A computer simulated virtual patient for training clinicians

A Report for the Winston Churchill Memorial Trust

Nigel W. John, Bangor University
1/1/2013
Fellowship Itinerary – June 2013

1. The Fraunhofer Project Centre for Interactive Digital Media at Nanyang Technological University, Singapore, June 4-9th, http://www.fraunhofer.sg/

   Hosts:
   Prof. Dr. Alexei Sourin
   Deputy Director
   Division of Visual & Interactive Computing,
   School of Computer Engineering
   College of Engineering, NTU

   Dr. Olga Sourina
   Head, Cognitive Human-Computer Interaction

   The Centre looks at real world problems and uses technologies in the field of interactive digital media to provide visual solutions. In essence, the Centre looks at user-centred, immersive, real-time visual environments that allow users to interact with information.

   John gave a seminar about his Fellowship and project goals.

2. The Australian e-Health Research Centre (AEHRC), Brisbane, Australia, June 9th – July 1st, http://www.aehrc.com/

   Hosts:
   Cedric Dumas, PhD
   Surgical Simulation Team Leader, Biomedical Imaging Group
   Tim Coles, PhD
   Post Doctoral Research Fellow

   The AEHRC is a joint venture of CSIRO and the Queensland Government. It employs a multi-disciplinary team dedicated to serving the needs of patients, clinicians and health agencies, and has expertise in: ontology (clinical terminology) engineering; database and data integration technology; clustering and analysis of patient data; analysis and manipulation of biomedical images; delivery of healthcare interventions using mobile computing platforms; developing systems for medical training; natural language processing of medical records.

   The Surgical Simulation and Planning team performs cutting edge research and development of computer-based surgical training and pre-operative planning software. Our aim is to improve patient safety by reducing the need for on patient training and provide surgical teams with the tools required to improve surgical outcomes.

   John gave a seminar about his Fellowship and project goals.
Meetings, Visits and Events

1. Caroline Cao, Department of Biomedical, Industrial, & Human Factors Engineering, Wright State University, Ohio, USA. Prof Cao was visiting AEHRC at the same time. Her research addresses human factors issues in the hospital operating room, where technology is being faster than surgeons can learn to use them.

2. Australian Information Industry Association (AIIA) Smart Australia Dinner 

   Part of the Digital Productivity Conference in Brisbane. Several hundred of Australia’s invited top executives attending this networking opportunity. Keynote speakers address the Economic and Business Imperatives for Australia and the role of digital innovation: Louis Zacharilla, Intelligent Community Forum, USA; Andrew Stevens, IBM Australia & New Zealand; and Senator Stephen Conroy, Minister for Broadband, Communications and the Digital Economy.

   The dinner featured Australia’s iAwards technology awards program for the most innovative technology firms and influencers and the transformation they are bringing to business, governments and the community.


   Marcus Watson, Director

   CSDS is one of most technologically advanced and comprehensive skills development services in the world. It provides healthcare professionals (doctors, nurses, and allied health professionals) with the tools to improve their skills and enhance the quality of patient care through simulation-based education and training. The centre covers over 3500m², with 26 session rooms, laboratories, and even a fully functional operating theatre and hospital ward.

4. Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane

   Professor Christian Langton DSc FAIP (christian.langton@qut.edu.au)
   Medical Physics, Science and Engineering Faculty

   IHBI is a collaborative institute based at QUT, devoted to improving the health of individuals through research innovation. Medical Engineering and Physics research undertaken by the Medical Device Domain includes the utilisation of ultrasound technology to improve targeting of tumours in radiotherapy, orthopaedic applications of magnetic resonance imaging (MRI), and development of heart assist devices.

