

Bottlenecks in Keyhole Surgery

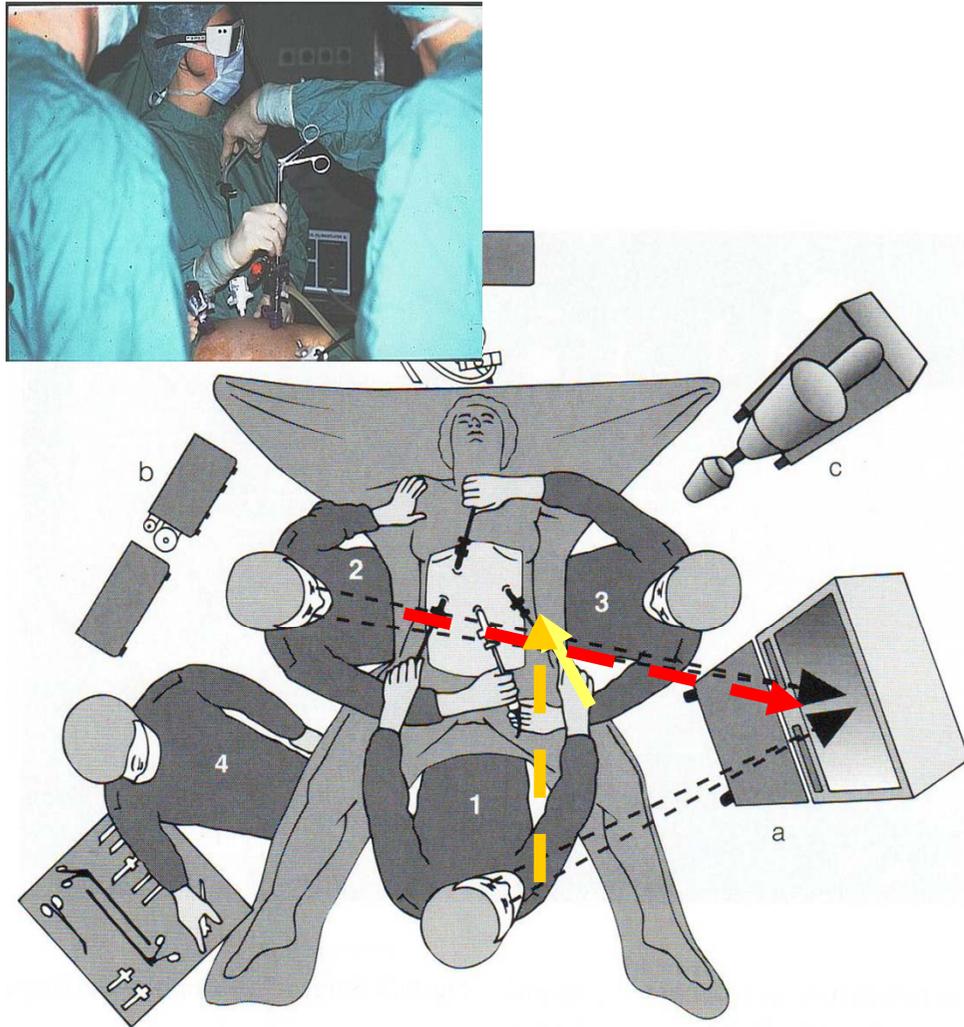
K. Radermacher, Helmholtz-Institute f. Biomedical Engineering, Aachen, Germany, 2005



Complex Manipulations with suboptimal instruments

<https://www.meditec.hia.rwth-aachen.de/en/research/former-projects/>

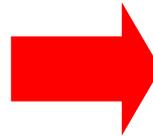
Minimal Invasive Endoscopic “Keyhole Surgery”



- *Long instruments*
- *Short cuts (5-10 mm)*
- *Indirect video view*
(partially incompatible EHK)
- *monoscopic > flat image*
- *stereoscopic > visualisation aids*
- *reduced haptic feedback*
- *no tactile feedback*
- *unsuitable working postures*

Example: Laparoskopische Cholezystektomie

Working Posture Analysis in Field Studies and Lab Test (HIA, 1994-1996)



Analysis

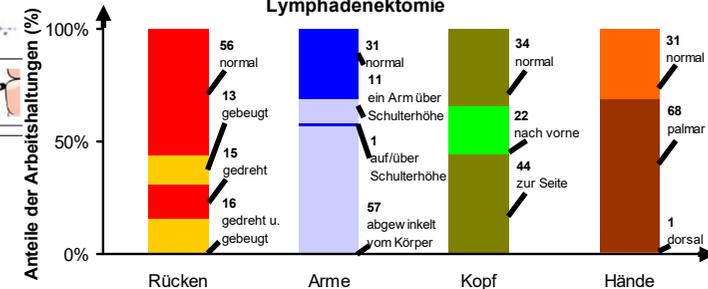
- => *Field Analysis*
- => *Video-Analysis*
- => *Multimoment-Studies*
- => *Body-Tracking*
- => *OWAS, RULA, NIOSH, Burandt-Schultetus...*

RAPID UPPER LIMB ASSESSMENT		
Client:	Date/Time:	Assessor:

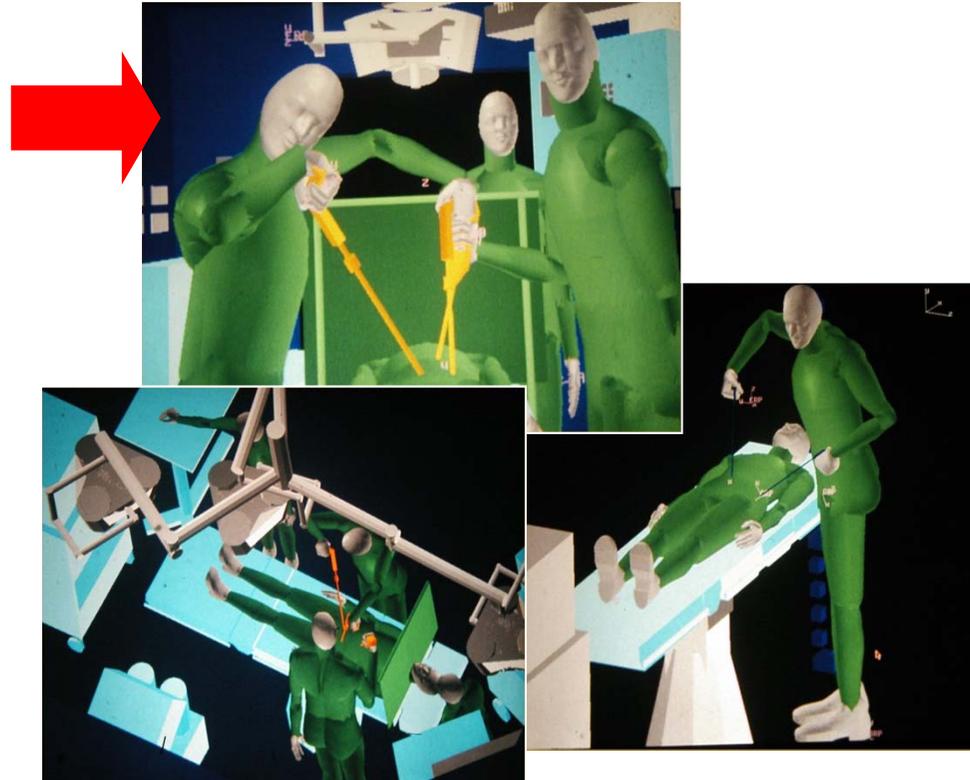
Right Side:

Right Upper Arm	<input type="checkbox"/> Shoulder is raised
Right Lower Arm	<input type="checkbox"/> Upper arm is abducted
Right Wrist	<input type="checkbox"/> Leaning or supporting the weight of the arm
Right Hand	<input type="checkbox"/> Working across
Muscle Use	

OWAS-Analyse / OPERATEUR bei laparoskopischer Lymphadenektomie



Simulation and Optimization (HIA, 1994-1996)

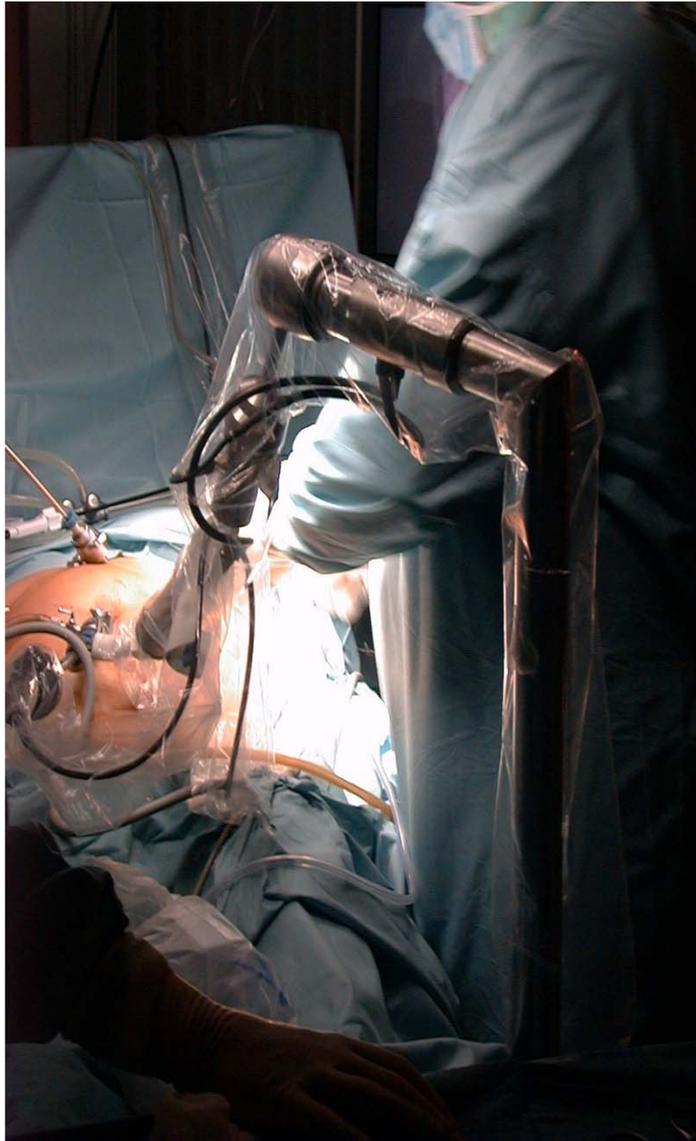


- *CAD-based Simulation*
(Autodesk Inventor, ProEngineer)
- *Man-Models*
 - RAMSIS
 - ANTHROPOS
 - AnyBody

Bottlenecks related to static working postures and holding work

- Camera needs an additional hand (person)
- Limits bimanual cooperative work (blocks one hand)
- May block primary hand
- 99% static holding work for the camera assistant > fatigue > „tremor“ & „shifting“ of the image
- Accidental touching of the tissue makes repeated cleaning of the optical system necessary (time loss)
- Additional camera assistant limits work space of the team
- OP team has to remain in unsuitable (stressing) working postures for long periods of operation

