Medical Imaging Summer School 2014

28 July - 1Aug 2014 Favignana, Sicily

Medical Imaging meets Computer Vision

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Lectures (in joint with Nassir Navab): Advanced Imaging and Visualization for Computer Assisted Interventions: motivation, state-of-art and future challenges

Part I – Elastography imaging
Speaker: Tim Salcudean

Elastography imaging is concerned with the measurement and display of tissue strain or with the identification of tissue intrinsic properties from the measured strain in response to a mechanical excitation. It can be thought of as a form of objective, remote palpation. Elastography as an imaging modality presents us with a rich and beautiful set of inter-disciplinary problems, and includes tissue actuator design, specific image sequence design, motion estimation from images, viscoelastic parameter estimation from motion, and computational acceleration of these to the level where real-time performance is achieved.
We will start with a tutorial introduction to elastography, including basic imaging principles and an overview of the field. We will also present our own contribution to this type of imaging, including high frequency motion estimation and solutions of the inverse problems in elastography. Both ultrasound and magnetic resonance elastography will be discussed. We will describe applications to prostate and breast cancer imaging, to image registration, and to procedure simulation exemplified in a prostate brachytherapy simulator and treatment planner.

Part II – Navigated Nuclear Probes
Speaker: Nassir Navab

Freehand SPECT from research to clinical applications: In this talk, I will trace the Freehand SPECT from the early development of research ideas within our multi-disciplinary research laboratory to its deployment in many hospitals around Europe and its introduction to United States. I first focus on the theoretical concepts of navigated nuclear probe imaging within operating room. The multi-disciplinary nature of this research guides us through different aspects of medical physics, computer assisted surgery and advanced imaging and visualization. The ‘real world laboratory’ at our university hospital demonstrates its efficiency through the path it smoothly paves into the surgical theatre. I will then discuss the introduction of robotic imaging for navigated nuclear imaging. This allows us to provide patient and process specific flexible imaging with much higher reproducibility. I will then talk about the fusion of such imaging with optical and ultrasound imaging providing surgeons with anatomical as well as functional imaging.

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Part III – Ultrasound-guided Interventions
Speaker: Tim Salcudean

We will provide an introduction to image-guided interventions, focusing on ultrasound. Ultrasound imaging enables real-time anatomical modeling that includes organ and vasculature segmentation and tissue elasticity imaging. Starting with some clinical examples, we present our work towards the integration of ultrasound as a generic medical robotics tool. This includes the design of new ultrasound imaging systems, their calibration to the medical robot and the camera, and their control from the surgical console. When used with medical robots, such imaging can provide a substitute for haptic feedback during surgery, and may enable accurate registration of intra-operative imaging to pre-operative imaging such as multi-parametric MRI.
We will present our experience with the use of intra-operative, registered, operator-controlled ultrasound in radical prostatectomy procedures carried out with the da Vinci robot.

Part IV – Medical Augmented Reality
Speaker: Nassir Navab

This tutorial focuses on the problem of design and development of advanced imaging and visualization solutions for computer assisted interventions. The first three sections present methods for multi-modal image acquisition, analysis and modeling of heterogeneous data and their intelligent real-time fusion. Here we present advanced methods for visualization of such data during focused, high-intensity surgical procedures. In particular, we review the state of art in Medical Augmented Reality, and discuss challenges faced by scientific community in the upcoming years. Throughout this presentation, we present recent results obtained in our real-world laboratories within several clinics in Munich to demonstrate the issues and to provide exemplary paths towards possible solutions. Such examples include visualization of Intra-operative Free-Hand SPECT reconstruction, Camera-Augmented Mobile C-arm (CAMC) for trauma and orthopedic surgeries, and Magic Mirror and HMD based AR for serious gaming, teaching and medical training.