FWO Scientific Network (WOG)
Turning images into value through statistical parameter estimation

Meeting on Advanced Reconstruction Methods in Tomography

Wednesday, September 19, Medical Campus of the Vrije Universiteit Brussel.

PROGRAM

13:00 Welcome

13:15 - 14:15
Paul Kinahan, PhD
Department of Radiology, University of Washington, Seattle, WA USA
"Quantitative PET/CT imaging in multi-center clinical trials:
When it matters, what the challenges are, and what we can do"

14:15 - 15:15
Rolf Clackdoyle, PhD
Laboratoire TIMC-IMAG (Techniques de l'Ingénierie Médicale et de la Complexité - Informatique, Mathématiques et Applications), Université Grenoble Alpes, France
"D-symmetric density functions in tomographic image reconstruction"

15:15 - 16:15 Break

16:15 - 17:15
Frédéric Noo, PhD
Department of Radiology and Imaging Sciences, University of Utah, Salt Lake City, USA
"On the challenging problem of image quality assessment in medical imaging"

17:30 Reception

ABSTRACTS

P. Kinahan

Quantitative PET/CT imaging in multi-center clinical trials:
When it matters, what the challenges are, and what we can do

The ability to assay tumor biologic features and the impact of therapy on cancer biology is fundamental to therapy development. Advances in our ability to measure genomics, gene expression, protein expression, and cellular biology have led to a host of new targets for anticancer therapies. Clinical trials that test the safety and therapeutic benefit of promising treatments are essential in translating new knowledge into tangible benefits for patients with cancer. Advances in quantitative molecular imaging, particularly positron emission tomography (PET) imaging, have enabled quantitative imaging biomarkers. To use this potentially powerful method, we need to both characterize and improve accuracy using methods appropriate for multi-center clinical trials.

R. Clackdoyle

D-symmetric density functions in tomographic image reconstruction

A three-dimensional density function (or "object function") generates 2D parallel projection images when irradiated by an x-ray source far from the object ("at infinity"). These projections are parametrized by the relative orientation of the x-ray source with respect to the object. Each orientation, i.e. each point on the unit sphere, gives rise to a different projection.

On the other hand, if the x-ray sources lie relatively close to the object, the resulting projections are called cone-beam (CB) projections rather than parallel projections. The CB projections are parametrized by the location of the x-ray source in space; each source location gives a different CB projection.

Twenty-five years ago, Edholm and co-workers demonstrated that for x-ray sources lying on a plane, the CB projections of a given object will all perfectly match the parallel projections of another suitably-defined object. The correspondence of the projections is determined by mapping each source location on the source plane to a specific orientation of the parallel projections.

This result appears to be nothing more than an amusing geometrical fact about parallel and CB projections. At the time, Edholm wrote, "it is unlikely that it will provide us with fundamentally new insights." However, image reconstruction theory from parallel projections is much simpler than from CB projections, and recently there has been substantial progress on data consistency conditions for CB (and fan-beam) projections heavily based upon this link between CB and parallel projections.

Here, we discuss the operation of D-symmetrization, which produces special "D-symmetric" density functions. These D-symmetric objects have the magical property that their parallel projections are the same as their CB projections. The parallel and CB projections match perfectly when viewed on a (possibly virtual) detector that is a distance D from the plane of the x-ray sources.

Frederic Noo

On the challenging problem of image quality assessment in medical imaging

Tremendous scientific effort is currently spent on developing new methods for image reconstruction. These methods typically rely on optimization algorithms either applied directly to the measured data, or used indirectly through the development of a deep learning-based tool. Clinical acceptance of these methods is however not straightforward. As they are highly non-linear, conventional image quality assessment techniques based on resolution and noise power spectrum are not applicable anymore, and newly introduced metrics such as SSIM and UQI have major shortcomings. A robust way to properly evaluate image quality is task-based assessment with the Receiver Operating Characteristic (ROC) curve. We will discuss the use of ROC analysis to evaluate image quality assessment, using examples related to early evaluation of CT reconstruction algorithms for illustration. The presentation will start with a review of the ROC concept and of an important extension that accounts for unknown lesion location, called Localization ROC analysis. Further extensions that involve Free Response will also be briefly discussed, with emphasis on understanding which method is most relevant given the targeted clinical problem. Due to the limited availability of cases and of expert human observers, accurate statistical estimation and reporting of figures of merit associated with ROC analysis is critical in a medical imaging context. We will discuss parametric and non-parametric estimation together with the multi-reader multi-case (MRMC) paradigm. To reduce costs of ROC analysis, human readers may be replaced with model (computerized) observers: we will last discuss their pertinence and limitations along with statistical approaches to rigorously report their performance.