

Institution: The University of Salford
Unit of Assessment: B11 Computer Science and Informatics
Title of case study: Collaborative Visualisation
<p>1. Summary of the impact</p> <p><i>Collaborative visualisation</i> at the University of Salford focuses on how people communicate through and around shared simulation, whether co-located or telepresent in remote collaboration, demonstrating the following impact:</p> <ul style="list-style-type: none"> • Developing information rich spaces and making the teamwork within them intelligible, flexible, productive and environmentally and economically advantageous for a range of organisational settings with a broad focus on; <ul style="list-style-type: none"> ○ Developing enhancements in distributed visualisation telepresent technology with the aim of offering environmental, economic and social benefit in reducing the need for travel, by supporting holistic non-verbal communication. • And significant impact through; <ul style="list-style-type: none"> ○ Establishing the implementation of exponentially enhanced co-located visualisation in the automobile industry by fitting visualisation to the diverse needs of design teams and bringing step changes in vehicle design processes, leading to significant economic growth in the industry, internationally.
<p>2. Underpinning research</p> <p>The key researchers and positions they held at the institution at the time of the research are as follows: David Roberts, Professor of Telepresence, School of Computing, Science and Engineering (from 2004). Research in Virtual Environments at Salford is a leading contributor to the development and application of Virtual Reality (VR). Roberts' research focuses on building and studying the use of systems that support an ever-growing range of non-verbal communication, remote collaboration and shared simulation. In particular he has focused on understanding the balance between the visual and spatial qualities of shared simulations and the teamwork around them. His approach has been to iteratively increase the quality of each through technology intervention. The impact of this case study is underpinned by the following research and research infrastructure:</p> <ul style="list-style-type: none"> • 2003-2008: <u>Virtual Reality Telepresence:</u> In the late 90's the principle of using 3D tele-immersion to overcome the 2D limitations of video conferencing was demonstrated in the States in projects like the tele-immersive initiative and office of the future. While these demonstrated the principle of communicating both visual and spatial aspects of non-verbal communication, the quality of either was insufficient for general use or meaningful study. In 2003 Roberts was the first to allow motion-tracked avatars to share the manipulation of virtual objects. [1] • 2005: Roberts showed that the efficiency of teamwork and conversation was related to the spatial match of the task and the display [2]. He led the <u>EPSRC eye-catching</u> project, partnering Salford with UCL, and Universities of Reading and Roehampton [8]. This project produced the first communication system capable of communicating eye gaze between moving people [4]. The international importance of Eyecatching was marked by a keynote by Roberts at ACM MultiMedia. In 2007 he also linked the fit of task to both shape and resolution of the display, not only to efficiency of collaboration but also to creativity [3]. • 2007-2013 <u>Virtuality telepresence:</u> While Eye-catching had managed to do what any other technology had not; faithful communication of attention between moving people, it could not faithfully communicate what they looked like. Thus Roberts changed the emphasis of his technical approach to develop 3D video based telepresence. Prototypes were available which did not sufficient visual and spatial quality to support meaningful behavioural experiments. Roberts led research that brought this technology to a point where natural non-verbal communication and thus meaningful user studies could be supported [5]. This work began with a 'seedcorn' project with the BBC, which led to three EPSRC studentships. Roberts was the first to provide empirical evidence that eye gaze can be robustly supported in a medium that also attempts to faithfully reproduce appearance [9].

- Although beginning beyond the impact assessment period for this exercise, the expertise and leadership demonstrated by Roberts in the field is demonstrated in the University of Salford's success in winning funding for the collaborative CROSS-DRIVE project which starts in Jan 2014, which will link European space scientists across Europe by giving them the impression of being teleported to Mars to stand side by side while surrounded by their simulations. [12]
- Roberts' current standing in the field is also demonstrated by being asked to lead a telepresence demo session that will link major VR conferences in Europe and Japan in Dec 2013. Much of this research has been underpinned by the HEFCE SRIF III, IV AND V funded OCTAVE display and capture space, designed by Roberts. This is the only large immersive display to incorporate 3D video capture. It is also the world's most reconfigurable large immersive display allowing the fit of display shape to application to be undertaken. [11]

