Environmental Sensing II

EE382V Activity Sensing and Recognition

UT Austin • Dept. Electrical and Computer Engineering • Fall 2016

Admin

How are the projects going?

Posted PDFs of lecture slides (excluding today's)

Make sure you got your Panel of Experts grade

Coming up

2 weeks of lectures left

2 Panels of Experts (sign-up if you haven't done so)

2 Summary + Critique reports (due Nov 8th and Nov 15th)

Assignments and readings posted

Admin

Next Week Classes

Applications in HCI and Health

Nov 17th Emerging Topics Class

Any topic you would like to see covered?

Discuss final exam

Nov 22nd Project Workday Class

No class, I will be available on email

Use the time to work on your projects (e.g., presentation + report)

Presentations right after Thanksgiving

Today

Infrastructure-Mediated Sensing

Recognizing Water-Based Activities in the Home with IMS

Papers + Panel of Experts

Infrastructure-Mediated Sensing (IMS)

What is it?

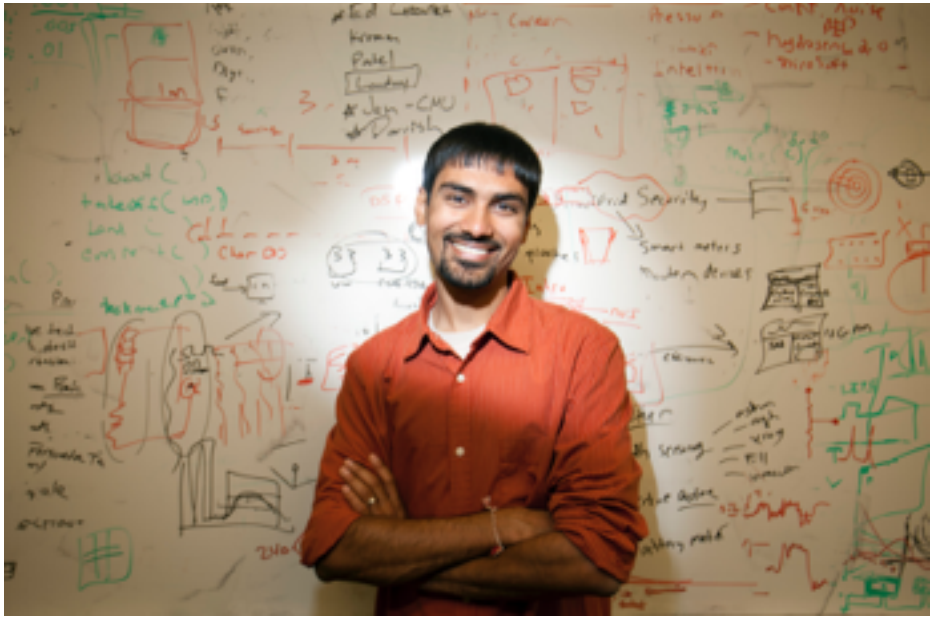
A class of activity monitoring systems which provides a whole-house solution for sensing activity and the location of people and objects. Infrastructure mediated sensing **leverages existing home infrastructure** (e.g, electrical systems, air conditioning systems, etc.) to mediate the transduction of events. In these systems, infrastructure activity is used as a **proxy** for a human activity involving the infrastructure.

Who invented it?




Does IMS Matter?

Shwetak Patel is a computer scientist who has invented a series of sensor technology systems for home environments with the goal of saving energy and improving daily life through a broad range of applications. Much of his work to date has focused on the development of low-cost and easy-to-deploy devices that can detect and measure household energy consumption without an elaborate network of expensive instruments.



MacArthur Foundation

Infrastructure-Mediated Sensing

What are the advantages and disadvantages?

Discuss with your neighbor (5 minutes)

Infrastructure-Mediated Sensing

What components of infrastructure can be used?

Water

Electricity

Gas lines

HVAC

Network Router

TV cable

Infrastructure-Mediated Sensing

Which applications have been developed?

