ULTRASONIC DETECTION
Invention of ultrasound devices to detect underwater objects, such as icebergs and submarines, and the resulting patent war.
SCIENTIFIC EXCELLENCE

Dr Janet De Wilde (Heriot-Watt University, Edinburgh) explains more about SINAPSE, a programme to collaborate on research in brain imaging across Scottish universities.

SINAPSE (Scottish Imaging Network – A Platform for Scientific Excellence) is a consortium of six Scottish universities (Aberdeen, Dundee, Edinburgh, Glasgow, St Andrews and Stirling) that has been established with funding from the Scottish Funding Council, the Chief Scientific Office and the universities. The aim of the consortium is to create a strong dynamic network for a shared environment that leads to the development of brain imaging research. The focus is primarily on the technologies of magnetic resonance imaging (MRI), positron emission tomography (PET), single photon emission computed tomography (SPECT), electrophysiology (EEG) and event related potentials (ERPs).

The network is already gaining significant strength, with key research staff appointments being made in the areas of image acquisition, fMRI paradigm design and image analysis. A key area is the development of novel tracers in PET brain imaging. To follow this, in the near future, strategic appointments to five Professorial Chairs will be made, covering all areas of brain imaging, including image analysis, brain imaging physics, functional imaging, oncology and vascular imaging.

One of the most exciting parts of SINAPSE for early career research scientists is that this first-rate research base will have its capacity enhanced by the appointment of 24 postgraduate studentships over the next few years. Two PhD calls have already been completed, with two students currently active and more due to start in October 2008. The SINAPSE network will provide these students with a strong cohesive doctoral training programme between universities, allowing them to develop their careers, and effectively establishing a future generation of imaging researchers in Scotland.

Below is the view on the ground from a selection of the SINAPSE centres.

**SINAPSE – A VIEW FROM EDINBURGH**

One of the aims of SINAPSE is to facilitate all the imaging centres as a single imaging lab at each site to be pooled together in one analysis. Clearly, with the mixture of make, model and field strength of the SINAPSE MRI scanners, preferred local protocols and coils, this is no easy task!

Another complicating factor is scanner performance, particularly in longitudinal studies providing data for quantitative analyses – hence it is so important to develop an appropriate quality assurance (QA) protocol.

Through our work for ‘Calibrain: multicentre structural and functional MRI in Scotland’, funded by the Scottish Government and a precurser to SINAPSE, involving the Universities of Edinburgh, Aberdeen and Glasgow, we have realised the importance of QA in determining the reproducibility of the acquired data. In a multi-centre environment, QA is particularly important as it ensures that any change in the subject’s images can be attributed to genuine, patient-specific changes and not changes in the scanner or associated protocols.

Building on this experience, we’re working with medical physicists from each SINAPSE centre to review and optimise our QA for our multi-centre work. As well as including the standard QA tests for our sMRI and fMRI, we hope to address specific
QA issues in some of the more advanced modalities such as DTI, with the development of dedicated test objects and protocols through our SINAPSE-funded PhD studentships.

THOUGHTS FROM THE GRANITE CITY
Aberdeen has an international reputation in neuroimaging research, particularly in ageing brain research, that includes multimodality imaging, such as PET, SPECT and structural and functional MRI. We are, however, a small group of researchers. We see SINAPSE as being the perfect route to generating a critical mass of researchers to allow us to compete more successfully on the international stage. The inclusion of 24 part-funded PhD studentships in the initial SINAPSE bid will also allow Scotland to develop the next generation of neuroimaging researchers, and with the first appointment made in Aberdeen in October 2007 we are already taking the first steps.

As mentioned above, our work with the Calibrain project introduced three of the six universities collaborating in SINAPSE to the advantages of pooling expertise and data. We know that the addition of Dundee, St Andrews and Stirling will add to the experience, making Scotland a major player in the arena of neuroimaging.

From a more personal view, although we all know that Scotland is relatively small geographically we, as researchers, have all been guilty of ‘re-inventing the wheel’ rather than asking our neighbours for help. Hopefully we will be a bit more willing to ask for help.

PRE-SINAPTIC THOUGHTS FROM GLASGOW
It is clear that Scotland has to function as a coordinated unit to be internationally competitive in clinical research, particularly in those fields that involve technologies of high complexity. Neuroimaging is a prime example. In recent years Glasgow neuroimaging researchers have made modest contributions to research in many clinical fields, have taken eight compounds from the experimental laboratory setting and developed them into SPECT tracers that have been used in clinical studies in many different centres around the UK, and have won a Proof of Concept award to develop a patented MRI contrast technique. It would have been easy for us to have delusions of adequacy, yet we struggle to recruit staff with appropriate skills.

The Wyeth/TMRC partnership has enabled us to embark on joint neuroimaging studies with Aberdeen on SPECT and PET tracer development, and with Edinburgh and Aberdeen on stroke. This is a start in promoting joint working, but does not address the long-term issue of developing skills and optimising the use of facilities across the whole of Scotland. This is what we expect will be achieved through SINAPSE. Early signs are encouraging. Post-doctoral researchers and PhD students are being recruited. Importantly, each PhD student will be co-supervised by experienced academics from two centres and will work on projects of interest to the SINAPSE partnership.

At a recent meeting of the New York Academy of Science in London, the Chairman made a plea to the Universities in the south-east of England to learn from the Universities of New York and work in partnership. By comparison SINAPSE will be small, but hopefully perfectly formed.

A STIRLING APPROACH TO IMAGING
Brain imaging at the University of Stirling has always played something of a back-seat role to the bigger universities in Scotland, largely because Stirling has no Department of Medicine. There is, however, an active
brain imaging laboratory within the Department of Psychology – where research is carried out to investigate the neural basis of basic mental abilities such as memory and language. The development of SINAPSE is a major plus for Stirling because it provides a great opportunity for the integration of different methods and approaches across the participating universities.

The Stirling approach has been to use event-related potentials (ERPs) to investigate the brain – a measure of neural activity recorded from electrodes placed on a subject’s scalp. ERPs provide a powerful means of assessing brain activity in real time, revealing the changing patterns of brain activity that occur during mental processing.

In fact, ERP laboratories exist in all of the participating universities that are part of the SINAPSE network, and the scientists in these laboratories have often worked in relative isolation from one another. The coordination of brain imaging across Scotland that is at the heart of the SINAPSE network looks certain to enhance the interaction between brain scientists and, as a result, lead to better research.

**DUNDEE DEVELOPMENTS**

In Dundee, a new Clinical Research Centre (CRC) has been built and a state-of-the-art 3 Tesla MRI scanner is very soon to be installed solely for research use. There is also space in the building for PET/CT and there are ambitious plans to install a cyclotron in the adjacent Medical Physics building. Hence Dundee plans to contribute fully to the SINAPSE network with academic appointments also pending. The MRI scanner will be set up for fMRI studies and it is expected that Dundee and St Andrews psychologists will make full use of this facility.

**BUILDING ON REPUTATION AT ST ANDREWS**

The School of Psychology at St Andrews has a well-established reputation for cutting-edge research into brain function and human behaviour. This includes a tradition of brain imaging research from the establishment of the first EEG laboratory in the School in the late 1970s, which spawned a generation of memory researchers, many of whom are still working in Scotland. EEG research continues to thrive in the School where it is currently used to investigate a range of cognitive processes. SINAPSE represents a new way of working and cooperating not only between institutions but also disciplines. Multidisciplinarity may be SINAPSE’s greatest strength and also its greatest appeal to both the research and clinical communities.

The opportunity for involvement in a network of leading scientists from such a broad range of disciplines who share a common interest in furthering knowledge about the brain is quite unique. SINAPSE will provide a platform for an exchange of ideas and knowledge that will benefit the research community and the Scottish population through the co-operation and collaboration of researchers and clinicians. This is a truly exciting development that we are delighted to be part of.

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Oncology Systems Limited
Wow, what a ride! I’d taken a sabbatical leave year from Purdue University starting at the beginning of July 2007 and spent most of that time on opposite sides of the globe; England and Australia. It seemed that fitting in 2 weeks for a seminar tour of the UK as part of the honour for receiving the 2007 AAPM–IPEM Medical Physics Travel Grant was going to be easy. After all, everything was leaning my way. I’m originally from Liverpool, England, a city that is home to the Beatles, world class soccer teams and a peculiar local accent known as ‘Scouse’. All my siblings, my parents, and about half a million other souls still reside in this 2008 European Capital of Culture plus I have friends abounding in the city and on the island at large. Yes, easy as eating pie, except life comes at you hard, fast and without warning sometimes. A family crisis, encountering sick parents and a career-related opportunity all colluded to force a change in my award travel plans from Fall 2007 to Spring 2008. Nevertheless, all went smoothly in the end and the tour was a great success.

**PROTON THERAPY AT CLATTERBRIDGE**

I’ve had an interest in proton therapy for a long time and this interest has recently been focused on problems concerning the treatment of lung cancer using this modality. How should we be doing true 4D proton therapy and may we take advantage of the time dimension to improve optimised intensity modulated therapy? Aspects of this question, together with scattered neutron dose to a fetus and prostate cryosurgery, comprised the six seminars given in part fulfillment of the award requirements.

First I visited the Clatterbridge Centre for Oncology (CCO) in Bebington, which is the second largest dedicated cancer centre in England. There I was hosted by Professor Alan Nahum to deliver the seminar entitled ‘Proton Therapy in Motion?’ This was obviously a pleasant experience judging by the big smile on my face in the picture shown in figure 1! Clatterbridge has the only proton therapy treatment centre in the UK, a low energy facility that treats eyes exclusively. However there is great interest in acquiring funding for a high energy proton treatment facility by Clatterbridge and I met with the centre’s Chief Executive Officer, Mr Darren Hurrell, to discuss the opportunities presently available. The CEO attended my seminar and I hope he was educated as to the potential of this modality and the cutting edge research that would be translated into the clinic by the time their proton facility is built.

**RADIOBIOLOGICAL MODELLING COURSE**

Alan is an expert in Monte Carlo calculations and radiation dosimetry who has an increasing profile in biological modelling of radiation therapy treatment. In fact I arrived a few days before the annual international course he organises on Radiobiological Modelling in Radiotherapy at the CCO (see www.ccotrust.nhs.uk or contact Alan directly for details on the 2009 course, alan.nahum@ccotrust.nhs.uk). Not only did Alan host me for the seminar at one of his busiest times of the year but he had kindly been my sponsor for a long stay at Clatterbridge in 2007 as part of my sabbatical. Alan’s boss and Director of the Medical Physics Department at Clatterbridge is Dr Philip Mayles. Somewhat coincidentally, I had two prior connections with Philip but I had never spoken with him.
mountainside views of splendid valleys and lakes unravelling before me with each turn of the road. It taught me to get lost more often around Sheffield and then enjoy the trip. I’d started out early and so fortunately arrived only a few minutes late for my meeting with John. Actually this was quite a miraculous feat since getting around hospital buildings in the UK is now a high security event with electronic keys cutting off non-patient areas from visitors. John gave me a tour of the clinic, treated me to lunch, and hustled so the seminar was well attended by a large cross section of staff.

THE OLD AND NEW IN RESEARCH IN OXFORD
Next was a trip to Oxford where I was hosted by Ms Elizabeth Macaulay (figure 3) to deliver a seminar entitled ‘Secondary Neutron Dose to the Fetus from Proton Radiotherapy of the Mother’. Interestingly, there are no specified radiation dose limits to the fetus of a mother undergoing radiation therapy treatment. I compared the scattered neutron dose equivalent between proton beam passive scattering systems and scanning systems to each other and to high energy x-ray treatments. Elizabeth took me on a tour of the Churchill Hospital’s radiation therapy facilities and over the plans for the new facilities at the Oxford Cancer Centre in the process of being built as part of a new hospital complex costing over £200 million. Courtesy of Dr Chris Gibson, Director of Medical Physics and Clinical Engineering, we three then ate lunch at the University of Oxford’s old observatory building located within the grounds of the newest of the Oxford colleges, Green College. This very attractive College was established in 1979 and is 730 years younger than the first, University College, established in 1249. Green is devoted to students in the medical disciplines and boasted Regis Professor of Medicine Sir Richard Doll as its first Warden. He, along with another Medical Research Council scientist Sir Austin Bradford Hill, published in 1950 the first article describing an epidemiological study linking lung cancer with a major causative agent, smoking.
SIGHTSEEING IN OXFORD
A well-deserved rest day saw me spending my leisure time in the oldest British museum, the Oxford Ashmolean Museum. Initially based on a private collection of Elias Ashmole it was opened to the public in 1683, and now contains incredibly rare and incomparable works of art and craft including two Stradaveri violins and a guitar among the master musical instrument collection. Then later I toured the Bodleian Library complex which houses an astounding number of ancient medieval books and manuscripts in its oldest part. This part of the library was finalised in 1488 as a gift to Oxford University by Humphrey, Duke of Gloucester, who was younger brother to King Henry V. The Bodleian, named after Sir Thomas Bodley, a Fellow of Merton College in the late 16th century, is Oxford University’s oldest and main research library. The inside will be familiar to many as it is featured in several scenes of the Harry Potter movies as the Hogwarts library.

DISCUSSING FUTURE PROSPECTS WITH STUDENTS
From Oxford I travelled to the University of Surrey, Guildford, to join my host Dr David Bradley in the Centre for Nuclear and Radiation Physics, Department of Physics. I arrived just in time to deliver my seminar on ‘Contemporary Problems in Proton Therapy’ to the graduate medical physics students and faculty. Then I spent another hour chatting in a freestyle format with the students answering any questions they had. Mostly their interests lay in jobs, clinical training and further education at the PhD level. Some were interested in my thoughts on the best medical physics programmes to apply for in the USA. Later I was treated to lunch at the faculty club by David and we were joined by Emeritus Professor Nikolas Spyrou and Professor Andrew Nisbet, Head of Medical Physics at the Royal Surrey County Hospital. We chatted about the exciting and ground-breaking research being pursued at Surrey University including plastic radiation detectors, proton microbeam tomography, determination of trace element analysis using neutron activation, and the use of proton induced x-ray excitation (PIXE) for determining the metabolism and pathology of disease. Proton work is carried out at the university’s ion beam analysis and accelerator facility and following lunch David took me on a grand tour. One of the highlights of this tour for me was the ongoing construction of an £11 million nanobeam charged particle facility that is to be dedicated in part to cellular radiation damage studies looking at mechanisms for the bystander effect. David and I also stumbled across a mutual friend and colleague in our conversations, Dr Suprakash Roy. He is an Indian scientist based in Calcutta who is an expert in neutron bubble detectors and had previously spent two summers on Visiting Professorships with me doing the work on scattered neutron dose equivalent to a fetus from x-ray and...
proton radiation beams. David had also worked with him several times in Calcutta. Yes, the world of medical physics is a small one!

TIME AND MOTION, AND MUSIC!
My visit to the prestigious Institute of Cancer Research and Royal Marsden Hospital was hosted by Professor Steve Webb. Steve is not only an outstanding and accomplished medical physicist but also a serious artisan and musician. He has built copies of renaissance stringed instruments including copies of the Sellas guitars in the Ashmolean Museum. In the photograph in figure 4 he is playing one of several renaissance copy guitars that he built himself, this one being quite a lot smaller than the 180 cm string length Tiefenbrucker copy he built to exact scale from the design of the original bicycle-sized one housed in the Royal College of Music. Steve organised a full day of meetings with various leadership teams and a ‘meet the professor’ session for graduate students as well as my lunchtime seminar entitled ‘Time and Motion – Enemy and Friend’. The Institute of Cancer Research and the department led by Steve is the home of British expertise in dynamic therapy and 4D procedures so I was happy to provide in detail some of my thoughts on the topic relating to proton therapy and also covered the most recent work of Zhao Li and Ryan McMahon, PhD candidates in the School of Health Sciences at Purdue University. This seminar was very well received and, I learned, an appropriate precursor to the visit of Dr Thomas Bortfeld, MGH and Harvard Medical School, an acquaintance who was also to speak on the topic of proton radiation therapy the following week since he was invited to give the Institute’s 2008 Haddow Lecture in recognition of his many scientific contributions to radiation therapy physics research. Yes, the world of medical physics is a small one!

