Digital Fabrication Techniques in Art/Craft and Designer/Maker Ceramics

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Abstract

While the development of rapid prototyping and digital fabrication technologies has transformed the production of models and prototypes in the industrial ceramics world, the use of these techniques in Art/Craft and Designer/Maker ceramics has been minimal, due to the cost and complexity of their implementation.

The Centre for Fine Print Research at the University of the West of England is conducting a research project into facilitating the use of digital fabrication techniques in the area of Art/Craft and Designer/Maker bespoke ceramics.

The aims of the project are to develop methodologies and practices to allow the Art/Craft and Designer/Maker ceramist to use and fully utilize these technologies.

The project is investigating three main areas:

The use of 3D printing technologies and CNC machining to translate a computer generated three-dimensional virtual model into a mould capable of producing a bespoke ceramic artifact.

To research the possibilities, and then develop the methodology of forming a bespoke ceramic artifact, directly by the use of 3D printing and other rapid prototyping technologies.

The use of laser scanning equipment, reverse engineering and digital fabrication techniques to facilitate the production of short runs of bespoke ceramic artifacts

Introduction

The Centre for Fine Print Research at the University of the West of England in Bristol has recently been awarded a substantial grant from the United Kingdom Arts and Humanities Research Council to fund a three year project to investigate the use of 3D rapid prototyping and digital fabrication techniques in the areas of Art/Craft and Designer /Maker Ceramics.

The CFPR has had much experience in working with industry to incorporate unique and useful fine art based paradigms into industrial research partnerships and commercially successful developments. This integration of industrial needs and academic research has formed the basis of a number of the Centre's previous AHRC grants and Knowledge Transfer awards.

The CFPR has ongoing experience in the application of digital fabrication techniques to the Art/Craft world and has recently completed a project using digital technology to convert photographic images into a ceramic relief surface by using 3D design software and a desktop CNC milling machine. The application of a specially tinted glaze to this surface allows a permanent fully continuous tone image to be produced on a ceramic tile.

Further funding has been obtained to investigate the commercial possibilities of this process and it is expected that current collaborations with the ceramic industry will allow this process to come to market.

The Centre has an ongoing collaboration with Hewlett Packard in other areas of research.

Within the Centre, the company sponsors a broad range of activities from pure research, philanthropic projects with schools and the community through to the post of professorial chair. Also as a result of this link, unique knowledge and technical insights have recently led to the formulation of routes for addressing issues surrounding the application of 3D digital fabrication technologies as a tool for the actual fabrication of permanent, artist quality artefacts.

An Overview of Rapid Prototyping and Digital Fabrication Techniques

Rapid prototyping technologies have been in use for many years in a variety of industries, however**,** both the equipment and software have reflected the high cost of industrial based systems and are out of reach of the Art/Craft ceramist and Designer/Maker.

Rapid prototyping was initially based on Layered Manufacturing Technology (LMT) techniques, an additive process that produces models by building up layers. The first LMT process that became commercially available was stereo lithography from 3D Systems, using a liquid polymer material that solidifies when hit by an UV laser. Soon other processes were developed some of them variations on the stereo lithography process, some of them applying a new technology.

Examples of such processes that have appeared in the past years include:

Selective Laser Sintering from DTM Corp, applying a laser to locally fuse layers of powder.

Fused Deposition Modeling from Stratasys, extruding very thin plastic filament to form layers.

Layered Object Manufacturing from Helisys, using 'prefabricated' paper layers, cut to size by a laser.

Multi Jet Modeling from 3D Systems, depositing small drops of material using inkjet heads.

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Three Dimensional Printing from MIT (commercialized by Z Corp), also using inkjet heads to deposit glue to locally bind layers of powder.

These newer technologies offer advantages of a wider choice of materials and a significant increase in model build speeds. The other process for producing rapid prototype models is CNC milling; this is a subtractive process where small pieces of material are systematically removed from a large block to produce a model. CNC milling has developed from the engineering industry where large complex milling machines controlled by expensive software and requiring skilled machine operators have been in use for many years.

Relatively recently small desktop CNC milling machines have become available along with less expensive and simpler to use software making the whole area more accessible.

There are ongoing developments in all these technologies in terms of ease of use and increases in both resolution and all round capabilities. More recently developments, particularly on a micro-scale have occurred in the area 3-D printing, where these processes can be considered to be a form of digital fabrication rather than simply a method of producing prototypes or sample models.

It is now becoming increasingly possible to expand on some of these developments and to use these technologies to fabricate unique artefacts.

Digital Fabrication Techniques in the Context of Art/Craft and Designer/Maker Ceramics

3D computer aided design is a relatively new visualisation tool, assisting in many aspects of contemporary industry. It has also become increasingly evident that it holds enormous potential as an exciting tool for the creation of artefacts by artists and crafts people. However as observed by Aitkin in 1999 “a minority of makers have had the opportunity to investigate the benefits of new digital media..." This situation is on the cusp of change due to the rapid advance of technology.

