Robots for the Benefit of Humans

Contributions of our Lab and its Cooperation Partners

Professor Günther Schmidt

Faculty of Electrical Engineering and Information Technology
Technische Universität München
Munich, Germany

Lecture at
Takamatsu High School, 19 September 2007

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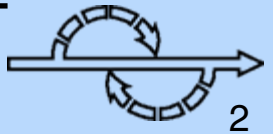
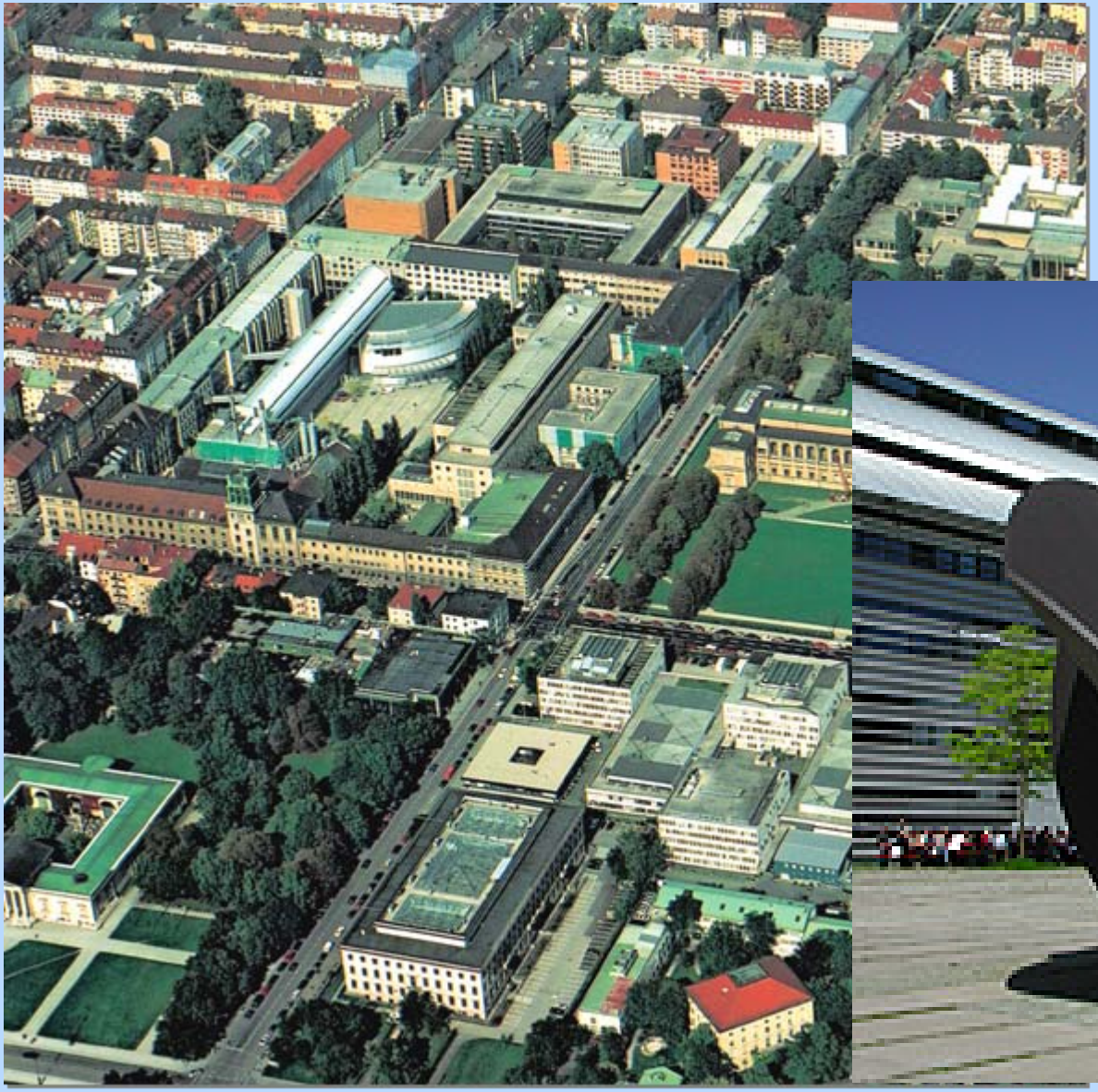


The SICE Conference

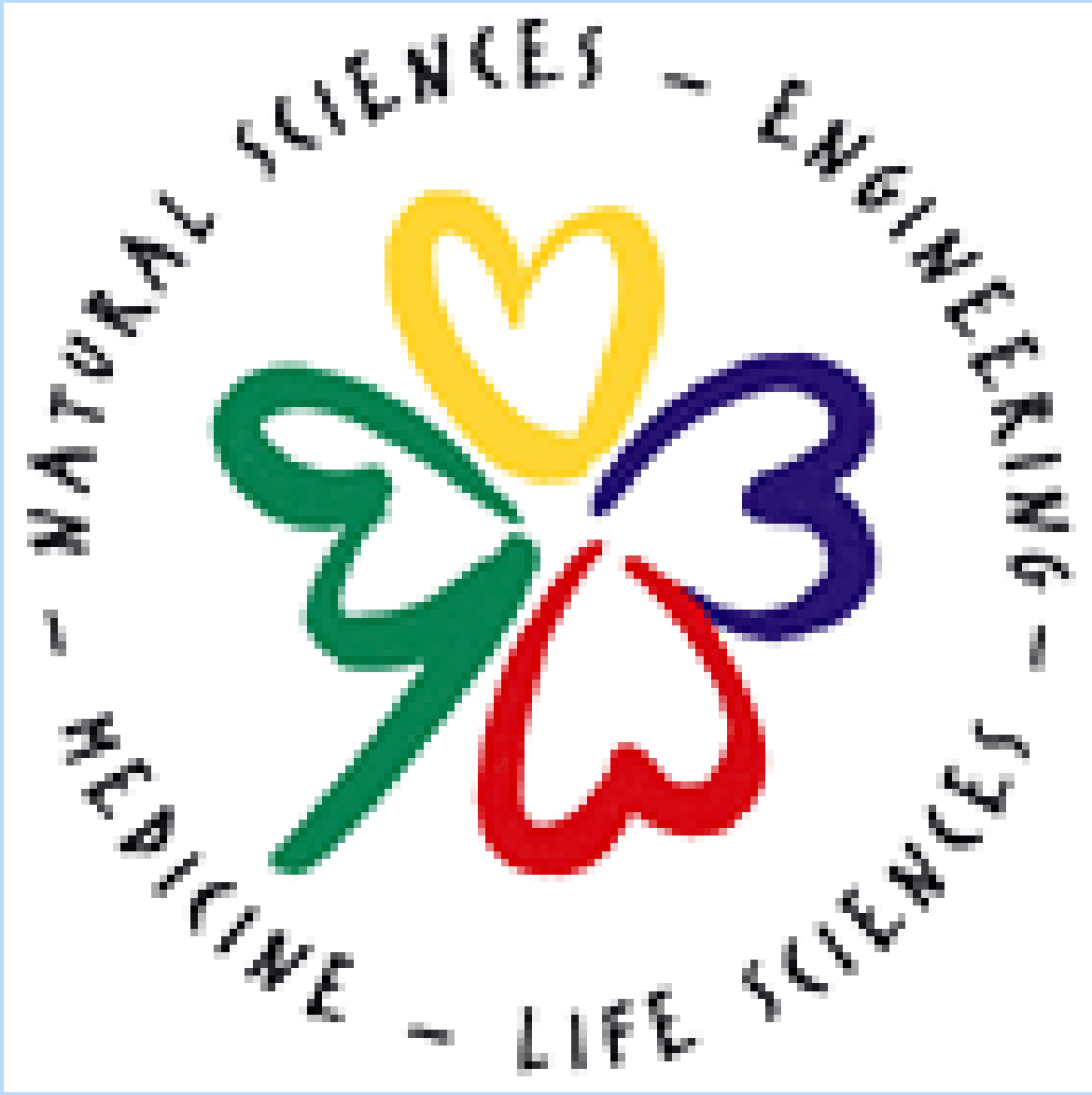
München: “Weltstadt mit Herz”

“The Cosmopolitan City with a Heart”

The Annual Beer Festival



City Campus of TU München



The Cloverleaf Logo of TU München

TECHNISCHE UNIVERSITÄT MÜNCHEN

香川大学工学部及び大学院工学研究科とミュンヘン工科大学工学系学部との学術交流協定書に関する実施細則

第Ⅰ部　目的

香川大学工学部及び大学院工学研究科とミュンヘン工科大学の土木工学・測量学，建築学，機械工学，電気工学，情報技術及び情報工学の諸学部（以下「工学系学部」という）は，「香川大学とミュンヘン工科大学との学術交流協定書」に基づき，両機関の親密な関係を確立することを切望し，この関係が相互の教育研究体系の理解，共同研究プロジェクト及びその他の共同事業を推進することを希望する。

第Ⅱ部　協力分野

上記目的を促進するために，両機関は以下の事項に同意する。

1．教育研究目的での相手方機関の教員の受入れ
2．学生の交流
3．両機関のリソース及び両機関の利益になる範囲での公式交流

第Ⅲ部　教員交流

1．教員の交流は，各種規定の許す範囲で，教育効果及び学生の興味を促進する観点から，相手機関のカリキュラムの導入と評価を目的として，定期的に実践する。
2．両大学の教員は，可能な範囲で適宜，共同研究を行い，学術情報を交換することができる。
3．両大学の教員は，学術専門会議への招聘，国内会議や国際会議への参加準備の援助をすることができる。