5. School of Information Technology and Electrical Engineering, University of Queensland, http://www.itee.uq.edu.au

   Professor Janet Wiles (j.wiles@itee.uq.edu.au)

   Janet Wiles is Professor of Complex and Intelligent Systems. Her research program involves using computational modelling to understand complex systems with particular applications in biology, neuroscience and cognition. She is Director of the Thinking Systems Project.
6. School of Human Movement Studies, University of Queensland, 

Dr Guy Wallis, Senior Research Fellow (gwallis@hms.uq.edu.au)

Dr Wallis' research aims to bring his formal training in computer graphics, neural networks and 
systems engineering to the field of visual neuroscience, in an attempt to better understand how 
recognition takes place and representations are built. He has made extensive use of behavioural 
studies conducted in virtual worlds to test and inspire theories emerging from his theoretical 
and network simulation work. Specific interests include the perception and representation of 
object location, object representation and recognition.

7. Thoracic Medicine, Royal Brisbane and Womens Hospital.
Dr David Fielding, Thoracic Physician

Invited to observe a bronchoscopy procedure being performed in the operating room.

8. Department of Paediatric Critical Care Medicine, Mater Children’s Hospital, Brisbane 
http://www.mater.org.au/Home/Education/Mater-Children-s-Hospital-s-Education- 
Programs/Intensive-Care

Dr Bruce Lister, Consultant Paediatric Intensivist (Bruce.Lister@mater.org.au)

The Paediatric Intensive Care Unit (PICU) at Mater Children’s Hospital is an eight bed unit which 
admits approximately 500 patients per year and has 24 hour medical cover provided by four 
registrars. They maintain a dedicated simulation training area.

9. Wearable Computer Lab, University of South Australia, Adelaide 

Prof Bruce Thomas (Bruce.Thomas@unisa.edu.au) / Dr Ross Smith (ross.t.smith@unisa.edu.au)

The Wearable Computer Lab specialises in Augmented Reality, wearable computing, and 
advanced Human Computer Interaction techniques and visualizations.

John gave a seminar about his Fellowship and project goals.

10. Academy of Surgical Educators, Royal Australasian College of Surgeons, Melbourne

Seminar by: Professor Tim Dornan, Professor of Medical Education at Maastricht University 
“Where does apprenticeship stand in the competency era?”

Also met: Debra Nestel, Professor of Simulation Education in Healthcare, School of Rural Health, 
Faculty of Medicine, Nursing and Health Sciences, Monash University, Victoria, Australia

11. Air Operations Division, Defence Science and Technology Organisation, Melbourne 

Dr Peter Ryan (Peter.Ryan@dsto.defence.gov.au)
John gave a seminar about his Fellowship and project goals.

12. Centre for Intelligent Systems Research, Deakin University, Waurn Ponds, Victoria

Dr Doug Creighton (douglas.creighton@deakin.edu.au), Deputy Director
(Prof Saeid Nahavandi was away.)

CISR investigates and develops state-of-the-art algorithms and methodologies that provide practical solutions to real world problems that are encountered by systems operating with uncertainty, variability and change. This practical approach is complemented by research on next generation robotic control systems and force emulation methodologies that improve process reliability, product quality and operator safety in complex environments. CISR is home to more than 60 researchers.

1.0 Introduction

Today, more than at any time in the history of medicine, there is unrelenting pressure for changes to accepted medical practice, particularly as a consequence of legislation such as the European working time directive, and the Calman reforms. Issues include the increasing cost of training, little possibility for replacement of medical staff during their training, the travelling costs of staff that are typically located at several different centres over their training period, limited availability of medical staff for long life training, and inherent skill loss. Medical and healthcare skills training remains a challenge, as stated by Health Workforce Australia in their recent report Health Workforce 2025, which provides medium to long-term national workforce planning projections to the Australian government, and identifies the limitations in the delivery of high quality health services: “bottlenecks, inefficiency and insufficient capacity in the training system, especially for doctors”.

