Noond, J., Schofield, D., March, J. and Evison, M. (2002). Visualising the scene: computer graphics and evidence presentation. *Science and Justice*, **42(2)**, 89-95. **DOI:** 10.1016/S1355-0306(02)71804-2

“Visualising the Scene”

“Computer Graphics and Evidence Presentation”

Mr. J. NOOND [1], Dr. D. SCHOFIELD [2], Mr. J. MARCH [3], Dr. M. EVISON [4]

AIMS Research, SChEME, The University of Nottingham, University Park, Nottingham NG7 2RD, UK.

Keywords: Computer Graphics, Virtual Reality, Litigation Graphics, Crime Scene

This paper will introduce and discuss techniques that utilise new developments in Computer Graphics (CG) and Virtual Reality (VR) for evidence presentation applications.

Abstract

In the UK forensic animations are becoming an increasingly important visual aid in courtroom situations, where complex data relating to a sequence of events is being visualised before a general public who may have little or no understanding of established forensic procedure or methodology. This paper will introduce and discuss a spectrum of new technologies that utilise new developments in Computer Graphics (CG) and Virtual Reality (VR) for a range of incident investigation and presentation scenarios.

Introduction

In any incident scenario there are a vast range of complex parameters that both investigators and forensic animators have to deal with. No matter how coherent and formalised the data transfer is between the two parties involved, there will always be conjecture and debate as to how the information is not only visualised, but also presented in a legally admissible and meaningful way to jurors and legal professionals. It is evident that no matter how much the speed and power of computers develop, the issues surrounding the interpretation of results remain open to debate. Moreover, it is important to recognise that CG are only the current manifestation of graphical visualisation in a long history of litigation graphics, and that using any new visualisation medium has always had to establish and win precedent in a legal context. CG presents in a visual manner real scenarios that are based on scientific methodologies, as well as depicting a witness perception of what may have occurred at a given time and location. More meaningfully, CG can also explore and illustrate “what if” questions and expose the inconsistencies and discrepancies within evidence and expert witness results and testimony. Therefore CG is an important development in the history of litigation graphics that is unparalleled in its approach and ability to assimilate and correlate witness testimony, expert data and forensic procedure.

Researchers from the universities of Nottingham and Sheffield have been involved in pioneering new methodologies that utilise both CG and VR for incident investigation and courtroom presentation in the UK and abroad. A number of innovative training applications have also been developed using VR technology. This paper will include several examples from real cases and research projects utilising CG and VR produced by the research.

Technology

‘Computer Graphics’ or ‘CG’ refers to a suite of computer applications that can be used to produce images and animations. CG utilise numerical three-dimensional (3D) models of real world objects to create artificial environments. Computer technology is employed to build an animation of these environments frame by frame (a series of still images), that, when played back in quick succession, create an experience of space, motion and time. Popular cultural examples of this technique include animated movies such as “Shrek”, and special effects scenes from “The Matrix".

Software companies have kept pace with advances in hardware technology by developing packages that exploit the increased computational power of computers. In a commercial context, versions of graphical applications that would have needed super computers a few years ago will now install and run on a contemporary Personal Computer (PC). In a professional setting many workers are now familiar with, for example, 3D Computer Aided Design (CAD) systems and many use them routinely in their work place.

Based on scene survey data, the courtroom presentation of evidence using CG will visualise the accurate position of objects such as vehicles, environment details, landscape features and other relevant evidence items within the 3D environment. All scene objects are scaled precisely, and can be texture mapped with relevant images to produce credible lifelike appearances. The facility to visualise and then explore a crime scene utilising CG enables investigators and jurors to comprehend the important and underlying issues within that scene.

