



**HAL**  
open science

## **Interventional radiology core skills simulation: mid term status of the CRit aIVE projects**

Derek A. Gould, Franck P. Vidal, Chris Hughes, Pierre-Frederic Villard, Vinent Luboz, Nigel W. John, Fernando Bello, Andy Bulpitt, V. Gough, David Kessel

### ► **To cite this version:**

Derek A. Gould, Franck P. Vidal, Chris Hughes, Pierre-Frederic Villard, Vinent Luboz, et al.. Interventional radiology core skills simulation: mid term status of the CRit aIVE projects. Cardiovascular and Interventional Radiological Society of Europe 2008 (CIRCE 2008), 2008, Copenhagen, Denmark. pp.P 130. hal-00849271

**HAL Id: hal-00849271**

**<https://inria.hal.science/hal-00849271v1>**

Submitted on 30 Jul 2013

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



## **Interventional radiology core skills simulation: mid term status of the CRaIVE projects**

EPOS: P-130

Congress: CIRSE 2008

Type: Scientific Poster

Topic: Others

Authors: D.A. Gould<sup>1</sup>, F.P. Vidal<sup>2</sup>, C. Hughes<sup>2</sup>, P.F. Villard<sup>3</sup>, V. Luboz<sup>3</sup>, N.W. John<sup>2</sup>, F. Bello<sup>3</sup>, A. Bulpitt<sup>4</sup>, V. Gough<sup>1</sup>, D.O. Kessel<sup>4</sup>; <sup>1</sup>Liverpool/UK, <sup>2</sup>Bangor/UK, <sup>3</sup>London/UK, <sup>4</sup>Leeds/UK

MeSH:

Education, Medical, Graduate [I02.358.399.350]

**Keywords:** Interventional Radiology, Training, Simulation, Ultrasound guided needle puncture

Any information contained in this pdf file is automatically generated from digital material submitted to e-Poster by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply CIRSE's endorsement, sponsorship or recommendation of the third party, information, product, or service. CIRSE is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold CIRSE harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

[www.cirse.org](http://www.cirse.org)

## 1. Purpose

The aim of this project is to develop Interventional Radiology (IR) simulator models for core skills training.

**Background.** There is a shortage of radiologists trained in performance of [\[Interventional radiology uses imaging to guide minimally invasive procedures\] IR procedures](#). Visceral and vascular IR techniques almost universally commence with a needle puncture, usually to a specific target for biopsy, or to introduce wires and catheters for diagnosis or treatment. These skills are learnt in an apprenticeship in simple diagnostic procedures in patients, though there are [\[Apprenticeship training: the drawbacks\] drawbacks to this training method](#) [1,2]. In addition, certification depends partly on a record of the number of procedures performed, with no current method of objective IR skills assessment.

Despite the presence of an effective mentor, the apprenticeship method of training presents some risks to patients: these could be mitigated in a [\[Pre-patient training.\] pre-patient training curriculum](#), which would use [\[Simulation\] simulation](#) to provide skills training [3].

[\[Applications of Computer Based Simulation\] Computer based simulation](#) is just one of a range of [\[Simulations for training\] alternatives](#) to apprenticeship training, which include physical and animal models, and rapid prototyping models to train catheterisation skills. Fixed models are expensive, lack physiology, have fixed anatomy and are destroyed by repeated needle puncture. Animal models have anatomical differences, lack pathology and, in the UK, political acceptability.

Realistic Virtual Environments (VEs) [\[DICOM data as a basis for creating virtual environments.\] can be derived from imaging data](#), with potential to introduce *physiological processes, tissue deformation* and [\[Haptics devices\] haptics\(touch\)](#). Patient anatomical variability and pathology can be obtained from multimodality (MR, CT) imaging studies using a series of semi-automated processing steps to segment ('label' in 3D) the anatomical data.

There are existing computer based simulations of catheterisation and needle puncture procedures such as venepuncture, percutaneous nephrolithotomy, [\[Mediseus Epidural Simulation, MedicVision\] epidural](#) and lumbar puncture and liver biopsy simulations [4-7]. Surgical virtual reality (VR) simulators for [\[Promis Simulator from Haptica in a skills centre setting\] laparoscopic training](#) have been shown to improve operator performance, though [\[A computer based simulation\] vascular catheterisation simulations](#) have yet to convincingly transfer fine motor skills to procedures in patients [8]. Chaer et al have shown transfer of some cognitive and coarse motor skills using the VIST-VR (Mentice) endovascular simulator model, though the authors acknowledge that training in the randomised cohorts was not completely matched, and the observer based assessment tool used was unvalidated [9]; neither did the assessment tool evaluate fine motor skills.

Haptics have been shown to be important in influencing visual perception [10], and in the authenticity of a simulated procedure [11]. Yet in the main, fine motor skills transfer remains elusive, owing to limitations in simulator model fidelity and content. This inability to emulate low level operator actions represents a rate limiting step in attaining procedure simulations that reflect real world performance. Hence our aim in this project is to produce higher fidelity simulations in an attempt to model fine motor behaviours.

There is, currently, no validated VR model of [\[Ultrasound simulation using a laptop computer\] ultrasound guided IR visceral needle access](#) where a trainee can experience the authentic 'feel' of a procedure, viewing realistic, variable case scenarios that take into account patient variability. This type of simulation is novel, but presents a range of technology challenges.

Accurate simulation requires incorporation of data from procedural *Task Analysis* into the development phase, including critical procedure steps and their metrics for *objective measures* of operator competence. Novel, *semiautomatic segmentation of patient specific imaging data* have been developed at Leeds and Imperial to generate anatomically realistic three dimensional VEs that reflect variability across patients.

[\[Haptics devices\]](#) [Haptics](#) in existing VR simulations of needle puncture are typically based on mathematical models and subjective assessment by experts. Work at Liverpool is providing *procedural force data* which will be used to validate our models and enhance the authenticity of the simulator.

*Validation:* Few, if any, simulations have been convincingly validated for training IR skills [12], though this should be achievable where content (replication of procedure steps) and fidelity (faithfulness of that replication) are appropriate to real world tasks [13]. Indeed correct reproduction of the task, and appropriate fidelity are the cornerstone of producing a simulation that has relevance to a particular training objective. In our projects, validation draws on the team's occupational psychology expertise (at University of Hull) [14] with evaluation by clinical radiologists at Liverpool, Leeds and Manchester. The simulator has been designed for use exclusively within radiology training curricula.

This report/article presents independent research commissioned by the National Institute for Health Research (NIHR). The views expressed in this publication are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

## 2. Material and Methods

Ethics and research governance approvals were obtained for collection of procedural force and video records, as well as use of anonymous patient imaging data: these images are then uploaded to an ftp server at Bangor University where they are available to the CRAIVE research team.

Task analysis: subject matter experts (SME) were identified by IR Societies (CIRSE, BSIR, SIR) for purposes of collecting video data from SME procedures, and subsequently interviewing SME's to distil key procedure steps (cue perception, decision making, operator actions) [14]. To achieve this task analysis, [\[Video-recording procedures\]](#) [video-recorded IR procedures](#) performed by subject matter experts (SME), were [\[Part of a task analysis document.\]](#) [decomposed by trained psychologists in operator interviews](#). A Wiki based web site was used to inform simulator design using an annotated task analysis. SMEs and computer scientists were able to input comments on the procedure steps, but particularly on the realisation of the analysis, and its derived content, in the simulation.