Safe, effective training of the next generation healthcare professionals and skills maintenance for existing practitioners, however, can benefit by taking advantage of new digital technologies and approaches emerging from computer science. We hypothesise that a completely virtual patient will be substituted for a real patient during (at least part of) the learning, diagnosis, and planning stages of many medical practices. There are challenging research problems to solve before this hypothesis can be proven, including realistic modelling of physiological processes, human perception issues, time-efficient segmentation and the step change introduced by new disruptive technologies such as augmented reality.

The Fellowship aims to establish collaborations with world leading groups in Australia and Singapore to pilot basic research themes that lead the way for the deployment of a computer simulated virtual patient - a patient specific computerised database containing the required image data, physiology, and pathology models that can be interacted with in real time using natural senses and skills. The objective is for the virtual patient to become both an accepted tool in the international medical education curriculum; and an aid to the medical practitioner carrying out the daily tasks of their profession.

2.0 Healthcare Simulation

The Queensland Health Clinical Skills Development Centre uses a wide variety of different mannequins for simulating patient scenarios. All training is in a safe learning environment without the potential to cause any patient harm. They define healthcare simulation as allowing clinicians and students from various disciplines to:

- practise procedures and develop procedural skills
- refine communication techniques
- gain experience in recognising and treating medical conditions
- undertake multi-disciplinary teamwork training.

This Fellowship project aims to assess these goals from the perspective of a computer simulation (or virtual environment). A virtual environment is a collection of technologies that allow people to interact efficiently with 3D computerised databases in real time using their natural senses and skills. Of the different approaches can be used for training, there is strong evidence to show computer based simulations are very effective in delivering clinical training. (Cook, 2011) have reviewed over 10,000 published studies and conclude "In comparison with no intervention, technology-enhanced
simulation training in health professions education is consistently associated with large effects for outcomes of knowledge, skills, and behaviours and moderate effects for patient-related outcomes."

Designing and developing medical training tools need to address the different aspects of the medical process, from team communication/coordination to motor skills. These training tools have to be adaptable to the real clinical environments in the hospitals where a large part of medical education takes place, as well as in learning environments for simulation training outside of the operating room. Medical training can target various teamwork competencies and learning objectives: such as technical skills, problem-solving and decision-making skills, communications skills, leadership, etc.

2.1 Computer-based Simulators versus Hands-on training
Training in simulated environments has many potential benefits. Off-patient training removes the patient safety issues and you can repeat as much as you want, also exposing trainees to rare cases. One of the key requirements of any training system is methods or metrics that can be used to measure the task performance of the trainee during various training sessions (Smith et al, 2000). Effective scoring systems should also include measures of movement kinematics of the tool manipulation for each predefined medical task component (Cotin et al, 2002). With a computer-based simulator it is straightforward to obtain such metrics.

There are also potentially economic benefits such as the elimination of the need for consumables needed for mannequins since everything is simulated/virtual and less requirement for support staff to run the scenario or proctors to evaluate performance (which is subjective). Conversely, a mannequin can provide a more realistic tangible interface. Real life forces can be applied. A mannequin can (currently) also be closer to the real life scenario.

A number of researchers and companies have developed virtual training systems; although these systems have gained some acceptance in the research community, they are just starting to be accepted by medical staff, as the recent emphasis on patient safety and procedural competence make the use of virtual simulation for trainees necessary (Sedlack, 2012). A direct linkage between simulator training and improved patient outcomes is difficult, if not near impossible to prove [Dutta et al 2006].
2.2 Design of Computer-based Simulators

Many current training environments try to mimic the feel and look of the actual surgical environment. However, a simpler intermediate training environment can also offer an incremental training process (Satava, 2001; Gorman, 2000). More importantly, it has been shown that a training environment, one that can provide the critical information with respect to performance outcome or that aids in problem-solving and decision-making, even with low fidelity representation, can be an effective trainer (Cao, 2001; Payandeh et al., 2002).

