

Hvad er en robot i sundhedssektoren - nu og i fremtiden?

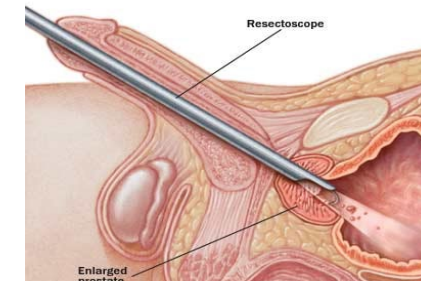
Thiusius Rajeeth Savarimuthu
Professor, PhD.
Head of Medical Robotics
Mærsk McKinney Møller Institute
University of Southern Denmark



History of surgical robots

In 1985 a robot, **The PUMA 560**, was used to place a needle for a brain biopsy using CT guidance. Three years later the same machine was used to perform a transurethral resection.

- In 1987 robotics was used in the first Laparoscopic surgery, a cholecystectomy.
- In 1988, **The PROBOT**, developed at Imperial College London, was used to perform prostatic surgery.
- **The ROBODOC** from Integrated Surgical Systems was introduced in 1992 to mill out precise fittings in the femur for hip replacement.
- Further development of robotic systems was carried out by Computer Motion with the **AESOP** and **ZEUS** Robotic Surgical Systems and Intuitive Surgical with the introduction of **The da Vinci Surgical System**.



History of surgical robots

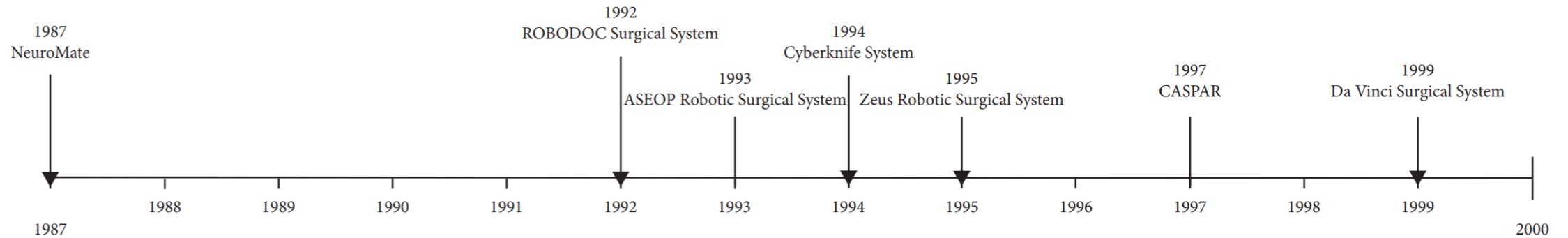


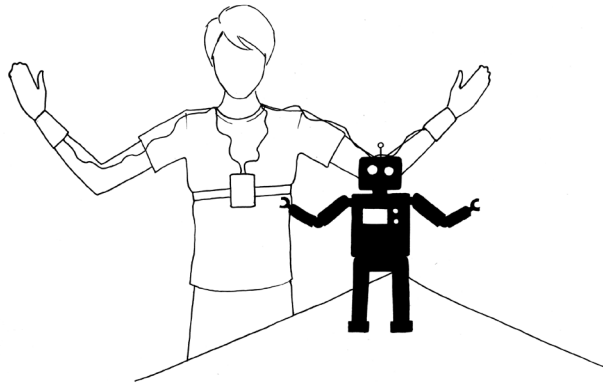
FIGURE 1: Decade I: timeline of robotic systems that founded and created the base for usage of robots in the medical field.

