Poster: Audio-Kinetic Model for Automatic Dietary Monitoring with Earable Devices

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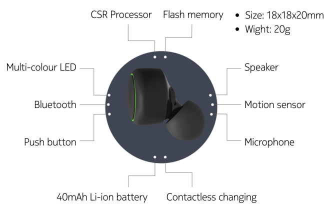
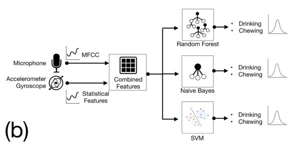


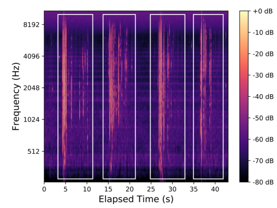
(a)



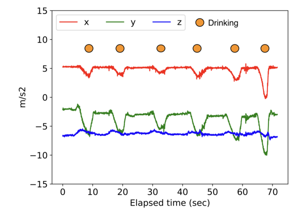
(b)

Task	Audio Only	Inertial Only	Both
Chewing	0.7	0.21	0.73
Drinking	0.3	0.69	0.78

(c)



(d)



(e)

Figure 1: (a) Earable platform, (b) Audio-kinetic model, (c) F-1 score, (d) Spectrogram for chewing, (d) Gyroscope for drinking

CCS CONCEPTS

• **Human-centered computing** → **Ubiquitous and mobile computing systems and tools**;

1 INTRODUCTION

Monitoring dietary intake has a profound implication on healthcare and well-being services in everyday lives. Over the last decade, extensive research efforts have been made to enable automatic dietary monitoring by leveraging multi-modal sensory data on wearable devices [1, 2].

In this poster, we explore an *audio-kinetic model* of well-formed multi-sensory *earable devices* for dietary monitoring. We envision that earable devices are ideal for dietary monitoring by virtue of their placement. They are worn close to a user's mouth, jaw, and throat which make them capable of capturing any acoustic events originating in these body parts. Inertial sensors can potentially capture movements of the head and jaw that are often associated with food intake. As such, fusing the inertial and acoustic data carries a potential for accurate detection of food intake-relevant activities.

We showcase two primitive activities with our audio-kinetic model, *chewing* and *drinking*. These primitives are simple but provide useful contextual cues. For example, analysing the food intake behaviour from chewing can provide insights into the development of obesity and eating disorders. Similarly, tracking drinking events is useful for estimating a user's water intake over a period of time.

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2 PRELIMINARY STUDY

Device: We developed a customised earbud platform with a dimension of $18mm \times 18mm \times 20mm$ and instrumented with a microphone, a 6-axis inertial measurement unit, Bluetooth, and BLE and powered by a CSR processor and a 40mAH battery (See Figure 1(a)).

Audio-Kinetic Model: Figure 1(b) shows our model, consisting of the inertial and audio pipelines. We extract time-domain and frequency-domain features from inertial data, and MFCC features from audio data. Both the features are concatenated and used as a combined feature set with three off-the-shelf classifiers: SVM with RBF kernel, Random Forests, and Naive Bayes.

Results: We recruited 8 users for data collection. They wore a pair of earbuds and were asked to eat and chew solid foods for 4 minutes. Next, they performed 10 'drink' actions by drinking water from a bottle. They took as much break between two consecutive chewing or drinking activities. Figure 1(c) shows the performance of the best-performing Random Forest. The results show that our audio-kinetic model achieves higher accuracies by fusing two sensing channel and providing richer information. Each feature set carries useful cues for different activity; the acoustic features carry more importance for chewing and the inertial features are more suited for drinking. However, their combined use enables to cover corner cases.

We present interesting cases. Figure 1(d) shows the audio spectrogram of the four chewing events. The intensity of the audio signal gradually decreases as the chewing event progresses. This corresponds to the normal chewing habits which start from crushing sounds with high energy content and end with lower amplitude sounds when the food is fully crushed. Figure 1(e) shows the gyroscope data captured while the drinking actions. The head movement while drinking induces a change in pitch and roll axis.

REFERENCES

[1] Merck et al. Multimodality Sensing for Eating Recognition. In *PervasiveHealth* 2016

[2] Bedri et al. EarBit: using Wearable Sensors to Detect Eating Episodes in Unconstrained Environments. In *ACM IMWUT* 2017