

Quantitative (and qualitative) methods in mechatronics research

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Mechatronics is integration

- Integration of engineering domains
 - Models, disciplines
- Functional integration
 - E.g. software and control can simplify and reduce complexity of mechanical designs
- Spatial/physical integration
 - Compact solutions with better functionality and performance

Types of research

- Research on the design process, e.g.:
 - How to teamwork in a multidisciplinary setting?
 - What's a good design process?
- **Research on design methods and tools, e.g:**
 - How to create and optimize multi-domain designs (everything affects everything)?
 - How to integrate models from different domains?
 - How achieve new functionality by optimally combining mechanics, electronics, software and control
- **Innovation oriented research**
 - There is this need – create a solution (product concept) for it?
 - We've invented this technology – where can we use and sell it?

From drivers to effects

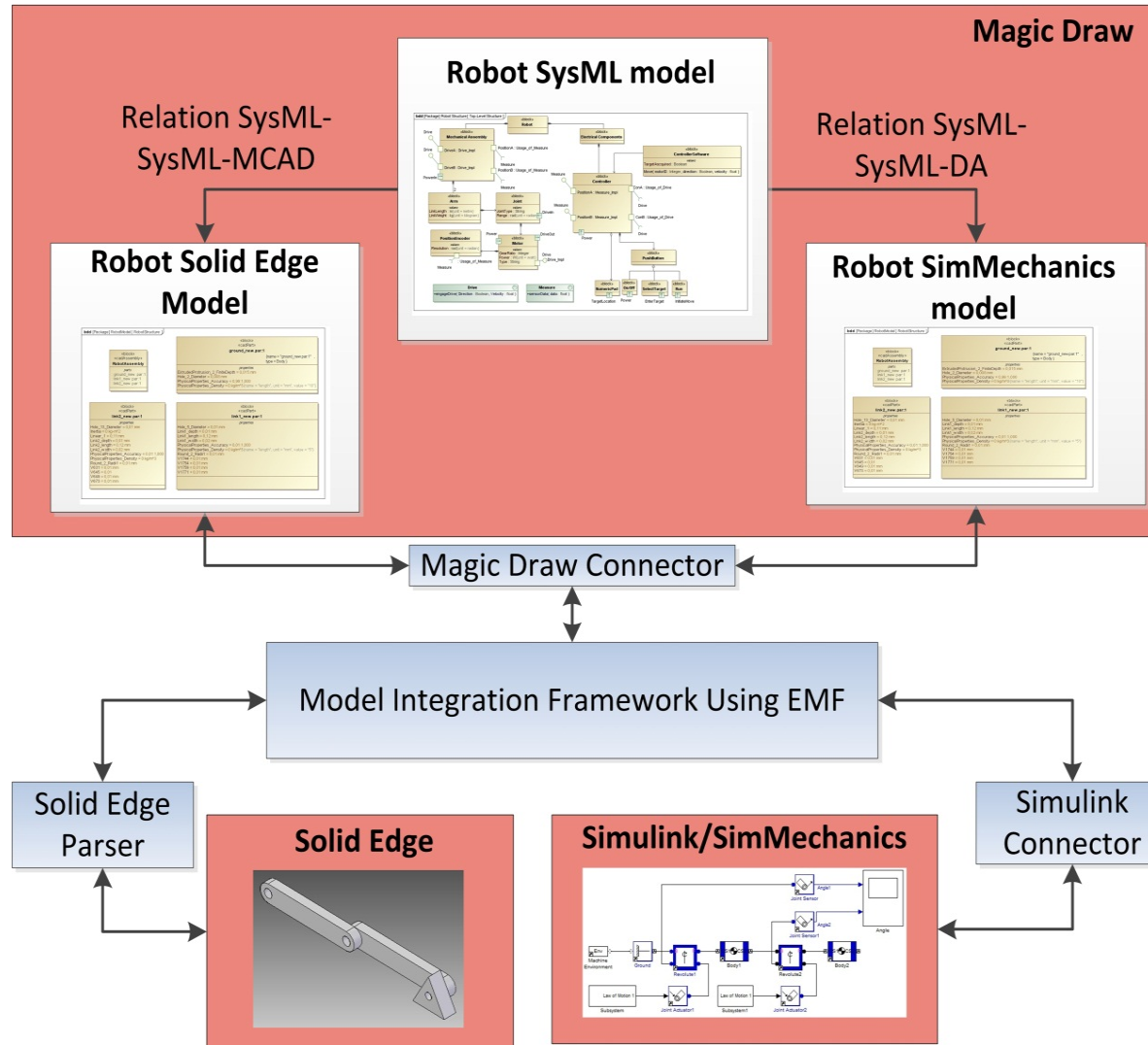
Drivers	Resources	Activities	Output	Results	Effects
Curiosity and creativity	Competence, state of the art	Technical research	Publications	New knowledge	Better products for a sustainable society
Funding	Funding	Courses, coaching, feedback	Theses	Educated people	Growth and work opportunities
Need - in industry - in society	Colleagues and partners	Communication, reporting, meetings, evaluations, workshops	Tool concepts	New business	Better education
	Students	Innovation	Product concepts	Scientific impact	University ranking
	Experimental Equipment		Patents		