[Ginoya et al. 2021]

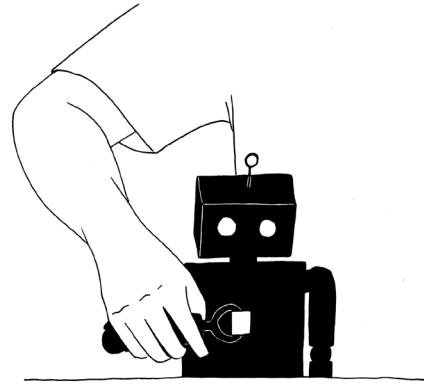
Robots in the medical domain



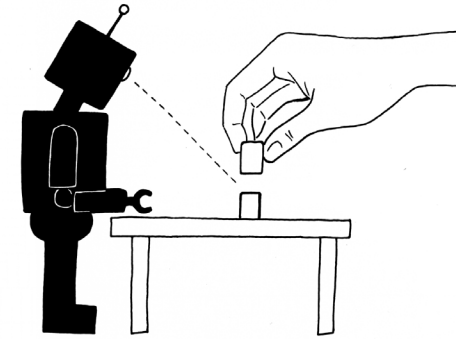
Basic control schemes of medical robots



Teleoperated

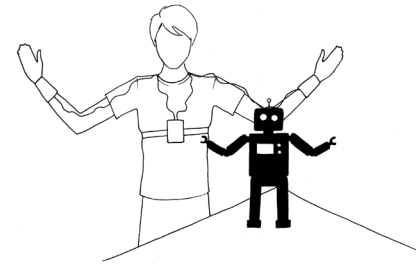


Robot assisted



Fully automatic

Teleoperated

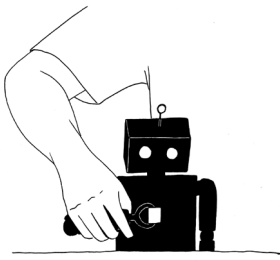


Da Vinci Surgical System

- Surgeons control every movement

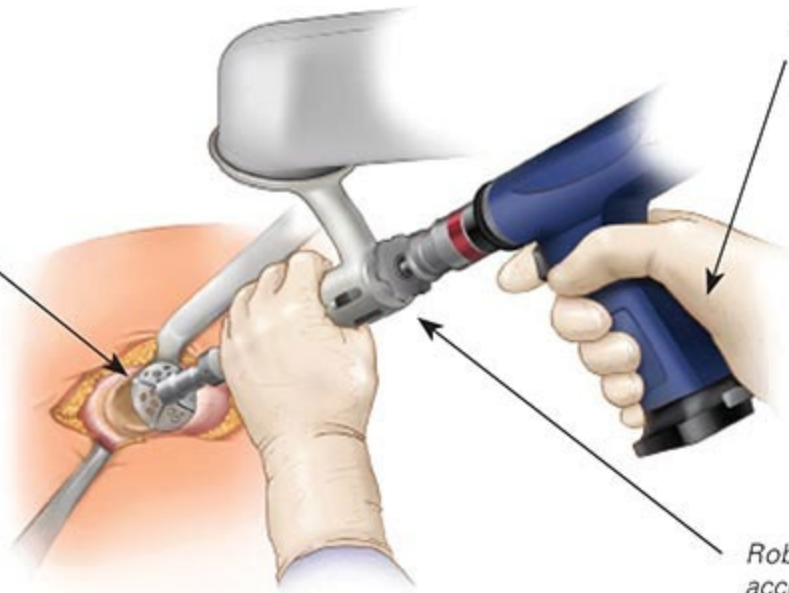


Robot assisted



MAKOplasty Hip

*MAKOplasty®
solution provides
accurate acetabular
cup placement*

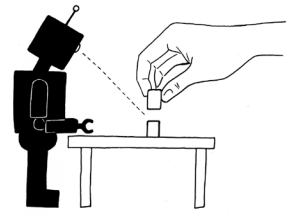


*Surgeon operates
robotic arm within the
tactile safety zone*

*Robotic arm for
accurate preparation
of acetabulum*



Fully automated



Personalized treatment plan – CyberKnife

- Radiation Dose Control
- Motion compensation



Which is the moral action in A?

1) Killing several pedestrians

2) One passer-by?