第Ⅳ部　学生交流

「香川大学とミュンヘン工科大学との学生交流プログラムの実施細則」に基づき，それぞれ1年に2名を超えない学生を交流できるものとする。ただし，2名を超える場合には，あらためて両大学で協議の上，交流できるものとする。

Renewal of Academic Cooperation Agreement in February 2007

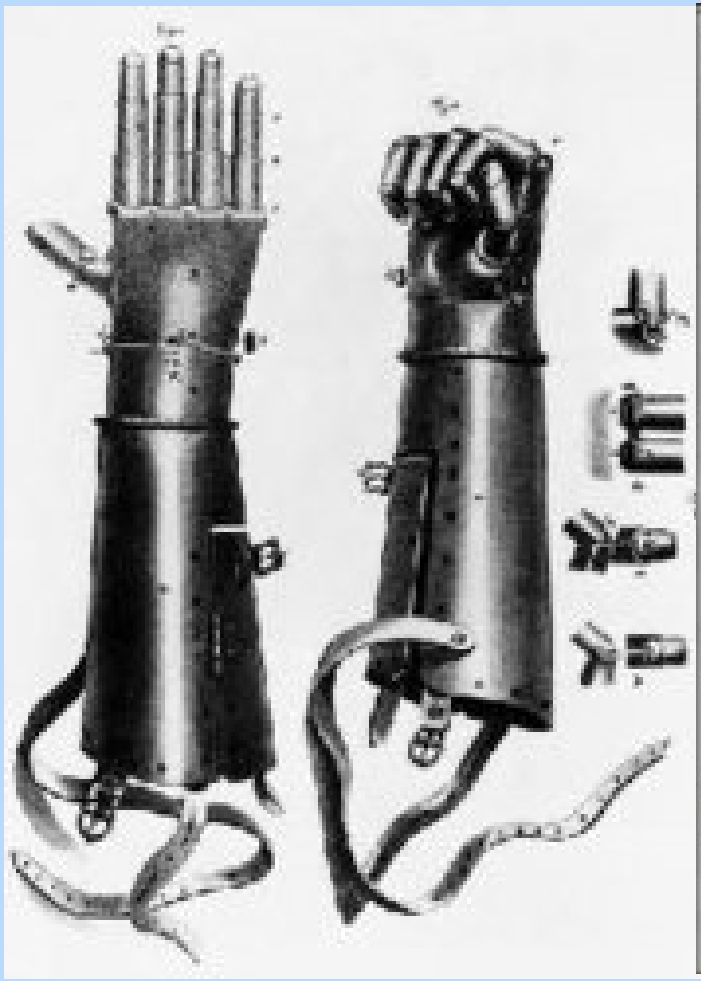
Leibniz Gymnasium

Abitur – Graduation, March 1955

Gottfried Wilhelm Leibniz
1646 – 1716
Philosopher and Mathematician

Inventor of
- **Determinants,**
- **Differential & Integral Calculus**
- **Binary Number System**
  - Chinese sources

Excursion to Deutsches Museum, München in 1952



Hand Prosthesis, Goetz von Berlichingen

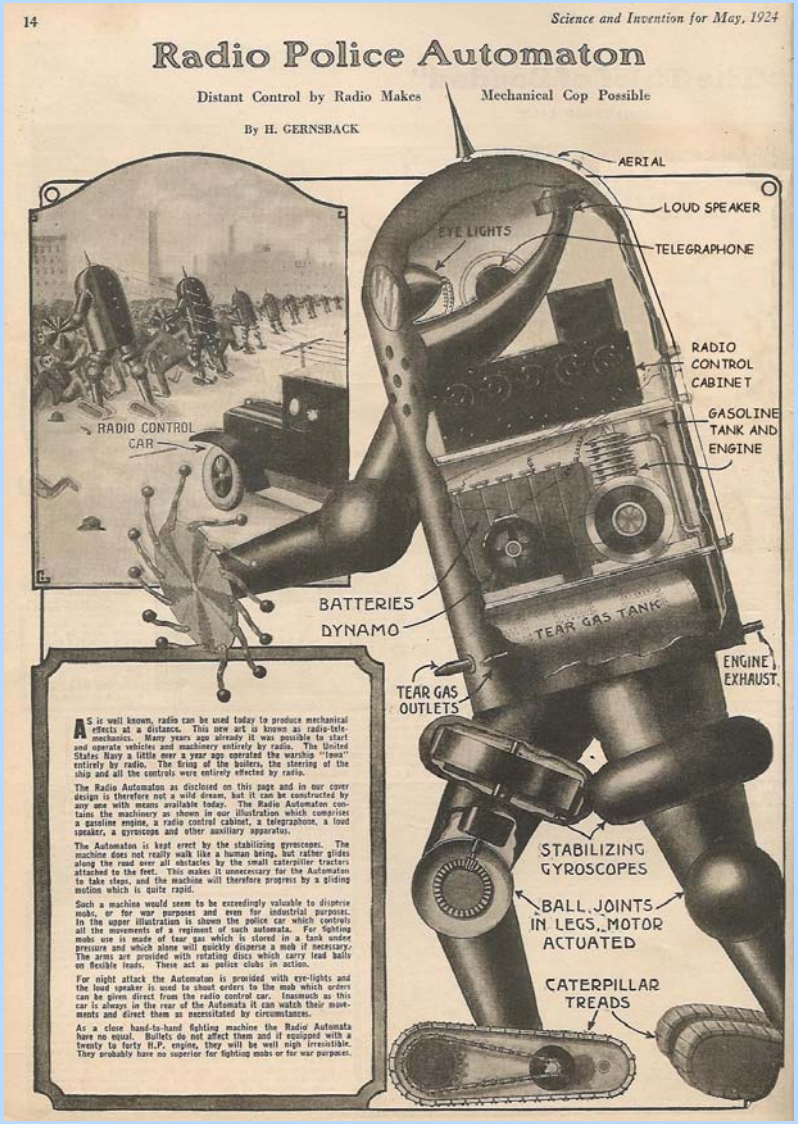
“The Knight with the Iron Hand”, 1504

Mechanical Trumpet Players

Friedrich Kaufmann, Dresden, 1810

Tea-serving Puppets, 18th & 19th century

Karakuri ningyo - Mechanized Puppets



14 Science and Invention for May, 1924

Radio Police Automaton

Distant Control by Radio Makes Mechanical Cop Possible

By H. GERNSBACK

AERIAL
LOUD SPEAKER
EYE LIGHTS
TELEGRAPHONE
RADIO CONTROL CABINET
GASOLINE TANK AND ENGINE
RADIO CONTROL CAR
BATTERIES
DYNAMO
TEAR GAS TANK
ENGINE EXHAUST
TEAR GAS OUTLETS
STABILIZING GYROSCOPES
BALL JOINTS IN LEGS, MOTOR ACTUATED
CATERPILLAR TREADS

As is well known, radio can be used today to produce mechanical effects at a distance. This new art is known as radio-tele-mechanics. Many years ago already it was possible to start and operate vehicles and machinery entirely by radio. The United States Navy a little over a year ago operated the warship "Iowa" entirely by radio. The firing of the boilers, the steering of the ship and all the controls were entirely effected by radio.

The Radio Automaton as disclosed on this page and in our cover design is therefore not a wild dream, but it can be constructed by any one with means available today. The Radio Automaton contains the machinery as shown in our illustration which comprises a gasoline engine, a radio control cabinet, a telegraphone, a loud speaker, a gyroscope and other auxiliary apparatus.

The Automaton is kept erect by the stabilizing gyroscopes. The machine does not really walk like a human being, but rather glides along the road over all obstacles by the small caterpiller tractors attached to the feet. This makes it unnecessary for the Automaton to take steps, and the machine will therefore progress by a gliding motion which is quite rapid.

Such a machine would seem to be exceedingly valuable to disperse mobs, or for war purposes and even for industrial purposes. In the upper illustration is shown the police car which controls all the movements of a regiment of such automata. For fighting mobs one is made of tear gas which is stored in a tank under pressure and which alone will quickly disperse a mob if necessary. The arms are provided with rotating discs which carry lead balls on flexible leads. These act as police clubs in action.

For night attack the Automaton is provided with eye-lights and the loud speaker is used to shout orders to the mob which orders can be given direct from the radio control car. Inasmuch as this car is always in the rear of the Automata it can watch their movements and direct them as necessitated by circumstances.

As a close hand-to-hand fighting machine the Radio Automata have no equal. Bullets do not affect them and if equipped with a twenty to forty H.P. engine, they will be well nigh irresistible. They probably have no superior for fighting mobs or for war purposes.