Acknowledgements to all involved
I’d like to thank the AAPM and IPEM for the financial support and opportunity to interact with some of the most prominent medical physicists in the UK. Hopefully this experience will result in some future collaborations reaching across the Atlantic. I’d also like to thank all my hosts for their graciousness and kindness while participating in this event. Finally, I’d like to thank my many past graduate students, post-docs and scientific collaborators whose work and role in the research presented was formally recognised at the beginning of each seminar. Even though the world of medical physics is a small one, it is a beautiful one filled with some of the finest people one could ever hope to meet. My wish is that the 2008 award recipient of the AAPM–IPEM Travel Grant has as much fun as I did.

Cancer Using Cryosurgical Freezing’ was delivered to the Department of Medical Physics and Bioengineering, University of London, and I was hosted by the Head of the Department Professor Andrew Todd-Pokropek. This department is strongly focused on imaging problems related to medicine and I felt members would be interested in the imaging problems of ultrasound for cryosurgical procedures and the benefits of using x-ray CT guided procedures instead. I am an alumnus of the University of London and upon touring and meeting with various faculty members to discuss their research I learned several were intimately familiar with the medical physics programme from which I had graduated. It felt good to have a feeling of belonging and I even reminisced with Andrew about spending time writing up my MS project around the corner in my girlfriend’s apartment on Gower Street. This project centred on the evaluation of the first commercial SPECT machine (J and P Engineering, manufacturer). Andrew shocked me when he revealed that he was the designer of the first prototype for that machine. Yes, the world of medical physics is a small one!

Back to my roots in London
The last seminar of this series entitled ‘Treatment of Prostate Cancer’ was delivered to the Department of Medical Physics and Bioengineering, University of London, and I was hosted by the Head of the Department Professor Andrew Todd-Pokropek. This department is strongly focused on imaging problems related to medicine and I felt members would be interested in the imaging problems of ultrasound for cryosurgical procedures and the benefits of using x-ray CT guided procedures instead. I am an alumnus of the University of London and upon touring and meeting with various faculty members to discuss their research I learned several were intimately familiar with the medical physics programme from which I had graduated. It felt good to have a feeling of belonging and I even reminisced with Andrew about spending time writing up my MS project around the corner in my girlfriend’s apartment on Gower Street. This project centred on the evaluation of the first commercial SPECT machine (J and P Engineering, manufacturer). Andrew shocked me when he revealed that he was the designer of the first prototype for that machine. Yes, the world of medical physics is a small one!

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65th Anniversary of the HPA
Meeting notes from the inauguration of the Hospital Physicists Association

A s well as being the 60th anniversary of the NHS, 2008 marks the 65th anniversary of the formation of the Hospital Physicists Association. The HPA was the first national organisation for medical physicists and medical physics in the world. Its inaugural meeting, during wartime in September 1943, had been preceded by a meeting of 11 physicists in Leeds in May 1943, when Bill Spiers had organised the launch meeting of the Northern Group of Medical Physicists, which became the first regional group of HPA.

The minutes of the first cycle of meetings of HPA, held on Friday 24th and Saturday 25th September 1943, are reproduced here to mark this historic event.

FRIDAY 24TH SEPTEMBER
Inaugural meeting held at 2.30pm Friday 24th September 1943 in the British Institute of Radiology
About 30 present

The meeting; after some discussion, resolved that the body formed should interest itself in, and discuss, all matters arising out of the mutual interests of those engaged in hospital physics.

It was decided that membership is to be open to physicists attached to hospitals, medical schools, medical or biological research departments who have had one years’ experience.

The meeting agreed that there should be a chairman who would hold office for one year only and a secretary who would hold office for one year in the first instance, but who should be eligible for re-election for a maximum period of three years.

Professor F.L. Hopwood proposed that Professor S. Russ (picture) should be the first Chairman of the body. This motion was seconded by Professor W.V. Mayneord and carried by the meeting unanimously.

Drs J.E. Roberts and C.W. Wilson were nominated for the office of secretary and the latter was elected.

Finally it was resolved that the body should hold three ordinary meetings of its members each year, at least one of these to take place outside London.

Before he left, Mr Phillips proposed that Birmingham should be the place of our first meeting outside London, the provisional time of this meeting being May 1944.

A message of goodwill to our new body was received through Dr L.H. Clark from the National Radium Commission.

Saturday morning 25th September 1943 10.30am – 12.30pm
Visits were paid by groups of members to The Royal Cancer Hospital, The Middlesex Hospital and The Westminster Hospital where comprehensive exhibits dealing with the work were shown.

SATURDAY 25TH SEPTEMBER
Meeting held at 2.30pm Saturday 25th September 1943 in the British Institute of Radiology
In the Chair: Professor Sidney Russ
About 30 present

Professor Russ read to the meeting a letter received from the British Institute of Radiology welcoming the formation of our Association, in particular, the fact that we desired its formation to take place within the framework of the Institute if this could be so arranged.

Professor F.L. Hopwood proposed that the name of our body should be ‘The Hospital Physicists Association’. The motion was seconded by Dr L.H. Clark and carried unanimously by the meeting.

It was resolved unanimously that a Governing Committee should be elected and that its constitution should be discussed at the next meeting which should take place in London during the week-end before Christmas 1943.

In connection with the scope of our future meetings Professor Russ expressed the opinion that we had been too ambitious that morning in providing three hospitals for members to visit and that in future one hospital would be sufficient. The meeting endorsed this view.

Dr H.J. Flint read a paper on ‘Technique with Radium Gramme Units’ in which he stressed the fact that our Association could be useful in educating radio-therapists in the need for the fullest application of physical information to their therapy.

Professor F.L. Hopwood read a paper on ‘The Betatron’ which emphasised the potentials of this new physical tool in the future work of hospital physicists and gave considerable encouragement to the younger members of our Association.

In a paper on ‘Teaching for the Diploma’ Professor G. Stead gave a most interesting account of the history of radiological teaching in this country up to the present time, and pointed out that it seems necessary in the future to provide separate courses for diagnostic and therapeutic radiologists.

In the final paper on ‘The Equipment of a Hospital Physicist’, Professor Russ dealt with the kind of knowledge a hospital physicist must acquire, outside his own science, if he is to be of maximum service to medicine, and so indicated, that another line of future work for the Association, would be to arrange facilities for the acquirement of this knowledge.

After some discussion on the papers the meeting closed when it had expressed its thanks to the conveners.
Francis Duck provides the fascinating story of how underwater detection was developed using ultrasound and the resulting patent wars across the globe.

ICEBERGS AND SUBMARINES
THE GENESIS OF ULTRASONIC DETECTION
Ultrasonic waves over 100 kHz, well above the limit to human hearing, were being explored by the early 20th century using tiny tuning forks, whistles and spark generators as sources. But no practical use had been made of this knowledge until two events triggered the developments to be described. First, on 15th April 1912, the Titanic collided with an iceberg and sank with a huge loss of life (figure 1). And, secondly, 2 years later, war broke out in Europe.

**RICHARDSON’S PATENTS**

Five days after the Titanic disaster, Lewis F. Richardson filed the first of two echo-ranging patents with the British Patent Office. Richardson was born in Newcastle, educated in York and Cambridge, and worked briefly at the NPL. He recognised the potential offered by ultrasound for underwater detection, specifically the ability to create a directional acoustic beam. In his second patent, filed on 10th May 1912, he proposed an underwater pulse-echo system instead of the airborne system of the first patent. The purpose of the apparatus was to warn a ship of its nearness to an object ahead. Richardson declared that the best frequency ‘will probably be of the order of 100,000 complete vibrations per second’, and imagined that the sound would be ‘produced by whistles or reeds, blown with water or other liquid’. The sender would be ‘a body somewhat resembling in shape an enormous motor car lamp 85 cm diameter and about 1 m long placed just inside the ship’ within which there would be a parabolic mirror with the whistle at its focus.

However brilliant in concept, Richardson’s apparatus was never built. It was left to the impetus of submarine warfare to cause the development of the first operational ultrasound pulse-echo location system. At the start of the war Germany had just 30 submarines. The sinking of three British cruisers in September 1914, by submarine-launched torpedoes, served to emphasise the huge threat they posed to allied shipping. At that time, there existed no practical device for detecting undersea obstacles. Depth measurement had barely developed since the Greeks first used lead-loaded lines to determine the sea depth. So it is not surprising to find several reports of new underwater detection systems at this time. In the USA, RA Fessenden built and tested the first practical echo-locating device, albeit working at a much lower frequency, about 1 kHz. This system measured the time taken for an echo to return from an object to determine its range, and on 27th April 1914 an iceberg was detected at a distance of 2 miles. During the next decade a number of prototype echo-location systems were developed and tested, both in Europe and America. Some systems used explosive charges, bullets or detonators fired into the water to generate the pulse of sound. Concerned about the safety of these techniques, the British Admiralty developed a mechanical system. A steel diaphragm sounder, 5 inches in diameter, was fixed to the hull of the...
vessel and was thumped by an electromechanical hammer twice a second, emitting a sound pulse with a centre frequency about 1.25 kHz. The receiving hydrophone, also fixed on the hull, was a microphone mounted in rubber. An insulating segment on the receiving drum, which could be rotated by hand, allowed an estimate of the pulse–echo transmission time and hence the target range.

**PROGRESS DURING THE WAR**

All these acoustic echo-locators, however, suffered from the deficiency recognised by Richardson. They were inherently omni-directional, because both source and detector were significantly smaller than the wavelength, \( \lambda \), at the frequency used. Richardson’s second patent explicitly foresaw the need for directional source and detector, both source and detector were significantly smaller than the wavelength, \( \lambda \), and hence the target range.

**FIGURE 2.**

**TOP**

Detail from the Chilowsky and Langevin patent, 1917, showing proposed mounting of the ultrasonic source and receiver on the bow of the ship, and alternative designs for the singing condenser.

**MIDDLE LEFT**

A photograph taken in Toulon during Boyle’s visit in 1917. From left to right: Capitaine de Frégate Colin, Lieutenant Saville, Paul Langevin, Robert Boyle and Marcel Tournier.

**MIDDLE RIGHT**


**TABLE 1.**

Chronology of the development of underwater ultrasonic pulse–echo detection.

**IMPROVEMENTS BY LANGEVIN**

Langevin was initially put off the use of quartz transducers because of Rutherford’s pessimistic view. However he must have reconsidered this judgement following the significant practical problems that were being experienced with the condenser/microphone system. His team initially made two significant practical advances. The first was to replace the carbon microphone with a quartz plate as the receiver of ultrasound, amplifying the small signal using a multi-stage high-frequency triode amplifier which had just become available as part of a separate French research programme. Secondly, he started to make progress in obtaining quartz plates of sufficient size to act as directional sources. The first was a slice, 10 x 10 x 1.6 cm, which he persuaded an optician in Paris to cut from a showpiece in his shop window. It was the initial results, obtained in February 1917, using this crystal as a receiver, which Langevin shared with the British group during his visit in March.

**FIGURE 3.**

**TOP**

A photograph taken in Toulon during Boyle’s visit in 1917. From left to right: Capitaine de Frégate Colin, Lieutenant Saville, Paul Langevin, Robert Boyle and Marcel Tournier.

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Meanwhile, spectacular success had been achieved using the same crystal as a transmitter. The key to this success was that the drive voltage was tuned to the resonant frequency of the quartz, which in this case was about 150 kHz. Driven at 12 kV, Langevin estimated that the transducer generated about 1 kW acoustic output power, a result that immediately placed a practical system within the bounds of possibility. Langevin reported that any ‘fish in the neighbourhood of the beam were killed immediately’, and Robert Wood, one of the visitors from the USA at this time, recalled later that ‘if the hand was held in the water near the plate an almost unsupportable pain was felt’: these reports can probably be credited as the first observations of ultrasound bioeffects. No matter how successful these initial experiments were, however, there remained two final challenges. 12 kV was viewed as too high a voltage for practical use; and there was little prospect of finding enough large quartz crystals. The final innovation from Langevin’s laboratory dealt with both with a single design change. The quartz plate was reduced in thickness to a few millimetres, and sandwiched between two thicker plates of steel. Such an arrangement amplifies the piezoelectric response allowing a much lower...
TABLE 1

<table>
<thead>
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<th>YEAR</th>
<th>ULTRASOUND SOURCE</th>
<th>ULTRASOUND RECEIVER</th>
<th>COMMENT</th>
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<td>Richardson</td>
<td>1912</td>
<td>Underwater whistle</td>
<td>Microphone</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Never constructed</td>
</tr>
<tr>
<td>Chilowsky</td>
<td>1914</td>
<td>Electromagnetic diaphragm</td>
<td>Microphone</td>
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<td>Never constructed</td>
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<td>Chilowsky and Langevin</td>
<td>1916</td>
<td>Singing condenser</td>
<td>Carbon microphone</td>
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<td>Langevin, Boyle</td>
<td>1917</td>
<td>Singing condenser</td>
<td>Quartz plate</td>
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<tr>
<td>Langevin, Boyle</td>
<td>1918</td>
<td>Quartz mosaic and steel sandwich</td>
<td>Quartz mosaic and steel sandwich</td>
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drive voltage to be used. The resonant frequency is defined by the thickness of the whole sandwich, allowing much thinner quartz to be used. And finally, instead of a single crystal, the quartz plate was made up from a mosaic of small pieces. The relative thickness of steel and quartz layers can be seen in figure 4, a diagram of the final transducer assembly. By mid 1918, the French system had demonstrated submarine detection with a range extending occasionally to 1,500 m. Table 1 shows a summary of the steps from Richardson’s 1912 patent to the operational prototype in 1918.

**SOURCING SUFFICIENT QUARTZ CRYSTALS**

Co-operation between the French and British groups was sufficient at this stage for Langevin to supply one of the 10 x 10 cm crystals to Boyle, who by then was working at the Admiralty Experimental Station at Parkeston Quay, Harwich. The British group also built a quartz mosaic transducer, bonded to a single steel sheet with a resonance at 75 kHz, with which, by the end of 1917, they had transmitted signals for nearly a mile. By March 1918, Boyle had successfully detected echoes from a submarine at a distance of 500 yards, within a month of the first submarine detection in France. Boyle was particularly conscious of the difficulty that would be encountered in finding enough quartz crystals, even those suitable for mosaics. His first source was an optical manufacturer, Culver and Co. in London, and he arranged for the crystals to be cut by Farmer & Brinlay, tombstone-makers of Lambeth. Later, a determined search even threatened to requisition all the quartz specimens in British geological museums. He finally tracked down a French supplier of chandelier pendants in Bordeaux where he was astonished to find, in a warehouse, a huge mound of natural quartz crystals piled up like coal.

During the final successful testing, the news was communicated to naval laboratories of other allied countries. The combined progress of French and British programmes was presented in Washington on 15th June 1917 during a visit of a Franco–British Commission to the USA, which included Rutherford and Fabry. Shortly thereafter, work started at the Naval Experimental Station in Connecticut. Once war was over, however, the period of generous co-operation between the allies seems to have ended and a rather silly debate emerged over prior rights. Langevin filed a French patent on 17th September 1918 describing the steel-quartz-steel transducer for echo-ranging. The equivalent British patent was challenged by the Admiralty, who asserted that it should be filed jointly in the names of Langevin, Boyle and Rutherford. This caused Rutherford considerable embarrassment. Quoting in Rutherford’s biography, A.S. Eve gives his short and final comment: ‘If Langevin says that the idea was his, then the idea was Langevin’s’. The debate rambled on rather acrimoniously and was not closed until 1925. Rutherford said at the time that he was ‘surprised and disappointed by the attitude of the Admiralty, and that it would be a grave injustice to Langevin if the services given to the Admiralty during a very difficult period were not generously recognised’. Patent challenges in the United States were not finally resolved until 1946, shortly before Langevin’s death. It seems clear that Langevin must have considered piezoelectric methods at an early stage in this development. As a student he was supervised by Pierre Curie, the co-discoverer of the piezoelectricity of quartz. He was close friends with the Curies, and would have undoubtedly understood the function of ‘quartz piézo-électrique’ with which they quantified the radioactivity of radium. He remained very close to Marie Curie and her family after Pierre’s death, and later ensured that 10 per cent of the income associated with his patents was shared between their daughters, Irène and Ève, and Jacques Curie.

**SUBSEQUENT WORK OF THE INVENTORS**

Boyle returned to Alberta in 1919, and commenced a research programme into acoustic cavitation. Langevin continued to work to improve piezoelectric pulse-echo systems, working with C.L. Florisson to develop depth-sounding equipment at 40 kHz. He became a convinced pacifist and internationalist who took a strongly anti-fascist position between the wars, actively participating in campaigns aimed at securing peace. He was imprisoned after the capitulation of France and subsequently held under house arrest until May 1944. After the war, he devoted his efforts to educational reform, and supported the Communist Party in the hope of encouraging a brotherhood that he judged capitalism had failed to establish. Paul Langevin died in 1946 after a short illness.