From research to product

2019



2020



2021



First AI-powered Robotic Scanning for RA Arthritic Ultrasound Robot: ARTHUR

Watch Ropca Robot - ARTHUR
- video how it works



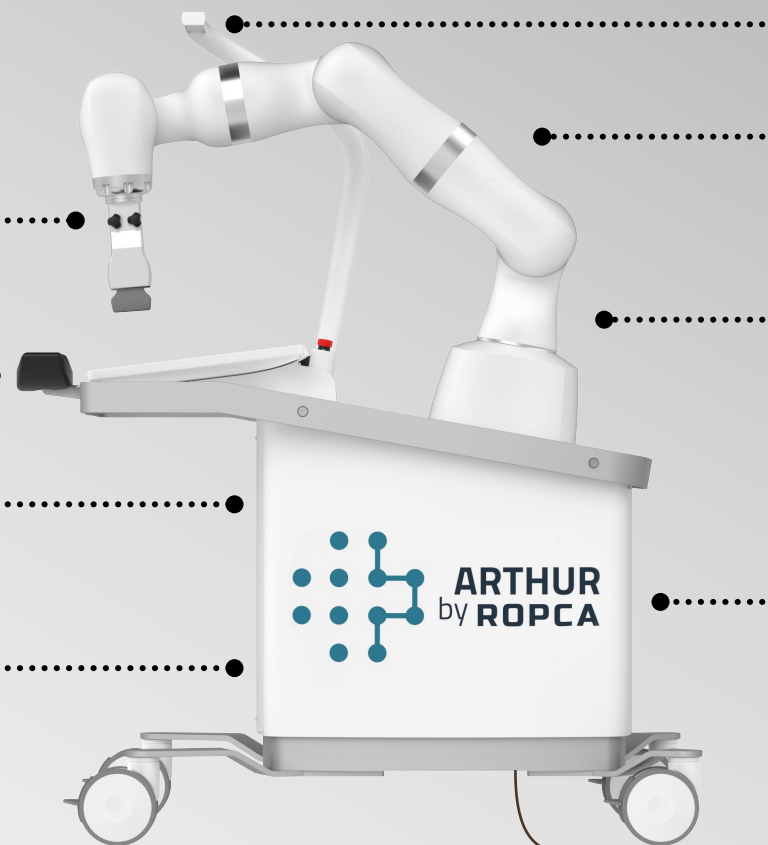
Robot gives visual and verbal
instructions to patient



The **US probe** from the **connected US machine** is attached to the robot.
Both **gray-scale** and **power Doppler images** are acquired. Motion coded from demonstration by expert doctors. A hybrid position/force controller ensures gentle scanning.
Patients hand & wrist on the **medical-approved touch screen**

Disease activity scores are automatically sent to **Electronic Patient Journal**

Patient US Images are analyzed by **Ropca Neural Network based AI Processing Algorithm** in to establish **disease activity score** according to EULAR-OMERACT

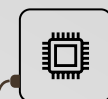


Intel RealSense **camera** feeds patient hand and wrist image to **Ropca Image Processes Algorithm**. The positions of the **22 joints** are mapped to direct **ultrasound (US)** probe toward the joints

Robot is instructed to position the US probe precisely on joints using **Ropca patent-protected AI Search Algorithm** (*Programming by Demonstration*)

Medical robot is **ISO 13485 & MDR Class 2a** approved for **hospital environments**. Motion was **coded** from demonstrations by **expert doctors**. A **hybrid position/force controller** ensures **gentle scanning** of the patient

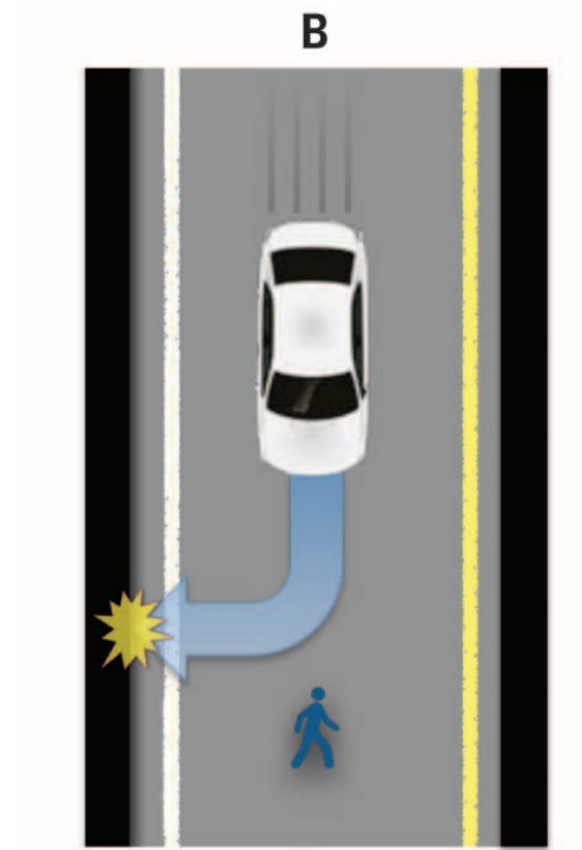
Image quality is **continually controlled** by the **Ropca AI** in a cascaded convolutional neural network architecture



