RAPID MANUFACTURING FOR THE REALISATION OF 'USER DESCRIBED' ENTERTAINMENT AND RECREATIONAL CONTENT

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Abstract: *This paper discusses commercial applications of Rapid Manufacturing and specifically 3D Printing for the realisation of consumer products, where a significant element of the design content is 'described' by the customer. Applications include the realisation of internet gaming characters, 3D topological representations and giftware. The paper discusses how different web enabled RM business models operate and the implications of these on product 'personalisation', intellectual property control, branding, product liability and licensing. The paper then discusses how the concept of 'Grid-RM' or 'distributed manufacturing' is being developed to maximise latent global RM capacity, whilst maintaining content provider value. 'Grid-RM' is a networked methodology being developed by the author to broker the supply and demand of RM parts globally, and is part of a larger UK government funded project with Boeing, Virgin Atlantic, Caterpillar and Delphi amongst others. However, as this paper demonstrates, Grid-RM is just as applicable in the manufacture of consumer goods as in the manufacture of aerospace parts.*

Keywords: *Rapid, Manufacturing, Distributed, 3DP, Games*

1. Introduction

Much has been written about the technological capabilities and constrains of Additive Layer Manufacturing (ALM) for the production of end-use component parts, in the application we now know as 'Rapid Manufacturing or RM'[1]. In most cases RM has been investigated as a 'tool-less' alternative production technology to displace moulding processes, machining or casting. This has to-date resulted in limited market penetration. Much of this limited penetration stems from a need for robust process and materials validation, within the early adopters such as the aerospace, automotive and medical sectors. However, within more *'customer-centric'* areas such as homeware, lightings, games and toys, these barriers to entry can be much lower. Within this paper it is suggested that these *'customer-centric'* applications, do in fact make up the majority of today's successful RM business applications, and present a significant market opportunity in the future for application where the end consumer is engaged in the product design process.

2. The integration of the consumer in the Rapid Manufacturing supply chain

Two of the greatest business drivers to the adoption of RM are the ability to manufacture complex geometry components without the need for fixed asset tooling. Hence, RM is well positioned to support the fulfilment of individualised or consumer personalised products. A good example of where these benefits have been applied is in the medical sector, where complex geometric data has be derived from individual patients and used to drive the downstream manufacture of individualised products, which can now be produced cost

effectively using RM. Applications include the manufacture of personalised hearing aid shells[2], dental bridges, crowns and implants[3], maxiofacial and cranial implants[4] and prosthetic limb sockets[5].

In each of these cases if could be argued that the end user or consumer has been the source of the products geometric data, hence enabling user defined content. However, in reality the data used to drive RM will have been a combination of user generated surface data and geometric manipulation by healthcare professionals using products such as Materialise 3Matic, Rapid Shell Modelling, SurgiCASE, Simplant or Sugiguide[6]. In many cases, this downstream data manipulation requires a high level of skills or process knowledge and can add significantly to the piece-part price of the RM product.

However, a number of recent business models have been developed with couple either user-selected or user-defined content with Rapid Manufacturing production, where minimal secondary data manipulation is performed between the consumers design input and the production process. In the main, these applications have been in either the realisation of computer games characters or in the fulfilment of RM products designed online using basic user interface tools.

3. The Rapid Manufacturing of User-selected content

Probably the earliest example of using RM to enable the manufacture of on-line user described content was the launch of www.fabjectory.com by Mike Buckbee in 2006. The Fabjectory business model enables player from the Metaverse 'Second Life' to purchase models of individualized avatar characters manufactured using Z-Corporation 3D-Printing[7]. Unlike other Massively Multiplayer online role-play games or MMORPG's, the creators of Second Life, Linden Laboratories of San Francisco USA, have assign all intellectual property rights for characters, building and vehicles to the games users[8]. In essence giving all estimated 1,000,000 Second Life 'active residents' the right to exploit their own designs. This has lead to a number of interesting business cases, where real-world clothing brands have been developed based on virtual world designs. Moreover, this also allows every Second Life users to extract the geometric and colour data of their individual avatar characters and provide this to Fabjectory for 3D printing, without any infringement of Linden Laboratories intellectual property. However, it should be noted that although Second Life has an estimated user base of over one million active players and over 13-million registered users, Fabjectory is far from a thriving company[9] with Buckbee stating in April 2008 that the company produces just 5 to 10 avatar characters by 3DP per month. Moreover, it should be noted that Fabjectory is a 'virtual' business that owns no manufacturing capacity and uses a subcontract supply chain for part fulfilment. Hence, the company has no real exclusivity to print Second Life content, nor the capacity to migrate to other data sources.

