Institution:
University of Cambridge

Unit of Assessment:
UoA9

Title of case study: Geomerics: graphics Software

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

A new company, Geomerics, was created as a spin-out from the Cavendish Laboratory. Geomerics now employs 22 full time staff, with offices in Cambridge, UK and Vancouver, Canada. Geomerics has pioneered a new business sector in selling lighting middleware technology, based on Cambridge research, to games developers. Customers include Electronic Arts, Square Enix and Take 2 (three of the five largest publishers) and licenses have been sold in Europe, North America, Japan and Korea. In 2011 the first game released using Geomerics software, Battlefield 3, became the fastest selling game in Electronic Arts' history, having sold nearly 20M copies.

2. Underpinning research (indicative maximum 500 words)

Research on 'Geometric Algebra' (GA) carried out at the University of Cambridge in the Astrophysics Group in the Department of Physics and in the Signal Processing Group at the Department of Engineering between 1993 and 2005 led to the formation of Geomerics. The main focus of this research in Physics was towards theoretical physics, cosmology and astrophysics, but the new geometrical methods involved were of wider applicability. The groundwork for this broadening of application was laid in a 5 year EPSRC Advanced Fellowship awarded to Dr Chris Doran in 1999, held in the Astrophysics Group. The Fellowship was awarded to investigate ways that GA could be exploited in the fields of computer graphics and computer vision. This research was conducted in collaboration with Anthony Lasenby (Assistant Director of Research from 1987, Reader from 1996, Professor from 2000 to present, Department of Physics) and Joan Lasenby (Royal Society Research Fellow from 1994, Lecturer from 2003, Senior Lecturer from 2010, Department of Engineering). The outcomes of this research were a series of results demonstrating how algorithms based on GA could solve problems in graphics and vision faster and more robustly than traditional techniques. During this period the research was broadened to include applications to rigid body dynamics.

The initial IP that went into Geomerics formation was generated primarily at Cambridge University, with a secondary contribution from a researcher based in Arizona State. The contributors at Arizona State University were Prof David Hestenes and Prof Alyn Rockwood, who granted Geomerics a non-exclusive license to exploit a patent around the use of conformal geometric algebra in robotics. This patented technology did not form part of the final Enlighten product from Geomerics.

The research that led to the breakthrough product, 'Enlighten', in 2007 was carried out jointly by Geomerics internal team and staff at Cambridge University, in particular Mike Hobson (Reader at that time, promoted to a Professorship in 2011) and Anthony Lasenby from the Department of Physics. Enlighten computes the bounced light in a world in real time, which has always been viewed as an extremely hard problem. Enlighten is not the result of a single clever algorithm; it has required years of research and engineering across disciplines in signal processing, compression, de-noising, surface mapping, spherical harmonic lighting, etc. to produce a polished product. At various points Cavendish staff have contributed to this effort. Mike Hobson led the effort in de-noising research, applying ideas developed in his own research to the problem faced in Enlighten. He worked on the use of wavelets to compress images and speed up calculations. Anthony Lasenby contributed to the problem of surface mapping (unwrapping a curved surface to a 2D planar map.) He used ideas from his research on conformal geometric algebra to help develop new algorithms for unwrapping geometry that minimised distortion.

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

1. *Geometric Algebra for Physicists, CUP (2003, Paperback Edition 2007) (C. Doran and A.N. Lasenby), ISBN-13: 978-0521715959
2. *New geometric methods for computer vision: An application to structure and motion estimation, Int. J. Computer Vision, 26, 191 (1998) (J. Lasenby, W.J. Fitzgerald, A.N.

Lasenby and C.J.L. Doran), DOI: 10.1.1.41.7256
3. *Estimating tensors for matching over multiple views, Phil. Trans. R. Soc. Lond. A, 356, 1267 (1998) (J. Lasenby and A.N. Lasenby), DOI: 10.1.1.40.7761
4. A new methodology for computing invariants in computer vision, Proceedings of the International Conference on Pattern Recognition (ICPR'96), Vienna, Vol. I, p334 (1996) (J. Lasenby, E. Bayro-Corrochano, A.N. Lasenby, and G. Sommer), ISBN:0-8186-7282-X
5. Surface evolution and representation using geometric algebra, The Mathematics of Surfaces IX, Proceedings of The Ninth IMA Conference on the Mathematics of Surfaces, Cambridge, U.K., p144, (2000) (A.N. Lasenby and J. Lasenby), DOI: 10.1007/978-1-4471-0495-7_10
6. Recent applications of conformal geometric algebra, in Computer Algebra and Geometric Algebra with Applications, 3519: pp.298-328 (2005) (A.N. Lasenby), ISBN: 0302-9743

* References which best represent the quality of the underpinning research.