PiezoTEN –Endo-Camera Holding Arm



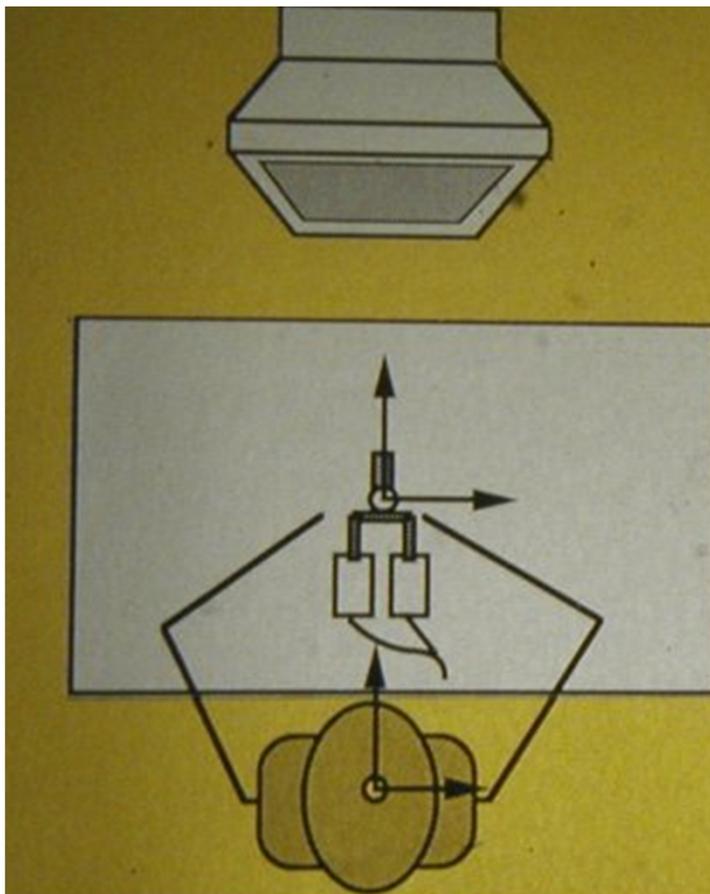
PiezoTEN –Endo-Camera Holding Arm

Publications

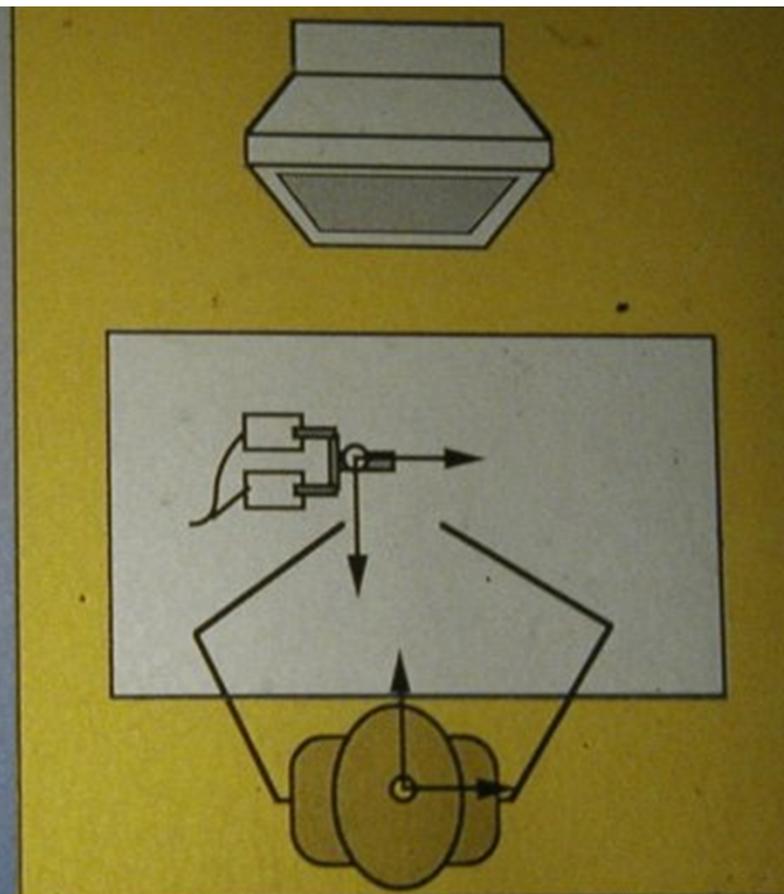
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- Rau, G., C. v. Pichler, K. Radermacher: Surgical Reality. Medical Technology International, Cornhill Publications Ltd. 1995, pp.46-51
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- Radermacher, K., Pichler, C. v., Erbse, St., Boeckmann, W., Rau, G., Jakse, G.: Using Human Factor Analysis and VR Simulation Techniques for the Optimization of the Surgical Worksystem. Weghorst, S.J. , Sieburg, H.B. , Morgan, K., (eds.): MMVR 4 - Health Care in the Information Age -Future Tools for Transforming Medicin , IOS Press, 1996, pp. 532-541
- Erbse, St., Radermacher, K., Anton, M., Rau, G., Boeckmann, W., Jakse, G., Staudte, H.-W.: Development of an automatic surgical holding system based on ergonomic analysis. in: Troccaz, J. Grimson, E., Mösges, R. (eds.): CVRMED II and MRCAS III, Lecture Notes in Computer Science, Springer-Verlag, 1997, pp. 737-746
- Radermacher, K., Erbse, St.,Winkler, M., Rau, G., Rath, W.: Einsatz eines neuen automatischen chirurgischen Kameraassistenzsystem in der gynäkologischen Laparoskopie. Zeitschrift für Biomedizinische Technik, Band 45, Ergänzungsband 1, 2000, S. 165-166
- Winkler, M., Erbse, St., Radermacher, K., Rau, G., Rath, W.: An automatic surgical camera-holding system: initial experiences in gynecological laparoscopy. Journal of the American Association of Gynecological Laparoscopists, May 2001, Vol.8, No.2, pp. 303-306