Science Fiction: Robocop 1924

TECHNISCHE UNIVERSITÄT DARMSTADT

Engineering Education and Research Positions

Dornier Do 31E

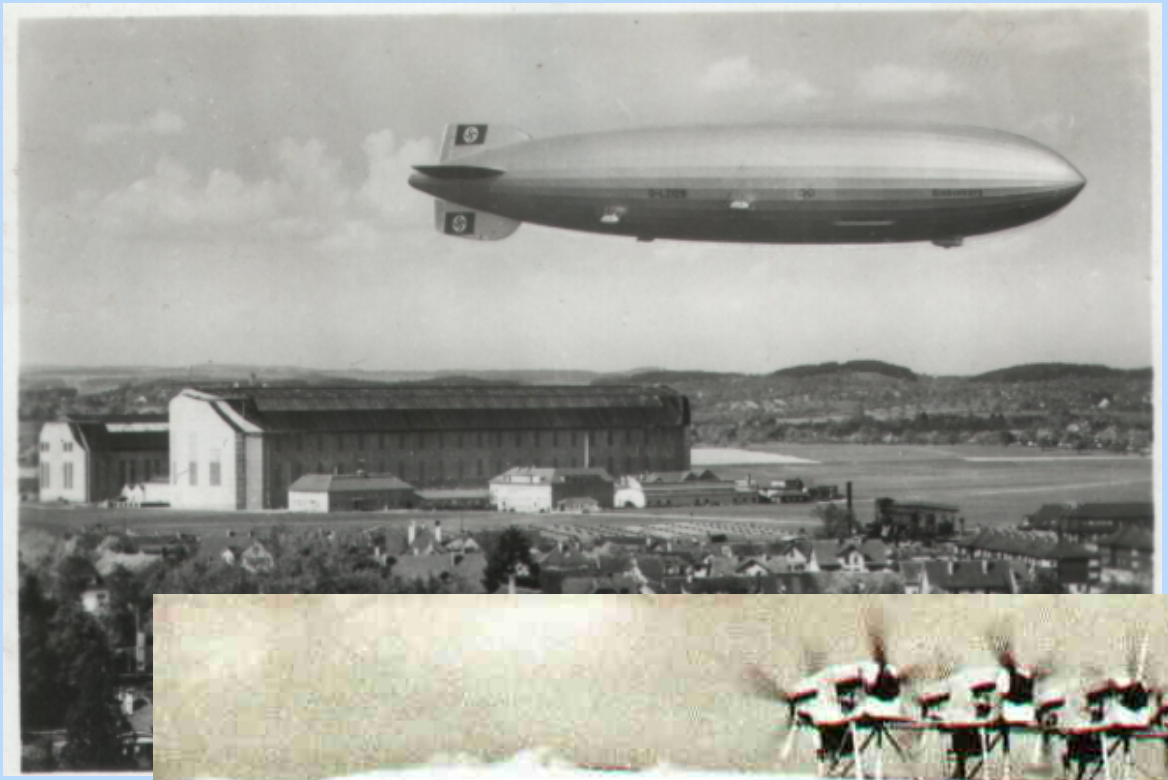
Vertical Take-Off and Landing – VTOL Transport Aircraft,

Friedrichshafen, Germany 1968

***KIEBITZ* – peewit**

Teleoperated Helicopter with Reconnaisance Radar,

Friedrichshafen, Germany, 1970



Airship *Zeppelin*, 1920
and Flying Boat *Dornier DO X*, 1929

Contents

Introduction and Motivation

Robots for Amusement
Autonomous Mobile Robots
Robots and Robotic Approaches in Medicine
Telepresence and Teleoperation
Humnoid Robots

Final Remarks

The KUKA Robocoaster

KUKA Co., Augsburg, Germany, 2004

Productivity

Entertainment

From the Factory-floor
to the Amusement Park

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Excitement by a Ride with the Robocoaster

Contents

- *Mobile Robots on the Factory-floor, 1990 - 1998*

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- *Mobile Manipulator in Fetch-and-Carry Task, 2000*

Information Processing in Autonomous Mobile Systems

Exemplary scenarios

Production

Service

*

- *Mobile Manipulator in Hospital Environment, 2001*

*

Contents

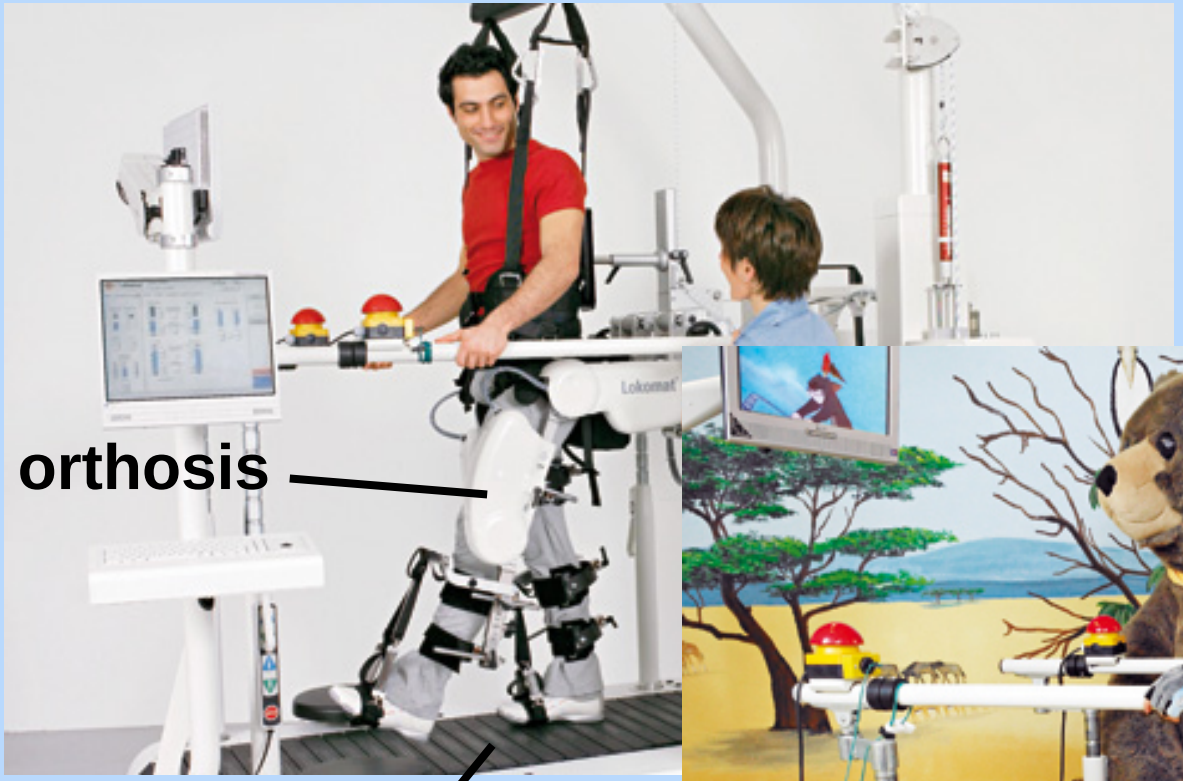
Interaction of Human and Artificial System

Robotics and Automation in Medicine

Organ Function Replacement Systems Life sustaining/improving	Support Systems Physicians, Patients, Health Care Staff	Educational and Training Systems Students, Physicians, Health Care Staff	Laboratory Automation Systems
Mechanical Ventilators	Surgical Field Robots	Anesthesia Simulator	Analytics (chem./biochem.)
Dialysers	Intelligent Wheelchairs	Laparoscopy Simulator	Imaging Techniques (MRI, CT, US)
Cardiac Pacemakers	Rehab. Robots (LOKOMAT)	Knee Simulator (VOR)	Data Acquisition (ECG, EEG)
Neuroprosthesis (WALK)			

❖ *LOKOMAT –A Driven Robotic Gait Orthosis*

HOCOMA Co. Zürich, Switzerland, 2006



LOKOMAT Systems for Adults and Kids

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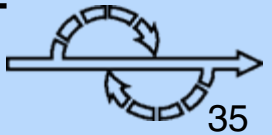
Therapist-assisted Training of Patient



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Functional Locomotion Therapy with Robotic Gait Trainer

- *A Patient-driven Gait Neuroprosthesis, 2000-2004*

WALK! - A Patient-driven Gait Neuroprosthesis

- **Generation of motion patterns relevant for locomotion by means of**
  - **Functional Electrical Stimulation (FES)**

of paralyzed limbs

Lehrstuhl für Steuerungs- und Regelungstechnik

Neurologische Klinik Klinikum Großhadern

LMU

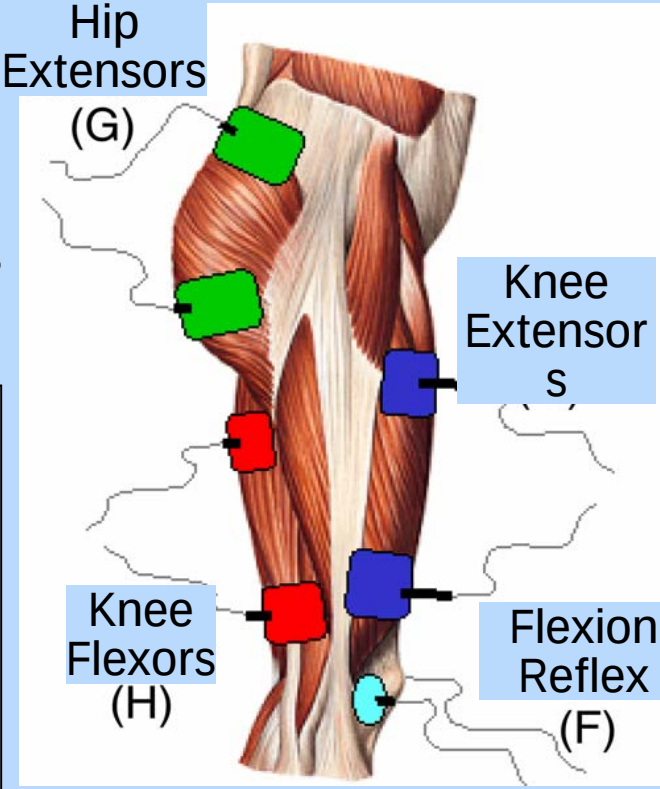
Target Group

- Patients with complete spinal cord injury (thoracic lesions)