A similar application of Z-Corporation 3D Printing to Fabjectory was launched in December 2007 by www.figureprints.com. However, the FigurePrints business model could not be more different to the Fabjectory business model[10]. FigurePrints is an exclusive licensing partnership between a former Microsoft executive, Ed Fries, and global software house Blizzard entertainment. The FigurePrints website allows players of the MMORPG World-of-Warcraft, or WoW, to order 1/16th scale models of their online gaming characters manufactured using 3DP. However, unlike Second Life where the character IP resides with the designer, all WoW character definitions remain the exclusive intellectual property of Blizzard entertainment, albeit they are designed using a suite of 'character building tools' by the games players. Hence, FigurePrints provides a closed-loop revenue and licensing opportunity for Blizzard. By March 2008 FigurePrints had received over 100,000 order enquiries for characters costing $100 each[11].

At present these orders are being fulfilled using 4 in-house Z-Corporation Z510 colour printers. Albeit, at present demand appears to far out weight supply, with order fulfilment based on a monthly lottery system. It should be noted that WoW currently has 10-million registered players[12]. Hence FigurePrints current penetration represents only 1% of the potential market. Although it is possible for anyone to extract monochrome character data from WoW using tools such as OGLE-Eyebeam 'OpenGL Extractor'[13], it would be a breach of design rights to then 3D-print the resulting data, irrespective of whether the person extracting the data was the original characters designer.

A similar closed loop RM fulfilment model to FigurePrints has also been developed by the 3D Outlook Corporation, where users are able to select topographic data of the earth's surface and use this as the basis for a 3-dimensions colour relief map printed in a selection of sizes using Z-Corporation 3DP technology. Using a simple web enabled interface (www.landprints.com), US based customers can order 5", 6" and 8" models for $37.95, $49.95 and $69.95 respectively. There are also plans to allow users to upload their own topological data or imagery. At present LandPrints accesses its digital terrain data from both NASA and the US Geological Survey, albeit it should be noted that the terms of conditions of use for landprints.com state that the user must own the intellectual property of the image they are printing.

Another 'web tools' based RM fulfilment business has also been launched in Singapore by Genometri PTE Ltd, which is a spin-off company from the national university of Singapore. www.jujups.com is a 3-D design creation portal that allows web users to design a range of 'giftware' products such as photo frames, key fobs, tokens and gifts, which are then 3D Printed to order using Z-Corporation 3D Printing. Using a series of simple web based design tools; users have the ability to select from a pallet of 3D objects, such as picture frames, which can then be personalised with text, relief objects such as flowers or with photo images uploaded by the user. On completion the 'virtual designer' can either save the design or commit to print, at which point payment is made by credit card. As a closed loop system, all resulting 3D data remains within the Genometri Ltd fulfilment model, and as such cannot be printed by an external third party.

4. The Rapid Manufacturing of User-defined content

With the exception of Fabjectory and Second Life avatar printing, where content is truly defined by the user, all the other business models discussed in this paper are based on the realisation of 3D data that is either defined from a 'selection pallet' (JuJups, LandPrints) or from a 'parts library' (Figureprints). In these cases a number of rules have been / can be defined to minimise the need for secondary file manipulation post user definition, such as minimum feature size, maximum part size, colour distribution and pallet choice. There is no doubt that many other business models will be developed based on the 3D Printing of user selected content, be this for toys, gifts, games, avatar characters, home ware, apparel or even foot ware.

However, a number of software tools and computer games programs are also emerging that will enable the generation of truly user defined or generated content that is suited to 3D Printing.

