APPROACHES TO POWERED UPPER LIMB ORTHOTICS

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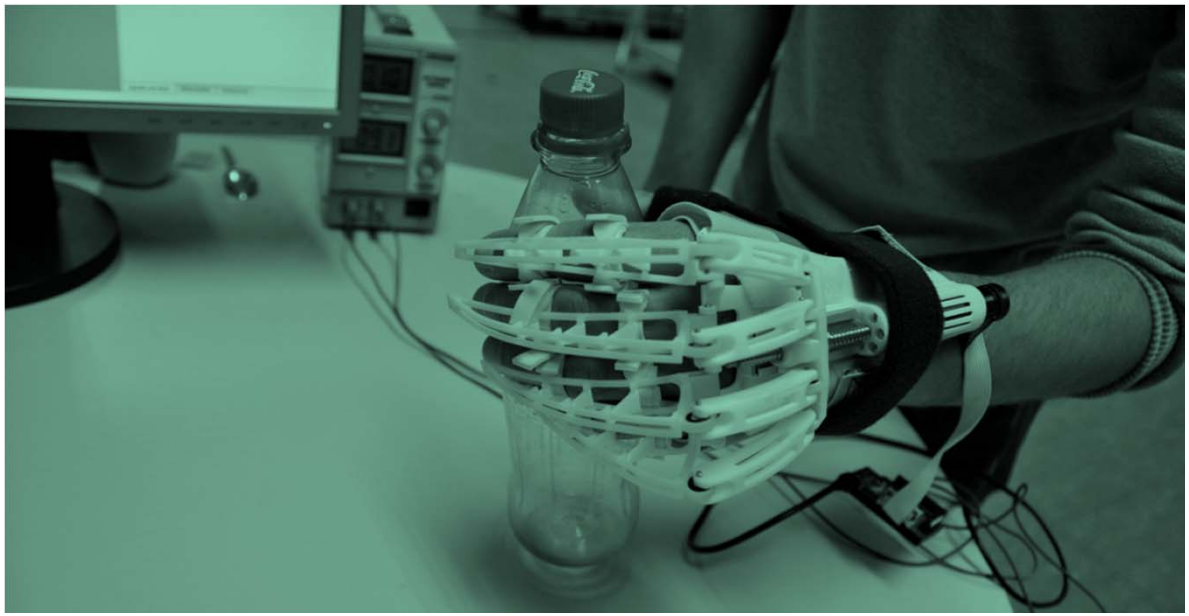

Fraunhofer IPA

- **Rehabilitation of hand function after stroke:**
  BCI activated and motorised finger gripping function

- **Rehabilitation of elbow function after stroke, br plexus injuries:**
  EMG activated and motorised elbow flextion function

- **Prevention from elbow and shoulder overload in heavy physical work:**
  User activated power assist approach for elbow and shoulder actuation

BCI activated and motorised finger gripping function

Wearable interfaces for hAnd function recoverY
FP7-ICT-288551

Background

- Reduced hand function is significantly ristricting in daily functions
- after stroke, brachial plexus injuries or cervical spine injuries
- In early stroke rehabilitation the patient may be able to generate the intended motor cortex signal but may not be able activate the related hand muscles properly.
- Sensory feedback from hand movement may stimulate brain function regeneration.
- In some patients no sufficient hand gripping forces can be restored.

BCI activated and motorised finger gripping function

Wearable interfaces for hAnd function recoverY
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Concept

- Brain Computer Interfaces (BCI) can detect„open hand“ versus „close hand“ motor cortex signals with above 90% repeatability (here Tuebingen BCI model).
- These signals may be used to activate a powered glove.
- Afferent feedback to the sensory cortex can be generated from hand function.