**REFERENCES**

**IMAGE REGISTRATION FOR MEDICAL IMAGING: PAST, PRESENT AND FUTURE**

William R. Crum explains image registration; mapping between images obtained from medical imaging equipment

**WHAT IS IMAGE REGISTRATION?**
Image registration is a technique for mapping corresponding pixel positions across images, which has been applied in medical imaging for at least two decades. By mapping between images, scans acquired on different imaging equipment, at different times, or of different people can be accurately compared and analysed. [4] The images are most often derived from medical imaging equipment such as Magnetic Resonance Imaging (MRI), X-ray Computed Tomography (CT), UltraSound (US), Positron Emission Tomography (PET) etc., but may also come from video, microscopy or endoscopy, or be derived from digital models of prosthetics and surgical implants. Medical imaging applications of registration include associating structure with function by giving nuclear medicine images a structural context from MRI or CT, correcting for patient motion during dynamic processes such as dynamic contrast enhanced MRI, and exploring population variation in anatomical shape and function by registering a group of subjects to a common template. Registration is fundamental to techniques like functional-MRI of the brain which are susceptible to subtle patient movement. Left uncorrected, this movement can at best prevent activations being detected, and at worst correlate with a functional task in such a way as to create apparent activation where none really exists.

It quickly becomes apparent that the catch-all term ‘registration’ actually encompasses a variety of applications which have specific demands on robustness, user intervention and compute-time. For instance an off-line fusion of 3D MRI and CT volumes can be performed at a relatively leisurely pace compared with registration of pre-operative and intra-operative imaging which must be near real time. Similarly, registration accuracy requirements may be different in radiotherapy treatment planning compared with image-guided neurosurgery because of the treatment margins built into the former and the importance of avoiding eloquent areas in the latter. In this tutorial, we review the key concepts underlying registration in medical imaging, highlight some recent advances and risk ridicule by trying to second-guess future developments.

**COMPONENTS OF A REGISTRATION ALGORITHM**
Image registration relies on three related concepts: (i) the transformation model which defines the class of allowed mappings between images, (ii) a measure of registration quality, and (iii) an optimisation procedure for choosing the best allowed mapping by maximising the registration quality. The most common distinction in registration is between so-called ‘rigid’ and ‘non-rigid’ techniques. Rigid registration is defined by a transformation model where only global translation and global rotation is allowed. These are the same operations used to guide a key into a key-hole (see panel 1). The key must have the correct 3D orientation and be translated into the correct position to fit the lock. Rigid registration is most-often used when images are of the same objects but with different positions and orientations. One example is someone who has a CT and MRI brain scan on the same day but of course in different scanners; the positioning of the head may be similar but will never be the same in two scans. MRI and CT are 3D scanning techniques which generate a stack of 2D slices; these slices will be inconsistent, even between scans of the same person, due to positioning differences and may be of different thicknesses or orientations. Rigid registration can correct for these differences.

There is sometimes confusion about terminology. Usually one image is defined as a ‘reference’ or ‘target’ or ‘template’ image and the mappings between this image and other ‘floating’ (or ‘source’) images are determined by registration. Unfortunately there is still some inconsistency in the literature about how these terms are used. The registration result is the set of parameters which define the transformations (mappings) between images. These transformations can be applied to the floating images to generate new images which have been ‘transformed’ (or ‘realigned’ or ‘resliced’) into the space of the reference. In the key and lock example above, the transformation parameters describe the distance the key has to travel and the angle it has to rotate by to fit into the lock. If I actually pick up the key and translate and rotate it into place then I am applying that transformation.

**ROTATIONS, TRANSLATIONS, SCALES AND SKEWS**
For 3D rigid registration, six parameters (translation along three orthogonal directions and rotation around three orthogonal axes) completely specify the problem. In 2D only three parameters are required (translation in x- and y-directions and rotation around the z-axis). In many practical applications, global scaling in three orthogonal directions is also required which adds three more parameters to determine. In the example above this would allow us to change the size of the key (but not its shape) to fit the key-hole. Scaling parameters can account for calibration variation when registering images from more than one scanner, or size differences when comparing scans of different individuals. A common short-hand is to refer to a transformation as a 9df registration problem – see text for further details. Knowing the correct parameters which describe this transformation allows the key to correctly fit the lock. Note that registration determines the parameters which define the transformation which must then be applied to the key to guide it into the lock.

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**PANEL 1.**
A conceptual view of registration. Registration is about determining the correct geometric transformation to match images. The process is analogous to ensuring a key is of the right size, at the correct orientation and in the correct position to engage with a lock. The panel shows the progressive recovery of mismatches in scale, orientation and translation between a key and lock corresponding to a 9df registration problem – see text for further details. Knowing the correct parameters which describe this transformation allows the key to correctly fit the lock. Note that registration determines the parameters which define the transformation which must then be applied to the key to guide it into the lock.
**SCOPE | TUTORIAL**

*PANEL 2. Registration for position and scale correction in brain imaging*: When groups of subjects are studied using MRI brain imaging, an analysis of consistent brain regions in all subjects is required. Before this can be performed, image variation due to differences in head size and positioning in the scanner must be removed. Affine registration is the first step in this process. Left: the mean of a single slice in two different planes (coronal and axial) of 20 subjects. The variation in size and positioning results in a blurred mean image. Right: the same average slices after affine registration of each subject to a reference scan. Scans from the Open Access Series of Imaging Studies (OASIS) available at http://www.oasis-brains.org/. [5]

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<th>STRETCHES, COMPRESSIONS, TWISTS AND WARPS</th>
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| Non-rigid registration introduces more degrees of freedom and in principle allows more accurate mapping of anatomical or functional features across scans. These extra degrees of freedom are used to describe more localised differences in shape and size and can be thought of as 'stretching' or 'compressing' parts of one image to fit another. For example, the brains of different people are not simply of different sizes which can be accounted for in a registration context by global scaling parameters. Rather, the various structures which together comprise the human brain vary in size and shape across the population. So using rigid or affine registration to map two different brain scans together will not generally result in the boundaries of internal structures such as the ventricles, the hippocampus, the corpus-callosum etc. being well-aligned. Non-rigid registration techniques produce higher degree of freedom mappings which do align these boundaries resulting in a pair of brain scans which look more similar. In broad terms, a non-rigid registration technique with a high number of degrees of freedom can account for more localised differences between scans than a technique with fewer degrees of freedom, but with much higher computational cost due to the increased number of parameters to compute and an associated risk of converging to the wrong answer.

The design, optimisation and application of non-rigid registration is a key contemporary research focus. [2] The specified transformation model is superficially what defines a non-rigid registration technique. However, implementation details concerned with the representation of the model in software, the optimisation procedure to determine the parameters associated with an instance of that model, and the computation of a suitable measure of registration quality mean that there is considerably more variety and variability in non-rigid techniques. We also need some more terminology to describe the mapping resulting from non-rigid registration. These are known variously as 'warps', 'deformation fields', 'displacement fields' and [coordinate] transformations but all these terms simply refer to the mapping between points in images described earlier.

Some early non-rigid registration approaches used higher order polynomial functions of pixel coordinates to encode the mappings. A simple example is going from $x' = ax + by + t$ for a 2D rigid coordinate transformation to $x = ax + by + cxy + dxx + eyy + t$ for a second order polynomial transformation. A very important property of polynomial transformations is that although they are non-rigid (i.e. describe mappings which may include some local volume change) they are global in their parameters. This means that changing any of the parameters ($a, b, t$) affects the mapping of all points in the images, and a global optimisation procedure is required which can be very computationally expensive for large numbers of parameters. Recently the emphasis has been on more local descriptions of transformations. One of the most popular contemporary non-rigid registration techniques is the so-called free-form deformation approach using B-spline basis functions. Put simply, these techniques embed a grid of points in one image so that when points move, they drag part of the image with them. The registration proceeds by...
Non-rigid transformations originate from applying physics-based models of elastic solids and viscous fluids. Modelling the mapping between images using the theory of elasticity leads immediately to a pleasing mental image of the floating image being stretched like a sheet of rubber to match the reference image. One unfortunate consequence of elastic transformations being one of the earliest non-rigid transformation models is that many scientific papers use ‘elastic’ to describe any non-rigid transformation model. Elastic transformations are intuitive and relatively straightforward to compute. Their main disadvantage is that the restoring force of an elastic medium is proportional to the local displacement. Therefore registration using purely elastic models will tend to reach some equilibrium point dictated by the manner in which the elastic forces driving the registration are applied. More recently, attention has turned to transformations based on viscous fluid flow which can be imagined as the floating image slowly flowing into registration over the reference image. Fluid transformations are more complicated to compute than elastic transformations but have several advantages. The main one is that the restoring forces relax over time which means that fluid transformations can successfully model large magnitude localised displacements. Another advantage is that they produce so-called ‘diffeomorphic’ transformations which, loosely speaking, have the property that every point in the reference image is uniquely associated with a single point in the floating image. This property prevents parts of the floating image ‘turning inside-out’ which is a common problem for highly localised non-rigid transformations – these inversions are generally not physically meaningful. The disadvantage of fluid transformations is that with such flexibility, optimising for the best – in an application sense – transformation instance is difficult.

**SURROGATE MEASURES OF REGISTRATION QUALITY**

To determine the correct transformation parameters requires a measurement of correspondence to quantify how successfully a registration transformation maps points across images. For example in brain registration, if a candidate transformation maps ventricles onto hippocampus it is low quality in terms of correspondence. The correct transformation is assumed to be the one that maximises the correspondence measure. In practice the true correspondence is rarely known (this is why registration is required!) so surrogate measures of correspondence are used. Historically these were derived in two ways: by comparing geometric features and by comparing voxel (3D pixel) intensities.

Geometric features can be as simple as point landmarks but also include lines, curves, ridges, corners, surfaces etc. Identifying the same set of geometric features in a pair of images in terms of their location, orientation and size allows a mapping to be computed. Modern feature registration techniques account for errors inherent in taking measurements from noisy digital images and can select the best pairs of features to use for registration from larger sets identified on each image. Much recent research has focused on automating both the identification and pairing of meaningful features and the best way to use sparsely defined feature-sets in non-rigid registration. The caveats with feature-based methods are that they often still require considerable user input to identify the feature sets and by definition the mappings computed by matching individual features are not necessarily correct for image regions where identified features do not exist. These drawbacks have lead to the wide-spread adoption of voxel-intensity based registration where a surrogate measure of correspondence is defined as a function of the intensities of pairs of voxels in the reference and floating images. The assumption is that when the correct transformation parameters are found, the so-called image-similarity will be maximised. Different

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**A PANEL 3. Registration applied in dynamic lung imaging:** Rigid and non-rigid image registration of lung CT images has been used to analyse the chest motion associated with regular breathing. A floating image is first acquired in a single breath hold i.e. with the chest and lungs static. Then a series of reference images are collected dynamically while the patient is freely breathing. Registration enables the anatomy to be tracked in space as the lungs fill and empty. The goal is to track this motion in real time in a radiotherapy application to improve the targeting of tumours. This will in turn increase the radiation dose which can safely be delivered to the tumour while reducing the dose received by unaffected tissue. The first column of the figure shows a floating image (top) and reference image (bottom) before registration. The next three columns show the floating image (top) after no registration, rigid registration and non-rigid registration, respectively. The corresponding images on the bottom row show the reference image for each case with colours indicating regions where structures do not match properly. Before registration there are large regions of colour but after rigid and non-rigid registration there is virtually no registration error within the chest cavity. Technical details: the floating image was acquired at breath-hold, and covers the entire lungs. The reference image was acquired while the patient was freely breathing with the scanner operating in cine mode, and so only covers a thin ‘slab’ of data (16 slices). The non-rigid registration used a free-form deformation algorithm with B-spline basis functions. The grid-points defining the mapping were defined at 20 mm intervals in all directions. This work concerned registration of CT images of the same subject so a simple image similarity measure based on the difference in intensity between each point in the reference and floating image could be used. Images courtesy of Dr Jamie McClelland of the Centre for Medical Image Computing, University College London. [6]
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similarly measures make different assumptions about the intensity relationships between registered images. Common examples of these measures include normalised cross correlation (appropriate when intensities in one image are linearly related to those in another, e.g. two MRI images) and mutual information (where only a probabilistic relationship exists between intensities, e.g. MRI and PET). Intensity-based methods are attractive as they are largely automatic and make use of all the information available in the images; however they can be sensitive to intensity-related artifacts, particularly with an inappropriate choice of similarity measure. As the underlying assumption is that at registration both images contain the same information, intensity methods must also be used with caution when registering scans which contain large age-related or disease-related structural or textural differences. [3]

COMBINING FEATURES AND INTENSITIES

It has long been recognised that the distinction between feature-based and intensity-based methods is somewhat artificial and that more powerful methods might result if they could be combined. Intensity-based similarity measures defined throughout the images provide continuity in regions which lack features. Features, on the other hand, are a way of injecting prior knowledge about the spatial location, orientation and correspondence of specific localised regions which can improve robustness. Many methods define a composite surrogate correspondence measure which is a function of both feature correspondence and intensity similarity. These composite measures must be carefully crafted and there is usually a parameter choice to determine the relative importance of features over intensities. There are also issues of noisy, artifactual image intensities and features measured by processes subject to error to contend with. A slightly different approach, typified by the HAMMER (Hierarchical Attribute Matching Mechanism for Elastic Registration) method of Shen and Davatzikos, constructs features from the intensities themselves. [7] These approaches try and capture the unique image environment at a point by computing various intensity-based measures which are functions of the local image structure at a number of different scales; the result is a vector defined at each point summarising the local image content. The underlying assumption is that points which are biologically or functionally similar will have similar local image environments and that these image environments will be substantially different to most other points in the images. The challenges are to define appropriate ways of compactly capturing this information and to separate the wheat from the chaff by identifying so-called ‘salient’ points. These are biologically or functionally significant, uncommon but consistent, and therefore reproducibly identifiable in terms of their vector description, from one image to another.

IT LOOKS GOOD BUT IS IT RIGHT?

Testing and evaluation of registration is generally difficult. The bottom line is that it is hard to characterise registration errors for arbitrary applications in advance and there are many subtleties in estimating and measuring registration error. One of the main ones is the distinction between optimisation problems, correspondence problems and degrees of freedom. If the similarity measure being used truly measures the correspondence between two images then the only thing to worry about is whether or not a global maximum has been found. This is a standard optimisation task (which doesn’t mean that it is necessarily a straight-forward task). However, usually the similarity measure is an approximation to the correspondence so we have to consider whether a global maximum necessarily corresponds to the ‘correct’ registration. To rigorously determine whether a registration algorithm has determined the correct correspondences between images requires an evaluation procedure which is independent from the process used by the algorithm and will usually be more costly in terms of operator time, imaging time or computing time. An additional confound is that if the transformation class or the number of allowed degrees of freedom within that class are not sufficient to accurately map the differences between two images, then the maxima of the similarity measures are likely to be poorly defined. In applications involving clinical images where there may be noise and scanner-induced artifacts in addition to physiological, population and disease-related differences between scans, evaluation is particularly challenging. There are a number of different measures of registration quality which are commonly quoted: accuracy, robustness and consistency. Accuracy (in terms of mm) measures the extent to which corresponding features are correctly mapped by registration. Measuring accuracy relies on knowledge of the true, underlying, mapping. The accuracy of registration driven by geometrical features can be measured directly at those features and, for rigid transformations, computed elsewhere. The accuracy of registration driven by voxel intensities must usually be assessed using additional information. Methods to obtain this information for evaluation purposes include scanning artificial test objects [phantoms], using synthetic, computer-generated objects (‘digital phantoms’), generating new synthetic images from existing real scans (e.g. to simulate patient-positioning differences or the impact of disease), adding artificial features to subjects being scanned (e.g. markers attached to the skin), and asking clinicians to manually identify mappings between anatomical features on a series of test scans. All of these methods can be used to measure accuracy in specific image-pairs and provided these are chosen to be representative of the data collected in the chosen application, accuracy can be associated with the registration method when applied to new scans.