Four examples:

- Methodology and tool oriented
- Curiosity driven
- Towards innovation and business
- Need driven

An Integrated Approach towards Model-Based Mechatronic Design (need driven)

The developed infrastructure



Quantitative issue:

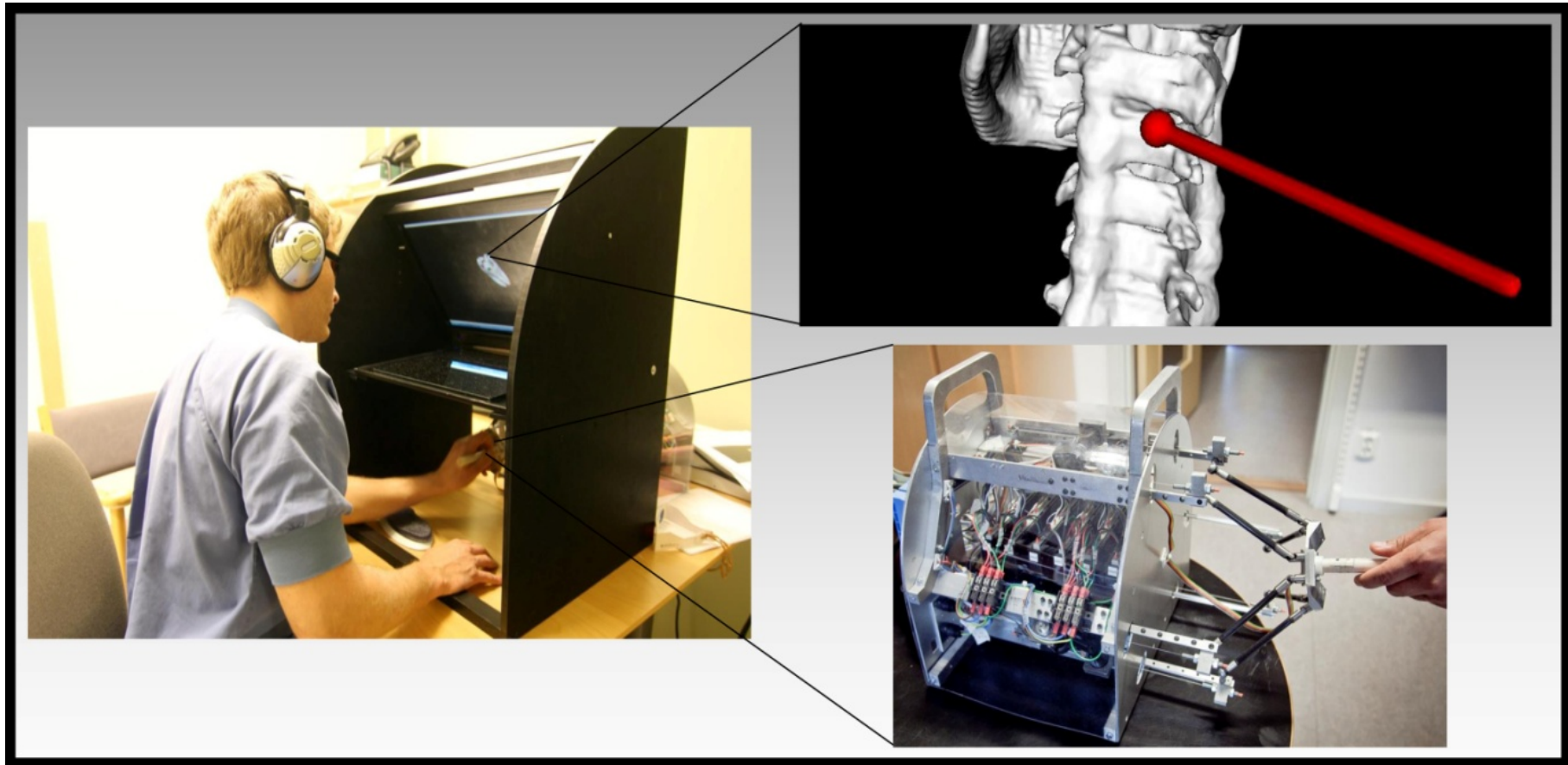
Can we demonstrate that model changes in one domain are correctly and automatically reflected in other domains/views? Are the models always consistent?