Medical training has to be addressed through a global approach: instead of training with a single method (such as scenario based training), a combination of education techniques and technology are used to implement a curriculum. The innovation in medical education and its adequacy to meet the real need of medical skills can be achieved with:

- Observation and task analysis of actual procedures (cognitive task analysis for the teams).
- Real multidisciplinary work versus multidisciplinary in sequence (with less interaction).
- A global approach of medical training.
- Simulation including a larger view, with Environmental Health issues in the hospitals: patient safety and protection, medical staff protection, environment protection.
- Use of part task simulators, e-learning, mobile technology or others when adequate.
- Using metrics and measurements when possible, especially with computer based training.
- Provide the persistence of training results in a long life training perspective.
- Provide online community based communication tools for isolated workers.
- Provide self-training tools for retention tests and manage skill loss.
- Design of simulation platforms to address different skills in different time for different levels of trainee, but also for different group sizes.
- Take into account the existing expertise, and provide advanced training opportunities.
- Include remote training to overcome the limited budget, busy planning, limited spare time for training, and include remote or isolated staffs.

The training program needs to be designed to address the whole process: a curriculum, the assessment methods, concrete examples, simulation with real and virtual training tools, and training for technical and non-technical skills.

2.3 What Level of Fidelity is needed?

Do you need a simulator that is exactly the same as the real life scenario being trained? In the field of medical education, the challenge is to:

1. Develop techniques and technologies to identify the organisation and training requirements for ICT and medical technologies, 
   versus 
2. Develop techniques to simulate real phenomena,

If these are not incompatible, they can drive simulation research in different ways; especially as (1) can rely on objectives criteria and measurements, where (2) will be driven by subjective observations. However, fidelity requirements may also differ depending on the experience of the practitioner. Considering a whole training cycle, can the level of fidelity be split into task categories? For example can low fidelity / park task simulators provide the best tool for training initial skills -
image recognition of polyps, tissue types, basic manipulation tasks - and high fidelity trainers best used to combine the basic or separate skills learnt in part task trainers?

In the ideal world, we would have a single simulator that can be used adaptively according to the training goals, the expertise level of the trainee, training needs (new procedure or refresher course; basic manipulation skills vs. diagnosis vs. decision-making), etc. In fact, if we could have an intelligent system, we could even have the adaptation to be automatic!

3.0 Technology needed for the Virtual Patient

Technology is (should be) specific to goals, i.e. what do we need the simulation to do? There is no need for a single system to do everything. Even so, current technology is not sufficient to allow natural interaction necessary for optimised learning/practice. We examine specific technology components below.

3.1 Modelling

Accurate modelling of human physiology is an important requirement and this typically requires access to high performance computing. However, there is a trade-off between accuracy and real time response, with the latter being essential for our purposes. The graphics processing unit (GPU) found on most high end PCs can be exploited as a massively parallel device to achieve real time performance and there are examples of soft tissue deformation using Finite Element Modelling (Comas, 2008), catheter manipulation (Yu, 2010), etc. implemented on the GPU. It does not solve everything, however.

Another challenge is the size of medical data sets. Medical scanners are offering ever increasing resolution and therefore gigabytes of patient data. Ideally all patient data available will be used in the modelling process.

Data is also required on forces, e.g. how much force is applied when deploying a surgical tool, and the mechanical properties of the tools themselves. Such information is not readily available in the public domain and often requires researchers to conduct their own experiments to determine such data (Vidal, 2008).

There is software available to help with modelling tasks, and some is in the public domain. A specific example for medical simulation is the Simulation Open Framework Architecture (SOFA, http://www.sofa-framework.org/). Other initiatives in this area are under development.

3.2 Vision

Graphics cards continue to get faster and more affordable, allowing more realistic rendering of anatomy (ap Cenydd 2012) and surgical tools. In general, however, computer generated models do not look exactly the same as in the real world.

