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On the Use of Underactuation in Adaptive Robotic Grasping

Clément Gosselin
Canada Research Chair
Département de génie mécanique
Université Laval
Québec, Canada

Laboratoire de robotique

Contents

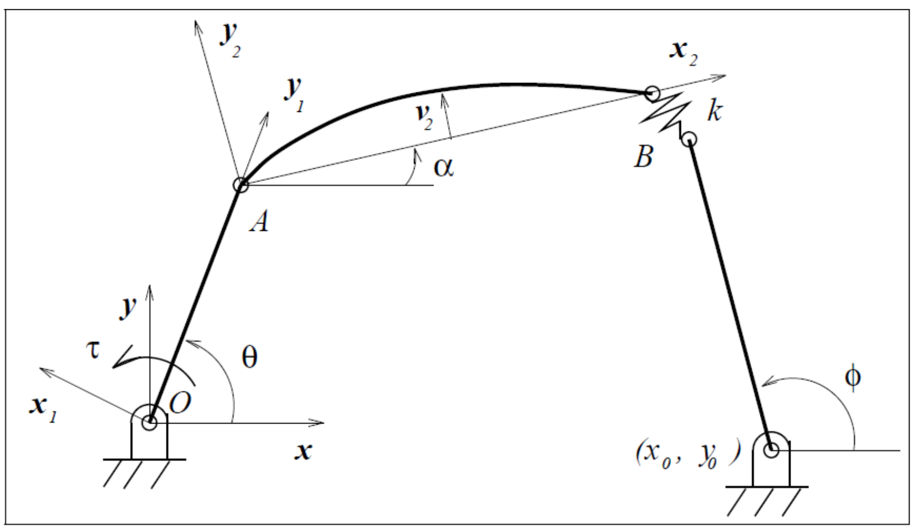
- Grasping: definition
- Underactuation: definition, objectives
- Underactuated grasping
- The Laval hands
- Industrial and commercial applications
- Conclusions

Grasping

- To stably constrain an object (graspers are different from manipulation interfaces)
- Form closure: the object is geometrically constrained
- Force closure: the grasp can be maintained for any object wrench (friction is introduced)

Underactuation

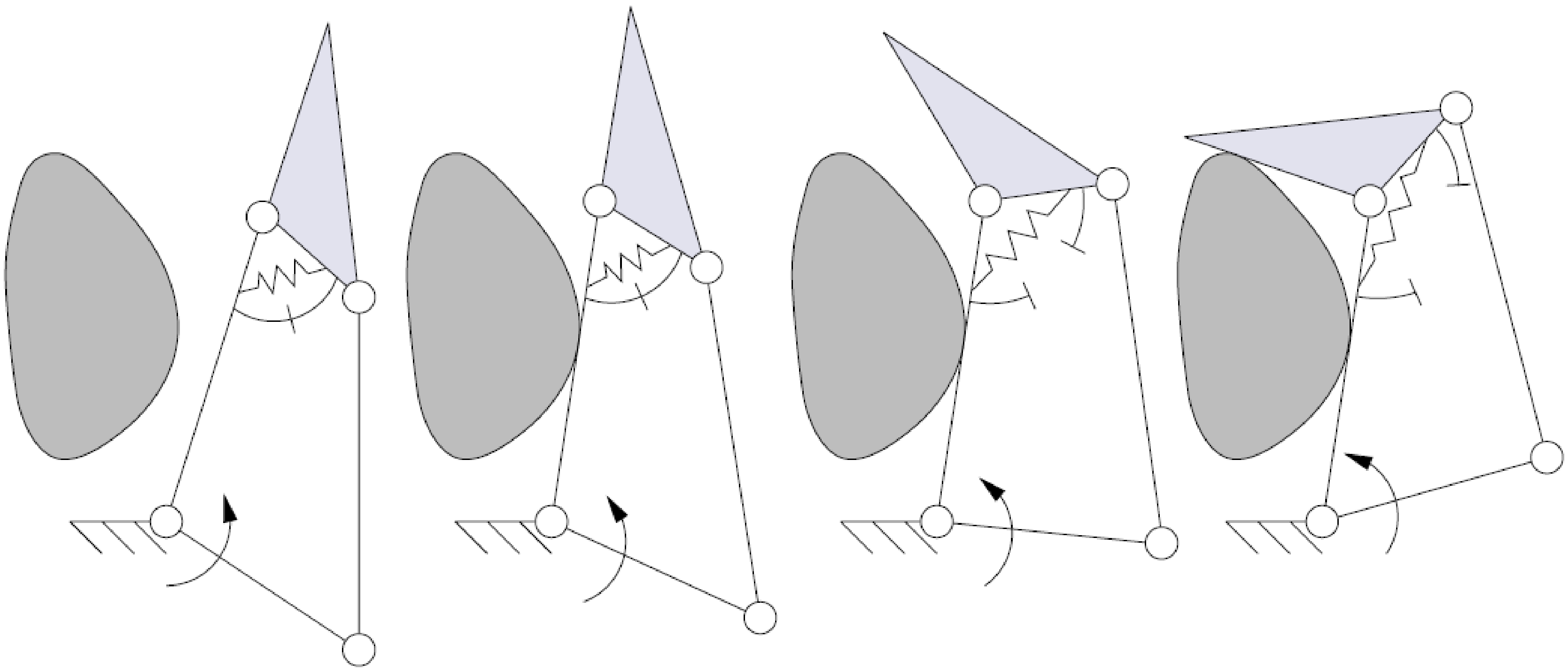
- Fewer actuators than degrees of freedom
- In fact, most mechanical systems exhibit some form of underactuation (e.g. flexible robots)



