ARTICLE:

The use of computer generated imagery in legal proceedings

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Court environments, which have been one of the last bastions of the oral tradition, are slowly transforming into cinematic display environments.[1] The persuasive oral rhetoric of lawyers is increasingly being replaced by compelling visual media displays presenting a range of digital evidence in a convincing and credible manner.[2] Advances in media formats and devices have made available new mechanisms for presenting evidence in court. Digital visual evidence presentation systems (including digital displays, computer-generated graphical presentations, animated graphics and immersive virtual environment technology) have already been used in many jurisdictions.[3]

There are a number of fundamental implications inherent in the shift from oral to visual mediation, and a number of facets of this modern evidence presentation technology need to be investigated and analysed. At first glance, these computer-generated graphical reconstructions may be seen as potentially useful in any court, and they are often treated like any other form of digital evidence regarding their admissibility.[4] However, perhaps this specific form of digital media warrants special care and attention due to its inherently persuasive nature, and the undue reliance that the viewer may place on evidence presented through a (potentially photorealistic) visualisation medium.[5]

As courts begin to increasingly use multimedia and cinematic displays, this has profound implications for the legal processes taking place that are intrinsically tied to the application of such technology. It must be questioned whether the decisions made in courts when using such technology are affected by the manner in which the evidence is presented.[6]

This paper describes research undertaken to assess the effect of the technology on jurors, and describes some of the issues raised by the results. The paper concludes with a discussion of the potential benefits and problems of implementing this technology in court settings.

Introduction

In a modern court, the presentation of forensic evidence by an expert witness can bring about the need for arduous descriptions by lawyers and experts to get across the specific details of complicated scientific, spatial and temporal data. Technological advances have also meant that experts have had to develop new ways to present such increasingly complex evidence in court. Digital visual evidence presentation systems (including digital displays, computer-generated graphical presentations and three-dimension virtual simulations) can be used to present evidence and illustrate hypotheses based on scientific data, or they may be used to depict the perception of a witness, and to illustrate what may have occurred (seen from a specific viewpoint) during a particular incident. Digital reconstruction technology may also be applied in a court to explore and illustrate

[1] Heintz, M.E. (2002), ‘The digital divide and courtroom technology: can David keep up with Goliath?’ *Federal Communications Law* Journal, 54, pp 567–589.

[2] Lederer, F.I. (2004), ‘Courtroom technology: for trial lawyers, the future is now’, *Criminal Justice*, 19(1), pp 14–21; Schofield, D. (2007), ‘Animating and interacting with graphical evidence: bringing courtrooms to life with virtual reconstructions’, in: *Proceedings of IEEE Conference on Computer Graphics, Imaging and Visualisation*, Bangkok, Thailand, pp. 321–328.

[3] Leonetti, C. and Bailenson, J.N. (2010), ‘High-Tech View: The Use of Immersive Virtual Environments in Jury Trials’, *Marquette Law Review*, 93(3), pp 1073-1120; Bailenson, J.N., Balscovich, J., Beall, A.C. and Noveck, B.S. (2006), ‘Courtroom Applications of Virtual Environments, Immersive Virtual Environments, and Collaborative Virtual Environments’, *Law and Policy*, 28(2), pp 249-270.

[4] Schofield, D. and Mason, S. (2012), ‘Using graphical technology to present evidence’, in: Mason, S. (Ed.), *Electronic Evidence*, 3rd edn, LexisNexis Butterworths, pp. 217 – 253.

[5] Girvan, R. (2001), ‘An overview of the use of computer-generated displays in the courtroom’, *Web Journal of Current Legal Issues*, 7(1), pp 1–80; Sherwin, R.K. (2007), ‘Visual literacy in action: Law in the age of images’, in Elkins, J. (ed), *Visual Literacy in Action*, Routledge, pp 179–194; Galves, F. (2000), ‘Where the Not So Wild Things Are: Computers in the Courtroom, the Federal Rules of Evidence, and the Need for Institutional Reform and More Judicial Acceptance’, *Harvard Journal of Law and Technology*, 13(2), pp 161–302; Spiesel, C.O., Sherwin, R.K. and Feigenson, N. (2005), ‘Law in the age of images: The challenges of visual literacy’, in Wagner, A., Summerfield, T. and Vanegas, F.S.B. (eds), *Contemporary Issues of the Semiotics of Law*, Oñati International Series in Law and Society, 13.

[6] Fowle, K. and Schofield, D. (2011), ‘Visualising forensic data: investigation to court’, Woodward, A. and Valli, C. (eds), *Proceedings of the 9th Australian Digital Forensics Conference*, Security Research Centre, Edith Cowan University, Perth, Australia; Gallant, J. and Shepherd, L. (2009), ‘Effective visual communication: Scientific principles and research findings’, in Solomon, S.H., Gallant, J. and Esser, J.P. (eds), *The Science of Courtroom Litigation: Jury Research and Analytical Principals*, ALM Publishing.

'what if' scenarios and questions, testing competing hypotheses and possibly exposing any inconsistencies and discrepancies within the evidence.[7]

The use of such computer-generated presentations in a court is sometimes viewed as nothing more than the current manifestation of the illustration of evidence and visualisation in a long history of evidential graphics used in litigation.[8] However, computer animations and interactive virtual simulations are potentially unparalleled in their capabilities for presenting complex evidence.[9] The use of such enabling visualisation technology can affect the manner in which evidence is assimilated and correlated by the viewer. In many instances, visual media can potentially help make the evidence more relevant and easier to understand. In other cases it may be seen to be unfairly prejudicing a jury.[10]

The vast majority of people called to be on a jury have grown up watching visual media on screens: cinemas, televisions, computers and even on their mobile telephones. Research has shown that many people tend to believe what they see in the mass media and merge mediated fictions into their beliefs about the world.[11] The cognitive default when viewing visual media is to believe what is seen, only later engaging in the effort needed to suspend or reject belief. Pictures on a screen which move tend to be even easier to believe. These are usually more engaging and entertaining, and hence decrease the mental resources of the viewer that are available for doubt.[12]

However, audiences receive visual information differently when they watch it on a screen compared to when they see it in real space, and these differences can affect everything they see. This difference can be described in two contexts, firstly the way the screen frames and what the viewer sees; a physical border that limits and creates new relationships between the elements displayed inside it. Secondly, the visuals presented also act as a carrier of personal and cultural associations.[13]

This ability of viewers to place undue reliance on visual evidence has profound implications for the use of any form of animated visual digital technology to present evidence in courts.[14] The potential life-and-death weight of the issues means that those undertaking this important civic duty by acting as jurors need to able to make objective assessment of the evidence before making their decisions. The way the evidence presented must be probative, not unfairly prejudicial.

This paper gives a brief background to the use of animated visual digital technology in courts and describes past research that has been undertaken to examine the effect any form of animated visual presentation has upon members of the jury. The paper also provides an extensive discussion of the issues arising from the use of animated visual digital presentation, specifically those based on video game technology, in courts. This includes an analysis of the emotional and psychological effect of the use of this technology, the creation of narrative through interaction with virtual environments and the influence of viewer perspective on the user experience. The paper concludes by comparing the advantages and disadvantages of using such a medium to present evidence.

Technology

It is beyond the remit of this paper to provide an extensive catalogue of every aspect of technology employed and utilised in modern courts, this has been undertaken by many other authors.[15] However, it is

[7] Burton, A., Schofield, D. and Goodwin, L.M. (2005), 'Gates of global perception: forensic graphics for evidence presentation', in: *Proceedings of ACM Symposium on Virtual Reality Software and Technology*, Singapore, pp. 103–111.
[8] Schofield, D. and Mason, S. (2012), 'Using graphical technology to present evidence', in: Mason, S. (Ed.), *Electronic Evidence*, 3rd edn, LexisNexis Butterworths, pp. 217–253.
[9] Joseph, G.P. (2009), *Modern Visual Evidence*, Law Journal Seminars Press; Feigenson, N. and Spiesel, C.O. (2009), *Law on Display: The Digital Transformation of Legal Persuasion and Judgment*, NYU Press.
[10] Burton, A., Schofield, D. and Goodwin, L.M. (2005), 'Gates of global perception: forensic graphics for evidence presentation', in: *Proceedings of ACM Symposium on Virtual Reality Software and Technology*, Singapore, pp. 103–111; Mervis, J. (1999), 'Court Views Engineers as Scientists', *Science*, 284(5411), p 21; Tufte, E.R., 'The visual display of quantitative information', *American Journal of Physics*, 53(11), pp 1117–1118.
[11] Burgoon, J.K. (2000), 'Interactivity in human–computer interaction: a study of credibility, understanding and influence', *Computers in Human Behavior*, 16(6), pp 553–574; Shapiro, M.A. and McDonald, D.G. (1992), 'I'm not a doctor, but I play one in virtual reality: implications of judgments about reality', *Journal of Communication*, 42(4), pp 94–114.
[12] Gilbert, D.T. (1991), 'How mental systems behave', *American Psychologist*, 46(2), pp 107–119.
[13] Hopkins, R. (1998), *Picture, Image and Experience*, Cambridge University Press, Cambridge.
[14] Schofield, D. (2007), Animating and interacting with graphical evidence: bringing courtrooms to life with virtual reconstructions, in: *Proceedings of IEEE Conference on Computer Graphics, Imaging and Visualisation*, Bangkok, Thailand, pp. 321–328.
[15] Brown, M. (2000), 'Criminal Justice Discovers Information Technology', *Criminal Justice*, 1, pp 219-259; Goodwin, L. (2007), *Visualising Vehicle Accidents: Evidence Uncertainty, Presentation and* Admissibility, PhD Thesis, University of Nottingham; Lederer,

perhaps appropriate to define and describe the technologies under discussion in this paper.

Visual evidence displays and digital court presentation systems cover a wide variety of technologies. This paper focuses on computer-generated imagery, particularly computer graphics. Computer Graphics or 'CG' in this context refers to a range of software applications that can be used to produce outputs such as rendered images and animations. Rendering is the process of generating a digital image from a three-dimensional virtual computer model. The term may be thought of by analogy with an 'artist's rendering' of a scene. Most current computer graphics systems utilise numerical three-dimensional models of physical world objects to create artificial virtual environments. Based on the data surveyed (physical measurements) of objects such as equipment, vehicles, human figures, environment details, landscape features and other relevant evidence from and in respect of the scene, items can be accurately positioned and precisely scaled within the virtual three-dimensional environment. The objects within this virtual scene can then be 'texture mapped' or painted with relevant photographic images to produce a credible lifelike appearance. Hence, a brick wall in the virtual environment will use a photograph of a brick to give the impression that the virtual object has the texture of a real brick wall.[16]

Computer technology can be used to build an animation from one of these virtual environments. This is usually achieved by developing the material frame-by-frame (as a series of still images). These frames, when played back in quick succession, create an experience of space, motion and time. Popular cultural examples of the use of this technology include animated movies such as those made by Pixar Animation Studios (for example *Shrek* and *Toy Story*). In the context of a court, the term often used to describe evidence presented in this format is 'forensic animation'.

Virtual Reality or 'VR' is a development of this technology that relies on the faster processing power of modern computers to produce interactive, real-time, three-dimensional graphical environments that respond to user input and action, such as moving around in the virtual world or operating virtual equipment. An important aspect of such a virtual reality system is its underlying processes, simulations, behaviour and reactions, and the way a user can interact with objects within the virtual world. A virtual reality user could, for example, sit in a virtual vehicle and drive it. Popular cultural examples of this technique include modern three-dimensional computer games such as *Unreal Tournament* (Epic Games) and *Grand Theft Auto* (Rockstar Games). In the context of a court, the term often used to describe evidence presented in this format is 'virtual simulation' or 'virtual reconstruction'.