Stereoscopy, which provides true 3D viewing, has also become a consumer level product. The quality of passive stereo using polarised glasses has improved tremendously (e.g. Z-Space display, http://zspace.com/). However, clinicians really require glasses-less stereo and autostereoscopic displays are not yet good enough. There is also interest in hyper-stereopsis for enhanced interaction. Here the binocular cues available to the operator are exaggerated so that distances around fixation are magnified. The current implementation of stereo technology in a clinical environment remains difficult due to unique environmental factors and use conditions.
Projection of data directly on to a real patient or mannequin (e.g. technology developed at Wearable Computing Lab, University of South Australia) is an interesting research area. This could be used to show location of internal anatomy/pathology onto the surface of the patient, or even display equipment readings so that the surgeon does not have to turn their head away from the patient. In training, hints can be provided for completing the task. Challenges include self-shadowing, focal length problems, need for multiple projectors, tracking non rigid bodies.

![Projectors on the ceiling of the "Holodeck" at the Wearable Computing Lab, University of South Australia](image)

**Figure 2:** Projectors on the ceiling of the "Holodeck" at the Wearable Computing Lab, University of South Australia

### 3.3 Touch

While vision remains the most important cognition channel, the sense of touch significantly enhances our perception of the world around us. We touch objects to better understand their properties. The particular requirements for haptics (i.e. technology related to the sense of touch) within a surgical simulator vary with the application (Coles, 2011) but the common trends and issues identified above can be summarized as follows:

- How to use haptics and still have an affordable simulator? The cost of multipurpose force feedback devices has greatly reduced but custom devices often needed by surgical simulators are still expensive.
- The availability and development of tactile interfaces is still in its infancy.
- There are always technology questions to consider, with real-time response essential.
  - How many DOFF are needed? Is three DOFF sufficient as six or more is expensive?
  - What computational power is needed? Is dedicated processor required for the haptics pipeline?
  - Is the force range sufficient? Will the range cover the whole pathology and patient variability that the simulator will encounter?
- Multipurpose haptics devices are by far the most commonly employed, but do they compromise the fidelity of the simulation, particularly, when compared to custom-built haptics devices? However, software support for multipurpose devices is good with several haptics libraries now available. In many cases, new and novel algorithms are also being implemented to improve performance and fidelity of simulation.
- What is the objective of the simulation? Clinical skills or tool training? A higher fidelity is typically needed for the latter. In both cases, a more successful simulation is provided if a detailed task analysis has taken place.
• There is a marked lack of validation studies that can report on the benefit (or otherwise) of using haptics in a surgical simulator. The question of appropriate simulator metrics for the use of haptics remains open.

Haptic interaction requires the content creators to make physical (haptic) models of the virtual objects that are used when solving the collision detection and force-feedback calculation tasks. These haptic models are usually based on using polygon meshes, sets of points, or procedural models topologically collocating in the modelling space with the geometric model of the object. However it is not always possible or feasible to make such models when it comes to using real images or videos as elements of interaction. Researchers at NTU in Singapore have developed a novel solution using image-based haptics where a displayed image, real or simulated, is used as a source of the force-feedback calculations at any given pixel of the image (Rasool, 2013). They achieve this by using mathematical functions and procedures to augment images with invisible physical (haptic) models, and collision detection algorithms based on using mesh-less function definitions.

![Figure 3: Image-driven haptics. The surface of the leg in the image can be "felt" using a force feedback joystick.](image1.jpg)

Nanyang Technological University

Including a tactile response is also desirable, but less developed than force feedback. Approaches have included use of pin arrays, hydraulics, air jets, and ultrasonics (Hung, 2013). The Digital Foam developed at the University of South Australia (Smith, 2008) incorporates many sensors to capture the location of user’s touch-point and the individual depth of each touch-point. Thus it can detect multiple simultaneous deformations in its surface and offers new potential to medical simulators.

