

Augmented Gravity: Making bodily interaction natural

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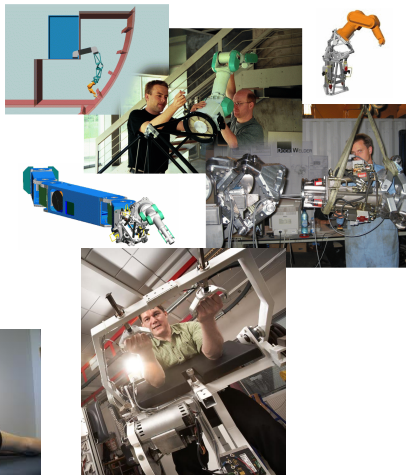
Invited talk at: The full day workshop on bodily human robot interaction
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Anders Stengaard Sørensen

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- **Expert in computer control**
 - Sensors
 - Robots
 - Electronics
 - Physics
- **Curious outsider in**
 - Training
 - Rehabilitation
 - HRI



Consider this scenario



Film:

Jesper Kiersgaard is Training his Biceps and Triceps (june 2011)

How much "weight" is he pulling here?

(Hint: I can pull 15-20kg)

Gravity is 1...200% too strong!

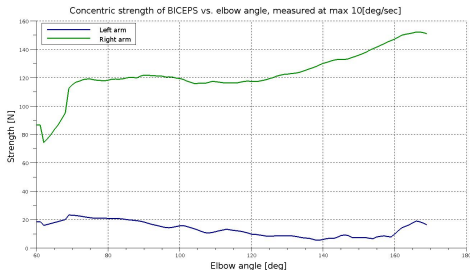
How much weight is he pulling?

How much weight is he pulling?

Answer: $\approx 1\text{kg}$

... and the robot is lifting the remaining 1kg of his arm

He is 90% paralyzed in left arm (motorcycle accident)



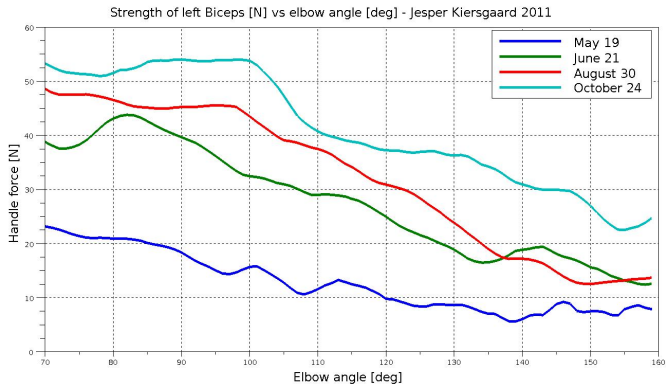
Jesper started training 3 years after the accident. With only 10% strength after 3 years of recovery and standard rehab training.

Procedure:

- The robot “removes” gravity
- But provide resistance — like friction
- It creates an illusion of the arm working
- That stimulates growth of neural pathways
- Jesper has been training $\simeq 3 \times 20$ minutes / week for 6 months.



Lets look at the data



Film: 3D-data

Today, Jesper can use his arm — but shoulder is still lame

Exoskeletons - exotic



Simpler alternatives



Film: Universal Robotrainer

We want to develop feasible technology for ordinary people

- Cost
- Ease of use
- Acceptance

A center with 10 Universal RoboTrainers



And ≈ 2 therapists

Can perform 100-200 specialized sessions per day

A center with 10 Universal RoboTrainers



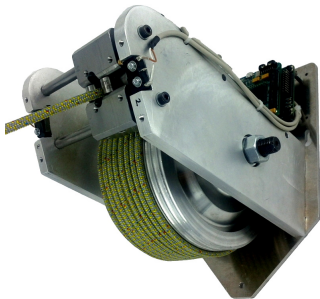
And ≈ 2 therapists

Can perform 100-200 specialized sessions per day

But not at home — too expensive.

Let's go simpler still.

An interactive crane assisting with the training



50% of the effect — for 1% of the price ... maybe

At 500EUR, it is feasible for home use, specialized for

- Stroke victims
- Accident victims
- Neurological diseases
- Muscle-skeletal impairments

film

- Implemented in FPGA
- Using TOS-NET framework
- Detailed control of motor switching
- Ultra fast DSP and control loop (800kHz)
- Optional link btw 15 robots
- USB connection to PC
- High level control on PC
- GUI on PC, Tactile UI on Robot



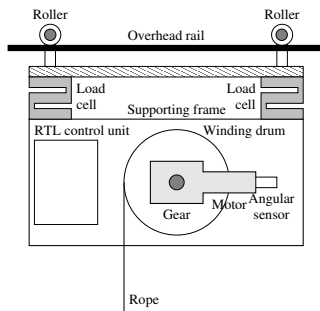
- 0 . . . 30 kg weight relief
- Full range of motion calibration
- Hysteresis control to counter spasticity
- Works with paralysis victims with 2 . . . 20% remaining strength

Film:



Film:

- Refurbished commercial lift
- 0...200kg relief
- Straight Walking
- Sit to stand
- Stair walking





- Case: 45 year stroke victim
- Left side paralysis
- \approx 2 years of good rehab training
- Prognosis: Wheelchair for life
- Prognosis: Useless arm
- Training 3 \times 90 min weekly
- For 16 weeks

Film:





- Astronaut training
- Simulated microgravity
- Pulleys and long ropes
- Robots simulate 0 . . . 0.5 g
- Normal strengths exercises

Film:

This research inspired the Tarzan device recently commissioned by ESA

Augmented Gravity appear to be effective and versatile

- Accident victim
- Stroke victim
- Astronauts
- Elite athletes

We will continue by:

- Creating a Clinic: RoboTrainer-Academy
- Collaborate with hospitals in taking in on more patients
- Collaborate with Danish Olympic Teams to train athletes
- Expand collaboration with Danish Aerospace Company
- Securing international partners for commercialisation