Integrating humanistic research in the development of training robots

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Invited talk at: The full day workshop on bodily human robot interaction
IEEE Human Robot Interaction Conference, Daegu Korea, 2019

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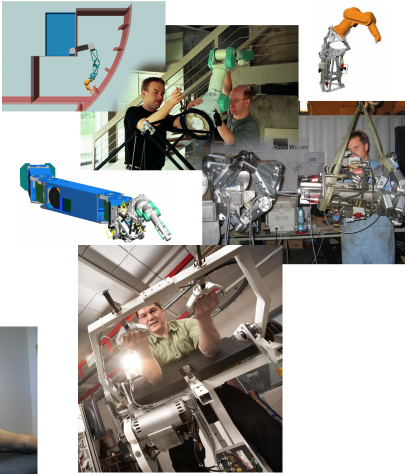
Created in LaTeX

Anders Stengaard Sørensen

Ph.D. Associate Professor Head of Training Technology Lab

- **Expert in computer control**
  - Sensors
  - Electronics
  - Physics
  - Math
  - Embedded systems
  - Robots
- **Taking an interest in**
  - Training
  - Rehabilitation
  - Bodily HRI



$$\int e^x dx = e^x$$
$$e^{j\pi} + 1 = 0$$

Talent: Experimental robot controllers

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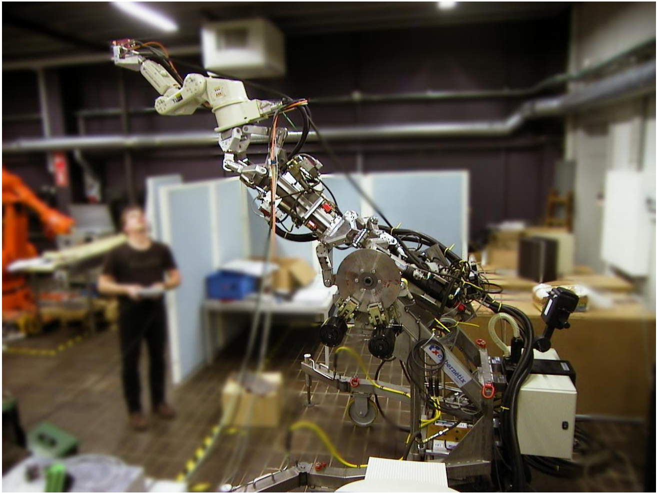

Ambition: μm precision — μs timing
Genric controller platform

Training Robots

SDU Training Robots 2010 — today

- **Rehab training**
- Elite training
- Preventive & recreational training

Tech	Health	
Robotics	Training physiology	
Platform	*Process*	

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Tech	Health	Hum
Robotics	Training physiology	Social practices
Platform	*Process*	*Meaning*

Example: Maximum load eccentric training

Film:

Mechanistic view is not enough!

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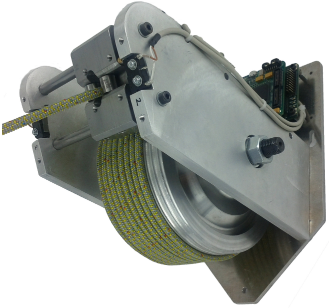
There is more to physical human interaction than physics!

Unknown author

First steps

- **Establishing the simplest possible framework**
  - Coordinated sequential interaction
  - Examples of actions
  - Examples of interaction sequences
- **Establishing common concepts and terminology**
  - Discussions and debate
  - Experiments and analysis
  - Teaching engineering students EMCA & Embodied interaction
  - Workshops
- **Describing, analyzing and learning from experiments**
  - Impedance states
  - Impedance transitions
  - Actions that are recognized (Cataphoric)
  - Actions that are not
  - Tools for integrated video-, state- and sensor- analysis
- **Conclusions, suggestions and improvements**
- REPEAT!



RoboTrainer-Light

- Rope pulling "robot"
- "Impedance machine"
  $F = \psi\left(t, x, \frac{dx}{dt}, \frac{d^2x}{dt^2}, \ldots\right)$
- High bandwidth dynamics
  FPGA control system
  (Much faster than humans)

Remember Gitte's talk?

Embodied actions. . .

- Production
- Perception
- Typification

Simplest possible robot equivalent?

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State machine (DFA)

- Set of states
- Set of input 'symbols'
- Transition function

It is far from a perfect equivalent!

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Detailed:
Humans are oriented towards details when categorizing behavior as actions, and typifying these.

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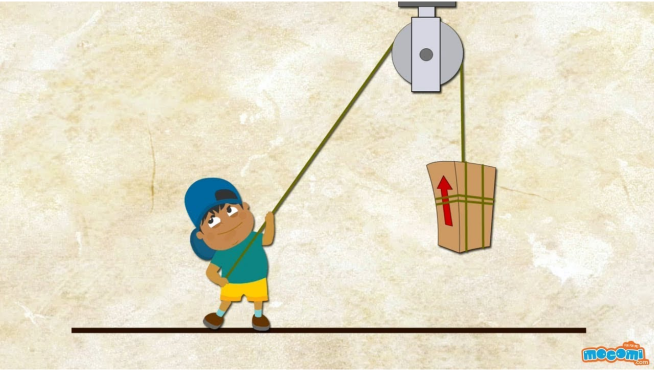
Detailed:
Humans are oriented towards details when categorizing behavior as actions, and typifying these.

Coarse:
The robot's ability to differentiate human behavior onto a set of 'input sybols' is extremely limitied compared to the humans.