Force sensor pads were attached to the interventionist's fingers during IR procedures, with force data generated and recorded using a laptop computer [15]. Novel sensors have now been developed to record IR instrumentation forces and are geared to the dimensions of needles and guidewires.

Creating virtual environments. [\[DICOM data as a basis for creating virtual environments.\]](#) [Relevant target anatomy and pathology](#) in selected, anonymised, patient imaging studies was segmented and a surface and volume mesh, created. These data were also used to create simulated ultrasound images for needle guidance. Tissue deformations ([\[Kidney and liver penetration resistance modelling\]](#) [needle insertion](#), intrinsic motion), calculated using a mass-spring algorithm, were mapped to human-computer interface devices.

Validation. Preliminary demonstration of integrated simulations to trainees and practitioners provided feedback.

### 3. Results

[\[Create virtual environment\]](#) Virtual environments (VEs) have been created using a range of segmentation methods (manual, semi-automatic, automatic), followed by mesh generation. [\[Immersive environment for needle puncture simulation: 3D-IW by SenseGraphics\]](#) Haptic devices (e.g. the [\[Catheter / wire haptics devices\]](#) Xitact [\[Mentice\]](#) wire/catheter haptic device) are mapped to the virtual environment using a [\[Simulation of wire / catheter\]](#) mass spring system.

Force studies: Initial work used capacitance pads (PPS, Los Angeles) to provide preliminary data. [\[Capacitance force sensor pads \(PPS, Los Angeles\)\]](#) This slide shows a waveform obtained during penetration of an arterial wall. It is probable that the needle tip is in contact with the arterial wall during what appears to be an approximately periodic waveform, occurring just before penetration of the wall. This pulsatile force may be detectable by an operator as a 'haptic cue'. Deformable models (see 'Virtual Environments', above) have incorporated data from these procedural instrument force measurements. Further work is now progressing using novel sensors developed at Liverpool, and incorporating [\[Tracking during force data collection\]](#) motion tracking to identify the velocities of needles during penetration into tissues in vitro, as well as during actual IR procedures in patients.

Evidence based content. [\[Videorecording procedures\]](#) Task analysis informed simulator development. Subject expert and technical input to this was obtained in a [\[Wiki format of task analysis\]](#) web-based, wiki format. This input of computer scientists and IRs proves invaluable in simulator development.

Validation. Preliminary content validation studies yielded favourable observations, which are also driving revisions, including implementation of an [\[Needle puncture simulation with 3D viewing\]](#) immersive virtual environment, with haptic devices and [\[Immersive environment for needle puncture simulation: 3D-IW by SenseGraphics\]](#) stereoscopic viewing.

### 4. Conclusion

Virtual environments have been integrated into a novel framework for training ultrasound guided biopsy and the [\[An interim depiction of the Seldinger technique simulation.\]](#) Seldinger technique. We have described the evidence based development of these simulations, which is specific to training objectives in an IR curriculum. This work is guided by physical and cognitive analysis of the required task (performance objective). It uses real patient imaging data as the source of segmented anatomy, and thence the underlying virtual environment. The algorithms used within these anatomical data are informed by studies of procedural forces, provided the refining data required for realistic 'feel' in the simulations.

Review by subject experts has provided invaluable information in the form of repeated content validations, contributing to the re-design of each iteration and hence increasing relevance to the procedure in the real world.

Ongoing work includes review and refinement of the human-computer interface devices, novel segmentation methods, and further validation studies (construct, skills transfer).

[\[Come along to the Simulator Gallery at CIRSE 2008!\]](#) Thanks, and why not try out the simulator for yourself?

### 5. References

1. Bridges M, Diamond DL. The financial impact of training surgical residents in the operating room. *Am J Surg.*, 1999;177:28-32.
2. Crofts TJ, Griffiths JM, Sharma S, et al. Surgical training: objective assessment of recent changes for a single health board. *BMJ* 1997;314:814.
3. Grantcharov TP, Reznick RK. Teaching procedural skills. *BMJ* 2008;336:1129-1131 (17 May), doi:10.1136/bmj.39517.686956.47
4. NW John, et al. *Web-based Surgical Educational Tools*, MMVR 2001, *Studies in Health Technology and Informatics*, IOS Press, pp 212-217
5. K Moorthy, et al, Validation web based training tool for lumbar puncture. *MMVR* 11, Ed JD Westwood et al. IOS press, 2003, 219-225.
6. F. P. Vidal, N. W. John, D. A. Gould, and A. E. Healey: Simulation of Ultrasound Guided Needle Puncture using Patient Specific Data with 3D Textures and Volume Haptics. *Computer Animation and Virtual Worlds* (May 2008), John Wiley & Sons. Volume 19, Issue 2, pp. 111-127. DOI: 10.1002/cav.217
7. Horus website:  
  
<[http://www.ircad.fr/virtual\\_reality/horus.php?lng=en](http://www.ircad.fr/virtual_reality/horus.php?lng=en)> (accessed 22<sup>nd</sup> June 2008).
8. Seymour NE. Gallagher AG. Roman SA. O'Brien MK. Bansal VK. Andersen DK. Satava RM. Virtual Reality training improves operating room performance: results of a randomised, double-blinded study. Yale University & Queen's University, Belfast. *Annals of Surgery*. 2002 Oct 236(4):458-63; discussion 463-4.
9. Chaer RA, De Rubertis BG, Lin SC et al. Simulation improves Resident Performance in Catheter-Based Intervention. *Ann Surg* 2006;244: 343–352)
10. Rosas P et al. Texture, haptic cues in slant discrimination: reliability-based cue weighting. *J Opt Am A Opt Image Sci Vis*, 2005 May;22(5):801-9.
11. O Gerovichev et al, Effect of visual and haptic feedback on manual and teleoperated needle insertion, *MICCAI* 2002, Tokyo, Japan, pp 147-154.
12. Gould DA. Reekers JA. Kessel DO. Chalmers NC. Sapoval M. Patel AA Becker GJ. Lee MJ. Stockx L. *Simulation Devices in Interventional Radiology: Validation Pending*. *J Vasc Interv Radiol* 2006; 17:215–216
13. Derek A Gould. *Interventional Radiology Simulation: Prepare for a Virtual Revolution in Training*. *J.Vasc. Interv. Radiol.* 2007 18: 483-490.
14. Johnson SJ, Healey AE, Evans JC, Murphy MG, Crawshaw M, Gould DA. Physical and cognitive task analysis in interventional radiology. *Journal of Clinical Radiology*: Volume 61, Issue 1, January 2006, Pages 97-103
15. AE Healey, JC Evans, MG Murphy, S Powell, TV How, D Groves, F Hatfield, BM Diaz, DA Gould. In vivo force during arterial interventional radiology needle puncture procedures. *Medicine Meets Virtual Reality* 13. James D Westwood et al (Eds). IOS Press. 2005. p178-184.