Many novel applications have emerged because of recent and rapid developments in personal computer technology, especially in the realms of desktop VR systems. In particular, the home computer games market has encouraged the development of software tools together with specialist three-dimensional graphics accelerator boards and peripheral products. Whilst much of the development is aimed at the home and leisure industry, there are many applications that have been developed for a range of commercial sectors. This has consequently also had an effect on the legal profession, and is one of the reasons for the technology being increasingly introduced into courts around the world over the past few years. These types of VR display systems can offer major advantages over other visualisation media, because of the interactive nature of the experience they create.[17]

It is useful at this point to clarify the terms used to describe such technology. The standard form of evidence from such virtual environments usually consists of a series of still images and animations. In this context, the term 'computer animation' is often misused to describe an animation created from a virtual environment that is not based on the laws of physics, but is still represented as 'simulating' a given event.

F.I. and Solomon, S.H. (1997), 'Courtroom technology – an introduction to the onrushing future', *Proceedings of Fifth National Court Technology Conference (CTC5)*, National Centre for State Courts, Detroit (MI); Wiggins, E.C. (2006), 'The Courtroom of the Future is Here: Introduction to Emerging Technologies in the Legal System', *Law and Policy*, 28(2), pp 182-191.

[16] Schofield, D. (2007), 'Animating and interacting with graphical evidence: Bringing courtrooms to life with virtual reconstructions' in Banissi, E. Sarfraz, M. and Dedumrong, N. (eds), *Proceedings of Computer Graphics, Imaging and Visualisation*, Bangkok, Thailand; Watt, A.H. and Watt, A. (2000), *3D Computer Graphics*. Vol. 2. Reading: Addison-Wesley.

[17] Schofield, D., Noond, J., Goodwin, L. and Fowle, K. (2001), 'Accident Scenarios: Using Computer-generated Forensic Animations', *Journal of Occupational Health and Safety – Australia and New Zealand*, 17(2), pp 163-173.

The terms ‘animation’, ‘scientific animation’ and ‘simulation’ have had specific definitions in the reconstruction community for many years (note: all the quotes in the paragraphs below are from Grimes):[18]

> ‘Animation’ is a general term describing ‘any presentation which consists of a series of graphical images being sequentially displayed, representing objects in different positions from one image to the next, which implies motion’. This term may be used to describe a presentation consisting of artist renditions or illustrated moving graphics, sometimes referred to as a ‘cartoon animation’.
>
> The phrase ‘Scientific Animation’ is consequently used to describe a more technically based presentation, and is defined as ‘a computer animation that is based on the laws of physics and the appropriate equations of motion’. Velocities and positions are time integrals of the acceleration data, and the objects and environment in a scientific animation are properly and consistently scaled. For example, a scientific animation showing the movement of vehicles involved in a road traffic accident, based on calculations from an accident reconstruction expert witness.
>
> In the reconstruction community, a ‘Simulation’ is often defined as being based on the laws of physics and containing specific underlying equations. A simulation goes further than a scientific animation, and can be further defined as ‘A model that predicts an outcome. The model may be a physical or a mathematical model, but the significant property is that a simulation predicts a future result’ – for example a computation fluid dynamics model used to predict smoke flow through an enclosed environment.

In summary, an ‘animation’ may only be illustrative or demonstrative evidence, whereas a ‘scientific animation’ is more technical, and relies upon scientific laws, and thus might be categorised as substantive evidence. A ‘simulation’ is more predictive in nature, and consists of data or forecasts that are usually created via a computer program.

Visual evidence

Modern culture is dominated with images whose value may be simultaneously over-determined and indeterminate, whose layers of significance can only be teased apart with difficulty. Different academic disciplines (including critical theory, psychology, education, media studies, art history, semiotics, etc) have been developed to help explain how audiences interpret this visual imagery.[19] Improvements in forensic science have led to an increasing amount of complex, technical evidence being presented in courts. The issues in question can be extremely complicated and difficult to explain without some form of graphical representation. A further survey by the American Bar Association found that members of a jury are often confused, bored, frustrated and overwhelmed by technical issues or complex facts.[20] Other research has indicated that the attention span of the average member of a jury in a court is, on average, only seven minutes.[21]

Any visualisation or graphic can potentially be a valuable aid to help construe and convey a large amount of complex information. An American judge, C. B. Rubin, highlighted the problem of retaining the interest of the jurors when he stated:[22]

> ‘It isn’t difficult to tell when jurors have lost interest … Such wandering attention is much less likely in a paperless trial, because the evidence is presented in a format jurors are used to watching … I have noticed repeatedly that when a document is displayed on the monitors, the jurors sit up and pay attention. Such attention is far greater than that given to a document which they

[18] Grimes, W.D. (1994), ‘Classifying the Elements in a Scientific Animation, Accident Reconstruction: Technology and Animation’, SAE Paper No 940919, *USA Society of Automotive Engineers*, pp 39-404.

[19] Schofield, D. and Mason, S. (2012), ‘Using graphical technology to present evidence’, in: Mason, S. (Ed.), *Electronic Evidence*, 3rd edn, LexisNexis Butterworths, pp. 217–253; Spiesel, C.O., Sherwin, R.K. and Feigenson, N. (2005), ‘Law in the age of images: The challenges of visual literacy’, in Wagner, A., Summerfield, T. and Vanegas, F.S.B. (eds), *Contemporary Issues of the Semiotics of Law*, Oñati International Series in Law and Society, 13.

[20] Kuehn, P.F. (1999), ‘Maximising your Persuasiveness: Effective Computer Generated Exhibits’, *Journal of the DuPage Country Bar Association*, available online at http://www.dcba.org/mpage/vol121099art4.

[21] Schroder, K.J. (1997), ‘Computer Animation: The Litigator’s Legal Ally’, *Computers and Law* (University of Buffalo); Devine, D.J., Clayton, L.D., Dunford, B.B., Seying, R. and Pryce, J. (2001), ‘Jury decision making, 45 years of empirical research on deliberating groups’, P*sychology Public Policy, and Law*, 7(3), pp 622–727; Durkin, K.P. and Dunn, C.H. (2010), ‘Building your case for the jury’, *Litigation Journal*, 36(3).

[22] Rubin, C.B. (1992), ‘A Paperless Trial’, *Litigation Magazine*, 19(3).

> cannot see as it is being discussed by the attorney and the witnesses …'

This comment illustrates the perceived need to reduce lengthy verbal explanations and increase the use of visual tools for a media-literate modern audience. This, in turn, offers a lawyer the possibility of improving the capacity of a jury to retain the evidence they present, to maintain their interest in the proceedings, and to allow the jury to understand the nature of the case more fully.[23]

In court settings, static images such as diagrams, plans and charts have been traditionally used to explain the testimony of an expert witness. A number of modern expert witnesses now provide animated multimedia explanations illustrating their evidence. Such forensic animations or virtual reconstructions can be seen as an advance due to their unique ability to visually illustrate and animate visually the passing of time. This extra temporal dimension can be extremely useful when explaining a chronological sequence of events, such as the reconstruction of the occurrences leading up to a vehicle collision. In this case the dynamic movement of the vehicles involved in the collision may be dependent on complicated engineering or mathematical principles that are potentially difficult to explain to members of the jury – but easy to understand when visually represented in an animated, photo-realistic reconstruction.[24]

A particularly relevant aspect of the technology under discussion is the ability to visualise unseen or imaginary environments. In a court context this manifests itself as the ability to visualise evidential information that may not be naturally or readily visible to the naked eye. The virtual camera can break free of the physical restrictions restraining real world cameras and show processes that occur on too large or too slow a scale (from the unfolding of a storm to the replication of DNA), or processes that are occluded by other objects.[25]

The precise effect that this increasing reliance on visual media over the more traditional mechanism of oral presentation is having on members of a jury, witnesses and other viewers in the court is not currently known. Concerns are beginning to be articulated that the use of computer-generated visualisation technology can distort perceptions, memories, attitudes and decision making in the court. Some research work, previously undertaken in the USA, has examined how members of a jury retain details in their memory from different forms of evidence:

> (i) Research evidence has also shown that members of a jury are more likely to be persuaded if the arguments are supported by visual aids.[26]
>
> (ii) One study showed that the average person retains 87 per cent of information presented visually, but only 10 per cent of information presented orally.[27]
>
> (iii) Another study showed that the average person retains 65 per cent of information presented visually and 15 per cent of that presented orally.[28]
>
> (iv) A further survey showed that members of a jury will retain twice the amount of information when using a visual presentation, as distinct to an oral presentation.[29]

When the evidence is animated, the improvement in memory retention is even more apparent: another survey revealed that members of a jury will retain an increase of 650 per cent of information when presented with presentations using a form of computer animation.[30] However the Visual Persuasion

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[23] Loftus, E.R. and Loftus, G.R. (1980), 'On the permanence of stored information in the human brain', *American Psychologist*, 35(5), pp 409–420; Leader, L. and Schofield, D. (2006), 'Madness in the method? Potential pitfalls in handling expert evidence', *Journal of Personal Injury Law*, 6(1), pp 68–86.

[24] Schofield, D. (2006), 'The future of evidence: new applications of digital technologies, forensic science: classroom to courtroom', in: *Proceedings of 18th International Symposium of the Forensic Sciences*, Fremantle, Western Australia, 2006.

[25] Richter, E.M. and Humke, A.M. (2011), 'Demonstrative evidence: evidence and technology in the courtroom', in Weiner, R.L. and Bornstein, B.H. (eds), *Handbook of Trial Consulting*, Springer, pp187-201; Schofield, D. (2011), 'Playing with evidence: using video games in the courtroom', *Journal of Entertainment Computing (Special Issue: Video Games as Research Instruments)*, 2(1), pp 47-58; Speisel, C.O. and Feigenson, N. (2009), *Law on Display: The Digital Transformation of Legal Persuasion and Judgement*, New York University Press, New York, 2009; Jones, I.S., Muir, D.W. and Groo, S.W. (1991), 'Computer animation – admissibility in the courtroom, accident reconstruction: technology and animation', *Society of Automotive Engineering*, 1, 143–151.

[26] Lederer, F.I. and Solomon, S.H. (1997), 'Courtroom technology – an introduction to the onrushing future', *Proceedings of Fifth National Court Technology Conference (CTC5)*, National Centre for State Courts, Detroit (MI); Lederer, F.I. (2004), 'Courtroom technology: for trial lawyers, the future is now', *Criminal Justice*, 19(1), pp 14–21.

[27] Seltzer, R.F. (1990), 'Evidence and Exhibits at Trial', 387 *PLI/Lit* 371.

[28] Cobo, M.E. (1990), 'A Strategic Approach to Demonstrative Exhibits and Effective Jury Presentations', 3 *PLI/Lit* 359.

[29] Krieger, R. (1992), 'Sophisticated Computer Graphics Come of Age—and Evidence Will Never Be the Same', *Journal of the American Bar Association* (December), pp 93-95.

[30] Thomas, R.D. (1997), *Computer Re-Enactment*, available online at http://www.pimall.com/nais/n.reenact.html .

Project, run by the New York School of Law, identified a number of issues and problems with the use of visual technology.[31] These issues, along with many others will be expanded upon and addressed later in this paper.

Kassin and Dunn undertook two experiments to assess the effects of computer-animated displays on mock jurors.[32] In both experiments, participants watched a trial involving a dispute over whether a man who fell to his death had accidentally slipped or jumped in a suicide. They observed that when the claimant and defence used an animation to depict their own partisan theories, participants increasingly made judgments that contradicted the physical evidence, suggesting that computer-animated displays can have a greater effect than oral testimony. More recent research by Dunn and others examined the prejudicial effects of computer-generated animations in more detail.[33] This research work offered varying results, depending on the familiarity of the viewers with the scenarios depicted. These experiments also showed that the juror's expectations about the persuasiveness of animations were at odds with the animations' actual influence on jurors' verdicts.

