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Control of a Flexible Multi-Manipulator System

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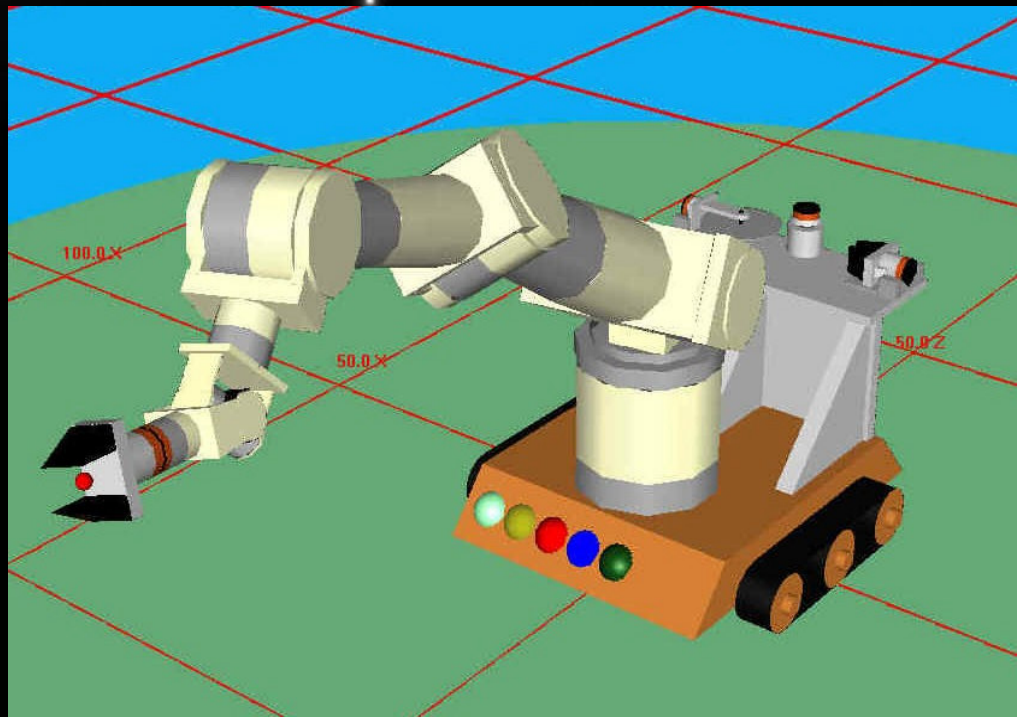
Flexible Manipulators

The way to go complex

- Increased manipulability due to redundant degrees of freedom
- Access to small places
- Obstacle avoidance
- Power efficiency



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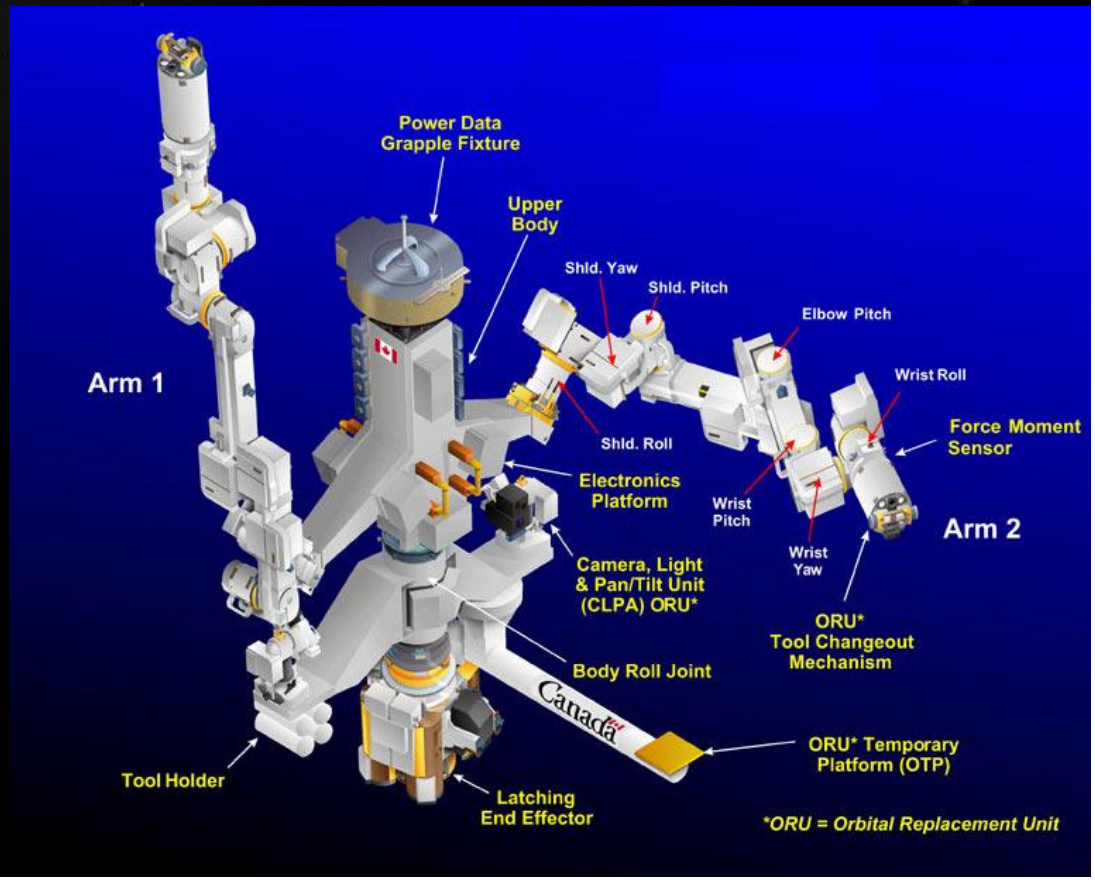
In space applications I.