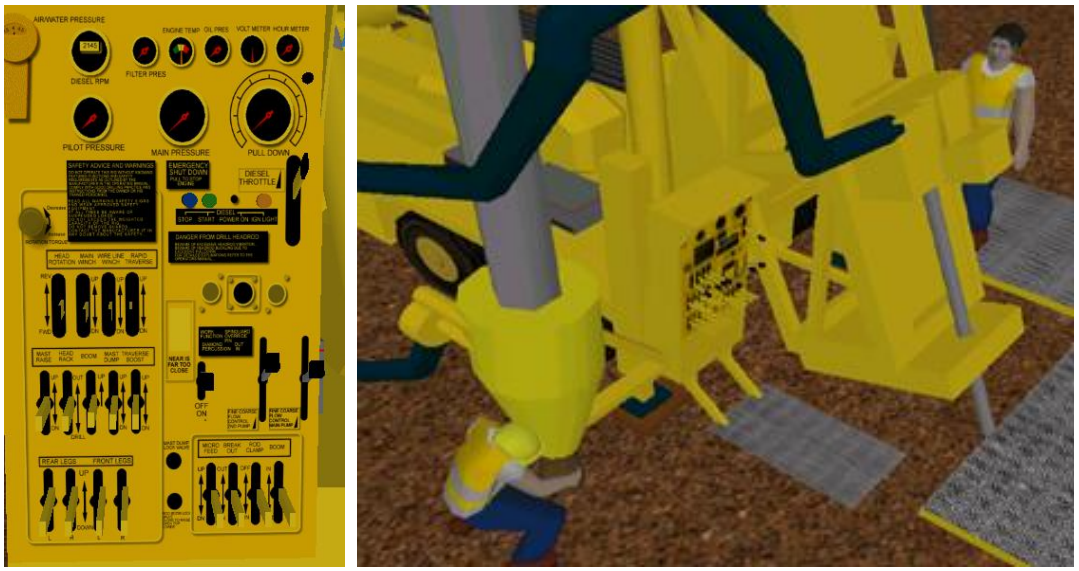

Figure 1: Images from a virtual drill rig training system developed by AIMS Research

'Virtual Reality' or 'VR' is an interactive real-time 3D graphical environment that responds to user input and action, such as moving around the virtual world or operating virtual equipment. These 'worlds' allow the user to explore a range of numerical models including sophisticated CAD engineering models, or allow interaction with a scientific simulation, or allow a view into a 3D information database [1]. An important aspect of VR is its underlying processes, simulations, behaviour and reactions, and the way users interact with objects within the world. A virtual reality user can, for example, sit in a virtual vehicle

and drive it. The virtual vehicle will respond to the driver's input and behaviour causing other vehicles in the world to respond to those inputs as in the case of a collision.

Recent and rapid developments in PC technology and the huge potential market for desktop VR have created a climate where novel applications have emerged. The home computer games market has driven the development of software tools for the creation of 3D environments alongside specialist 3D graphics accelerator boards and input/output (I/O) peripherals for PC games systems. Whilst much of the development is for the leisure industry, there are real industrial applications being developed under rigorous guidelines [2].

Examples of VR based training exist in other sectors; anyone who has flown in a large passenger aircraft has entrusted his or her life to a pilot who has been trained with the assistance of a VR simulator. These techniques that have been developed over a number of decades in industrial sectors are now available on a PC and can be adapted for a whole range of training and visualisation applications. These types of VR systems can offer major advantages over other visualisation media due to the real-time visual and interactive nature of the experience they create, which can lead to increased memory retention.

Investigation

Traditionally at a scene investigators make field measurements, produce rough field sketches, take sets of photographs and then later draft up plans of the scene and collate the information. The evidence from the scene is analysed by experienced and suitably qualified forensic investigators. Finally, the investigators present their findings in a clear and precise manner in the courtroom, to a mixed audience of experts and lay people. The evidence must augment the testimony of the witnesses and reflect accurately the forensic data available. However, to be effective, the evidence must not only tell "the story" but also be understood easily. To that end, forensic investigators must strive continuously to develop new and creative ways to present complex evidence.

