# MachineSense: Detecting and Monitoring Active Machines using Smart Phone

Mostafa Uddin
Department of Computer Science
Old Dominion University
muddin@cs.odu.edu

Tamer Nadeem
Department of Computer Science
Old Dominion University
nadeem@cs.odu.edu

## 1. INTRODUCTION

Detecting and tracking individual running machines at home have variety of implication at context-aware application for home automation, energy monitoring, machine health monitoring, human activity detection, etc. Researchers have came up with various ideas of detecting machines or machine related events based on their interest of problems[**?**, 1, 2]. Unfortunately, all these solutions require invasive and expensive installation of sensor devices. In order to address these problems, we propose a simple and flexible machine monitoring system using smart phones. We call our system MachineSense in which it exploits various sensors in smart phones to build a unique fingerprint profile for each individual machine. In building fingerprint profiles, characteristics of each machine are analyzed to identify the appropriate sensors (e.g., magnetic sensor, light, microphone, temperature, camera, RF etc.) that could be utilized to collect corresponding sensing data. These sensing data in collective way represent a fingerprint profile of the machine. Later, we apply a machine learning method using the fingerprint profiles to recognize and detect the running machines. In this poster, we refer to all kind of home appliances, computing machines and non-computing machines as "machine".

## 2. SOUND SENSING FRAMEWORK

Towards proof of concept, we utilize only the microphone sensor of the smart phone to detect active machines within it's vicinity. In this implementation, we use only sound profile of each machine as a fingerprint profile. This sound profile represents an acoustic model for each individual machine. For creating these models,we collected 2 seconds of raw audio samples to generate MFCC features and then apply Maximum-Likelihood algorithm to generate Multivariate Gaussian Distribution model for the machine. In the prototype implementation, we use equal prior bayesian classifier for detecting and monitoring a running machine.

In our preliminary experiment, we create sound profiles for microwave, table fan, and vacuum cleaner. Then, we put all three machines in a single room and run our developed prototype application on Nexus S phone for 105 minutes. The prototype application continuously sense surrounding sound and identify any running machine in real-time. We run one machine at a time. In Figure 1, we show the detection results of our prototype application in comparison with the actual active machine between the minute 25 and minute 50. From Figure 1, it is noticeable that the detected machine at some points in time outlie the actual detected machine at the adjacent times. These outliers can be removed using further smoothing technique. In the figure 1, "none" is a sound profile that we build when none of the machine is running.

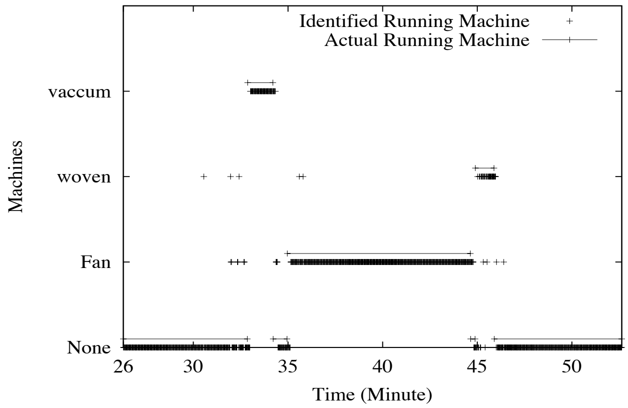


**Figure 1: The recognized machines by MachineSense prototype and the actual running machines during 25 min period.**

## 3. CHALLENGES AND ONGOING WORK

Nowaday, smart phones have potential sensors that can have several implications in our real life. However, in our study we found out that some sensors may have functionality limitaion. For Example, we observed that the magnetic sensor chip in Nexus S phone uses a very low pass filtering technique that generates only the DC component of the signal. As a result, magnetic sensor reading is less sensitive to high frequency changes in magnetic field reading. This characteristic make magnetic sensor in smart phone less useful to be utilized in detecting running machines. Also, the microphone sensor at different devices and platforms show different sensitivity to acoustic data reading. In continuation to our work, we like to understand more about the limitation, sensitivity and characteristic of different sensors in different smart phones for creating suitable fingerprint for the machine.

Although our evaluations for detecting a single running machine based on sound is promising, detecting active machines in real life is far more challenging. Detecting multiple running machines at a time, detecting machines with significant background noise, and recognizing running machines from different positions are some of the key challenges. In order to make these challenges more addressable, we could make some presumptions such as knowing the layout and positions of the machines as well as the smart phone. In summary, our ongoing work on MachineSense project based on the above challenges and presumptions include, (1) extensive experiment on using smart phones location in addition with layout information of the machines, to detect multiple machines, (2) leveraging multiple smart phones with wireless communication for further evaluation of our system, (3) interfacing additional or external sensors with the smart phone to create sophisticated fingerprints for the machine.

## 4. REFERENCES

[1] Y. Kim, T. Schmid, Z. M. Charbiwala, , and M. B. Srivastava. Viridiscope: Design and implementation of a fine grained power monitoring system for homes. In *Ubicomp 2009*, Sep 30- Oct 3 2009. Orlando, Florida, USA.

[2] Z. C. Taysi, M. A. Guvensan, and T. Melodia. Tinyears: Spying on house appliances with audio sensor nodes. In *Buildsys 2010*, November 2 2010. Zurich, Switzerland.