Ultra Sound (US) Machine

Which is the moral action in B?

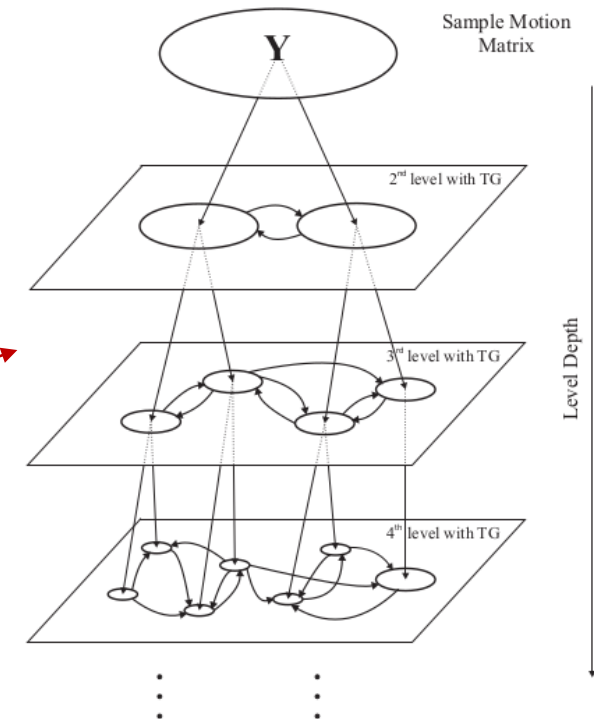
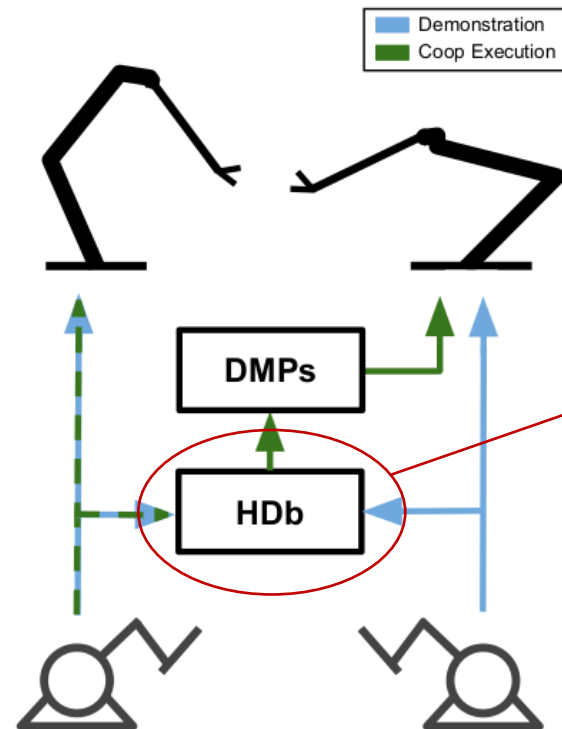
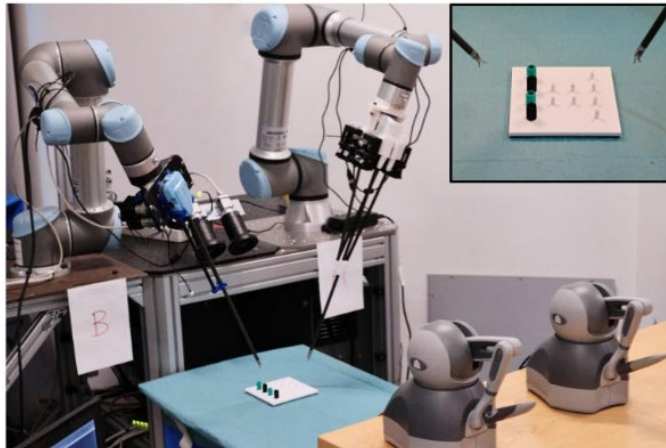
- 1) Killing one pedestrians?
- 2) Killing the passenger?