Method

- Electrical stimulation of peripheral motor neurons by surface electrodes

Muscle activation

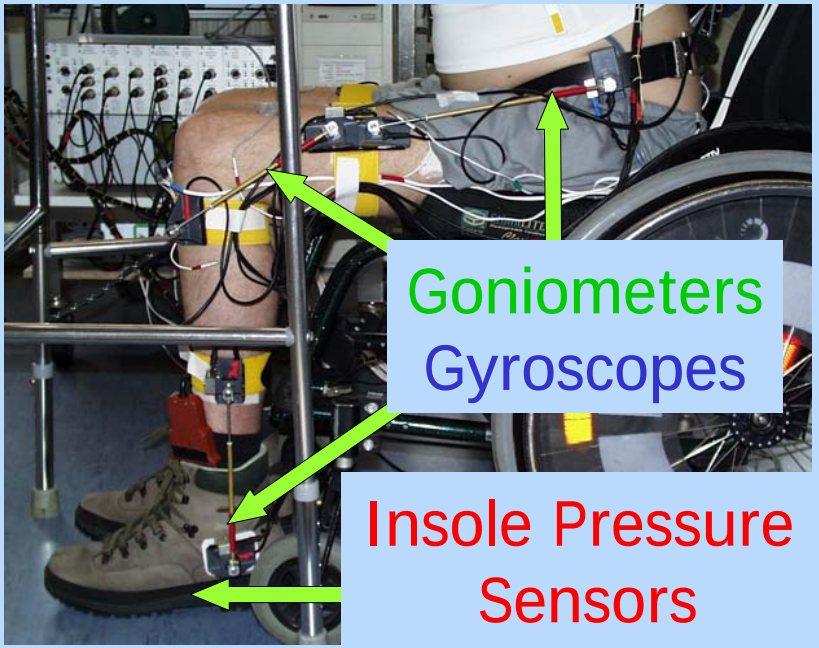


Relevant Motion Tasks

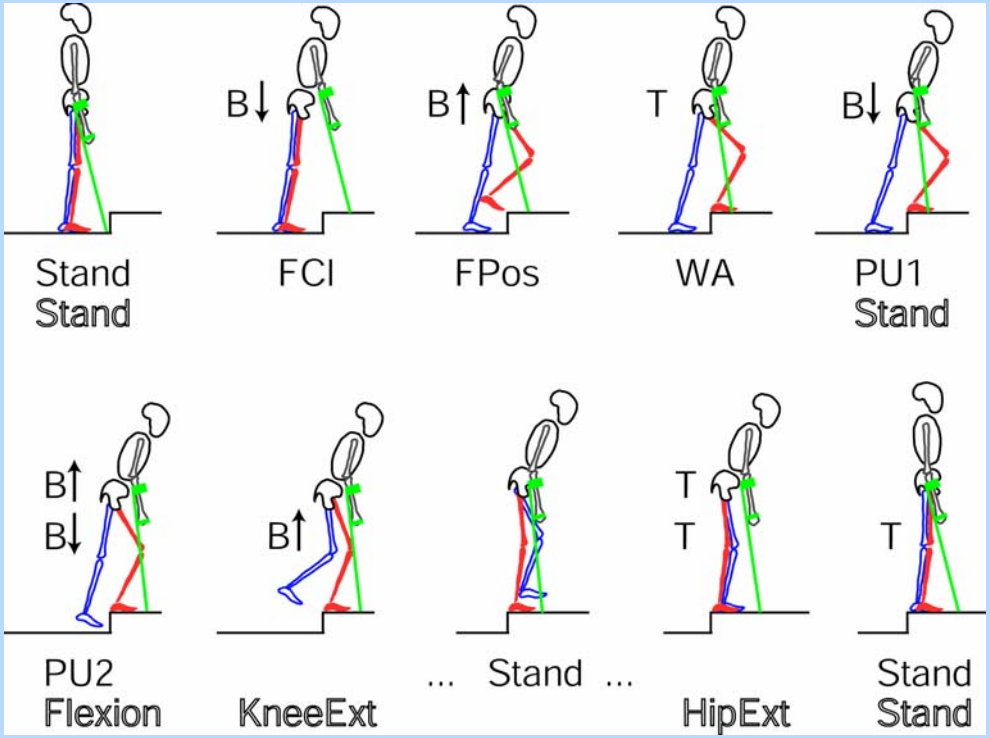
- Standing: *Standing up, Standing, Sitting down*
- Gait: *Step Forward*
- Climbing: *Stair ascent and descent*

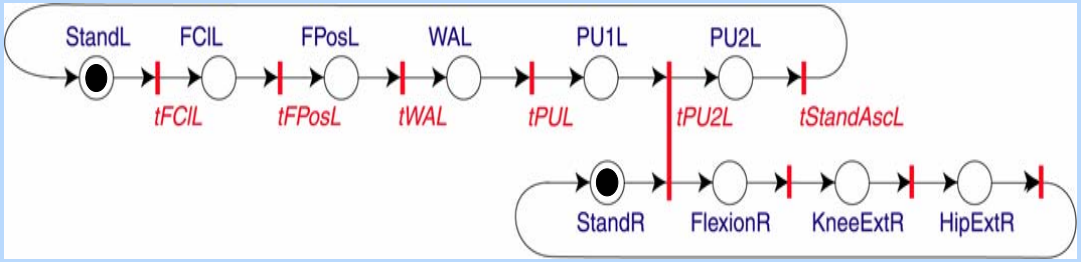
Patient mounted
Sensors and Actuators

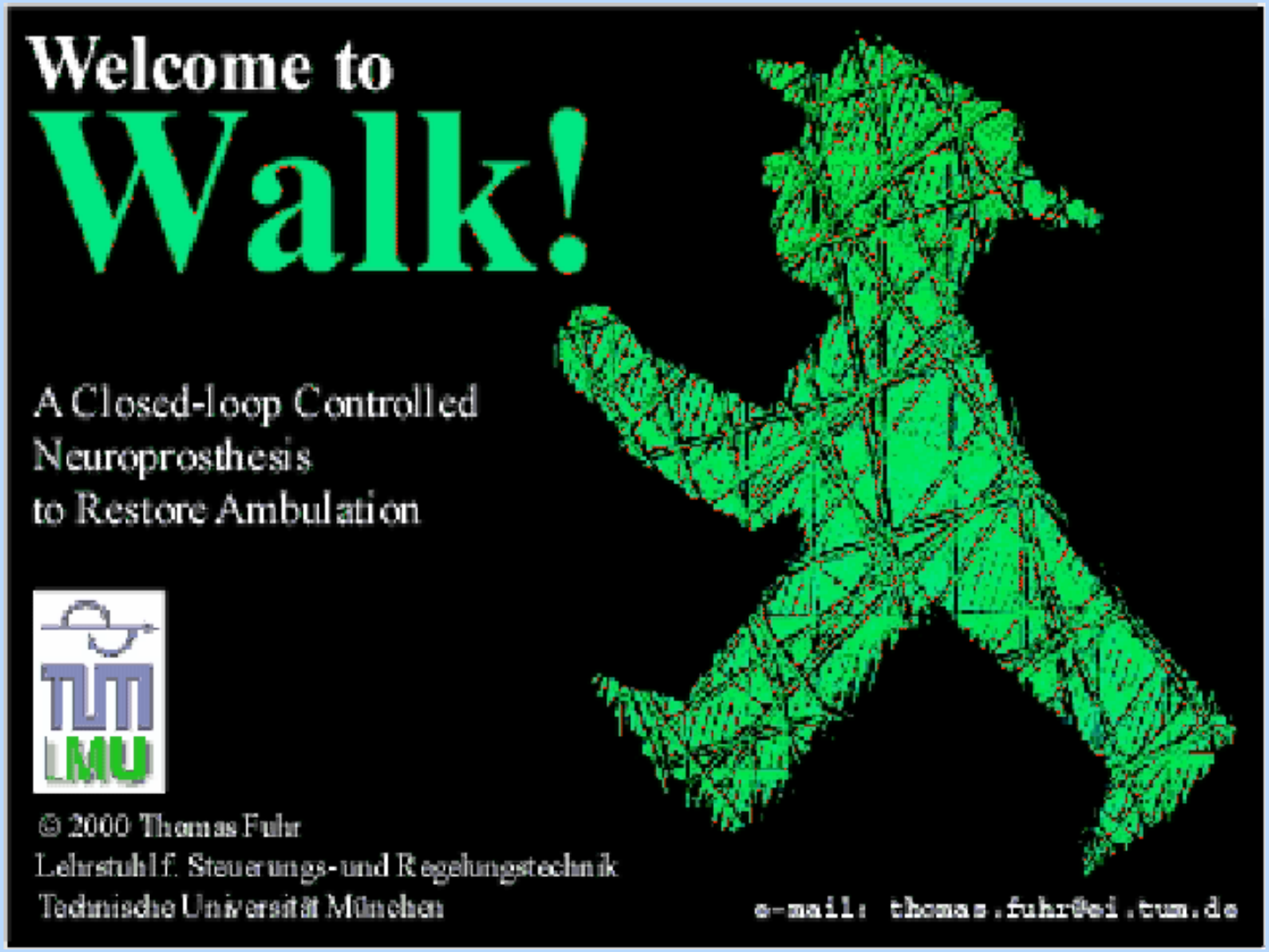
- Knee angles + angular velocities
- Force sensing soles
- Electrodes + Neurostimulator + Muscles



