Computer-assisted Surgery for the Operating Room of the Future

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NCT Dresden

- Research area: Computer- und robot-assisted Surgery
- Infrastructure: Experimental Operating Room
Translational Surgical Oncology

• Interdisciplinary Group

• Expertise
  • Machine Learning/Computer Vision for surgery
  • Surgical Data Science: Multimodal sensor analysis
  • Context-sensitive assistance
Surgery 4.0: SensorOR

Computer-assisted Surgery

Diagnosis

Planing

Intervention
Virtual 3D-Model

CT Images → Segmentation → 3D-Model
Example 1: Pre-operative VR-Assistance

M. Pfeiffer, ... S. Speidel UCARS 2018 (IPCAI): „IMHOTEP - “

http://imhotep-medical.org/
Computer-assisted Surgery

- Diagnosis
- Planing
- Intervention
Challenges in the OR

Challenges in the OR

Navigation: Virtual Model -> Patient

Intra-operative

Pre-operative
Pre-operative: Biomechanical Model

- Mechanical as well material-specific properties that model the behavior of soft-tissue

Deformation through breathing

S. Suwelack ... S. Speidel MICCAI: Computational Biomechanics for Medicine. 2012 „Quadratic corotated finite elements ..“
S. Suwelack ... S. Speidel Symposium on Computer Animation, 2013 „Accurate surface embedding for higher order finite elements“
S. Suwelack ... S. Speidel SPIE Medical Imaging, 2011 „A biomechanical liver model for intraoperative soft tissue registration“
Intra-operative Model

S. Röhl ... S. Speidel MedPhys 2012 „Dense GPU-enhanced surface reconstruction ... for intraoperative registration“
S. Speidel et al. SPIE Medical Imaging 2015 “Image-based tracking of the suturing needle during laparoscopic interventions”
D. Reichard ... S. Speidel Journal of Medical Imaging 2015 “Intraoperative on-the-fly Organ-Mosaicking for Laparoscopic Surgery”
Navigation: Virtual Model -> Patient

S. Suwelack ... S. Speidel MedPhys2014: „Physics-based shape matching for intraoperative image guidance“
Example 2: Soft-tissue Navigation

D. Reichard, ... S. Speidel IJCARS 2017 (IPCAI): „Projective biomechanical depth matching for soft-tissue registration in laparoscopic surgery”
Example 3: Quantitative Laparoscopy
Surgical Phase Detection

Semantic Scene Graph

OR Workflow

Interpretation: Rule-based

Interpretation: Machine Learning

Interpretation: Combination

D. Katic ... S. Speidel IPCAI 2016 “Bridging the Gap between Formal and Experience-Based Knowledge for ...”
D. Katic ... S. Speidel IPCAI 2014: „Knowledge-Driven Formalization of Laparoscopic Surgeries for Rule-Based Intraoperative ...”
D. Katic ... S. Speidel SPIE Medical Imaging 2013: “Ontology-based prediction of surgical events in laparoscopic surgery”
Example 4: Workflow-analysis
Example 5: Context-aware Camera Guidance

Bihlmaier, Speidel et al. : Best Live Demo Prize, Surgical Robot Challenge 2015, Hamlyn Symposium
“A Learning Camera Robot for Laparoscopic Surgery”
"Hello, I am OR 2030. I see you are beginning the surgery, should I start the augmented reality app?"

S. Speidel, S. Bodenstedt et al. Coloproctology 2017 "Kognitive Chirurgie/Chirurgie 4.0"
OP 4.1 http://www.op41.de