MOPS – Modular and Open Platform for Surgical robotics



Learning Cooperative Tasks





AI for segmentation maps

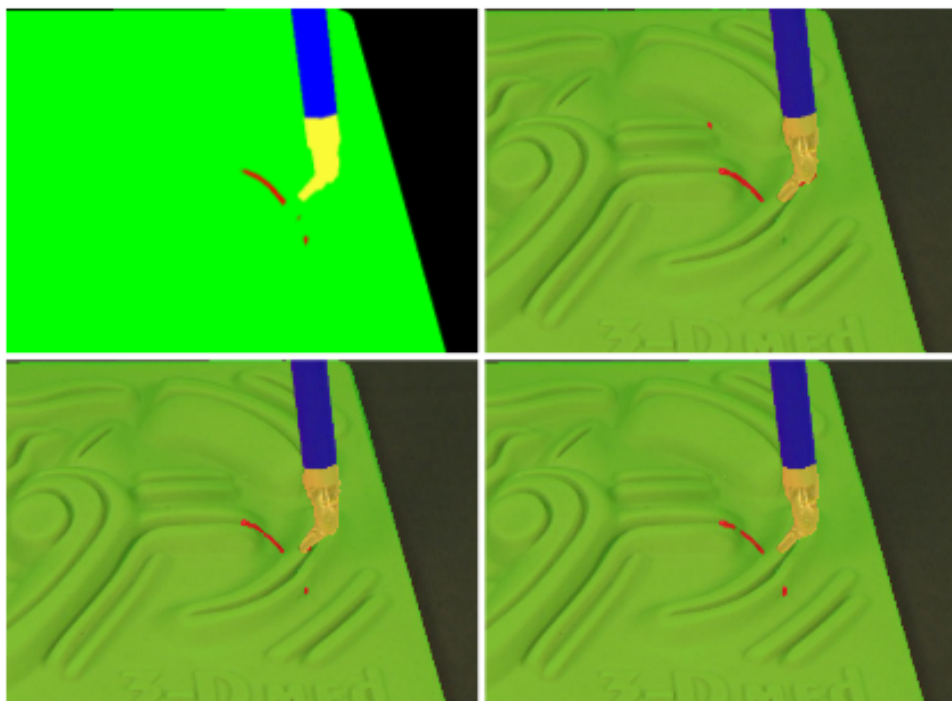


Fig. 5. Example laboratory data ground truth segmentation mask (zoomed in) and network outputs overlaid on the input image. Top row: ground truth (left) and single 1×1 kernel output network. Bottom row: Multiple 1×1 kernel output network (left) and multiple kernel output network with kernel sizes K_1, K_3, K_5 (right). Network outputs are generated from the network with the highest needle IoU score of the three trained for each output layer configuration.