## 6. Personal Information

Project Participants:

University of Liverpool, Dept Clinical Engineering: *Thien How, Jianhua Zhai, Tony Fisher*. Dept Computer Science: *Bernard Diaz*.

Royal Liverpool Hospital: *Steven Powell, Andy Healey, Amrita Sinha, Andy Fagan, Derek Gould*

Bangor University, Dept of Informatics: *Nigel John, Franck Vidal, Chris Hughes*

Imperial College: *Fernando Bello, Vincent Luboz, Pierre Villard*.

St Mary's Hospital Paddington: *Mohamad Hemady*.

University of Leeds, School of Computing: *Andy Bulpitt, Ken Brodley, Richard Holbrey, Yi Song*.

St James' Hospital, Leeds: *David Kessel*.

University of Hull, Dept Computer Science: *Roger Phillips, James Ward, Martin Crawshaw, Derek Wills, Sandhya Pisharody, Yan Zhang*.

Hull Royal Infirmary: *Duncan Ettles*,

Manchester Royal Infirmary: *Nicholas Chalmers*.

*Manchester Business School: Sheena Johnson, Helen Woolnough, Carianne Hunt*.

WE Lewandowski Consulting, West Virginia: *Bill Lewandowski*

Patient Users Group, CTC-Liverpool: *Norman Heritage*

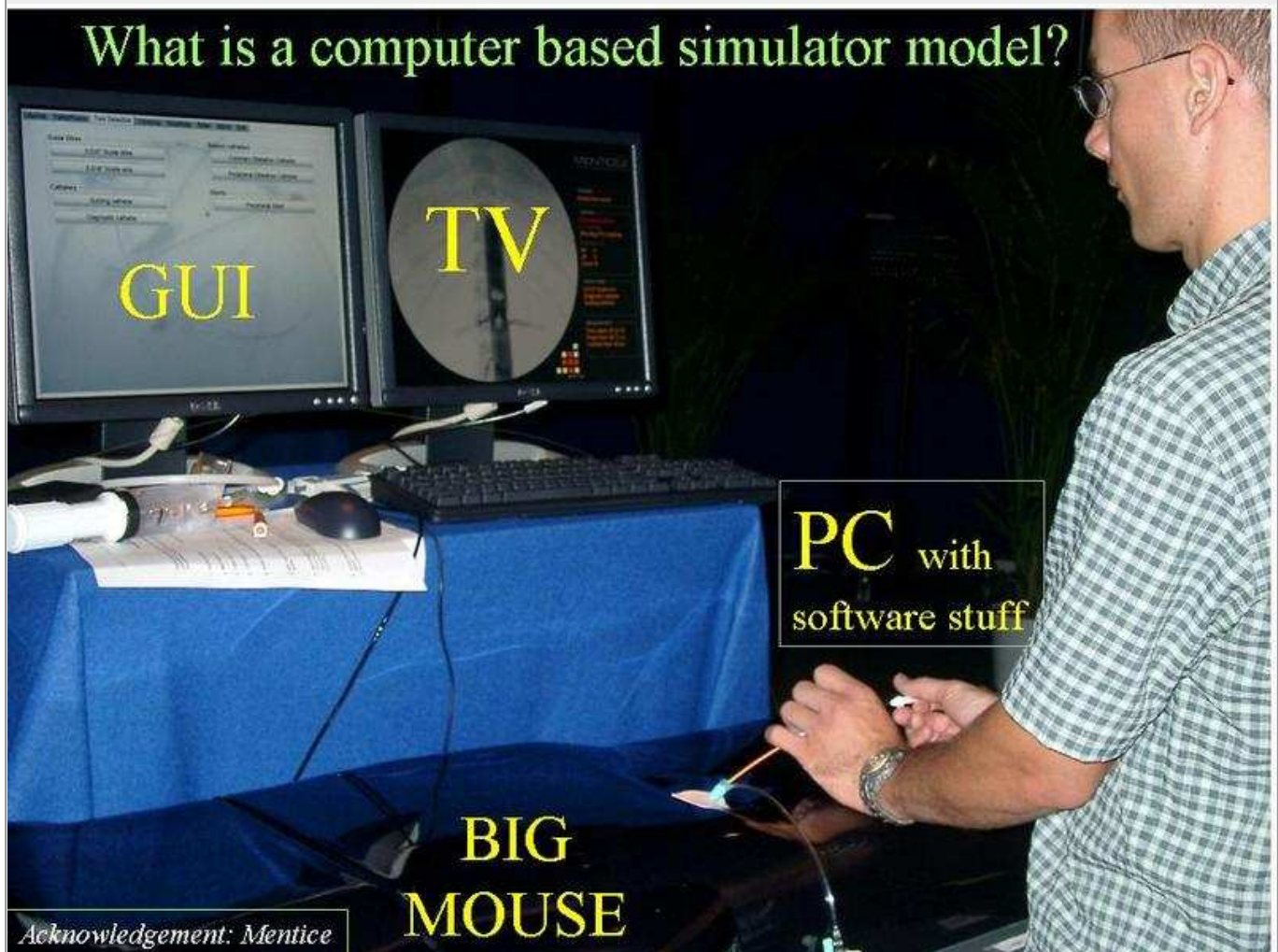
Project advisor: *Steve Dawson*, Harvard

Industrial partner: *MedicVision*

Project partner: *Vitalis Plc*

## 7. Mediafiles

### A computer based simulation



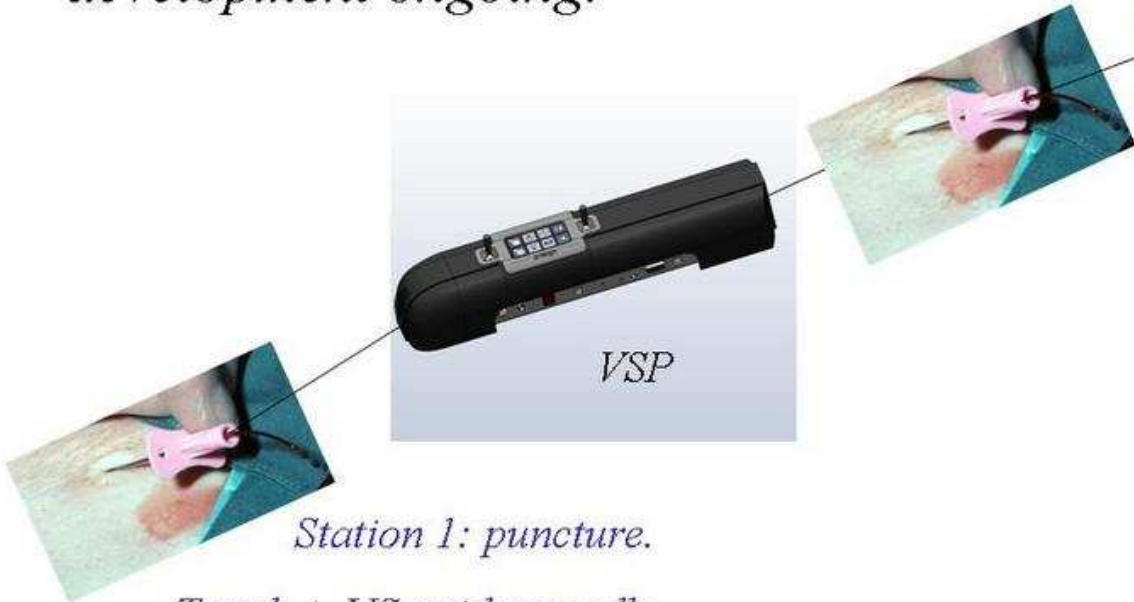
This is the Mentice V1st-VR simulation which uses a PC, a monitor and graphic-user interface, and a modified 'mouse' to deliver the 'feel' of a procedure: this is a haptics (=touch) device. The technology is very similar to that produced by the games industry. A medical training simulation, however, aims to replicate a task from the REAL world, and is subjected to validation for that specific training objective.