Australia currently has a number of projects underway in this thematic area. In Western Australia, rare permission has been given by the Attorney General for a researcher to interview jurors after criminal trials in which a range of expert evidence was presented. While the data showed statistically significant findings that jurors are clearly influenced in their treatment of some forensic evidence by the manner of presentation, reassuringly, no support was found for the operation of a detrimental effect of the technology. In fact the study found support for the proposition that most jurors assess forensic evidence in a balanced and thoughtful manner, whatever the mode of presentation.[34]

The author was a member of a large international research project based in Australia, the Juries and Visual Evidence Project (JIVE), which also examined some of these issues. The project measured the effect of interactive displays on the trial process; specifically whether forensic animation and virtual reconstruction technology better informs juries or potentially increases prejudice against defendants. In January 2008, the JIVE project team ran a number of mock trials in the Supreme Court in Sydney, Australia. A range of forensic animations and interactive reconstructions of evidence relating to a terrorist bombing were shown to a number of different groups of jurors (Figure 1). Each jury deliberation was filmed and recorded. A major theme emerging from the analysis of the project data is that the main experimental effects (interactive visual evidence and judicial instructions) have relatively modest influence overall. However, they do show stronger effects in some groups of people, particularly those who are most prone to convict. The JIVE data has so far shown that fear of terrorism may be a better predictor of a verdict than either the method of presentation, experimental interventions, deliberation or any demographic characteristics. The research team intends to publish a book on the data from this project which will focus on issues of juries and trials in terrorism cases.[35]

There is little argument regarding the effectiveness of animated visual media as a tool for communication and knowledge transfer. The technology can offer significant benefits over traditional static (photographic) or moving (film) media captured in the physical world. The rendered images from virtual worlds are not bound by the limitations of available lighting; they can avoid extraneous information, focusing only on salient evidential items; and they can

[31] Sherwin, R.K. (2002), *When Law Goes Pop: The Vanishing Line between Law and Popular Culture,* University Of Chicago Press, 2nd Edition.

[32] Kassin, S.M. and Dunn, M.A. (1997), 'Computer-Animated Displays and the Jury: Facilitative and Prejudicial Effects', *Law and Human Behavior,* 21(3), pp 269-281; Selbak, J. (1994), 'Digital Litigation: The Prejudicial Effects of Computer-Generated Animation in the Courtroom', *Berkley Technology Law Journal*, 19(9:2).

[33] Dunn, M.A., Feigenson, N. and Salovey, P. (2006), 'The Jury Persuaded (and Not): Computer Animation in the Courtroom', *Law & Policy* 28(2), pp 228-248.

[34] Fordham, J.G. (2006), 'Muddying the Waters with Red Herrings: a Progress Report on Western Australian Jury Research', in Brooks-Gordon, B. and Freeman, M. (Eds), *Law and Psychology Current Legal Issues* 9, Oxford University Press, pp 338–360; Holmgren, J.A. and Fordham, J.G. (2011), 'The CSI effect and the Canadian and Australian jury', *Journal of Forensic Sciences*, 56(S1), pp S63-S71.

[35] Tait, D. (2007), 'Rethinking the role of the image in justice: visual evidence and science in the trial process', *Law, Probability and Risk*, 6(1–4), pp 311–318; Tait, D., Goodman-Delahunty, J., Schofield, D. and Jones, D. (2008), 'Evidence on the Holodeck: Jury responses to Computer Simulations', *Proceedings of the 4th Law and Technology Conference*, Australian Institute of Judicial Administration, Sydney, Australia; Schofield, D. (2009), 'Animating Evidence: Computer Game Technology in the Courtroom', *Journal of Information Law & Technology (JILT)* 1 (2009); Schofield, D. (2011), 'Playing with evidence: using video games in the courtroom', *Journal of Entertainment Computing (Special Issue: Video Games as Research Instruments),* 2(1), pp 47-58.

Figure 1: Computer generated graphical images from the JIVE Terrorism Trial

be colourful, animated and lively enough to guarantee the attention and engagement of the viewer.[36]

Examples of computer-generated graphical evidence

Computer-generated displays, and more specifically, scientific animations or simulations, must meet certain criteria before being admitted as evidence in court due to potential bias and unfairness. A number of examples are set out below to illustrate the nature of what can be achieved. Although computer-generated displays have often been used at jury trials, it is suggested that many of the same advantages and concerns raised when showing such graphical displays to members of a jury, apply to judges or any other trier of fact.[37]

Legislation and case law exists in most countries that govern the admissibility of computer-generated displays (and in fact, any visual or scientific evidence or display) in court, in order to ensure fair, unbiased, and appropriate use of this evidence. Digital visualisations have been widely used in American courts for the last 20 years; hence much of the applicable case law is from the United States. The technology has only relatively recently begun to be introduced into the United Kingdom and Australian courts. Recently, there have been a number of articles reporting on the use of this technology in other jurisdictions, such as India and China.[38] Although this

[36] Dunn, M.A., Feigenson, N. and Salovey, P. (2006), ‘The Jury Persuaded (and Not): Computer Animation in the Courtroom’, *Law & Policy* 28(2), pp 228-248.

[37] Schofield, D. (2009), ‘Graphical Evidence: Forensic Animations and Virtual Reconstructions’, *Journal of the Australia and New Zealand Forensic Science Society,* 41(2), pp 1-15.

[38] Liao, G., Zheng, Y., Zhao, L. and Wu, X. (2015), ‘A Novel Plan for Crime Scene Reconstruction’, *Proceedings of the 5th International Conference of Computer Engineering and Networks*, Shanghai,

technology is more common in civil trials, it is seeing greater use in the criminal arena and has been used in high-profile criminal cases such as the O. J. Simpson and Oklahoma City bombing trials in the US.[39]

Computer-generated graphical evidence in the USA

Computer-generated evidence in the US has primarily been used in civil cases. One of the first major uses of computer-generated animations in court took place in the federal civil case for the Delta flight 191 crash. In August 1985 a Delta aeroplane with 163 people aboard was caught in a wind vortex and crashed while attempting to land at Dallas-Fort Worth Airport, a mile from the runway.[40] 128 passengers, 8 crew members and 1 person on the ground were killed, and there was extensive property damage. In the subsequent litigation, computer-generated animations were used to explain the complex issues and technical matters to the members of the jury, without overwhelming them with the complexities of the evidence. The US government offered a 55-minute computer-generated presentation, including forensic animations to the court to explain the details of each item of evidence. The animations that were created were based on ground-radar data and the design capabilities of the radar used by Delta 191.[41]

The use of computer-generated evidence in criminal cases can often be more problematic. The benefits and disadvantages of using such evidence in court can become magnified, due to the importance of the result of the trial. Admittance of computer-generated evidence to a civil trial may mean an award or loss of money, whereas in a criminal case loss of liberty may result.[42]. Computer animations and simulations may not only be used by the prosecution, but also by the defence to show that the prosecutor's version of events could not possibly have happened. An example of the latter is the state case of *People v McHugh*,[43] which involved one of the first uses of a computer-generated simulation in a criminal trial. McHugh was driving his vehicle in New York City when he was alleged to have killed several people. He was charged with their deaths, but argued he had not been criminally negligent. The defence claimed the incident occurred because the weather conditions caused the vehicle to leave the road and to hit an electrical box that was open at ground level. This in turn caused a tyre to rupture, which caused the vehicle to spin into a concrete abutment.[44] On behalf of the defence, a specialist in reconstructing accidents introduced a simple simulation illustrating the defence theory relating to the path the vehicle took. The prosecution moved for a pre-trial conference to evaluate the admissibility of the computer-generated evidence. After the court reviewed the expert's report outlining the construction of the computer simulation, it was ruled that there would be no need for a pre-trial hearing on the issue. Collins J classified the computer-generated evidence as demonstrative, at 722:

> 'The evidence sought to be introduced here is more akin to a chart or diagram than a scientific device. Whether a diagram is hand drawn or mechanically drawn by means of a computer is of no importance.'

The judge ruled that the expert could use the simulation, provided the defence laid the proper foundations and qualifications of the expert.[45]

As a result of the possible loss of an individual's freedom, and sometimes life, the use of computer animations and simulations in criminal cases must be analysed carefully. This is particularly important since scientific evidence is far more difficult to admit than illustrative evidence. There is a risk in a criminal trial that the members of the jury can be overwhelmed by the scientific techniques or devices employed.

A further relevant example is the case of *State of Connecticut v Michael Skakel*,[46] which involved

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China; Sahu, A., Mandla, N. S. and Yogesh, G. (2014), 'Advantages of Computer Generated Evidence: Forensic Animation in Indian Judiciary System', *Indian Journal of Forensic Medicine and Toxicology*, 8(1), pp 13; Lalwani, S., Raina, A., Pokle, R.C. and Dogras, T.D. (2014), 'Reconstruction of Scene by Forensic Animation: Two Case Reports', *Journal of Indian Academy of Forensic Medicine*, 36(1), pp 104-107.

[39] Lederer, F.I. (2004), 'Courtroom technology: for trial lawyers, the future is now', *Criminal Justice*, 19(1), pp 14–21

[40] Marcotte, P. (1989), 'Animated Evidence: Delta 191 Crash Re-Created Through Computer Simulations at Trial', *American Bar Association* Journal, 75(12), pp 52 – 56.

[41] Gold, S. (2001), 'Forensic Animation – Its Origins, Creation, Limitations and Future', *Expert Law*, available online at http://www.expertlaw.com/library/animation/forensic_animation.html; Marcotte, P. (1991), 'Animated Evidence: Delta 191 Crash Re-Created Through Computer Simulations at Trial'; *In re Air Crash at Dallas/Fort Worth Airport on August 2, 1985*, 720 F. Supp. 1258 (N. D. Tex. 1989), aff'd, 919 F.2d 1079 (5th Cir. 1991), cert. denied sub nom. *Connors v. United States*, 112 S. Ct. 276.

[42] Bardelli, E.J. (1994), 'The Use of Computer Simulations in Criminal Prosecutions', *Wayne Law Review*, pp 1357-1377.

[43] 124 Misc.2d 559; 476 N.Y.S.2d 721 (Sup. 1984).

[44] Kassin, S.M. and Dunn, M.A. (1997), 'Computer-Animated Displays and the Jury: Facilitative and Prejudicial Effects', *Law and Human Behavior,* 21(3), pp 269-281.

[45] Bohan, T.L. and Damask, A.C. (1995), *Forensic Accident Investigation: Motor Vehicles,* Michie-Butterworth, Charlottesville, VA; D'Angelo, C. (1998), 'The Snoop Doggy Dogg Trial: A Look at How Computer Animation will Impact Litigation in the Next Century', *University of San Francisco Law Review*, pp 561-585.

significant use of computer-generated imagery. Michael Skakel's audiotaped interviews were digitised and re-formatted into an interactive multimedia presentation. The digital audio from the interviews was synchronised with the digital transcripts so that the jury could listen and read along in order to increase their understanding of the content. This was developed into a closing argument presentation, which allowed jurors to hear Skakel describe the panic he felt when the victim's mother asked him about her daughter the morning after the night of the murder; and simultaneously saw on the screen a photograph of the lifeless body next to the transcript of Skakel's words.[47] The defense appealed to the Supreme Court of Connecticut on this point, amongst others. The appeal was rejected (for which see paragraph VII item F of the judgment).

