

Rehabilitationsroboter, Exoskelette und Braitenbergvehikel

Lehrevaluation

Indikator: Zufriedenheit mit der Lehrgestaltung.

Die Lehrveranstaltung ist außerordentlich gut organisiert.

Der inhaltliche Aufbau der Lehrveranstaltung ist für mich nachvollziehbar.

Die Ziele der Lehrveranstaltung werden transparent gemacht.

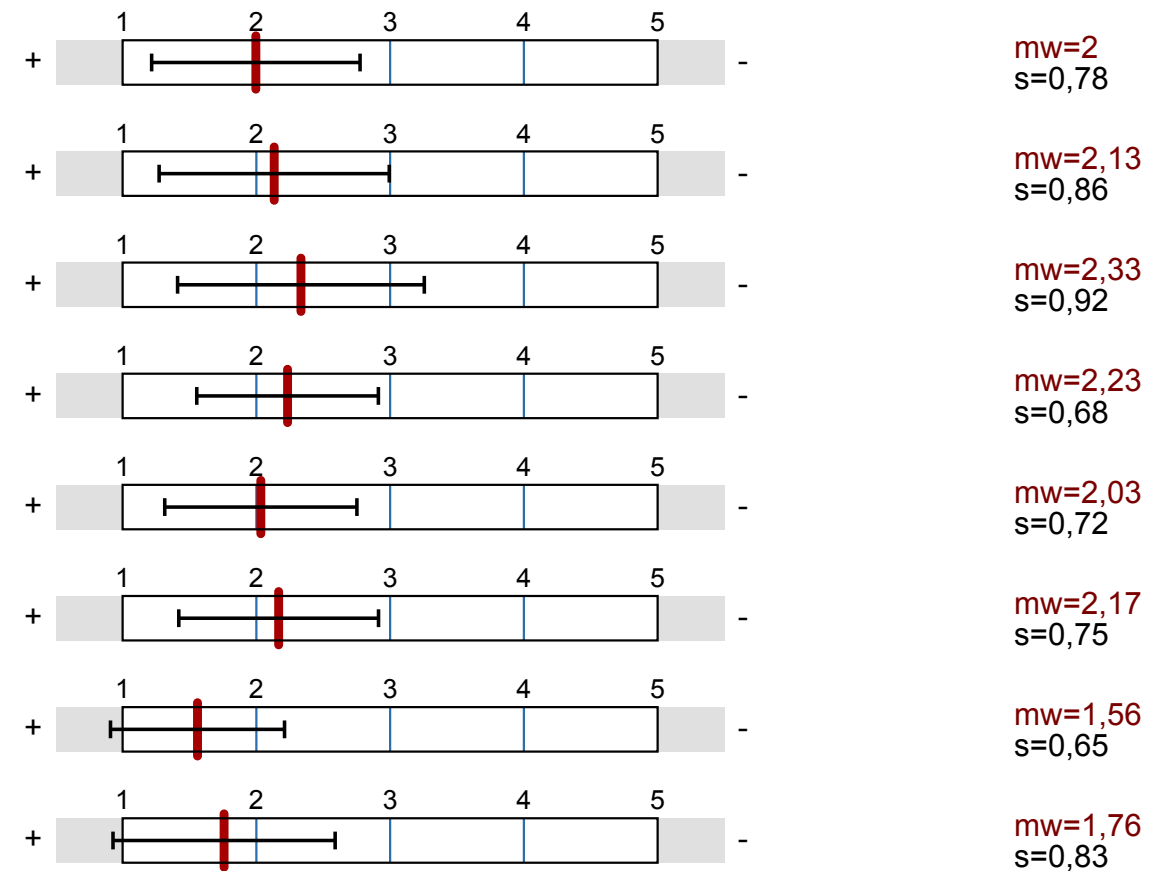
Die Inhalte werden verständlich erklärt.

Ich werde zum Mitdenken motiviert.

Vor und nach den Lehrveranstaltungen wird auf die Belange der Studierenden eingegangen.

Mir wurde klar, welche Bedeutung die behandelten Themen für mein Studienfach haben.

- **gut:** Beispiele, LEGO, M3 Seminar, fachkundige Dozenten



- **schlecht:** Folien, Muskelphysiologie bekannt, Organisation M3 Seminar

Exoskelette

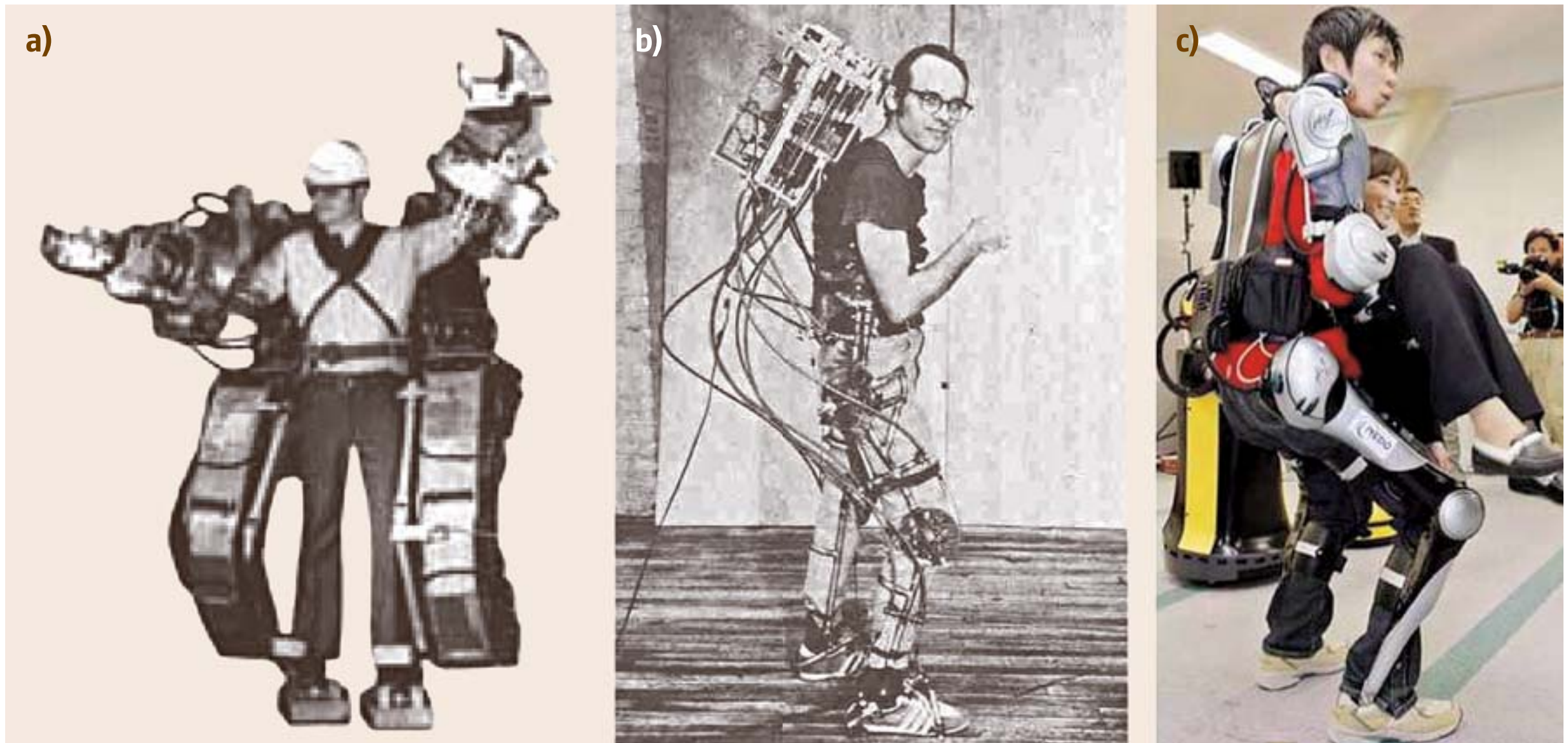


Fig. 33.1 (a) Hardiman; (b) An exoskeleton system designed for paraplegics by Seireg et al. [33.9]; (c) HAL

Exoskelette der oberen Extremität



Fig. 33.3a,b Two-handed upper-extremity exoskeleton where artificially built friction forces between the load and the arms allow for grasping objects [33.25]



Fig. 33.4 One-handed upper-extremity exoskeleton where a griper allows for grasping of heavy objects [33.21]

Exoskelette

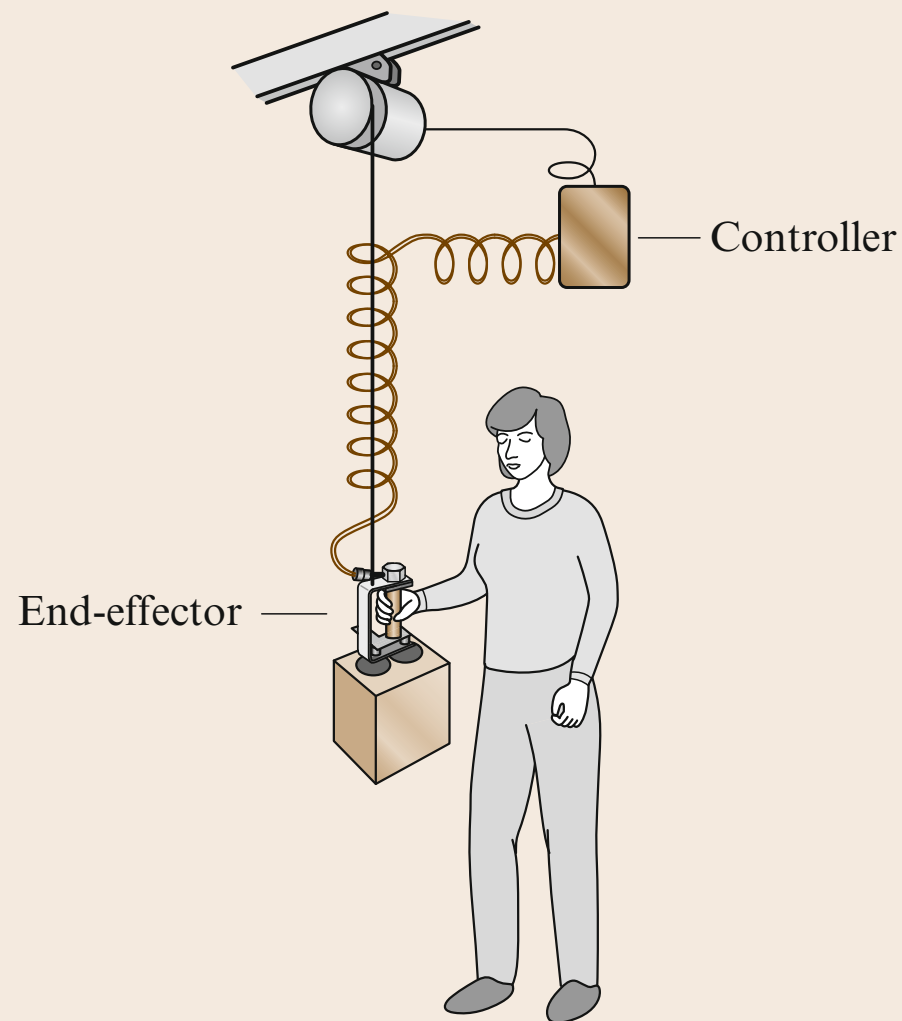


Fig.33.5 Intelligent assist device: the simplest form of upper-extremity enhancers for industrial applications. The IAD can follow a worker's high-speed maneuvers very closely during manipulations without impeding the worker's motion.