![Figure 4: Digital Foam prototype. University of South Australia](image2.jpg)
Tangible haptics is often a concern – the immersive feel is enhanced if there is a physical object that can be touched. Recent advances in 3D Printers could be of use here. Could mannequins become more affordable, printing replacement parts on 3D printers? The variety of materials available is increasing.

Research and development in haptics for medical simulation has focused on force feedback and need to take into account other haptic information. We still don’t know if those other haptic parameters are important. Understanding haptic perception can help with design of haptic interface. Much of the development effort is aimed at recreating accurate force feedback. Perhaps a better use of simulation is to recreate haptic perception. This means that the feedback may not be accurate in the physical sense, but is accurate in the psychophysical sense. In fact, if we could push the envelope to enhance skill acquisition or performance with effective use of haptic feedback (e.g., exaggerated force/vibration/temperature, etc., to heighten sensitivity, much as hyperstereopsis in visual feedback), this may be a more interesting use of simulation.

3.4 Other Human Senses

Vision and touch are the only human senses supported in the vast majority of medical simulators today. Smell, sounds, temperature, lighting, safety to self (i.e. other people and activities in the vicinity such as in an emergency room) can either enhance or distract from the task. These are important factors in training for skill transfer, and situated learning.

Clinicians are taught to use the sense of smell to diagnose disorders even before a patient begins exhibiting symptoms. Syphilis, kidney failure, abscesses of the lung, uremia, scurvy, liver failure, typhoid, scrofula, smallpox, rheumatic fever, diphtheria, pneumonia, and scarlet fever are also just a few of the conditions described by clinicians as having distinctive odours. In addition, odours that can be associated with surgery, such as infected wounds, human tissues, and human body fluids such as blood or bile, have also been considered in terms of telepresence surgical applications (Keller, 1995). Only a few groups have so far addressed smell in surgical simulators (e.g. Spencer, 2006). There are commercially available platforms for generating smells that may help (http://www.scentpalette.com/index.php).

Audio too is little used but during part task and procedural training randomly timed simple questions could be effective to increase the cognitive load. This would be an advanced task but one the practitioner will encounter during real life procedures.

3.5 Tracking

The ability to track the tools being used, or the position of the operator, is an important component of any simulator. Technologies available include optical, magnetic, ultrasonics, and inertial tracking. There is a trend for inexpensive options to become available, particularly benefiting from the games market. Microsoft’s Kinect is a very sophisticated camera for optical tracking. New products such as the Leap Motion (https://www.leapmotion.com/) are also set to have an impact. Tracking the posture of operators now becomes far easier to achieve as little set up time or the use of distracting markers are not needed. These can be integrated into task analysis and procedure simulation. Viewpoint tracking for multiple users would also allow more complex situations and scenarios to be simulated.
Use of eye tracking during simulation could also be exploited. If a trainee is looking off the screen during a bronchoscopy procedure, for example, you could deduce that they are not confident or are struggling with operating the scope. Also, if the operator is focussed on the procedure site they may not be paying attention to other symptoms. Maybe the patient has turned blue and stopped breathing, how long does the operator take to have a look around and notice? Eye-tracking could also be used for assessment of expertise. Novices tend to focus on the tool end-effectors in laparoscopy surgery, while experts tend to scan the surgical site on the monitor frequently. Eye-blinks can also be used to infer stress levels of the human operator.

4.0 Commercial Solutions
There are a small number of companies world-wide that market medical simulators. They include Simbionix (http://simbionix.com/), Mentice (http://www.mentice.com/), Surgical Science (http://www.surgical-science.com/), Medaphor (http://www.medaphor.com/), Medical Synergies (http://medicalsynergies.com.au/), and a few more. Surgical-Science, for example, have licensed the colonoscopy simulator developed at the Australian e-Health Research Centre.