An interim depiction of the Seldinger technique simulation.

## Alpha model simulation of the Seldinger technique: *development ongoing.*

*Station 2: manipulation of  
wire and needle, and catheter  
exchange.*



*Station 1: puncture.  
Touch + US guides needle*

This two stage simulation lacks face validity. Considerable development work is ongoing to develop this into a practicable simulation for training purposes.

# Computer based simulations

**Games** — pure entertainment!

**Workspace**

**Serious games**

**Aviation**

**Medical simulation**

**Fluid dynamics**

**Economics**

**Phobias**

**Blue brain project**

**Computational**

**Engineering**

**Design**



Only Computer Games are used for pure entertainment. The picture shows use of Second Life for a conference setting. The figures are 'avatars' of delegates at a conference conducted in the virtual world.

## The problems facing Interventional Radiology cognitive / motor skills training

- New imaging methods
  - replace invasive diagnosis
  - reduce core skills training
- Less time to train
  - work time directives
  - ‘modernisation’ schemes
- Risk to patients
  - learning from error
- Random exposure to
  - case mix
  - critical events
- Other specialties learning
- No objective assessments



*Apprenticeship IR training  
See one - do one - teach one*

Need an alternative to patients, to train and assess core skills

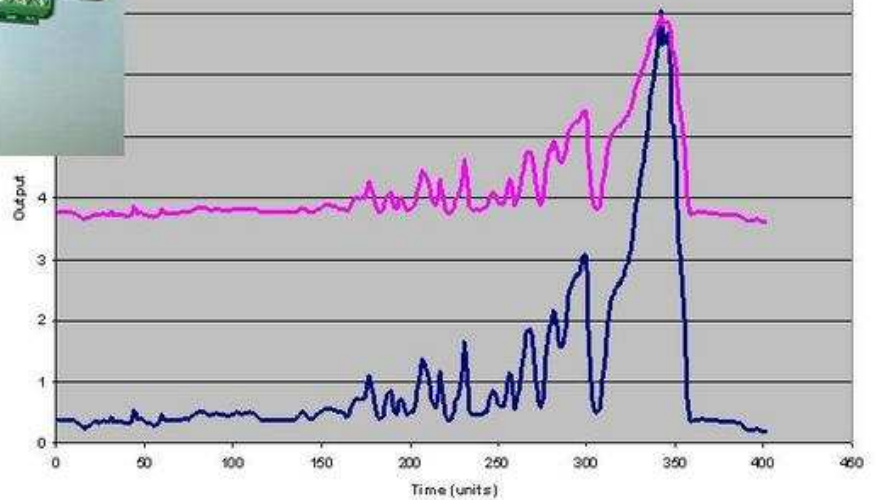
## Capacitance force sensor pads (PPS, Los Angeles)

### Measure 'feel'



Capacitance force pads worn on fingertips.

Needle forces during puncture of arterial wall



*In vivo force during arterial interventional radiology needle puncture procedures. AE Healey, JC Evans, MG Murphy, S Powell, TV How, D Groves, F Hatfield, BM Diaz, DA Gould. Medicine Meets Virtual Reality 13. James D Westwood et al (Eds). IOS Press. 2005. p178-184.*

The pads are worn on operator's fingers. Data is collected into a laptop computer, recording forces generated during the procedure. Here the pads are positioned over a needle during arterial puncture.

## Catheter / wire haptics devices

### Catheter / wire manipulation: simulation of cues, detection of metrics




*Mentice, Gothenberg*



These devices convey the sense of feel of a wire and catheter, while mapping the operator's actions to the virtual catheter / wire.

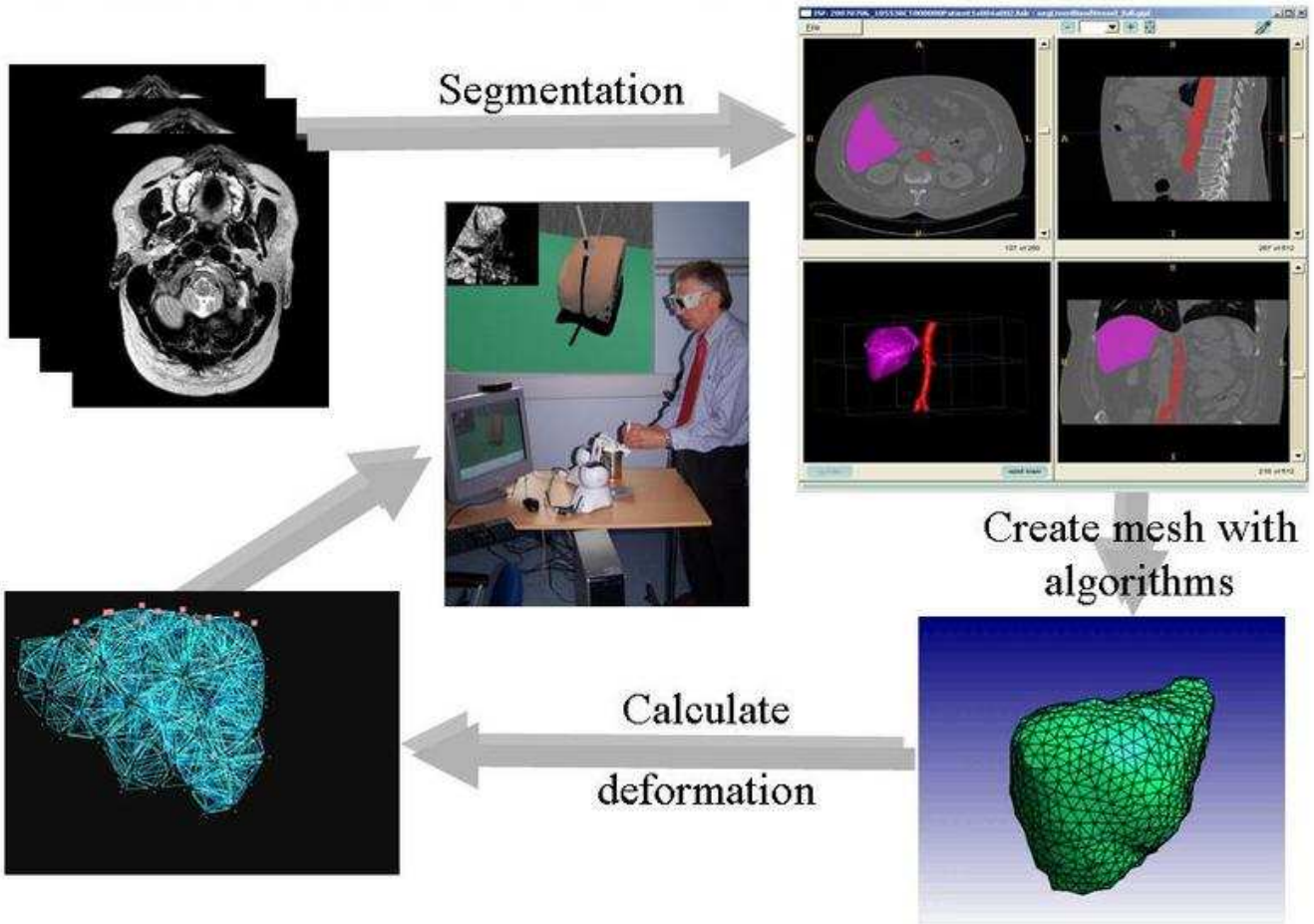
Come along to the Simulator Gallery at CIRSE 2008!

