INTERNATIONAL DESIGN CONFERENCE - DESIGN 2004
Dubrovnik, May 18 - 21, 2004.

DESIGN 2004

'FUTURE FACTORIES': SUPPORTIVE TECHNOLOGIES AS CREATIVE PROCESSES

P. Atkinson, E. Unver and L.T. Dean

Keywords: 3D generative processes, rapid prototyping, direct digital manufacture

1. Introduction

Envisage a future where you could visit a dedicated 'Future Factories' website, accessed in a gallery, a department store or directly from your own home. This website would display a range of products, and you could select any one of them. Once you made a choice, you would be presented with an animation, which would show that particular product in a constant state of metamorphosis, as it grows, changes and mutates on the screen. At any given moment you could pause the animation and view a three-dimensional computer model of the product, rotating it to see it from any angle. The animation would continue, and any number of 'snapshots' of the product at various stages of its growth could be taken, and if required, printed onto paper for closer examination. Each one of these 'snapshots' would be a unique form – never to be repeated. If you then decided to purchase one of the designs, you could order it directly from the website, and the product you had selected would be manufactured automatically, exactly as you had seen it on screen, and delivered directly to your door. An original. A one-off. A work of art?

The School of Design Technology at the University of Huddersfield recently decided to allocate an amount of research funding to provide an 'Artist-in-Residence' to work alongside Fine Art students, and a 'Designer-in-Residence' to work alongside Product and Transport design students for a period of one year. The work undertaken by the Designer in Residence along with contributions made by other academic staff are the subject of this paper. The title of the project 'Future Factories' describes an exploration of the creative potential inherent in digital design and manufacture to offer more than a single discrete 3D outcome. The outputs from this practice-based research project consist of a number of inspirational products which have been exhibited in a number of traditional gallery environments and will be later disseminated digitally – either on-line or by CD-ROM. Alongside the practice-based research outputs there have been a number of different academic papers addressing the different technical, theoretical and contextual issues raised by the content of the 'Future Factories' project.

2. Methodology

'Future Factories' is an exploration of the possibilities for flexibility in the manufacture of artefacts inherent in digitally driven production techniques. All such production techniques are considered, the focus however is on the layer additive manufacturing techniques associated with Rapid Prototyping (RP). In essence the project proposes an inversion of the mass production paradigm to one of mass-customisation. However, unlike previous work on mass-customisation, where many design decisions are taken by the consumer or with reference to the particular consumers needs, 'Future Factories' considers individualised production – in which a random element of variance is introduced by the computer within a parameter envelope defined by the designer. Each artefact physically produced will be a one-off variant of an organic design that has been defined by the designer and maintained in a constant state of metamorphosis by the computer software. This variance may be over parameters such as the relative positioning of features, scale, proportion, surface texture, pattern, and the like. These variable factors may be multiple and interrelated. The intention is to achieve subtly different aesthetics based on a central theme rather than mere differentiation that might be achieved by say scale or colour change alone. This random variance would simulate the lack of uniformity in one-off craft production where the craftsperson may be guided by a design intent rather than a toleranced production drawing. In this way, 'Future Factories' aims to overcome the split between the technological and the aesthetic, between artistic creativity and machine production

The creation of computer generated art has little in the way of physical constraints. The adaptation of these forms into functional products though, obviously requires stricter control. Advances in computer added design have brought a shift to parametric solutions as a methodology for the definition of computer models (3d designs). In parametric design, relationships between the degrees of freedom of a model, instead of the degrees of freedom themselves, are specified. Using parametric design software designs can be quickly manipulated, and alternate solutions considered, simply by changing the variables, or parameters that define the product.

The 'Future Factories' designs are defined by 3d parametric models. In these models, ranges are set for certain parameters within which values are assigned at random by the computer. The range limits, along with further interdependent parametric relationships are imposed by the designer to maintain function and the desired aesthetic. This leaves an organic model free to mutate within a series of interrelated parameter envelopes. Each organic design is defined by a production formula, which can yield an infinite range of equally valid outcomes. We are able to categorise objects in nature by the recognition of certain common patterns and proportional relationships in spite of significant variance. 'Future Factories' aims to achieve this same balance between order and chaos, between manufactured uniformity and individual sensibilities. It aims to develop a system for the automated production of one-off outcomes that are at once distinctly individual and at the same time of a recognizable design.

