Sensory Wound Dressing for the Continuous Monitoring of Chronic Wounds

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Introduction

Efforts have been made in the treatment of chronic wounds during the last few years towards smart wound dressings incorporating sensors for the monitoring of important wound healing parameters. Aim is the extension of dressing change intervals to reduce the associated wound healing problems and to support the main functions of wound dressings like skin protection, moisture balance, exudate adsorption, and germ barrier [1]. The integration of electronics, textile- and foil-based sensors into a multilayer wound patch is shown in this study. Capacitive moisture sensor yarns, capacitive pH-sensor printed on a flexible circuit and a temperature sensor are combined within a wound dressing patch connected to a specially designed micro controller for signal acquisition, processing and telemetry.

Methods

Yarn-based capacitive sensors for moisture were developed by the DITF. KOB GmbH integrated the sensor yarns into warp knitted fabrics by weft insertion technique. A foil-based sensor for the capacitive measurement of the pH in the wound exudate was developed by Fraunhofer EMFT which is also equipped with a thermistor. A foaming process with a thermoplastic PU foam absorber was developed at KOB forming a multi-layer wound dressing. Electronics for the sensor readout was designed by GED GmbH using a new type microcontroller by NXP combining processing and telemetry via Bluetooth Low Energy.

Results

Sensors for temperature and pH were located close to the wound base, while the moisture sensor is placed between the absorbing foam layers. The controller module is separated from the patch not affecting the wound healing or interfering with compression therapy. The multilayer sensory wound dressing with connected electronics was realized as a demonstrator for in-vitro testing.

Conclusion

This approach shows a high-level integration of minimal invasive sensors in a wound dressing. It realises therapeutically relevant sensitivities, but still needs to be proven in a dynamic testing environment.

Acknowledgment

This work is part of the ULIMPIA project [2] funded by PENTA under grant number PENTA-2017-Call 2-16101

References

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[2] Ulimpia project proposal by PENTA, Grant nr: PENTA-2017-Call 2-16101. www.ulimpia-project.eu

Development of an app-controlled simple, wearable teeth grinding sensing device.

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Introduction

Teeth grinding, so called bruxism, is a highly discussed clinical issue in dentistry. It can damage the dental system, cause pain in the oro-facial region and beyond and thus affect the quality of human life. Presently, there is no satisfactory method for diagnosing bruxism. Most of the portable devices already available are not enabling diagnosis of awake bruxism sufficiently, are expensive or only offer inadequate data analysis options. This paper presents the development of an inexpensive device, suitable for everyday use, which enables reliable (self-) monitoring of teeth grinding activity.

Methods

The prototype presented is entirely assembled from off-the-shelf electronics including a small stand-alone EMG sensor unit that outputs signals between 0-5 V. Electrodes are placed over the *M. masseter*, a muscle involved in the grinding movement, and on the neck. An Android app is developed to control the sensor unit via Bluetooth and to give the user access to their data, making analysing possible. A vibromotor, placed near the skull-side of the device, informs the user about grinding detected. The entire system is designed to be worn behind the ear.

Results

Using the EMG sensor unit, the activity of the *M. masseter* is recorded. The prototype could therefore successfully detect teeth grinding. Initial tests with different test subjects showed a high level of measurement accuracy when performing measurements without feedback at rest (97.5 – 100 %).

The developed device offers optional biofeedback: patients can choose to be notified by vibration if teeth grinding is detected in order to decrease their grinding activity.

Conclusion

The sensor unit at hand offers detection of teeth grinding due to measurement of muscle activity. It requires no custom-made components or proprietary software and costs below 80 €. Further work on increasing the usability by miniaturization of the electronical circuits and the housing along with testing on subjects affected by bruxism are still pending.

A mobile app for cardiopulmonary coupling analysis of electrocardiograms measured by textile sensors

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Introduction

Cardiopulmonary coupling analysis (CPCA) links heart and respiration rates for sleep quality assessment. Typically, this information is acquired from a multi-lead electrocardiogram (ECG). Recently, textile sensors woven into fabric became available.

Methods

We develop and evaluate a mobile app for CPCA in combination with a commercially-available shirt with textile sensors (Pro-Kit, Hexoskin, Quebec, Canada). It offers a single-lead ECG (256Hz, 12bits) which is transmitted continuously via Bluetooth Low Energy (BLE) using a vendor-provided software development kit. We integrate it into a custom mobile app and deploy it on an off-the-shelf mobile phone (Pixel 4a, Google, California, USA).
We implement conventional CPCA by combining intervals between consecutive R-waves with R-wave amplitude variations induced by respiration (ECG-derived respiration (EDR)). In the resulting spectrogram, oscillations in lower frequencies ([0.01,0.1]Hz) are associated with unstable sleep and higher frequencies ([0.1,0.4]Hz) are associated with stable sleep.
The app is activated before going to sleep and data is transmitted until the process is stopped the next morning. Subsequently, computations commence and the results are displayed as a 2D or 3D heatmap diagram.
We evaluated the system online in five nights of a healthy volunteer (male, 28years; [06:00-07:42]hh:mm) and offline using pre-recorded data (1 female, 2 male, [20-33]years; [07:34-08:18]hh:mm).

Results

After 8h, batteries of the mobile phone and shirt were reduced to approximately 90% and 70%, respectively. ECGs did not show dropouts or corruption and signal quality was high in general, clearly showing P-/T-waves. During significant body motion, signal quality was significantly reduced.
Computation of CPCA spectrograms took approximately one minute. They showed clearly visible high-frequency oscillations. Occasionally, EDR was inaccurate, due to vanishing R-wave amplitude variations, leading to noise.

