EUROPEAN INSTITUTE FOR BIOMEDICAL IMAGING RESEARCH

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Abstracts of Lectures

Learning Imaging biomarkers
Mads Nielsen
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Analysis of medical images (x-ray, CT, MR, ..) is normally performed by radiologists, and at the best in a semi-quantitative way. Computer analysis facilitates the objective and quantitative analysis of images making large scale clinical investigations feasible. Combined with statistical analysis new insight on how the anatomical shape and appearance correlate with patient development and physiology may be obtained. In turn, this is used for early diagnosis, treatment planning and discovery medicine. We will give examples from development of new biomarkers in lungs imaging, arthritis, vascular calcification, and breast cancer. This will include an intuitive introduction to some of the mathematical and statistical tools.

Computer Aided Diagnosis in Oncology
Nico Karssemeijer
Radboud University Nijmegen Medical Centre, Department of Radiology

Early detection may prevent that cancer develops into a life threatening disease. Therefore, research aimed at development of effective screening methods is of high importance. Computer aided detection (CAD) and diagnosis are seen as a key technology for the future, in particular in applications like screening, where high volumes of cases have to be scrutinized for potential abnormalities. Due to the large fraction of normal's in screening populations, specificity needs to be extremely high. As a consequence, proven diagnostic tests may not be suitable for screening. The purpose of CAD is to increase quality of screening and diagnostic tests and to make image interpretation more efficient. By exploiting data in huge radiological archives computers can be trained to perform well defined interpretation tasks in medical imaging automatically, either as a first or second reader. This lecture will provide examples of successful CAD methods in breast, lung, and abdominal applications, and will discuss technical issues related to development and validation of CAD.

Introduction to cardiovascular pathophysiology and its modelling
Bart Bijnens
K.U. Leuven, Department of Cardiovascular Diseases

This lecture will give an introduction to cardiovascular (patho-) physiology for biomedical imaging and modelling researchers. Starting from describing the normal structures and functioning of the heart, the changes and remodelling induced by the most common cardiac disease will be discussed and illustrated with clinical images. Special focus will be placed on how the heart muscle generates force and deforms. The influence of abnormalities (perfusion defects, altered electrical activation, increased valve or peripheral vessel resistance) will be discussed. Additionally, an introduction in (arterial) vessel structure and remodelling will be provided. At each stage of the description of the cardiovascular diseases, emphasis will be placed on which aspects are crucial when modelling approaches are used to describe and quantify the abnormalities. By approaching imaging and image based research in cardiovascular diseases from a clinical point of view, the students will learn which aspects are important when discussing with clinicians.

References:
Bijnens B, Cikes M, Claus P and Sutherland GR. Velocity and deformation imaging for the assessment of myocardial dysfunction. Eur J Echocardiography,10(2):216-226, 2009
Bijnens B, Claus P, Weidemann F, Strotmann J and Sutherland GR. Investigating Cardiac Function Using Motion and Deformation Analysis in the Setting of Coronary Artery Disease. Circulation,116(21):2453-64, 2007

Challenges in diagnostic computational imaging in oncology and cardiology

Cristian Lorenz,
Philips Research

The power of medical imaging, providing non-destructive views into the human body, increased substantially during the last decade. This on the one hand opens up new diagnostic possibilities but on the other hand more and more overburdens the clinical personnel by the flood of images being generated. Consequently, computer aided image analysis is an important option for efficient reading of medical images. However, high demands have to be met, in terms of robustness, runtime performance, and workflow compatibility to become accepted by the clinical community. For the example of imaging in cardiology and oncology the lecture will illuminate current challenges and exemplify the way of advanced image processing techniques into products. Topics touched will include automated extraction of organ boundaries, estimation of organ motion and subsequent use for diagnosis and therapy planning.

References:

Thomas Köhler, Tobias Klinder, Udo van Steevendaal, Cristian Lorenz, Peter Forthman: “Correction of Breathing Induced Rib Cage Motion in Helical CT”, Fully 3D 2009, Fully Three-Dimensional Image Reconstruction in Radiology and Nuclear Medicine, Beijing, China, September 2009

Tobias Klinder, Cristian Lorenz, Jörn Ostermann: “Free-Breathing Intra- and Intersubject Respiratory Motion Capturing, Modeling, and Prediction”, SPIE 2009, SPIE Medical Imaging, Orlando, Florida, USA , February 2009

