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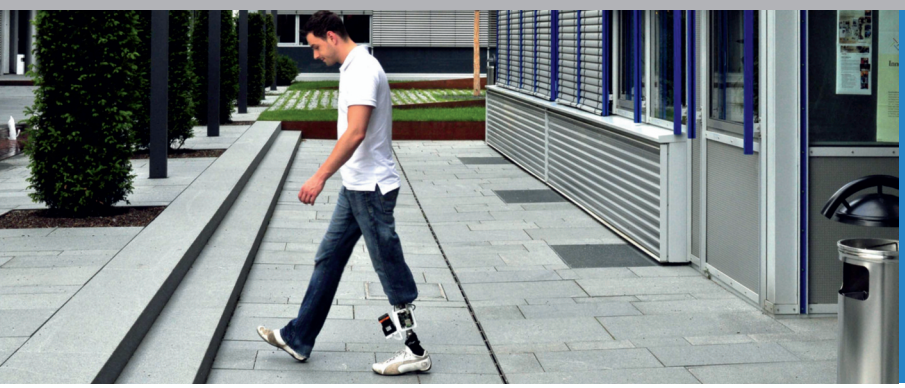


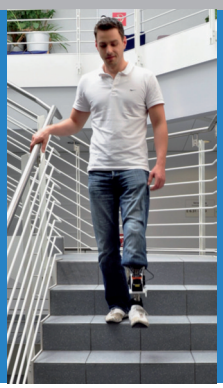

TERRAIN DETECTION FOR PROSTHESES

ROBUST TERRAIN DETECTION SYSTEM FOR CONTROLLING ACTIVE LEG AND FOOT PROSTHESES

Introduction

The »Orthopaedics and Motion Systems« department at the Fraunhofer Institute of Manufacturing Engineering and Automation IPA develops technical solutions both on the field of orthopaedic technology and three-dimensional motion detection.

Not long since, joints in prostheses for the lower limbs were equipped with a passive mechanism only. A dynamic adaptation of the joints while walking was impossible. Thus, restoring the locomotory system is can only be accomplished in a restricted way, and movements as walking or running are exclusively supported by a special type of prostheses only. Also, mounting stairs and walking on inclined planes cannot be performed easily with this kind of prostheses. Most frequently, a downfall is caused by doorsteps and obstacles, which nondisabled people perceive subconsciously and process them accordingly.

These functionalities require a simultaneous adaptation of the prosthesis to the ground. Recent developments do not include an anticipating adaptation concept and count on an adaptation of the active prosthesis joints after the first ground contact.

Objective

Our access to the problem describes an anticipatory adaptation of the prosthesis by measuring detecting the ground structure during the gait cycle.

A combination of optical distance sensors and inertial movement sensors deliver the data of the environment of the gait track. The objects detected in the direction of

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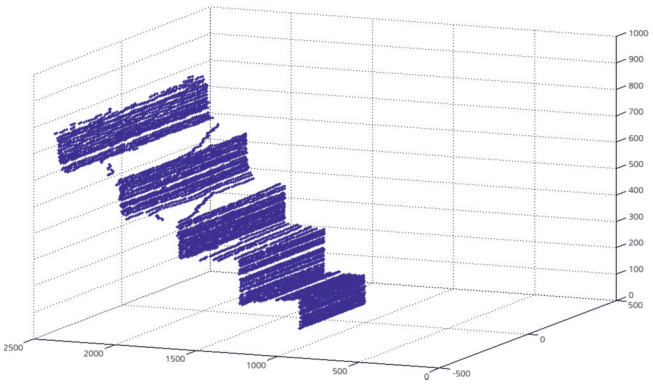

movement are identified in real-time during the phase of rest and impetus and are transmitted to the prosthesis control. Thus, the joints of the prosthesis can anticipatory adapt to detected stairs, uneven surfaces and obstacles.

Procedure

The distance to the environment in the direction of movement is determined by a laser scanner and by ultrasonic sensors. The movement of the prosthesis enables the sensors to measure in a vertical plane. An inertial measurement unit (IMU) supplies information on orientation and position of the prosthesis and the sensors.

By means of this concept three-dimensional objects, such as planes, stairs, obstacles, ramps, are extracted from the information on distance. The procedures applied hereby are, to some extent, already known from robotics, however, due to rapid scan movements, a relatively imprecise positioning and the necessary real-time capacity, they require a reprocessing and a partially new concept.

The collected information on the immediate environment forms the basis for controlling the prosthesis during the gait cycle.

Result

With this patented and worldwide first system of step-by-step adaptation of leg and foot prostheses, stairs and planes could already be recognized simultaneously. An active and

anticipatory adaptation to the ground enhances safety for the person wearing the prosthesis and brings about a more natural gait pattern. The described sensors can be implemented in below-knee and above-knee prostheses and can be integrated as a separate module.

An important topic is the system's acceptance by the patient. Applying an optically based system for recognizing obstacles reduces practicability depending on different weather conditions. Alternative procedures for measuring distances are already being evaluated.

The system is intended as a module that can be activated when needed. Integrating the system into an optically appealing prosthesis is part of current research.

Your advantage

The research results and comprehensive expertise of the Fraunhofer IPA can be utilized for development projects in your company. The processes and technologies developed form the basis for a transfer into a prototype.

The technology of active adaptation to different terrain can also be utilized in other fields of application. For this purpose, a modular software kit is available, and, on special demand of the customer, adaptable sensor systems.