

BIOMECHATRONIC SYSTEMS





THE DEMOGRAPHIC CHANGE DRIVES MEDICAL TECHNOLOGY AND ERGONOMICS

Medical technology is one of industry's most innovative sectors. The demographic change requires manufacturing systems to be planned with a view towards people's needs. In the course of this development, the prevention of bodily harm and the treatment of musculoskeletal disabilities become more and more important. 50 percent of all chronic illnesses in our society involve the musculoskeletal system. In particular, the relevance and importance of maintaining health at work is on the increase; this is because 6.9 million people suffer serious damage to their health at the workplace every year.

Solution approach taken by Fraunhofer IPA

Biomechatronics is an interdisciplinary science that generates new technical solutions using knowledge from engineering and natural science in order to improve people's mobility.

The department of »Biomechatronic Systems« at Fraunhofer IPA designs technical solutions to detect, control and generate movements. An interdisciplinary team uniting the fields of mechanical engineering, electrotechnology, mathematics, cybernetics, mechatronics, sport science, medical technology, biology, physical therapy and medicine ensures that the problems of predictive and preventative ergonomics are considered from all angles. In addition to this, the team works on solutions for socially-sustainable mobility for the elderly and for people with restricted mobility.

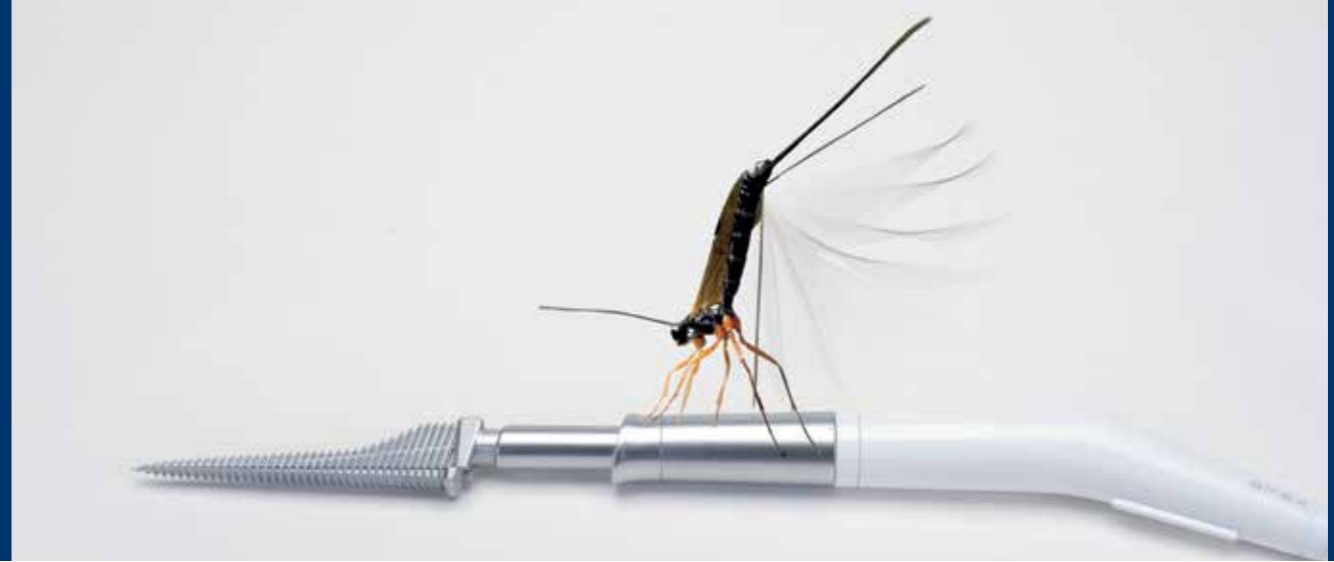
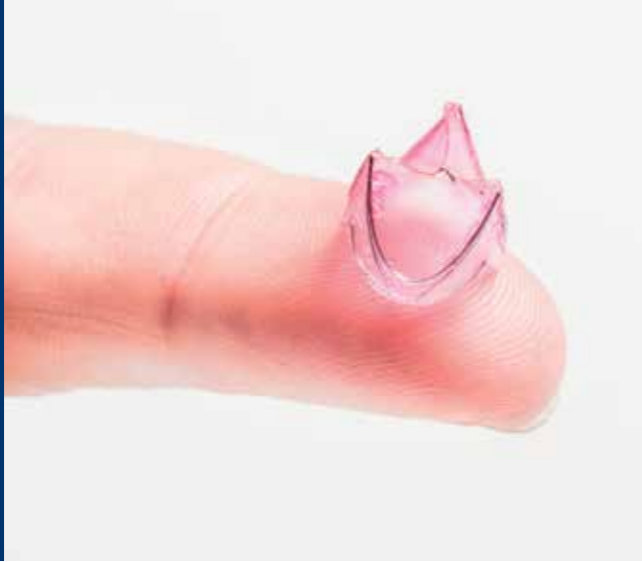
Together with you, our customers, we want to develop new solutions for a mobile society in the process of demographic change.

