SPERICAL HARMONICS: EXPERIMENTS IN 3D PRINTED CERAMIC FORM

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ABSTRACT

This research is twofold – first it is about exploring the mathematical shape of Spherical Harmonics in computer code to extend the vocabulary of ceramic form. Secondly to develop techniques to 3D print these computers generated forms using DIY 3D ceramic printing techniques.

DESCRIPTION

As self-directed personal research this material is about exploring audience response to a particular set of forms. My interest is in how at a basic evolutionary level we respond to natural forms. We have an inbuilt propensity towards natural forms and patterns, such as curvature, repetition, symmetry because we are part of that same natural world.

In mathematics, spherical harmonics are represented as a system of coordinates on a sphere. Using the latitude and longitude coordinates each point on a closed spherical object can be distorted using the spherical harmonics function creating a variety of organic looking visualisations. The Spherical harmonics function is used in many theoretical and practical applications, such as in the computation of atomic orbital electron configurations, the representation of gravitational fields, and the magnetic fields of planetary bodies and stars.

For some years I have used computer 3D modelling programs as a tool to explore and extend my knowledge of form for producing ceramic objects. This has developed to a point where I now generate 3D forms directly in computer code using the Processing open source programming environment based on the java computing language. Working at the level of code offers a way of creating forms where the systems and patterns found in the natural world can be simulated through mathematical calculations. Spherical harmonics is an example of this. My programming skills are limited but Processing offers a large community of shared libraries from which to borrow and then edit code. For this project I have relied heavily on the toxiclibs library. Karsten Schmidt of toxiclibs in tern credits Paul Bourkes for his information on the spherical harmonics function.

Figure 1: 3D printed ceramic forms generated from spherical harmonics mathematical function. Average size 7 x 7 x 7 cm.

As described in the abstract there are two parts to this research. The first to generate the three dimensional forms using computer code. The second is to get the forms out of the computer into the material world to be considered as physical objects. For the last two years I have been doing this through 3D printing directly into clay. I make use of a diy RepRap kit 3D printer that has been converted to print with clay. The plastic print head has been replaced with a syringe type print head, filled with soft clay and then pressurised with compressed air that extrudes a continuous vein of clay. This enables the printer to build the ceramic object layer by layer as developed by Belgium based Unfold Design Studios. Refreshingly simple this printing method is good for vertical forms but does not cope very well with the compound forms as generated by the spherical harmonics function.

For these and other complex shapes I have been researching an adaption to the basic RepRap printer to use powder clay to support the form as it is printing. The adaption is such that the usual print base that lowers while the print head remains at a fixed height plotting out each sliced cross section lowers into a box void enabling the supporting dry clay powder to be spooned in around the form as it is printed.

Figure 2: RepRap 3D kit printer converted for printing in ceramic. Top left: printer without powder adaption. Top right: Close up of spherical harmonic being printed. Bottom left: View of adaption to contain powdered clay support during printing. Bottom right: Finished print ready to be extracted from powder.

The achievement of this experiment in design research is illustrated by the successful production of a large number of glazed porcelain organic forms generated from computer code and directly printed using 3D printing. A problem with using an extrusion type print head in 3D printing is often the lack of physical support under protrusions on a form or element in a design that float above the base or float free from the main body. This technique offers support in the form of the clay powder and therefore over comes the problem. With the support there is also less distortion of the layers under each new extrusion of clay resulting in a much crisper and rounded result. The clay powder helps dry the print enabling it to be handled soon after printing. The powder is easily brushed from the object leaving no marking on the surface. The clay print is fired and glazed in a conventional manner.

This is certainly no plug and play system with the powder needing to be continually offered up by hand. However what it does show is that there is a place for interacting with and adapting these new technologies to be used as creative tools for artists, makers and designers in a very hands on craft based context.

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