creative means. The digital era has been no different; and as technology emerges, digital practice develops consequentially. Since the introduction of 3D computer graphics, practitioners have been creating virtual realms and digital objects in parallel. At the same time, advances in computer processing, coupled with high-end technologies such as the availability of additive manufacture have allowed physical artefacts to be created on demand, leading to a proliferation of experimental practice. Whilst experimentation is the norm in art, commercial design tends to favour more established and formalised methodologies. For instance, software developers that aim to create dependency on their products adopt structured workflows that discourage practitioners from straying from the established path. In furthering the search for creativity, this paper argues that designers must look to the unorthodox experimentation of art and to harness the use of emerging technology. The paper reviews current literature and examines several examples on the use of experimental digital techniques in design practice. It then discusses the benefits and pitfalls of such an approach and finally speculates future developments in 3D digital design practice.

Keywords: *Additive Manufacture, Emerging Technologies, 3D Digital Techniques*

1. Introduction

According to Bürdek (2005), design is defined as a plan or a scheme devised to develop an object with a specific purpose. Similarly, it can also refer to the arrangement of elements in a product or as a work of art (Dictionary of Art Terms 2003). Kim and Kang (2008) viewed design as a bridge between technology and customer needs; and a central activity that connects with other domains. The act of designing involves creatively building the nature, appearance and social function of objects (Tjalve 1979). In an engineering perspective, design involves problem solving and creativity to produce the desired properties of a product (Andreasen et al. 1988). In contrast, design at an artistic level involves less technical aspects and engages with a number of creative iterations where steps are repeated in trial and error. These iterations occur throughout the process and involve innovation, analysis, decision making and evaluation; and continues until the desired solution is achieved (Wright 1998). Design at an individual level requires conveying visual information succinctly to others, entailing personal characteristics such as the ability to visualise; and having flair, intuition, creativity, judgment, reflection, feeling and experience (Schön 1983).

Of these, visualisation is regarded as an important ability for the designer; and Rodriguez (1992) classified visualisation as ideas being imagined in the mind and it occurs when the designer constructs and incorporates features such as form, proportions, orientation, material, colour, symmetry, contrast and repetition, etc. into the design. Those mental images are further processed, and then externalised through words, gestures, and as representations that take place as objects or as things that stand for something else (Kaplan and Kaplan 1982), and can be defined as artefacts that reproduce the properties of an object by means of a physical or digital medium. The most common form of visual design representations take place as marks on paper with colour, shading and text (Pei, 2010). Traditionally, paper-based representations are used before computers, thus the term ‘pencils before pixels’ (Baskinger 2008). Other modes of representations include the use of models, scenario storyboards, working prototypes, 3D CAD models and virtual reality. With use of technology, digital platforms offer greater possibilities for collaboration and cross-fertilisation among disciplines. Previously published research explored the implications of using 3D CAD for design development and investigated the quality of design outcomes. It was found that creative behaviours were displayed whilst using CAD (Musta’amal et al., 2008). Other advantages of using CAD include greater efficiency, higher precision, allowing for more iterative modifications, and the ease of information transfer (Schweikardt and Gross 2000). Most importantly, CAD allows designs to be reproduced as a photo realistic image through rendering or as physical objects by means of additive manufacture.

2. Related Work

2.1 Co-creation

The use of digital platforms offer tools that facilitate interaction and allow seamless input by members involved in the design process. The role of the designer involves creative direction and orchestrating the inputs of various co-artists and stakeholders. In art, the process of creating itself is seen to be as important as the output that it generates; and this itself differentiates it from design or engineering where the final output is key. In art, the process of experimentation is not limited to human activities but can also involve mechanical means. One example is Roxy Paine who is well known for his machine-based works, including the *Paint Dipper (*1997) that encompassed an arm which continuously dips canvases into a vat of paint to create solidified latex stalactites along the bottom edge. The *SCUMAK or Auto Sculpture Maker (*1998) uses an industrial-extruder to melt plastic and extrude the material onto a conveyor belt, thereby creating organic sculptures. This is in contrast with other disciplines such as industrial design that takes a more structured view by creating physical artefacts suitable for mass production through synthesising engineering, technology, materials and aesthetics, balancing the needs of users within technical and social limitations (Fiell and Fiell 2003). In light of this, the authors argue that design disciplines with a structured approach lack an experimental drive and propose that the use of emerging technologies such as additive manufacture (AM) may offer a potential solution where practitioners can generate physical objects on demand, create one-off pieces, or customise artefacts that allow a greater degree of consumer participation. The next section centres on AM technologies, following which examples are then discussed.