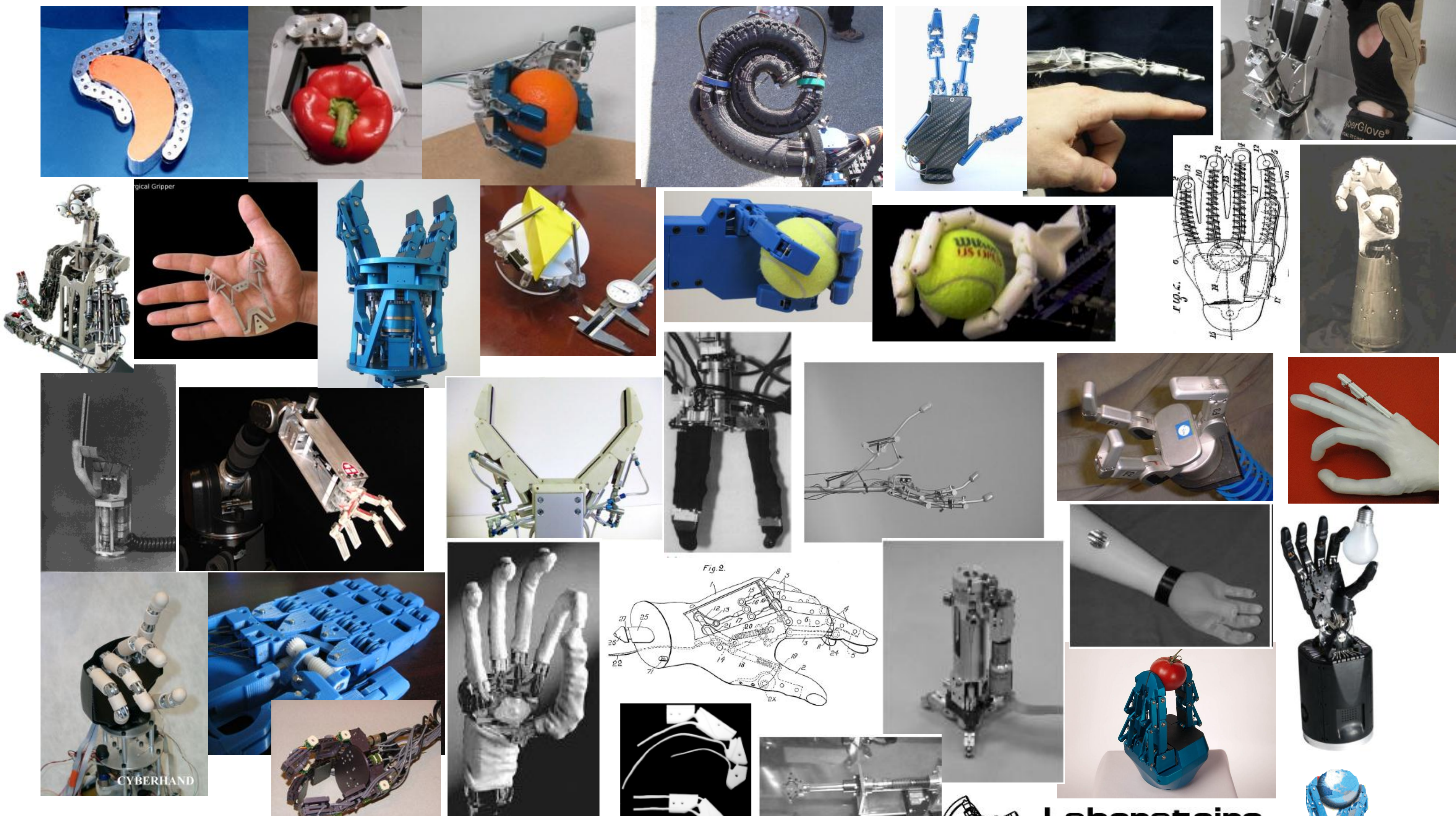
Underactuation in grasping

- Use underactuation to perform grasping tasks with a minimum number of actuators
- Design problem: exploit underactuation in order to produce a certain ‘behaviour’
- Fundamental Issue: how can we formulate this design problem mathematically?
- Necessary to make simplifying assumptions

