MEDICAL PHYSICS RESEARCH GROUP

FACULTY OF SCIENCE AND INFORMATION TECHNOLOGY

THE UNIVERSITY OF NEWCASTLE AUSTRALIA

OVERVIEW

The Medical Physics Research Program is concerned with the application of mathematics and physics to the advancement of human health. We are part of the Information Based Medicine Priority Research Centre and are a collaboration between the Calvary Mater Newcastle (CMN) and The University of Newcastle.

Our major research areas are the application of MRI to radiation therapy for planning and adaptive treatment, and improved patient dose verification using imaging devices.

OBJECTIVES

Our objectives are to improve patient outcomes by developing improved diagnosis and therapy. Our major focus is on improved cancer treatment using advanced imaging, treatment and computational technology. We aim to translate our research findings into clinical practice at the CMN and further afield for patient benefit.

EXAMPLES OF CURRENT PROJECTS

MRI-based prostate radiation therapy treatment planning
Current planning for radiation therapy is CT based due to the ability to calculate doses with CT electron density data. However, the low image contrast makes identification of targets and normal tissue difficult. In collaboration with computer scientists at CSIRO we have developed methods to use high-contrast MRI scans for therapy planning. We developed atlas-based deformable image registration methods to detect organ boundaries on MRI scans and map electron densities to MRI scans for dose calculations. These methods will be developed further to investigate patient positioning and adaptive planning using MRI-linear accelerator combined systems currently in development.

Dosimetric verification of patient dose delivery for radiation therapy with imaging devices
Most therapy treatments are currently delivered without any verification of the dose at the time of treatment. The beams consist of multiple beamlets of different intensity produced by moving 120 individually computer controlled tungsten collimation leaves during the beam delivery while the linear accelerator rotates about the patient.

The complex delivery and high doses used to sterilize tumours are potentially very dangerous. Therapy linear accelerators are equipped with high resolution digital imaging devices (EPIDs) that can record an image of the beam delivered to the patient. We are working on methods to verify patient dose delivery in real-time using these devices.

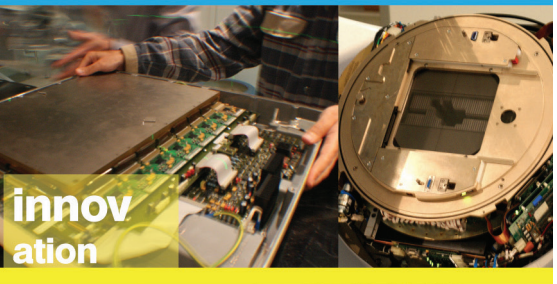
RESEARCH SUPPORT

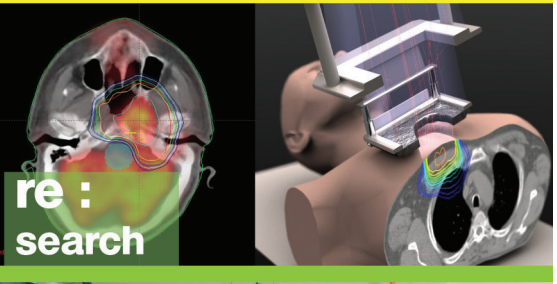
We have access to the following facilities and equipment through the CMN and University:

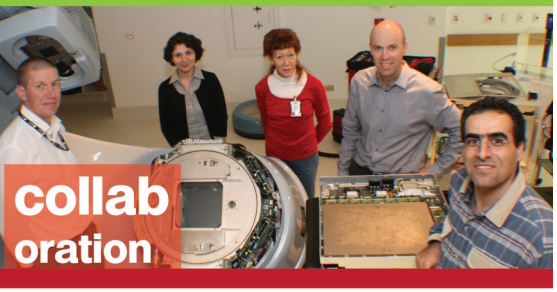
- 3T MRI scanner
- CT scanners including 4D CT
- Medical linear accelerators including cone-beam CT imaging, EPID, IMRT, RapidArc
- Thermoluminscent and film dosimetry, anthropomorphic phantoms.

Dedicated research equipment includes:

- Eclipse treatment planning workstation
- EPID (imaging device)
- Matrixx Ion-chamber array
- Web-based Matlab repository
- Monte-Carlo cluster
- GPU workstations and cluster







Calvary Mater Newcastle

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RESEARCH TOPICS

- Dose-planning on MRI scans using atlas-based electron density mapping
- Automatic prostate and organ segmentation on MRI
- Investigation of patient setup and plan adaptation using MRI scanning
- Dose verification for MRI-linear accelerators
- Novel imaging devices for dual imaging and dosimetry in radiation therapy
- 3D dose reconstruction from treatment images for patient dose verification
- Real-time patient dose verification with therapy imaging devices
- Hypofractionated prostate therapy with rectal balloons
- Improving margin calculations for prostate therapy
- Real-time tumour tracking and gating for prostate treatments

RESEARCH OUTCOMES

- The first clinical implementation of fiducial marker image-guided radiation therapy treatment in Australia.
- Development of the first atlas-based deformable image registration method to map electron densities to MRI scans to enable MRI based dose calculations.
- The first work to comprehensively examine a new method of ensuring that patient treatment is accurate in radiation therapy using time-resolved dosimetry.
- Development of a new design for imaging systems in radiation oncology that promises to both acquire high quality anatomical images and accurately measure dose.
- Collaboration with the largest linear accelerator vendor using their prototype imaging system to implement imaging-based dose verification.

GROUP MEMBERS

A/Prof Peter Greer
Prof Fred Menk
Prof John O'Connor
Dr Brian King
Dr Maura Monville
Dr Patricia Ostwald
Dr Jason Dowling
Dr Kym Nitschke

EXTERNAL COLLABORATORS

We have strong collaborative links with many centres:

- CSIRO, Australian eHealth Research Centre, Brisbane
- Varian Medical Systems Imaging Lab, Switzerland
- Institute of Medical Physics, University of Sydney
- Virginia Commonwealth University, USA
- CancerCare Manitoba and University of Manitoba, Canada
- BC Cancer Agency, Canada
- Peter MacCallum Cancer Centre, Melbourne
- Prostate Cancer Trials Group, Newcastle
- Radiation Physics Laboratory, University of Sydney
- Trans-Tasman Radiation Oncology Group, Newcastle

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