Demo: Single-Point Vibration Sensing for Product Pickup/Put-Down Detection in Autonomous Retails

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Figure 1: (a) A prototype of our single-point vibration sensing system with the physical augmentation structure. (b) Example signals of the pickup event with and without the physical augmentation.

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1 MOTIVATION AND DESIGN

Product pickup/put-down detection is important for autono-mous retails [2]. Many types of sensors are used to detect these events, including load cell [2], RFID on items [1], and camera[2]. However, they are limited by Line-of-Sight (LoS) or dense deployment requirements. To address these limitations, we propose a vibration-based single-point sensing system without requiring LoS and dense deployment to detect product pickup/put-down events for autonomous retails.

When the customer pickup/put-down product on the shelf, the load change/impact on the shelf would cause vibrations. If we can recognize these vibrations, we can detect customer pickup/put-down events. However, the pickup/put-down of products induces low-amplitude vibration, which is difficult to recognize from ambient noise, especially for the **pickup of light products**. On the other hand, to reduce the shelf retrofit cost, our goal is to monitor multiple shelves on the gondola **using one low-cost vibration sensor** – sensing from a single point. It is challenging to design a system that satisfies both requirements.

We place the vibration sensor on the center of the gondola's back panel and design a **physical augmentation structure** to enhance the signal propagation path from the shelf to the back panel. As shown in Figure 1(a), the physical augmentation structure is a 90-degree arc structure that connects the shelf and the back panel. When the pickup/put-down induced vibration propagates to the sensor, the arc structure provides a path of less attenuation between the shelf and the back panel. Figure 1(b) shows the same pickup event induced vibration signal, with and without physical augmentation. The signal with augmentation shows a distinguishable waveform from the noise, while the one without does not.

2 DEMONSTRATION

We plan to set up a gondola with two shelves – one with physical augmentation and one without. The audience can interact with our demo and pick up different products from these shelves, our system will show the time-domain signal and mark out the detected events. The audience can compare the detection efficiency of the two settings over different products.

3 ACKNOWLEDGEMENT

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REFERENCES

[1] George Roussos. 2006. Enabling RFID in retail. *Computer* 39, 3 (2006), 25–30.
[2] Carlos Ruiz, Joao Falcao, Shijia Pan, Hae Young Noh, and Pei Zhang. 2019. Aim3s: Autonomous inventory monitoring through multi-modal sensing for cashier-less convenience stores. In *Proceedings of the 6th ACM International Conference on Systems for Energy-Efficient Buildings, Cities, and Transportation.* 135–144.

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