2.2 Additive manufacture

The term additive manufacture (AM), also known as layered manufacturing or rapid prototyping, is the collective name for the set of technologies that include but not limited to Stereolithography (SLA), Laser Sintering (LS), Fused Deposition Modelling (FDM) and Three-Dimensional Printing (3DP); all of which utilise Computer-Aided-Design (CAD) data to build a physical object layer-by-layer (Pei, 2011). The use of AM is a relatively effective and fast approach for fabricating physical parts for final products and to create moulds for casting. These physical objects allow artists, designers and stakeholders of a multi-disciplinary team to see, interact, clarify and evaluate the design (de Beer et al. 2009). Ideas can be vigorously tested since there is an opportunity to fabricate those parts on demand. Advances in technology now allows for 24-bit full colour models to be “printed” on 3DP machines and Siemer (2005) noted that the ability to provide high-definition colour prototypes mean that artists and designers are able to better communicate their design intent, leading to better creative direction.

In addition, as the use of the Internet is now mainstream, there is a potential for greater co-creation, as well as more user engagement in the creative process.

The combination of digital form generation and manipulation with AM provides plentiful creative opportunities. There is an increase in the number of artists experimenting with these techniques, including Robert Lazzerini who scanned, distorted and reproduced 3D artefacts; Geoffrey Mann who produced “Blown”, a cup and saucer digitally distorted by a cooling breath on the liquid surface (Figure 1); and who also attempted to materialise sound as an installation piece; and employed motion capture to materialise the flight of a moth around a light bulb in the luminaire “Attracted to Light”. Motion capture was employed by Belgian artist Marcel Wanders to reproduce airborne mucus as vase forms in the Snot vases. Tavs Jørgensen employs the use of motion-capture and 3D digitisers, and used these as free-hand tools or by capturing gestures in thin air to create spatial drawings as a basis or 'sketch' for making physical artefacts.

Figure 1. Geoffrey Mann’s “Blown” cup and saucer

The following sections contain four examples that support the claims where designers need to take advantage of emerging technologies that support creative practice. Super Kitsch utilises a virtual library to store 3D models that can be printed as jewellery; Cuore as an example of creative use of user-centric digital manipulation tools; topological optimisation that combines both engineering performance and innovative aesthetics; and cinema graphic animation techniques that employs animation capture and computational fluid dynamics to generate physical artefacts.

3. Examples

3.1. Super kitsch

SuperKitsch is a jewellery point-of-sales concept that is based upon the traditional charm bracelet (Figure 2). These charms exist as 3D models in a digital repository and they are virtually assembled to form composite geometries that can be “printed” as physical objects. The concept is that buyers select those icons of their preference for their piece but not the configuration in which they will appear as this will be random. There is a potential for users to submit their own models for inclusion and the contributed pieces could be further offered to other buyers with an incentive given back to the creator; similar to the manner of content sharing such as in Turbosquid or as an open-source format. Whilst there is a significant degree of user-input and contribution, the process does not dilute the design intent of the creator or the brand image of the product. This example serves to show how the use of a 3D virtual library could aid designers in their creative process by acting as a repository to store, share and build design components on demand.

Figure 2. Super Kitsch necklace

3.2. Cuore

Cuore was created to showcase the use of additive manufacture in metal, based on a geometry that lends itself to change and mutation. The Cuore CAD model was used to demonstrate the use of geometric modelling software that empowers lay users to co-manipulate potentially complex geometries. Whilst intended only as a demonstration, these jointly created designs produced further developments that dramatically differ from anything originally envisagement for the design (Figure 3) and led ultimately to a new production variant of the piece.

Figure 3. Manipulations of the Cuore design in CAD and the finished product in gold

This is an example of both the creative use of advanced digital manipulation tools and user-input resulting in a custom creation based on a singular concept. Through this, more creative means of design could be explored and the final output can be formalised with a shorter development time.

