MARS Spectral CT Group
PhD Positions

PhD positions available:
Several fully funded PhD projects are available immediately in the MARS Spectral X-ray CT Group (University of Otago and University of Canterbury) as part of a 6 year project to develop Human Scale Spectral CT Technology incorporating X-ray photon processing detectors. Details on specific projects can be found on the next page. The MARS Bioengineering team comprises scientists from a broad mix of disciplines, with engineers, physicists, computer scientists, mathematicians, biologists, radiologists and surgeons making up the team. The project spans photon counting detector based cameras, image processing, quantification of materials, and applications of multispectral CT in biology and medicine. It is expected that the candidate will earn a PhD Scholarship from either of the above universities.

Topics:
There are several areas of research with the MARS group, including but not limited to:
- Medipix detector characterisation, sensor layer physics, and next generation ASICs.
- Spectral image processing for simultaneous multi-material discrimination and quantification.
- Image processing and software development for 3D visualization, and PACs integration.
- Data handling techniques for large volumes of data from the multi-chip spectral camera.
- Pre-clinical biomedical research in Osteoarthritis and Atheroma diagnosis, image based quantification of novel bio-markers and targeted nanoparticles for Cancer detection, Bone health and quality metrics.

Student skills:
Students should be have strong skills in either Physics, Engineering, Computer Science, Biology, or Mathematics. And a strong desire to become familiar with the wide range of disciplines that make up Bioengineering research. The student needs excellent undergraduate grades, and good English language skills that meet the scholarship requirements of the host university.

Research location:
The student(s) will be hosted by New Zealand universities located in Christchurch, where they will work for the majority of their time. Most international PhD students are eligible for a NZ student visa.

To Apply:
Please send a copy of your full CV including references to publications/conference proceedings; copies of undergraduate/postgraduate academic transcripts; letters of reference from two referees, and any other supporting information relevant to the project to:

Contacts:
phil.butler@canterbury.ac.nz  
anthony.butler@otago.ac.nz

For more information please visit: http://www.bioengineering.otago.ac.nz/mars
Clinical Applications

**Assessment of bone mineral density by MARS**
Research will focus on developing a quantitative assessment of bone quality and scoring techniques using MARS Spectral CT. The distribution of new bone will be measured and distinguished from 'old' bone using spectral CT. Bony architecture will be measured using the 3-dimensional CT information of bone structure combined with bone mineral density to derive a quality metric. This will be compared with the industry standard bone measurement system DEXA (Dual Energy X-ray Absorptiometry). Existing bone scoring products measure bone mineral density not bone quality.

**Spectral imaging of metallic implants and new bone ingrowth within scaffolds**
There is a requirement to assess bone growth/loss around metal implants in response to treatment of infection and to design better implants. This PhD project will investigate imaging and quantification of new bony ingrowth into porous titanium implants. This will be accomplished by using artifact free X-ray CT imaging methods to provide 3D information of bone growth around the titanium implants. Porous titanium scaffolds in sheep models will also be used to develop novel imaging strategies for measuring new bone.

**Measuring activity of cancer, infection and inflammatory diseases using targeted nanoparticles and MARS imaging**
Nanoparticles can be targeted to specific cell types. If labelled with high-Z metals, MARS spectral imaging could distinguish and measure cellular markers and/or drug penetration and/or immune response to cancer, infection, or inflammatory diseases. There are many common features to the imaging approach and nanoparticle selection for diseases as diverse as solid cancers, atherosclerosis, and fungal infection. We have collaborating clinical researchers in each of these areas, so there is flexibility in choice of a specific project under the broad umbrella of this topic.

Technical Development

**Realistic volume rendering algorithms for "real-time" visualisation of large multivariate datasets**
We currently have a visualisation application that provides high quality images for analysing MARS Molecular Imaging datasets. However, the rendering algorithm is too slow for all of our intended features (high quality stereo 3D volume rendering at +120fps). In addition, our datasets are expected to significantly increase in size in the near future. We would like a new set of rendering algorithms, or better implementation of the current algorithms that can support large datasets and reliably draw at the required frame rate (+120fps).

**Image Processing Techniques for MARS Spectral Computed Tomography**
The MARS team is looking for new PhD students who have an interest in developing new methodologies for analysing energy resolved x-ray data produced by MARS Spectral CT. Our current lines of inquiry are directed towards (but not limited to) reconstruction techniques that use energy resolved 2D x-ray projections to produce 3D density volumes describing the material composition of the given scanned object. Possible starting points for this work may include looking at iterative reconstruction, statistical reconstruction, and/or projection decomposition in the spectral imaging problem.

**MARS molecular imaging and the future clinical workflow**
Our developments in the MARS project have led to a new type of data containing a set of volumes representing materials in an object e.g. fat, water, calcium, etc. Our current visualisation solution is based on tools commonly used in basic clinical diagnosis. We are interested in a formal investigation of how such data would fit in the future of clinical diagnosis. How could the data be used with current diagnostic tools? What new diagnostic tools can our data offer?