Robustness describes the extent to which mappings can be recovered under challenging or non-ideal conditions including noisy or restricted field of view, differences in patient positioning, differences in scan type and differences between subjects. Robustness to positioning differences is often quoted in terms of a ‘capture range’ which reports how much initial misregistration can exist before the registration procedure fails to converge to the correct result. In non-rigid registration applications, robustness may not simply refer to positioning differences, but also to how variable the anatomy is before registration fails. Applications where this is important tend to involve parts of the body which are highly variable even in the individual, e.g. the abdomen [and its contents!] imaged on different days, the breast imaged by digital mammography over several years, or changing due to growth or disease. Any differences within subjects are usually magnified when comparing one person with another. In some applications it is

| "Geometric features can be as simple as point landmarks but also include lines, curves, ridges, corners, surfaces etc." |

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possible to simulate these complicated variations using computer models of the anatomy and its response to various external mechanical stimuli including gravity.

Sometimes consistency measurements, again in terms of mm, are reported. The simplest case is when a registration is run twice with the images designated as reference and floating swapped between runs. It is desirable for the obtained mapping to be independent of the choice of reference and a measure of inverse-consistency captures the extent to which this is true. Many emerging registration methods are inherently inverse-consistent, at least to some specified tolerance. Other consistency measurements come into play when there are several concurrent registrations. One classic example occurs when three scans A, B and C of a subject have been collected over a period of time. It is desirable that registering C → A should result in the same overall mapping as combining the mapping from C → B with B → A. Again, some contemporary registration algorithms attempt to solve the three-way problem directly to enforce this consistency.

**CHOOSING THE RIGHT REGISTRATION ALGORITHM**

Rigid and affine registration is now readily available but there remain traps for the unwary. The bottom-line in registration is that it relies on the images being inherently similar by virtue of being scans of the same subject acquired in different ways or of the same anatomy in different subjects. Errors can creep in when these assumptions are violated, usually because of combinations of effects which cannot be separated by registration. For instance, (i) changes in tissue morphology (shape) combined with distortions introduced by the image acquisition, (ii) changes in tissue texture (intensity) combined with intensity-related imaging artefacts, (iii) a disease process which causes changes in both shape and texture of normal anatomy. Similar problems can occur when an inappropriate correspondence measure or transformation model is chosen. Often, several registration approaches may need to be trialled for a new application. The use of highly non-rigid registration changes the way analysis is performed. Some techniques can make even very different images highly similar by locally stretching and compressing the floating image. When rigid registration is used to align two scans, it is usually just correcting for positional differences. Non-rigid registration is also correcting for structural differences fundamental to the scans. After rigid registration, significant differences in scans are often detected by examining the registered images. After non-rigid registration, significant differences in scans may have been removed by the very act of registration but that information is encoded in the transformation parameters used to map the images. Therefore after non-rigid registration, analysis may be performed on the transformation parameters themselves rather than the registered images. In practice, non-rigid registration is imperfect and there may be useful information in both the registered scans and the transformation parameters. In these cases, a hybrid analysis which includes information from both domains may be performed. This is typified by the voxel-based morphometry approach to brain scan analysis. [1]

**THE PRESENT AND THE FUTURE**

There has been immense progress in medical image registration and it has developed from early borrowings from computer vision and remote-sensing to a research area in its own right. Registration is a generic problem which crops up in many branches of science but applications in medical imaging are particularly challenging. Three reasons for this are the diversity of image types, the diversity of image content and the diversity of application requirements. Related challenges include the relatively uncontrolled environment in which many images are acquired, the inability to test registration against the ‘truth’ in the majority of every-day applications, and the critical importance of the registration being correct. If there is a subtle mis-registration in a neuroimaging study investigating normal ageing processes it is potentially damaging to the researcher but not life-threatening to the participants. If there is an undetected mis-registration between MRI, CT and the operating environment in image-guided neurosurgery it is potentially much more serious. Hence the relatively slow transition of registration technology to front-line clinical applications.

There are many computational challenges to address, particularly in non-rigid registration, concerning the practicalities of optimising a large number of transformation parameters over a pair (or a larger number) of images. Fast registration solutions are particularly important for intra-operative applications including image-guided interventions. Of more intellectual interest are fundamental challenges related to choice and definition of appropriate similarity measures and transformation models and in particular the potential for information from multiple sources to be incorporated into the registration problem. The latter can include scans from different sources, operator-defined labels, biomechanical deformation models, 1D signals such as ECG in cardiac applications and statistical models of the ‘expected’ results. A gradual move away from pairwise registration to the consistent registration of ensembles of images will continue.

There is also evidence to suggest that registration should not be researched as an isolated technique. Most basic processing tasks in medical imaging rely on one or more of these core technologies: image registration, image segmentation (region labelling) and statistical modelling of images. Knowledge from one of these processes can often strengthen the others. For instance, consistently labelled regions on a group of images provide additional information for registration. Registration across the group can be used to generate a statistical model of population intensity and shape variation. Such a statistical model can be used to improve region labelling. Researchers are starting to tackle these combined problems directly. The most common example is combining region labelling across two or more images with image registration. It is thought these combined approaches, while superficially more complicated than performing registration or labelling in isolation, are actually more elegant, more robust and make the best use of all the available information. Combined approaches are likely to grow in importance.

All these advances will rely on developments in maths, numerical analysis, computer science, physics and medicine. With the continued expansion of imaging in modern medicine, medical image registration and its related technologies and applications will remain a rich and fertile area for future research. Image registration has the potential to transform the way we use medical images and maximise their value for both medical research and patient care.

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**One classic example occurs when three scans A, B and C of a subject have been collected over a period of time.”**

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REFERENCES


LETTER TO THE EDITOR
MAC E. MIQUEL

Letters for publication should be sent to: m.e.miquel@qmul.ac.uk

Following the second part of the Publishing Professional Writing tutorial (Scope 17[2]:19-21) Prof. Salmons sent me the following letter:

Mark McJury et al.’s article ’Publishing Professional Writing [2]’ contained a lot of good advice.

Although it’s certainly conventional to restrict Results sections in the way suggested, I’ve always felt it was a disservice to the reader. By its very nature, research tends to be unpredictable: the result of an initial experiment often suggests a change in design or the addition of other steps or measurements. When you then come to writing up the Results section, it’s helpful to the reader if you provide a little interpretation to lead them through it. Interpretation in the broader context of current knowledge should, of course, be confined to the Discussion.

When I’m refereeing a paper, I will allow this sort of latitude, but I sometimes find those refereeing my own submitted work more rigid in their application of this ‘rule’. My view is that papers are for communication, and if deviating from the accepted straitjacket for presentations helps communication, I’m all for it.

Of course the guidance in this article will be read by newcomers to publishing, and it’s right and proper that they should learn the rules before bending them.

I could list a few more ’dos and don’ts’. Do read the Guide to Authors and submit in the format requested by the journal. This is especially important in the way references are cited and the bibliography is formatted. (Don’t assume the endnote style is correct either – it often isn’t.)

Don’t repeat the same information in the text, in tables and in figures.

Don’t quote a mean to more decimal places than are justified by the standard error. Believe your own statistics: if \( P > 0.5 \), it’s not significant at that level, so try not to be tempted to talk about a ‘trend’. And if \( P < 0.5 \) for one comparison and 0.7 for another, it doesn’t mean that the first difference is ‘more significant’ than the second! Remember that the abstract is the only section that will be read by a lot of people, so be responsible and conservative in the conclusions drawn there.

Finally, I can’t resist remarking that the trouble with writing about writing is that the same standards will be applied to you. I’m afraid all four of the authors missed ‘loose’ instead of ‘lose’ (p. 20, column 1) and ‘very’ instead of ‘vary’ (p. 21, column 3)! Perhaps the last word should be: don’t rely on spell checkers....

Whoops!

Best wishes

Stanley Salmons, Emeritus Professor, Department of Human Anatomy & Cell Biology, University of Liverpool
Thank you for letting me have sight of Professor Salmons’ letter, the points he makes are most helpful. Examining the structure and content of articles published in a broad range of professional and scientific journals would help would-be writers understand options available in order to express themselves and best represent their information / data. Consequently, depending upon the journal, there can be a wide range of acceptable ways in which the work might be presented. Instructions to Authors can help in elucidating this.

I would like to comment upon typographical errors (and also standard of English). I have been the editor of an international journal for 6 years and have listened to the experiences of many other editors too. On reading published texts, it is common to see mistakes, no matter how minor. Mistakes are fairly common in tabloids and fiction / non-fiction books too. Professional and scientific journals are no different and the level of [minor] errors in some can be quite high. Some ‘financially rich’ (and usually eminent) journals and professional magazines employ copy editors to help address these problems. These editors are trained and then employed solely to proof read articles, to make corrections, picking up particularly on typographical and grammatical deficiencies. The [final] published article, as such, is highly polished. The majority of journals and professional magazines cannot afford the luxury of being able to employ copy editors. Consequently published articles will be variable in their quality; their quality will be down to the ability of the author[s] and the editor. In this scenario the editor is normally a professional drawn from the field represented by the journal / professional magazine, they might be a scientist or clinical practitioner. It is unlikely their professional background would be in journalism or editing. I fall into this category. Given that many journals and professional magazines operate upon this basis the onus placed upon the author[s] to get it right becomes critical. Proof reading immediately prior to article submission is essential and should not be treated lightly. In our case, in spite of giving sight of the final version to all authors for comment we still managed to miss one grammatical error and one typographical error. I am really pleased that Professor Salmons spotted these errors as it gave us another chance to highlight the importance of proof reading prior to submission. Let this be an important lesson to us all, no matter how experienced or inexperienced we think we are.

Finally, on the theme of standard of English, we are told that the [contemporary] spoken word is poorly represented too. Only yesterday morning, during BBC’s Breakfast TV programme, an expert in English was commenting that the standards of newsreaders had slipped to a particularly low level. He claimed that grammar was poor. He also claimed that there was often an inappropriate choice of words.

What is the solution if one is not particularly gifted at spoken or written English? I would suggest that you get advice from somebody who is. This would be done prior to submitting the work to a journal or giving a paper at a conference. Consequently, during the proof reading phase consider getting help from somebody who is good at [written] English and has an eye for detail.

Yours sincerely,

Professor Peter Hogg, University of Salford

PS. Would you mind proof reading this letter carefully, because I am certain there will be a mistake or three!
CAN OPEN SOURCE SOFTWARE BE USED FOR CLINICAL WORK?

DOM WITHERS  Formerly Guy’s & St Thomas’, now at Computerized Medical Systems

IN NOVEMBER 2006 INFORMATICS and Computing SIG (ICSIG) considered the idea of a meeting to discuss the possibility of writing an open-source MU (monitor unit) check program; many hospitals write their own, so collaboration seems sensible to produce a program developed and tested by many different centres. This meeting idea evolved to a more general title, to address practical and legal aspects of sharing software in healthcare.

In the introduction, Dom Withers (Guy’s & St Thomas’ Hospital, London) gave some definitions: the Open Source Initiative (www.opensource.org) says: ‘Open Source is a development method for software that harnesses the power of distributed peer review’; the Free Software Foundation (FSF, www.fsf.org) is quite defensive in its definition of free software, listing four fundamental freedoms that must be complied with in order for software to be ‘free’: the oft-used phrase is ‘free as in speech, rather than free as in beer’.

LEGAL IMPLICATIONS

Phil Cosgriff (Pilgrim Hospital, Boston, Lincolnshire) gave a useful overview of the issues, with the disclaimer ‘I am not a lawyer’. Phil’s four reasons for a perceived decline of in-house software were: commercial software has improved; physicists have less time to spend writing software; there are questions about competency, and legal liability presents worries. If your software is a medical device you can use it yourself and the Medical Device Regulations do not apply. If you give it away or sell it to another legal entity, then the regulations apply. There is room for manoeuvre in the interpretation of what constitutes a medical device.

Most open source software used in healthcare would not be considered a medical device. Talks were given which showed such successful and useful applications.

Dudley Ibbett (Derby Hospitals, Derby) described applications used in his nuclear medicine department, including packages that monitored QC readings on radionuclide calibrators and gamma cameras and kept track of radioactive waste. Dudley also talked about the validity of disclaimers in licences, and quoted from the Unfair Contract Terms Act of 1977: ‘Liability for death or personal injury resulting from negligence cannot be excluded or restricted by any contract term or notice’. This seems to suggest that software authors cannot disclaim responsibility for the use of their software.

James Moggridge (St George’s Hospital, London) uses JDICOM and the dcm4che DICOM toolkit to create worklists for use with a PACS system. This has reduced errors in demographic data entry and increased workflow efficiency.

Gunaranjan Bose (Queen Elizabeth Hospital, Birmingham) described a web-based system to facilitate movement of radiotherapy and diagnostic images between different hospital systems. The medical physics department has a dedicated computing section which provides such software. Another database system for QA was described by Lindsay Cherry (Edinburgh Cancer Centre) which used Visual C#.NET and featured a GUI that could be used to add and retrieve records.

Invited speaker Matt Lee (GNU Project, www.gnu.org) spoke on ‘Examining freedom – free software in healthcare’. He emphasised the differences between the Open Source Movement and the Free Software Foundation from his viewpoint; in particular, not all open source software can be described as ‘free’. The FSF wants users to have these freedoms: to run the program, for any purpose; to study how the program works, and adapt it to their needs; to redistribute copies so they can help their neighbours; to improve the program, and release their improvements to the public, so that the whole community benefits.

Matt pointed out the social and philosophical similarities of the FSF and the NHS – a desire to offer services free to all. It is obvious that this radicalism has been diminished in today’s NHS, where Trusts are separate legal entities, encouraged to protect and profit from their intellectual property rather than share for the benefit of all.

EXAMPLES OF SOFTWARE

Ed McDonagh (Royal Marsden Hospital, London) presented IQWorks – a collaboration between the RMH and NHS Lothian in Edinburgh, developing a software package for automating CT QC procedures. IQWorks uses 11 packages, all issued under different licences. As a tool specifically designed for measuring a medical device, IQWorks can be considered a medical device itself.

More obviously, a radiotherapy treatment planning system (TPS) is a medical device, and Henry Lawrence (Bristol Haematology and Oncology Centre, Bristol) talked about open source TPSs developed in the UK and abroad, including a project he worked on called Europlan, designed to work on affordable PC hardware for developing countries. Henry also described accidents in radiotherapy due to errors in the implementation and use of TPSs: open source development could help users understand their algorithms more thoroughly, and allow testing by third parties to limit the likelihood of errors.

Alan J. Green (Centre for Professional Ethics, University of Keele) examined ethical considerations in a talk entitled ‘Trust me, I’m a geek’. He emphasised that the chain of trust has a loose end when using open source software, and that chain ‘must be anchored on your desk’, as Alan put it – the responsibility will lie with the person implementing it.

Concluding roundtable discussion was extensive. With no definite legal answer to the meeting’s title, it
was suggested that a tried case may be required to establish precedent. Medical device directives prevent sharing software between hospitals. As physicists and engineers, we would like the freedom to choose what tools we want to use, accepting that we have the professional responsibility to go through an acceptance and commissioning process — much as we already do for commercially-bought medical devices. The benefits of the open source model are obvious but require, in our community, willing developers with time available.

Further action is required, and ICSIG is working on two fronts: firstly, to produce guidelines for the development of in-house software, building on guidelines produced by the British Computer Society and others; and secondly, by creating example case studies indicating how open source software could be used in healthcare, to circulate to interested parties such as the National Patient Safety Agency, the NHS Litigation Agency, MHRA and CfH (Connecting for Health).

If you would like to take part in either of these projects, please contact ICSIG Chair Ed McDonagh (chair@icsig.org.uk).

**ADVANCED NEUROLOGICAL MR: CLINICAL APPLICATIONS UPDATE**

**JOHN THORNTON** The National Hospital for Neurology and Neurosurgery, London

**THE UCL INSTITUTE OF CHILD HEALTH, LONDON 13th February 2008**

MAGNETIC RESONANCE (MR) IMAGING of the brain has continued to progress markedly in the last 15 years, exciting developments precipitating new insights into the structure, function and physiology of the nervous system. More recently, advanced quantitative neurological MR methods, originally developed in a neuroscience-research context, have begun to find application in hospital imaging departments, contributing directly to patient diagnosis, monitoring and treatment.

Close to 50 participants attended this one-day meeting organised by the MR SIG, co-sponsored by the British Association of MR Radiographers, and supported by the British Chapter of the International Society of Magnetic Resonance in Medicine. Speakers, including a number of the UK’s leading authorities on neuro-MR physics, addressed an audience comprising a multi-disciplinary cross-section of hospital physicists, academic researchers, clinicians and MR radiographers.