A photograph of a clownfish with orange, white, and black stripes swimming in a large, pink sea anemone. The background is a sandy ocean floor with some green algae.

See these **new** visceral  
simulations at the CIRSE  
2008 Simulation Gallery

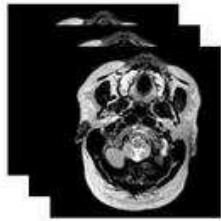
[www.craive.org.uk](http://www.craive.org.uk)

# Create virtual environment



DICOM data is first segmented, then target anatomy is identified by segmentation (i.e. is labelled). A surface and volume mesh is created which contains nodes at intersections where mathematical formulae are located, to calculate deformations. Fidelity can be increased by increasing the number of intersections and therefore nodes, though this increases the computational load.

## DICOM data as a basis for creating virtual environments.



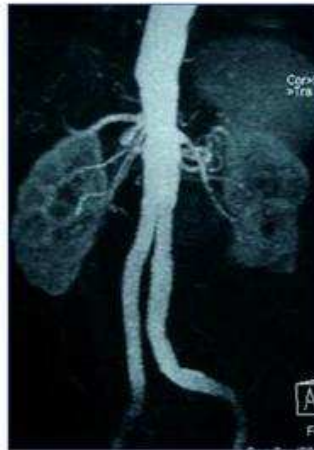
DICOM DATA

### Anonymised patient imaging data

- Informed consent



CT



MR



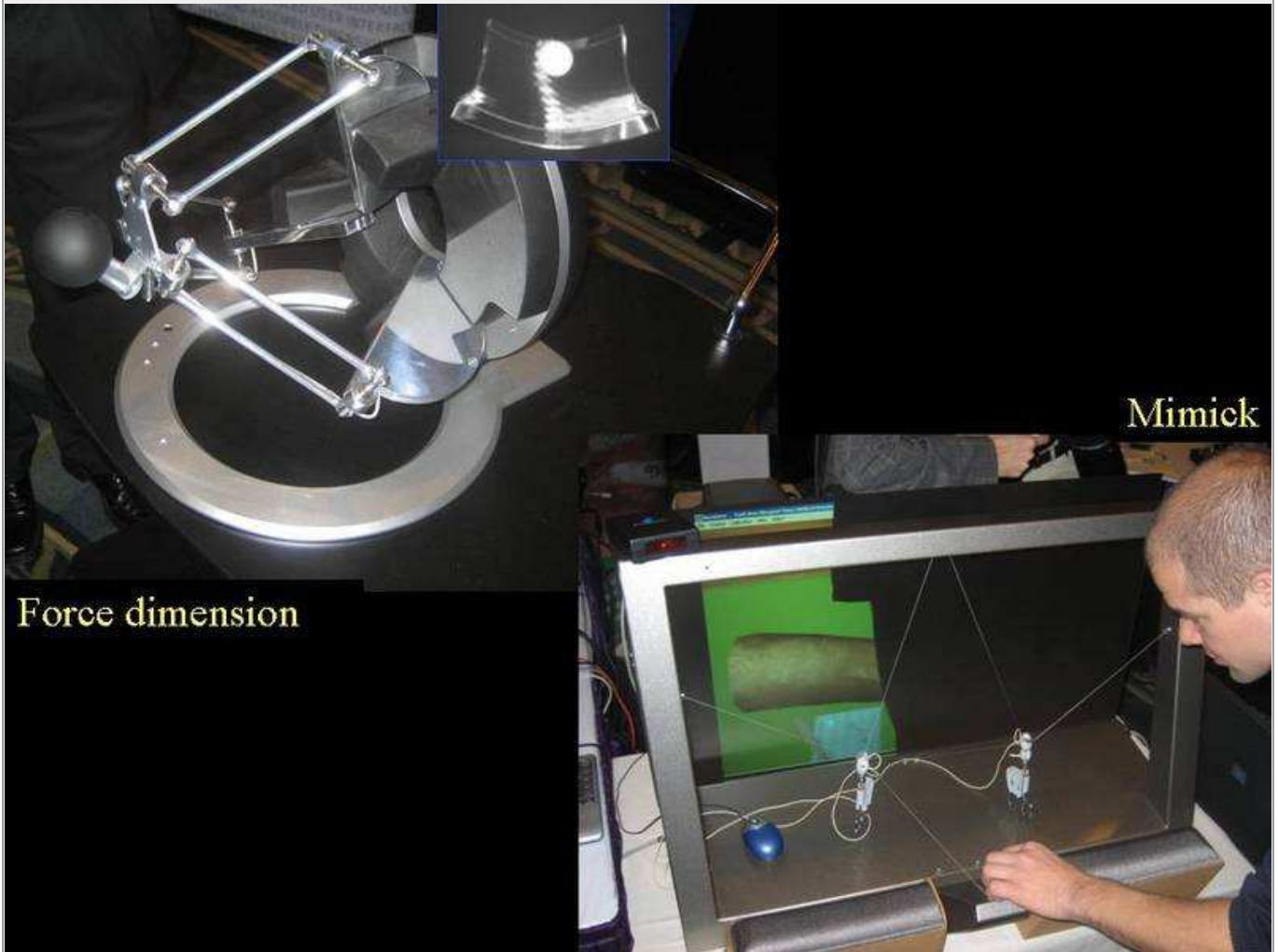
US

Liverpool, Leeds, Imperial / St Mary's: *Val Gough, Damian Mullan, Peter Littler, David Kessel, Mo Hemady, Andy Fagan, Derek Gould*

Use of patient imaging data is key to valid virtual environments, though requires patient consent, and anonymisation of data. Our imaging data sets are held on an ftp server at Bangor University Dept of Computer Science.