- Deployment and retrieval of hardware
- Assembly missions
- Transportation
- Capturing and launching satellites
- Servicing
- Maintenance and repair
- Supporting EVAs

In space applications II.

Dextre – The Special Purpose Dexterous Manipulator

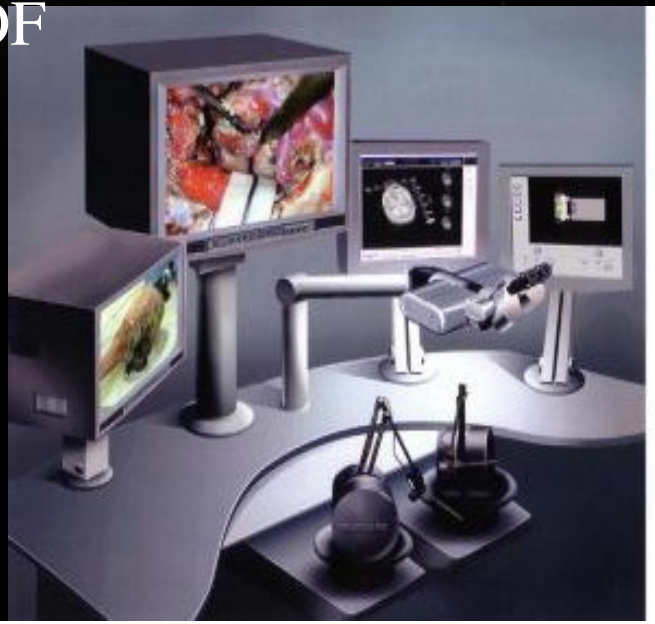
- 2 arms, 15 DOF
- Anthropomorphic design
- High functionality
- Displaceable
- New robot architecture
- Complete monitoring