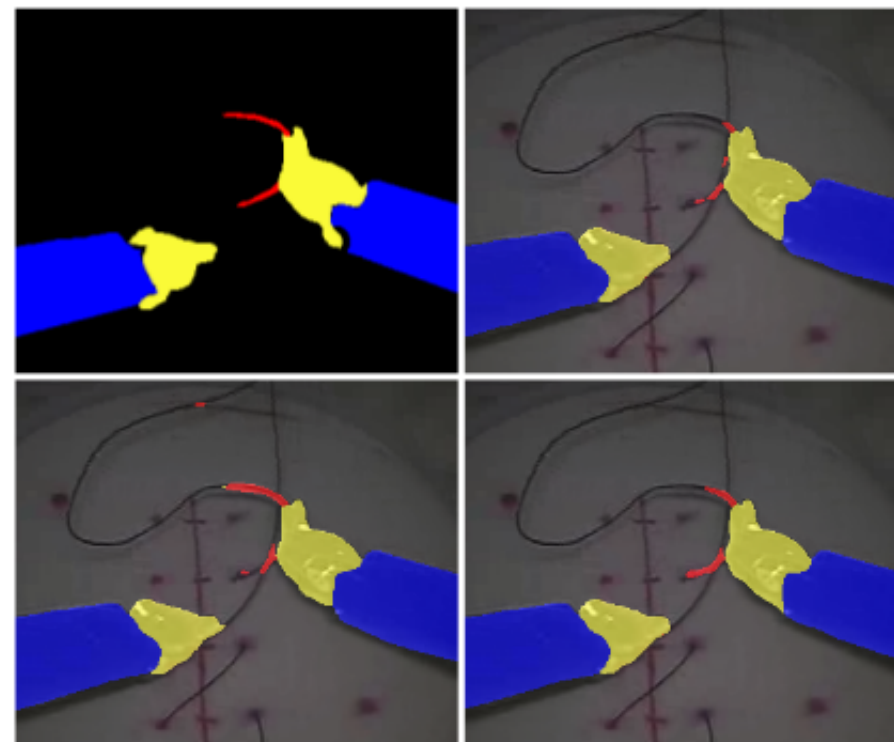
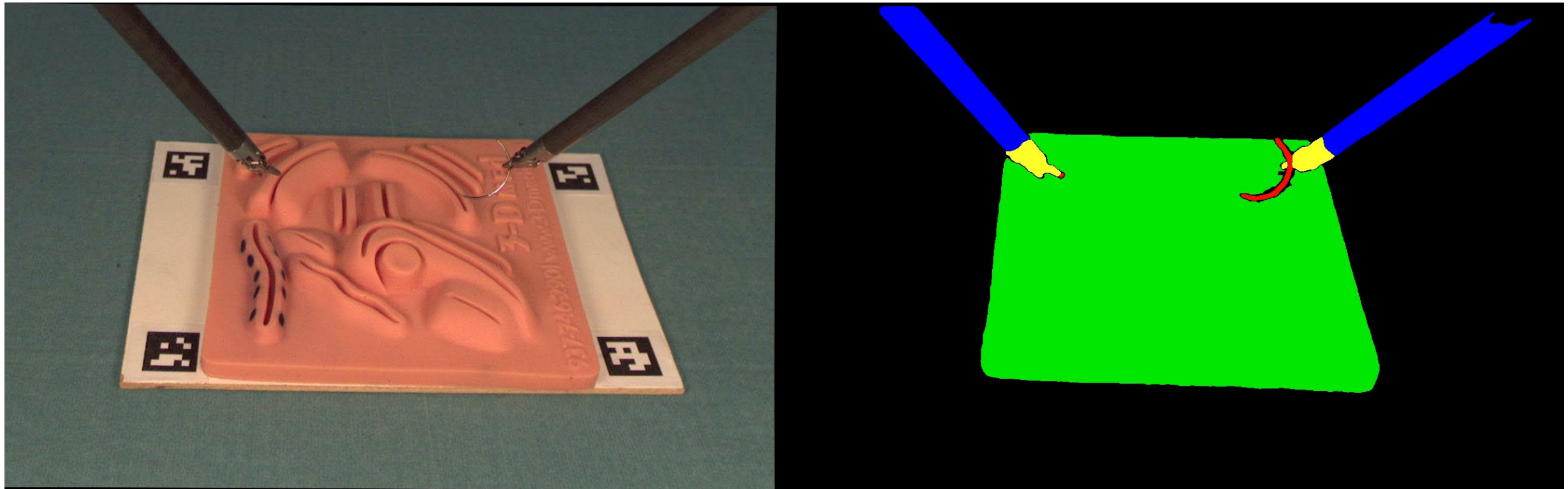


Fig. 6. Example JIGSAWS data ground truth segmentation mask (zoomed in) and network outputs overlaid on the input image. Top row: ground truth (left) and single 1×1 kernel output network. Bottom row: Multiple 1×1 kernel output network (left) and multiple kernel output network with kernel sizes K_1, K_3, K_5 (right). Network outputs are generated from the network with the highest needle IoU score of the three trained for each output layer configuration.