BCI activated and motorised finger gripping function

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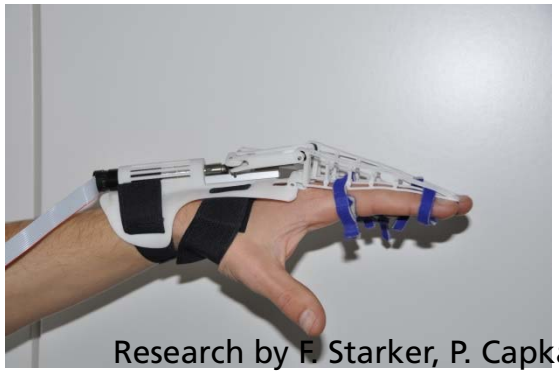
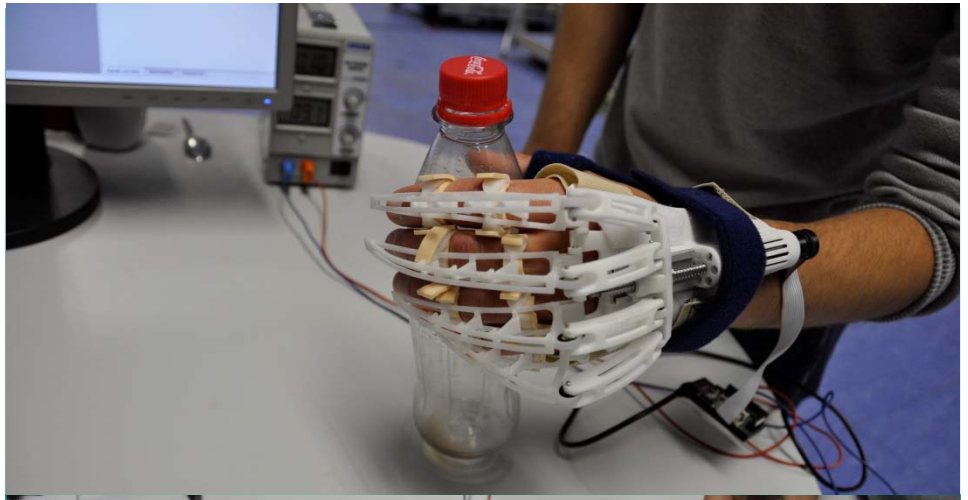
Functional Prototype 2

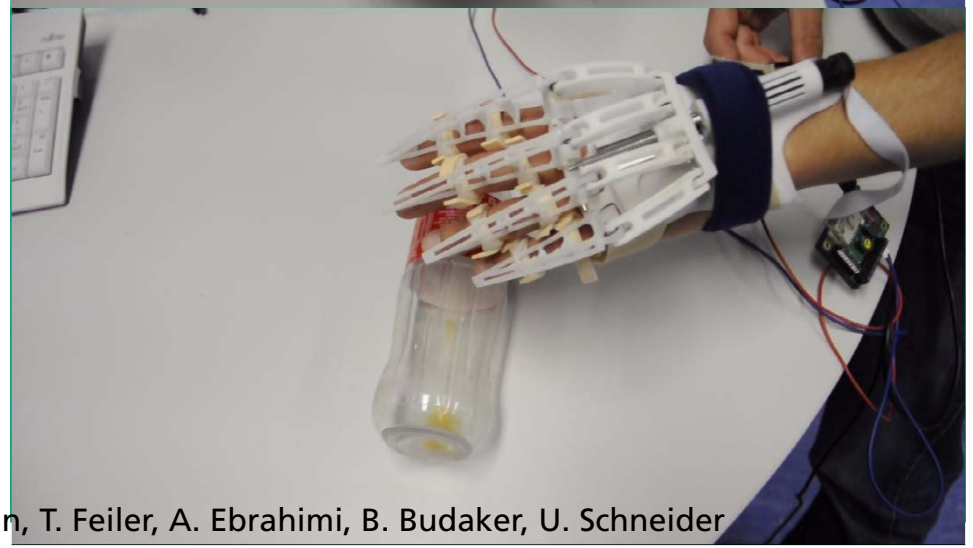
- Simplified ergonomics
  - for user with hemiparesis -> hardshell easy entry
  - Simplified 3D finger mechanics
  - Minimized weight
  - Optimized tolerances between drive system and hard shell



Research by F. Starker, P. Capka, F. Dennerlein, T. Feiler, A. Ebrahimi, B. Budaker, U. Schneider

BCI activated and motorised finger gripping function





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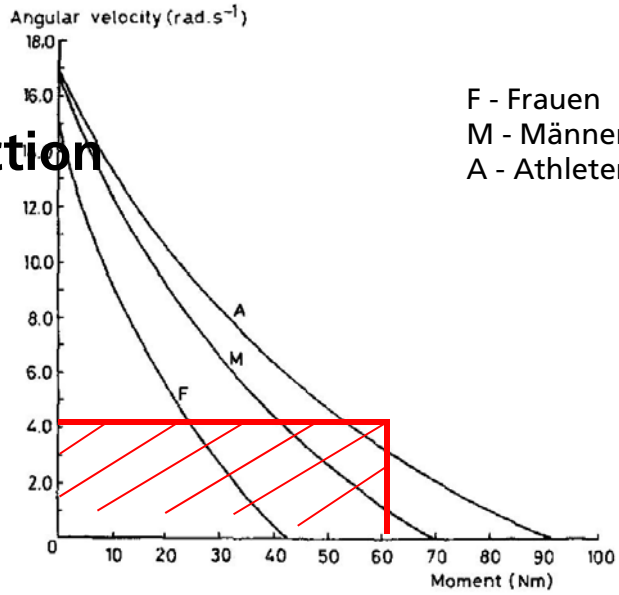
EMG activated and motorised elbow flexion function