Olivier Ecabert, Jochen Peters, Hauke Schramm, Cristian Lorenz, Jens von Berg, M. J. Walker, M. Vembar, M. E. Olszewski, K. Subramanyan, G. Lavi, Jürgen Weese: “Automatic Model-Based Segmentation of the Heart in CT Images”. IEEE Trans. Med. Imaging 27(9): 1189-1201 (2008)

Cristian Lorenz and Jens von Berg: „A comprehensive shape model of the heart” Medical Image Analysis, Volume 10, Issue 4, August 2006, Pages 657-670

Vascular image analysis and modelling

Wiro J. Niessen,
Erasmus MC, Biomedical Imaging Group Rotterdam

Atherosclerosis, a localized disease of the vessel wall caused by systemic risk factors, is the main cause of morbidity and mortality in the western world. There is large evidence that the risk of clinical events such as stroke and heart attacks depend both on vessel lumen morphology, and atherosclerotic plaque composition. Currently, a number of imaging techniques, such as MRI, CT, and (intravascular) ultrasound are capable of visualizing the vessel lumen and wall. In this talk, we will describe advanced image analysis technologies to automatically, accurately and reproducibly extract quantitative descriptors (quantitative imaging biomarkers) of the vessel lumen and wall from these imaging modalities. We will concentrate on quantitative analysis of the coronary arteries, carotid arteries and cerebral vasculature. Also, we will focus on the implementation and validation steps required to introduce these quantitative

References:

Vukadinovic, D; van Walsum, T; Manniesing, R; Rozie, S; Hameeteman, R; de Weert, T. T.; van der Lugt, A; Niessen, W. J.
“Segmentation of the Outer Vessel Wall of the Common Carotid Artery in CTA”
IEEE Trans Med Im 2009, in press, available online IEEE Xplore.

Schaap M, Metz CT, van Walsum T, van der Giessen AG, Weustink AC, Mollet NR, Bauer C, Bogunović H, Castro C, Deng X, Dikici E, O'Donnell T, Frenay M, Friman O, Hernández Hoyos M, Kitslaar PH, Krissian K, Kühnel C, Luengo-Oroz MA, Orkisz M, Smedby O, Styner M, Szymczak A, Tek H, Wang C, Warfield SK, Zambal S, Zhang Y, Krestin GP, Niessen WJ.
“Standardized evaluation methodology and reference database for evaluating coronary artery centerline extraction algorithms.” Med Image Anal. 2009 Oct;13(5):701-14.

Cardiac image analysis and modelling
Alex F. Frangi
Universitat Pompeu Fabra, Center for Computational Imaging & Simulation

This lecture will overview several state-of-the-art methods for cardiac image analysis as well as computational cardiac atlases. The lecture will start by quickly summarizing the key indexes used to evaluate cardiac function followed by a classification of the computational methods presented in the literature. Some of the key methodologies will be presented to illustrate prototypical methods for 3D and 3D+t cardiac segmentation, and morphological, wall motion and deformation analyses. The lecture will also present some of the techniques used to construct cardiac atlas as well as some of the applications of atlas-based cardiac image analysis. Some recent developments in the field of cardiac physiological modeling will be overviewed showing the use of cardiac models for personalization of physiological models and, conversely, some of the techniques for physics- or physiology-based regularization of image analysis tasks.

References
A.F. Frangi, W.J. Niessen, M.A. Viergever (2001). Three-Dimensional Modeling for Functional Analysis of Cardiac Images: A Review. IEEE Trans on Medical Imaging. 20(1):2-25.
A.A. Young, A.F. Frangi (2009) Computational Cardiac Atlases: From patient to population and back, Exp Physiol. 2009 May;94(5):578-9.

Cardiac image acquisition and registration for guidance and modelling of interventions
Kawal Rhode
King's College London, UK

Cardiovascular disease is the leading cause of morbidity and mortality in the Western World. Recent advances in medical imaging have allowed the acquisition of high fidelity patient-specific anatomical and functional information. All the leading imaging modalities, including X-ray fluoroscopy, CT, MRI, US, and RXA, are in widespread use for the diagnosis and treatment of cardiovascular disease. This lecture will show how the co-registration of these imaging modalities can be performed to provide integrated solutions for diagnosis, treatment planning and treatment guidance. These types of solutions are becoming more useful especially since the majority of procedures are now performed using a minimally-invasive approach, relying heavily on imaging for guidance. Furthermore, the lecture will show how physiological measurements, such are intra-cardiac electrical data, can be combined with anatomical information from imaging. A particularly exciting use of this integrated data is for the validation and application of cardiac biophysical models that describe the functioning of the heart using mathematical equations. For the first time, these models are well developed enough to provide meaningful application in the clinical environment for influencing patient treatments.