In the field »motion control systems«, we focus on detecting and reproducing motion patterns based on natural human movements. Customers appreciate the department's ability to combine implementation know-how in tests, such as dynamic tests on prototype drive systems, with the further development of sensors. The knowledge gained enables key technologies to be developed for actively-driven orthoses, prostheses and exoskeletons for rehabilitation and manufacturing purposes. Furthermore, customers can apply this design competence in drive systems to other disciplines.

The aim of biomechanics is to develop technical solutions in the areas of prosthetics, orthotics, rehabilitation and implant technology in order to restore lost mobility and a high quality of life. To achieve optimum results, an abstract form of the natural model is always "recreated" and combined with mechanical features (biomimetics).

The still relatively-young field of activity of (computer-aided) biomechanics gives medical enterprises support in research, science and application. The objective of the virtual development environment for orthopedics is to create a simulation environment for orthopedic research and development. The "Virtual Orthopedic Lab" generates a simulation-assisted workflow for product development in orthopedics which is planned to become available in the future as a tool that can be licensed "made by Fraunhofer".





OUR RANGE OF SERVICES

EXOSKELETONS TO ENHANCE STRENGTH AND AID MOBILITY

Services

- Man-machine solutions for manufacturing, rehabilitation and the home
- Development of prostheses, orthoses and exoskeletons
- Design and construction based on aspects of ergonomics, biomechatronics and safety
- Sensors, actuators, drive and control of machines worn on the body
- User tests, norm-compliant safety analyses, ergonomic tests

Advantages

- Team of experts with longstanding experience in the field of biomechatronics which cooperates on an international scale
- Simultaneous consideration of ergonomic, biomechatronic and medical aspects

BIOMIMETIC SOLUTIONS FOR MEDICAL TECHNOLOGY

Services

- Transfer of successful biomimetic principles that are found in nature – even in the specialized field of medical technology
- New development and optimization of implants, prostheses and surgical instruments
- Measuring instruments for diagnostics and quality assessment in medicine and medical technology

Advantages

- Interdisciplinary team of experts with application know-how and associations with the latest fundamental research in biology
- Novel solutions to problems with major springboard innovation potential based on the transfer of natural principles
- From conception of the idea through product design right up to testing – everything from a single source

BIOMECHANICAL HUMAN WHOLE MOTION CAPTURING

Services

- Determination of individual kinetic and kinematics data via 3D motion capture, 3D body scan as well as force, pressure and electromyographic sensors
- Basis for the development and functional validation of medical products and also preventative ergonomics

Advantages

- Fast, high-quality test results thanks to extensive measuring equipment and know-how
- Biomechanical knowledge as a basis for developments and functional validation
- Ergonomic overall consideration even in the working environment with a focus on optimized workflows and motion sequences
- Depiction of a wide range of different scenarios made possible by a modular motion laboratory

3D TEST SYSTEMS FOR APPLYING MECHANICAL LOADING TEST TO COMPONENTS

Services

- Mechanical product and component testing using a range of testing machines
- Real 3D loading test using a 6-axis robot

Advantages

- Rapid meaningful results thanks to extensive testing know-how
- Realistic load and load situation through a global fundamental understanding of biomechanics
- Structural optimization support

BIOMECHANICAL SIMULATION

Services

- Modeling and simulation with the aid of the finite elements method
- Multiple body simulation
- Skeletal and muscle models
- Forward and inverse dynamic simulations of the human musculoskeleton system
- Patient-specific simulation
- Simulation-accompanied product development for prostheses, orthoses and implants
- Workflow systems with intuitive graphical interface
- Statistical analysis

Advantages

- Fast, transparent development decisions
- Reduced number of iteration loops in development processes
- Efficient workflow
- Intuitive portrayal of simulation results

DRIVES AND DRIVE SYSTEMS

Services

- Design, implementation and testing of electrical drives, primarily for medical technology products
- Simulation of drive systems in medical products
- Analytical calculation and optimization of electrical machines and drivetrains
- Mechanical and electrical drive testing
- Development and construction of power and signal electronics (analog/digital)
- Development of mechatronic systems, taking the special demands of medical technology into account
- Development and construction of specific power and signal electronics (analog/digital)