Identify human activity and location

Measure human health

Track utility consumption

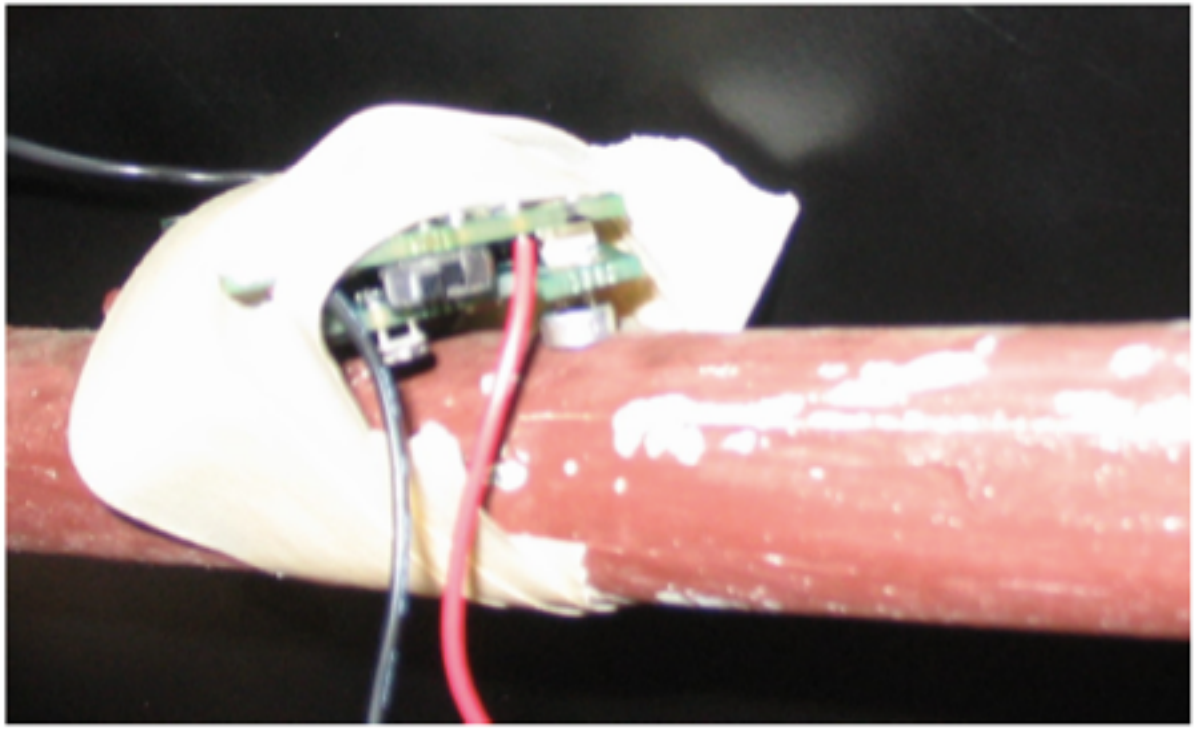
Behavior change

Human-Computer Interaction

Papers + Panel of Experts

Sensing from the Basement: A Feasibility Study of Unobtrusive and Low-Cost Home Activity Recognition

Fogarty et al. (UIST 2006)



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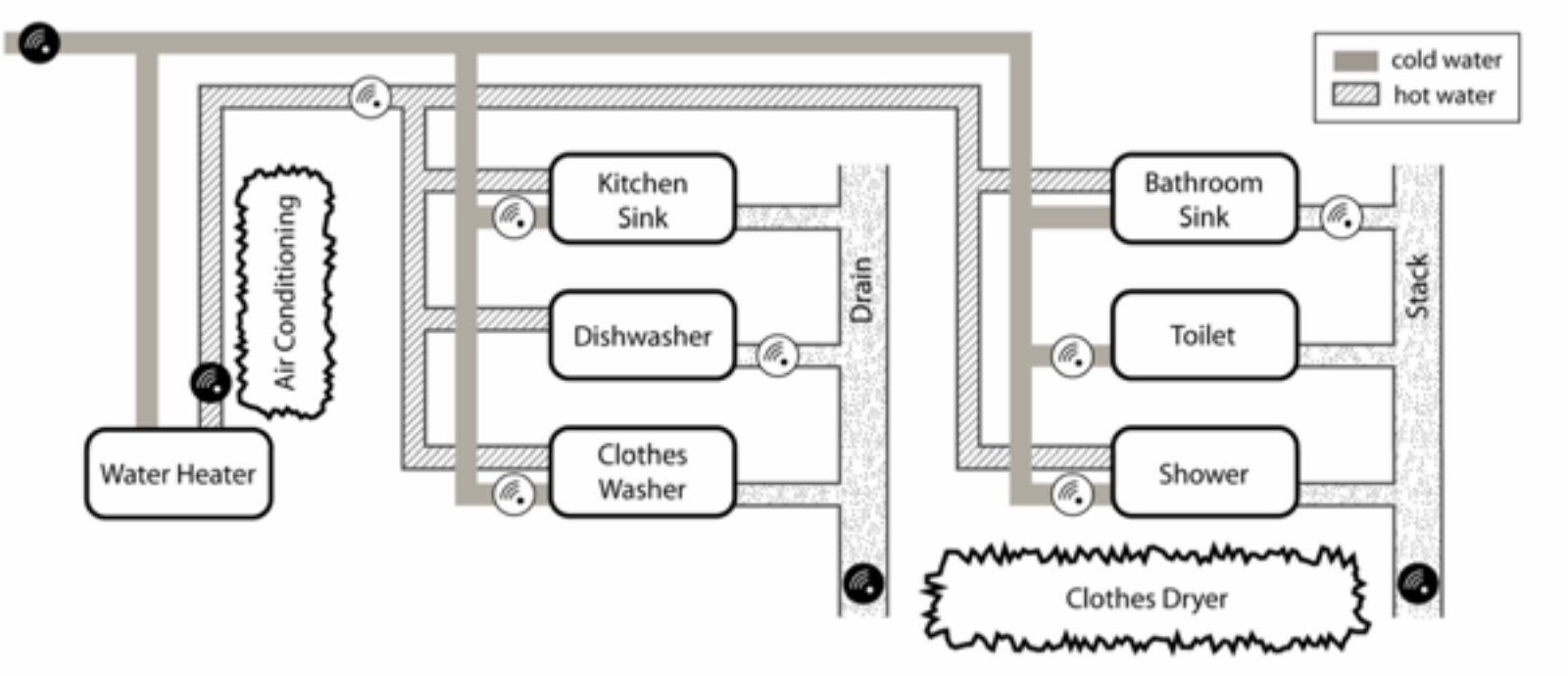


Figure 1. Schematic of the water pipes in the home where we conducted our feasibility study. The air conditioning and clothes dryer are shown because they rattled nearby pipes, introducing noise that needs to be considered in analyses. The four shaded sensors are used for modeling activities, while the unshaded sensors are included only for validating our results.