Illustration of the basic principle



Examples of underactuated hands



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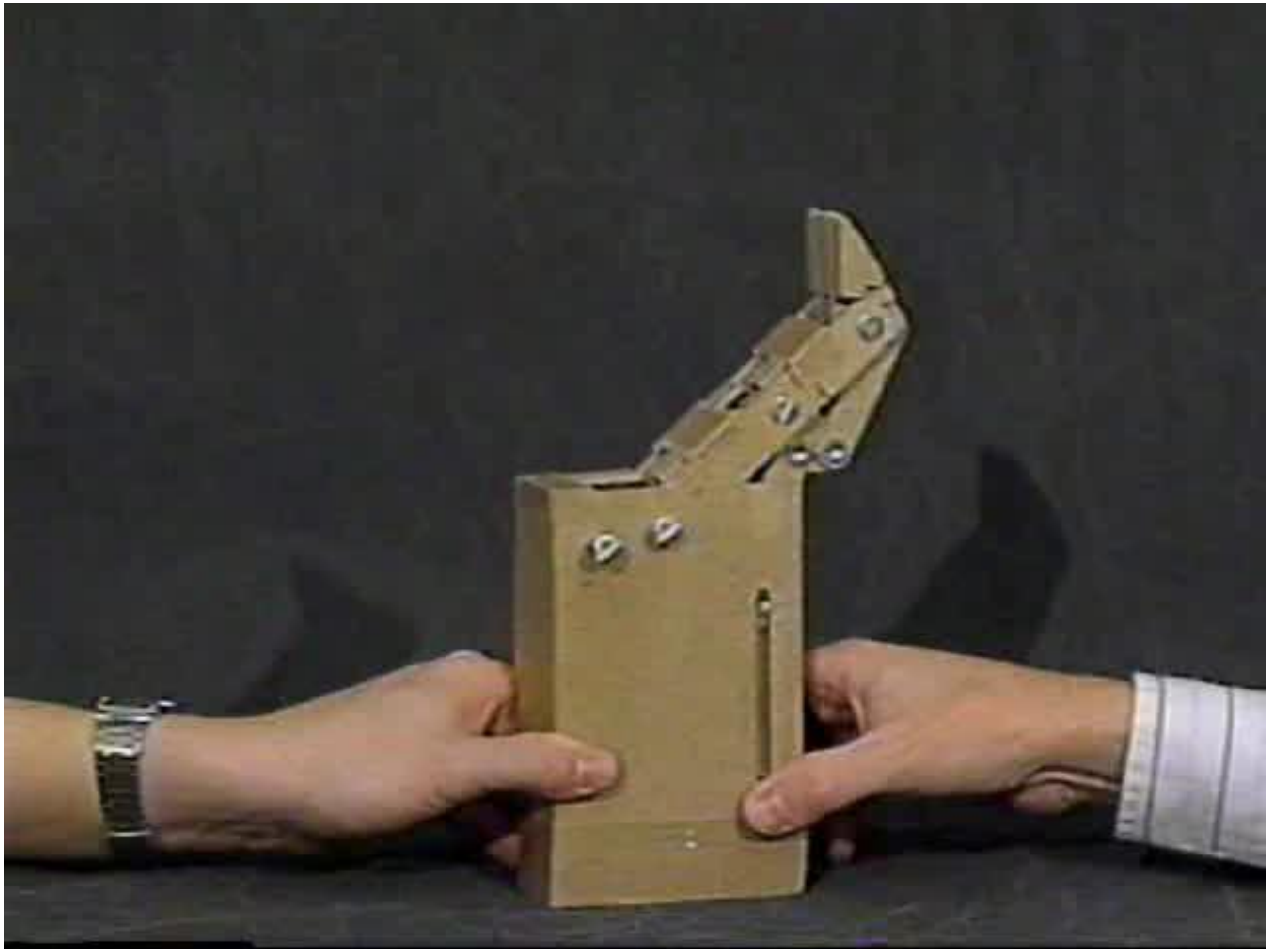
The Laval hands

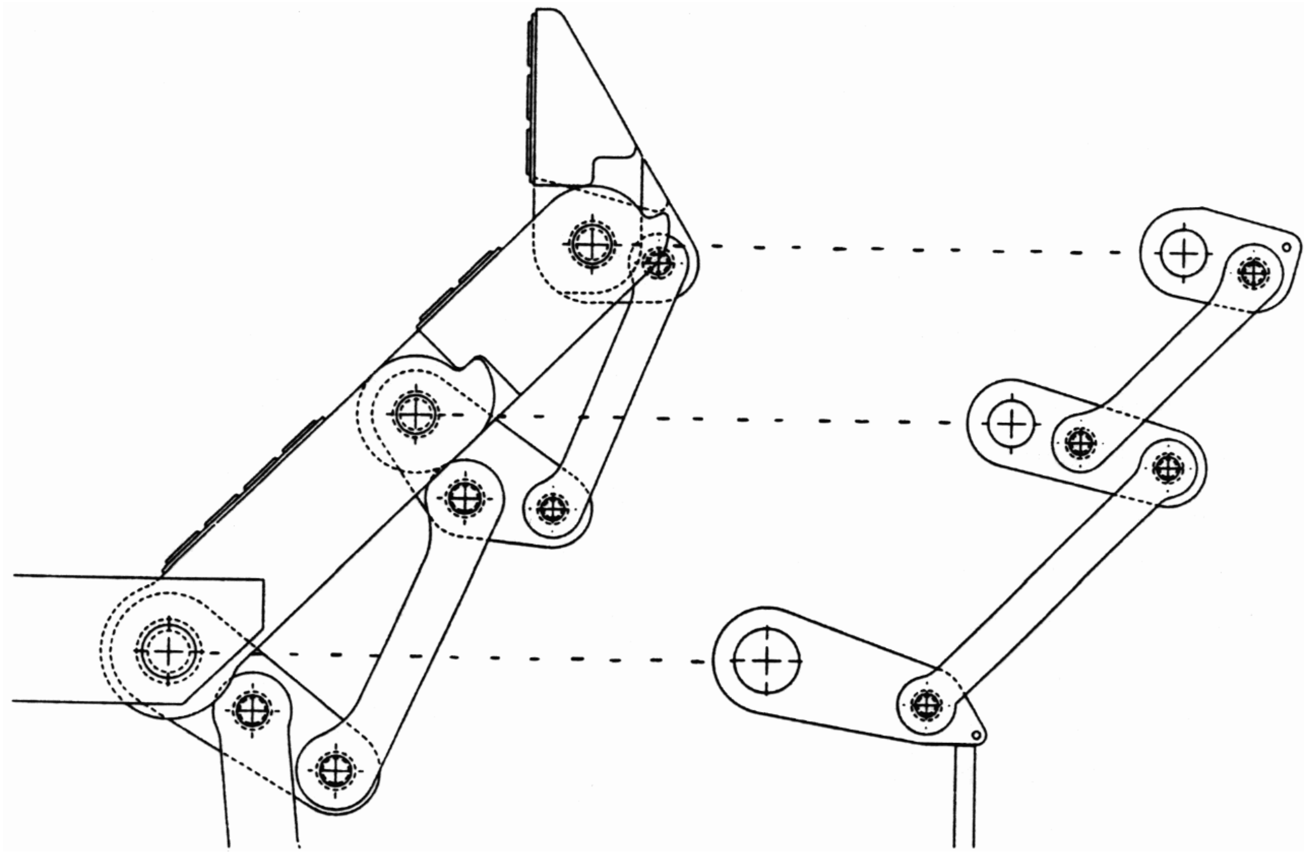
- Modelling of underactuated hands
- Several prototypes built over the last two decades
- Some of the designs have been commercialized

