Poster: Towards Radio-based Sensing on Wearables

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1. ABSTRACT

The popularity of wearables continues to rise. However, their functions and applications are constrained by the types of sensors that are currently available. Inertial sensors can only track motions of body parts to which they are attached. Microphones and cameras are powerful but also capture privacy sensitive information. Physiological sensors are intrusive since firm skin contact is necessity. Recently, radio-based sensing has drawn significant attention as it provides a contactless and privacy-preserving approach to detect and monitor human activities. In this work, we demonstrate the search for a new sensing modality for the next generation of wearable devices by exploring the feasibility of radio-based human activity sensing and vital sign monitoring in the context of wearable setting. We envision radio-based sensing has the potential to fundamentally transform wearables as we currently know them.

First, we have developed *HeadScan*, a first-of-its-kind wearable for radio-based sensing of a number of human activities that involve head and mouth movements include eating, drinking, coughing, and speaking [2]. Experimental results highlight the enormous potential of our radio-based sensing approach and provide guidance to future explorations. Second, we have developed *BodyScan*, a wearable system for radio sensing of human whole body movement [1]. Experimental results indicate that BodyScan is capable of capturing whole body activities with a lifetime of 15 hours.

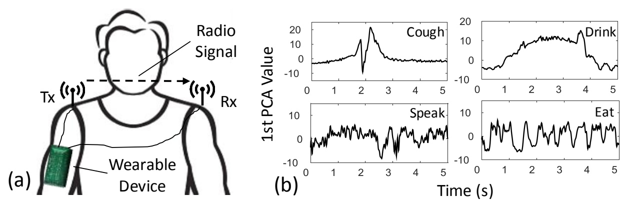

Figure 1: (a) Illustration of HeadScan. (b) Example waveforms of the targeted four activities: coughing, drinking, speaking, and eating.

2. HEADSCAN

Figure 1 (a) provides a conceptual illustration of how HeadScan is worn while it tracks the movements of head and mouth of the user. HeadScan consists of two small unobtrusive commercial off-the-shelf 5GHz antennas placed on the shoulder and collar of the user respectively as well as one wearable unit that can be worn on the arm of the user. One antenna acts as the radio transmitter (Tx) that continuously sends the radio signals while the other antenna acts as the radio receiver (Rx) that continuously receives the radio signals. The wearable unit contains two HummingBoard Pro (HMB) devices that is capable of extracting Channel State Information (CSI) continuously. It then incorporates a radio signal processing pipeline to convert the raw CSI measurements into the targeted human activities. Figure 1 (b) shows the example waveforms of the targeted four activities. As illustrated, HeadScan is able to capture the characteristic head and mouth-related movements of the four activities. As an example, the waveform of eating reflects the periodical mouth movements when people are chewing food. Experimental results show that HeadScan outperforms a state-of-the-art audio sensing platform also dedicated of capturing head and mouth related activities.

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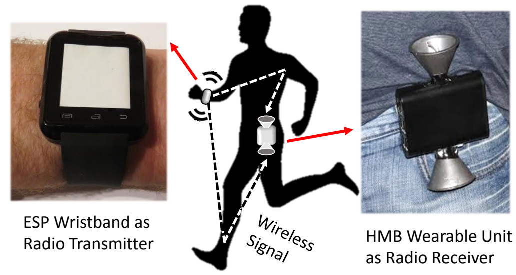

Figure 2: The user model of BodyScan.

3. BODYSCAN

Figure 2 illustrates the user model of BodyScan where our wearable platform is being worn by a user. As shown, the platform consists of two small form-factor hardware devices: 1) an ESP wristband that is worn on the wrist; and 2) a Hummingboard Pro (HMB) wearable unit that is worn on the hip. It is designed to emulate an increasingly popular scenario where users wear a smartwatch or wristband on the wrist while carrying a smartphone in the pocket. Specifically, ESP acts as radio transmitter and continuously sends packets to ambient environment. The HMB wearable unit acts as radio receiver and contains two directional antennas, pointing at upper and lower body. By receiving the radio signal transmitted by ESP which is deflected, reflected or diffused by the target body parts, the HMB wearable platform is able to extract CSI measurements caused by corresponding movements. As such, BodyScan is able of classifying the CSI into target activities according to different patterns. Specially, BodyScan is designed to recognize activities including transportation mode (e.g., walking and biking), hand-related activities (e.g., typing keyboard and shaking hands), and free-weight exercises (e.g., biceps curl and bent-over row). Experimental results show that BodyScan delivers a reasonably acceptable results in both laboratory setting and in the real world environment.

4. REFERENCES

[1] B. Fang et al. BodyScan: Enabling radio-based sensing on wearable devices for contactless activity and vital sign monitoring. In *International Conference on Mobile Systems, Applications, and Services (MobiSys' 16)*, 2016.

[2] B. Fang et al. HeadScan: A wearable system for radio-based sensing of head and mouth-related activities. In *International Conference on Information Processing in Sensor Networks (IPSN' 16)*, 2016.