Recognizing Water-Based Activities in the Home Through Infrastructure-Mediated Sensing

14th ACM International Conference on Ubiquitous Computing

Sept 4th 2012 • Pittsburgh, PA

Edison Thomaz
Vinay Bettadapura
Gabriel Reyes
Megha Sandesh
Grant Schindler
Gregory D. Abowd
Irfan Essa

School of Interactive Computing
Georgia Institute of Technology
Atlanta, GA, USA

Thomas Ploetz

Culture Lab
School of Computing Science
Newcastle University, UK

Recognizing human activities at home for health applications

Many Challenges

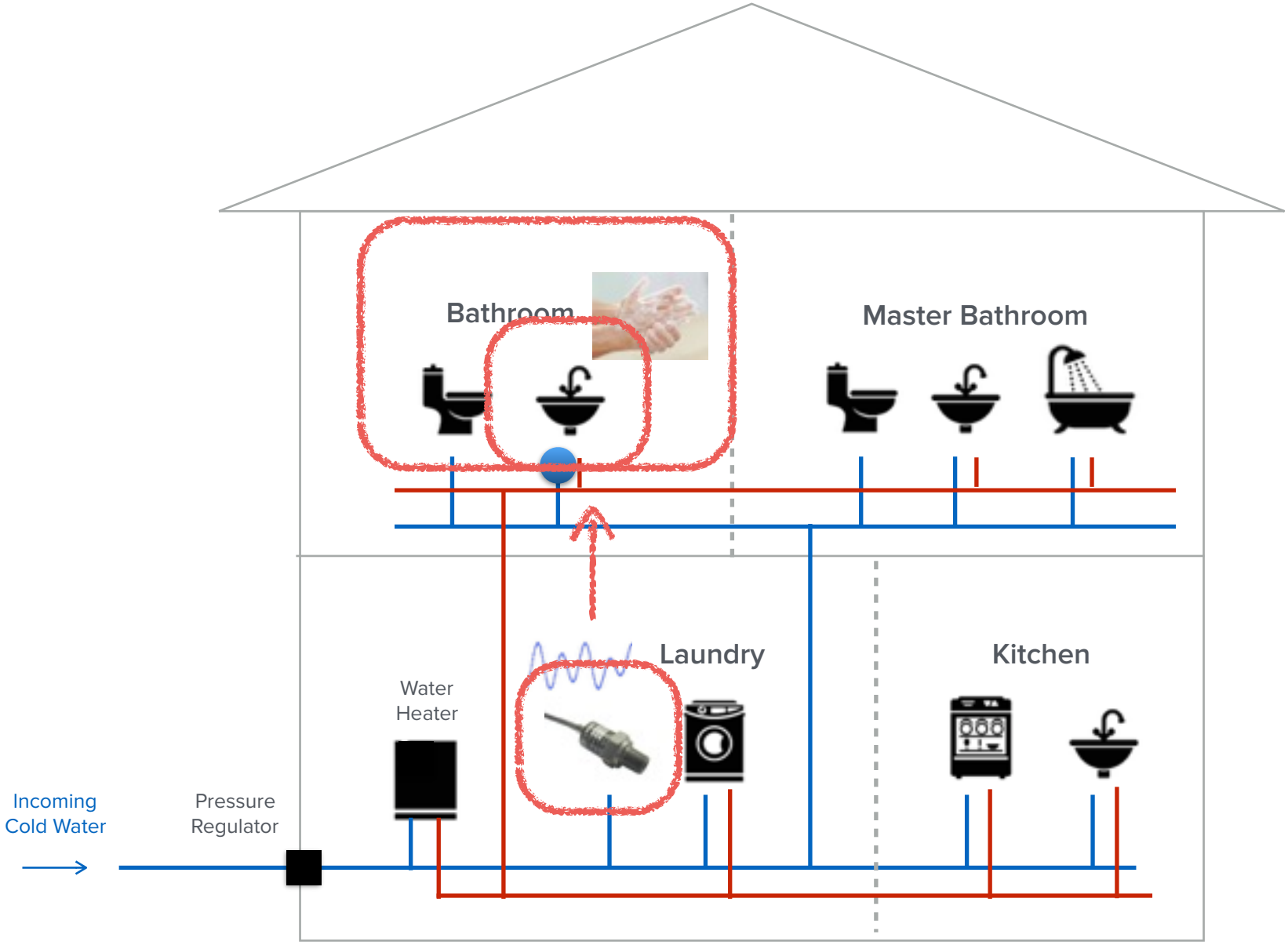
Infrastructure-Mediated Sensing

The Home as the Sensor: Electricity, Gas, Water

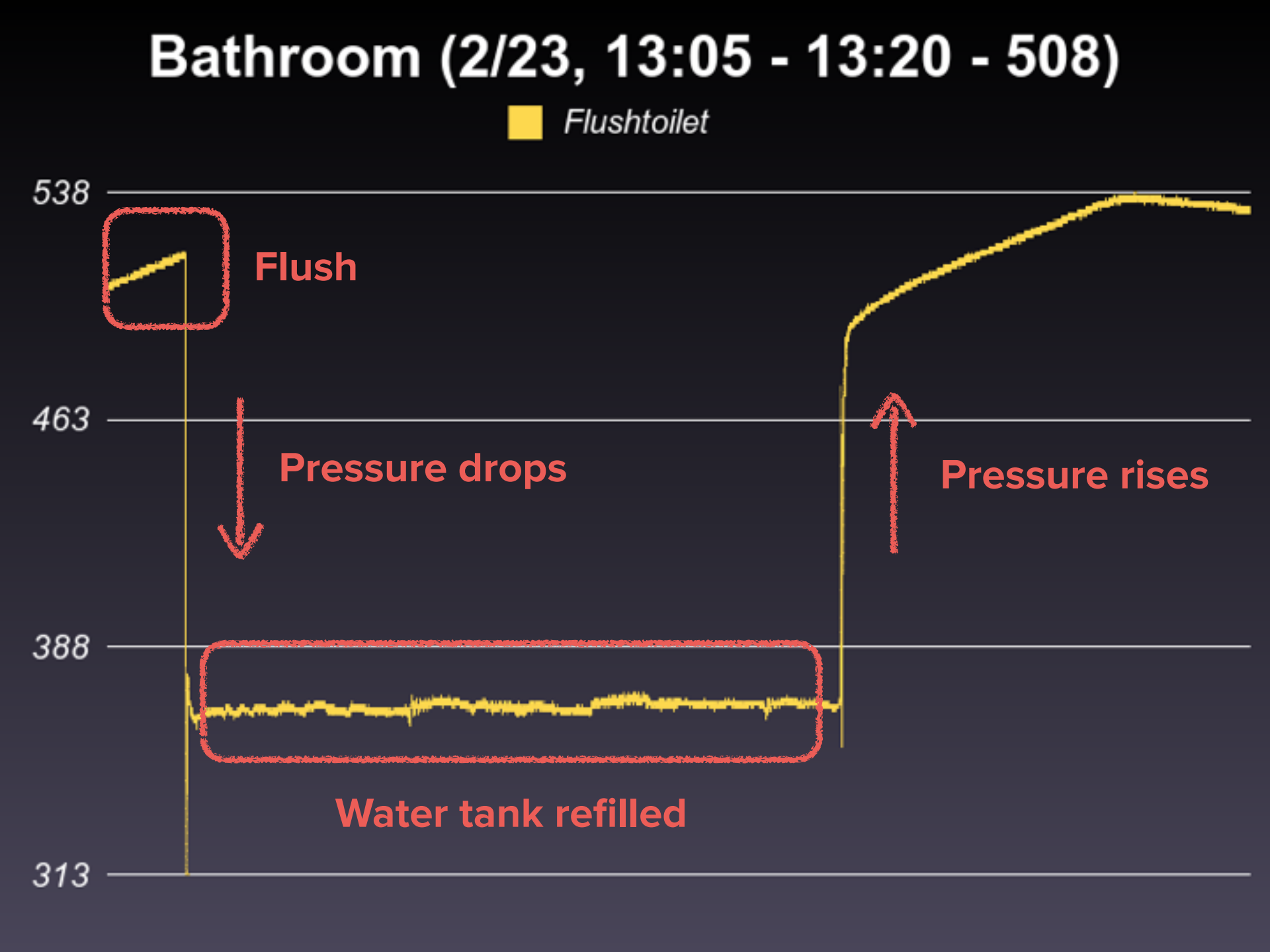
Leverages physical phenomena of infrastructure

One sensor per household

Low cost, easy to install, scalable



Froehlich *et al.*. A Longitudinal Study of Pressure Sensing to Infer Real-World Water Usage Events in the Home. Pervasive Computing 2011.


Bathroom (2/23, 13:05 - 13:20 - 508)
Flushtoilet
538
463
388
313
Flush
Pressure drops
Pressure rises
Water tank refilled

