Knetex - Development of a textile-integrated sensor system for feedback-supported rehabilitation after surgery of the anterior cruciate ligament

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Introduction

Patients often report an "giving way “ effect after surgery of the anterior cruciate ligament which manifest itself by a drop of the knee or a felt instability. This phenomenon is difficult to measure and validate because it does not occur regularly and is not reproducible under laboratory conditions.

Methods

The Knetex project takes up this point by trying to actively support the rehabilitation process with a bandage for everyday life and is constructed as a smart textile using sensors and actuators. For this purpose it is attempted to record the phenomenon of the "giving way" by measuring knee angles etc. and by active user feedback. Furthermore, the patient is advised by an actuator to correct incorrect postures/movements to make the rehabilitation process more effective and prevent further damage. Two 9-axis IMUs form the basis system and used to calculate the knee angles.

Results

First results for "walking" and "climbing stairs" show very small deviations compared to the MoCap reference (mean 2,40465°/9,1958° STD and mean 6,17735°/4,7399° STD).
The actuator systems were evaluated in a separate test series with resulting response times of average 3,19s/0,28s STD for vibrotactile stimulation and average 9,96s/5,57s STD for thermal stimulation.
The knee angle measurement currently shows deviations due to slipping of the bandage and due to errors in the reference measurement, but it could be shown that the initial system is able to derive suitable knee angles. It was also possible to show that a "giving-way" can be detected. For the actuator technology it could be shown that a vibrotactile stimulus is preferable to a thermal stimulus.

Conclusion

Overall, it could be proved that the approach can be used for a bandage functionalized by means of sensors and actuators and will be further developed and equipped with additional sensors and methods of biosignal processing.

Sensation thresholds in electrocutaneous stimulation: Comparison of textile cuff and TENS electrodes

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Introduction

The warning of workers in hazardous situations must work reliably. Current methods use acoustic or visual warning signals, which might fail under loud and/or low-visibility work situations. A warning system should be developed that uses electrocutaneous stimulation through textile electrodes. Previous work investigated suitable stimulation parameters for a future warning system using TENS electrodes. The aim of this study was to compare TENS and textile cuff electrodes in terms of sensation thresholds, qualitative and spatial sensation.

Methods

A group of 30 healthy volunteers (f=13, m=17) of mean age of 26.7 years participated in the study and signed an informed consent. The study was approved by the Local Ethics Committee. A rectangular bi-phasic stimulation pulse (width=150 µs) was transmitted to electrodes attached to the right upper arm. While increasing the stimulation amplitude, the thresholds for perception, attention and intolerance were determined. Additionally, the qualitative and spatial sensations have been investigated. Thresholds and sensations have been determined for TENS and textile cuff electrodes, each with 3 electrode pairs located at the lateral to posterior side of the right upper arm. Thresholds have been compared using boxplots and Wilcoxon signed rank test (α=0.0055).

Results

The study revealed that sensation thresholds with TENS and textile cuff electrodes are comparable. Only for the posterior electrode pair, the Wilcoxon test revealed a difference between TENS and textile cuff at attention (p=0.005) and intolerance (p=0.001) threshold, with slightly higher thresholds for the textile electrodes. The qualitative and spatial results showed no difference between TENS and textile cuff electrodes.

Conclusion

We conclude that future studies with the textile cuff electrodes can be generally based on the previous results with TENS electrodes, but slightly increased thresholds might be present for the textile cuff electrodes for varying electrode positions around the upper arm.

Words: 290 (max. 300 allowed)
(without title, authors and headers)

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Machine Learning Techniques for Parkinson's Disease Detection using Wearables during a Timed-up-and-Go-Test

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Introduction

In this paper, the classification models for Parkinson Disease (PD) detection through timed-up-and-go test performed on PD patients are given. The models are based on the supervised learning. The data are extracted through Myo gesture armband worn by two hands. The corresponding models are based on extracted features from signal data and raw signal data respectively.

Methods

Classical machine learning approaches have been utilized to detect the Parkinson disease mode in OFF and ON states corresponding to the medication intake. The approaches begin with the data acquisition and pre-processing followed by feature engineering in the fist model. A deep learning approach based on the CNN is introduced as the second approach in which the features are extracted automatically.
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Results

In the first model, the length of each feature vector is 140 elements per test in which the UPDRS data are also included. The achieved accuracy in this setting is 0.91 via a KNN classifier. In the CNN-based model, there are 1639 samples of raw sequence data each of length 4 s. Our presented deep network achieves accuracy of 0.93 and vonverges within 30 epochs.

Conclusion

Two classification model based on naïve statistical features and CNN architecture have been presented aiming at ON/OFF state detection in timed-up-and-go test in PD patients. The achived classification parameters are quite acceptable. As a future work, mode/activity detection and recognition in which the type of activity (sitting, running, turning) will be recognized is planned.