Surgical applications

From Space to Earth

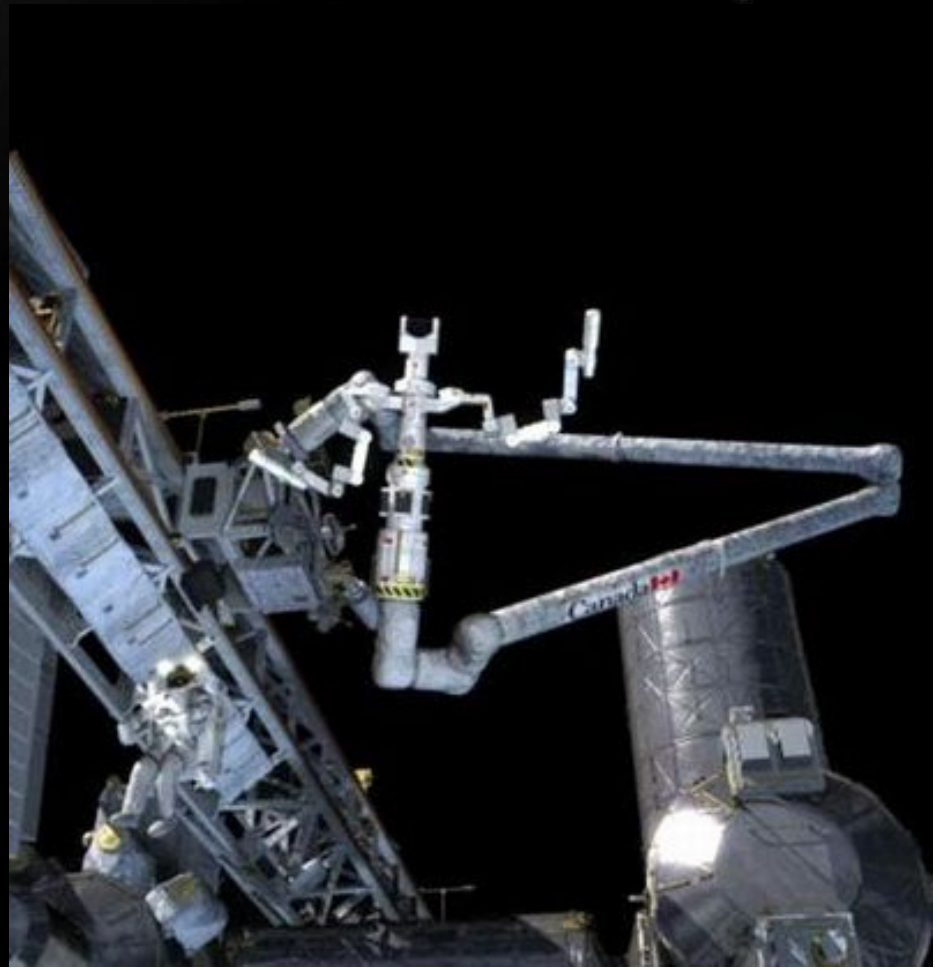
- MD Robotics - University of Calgary: neuroArm
- Intuitive Surgical: Zeus– 2x 6DOF + camera
- da Vinci– 2x 6 DOF
- Other systems



Using redundancy

Introducing an additional degree of freedom

- Compensate limitation of working through incisions
- Easy smoothening of movements
- Obstacle avoidance
- Complex task performance



Control of Flexibility I.

Emerging problems

- Differential kinematics

$$\dot{\mathbf{x}} = \mathbf{J}(\mathbf{q})\dot{\mathbf{q}}$$

- Motion equations are getting more complicated
- Lack of closed-form general formula for differential kinematics
- Several possible optimums
- Singularity manifolds

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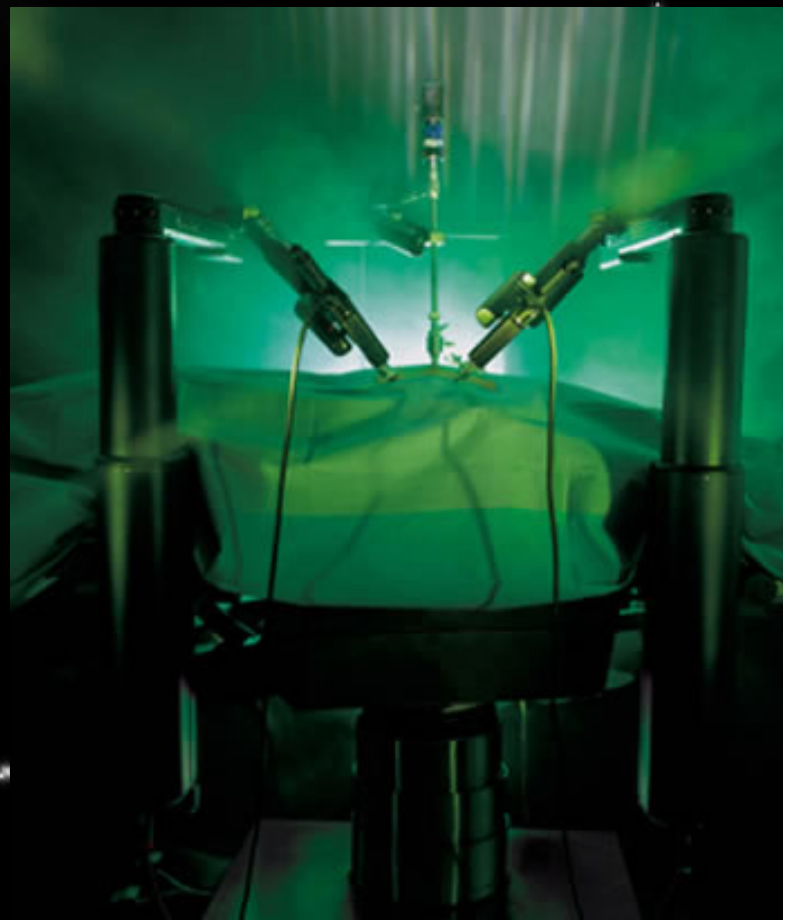
Control of Flexibility II.