Another example was the case of *Commonwealth v Serge*.[48] Here the defendant appealed his conviction for murder after the prosecution introduced a computer-generated animation based on their theory of the case. The court held that a computer-generated animation was admissible evidence and had to be weighed by the same criteria of admissibility as other evidence; probative value versus prejudicial effect. The court also stated that certain concerns prior to admission carry more weight and deserve closer scrutiny for such computer generated testimony than for more traditional forms of evidence[49]. The court also decided that because in this case the computer generated animation was a graphic illustration of an expert witness's reconstruction rather than a simulation based on computer calculations, it was not subject to the test governing admissibility of scientific evidence established under *Frye v United States*.[50]

[46] An appeal was argued before Sullivan, C.J., and Katz, Palmer, Vertefeuille and Zarella, J.J. on 14 January 2005, and judgment officially released on 24 January 2006. It is available at https://www.jud.ct.gov/external/supapp/Cases/AROcr/CR276/276CR155.pdf .
[47] Carney, B. and Feigenson, N. (2004), 'Visual Persuasion in the Michael Skakel Trial: Enhancing Advocacy through Interactive Media Presentations', *Criminal Justice Magazine* 19(1).
[48] 586 Pa. 671, 896 A.2d 1170 (Pa. Sup. Ct. 2006).
[49] Mentioned in this judgment was an article by Joseph, G.P. (2009), 'A simplified approach to computer-generated evidence and animations', 43 *New York Law School Law Review*, 875 (reprinted in part in Shira, A., Scheindlin, D., Capra, J. and The Sedona Conference, *Electronic Discovery and Digital Evidence*.
[50] 293 F. 1013; 1923 U.S. App. LEXIS 1712; 54 App. D.C. 46; 34 A.L.R. 145 (D.C. 1923).

Virtual reality technology as evidence in the USA

The case of *Stephenson v Honda Motors Ltd of America*[51] saw the first use of an interactive real time simulator (based on real time VR technology) in US courts. After an accident on her motorcycle, Ms Stephenson claimed that the ground she was traveling on was smooth, and her vehicle inherently unstable, because it caused her to fall. Rain had eroded the road by the time of trial, so it was impossible to determine the condition of the road. Honda argued that it was too dangerous to drive safely upon the terrain. Honda produced a virtual reconstruction of the terrain, which members of the jury could view by using VR headsets and a demonstration motorcycle simulator. Honda claimed that this method of viewing the environment was more realistic and relevant than photographs and videos, as it gave the jury a better idea of the nature of the terrain. The motorcycle simulator and accompanying virtual environment was admitted as evidence.[52]

Other new forms of evidence are also now becoming available. The Court 21 Project, based at the William and Mary Law School, Williamsburg, Virginia, is a renowned centre for experimental work in court technology. In 2002, the School conducted a laboratory trial involving a federal homicide prosecution of a company accused of manufacturing a medical device that it knew or should have known would kill its first patient. That case included the first known use of holographic evidence (allowing the circulatory system to be seen in three dimensions in the air in front of each juror) and an immersive VR system involving a head mounted display was used for each juror.[53]

Computer-generated graphical evidence in England and Wales

For examples of computer-generated visualisations and computer-generated evidence in England and Wales, see the forthcoming fourth edition of *Electronic Evidence*, edited by Stephen Mason and to be published in early 2017 by the University of London and the Institute of Advanced Legal Studies.

[51] No. 81067 (Cal. Sup. Placer County, June 25, 1992).
[52] Dunn, J.A. (1999), 'Virtual Reality Evidence', available online at http://www.lectlaw.com/files/lit04.htm .
[53] Lederer, F.I. (2004), 'Courtroom technology: for trial lawyers, the future is now', *Criminal Justice*, 19(1), pp 14–21.

Computer-generated graphical evidence in Australia

Over the last decade, Australia has been a relative pioneer in the introduction of high technology into courts. Queensland University of Technology houses (what it claims to be) the most high-tech court in the southern hemisphere. Here, law students are taught to handle a range of advanced technologies for use in the court.[54]

There are few published examples of the use of computer-generated animations in Australian courts. One early example is *King v The Queen*[55] where three men allegedly raped a young woman in November 1995. The men each pleaded not guilty to deprivation of liberty and six counts of sexual penetration without consent. A reconstruction was admitted on behalf of the defence to illustrate how measurements of the crime scene were taken, and that it was impossible to re-enact the crime without removing certain physical parameters from the scene, such as obstructing objects and wall geometry. In the animation that was produced, it was demonstrated that the perpetrator's frame had to protrude through the shower wall in order for the assault to have occurred in the manner described by the prosecutor.

The case of *Brambles Australia Ltd v AM and JP Keune Pty Ltd*[56] involved the collision of two heavily laden road trains on the Brand Highway, near Regans Ford. On 2 December 1991, the road train, owned by Brambles Australia Ltd ('Brambles') was travelling south, and being driven by Mr Steven Lee, who died in the collision. The road train owned by AM and JP Keune Pty Ltd ('Keune') was travelling north from Perth to Tom Price, driven by Mr Ian Jones, who was injured in the collision. Mr Jones' evidence was tested before the trial, both practically and theoretically. The practical test involved the reconstruction of the movements of the Brambles road train as described by Mr Jones, by an experienced vehicle accident consultant. An animation of this reconstruction based on Mr Jone's testimony was introduced as evidence. A further computer-generated reconstruction was also created by a qualified vehicle accident consultant in conjunction with ARRB Transport Research Limited. Although the virtual simulations demonstrated that it would have been possible for both road trains to have moved in the way described by Mr Jones, the simulations did not concur fully with the physical evidence recovered from the scene. The simulation showing Mr Jones's version of events was not in full accordance with the video recording, and the ARRB report findings on times of lane changes and the limit of stability of the road trains. Therefore, testing the reconstruction built from Mr Jones's account against the evidence described above illustrated that although Mr Jones's account was seemingly probable, it did not provide a satisfactory explanation. Templeman J concluded that the version of events put forward by Brambles was more probable, and that Mr Lee was not responsible for the collision. The judge stated that Mr Jones was a competent driver and did not intentionally allow his vehicle to drift to the wrong lane, but that he had fallen asleep at the wheel.

Issues arising from the use of computer-generated graphical evidence in court

The previous sections have described how computer generated visual evidence can be extremely advantageous to the court, providing they are used appropriately. Such displays may be used in different ways in the court: as substantive evidence (used to prove a specific case hypothesis or argument), or to generally illustrate or demonstrate a fact (such as a medical illustration showing how a lung works or demonstrating the interior workings of a piece of machinery).

However, potential difficulties can occur from the application of this technology, and when these reconstructions are examined in further detail, a number of issues and questions can arise. The consequences of these problems cannot be underestimated, since errors, inaccuracies, misuse, tampering or bias within visual and graphical evidence are capable of leading to miscarriages of justice.[57] A number of these potential issues are discussed below.

Viewpoint

One issue is how to correlate the viewpoint of a witness in a 'virtual' environment with the view from their physical position at the scene. For example, compare the problem of accurately replicating the 'physical world' view of the driver of the vehicle involved in a road traffic accident with the field of

[54] Macdonald, R. and Wallace, A., 'Review of the extent of courtroom technology in Australia', *William and Mary Bill of Rights Journal*, 12, pp 649-979.
[55] [1998] WASCA 3 (19 January 1998).
[56] [1998] WASC 57 (26 February 1998).

[57] Worring, M. and Cucchiara, R. (2009), 'Multimedia in forensics', *Proceedings of the 17th ACM International Conference on Multimedia*, New York, USA, pp 1153-1154.

view of a camera in a virtual reconstruction. The driver has a wide field of vision through two eyes with differing levels of visual acuity across the field of view (for example there will be lower resolution vision at the periphery of the field of view compared to the current focus of attention), and the driver may also move their head around within the car to gain a better view. Whereas, animated driving simulations often rely on a fixed camera viewpoint within the vehicle.[58]

Popular computer game titles provide a good example of distinct viewing configurations through various playing styles. *Unreal Tournament* (Epic Games) and the *Halo Series* (Bungee Studios) are examples that belong to a genre known as the First Person Shooter (FPS), distinguished by a first person perspective (egocentric) that renders the game world from the visual perspective of the player character. *Grand Theft Auto* (Rockstar Games) and *Tomb Raider* (Core Design) are games that belong to a genre known as the Third Person Shooter (TPS), this is a genre of video game in which an avatar of the player character is seen at a distance from a number of different possible perspective angles (exocentric). In any forensic reconstruction (as in any computer game), the choice of the viewing perspective may have significant effect on the way an image is interpreted by the viewer. Changing the viewing perspective can potentially alter which 'character' in an evidence presentation a viewer identifies with, or aligns themselves with.[59]

In fact, this is why there is a common (albeit not universal) rule prohibiting lawyers from asking jurors to put themselves in the place of a party (or witness). Images rendered to the screen may seem objective to the viewer, because they 'appear' not to be operated by human beings who by definition have a subjective position.[60] However, these cameras have a point of view that engages the viewer in familiar ways. The viewer becomes the driver, the game player, observing from inside the scene and every aspect of the way the images are presented on the screen can evoke an emotional response.[61]

However, research has shown that positioning the virtual camera to represent a specific subject's viewpoint can actually incline the viewer to attribute less responsibility to the person whose point of view the simulation leads them to adopt and more responsibility to others or to the circumstances. Cognitive psychologists call this actor-observer bias, and it is a bias since this point of view ought to be irrelevant to judgements of responsibility. This actor-observer effect is well established in the social psychology literature.[62]

Correlating location

There is also a possible issue regarding the correlation of the locations of witnesses when viewed in a virtual environment, in comparison to their actual position at the scene. It is a reasonable assumption to make that most people would be better able to correlate their actual spatial location from a three-dimensional 'virtual' simulation, than they might be able to on a two-dimensional plan or map.

It is interesting to note that research has indeed shown that a significant proportion of people tested have problems relating and correlating two-dimensional (eg maps and plans) and three-dimensional (eg real and virtual) spatial information.[63] In practice, this means that some witnesses may find it easier to identify their physical position by referring to their location within a virtual environment (relating physical three-dimensions to 'virtual' three-dimensions) rather than picking a position on a two-dimensional plan or map of the scene of the incident.[64]

One of the main advantages of the use of an interactive 'real-time' virtual simulation over a passive forensic animation is the ability to control the virtual camera movement dynamically within the

[58] Noond, J., Schofield, D., March, J. and Evison, M. (2002), 'Visualising the scene: computer graphics and evidence presentation', *Science & Justice* 42(2), pp 89–95.
[59] Bryce, J. and Rutter, J. (2002), 'Spectacle of the Deathmatch: Character and Narrative in First-Person Shooters', in King, G. and Krzywinska, T. (Eds), *ScreenPlay: Cinema/Videogames/Interfaces*, Wallflower Press, pp 66-80.
[60] Feigenson, N. and Spiesel, C.O. (2009), *Law on Display: The Digital Transformation of Legal Persuasion and Judgment*, NYU Press.
[61] Schofield, D. (2006), 'The future of evidence: new applications of digital technologies, forensic science: classroom to courtroom', in: *Proceedings of 18th International Symposium of the Forensic Sciences*, Fremantle, Western Australia, 2006.
[62] Jones, E.E. and Nesbett, R.E. (1971), 'The actor and the observer: divergent perceptions of the causes of behavior', in: Jones, E.E. (Eds.), *Attribution: Perceiving the Causes of Behavior*, General Learning Press, Morristown, NJ, pp. 79–94.
[63] Schnabel, M.A. and Kvan, T. (2003), 'Spatial Understanding in Immersive Environments', *International Journal of Architectural Computing*, 1(4), pp 435–448.
[64] Schofield, D. (2009), 'Animating Evidence: Computer Game Technology in the Courtroom', *Journal of Information Law & Technology (JILT)* 1 (2009).

environment.[65] This permits the user to adjust the view of the digital evidence 'interactively' – for example, a witness could move a camera around until the virtual view matches their memory of their view of the incident. However, it should be noted that how humans position themselves and correlate spatial information between the three-dimensional views of the virtual world and the physical world are still not fully understood.[66]

Realism

The environment surrounding any particular scene that is to be reconstructed may be included within the virtual model. For example, a model may not only show the location of items or objects that form part of the evidence, but also the position of such items in relation to nearby buildings or other environment features, and these items may be placed and animated within a chronology of events or a time frame. The realism of these 'virtual' environments continues to improve. Popular types of animated film demonstrate two distinct representation styles. *Shrek* (Dreamworks Animation) or *Toy Story* (Pixar Studios) rely on a cartoon-like, abstract approach to present its narrative. On the other hand, films such as *Polar Express* (Castle Rock Entertainment) or *Beowulf* (Imagemovers) rely on a more realistic representational form. A number of researchers have noted an interesting observable fact relating to the realism in such animated imagery, where many viewers become 'unnerved' by images of humans which are close to, but not quite real. This phenomenon (experienced by a number of viewers of the *Polar Express* and *Beowulf* movies) has become known as the 'uncanny valley', because of the sharp dip seen in a graph of familiarity against the perception of reality.[67] As computer-processing power increases and software tools develop, it is natural to assume that it will be possible to achieve a similar level of realism to that used in photorealistic animated Hollywood movies within the computer-generated environments used in a court.