Background

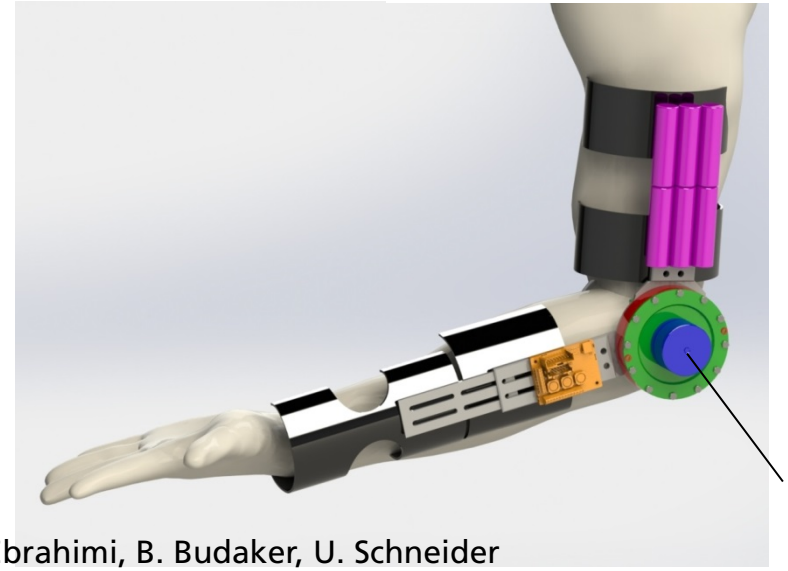
- Reduced hand arm function is significantly ristrictingin daily functions
- the arm is rarely used if elbow flexion remains weak after stroke, brachial plexus injuries or cervical spine injuries.
- If sensoric perception is still available the upper extremity can still be part of the perceived own body.
- An EMG actuated powered elbow orthosis combined with passive shoulder and hand stabilisation may give back holding and eating assist functions in daily life.

EMG activated and motorised elbow flexion function



F - Frauen
M - Männer
A - Athleten

- **Drive Parameters**
  - Power
  - Nominal Torque
  - Nominal Speed
  - Dynamic Torque Velocity Charactristics



