ISCAS 中国科学院软件研究所学术年会'2024 暨重点实验室科技活动周

学术论文

基于分布式车载声学器件的儿童存在性检测系统

Embracing Distributed Acoustic Sensing in Car Cabin for Children Presence Detection

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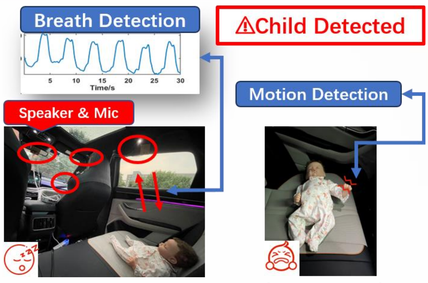
Motivation

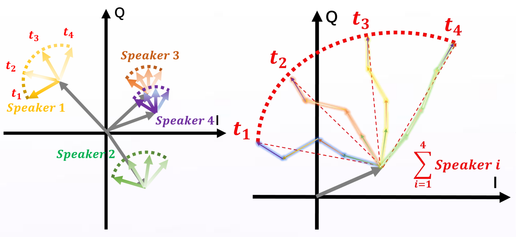
- The demand for **Child Presence Detection (CPD)** in car rapidly grows in the last few years. However, existing solutions still have some limitations, such as privacy issues, detection blind spots, etc.
- More and more cars are equipped with a large number of acoustic modules, which provides us an unique opportunity to achieve **not only highly accurate sensing but also full-coverage sensing**.



Breath Detection **Motion Detection**

CPD based on distributed acoustic sensing

- In this work, we propose the concept of distributed acoustic sensing for the first time, bringing full-coverage sensing to car cabin platform.
- Our approach leverages the acoustic modules in car cabins to **detect child's breath and motion.** However, there are two challenges that need to be addressed before implementing such a CPD system: **non-synchronous speakers and microphones** and **non-line-of-sight (NLoS) issues**.
- To address the first challenge, we propose to use **signal phase amplification technique** for sensing. To address the second challenge, we propose to leverage the unique characteristics of extremely rich multipath in car cabin. By **fusing multiple weak secondary reflections**, we are able to achieve full-coverage in-cabin sensing even when the primary reflection is 100% blocked.



- We propose **a novel design** to enable highly accurate in-cabin sensing without the need of modifying the existing hardware, which provides more possibilities for **various in-car sensing applications**.

Evaluation & Results

- We implement the CPD system on the audio modules embedded in a real car, which consists of six Bose speakers and eight microphones. Meanwhile, two high-fidelity child simulators with realistic newborn traits are used in our system to serve as the targets.

- We conduct experiments in various types of cars for CPD by detecting baby motions and subtle breaths. We collect a large data set to thoroughly analyze the impact of different factors, including **the presence or absence of a child, child's locations, multiple car models, NLoS scenarios, interference, etc**.

- Our experiments show that the proposed system can robustly work in different cars, achieving **an average detection accuracy of 97% and a false alarm rate below 2%** under different scenarios.