Demo: eSense - Open Earable Platform for Human Sensing

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Abstract
We present eSense - an open and multi-sensory in-ear wearable platform to detect and monitor human activities. eSense is a true wireless stereo (TWS) earbud with dual-mode Bluetooth and Bluetooth Low Energy and augmented with a 6-axis inertial measurement unit and a microphone. We showcase the eSense platform, its data APIs to capture real-time multi-modal sensory data in a data exploration tool, and its manifestation in a 360° workplace well-being application.

Author Keywords
Earable; Human Sensing; Behaviour Analytics

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
Wearables are finally here. Established forms, e.g., a timepiece, a ring, and a pendant are getting a digital makeover and are reshaping our everyday experiences with new, useful, exciting and sometimes entertaining services. However, to have a broader impact on our lives, the next generation wearables must expand their sensing capabilities beyond the narrow set of exercise-related physical activities.

Figure 1: eSense open wearable platform with audio, motion, and proximity sensing.

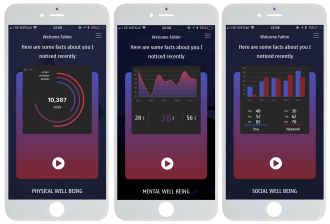

Figure 2: A personalised well-being feedback app with eSense capturing physical, mental and social well-being at workplace.

To this end, we present eSense - an aesthetically pleasing, and ergonomically comfortable in-ear high definition wireless stereo wearable [1]. As illustrated in Figure 1, eSense is equipped with a microphone, a 6-axis inertial measurement unit, and a dual-mode Bluetooth and Bluetooth Low Energy (BLE). Leveraging the combination of microphone, accelerometer, gyroscope, and BLE, eSense offers three sensing modalities - audio, motion, and proximity. It is powered by a CSR processor and a 45 mAh battery. Most importantly, eSense is an entirely open data platform that allows developers to gather real-time data streams of these multi-sensory modalities as well as offering them with several configurations and reprogramming capabilities.

We have extensively explored the characteristics of audio, inertial, and BLE signals captured by eSense in a variety of experimental settings. We compared eSense against a smartphone and a smartwatch considering several key factors that impact activity recognition pipelines, including sampling variability, signal to noise ratio, placement invariance, and sensitivity to motion artefacts. Analysis of our experimental results suggests that eSense is robust in modelling these signals and in most conditions demonstrates superior performance concerning signal stability and noise sensitivities. Inspired by these characteristics, we have designed a set of human activity primitives. Bespoke classifiers are then trained to model these activities with audio, motion, and BLE signals, and their combinations. The experimental results demonstrate that eSense can reach up to 88% detection accuracy for the targeted human activities [1, 3]. Taken together these and the rest of our findings demonstrate the exciting potential of eSense as an in-ear wearable sensing platform for designing individual scale multi-sensory applications.

Figure 3: eSense data exploration tool showing real-time data from accelerometer, gyroscope, microphone and BLE.

Demonstration

We will showcase the eSense hardware and its real-time data APIs manifested in a dynamic data exploration tool as illustrated in Figure 3. We will invite the conference attendees to wear the device and see the real-time multi-modal signal patterns (accelerometer and gyroscope data, BLE RSSI, and microphone data) while experiencing eSense. Besides, we will demonstrate a 360° workplace well-being application as depicted in Figure 2. The application models eSense sensory streams for a variety of physical, digital, and social well-being metrics [2]. Then, it provides personalised and actionable feedback in conversational and visual representations.

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