Institution: Heriot-Watt University

Unit of Assessment: B11 Computer Science and Informatics

Title of case study: Heriot-Watt 3D texture capture system enable 'virtual' production of 210 million IKEA catalogues annually

1. Summary of the impact (indicative maximum 100 words)

HWUCS Texture Laboratory research since 1995 has developed techniques to capture 3D surfaces via stereo scanning, resulting in capability for fast, accurate capture in a way that supports realistic rendering. In 2007 the Texture Lab installed its texture capture system at IKEA, Sweden. Since then it has been used continually to amass a digital library of over 5,000 materials for generating sales imagery, and is behind 30% of room-set and 75-80% of single product shots in ~1.5Bn IKEA catalogues printed 2008--2013, in addition to online content. Meanwhile IKEA's r 3D graphics team has grown from 3 to 50.

2. Underpinning research (indicative maximum 500 words)

The Texture Laboratory in HWUCS has been researching the capture, analysis and perception of 3D texture since 1995. Chantler pioneered the use of 3D surface textures (normal and displacement maps) in texture classification [1--4] at a time when the de facto research benchmark was Brodatz's 2D photographic album. He raised the profile of these issues by organising and chairing a series of international workshops on Texture Analysis and Synthesis in Copenhagen, 2002; Nice, 2003; and Beijing, 2005 and published seminal theory in this area jointly with Petrou (Surrey) who he held a joint EPSRC grant (GR/M73422/01). Subsequent grants: VirTex: Virtual Catalogues using 3D Surface Textures (GR/R35360/01), Perceptual Measurement of Surface Texture (EP/D059364/1) and a number of IMRC grants (GR/S12395/01) continued this work.

During this time, Chantler's lab continually refined the photometric stereo-based, frequency domain methods for estimating displacement and colour maps of surface texture. In [1--4], the group broadly investigated and determined appropriate representations for captured surface maps, while exploring alternative ideas for the setup of 3D texture capture systems and associated algorithms. Building on this, the team then rigorously investigated the optimal lighting conditions for such systems in [5, 6], specifically exploring how lighting should be configured to allow capture of maximally accurate 3D texture maps from a photometric stereo system in the presence of various sources of noise, given 3 or more light sources.

In [5], which theory was developed to characterize the various sources of noise, and ideal lighting configurations were determined by theory-guided empirical studies. Findings were strengthened further in [6], which contained mathematical analyses identifying the lighting configurations that, under reasonable assumptions, guarantee minimal uncertainty in the captured texture maps. [6] was published at one of the top Computer Vision Conferences (ICCV 2005, Beijing), At the time, Chantler's co-author, Drbohlav was sponsored by a prestigious two year Marie-Curie fellowship.

The research described was fundamental to the combination of texture capture algorithms and light source illumination settings and configurations that were installed by the Texture Lab at IKEA Systems, Älmhult, Sweden in 2007.

3. References to the research (indicative maximum of six references)

[1] J. Dong, M. J. Chantler, "Capture and Synthesis of 3D Surface Texture", International Journal of Computer Vision (VISI) 62(1-2)2005pp177-194. http://dx.doi.org/10.1007/s11263-005-4641-6

[2] M. Robb, A.D. Spence, M.J. Chantler, M. Timmins, "Real-Time Per-Pixel Rendering of Bump-mapped Textures Captured using Photometric Stereo", Vision, Video and Graphics, 2003, Bath UK. 10-11 July 2003 http://dx.doi.org/10.1108/09556220410520351

[3] G. McGunnigle, M.J. Chantler, "Rough surface classification using first order statistics from photometric stereo", Pattern Recognition Letters 212000 pp593-604.

[4] M.J. Chantler, G. McGunnigle, J. Wu, "Surface rotation invariant texture classification using photometric stereo and surface magnitude spectra", BMVC2000 British Machine Vision Conference, 11-14 September 2000, Bristol, Vol. 2, pp486-487.