IMS :: Hydrosense

IMS :: Hydrosense

System

+

User Study

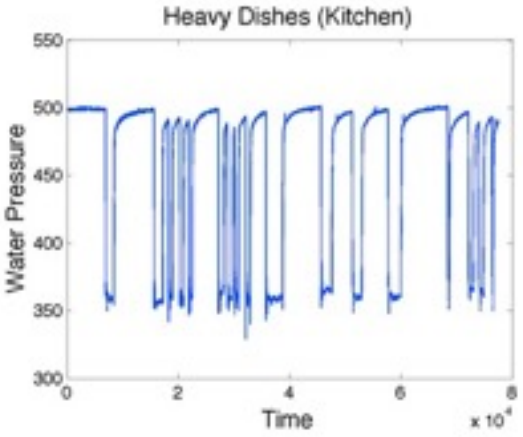
System

+

User Study

System

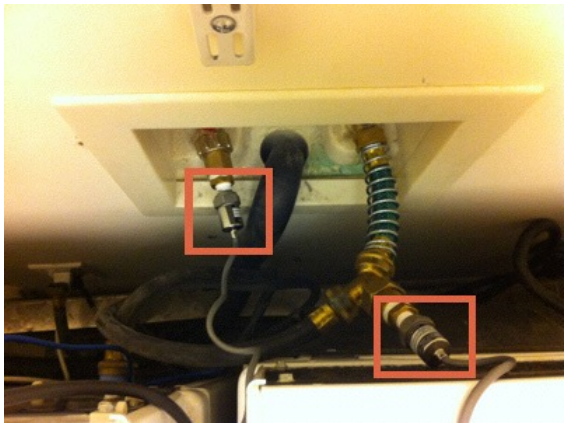
Data Collection



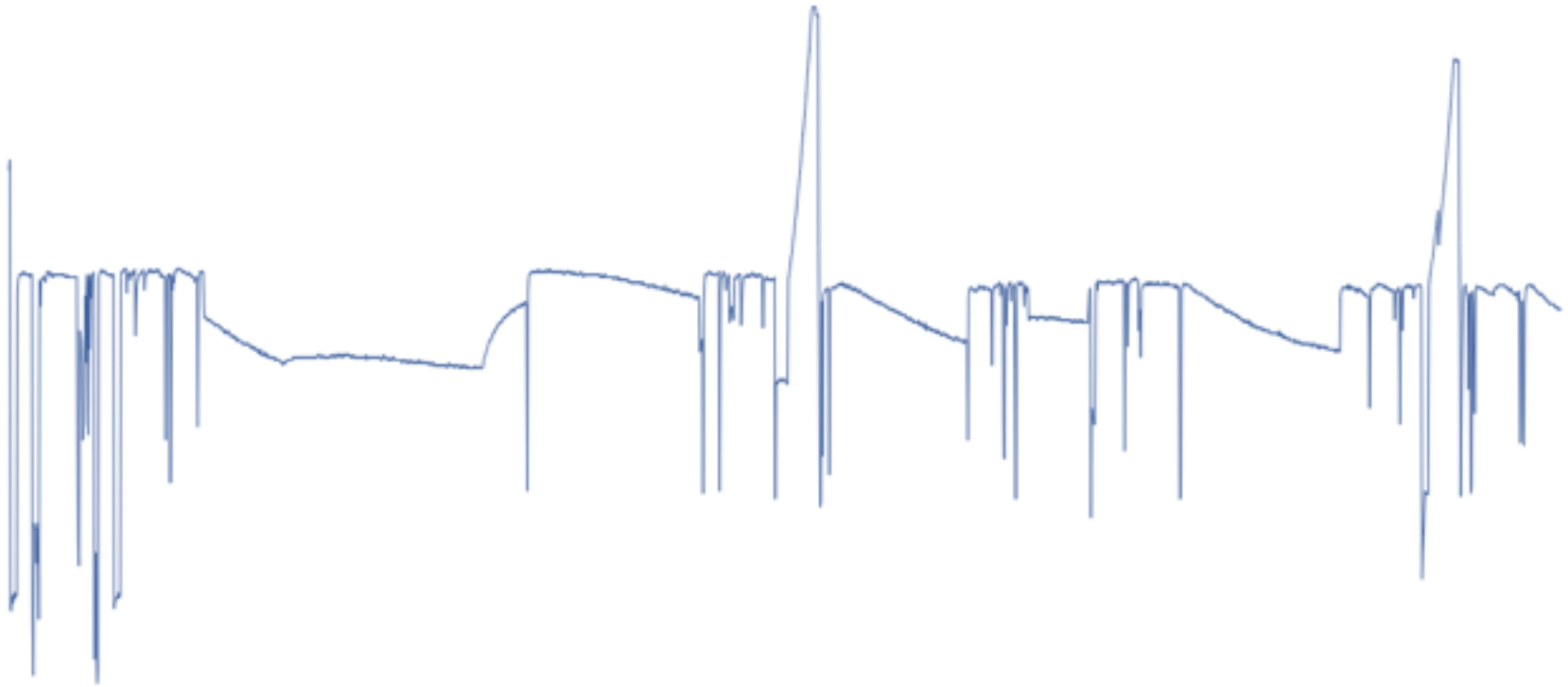
Data Analysis

Data Collection

Data Collection



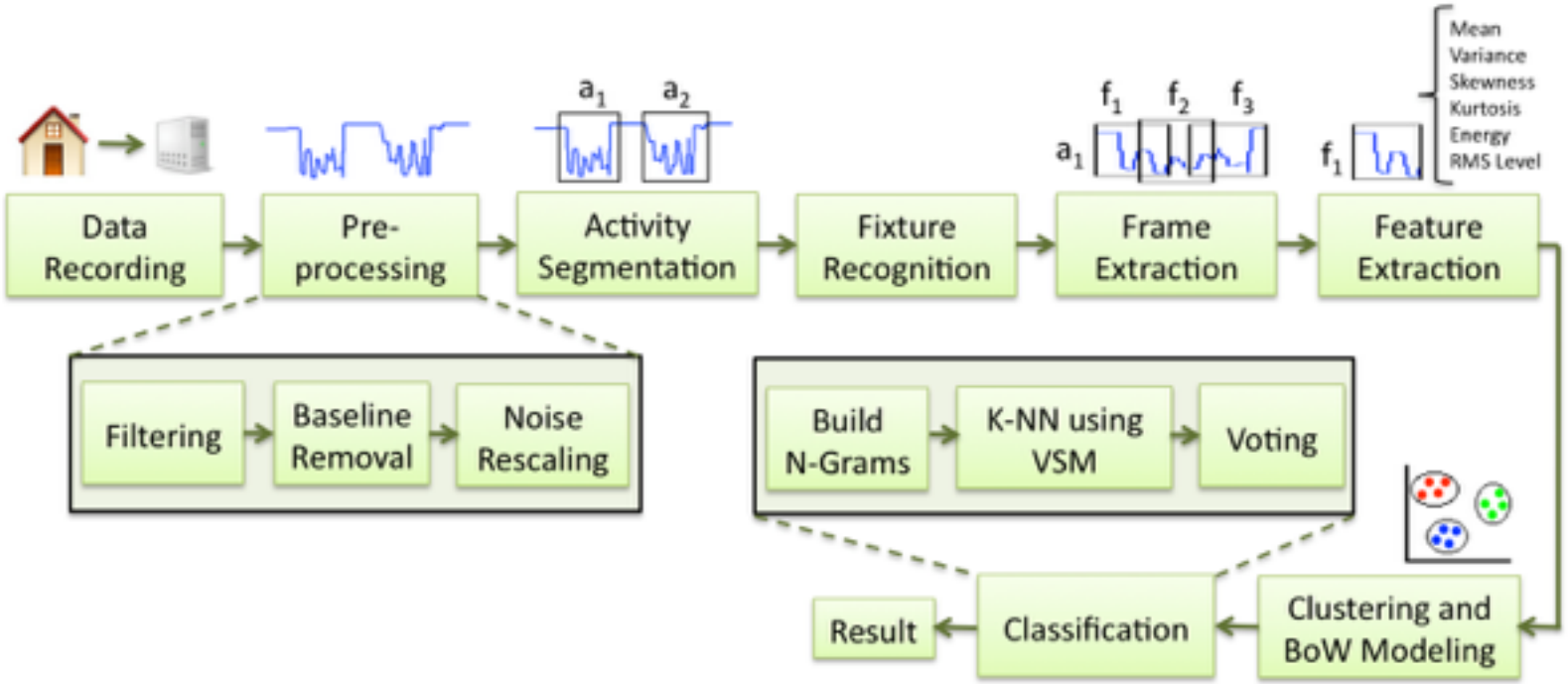
Data Collection



24 hrs of data 160Hz 15M points

Data Analysis

Activity Recognition



We've discussed this approach already

How good is the system?

System

+

User Study

User Study

Aware Home
2 weeks
28 participants
8 senior adults