Virtual objects in a court reconstruction can be modelled with varying degrees of accuracy to explain and visualise the certainty, believability and veracity of the information related to that object. For example, the trajectories of bullets are often displayed as cones or wedge shapes within shooting reconstructions to show a range of possible positions of the weapon, instead of showing a single definitive line trajectory.[68] However, the mixing of visual metaphors and modes may be potentially disorientating to some viewers. Combining abstract data representations in photo-realistic environments may provide an unnatural experience for the viewer. Fielder[69] has commented on the way members of juries may be misled by the use of visual metaphors and abstract representations in forensic animations. Combining different degrees of photorealism and expecting the viewer to draw additional information from a number of abstract representations in the virtual environment may overload the viewer and potentially add to their confusion, rather than increasing their comprehension of the evidence that is presented. In a forensic graphics context, many presentations used in court currently rely on fairly abstract representations (such as the examples shown in Figure 1).[70] However, as technology develops, the development of increasingly photorealistic evidence reconstructions becomes ever more likely. Increasing use of the rendering of photorealistic components of the virtual model may lead to instances where viewers may be lulled into a 'seeing is believing' attitude, causing a potential relaxation of their critical faculties.[71]

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[65] Ware, C. and Osborne, S. (1990), 'Exploration and virtual camera control in virtual three dimensional environments', in: *Proceedings of the 1990 Symposium on Interactive 3D Graphics,* SIGGRAPH: ACM Special Interest Group on Computer Graphics and Interactive Techniques, Utah, USA, pp. 175–183;Lipski, C., Linz, C., Berger, K., Sellent A. and Magnor, M., 2010, 'Virtual video camera: image-based viewpoint navigation through space and time', *Computer Graphics Forum*, 29(8), pp 2555-2568.

[66] Montello, D.R., Hegarty, M., Richardson, A.E. and Waller, D. (2004), 'Spatial Memory of Real Environments, Virtual Environments and Maps', in Allen, G.L. (Ed), *Human Spatial Memory: Remembering Where*, Lawrence Erlbaum Associates, pp 251–286; Arthur, E.J., Hancock, P.A. and Crysler, S.T. (1997), 'The Perception of Spatial Layout in Real and Virtual Worlds', *Ergonomics*, 40(1), pp 69–77.

[67] MacDorman, K.F. (2006), 'Subjective Ratings of Robot Video Clips for Human Likeness, Familiarity, and Eeriness: an Exploration of the Uncanny Valley', P*roceedings of the ICCS/CogSci-2006 Long Symposium: Toward Social Mechanisms of Android Science*, pp 26–29.

[68] Ken Fowle and Damian Schofield, 'Visualising forensic data: investigation to court', 9th Australian Digital Forensics Conference.

[69] Fielder, B.S. (2003), 'Are Your Eyes Deceiving You? The Evidential Crisis Regarding the Admissibility of Computer-Generated Evidence', *New York Law School Law Review*, 48(1-2), pp 295–321.

[70] Schofield, D. (2009), 'Animating Evidence: Computer Game Technology in the Courtroom', *Journal of Information Law & Technology (JILT)* 1 (2009);

[71] O'Flaherty, D. (1996), 'Computer-generated displays in the courtroom: for better or worse?', *Web Journal of Current Legal Issues*, 2(4), pp 1–14; Fielder, B.S. (2003), 'Are Your Eyes Deceiving You? The Evidential Crisis Regarding the Admissibility of Computer-Generated Evidence', *New York Law School Law Review*, 48(1-2), pp 295–321; Galves, F. (2000), 'Where the Not So Wild Things Are: Computers in the Courtroom, the Federal Rules of Evidence, and the Need for Institutional Reform and More Judicial Acceptance', *Harvard Journal of Law and Technology*, 13(2), pp 161–302.

Figure 2: Image from a virtual simulation, showing vehicle debris at the crime scene

Media mode

It is rare that one form of media will be sufficient to explain fully every facet of a complex process or case to a viewer. Many people see three-dimensional technology as a universal solution, and it has been ‘over-applied’ or ‘misapplied’ in many visualisation applications. It is important to choose an appropriate representation mode (photographs, text, video, graphics etc) for the evidence that needs to be presented. Additional forensic data may be included and displayed within any virtual environment; for example, location based statistical or analytical data may be displayed, calculation and test results may be presented in a visual format, and original documents and photographs can be linked to three-dimensional virtual objects.

A reconstruction developed for the West Midlands Police in the United Kingdom by the author, for instance, uses real-time VR technology (Figure 2).[72] The user can pass the mouse over any relevant piece of evidence and view textual data about that item, and by clicking on any particular object in the virtual world (in this case, mainly items of vehicle debris), relevant crime scene photographs and evidential data will be displayed. The linking of ‘real’ evidence to spatially contextualised hotspots in a virtual environment has the potential to provide an effective mechanism to help the viewer understand the spatial relationship of the evidence. Such a multi-modal approach can be very effective, and different media may also be used as a device to help to retain the attention of the viewer and thereby increase understanding.[73]

Audio

The integration of physical-world audio evidence with a forensic animation has been used in the United States for many years. One of the first recorded applications of such a forensic animation was the reconstruction of the Delta 191 aeroplane crash in 1985, as described previously. In the court, the animated evidence showing the movement of the aeroplane was played simultaneously with an audio recording from the cockpit voice recorder. Research suggests that adding audio to a computer-generated visual can have a significant effect on the level of engagement of the viewer, and hence may potentially affect their understanding and interpretation of the evidence viewed.[74]

Resolution

One difficulty is to correlate the resolution of the virtual scene with that subjectively perceived by the viewer in the physical world. In this instance, resolution not only refers to screen image dimensions (the pixel count), but also to the level of photorealism of the virtual environment that is created.[75] This also

[72] Schofield, D. (2011), ‘Playing with evidence: using video games in the courtroom’, *Journal of Entertainment Computing (Special Issue: Video Games as Research Instruments),* 2(1), pp 47-58; Schofield, D. and Fowle, K. (2013), ‘Technology Corner: Visualising Forensic Data’, *The Journal of Digital Forensics, Security and Law*, 8(1).

[73] Clark, R.C. and Mayer, R.E. (2008), *E-learning and science of instruction: Proven guidelines for consumers and designers of multimedia learning*, John Wiley and Sons.

[74] Porschmann, C. and Pellegrini, R.S. (2010), ‘3-D audio in mobile communication devices: effects of self-created and external sounds on presence in auditory virtual environments’, *Journal of Virtual Reality and Broadcasting*, 7.

[75] Slater, M. Khanna, P., Mortensen, J. and Yu, I. (2009), ‘Virtual realism enhances realistic response in an immersive virtual environment’, *Computer Graphics and Applications*, IEEE, 29(3), pp 76–84.

relates to the display mechanisms used: a viewer watching a reconstruction on a mobile device such as a mobile telephone or a smartphone has a very different experience to one who watches it on a cinema screen. In addition, a viewer watching a computer monitor or screen may not have the same experience (depth of field, motion parallax, peripheral vision etc.) as a viewer watching the actual event.[76]

A relevant factor which needs to be considered is the way the technology is used, and for what purpose. One crime scene reconstruction created by the author was used extensively during the pre-trial phase as an interactive briefing tool. This gave investigators the opportunity to become familiar with the evidence and to test hypotheses. The simulation was also run on laptop computers by investigators who physically walked along the scene long after the incident (all transient evidence had been removed). The investigators were able to walk round the physical location while simultaneously moving through the virtual environment; jumping to points in the event chronology, and correlating the virtual evidence of the event spatially with their physical world view. [77] This could be considered, in a basic way, a form of augmented reality.[78]

Accuracy

Any forensic investigation begins with data collection: accuracy is crucial, because this data serves as the foundation for the evidence. At the scene, an investigator makes field measurements, rough scene sketches may be produced, and usually sets of photographs or video are taken. At a later stage, accurate plans of the scene are drafted and the information and evidence is collated in some sort of a visual format. The evidence taken from the scene is analysed by experienced and suitably qualified investigators and, finally, the investigators present their findings to a mixed audience of experts and lay people in a court.[79]

The technology used for collecting data and measurements ranges from tape measures and traditional surveying tools (still used by many private accident investigators), to Electronic Distance Measurement (EDM) technology (used by many police organisations), to three-dimensional laser scanners (used by many large forensic organisations and government agencies). Collecting the data digitally allows for the automatic generation of three-dimensional coordinate information of the scene that can be imported directly into a range of drafting and mapping software. These coordinates provide a reliable numerical data set for the creation of the geometry that is the foundation of any credible computer model or virtual reconstruction of a scene. If the virtual environment is created to a sufficient level of accuracy, then it may potentially be used to test hypotheses, such as to verify the location of a witness (especially where lines of sight around obstructions or hazards that are present in the environment may call into question the physical location of the witness) or perhaps to evaluate potential alternative bullet trajectories through the environment.[80]

Unlike the environment surrounding a road traffic accident or crime scene reconstruction where exact, surveyed measurements are usually available, pathology or medical visualisations are often based on descriptive post-mortem findings or approximate measurements. The use of generic anatomical computer models allows the recreation of dynamic events in which wounding or damage to a human body occurs. Such a reconstruction is, by its very nature, often dependent on the knowledge, expertise and opinion of medical experts.[81] Hence, in many of

[76] Machado, L.S., Morales, R.M., Souza, D.L., Souza, L. and Cunha, I.L. (2009), 'A framework for development of virtual reality-based training simulators', in Westewood, J.D. (Eds), *Medicine Meets Virtual Reality*, IOS Press, (2009); Tromp, J. and Schofield, D. (2004), 'Practical Experiences Of Building Virtual Reality Systems', *Proceedings of Designing and Evaluating Virtual Reality Systems Symposium*, University of Nottingham, UK; Schofield, D. (2009), 'Animating Evidence: Computer Game Technology in the Courtroom', *Journal of Information Law & Technology (JILT)*, 1.

[77] Schofield, D. (2007), 'Animating and interacting with graphical evidence: bringing courtrooms to life with virtual reconstructions', in: *Proceedings of IEEE Conference on Computer Graphics, Imaging and Visualisation*, Bangkok, Thailand, pp. 321–328.; Burton, A., Schofield, D. and Goodwin, L.M. (2005), 'Gates of global perception: forensic graphics for evidence presentation', in: *Proceedings of ACM Symposium on Virtual Reality Software and Technology*, Singapore, pp. 103–111; Schofield, D. and Mason, S. (2012), 'Using graphical technology to present evidence', in: Mason, S. (Ed.), *Electronic Evidence*, 3rd edn, LexisNexis Butterworths, pp. 217–253.

[78] Augmented Reality is defined as a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. A popular recent example is the Pokemon Go game (developed by Niantic for a range of mobile devices) where imaginary creatures are superimposed over views of the real world environment. For more information see Woodrow, B. (2015), *Fundamentals of wearable computers and augmented reality*, CRC Press.

[79] Burton, A., Schofield, D. and Goodwin, L.M. (2005), 'Gates of global perception: forensic graphics for evidence presentation', in: *Proceedings of ACM Symposium on Virtual Reality Software and Technology*, Singapore, pp. 103–111.