One such package is Cosmic Blobs, which is a 3D Solid Modelling package aimed at the 7 to 14 year old market place, and has until recently been available to purchase for £24.95 from a number of online retails outlets such as Amazon.com. Cosmic Blobs is a product of Dassault Systems and Solid Works and has been used as an initiative to democratize the use of 3D CAD within schools and the home. The program uses simple graphical user interface tools to allow users to model in full 3D using a range of free-form modelling tools. Objects such as characters, animals, toys and vehicles can be sculptured as 3D solid models from primitive shapes, with

surface patterns, colours and images also being added. On completion of modelling Cosmic Blogs allows models to be saved and exported in VRML-2 format, which can be input directly into Z-Print software and used to enable full colour 3D-Printing. Unfortunately, Cosmic Blobs has recently been suspended as a Dassault / Solid Works product. However, a beta test version of Cosmic Blobs Model Pro has recently been released free of charge by Dassault (www.cbmodelpro.com). Cosmic Blobs Pro also allows the export of STL, VML, 3DXML and OBJ files.

A much more powerful modelling tool aimed solely at the creation of user defined computer games characters was recently developed by Maxis and released in June 2008 by EA games, one of the world's largest entertainment software developers. Spore Creature Creator (www.spore.com) can be purchased online for £4.99 and allows users to create an infinite range of online characters using a highly complex yet intuitive modelling tool. Within the first month of release, over 1,882,000 characters have been created using the software.

At present there is no export tool within Spore to extract character data. However, the function has clearly been embedded into the software, as the Rapid Manufacturing of Spoor characters using colour 3DP was demonstrated as early as July 2006 using beta test versions of the software[14]. It is widely anticipated that a similar closed-loop licensing and fulfilment model will be developed for Spore as used with WoW. However, it should be noted that the complexity and details of some character features goes beyond the capabilities of current 3DP technology. To this end, technology developers such as Z-Corporation are embedding logic into their software to compensate for excessive feature details, such as ZEdit Pro which can now automatically detect features that are too small to print and will automatically remove the feature as part of the geometry and replace the feature with a printed surface definition[15]

As we have demonstrated in this paper, there are already a number of both user selected and user defined methodologies for the generation of the geometric data needed to enable RM, some of which have enabled new and operational business models. The data sources and business models discussed have been summarised in Table 1, where the author has identified the data source, IP ownership model, model fulfilment methodology and the need for post design data manipulation prior to printing.

Example	User defined content	User selected content	User IP ownership	User Fulfilment choice	Manual data manipulation prior to print
Fabjectory	YES	NO	YES	YES	NO
FigurePrints	NO	YES	NO	NO	YES
LandPrints	NO	YES	NO	NO	NO
JuJups	NO	YES	NO	NO	NO
Cosmic Blobs	YES	NO	YES	YES	NO
Spore	YES	NO	NO	NO	YES

Table 1. Analysis of existing Rapid Manufacturing 3DP business models

5. Limitations to existing RM business models for user generated content

On evaluation, there appear to be a number of limitations at present to the wide spread adoption of RM within both the user-defined and user-selected content fulfilment markets. These include the need to maintain brand identity whilst exploiting intellectual property control for commercial gain and the need to have sufficient capacity to fulfil demand whilst maintaining a competitive pricing policy based on long term machine depreciation.

Brand identity is key to any company engaged in either virtual or tangible product design and realisation. However, where that design can be manipulated by the end user, brand control becomes paramount, as without sufficient safety measures the end user could in effect destroy the brand through the creation of poor quality content. Within RM, this could be manifested in the user designing a product, such as a computer games character or avatar that is too detailed for the RM process, resulting in a part with missing features and a poor perceived quality, hence impinging the quality of the brand. One solution would be the 'free issue' of data to users with the caveat 'print at your own risk'. However, this would require the release of core intellectual property data including both the geometric and colour information relating to the design. Even based on a 'pay-to-download' business model, this would in effect allow the user access to make multiple copies of their design with no ongoing revenue to the software provider. This will be further exacerbated in the future with the advent of home based RM systems such as the proposed polymeric layer manufacturing machine due for launch in Q1 2009 from Desktop Factory, Pasadena[16].

