Automated Activity Identification for Sustainable Demolition Management and Operations

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Introduction

- The reusability and recyclability of demolition waste are significantly affected by the demolition operations, which are largely driven by productivity considerations.

→ Investigating the productivity of demolitions operations is key to understand the decision-making processes affecting the recyclability and reusability of demolition waste.

- Traditional approaches for tracking the duration of demolition operations and thereby monitoring the productivity have several cost, time, and human error drawbacks [1],[2].
- Automated productivity monitoring approaches [2]–[4] have been proposed for construction activities but not for demolition activities.
- To enable more effective and efficient demolition productivity monitoring, this research aims to develop an automated demolition activity identification model that uses angular and linear acceleration data of the demolition equipment.
- Small-scale heavy equipment, equipped with Inertial Measurement Unit (IMU) sensors collecting acceleration data. are used to simulate demolition operations.

Methods

Materials:

- Color-coded cement and metal debris (Fig. 1)
- Small-scale heavy equipment
- IMU sensors (Fig. 2)
- Digital scales
- Cameras

Fig. 1. Cement and metal materials transformed into color-coded debris

Fig. 2. IMU sensors attached to members of the small-scale heavy equipment

Procedure:

1. Cement and metal debris were weighed out and mixed thoroughly:
   - 2 kg of large brown cement pieces
   - 1 kg of small purple cement pieces
   - 100 g of metal pieces
2. The debris was sorted by operating the small-scale heavy equipment (Fig. 3).
3. IMU sensors recorded the linear and angular acceleration data of the equipment during the debris sorting and was subsequently uploaded to Excel.
4. The duration of the experiment (i.e., debris sorting duration) and its video footage were recorded.
5. Video data was used to label the time-stamped sensor data by the activities being executed:
   - Activities: leveling, grabbing, swinging, dumping, and moving
   - The minute, second, and millisecond the activity started and ended was recorded into excel
6. A median filtering technique was used to reduce the noise of the IMU sensors.
7. The labeled motion data will be split for use in training and testing activity identification models using different machine learning classification algorithms.

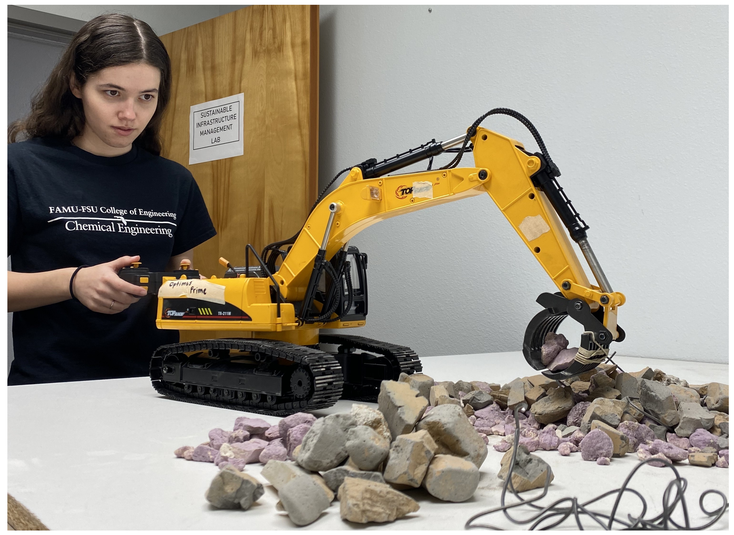

Fig. 3. Simulating demolition operations using small-scale heavy equipment

Results

- Small-scale simulation of the debris sorting operations were carried out.
- The shortest duration to sort the debris was roughly 30 minutes.
- Collected sensor data is being labeled in Excel using the video footage from different camera angles (i.e., GoPro footage, footage focused on sorted debris piles, footage focused on the mixed debris pile).
- Labeled data will be used to train a classification model using machine learning.

Conclusions

- Using small-scale heavy equipment is a cost-effective way to simulate demolition operations and monitor productivity.
- Different activities can be identified automatically using data collected by IMU sensors attached to the demolition equipment (Fig. 4).
- This can enable accurate, cost-effective, and real-time demolition productivity monitoring.
- Demolition equipment operators can use the productivity information for more informed decision-making and resource management in favor of recycling and reuse of demolition waste.
- Future research should be done to see how the automated activity identification model is affected when the types of debris being sorted are varied (i.e., grabbing a piece of steel is harder than grabbing and a big size of cement).

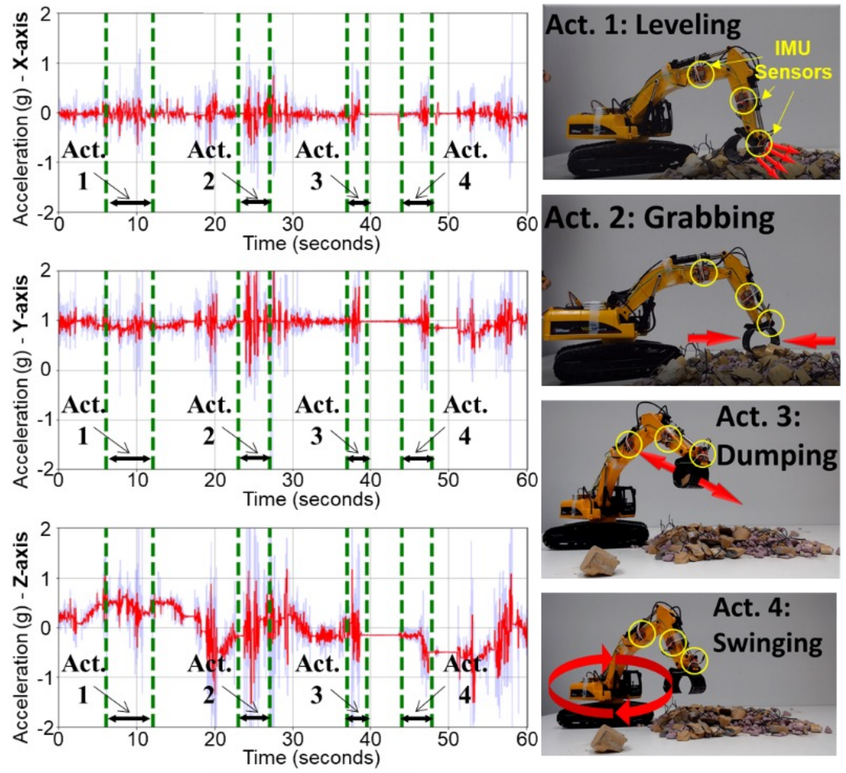

Fig. 4. Identification of demolition activities from the filtered IMU data

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