Detection and Quantification of Evolving Processes in Medical Images

Description

Longitudinal series of medical images exhibits evolving processes, due to pathologies (Alzeihmer, dementias) or to aging. Detecting and quantifying these evolutions allows to investigate new problematics: early diagnosis, efficiency of a treatment, etc. This tutorial will present a panel of typical methods.

Detailed Schedule

- 1:30pm: **Pannel Introduction + Some Registration and Shape Analysis Tools for Detecting and Measuring Changes in Longitudinal Studies**, Nicholas Ayache
- 2:00pm: **Change Detection and Quantification in Multiple Sclerosis, Alzheimer Disease, and between pre- and post-surgery images**, Louis Collins (McConnell Brain Imaging Center)
- 2:30pm: **Detecting early change and measuring progression in the dementias using serial MRI's**, Nick Fox (Institute of Neurology, London)
- 3:00pm: BREAK (30')
- 3:30pm: **Measuring longitudinal brain changes in humans and small animal models**, Christos Davatzikos (UPenn)
- 4:00pm: **Cerebral damage in epilepsy: longitudinal quantitative MRI**, Louis Lemieux (Dept of Clinical Neurophysiology, Institute of Neurology, UCL)
- 4:30pm: **Mapping Brain Changes in Aging and Alzheimer's Disease**, Paul Thompson (UCLA)
- 5:00pm: end of Pannel

Responsible organiser

Pr. Nicholas AYACHE, `nicholas.ayache@sophia.inria.fr`

Detailed schedule

- **General Introduction**, Nicholas Ayache (INRIA)

  Nicholas Ayache is the scientific leader of the Epidaure Laboratory at INRIA Sophia- Antipolis, a research group on Bio-Medical Image Analysis and Simulation. His main research interests include the application of mathematics and computer science to extract quantitative information from medical and biological images useful for diagnosis, therapy planning, guidance and follow-up. N. Ayache is the author and coauthor of numerous scientific publications in these domains, and editor or associate editor of several scientific journals including Medical Image Analysis (Elsevier) and Trans. on Medical Imaging (IEEE).

  http://www-sop.inria.fr/epidaure/personnel/ayache/ayache.html

- **Change Detection and Quantification in Multiple Sclerosis, Alzheimer Disease, and between pre- and postsurgery images**, D. Louis Collins (McConnell Brain Imaging Center)

  D. Louis Collins is an Assistant Professor in the departments of Neurology & Neurosurgery, and Biomedical Engineering at McGill University of Montreal, Canada. He works at the McConnell Brain Imaging Centre of the Montreal Neurological Institute. His research involves automated anatomical segmentation and atlasing in a neurosurgical context. Computerized image processing techniques, such as non-linear image registration and model-based segmentation, are used to automatically identify structures within the human brain. These techniques are applied to a large database of magnetic resonance (MR) data from normal subjects to quantify anatomical variability. In image guided neurosurgery (IGNS), similar techniques provide the surgeon with computerized tools to assist in interpreting anatomical, functional and vascular image data to effectively plan and carry out minimally-invasive neurosurgical procedures.
  http://www.bic.mni.mcgill.ca/users/louis/

- **Measuring longitudinal brain changes in humans and small animal models**, Christos Davatzikos (UPenn)

  A framework for morphological analysis of serial MRI scans of the brain is presented, based in part on high-dimensional shape transformations. In order to obtain smooth estimates of longitudinal changes, 4-dimensional transformations are estimated jointly from all scans in a series, rather than obtaining individual measurements from each time-point. Two applications are examined: a study of aging and early prediction of dementia in a group of older adults, and the study of post-natal development of the mouse brain using diffusion tensor images.