Synthesis of Motion Task : Stair Ascent






Welcome to
Walk!
A Closed-loop Controlled
Neuroprosthesis
to Restore Ambulation
TUM
LMU
© 2000 Thomas Fuhr
Lehrstuhl f. Steuerungs- und Regelungstechnik
Technische Universität München
e-mail: thomas.fuhr@ei.tum.de

*

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Stair-climbing by Means of FES

- *Virtual Orthopaedic Reality – VOR, 2003*

Novel Approach to Orthopaedic Education

- **Joint diagnosis requires high level of experience and sensitivity**
- **Training with patients is cumbersome and time-consuming**

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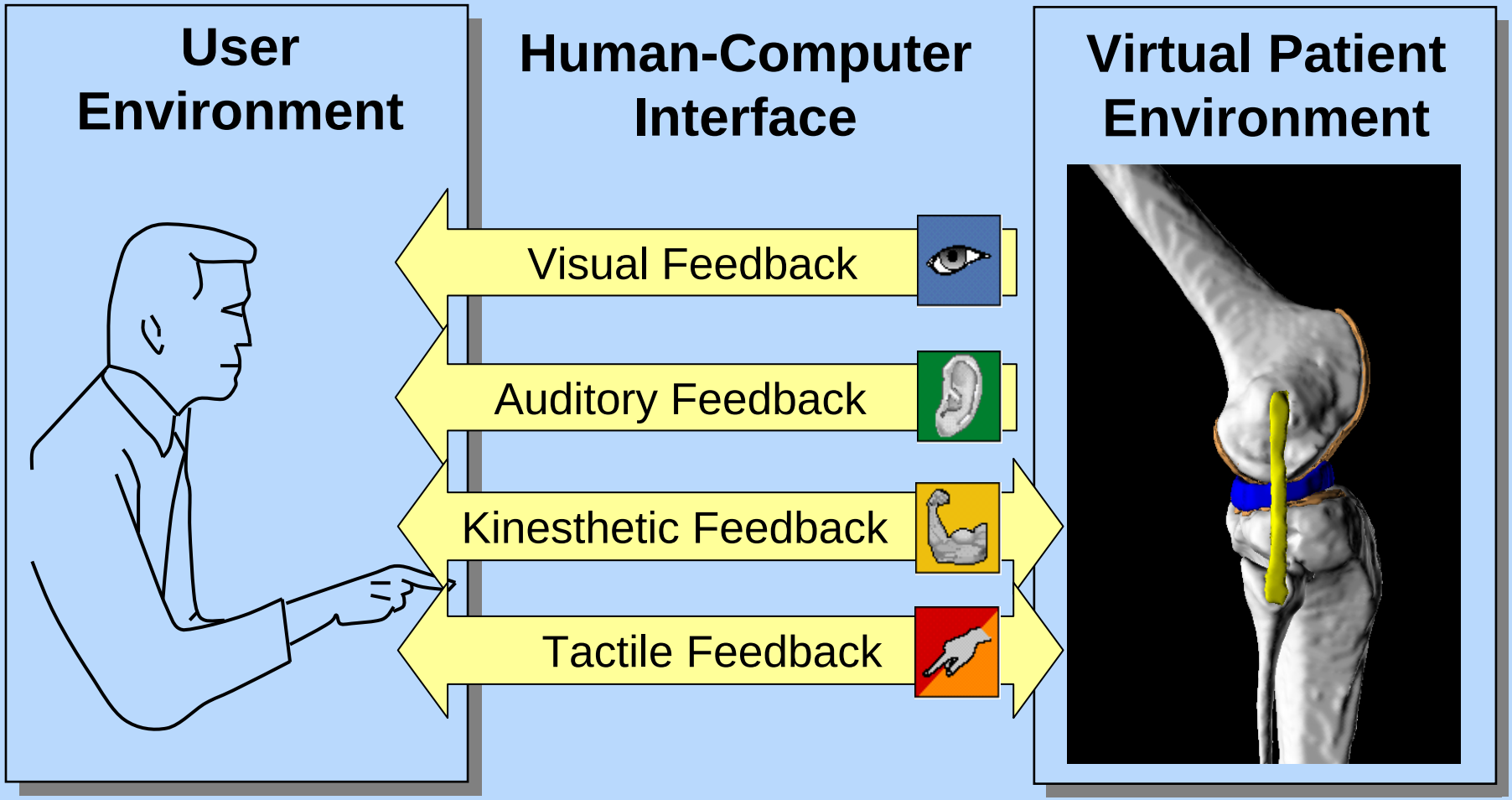
Example

McMurray Test
for diagnosis of meniscus injuries

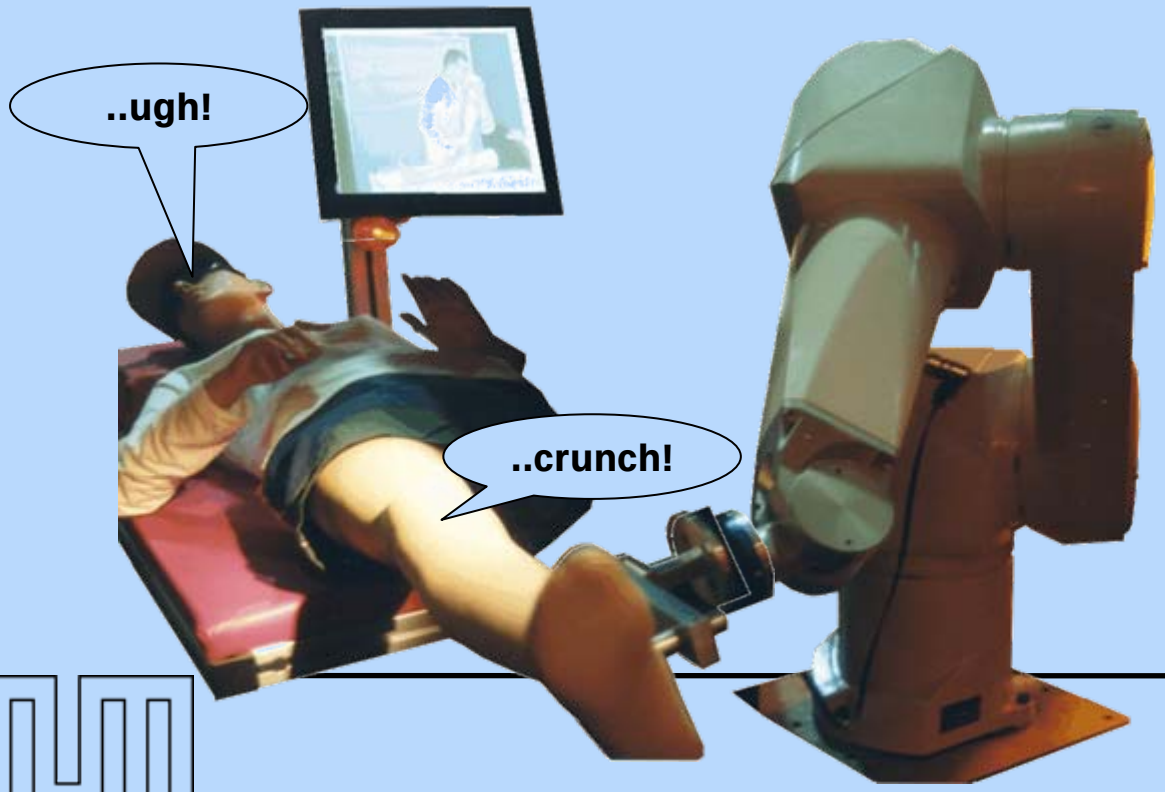
Principle of Multimodal VR



The Munich Knee Joint Simulator

... a *multimodal* platform for interactive training

- **Industrial robot for *kinesthetic* feedback**



- **Artificial leg for *tactile* feedback**
- **Realistic examination environment**
- ***Visual* feedback**
- ***Auditory* feedback**

