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Boosting the Efficiency of Smart Wearable Devices for the Long Term Monitoring of Vital Signs

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Abstract: Recent advances in wearable devices hold the promise to enhance the efficiency and applicability of telemedicine solutions. These devices allow seamless, non-invasive and inexpensive gathering of biomedical signals such as electrocardiogram (ECG), photoplethysmogram (PPG), heart rate, blood pressure, blood oxygen saturation, and respiration (RESP). They can be integrated into wireless body sensor networks (WBSN) to update medical records via the Internet, improving prevention, and can be used within personalized training applications. Since wearables are required to be small and lightweight, they are often resource constrained, and as such they need dedicated algorithms to optimally manage energy and memory. In this talk, we first review a number of compression algorithms for physiological quasi-periodic signals such as ECG, PPG and RESP. The data volume reduction that they achieve allows efficient storage and transmission, and thus helps extend the devices' lifetime. We then present two new designs: the first exploits denoising autoencoders, whereas the second is based upon a subject-adaptive dictionary which is constructed and adapted at runtime without requiring any prior information on the signal itself. This is achieved utilizing the time-adaptive self-organizing map (TASOM) unsupervised learning algorithm. Both approaches outperform the algorithms in the state-of-the-art and their pros and cons will be discussed in the talk. Quantitative results will be shown: as we will see, compression ratios of up to 35-, 70- and 180-fold are generally achievable respectively for PPG, ECG and RESP signals, while reconstruction errors (RMSE) remain within 2% and 7% and the input signal morphology is preserved. In addition, these high compression ratios entail a substantial reduction in the energy required for the data transmission, e.g., using a wireless interface such as Bluetooth Low Energy. Finally, current research directions are briefly discussed.

Bio: Michele Rossi is an Assistant Professor at the Department of Information Engineering (DEI), University of Padova (UniPD), Italy. His research interests are centered around stochastic modeling, optimization and protocol design for Wireless Sensor Networks (WSN) and Internet of Things (IoT). He has authored more than 100 scientific papers published in International conferences, book chapters and Journals, mainly of the IEEE, two patents (with DOCOMO) and he has been the recipient of four best paper awards from the IEEE. Since 2005, he has actively supervised the research activity on Internet of Things (IoT) within the Signet group @ DEI. In 2005–2009, he has collaborated with the Ubiquitous Networking Research group @ DOCOMO Euro-Labs (Munich, Germany) in the design of distributed processing, storage and data dissemination for ad hoc networks (Network Coding and Compressive Sensing). Since 2010, he has been working with Worldsensing (http://www.worldsensing.com/) on optimized WSN solutions for Smart Cities and environmental monitoring, this collaboration continues nowadays through the involvement in the H2020 MSCA SCAVENGE ITN. Since 2002, Dr. Rossi has been involved in numerous EU projects on WSN/IoT such as EYES (protocols for energy efficient WSN, 2002–2005), e-SENSE (protocols and architectures for WSN, 2004–2007), SENSEI (WSN as enablers of the future Internet, 2007–2010) and SWAP (Marie Curie, Symbiotic Wireless Autonomous Powered systems, 2010–2014). In 2010-2013, he has been the technical coordinator of the protocol design activity (WP3) carried out in the EU IOT-A project (the flagship FP7 EU project on Internet of Things Architectures, 2010–2013) and has been senior Marie Curie researcher within SWAP. Since 2010, he has been the Principal Investigator of six research projects, including MOSAIC ("MOnitoring Sensor and Actuator networks through Integrated Compressive Sensing and data gathering", 2010–2012), a SAMSUNG GRO award on biometric signal processing for wearable IoT devices (2014–2015), the H2020 MSCA project SCAVENGE on cellular networks exploiting ambient energy (2016–2019) and the IoT-SURF project on software libraries and processing tools for connected and unconnected IoT objects (2016–2017). He is Associate Editor of the IEEE Transactions on Wireless Communications, has been on TPC of 80+ international conferences and serves as reviewer for scientific Journals of the IEEE, ACM, Springer and Elsevier. He is a Senior Member of the IEEE. Web: http://www.dei.unipd.it/~rossi/