Reflect a real-world scenario as much as possible, within a controlled environment

User Study :: Activities

Location	Activity
Bathroom	Shave
Bathroom	Brush Teeth
Bathroom	Wash Hands
Bathroom	Flush Toilet
Kitchen	Wash Hands
Kitchen	Fill Up Teakettle
Kitchen	Make a Salad
Kitchen	Rinse a Fruit
Kitchen	Take Glass of Water
Kitchen	Do Dishes

User Study :: Protocol

Participants followed a script

Sequential script read out loud by researcher

Beginning and end of activities were tagged

Web-based labeling tool (mobile)

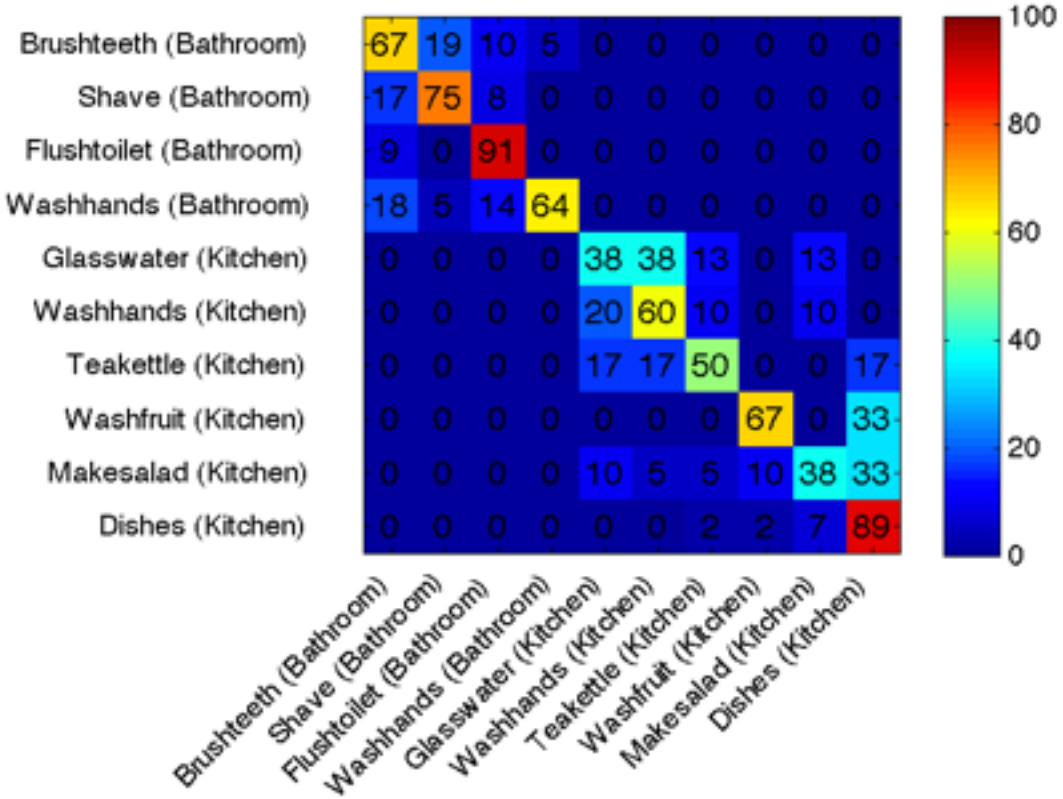
Staged realistic environment for participants