The development of rapid prototyping technology has already seen several phases; the first being purely a virtual visualization tool for assisting conventional fabrication, the second a means of visualizing and outputting 3D objects using both stereo lithography and subtractive, numerically controlled modelling techniques. The most recent however, enables 3D computer rendered objects to be created using a far more user friendly digitally driven output, especially through the additive 3D printing process.

While the subtractive and now the additive processes have fed both general and specialist industrial needs, high equipment and access costs have impeded the development of their potential for art and craft use. The new generation of relatively low cost (office, or in the case of the artist-studio friendly) rapid prototyping systems have now become available. This allows more than ever before the full scope of the process to be accessed and explored by the creative practitioner. Not only can its potential for art and craft use be speculated and tested, a hands on skill base for this particular sector can also be finally developed.

As suggested by the title "Rapid Prototyping", the technique in industrial terms has become a means of creating prototypes for the visualization of an actual product, or in many cases a source for creating moulds to fabricate production line products. While previously subtractive and additive processes have needed a certain amount of extra manual finishing to prepare smooth surfaces and colored finishes. In 1998 Rees predicted "Full photo - resolution color models would be able to contain color and pattern with as much variety as a 2D printer, and could have notes photographs, patterns and solid colors printed directly on the model”. Developing color may yield other important results. As materials are selectively applied in areas of the model to make different colors, the same mindset could imagine materials applied selectively towards greater strength characteristics and variations of material characteristics."

This era has now begun to dawn with the resolution of systems such as the new Z Corp 3D printers allowing the production of a relatively finished surface without the need for external intervention. Significantly in addition to this the technology is now moving towards the production of printed objects with photo quality colour.

This new more finished output, when viewed from the perspective of art and craft practise - (especially in relation to the traditional 'one off' and 'limited edition' paradigm) marks the emergence of a unique possibility. As observed by Dr Ian Gibson in 1998 'As RP (rapid prototyping) processes become more refined, so the prospect of functional prototyping extends into mainstream fabrication. Already in some cases we don't just use these machines to make prototypes but to make real products. CAD systems also have greater capability for realism which we want to transfer into physical forms with relative ease."

However, in considering the objectives behind the manufacture of this technology and the formulation of its output, the transient properties calibrated specifically for facilitating a range of industrially derived purposes hold little in common with traditional art and craft materials. In assessing possibilities in art and craft terms, these existing modes may prove to hold new value for creating certain types of artefacts, however, by comparison with traditional analogue fabrication methods, their colour and longevity at this point of development may be seen to be lacking.

As this technology gains maturity and its user base expands it becomes increasingly evident that there are many opportunities for incorporating a further art and craft dimension to the process. A similar possibility has recently been echoed in the field of inkjet printing with several new generations of printer’s capacities being developed and expanded to accommodate artist quality archival papers and permanent pigmented inks. In the case of 3D printing there is a wide range of similar areas to be examined relating essentially to the permanence, colour and material qualities of output for the production one off bespoke artefacts or limited edition 3D originals.

The Aims and Objectives of the Project

In light of the current level of quality achievable through the new generation of 3D printers and the enormous potential of this technology for art/craft production this research aims to theoretically define and practically consolidate routes which can assist in incorporating the creative flexibility of digital 3D rendering with the material and tactile qualities intrinsically associated with art and craft practice. The research will focus on the direct output of finished objects produced through the additive 3D printing process and the use of CNC subtractive processes to directly mill both moulds and ceramic material to produce of ceramic artefacts.

In order to fulfill the aims and objectives of the project a number of strands of research will be employed. These include:

Data searches and surveys to build an overall picture of the emerging field.

Practical research to assess the value of existing technology for addressing the research question

Experimental research to modify and refine existing technology to reflect needs identified within the art and craft sector

Evaluation of methods identified and developed through the research by the production of artifacts from a diverse selection of arts & craft practitioners.

The ongoing dissemination of findings to facilitate a loop of dialogue between art & craft practitioners, industry and the findings of the research.

Although the overall research aim is broad, it is envisaged that the pursuit of the problem principally from a ceramic building perspective will provide a model, which will have and imply possibilities for other areas of art and craft related needs. Also through linking virtual 3D digital modelling directly with the output of objects embodying art and craft values, it is envisaged that a new knowledge base for the sector will be developed. This ultimately has the potential to feed back into industry as well as enrich contemporary art and craft practice.

Areas of investigation:

The use of 3D printing technologies and CNC machining to translate a computer generated three-dimensional virtual model into a mould capable of producing a bespoke ceramic artifact.

In common with many industries, in the ceramic world the use of rapid prototyping techniques in the design and modeling phase of product development has become the norm in larger organizations. The techniques are used to design objects with dedicated 3D software (e.g. DeskArtes Design Expert). It is possible to design, view and review the model on screen and to make any alterations that are required to adapt the model for production. The final virtual model is the machined using an industrial CNC milling machine to form an original model, an original mould is then produced by using a silicone rubber interface. This process is not easily available to small-scale manufacturers and to the Art/Craft and Designer/Maker ceramist due to the cost and complexity of the software and equipment required.