  Christos Davatzikos is Chief of the Section of Biomedical Image Analysis, and Associate Professor, Department of Radiology at University of Pennsylvania. He has a Joint Appointment with the Department of Bioengineering Graduate Group University of Pennsylvania.
  http://oasis.rad.upenn.edu/~christos/

- **Detecting early change and measuring progression in the dementias using serial MRI's**, Nick Fox (Institute of Neurology, London)

  The emergence of new therapies for degenerative dementias has significantly increased the importance of early diagnosis. Early and specific diagnosis is important to be able to direct therapies appropriately and at the earliest possible stage. Accurate measurement of progression is of interest as a means of determining which treatments actually slow these devastating diseases as opposed to providing transient symptomatic relief. Serial MRI may be used to quantify brain volume changes. Work using linear and non-linear image registration of serial MRI will be presented, showing how these methods may have applications in these important areas. In addition, a discussion of problems in applying and interpreting these analyses will be discussed.

  Nick Fox is a Honorary Consultant Neurologist and Senior Lecturer in Neurology, MRC Senior Clinical Fellow at the Institute of Neurology, London. His research interest over the last ten years has been the development of MRI analysis methods to improve diagnosis and measurement of disease progression in Alzheimer's disease and related disorders. He has shown that AD has a pre-symptomatic period where hippocampal and global cerebral atrophy are already established and accelerating, and that subtle cognitive deficits pre-date overt symptoms (Fox et al 1996; Fox et al 1998; Scahill et al 2002). He has developed techniques of image analysis that offer precise registration-based atrophy measurements from serial MRI (Fox et al 1996; Fox et al 1997). Using these techniques he has shown that rates of cerebral atrophy predict conversion to AD from mild cognitive impairment (MCI) (Fox et al, Lancet 1999; Scahill et al 2002) and that rates of atrophy correlate with clinical decline (Fox et al, Neurology 1999). It has been possible to calculate sample sizes needed to track progression of atrophy (Fox et al 2000). These techniques are now widely used in longitudinal studies and clinical trials in AD and MCI.
  http://dementia.ion.ucl.ac.uk/DRG_Website/DRG%20Staff/members_of_the_dementia_research_group.htm

- **Cerebral damage in epilepsy: longitudinal quantitative MRI**, Louis Lemieux (Dept of Clinical Neurophysiology Institute of Neurology UCL)

  We present a set of methods for the quantitative analysis of change in longitudinally acquired structural MR data, based on automatic registration, segmentation, spatial normalisation, noise mapping, and ROI atlas and difference image analysis. The methodology allowed us to investigate the relationship between seizures and other factors, and brain morphology in 190 patients and 90 controls. We review the methods, findings, limitations and possible avenues for future research, including methodological refinements.

  Louis Lemieux is Reader in Physics, Department of Clinical and Experimental Epilepsy, Institute of Neurology, University College London. Born in Quebec. Educated in Physics in Montreal (BSc, PhD) and Toronto (MSc), Post-doc in image analysis and surgery planning applied to epilepsy at Institute of Neurology and Hammersmith Hospital (1990-1995); Lecturer then Reader (from 2000) in Physics at Department of Clinical and Experimental Epilepsy, Institute of Neurology (UCL).
  http://www.erg.ion.ucl.ac.uk/

- **Mapping Brain Changes in Aging and Alzheimer's Disease**, Paul Thompson (UCLA)

  We report a technique that computes dynamic maps (time-lapse movies) of brain changes in aging and Alzheimer's disease. 3D geometric models of the cortex and deep subcortical structures are extracted from MRI brain scans of large numbers of subjects scanned longitudinally ($N > 200$). Partial differential equations and surface-based statistics are developed to visualize disease progression, and compare it to the normal brain changes that occur over the human lifespan. Applications to clinical trials are discussed, as well as the key mathematical challenges in developing these algorithms.

  Paul Thompson is an Associate Professor of Neurology at the UCLA School of Medicine. His research focuses on the neuroscience, mathematics, software engineering and clinical aspects of neuroimaging and brain mapping. Dr. Thompson obtained his M.A. in Mathematics from Oxford University, England, and his Ph.D. in Neuroscience from UCLA. Dr. Thompson's recent work, reported in the journals Nature, Nature Neuroscience, and PNAS, has focused on mapping dynamic (4D) processes in brain development, dementia, and schizophrenia, and genetic effects on brain structure. He is Associate Editor of IEEE Transactions on Medical Imaging and Human Brain Mapping, and serves on the Editorial Board of the journal Medical Image Analysis.
  http://www.loni.ucla.edu/~thompson/thompson.html