Two fundamental approaches to the concept of product variance in the FF model have been identified in the work to date; manipulation of the core 3D form and the application to the core 3D form of a variable feature.

As an example of the first approach, a three-legged candlestick was designed, having a series of functional requirements – to stand upright and support three candlesticks of a fixed size. The candlestick's footprint is fixed, the legs being evenly spaced and at a fixed separation, for stability. The tops of the legs are also constrained but not fully. Each top is required to remain in the same radial plane as a foot, again for stability. The height of each leg may vary, separately, between a maximum and a minimum value. A relationship is applied to ensure an even spread of heights between the legs. This relationship prevents an outcome with two legs close to maximum height and one close to the minimum, or the reverse scenario. The only constraints on the form of the legs between top and bottom are the degree of interference required for a joint to be made, and that the legs spiral in the same sense and in a smooth curve.

As an example of the second approach, a light fitting was designed which took the existing form of a light bulb, but with a solid metal body. Instead, the light source is a series of high intensity white Light Emitting Diodes (LED's) mounted in the ends of 'tentacles' which appear to grow at random from the bulb form. The end of each 'tentacle' is dimensionally constrained to accept an LED and the direction in which the LED points is restricted to certain angles from the vertical (to avoid glare). Three distinct characters of 'tentacle' have been designed;

'Drops' form like stalactites on the lower half of the bulb tapering as they 'grow' downwards as if under gravity.

‘Tentacles’ form like drops from the lower half of the bulb, these however are able to resist gravity to an extent, they have a tendency to curl and coil.

‘Risers’ form like stalagmites rising from the upper half of the bulb. As they rise they lean out from the bulb body and begin to curl under gravity.

These ‘Tentacle’ types appear in varying proportion and random positions over the bulb form. Each can then vary in form based on its type.

3. Virtual Merchandising

Conventional marketing usually centres around a glossy photograph of the product shown from its best angle. VR content enables websites to bring the products 'to life' with 3D models, user interactivity, animation, sound, and detailed views. An interactive image allows the product to be seen from all angles. Potential customers are able to examine the design in the form of a 3D model moving, rotating, and zooming in and out at will. This ‘hands-on’ interaction allows something of a “try before you buy” experience. Internet shoppers have been reported to spend 50% more time in the part of the site that offers interactive 3D images, yet VR on the Web is not yet mainstream or widespread. Why has this exciting technology made such slow progress? This may be due to the fact that VR content is costly to develop, mostly because the expertise to create it is still rare, and a direct link to sales revenue is as yet unproven. In addition, content creators typically make a substantial investment in computers, software, and digital equipment. Technical difficulties have discouraged the take up of website based VR marketing. The technology is most convincing and pleasing when it uses realistic textures, lighting and sounds. The use of these elements requires large files which leads to slow performance, and web designers fight a constant battle between high graphical appeal and slow download times. High resolution graphics and elaborate animations are notoriously slow to download, especially through a dial-up connection. Add to that bandwidth limitations and the possibly unreliable connections of the Web, and you have the potential for a deeply dissatisfying experience.

We can assume that consumers will always prefer hands-on experience with a product before purchase. Barring cumbersome and expensive gloves and goggles, VR is still strictly an audiovisual experience. Even gloves have serious limitations in that they cannot provide a tactile experience of texture. This might be solved if the website access was via a retail outlet and samples were available. It would also avoid ‘user end’ technical issues. VR content cannot be viewed with a standard browser - a special-purpose browser or a plug-in is required. In addition there is no single viewer that can handle all VR content. The requirement to download additional software merely to, in effect, browse a shopping catalogue is a severe disincentive. The user may not even have administrator rights to the computer or the desire to involve themselves in IT issues. The lack of an industry standard also affects content creators (and their cost), as each viewer typically has its own authoring tool. There is no single tool that a programmer can learn with any expectation of addressing more than a fraction of Web users. The limitations of computers and the technological demands of VR should not be exaggerated however. VR files are not necessarily huge. Files consisting mostly of vector graphics are relatively small. Problems of speed and resolution will be solved over time as standard-issue desktop computers gain speed and are optimized for 3D graphics. Higher-bandwidth and more reliable connections to the Internet will also become more common. Proprietary viewer and content creation software offer increasingly high-quality images within compact, efficient files.

