Poster: Vocal Resonance as a Passive Biometric

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1. INTRODUCTION

With continuing advances in the development of low-power electronics, including sensors and actuators, we anticipate a rapid expansion of pervasive computing. Wearable devices, in particular, require new modes for interaction – many have no keyboard or touchscreen.

In this work, we focus on *user authentication* on wearable devices. For an entertainment device, such as a VR headset, it can recognize the user and load the right game profile or music playlist. For a house climate-control system, it can adjust the environment to the wearer's preference. Most compellingly, for a health-monitoring device, it can label the sensor data with the correct identity so that the data can be stored in the correct health record. (A mix-up of sensor data could lead to incorrect decisions, with harm to the patient.)

Because not all devices are personal devices – *my* phone, *your* fitness sensor – many devices will need to automatically recognize their wearer. They may have no interface for user identification (or PIN or password for authentication). Thus, we need a simple, wearable biometric technique to identify the user – which could be embedded in one authentication device that shares the identity with a body-area network of other devices (earlier confirmed to be on the same body [1]). This device should be trained once, for each user that might wear it, but thenceforth be completely automatic. Although a wristband could use a physiological biometric to recognize its wearer [2]; we seek an alternative biometric, notably, one that might work for devices mounted on the head, neck, or chest.

2. VOCAL RESONANCE

We present a novel, unobtrusive biometric measurement that can support user identification in wearable body-mounted devices: *vocal resonance*, that is, the sound of the person's voice as it travels through the person's body. In our method, a microphone is placed into contact with the body. It records audio samples and compares them with a model, built earlier during a training phase. If the samples fit the model, then we conclude that (a) the speaker is indeed the person for whom we trained the model, and (b) the microphone device is physically *on* the speaker's body. If we train the device for a set of known users, the device should be able to identify which of those people is wearing the device, or that none of them are wearing the device.

We explore two machine-learning approaches; our first approach runs *stand-alone*, processing all data on the microphone-enabled wearable device. Our second approach off-loads data to a *remote host* to run a more expensive deep-learning algorithm. In the latter, we aim to achieve higher accuracy in anticipation of the day when these complex algorithms can be migrated into wearable or portable devices.

3. RESULTS

This poster shows that our system achieves reliable speaker identification through a wearable, body-contact microphone, can reliably distinguish among multiple individuals, and can distinguish between the situation where the microphone is on the body of the identified speaker and where the microphone is simply nearby, even on another body. We evaluated the feasibility of this biometric through two distinct machine-learning algorithms, and evaluated their performance on data from 25 volunteer subjects. We found that a Recurrent Neural Network (RNN) with Long Short Term Memory (LSTM), in combination with a fully-connected layer architecture, achieved the best accuracy (95.6%). Furthermore, we implemented two wearable prototypes and verified that the algorithms have acceptable latency and energy consumption when used for occasional or periodic verification or identification.

4. ACKNOWLEDGMENTS

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5. REFERENCES

[1] C. Cornelius and D. Kotz. Recognizing whether sensors are on the same body. *Journal of Pervasive and Mobile Computing*, 8(6):822–836, Dec. 2012.

[2] C. Cornelius, R. Peterson, J. Skinner, R. Halter, and D. Kotz. A wearable system that knows who wears it. In *Proceedings of the International Conference on Mobile Systems, Applications, and Services (MobiSys)*, pages 55–67, June 2014.

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