The intention is to use currently available low cost 3D software (e.g. Rhinoceros 3D) and a desktop CNC machine to develop methodologies and practice to enable the Art/Craft and Designer /Maker ceramist to access these processes.

For the production of one off bespoke ceramics it is anticipated that it will be possible to produce a short cut to the traditional modeling/mould making process to form a working mould directly from the 3D computer model by using the CNC process cutting into a plaster substrate or by the use of a 3D printer such as the Z Corp machine to print a mould in a plaster material.

To research the possibilities, and then develop the methodology of forming a bespoke ceramic artifact directly by the use of 3D printing and other rapid prototyping technologies.

Industrial ceramic modeling techniques and practices are intended to produce the tooling to enable the mass production of ceramic objects. The suitability of these processes to the Art/Craft and Designer/Maker ceramist is limiting in that there may only be the need to produce a small number of items. The industrial process where the cost of design and tooling is amortized over long production runs can be prohibitively expensive for one offs and short runs.

To be able to digitally fabricate a ceramic object directly by outputting a 3D design file to either a 3D printer or to a CNC machine could have enormous benefits in the area of Art/Craft and Designer/Maker ceramics. Previous research at the CFPR on the photo ceramic relief project has proved the viability of machining unfired ceramic such as “green” clay and dust pressed materials. This project seeks to extend this research to develop methodologies both for the design process and for the machining strategy and parameters.

Developments in 3D printing have highlighted some intriguing possibilities for digital fabrication of unique artefacts. One such route relating to the area of ceramics has already revealed promising results through pilot tests run in anticipation of this project.

This involves the possibility of substituting the powders used in the Z Corp 3D printing system with a complete prepared ceramic body, comprising of a mixture of clays, fluxes fillers and modifiers. This body is mixed using a conventional process and then spray dried and ground to produce a powder of specific particle size distribution and properties.

By utilizing the Z Corp process a physical ceramic object could be produced that is not subject to the limitations of conventional ceramic forming techniques. No moulds or machining would be involved and a direct translation could take place between the virtual object designed on the computer and a physical artefact.

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It is anticipated that by further development of this method a completely new form of digital fabrication for ceramic objects may be possible allowing a 'green' ceramic article to be formed, glazed and decorated in one process, leaving only the final firing to be completed.

This would have important implications in the area of Art/Craft and Designer/Maker ceramics allowing the production of unique works and limited production runs to be achieved without the costs of modeling and tooling.

The use of laser scanning equipment, reverse engineering and digital fabrication techniques to facilitate the production of short runs of bespoke ceramic artifacts.

Although the previously discussed areas of investigation have related to the opportunities offered by digital fabrication and rapid prototyping in the production of one off artifacts or very small production runs, another area where the use of digital fabrication techniques can be of use to an Art/Craft or Designer/Maker ceramist is to use the technology to produce the tooling for what is by industry standards a short production run.

A typical scenario is when the artist has produced a range of articles by hand or a labor-intensive process, and then due to sales success has the need to produce a short production run of several hundred pieces. The conventional way to produce the articles would be to have each of the pieces modeled by hand, and to follow the conventional mould making procedure to produce a set of working moulds to form the article. This is an expensive and time-consuming way to achieve the result and in many cases the cost is prohibitive and the opportunity is lost.

The project aims to investigate the use of laser scanning and digital fabrication techniques to facilitate this process.

Each individual piece would be scanned by a laser scanner and digitized. The information would be outputted via suitable 3D software, to a 3D printer or CNC machine to form a model.

This model is used as the basis to make a set of working moulds to produce the short production run.

Alternatively it is anticipated that for a very short production runs it may well be financially advantageous to produce a working mould by using either a 3D printer or a CNC machine using the techniques described above.

Summary

Digital fabrication, rapid prototyping and the associated technologies contain great-untapped potential for the area of Art/Craft and Designer/Maker ceramics. Although we are at the beginning of a three-year project, to investigate the subject and to develop methodologies and practices, we have already started to work with artists and practitioners in the area. We are in the process of commissioning a digital fabrication laboratory containing two Z Corp 3D printers, two desktop CNC machines and a larger multi axis CNC machine, and a laser scanner to aid reverse engineering. We intend to invite Art/Craft and Designer/Maker ceramists to collaborate with the project and to be involved with the development of the processes. It is envisaged that the creation of new artworks will refine and expand the findings of the research. There will be an ongoing assessment of the results, consultations with industry, and workshops and seminars, culminating in an exhibition of the artworks produced.

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Author Biography

David Huson is a Research Associate at the University of the West of England. Previously he has worked in the ceramic industry, holding positions of Research and Development Manager, Technical Manager and Works Manager. He also ran his own business for five years producing commercial ceramics. He is currently researching photo ceramics and the use of digital fabrication techniques for Art/Crafts and Designer/Maker ceramics.