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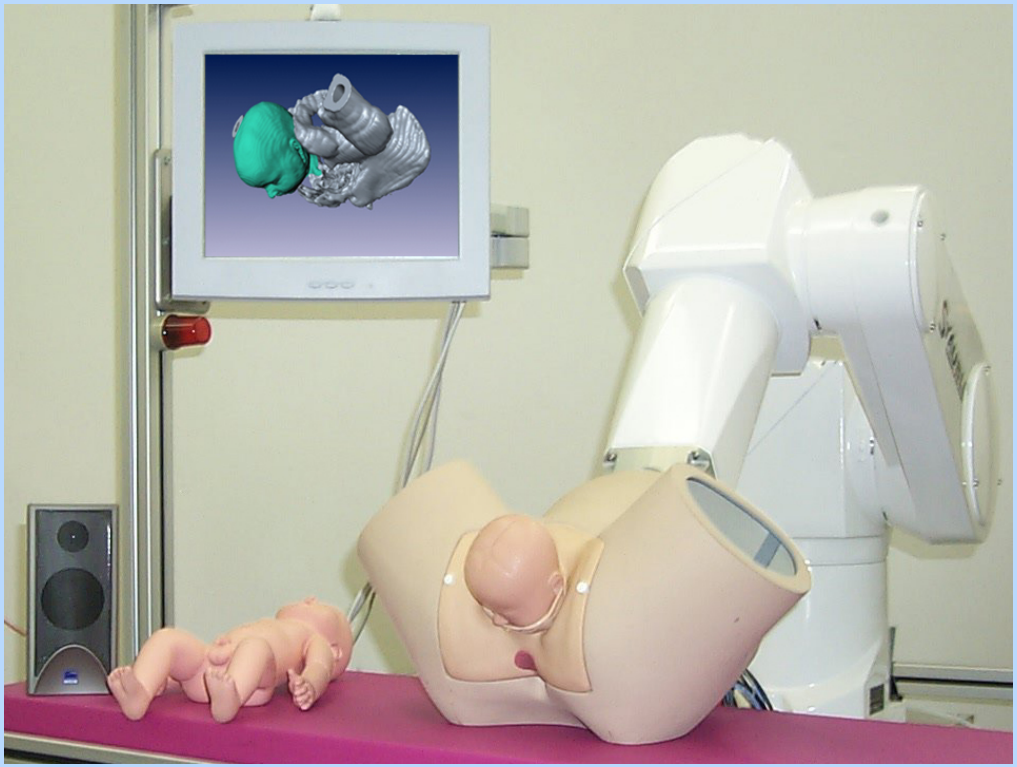
The Knee Joint Simulator in Action

Delivery Training Simulator

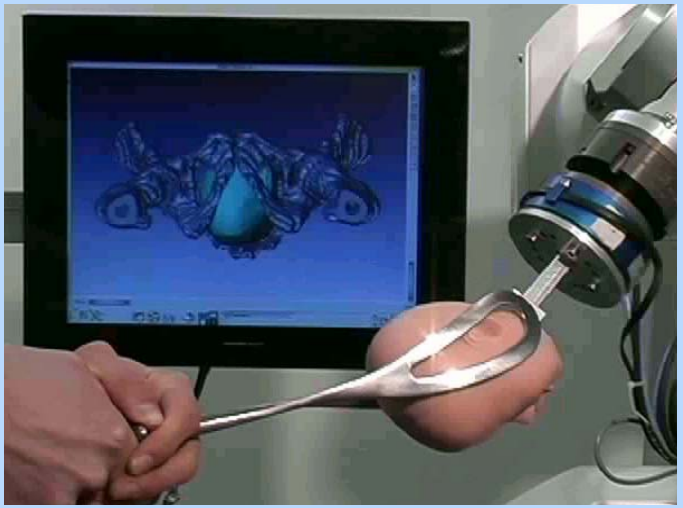
for medical students and midwives



Baby passing through cervix without and with (right) doctor‘s intervention

Cooperation Partners

- **Orthopedic Clinic**
- **Clinic for Gynaecology**



Contents

Long-Term Goal for Telepresence Research:
Multi-Modal Full-Body Immersion in RE?

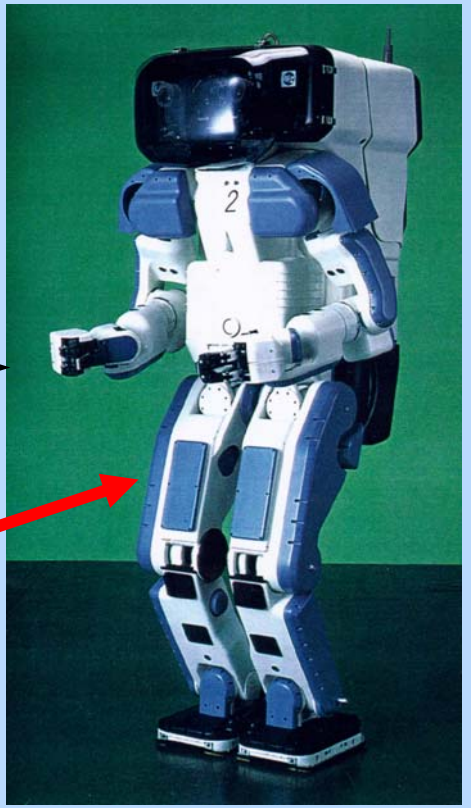
Modalities of Human Perception

audition, vision, haptic, taste, smell

local

kinesthesia - tactility

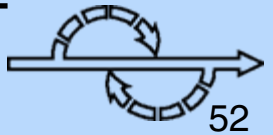
remote



Humanoid teleoperator

Full-body haptic suit

- Guiding of a Remote Mobile Teleoperator by Visual Telepresence, 2003



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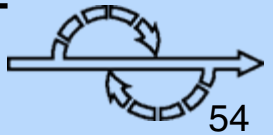
Motion Compression
applied to
Guidance of a Mobile Teleoperator
Wiesbaden
Mayence
Saarbrücken
Karlsruhe
Stuttgart
BAVARIA
München
BADEN-WÜRTTEMBERG

- Walking About a Virtual Museum, 2002



Motion Compression

Walking About a Virtual Museum

N. Nitzsche, Uwe D. Hanebeck, G. Schmidt

Institute of Automatic Control Engineering
TU München, 80290 München, Germany

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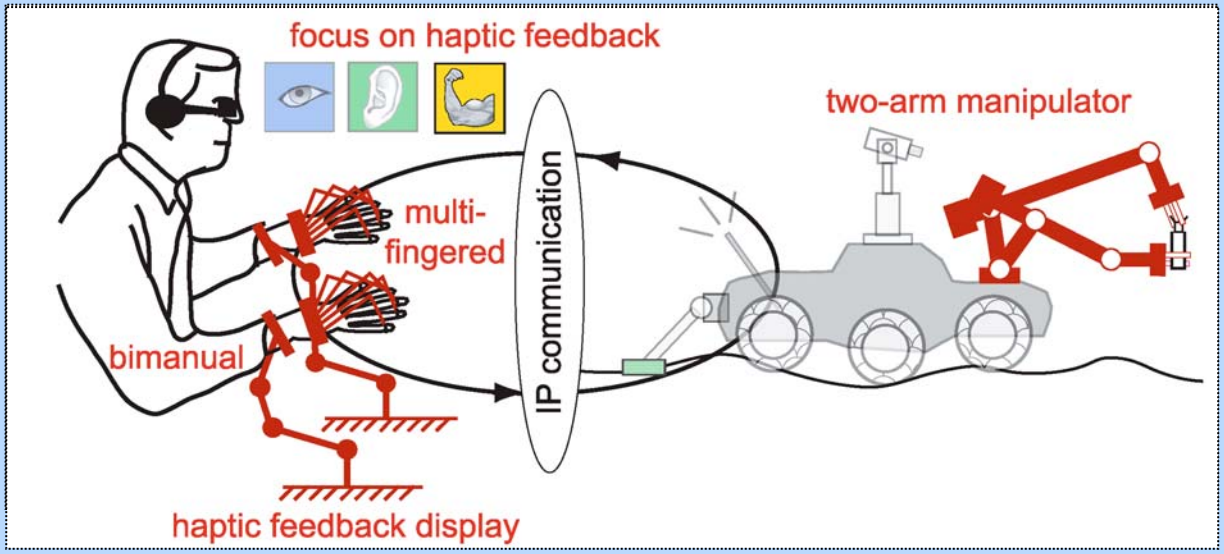
- Disposal of Explosives and Demining, 2003

Remote Disposal of Explosives . . .

needs an increased sensation of operator immersiveness via

- multimodal perceptional feedback: stereo vision, audition and haptics = touch and force,
- two-arm manipulator system
- intuitive human system interface (HSI)



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Manual Disposal of Mine

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Telepresent Disposal of Mine

- Advanced Virtual Prototying, 2001

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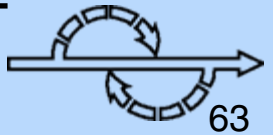
Inserting a Radio into Instrument Panel