[80] Buck, U., Naether, S., Räss, B., Jackowski, C. and Thali, M. J. (2013), 'Accident or homicide–virtual crime scene reconstruction using 3D methods', *Forensic Science International*, 225(1), pp 75-84.

[81] Benali, L., Gromb, S. and Bou, C. (2013), 'Post-mortem imaging in traffic fatalities: from autopsy to reconstruction of the scene using

these cases, the advice of the expert is seen as crucial in creating a graphical representation that accurately matches the medical opinion. However, the potential inaccuracies involved mean that these reconstructions must be viewed cautiously and the uncertainty associated with the exact position of virtual objects must be explained to the viewer.[82]

Simulation

It should never be forgotten that a virtual simulation is by its very definition a 'simulation' of reality. In the context of the court, it is necessary to understand the nature of the simulation and the veracity of the representation – that is how close it is to the original evidence from which it was derived.

For example, the vehicle movement in a road traffic accident virtual simulation may be based on the same equations as used by an accident reconstruction expert witness. However, questions that arise include whether the virtual simulation applies them in the same way; whether the simulation works to the same level of accuracy; whether the simulation makes the same assumptions as the expert witness; and whether the visual representation provides a realistic and relevant portrayal of the simulation data.[83]

Narrative

The ability to move through time and along a chronology of events in the virtual environment may be potentially disorientating to many viewers. Most members of the general public are used to linear narratives (such as those in books or films), and may struggle to follow multiple narrative threads when faced with such a non-linear approach.[84]

Lighting

Consideration needs to be given as to how it is possible to correlate the lighting in the virtual world with that available at the scene at the time of the incident. It has to be determined whether an approximation is acceptable. Arguably, it might not be crucial in some cases, because only the line of sight might be under investigation, not the illumination, and hence the visibility, of the objects.[85]

Disneying evidence

The emotive nature of the visual media that is produced can support a hypothesis that one of the possible dangers of using computer-generated visual evidence is that they can be 'loaded' with emotive content that may have a prejudicial effect on the viewer.[86] This process of adding emotive content has been called 'Disneying-up' the evidence.[87]

The effect of the use of computer-generated graphical evidence in court

There are a number of concerns relating to the viewer's understanding of the visual evidence, based on the issues described above. These are identified and classified below. These are areas that should be considered whenever a computer-generated visualisation is to be used in a court.

Memory

Loftus has demonstrated that the memory of a witness to an event can be biased by a wide variety of seemingly inconsequential factors.[88] The results of Loftus's work can be extrapolated to predict that

freely available software', *International Journal of Legal Medicine*, 127(5), pp 1045-1049; Urschler, M., Höller, J., Bornik, A., Paul, T., Giretzlehner, M., Bischof, H. and Scheurer, E. (2014), 'Intuitive presentation of clinical forensic data using anonymous and person-specific 3D reference manikins', *Forensic Science International*, 241, pp 155-166.

[82] March, J., Schofield, D., Evison, M. and Woodford, N. (2004), 'Three-dimensional computer visualisation of forensic pathology data', *American Journal of Forensic Medicine and Pathology,* 25(1), pp 60-70; Maksymowicz, K., Tunikowski, W. and Kościuk, J. (2014), 'Crime event 3D reconstruction based on incomplete or fragmentary evidence material–Case report', *Forensic Science International*, 242, e6-e11.

[83] Grimes, W.D. (1994), 'Classifying the Elements in a Scientific Animation, Accident Reconstruction: Technology and Animation', SAE Paper No 940919, *USA Society of Automotive Engineers*, pp 39-404; Noond, J., Schofield, D., March, J. and Evison, M. (2002), 'Visualising the scene: computer graphics and evidence presentation', *Science & Justice* 42(2), pp 89–95.

[84] Craven, M., Taylor, I., Drozd, A., Purbrick, J., Greenhalgh, C. and Benford, S. (2001), 'Exploiting interactivity, influence, space and time to explore non-linear drama in virtual worlds', *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp 30–37.

[85] Hoang, R., Koepnick, S., Mahsman, J.D., Sgambati, M., White, C.J. and Coming, D.S. (2010), 'Exploring global illumination for virtual reality', *Proceedings of SIGGRAPH 2010*, New York, USA.

[86] O'Flaherty, D. (1996), 'Computer-generated displays in the courtroom: for better or worse?', *Web Journal of Current Legal Issues*, 2(4), pp 1–14; Bailenson, J.N., Balscovich, J., Beall, A.C. and Noveck, B.S. (2006), 'Courtroom Applications of Virtual Environments, Immersive Virtual Environments, and Collaborative Virtual Environments', *Law and Policy*, 28(2), pp 249-270; Fielder, B.S. (2003), 'Are Your Eyes Deceiving You? The Evidential Crisis Regarding the Admissibility of Computer-Generated Evidence', *New York Law School Law Review*, 48(1-2), pp 295–321; Girvan, R. (2001), 'An overview of the use of computer-generated displays in the courtroom', *Web Journal of Current Legal Issues*, 7(1), pp 1–80.

[87] Galves, F. (2000), 'Where the Not So Wild Things Are: Computers in the Courtroom, the Federal Rules of Evidence, and the Need for Institutional Reform and More Judicial Acceptance', *Harvard Journal of Law and Technology*, 13(2), pp 161–302.

[88] Loftus, E.F. (1996), *Eyewitness Testimony*, Harvard University Press; Loftus, E.F. (2003), 'Our Changeable Memories: Legal and Practical Implications', *Nature Reviews Neuroscience,* 4, pp 231-234.

computer-generated visualisations can possibly to lead to similar biases. Critical variables in such visualisations may include the representation of depth, speed, colour and distance. The question of how much detail or realism is needed in order for a visualisation to be effective (ie believable) is considered crucial. Object recognition studies have shown that outline drawings can often be just as effective as colour photographs,[89] but in other circumstances the interpretation of small details can be critical, such as the difference between an object being perceived as a gun or a stick, as was demonstrated in the case of Harry Stanley.[90] Critics of computer animated evidence contend that media displays can occasionally create false memories. Brian Stonehill, the director of media studies at Pomona College in Claremont, California is reported to have indicated that such animations can 'create pseudo-memories of an event' and the 'memorability of having witnessed the crime [or event in dispute] but [with] no validity in fact'.[91]

Attitudes

Research has found that when people believe they have a sufficient volume of evidence, they feel more confident about making judgments, even when the information is irrelevant.[92] Computer-generated visualisations can provide just such an illusion of sufficiency. Members of the public are often more comfortable with visual simulations over legal discourse, and hence the visualisations may be considered more believable. Many factors also influence the credibility of witnesses' testimony, such as the gender of a witness, their race, appearance, and socioeconomic circumstances.[93] A computer-generated visualisation based on witness testimony has the potential to cause members of the public to discount such factors. The anonymous and abstract nature of a well made computer generated reconstruction (one which takes into account the issues discussed in this paper) may help to remove any such bias or prejudice. On the other hand, a poorly made one may serve to emphasise any such differences.

Decision making

Research on group decision making has found that once a group starts a communal discussion, many social and linguistic biases are exhibited, such as group polarisation, production losses and Grice's maxims (which are a way to explain the link between utterances and what is understood from them).[94] Computer-generated visualisations can provide a shared memory or representation for a group of decision makers, such as members of a jury. Although this has the potential to reduce a number of social and linguistic biases, it is likely to increase others (for example, production loss). It is necessary to determine if the technology being used undermines critical reasoning; in other words, whether the display that is to be used supports or hinders decision making, and whether it affects the way in which members of a jury or witnesses interact. A reconstruction often contains uncertain or inferred data, which may need to be represented in order for it to be understood by the viewer.[95] The communication and collaborative process between individuals will also be affected by the type and extent of the display and will also determine content, in as much as it might affect the way groups reach decisions.[96]

Advantages and disadvantages of computer-generated graphical evidence in court

Many of the issues regarding the use of this technology affect the admissibility of the reconstructions as evidence, and can be expressed as a list of advantages and disadvantages.

[89] Biederman, I. and Ju, G. (1998), 'Surface vs. Edge-Based Determinants of Visual Recognition', *Cognitive Psychology*, 20, pp 38-64.

[90] CPS decision in Henry (Harry) Stanley case 20 October 2005, available online at https://www.cps.gov.uk/news/latest_news/153_05/.

[91] Cooper, C. (1993), 'Computer Animation on Trial', *The San Diego Union Tribune* (27 January 1993), E1.

[92] Darley, J.M. and Gross, P.H. (1983), 'A Hypothesis-Confirming Bias in Labeling Effects', *Journal of Personality and Social Psychology*, 44(1), pp 20-33.

[93] Nunez, N., McCoy, M.L, Clark, H. L. and Shaw, L. A., (1999), 'The testimony of elderly victim/witnesses and their impact on juror decisions: The importance of examining multiple stereotype's, *Law and Human Behavior,* 23(4), pp 413–423; Schuller, R.A., Terry, D. and McKimmie, B. (2005), 'The impact of expert testimony on jurors' decisions: Gender of the expert and testimony complexity', *Journal of Applied Social Psychology,* 35(6), pp 1266–1280; Wuensch, K.L. Campbell, M.W., Kesler, F. C. and Moore, C. H. (2002), 'Racial bias in decisions made by mock jurors evaluating a case of sexual harassment', *Journal of Social Psychology,* 142(5), pp 587–600.

[94] Grice, H.P. (1975), 'Logic and Conversation', in Cole, P. and Morgan, J.L. (Eds), *Speech Acts (Syntax and Semantics Volume 3*, Academic Press, pp 41-58.

[95] Goodwin, L. and Schofield, D. (2002), 'Visualising Uncertainty: Combining Evidence with Statistics', *Proceedings of Conference on Expert Evidence: Causation, Proof and Presentation*, Florence, Italy.

[96] Klein, G. (1989), 'Recognition-Primed Decision's, in Rouse, W.B. (Ed), *Advances in Man-Machine Systems Research,* 5, JAI Press: NY, pp 47-92; Lurie, N.H. and Mason, C. (2007), 'Visual representation: Implications for decision making', *Journal of Marketing*, 71, pp 160-177.

Advantages of computer-generated graphical evidence in court

In court, computer-generated displays are either substantive evidence (scientific or forensic animations, or simulation) or illustrative (a demonstrative visual aid). As technology advances, such displays are likely to become more prevalent, due to a number of perceived benefits:

(i) Such displays can provide an effective means of conveying complex evidence to the judge and jury. Visual memory has been found to be highly detailed and almost limitless, in contrast with memory for verbal material.[97] Forensic animations and virtual reconstructions have the potential to improve a viewer's ability to retain complex spatial and temporal data and hence increase the potential comprehension of complex evidence by members of a jury.