Electronic Distance Measurement (EDM) technology, such as a Total Station, automatically generates 3D coordinate information that will allow a forensic modeller to view a recorded scene in 3D directly via drafting software. These 3D coordinates provide a reliable numerical set for the further visualisation of the geometry that is the foundation of any credible 3D computer model of a scene. The total environment surrounding the scene may be included within the model. For example, an animation may

not only show the location of a murder weapon, but also the position of this item in relation to nearby houses or other environment features, and place this item within a time frame of scene activity. As seen in the CG used for film and television, the realism in these 'virtual' environments is increasing. As computer-processing power increases and software tools develop we envisage the same level of realism increasing within the computer-generated environments used within an evidential context. It is important to remember and consider the pertinence of portraying scene events, which are derived directly from recorded evidence, in an accessible and visual manner to a jury.

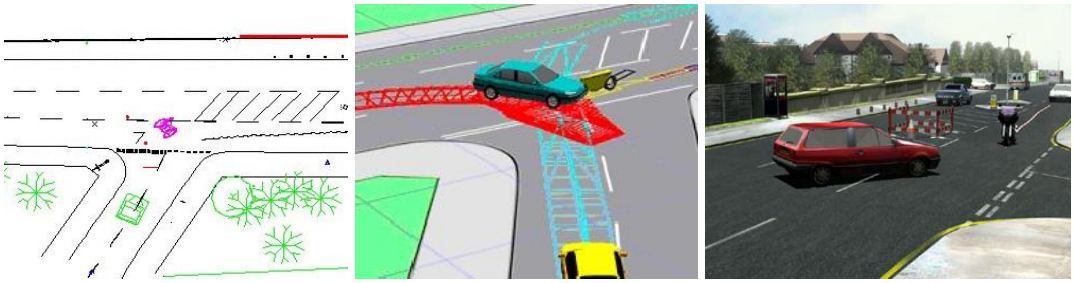

Figure 2: The progression from two-dimensional CAD data to three-dimensional reconstruction

Animated CG are an accurate and effective method of reconstructing and visualising how an event occurred, or to present possible alternative scenarios. They are accessible to a viewer as any animation has the potential to portray a real life event. Also, recreating the incident environment with CG may be useful since the site of the incident may have changed since the time of the event. Similarly, the removal or masking of prejudicial items within that environment may be desirable.

Use of Forensic Animations in the USA

Although CG evidence has only just started appearing in UK courts, relevant case law from the US and other jurisdictions may be referenced for admissibility requirements. This is particularly true for forensic animations, which by American standards are substantive evidence and thus more complex to admit to trial.

CG evidence must pass through a set of criteria before being admitted as evidence in US courts due to potential bias and unfairness, particularly with reference to animations or simulations. CG evidence is frequently used to explain a broad range of subject matter, in many criminal cases as well as civil cases of personal injury, product liability and patent infringement. The issues in question may be extremely complicated and difficult to explain to the court without some form of graphical representation. A survey by the American Bar Association (ABA) found that jurors are often confused, bored, frustrated and/or

overwhelmed by technical issues or complex fact patterns [3]. Other research indicated that the attention span of the average juror is seven minutes [4]. This illustrates the need to reduce lengthy explanations that use charts and diagrams alone.

There are three main perceived benefits to using Computer-Generated (CG) displays in the courtroom:

- Firstly, they aid in jury and judge understanding, as they provide an effective means of conveying evidence to the judge and jury. As the complexity of the issues presented to a jury increases, the amount of interest, comprehension, and retention will decrease [5]. According to the ABA, jurors are 650 percent more likely to retain information when oral arguments are combined with visual presentations during a trial [6].
- The second perceived benefit is that CG displays can be a tool of jury persuasion. A study comparing static visual presentations to computer animations of the same information found the computer animations to be much more persuasive. This implicates not only retention, but also the weight given to the evidence by the juror. According to research, people are twice as likely to be persuaded if the arguments are supported by visual aids [7].
- The third benefit is that CG displays provide the presenter with a better illustration of their arguments; relevant documents and exhibits are easier to find, evidence can be retrieved instantaneously during a presentation, and the display can be manipulated for better vantage points (for example, one can ‘zoom in’ to an item of evidence or possibly see it from another viewpoint).

