Robotics, telepresence and minimal access surgery
- A short and selective history
Luke Hares, Technology Director, Cambridge Medical Robotics
Overview

- Disclaimer!
- Highlights of robotics and telepresence
- A brief history of Minimal Access Surgery
- A natural fit
- Next steps
Minsky invented the term Telepresence in 1980 but the idea had been around for much longer
The first teleoperators were mechanical master slave devices such as those developed by Ray Goertz at Argonne National Laboratory in the US; quickly the advantages of electrically operated devices were realised.
Nuclear, submarines and space

Through the 60s and 70s remote manipulators improved in performance and imagination enabling human operators to be remote from various hazardous environments.
Nuclear, submarines and space

Through the 60s and 70s remote manipulators improved in performance and imagination enabling human operators to be remote from various hazardous environments.
At the start of the 80s, a key breakthrough was the realisation that the master and slave could be mechanically different, with mappings between them performed by computer.
Minimal Access Surgery

A brief history of surgery

- Fast
- Hygiene and anaesthetics
- Minimal Access Surgery (MAS)
Minimal access surgery

Beginnings

- The first experimental laparoscopy was performed on a dog in Berlin in 1901 using a previously invented viewer system called a Cystoscope.

- The first human laparoscopic procedure was carried out by Hans Christian Jacobaeus in Stockholm in 1910; he invented the term “laparothorakoskopie” in 1911.

- Various advances in optics helped it start to become common in gynaecology in the 1970s.

- Early 80s – CCDs, first endoscopic video cameras

- 90s onwards – significant uptake, explosion of tools and methods.

Hans Christian Jacobaeus
Minimal access surgery

Specialised tools

A huge growth in staplers, needle holders, needle drivers, vessel sealers, tackers, graspers......
Minimal Access Surgery needs

*MAS is hard*

- Precision
- Specialised manipulators – Remote Centre of Motion (RCM) a natural fit
- Frame of reference transformation
- Ergonomics
- Good visualisation - stereo 3D vision

Robotic for Minimally Invasive Surgery: A Historical Review from the Perspective of Kinematics Kuo and Dai, 2009
Consequences

Minimal Access Surgery is hard, and this has consequences

- Total MAS Procedures in 2015: 6M

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cholecystectomy</td>
<td>31%</td>
</tr>
<tr>
<td>Uro-Gynecology</td>
<td>16%</td>
</tr>
<tr>
<td>Thoracic</td>
<td>2%</td>
</tr>
<tr>
<td>Colo-Rectal</td>
<td>26%</td>
</tr>
<tr>
<td>General</td>
<td>10%</td>
</tr>
<tr>
<td>Bariatric</td>
<td>8%</td>
</tr>
<tr>
<td>ENT</td>
<td>7%</td>
</tr>
</tbody>
</table>

- **Cooper et al BMJ. 2014; 349**
  - Mean hospital MAS utilisation:
    - Appendix: 71% (40 – 93%)
    - Colectomy: 28% (6 – 49%)
    - Hysterectomy: 13% (0 – 33%)
    - Lung lobectomy: 32% (3.6 – 65%)
  - Complication rate:
    - Appendix: MAS 3.9% Open 7.9%*
    - Colectomy: MAS 13% Open 35%*
    - Hysterectomy: MAS 4.6% Open 6.6%*
    - Lung lobectomy: MAS 17% Open 25%*

- Cost of Complications - $25 billion annually
- Estimated 6 million procedures p.a. which should be performed using MAS techniques today

A natural fit

First steps - Precision

- In 1985, Kwoh used a robot based upon a Unimate PUMA 200 to perform stereotactic brain surgery

![Fig. 5. Complete Software Maintains the Probe Holder Trajectory Pointing at the Target Constantly](image)

*Figure 2. The first robot that performed (assisted with) human surgery in 1985 (Kwoh, 1988); Dr. Kwoh with the Unimate robot prepared for stereotactic neurosurgery (Image credit: Corbis)*

- An initial objective for surgical robots was precision

- In the late 1980s Brian Davies developed a robot to perform precise proctectomies
A natural fit

First steps

- By 1993, Colonel Richard Satava speculated that robotic systems could be used for telepresence general surgery.
- Robots were also being developed for orthopaedic procedures to give precise bone removal and joint positioning.
A natural fit

In the US

- During the 90s, in the US, DARPA projects explored the concept of telesurgery for the military
- Yulun Wang and his company, Computer Motion, developed AESOP – a robotic endoscope holder to perform the role of the surgical assistant
- Akhil Madhani developed a remote centre of motion manipulator for surgery
A natural fit

Late 90s, Europe

- ARTEMIS
- Karlsruhe Research Centre, Central Engineering Dept.
- Wristed instruments, RCM mechanism, 3D endoscope

Eventual fate unknown...
Computer Motion & Intuitive

*Early 2000s*


All images uses assumed to be fair use, copyright respected
Unmet needs

Present day

- Not general purpose – limited in application due to the need to adapt surgery to the limitations of the system
- Difficult to set up and move about
- Poor utilisation ~once every other day
- Far too expensive
- ~750k of 12M-15M
- The problem of universal access to MAS has not been solved

But robotics is here to stay, one big incumbent but several companies working in the area
Collaborative robotics and (eventually) big data

The future

- A surgical robotic system must work closely with OR staff, in a conventional OR environment
- Integrate tele-presence, MAS and collaborative robotics
  - General purpose
  - Easy to use
  - Drive up utilisation
  - Transform the economics – and so make it available
- Big data comes next