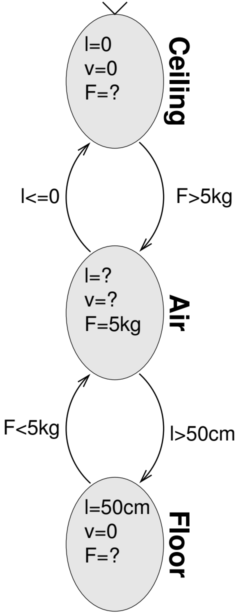
EMCA study of a pulley

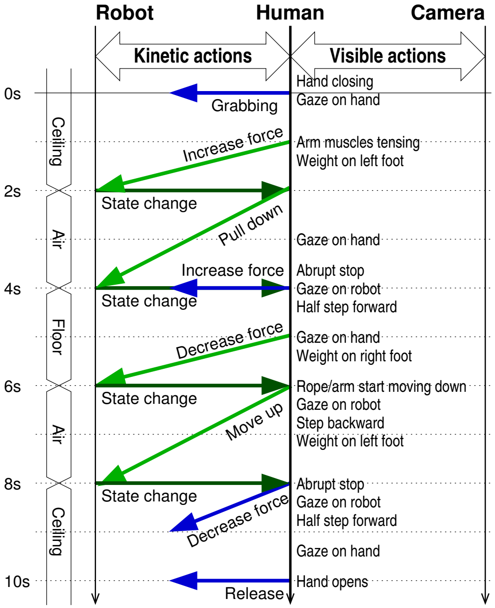


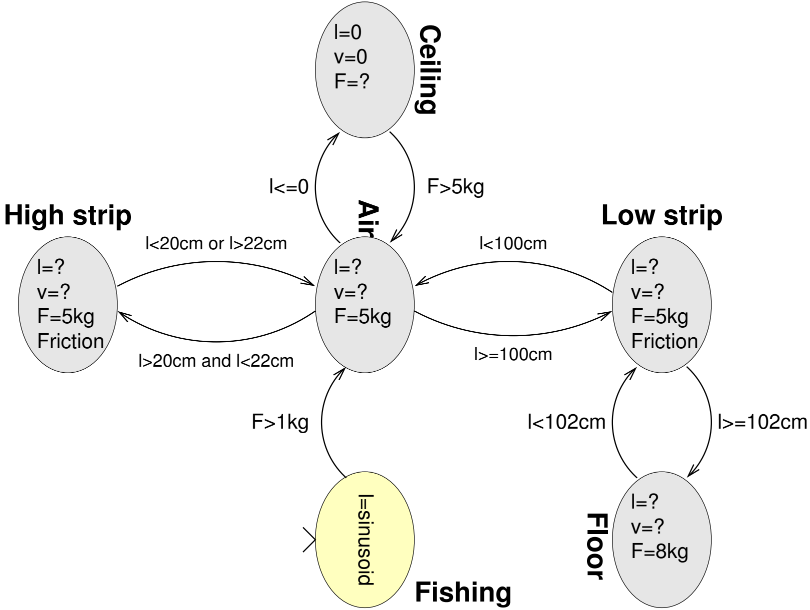
Unknown artist

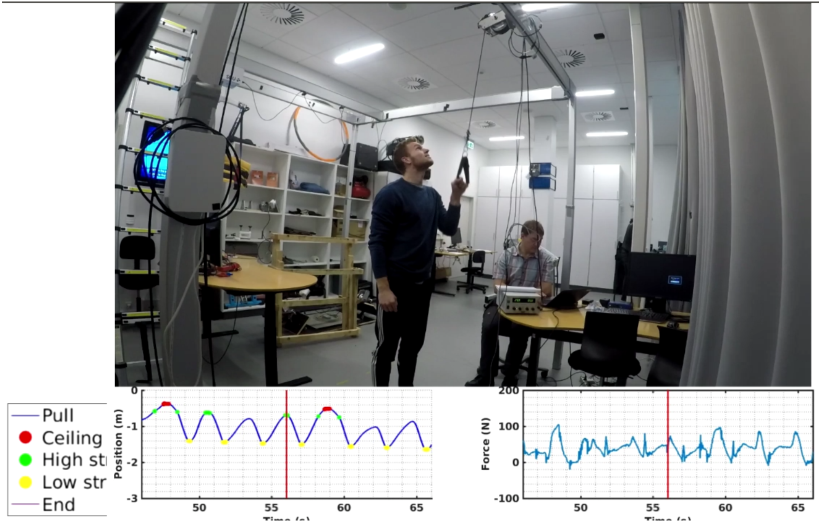
- 2 end-stops: Ceiling and Floor.
- Constant load in the air between them.

Example state machine






Ceiling
l=0
v=0
F=?
l<=0
F>5kg
Air
l=?
v=?
F=5kg
High strip
l=?
v=?
F=5kg
Friction
l<20cm or l>22cm
l>20cm and l<22cm
Low strip
l=?
v=?
F=5kg
Friction
l<100cm
l>=100cm
F>1kg
l=sinusoid
Fishing
l<102cm
l>=102cm
Floor
l=?
v=?
F=8kg


Pull
Ceiling
High st
Low str
End
Position (m)
0
-1
-2
-3
50
55
60
65
Force (N)
200
100
0
-100
50
55
60
65

Film:

Much can be learned about Bodily Human Robot Interaction from this.

Very obvious was:

- Subjects engage differently, highly influenced by intial visual cues.
- Subjects react differently to the slow range change.
- All subjects reacted identically to the floor. 60% force increase convinced everyone to change direction.

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Lessons on integrating HUM

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    - And we empower the engineers to understand and analyze human behavior as it is, not as math models

Thank you