Despite these benefits, as with any other form of graphic evidence, CG displays may be misused in court, and the consequences of this cannot be underestimated. The persuasive power of CG displays is also their greatest disadvantage; they leave a strong impression on jurors, they tend to mesmerise, and they relax an individual’s natural critical nature. Jurors are inclined to have a “seeing is believing” attitude, as they do with television [5].

Use of Forensic Animations in the UK

The use of forensic animation in the UK is still in its infancy. Reasons quoted for the slow progression of CG evidence in UK courtrooms include a lack of skills, or simply tradition [8] or that lawyers (who may not be highly trained in computer operation) perceive an air of mystery about the use of computers and await a ‘scientific foundation’ for courtroom use [9].

The first forensic animation utilised within the UK was during a Crown Court criminal case involving a road traffic accident. This animation was generated by PC Mike Doyle of the West Midlands Police Crash Investigation and Training Unit. Since then a number of forensic animations have been admitted to UK courtrooms [10].

An important case, in which the authors of this paper were involved, concerns an accident that occurred in the West Midlands in 1999. The animations that were produced from survey data were used extensively in a Walsall Coroner's inquest in helping to establish the events that lead up to the death of two motorcyclists. The animated reconstruction visualised how the two motorcyclists were killed when they collided with a vehicle that pulled across their path at a junction. A significant and interesting aspect of this particular case was the way in which the animated evidence was subsequently utilised. In the courtroom the animations were used 'interactively', with the reconstructions being stopped at key moments so that witnesses could discuss the speeds and positions of vehicles relative to the scene and to each other. This experience has encouraged the possibility of using a more interactive technology such as VR in the courtroom. This would facilitate the opportunity of allowing the witnesses and investigators involved in a particular case to show interactively their view of what happened.

Figure 3: Images from an animated reconstruction of the dual motorcycle fatality.

It was important to safeguard against emotive imagery that could introduce bias into the court. To this end the animations included only the vehicles involved, not victims or any content of a visceral nature. Human figures should be used in animations only when absolutely necessary, for example, in cases of pedestrian collision or relevant major crime scenes [11].

A good working relationship between University of Nottingham researchers and police experts has increased the prevalence of computer-generated evidence in the UK legal system. This has led to the production of a set of guidelines that have been effective in terms of admitting digital evidence to UK courtrooms. These include:

- Any animation must support and corroborate existing evidence.
- The supportive evidence will be used in conjunction with the animation.
- There will be documentary evidence detailing the animation methodology.
- Any distinction between ‘animation’ and ‘simulation’ will be defined and indicated.

Recent cases using this technology have established a number of new technologies for use in UK courtrooms. These include:

- The digital projection of all documentary evidence.
- The digital projection of individual witness statements in the form of computer-generated animations.
- The use of three-dimensional computer models to visualise the site of the incident.
- The use of three-dimensional computer models to visualise calculated movement of dynamic objects.

Modern forensic science and technology is often reliant upon computer data to provide evidential information. There is obviously a need to rigorously authenticate the forensic animations produced to ensure that satisfactory standards are maintained and that admissibility is viable. Like any other evidence, proving the forensic animation evidence trail chronologically is necessary.

Audit chains for CG evidence can become extremely complex, consisting of numerous links to form the whole. It should be possible to start at any link and move forwards to any item within the finished evidential presentation or backwards to source maintaining the integrity of all data or information throughout.

As software companies have developed user-friendly graphics packages that utilise the hardware available, more people have become familiar with 3D graphics systems. CG animation software has also reduced in price and professional quality results can be generated using PC software, including

video postproduction and editing. It is fair to state, however, that graphics produced by amateur animators without a forensic animation background will not be of sufficient accuracy or quality to be presented professionally in a UK courtroom.

Case Study 1

Visualising a Major Crime Scene

This 3D computer generated environment is used as a hypothetical testing ground for ideas and concepts within a research context. It is a real section of the M5 motorway that has been built directly from raw police survey data and supplemented with relevant Ordinance Survey digital plan data.