3.3. Topological optimisation

In the context of a population increasing in both weight and age, walking aids are becoming increasingly important. In performance terms, these devices have developed significantly from the walking stick with specific consideration of mechanics, materials and ergonomics. Topology Optimisation is a research specialisation that identifies the best material distribution within a fixed boundary, under given loading scenarios. This method effectively 'strips away' unnecessary material to create more efficient structures. Working in collaboration with researchers, the designers explored concepts where there might be an opportunity for innovative aesthetics as well as a need for engineering performance. From an engineering standpoint, the objective was to minimise the weight of the part in relation to the yield stress of the stainless steel and titanium materials used. A density based method of topology optimisation was utilised whereby material across the model was added or removed. Over a number of iterations the weight is gradually reduced whilst constraints placed on the mechanical performance of the part remain satisfied resulting in a topologically optimal design (Figure 4). This would suggest an iterative refinement toward a single optimal design solution based on mechanical performance. The use of topological optimisation also often results in striking, and counter intuitive aesthetics. It can also generate outcomes that, whilst mechanically optimal, are visually unremarkable. A monocoque structure in a curvaceous part can be an excellent mechanical solution and topological optimisation software that is used will often revert to this option. Visually the monocoque is indistinguishable from a solid part. By adjusting the loading conditions it was possible to achieve a part that was both visually striking and that, at the same time, offered high mechanical performance. The resulting design is eccentric. It is difficult to imagine arriving at such an outcome without the use of digital tools, certainly not without compromising rather than optimising the mechanical performance. This is an example of how the use of specialised technology could help suggest novel forms, yet retain and enhance the functional constraints of the project.

Figure 4. A walking aid produced using Topological Optimisation

3.4 Cinema animation techniques

Collaborative research with has explored the use of visual effects from the computer graphics industry in a product design context. “Not made by hand, Not made in China” was a project by Arad (2000) who illustrated the potential offered by animation techniques employed in a product design context. Maya, a 3D software aimed at the video animation industry, was used to create a series of “bouncing vases”. A helical vase form was created, that was expanded and compressed in an animation clip. More than a decade on from this work, the sophistication of animation software and the computation power available to drive it has developed significantly. Methods for animating and rendering natural phenomena, such as water wind and fire, are increasing in power and sophistication to meet the leisure industries demand for ever greater photo realism. At the same time fluid engineering simulation tools such as Smoothed Particle Hydrodynamics (SPH) have become highly accurate and widely available. In joint research, computational fluid dynamics and physically based animation techniques have been employed to generate form and difference between design iterations. The complex and seemingly random behaviour of water, real or modelled, offers significant potential for creating difference within a theme. Moreover, given the ubiquity of water and the role it plays in our daily lives, it is something everyone can relate to. The droplet lamp was designed by Lionel Dean in collaboration with Dr Ertu Unver at the University of Huddersfield, who investigated an animated sequence of a water droplet hitting a sphere and spreading around it, trapped by a hidden outer boundary sphere (Figure 5). The natural phenomena was captured which was then translated into the geometrical shape for the lamp. The use of such techniques enable random forms to be generated as a way to inspire new and novel ideas based on a central theme to be developed further.

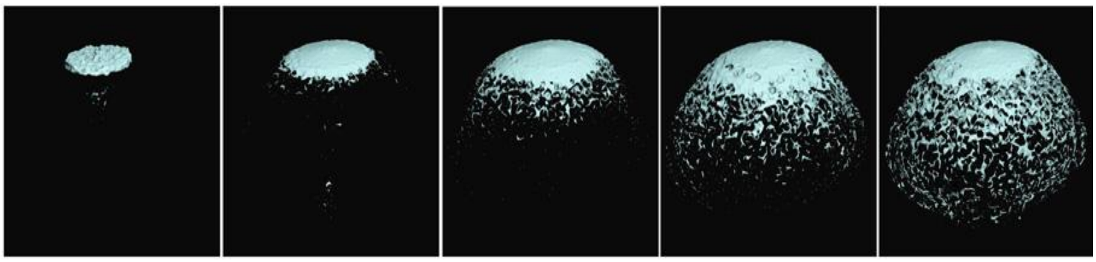

Figure 5. An animation sequence of a water droplet in motion

4. Conclusion

Advances in computing power and technology have empowered artists with greater freedom to experiment. By engaging directly with technology, practitioners are now able to collaborate over the Internet to connect, interact and develop their work on a global scale (Tapscott 2009). This phenomenon has grown whereby niche research groups such as De Montfort University's Institute of Creative Technologies explore human interactions with new media, interactive systems and applications in the arts. Other researchers such as Bunnell (2004) have looked at adopting craft-based methodology of making that embraces the use of digital technologies. Bunnell investigated how makers and craftsmen have effectively integrated digital technologies into their creative practices and go on to state that this approach is 'highly relevant to an emerging post-industrial culture of customisation in 3D production and consumption'. This is in line with the four examples that have examined the innovative potential of harnessing digital technologies into art practice. In addition, more institutions are offering the teaching of digital art practice such as at Concordia University (Graduate Certificate in Digital Technologies in Design Art Practice) or as an independent module for Digital Arts and Culture (King's College London). This broadly interprets that as the use of technology becomes ever more mainstream, experimental 3D digital techniques in design practice will become more accepted. This is supported by the four examples where Super Kitsch highlights how the designs of 3D models can be stored in a repository and "printed" on demand; the creative use of user-centric digital manipulation tools in Cuore; how a balance of engineering performance and innovative aesthetics can be achieved by using topological optimisation; and the atypical combination of using complex computational fluid dynamics with animation capture to generate inspirational forms for physical artefacts.