Problem: Decoupled Hand-Eye-Coordinates

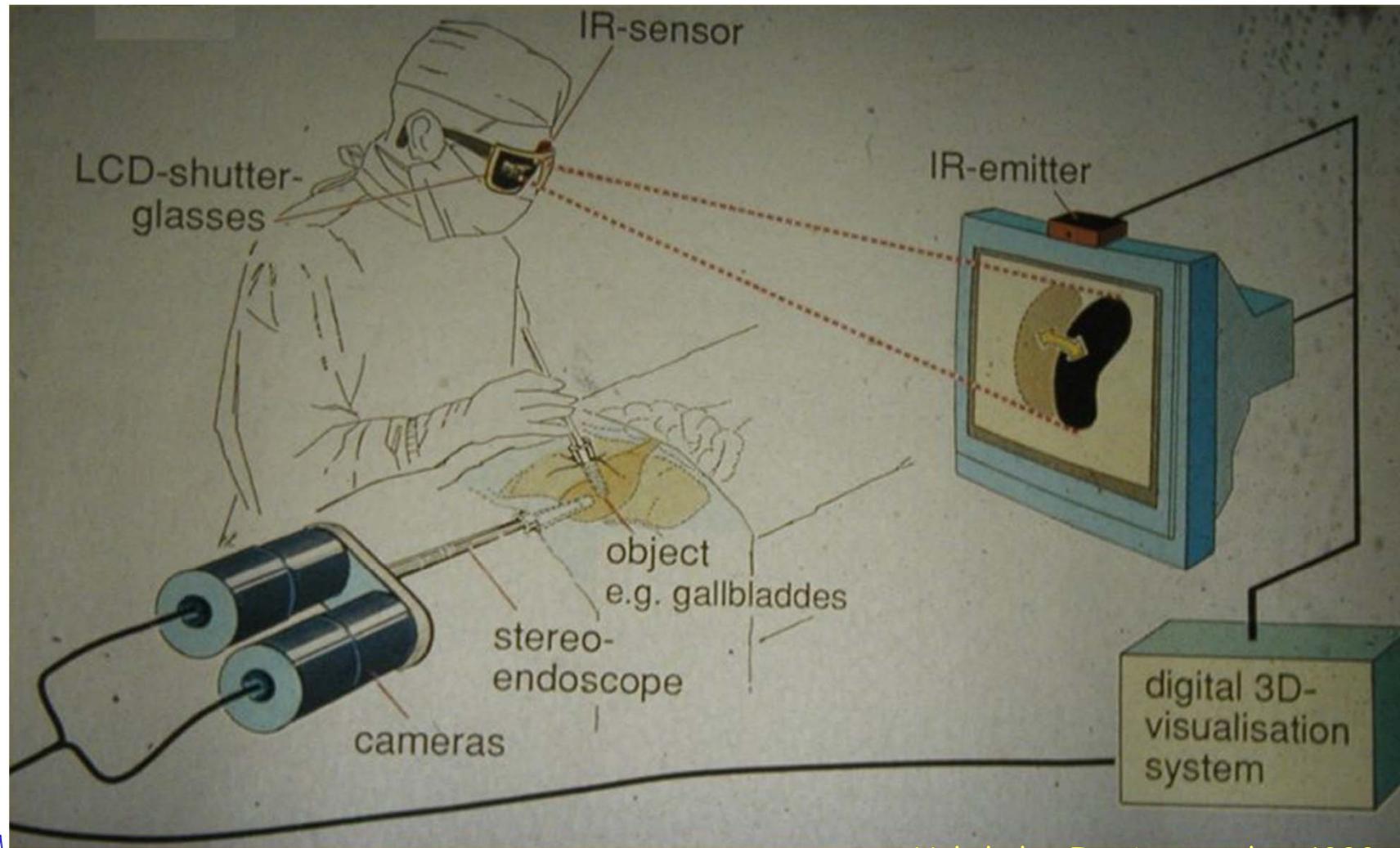
compatible arrangement



Incompatible arrangement

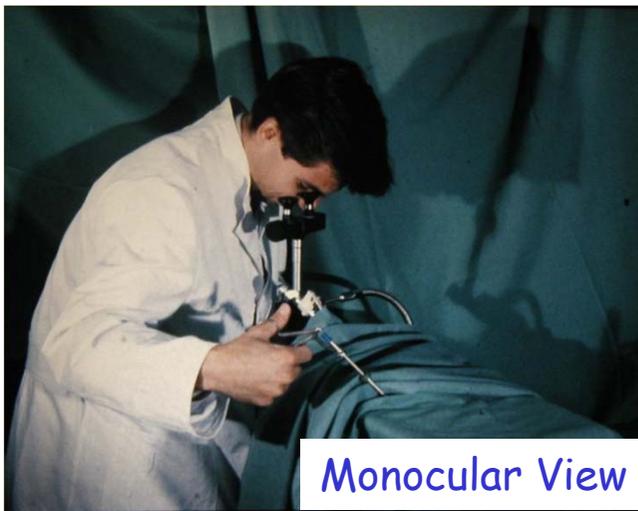
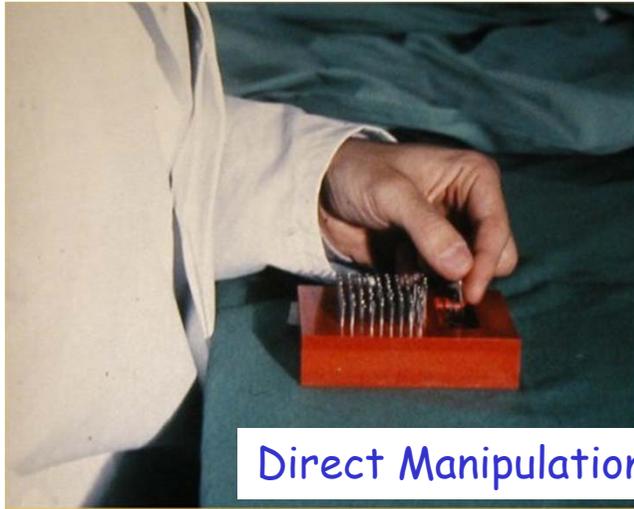


3D-Stereo-Endoscopy? (HIA 1992-2000)



Helmholtz-Institut Aachen 1992

Comparative Study (1) (HIA 1992-2000)



Comparative Study (2) (HIA 1992-2000)



