Demo: Wearable Sensor System for Human Biomechanics Monitoring

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Abstract

We propose a system that combines wired and wireless sensors for human bio-mechanics monitoring during physiatric rehabilitation. The wearable system consists of sensors that are able to acquire vital signs data from and array of sensor nodes attached to patient's body. Data is transmitted in real-time via wireless communication channel to a mobile application for analysis, visualization and communication. Prototypes were developed and tested in real life conditions by involving patients completing rehabilitation exercises with physiotherapists. The user experience of the demonstration will include prototypes for different applications: knee joint and 3D printed palm prosthetic dynamics monitoring, posture and head position detection in real-time.

Categories and Subject Descriptors

B.7.1 [**Integrated circuits**]: Types and Design Styles—*Algorithms implemented in hardware*; B.7.2 Design Aids [**Placement and routing**]: Verification

General Terms

Measurement, Design, Experimentation

Keywords

Sensor network, Vital Signs, Monitoring, Rehabilitation

1 Introduction

Long-term monitoring of physiological data could lead to significant improvement in the diagnosis and treatment of diseases [1]. Continuous and real-time monitoring can be achieved by using wearable devices and wireless sensor networks. There have been existing solutions aiming to provide dynamics monitoring, for example by using 3-axial accelerometers [7, 3, 2]. However these solutions lack data analytics and communication with patients and health specialists. Our solution provides a combination of wired and wireless sensors for data processing and transmission and mobile software for analysis, storage and communication interface with patients and health specialists [5, 6]. Con-

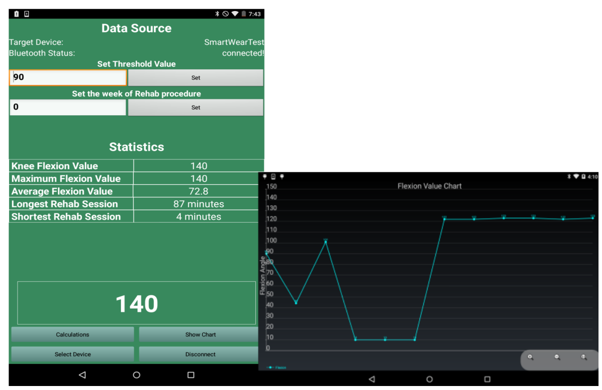

Figure 1. Rehabilitation software with built-in data analytics.

Figure 2. Patients participate in system prototype testing.

necting device to an application, that is installed on a smart device (such as smartphone etc.), will give an opportunity to a patient to view visualisation of his health indicators, as well as to receive notifications if these indicators will exceed certain limits (threshold value) defined by health specialist (Figure 1). From other perspective, health specialist has an opportunity to view real-time and historical measurements of patient's knee joint dynamics. As a result, system will help physiotherapists to perform deeper analysis of patient's state of health and to monitor dynamics of convalescence - in this way doctor can timely make changes in treatment process.

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System would also help patients to complete rehabilitation process more effectively and increase the rate of successful rehabilitation.

2 Proposed Solution

System consists of a combination of embedded device, sensor nodes for data acquisition and mobile application for data analysis. One of the developed system's parts is wearable device used for data acquisition from patient in real-time during the rehabilitation sessions. Wearable sensor system consists of a circuit board with MSP430 microcontroller for data sampling with 50 Hz rate and 4 sensor nodes that include 3-axial accelerometers and magnetometers (Figure 3). Sensor nodes are interconnected with a wired and wireless network daisy chained and equipped with BTM-112 Bluetooth module for wireless communication with mobile application using SPP (Serial Port Profile) [4]. Power consumption of one sensor node is 450 microamperes. Data analysis is performed on mobile device in order to increase system's battery life. After successful transmission data from various sensor nodes (in case of posture monitoring - 63 nodes, knee joint - 4 nodes) is being analyzed, visualized and stored on mobile device. Alerting about the dangerous situations (exceeding doctor prescriptions) on-time can help to decrease the chance of repeated injuries. Notification system was implemented based on health specialist patient communication style aiming to create a similar feeling of safety when a patient is near physiotherapist. Patient is notified when exceeding the threshold value and also when reaching the end of rehabilitation session.

3 User experience

During demonstration session we will present following prototypes that are using described technology: knee joint dynamics monitoring system, motion tracking solution for 3D printed prosthetic during rehabilitation as well as a smart surface that could be worn on the back for posture detection. Users will be able to try the system used for rehabilitation needs. Presented system will give notification to users when exceeding customized limits. System for 3D printed prosthetic will ease the process of rehabilitation for patient and provide detailed information for health specialists by providing detailed information for health specialists and rehabilitation instruction for patients (Figure 4). User will have a possibility to see systems functionality, electronic circuity and participate in discussions about proposed solution, implementation and further improvements.

4 Conclusions

System provides human motion and pose monitoring during rehabilitation. This allows real time monitoring of patients, remote data acquisition and analysis. Main drawbacks include measurement errors that arise from different noise sources such as dynamic accelerations and magnetic perturbations. Also the problem of integration of electronic components into clothing is not fully resolved. System performance could be improved by additional sensors such as gyroscopes and more advanced signal processing including improved data filtering and sensor fusion algorithms.Developed solution was tested in dynamic conditions - patients used the system during their rehabilitation sessions in real life conditions (Figure 2). Authors received positive feedback both from patients and health specialists.

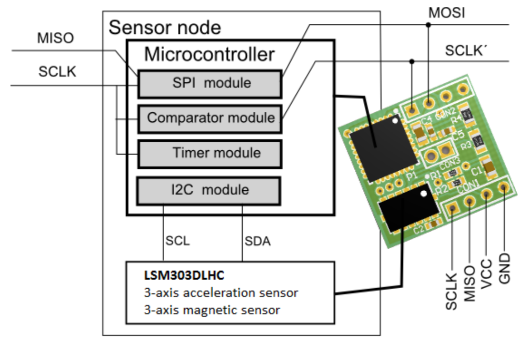

Figure 3. Structure of sensor node architecture.

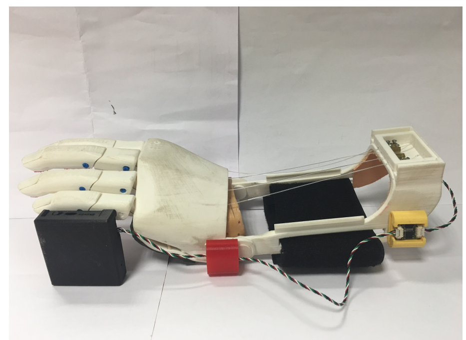

Figure 4. 3D printed prosthetic with sensor attached.

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