Occupant-Induced Office Floor Vibration Dataset for Activity Level Monitoring

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1 INTRODUCTION

Occupant activity level plays an important part in many smart building applications, such as power management [5] and elderly care [1]. There are several approaches to obtain occupant states, including visual-, acoustic-, and radio frequency based techniques. However, visual-based approaches require light-of-sight, while acoustic-based approaches are sensitive to background noise. On the other hand, radio-based approaches often require the occupant to carry a particular device to receive signals from base stations, which requires direct participation from the monitored occupants at all times.

To overcome these limitations, we utilize structural vibrations to detect occupant information by capturing the occupant-induced vibration signals on the floor. Prior works have successfully utilized this sensing modality to achieve occupant localization [2], identification [4], and traffic estimation [3]. To further advance this field, we have developed an occupant-induced floor vibration dataset that can be used for activity-level monitoring in indoor environments.

In the rest of this abstract, we will introduce the data collection procedure (i.e., vibration signals and ground truth), the sensor unit characteristics, the dataset formation, as well as the challenges associated with interpreting the vibration data.

2 DATASET DESCRIPTION

To enable the activity level estimation using this provided dataset, we provide both 1) the office floor vibration data and 2) the access control record used as ground truth of one of the deployed sensors.

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2.1 Vibration Data

We have collected vibration data caused by occupant activity in a campus building in Shenzhen, China. In this section, we first describe the vibration-based dataset, including the sensing unit (Section 2.1.1), the spatial and temporal coverage of the sensors (Section 2.1.2), and the dataset format (Section 2.1.3). Then, we discuss the ground truth system (Section 2.2) and conclude the paper.

2.1.1 Sensing unit. The sensing unit used to obtain the occupant-induced floor vibration mainly consists of four components: a geophone sensor, an amplification module, an ADC module, and a processor. This sensing unit is shown in Figure 1. The geophone converts the vibration of the floor to voltage, which is then amplified by the amplification module. Due to the high stiffness of the floor structure, we use two op-amp boards to increase the signal resolution of the recorded low SNR (signal-to-noise ratio) vibration response. The amplified signal is then digitized by the ADC module shown in the figure. The processor uploads the data through Ethernet to the server.

2.1.2 Sensor Deployment and Data Collection. Four vibration sensors are deployed in the 15th floor of an office building with a

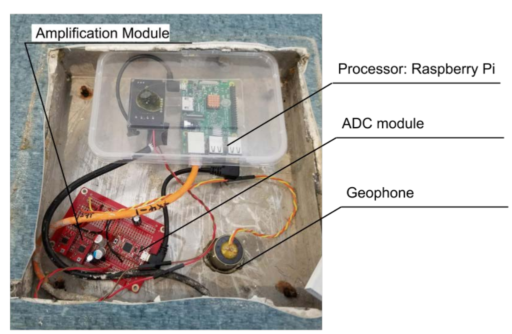

Figure 1: A sensor unit consists of four major components: a geophone sensor, an amplifier, an ADC module, and a processor (Raspberry Pi in this deployment). To ensure occupant safety and protect the sensors, each sensor was placed below the floor surface and covered with a metal plate.

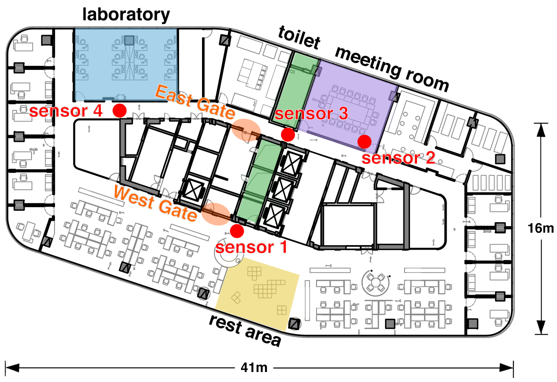

Figure 2: Sensor deployment map. Four sensors are deployed on the floor to monitor designated regions, including a rest area, a meeting room, a restroom, and a laboratory.

sparse configuration over predetermined areas-of-interest (based on observed occupant activity in prior time periods and general floor layout). As shown in Figure 1, sensors were deployed below the floor surface and adhered directly to the concrete slab. To ensure the safety of the occupants, the sensor enclosures were covered with a steel plate. To maximize the sensing area and occupant information, sensors were spaced throughout the floor and located in high traffic hallways as shown in Figure 2. The provided dataset includes four sub-datasets which correspond to the vibration data from each of the four sensors (Sensors 1 through 4 in Figure 2). We continuously recorded the vibration signals from all the sensors during 35 days (5 weeks), and each file in the dataset represents 1 minute of vibration data. Figure 3 shows an example of the collected vibration data after filtering the background noise in a sample file. The red box indicates an example of an impact response due to human activity in the area of the sensor.

2.1.3 Dataset format. In the dataset, each sample is saved in one TXT file. We name the sample file with the recording time in the format of "year-month-day_hour-minute.txt". For example, a sample file name "2017-12-30_07-56.txt" means this file recorded the vibration signals from 7:55:00 to 7:55:59 on December 30, 2017. In addition, vibration data from each of the four sensors is contained in the dataset, and each sensor generates one file every minute. Therefore, we can utilize the recorded time contained in the file name to synchronize the signal clock for different sensors. The synchronization error is less than 100 ms. We utilize a 12-bit ADC to digitize the signal at a sampling rate of 2.5 kHz. As a result, each file contains nearly 150,000 integers in the range of [0, 4095]. The integer value represents the amplitude of the vibration signal.

2.2 Ground Truth

To offer a basic ground truth of the occupant traffic, the access record is also contained in the dataset. As shown in Figure 2, the building includes two gates: a Western gate, and an Eastern gate. Everyone needs to pass an access control system using a RFID badge to enter the building from the either gate. To protect the occupant's privacy, the access record only includes the gate ID and access time; occupant ID and another private information are not contained in the record. The access record is saved with the format of EXCEL. As shown in Table 1, each row of the excel table represents an occupant entering the building, where the first column of the table is the access time, and the second column is the gate ID.

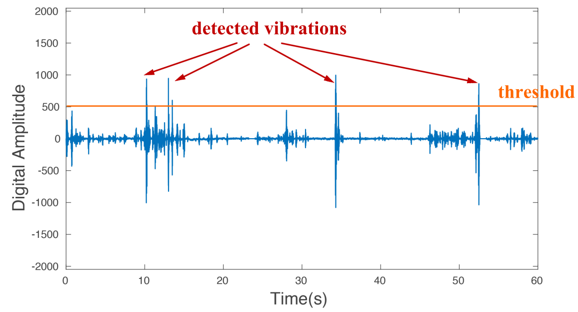

Figure 3: This figure shows the vibration data after filtering the background noise in a sample file.

Table 1: Access record format with data examples

Access time	Gate ID
2018-01-01 14:27:17 Mon.	west_gate
2018-01-01 14:11:20 Mon.	east_gate

3 CONCLUSION

In this paper, we present a dataset of occupant-induced structure vibrations in an office building across 35 days. The dataset consists of two parts: vibration data and access record (for ground truth). The provided vibration data contains more than 200,000 files in 35 days covering four area-of-interests (four sensors of data). Each file represents the vibration signal of the floor in one minute with a sampling rate of 2500Hz. The access record contain the exact time that an occupant enters the building, which can be used as the ground truth for occupant traffic. This dataset provides opportunities for studies in vibration-based occupant monitoring, such as traffic estimation and regional activity estimation.

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