Journal of Medical Radiation Sciences

Open Access

EDITORIAL

The opportunities of computer simulation training in radiation therapy

Andrew W. Beavis, PhD[1,2,3]

[1]Department of Medical Physics, Hull and East Yorkshire Hospitals NHS Trust, Cottingham, UK
[2]Faculty of Health, School of Life Sciences, University of Hull, Hull, UK
[3]Faculty of Health and Well Being, Sheffield-Hallam University, Sheffield, UK

J Med Radiat Sci **65** (2018) 77–79

doi: 10.1002/jmrs.283

In 2017 Vertual Ltd (Hull, England, UK) the company responsible for VERT (Vertual Environment for Radiotherapy Training) celebrated its tenth anniversary, however the origins of the VERT system go back to the turn of the century. The inventors had already worked together on other projects and like many interesting developments VERT was sparked by “do you think we could.....”, or “what if we ....” ‘corridor-conversations’. The system evolved from a collaboration, feeding on the ideas of an experienced radiotherapy physicist (the author) and his need for, and interest in developing, more effective teaching tools for radiotherapy and two computer scientists (Roger Philips and James Ward) who were experienced in the use of medical simulation and shared an interest in efficient visualisation of large-scale data. It is an excellent example of how multi-disciplinary collaborative research can yield something much greater than that developing from isolated thinking. VERT began with the desire to bring a linac into the classroom, wherein virtual reality was used to copy reality. However, it has developed into a much richer simulation environment, where virtual reality is used to provide experiences for the trainees that they are unable to get in the real bunker, for example, see an isocentre or see the dose coverage on the relevant organs change as the position moves. In an interview with Prof Angela Duxbury from Sheffield Hallam University[1] the author discussed the history of VERT and interested readers are directed towards that.

Simulation training is not novel to medical training, in fact the use of such in military training was a partial inspiration to the author when developing ideas with his collaborators for VERT. Records of simulation of battle field techniques go back 5000 years[2] and the concept has continued to the modern day. This reference provides an interesting read about the development of scope of simulation training. Flight simulation in the aeronautical industry is a definitive part of pilot training, both for earth-bound and space travel. The famous 1970 Apollo 13 mission illustrates the benefit of rehearsing emergency procedures and developing vital off-the-cuff procedures in a safe or relatively unpressured environment. Prior to reaching the moon, the explosion of an oxygen tank resulted in the abortion of the mission and a very real risk of the crew losing their lives.[3] Very soon after this event, the crew executed an emergency procedure that had been suggested during an earlier training simulation.[4] It is documented in the Hollywood movie that implications of this action could still have led to fatal consequences. However, comprehensive simulations in the earth-based vehicle replica found a ‘return’ procedure that worked. To summarise, the lives of the crew were saved by the result of practicing deviations from expected procedure in a pre-mission simulation and simulations of emergency procedures ‘off-line’ by the support team.

Radiotherapy is a high-risk procedure, once delivered the radiation dose cannot be removed or nullified and the consequences of moderate mis-treatments can be debilitating and more severe errors can be life threatening. Historically, we have trained our personnel with a mixture of didactic lecturing and ‘on the job’ training. The latter is irreplaceable, however can be very inefficient for the trainee who may feel very pressured in the clinical environment or merely end up in an observation role within a group of fellow trainees. It can be stressful for the clinical tutor[5] who may experience a conflict in providing quality training to their charges while simultaneously ensuring quality treatment for the patient. Finally, the patient may experience loss of confidence if witnessing trainees being counselled that they are not following the correct procedure. In essence, in clinical observations, we tend to show trainees the 'correct procedure' and rely on them to understand the process and its rationale learning 'by rote'.

The author believes that there is a significant shortfall with this philosophy and practice. In the rest of our lives, we learn from the experiences of having made mistakes. When learning to ride a bicycle, we quickly learn to balance, given the experience of falling off is not pleasant. Having passed a motorcar driving test and gained a licence, we then spend 6 months or so really learning to drive! In medicine, we do not have that luxury as mistakes tend to have significant consequences. In VERT there is a built in philosophy that an instructor can demonstrate the correct execution of a treatment, they (or better still the trainees themselves) can explore what happens if the patient is mis-positioned or the machine is incorrectly calibrated. It is easy to chant the mantra that in radiotherapy, accuracy is important, it is critical we are accurate and that we must be accurate. However, it may not be clear to a trainee what 'accurate' entails. When parking a car accuracy is defined typically in the order of metres, however in radiotherapy 10 mm could be an infinite error. The ability to execute a treatment with the patient shifted by 5 mm and then explore the consequences to the planning target volume and the organs at risk (OAR) gives a better understanding of what the need for accurate treatment really means. The ability to integrate information of diverse sources, in the simulation suite, is extremely powerful and enhances overall understanding. In VERT dosimetric displays can be overlaid on internal anatomy or volumetric structures, whilst imaging evidence (digitally reconstructed radiograph, planar kV/MV or cone beam CT) and surface anatomy/rooms-eye-view are simultaneously accessible. It outweighs the experience gained from studying a treatment plan in the planning room, examining the patient lying on the treatment couch and then reviewing treatment verification images at the control desk in sequence or in isolation. Of course, we can never experiment with purposeful mis-treatments in the clinic, even if we argued the benefit gained from the learning of doing so!