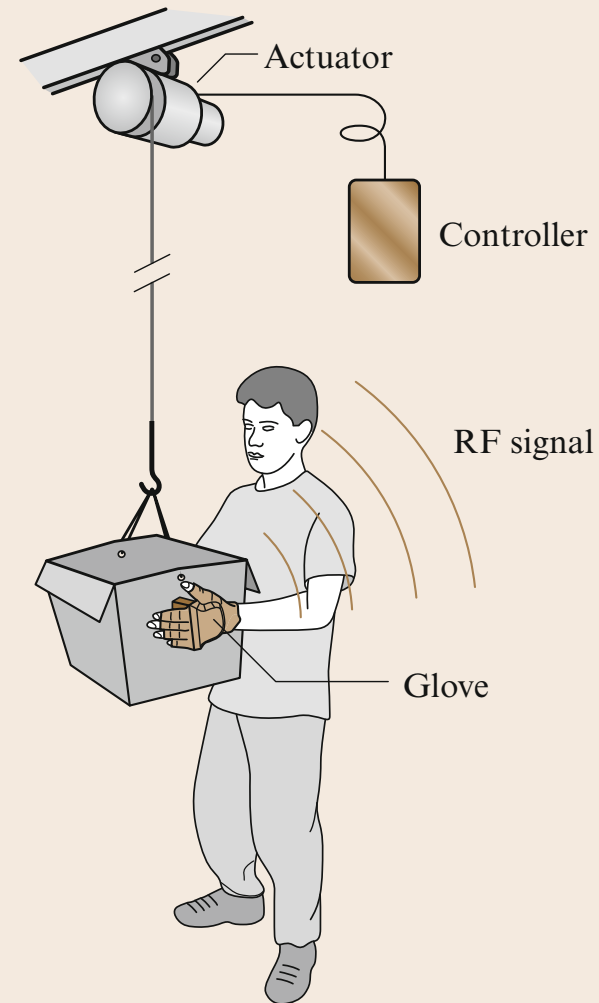
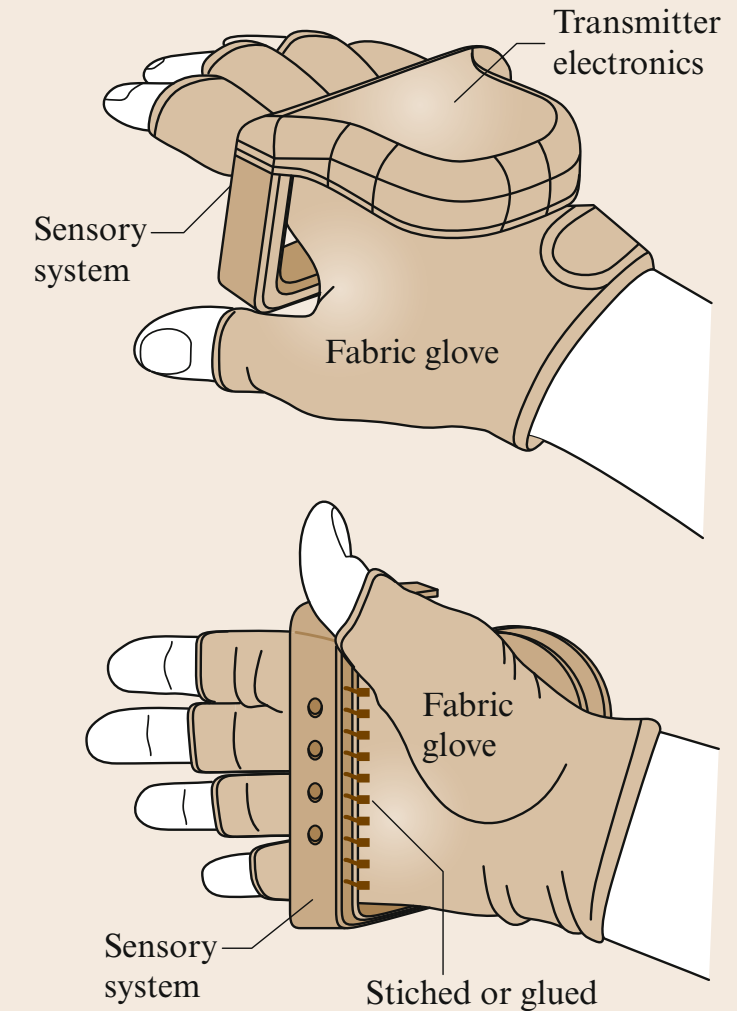


Fig. 33.7 An instrumented glove allows an operator to lift and lower objects naturally while using a hoist, similar to the way one maneuvers objects manually without activating switches or push buttons [33.34]



Kontrolle von Exoskeletten der o. Extremität

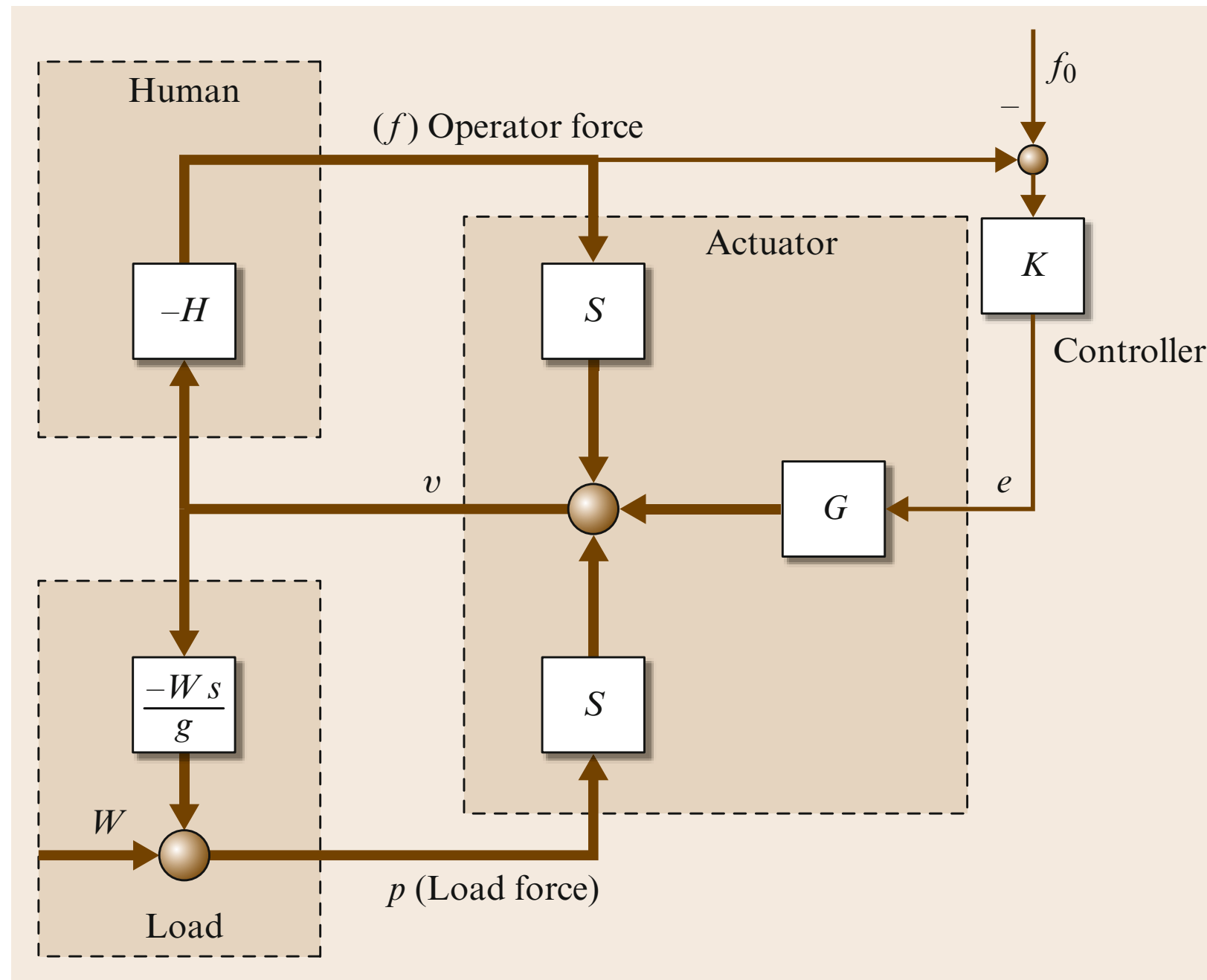


Fig. 33.8 The control block diagram of an intelligent assist device

Exoskelette der unteren Extremität



Fig. 33.10 Berkeley lower-extremity exoskeleton (BLEEX) and pilot Ryan Steger. 1: The load occupies the upper portion of the backpack and around the power unit; 2: rigid connection of the BLEEX spine to the pilot's vest; 3: the power unit and central computer occupies the lower portion of the backpack; 4: semirigid vest connecting BLEEX to the pilot; 5: one of the hydraulic actuators; 6: rigid connection of the BLEEX feet to the pilot's boots

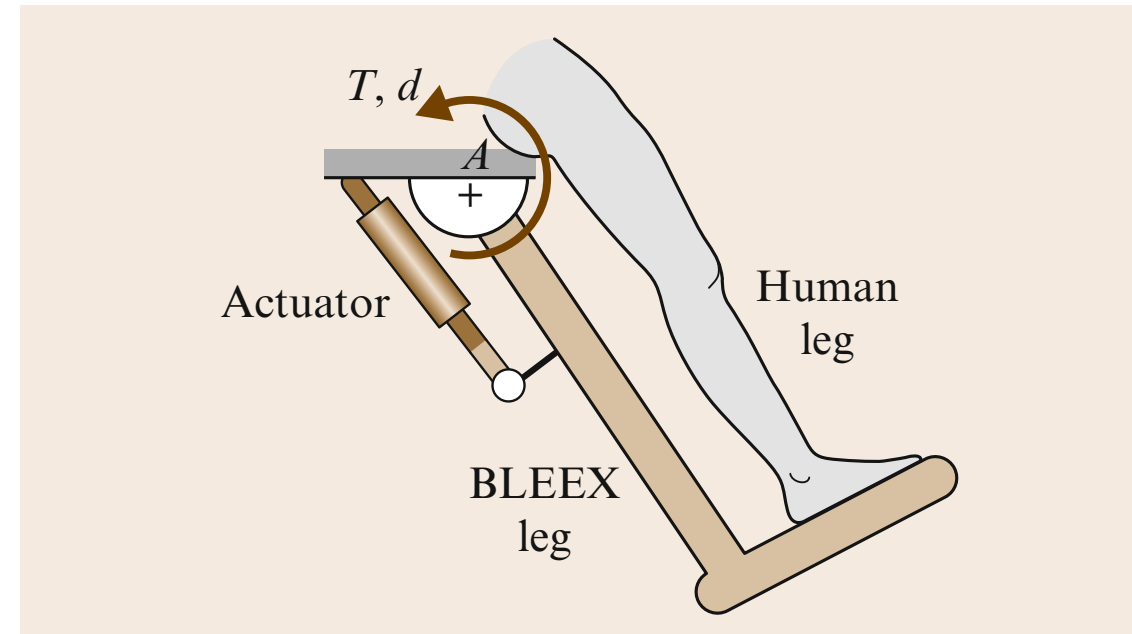


Fig. 33.11 Simple one-DOF exoskeleton with the pilot leg. The exoskeleton leg has an actuator that produces a torque T about the pivot point A . The total equivalent torque associated with all forces and torques from the pilot on the exoskeleton is represented by d