Contents

- **Intelligent Humanoid Robot Walking, 1998 - 2005**

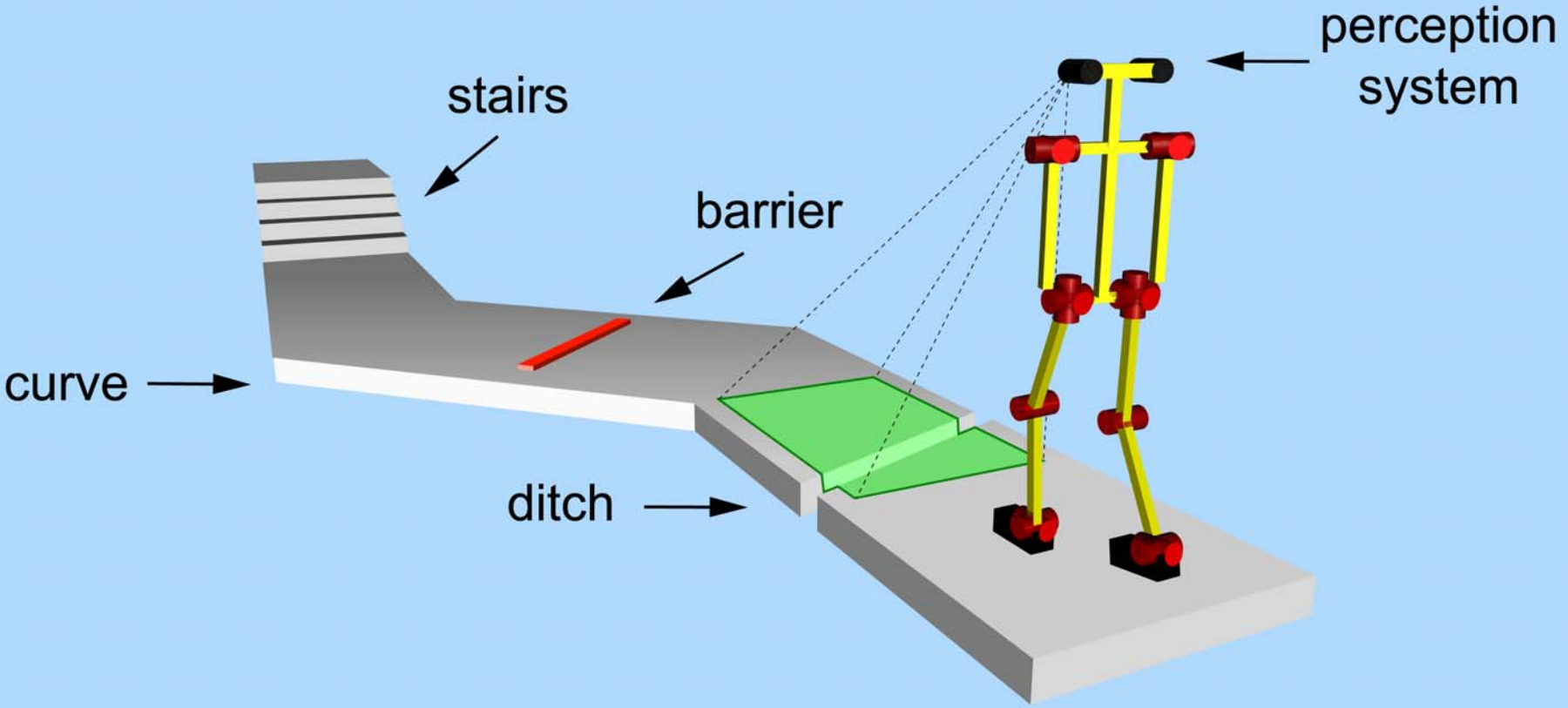


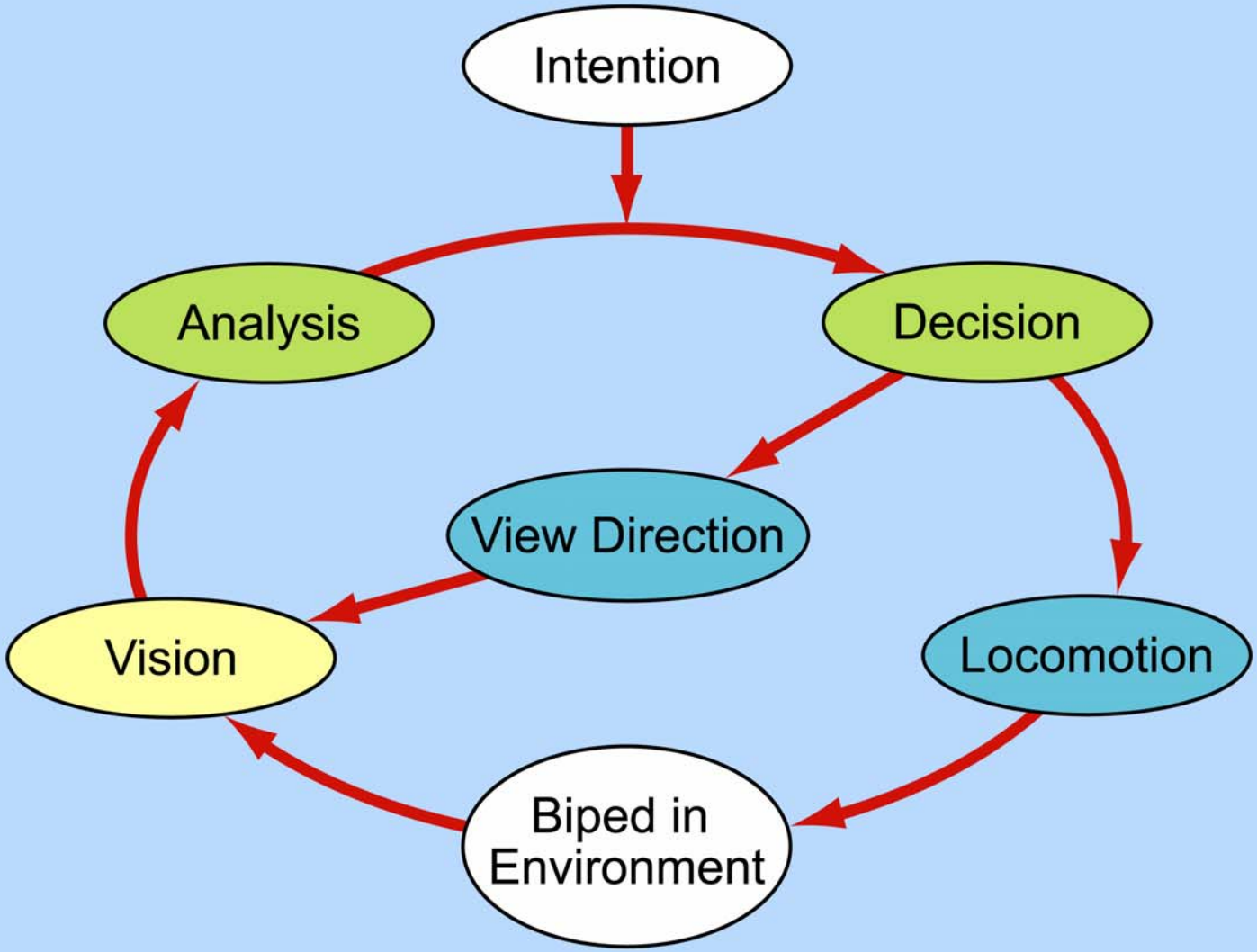
Basis of Locomotion Autonomy in Humans and Robots ?

- **Cognitive Functionalities,**

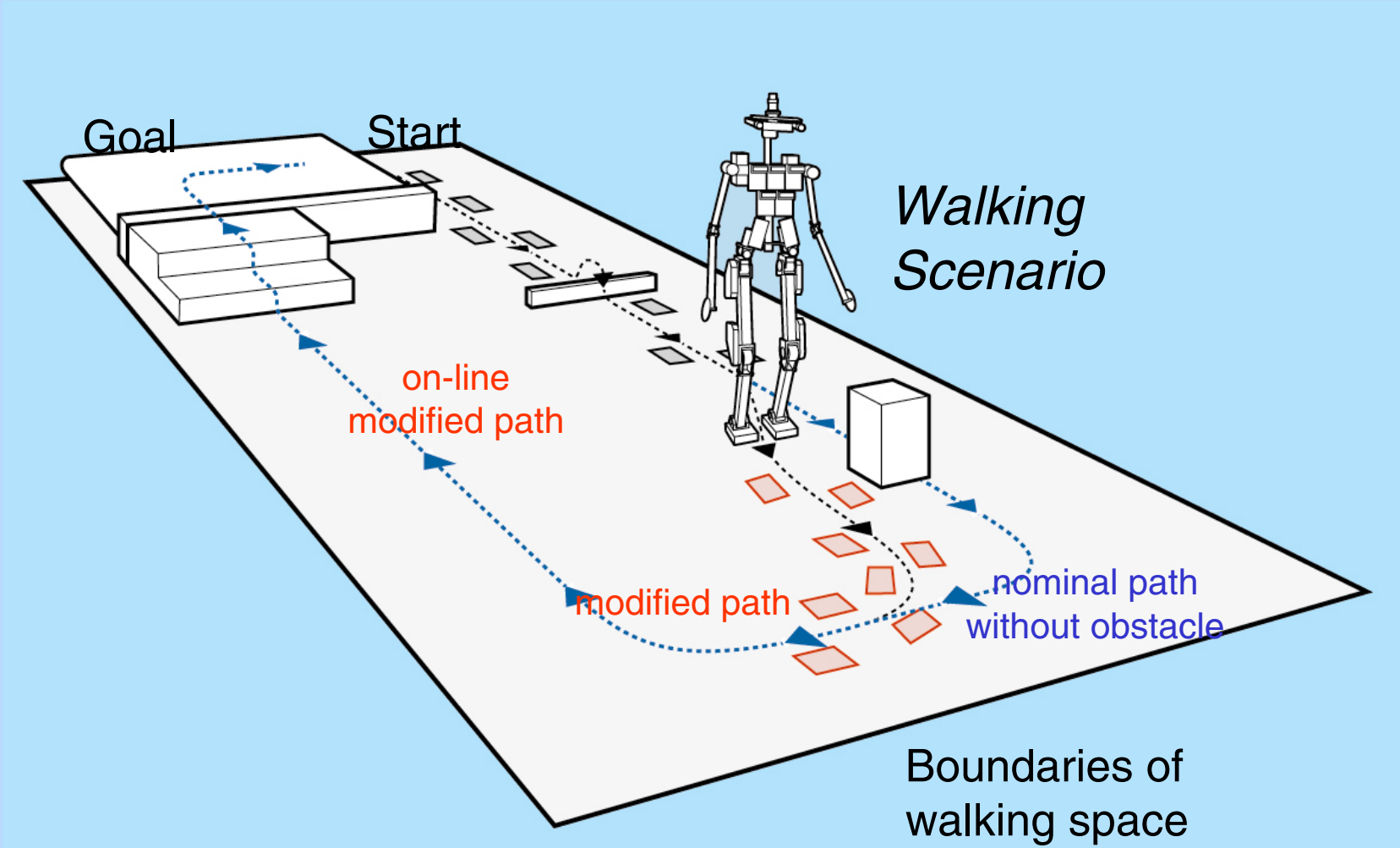
"interplay of perceptional and locomotion behaviours"