Gareth Barker (King’s College London) began the morning session with a comprehensive overview of quantitative MR, starting with the premise that the MR scanner may be usefully treated as an instrument for scientific measurement, rather than simply an image formation device. In this invited talk, Gareth provided a summary of the underlying physics, acquisition requirements, analysis strategies and clinical applications of a variety of methods, including high-resolution morphometry, relaxometry, magnetisation transfer imaging and diffusion tensor imaging (DTI).

DIFFUSION TENSOR IMAGING

The theme of diffusion tensor imaging was further developed by the next two invited speakers, Derek Jones (University of Cardiff) and Chris Clark (University College London). Derek provided an in-depth introduction to the physics of DTI and the metrics available to quantify aspects of nervous tissue microstructure and geometric organisation, including the technique of ‘diffusion tractography’, a method with the potential to non-invasively trace specific white matter tracts in the human brain. A number of clinical applications were reviewed, as well as the advantages and potential pitfalls of the various approaches to data analysis. Chris Clark reviewed the applications of DTI in the specific area of neurosurgical planning, where the ability to delineate white matter tracts may provide surgeons with information vital in planning their surgical approach to, for example, tumour resection. While data analysis methods are not yet mature, and the technique is presently limited to specialist research centres, initial corroborative comparisons with intra-operative cortical stimulation data, and successful neurosurgical outcomes, are very encouraging.

ADVANCED NEURO-MR IN PAEDIATRICS

After coffee two speakers explored paediatric applications of advanced MR techniques. In his invited presentation, David Gadian (UCL Institute of Child Health, London) described work addressing the relationships between focal brain abnormalities, as determined by MR methods such as voxel-based morphometry, volumetry and T2 relaxometry, and cognitive function as measured on neuropsychological testing. Fascinating examples illustrated the success of this approach in children with temporal lobe epilepsy, a study in an extended family with an inherited neurodevelopmental condition, and cases of developmental amnesia. Ernest Cady (UCLH NHS Foundation Trust, London) next described applications of MR imaging and particularly MR spectroscopy, a method providing a non-invasive window into brain biochemistry, to the detection of brain injury in newborn infants. These techniques can provide vital prognostic information in the first few days of life, and information invaluable in the clinical management perinatal encephalopathy, especially with the recent availability for the first time of cerebroprotective therapies such as cerebral hypothermia.

CEREBRAL BLOOD FLOW

The afternoon session commenced with an overview of clinical cerebral perfusion MRI provided by Iain Wilkinson (University of Sheffield). Assessment of the local blood supply to the brain is important in patients...
**FIGURE 1.**
Functional MR imaging results obtained during preparation for surgical resection of a brain tumour visible in the lower right-hand corner of the images. The highlighted areas represent regions of brain activity associated with various motor functions. The data are useful in neurosurgical planning where minimising damage to these regions, thereby reducing postsurgical functional impairment, is a priority. Slide provided by Dr Laura Mancini, National Hospital for Neurology and Neurosurgery, London, and reproduced by permission.

**FIGURE 2.**
Images produced with a number of complementary MR imaging techniques in a patient with an acute stroke showing anatomical images (top row) and images depicting changes in the diffusion properties of tissue water, cerebral blood flow and an MRI angiogram (bottom row). Slide provided by Dr Iain Wilkinson, University of Sheffield, and reproduced by permission.
with a number of conditions such as transient ischaemic attacks, disabling stroke, fits and headache, and has potential for staging and grading tumours. There are currently two complementary MR perfusion methods: dynamic susceptibility-contrast imaging, wherein the passage of an injected bolus of paramagnetic tracer through the vascular bed may be followed, and arterial spin labelling (ASL), in which blood magnetisation is manipulated to provide an entirely non-invasive endogenous contrast label. While both methods present different challenges in terms of absolute quantification and sensitivity, the clinical assessment of cerebral perfusion by MRI is set to expand as the methodologies improve and new applications emerge. Iain’s invited overview was followed by a presentation of an experimental study of methodological aspects of ASL, presented by Marta Varela (Hammersmith Hospital/Imperial College London). Marta described her work in determining the T1-relaxation time of blood and presented encouraging results from both adults and newborn infants, which may significantly improve the accuracy of ASL perfusion measurements.

In a sharp change of subject matter, David Carmichael (UCL Institute of Neurology, London) next presented experimental work addressing the safety of using MR imaging to accurately determine intracranial electrode locations during the presurgical work-up of patients with temporal lobe epilepsy. Computer simulations were presented depicting the electromagnetic interactions between the MR scanner and the conducting electrode implants, suggesting that with suitable precautions electrode-associated tissue heating during MR imaging should remain within safe limits.

**FMRI AND NEUROSURGICAL PLANNING**

After a tea break, the final two speakers presented clinical applications of functional MR imaging (fMRI), in which active brain regions may be detected due to localised blood-oxygenation changes which modify the MR properties of tissue. Laura Mancini (National Hospital, Queen Square, London) gave an overview of how fMRI may be useful in identifying areas of eloquent cerebral cortex in the presurgical planning stages of tumour resection, in order that damage to areas directly implicated in for example motor or speech function may be minimised. This approach complements, and is increasingly used in conjunction with, the diffusion tractography method described by the morning speakers. Finally, Sarah Peel (Southampton University Hospitals Trust) addressed the tricky issue of the reliable presurgical determination of language lateralisation by fMRI using just an auditory prompt, in the absence of a sophisticated (and expensive) visual projection system. The presentation prompted a lively discussion of various methodological alternatives to providing patients with shouted instructions to ‘stop thinking!’ during the rest periods of fMRI acquisitions, and provided an excellent illustration of the value of meetings such as this in bringing together members of the academic research community with clinical practitioners to exchange methodological expertise on the one hand, and knowledge of important real-world clinical applications on the other.

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**RADIATION PROTECTION IN NUCLEAR MEDICINE**

**DR MF DEMPSEY West of Scotland PET-CT Centre**

THIS MEETING WAS JOINTLY organised by the Nuclear Medicine and Radiation Protection Special Interest Groups (SIGs). Wendy Waddington (UCL Hospitals NHS Foundation Trust, London) and Michaela Moore (Newcastle General Hospital, Newcastle) were the scientific organisers representing each SIG, respectively. Recent expansion and diversification of nuclear medicine services has provided us with significant radiation protection challenges. Consequently, there was little surprise that this one-day meeting offered a packed programme to a packed lecture theatre – the British Institute of Radiology was full to capacity with many more expressions of interest but unfortunately, despite IPEM’s efforts, an alternative larger venue could not be identified.

Wendy Waddington opened the day by highlighting how the significant interest shown in this meeting reflected how timely it was for the SIGs to co-host such an event and perhaps organisation of joint meetings by these SIGs is something that should be re-visited more regularly.

PET ISSUES

With the recent rapid growth in the use of PET imaging in the UK, the first session of the morning was dedicated to this theme. Deborah Tout (Christie Hospital, Manchester) provided a review of extremity dose monitoring at the Christie Hospital Manchester and illustrated how this work was used to improve design of their new dispensary area. In a similar vein, Matthew Guy (Royal Surrey County Hospital, Guildford) presented on how his team had employed a review of video monitoring data in combination with extremity dose monitoring to minimise staff extremity doses.

Following this, Debbie Peet (Royal Surrey County Hospital, Guildford) presented on the RPA’s perspective on radiation protection challenges for mobile PET/CT with ‘challenges’ being the operative word. By virtue of being mobile, the shielding and physical space of these units is limited (as illustrated in figure 1) with serious implications for radiation doses to staff and potentially members of the public using the car park or working in nearby buildings. Facility design has to consider patient
FIGURE 1. Diagram showing plan of mobile PET unit (courtesy of Dr Debbie Peet).

FIGURE 2. Table showing peptide receptor radioligands in development (courtesy of Dr Glenn Flux).

### Radioligands in development

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<thead>
<tr>
<th>Peptide receptor</th>
<th>Radioligand</th>
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<tbody>
<tr>
<td>sst2, sst3, sst5</td>
<td>DOTANOC</td>
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<td>DOTABOC</td>
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<td>TETA-octreotide</td>
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<td>Bombesin GRP-R</td>
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clerking, dose preparation, administration and uptake, toilets and scanning. There are many RSA93 issues to be overcome which ultimately require cooperation between employers, RPA’s and estates departments. Furthermore, risk assessments/training requirements must be considered for work in such a new environment in addition to working through all the logistical issues regarding deliveries, QC testing etc. and potentially dealing with radioactive spills in difficult locations. As if these RPA radiation protection issues are not challenging enough, Debbie indicated that the MPE with responsibility for resolving the many site and equipment specific IRMER and ARSAC considerations does not have an easy task either!

**RADIONUCLIDE THERAPY**

Following a coffee break, the first invited speaker of the day, Glenn Flux (Royal Marsden Hospital, Sutton), gave us food for thought by presenting on the many new products that could be making their way to nuclear medicine departments in the UK in the near future (some examples are shown in figure 2). Of course such developments in patient care are always welcome but the intrinsic radiation protection challenges need some attention. For example, with the new alpha emitting agent of Ra-223, are we prepared for its arrival? Have we considered RSA93 issues (waste disposal) and licences? Do we know how we would deal with spills? With an imminent phase 3 multicentre trial involving several UK sites, will we be expected to resolve all these radiation protection issues in a short time? Glenn suggested that a systematic and supported introduction of this and other new agents would be hugely beneficial.

Philip Anderson (Queen Elizabeth Hospital, Birmingham) then presented the results of a multicentre study on internal radiation dose to families of thyrotoxic patients treated with I-131. It was reassuring to hear that although transfer of contamination can occur to family members (thought to be primarily through salivary routes), internal dose to family members is low. Combining this with a previous study to hear that although transfer of contamination can occur to family members (thought to be primarily through salivary routes), internal dose to family members is low. Combining this with a previous study on external dose to family members, findings suggest that most families can comply with EU recommended dose limits/constraints. Fred Wickham (Royal Free Hampstead NHS Trust, London) then discussed two different techniques on calculating restriction periods for patients discharged following I-131 therapy for thyroid cancer before Richard Fernandez (Guy’s & St Thomas’ Hospital, London) illustrated how periodic environmental monitoring to check areas remain adequately designated can prove hugely worthwhile – he demonstrated that sometimes a small change to practice can significantly affect designation of nearby areas. Fionnuala Barker (St Luke’s Hospital, Dublin) then showed how in-patient treatment of thyroid cancer patients with significant physical disabilities is possible despite what may seem like daunting radiation protection issues. This session was brought to an end by Hamish Richardson (King’s College Hospital, London) discussing nurse training in radio-iodine therapy.

**CT IMAGING IN NUCLEAR MEDICINE**

Be it as part of the explosive growth of SPECT/CT or PET/CT systems in nuclear medicine, an increasing number of nuclear medicine staff have to get to grips with CT. The first presentation after lunch was by David Platten (King’s College Hospital, London), the second invited speaker of the day, talking about radiation protection in CT. David provided a very comprehensive review of shielding issues, scanning protocols, image quality parameters, single vs. multi-slice and dose optimisation. Shielding requirements really depend on the current and planned use of the facility, e.g., will the CT be used diagnostically or for anatomical localisation and attenuation correction purposes? Regarding image quality parameters, he stressed that unlike dose administration in nuclear medicine, there is not always a linear relationship between image quality parameters and effective dose, e.g., changing from 80 kVp to 100 kVp with all other parameters constant could effectively double the patient’s dose.

On a similar theme, Dudley Ibbett (Derbyshire Royal Infirmary, Derby) then presented on looking inside the dosimetry black box of SPECT-CT. This involved consideration of calculating effective dose from DLP, pregnancy issues and IRMER training requirements to minimise risk if incorrect exposure.

**AND SOME OTHER STUFF**

Of course there are always other radiation protection issues affecting nuclear medicine departments. The first presentation to fall under this umbrella was by Ben Johnson (Guy’s & St Thomas’, London), whose report on the recent experiences at Guy’s and St Thomas’ of transport inspections of both the old and new transport regulations. Richard Peace (Royal Victoria Infirmary, Newcastle) then presented on the issues of nuclear medicine patients at UK ports and airports and the recent ARSAC guidance on this – some discussion post-presentation led to the suggestion that a credit card type document should be given to patients for these purposes – several departments already do this and advocate the practice. Mike Haddaway (Robert Jones & Agnes Hunt Orthopaedic & District Hospital, Oswestry) then presented on the incidence and implications of extravasation of bone scans suggesting that the incidence is probably greater than we think as extravasation dissipates with time. Dr Ibbett then returned to the floor for his second presentation of the day about improving compliance with an RSA93 Accumulation and Disposal of Radioactive Waste Authorisation Certificate. He discussed the introduction of best practicable means into these certificates and subsequent implications. The final presentation of the day was by Hugh Wilkins (Royal Devon & Exeter NHS Trust, Exeter) on using wristbands to identify radioactive in-patients. With the National Patient Safety Agency standardising the wristbands nationally, making use of this system to identify nuclear medicine patients returning to wards may not be feasible for much longer.

**IN SUMMARY**

This was a well-organised, well-attended interactive meeting with a good complement of invited speakers and proffered papers. For those who didn’t get a space because it was such a rapid sell-out, the good news is that a re-run has been organised for 4th November 2008 (further details to be posted shortly).
ICMP 2008: CURRENT AND FUTURE SCIENCES IN RADIATION MEDICINE

DAVID AND ROSEMARY EATON 1Royal Free and 2Guy’s & St Thomas’ Hospitals, London

DUBAI, UNITED ARAB EMIRATES 14th–16th April 2008

BRIEF HISTORY
In 1894, SHEIKH Maktoum bin Hasher al-Maktoum exempted foreign traders from paying tax in a small fishing settlement on the Arabian peninsula. A century of exponential growth later and Dubai is an international hub of industry, commerce and tourism. Contrary to popular belief, only 10 per cent of Dubai’s income is derived from oil, but generous investment by a series of ambitious rulers has provided the infrastructure and iconic buildings to match the booming economy. The emirate is currently home to the world’s only 7-star hotel (the scale was extended specially after construction), the Burj al-Arab, and the world’s tallest building, the Burj Dubai. Construction on an unprecedented scale is proceeding apace (figure 1), including extension of the existing coastline with an artificial marina and series of islands in the shape of palm trees and the entire world. The Health City district aims to attract international clinics into setting up outposts there, making Dubai a ‘world hub in curative tourism’.

Although medical physics had been practised in the United Arab Emirates (UAE) for more than two decades, it was only in 2005 that the profession became officially established. A physics department was created at the Dubai Hospital and the Emirates Medical Physics Society (EMPS) was inaugurated. The following year the society joined the International Organisation of Medical Physics (IOMP). Through this connection, and in recognition of development throughout the Middle East in healthcare science, the International Conference on Medical Physics (ICMP) was hosted by Dubai in 2008. The 350 delegates came from all over the world, but the Middle East, Africa and Asia were particularly well represented.

INFORMATION AND COLLABORATION
The title of the conference was ‘Current and Future Sciences in Radiation Medicine’, and it had two main aims: the first was to inform and educate participants in the latest developments around the world. For this purpose invited presentations were given by a host of internationally renowned speakers in plenary sessions and educational streams. The second aim was to provide a
In the opening ceremony, Barry Allen (Centre for Experimental Radiation Oncology, University NSW, Australia and IOMP chairman) challenged delegates to consider ‘what is the greatest benefit to the most people in your country?’ when weighing up all the technologies and techniques on offer. He also reminded us that ‘science is international, beyond national boundaries’ and this collaborative spirit could be clearly seen during the week. ‘People to people contact is the most important [aspects of the meeting]’, said one Pakistani physicist over lunch. With over 150 proffered oral and poster presentations, from more than 35 countries, there was plenty to talk about.

PRESENT AND FUTURE

Two symposia book-ending the first day described the current and potential future state of radiation therapy. William Hendee (Medical College of Wisconsin, USA) described how image-guided radiotherapy (IGRT) is bringing together diagnostic and therapeutic disciplines once again. As with image-guided ablation, or surgery, ‘precise [physical] delivery requires precise [biological] knowledge’. In the future, we can expect a shift from margins to molecular differentiation with greater hybridisation of modalities broadening the physicist’s remit like never before. However, the responsibilities of the profession remain unchanged:

- expansion of knowledge;
- contribution of research;
- involvement in patients;
- assurance of quality;
- excellence of teaching;
- accountability of performance.