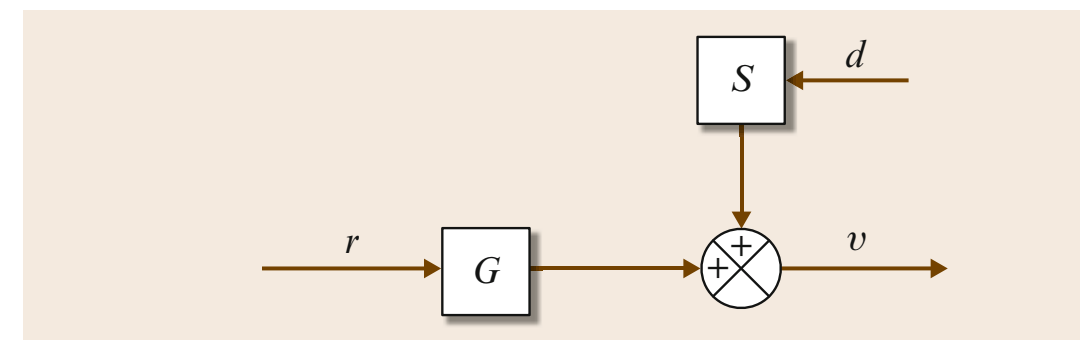


Fig. 33.12 The exoskeleton's angular velocity is shown as a function of the input to the actuators and the torques imposed by the pilot on the exoskeleton

Kontrolle von Exoskelette der u. Extremität

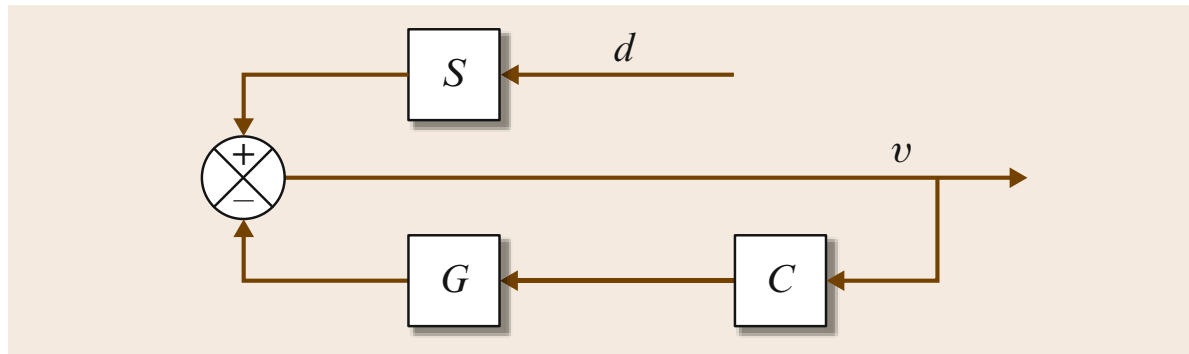


Fig. 33.13 The feedback control loop added to block diagram of Fig. 33.12; C is the controller operating only on the exoskeleton variables

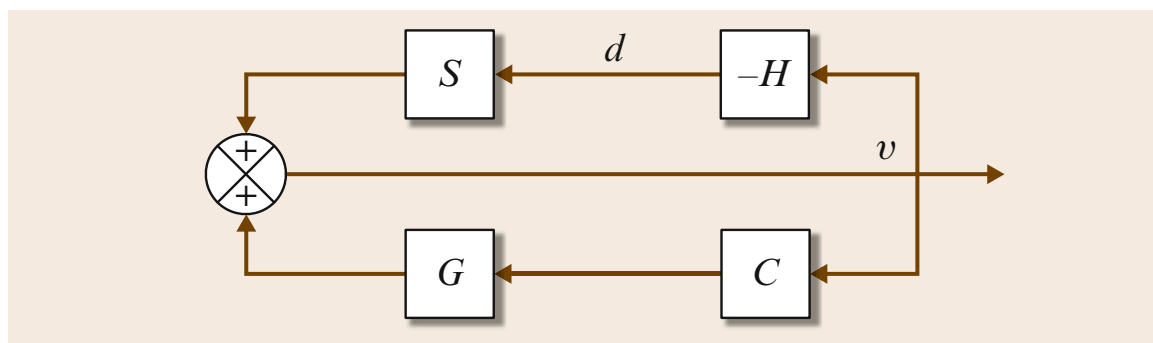


Fig. 33.14 Block diagram showing how an exoskeleton moves. The upper loop shows how the pilot moves the exoskeleton through applied forces. The lower loop shows how the controller drives the exoskeleton

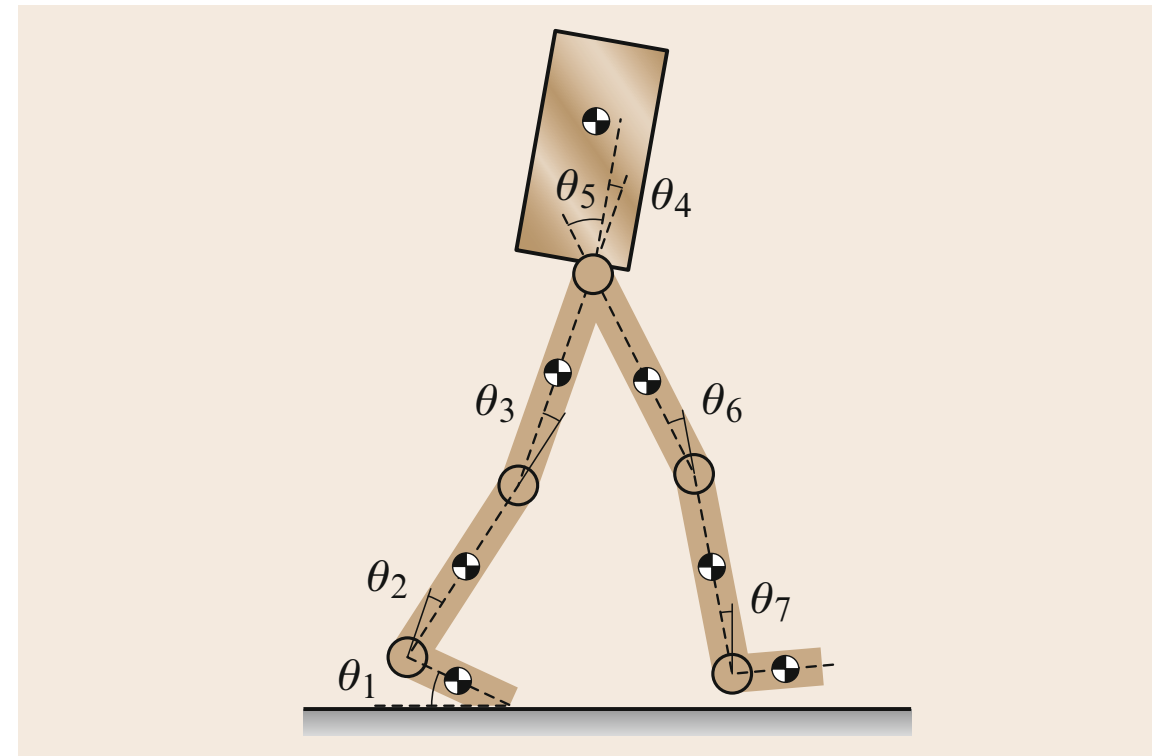


Fig. 33.15 Sagittal plane representation of the exoskeleton in the single stance phase. The torso includes the combined exoskeleton torso mechanism, payload, control computer, and power source

Kontrolle von Exoskeletten der u. Extremität

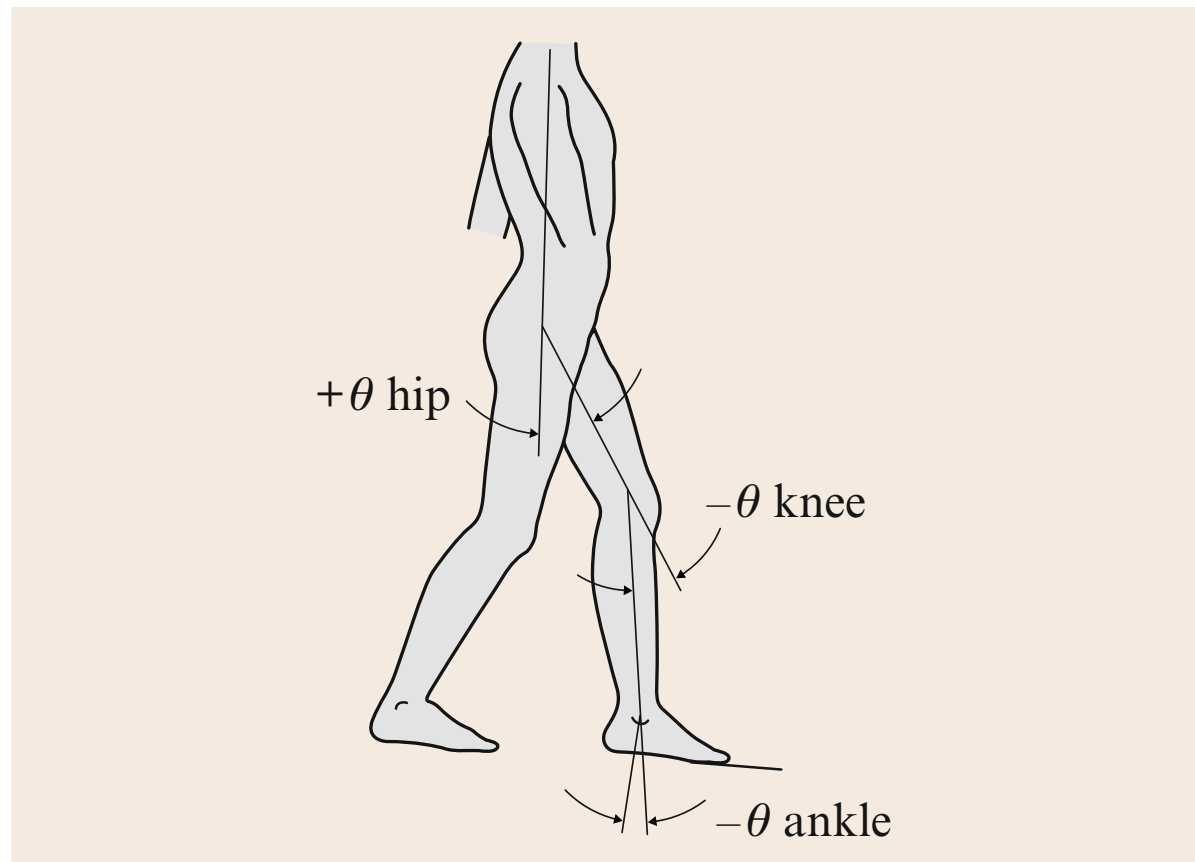


Fig.33.16 Each joint angle is measured as the positive counter-clockwise displacement of the distal link from the proximal link (zero in standing position) with the person oriented as shown. In the position shown, the hip angle is positive whereas both the knee and ankle angles are negative. Torque is measured as positive acting counter-clockwise on the distal link