The current incident being reconstructed within the confines of this area is one of an assault involving one or more potential weapons that have been lost, discarded or poorly concealed. The environment explores animation technology in relation to the different sized objects that represent the extent of the scene, in this case several hundred metres of river and motorway and relatively small objects such as potential murder weapons.

The spatial dynamics of evidence and its possible chronology are important concepts to consider when establishing a sequence of events. The environment is designed to highlight possible paths through the urban landscape in relation to significant objects, which have been detected and recorded there. These significant objects can then be examined in more detail using further animated sequences. Notions of modus operandi, signature and staging can be explored in this context [12].

Figure 4. Large scale scene image from an animation of the crime scene and stills from weapon animation.

The whole catalogue of information including the animations, police survey data and any other relevant information (interviews, pathologist report, psychologist report etc.) can be accessed using an Internet

browser interface. These technologies allow non-linear and linear progression through the material, and are also being explored as a means of archiving significant incidents where VR is not required. Potential cross-discipline interaction and discussion, (detective and psychologist for example), within a team training context would benefit greatly from a single, clear collection of data that uses animation technology to explore the location, and focus on the relevant events and objects concerned.

Case Study 2

Post-Mortem Visualisation

This aim of this project is to explore novel techniques of 3D CG visualisation within the field of forensic pathology. Rather than generate the sophisticated medical imagery familiar to professionals within these disciplines, the project aims to assess the plausibility of presenting complex medical evidence and expert opinion in a visual form to a lay audience. CG can provide an array of significant tools for architectural and scene visualisation [13] and the reconstruction of collision events based on the laws of physics. The emphasis here was to visualise an essentially more organic system; the human body and a wide range of possible physical circumstances that were related directly to an autopsy report.

The photographic realism that is possible with modern CG was not an objective in this project. Instead, dimensionally accurate schematic computer models of the human body consisting of case specific external and internal anatomy incorporating inflicted injuries were employed. This mode of representation was deemed more appropriate given the sensitive nature of the data selected, and the overall project aim of demonstrating interaction and process in a broad and general context.

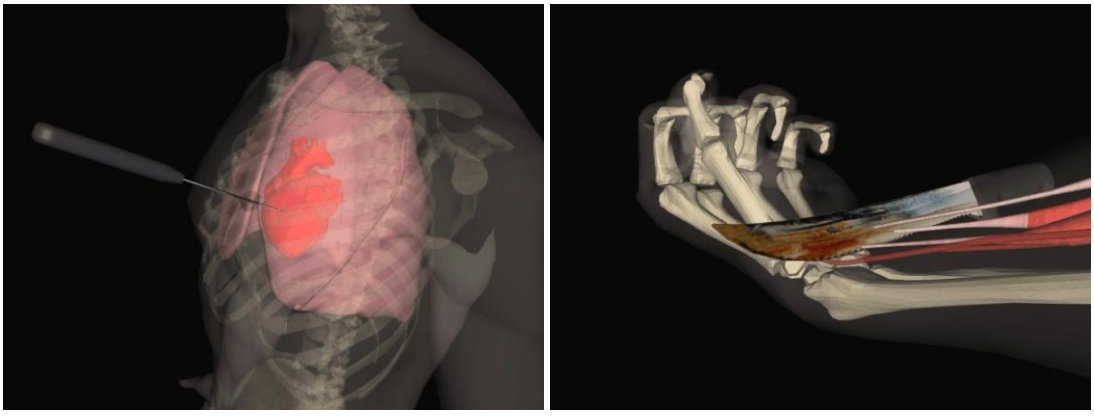

Figure 5. Image from an animated pathology sequence.

To this end, two stabbing cases were selected for visualisation. The two cases, one murder and one suicide, presented the opportunity to make a series of visual comparisons related to both weapon type and to the type of trauma inflicted upon the body.

Staff at the Sheffield Medico Legal Centre and researchers at the University of Nottingham felt the animations raised a number of issues that warranted further exploration. These issues include an agreement on the mode of representation of objects involved in the cause of death, the use of dynamic representation, both of individuals (to include accurate body physics) and their environment, as well as the dynamics of anatomical structures in live situations and under autopsy conditions. With continued development, this type of data visualisation may ultimately be used in UK courtrooms and may have a potential in hypothesis testing, with its possible inclusion within other CG or VR scene visualisations providing alternative exploratory directions, processes and results.