The keynote address continued the topic of IGRT and was given by Rockwell Mackie (University of Wisconsin, USA). He described the benefits of daily imaging in greatly reducing setup errors greater than 3 per cent and visualising tumour shrinkage. He also described progress in deformable registration and adaptive planning. In the future, radiotherapy may expand its remit into the realms of surgery and chemotherapy, with increasing precision and ability to treat metastatic disease (figure 2).

The ever-present concerns of risk and staffing levels were addressed by Cari Borrás (Washington, DC, USA) who described work by AAPM task group 100 on revising guidelines for quality assurance in radiotherapy. Their report will contain detailed process trees with failure mode and effect analysis to allow departments to quantify risks and focus on the greatest ones. In the ensuing discussion, it was suggested by one speaker that the greatest risk in radiotherapy is underdosing from lack of clinical aggression, or side effects from denial of the latest technologies. However, the take home point for these authors was how advanced the UK is to have staffing levels supported by legislature and an established formal training scheme. It also became clear during the week that UK publications are often taken as a benchmark for many countries developing their own reference systems. For example, IPEM Reports, dose survey data published by the former NRPB and ImPACT’s CT Dosimetry Calculator were all mentioned during the conference, with little need for explanation.

![FIGURE 2.](image)

The keynote presentation on IGRT given by a famous Canadian (at heart) medical physicist.
At the close of the day, further review presentations included less common approaches such as light ion therapy, adaptive radiotherapy and high intensity focused ultrasound. Natalka Suchowerska (Royal Prince Alfred Hospital, NSW, Australia) also described recent work on the Bystander effect in regions of spatial or temporal modulated irradiation. Various additional effects were noticed, such as increased survival of shielded cells when their unshielded neighbours were given a lethal dose. At low doses unshielded cells showed increased survival compared to uniform irradiation. Other groups have demonstrated that modifying the order of beam delivery can optimise cell kill. Greater understanding of this area of radiobiology could profoundly affect control probabilities.

On the afternoon of the second day, Madan Rehani (IAEA, Vienna, Austria) introduced the work of the International Atomic Energy Authority (IAEA) in promoting the radiation protection of staff and patients. Training plays a large part in this, with the provision of on-line resources as well as worldwide courses on various aspects of radiation protection in clinical practice. So-called technical cooperation projects are run in 82 countries, with a budget of $1 million and the aim to ‘build competence in member states’. Seven key tasks have been identified (figure 3). The realisation of these targets was evident at the conference, with a total of 11 oral and nine poster presentations on patient dose audit and dose optimisation projects in diagnostic radiology. Many of these had been carried out with support from the IAEA. Dose optimisation, particularly of CT and mammography examinations, is being taken seriously in countries as diverse as Iran, Bosnia & Herzegovina, Kenya, Sudan, Syria, Malaysia and, of course, the UAE.

### LOCAL INVESTIGATIONS

Several specific sessions for proffered papers formed part of each day. One such session on the biological effects of non-ionising radiation shows the breadth of research being reported. Lama Sakhnini (University of Bahrain) described work into the effects of electromagnetic fields on sea urchins, found in abundance off the shores of this small island. Static fields inhibited the cell cleavage after fertilisation and time-varying fields disrupted the cells in a more complex way. It was a salutary reminder that non-ionising radiation may affect our environment even if not our own health. A. Hashish (University of Mansoura, Egypt) considered similar effects of continuous exposure on mice. His group measured weight loss, decreased liver glucose and protein along with changes in a range of blood counts with exposure to fields of a few mT (static) or µT (50 Hz dynamic). This could be due to disruption of anti-oxidant enzymes within the cells. Whether effects are reversible or if a threshold exists is a subject for further research. Finally, S. Mortazavi (Shiraz University of Medical Sciences, Iran) investigated the subjectivity of health symptoms in humans. In a country where there has been no media frenzy about the potential detriment of using mobile phones, a handful of students from the local university were still self-diagnosed hypersensitive. However, a double-blinded study of this group showed no significant difference between real and sham exposure. Some of the participants claimed symptoms in either case, and did demonstrate increased heart rate as a result. Discussion following this talk showed that the audience was mostly in agreement that effects were unproven and psychological. A significant minority were still cautious about the timescales of cellular effect though.

**FIGURE 3.** Seven key tasks for the radiation protection of patients, as defined by the IAEA.

<table>
<thead>
<tr>
<th>TASKS</th>
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<tbody>
<tr>
<td>1. Avoiding radiation injuries, in interventional procedures using x-rays and reducing the probability of stochastic effects, especially in children</td>
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<td>2. Establishing reference levels in radiography</td>
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<td>3. Reducing doses by rare earth intensifying screens</td>
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<td>4. Optimisation of protection in mammography</td>
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<td>5. Patient dose management in computed tomography with special emphasis to children</td>
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<tr>
<td>6. Protection of family members and public from the radiation exposure from the release of patients after radionuclide therapy (ICRP guidance)</td>
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<tr>
<td>7. Avoidance of accidental exposure in radiotherapy</td>
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Poster presentations were on a similar breadth of topics. Highlights for these authors included:

- Design and fabrication of a prototype add-on multileaf collimator (Avicenna Research Institute, Mashhad, Iran);
- Effects of natural radiation on neural function in Brazil (Dawndesh Research Institute, Barcelona, Spain);
- Assessment of gamma background in outdoor and indoor areas in Zanjan province (Zanjan University of Medical Sciences, Iran).

UK INVOLVEMENT
In addition to the handful of UK delegates, several of the invited speakers were from Britain and a number of IPEM members served on the committees of IOMP.

Martin Leach (Institute of Cancer Research and Royal Marsden Hospital, Sutton) described current progress in the use of magnetic resonance techniques in cancer biology; in particular, how dynamic contrast enhancement, diffusion-weighting and spectroscopy can be used to visualise cell vasculature, death and metabolism, respectively. He also related the establishment of MR screening for women at high risk of developing breast cancer, and NICE guidelines for its use alongside mammography in a cost-effective manner.

Richard Bowtell (University of Nottingham) presented the latest results from the UK’s only 7T scanner, weighing the advantages and disadvantages of a high field system. Features resulting from shorter T2*, longer T1, increased signal-to-noise and so on were described. One area of detailed investigation was use of the phase information available from increased susceptibility effects. After some complex processing, it was possible to construct susceptibility maps, giving effectively susceptibility-weighted images.

The EMITEL project, an online encyclopedia and multilingual dictionary of medical physics, was described by Peter Smith (Northern Ireland Medical Physics Agency, Belfast). It will contain several thousand peer-reviewed articles at MSc level and above, with 1,200 currently written. Translation of key terms between 20 languages, including Arabic, will be possible. The project is aiming for an official launch at the World Congress next year. In the meantime, further details can be found at http://www.emerald2.eu.

The ICMP was an eye-opening chance for these authors to gain a better understanding of how far and how fast medical physics has developed around the world. However, it is also apparent that the UK has much to offer the wider medical physics community from our own experiences. The next international meeting to be hosted by the IOMP will be the 2009 World Congress on Medical Physics and Biomedical Engineering. This will be held a little closer to home in Munich, so why not start writing that abstract now?

FOR MORE INFORMATION
Educational presentations can be found on the conference website (http://www.icmpdubai.com/ap/default.asp) along with abstracts for all talks and posters.

SOUTH WEST IPEM MEETING: REGIONAL UPDATES
PENNY LATIMER AND AMANDA BRASON Gloucestershire Hospitals NHS Trust

THIS YEAR THE SOUTH WEST IPEM meeting was hosted by Gloucestershire Hospitals NHS Trust (GHNHST) (figure 1). While many conferences focus on a particular topic, regional meetings offer an opportunity to hear about some of the varied work being carried out in engineering and physics groups locally. Some talks cover topics that are applicable to many departments such as training and competency assessments, by Morad Toussand (Medical Equipment Management Organisation, MEMO, Bristol) or risk assessment techniques, by Nick Powell (Royal Cornwall Hospitals NHS Trust, Truro). Others offer a reminder that there is life outside one’s own speciality!

NEW SOUTH WEST REPRESENTATIVE
The programme started on Friday afternoon with a heads of department meeting. In the evening delegates had a guided tour of Gloucester cathedral followed by a meal and the first talk of the meeting. This was given by Brian Witcombe (GHNHST), a winner of the Ig Nobel Prize for his paper on ‘Sword swallowing and its side effects’.

The main meeting started the next day in Cheltenham and began with an introduction to the developments and structural changes taking place at the IPEM. It was an opportunity for the new IPEM South West representative Liz Pitcher (Bristol General Hospital) to introduce herself and request feedback so that she could accurately represent the members from the region at meetings.

During the first session, Dominic Nolan (Salisbury District Hospital) talked about the work to develop technology to support a teenager with a C1 spinal cord break. The engineering challenge was to find and develop appropriate methods of access to everyday activities, in particular communicating through different media, and using equipment such as television and a PC. Part of the solution was to adapt an eye tracking computer system. Dominic described the system used for this patient (MyTobii) and how the complexity of access was tailored to meet the patient’s needs. In addition they have developed an EMG switch which is worn on the patient’s forehead. As a result of the work, this patient now has access to email, text messaging and internet along with computer games and music.

John Archer (Gloucester Royal Hospital) presented his PhD research work on the application of Raman spectroscopy to cerebral tissue as a potential tool to
FIGURE 1. Gloucester Royal Hospital (left) and Cheltenham General Hospital.

FIGURE 2. Image derived from an art collaboration at Gloucestershire Hospitals NHS Trust.
FIGURE 3. The new Oxford Cancer and Haematology Centre.

FIGURE 4. Several speakers discussed doses in diagnostic radiology.

Dose Calculations in Diagnostic Radiology

Tools available

- XDOSE
- PCXMC
- ImPACT DOSE CALCULATOR
- a calculator!
diagnose dementias. The work hopes to aid more accurate diagnosis of Alzheimer’s disease, which is currently identified using the patient’s symptoms. The use of drugs to treat this disease is expensive and a definitive test is needed to establish who would benefit. John’s research used ethically-approved post-mortem brain tissue from patients that had either Huntington’s disease, Alzheimer’s disease or were a normal control. By using multivariate analysis and processing he displayed results that could identify the different pathologies. The research will be used to find out whether other less invasive tissue could be used and other neurodegenerative diseases could be identified.

Later in the session, Belinda Christie (GHNHST) gave a presentation on the experiences that the Nuclear Medicine Department in Gloucester had with an artist in residence. The project aimed to promote the profile of lesser-known departments to the public through art. The artist, Simon Ryder, developed his ideas over 6 months and kept a blog of his experiences as a non-scientific person in this environment. One interesting idea that Simon and Belinda developed was to image nature using radio-isotope Tc99m. This led to various flowers and leaves being applied with radioactive material. As well as being a useful training exercise on the uptake and imaging of radioisotopes, it also generated some stunning images. They concluded that rhubarb leaves were the best at taking up the radioisotope and being imaged. The final art presentation is displayed to the public in the entrance atrium of Gloucestershire Royal Hospital (figure 2). Two talks in this session mentioned the consequences of unforeseen water in a radiotherapy department. In the first, Rosemary Belton (Churchill Hospital, Oxford) spoke about the planning and commissioning of the new Oxford Cancer and Haematology Centre (figure 3). After a lot of planning, it is becoming a reality and Rosemary described the commissioning of four new linacs and other equipment. One unexpected setback was flooding due to leaking heating pipes. Impressively, despite this setback and all the extra workload that commissioning entails on top of maintaining the current service, the project is progressing well.

**VARIED RESEARCH INTERESTS**

In contrast, the unexpected water in Gloucestershire was external to the department – the severe floods experienced in July 2007. Jason Brimelow (Cheltenham General Hospital) spoke about the impact and the challenges of continuing to treat patients when the Cheltenham water supply was cut off and access for patients and staff was restricted. The contingency plans were severely tested during both the initial flooding and in the weeks that followed.

Other talks throughout the day discussed many different subjects, including a recent visit to the proton facility in Houston by Tony Bedford (Derriford Hospital, Plymouth), and an insight into the role of an IR(ME)R inspector by Carol Scott (Cheltenham General Hospital). Three of the speakers discussed different aspects of patient doses in diagnostic radiology: CT quality assurance, Trevelyan Foy (Truro Hospital); estimation and measurement of CBCT (cone beam computed tomography) doses, Edward Matthews (Royal United Hospital, Bath); and the ICRP 103 report, Pravin Mistri (GHNHST) (figure 4).

In addition to hearing the talks, the SW meeting is a good occasion to catch up with old friends and colleagues from neighbouring hospitals as well as meeting new faces.

During the breaks there was a welcome opportunity to talk to the companies who kindly sponsored the meeting and to find out about their latest products and developments.

**SPONSORS**
The meeting was sponsored by Bentham Ltd, Clifden Healthcare Ltd, Imaging Systems Ltd, Oncura Ltd, Oncology Systems Ltd, Qados and Southern Scientific Ltd.

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**CLINICAL TRIALS IN RADIOTHERAPY: OVERVIEW OF THE RATIONALE**

**CATHARINE CLARK** Royal Marsden Foundation NHS Trust, Sutton, Surrey

THE CLINICAL TRIALS IN Radiotherapy meeting was held at The Society of Chemical Industry in the heart of Belgravia, aiming to provide an overview of the rationale behind radiotherapy clinical trials and their QA entry requirements. Physicists, radiographers, clinicians and trials management staff attended.

Neil Richmond (James Cook University Hospital, Middlesbrough) opened the day by welcoming everyone and explaining that the day would include speakers from trials, quality assurance (QA) groups and individual radiotherapy departments.

**TRIALS IN EARLY BREAST CANCER**

John Yarnold (Royal Marsden Hospital, Sutton) opened the one-day meeting by giving an overview of the results from the very successful START (STAndardisation of breast RadioTherapy) breast trial. In total START recruited 4,451 patients and both parts of the trial are suggesting that fewer larger fractions give better normal tissue sparing whilst maintaining the same local recurrence rates as the control arm. He then went on to explain how the IMPORT (Intensity Modulated and Partial Organ RadioTherapy) LOW and IMPORT HIGH trials have been designed to question whether IMRT (intensity modulated radiation therapy) can be used to modulate fraction size and thus gain normal tissue tolerance by reducing the dose to the tissue surrounding the tumour.
FIGURE 1. The QA processes for radiotherapy trials.

FIGURE 2. Different levels of QA for radiotherapy trials.
EFFECTS OF RADIOTHERAPY ON NORMAL TISSUES IN EARLY BREAST CANCER

This talk was followed by Penny Hopwood (Christie Hospital, Manchester) who explained some of the quality of life endpoints in START and pointed out that the shorter treatment times suggested should also improve resource allocation.

WHY PARTICIPATE IN CLINICAL TRIALS?
A PHYSICIST’S PERSPECTIVE

Karen Venables (Mount Vernon Hospital, Northwood) was up next and spoke on behalf of the Radiotherapy Trials QA team (RTTQA) at Mount Vernon to describe the philosophy behind quality assurance programmes in trials. She explained that the RTTQA team is coordinating and streamlining the QA process (as can be seen in figure 1) between the different trials to try to reduce the QA burden on individual centres. One aspect of this is the baseline questionnaire which is filled in once by each department and the information is shared between all the trials. It only needs updating every 2 years or after a major upgrade has taken place. She also explained that each trial is assessed at the time of protocol writing to ascertain the appropriate QA level (see chart in figure 2). Finally Karen gave the pros and cons of joining a trial to implement a new technique (see the slide used in figure 3) and concluded that the advantages of the external audit and support outweighed the extra work required to undertake the QA exercises.

RADIOTHERAPY CLINICAL TRIALS – RESOURCE IMPLICATIONS

Gill Lawrence (Newcastle General Hospital) then spoke about what it is like to be in a department which is currently contributing to eight radiotherapy trials. She showed some tables of how much time each trial had taken to set up and support. It was interesting to see the large discrepancy in staff time and input across the different trials.

AN IMRT CREDENTIALING PROGRAMME FOR CLINICAL TRIALS IN THE UK

Just before lunch there were presentations from two of the posters which were on display in the exhibition. Catharine Clark (Royal Marsden Hospital, Sutton) spoke about the IMRT credentialing programme which is being run by the RTTQA team (http://rtttrialsoa.org.uk). The aim of the programme is to provide any centre which joins an IMRT trial with a full audit on all aspects of the IMRT process for their first trial. The programme includes outlining and planning exercises, TPS (Treatment Planning System) verification and field and point dose measurements, as well as an assessment of the processes in the patient pathway. For subsequent IMRT trials the QA can then be substantially reduced with streamlining of the QA between the different IMRT trials. Laura Ciurlionis (Mount Vernon Hospital, Northwood) then described the design and implementation of IMPORT LOW in the second of the presentations from the posters.