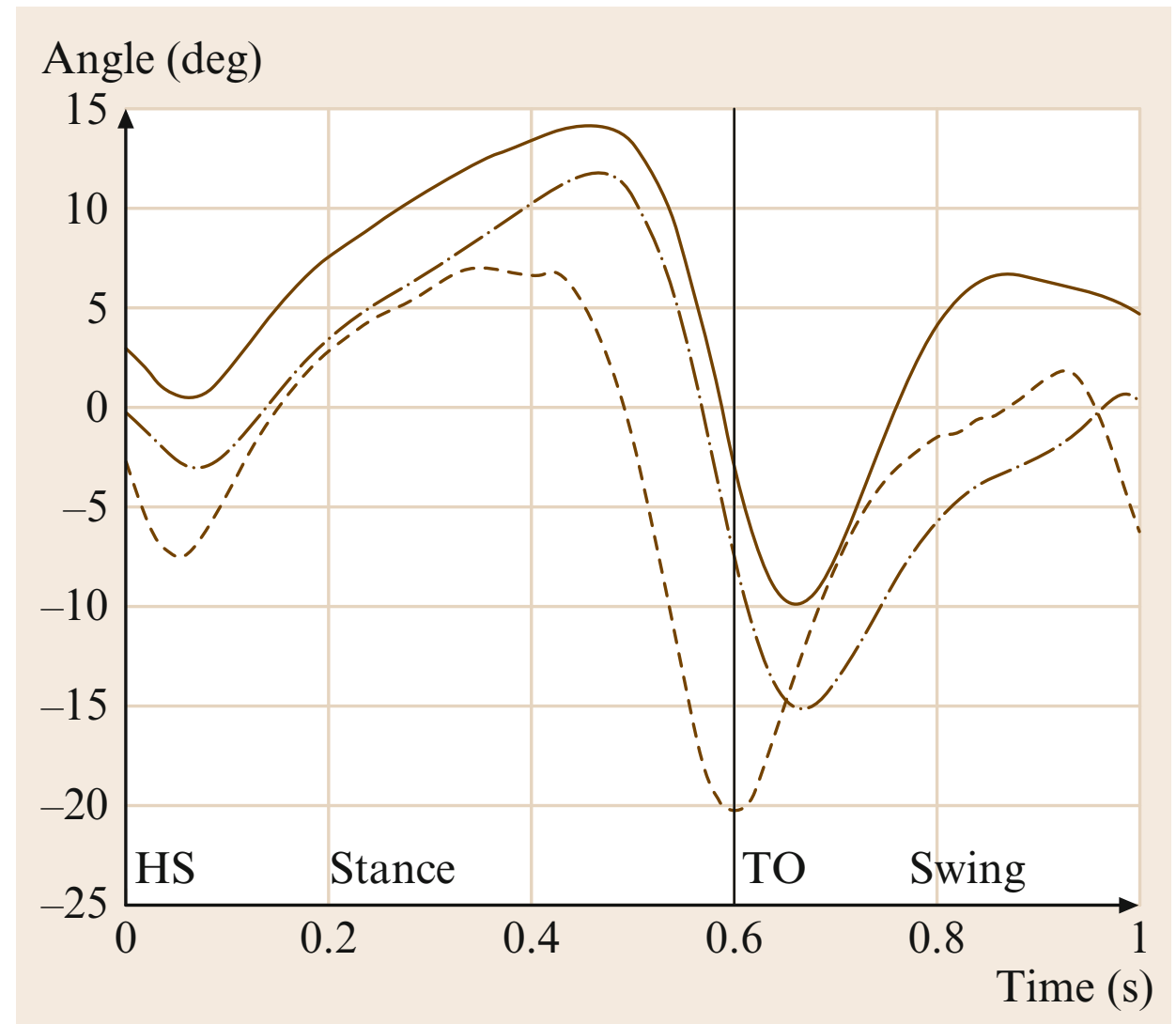


Fig.33.17 Three sets of adjusted CGA data of the ankle flexion/extension angle. The minimum angle (extension) is $\approx -20^\circ$ and occurs just after toe-off. The maximum angle (flexion) is $\approx +15^\circ$ and occurs in late stance phase

Kontrolle von Exoskeletten der u. Extremität

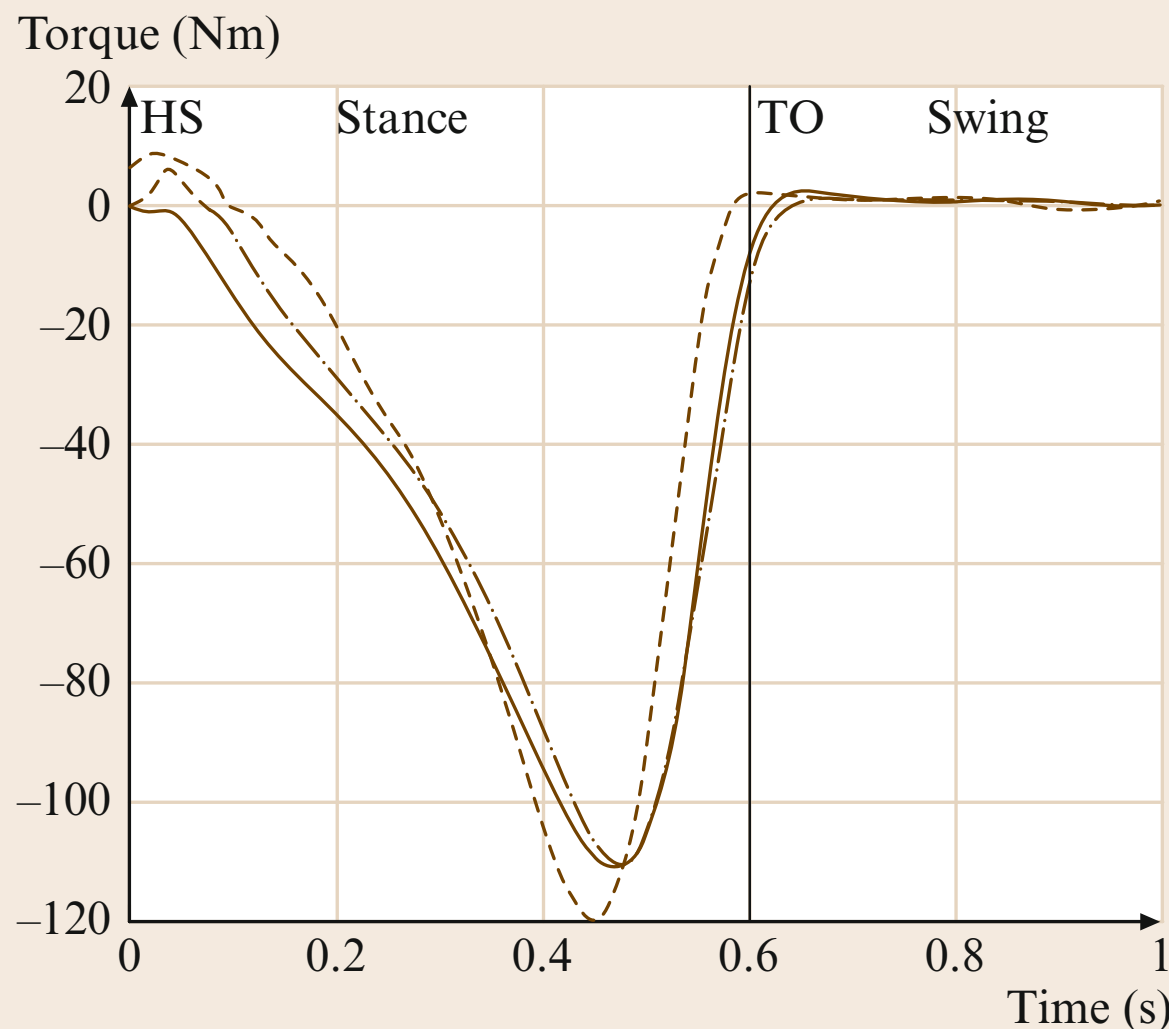


Fig.33.18 Three sets of adjusted CGA data of the ankle flexion/extension torque. Peak negative torque (extension of the foot) is very large (≈ -120 Nm) and occurs in late stance phase. The ankle torque during swing is quite small

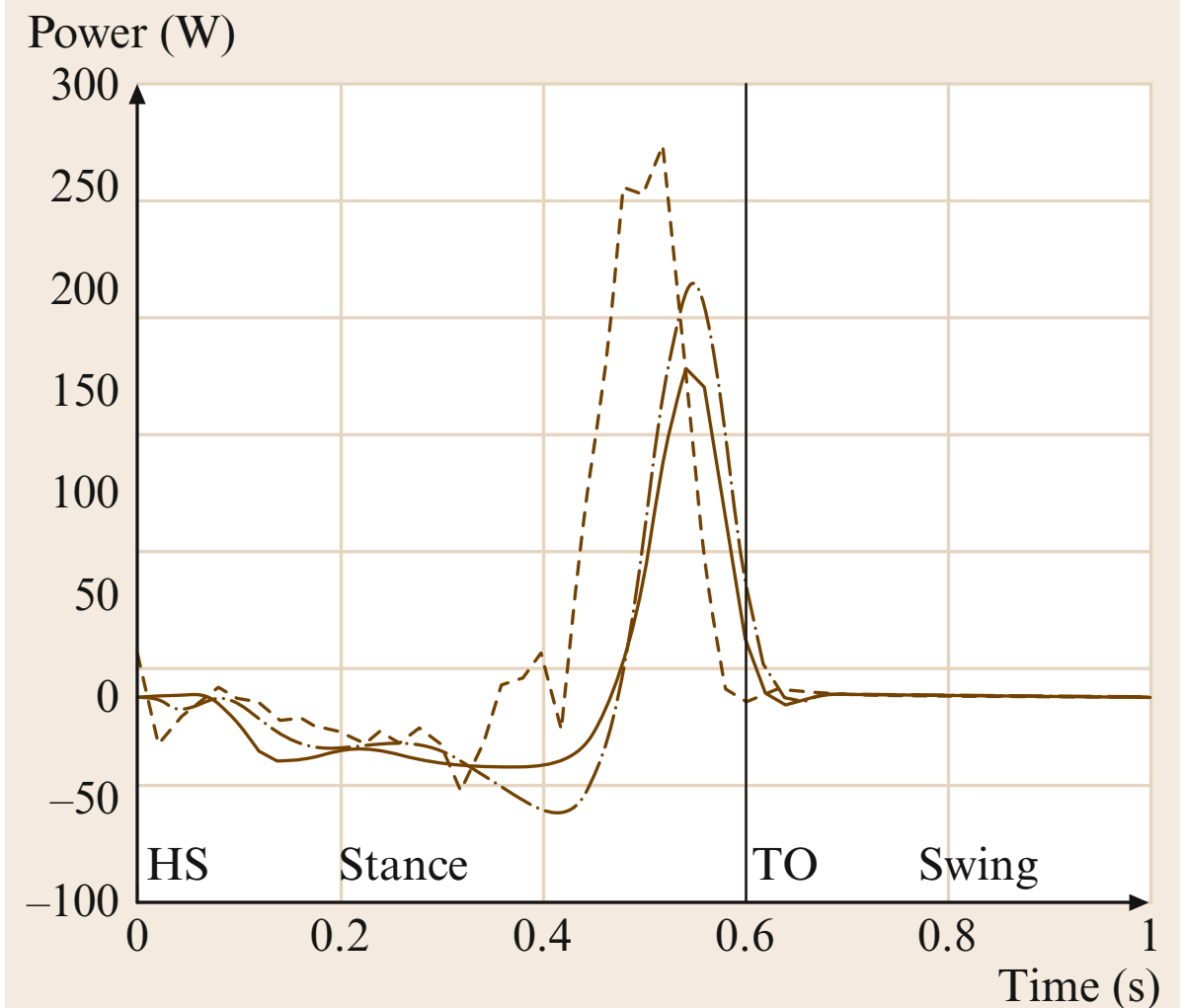


Fig.33.19 Three sets of adjusted CGA data of the ankle flexion/extension instantaneous mechanical power. The average ankle power is positive, indicating that the ankle does positive work and requires actuation

Exoskelette der oberen Extremität

„Call it an **exoskeleton** or a **bionic suit**, but for paraplegics, it's **freedom**. This innovative device, developed by a quadriplegic Israeli scientist, relies on sensors that anticipate shifts in the user's balance and translates them into movements like walking and standing. Already available in Europe, the suit had its prime-time debut on an episode of Glee and is being reviewed by the FDA for use in the U.S.“, TIME Magazine

ReWalk exoskeleton is ranked as world changing among the 25 best inventions in 2013.