Advantages

- Many years of experience in developing mechatronic (drive) systems in medical technology
- Project support from the moment an idea is conceived right up to construction of the first prototype
- System integration of electrical machines and electro-mechanical drivetrains into rehabilitation, orthopedic and automation products

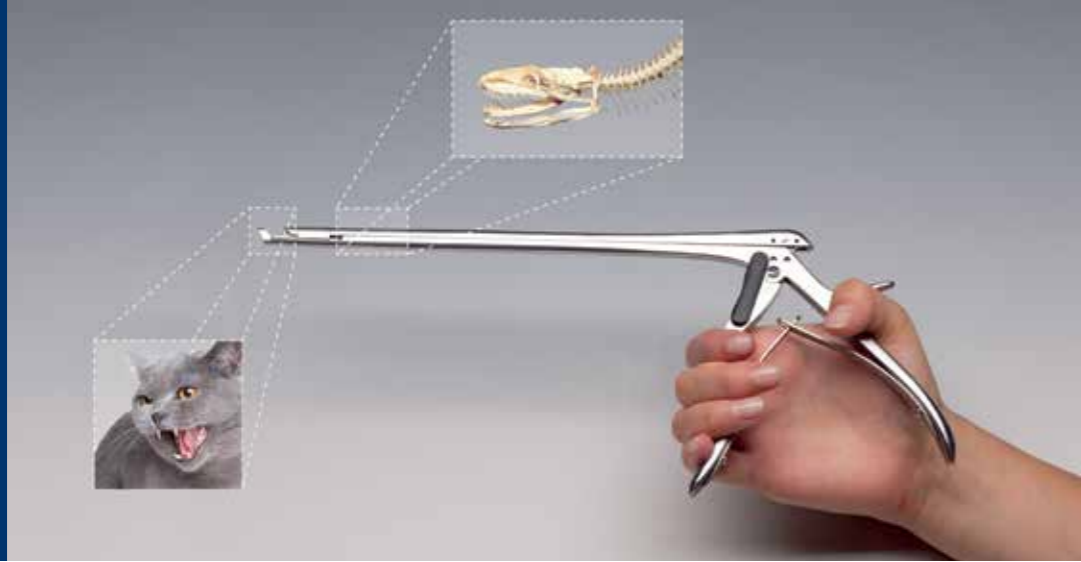
SENSOR TECHNOLOGY AND SENSOR DATA FUSION

Services

- Merge and combination of different sensor signals to create an overall image
- Development and implementation of innovative sensor systems in our own electronic hardware laboratory
- Commissioning of sensor systems, including firmware design and implementation
- Software framework with algorithms for different application scenarios in the field of inertial and visual navigation
- Customer-specific sensor connection
- Calibration and testing of inertial navigation systems (INS)
- Evaluation of visual and inertial motion measurement systems on robot test bench

Advantages

- Long-standing development expertise in electronic hardware and software
- From system identification through the construction of corresponding functional samples of sensor systems right up to the implementation of sensor systems in hardware and software



REFERENCE PROJECTS

NEW MANUFACTURING PROCESS FOR POLYMER-BASED ELASTIC IMPLANTS SUCH AS VENOUS VALVES

Valve design that imitates the natural counterpart; made from gradient material composed of different elastic polycarbonate-thanes generated by a 3D droplet dispensing process.

Task

To develop elastopolymer venous valve prostheses using 3D droplet dispensing process (InnoNet funded by BMWI).

Services

- Development of an appropriate production strategy and manufacturing process for a gradient polymer implant
- Development of workpiece kinematics to execute complex freeform surfaces and edges along the length of curved paths

DEVELOPMENT OF A BIOMIMETIC BONE PUNCH WITH INTEGRATED MATERIAL COLLECTION

Task

To develop an innovative bone punch that can be used several times by the surgeon without needing to be emptied during use. To achieve this, a cartridge was developed for the resected material, which extends the bone punch by a “swallowing mechanism” (ZIM KA by BMWI).

Services

- Conception, design, simulation, realization and evaluation of possible methods for transporting and, in particular, retaining resected material in the cartridge
- Determination of appropriate materials, especially with regard to realizable tolerances, dimensional stability during sterilization, storage and disposal
- Evaluation of processing techniques required to realize the cartridge

NEW ACTIVELY DRIVEN ARM ORTHOSIS

Project to develop an actively driven elbow orthosis. “Active smart wearable orthosis using painted EMG electrodes for home-based therapy with augmentative feedback.”