(ii) Visual media can provide an increase in the attention span of the viewer, since human attention is naturally drawn to animated images. Moving objects rank top on the hierarchy of methods to draw attention, which covers actions, objects, pictures, diagrams, the written word, and the spoken word.[98] A modern audience will more readily engage with audio-visual forms of communication, rather than relying solely on verbal modes of discourse. This increased attention can potentially lead to the triers of fact (in particular, members of a jury) studying this visual evidence more intently than more traditional (predominantly oral or textual) forms of evidence.[99]

(iii) Computer displays can also act to help persuade members of a jury. Studies comparing oral, textual, and static visual presentations to computer animated presentations containing the same information found the animations to be more memorable.[100] This has implications not only for the retention of information, but also the weight given to the evidence by the member of a jury or other trier of fact.[101] Also, visual, rather than verbal information, more readily activates the formation of an impression.[102]

(iv) Digital displays also have the ability to provide the presenter with an improved illustration of their arguments; evidence can be retrieved instantaneously during a presentation, and the display can be manipulated for better vantage points. The person using the display can 'zoom in' to an item of evidence, pull apart a piece of machinery or present a crime scene from the point of view of a significant witness.[103]

(v) Such computer-generated displays may improve efficiency in the court, thus saving court time, as arguments and complex information are understood at a faster pace. The increase in efficiency because of the use of graphical display technology is a factor of the potential improvements in the speed with which complex information can be imparted to an audience, which therefore may shorten the length of a trial. However, poorly created virtual reconstructions may also be responsible for causing confusion, and cause an increase in the length of a trial.[104] This saving of court time can potentially lead to a reduction in costs. Some authors report that the technology can save between a quarter to a third of the time taken for a traditional

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[97] Chapman, P. (2005), 'Remembering What We've Seen: Predicting Recollective Experience from Eye Movements When Viewing Everyday Scenes', in Underwood, G.D.M. (Ed), *Cognitive Processes in Eye Guidance,* Oxford University Press, pp 237-258.
[98] Drummond, M.A. (1999), *Courtroom Persuasion: Eight Keys to Success*, Institute for Continuing Legal Education, Loyola University.
[99] Worring, M. and Cucchiara, R. (2007), 'Multimedia in forensics', *Proceedings of the 17th ACM International Conference on Multimedia*.
[100] Seltzer, R.F. (1990), 'Evidence and Exhibits at Trial', 387 *PLI/Lit* 371; Cobo, M.E. (1990), 'A Strategic Approach to Demonstrative Exhibits and Effective Jury Presentations', 3 *PLI/Lit* 359; Krieger, R. (1992), 'Sophisticated Computer Graphics Come of Age—and Evidence Will Never Be the Same', *Journal of the American Bar Association* (December), pp 93-95; Thomas, R.D. (1997), *Computer Re-Enactment*, available online at http://www.pimall.com/nais/n.reenact.html.
[101] Yale, D. (1996), 'Computers on the Witness Stand: Expert testimony that relies on data generated by computers in the age of Daubert', available online at http://www.dcyale.com/law_papers/daubert.html; Feigenson, N. and Spiesel, C.O. (2009), *Law on Display: The Digital Transformation of Legal Persuasion and Judgment*, NYU Press.
[102] Brewer, M.B. (1998), 'A Dual Process Model of Impression Formation', in Wyer, R.S. and Srull, T.K. (Eds), *Advances in Social Cognition Volume 1,* Psychology Press, pp 1-36.
[103] Schofield, D. (2011),' Playing with evidence: using video games in the courtroom', *Journal of Entertainment Computing (Special Issue: Video Games as Research Instruments),* 2(1), pp 47-58.
[104] Devine, D.J., Clayton, L.D., Dunford, B.B., Seying, R. and Pryce, J. (2001), 'Jury decision making, 45 years of empirical research on deliberating groups', P*sychology Public Policy, and Law*, 7(3), pp 622–727.

trial.[105] However, it should be noted that part of this saving comes at the cost of increased pre-trial preparation, which may involve the assistance of additional staff or technology vendors and consultants.

Disadvantages of computer-generated graphical evidence in court

Despite the many benefits of using computer-generated visualisations in court, there are a number of potential dangers and disadvantages:

(i) The very fact that computer-generated visualisations impress themselves on the memory, and are persuasive and convincing, is also their greatest disadvantage: they can leave a strong impression on viewers. Moving images tend to mesmerize, and they can relax an individual's natural critical nature. This means that viewers are inclined towards a 'seeing is believing' attitude, as they do with television, potentially reducing the standards expected of the evidence.[106] Simulations can assume a 'hyper-real' character that eclipses the significance of the reality.[107] Small alterations to a computer-generated representation can have a substantial effect on the impression it gives. For example, judgments of speed and recklessness are critical in determining responsibility for road accidents.[108] A driver traveling at speed may seem to be reckless if the animation includes young children near the road, but reasonable if adults are represented. Hence, apparently innocuous decisions about virtual object representation are often critical.[109]

(ii) Similarly, the appearance (and visual effect) of the virtual environment in a reconstruction depends largely on small details such as textures, foliage and litter among other items. Without guidelines or knowledge of the relevant factors, it can be surprisingly easy for a forensic modeller or animator to present a location as either a likely or unlikely location for a crime or accident based on small, seemingly insignificant details. Atmosphere, lighting, colour saturation and the camera configuration (lens, camera angle) will also all have some effect on the viewer.[110]

(iii) Another possible disadvantage of such visualisations is the potential prejudicial effect of not using the technology. A party deciding to present a case without the use of visual aids such as those described in this paper may be prejudiced by the use of such technology by the other side. The use of computer-generated displays (by either side) may, however, assist in achieving early settlement, thus avoiding the time and expense of a drawn-out court hearing.[111]

(iv) It is often difficult to represent uncertainty in computer-generated evidence. Viewers often wrongly believe there is little or no margin of error in evidence presented using a forensic animation or virtual simulation.[112] Research undertaken at the University of Nottingham has examined how to visualise uncertainty and provide non-prejudicial representations of uncertain evidence. As an example, consider the uncertainty that is inherent in vehicle speeds when calculated for traffic accident reconstructions.[113] The police calculate vehicle speed ranges (not single speeds),

[105] Lederer, F.I. (2004), 'Courtroom technology: for trial lawyers, the future is now', *Criminal Justice*, 19(1), pp 14–21.

[106] Loftus, E.R. and Loftus, G.R. (1980), 'On the permanence of stored information in the human brain', *American Psychologist*, 35(5), pp 409–420; O'Flaherty, D. (1996), 'Computer-generated displays in the courtroom: for better or worse?', *Web Journal of Current Legal Issues*, 2(4), pp 1–14.

[107] Habermas, J. (1996), *The Structural Transformation of the Public Sphere,* MIT Press; Baudrillard, J. (1994), *Simulacra and Simulation*, University of Michigan.

[108] Chapman, P., Cox, G. and Kirwan, C. (2005), 'Distortions of Driver's Speed and Time Estimates in Dangerous Situations', in *Behavioural Research in Road Safety: Fifteenth Seminar*, Department for Transport, pp 164-175; Lawrence, C. and Richardson, J. (2005), 'Gender Based Judgements of Traffic Violations: The Moderating Impact of Car Type', *Journal of Applied Social Psychology*, 35(8), pp 1755-1773.

[109] Nichols, S., Haldane, C. and Wilson, J.R. (2000),' Measurement of Presence and Side Effects in Virtual Environments', *International Journal of Human-Computer Studies* 52(3), pp 471-491.

[110] Schofield, D., Noond, J., Goodwin, L. and Fowle, K. (2001), 'Accident Scenarios: Using Computer-generated Forensic Animations', *Journal of Occupational Health and Safety – Australia and New Zealand*, 17(2), pp 163-173.

[111] Lederer, F.I. (2004), 'Courtroom technology: for trial lawyers, the future is now', *Criminal Justice*, 19(1), pp 14–21.

[112] Goodwin, L. and Schofield, D. (2002), 'Visualising Uncertainty: Combining Evidence with Statistics', *Proceedings of Conference on Expert Evidence: Causation, Proof and Presentation*, Florence, Italy; Hussin, N., Schofield, D. and Shalaby, T.M. (2004), 'Visualising information: Evidence analysis for computer-generated animation (CGA)', in *Eighth International Conference on Information Visualisation* IV, London, UK, pp 903–908.

[113] Goodwin, L. (2007), *Visualising Vehicle Accidents: Evidence Uncertainty, Presentation and* Admissibility, PhD Thesis, University of Nottingham.

drivers remember their own speed and witnesses may report a different speed, yet only one single speed value (usually an average) will typically be represented in any individual animated or virtual reconstruction of the vehicle accident.[114]

(v) The flexibility of a computer-generated display also implies that they inherently contain the potential for tampering. Admissibility does not equate with sufficiency, and the public's general knowledge that filmmakers can use computers to resurrect dinosaurs and create alien landscapes make allegations of digital alteration a potentially major issue when it comes to weight.[115] Hence, it is highly recommended that all computer-generated visual evidence should include a comprehensive audit trail and an expert report. The expert witness presenting such evidence must also be able to prove the accuracy of their reconstruction, both with reference to the original data used to reconstruct the incident, and to validate the development stages of the visualisation itself.[116]

(vi) A party may intentionally create an animation or simulation that provides a favourable perspective to support a particular hypothesis, or unintentionally choose a viewpoint, perspective, illumination model or colour scheme that alters the appearance of the animation to work against the same hypothesis. This could create bias in the trier of the fact, whether that is conscious bias (a form of evidence tampering) or subconscious bias.[117] The ability to change the perspective of a virtual camera, the use of slow motion and stop-action in displays, or the alteration of the colour palette of a display – all give the potential to portray the events being simulated in a tainted light. Forensic animations and the creators of virtual reconstructions can learn much from the work of film and media theorists who continually strive to define the nature and functions of the media in which they work, particularly in relation to viewer perception and engagement. By studying how film makers elicit emotion from a viewer by manipulating lighting, camera angles, editing and such like, a forensic animator or reconstructionist can 'reverse engineer' the process and attempt to remove all such emotive content from evidential graphics.[118]

Recommendations regarding the use of computer-generated graphical evidence in court

By their very nature, any recommendations and guidelines formulated are likely to be broadly defined and generic. Many of the recommendations offered below are little more than general suggestions that users of the technology be aware of these issues when involved in developing the types of forensic animations and virtual reconstructions described in this paper. Unfortunately, many of these recommendations have been ignored in the past when such technology has been used, and this may have been a contributing factor to the admissibility problems encountered when using this technology in certain jurisdictions.

Field of view

Designers of virtual environments ought to study film-making techniques for two reasons. First, to be able to achieve the same effects as a film-maker; perhaps getting the viewer to identify emotively with a particular character in a reconstruction to enhance the power of the message. More importantly, an animator or reconstruction engineer may wish to eliminate these effects and to remove the emotive content to provide an objective, understandable view of a forensic data set, with no distracting emotive attachment. An awareness of the ways in which the viewer can be manipulated (for example, through the use of egocentric and exocentric viewpoints) is essential.

[114] Goodwin, L. and Schofield, D. (2002), 'Visualising Uncertainty: Combining Evidence with Statistics', *Proceedings of Conference on Expert Evidence: Causation, Proof and Presentation*, Florence, Italy.
[115] Lederer, F.I. (2004), 'Courtroom technology: for trial lawyers, the future is now', *Criminal Justice*, 19(1), pp 14–21.
[116] Schofield, D. (2009), 'Animating Evidence: Computer Game Technology in the Courtroom', *Journal of Information Law & Technology (JILT)* 1 (2009).
[117] Selbak, J. (1994), 'Digital Litigation: The Prejudicial Effects of Computer-Generated Animation in the Courtroom', *Berkley Technology Law Journal*, 19(9:2).
[118] Porter, G. (2007), 'Visual culture in forensic science', *Australian Journal of Forensic Sciences* 39(2), pp 81–91; Schofield, D. (2007), 'Animating and interacting with graphical evidence: bringing courtrooms to life with virtual reconstructions', in: *Proceedings of IEEE Conference on Computer Graphics, Imaging and Visualisation*, Bangkok, Thailand, pp. 321–328.

Interaction and resolution

Careful thought needs to be given to the enabling technology; it is necessary to know how the user will interact with any virtual simulation created. For example, the best mechanism for a particular case could be to deliver a spatially contextualised evidence visualisation to a user's personal device (a mobile telephone or smartphone) as they traverse the actual scene. Alternatively, a complex forensic data set with many spatially interlinked evidential items may be best utilised as a shared viewing experience on a large screen in the court.

Modes of representation

Developers need to be aware that three-dimensional virtual reconstructions are not a panacea solution to all visualisation requirements – they are not ideal for representing every case. Any developer should adopt a holistic, multi-modal visualisation approach using appropriate technology (whether that is text, photography, video, computer graphics etc) for the particular type of material and evidential content to be displayed.