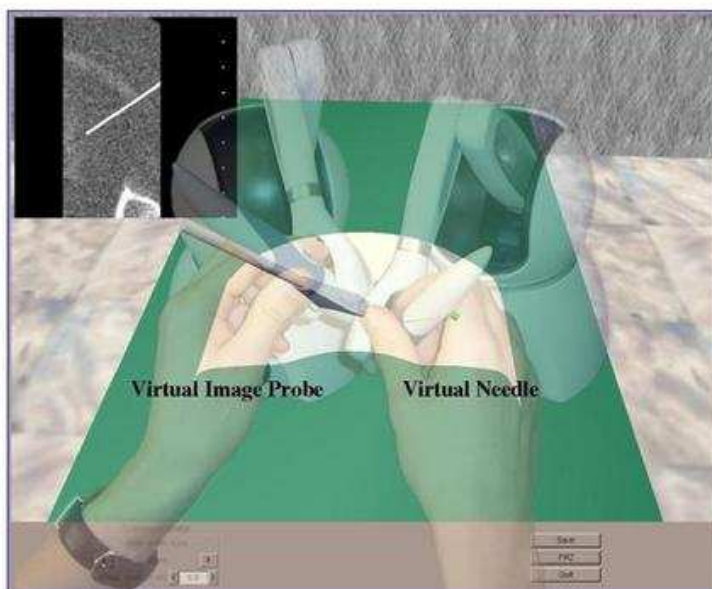


## Haptics devices



Haptics (always plural) means touch. The two devices illustrated use different mechanical methods to impart the 'feel' of a simulation to an operator. Force Dimension uses servo-driven, articulated arms. The Mimick device provides force sensation via a series of cables driven by motors.

## Face validation



Here the operator's hands can be partially seen through the half silvered mirror which reflects the computer screen image. The hands are co-located with the instruments of the virtual world, while actually holding the haptic devices.

Interventional radiology uses imaging to guide minimally invasive procedures

# MINIMALLY INVASIVELY...

Unblock vessels

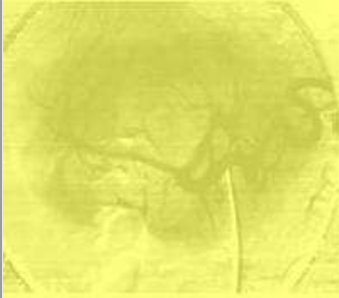
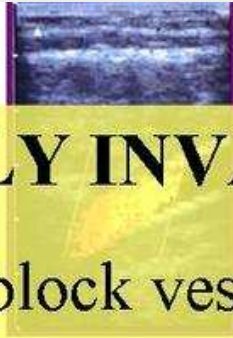
Block vessels

Re-line arteries

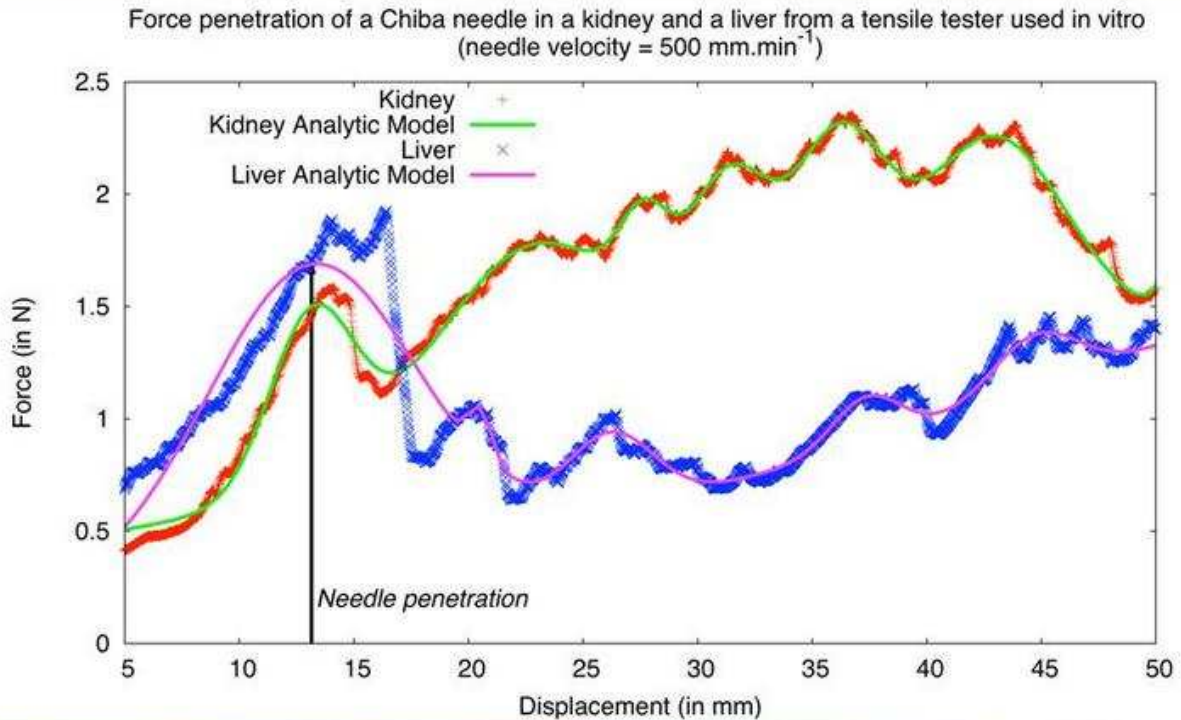
Infuse drugs

Biopsy masses

Drain obstructed organs and abscesses...



## Kidney and Liver Penetration Resistance Modelling using Radial Basis Function (RBF)



11

These force data provide more realistic feel to an operator when incorporated into the simulation.

## Mediseus Epidural Simulation, MedicVision



This epidural simulation is notable for faithful replication of the characteristic tactile sensations encountered during performance of an epidural needle placement.

## Needle puncture simulation with 3D viewing



This iteration of the simulation uses the 3D-IW (SenseGraphics, Färögatan, Sweden). The computer screen reflection is seen by the operator, and overlays the operator's hand, which are 'immersed' in the virtual environment.

## Task analysis: identify critical steps that require metrics

### 11. Puncturing artery

- 11.1. Position vascular access needle on incision site – between 2 fingers pressing down (see step 1.11), Bevel uppermost (see holding a vascular needle algorithm)
- 11.2. Insert needle through the nick in the skin at a 45 degree angle towards artery (with the orifice on the bevel of the needle pointing upwards and forwards so the wire can exit easily)
- 11.3. Feel the artery pulsation using non needle holding hand and align the needle trajectory with the artery
- 11.4. Advance the needle towards the artery.
- 11.5. Is there any indication from patient that more local anaesthetic is needed?
  - Yes (insert more local through arterial puncture needle and go to step 11.6)
  - No (continue to step 11.6)
- 11.6. Feel for the artery pulsating through the needle. Can you feel pulsation?
  - Yes (indicates near artery, go to step 11.7)
  - No (reposition needle and repeat step 11.6)
- 11.7 Puncture artery with either:
  - A sharp stab
  - Gently increase pressure
- 11.8 Immediately but gently decrease angle between needle and patient

<http://www.craive.org.uk/>

This analysis of arterial puncture shows just a part of the procedure. The procedure steps are identified in a hierarchical format and key, critical steps that require measurements to be applied (metrics) for assessments, are highlighted in green. The website ([www.craive.org.uk](http://www.craive.org.uk)) shows a number of analyses in full: these are in a constant state of evolution.

