Best of Bodynets 2014: Editorial

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A wireless body sensor network (or simply BSN) is a networked collection of wearable (programmable) sensor nodes that can communicate among themselves and also with other smart devices and other ambient sensors [1], [2]. The sensor nodes have computation, storage, wireless transmission, and different sensing capabilities depending on the physical transducer(s) they are equipped with. Common physiological signals/data include body motion, skin temperature, heart rate, skin conductivity, brain and muscle activities, and biomarkers. Interconnection of the BSN nodes with smart devices such as smartphones and IoT devices means they can be easily incorporated with the existing or emerging network architectures. The BSNs could be also Cloud-based [3] to be supported by a flexible storage and processing infrastructure to perform both online and offline analyses of data streams. A wide range of application scenarios is enabled by BSN technologies, even though m-Health applications probably represent the most emblematic and diffused example. Specifically, BSN-based systems can be used to directly monitor several vital signs continuously and non-invasively, as tiny wireless sensors are placed on the skin and sometimes integrated with the garments. These signals can, in turn, allow inferring the onset or progression of different diseases (e.g., cardiovascular or neurodegenerative diseases) at an early stage or supporting rehabilitation, e.g., of lower or upper limbs after injuries. Moreover, BSNs are strategic enablers for many other application domains such as: e-Sport, e-Fitness, and e-Wellness, where the goal is to help people maintain physical and mental wellness; e-Factory to support monitoring the safety of employees working on the field; e-Social, where the objective is to monitor emotional states of stand-alone persons or of people while they meet. Much research effort is also focused on the use of smartphones to enable the aforementioned domains of m-Health, e-Wellness and m-Sociality. However many issues still exist in the BSN research area from several points of view: hardware (e.g., new biosensor boards), communications (e.g., more efficient MAC-level protocols), distributed software architectures (e.g., collaborative smartphone- and/or BSN-based platforms [4]), and advanced data processing algorithms.

This special issue has been conceived as follow-up of the International Conference BodyNets 2014, London (United Kingdom), and to address some of the aforementioned issues. The six articles in this special issue are extended papers selected from those presented at Bodynets 2014. Such contributions address many research challenges related to BSNs and related applications. These include: smartphone-based methods and systems for real-time m-Health monitoring, wearable sensor-based methods and systems for the estimation of the circadian rhythm stability for supporting the realization of biomedical studies, novel methods for human action clustering based on BSN inertial data streams, definition of stress detection methods for just-in-time interventions in pervasive and affective applications, methods and system for the characterization of gait in patients affected by chronic diseases (e.g., Parkinson disease), methods and commercial tools for detecting daily activities through mood inference.

The paper "Real-Time Tele-Monitoring of Patients with Chronic Heart-Failure Using a Smartphone: Lessons Learned" authored by Daniel Aranki, Gregorij Kurillo, Posu Yan, David M. Liebovitz, and Ruzena Bajcsy, focused on identifying system and usability challenges correlated to tele-monitoring of patients with Chronic Heart-Failure (CHF). Specifically, tele-monitoring is carried out via smartphones. The study was conducted on a pilot composed of 15 subjects and conceived to evaluate the feasibility of the proposed smartphone-based tele-monitoring in the real world and elicit its requirements, privacy implications, usability, and other challenges encountered by the participants and healthcare providers. Their system is able to assess patient activity based on minute-by-minute energy expenditure estimated from embedded accelerometers, monitor relative user location via GPS to track outdoors activity and measure walking distance. Moreover, it also allows for daily surveys to inquire about patients' vital signs and general cardiovascular symptoms. Although the system was developed for CHF-affected individuals, the challenges, privacy considerations, and lessons learned from this pilot study apply to other chronic health conditions, such as diabetes and hypertension, which would certainly benefit from continuous monitoring through m-Health technologies.

