Building Blobs: Embedding Research in Practice

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Abstract. Through a model of engaging research in practice, we present the development of a technique for digitally resolving three-dimensional curves for documentation and fabrication. We suggest it is possible to distinguish the power of the computer as a design tool in the design development process, where the description of complex forms are not well served by the established methods of orthogonal representation.

Keywords. Architectural representation; complex form fabrication; practice-based research.

Introduction

Responding to the conference theme we might ask why is the computer considered to be an effective tool for creating and producing architecture? Is it perhaps to the extent the conventions of traditional architectural representation have been adapted to the digital realm? In this paper we suggest that one point at which the computer can discernibly augment design can be illustrated where an artefact is no longer well described through conventional methods.

Describing complex forms

Complex three-dimensional forms are challenging to document and construct using orthogonal representation. The architectural historian Robin Evans (1995) cited the example of the difficulty in realizing Hans Scharoun’s Berlin Philharmonie as it was translated from sketches and models to working drawings.

Physical modelling techniques have been used to advance the design development and construction of challenging buildings such as the Sydney Opera House and The Sagrada Familia Church in Barcelona. In the case of The Sagrada Familia Church, the use of modelling concurs with Gaudi’s codex of intersecting ruled surfaces, a system partly developed to aid complex form description (Burry 1993). Vollers (2001) has recently used ruled surfaces as a method of fabricating non-orthogonal architecture through the development of “twisted” window framing systems.

Digital modelling by contrast is generally not yet well established in practice beyond a visualisation tool. In education however, the profusion of relatively inexpensive software using mathematically defined curves such as non-uniform rational b-splines (NURBS), has afforded rapid form creation and experimentation. In this manner, designing using the computer has offered students a fluidity often leading to, at the more geometrically difficult end of the spectrum, curvaceous shapes or “blobs”.

Although rendered visually seductive, such forms can be critically challenging as they emerge from their transferral to an architecturally readable artefact (Burry 1999). Techniques often require “slice and dice” operations to extract two-dimensional profiles for the overlaying of conventional drawing techniques in order to produce plans, sections and elevations. Further development can
become reduced to a sectional stitching process imposing a rigidity described in practice as necessary for construction in ‘contractor space’. This is also where forms claiming to be animate have been criticised for being ‘frozen’ at their point of architectural documentation.

In this paper we reflect on design research for the development of a technique for documenting and constructing three-dimensional freeform curves. The work was undertaken by researchers and students at RMIT University’s Spatial Information Architecture Laboratory (SIAL) in the context of our practice-based research programme. Despite the existence of dedicated research and development departments in construction practice, innovation in project based work has been found to be extremely hard to capture (Gann and Salter 2000). Our research programme responds to this with a dual role methodology of design research for both practice and education. Its intention is to offer technical resolution at one point while sponsoring other types of design activity – a particularly important function of the student involvement.

Three-dimensional curves profligate in digital space, yet curves in built space are generally planar, separated into tangential arcs during the shop drawing process and fabricated by welding similar profiles of different lengths and radii. Although assemblies of planar curves have been used to give three-dimensional effect (Figure 1), the ability to build three-dimensional curves has the potential to ascribe a consistency between NURBS models in digital space and real space.

A method for doing this is to use circular profiles. By twisting tangential arcs relative to one another it is possible closely to emulate the construction of fully three-dimensional curves? Automotive exhausts made from several bends and straight tubes welded together in this manner are probably the most complex curves now constructed. An analogy in architecture would be the fabrication of well designed continuous hand rails. Using the computer to develop this project’s design rendered drawings superfluous to the task of transcribing over 10,000 individuated pieces information. We see this type of enquiry as a possible stimulator for design computing across all stages of the architectural process.

The Shoal Fly By project

Shoal Fly By is a public artwork comprising a collection of five separate sculptures intended to represent movement through water (Figure 2). Two artists, Cat Macleod and Michael Bellomo, hand crafted models at a scale of 1:100 composed entirely of freeform curves using wire as their malleable medium. In this way they could capture small bends and kinks, a ‘seamless yet not smooth’ aesthetic they wanted to retain in the final work to be built in stainless steel tube. The sculpture had been awarded first prize in a competition for construction on the foreshore of the

Figure 1. Examples of two-dimensional metal tubes used for three-dimensional effect.