A Concept for Context Awareness in Smart Environments

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Introduction

All aspects of daily life increasingly include digitization. So-called „smart home“ technologies, as well as „wearables“, are gaining attention from more and more dwellers. Therefore, sensor-based, individualized, AI-based services for improved post-intervention monitoring and therapy accompaniment will become feasible and possible if these systems offer a related context-awareness. This paper provides an approach on how to sense and interpret specific contexts with the help of wearables, smartwatches, smart home sensors, and emotion detection software.

Methods

The paper motivates the topic, then identifies relevant challenges and offers a corresponding approach to address aforementioned challenges. Afterwards, the concept will be discussed.

Results

Two relevant use cases are described to show the concept of context-awareness in smart environments: nutrition and activity-recommendations to improve healthy habits in general; detection and adoption of critical events like falls.

Conclusion

Context-awareness enables the possibility to use singleperson households systems in multi-tenants households as well. There exists an enormous potential for the usage of service robots, which can add lots of relevant information to verify context-awareness.

ForeSight - AI-based Smart Living Platform Approach

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Introduction

In the upcoming years, the internet of things (IoT) will enrich daily life. The combination of artificial intelligence (AI) and highly interoperable systems will bring contextsensitive multi-domain services to reality. This paper describes a concept for an AI-based smart living platform with
openHAB and Web of Things (WoT) as key components of our approach. The platform concept considers different stakeholders, i.e. the housing industry, service providers, and tenants.

Methods

The paper motivates the topic, then identifies relevant challenges and offeres a corresponding approach to address aforementioned challenges. Afterwards, the concept will be discussed.

Results

We show an approach for a context-aware smart living platform, called ForeSight. In ForeSight so-called Thinking Objects (TO) are interacting with each other and the environment.

Conclusion

Due to the utilization of the Web of Things architecture defined by the W3C, the smart home objects will be made available in a data model that was designed with cross-domain interoperability in mind. Therefore, the services of the ForeSight platform will be able to consume relevant information easily
and application development for horizontally and vertically integrated software will have a low barrier of entry for business partners.

Skeleton-based 3D real-time activity detection in living environments for elderly

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In an aging society, a growing lack of personnel leads to a need of technical assistance in public health care systems. Through the targeted use of intelligent technical assistance systems, elderly people can remain in their familiar living environment instead of being placed in a nursing home. For this reason, an assistance system was developed which is able to interpret the daily routines of these people.

To obtain the motion of a proband marker-less, RGB images and skeleton data were used to train a convolutional neural network. With the help of a depth-map the information can be extended to 3D skeletons. The time-dependent comparison of angles between the detected upper and lower leg and the downward optical flow concludes the activity “sitting down”. By comparing the activity to a reference image of this movement, the quality is evaluated through known parameters in real time. Thus, the system is able to record and interpret the most common activities of daily living (ADL). In the event of abnormal movements (falls), a medical emergency plan guarantees patients fastest possible help.

The technical assistance system is part of a living lab equipped with smart sensors in which possible medical scenarios can be tested. The activity detection has been shown to be a target-oriented measure for holistic care, while each person disposes of significant but various movement patterns. The deviation of the norm of daily activities can be described as anomaly. If this is detected, the probability of a fall is high and a personalized care is required.

With the help of an intelligent sensor system information from movement data in real time and and its evaluation was created. The activity recording in a assistance system records the patients daily routine, provides permanent medical monitoring and dedicated emergency.

Contactless Interactive Fall Detection and Sleep Quality Estimation for Supporting Elderly with Incipient Dementia

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Introduction

In recent years, the demographic change in conjunction with a lack of professional caregivers led to retirement homes reaching capacity.The Alzheimer Disease International stated that over 50 million people suffered from dementia in 2019 worldwide and twice the amount will presumably be effected in 2030. The field of Ambient Assisted Living (AAL) tackles this problem by facilitating technical system-aided everyday life. AUXILIA is such an AAL system and does not only support elderly people with dementia in an early phase, but also monitors their activities to provide behaviour analysis results for care attendants, relatives and physicians. Moreover, the system is capable of recognizing emergency situations like human falls. Furthermore, sleep quality estimation is employed to be able to draw conclusions about the current behaviour of an affected person. This article presents the current development state of AUXILIA.

Methods

AUXILIA relies on a combination of technology from acoustic and imaging sensors. For each room in a laboratory flat, the system uses one RGB camera for fall detection as well as one IR camera for sleep quality estimation. Both algorithms rely on background subtraction. Human falls are detected by determining the orientation of the person's shape in a single foreground mask. A commercial speech module establishes contact to the fallen person. In contrast, the sleep quality is estimated by comparing the person's movement in foreground masks over several minutes to specifically set thresholds.

Results

In its current state, AUXILIA can reliably detect human falls with a correct detection rate of 85%. First experiments with an average accuracy of about 61% show promising results for the estimation of sleep quality.

Conclusion

AUXILIA is a trustworthy AAL system that is able to support the daily life of elderly people with an early phase dementia by performing contactless fall detection and sleep quality estimation.