4. 3D Modelling and Software Development

Initially in order to test user interaction and finding out what each individual person choose during the exhibition, a new software FF (Future Factories) is developed. The software written in Delphi Language enabled user to choose, stop, replay, print a 2D picture as well as capturing the selected design parameters and creating a database.

In this study a series of organic product designs shown in Figure 1 were created using this software. Domestic interior products, principally lighting and tableware, have been considered for the project thus far. Domestic interior products is a market well used to paying a premium for design and materials technology. Lighting and tableware have been selected to keep the artefacts relatively small. This consideration is based on cost rather than capacity - the largest laser sintering machine commercially available in the UK is 700 x 500 x 350mm for manufacture in one piece, and building in sections could also be considered. The designs selected thus far are for production in cast metal. They make use of layer additive production methods to achieve complex forms almost impossible to achieve with multiple use tooling. This necessitates the use of investment casting, with the wax patterns for use in the process being produced by a layer additive process.

The software's database enables us to see when each design parameter is selected and if there are any correlations between similar chosen parameters. In future, this facility could provide data on the preferences of different genders and age groups or other criteria.

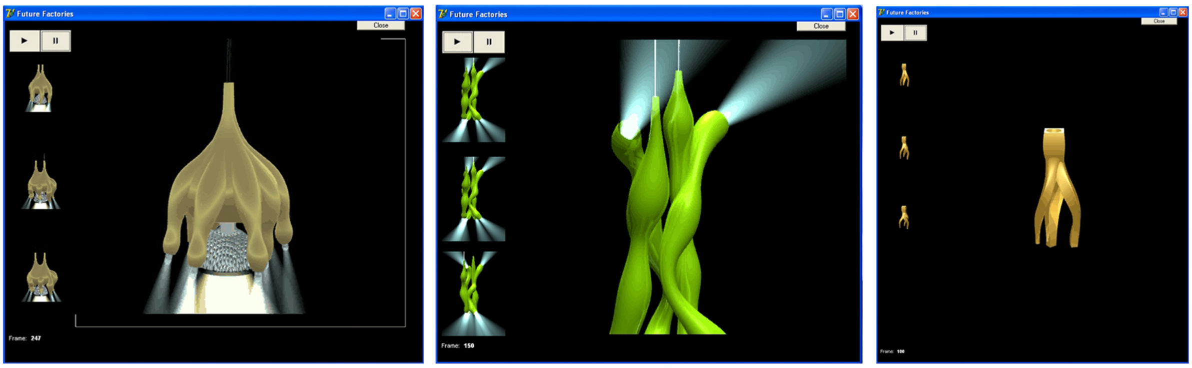

Figure 1. Organic designs created in Future Factories Software

In 'Future Factories', a production system is envisaged in which the consumer is presented with a 3D digital model of the artefact via a website. The web site, the 'Future Factory' itself, would have a series of 'production lines' corresponding to different products. When a particular production line is selected the user is presented with a computer animation showing that particular product design in metamorphosis within a parameter envelope specified by the designer. At any given point the consumer may freeze the animation effectively creating a one-off design on screen. Should the consumer wish they might then proceed with an order, in which case the relevant digital production files (stl etc.) would be generated automatically and sent to the relevant RP production facility. An artefact, effectively a one-off, will then be manufactured using layer additive manufacturing (rapid prototyping) techniques. This may be achieved directly, via laser sintering in a suitable material for example, or indirectly via the production of a single use tool or pattern. It should be pointed out that the intention is not for the consumer to use the animation to adjust design features to their liking. The animation is changing in real time and is outside their control (this would hopefully be part of the allure). A variant can be 'designed' for them and they can choose to order it or not.