General concepts and initial experiments



1994

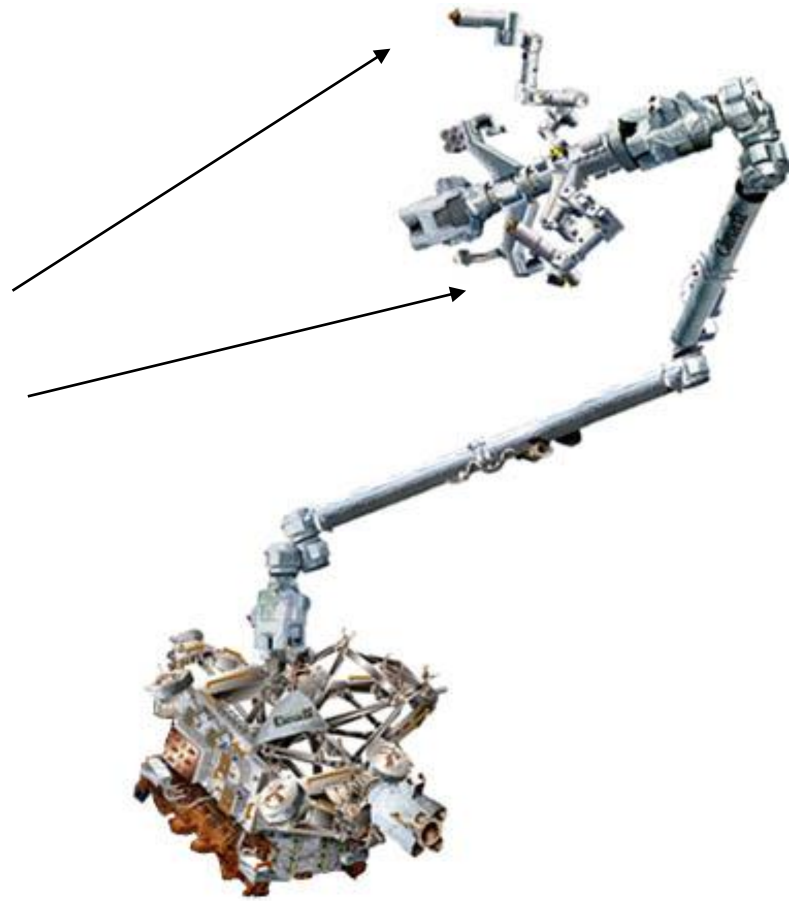
Basic principle of the finger



First fully functional hand (MARS): 12 dofs – 6 actuators

1996

THE SARAH HAND 10dofs – 2 actuators (2000)



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SARAH (Self-Adaptative Robotic Auxiliary Hand)