In light of this, the authors suggest that designers who are traditionally more conservative than artists, are now in a good position to explore, familiarise, select, harness and adopt digital technologies for creative practice. By doing so, designers will be able to gather inspiration, widen their skill base, and potentially achieve greater output. More importantly, these digital technologies have the power to aid visualisation and support co-creation of work at a global scale. However, despite these advantages, over-reliance on technology can have its drawbacks, for instance losing the human touch of design whereby the end result becomes sterile and machine-made. Therefore, personal engagement in the creative process still remains ever important to overlook, and technology should be seen a tool to support the process. Practitioners should avoid over reliance on singular software solutions with over-prescribed 'workflows'

This paper has reviewed current literature and presented four examples that describe how emerging technology has fused with today's creative practice. The examples provide evidence of the growing popularity of artists harnessing digital technologies; and authors propose that designers must now embrace such an approach to break new ground. It is through experimentation and straying from the established path that designers can achieve a greater degree of creative freedom. However, there still needs to have a balance so that the use of technology does not detract the creative spirit of designers.

References

Andreasen, M. M., S. Kähler, et al. (1988). "Design for Assembly" (2nd ed.) London: IFS Publishers. Quoted in: "A Typology of Designs and Designing," International Conference on Engineering Design ICED 03 Stockholm.

Baskinger, M. (2008). "Pencils Before Pixels: A Primer in Hand-Generated Sketching." Interactions March - April.

Bunnell, K. (2004). Craft and digital technology. key note speech at the World Crafts Council 40th Anniversary Conference in Metsovo, Greece. Available from <http://www.autonomatic.org.uk/team/kb/craft%20and%20digital%20technology.pdf> Accessed on 08 March 2012.

Bürdek, E. E. (2005). Design - History, theory and practice of product design. Basel, Switzerland, Birkhauser.

de Beer, D. J., Campbell, R. I., Truscott, M., Barnard, L. J. and Booysen G. J. (2009) "Client-centred design evolution via functional Prototyping" International Journal of Product Development Vol. 8 No. 1 pp. 22-41

Dictionary of Art Terms (2003). Thames and Hudson World of Art. E. Lucie-Smith (Ed.). London, Thames and Hudson.

Kaplan, R. and S. Kaplan (1982). Cognition and Environment: Functioning in an uncertain world. New York, Praeger Publishers.

Kim, B.-Y. and B.-K. Kang (2008). "Cross-Functional Cooperation with Design Teams in New Product Development." International Journal of Design Vol. 2(No. 3).

Musta'amal, A. H., Norman, E. and Hodgson, T. (2008) "CAD as a 'Recording' or 'Designing' Tool: Evidence From User Behaviours". Proceedings of the Design and Technology Association International Research Conference 2008, Loughborough University. <http://www.data.org.uk/generaldocs/journals/ConferenceProc08.pdf> Accessed 07/03/12.

Pei, E., R. I. Campbell and Deon J. de Beer (2011) "Entry-level RP machines: how well can they cope with geometric complexity?", Assembly Automation Vol. 31 No. 2, pp.153 – 160

Pei, E., R. I. Campbell and M.A. Evans (2010) "Development of a tool for building shared representations among industrial designers and engineering design", CoDesign Journal, Vol. 6 No. 3, pp. 139-166

Rodriguez, W. (1992). The Modelling of Design Ideas - Graphics and Visualization Techniques for Engineers. Singapore, McGraw-Hill Book Company.

Schön, D. A. (1983). The Reflective Practitioner: How professionals think in action. London, Temple Smith.

Schweikardt, E. and M. D. Gross (2000). "Digital clay: deriving digital models from freehand sketches." Automation in Construction (No. 9).

Siemer, M. (2005) "Mydea Technologies commissions first three-dimensional color rapid prototyping technology" Assembly Automation Vol. 25 No. 4 (Company News)

Tapscott, D. (2009) Grown Up Digital, New York: McGraw Hill, p.35.

Tjalve, E. (1979). A Short Course in Industrial Design. London, Butterworth & Co.

Wright, I. (1998). Design Methods in Engineering and Product Design. Berkshire, McGraw Hill Publishing Company.