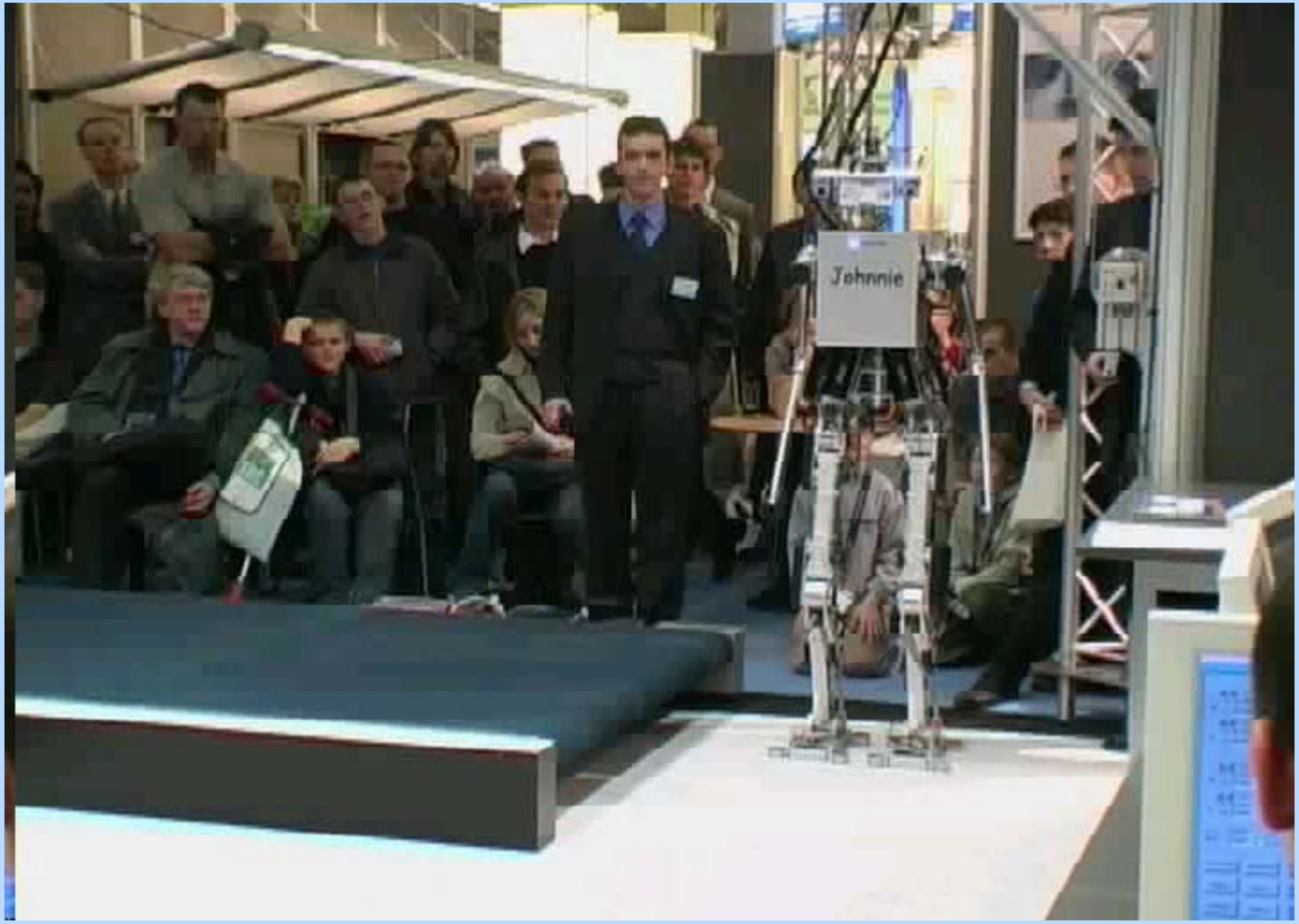
“The view anticipates the step”




Intention
Analysis
Decision
View Direction
Vision
Locomotion
Biped in Environment

Demonstration of Intelligent Humanoid Robot Walking





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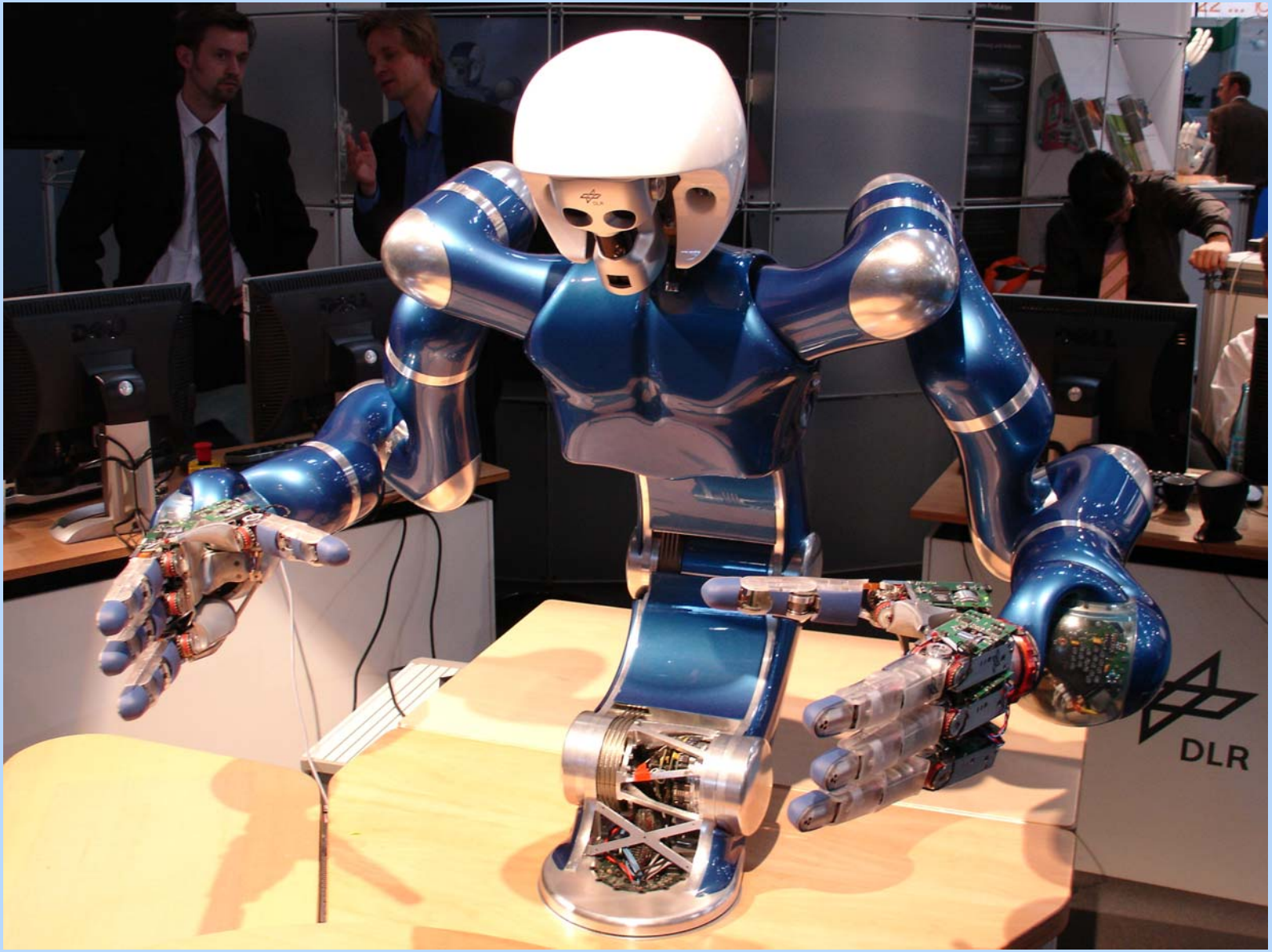
Obstacle Avoidance and Self-Localization

❖ **An Advanced Humanoid Two-arm Robot**

German Aerospace Establishment (DLR), 2007



JUSTIN – A Humanoid Robot Torso

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Contents

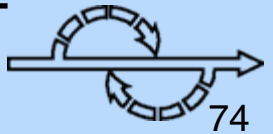
Bill Gates Article, March 2007

"Robotic Helpers for Everybody"

"To invent you need a good imagination and a pile of junk"

- Thomas A. Edison

"Converting an Invention into an Innovation needs
Imagination and Creativity,
a solid Education in
Maths, Natural and Computer Sciences,
a good Understanding of
Social Developments, Psychology, Kansei
Economics, Marketing, . . .
and last but not least an Openess to
Cross-disciplinary Team Work"



Past:

- **Economic Development driven by Technology**

Future:

- **Shift to Awareness of Customer Demands/Needs, *Aging Society***
- **Emergence of Novel Assistance Business**

→ **Excellent Opportunities for Macro-scale and Micro-scale Robots**

Thank you
for your kind attention

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