10 dofs and 2 actuators
3 configurations: cylindrical, spherical and planar

Designed for the space station manipulators

EXPERIMENTAL VALIDATION OF THE SARAH HAND

2002

- **Delivered to MDA**
- **Tested at CSA on the STVF robot**

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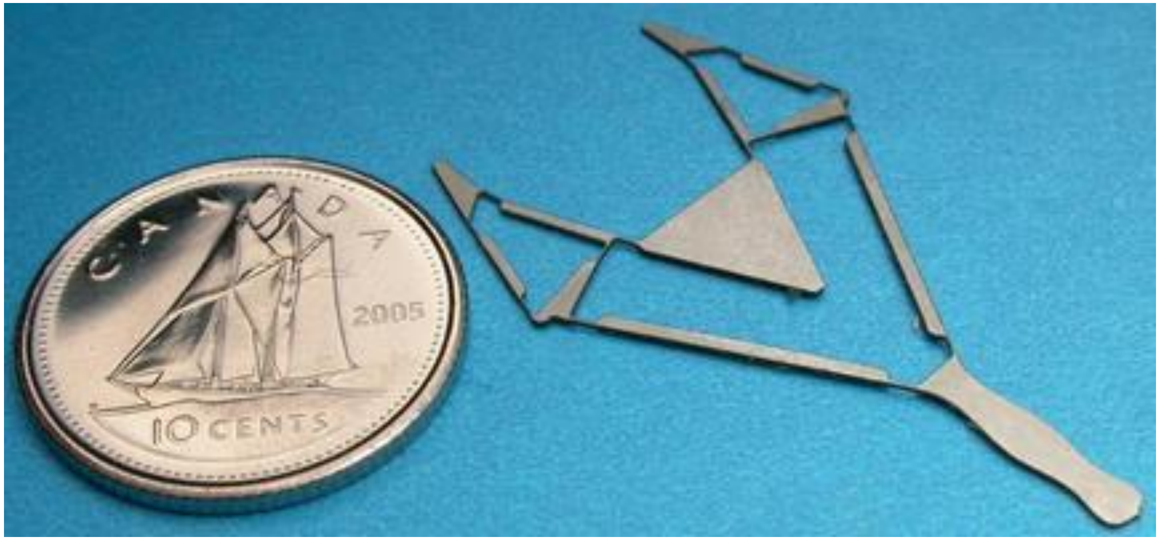
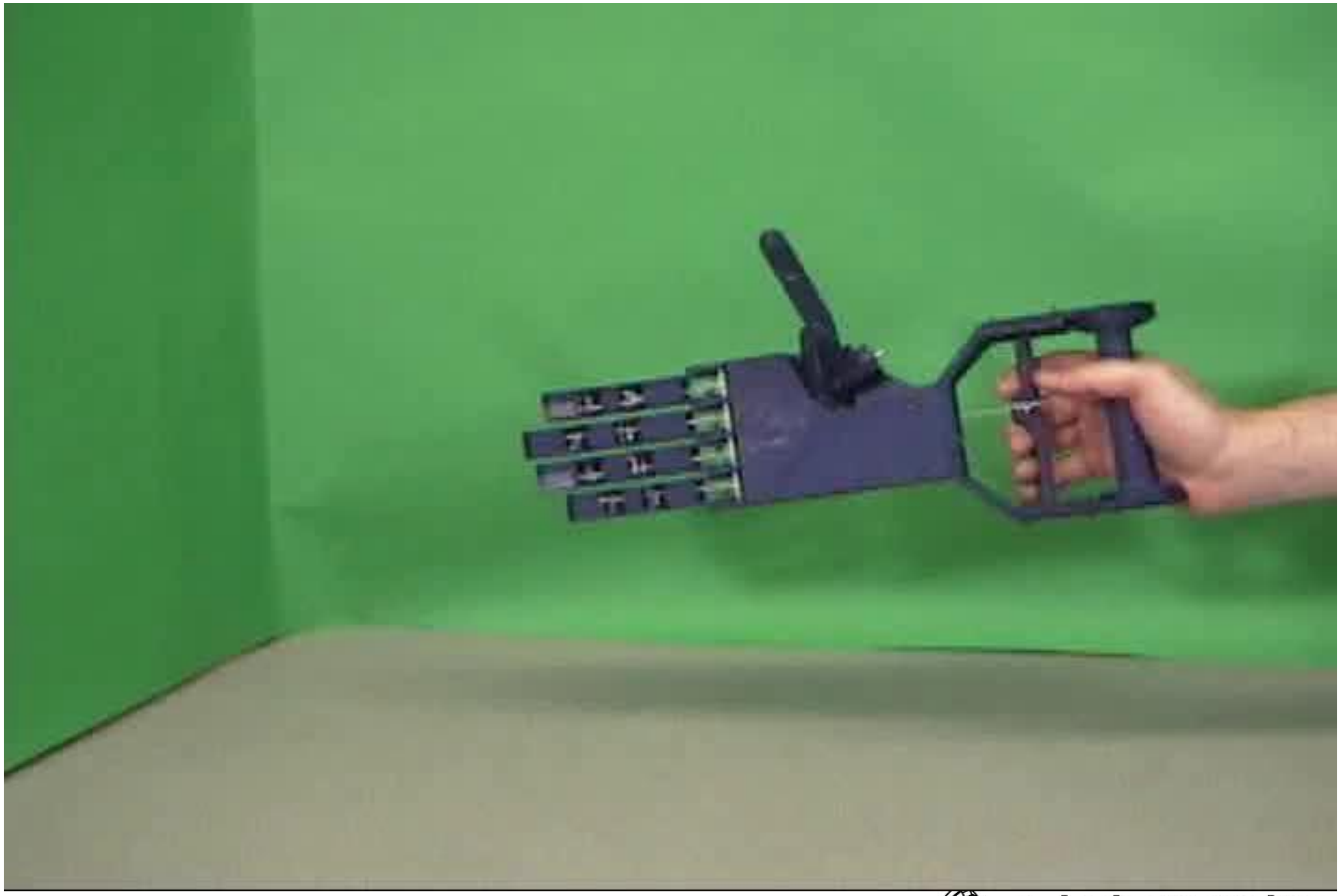
APPLICATIONS IN TELE-SURGERY : Elastically deformable components