Conclusion

We demonstrate the feasibility of a mobile app for CPCA processing data from textile sensors. This renders wire-free and unobtrusive sleep quality monitoring at home possible.

Validation of three mobile movement measurement systems to determine activity

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Introduction

Persistent physical inactivity of patients during hospital stay can have significant negative consequences. Hence, recording the activity of inpatients is of great importance to develop goal-directed interventions. This requires practical measurement systems that provide valid results. Therefore, the aim of this study is to investigate the suitability and accuracy of output parameters of mobile measurement systems for activity recording.

Methods

The analysis was performed on 11 healthy volunteers and included three different measurement systems: the fitness watch Polar Vantage V, the activity tracker ActiGraph wGT3X-BT and an inertial measurement system developed at the University of Applied Sciences in Münster. The systems record the body positions and movement executions according to a defined measurement protocol. A video camera was used as a gold standard reference system.

Results

In order to validate the various measurement systems the number of detected steps serves as a validation parameter of the activity. The analysis is based on the correct-positive and false-positive steps. For the inactive phases of lying, sitting and standing, the sensitivity, specificity, and positive and negative predictive values are determined. Up to now, evaluated results from one test person are available. In particular, by comparing the number of detected steps, initial tendencies become apparent. The Actigraph wGT3X-BT has a detection rate of 60%, while the Polar Vantage V fitness watch detects only about one third of the steps (32%). Most steps are detected by the inertial measurement system of the University of Applied Sciences in Münster (98%).

Conclusion

The focus of this study was to evaluate the accuracy of the measurement systems with regard to physical activity. The results reveal differences in the validity of the activity data. To confirm these preliminary tendencies, a statistical investigation of all participants is currently at the stage of analysis.

Field test of innovative digital technical assistance systems in the outpatient and inpatient care

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Introduction

The aim of the tecLA LSA project was to develop a modular system for the area of Ambient Assisted Living (AAL) that enables older people to have simple, intuitive access to medical and technical assistance systems. The project partners are: Harz University of Applied Sciences, University of Halle and Burg Giebichenstein University, cooperating with Johanniter Unfallhilfe and Exelonix.

Methods

The interoperable, growing system adapts flexibly and cost-effectively to changing abilities and needs of users. The focus is on the client. With the help of data sensors, the vital parameters are to be recorded automatically and made available to the medical services via a cloud system. Furthermore, it was possible to order services from external service providers such as hairdressers, taxis, etc. via an easy-to-use portal using a touch tablet. In addition, information on current events or train timetables are able to be easily retrieved. Another important point is the improved social integration through the use of social network services. The video consultation also established a direct line to the medical services and doctors. For this purpose, Bluetooth-enabled and medically approved vital parameter measuring devices (blood pressure, blood sugar, heart rate, activity analysis) have been integrated so that the caregivers and responsible doctors can view the current data in the patient file.
Another important point is the mental, physical and social activation, which stimulates the clients with appropriate apps and motion videos and thus improves their physical and mental condition..

Results

The usage phase in both field tests was 3 months each. A total of N = 9 test persons took part in the stationary and 12 in the ambulant field test. 17 of them were women and 4 men. On average, the people were M = 77.11 years old (SD = 11.53; range: 58-95 years). The frequency of use of the apps and their usage time were recorded in the background for all tablets and transferred to a secure server. The evaluation of the data shows an intensive use of the communication applications, the web search / Google as well as the recording of the vital parameters.

Conclusion

A commercially available AAL application portal has been subjected to acceptance tests and optimizations and has proven itself in field tests. Furthermore, when comparing the self-assessment values to cognitive measures before and after the intervention, a clear trend towards more positive values in the post-test was recorded.
The use of the system has very positive effects on communication behavior and cognitive self-assessment. The nurses and doctors can follow the vital signs online in the patient's file and evaluate them immediately.

Accuracy measurement of HoloLens2 IMUs in medical environment

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Introduction

As augmented reality devices become more available, collaborative work in the augmented space is expected to increase. Medical procedures are already being shared across multiple devices in the augmented reality environment.
The mixed reality smartglasses HoloLens2, in addition to displaying holograms, can be utilized to provide position coordinates, orientation vectors and eye-tracking data to participants in the augmented scene. Knowing the position of participants allows realistic interaction rather than passive participation. The data-fusion of camera and IMU data is used to derive the device coordinates. To validate the accuracy of these data, preliminary tests were conducted at the ICCAS in Leipzig.

Methods

The HoloLens2 was moved along Cartesian coordinate axes utilizing a KuKa robot as well as human volunteers. Environments with varying degrees of textures were employed. The KuKa robot allowed a precise three-dimensional maneuver at varying speeds. Human volunteers provided data on physiological trembling. Position and orientation of the device were recorded at 60Hz. Data analysis was performed in MatLab.

Results

Deviations to the KuKa path data were found. The HoloLens2 starting and ending position of subsequent manoeuvrers drifted slightly in one direction. When the main camera was covered or the room was darkened, no position coordinates were recorded by the HoloLens2, however this did not affect the orientation data. The amount of texture in the environment had a lower impact than initially anticipated. Human physiological trembling was clearly distinguishable from signal background noise.

Conclusion

The position and orientation data showed a high degree of accuracy, enough to track human motion and head rotation. A recording frequency of 60Hz allows for seamless reconstruction of paths travelled and device rotations. This shows, that displaying surrogates of multiple HoloLens2 users in a room will allow for realistic position presentation, which ties in with remote surgery or collaboration of multiple doctors over augmented reality.