Harmonic Drive

Motor

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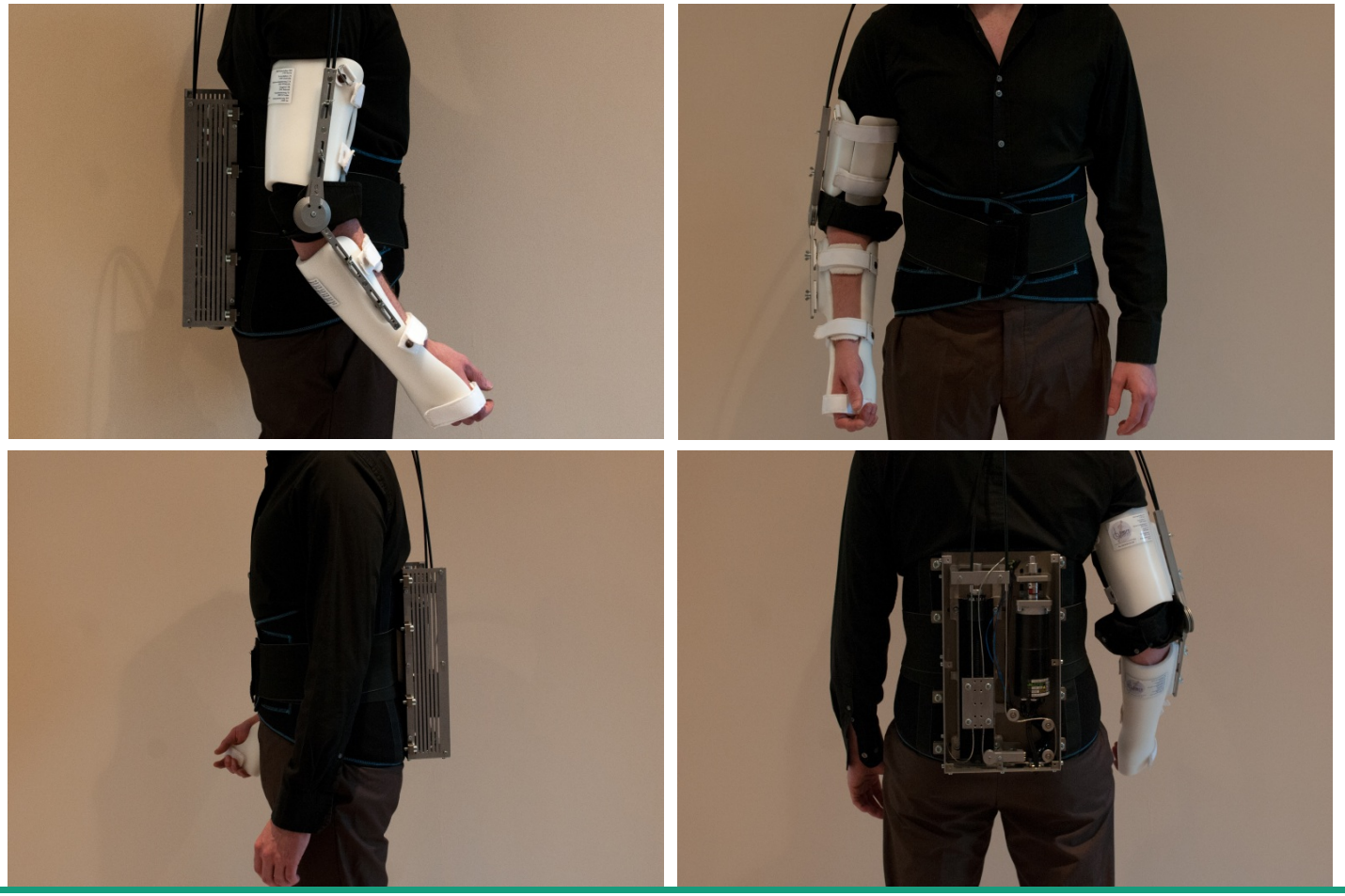
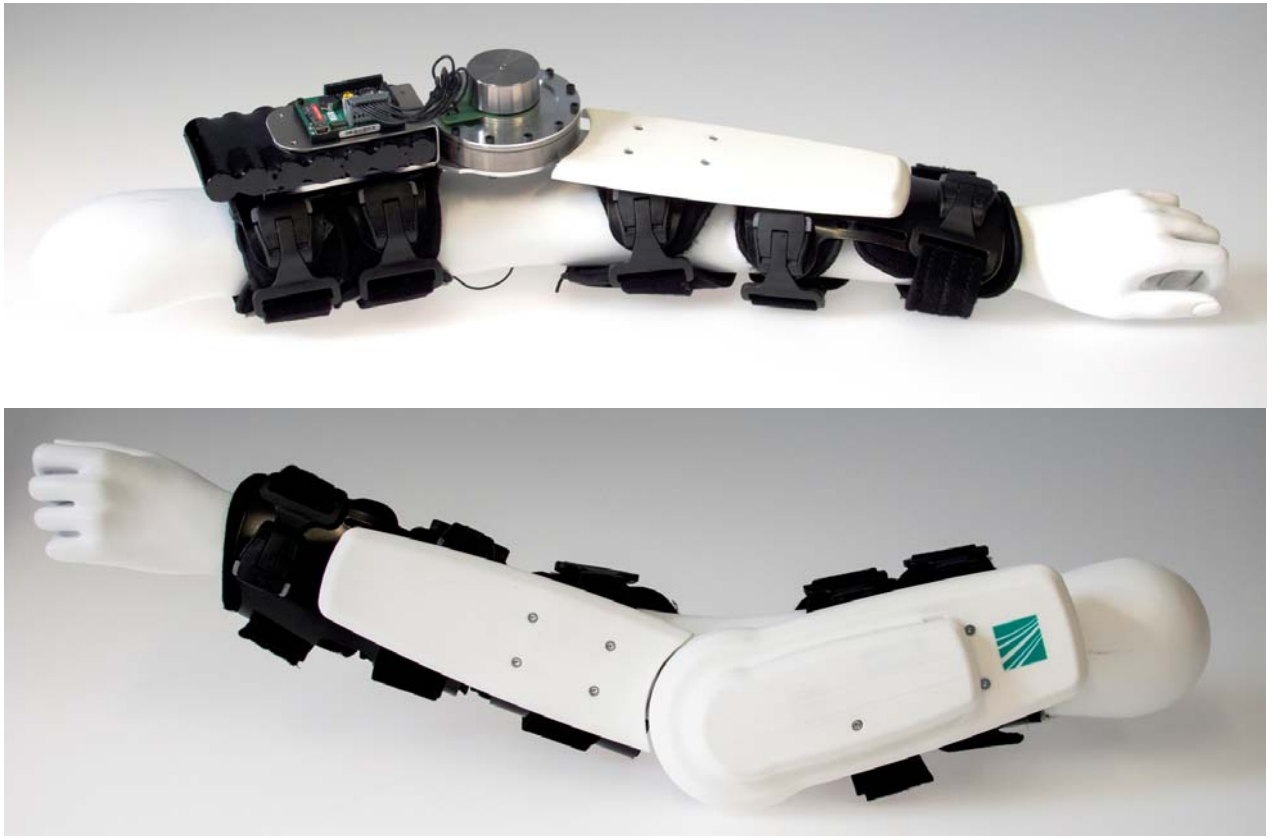
EMG activated and motorised elbow flexion function