3. References to the research

Key outputs

1. Roberts, D J, Wolff, R, Otto O, and Steed A, *Constructing a Gazebo: Supporting Teamwork in a Tightly Coupled, Distributed Task in Virtual Reality*, Presence: Teleoperators and Virtual Environments, December 2003, Vol. 12, No. 6 , Pages 644- [DOI](#)
- Roberts, D, J, Al-Liabi, M, Wolff, R, Otto, O & Al-Khalifah, A, 2005, *Reducing Fragmentation in Telecollaboration by Using IPT Interfaces*, In proceeding of: *Proceedings of the 9th Int. Workshop on Immersive Projection Technology*, 11th Eurographics Workshop on Virtual Environments, IPT/EGVE 2005, Aalborg, Denmark, 2005. pp 211-216, [DOI](#)
2. Roberts, D J & I, H & Otto, O & Wolff, R 2007, *Factors influencing flow of object focussed collaboration in collaborative virtual environments*, *Virtual Reality*, Springer, 10(2), pp.119-133 [DOI](#)
3. Roberts, DJ, Wolff, R, Rea, J, Steed, A, Aspin, R, McIntyre, M, Pena, A, Oyekoya, O and Steptoe, W 2009, *Communicating eye-gaze across a distance: Comparing an eye-gaze enabled immersive collaborative virtual environment, aligned video conferencing, and being together*, in: *IEEE Virtual Reality*, 14-15 March 2009, Lafayette, Louisiana USA. [DOI](#) (REF 2)
4. Duckworth, T & Roberts, D J, 2012, *Parallel Processing for Real-Time 3D Reconstruction from Video Streams*, *Springer Journal of Real Time Image Processing*. [DOI](#) (REF 2)
5. Roberts, D J & Rae, J & Duckworth, T & Moore, C & Aspin, R 2013, *Estimating the Gaze of a Virtuality Human*, *IEEE Transactions on Visualization and Computer Graphics*, 19(4), pp.681-690. [DOI](#) (REF 2)

Key grants

6. **2005:** Advanced Virtual Agents - AVATARS EC (Framework), £27,772.00. Investigator: D Roberts (100%).
7. **2006:** EYE-CATCHING, EPSRC, £232,507.00 Salford, of total £1.4M, Investigators: D Roberts (75%), N Murray (25%).(Grant EP/E007406/1) INTUITION
8. **2007:** Development of a 3D prototype system providing immersive collaborative techniques, BBC, £15,000.00. Investigator: D Roberts (100%).
9. **2007-2010:** Industrial CASE Studentship (Real-time distributed processing for motion capture from video). Financed by EPSRC and OMG Vicon, EPSRC CTA, £83,064.00. Investigator: D Roberts (100%).
10. **2011:** OCTAVE, HEFCE SRIF III, IV AND V. C. £2M
11. **2013:** CROSS DRIVE-Collaborative Rover Operations and Planetary Science Analysis System based on Distributed Remote and Interactive Virtual Environments, £497K Salford investigators T. Fernando (UoA 16) and D. Roberts, total £312,103