Solving Kinematics – Full State Parameterization

- Developed by Pin et al., 1995
- Workspace augmentation and gradient projection
- Main parts:
  - Forming a solution space of base vectors
  - Optimization within this space



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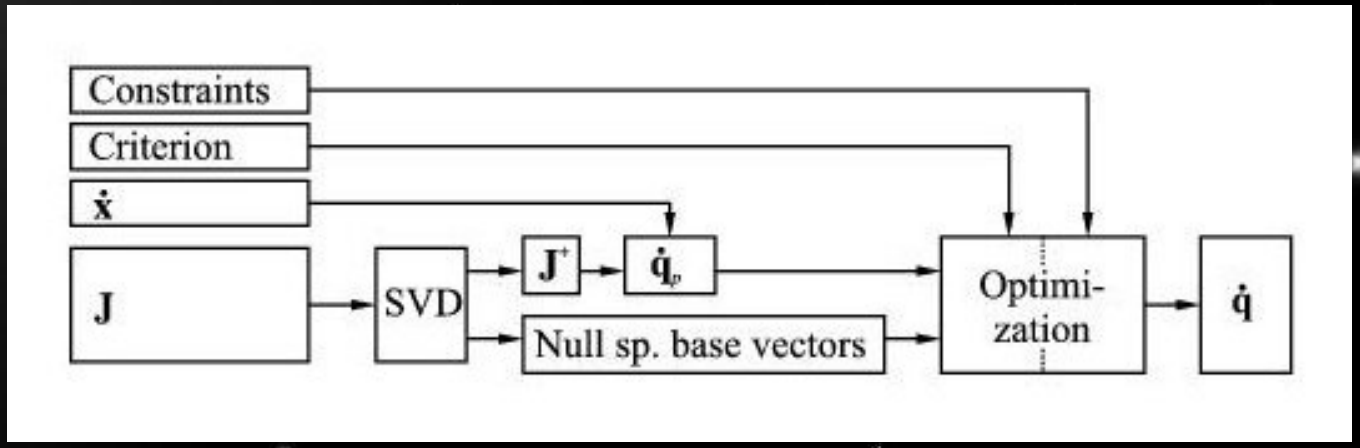
Control of Flexibility III.

New method –Parameterization Through Null Space

- Developed by Zsolt Kemeny, 2003



$$\dot{\mathbf{q}} = \dot{\mathbf{q}}_p + \dot{\mathbf{q}}_h = \mathbf{J}^+\dot{\mathbf{x}} + \mathbf{N}\mathbf{t}$$

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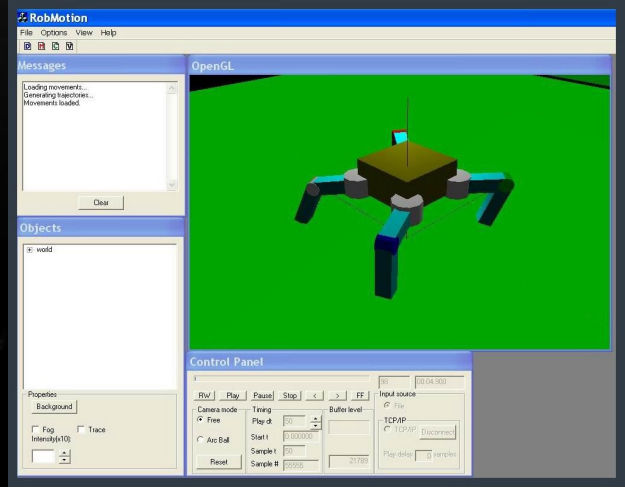
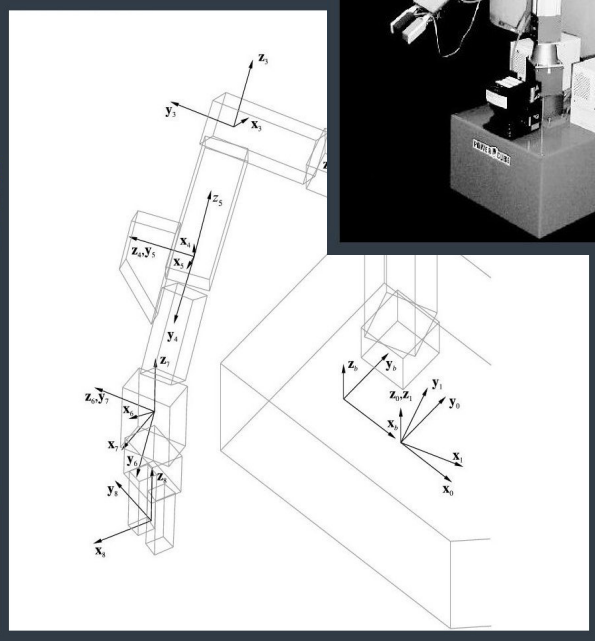
Simulation I.