Figure 2. Shoal, one of the Shoal Fly By sculptures, showing the network of freeform curves.
docklands precinct in Melbourne, which is currently undergoing massive redevelopment and as a place to work and live.

The Shoal Fly By project is the second of four projects in the current practice-based research programme, exemplifying the process of embedding our research within practice. Students were sponsored both to take part in the activity and to return the results in a manner promoting reflection on their own academic design work. Our research in this case was to develop a design development process that transferred scaled freeform curves into digital space, transcribing the curves as tangential arcs for a computer numerical controlled (CNC) tube bending operation followed by fabrication through their full size spatial relocation.

The artists had previously built relatively simple curved forms in steel, developing an appreciation of the fabrication processes involved. Through their own research they knew that without establishing tangential relations between the constituent parts of the work the result would be an exposition of joints, preventing a reading of the whole - in this case the network of freeform steel tubes.

The modern process of tube bending has its foundation in the 14th century when developments in methods for bending brass resulted in a musical horn of conjoined tubes - the forerunner to the trumpet. Today the bending of tube can be accomplished through highly controlled CNC processes where the tube passes either through rollers or around a fixed die. Most bends are planar and of fixed radius, although it is possible to offset the radius to draw a helical extrusion.

The students started by attempting to accurately and effectively measure the physical model. Beginning with a point probe on a three-dimensional digitising arm, repeatability of the wires on the scale model proved inaccurate. This led to a non-contact method using a laser scanner with the students then dealing with the materiality of sub-millimetre clouds of points. The wires were then traced from points to NURBS curves.

An algorithm was developed to approximate the wires to a series of tangential arcs. This involved assimilating the information required by the tube bending machine and for the fabrication procedure with a method for separating the NURBS curves to arcs. This is mathematically difficult and the result is always an approximation. This is because a curve is continuously changing in curvature whereas an arc is of fixed curvature and so steps through curvature changes. Our algorithm developed as we made visual iterations, finishing with eight constraints which could be varied for each curve such as minimum arc length, radius and maximum curvature change.

Interestingly an amount of tacit knowledge was developed in applying the procedure when reconciling the physical design with its expression in arcs. The artists didn’t want a ‘smoothed’ result so a balance was sought between using a greater number of smaller arcs for a very close approximation and longer arcs with fewer joints to achieve.
achieve a more economical budget (Figure 4).

The collaborative nature of the work, between those not normally collectively associated with the design development of built work – artists, fabricators, students, programmers and surveyors in this example, brought an unexpected method of representation to the project.

Output from the process was continually adjusted to report fabrication information. This was a combination of the arc data that could be directly inputted to the CNC tube bending machine and the spatial locations of each tube with the relative twist angle between each part. The largest sculpture contained 420 arcs conveying almost 3800 pieces of information, which was fully documented using spreadsheets with a digital model for cross referencing. Although such methods of representation are common in our research, they would be quite unfamiliar if placed amongst the conventions of most architectural practices.

Returning the research

Alongside this project, the students used the methods to reflect upon their own work. Figure 5 shows the results of one student who reinvestigated her design studio project using the isoparametric curves of the NURBS surfaces of an apparently amorphous form, to guide a structural system. The process of applying three-dimensional design development to a digital model instigated a reappraisal of the design, perhaps offering a view to a use of the computer as a design tool.

Figure 5. Another application. A student using isoparms to guide a structural system (in black)

Conclusion

In concluding and returning to the conference theme, we suggest that one reason for the apparent under exploitation of the power of the computer as a design tool and as a design stimulator may be due to the paucity of established methods to represent complex forms created using the computer. Through the results of our practitioner-based research, we have developed a technique to encourage more detailed and rigorous design development of digital models. This potentially offers an opportunity for the use of the computer for design and is surely of benefit to students, educators and practice alike.

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