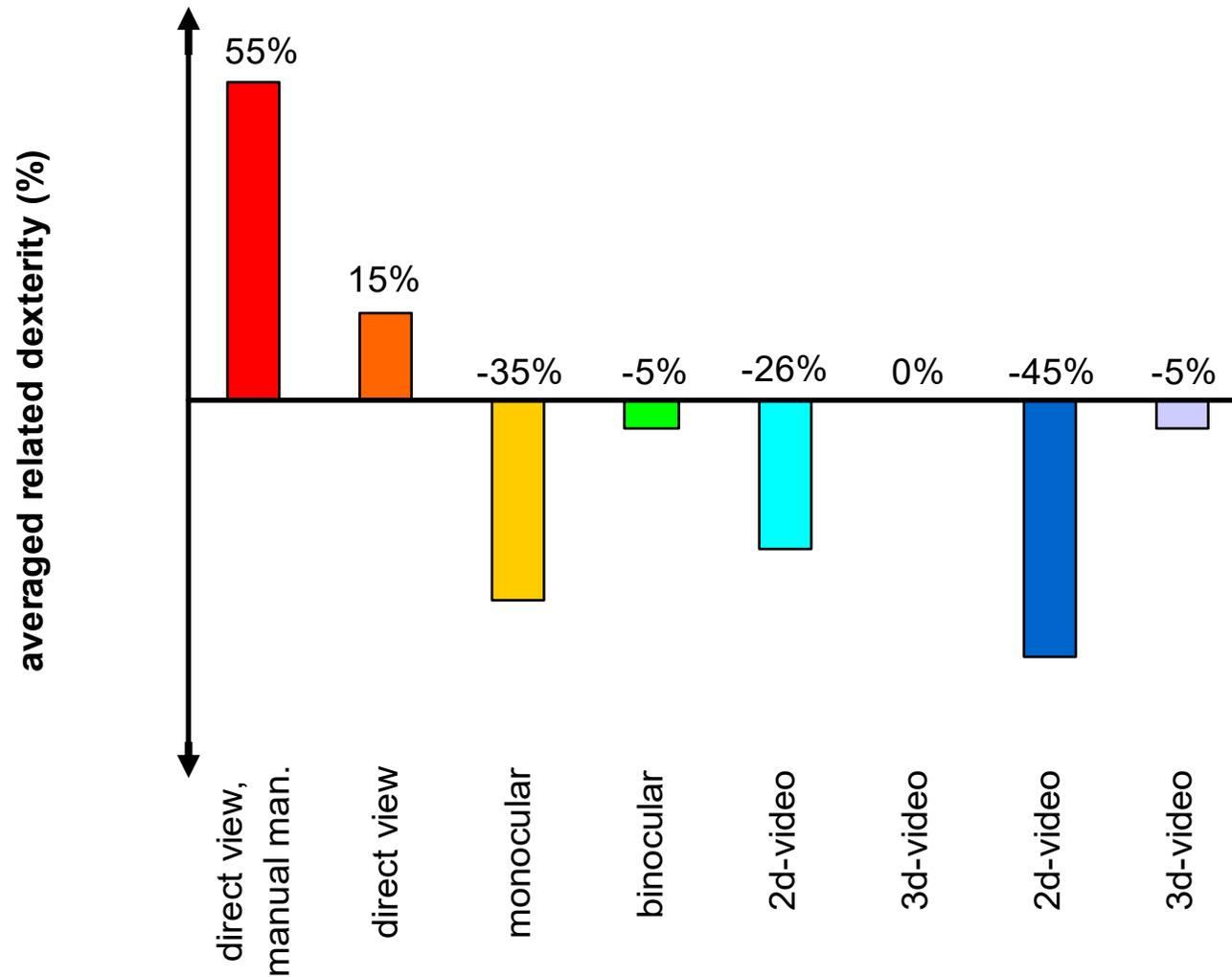
2D Video endoscopy



3D-Stereo Video endoscopy

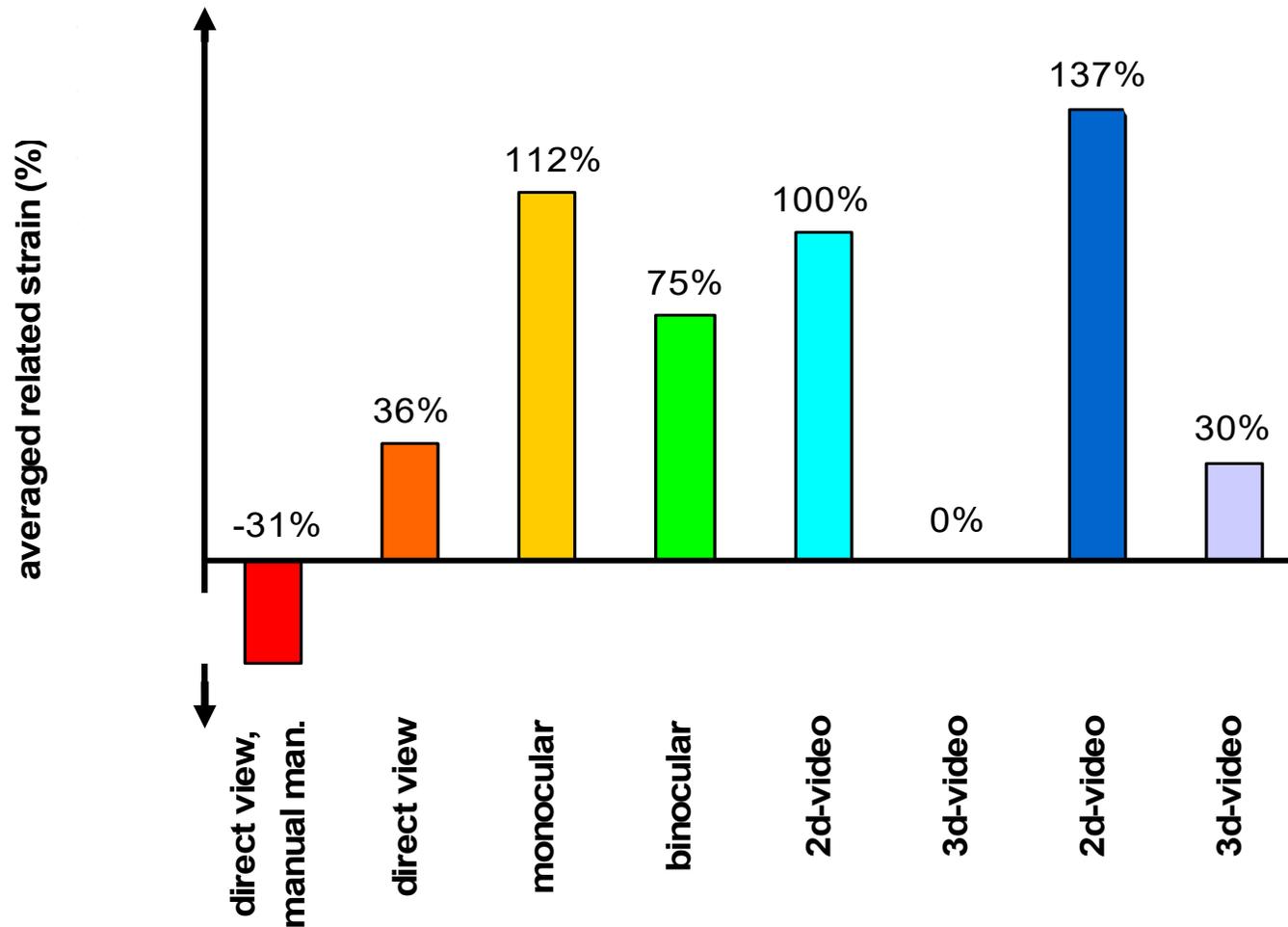
Comparative Study (HIA 1992-2000)

Dexterity measured by time per testcycle



Comparative Study (HIA 1992-2000)

Averaged Related Strain (Nitsch-Test)



Comparative Study (HIA 1992-1998)

Conclusion

- the variable positioning of the endoscopic camera may lead to incompatibilities in hand-eye-coordination (HEC)
- performance /dexterity as well as subjective strain levels are significantly affected by (a) the laparoscopic instrument, (b) monocular view and incompatibilities in HEC
- Binocular visualisation enables higher performance and lower strain levels compared to monoscopic view
- Stereo-Visualisation also compensates for incompatibilities in HEC

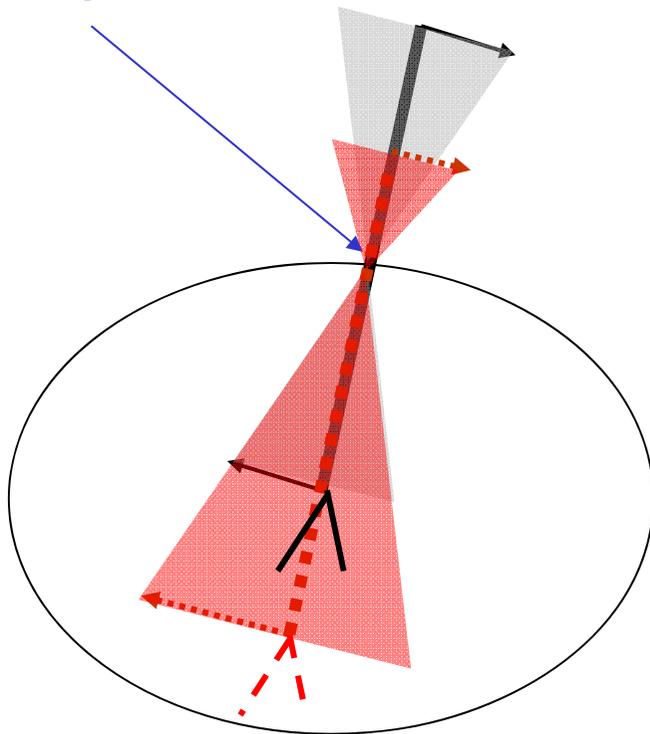
Comparative Study (HIA 1992-1997)