To add to this allure of one-off products, there are a number of ways in which the 'value' of the artefacts produced might be increased. An element of exclusivity can be introduced for customers such as corporate buyers, for whom specific commissions could be undertaken and unique design formulas produced. They could then order as many of the objects (such as light fittings for a particular chain of restaurants) as they required, secure in the knowledge that each product would be unique in itself as well as the design formula being unique to them.

Alternatively, the production of designs can automatically be 'capped' to a specified quantity as is the case, for example, with limited edition screen prints, with a numbered system being used to show how many have been produced, and how many opportunities to own a one-off variant of a particular design are left. Another option is not to cap the quantity, but to limit the amount of time for which any particular product will be produced.

Perhaps the most interesting possibility for increasing value is to employ the model of a single line of ‘evolutionary’ development in which a design is created, adapted and finished over a specified time span. Imagine a simple design being created for production for a period of, say, six months. Over that period, the design might become more and more complex, more organic, or more convoluted in form until it reached the end of its ‘growth’ pattern when it would no longer be able to be turned into a real object. At any point during that period, customers could view how the object started out and how it has developed since its inception. They could have the option of purchasing the object at that point (but not be able to purchase any of the forms from a previous time), or anticipate, like gamblers playing a game of chance, how the design might look in a month, when they might return and purchase it. They might plan to purchase a range of objects from a number of different points in its existence, or vectors along the animated production line. It is possible that ‘early’ incarnations of the design could become more valuable than later ones (as with limited edition screenprints having lower imprint numbers). The possible combinations of ways in which the process could be employed are potentially huge and are currently forming the basis of a funded attempt to commercialise the technology developed.

5. Conclusions

The ’Future Factories’ project demonstrates that the potential of computer-generated organic forms to produce viable artefacts for one-off production is at last a realistic proposition. Obviously, ‘Future Factories’ is not a suitable model for the production of complex technological objects (at least not yet). But the design thinking behind it, and the manufacturing system proposed fits comfortably with today’s drive for individuality.

In ’Future Factories’ a direct connection is made between playful desires and the will to take risks through predictive forecasting, as well as connecting with dominant modes of capitalist production via the technologies if not the processes of mass production. ’Future Factories’ is not mass customisation, the mode of production is craft placed momentarily in the hands of the consumer, temporarily liberating them by engaging them in a culture of chance, variability, selection and playfulness. This enables the consumer to engage with a plethora of possibilities through chance decisions that ultimately capture a particular moment, through which a unique object is cast out from a virtual environment into the real world.

It is clear that the implications of the wide scale adoption of such techniques by industry are potentially serious, and are such that moves to protect the process via patents have been made. The system has the potential to change the perception of design by consumers and manufacturers alike, and to influence considerably the education and training of designers. Despite the philosophical questions the process raises for the definitions of terms such as ’design' and 'designer', (which are potentially misleading in this context), and the scope for confusion as to whether the end results of the process are 'art', 'craft', or 'computer generated', there are a number of more pragmatic considerations. The potential for the process to impact on manufacturing and retail industries should not be overlooked. 'Future Factories' allows for the economic large-scale production of artefacts while providing important reductions in wastage arising from the over-production of unwanted items. At the same time the system promotes the move from reductive to additive manufacturing processes, cutting down on waste material from the production of goods. As such, it may point the way to a more sustainable model of a consumer society than the one we take for granted today.

References

Cook D (1996) 'Digital Darwin' in Creative Technology, Feb 1996 pp 14-19

Crayton, T (2001) 'The Design Implications of Mass Customisation' in Architectural Design, April 2001 pp 74-81

Davies, S (1987) Future Perfect, New York, Addison-Wesley

Fu, P (2002) 'Custom Manufacturing: from engineering evolution to manufacturing a revolution' in Time Compression Technologies, April 2002 10/2 pp 44-48

Todd S & Latham W (1992) Evolutionary Art and Computers, Academic Press Ltd, London

Paul Atkinson, Mr
University of Huddersfield, UK, Design Department, School of Design Technology
HD1 3DH Huddersfield, West Yorkshire, Queensgate, United Kingdom
Telephone: +44 (0)1484 472139, Telefax: +44 (0)1484 472940
E-mail: p.atkinson@hud.ac.uk