Set up dirty dishes, pots and pans

User Study :: Realistic Setting




User Study :: Results



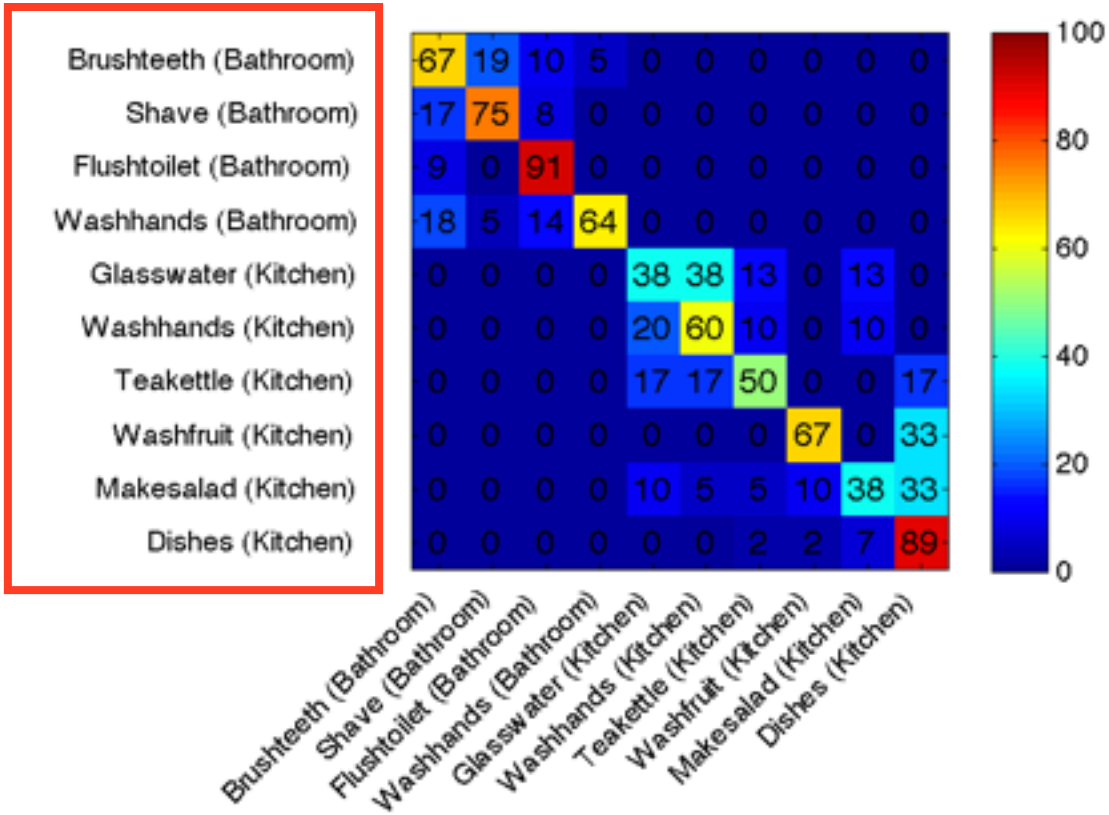
70.11%

Overall Accuracy

(253 Samples, 1 Example)

(LOOCV)

User Study :: Results



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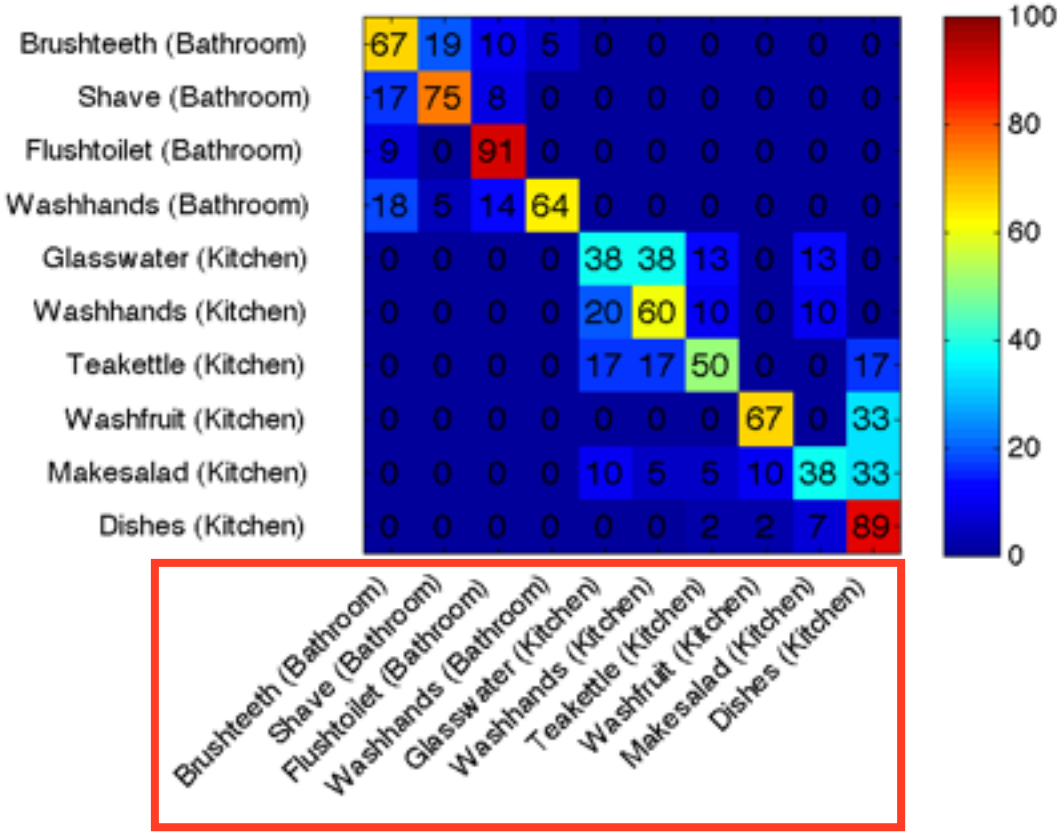
User Study :: Results