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

Upon the successful completion of his five year EPSRC Advanced Fellowship Doran was awarded a one year PPARC/RSE fellowship in New Venture Creation in 2004. These awards were designed to train research-council funded fellows in how to start a business. Significant commercial interest then led to the creation of spin-out Geomerics in 2005. The four founders of Geomerics were Chris Doran (who left the Cavendish to become CEO), Anthony Lasenby, Mike Hobson and Joan Lasenby. The background IP in geometric algebra was used to create a series of demonstrations and proofs of concept that were taken to potential customers. These demonstrations included applications in animation, physics and electromagnetic modelling (which was under consideration as a secondary market). Based on customer feedback Geomerics decided to focus attention primarily on lighting for computer games, tackling the problem of real-time calculation of global illumination in a virtual world.

Geomerics is now a well-established company employing 22 people in its UK and Canadian offices, up from 15 in 2008. Its technology runs across a wide range of platforms, from console to PC to mobile, and in 2013 Geomerics was one of the first groups of companies announced to be working on the PlayStation 4 with Sony. To date Geomerics' Enlighten software has been licensed by over 30 titles, with customers in the USA, Canada, Iceland, Germany, Sweden, Norway, Russia, Ukraine, Japan and Korea. These customers include three of the largest publishers on the planet: Electronic Arts, Square Enix and Take 2 Interactive. All of these titles have been developed since 2008.

Geomerics biggest customer is EA, and Geomerics' Enlighten product is now fully integrated with EA's Frostbite game engine, as described in a joint Geomerics / EA presentation [8].

The single biggest title Geomerics has been involved with is Battlefield 3, released by the EA DICE studio in 2011. EA DICE were the first customers of Geomerics, and Battlefield 3 has become viewed as the title that re-set the bar in graphics quality for games. The game has sold nearly 20 million copies, and brought around $1bn of revenue into Electronic Arts [7]. It has won over 60 game industry awards, including the 2012 BAFTA for best game. Many of the awards are for the quality of its graphics [6].

As well as Battlefield, Enlighten is now employed in some of the major franchises in the industry: Need for Speed (the leading racing franchise); Eve Online; Command & Conquer; XCOM; and even Plants versus Zombies (the top-grossing launch title on iOS).

In 2012 Geomerics was awarded a Develop Industry Excellence Award for Technical Innovation. These awards are the only ones voted for by developers, and represent a significant endorsement of the technology and team at Geomerics.

Since 2008 Geomerics' revenue due to sales of Enlighten have been in excess of £1.7M.[9]

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

1. COO, Geomerics
2. Advancing Dynamic Lighting on Mobile, SIGGRAPH 2012 (S. Martin and M. Wash) (held on file)
3. Lighting you up in Battlefield 3, GDC 2011 (K. Magnusson) (held on file)
4. A real-time radiosity architecture for video games, SIGGRAPH 2010 (S. Martin and P. Einarsson): http://dice.se/publications/a-real-time-radiosity-architecture/
5. Geomerics Middleware Bestows Gamers With Real-Time Global Illumination, 2012, Intel Software Adrenaline article (http://software.intel.com/sites/billboard/article/intel-gpa-lighting-way-better-performance).
6. Battlefield 3 awards: http://www.battlefield.com/uk/battlefield3/1/awards
7. EA's 2012 earnings report: http://bf3blog.com/2012/05/battlefield-3-ships-15-million-copies/
8. http://advances.realtimerendering.com/s2010/Martin-Einarsson-RadiosityArchitecture(SIGGRAPH%202010%20Advanced%20RealTime%20Rendering%20Course).pdf
9. COO, Geomerics (follow-up email)