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Editorial

Special Issue on "Wearable Technologies"

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Wearable technology will revolutionize our lives in the years to come. The current trend is to augment ordinary body-worn objects—e.g., watches, glasses, bracelets, and clothing—with advanced information and communication technologies (ICT) such as sensors, electronics, software, connectivity and power sources. These wearable devices can monitor and assist the user in the management of his/her daily life with applications that may range from activity tracking, sport and wellness, mobile games, environmental monitoring, up to eHealth.

The present Special Issue reports the recent advances in the multidisciplinary field of wearable technologies and the important gaps that still remain in order to obtain a massive diffusion.

In the frame of wearable technologies, this Special Issue of *Technologies* includes a total of 10 papers, including one review paper and nine research articles. Articles in this Special Issue address topics that include: wearable sensing and bio-sensing technologies, smart textiles, smart materials, wearable microsystems, low-power and embedded circuits for data acquisition and processing and data transmission.

The first feature paper from Münzenrieder et al. [1] focusses on advanced technologies to push forward the smart textile field. In the presented research, the authors benchmarked different fabrication techniques and multiple fibers made from polymers, cotton, metal and glass exhibiting diameters down to 125 µm, to obtain fully functional transistor fibres. In particular, by exploiting the most promising fabrication approach, they were able to integrate a commercial nylon fiber functionalized with InGaZnO TFTs into a woven textile. The second feature paper is from Santos et al. [2] and it presents a methodology for movement recognition in hand-assisted laparoscopic surgery using a textile-based sensing glove. The aim is to recognize the commands given by the surgeon's hand inside the patient's abdominal cavity in order to guide a collaborative robot. The glove, which incorporates piezoresistive sensors, continuously captures the degree of flexion of the surgeon's fingers. These data are analyzed throughout the surgical operation using an algorithm that detects and recognizes some defined movements as commands for the collaborative robot. The results obtained with 10 different volunteers showed a high degree of precision and recall.

Wearable technologies are fundamental building blocks for the Virtual Reality (VR) and Augmented Reality (AR) fields as underlined in the next two contributions. The work from Cutolo et al. [3] reports an innovative hybrid video-optical see-through Head Mounted Display (HMD). The geometry of the HMD explicitly violates the rigorous conditions of orthostereoscopy. For properly recovering natural stereo fusion of the scene within the personal space in a region around a predefined distance from the observer, the authors partially resolved the eye-camera parallax by warping the camera images through a perspective preserving homography that accounts for the geometry of the video see-through HMD and refers to such distance. The results obtained showed that the quasi-orthoscopic setting of the HMD; together with the perspective preserving image warping; allow the recovering of a correct perception of the relative depths. The paper of Maereg et al. [4] presents a low cost, wearable six Degree of Freedom (6-DOF) hand pose tracking system for Virtual

Reality applications. The wearable system is designed for use with an integrated hand exoskeleton system for kinesthetic haptic feedback. The tracking system consists of an Infrared (IR) based optical tracker with low cost mono-camera and inertial and magnetic measurement unit. Six DOF hand tracking outputs filtered and synchronized on LabVIEW software are then sent to the Unity Virtual environment via User Datagram Protocol (UDP) stream. Experimental results show that this low cost and compact system has a performance that makes it fully suitable for VR applications.

The next four contributions deal with applications of wearable technologies in the eHealth sector. The paper from Signorini et al. [5] describes a methodology for prenatal monitoring of fetal heart rate (FHR). As underlined by the authors, a wearable system able to continuously monitor FHR would be a noticeable step towards a personalized and remote pregnancy care. The wearable system presented employs textile electrodes and miniaturized electronics integrated in smart platform enabled by mobile devices. The system has been tested on a limited set of pregnant women whose fetal electrocardiogram recordings were acquired and classified, yielding an overall score for both accuracy and sensitivity over 90%. This novel approach can open a new perspective on the continuous monitoring of fetus development by enhancing the performance of regular examinations, making treatments really personalized, and reducing hospitalization or ambulatory visits. Another branch of eHealth is the monitoring of elderly people to early detect symptoms related to possible health treats (e.g., frailty, falls, dementia, etc.). In this context, Genovese et al. in [6] reports the sensor description and the preliminary testing of a an integrated fall detection and prevention ICT service for elderly people based on wearable smart sensors. Falls are one of the most common causes of accidental injury: approximately, 37.3 million falls requiring medical intervention occur each year. Fall-related injuries may cause disabilities, and in some extreme cases, premature death among older adults, which has a significant impact on health and social care services. The fall detector is intended to be worn at the waist level for use during activities of daily living; a dedicated logger is intended for the quantitative assessment of tested individuals during the execution of clinical tests. Both devices provide their service in conjunction with an Android mobile device. The work from Bock et al. [7] investigates on the reliability of consumer-grade physical activity monitors (CPAMs). The study is performed on thirty subjects that wore different activity monitors (a total of eight monitors are employed). The wearable devices were tested in the lab and in free-living setting. The results shown that all activity monitors yield reliable estimations of physical activity. However, all CPAMs tested provided reliable estimations of physical activity within the laboratory but appeared less reliable in a free-living setting. Finally, the eHealth section of this special issue includes the review paper from Sharma et al. [8]. This review paper focusses on a hot topic of the biomedical technology: cuffless and continuous monitoring of blood pressure (BP). As underlined by the authors, in the recent years, the indirect approach to obtain BP values has been intensively investigated, where BP is mathematically derived through the "Time Delay" in propagation of pressure waves in the vascular system, obtaining cuffless and continuous BP monitoring. The review highlights recent efforts in developing these next-generation blood pressure monitoring devices and compares various mathematical models. The unmet challenges and further developments that are crucial to develop cuffless BP devices are also discussed.

The paper from Ben Arbia et al. [9] investigates on wearable wireless networks (WWNs) as innovative ways to connect humans and/or objects anywhere, anytime, within an infinite variety of applications. In particular, the authors performed experiments on a real testbed to investigate the connectivity behavior on two wireless communication levels: on-body and body-to-body.

Flexible and stretchable materials and sensing substrates are a relevant topic in the wearable technology field, with potential of opening new applications in human bio-monitoring and human machine interaction. In this context, the work from Russo et Al [10] presents a stretchable tactile sensor based on electrical impedance tomography (EIT), an imaging method that can be applied over stretchable conductive-fabric materials to realize soft and wearable pressure sensors through current injections and voltage measurements at electrodes placed at the boundary of a conductive medium.

The articles published in this Special Issue present detailed views of some of the most important topics about wearable technologies underlining potential applications for the health and AR/VR sectors. Integration of sensors into flexible/stretchable substrates, such as textiles, will further increase the widespread diffusion of wearable technologies.

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