Automatic instrument segmentation



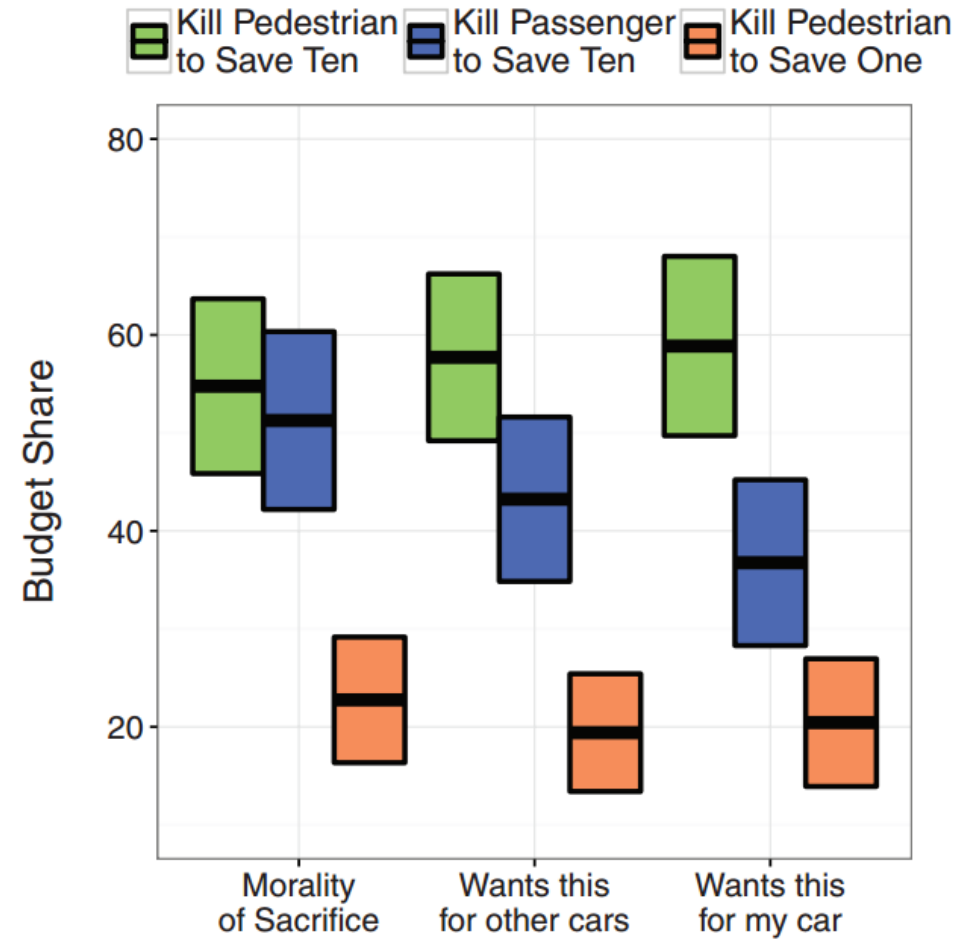


What do you want in other cars in situation C?

- 1) Killing several pedestrians?
- 2) Killing the passenger?



Study 4



Bonnefon, J.-F., Shariff, A., & Rahwan, I. (2016). The social dilemma of autonomous vehicles. *Science*, 352(6293), 1573.

Thank you for your attention

Thiusius Rajeeth Savarimuthu

**Professor, PhD,
Head of Medical Robotics,
Vice Head of SDU Robotics,**

The Maersk Mc-Kinney Moller Institute, SDU
trs@mmpi.sdu.dk
+24409545