Case Study 3

Running a Virtual Crime Scene

VR offers a unique platform for the collation, interrogation, analysis and presentation of forensic data across a wide spectrum of crime-scene scenarios. This section will explore concepts for real world computer applications, by referencing a hypothetical VR 'scenario' constructed using both proprietary software and software developed by AIMS Research.

This 'scenario' is designed to explore contexts relating to effective and interactive scene visualisation:

- To facilitate understanding of chronology and technical data for a jury.
- To train future investigative and scene management personnel.

An inner city underground car park has been the scene of two incidents:

- A vehicle fire involving a Renault 5.
- The suspicious death of a passenger within a Toyota pick-up vehicle.

interactive

The brief relating to this scene was to visualise any possible relationship between the two incidents, especially in relation to smoke toxicity and temperature. The main area of focus within the environment became the visualisation of Computational Fluid Dynamics (CFD) data. Sophisticated transient simulation geometry for smoke within the car park was calculated using CFD software and a CAD model of the environment. ‘Snap shot’ smoke geometry encompassing the entire duration of the fire was then selected from the data and imported into the VR world, allowing a user to explore the two incidents during the significant time frames of smoke density and extent. Users are given the option of correlating this experience with the recorded evidence of investigators, by selecting objects within the world and launching an Internet browser interface which allows them access to the relevant information required.

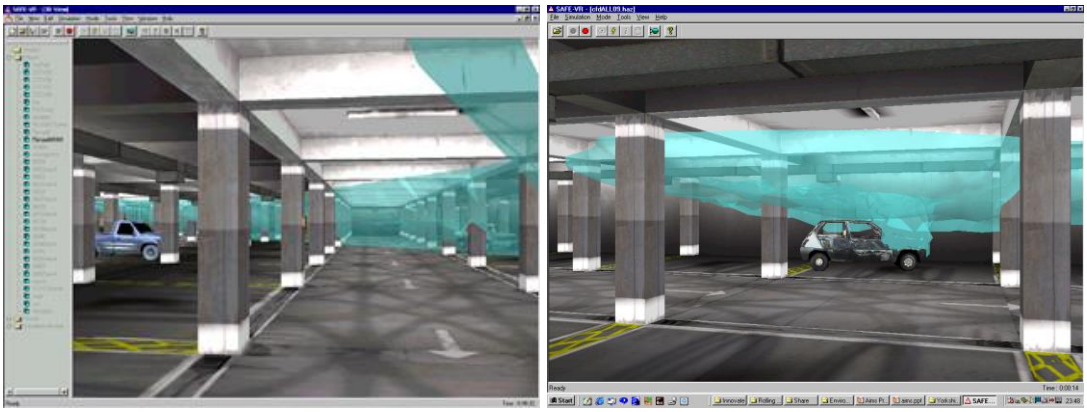

Figure 6. Images from an interactive VR environment and hypothetical crime scene.

A visualisation derived directly from calculated data has many significant implications for jury members. Improved understanding of technical data and a shared visual experience are the most obvious. Issues relating to a visualisation's scientific credibility are important too, as the jury members need to be as sure as possible that what they see is what has been calculated. VR will have an important impact within many cases as the technology and the forensic community develops. The landmark opportunities exist within the legal system, which would benefit enormously from accurate and interactive VR environments that jury members trust. VR will aid investigative personnel during training and later in dealing with the vast array of spatial and technical data associated with public enquiries, major incidents and disasters.

Conclusions

The ultimate question that must be answered is whether or not computer generated visualisations help us to understand what happened in an incident more clearly than can be achieved by existing means. The exponential increase in computational power and the development of sophisticated tools with which to create 3D worlds has led to a massive improvement in the realism and credibility of computer generated images, animations and environments. The ability to represent a range of dynamic, interactive scenarios on a computer screen and view those scenarios from any angle enables forensic investigators, expert witnesses, and lay people, to better understand the underlying issues related to a particular incident.