[5] D. Spence, M. J. Chantler, "Optimal illumination for three-image photometric stereo acquisition of surface texture" , Texture 2003, The 3rd International Workshop on Texture Analysis and Synthesis, Nice17 Oct. 2003 http://dx.doi.org/10.1049/ip-vis:20050229

[6] O. Drbohlav, M. J. Chantler, "On optimal light configurations in photometric stereo" Proc. IEEE International Conference on Computer Vision, Beijing October 2005pp. 1707-1712. http://dx.doi.org/10.1109/ICCV.2005.177

Grants

ESPRC GR/M73422/01 Texture Analysis Of 3d Surfaces 1 Oct 2009 – 30 Sep 2002 £152k

ESPRC GR/R35360/01 VirTex Virtual Catalogues using 3D Surface Textures 1 Aug 2001 – 31 March 2003 £207k
ESPRC EP/D059364/1 Perceptual Measurement of Surface Texture 1 May 2006 – 31 October 2009 £262k
ESPRC GR/S12395/01 Proposal for the Establishment of an EPSRC Innovative Manufacturing Research Centre 1 April 2003 – 31 Mar 2008 £4,221,984

4. Details of the impact (indicative maximum 750 words)

How the system is deployed by IKEA Communications AB

IKEA Communications AB is responsible for providing the image content for the product catalogue and the corresponding webpages of the global retailer.

Much of the imagery in the IKEA catalogue actually features rendered 3D models of the products since this allows the literature to be prepared well in advance i.e. before the season's new designs go into full production. A typical IKEA catalogue image of a kitchen, for example, is not a photograph - it is a computer-generated image, generated via access to a library of captured 3D textures. Similar is true of much of the online as well as catalogue content generated by IKEA communications AB. Producing a photorealistic version of each item of merchandise in this way can be a time-consuming process and requires precise attention to detail. Not only must the designers and artists generate an accurate 3D scale model but they also have to achieve a convincing surface finish in a wide variety of materials.

Capturing 3D textures in a way that that is fast and accurate is therefore essential. Throughout the entire assessment period (01/2008 to 07/2013), IKEA communications AB's 3D texture capture operations have relied solely on the system provided and installed by Chantler's Texture Lab at HWUCS.

The software and apparatus configuration provided by Chantler's lab enables the capture of extremely large and accurate 50M sample 3D surface normal maps within seconds that allow practical panoramic stitching to produce 16x 25k material maps. This is vital to the digital production of IKEA's catalogues and web content. It has enabled the development of a materials library of 5,000 to 6,000 samples. For production these material maps are combined with over

22,000 3D models covering the entire product range. It is simply not practical using conventional means to produce imagery of every product in every finish that a customer could buy it in.

Impact generated 2008—2013

Ikea Communications produces approximately 240 million catalogues across 43 countries annually, and currently 30% of room-set content is generated is digital. When considering the use in single product images, that percentage rises to 75 -80%. In 2013 alone, IKEA Communications AB generated over 18,000 images using this technology. In the current assessment period, approx 1.5 billion printed IKEA catalogues delivered globally have the great majority of their imagery generated using texture maps delivered via the system installed by the Texture Lab. This is exclusively sales imagery, relied upon by IKEA to support an annual turnover well in excess of €20 billion. Figures available for the period (from IKEA press releases) indicate both turnover and profits rising in 08/09 and 09/10.

In addition, the graphics team at IKEA Communications AB has grown from 3 to 50 staff over the assessment period, primarily to support the imagery generation pipeline enabled by the system we installed.

Additional notes concerning the importance of the system to IKEA

IKEA Communications AB investigated commercially available ways of facilitating this work such as utilising 3D laser scanners but they were unable to find a satisfactory solution. They subsequently approached Heriot-Watt University's Prof. Mike Chantler of the School of Mathematics and Computer Science, a specialist in the digitisation & presentation of three dimensional surface textures.

As Anton Berg, 3D specialist for Ikea Communications AB stated "In summary, this is very important software for Ikea Communications – it just works for us in the way we need it to. The creation of large library viable 3D textures through using the software enabled the ramping up of virtual content and it has completely transformed the way in which we produce both traditional and digital content."

5. Sources to corroborate the impact (indicative maximum of 10 references)

3D Specialist, IKEA Communications AB.