<http://www.rewalk.com>

Rehabilitationsroboter

Table 53.1 Prevalence and incidence of disability and aging in selected countries [53.6]

Country	Number of people with disabilities	Percentage of population with disabilities	Number of elderly people	Percentage of population that is elderly
France	5 146 000	8.3	12 151 000	19.6
USA	52 591 000	20.0	35 000 000	12.4
Great Britain	4 453 000	7.3	12 200 000	29.5
The Netherlands	1 432 000	9.5	2 118 808	13.4
Spain	3 528 220	8.9	6 936 000	17.6
Japan	5 136 000	4.3	44 982 000	35.7
Korea	3 195 000	7.1	16 300 000	36.0

Rehabilitationsroboter für Armtherapie

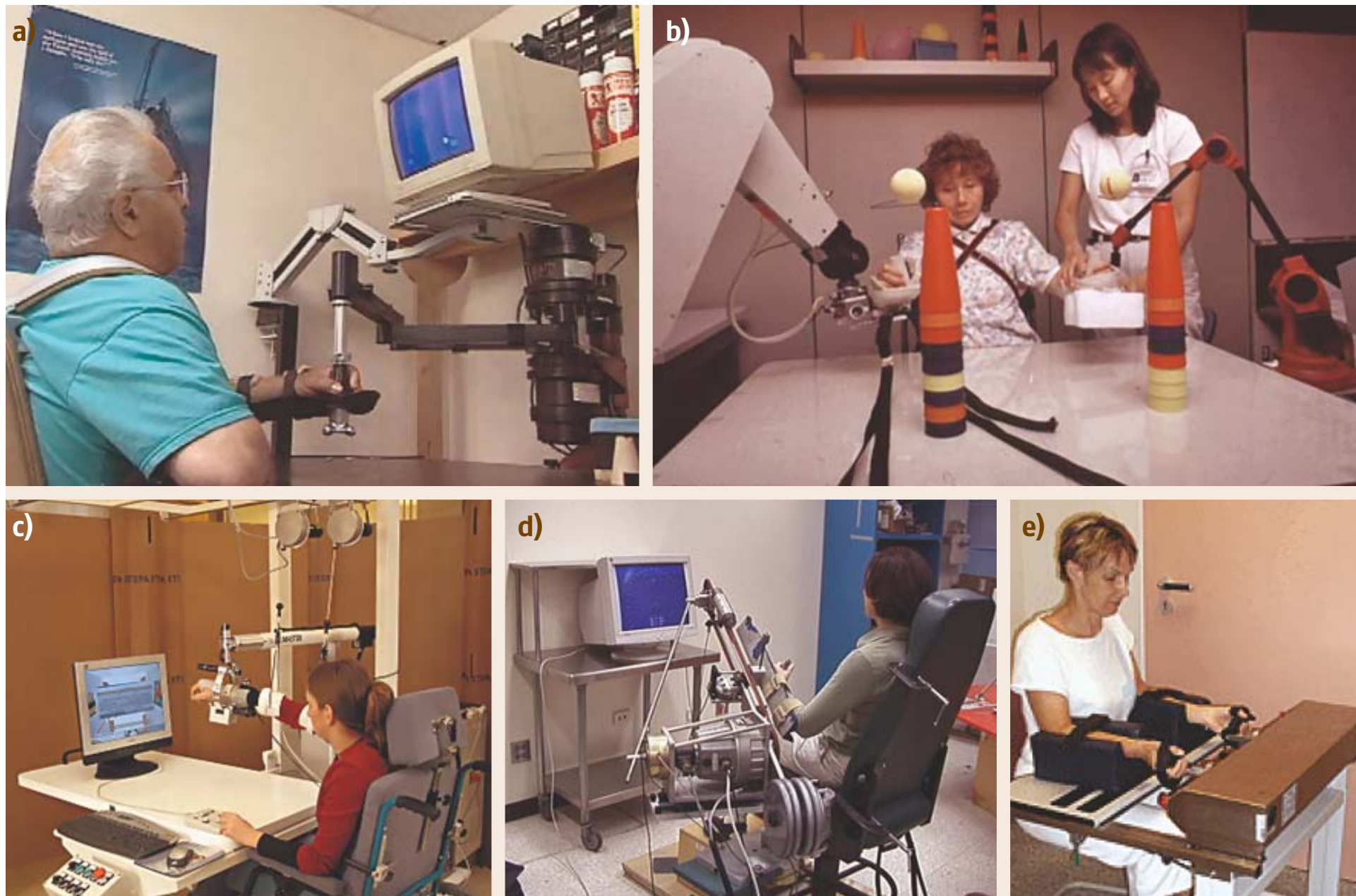


Fig. 53.1a–e Arm-therapy robotic systems that have undergone extensive clinical testing; (a) MIT-MANUS, developed by Hogan, Krebs, and colleagues at the Massachusetts Institute of Technology (USA); (b) MIME, developed at the Department of Veterans Affairs in Palo Alto in collaboration with Stanford University (USA); (c) GENTLE/s developed in the EU, (d) ARM-Guide, developed at the Rehabilitation Institute of Chicago and the University of California, Irvine (USA), and (e) Bi-Manu-Track, developed by Reha-Stim (Germany)