Task

To develop an actively driven elbow orthosis for rehabilitation purposes. To design high-performance mini-drives combined with electromyographic sensors (funded by EU ERANET-Cornet).

Services

- Methodical development of overall concept
- Drivetrain design
- Mechanical design
- Sensor development
- Overall system test

“VIRTUAL ORTHOPEDIC LAB” – SIMULATION ENVIRONMENT FOR DEVELOPING ORTHOPEDIC PRODUCTS

Task

Biomechanical simulation to aid the development and testing of orthopedic products.

Services

- Utilization of human biomechanical digital model to test virtual products
- Virtual ISO tests on prosthesis components
- Simulations for dental tasks

“GAIT-TO-ROBOT”

Task

To transfer individual gait and motion data to an industrial 6-axis robot for adaptation to special load situations.

Services

- Biomechanical motion capture
- Biomechanical analysis and development of algorithms
- 3D material tests on prostheses

EVALUATION OF THE STABILITY OF AN ACTIVELY DRIVEN FOOT PROSTHESIS

Task

To assess the stance stability of test persons with an innovative actively driven foot prosthesis.

Services

- Whole body motion capture
- Analysis and interpretation of measurement data

DEVELOPMENT OF A DRIVE SYSTEM FOR PROSTHESES AND ORTHOSES

Task

To develop an actively driven knee prosthesis whilst keeping manufacturing costs as low as possible. With this in mind, a particular emphasis was placed on the use of new manufacturing technologies (funded by the Federal Ministry of Economics and Technology subsequent to a resolution passed by the German Federal Parliament).

Services

- Design of actively driven systems in prosthetics
- Planning and execution of research projects
- Modeling and simulation of electromechanical drive systems

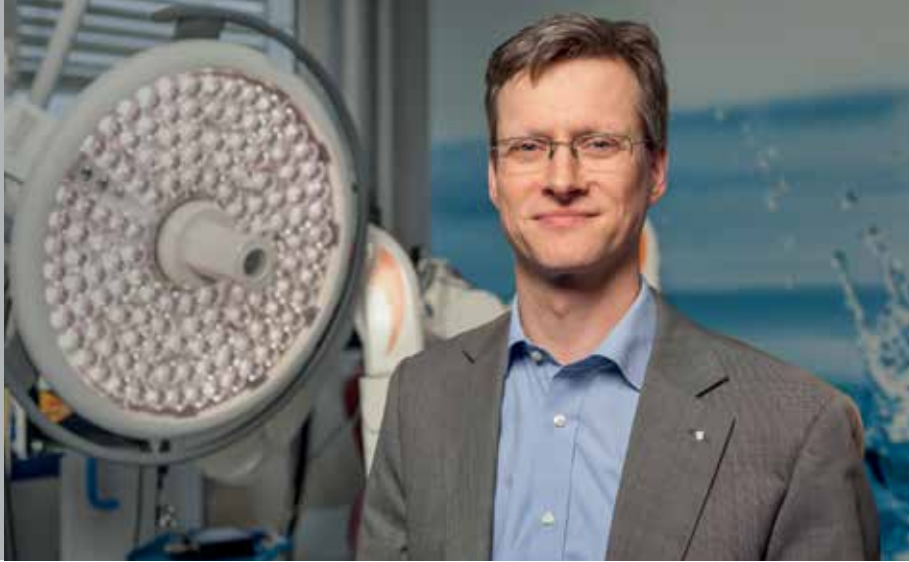
“LINPRO” – ADVANCED OBSTACLE RECOGNITION FOR HUMANS

Task

To develop a visual inertial measuring system for the mobile recognition of obstacles by prosthesis wearers. The sensors and algorithms are designed for human application.

Services

- Conception of the measuring system
- Development of sensor data fusion to combine different sensor data
- Implementation and assessment of algorithms for functional tests
- Execution of long-term reference measurements to evaluate motion measurements



CONTACT

Dr. med. Urs Schneider
Head of Department "Biomechatronic Systems"

Phone +49 711 970-3630
urs.schneider@ipa.fraunhofer.de

Teuta Bala
Assistant to the Head of Department "Biomechatronic Systems"

Phone +49 711 970-3731
teuta.bala@ipa.fraunhofer.de

**Fraunhofer Institute for Manufacturing Engineering
and Automation IPA**

Nobelstrasse 12
70569 Stuttgart
Germany
www.ipa.fraunhofer.de

Director of Institute
Prof. Dr.-Ing. Thomas Bauernhansl