FIGURE 3.
Are trials the driving force for change?
Evolving Quality Assurance Programmes in Clinical Trials

After lunch Annette Haworth (Peter Macallum Hospital, Melbourne, Australia) gave an overview of radiotherapy trials down under. They are also starting up several IMRT trials and are developing their own IMRT credentialing system. She proposed that the UK and Australia QA groups join forces to develop their respective programmes such that the two countries could have a reciprocal agreement for the QA required by centres joining each other’s trials.

Tribulations of a Trial Physicist

The day concluded with Stuart McNee (Beatson Cancer Centre, Glasgow) describing his experiences in undertaking the role of QA physicist for the SOCCAR (Sequential Or Concurrent Chemotherapy And Radiotherapy in non-small cell lung cancer) trial, which involved standard 3D conformal therapy, although it was a trial to determine the best chemotherapy practice.

Voice of Young Science: Standing Up for Science Media Workshop

Constantinos Zervides University College London

The workshop was divided into three distinct sessions. Session one, Science and the Media, involved a discussion on the changing image and role of science and scientists in the public domain. It was led by three scientists, Prof R Lovell-Badge (MRC National Institute for Medical Research), Dr S. Keevil (King’s College London) and Prof A.C.Ghani (Imperial College)- who all had in the past dealt with the media. Of particular interest to medical physicists and engineers was the talk given by Dr S. Keevil, who became involved in the MRI community’s campaign about the impact of the Physical Agents (EMF) Directive on MRI. He explained how he approached and used the influence of the media to accomplish his goals regarding this campaign.

The third and final session, Standing up for science – the nuts and bolts, had a more informal attitude. Representatives from Sense About Science, Voice of Young Science and the Science Media Center, took it in turns to inform the participants on what is available for early career researchers and how they can encourage good science and evidence in the public domain. They offered practical advice in getting your opinions heard in debates regarding science and how to respond to bad science when you see it. They concluded by giving tips on how to respond to journalists if you are contacted by them and also how to handle a face to face interview, experience.

All in all it was a very lively and informative day and after speaking to the majority of the participants, it was well received. The next workshop will be held in Edinburgh on Friday 21st November 2008.

For more information regarding the organizers, the workshop and how you can help protect science or get involved visit: www.senseaboutscience.org/VoYS.
FIGURE 1.
The first session panel.

FIGURE 2.
The workshop participants.
s we get older, most of us accumulate wisdom and lose flexibility. Organisations can however be different. The NHS, that great health system survivor, is now 60 years old. Can its experiences teach us anything about the future of healthcare in Britain and internationally?

**FOUNDATION OF THE NHS**

The roots of the NHS go back many years before its foundation but a pivotal moment was the publication of the Beveridge Report in 1942. This report recommended creating a free national health service while observing that the state of medical provision in Britain ‘fell seriously short’ compared with other countries of the world. Even with this analysis, it faced strong opposition from government and from professionals with vested interests. However, just 6 years later, opposition was overcome and the NHS came into being, to great popular acclaim. Why was this?

Crucially, the Beveridge Report provided a vision. Its proposals for a united health and social care system hit the popular mood. It became the best-selling UK government report ever (635,000 copies) and was widely discussed. It offered a positive aim for the war against Britain’s enemies. Over 90 per cent of the population were in favour of implementing the report, and it could not be ignored. After heated debate and prolonged negotiations through the war and afterwards, the NHS became a reality in July 1948.

The unifying and caring vision set out in the Beveridge Report also motivated the 53 founding members of the Hospital Physicists Association. ‘Hospital physics’ had developed steadily, following the appointment of academic physicist Sydney Russ to the first hospital post at the Middlesex Hospital in 1913. Twenty-five physicists came together in 1943 at the first meeting called by Russ, to build the science and subsequently its professional practice, including growing engineering and technology. The influence of these pioneers still resonates through IPEM. My first head of department was a founder member of the HPA, as concerned to use engineering and physics in the pursuit of patient care as he was to encourage academic endeavour and involvement with industry.

**WHAT IS THE FUTURE?**

Looking back over the last 65 years, it is hard to appreciate the battles needed to make Beveridge’s vision a reality. What has proved extraordinary is the lasting nature and influence of that vision. In 1942 Britain was fighting a war it might not win, hospitals were struggling due to lack of funds, and access to healthcare for the poor depended on charity. Fast forward to today and we face similar problems, except that in the developed world patchy access to healthcare has replaced no access at all. The achievements of technologists, engineers and scientists in healthcare have been phenomenal, and yet when looked at on a global scale there is far more yet to be done.

Looking to the future, medicine seems to be losing its way. Ten years ago, Professor Roy Porter wrote that medical consumerism – the fantasy that everyone and everything can be cured – was leading to inflated and unfulfillable expectations. Medicine needs to define its limits, he said, even as it extends its capabilities. He asked the question: what is the price of extending life if it leads to degrading neglect, as resources grow overstretched?

**DECIDING ON PRIORITIES**

So in an interconnected world facing common problems, what vision might we develop in IPEM to serve the NHS and other healthcare systems over the next 65 years? As international trends start to bring together leading academic institutions and health service providers, remember that the Beveridge Report was about both health and social care. The two cannot be separated in modern societies, where difficult decisions need to be made on priorities and allocations. In a resource-limited future, the NHS is seeking to change emphasis from sickness to health while improving delivery to all. Will its original twin values of unity and caring be sustained? And are these the ones on which IPEM should build its future?
AN IMAGE ISSUE

While shadowing Mark McJury, I enquired about comments and feedback. It did not take me long to realise they were infrequent. It also seems that only displeased readers found the time to write. I was therefore happy when finally some positive and some constructive messages landed in my inbox. The first email praised the photographs in Iain Chambers’ report (March); nothing to do with my work but still pleasing. The second message was a constructive comment on Mark McJury’s recent Publishing Professional Writing tutorial (June). The letter by Professor Salmons is re-printed in this issue with the answer from one of the tutorial co-authors, Professor Hogg.

One thing that has puzzled me since taking over is that the bulk of the questions and comments I have faced are neither positive nor negative (although some were cheeky) but have to do with the disappearance of the editor’s photograph. In an image-obsessed society, I was naïvely expecting scientists to be immune and have an interest in images limited to acquisition and quality assurance! Well, if you are that interested (and frankly I cannot understand why), rest assured that the photograph will come back; but only with the next editor. For this one, I hardly see the point as only the fastest CPU and largest memory would allow you to morph me into George Clooney. To achieve this small miracle you will also need to be an expert in image processing and to help you along the way I am kindly providing you with an excellent tutorial on image registration. This field is nowadays not limited to research but takes an increasingly important place in our professional life from new imaging modalities like PET/CT to MRI/CT fusion in radiotherapy planning. This is a vast and often complex subject and this substantial tutorial covers both the basics and advanced examples. The article was written by Dr William Crum of the Institute of Psychiatry (KC L). Bill not only is an expert in the field, he has the ability to make it accessible to most as I am sure you will agree when reading his article.

In the remainder of the issue you will find your usual items including meeting reports, book reviews and news. The news is now edited by Christie McComb (Glasgow); I would like to take this opportunity to welcome her and thank her predecessor, John McLean, for his sterling job. Christie is an MRI physicist and she now edited by Christie McComb (Glasgow); I would like to take this opportunity to welcome her and thank her predecessor, John McLean, for his sterling job. Christie is an MRI physicist and she did not hesitate to go in the scanner to illustrate one of her items. In the features, you will discover why it has been an exciting year for imaging in medicine with the creation of SINAPSE, a consortium of six universities with an interest in neuromaging. This year marks the 65th anniversary of the HPA and this substantial tutorial covers both the basics and advanced examples. The article was written by Dr William Crum of the Institute of Psychiatry (KC L). Bill not only is an expert in the field, he has the ability to make it accessible to most as I am sure you will agree when reading his article.

To finish in style, we travel further back in time with Francis Duck’s riveting article on the early days of ultrasonic detection. Hope you’ll enjoy this issue.
Study into adverse health effects of Magnetic Resonance Imaging (MRI)

On 21st May, the Chairman of the Health Protection Agency, Sir William Stewart, issued a press release stating that the Agency’s board had approved in principle the need for an epidemiological study of possible adverse health effects from high static field Magnetic Resonance Imaging (MRI) scanners.

Sir William said: ‘MRI scanning has some undoubted benefits in medicine, especially as an aid to accurate clinical diagnosis. However we need to bear in mind that the magnetic fields produced by the machines are quite substantial and that these fields are increasing in order to achieve improved clarity of image. The exposures to patients and medical staff from the magnetic fields can be high and there is a shortage of information on possible adverse long term health effects. The Agency’s Board therefore considers more research is needed in this area.’

The view that there is a need for more epidemiological research on people exposed to MRI is shared by the World Health Organization, which has suggested that an international collaborative study may be the most effective way to proceed, as it would ensure there are sufficient numbers of exposed cases in the study to draw accurate conclusions. The Agency will now examine the feasibility of such a study with specialists here and abroad, with the aim of launching such a study as soon as possible.

More information can be found using the following link:

PET probe images of immune system activation

The ability to monitor immune system function could have a considerable impact on the diagnosis and treatment of immunological disorders and therapeutic immune response. A technical report published online on 8th June in Nature Medicine (doi:10.1038/nm.1724) describes a new PET probe which has been developed to achieve this purpose.

The concept behind the probe involves a fundamental process called the DNA salvage pathway. This is essentially a recycling pathway that immune cells use to quickly and efficiently produce new cells in the event of infection. The probe consists of a molecule called FAC (fluoroarabinofuranosyl cytosine), which is effective at entering immune cells. In the presence of a particular enzyme involved in the first step of DNA recycling, FAC is phosphorylated and retained within the cell. It is labelled with 18F, a commonly used PET radionuclide, which allows its distribution to be imaged.

Experiments were conducted in mice to determine the effectiveness of 18F-FAC imaging in immune activation and systemic autoimmunity. In one such experiment, the mice were injected with an oncogenic virus, causing a tumour to develop, of a type which is quickly recognised and attacked by the immune system. An injection of the probe was administered, followed by repeated PET scans.

PET scans obtained 15 days post-injection, which corresponds to the peak anti-tumour immune response, showed an increased accumulation of 18F-FAC in the spleen and tumour draining lymph nodes with reduced retention in the tumour site, which suggests that 18F-FAC has good specificity for imaging immune rejection of virally-induced tumours.

Studies are currently underway to translate the use of the new probe into human subjects, and to evaluate its potential for monitoring autoimmunity, inflammation and cancer.

This story was reported on Technology Review on 9th June, and more can be found at:
http://www.technologyreview.com/Biotech/20876/page1/
http://www.nature.com/nm/index.html

PET probe image in a mouse.
Image courtesy of Professor Caius Radu, University of California, Los Angeles, at the Institute of Neurological Sciences, Glasgow.
Benefits of dose modulation in neuroradiology CT confirmed

Studies in the United States and Europe have revealed that computed tomography (CT) examinations account for up to 15 per cent of all imaging examinations, but contribute up to 75 per cent of the total dose to the population. One possible method of dose reduction available on most modern CT scanners is dose modulation, in which tube current is adjusted separately for each CT section according to patient attenuation. However, there is little documented evidence on the overall effect of using dose modulation.

A study published in Radiology (2008, 247[2]: 499) investigated the effect of dose modulation on four commonly-used CT protocols – unenhanced brain CT in adults, unenhanced brain CT in paediatrics, adult cervical spine CT and adult cervical and intracranial CT angiography. For each protocol, scans which had been performed with and without dose modulation were reviewed, and the weighted volume CT dose index (CTDII) and dose length product (DLP) which had been recorded by the scanner were compared. The image quality was also rated subjectively by a neuroradiologist who was blinded to the use of dose modulation.

The results showed a significant decrease in dose when dose modulation was used, with a reduction in CTDI and DLP during unenhanced brain CT in adults of 57.9 per cent and 55.4 per cent respectively with z-axis dose modulation, and 52.6 per cent and 25.8 per cent with x-y-z-axis dose modulation. The use of dose modulation had no effect on image quality.

The researchers recommend the use of dose modulation in neuroradiology CT procedures, and will be expanding their study to investigate the effect of dose modulation on CT protocols for other parts of the body.

This study was reported on Medical Physics Web on 29th April, and more information can be found using the following links:
http://medicalphysicsweb.org/cws/article/research/33987
http://radiology.rsna.org/cgi/reprint/247/2/499

Mobile imaging gets a new meaning

According to World Health Organization reports, around three-quarters of the world’s population currently has no access to medical imaging technologies, often because the systems are too costly to maintain or there is a lack of staff with the expertise to operate them. In a paper published on the PLoS ONE website in April 2008, researchers describe a method to overcome this by exploiting the prevalence of mobile phone networks, which are often available even in remote locations.

Conventional medical imaging systems usually consist of three components – the data acquisition hardware, the image processing system and an image display unit. In the new system, the components are physically separated, with the most complicated component – the image processing system – at a central location that could serve several remote sites. Only the acquisition device used to collect the raw data needs to be at the patient site, which reduces the cost and allows it to be operated by staff with basic technical training. The unprocessed raw data are transmitted via mobile phone to the central server, which processes the data and sends the resulting image back to the patient location. The image can then be viewed on the mobile phone screen and analysed by local physicians.

Its feasibility was tested using Electrical Impedance Tomography (EIT) to image a simulated tumour. A simple acquisition device was constructed using 32 stainless steel electrodes, 15 of which served as current sources and one as a current sink, with the remaining 16 electrodes used for voltage measurements. The device was connected to a gel-filled container that simulated breast tissue with a tumour and used to record 225 voltage measurements. The measurements were uploaded to a mobile phone, which sent the raw data to the central facility for processing. The resulting image was viewed on the mobile phone screen, and clearly showed the simulated tumour. According to the researchers, the system should work for any mobile phone that is capable of sending and receiving multimedia images.

This story was reported on Medical Physics Web on 2nd May, and more can be found at:
http://medicalphysicsweb.org/cws/article/research/34046
http://www.plosone.org/article/fetchArticle.action?articleURI=info:doi/10.1371/journal.pone.0002075

Image courtesy of Professor Boris Rubinsky, University of California, Berkeley.

IN BRIEF

MOBILE IMAGING
A simple data acquisition device can communicate with a central image processing centre via mobile phone, allowing access to medical imaging technology for populations who do not have the expertise or financial ability to maintain conventional imaging systems. The raw data from a scan can be sent from the phone to be processed, and the resulting image sent back for local analysis.

CT DOSE MODULATION
A study has confirmed significant reductions in dose when applying dose modulation techniques to commonly-used neuroradiology CT protocols. The use of dose modulation has no effect on image quality.

HEALTH EFFECTS OF MRI
The HPA has approved in principle the need for an epidemiological study of possible adverse health effects from high static field Magnetic Resonance Imaging (MRI) scanners. Fields used are becoming stronger and their long term effects on patients and staff need to be understood.

PET PROBE FOR IMMUNE SYSTEM
A new PET probe has been developed which allows imaging of immune system response in mice, and has the potential to monitor autoimmunity, inflammation and cancer in human subjects. The probe enters and is retained in immune cells so can be labelled and its distribution imaged.
Congratulations to the following members who were recently elected to Fellowship of IPEM.

Dr Panayiotis Kyriacou, London (elected March 2008); Dr David Brettle, Leeds (elected May 2008); Mrs Anne Walker, Manchester (elected May 2008)

Congratulations to the following who have recently been successful in the IPEM Viva Voce examinations for the Clinical Science Diploma of IPEM [DipIPEM(S)].

<table>
<thead>
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<tr>
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<tr>
<td>Alison Hand</td>
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<tr>
<td>Debbie Holmes</td>
<td>Oxford</td>
<td>Pass</td>
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<tr>
<td>Elaine Kennedy</td>
<td>Northern</td>
<td>Pass</td>
</tr>
<tr>
<td>Clara Marquez-Moreno</td>
<td>London North</td>
<td>Pass</td>
</tr>
<tr>
<td>Sarah Naylor</td>
<td>East Midlands</td>
<td>Pass with Merit</td>
</tr>
<tr>
<td>Barry O'Connell</td>
<td>Wales</td>
<td>Pass</td>
</tr>
<tr>
<td>Gregory Stevens</td>
<td>Surrey and South West</td>
<td>Pass</td>
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Congratulations also go to the following students who have successfully completed the Clinical Technology Diploma of IPEM [DipIPEM(T)].