Rehabilitationsroboter für Gehen

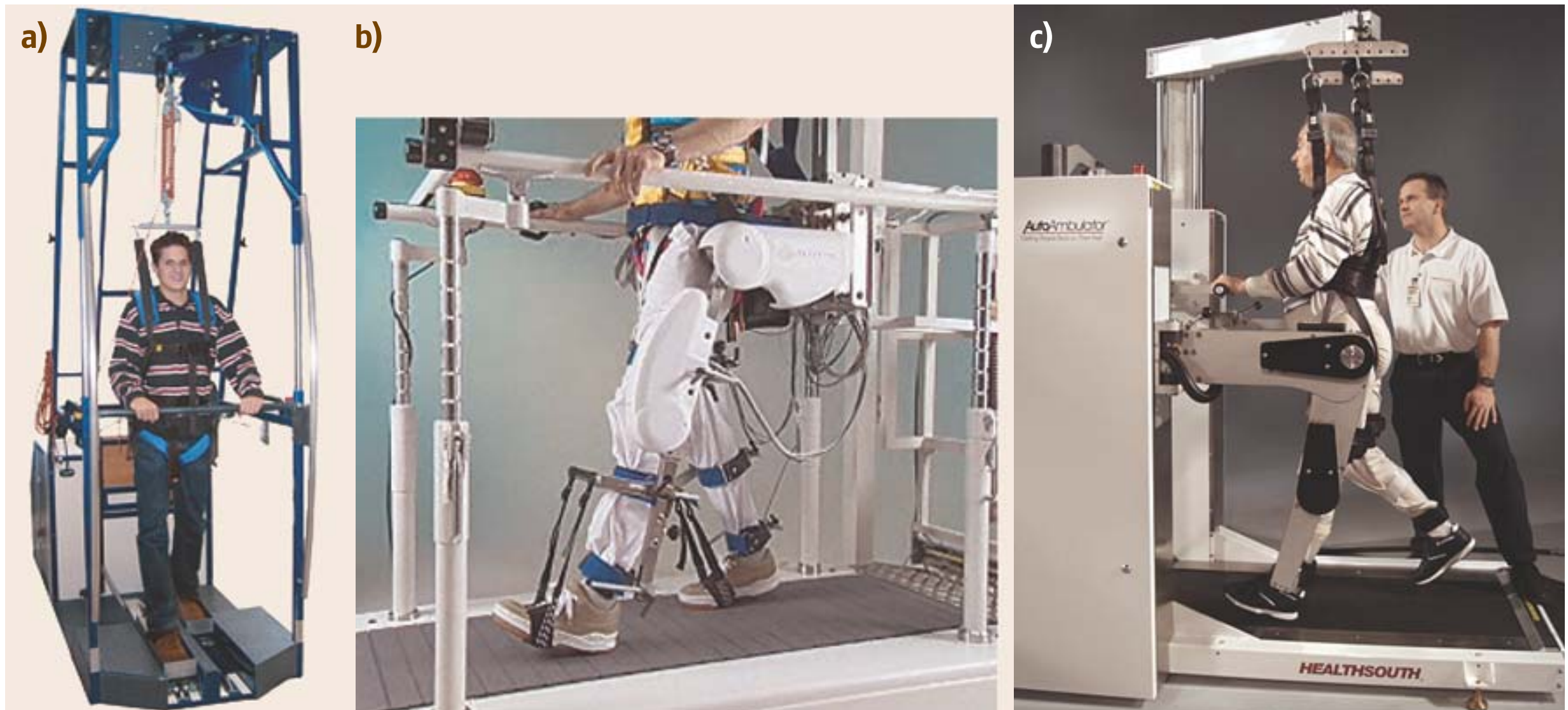
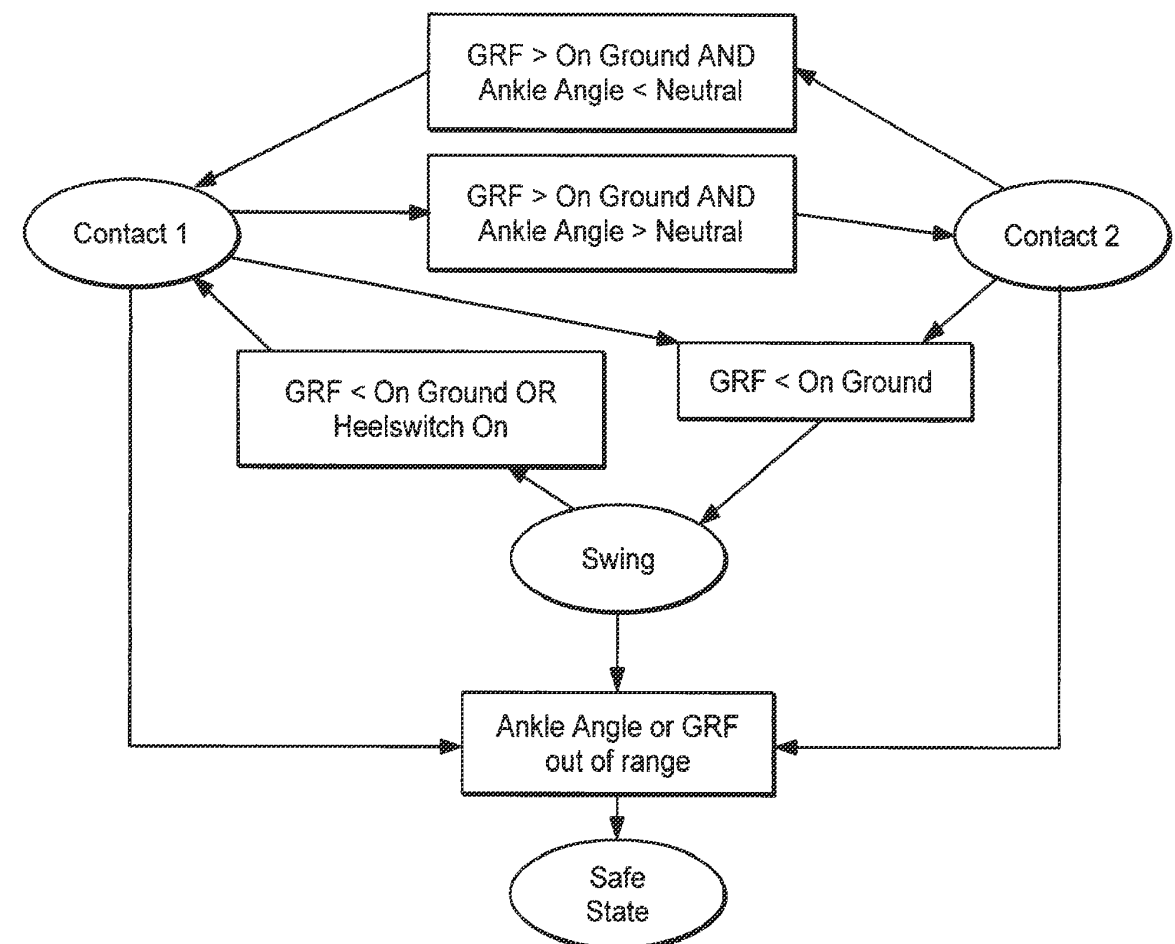
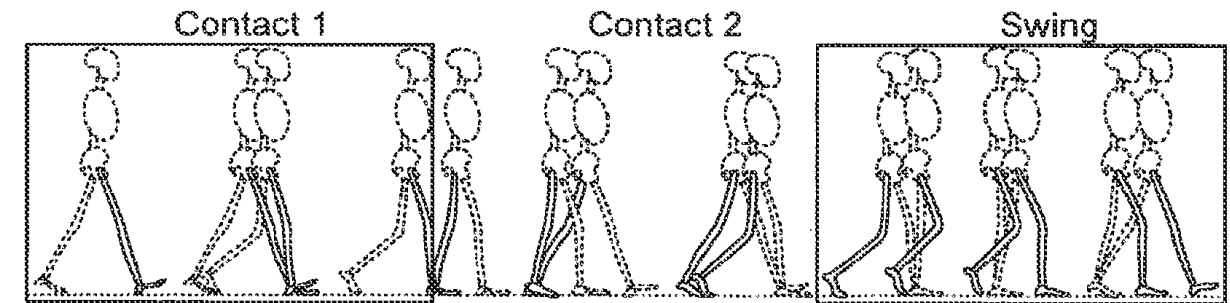
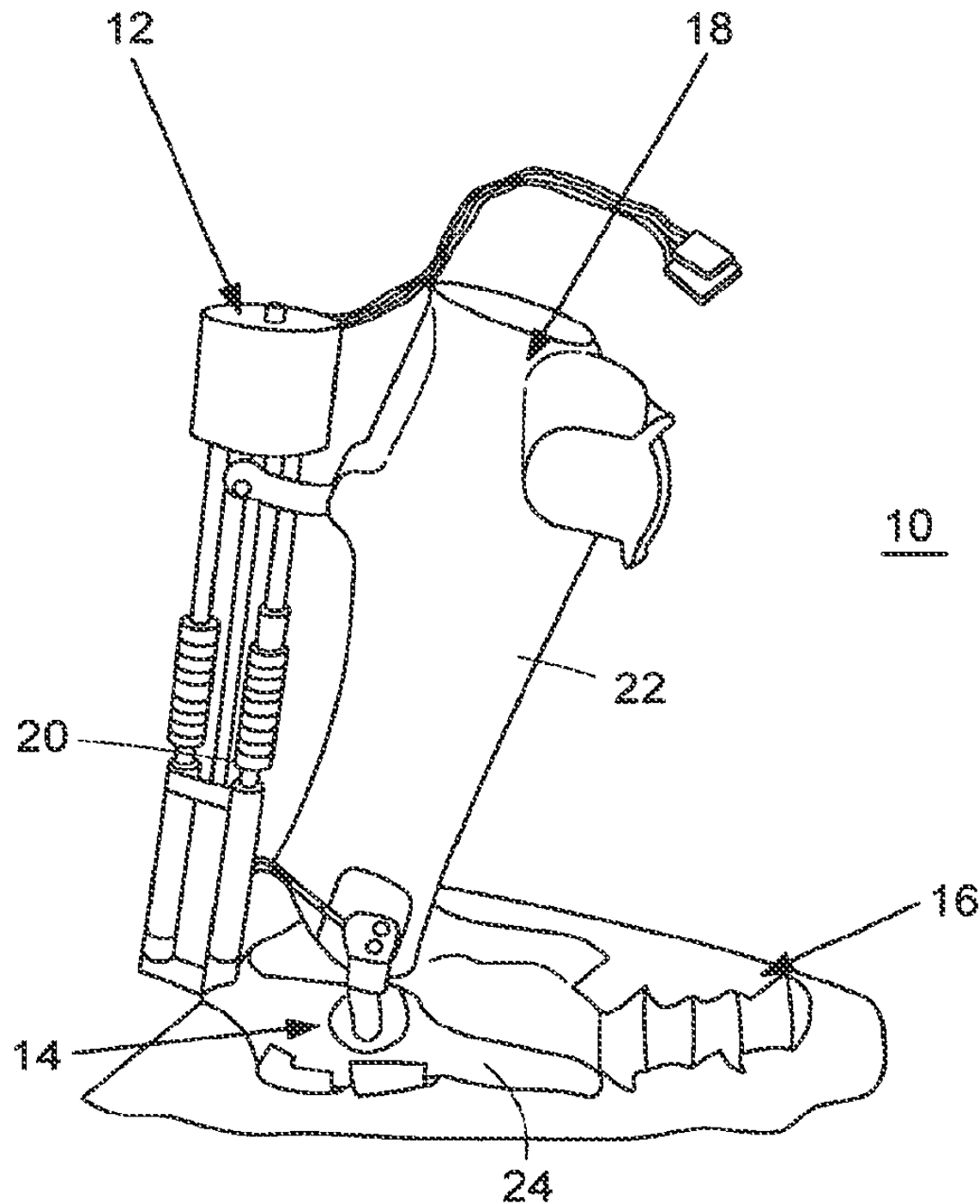
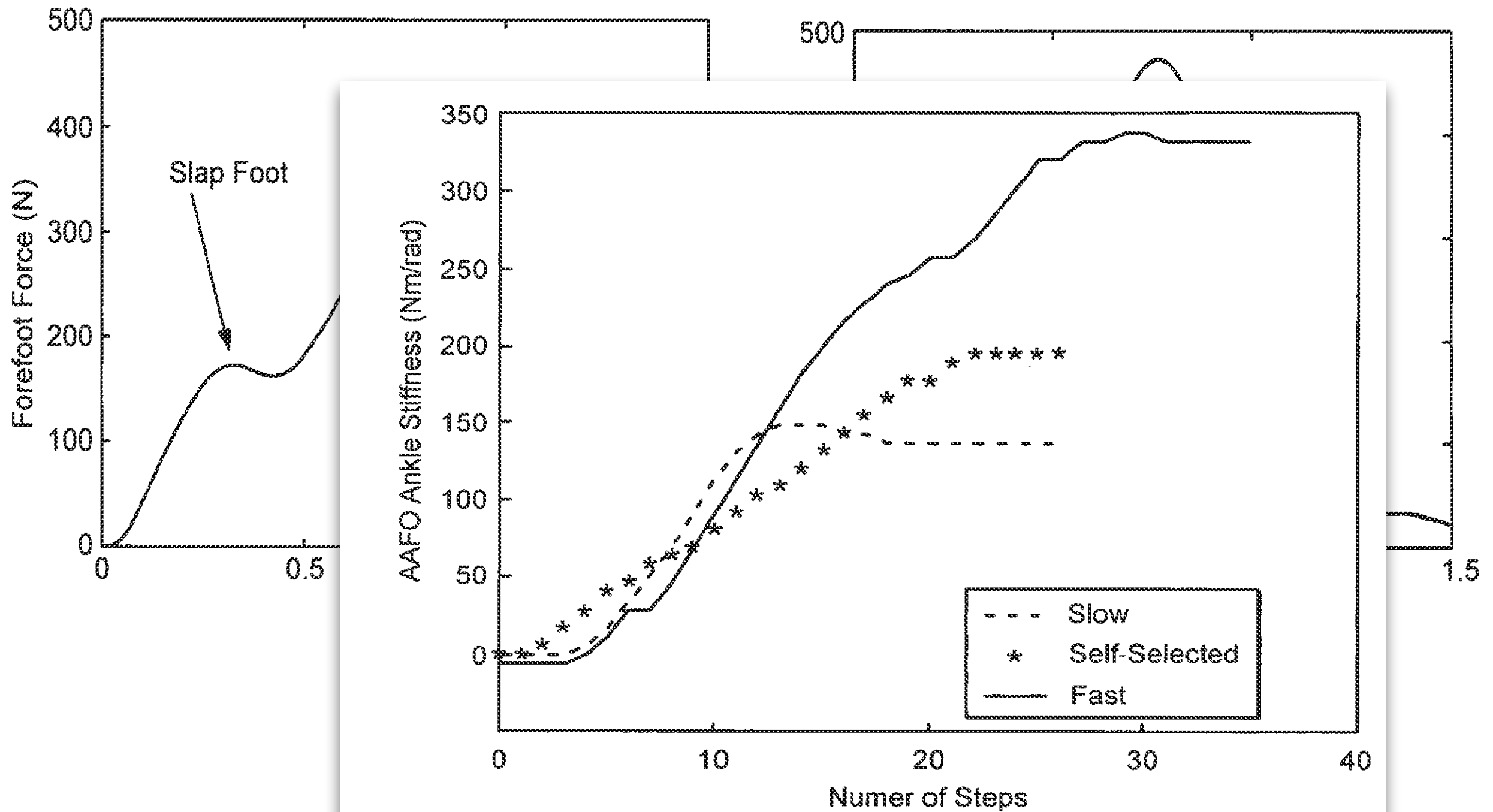


Fig. 53.2a–c Gait-training robotic systems currently in use in clinics; (a) the gait trainer GT-I, developed by Hesse's group and commercialized by Reha-Stim (Germany); (b) the Lokoma(t)r, developed by Colombo and colleagues and commercialized by Hocoma AG (Switzerland), and (c) AutoAmbulator™, developed by the HealthSouth Corporation (USA)