## For patient safety: meet ‘pre-patient’ proficiency criteria\*

- Knowledge
  - Specific procedural, procedure steps, equipment
- Skills
  - Prerequisite tasks
  - Basic / generic enabling skills
  - Fundamental elements to perform procedure
- Perform procedure in a simulation

... then *start* to learn in patients

*\*Grantcharov, Reznick, BMJ, 2008.*

Pre-patient training has been suggested as a method of reducing the risk of a novice's first exposure to patients.



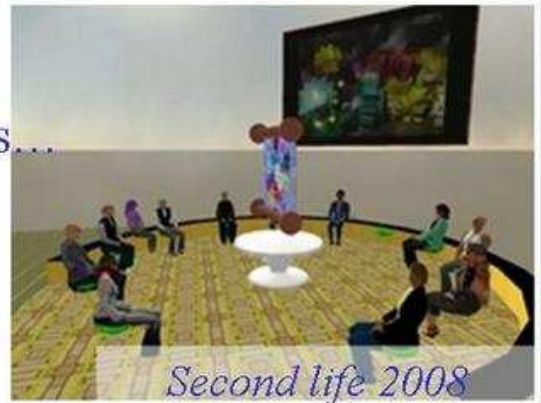
## Promis Simulator from Haptica in a skills centre setting



This is an augmented surgical simulator which allows one or more users to practice using real instruments held in a `normal' position with normal degrees of freedom: they operate on a manikin and use a laptop computer as a stacking unit view. Tasks may be physical or virtual (or a combination of both).

## Simulation: create a model to make predictions

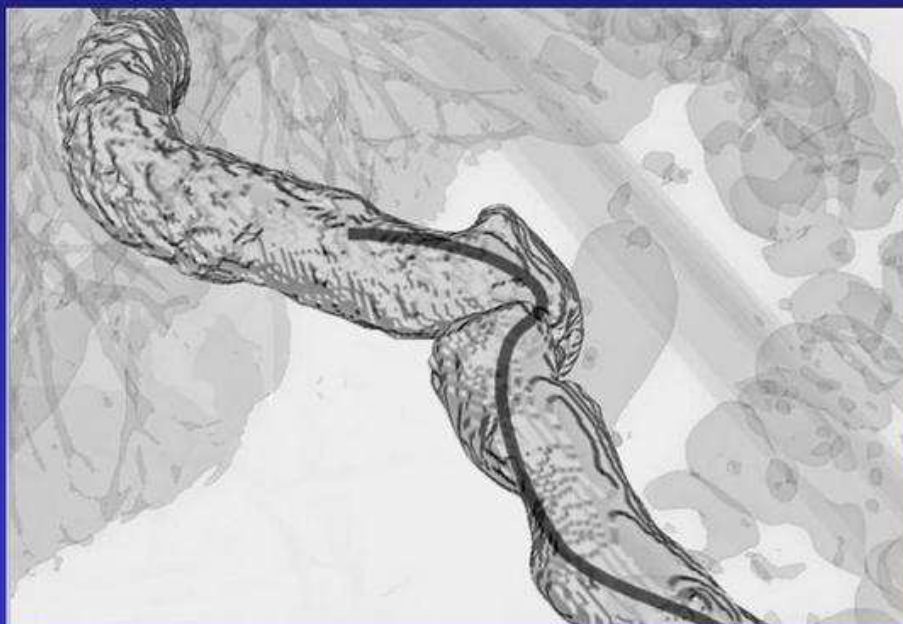
- Computer based simulations use a virtual environment informed by algorithms to
  - Train to meet virtual / real world challenges
  - Provide assessments of operator performance
  - Work within a virtual environment, e.g. conferencing
  - Play a game (competitive)
  - Eliminate phobias
  - Design: buildings, cars, artefacts...



Simulations fulfil a range of applications, from games, including the serious games initiative, to high fidelity medical and aviation simulations.

## Simulation of wire / catheter

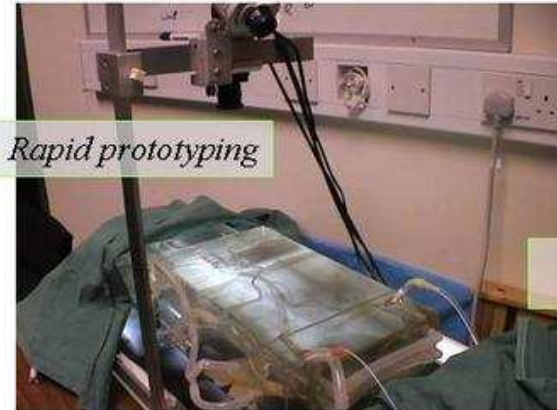
- Guide wire / catheter simulation
- A bounding box is used to provide basic collision / force feedback information
- Option to allow fluoroscopic or endoscopic views of guide wire.



The operator's actions are mapped to a virtual wire / catheter, which is navigated through the virtual vascular tree.

## Simulations for training

### Simulations....



*Models*



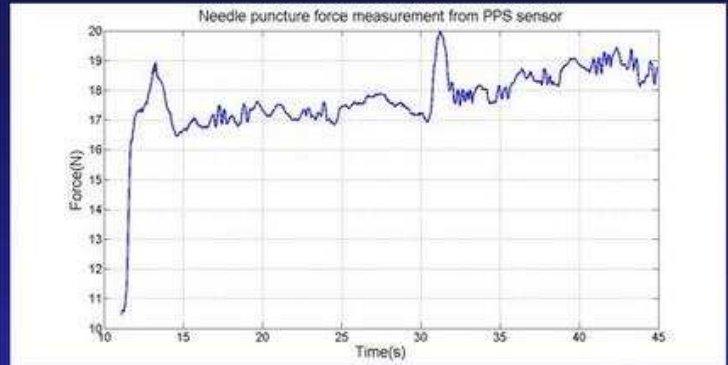
Fixed models are expensive, animals are expensive to maintain and use for training, and there are ethical issues, though they provide suitable content to mirror real world fidelity for physiology. Animals lack pathology though, and anatomy is dissimilar to human anatomy. Computer based simulations are an option, though are in an early state of development....