Training for most laparoscopic and endoscopic procedures has been implemented by these companies. Other solutions are available for some other procedures such as needle puncture, suturing, palpation, and bur hole drilling (skull). Mostly these are part task trainers that simulate simple basic surgical tasks well. Little work has been done on open surgery, however. Question is whether is it necessary to simulate entire surgical procedures? Trainees would then get to integrate all learnt skills in order, and learn how they link together, thus providing further confidence in their ability to complete the task. This is a big challenge for the available technology to deliver.

Medical Synergies, based in Australia, were interviewed to determine what the issues are for a commercial company in this domain. They reported:
- Training budgets big enough to buy and upgrade simulators.
- Networkable for remote access for guidance and mentoring.
- Need for e-learning modules to complete prior to hands on experience
- Providing diversity in pathologies.
- An integration pack so that hospitals don't need to ponder on how to integrate the simulator into existing training programmes.
- Complete removal of the old school surgeons and their idea that training on patients under their guidance is best.
- Not enough cost recovery research.

5.0 Validation

A simulator using a computer-based virtual patient needs to be validated to prove that the skill learnt does transfer to the real world procedure before it can be accepted as a useful training tool. Validation goes hand-in-hand with endorsement from the relevant authoritative body, whether it is legislation, or a professional organisation such as the Royal College of Surgeons (RCS) in the UK, or ACS in the US. The Fundamentals of Laparoscopic Surgery (FLS), a standard developed and endorsed by the Society of American Gastrointestinal Endoscopic Surgeons (SAGES) has inspired many low technology simulators for laparoscopy training. It is probably the most adopted simulator standard worldwide.

![Figure 6: Experiment for validation of colonoscopy simulator – the scope targets are visible on purple bowl.](image)

**School of Human Movement Studies, Queensland University**

Currently trainees and expert trainers are the market for training simulations. In surgical robotics, however, Intuitive Surgical (http://www.intuitivesurgical.com/) made an impact in the US by marketing their surgical robot to the patient (easier to do in the US due to everyone having private health insurance they can use to pick and choose to which hospital they travel). Could the same be done for simulation?

The performance metrics also need to be standardised. However, expert surgeons usually disagree on what good performance looks like and how to teach it. We need to work with human
A computer simulated virtual patient for training clinicians performance scientists and education scientists to derive the set of relevant performance metrics for surgery.

6.0 Conclusions and Actions from Fellowship

A goal of the Fellowship has been to establish opportunities for international collaboration on projects that can contribute to the creation of a computer simulated virtual patient - a patient specific computerised database containing the required image data, physiology, and pathology models that can be interacted with in real time using natural senses and skills. The objective is for the virtual patient to become both an accepted tool in the UK medical education curriculum and beyond; and an aid to the medical practitioner carrying out the daily tasks of their profession. Strong links have been established with the Australian eHealth Research Centre in Brisbane, and the Nanyang Technological University in Singapore. We are now planning to work together on projects for training endoscopy procedures, and for image driven haptics. We believe that this will lead to future grant capture to progress these aims and contribute to the impact that UK research can and is making on the field. Indirect benefits to patients in UK hospitals will be to increase their confidence in the skills of their clinicians, and to be the recipients of accurate treatment and shorter recovery times.

A more immediate output from the Fellowship will be the compilation of a comprehensive review that builds on the information reported above and will clearly identify the current and future research challenges in medical procedures simulation. The resulting paper will be submitted for journal publication.

References


Sedlack, Robert E. (2012). Incorporating simulation into the GI curriculum: the time is now. Gastrointestinal endoscopy 1 September 2012 (volume 76 issue 3 Pages 622-624 DOI: 10.1016/j.gie.2012.05.022)


**Acknowledgements**

I am indebted to the Winston Churchill Memorial Trust for providing the opportunity for me to go on the Fellowship trip. The support that the Trust provides has been amazing.

This report is the result of discussions with many of the people that I met during the trip. In particular, I would like to thank Tim Coles, Cedric Dumas, Caroline Cao, and Alexei Sourin for the fantastic input that they have given to the content of this report.