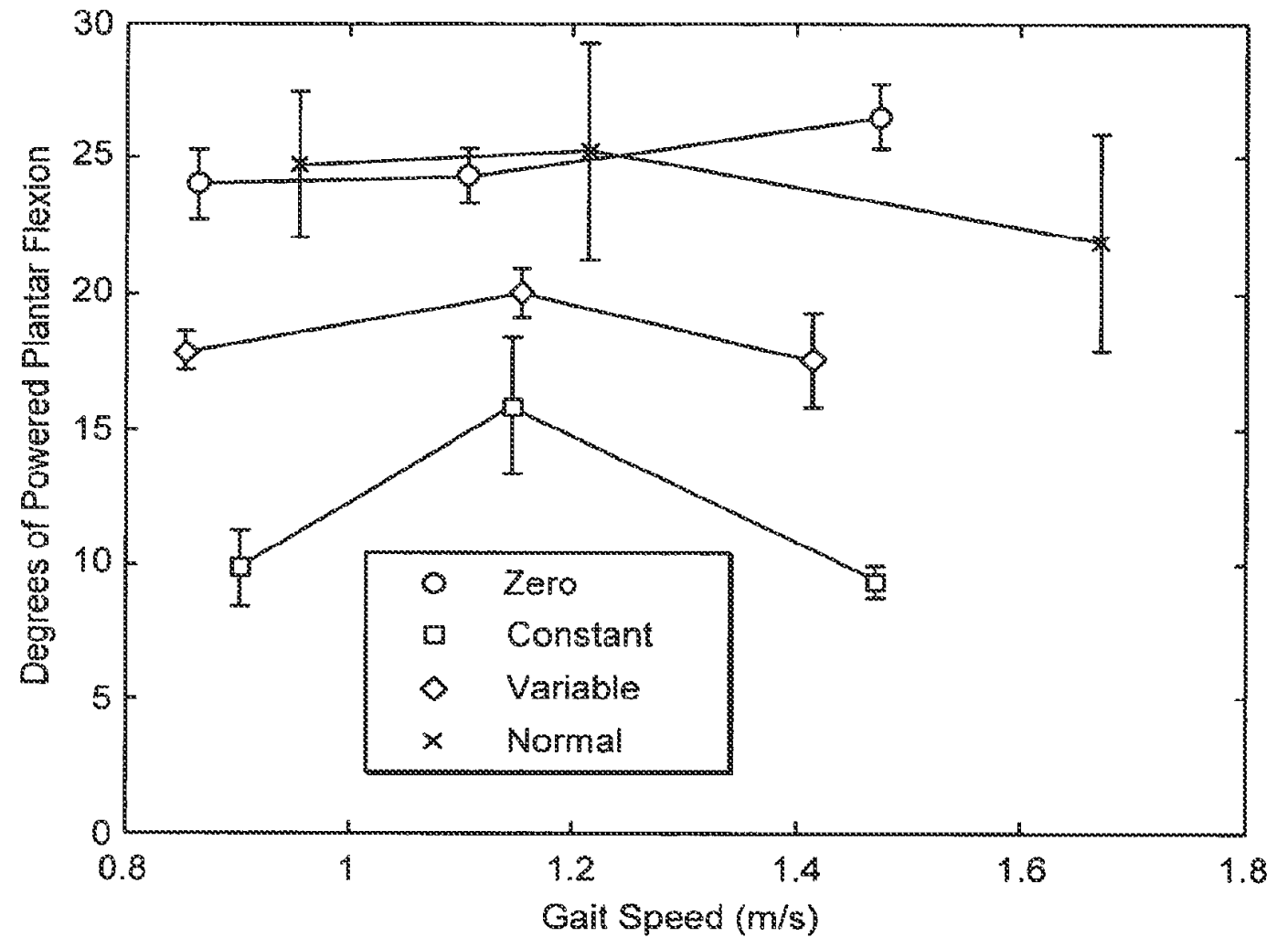
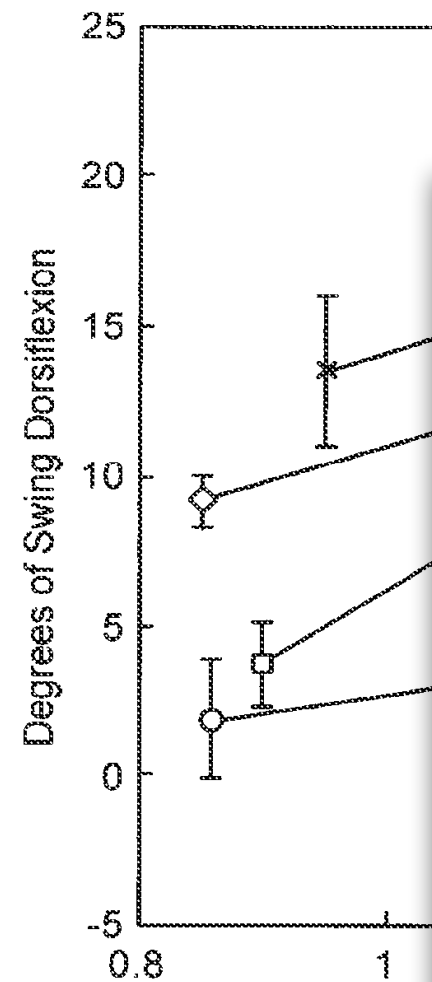
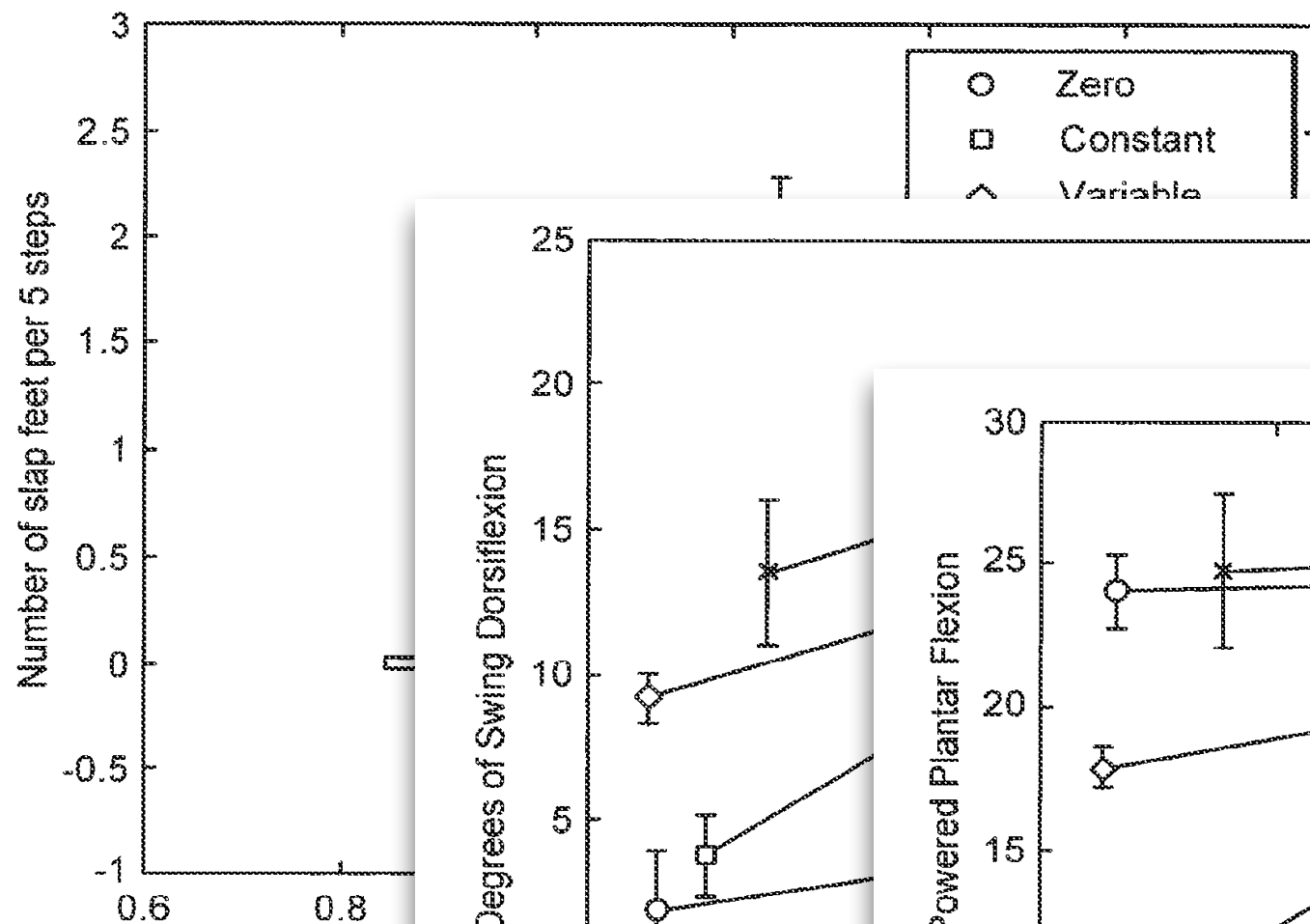
Reharoboter $\longleftrightarrow$ Aktive Gelenkorthesen



Reharoboter $\longleftrightarrow$ Aktive Gelenkorthesen



Reharoboter Aktive Gelenkorthesen



Reharoboter ↔ Aktive Gelenkorthesen



Fotos: Ryan Davis / Flickr

Forschung in Biophysik und Biorobotik

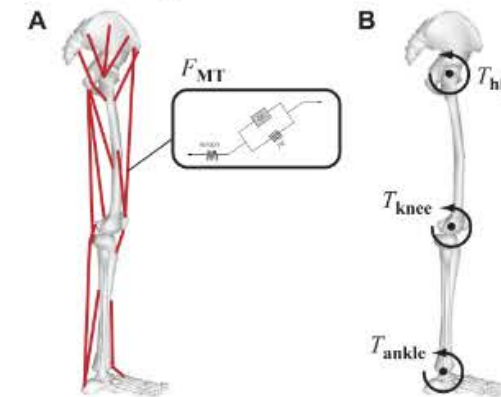
Forschungsmethodologie

Hypothesen

numerisch (in silico, Simulation)

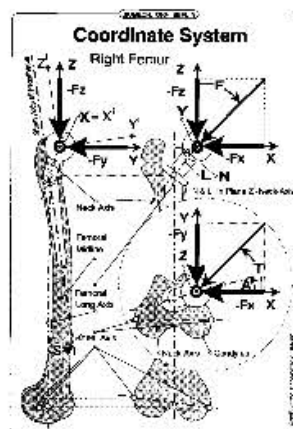
Erdemir A, McLean S, Herzog W, van den Bogert AJ. (2007) Model-based estimation of muscle forces exerted during movements. *Clinical Biomechanics* 22(2):131–54.

ungefähr 300 Zitate



Experiment

biologisch (in vivo, in vitro)



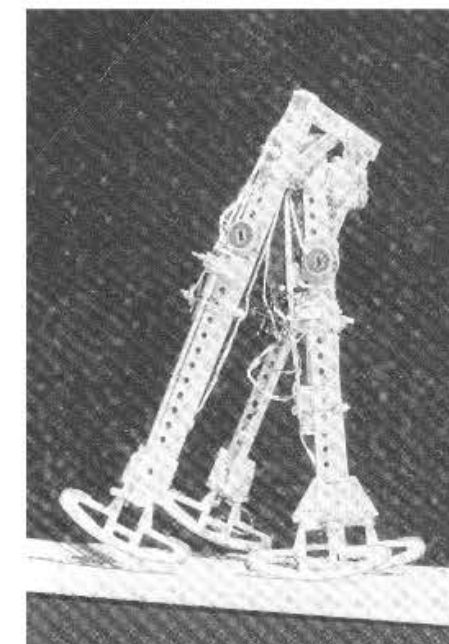
Bergmann G, Graichen F, Rohlmann A. (1993) Hip joint loading during walking and running, measured in two patients. *Journal of Biomechanics* 26(8):969–990.

ungefähr 1000 Zitate

technisch

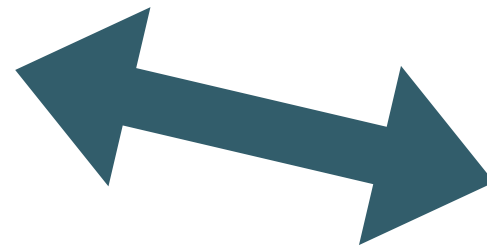
McGeer T. (1990) Passive dynamic walking. *The International Journal of Robotics Research* 9(2):62–82.

ungefähr 2500 Zitate



Forschungsmethodologie

Hypothesen

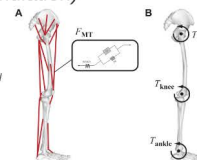


Experiment

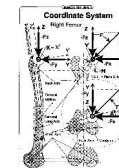
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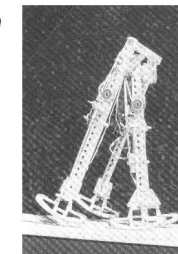
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Orthoload

technisch

McGeer T. (1990) Passive dynamic walking. *The International Journal of Robotics Research* 9(2):62-82.

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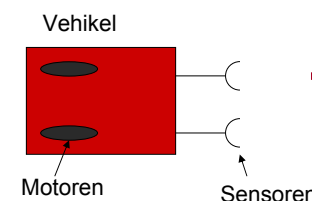


am Beispiel *Biologische Kybernetik*

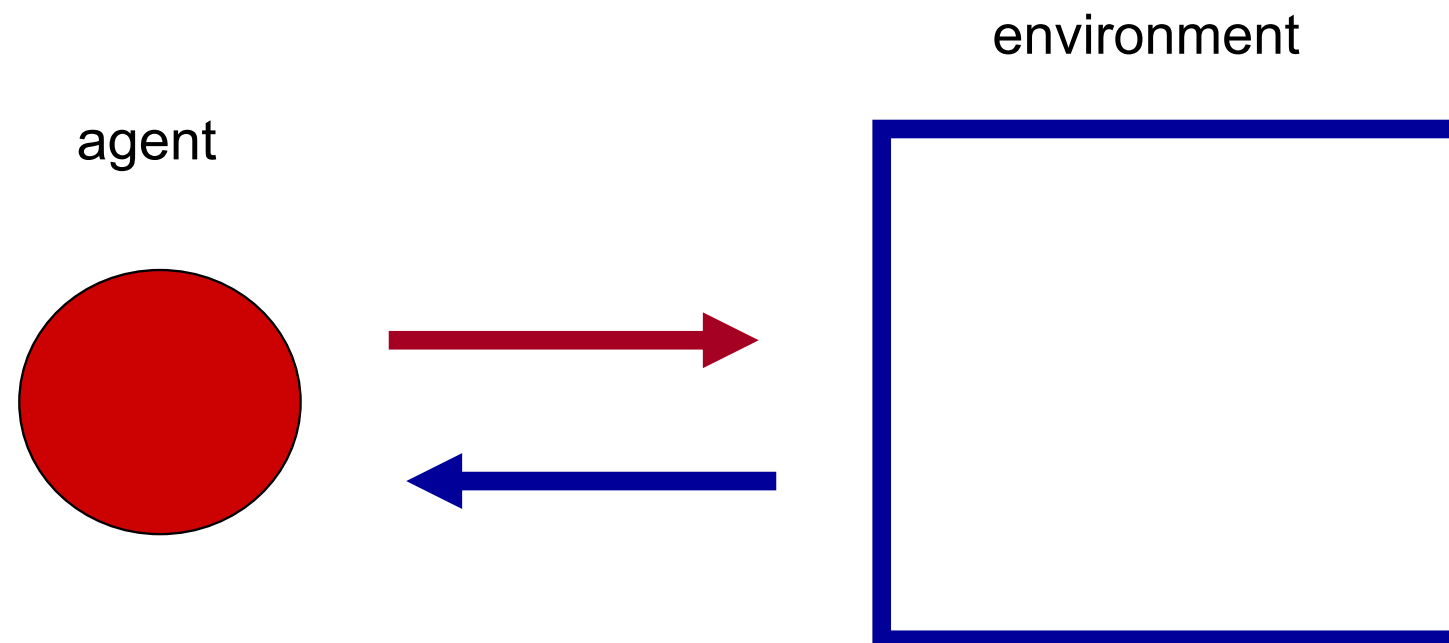
Braitenberg Vehikel

Testtrilogie

Biorobotik?