Effect of the media

Most interactive three-dimensional virtual environments have the capacity to allow the user to interact with a range of digital media (often using spatially context sensitive hotspots – which usually consist of clickable links connecting objects in the virtual world to other evidence such as photographs). It is necessary to be aware of the effect that the particular form of media being displayed will have on the viewers, and also to have an appreciation of the context in which it will be experienced by the user. The pedagogical effect of transitions between the forms of media should be considered. For example, switching between a virtual, rendered image of a crime scene and a real crime scene photograph may cause confusion in the viewer as they attempt to correlate evidence between the different forms of media.

Audio

The integration of sound into the virtual world is often overlooked or added as an afterthought. Very few virtual developers are also qualified as or competent at being sound engineers. Effective audio soundtracks can add new dimensions to the viewer's media experience. The addition of an audio track can be a positive alteration to the virtual environment, providing an increased understanding of events or it can be distracting, adding unnecessary emotional context.

Abstraction

Careful use of visual metaphors is essential. Thought needs to be given to each abstract data representation in the environment and how the potential audience will perceive it. Experience and literature from disciplines such as psychology, cultural and critical theory, visual media, art history, education and such like can inform how abstract (and realist) representations are interpreted by the viewer. This in turn provides for what the viewer remembers and understands from the evidence presented to them. As a simple example, imagine a forensic animation showing the rising temperature in a building during a fire – the dangerous parts of the building could be represented by a red colour. However, although red in Western culture (European and North American) represents danger and heat, in Eastern and Asian culture it is associated with joy and weddings, and in some parts of Africa it represents good fortune.

Navigation and interface

Many interactive virtual simulations have complicated navigation systems (often based on computer game style controls) that may add an extra layer of complexity to the data the users are trying to comprehend, rather than augmenting their understanding. Careful thought should be given to the options that will be made available to the user. If control is to be passed to the viewer, then it may be better to restrict their movement and control in the virtual environment (for example between set points) rather than allow them to become potentially 'lost' in the data or environment.

Behaviour

It is important that the developers of these virtual environments have an understanding of the processes and events being simulated (whether this is vehicle movement, bullet trajectories or human anatomy). The developers must be aware of the veracity and realism of the simulation – that is, the accuracy of the model. Also, it is important that if decisions are to be made based on the simulation, then it is necessary that information is made available to the court that explains how the simulation works and details of the underlying mathematical model.

Narrative

In an interactive simulation, the user may often take control of the narrative, altering the chronological presentation of information, and choosing which information they see at which time. This can easily become confusing to the viewer, particularly to those used to linear narratives in other media (for example, novels and films). Developers should produce a guide to the interactions in their environments and be aware (through user testing) of how the users are able to interact with the data and any possible unexpected interpretations that may result.

Lighting

It is very rare that light meters would be installed in the location of a scene, measuring the intensity of the illumination at a particular moment, thus allowing the designer of a virtual world to replicate exactly the luminosity in the virtual environment at the time of the incident. In many cases, it is possible to argue that this is not an issue, because the lighting may not be crucial to the viewing of the incident. However, taking into account how much effort is put into lighting a Hollywood movie to achieve a particular effect on the viewer, it is possible to grasp the enormous effect that the lighting of a virtual environment may have.

Testing

It is axiomatic that a reconstruction should be tested before it is released. It is common knowledge that a number of court visualisation systems have often received limited user testing before their release.

Skills

The ability to manipulate, operate and professionally utilise the technology needed to present advanced visual media in a court is a skill that a number of lawyers do not possess. If a lawyer wishes to use this technology, they must master this skill or use an outside vendor or expert. Lawyers must practice and rehearse their court presentations. The use of this type of technology requires perceptive construction, because a number of issues only come to light when the media are viewed on a large screen in the court. For example, the brightness may be too low, or the colours on the image that is projected may be different to how they appeared on a small monitor, or the resolution of the display may make some objects difficult to see. As with any technology, it is important to be aware that it has the potential to fail. There is no substitute for extensive testing, repeated rehearsals, and a back-up must always be in place.

Introducing computer-generated graphical evidence into legal proceedings

This section does not reflect the full gamut of issues the lawyer must consider when either seeking to adduce computer generated animations and simulations into proceedings, or when resisting the admission of such material. It cannot be over-emphasized that the leading text is that written by Gregory P. Joseph [119] Although Joseph only deals with the position in the United States of America, nevertheless his text provides incomparable guidance for lawyers across in the world on this topic. The discussion below is merely an outline.

Although animations and simulations are discussed in detail above, nevertheless, it is pertinent to make the observation that the distinction will not always be clear-cut, as observed by Katz J in the case of *State of Connecticut v Swinton*:[120] ‘Not only can we not anticipate what forms this evidence will take, but also common sense dictates that the line between one type of computer generated evidence and another will not always be obvious.’ Gregory offers a checklist of factors for the trial judge to consider before admitting computer-generated evidence into the proceedings.[121] They include the issues set out below.

The factual foundation

The factual foundation comprises three aspects: admissibility; the provision to use such evidence either by virtue of the relevant procedural rules or as provided for in statute, or both; and demonstrating the suitability of the animation or simulation by reference to the underlying evidence from witnesses, and whether there is sufficient witness testimony to admit the animation or simulation, which in turn will depend on the certainty or otherwise of the witness statements.

The underlying scientific or technical theory

The party wishing to adduce evidence of a computer animation or simulation will be required to provide evidence of the underlying mathematical model used in preparing the effect, together with the factual

[119] Joseph, G.P. (2009), *Modern Visual Evidence*, Law Journal Seminars Press.
[120] 847 A.2d 921, (Conn. 2004) at 938 [11].
[121] Joseph, G.P. (2009), *Modern Visual Evidence*, Law Journal Seminars Press, paras 7.01[4][c] and 8.03, 8.05.

premise upon which the effect is predicated. In addition, it will be necessary for the expert introducing the evidence to explain their opinion at the preliminary stage in order for the trial judge to decide whether the evidence of the animation or simulation, together with the opinion of the expert, embraces the ultimate issue to be decided. Consideration also ought to be given where the animation or simulation is accompanied with the recording of a narrative. Such a recording is an extrajudicial statement, and it must be determined whether the narration is to remain, or whether the narration is to be excluded.[122]

Authenticity of the simulation

The main difference between simulations and other forms of evidence generated by computers is the simulation model used, which means it is important to pay attention to demonstrating or undermining, whichever the case may be, the reliability and trustworthiness of the model. Apart from the normal considerations that are relevant to the authentication of computer evidence generally, Gregory has listed a number of issues that ought to be the subject of testimony:[123]

> '(1) that the model appropriately measures the factors that have been selected to represent the real life system;
>
> (2) that those factors are relevant and inclusive of all important aspects of the system;
>
> (3) that the mathematical techniques selected for constructing the model are appropriate so that the model actually performs the functions it was intended to perform;
>
> (4) that the mathematical tools are appropriately applied; and
>
> (5) that the problem at issue was appropriately translated into mathematical symbols comprising the model.'

The degree of reliability has been the subject of comment in the United States, and although the level of reliability may be variable, a degree of reliability that is consistent with the current state of the art in the modelling techniques used needs to have been applied.[124] In practical terms, where a simulation of a road traffic accident is presented, for instance, consideration ought to be given to the authenticity of the representations of physical objects, such as the road surface.

Prejudicial effect

In criminal cases in particular, the trial judge will be required to balance the probative value against the prejudicial effect of the evidence proffered during the trial within a trial. On the matter of probative value in the context of facial mapping,[125] Steyn LJ observed in *Clarke (Robert Lee)*[126] that 'the probative value of such evidence depends on the reliability of the scientific technique (and that is a matter of fact), and it is one fit for debate and for exploration in evidence.' There is always a concern that the simulation may have the effect of being overly persuasive to the members of a jury.[127]

The use of computer-generated simulations and animations can be very effective in helping the trier of the facts reach a decision. The matters set out in this section also apply to other forms of digital evidence, such as computer-enhanced photographic images, the product of digital photography and enhanced videotapes. Whatever the form of the computer-generated evidence that a party seeks to adduce, careful consideration ought to be addressed with respect to the underlying authenticity and reliability of the techniques used to generate the evidence. Finally, an assertion by the opposing party about the ease by which digital evidence can be altered or

[122] Campbell, K. L., Jones, L. A. and Datny, D. B. (2013), 'Avatar in the Courtroom: Is 3D Technology Ready for Primetime?'. *FDCC Quarterly*, 63(4), pp 295.

[123] Joseph, G.P. (2009), *Modern Visual Evidence*, Law Journal Seminars Press, para 8.03[2][b].

[124] Joseph, G.P. (2009), *Modern Visual Evidence*, Law Journal Seminars Press, para 8.03[2][b] for cases, and para 8.03[3] for a list of the types of illustrative simulations that have been used and some of the problems identified.

[125] For cases involving the use of techniques relating to facial mapping when CCTV footage is of poor quality from England & Wales, see: *R v Grey* [2003] EWCA Crim 1001; *R v Gardner* [2004] EWCA Crim 1639, 2004 WL 1808904; *R v Stubbs* [2002] EWCA Crim 2254, 2002 WL 31413980; *R v Buckland* [2007] EWCA Crim 1639, 2007 WL 1942806; *R v Mulgrew* [2008] EWCA Crim 1375. For facial mapping in relation to establishing identity, see *Beckett v Secretary of State for the Home Department* [2008] EWHC 2002 (Admin). For a discussion respecting the nature of the expert witness and facial mapping with the discussion of relevant case law, see *Atkins and Atkins v R* [2009] EWCA Crim 1876. For the admissibility of such evidence, see *A-G's Reference (No 2 of 2002)* [2003] 1 Cr App R 321. For judicial pronouncements of the reliability of facial mapping, compare *R v Bonython* (1984) 38 SASR 45 to *R v Ciantar* [2005] EWCA Crim 3559.

[126] [1995] 2 Cr App R 425 at 431F.

[127] For a critical analysis of video tape evidence, see: Elliott, D.W. (1998), 'Video Tape Evidence: The Risk of Over-Persuasion', *Criminal Law Review*, pp 159-174; Feigenson, N. and Spiesel, C.O. (2009), *Law on Display: The Digital Transformation of Legal Persuasion and Judgment*, NYU Press.

manipulated is not a sufficient claim to prevent the proponent of the evidence from adducing it. If the opponent cannot offer an objection of substance that acts to undermine the methods by which the authenticity of the evidence has been preserved, it is questionable as to whether the objections of the opponent are meritorious.

Concluding remarks

For many lawyers, the crux of any case is the presentation of information to the finder of fact, whether in the form of an opening statement, evidence or closing argument. Burns sums up the need for a clear presentation of evidence by an expert (forensic):[128]

> 'The presentation typically takes the form of a report, and the scientist must be prepared to explain this report in such a way that a typically science-phobic judge and jury are able to comprehend it. Presentation is everything.'

The unavoidable future for courts across the world is the introduction of technology; this technology could be merely electronic filing and teleconferencing, but is likely, depending on the level of damages that might be awarded, to encompass many forms of computer-generated evidence presentations, such as forensic animations and virtual reconstructions. As computer-graphics based technologies continue to evolve, this will inevitably lead to improvements in the realism of evidential forensic animations and virtual simulations. This could, in turn, result in jurors and triers of fact experiencing a greater depth of immersion when viewing and experiencing the incident within the virtual world. This could also potentially lead to a corresponding increase in their acceptance or belief in the hypotheses being presented; and conversely also result in a rise in any associated possible prejudice caused by the visual media.

In conclusion, lawyers and expert witnesses should endeavour to ensure that any virtual evidence presentation produced accurately reflects the scientific data available and augments the testimony of the witnesses. However, to be effective, the evidence must not only tell 'the story' but also be understood easily. To that end, forensic scientists and media specialists must strive continuously to develop new and creative ways to present complex evidence. As a technology for displaying evidence, forensic animation and virtual reconstructions have the potential to have an important effect on many future cases as the technology and the forensic and legal communities develop.

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[128] Burns, D.C. (2001), 'When used in the criminal legal process forensic science shows a bias in favour of the prosecution', *Science and Justice*, 41(4), pp 271–277.