Concept



EMG activated and motorised elbow flexion function

- Compact
- High Power Density
- Integration of Battery System and Motion Controller
- Position, Speed and Torque Control
- Modular Design
- Flexible safety features



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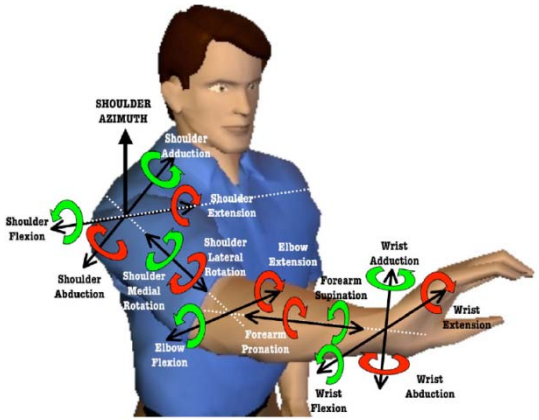
User activated power assist approach for elbow and shoulder actuation

Background

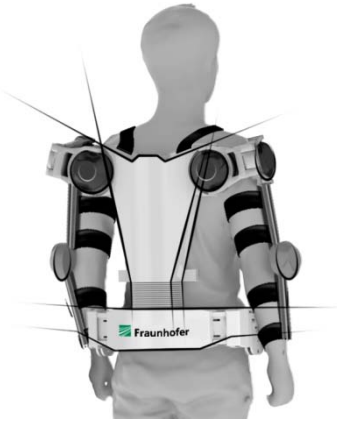
- Chronic diseases of the musclo-sceletal system caused by mechanical overload:
- in heavy industry assembly and airport logistics
- (e.g. Osteoarthritis of spine, shoulder joint, elbow joint)
- can make it impossible for workers to keep their speciality
- can lead to loss of job, retirement
- can lead to significant healthcare and retirement pay investments for employers.

User activated power assist approach for elbow and shoulder actuation



- Movement velocity, diversity and generated forces in healthy workers can be much higher than in medical treatment devices
- drive power-to-weight conflicts occur in engineering
  - due to high angular velocities and loads
  - multiple motion axes to be motorized (e.g. shoulder joint)
- Dynamic dexterity can easily be blocked by functionally limited orthotics
- User Intent to assess robustly in high velocities.

User activated power assist approach for elbow and shoulder actuation



Design J. Lefint

- To minimize the drive train work to additional net positive power during active dynamic arm lifting
- To create a highly flexible passive kinematic joint solution for shoulder and elbow
- To power assist only the sagital flexion axes of elbow and shoulder for weight lifting
- To activate power assist by user switch decission.
- To target < 10kg and < $k10 component costs

User activated power assist approach for elbow and shoulder actuation

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Summary

- Active upper limb orthotics may assist in early stroke rehabilitation.
- A new generation of power assist orthoses may qualify affected limbs to regain daily functions of the affected limb after stroke, brachial plexus injuries or cervical spinal cord injuries.
- Considering the dynamic torque velocity charactristics of drive systems is key to engineering solutions.
- This is a specific challenge in fast upper extremity exoskeletons for healthy workers.

Thank you for your attention!