Publications

- Radermacher, K., Pichler, C. v., Rau, G.: Aspekte der Minimalen Invasiven Chirurgie - Analyse und Ansätze im Bereich der Ergonomie -. Zeitschrift für Biomedizinische Technik, Bd. 37, Ergänzungsband 2, 1992, S. 210-211
- Pichler, C. v., Radermacher, K., Rau, G.: Analysis for an Optimization of Stereoscopic Visualization Systems for Clinical Routine. Satava, R.M., Morgan, K., Sieburg, H.B., Mettheus, R., Christensen, J.P. (eds.): Interactive Technology and the New Paradigm for Healthcare, IOS Press, 1995, pp.389-398
- Pichler, C. v., Boeckmann, W., Radermacher, K., Rau, G., Jakse, G., Schumpelick V.: 3D versus 2D Video Endoscopy - A Clinical Field Study in Laparoscopic Application. Weghorst, S.J. , Sieburg, H.B. , Morgan, K., (eds.): MMVR 4 - Health Care in the Information Age -Future Tools for Transforming Medicin , IOS Press, 1996, pp.667-680
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Minimal Invasive Endoscopic “Keyhole Surgery”

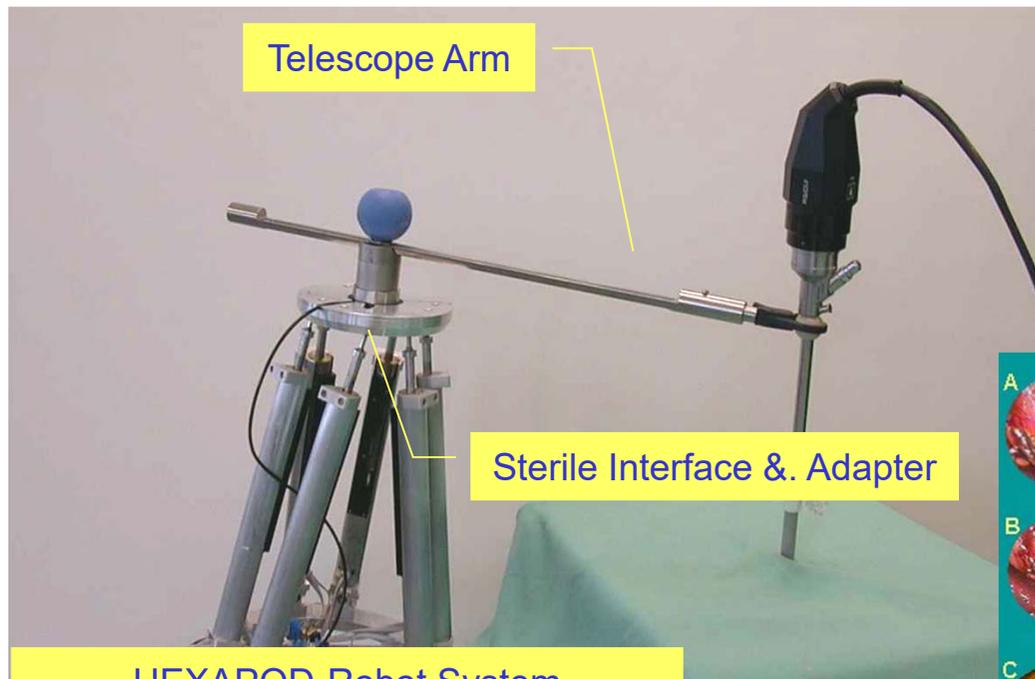
Pivotpoint



- *Loss of degrees of freedom*
($6 > 4$)
- *Inverted direction of motion*
- *Variable scaling of motion*
- *tremor amplification*

>>> *Motivation Telemanipulation !?*

PAROMIS – voice controlled robotic endocamera assistance



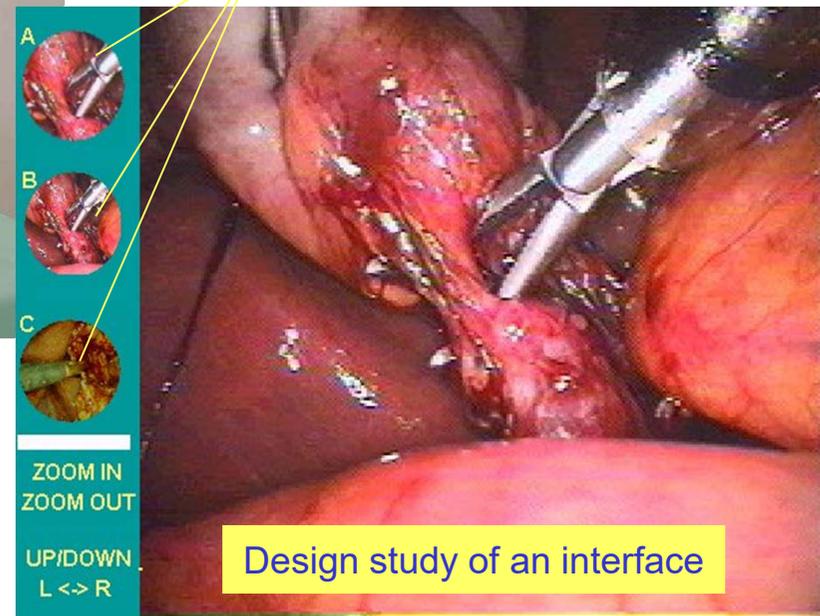
Telescope Arm

Sterile Interface & Adapter

HEXAPOD-Robot System
(Fixed on the OP-table)

Radermacher, K., Westrich, D., Heilige, M., Brandt, G., Jungk, A.,
Rau, G.: PAROMIS – Ein Parallelrobotersystem für die
sprachgesteuerte Kameraführung in der MIC. Zeitschrift f.
Biomedizinische Technik, Band 46, Ergänzungsband 1, 2001, S.
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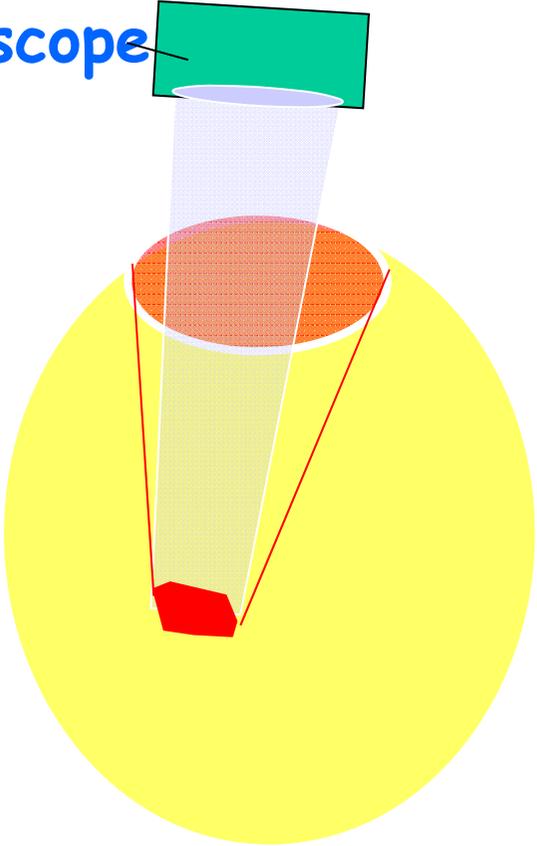
Stored positions