## Tracking during force data collection

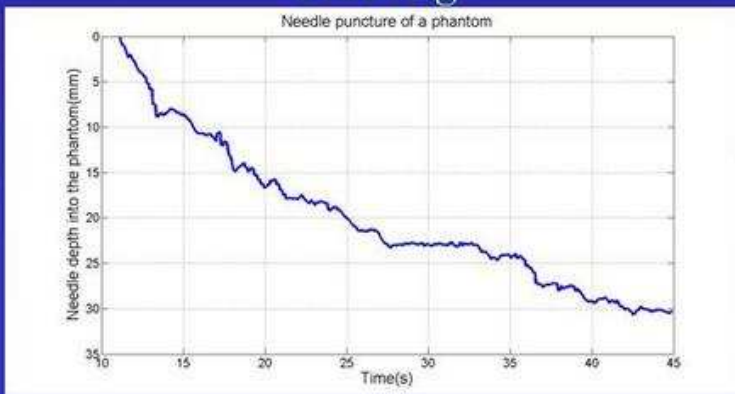
*Real time ultrasound needle guidance*



*Force*



*Tracking*

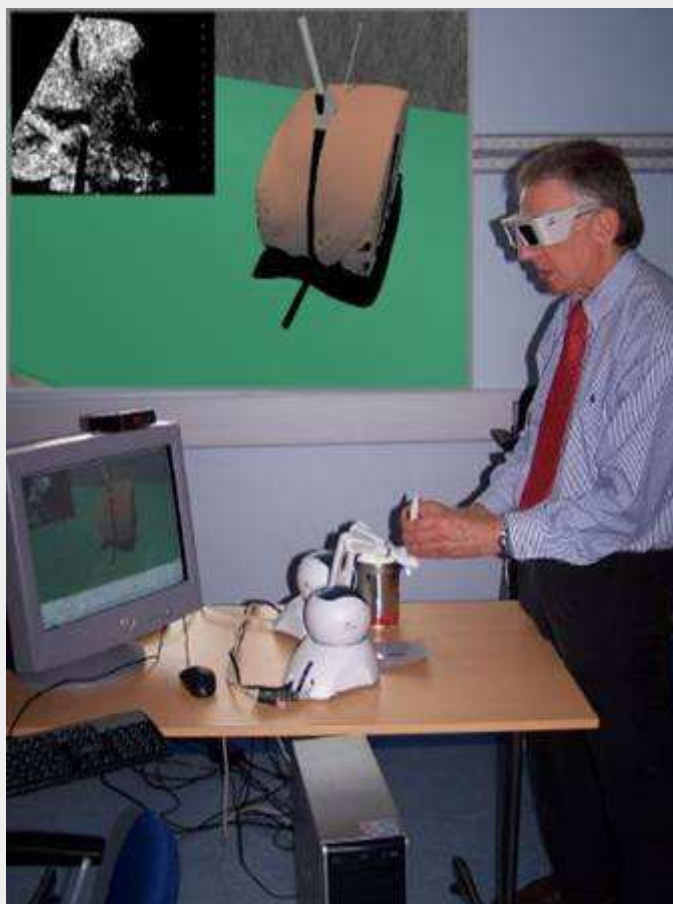


*Jianhua Zhai, Nigel Harrison, Raj Gedela*



Magnetic tracking (Aurora, NDI, Toronto) is used to determine needle velocities. This allows force vectors to be derived for more accurate representation of tactile feedback.

## Ultrasound simulation using a laptop computer



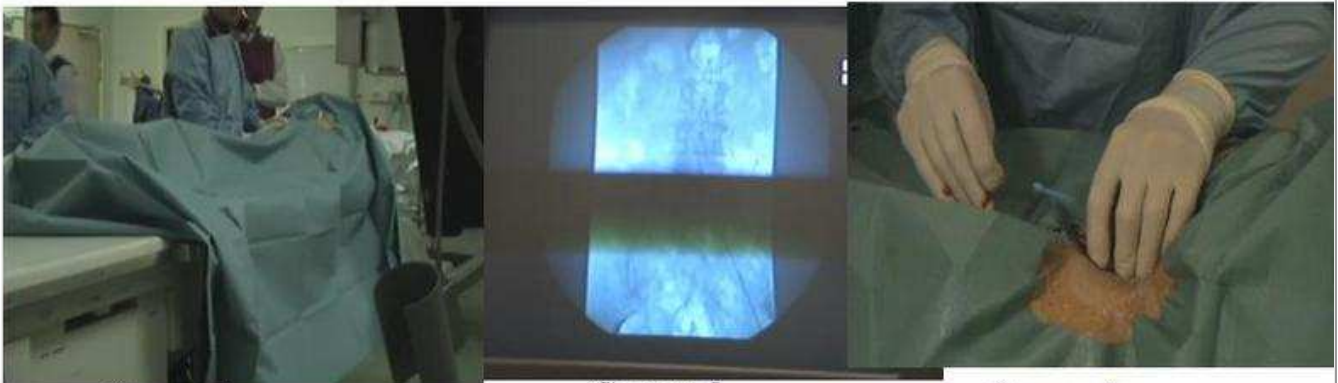
This shows the interim development of the CRaIVE ultrasound guidance simulation: see later.

## Video-recording procedures

### Task Analysis: *to decompose procedures*\*

#### 1. Video-record subject matter expert (SME) procedures

- informed consent
- 16 procedural video-records to date



Camera 1  
Room Overview

Camera 2  
Fluoroscopy

Camera 3  
Operator's Hands

*\*Johnson SJ, Healey AE, Evans JC, Murphy MG, Crawshaw M, Gould DA. Physical and cognitive task analysis in interventional radiology. Journal of Clinical Radiology: 2006.*

Procedures are performed by subject experts recommended by Societies. Three cameras are used to record the whole room scene, the operator's hands, and the fluoro / ultrasound screen.

## Analyse the task\*

Video procedure

Interview subject experts

Identifies steps

Informs simulator design ([www.craive.org.uk](http://www.craive.org.uk))



Camera 1  
Room Overview

Camera 2  
Screen

Camera 3  
Operator's Hands

*\*Johnson SJ, Healey AE, Evans JC, Murphy MG, Crawshaw M, Gould DA. Physical and cognitive task analysis in interventional radiology. Journal of Clinical Radiology: 2006.*

Procedures are performed by subject experts recommended by Societies. Three cameras are used to record the whole room scene, the operator's hands, and the fluoro / ultrasound screen. The video is used as a prompt during interviews of subject experts to break down procedure tasks.



## Wiki format of task analysis

Annotated task analysis (web based): to inform simulator design		
Task Analysis	Realisation	Comments
		seem too complex.
14.2 Insert needle through the nick in the skin at a 45 degree angle towards artery (with the orifice on the bevel of the needle pointing upwards and forwards so the wire can exit easily)	Trainee pushes needle phantom. Phantom provides 3DOF haptics. Trainee feels no torque on needle hub.	
14.3 Feel the artery pulsation using non needle holding hand and align the needle trajectory with the artery	Trainee feels artery pulsation on mannequin (via haptic pulse device) using non needle holding hand and aligns the needle trajectory with the artery.	
14.4 Advance the needle towards the artery.	Trainee advances the needle phantom towards the artery. The part of the needle inside the mannequin is entirely virtual.	
14.5 Is there any indication from patient that more local anaesthetic is needed? Q. What are the indications to be observed? A. Patient complains of pain.	Not realised.	Patient voice activated complaining pain could be included in later vers of simulator.
Yes (inject more local through arterial puncture needle and go to step 14.6)	Not realised.	
No (continue to step 14.6)	D (decision point)	
14.6 Feel for the artery pulsating through the needle. Can you feel pulsation? Q. What are the range and profile of forces felt? A. as 10.3	The phantom Omni provides this haptic feedback.	This is patient specific.  I can't say I'm aware of the artery pulsating through the needle. I'm guided by the other hand
Yes (indicates near artery, go to step 14.7)	D	
No (reposition needle and repeat step 14.6)	Trainee moves needle.	
14.7 Puncture artery with either;	NA	<a href="http://www.craive.org.uk/">http://www.craive.org.uk/</a>

In this format, computer scientists and subject experts can input the process of realisation of the simulation, deriving this from the task analysis.