Qualitative issue:

Can we demonstrate that the developed infrastructure actually improves development efficiency?

Surgical simulation (need driven)

Bone Surgery Simulator



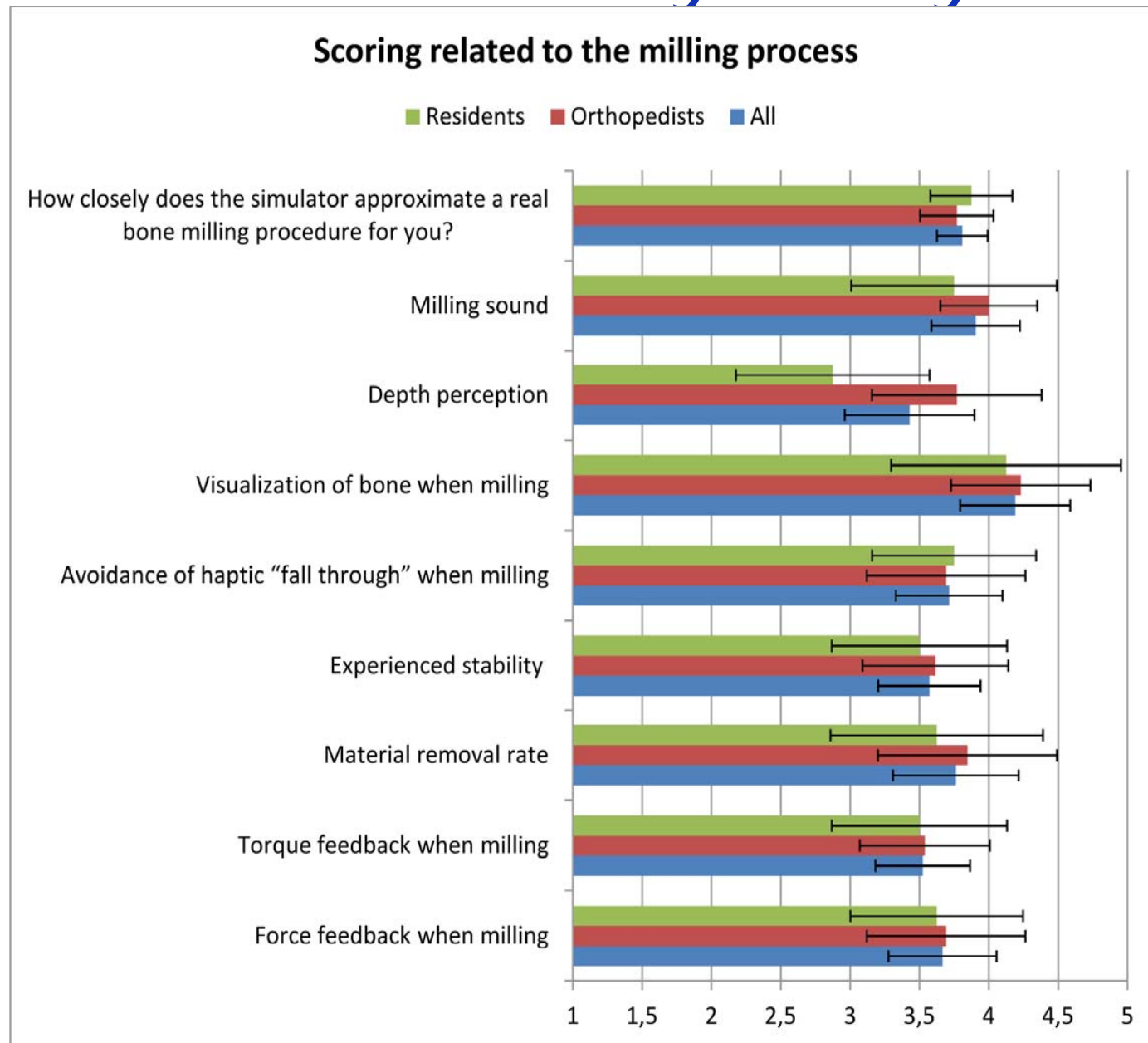
Quantitative issue:

How stiff surfaces can we simulate without stability problems?

Qualitative issue:

Does the system improve the medical skill? Does it save money in surgery education?

Face Validity Study



Mobile manipulation (curiosity and need driven)

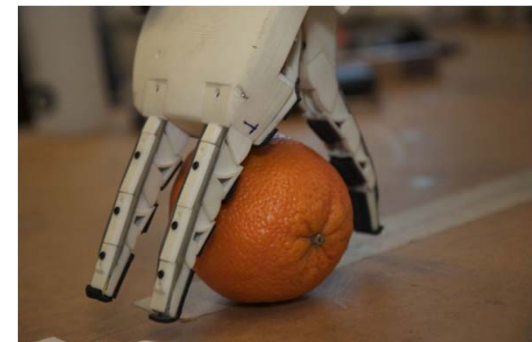
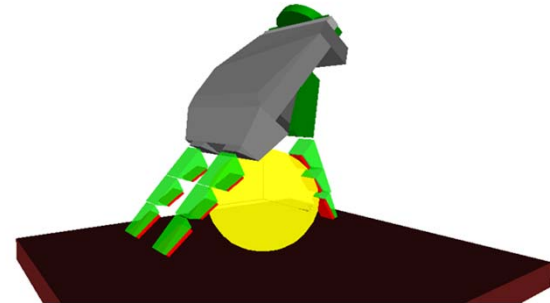
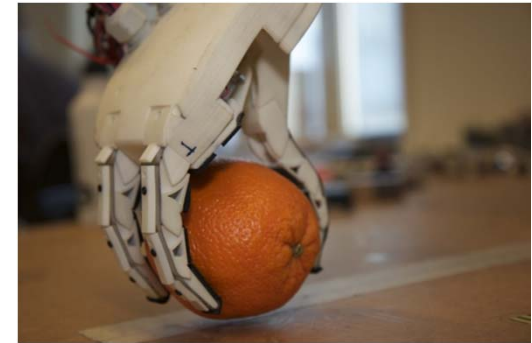
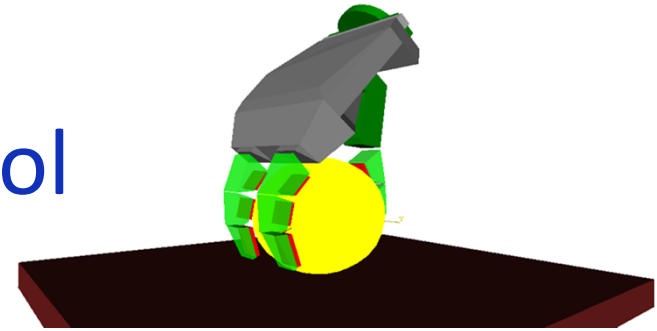
KTHand: Simulation & Control

Quantitative issue:

Is the control performance meeting the needs (precision, dynamics, force levels)? Is there a quantitative measure for grasp stability?

Qualitative issue:

How is this design accepted as a hand prosthesis?