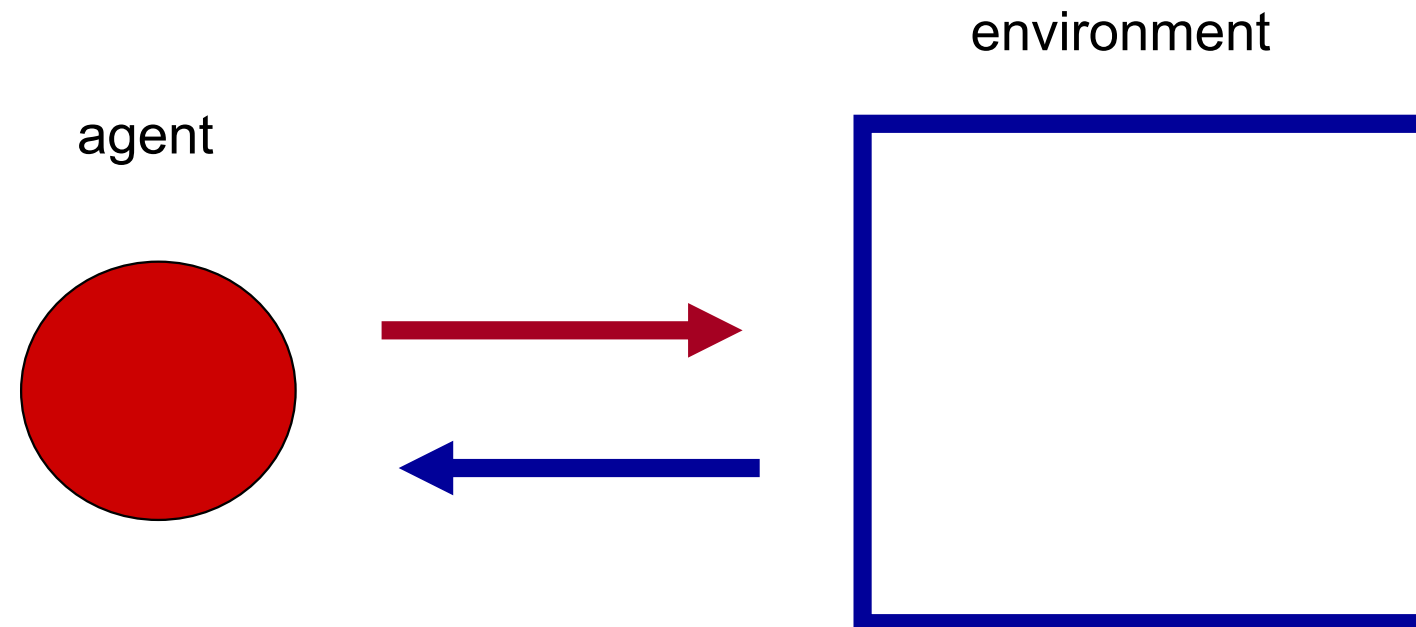


Was ist Kybernetik?



Kybernetik ermöglicht, die **Rückkopplung** in **unterschiedlichen Systemen** mit denselben mathematischen Methoden zu untersuchen.

Was ist Kybernetik?

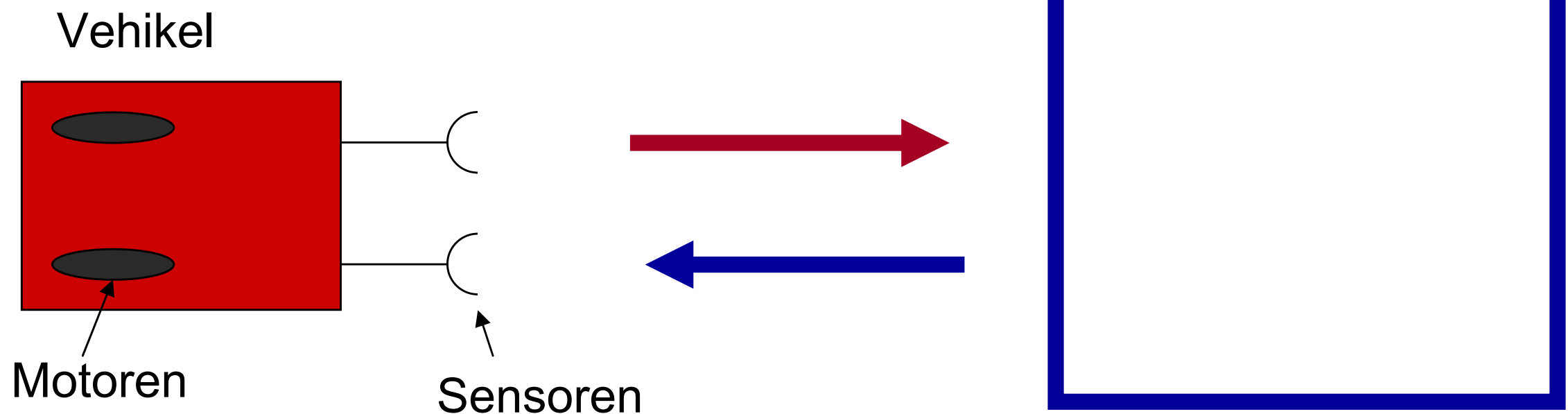


Die Vorgehensweise der **Kybernetik** ist zuerst eine **Modellierung** des Phänomens.

Das **Modell** soll, unter starker Vereinfachung, das **Verhalten** des Phänomens abbilden.

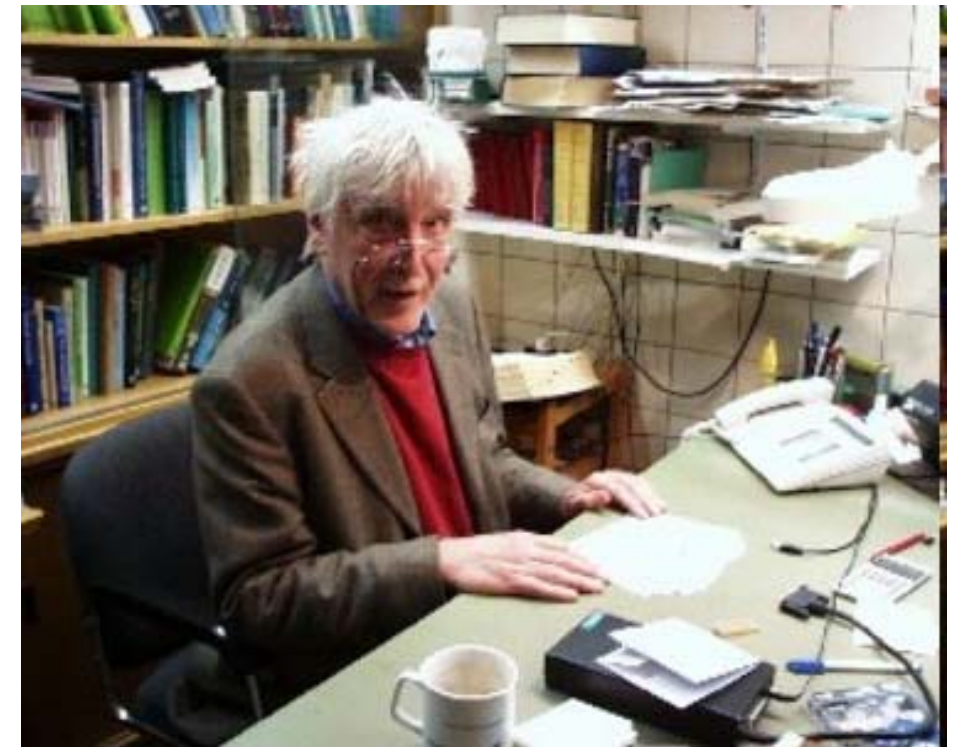
Was ist Kybernetik?

die "Vehikel" von Braitenberg sind Beispiele für kybernetische Modelle, die mit relativ einfacher Struktur Details im Verhalten von Phänomenen widerspiegeln.



Valentino Braitenberg

Prof. Valentino Braitenberg war ein Hirnforscher, Kybernetiker und Schriftsteller. Er war am **Max-Planck Institut für biologische Kybernetik** in Tübingen.



Valentino Braitenberg
(1926 - 2011)

**Vehicles – Experiments in Synthetic Psychologie,
1984 MIT Press**



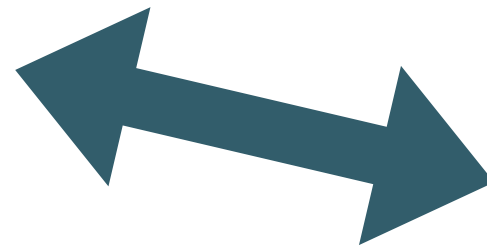
Braitenberg Vehikel

Prinzip

- Braitenberg Vehikel integrieren **Sensoren**, die direkt an die **Aktoren** (z.B. Motoren) **gekoppelt** sind.
- Die Sensoren melden **externe Stimuli** an die Motoren, die damit bestimmte **Reaktionen (Wesen)** auslösen.

Forschungsmethodologie

Hypothesen

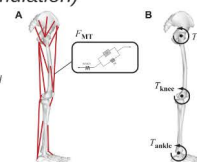


Experiment

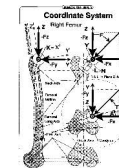
numerisch
(in silico, Simulation)

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ungefähr 300 Zitate



biologisch
(in vivo, in vitro)



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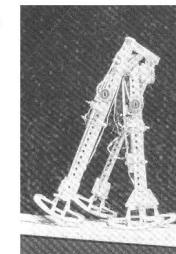
ungefähr 1000 Zitate

Orthoload

technisch

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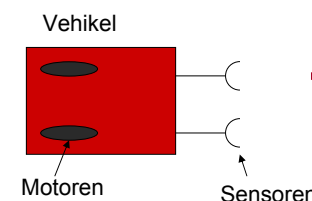


am Beispiel *Biologische Kybernetik*

Braitenberg Vehikel

Testtrilogie

Biorobotik?



Testtrilogie

test trilogy

Kalveram, K. T., & Seyfarth, A. (2009)



Forschungsmethodologie

„Über Braitenberg Vehikel und Testtrilogie zur Biorobotik als Forschungsinstrument?“

am Beispiel *Biologische Kybernetik*

Braitenberg Vehikel

Testtrilogie

Biorobotik?