Experimental setup

- Two 7 DoF arms: RRRRRRR
- Bases: Siemens – MobMan
- OpenGL based simulation environment





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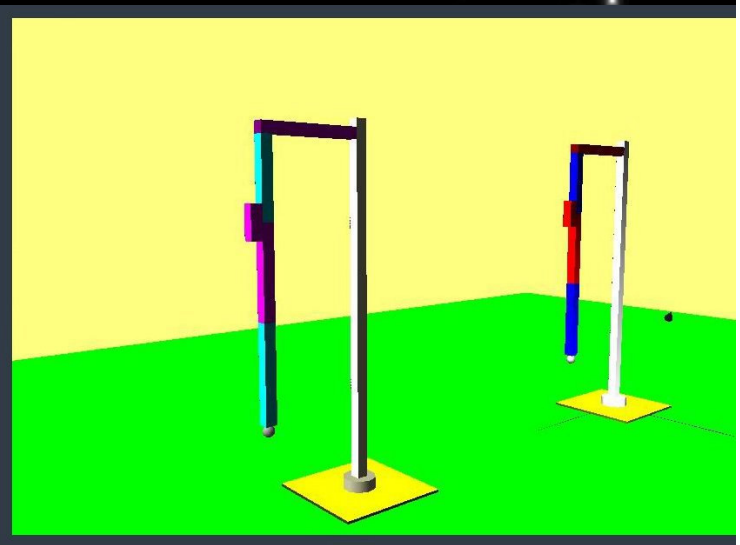
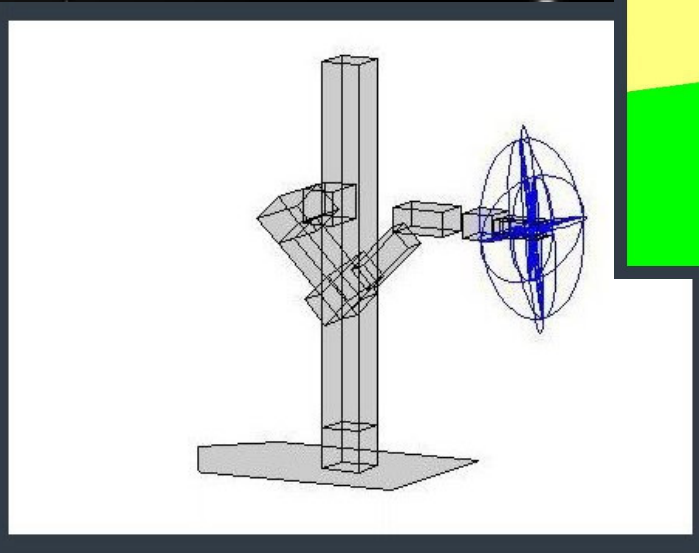
Simulation II.

Simulation of the system

- Low level motion planning
- Two arm simulation
- High level collision avoidance





Future work

- Including 6 DoF camera-arm
- High level task definition and planning (suturing)
- Perform comparison tests
- Implement security measures

Acknowledgement

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*Images were provided by:

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- Siemens Inc.
- Zsolt Kemeny, Thesis, 2003
- MD Robotics


INTUITIVE
da Vinci
Surgical System
OR 6