4. Details of the impact

- **Context:** The shared simulation industry is estimated by Cisco to be worth around \$5B per annum and an attractive option for businesses: *“The major issue has been that of combining distant spaces, of immersing multiple users in a shared virtual space where the technology will effectively cease to be a barrier to communication. The challenge for telepresence is to allow people to move around each other while seeing who and what they are looking at.”* ([Digital Studio, January 2011](#))
 - *Eye Catching and Eye Gaze and 3D video based reconstruction for Telepresence*
Salford’s research into virtuality telepresence produced the first empirical evidence that eye gaze could be reliably supported to a degree useful in social interaction, in a medium that could also faithfully reproduce appearance, taking communication technology from supporting particular small ranges of non-verbal communication sufficient for specific forms of interaction, to supporting the range of non-verbal communication used in most everyday encounters and teamwork. The research has informed BBC in its aim to retain team cohesion and creative critical mass between its sites in London and Manchester and resulted in a patent of a telepresent chair.
- **Automobile design:** Impact from a balanced emphasis on integrating teaching, research and enterprise extending significantly beyond the submitting HEI is demonstrated in a collaboration with Jaguar Land Rover (JLR) with Brian Waterfield, Jaguar Land Rover’s Virtual Reality Manager, undertaking an MSc dissertation project under Roberts, leading to the implementation of an exponentially enhanced co-located visualisation facility in the automobile industry;
 - Research that linked immersion to task performance and creativity fed into the design of JLR’s visualisation facility, leading to a roadmap for VR visualisation at JLR, and car designs that would not otherwise have been envisaged. Jaguar Land Rover asserts that investment in virtual tools and technologies has transformed its engineering and design capabilities, enabling quicker and more efficient processes to be introduced for advanced vehicle development, using Virtual Reality techniques to work faster and smarter, achieving higher levels of quality, durability and reliability in its vehicles with less reliance on expensive and time consuming prototypes.
 - JLR has invested in a new Virtual Innovation Centre (VIC) that provides a wider, more flexible and sophisticated range of functions that are being used by more departments across the business.
 - The opening of the VIC in July 2013 reinforced Jaguar Land Rover’s position as an auto industry leader in harnessing the benefits of VR and high-end visualisation. Already it has played a crucial role in the delivery of the Range Rover Evoque; internationally acclaimed as one of the most exciting design concepts of its age, the new Range Rover and Range Rover Sport, and the Jaguar F-Type sports car.
 - Its design and functionality were influenced by research undertaken at Salford University by Waterfield, who used his master’s course in virtual reality visualisation and game technology to help explore virtual processes and understand how best they might be adapted for use in the auto industry.
 - He explained: *“The work I did on that course helped me define the right responses in terms of what we wanted to achieve at Jaguar Land Rover, tailoring some of the activities so that we could help shape and progress our virtual solutions.”*
 - This included a focus on the resolution of the projector technology used to present the 2D and 3D VR images [3]. Rather than the low resolution typically favoured in the virtual imaging world, the research at Salford showed the importance of achieving fine detail. *“My studies proved that in our industry, or any in which products are manufactured, resolution is important. Gaining as much detail as possible is a prerequisite for our directors.”* Jaguar Land Rover’s virtual reality ‘cave’ comprises three screens covering three walls and the ceiling for 3D image projection. Two projectors are used for each screen at a resolution four times that of HD television pictures, controlled by 16 high performance PCs. The use of the ceiling rather than

floor for image projection (relating to importance of matching spatiality of display to task [2]) was also confirmed by Waterfield's Salford research, where tests with students revealed this was the best solution for creating an authentic environment in which to assess the quality of the driving position, be it the "command" style featured in Land Rover models, or the sports design associated with Jaguar.

- The VR cave has quickly established its value in allowing designers and engineers to undertake a wide range of tasks in vehicle development, exploring and interacting with the images using 3D glasses and hand-held controllers. In particular this has supported vehicle development areas such as interior packaging, the lay-out of controls, aerodynamics, crash performance and the routing of vehicle wiring and systems, without recourse to building prototypes.
- The Evoque has won over 100 design awards and the introduction of this and the other models coincided with substantial growth in sales. *"Range Rover Evoque tops 100,000 sales of 355,000 in 2012. The brand's top five markets were China, the UK, United States, Russia and Italy which accounted for 65% of sales alone. Notable product performances were delivered by the Range Rover Evoque with 108,598 vehicles sold in its first full year of sales - more than any other previous Land Rover model."* ([JLR News room](#))
- **2014-onwards:** Roberts (and Fernando, submitting to UoA C16) demonstrate further impact as partners in the FP7-SPACE-2013-1 collaborative project: CROSS DRIVE which aims to provide Europe's critical mass of space data, a diversity of Mars data experts to analyse these data, and tools for them to use, by linking all parties together in distributed virtual workspaces for collaborative scientific discovery, mission planning and operations.
 - CROSS DRIVE will lay the foundations for collaborative European workspaces for space science. Roberts et al are developing the software infrastructure to synchronise remote simulations such as interfaces for VR environment and equipments, and web portal.

5. Sources to corroborate the impact

- 1) Corroboration of the implementation of an exponentially enhanced co-located visualisation facility in the automobile industry from JLR.
- 2) Corroboration of the success of the Evoque [JLR Newsroom story](#)