As developers of the VERT system, we believe that computer simulation can be used in different ways. One of the manuscripts[6] in this journal presents a review of examples from the literature. Many users initially focus on its didactic use where it is used to illustrate the practical information being taught in the 'classroom'. This by itself is very powerful and efficient, obviating the need for using PowerPoint pictures/videos or complex diagrams and hand waving or, worse still, having to wait until a visit to a bunker is convenient and a machine is available. The experience gained from the use of VERT becomes more powerful when it is used interactively to explore a situation or a treatment scenario. This use is similar to the use of flight simulation illustrated above in the context of the Apollo 13 scenario. Using the DICOM import from treatment planning systems, patients for any (photon) treatment technique or site can be simulated, as illustrated in a manuscript[7] in this journal. Therefore, a variety of treatment techniques could be simulated for a particular patient, but this 'standard situation' appreciation is enriched by exploration of how the correct protocols could break down and errors introduced. Finally, in the modern 'inverted class-room' the students can take control of the system and individually or in groups work through various scenarios re-enforcing their understanding via discussion and/or involving the educator. In a manuscript in this journal[8], the authors report a study around an Interprofessional Education (IPE) workshop using VERT as a communication platform. VERT has capability to capture scenarios for later feedback/discussion or facilitate competency assessment (as well as reaccreditation) and has rudimentary tools to give users feedback. The inventors are always keen to get feedback as to how these features could be expanded.

As well as having modules to demonstrate the basic concepts of radiotherapy and to load patient examples from treatment planning systems, there are tools available to help teach and understand physics concepts, beam measurements and selected quality control processes. These can be used interactively to 'observe' the beams and to make (virtual) measurements for 6 and 15 MV beams. From the author's own experience (as a physicist teaching radiation therapists), it is clear that a trainee who does not understand radiation beam divergence having been shown a set of similar triangles is not going to benefit from being shown larger drawings, using different colours. However, showing a QC jig with a light projection matching onto an inscribed square and then showing it getting larger as the bed drops away is more intuitive than 20 more minutes of mathematics! Similarly, a measurement made at the isocentre followed by one at 101 cm (again having dropped the bed by 1 cm) and showing the output reduces by 2% is a great illustration to help understand the 'inverse square law'. The physics module is currently under significant expansion and will include support for electron beams and beam dosimetry support for multiple (international) beam calibration protocols with a view to develop similar philosophies, for physics trainees, as described above. Finally, the content of VERT continues to be broadened to remain contemporary; recently there has been an explosion in the interest in proton treatments. There are several key concepts to understand when moving from treating patients with photons to protons and if not grasped would result in mistreatments or safety issues. The Proton VERT module enables the user to not only be told that the Bragg Peak is less forgiving to patient motion and mispositioning that photons, but once again they can interactively explore this and other concepts to (hopefully) gain a much deeper understanding in their transition training.

In summary, it is interesting to see the radiotherapy community embracing the use of computer simulation training as it modernises its approach to training. Following a 25 years career (to date), this commentator believes that the more the delivery systems are computerised and the more we protocolise our processes in the clinic, there is increasing danger that we get desensitised to the risks and impact of deviant execution of those processes. Like in other high-risk, high-tech industries, the use of computer simulation (or flight simulation) is a relevant technology to use in initial early career training and in continued professional development as we seek to confirm continued competence or introduce new (black box) technologies into our clinical practice.

Acknowledgements

Roger Philips was one of the UK's first Computer Scientists. Throughout the initial development of what became VERT, he contributed incredibly with his enthusiasm and desire to see computer software and hardware be used for the benefit of professional training and patient safety. He passed away in 2011 just as VERT was becoming established internationally and around the time of the Australian installations and unfortunately he did not get to see the widespread excitement generated by his work. This editorial is dedicated to his memory.

Conflicts of Interest

The author is an inventor of the VERT system and a Director and owner of the company that produces and markets it.

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Correspondence
Andrew W. Beavis, Department of Medical Physics, Hull and East Yorkshire Hospitals NHS Trust, Cottingham, HU16 5JQ, UK.
Tel: +44 148 246 1383; Fax: +44 148 246 1379;
E-mail: andy@vertual.co.uk