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Designing a distributed sensor system for the spectral analysis of ambient air

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Ambient air can contain a number of organic chemicals known as volatile organic compounds (VOCs). These VOCs can not only affect human health, but can also be seen as indicators for various health problems, if they are detected in human respiratory air. As part of the BMBF-funded project “fast care” (2016 – 2019), HarzOptics GmbH is developing a distributed sensor system for the spectral analysis of ambient air (SAMBA – Spectral analysis of AMBient Air) to be integrated into a larger, real-time health monitoring system for patients with chronic conditions. SAMBA aims to deliver highly accurate information on a) the quality of the ambient air itself and b) the long-term presence of small quantities of VOCs in ambient air. While general air quality data gathered will primarily be used for controlling home automation systems (air quality improvement), data gathered on VOC concentration will hopefully be usable as indicators for hitherto undiscovered health problems, provided that the monitored rooms are occupied by a single person for prolonged periods of time (e.g. overnight measurements in single bedrooms without outside air circulation). This presentation will present the first technical draft for SAMBA, outline the intended development project within the larger “fast care” context and present some of the difficulties connected with spectral detection of VOCs in ambient air.

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Optimization of dynamic properties of exo-prostheses using a distributed inertial measurement system

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Modern exo-prostheses enable the amputees to (re)gain an increasing number of abilities ranging from an autonomous gait at different velocities, through bicycle riding and jumping, up to alternating stair-climbing. At the same time, the complexity related to fitting and configuring these devices correctly increases due to a broad choice of components with different properties and a large number of control parameters in the prostheses. The state-of-art approach for provisioning an amputee is based on a subjective choice of components by a certified prosthetist orthotist (CPO), followed by an objective statical alignment process and again subjective tuning of prosthesis' parameters based on a visual assessment of gait dynamics by a therapist. The subjectivity in the latter phase of the provisioning process has been addressed in clinical research by the employment of motion capture systems based on infra-red (IR) cameras and reflective markers. Although such systems offer a high-level of accuracy in the estimation of gait kinematics, they are not-widely used due to their space requirements, high price and relatively long set-up times.

We propose a portable, compact and affordable measurement system based on a network of distributed wireless inertial sensors. The system can be set-up quickly and intuitively by a non-technician and used even in space-constrained facilities while achieving a level of accuracy in the estimation of gait kinematics comparable to visual motion capture systems. The measurement system is complemented with an expert system which is capable of online estimation of gait parameters, their visualization and the derivation of objective suggestions for tuning the configuration of the prosthesis by a CPO/therapist either directly or remotely. Furthermore, through the connection to a cloud-based storage the measured data can easily be compared with reference measurements for properly provisioned subjects, used for statistical evaluation and as a proof of a high-quality provisioning for reimbursement institutions.

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Presentation of a concept to support rehabilitation through realtime feedback/monitoring in the home environment

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To assure an appropriate medical and therapeutical care particularly in economically underdeveloped and rural areas, we implement an interdisciplinary and integrated approach to home care. In the project fast care (fast care – Echtzeitfähige medizinische Assistenzsysteme, BMBF; <https://de.fast-zwanzig20.de/gesundheit/fast-care/>), we develop, implement and evaluate a patient-related concept, covering the areas diagnosis, monitoring and therapy/exercise in rehabilitation. To acquire data as discreet as possible, mobile inertial sensors as well as a stationary camera and a depth sensor are integrated in the user's everyday life. We aim to provide a real time feedback giving instantaneous gait corrections and additionally an exercise-related feedback allowing progress monitoring to support the user comprehensively. This concept is completed by an interface that allows a doctor or therapist to access measured data as well as to communicate with the user. Based on the collected data, an individual feedback can be given or adjustments to the treatment plan can be made. All interfaces in the depicted health care chain will be optimized to accomplish ultra low latency for the provided applications. The user benefits from a professional treatment by a specialist without having to overcome the long way to the doctor's office. This would help to preserve and improve the user's quality of life, in particular among people with limited mobility. After implementation, the application is evaluated with regard to effectiveness and user acceptance.

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Requirements of Low Latency Sensor/Actuator Networks for E-Health Applications

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fast care entwickelt ein echtzeitfähiges Sensordatenanalyse-Framework für intelligente Assistenzsysteme im Bereich Ambient Assisted Living, eHealth, mHealth, Tele-Reha und Tele-Care. Ziel ist die Bereitstellung eines medizinisch validen, integrierten Echtzeit-Situationsbildes auf Basis einer verteilten, ad-hoc vernetzten, alltagstauglichen und energieeffizienten Sensorinfrastruktur mit einer Latenzzeit von weniger als 10 ms. Das integrierte Situationsbild, das physiologische, kognitive, kinematische Informationen des Patienten umfasst, wird durch die intelligente Fusion der Sensordaten generiert. Es kann als Basis sowohl für die schnelle Erkennung von Risiken und Gefahrensituationen als auch für alltagstaugliche medizinische Assistenzsysteme dienen, die autonom in Echtzeit intervenieren und aktives telemedizinisches Feedback erstmals ermöglichen.

Für das echtzeitfähige Sensornetzwerk wurden verschiedene existierende Funkstandards evaluiert und hinsichtlich verschiedener Parameter qualifiziert. Ausgehend von den Use-Cases wird eine Systemarchitektur vorgestellt, welche für die Realisierung eines echtzeitfähigen Sensordatenanalyse-Frameworks für intelligente E-Health Assistenzsysteme ermöglicht.