Design study of an interface

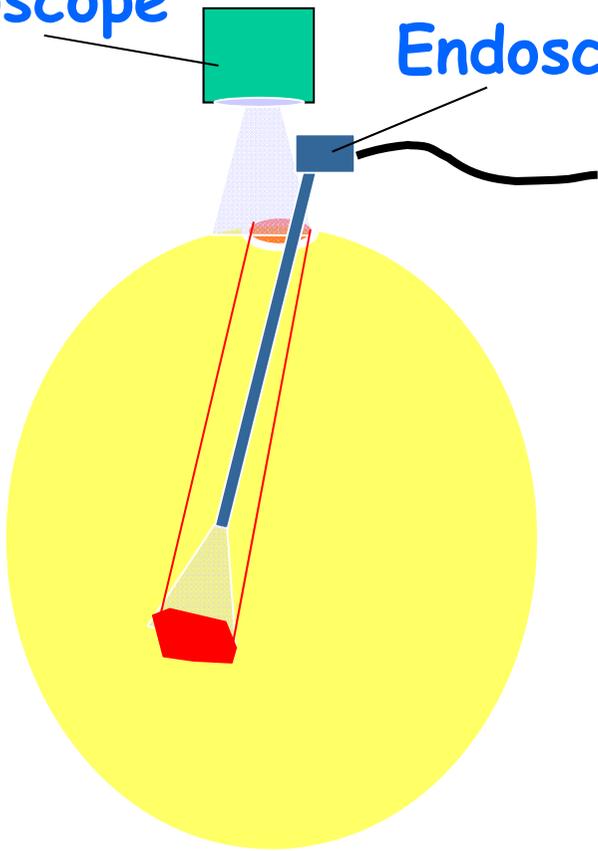
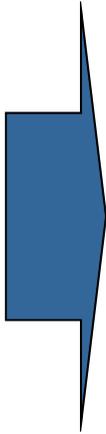
Conventional vs. Endoscopically Assisted Neurosurgery

Microscope



"Exoscope"