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<td>Peter Austin</td>
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<td>Paul Callaghan</td>
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<tr>
<td>Gordon Mitchell</td>
<td>Edinburgh</td>
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<td>Paul Musgrave</td>
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<td>Derek Ponsonby</td>
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<td>James Scobie</td>
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<tr>
<td>Leah Speirs</td>
<td>Glasgow</td>
<td>Pass with Merit</td>
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Member wins big engineering prize

Touch Bionics of Livingston has been awarded the 2008 Royal Academy of Engineering MacRobert Award for the world’s first commercially available hand.

Stuart Mead (chief executive), David Gow (director of research, founder and MIPEM), Stewart Hill (project manager), Hugh Gill (director of technology and operations), Phil Newman (director of marketing) and Nicky Holt (project coordinator) were presented the £50,000 prize and the solid gold MacRobert Award medal by HRH the Duke of Edinburgh.

The Touch Bionics i-LIMB Hand is a prosthetic device that looks and acts like a real human hand with five individually powered fingers. The project started in 1963 as part of a research programme at Edinburgh’s Princess Margaret Rose Hospital to help children affected by Thalidomide. The hand control system uses the electrical signal generated by the muscles in the remaining portion of the patient’s limb. The myoelectric signal is picked up by electrodes on the surface of the skin. The system is very intuitive and patients master the functionality of the device within minutes. The prosthetic device is manufactured using high-strength plastic making it lightweight, robust and highly realistic.

Since its launch in 2007 over 200 patients have benefited from this revolutionary device. One such patient is Ray Edwards (photographed). For Ray the new prosthetic is more than added functionality: ‘i-LIMB has helped me more psychologically than physically. That was the first time in 21 years that I had seen a hand opening there – it made me feel I was just Ray again. You can do so much with technology but it’s got to make the user happy – and i-LIMB does!’ Ray also noticed improvement within 4 weeks of having the prosthetic and now feels it is part of him.

You can watch Ray’s interview and David explaining how the hand works on the BBC website [http://news.bbc.co.uk/1/hi/sci/tech/7443866.stm]. When you read this you will still be able to see it for a few more days in the London Science Museum.

M.E.M.
# Diaries of Meetings

## Planned Meetings 2008

<table>
<thead>
<tr>
<th>Meeting</th>
<th>Dates</th>
<th>Venue</th>
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<tbody>
<tr>
<td><strong>Beyond Improvement: Can Enabling Technology Maximise Performance</strong></td>
<td>30th September</td>
<td>York</td>
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<tr>
<td>Assisting technology has made it possible to augment individuals beyond improvement to super performance. This meeting will provide an inspirational insight into the use of enabling technology to surpass boundaries in sport, rehabilitation and life achievement. Joint presentations with user experiences, technical explanation and research and development will be given.</td>
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<td><strong>Practical DICOM: Radiology, Radiotherapy and Beyond!</strong></td>
<td>7th October</td>
<td>Birmingham</td>
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<td>Birmingham This meeting is aimed at people who need to understand the technical issues behind the communication of electronic data around a department using DICOM.</td>
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<td><strong>Working Like Clockwork – the Equipment Management Database</strong></td>
<td>21st October</td>
<td>Birmingham</td>
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<tr>
<td>Birmingham The equipment management database is one of the most important tools in any EBME department. The aim of this conference is to stimulate greater utilisation of this valuable resource.</td>
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<tr>
<td><strong>Radiation Protection in Nuclear Medicine</strong></td>
<td>4th November</td>
<td>London</td>
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<td>London This meeting will bring together nuclear medicine and radiation protection professionals to share experiences in managing new radiation protection concerns and challenges.</td>
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<td><strong>Neurophysiological Intra Operative Monitoring</strong></td>
<td>6th November</td>
<td>York</td>
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<td>York This one-day meeting aims to focus on new developments within the speciality along with reviewing the standard practices.</td>
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<tr>
<td><strong>Challenges in Medical Equipment Design and Development</strong></td>
<td>2nd December</td>
<td>Coventry</td>
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<td>Coventry Framework topics addressed by the meeting will include how innovation is handled within the NHS, the importance of industrial design and also how to climb the ethical mountain.</td>
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## Diary of Meetings 2009

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<thead>
<tr>
<th>Meeting</th>
<th>Dates</th>
<th>Venue</th>
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<tr>
<td>UKRO 2009</td>
<td>6th–8th April 2009</td>
<td>Cardiff</td>
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<td>Cardiff</td>
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<td>A multidisciplinary conference for clinical oncologists, therapy radiographers, radiotherapy physicists, clinical radiobiologists and oncology nurses. For further details visit <a href="http://www.ukro.org.uk">www.ukro.org.uk</a></td>
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## Other Meetings Coming Soon in 2008/2009...

Clinical Science in Physiological Measurement, Managing Motion in Radiotherapy, Mammography Physics Training meeting, Radiographer QA training day, Risk and Maintenance, A code of practice study day

The meetings department of IPEM is delighted to announce its upcoming programme of meetings. Our programme is regularly updated so please visit our website at [www.ipem.ac.uk](http://www.ipem.ac.uk) for the latest details. Abstract submission instructions, programmes and registration forms can be downloaded for each meeting.
Towards Safer Radiotherapy

Towards Safer Radiotherapy has recently been published as a joint venture between IPEM, the British Institute of Radiology, the NHS Patient Safety Agency, the Society and College of Radiographers and the Royal College of Radiologists.

The document recognises that radiotherapy incidents in the UK are few but cites their impact as devastating to the patient, the staff and the integrity of the profession. It therefore addresses and outlines ways in which to minimise errors in radiotherapy. This is achieved in a number of ways; the main text explores the type of errors, the frequency of them, ways in which to detect them and things that can be learned from past incidents. It also looks at ways in which to deal with consequences of errors. The report also provides the reader with a list of recommendations in order to improve their own practice.

The report is aimed at radiotherapy professionals, patients and other interested individuals; for this reason it is written in a readable style that is approachable for those who are not from a radiotherapy background.

This is essential reading for those in a radiotherapy setting and is available as a PDF through a link on the IPEM website and from [www.rcr.ac.uk](http://www.rcr.ac.uk).

Digital Radiography and PACS

This 240-page book is intended for radiography students. However, trainee physicists, technologists and anyone who is unfamiliar with digital radiography and PACS may find this book a useful primer. The book was written by American authors. A mixture of metric and non-metric units is used.

The book is organised into five parts, with a useful glossary and abbreviation table at the end. Each part contains one or more chapters. The chapters are structured, with the topics that will be discussed, the objectives and key terms listed up front. At the end of each chapter, there is a summary in bullet point form, followed by chapter review questions. There is an abundance of pictures, diagrams and tabulated summaries throughout. It is a very ‘visual’ book which is helpful in many instances, but the brief treatment of some topics may leave the reader feeling rather lacking in depth or intellectual satisfaction.

Part I is the Introduction, which contains a tabulated comparison of conventional, computed and digital radiography. Part II is Basic Principles, which contains basic computer principles which some readers may find elementary. It should be considered up-to-date, although in the section on operating systems only Windows 95, 98, 2000, ME, XP and NT are mentioned, not Windows Vista.

The chapter on networking and communication basics contains a brief but useful description of network classes, communication basics contains a brief but useful description of network classes, DICOM and HL-7. The major sections of the book are in Part III and Part IV. Part III is Digital Radiographic Image Acquisition and Processing. It goes through the principles and mechanics of computed radiography (CR) and direct digital radiography in a descriptive way.

There are brief explanations of topics such as exposure indicator, image sampling, processing and manipulation. Topics such as modulation transfer function, detective quantum efficiency and aliasing are given a brief descriptive explanation, rather than mathematical definitions or scientific explanation. There is a conspicuous absence of equations. More emphasis is put on the practical side, such as collimation, technical factor and equipment selection and artefacts.

The section on artefacts encountered in computed radiography is well worth reading. It contains many high quality images of different types of artefacts, with clear explanation of the problems in the attending captions.

Part IV is PACS Fundamentals. PACS design, workflow, system architecture and types of display workstations are described and illustrated. There are one or more photographs or diagrams on most pages to show the reader what things look like.

There is a chapter on PACS archiving and a chapter on digitisers, imagers (printers) and CD/DVD burners. These chapters serve to give useful background information to the reader. Part V is Quality Control (QC) and Quality Management. There is a good section on radiographer’s QC of workstation monitors, reject analysis and other duties, but very little on QC of CR readers.

The chapters are structured, with the topics that will be discussed, the objectives and key terms listed up front. At the end of each chapter is a summary in bullet point form.

In summary, anyone who wants an easy-to-read and well-illustrated primer on digital radiography and PACS may find this book helpful.

Ruby Fong
Barts and The London NHS Trust

DIGITAL RADIOGRAPHY AND PACS
CHRISTIE E. CARTER AND BETH L. VEALE
Published by Mosby Elsevier US (2008)
Language: English
ISBN: 978-0-323-04444-8
Paperback, 240 pages
The Physics of Radiotherapy X-Rays and Electrons

This is without doubt an all-in-one book of radiotherapy physics, and even more. The title, which refers to the physics of X-rays and electrons, does not describe the whole content of the book, as the authors felt the need to top-up with extra subjects, like proton physics and radiobiology. The latter is added in the last chapter (14) probably for a supposed completeness, but it could have been very well omitted based on the book’s subject.

The book is well presented; the layout is clear and follows logically through the subject. The text practically covers all important aspects in connection with radiotherapy. It starts with medical linacs and, although not complex, the information in this chapter is enough to understand the science behind them, their construction and functional parts. It is followed by a chapter regarding the interaction of radiation with matter, where physics is properly explained using a suitable proportion of mathematics and concepts. The authors provide a comprehensive description of all the dosimetric techniques of interest in the third chapter, while the calibration of beams, including several codes of practice, is placed in Chapter 8. The codes of practice mainly discussed are IAEA TRS 398 and AAPM TG 51, but others, like TG 21 NACP or early HPA protocols, are also part of the subject. I must say I find useful the comparison between some of the protocols, which is provided in a sub-chapter.

The beam properties of X-rays and electrons and their related fundamental quantities are also suitably presented over two chapters, with good illustrations and just enough equations to keep the subject simple but clear. I was pleased to find a good and thorough presentation of beam and brachytherapy models, together with the concepts, physics and also the mathematics behind them, their strengths and weaknesses. There is quite a detailed discussion about the influence of inhomogeneities on dose distributions, and the characteristics of the various correction methods used. The inclusion of the Monte Carlo (MC) codes is a positive initiative, as this method becomes more popular in commercial software. It is disappointing though that the Macro MC is limited to one page, whilst this is an important and modern implementation of MC in terms of computational efficiency.

This edition is updated with modern techniques, including robotic radiosurgery and tomotherapy. A whole chapter is dedicated to these advanced procedures, where one can find a brief but plain description of their principles, technology and applications.

Another two chapters cover quality assurance and radiation protection of the treatment machines and bunkers, topics that could not be missed from the complete structure of the book.

Patient immobilisation, setup verification and treatment delivery are not forgotten, as they are fundamentally important for the accuracy aimed by radiation physicists.

Overall, the graphs, tables and pictures are well balanced. It is worth a mention here that the authors illustrated most of their discussion about radiation transport and interaction concepts using graphical Monte Carlo tracks, which I consider a great idea. Unfortunately, there are a few mistakes in the text, formulas and illustrations. One that I found quite amusing is where the abbreviation ESQ, which should mean equivalent square, is affirmed to be electrostatic quadrupoles!

To sum up, the book is a useful reference for the radiotherapy physicist – both junior and experienced. It is complete, up-to-date, and there is an adequate balance of graphics, mathematics, concepts and descriptive text.

Apart from to radiotherapy physicists, I would recommend it, even if not as a whole, to other radiotherapy professionals like radiographers or technologists.

Dr Virgiliiu Craciun
Southampton Oncology Centre

The Oxford Book of Modern Science Writing

For his latest book, and the last as Charles Simonyi Professor of the Public Understanding of Science, Richard Dawkins puts on his editor’s hat and tackles the difficult exercise of the popular science writing anthology. Unlike John Carey’s spectacular Faber Book of Science, this book only focuses on writings from the last century (hence ‘Modern Science’). It is also limited to pieces written by scientists and, with some rare exceptions (like the great Primo Levi), to original English texts.

The book is divided into four sections – ‘What scientists study’, ‘What scientists think’, ‘Who scientists are’ and ‘What scientists delight in’. Those categories are quite fuzzy, and as scientists often delight in what they study (and vice versa) and what they think is linked or derived from what they study, a lot of pieces could easily be moved around. However, this has the clear advantage of giving some structure to the book. All the pieces are short extracts from books, articles, magazine columns or talks. Sometimes shorter than a page and hardly ever exceeding eight, the texts are ideal for fragmented reading during your daily commute or before going to sleep.

Dawkins’ didactic and literary talents are not only apparent through his choices, very few texts are hard to read and even the extract from the notoriously hard A Brief History of Time is accessible to all, but also in his extremely well-written introductions to each author. In only a few lines, he delivers first hand anecdotes or details on the author’s life, work and field that instantly give you a sense of familiarity.

The volume starts with a short piece by James Jeans which looks towards the immensity of the Universe and the insignificance of Earth in space. Like an echo, it finishes with an extract from Carl Sagan’s Pale Blue Dot looking down on our small and fragile planet from the immensity.
Marc Miquel

THE OXFORD BOOK OF MODERN SCIENCE WRITING
Published by Oxford University Press
Language: English
Hardback: 448 pages

Just Published!

This quarter we have a range of new books that have just been or are about to be published.

If you are interested in them or would like to try your hand at reviewing them please contact the book review editors for details.

Diagnostic Imaging for Physical Therapists by James Swain, Kenneth W. Bush, and Juliette Brosing (Elsevier).
This book is aimed at giving the reader the knowledge to understand the basic principles of imaging in practice. There is an accompanying DVD with interactive activities to consolidate the readers’ understanding of the topic.

This is the second book in the series (the first was published in 2006) that intends to keep practicing medical physicists, technical staff and physicians up to date with the current advances in the field. The book covers all the recent developments in medical physics including computer-aided diagnosis (CAD), advances in quantitative MRT and image guided radiotherapy (IGRT).

Fundamentals of MRI: An Interactive Learning Approach by Elizabeth Berry and Andrew J. Bulpitt (Taylor and Francis).
This is an interactive book with accompanying CD-ROM on an introduction to the principles of MRI. It provides animations and exercises (with solutions) to help the reader to develop a deeper understanding of the topic.

Advances in Biomedical Engineering by Pascal Verdonck (Elsevier).
This book is a review of all the current research advances in the field of biomedical engineering from visualisation technology through to cardiovascular medical devices and is aimed at educating students and professionals.

Medical Devices into Healthcare by Alex Faulkner et al. (Palgrave Macmillan).
This work explores the world of medical device innovation and regulation including five technology case studies from orthopaedic surgery, intensive care nursing, haematology, cancer detection and regenerative medicine.

Sarah Misson
Southampton General

REVIEWERS WANTED!

Being a Scope book review editor is a funny old business. One minute you have no books on your desk and you’re worrying about where your next copy is coming from. Next minute there is an avalanche; you receive a package of books every day and the tower on your desk becomes higher and higher.

A way to make the whole process a bit easier is to have a good group of reviewers ready and waiting. We have recently been in consultation with the IPEM special interest groups, and they are willing to help us create a group of keen reviewers who we may refer books on to.

We need more than this however and this is where you come in. If you have seen a book in Just Published! that you might like to review, please drop us a line and we will try and get a copy for you, likewise with any recent book in print. You may also decide that you would like to be a reviewer but are unsure what to review. Please contact us and we could match you with a book. Either way, as a thank you, you get to keep the book. We don’t operate short deadlines, therefore allowing you to review at your own pace.

Popular Science is our newly launched column, and again we are on the lookout for reviewers. This time we cannot call on the SIGs for help so this is where volunteers like you are especially needed. Popular Science books are generally shorter and easier to read in one go, making them ideal for time-short reviewers, and again you would get to keep the book.

There are advantages to doing book reviews for Scope; in addition to increasing your library, it counts towards valuable CPD, and as a more junior member of IPEM it may be a good addition to your CV.

So please, ask you to consider becoming a Scope book review editor, it takes little time, there are clear benefits and it would make our lives easier!

Marc Miquel