CG technology has been successfully applied in a wide range of fields already, from vehicle accident reconstruction to major crime scenes, from industrial accidents to maritime and aviation disaster visualisations [14]. A thorough and rigorous application of guidelines during the generation and

presentation of CG material will win favour across a professional community striving to visualise complex scenarios. In this respect, can it be too long before legal precedents are won within the UK legal system, enabling CG and VR to become as admissible as other existing forms of litigation graphics such as photography and closed circuit television (CCTV) footage?

References

1. Denby, B and Schofield, D, Role of Virtual Reality in Safety Training, Mining Engineering, October 1999: 59 - 64.
2. Schofield, D, Denby, B and Hollands, R. Mine Safety in the Twenty-First Century: The Application of Computer Graphics and Virtual Reality, In: Karmis, M. ed. Mine Health and Safety Management. Colorado: Society of Mining, Metallurgy, and Exploration, Inc., 2001: 153-174.
3. Krieger, R. Sophisticated Computer Graphics Come of Age—and Evidence Will Never Be the Same, A.B.A. Journal 1992; Dec.
4. Lederer, FI. Technology comes to the courtroom. Emory Law Journal 1994; 43: 1095-1113.
5. O'Flaherty, D. Computer-generated displays in the courtroom: for better or worse? Web JCLI 1996; 4 (URL: http://webjcli.ncl.ac.uk/1996/issue4/oflah4.html).
6. Marriott, A. Alexandria firm courts lawyers by proving animation computes. The Washington Times 1996: November 25.
7. Lederer, FI. Courtroom 21: A Model Courtroom of the 21st Century. Court Technology Bulletin 1994; 6:1.
8. Collier, P and Spaul, B. A Forensic Methodology for Countering Computer Crime. In: Carr, I and Williams, K, ed. Computers and Law. Oxford: Intellect 1994.
9. Borelli, M. The computer as advocate: an approach to computer-generated displays in the courtroom. Indiana Law Journal 1996; 71:2.
10. Fisher, P. Should We Believe The New Realism. The Daily Telegraph 1998: June 18.
11. Elliot, DW. Videotape evidence: the risk of over-persuasion. Criminal Law Review 1998: 159-174.
12. Douglas, EJ. Violent crime scene analysis: modus operandi, signature, and staging, FBI Law Enforcement Bulletin, February 1992.
13. Girvan, R. Computer animations used In litigation, Forensic Science Society Newsletter 2001; July: 4-5.
14. Schofield, D. Recreating reality – reconstructing accidents using computer graphics. Criminal Justice Management 2001; February: 9-11.

“Visualising the Scene”

“Computer Graphics and Evidence Presentation”

Mr. J. NOOND [1], Dr. D. SCHOFIELD [2], Mr. J. MARCH [3], Dr. M. EVISON [4]

AIMS Research, SChEME, The University of Nottingham, University Park, Nottingham NG7 2RD, UK.

Individual Contact Details

[1] Mr. Jez Noond
Researcher, SChEME, The University of Nottingham, University Park, Nottingham NG7 2RD, UK.
+44 (0) 115 951 4094
jez.noond@nottingham.ac.uk

[2] Dr. Damian Schofield
Lecturer, SChEME, The University of Nottingham, University Park, Nottingham NG7 2RD, UK.
+44 (0) 115 951 4084
damian.schofield@nottingham.ac.uk

[3] Mr. Jack March
Researcher, SChEME, The University of Nottingham, University Park, Nottingham NG7 2RD, UK. +44 +44 (0) 115 951 4094
enxjm1@nottingham.ac.uk

[4] Dr. Martin Evison
Senior Lecturer, Forensic and Biological Anthropology, The Department of Forensic Pathology, The University of Sheffield, The Medico-Legal Centre, Watery Street, Sheffield S3 7ES, UK.
+44 (0) 114 273 8721
M.P.Evison@sheffield.ac.uk