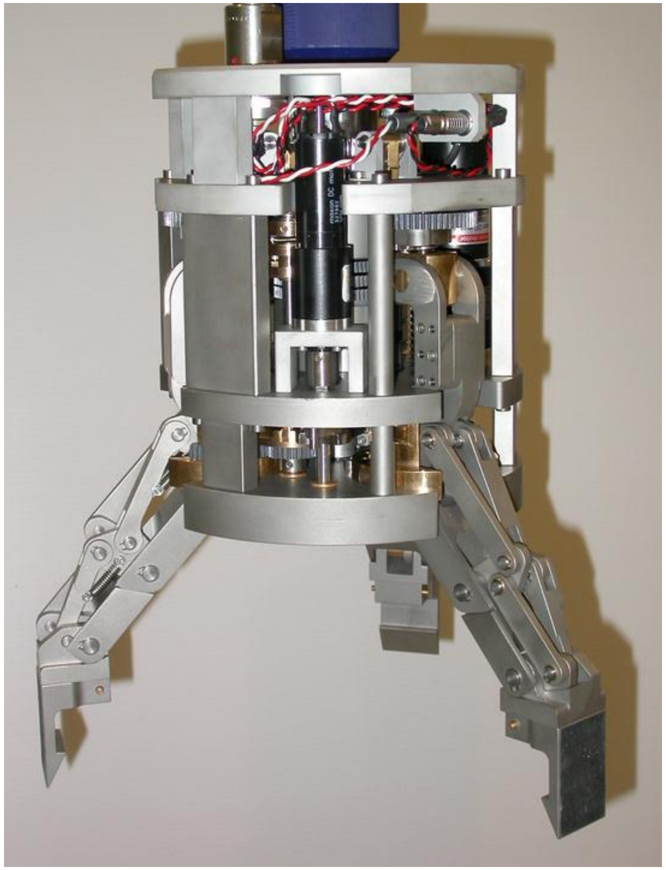
2004

APPLICATIONS IN PROSTHETICS AND HUMANOIDS



2005

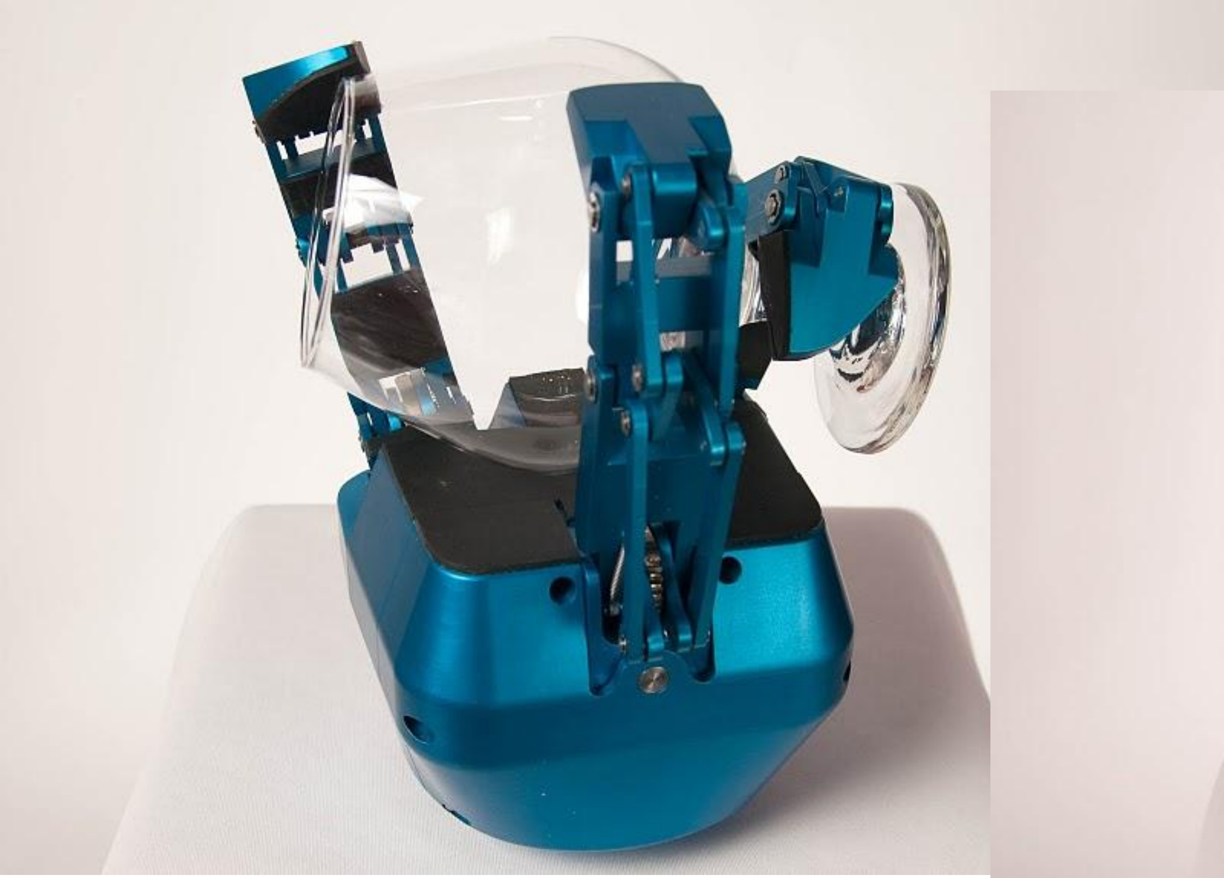
APPLICATIONS IN NUCLEAR INDUSTRY

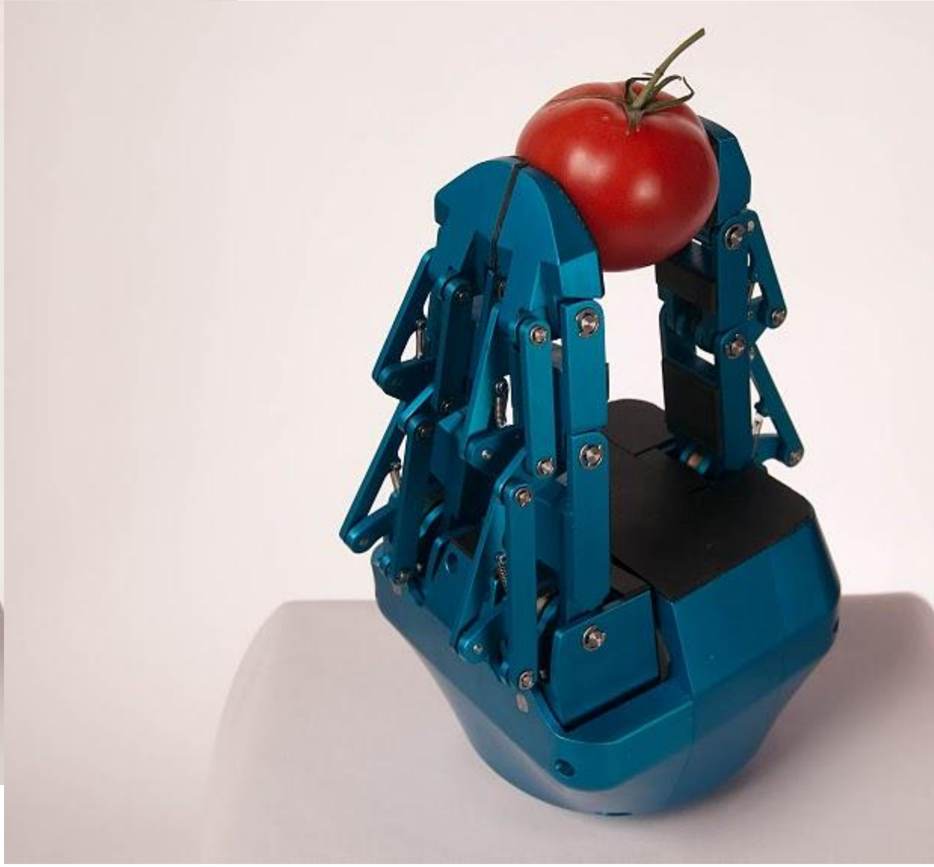


Built for UKAEA and delivered in 2006