The most simplistic model to manage revenue generation, as demonstrated by FigurePrints and JuJups, is where the fulfilment model is an integral part of the design software and where third party exploitation of 3D data, if possible, is expressly prohibited in the user licence, as with Spore. However, this model does require a closely coupled manufacturing and distribution chain, where access to RM and 3DP technology is either in-house or within a trusted third party. The main limitation of this approach is balancing supply with demand, as insufficient supply will disrupt the sales process (as with FigurePrints), whilst excessive supply or insufficient demand will drive up costs (as with Fabjectory), based on the depreciation of unused machine capacity.

6. Discussion

The author, as part of a large scale £2.9-million UK Government funded research project (www.atkins-project.com) has recently engaged in the development of a new RM fulfilment model based on the development of both a licensing portal and GRID-RM fulfilment network. The objective of the licensing portal is to provide a 'wrapper' that can integrated with existing content creation programs and where the content owner receives a licensing fee for all content that is realised from the virtual into real world. The model is then supported by a grid based network of RM fulfilment companies working to an agreed Quality, Cost and Delivery (QCD) model. The objective of the business model is to grow both content demand and fulfilment supply in parallel, by initially focusing on a small selection of high content creation MMORPG developers, design toy companies and graphic artists. In parallel, an initial beta-test group with

access to over 20 colour 3DP machines and post process infiltration systems have been established. The objective is then to migrate the 3DP offer across to other RM technology platforms including polymeric laser sintering and low cost metals processes such as the F-Cubic Process. The core element of the model is to maintain IP control, whilst enabling maximum user choice, in terms of product size, material, delivery timescales and surface finish.

7. Conclusion

In conclusion this paper has demonstrated that 3D Printing has become a viable technology for the Rapid Manufacturing of user selected and user defined content, and that a number of successful business models have been established to exploit the technology for the realisation of entertainment and recreational products. However, this paper has also shown that there are a number of both technological and business limitations, including brand and quality control, intellectual property control and licensing, supply and demand management and product cost modelling. This paper has then provided some insight into the current business activities of the authors company and the concept of GRID-RM as an alternative fulfilment model which when coupled with a product licensing portal could enable many hundreds if not thousands of companies and individuals to realise computer generated content into RM products.

8. References

[1] Hopkinson N., Hague R.J.M., Dickens. P.M. 2006. Rapid Manufacturing –An industrial revolution for the digital age. ISBN-13 978-0-470-01613-8, Publisher – John Wiley & Sons Ltd UK

[2] Martin R. Applications of Rapid Manufacturing for the production of individualised hearing instruments, 1st International Rapid Manufacturing Conference Proceedings, July 5-6 2006, Loughborough University UK.

[3] Schmidt C. Rapid Manufacturing of dental restorations, TCT 2006 Conference Proceedings, 19-20 September 2006, Heritage Motor Centre, Gaydon, UK

[4] Poukens J. Rapid Manufacturing of Cranio-Maxillofacial implants, 2nd International Rapid Manufacturing Conference Proceedings, July 11-12 2007, Loughborough University UK.

[5] Slemker T.C., Schall S.R. Modular distal plate for rapid manufacturing of a prosthetic limb socket, US Patent 6358453

[6] See www.materialise.be

[7] See www.play.girlz.com/fabjectory

[8] Au W.J., The making of Second Life : Notes from the new World, 2008, Harper Collins, ISBN 978-0-06-135320-8

[9] See http://www.rapidtoday.com/printingavatars.html

[10] The Wall Street Journal online, December 12th 2007

[11] See http://www.deskeng.com/articles/aaahgm.htm

[12] See www.commodoregaming.com

[13] See http://ogle.eyebeamresearch.org

[14] See http://www.joystiq.com/2006/07/26/our-one-of-a-kind-spore-figurine/

[15] See http://www.zcorp.com/Press-Room/ZEdit-Pro-Software-Makes-Files-3D-Printing-ready/news.aspx

[16] Lewis C., An Introduction to Desktop Factory, 3rd International Rapid Manufacturing Conference Proceedings, July 9-10 2008, Loughborough University UK.