MachineSense: Detecting and Monitoring Active Machines using Smart Phone

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1.MOTIVATION

➔ Detecting and tracking individual running home's appliances and electrical devices (Machines) provide important information for number of applications:

Detecting Human Activities, Monitoring Energy Usage for individual machines, Machine Health monitoring, Context-aware applications, Home automations.

➔ Smartphone comes with useful sensors that can be utilized.

2.MULTI SENSING FRAMEWORK

Multi-sensing frame work has two components:

Building fingerprint profile:

➔ Identify the sensors that are relevant to the machine.

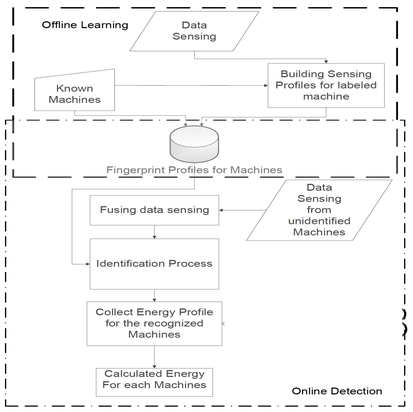
➔ Building sensing profile using each sensor.

➔ Combining multiple sensing profile.

Online detection:

➔ Collecting sensing data and fusing them.

➔ Detecting the running machines using pre-build fingerprint Profiles.



3.SOUND SENSING FRAMEWORK

➔We used microphone sensor of the smartphone as a proof of concept.

➔Build a sound profile, which represents an acoustic model for each machine.

➔Recognize the machine using the collected real-time features and pre-learned acoustic models.

$$\mu_{ML} = \frac{1}{N}\sum_{i=1}^{N} x_i$$

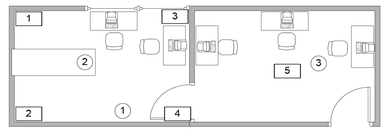
$$\Sigma = \frac{1}{1-N}\sum_{i=1}^{N}(x_i - \mu_{ML})^2$$

Multivariate Gaussian Acoustic Model

$$F^l = \arg\max_m \mathcal{N}(\vec{f}, \vec{\mu_m}, \Sigma_m)$$

Naïve Bayes classifier with equal prior probability

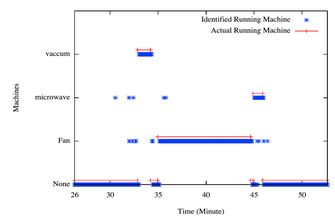
4.PRELIMINARY EVALUATION RESULT



Machine	Position	microwave	fan	vacuum	none
Microwave	1	**64.06%**	23.43%	3.12%	9.37%
	2	**71.87%**	9.37%	0.00%	18.75%
	3	**65.62%**	28.12%	0.00%	6.25%
	4	**60.93%**	20.31%	0.00%	18.75%
	5	**53.12%**	12.5%	0.00%	34.37%
Fan	1	32.81%	**67.19%**	0.00%	0.00%
	2	42.19%	**54.68%**	0.00%	3.12%
	3	43.75%	**56.25%**	0.00%	0.00%
	4	32.81%	**57.81%**	0.00%	9.37%
	5	**48.44%**	29.69%	0.00%	21.87%
Vacuum	1	3.12%	0.00%	**96.88%**	0.00%
	2	0.00%	0.00%	**100.00%**	0.00%
	3	15.66%	0.00%	**84.34%**	0.00%
	4	0.00%	0.00%	**100.00%**	0.00%
	5	0.00%	0.00%	**100.00%**	0.00%

Detection of running machines from different positions. In the table "none" is a sound profile that represents when none of the machine is running.
From each location we identified the machine using different orientation of the mobile phone.

Circle 1,2,3 shows the position of a microwave, a fan and a vacuum cleaner respectively at our lab office. Square 1,2,3,4 and 5 shows the position from we have identified the current running machine using our prototype application. We develop a prototype system in Android phone (Nexus S)



Comparison of actual running machine and recognized running machine using our prototype system for 25 minutes of time.

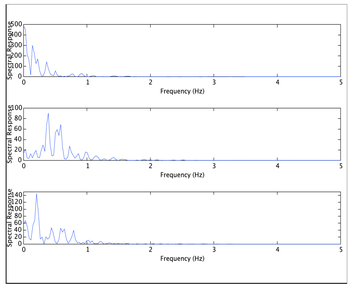
5.CHALLENGES

➔ Some smartphone sensors are limited in functionality.

➔ Smartphone sensors show differences in sensitivity among different devices and platforms.

➔ Detecting multiple machines at a time and recognizing running machines from different positions.

➔ Location and orientation of the smart phone.



Low pass narrow bandwidth Frequency Response of Magnetic sensor reading for X, Y and Z axis (Nexus S)

6.FUTURE WORK

➔ *Making the challenges more approachable by knowing the layout/position of the machines in addition with the smart phone location.*

Extensive experiment on using smart phones location in addition with layout information of the machines, to detect multiple machine.

➔ *Leveraging multiple smart phone with wireless communication for improvising the detection of multiple machines.*

➔*Interfacing additional sensors with the smart phone to create sophisticated fingerprints for the machine.*