In operation since then

Commercialization (Robotiq)





2009

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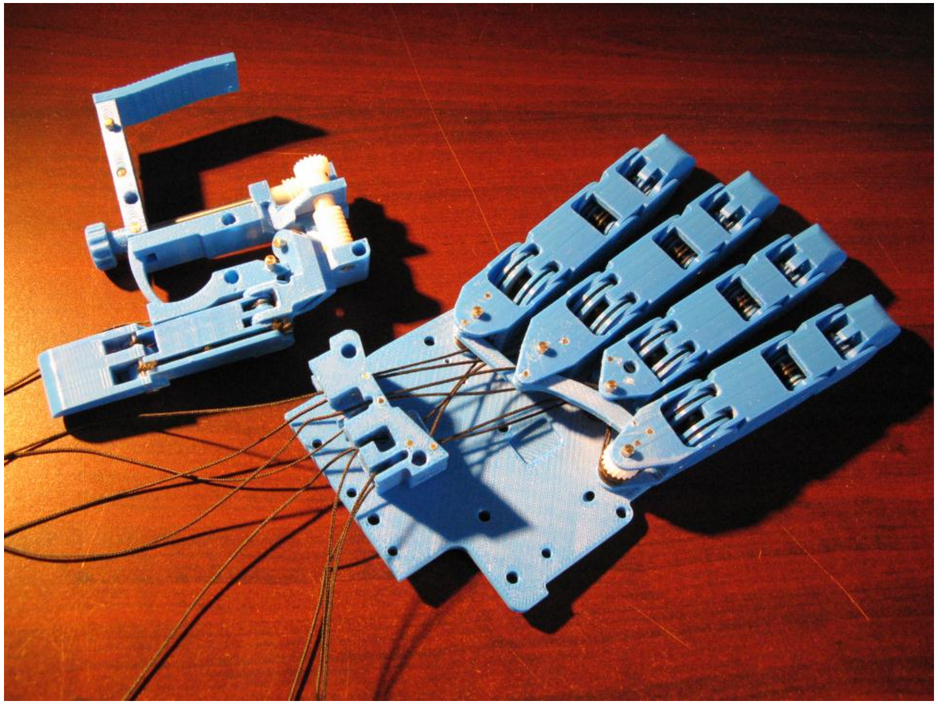
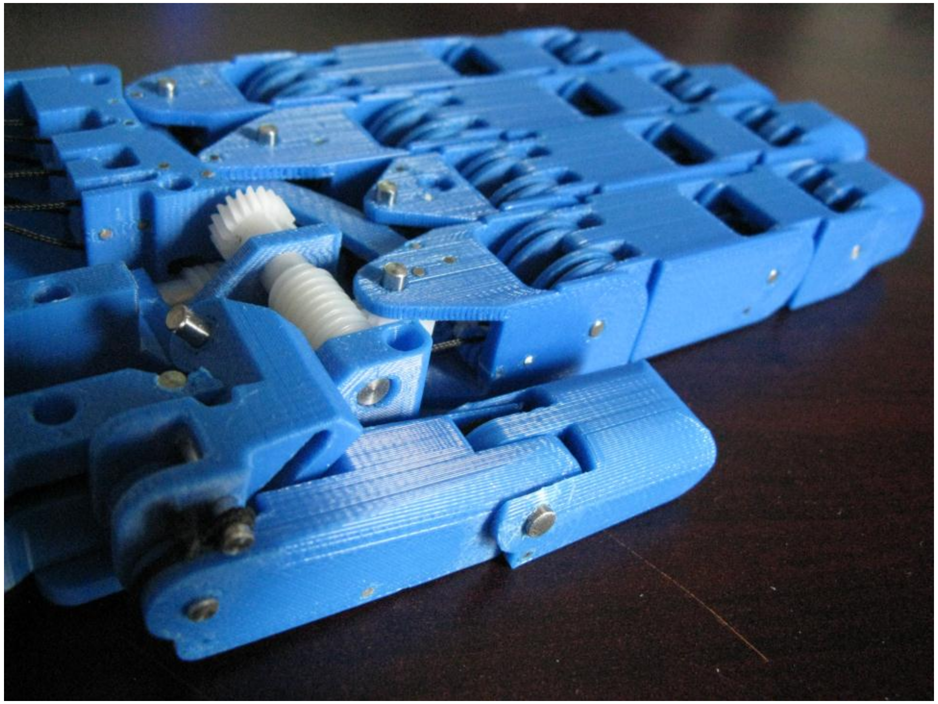
Commercialization (Robotiq)