“Soft extra muscles” (towards innovation and business)

Power enforcing glove (Exo-neuromuscular system)



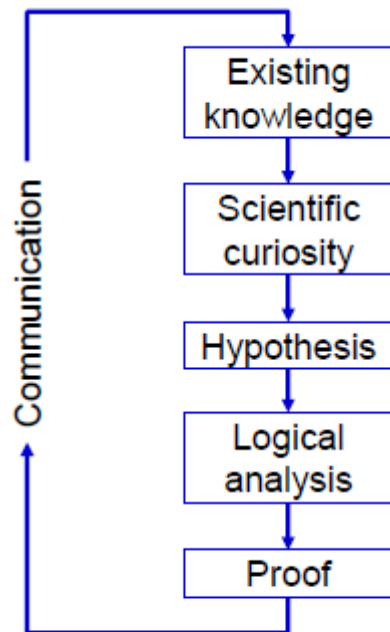
Quantitative issue:

Can the stability of the force-servoing control loop be proven?
How much can energy consumption be reduced by optimal control?

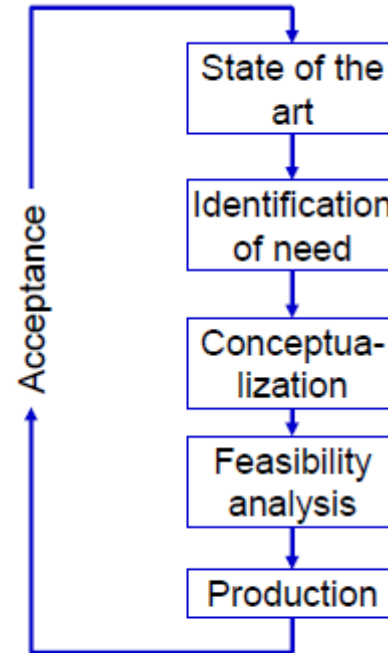
Qualitative issue:

Can we prove that this device helps in rehabilitation from one-sided paresis due to stroke?

Methods used

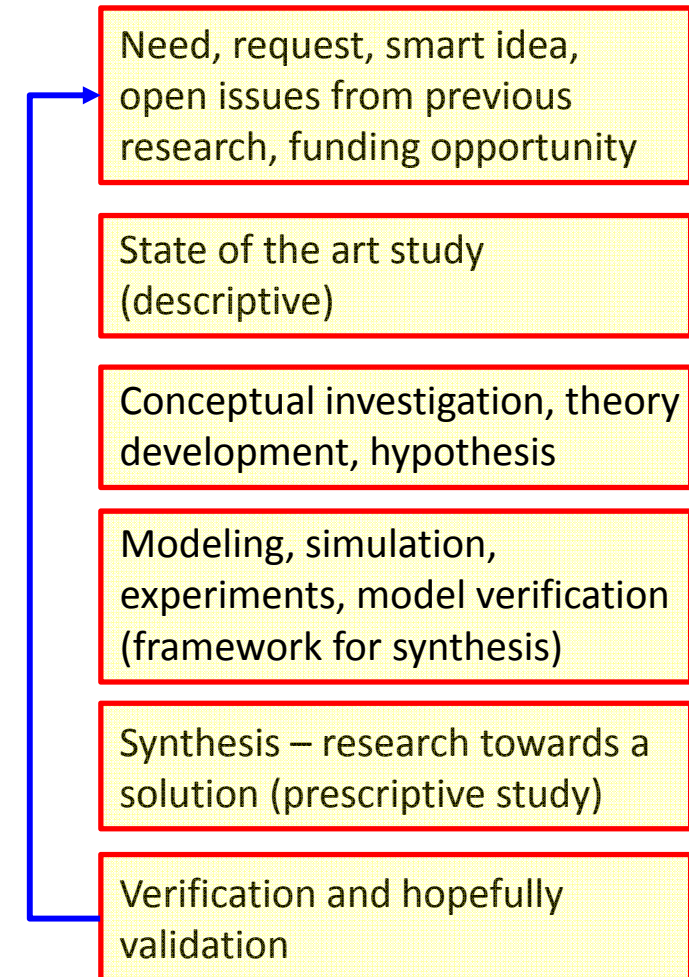


Scientific method



Design method

After Percy Hill, *"The Science of Engineering Design"*, Holt, Rinehart and Winton, New Yoork, 1970



Our method



Questions!