Integrated OR-systems for laparoscopic interventions
Department of Surgery, Research Group MITI
MITI

Minimally-invasive Interdisciplinary Therapeutical Intervention

- Development of innovative diagnostic procedures and therapeutic solutions for minimally invasive surgery
- Focus on the suitability and applicability of developments in daily clinical practice
- Interdisciplinarity: collaboration between clinicians and research engineers

Prof. Dr. med. Dirk Wilhelm
General Director

Lars Wagner
Research Engineer

Leon Mayer
Master Student
What are integrated OR-systems?

Modern operating rooms (OR) are becoming increasingly complex as new equipment, processes, surgical technologies, communication methods and the need for real-time patient data enter the clinical environment.

Integrated OR-systems are systems that support and connect functions in and around the OR.
What are laparoscopic interventions?

- Surgery performed in the abdomen or pelvis using small incisions with the aid of a camera
- Laparoscope aids diagnosis or therapeutic interventions with a few small cuts in the abdomen

Advantages
- Reduced pain due to smaller incisions
- Reduced hemorrhaging
- Shorter recovery time
Roles and tasks within the OR wing

**Surgeon**
- Performs surgical techniques
- Leads surgical intervention

**Assistant**
- Performs surgical techniques
- Guides laparoscopic camera

**Scrub Nurse**
- Manages surgical instruments
- Prepares instrument table
- Hands over instruments to the surgeon

**Circulator**
- Adjusts medical devices and OR environment
- Fetches sterile materials
- Manages phones
- Helps with hygienic dressing
- Documents spent materials etc.
- ...
Challenges affecting the future of surgery

Demographic change
• we will have more and more morbid patients and fewer health care workers to take care of them

Staff Shortage
• limits the use of available operating capacities in hospitals
• increasing recourse to unqualified staff, whose inexperience has a significant influence on the workflow of a surgery
Roles and tasks within the OR wing

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+ Anesthesiologist, Technicians, Cleaners ...

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Leon Mayer | Lars Wagner | Research Group MITI | Klinikum rechts der Isar | Technical University of Munich
Robots as solution?

**Strengths**
- Improvisation
- Flexibility
- Communication
- Learning
- Dexterity

**Weaknesses**
- Stress resilience
- Fatigue
- Attention span

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**Strengths**
- Immune to stress
- Precision / Repeatability
- Monotonous tasks
- Unergonomic tasks

**Weaknesses**
- Improvisation
- Flexibility
- Human-robot communication
Surgeon’s behavior during interventions

Robot control methodology
Sense - Plan - Act
Surgeon’s behavior during interventions

Robot control methodology

Sense  -  Plan  -  Act
Surgeon’s behavior during interventions

Surgeon control methodology

Plan - Act - Sense

Future Developments

• Collaborative approach for the establishment of new technologies in healthcare
• Close collaboration of physicians and research engineers
• Problem oriented research and development
• Involvement of industrial partners
• Model based medicine
• Surgineering
Surgineering: a new type of collaboration among surgeons and engineers

H. Foussen1 · D. Wilhelm1 · N. Navab2 · A. Knoll3 · T. Lirk4

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Situation Aware Sterile Handling Arm for the OR (SASHA-OR)

• Development of an intelligent robot arm to hand over surgical instruments
• Focus on laparoscopic cholecystectomy and sigmoid resection
• Context sensitive actions to anticipate the needs of the surgeon: Instrument prediction, cleaning instruments and optics, equipping clip applicators
• Interaction with non-sterile robotic surgical assistance (AURORA)
Shortage of surgical assistants

- Surgeons are heavily dependent in their work on skilled assistants
- There is a massive labor shortage when it comes to surgical staff
- Surgical assistants need to cope with long working hours, night shifts and tough physical work
- Vacancies lead to overworked staff and a decrease in the quality of patient care
- Due to population ageing, problems are expected to increase in the future

PERCENTAGE OF HOSPITALS REPORTING CONSEQUENCES OF STAFF SHORTAGES

- No effects
- Closing operating rooms
- Reduced number of surgeries
- Accumulation of overtime
- N/A

Thomas Busse. “Mangelware OP-Pflegepersonal”. In: Die Schwester Der Pfleger OP-Personalreport Pflege 2010.02/11
Challenges
The need for a predictive system

- Anticipation of surgical actions is critical for building a reliable robot assistant
- Use laparoscopic video as input to system

- Problem: Image data is very complex
  ➡️ Deep Learning
Integrated OR-systems for laparoscopic interventions

Internal makeup of the model
Simulating the surgeon‘s point of view

Simulating the surgeon‘s point of view
Making the system interpretable

A small feature in the overall system…

Integrated OR-systems for laparoscopic interventions

Robotic path planning
Collision modeling
Intraoperative cleaning
Clip arming
Sterility
Ethics
...

End effector technology
Instrument detection
Instrument prediction
Hardware development
Questions?