Robotic hands currently under development

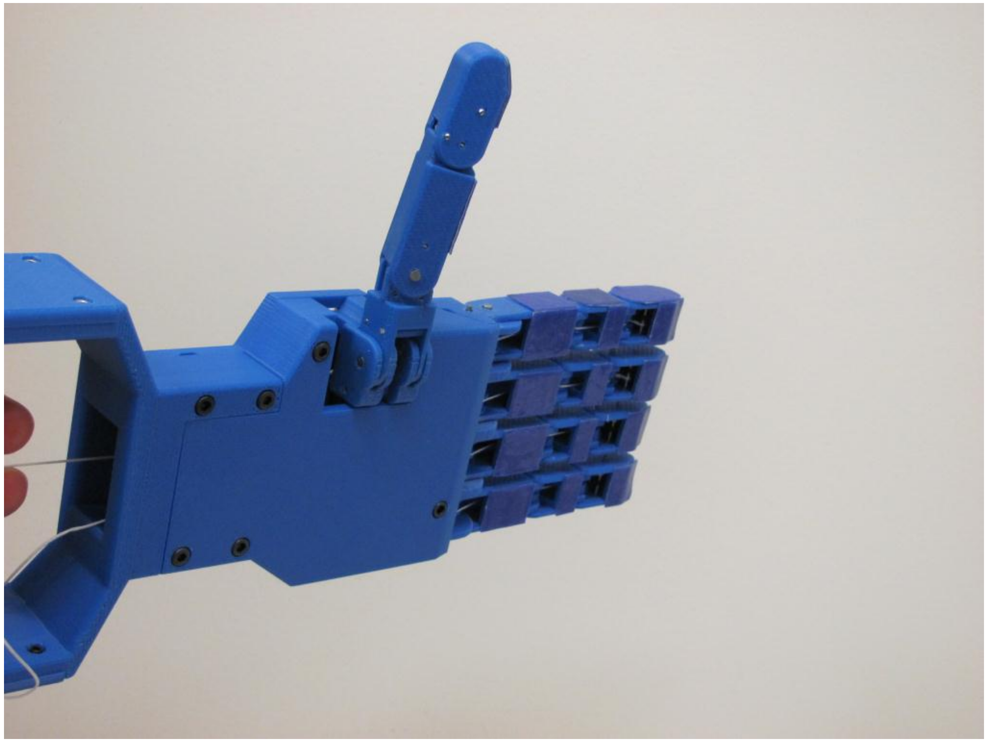
- 5-finger 4-actuator robotic hand (NAMUH)

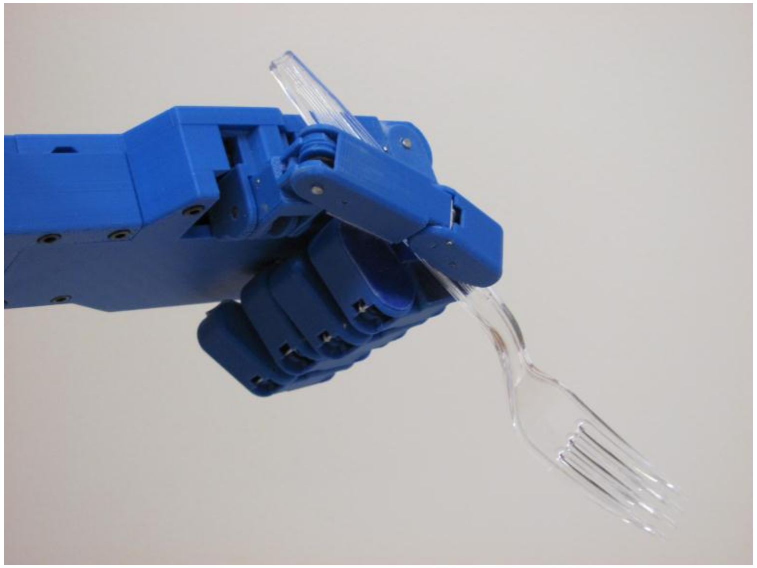




Robotic hands currently under development

- 5-finger 1-actuator prosthetic hand with reconfigurable thumb





- 5-finger 1-actuator prosthetic hand with reconfigurable thumb

- 5-finger 1-actuator prosthetic hand with reconfigurable thumb

Conclusions

- Underactuation is the most promising avenue for the development of robotic hands
- Mathematical modelling still poses several challenges
- Recent progress in actuators and sensors makes the development of effective underactuated robotic hands possible
- Many areas of application are open including industrial robotics

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