In the paper entitled "A Wearable Sensor System with Circadian Rhythm Stability Estimation for Prototyping Biomedical Studies" by Benjamin L. Smarr, David C. Burnett, Sahar M. Mesri, Kristofer S.J. Pister, and Lance J. Kriegsfeld, authors present an open-source, modifiable, and user-reconfigurable wearable sensor system capable of enabling biomedical investigations not feasible with currently-available devices. In their experimentations, the developed armband device was configured to measure skin temperature, light, and activity across days to detect internal circadian rhythms. Their monitoring is fundamental as the instability of internal circadian rhythms is linked to risk of many diseases, including mental illness such as depression, and has predictive power for personal affective state. Such novel sensor device enables long-term biomedical monitoring whereas the majority of

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(commercial) products focus on short-term personal fitness metrics. The authors' findings are positive indicators that their proposed device can lead to more precise and higher resolution measurements at less expense and with minimal disturbance of the subject, which are fundamental characteristic of 24/7 monitoring wearable devices.

The paper on "Piecewise Linear Dynamical Model for Action Clustering from Real-World Deployments of Inertial Body Sensors" by Jiaqi Gong, Philip Asare, Yanjun Qi, and John Lach, proposes PLDM (Piecewise Linear Dynamical Model), an extension of linear dynamical model for temporal clustering and segmentation of human actions from time streams generated by the inertial BSNs in real-world deployments. Such a model deals with two human factors that in real-world deployments of inertial BSNs make motion assessment challenging: mounting errors (where sensor displacement and orientation do not match what is assumed by processing algorithms) and insecure mounting (where sensors are loosely worn causing them to shake during operations). PLDM combines a robust motion stimulus detection algorithm and a modified linear dynamical model. While the former addresses the two aforementioned issues, the latter deals with variability of human actions and complexity of representing articulated body motion. Authors show how PLDM can robustly temporally cluster human motion in inertial BSNs data. Moreover, the performance of PLDM is compared to state-of-the-art algorithms for two real-world deployments with different temporal-scale requirements such as multiple sclerosis study and head impact identification during athletics, and achieve comparable performance.

The paper "PREVENTER, a Selection Mechanism for Just-in-Time Preventive Interventions" by Luis G. Jaimes, Martin Llofriu, and Andrew Raij, presents a three-layer architecture of a pervasive system for stress management and just-in-time intervention. Authors focused on the stress forecasting and intervention management layers. It is worth noting that chronic stress has significant long-term behavioral and physical health consequences, including an increased risk of cardiovascular disease, cancer, anxiety and depression. Experiments were based on physiological data (ECG signals then used to compute heart rate variability) collected by ten individuals in the natural environment for one week in the framework of the AutoSense project. Results show that simple Poisson Hidden Markov Models can be used to forecast physiological measures of stress with up to 3 minutes in advance, and Q-Learning combined with eligibility traces could be used by an affective computing system to adapt and deliver any number and type of interventions in response to changes in affect.

In the paper "Inertial BSN-Based Characterization and Automatic UPDRS Evaluation of the Gait Task of Parkinsonians" by Federico Parisi, Gianluigi Ferrari, Matteo Giuberti, Laura Contin, Veronica Cimolin, Corrado Azzaro, Giovanni Albani, and Alessandro Mauro, authors perform an exhaustive characterization of the gate task in Parkinsonians, based on the estimation of a large set of gait features, with the objective of investigating the connection between the measured kinematic features (both in time and frequency domains) and the UPDRS (Unified Parkinson's Disease Rating Scale) scores assigned to patients by neurologists. To carry out their experimentations (on 34 Parkinsonian patients), they used a BSN system based on three inertial nodes (one on the chest and one per thigh). A performance analysis of different classification techniques is carried out, showing the feasibility of an automatic (and, eventually, remote) UPDRS scoring system, suitable for e-Health applications in the realm of affective medicine.

The paper entitled "Naturalistic Recognition of Activities and Mood Using Wearable Electronics" by Zack Zhu, Hector F. Satizabal, Ulf Blanke, Andres Perez-Uribe, and Gerhard Troster, presents and investigates an end-to-end tool capable of conducting daily activity recognition and mood inference using a commercially available ecosystem of wearable devices. The developed tool is based on a fusion of motion, location, and temporal signals collected from existent commercial devices (e.g., smartphones) already in possession of the general population. Authors conducted a real-world study with the tool; specifically, they collected and evaluated data from 18 users, who provide over 93 user-days of labelled activity data. According to the obtained results that have more statistical significance than benchmark approaches, authors conclude that activity-based mood inference holds promise in the premise of ubiquitous context sensing and recognition.

We hope that the six papers included in this special issue will provide valuable knowledge for researchers and practitioners working in the area of BSNs and related applications.

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