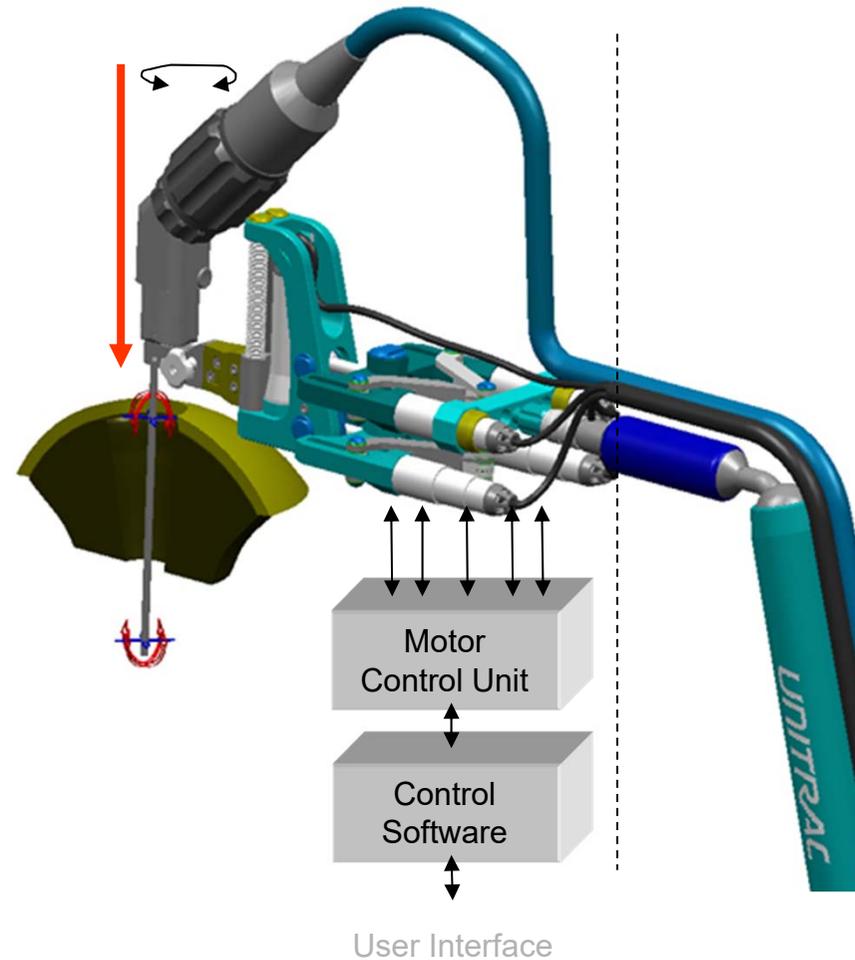
Endoscope



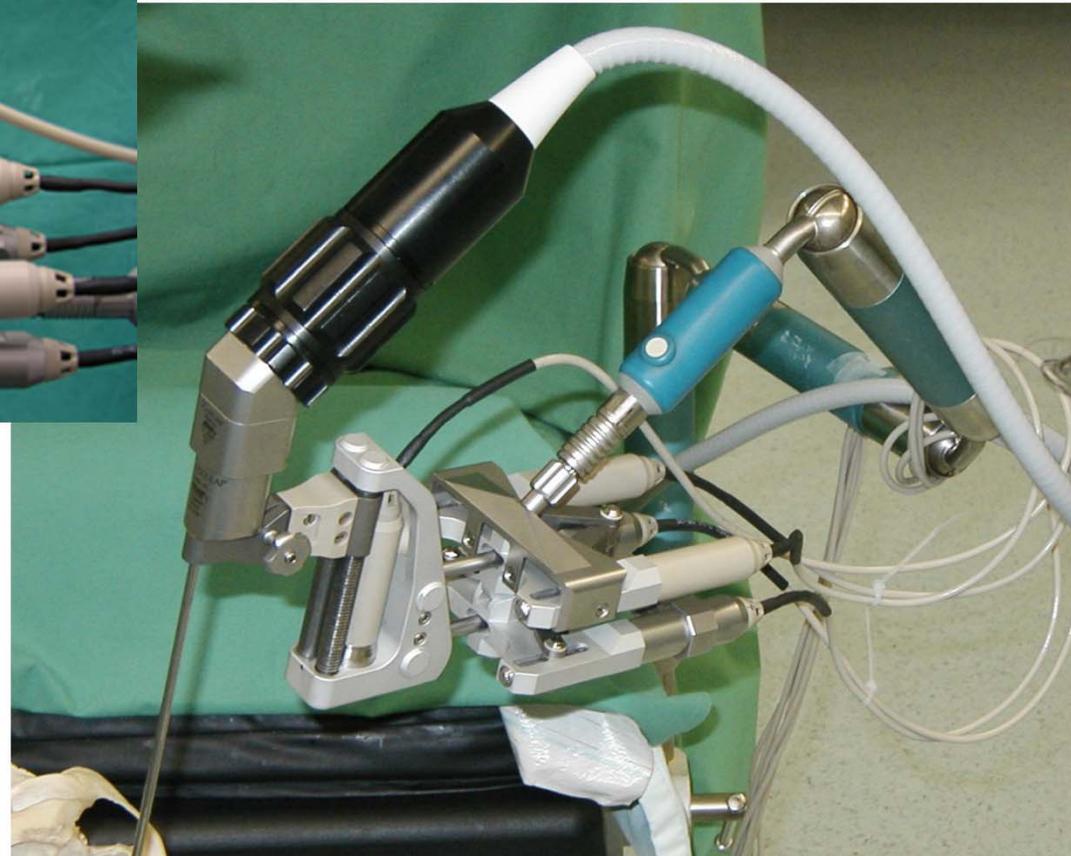
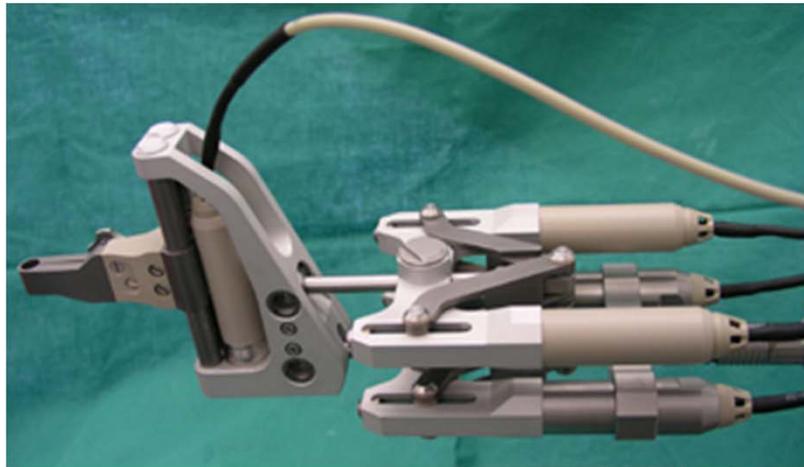
MINOP Neuroendoskope Manipulator

Hybrid Mini-Telemanipulator

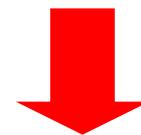
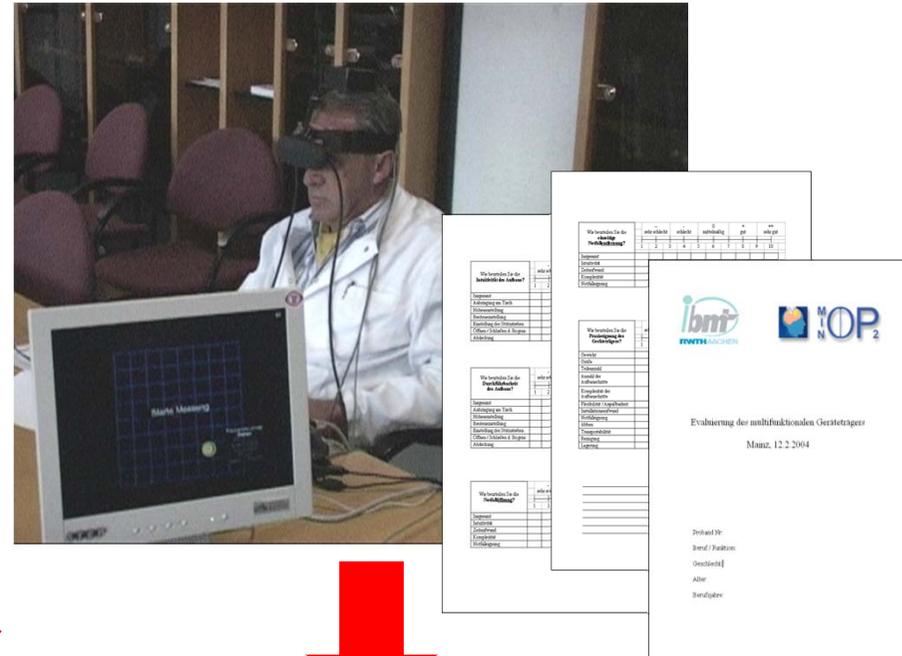
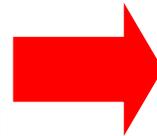
- Programmable RCM (Pivot point)
- Combination with the microscope possible
- Central user interface



MINOP Neuroendoskope Manipulator



Evaluation of Head-Tracking and Voice Control for Telemanipulation



- => *virtual Test set-up (Effectiveness, Efficiency...)*
- => *Questionnaires*
- => *Test-Setup in the OR (think aloud evaluation in simulated scenarios)*

Modus	Effizienz	Intuitivität	Komfort	Kontrollierbarkeit
Turn	+ 36 %	+ 16 %	+ 16 %	+ 24 %
Pivot	+ 20 %	+ 13 %	+ 18 %	+ 22 %
Lean	- 29 %	+ 7 %	+ 2 %	+ 16 %
Shift	- 10 %	+ 11 %	+ 11 %	+ 16 %
Zoom	- 6 %	+ 7 %	+ 7 %	+ 4 %

HIA Robots & Manipulators for Surgery (1994-2004)

(<https://www.meditec.hia.rwth-aachen.de/en/research/former-projects/>)



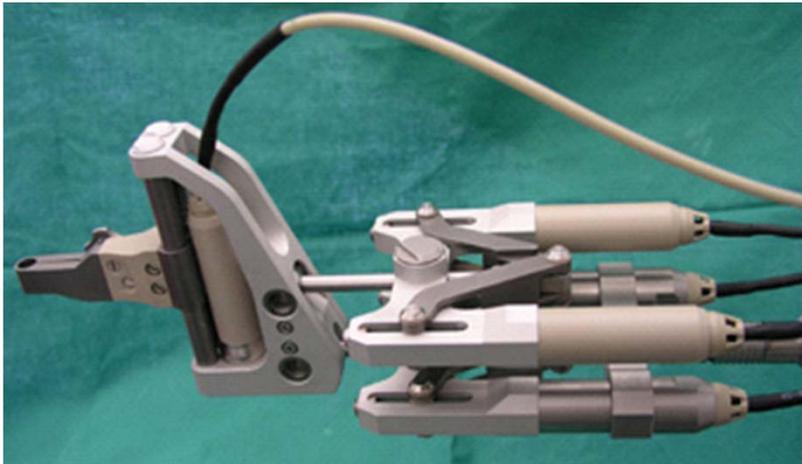
MINARO-3DOF-Minirobot



CRANIO-6DOF-Robot



PiezoTEN-System



MINOP II Endoscope-Manipulator



MINOP II Exoscope-Manipulator