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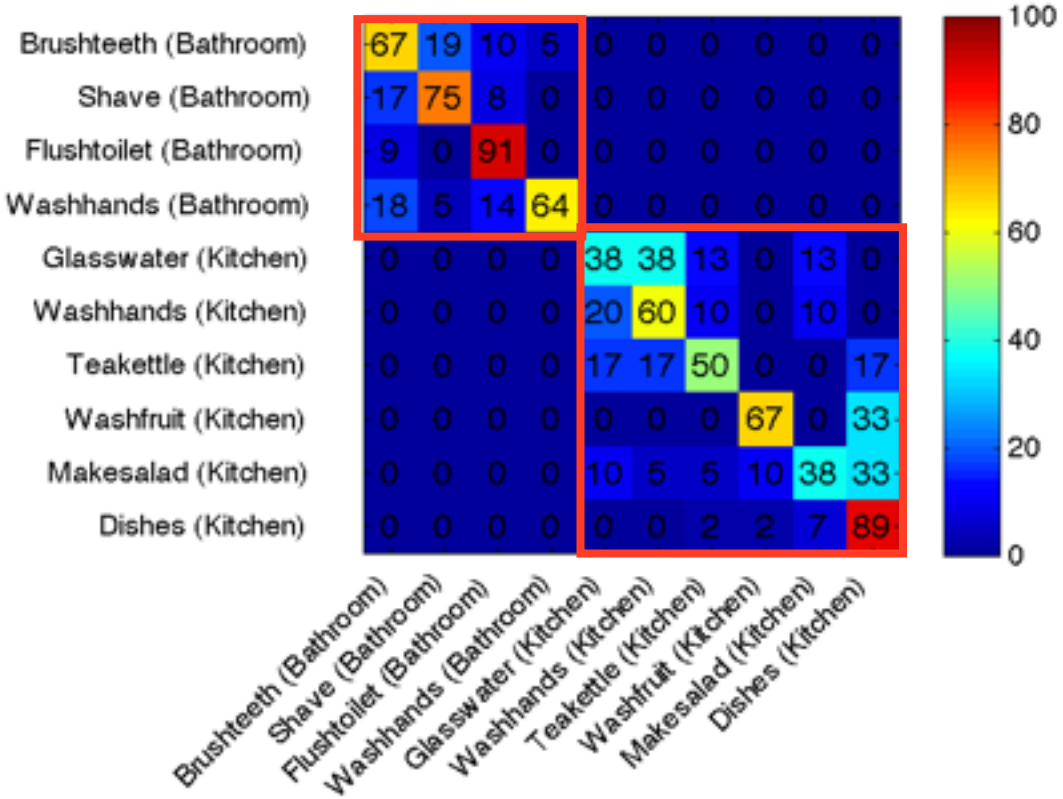
User Study :: Results



70.11%

Overall Accuracy

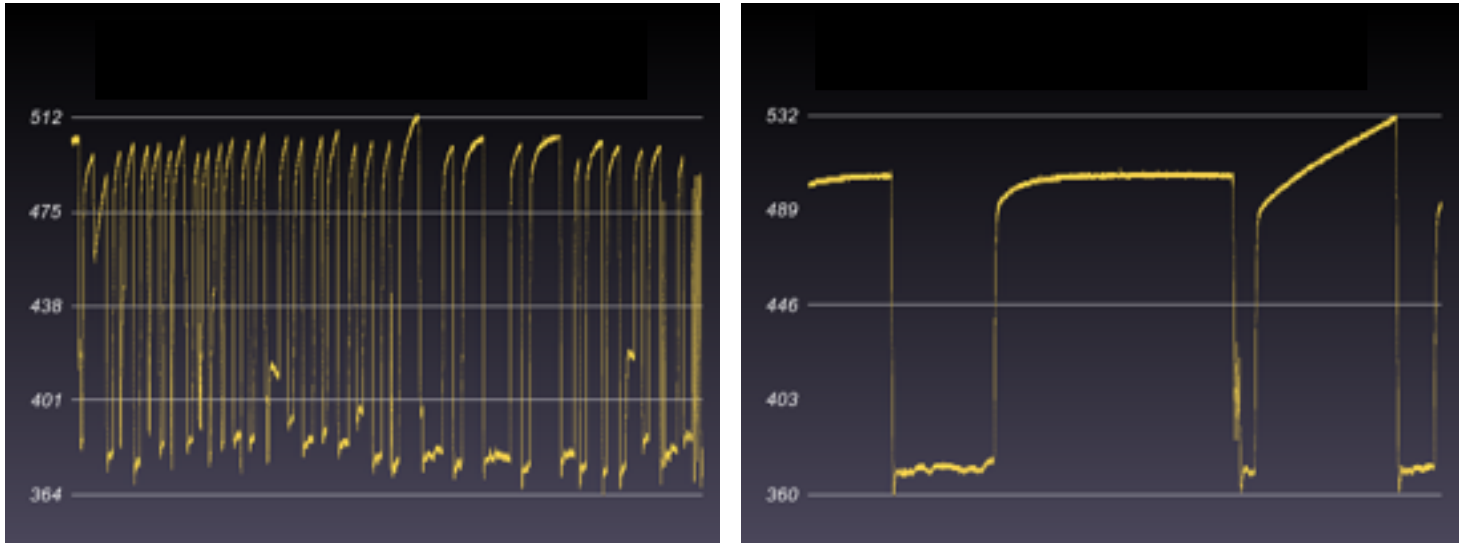
(253 Samples, 1 Example)

(LOOCV)

User Study :: Results

Can we do better?

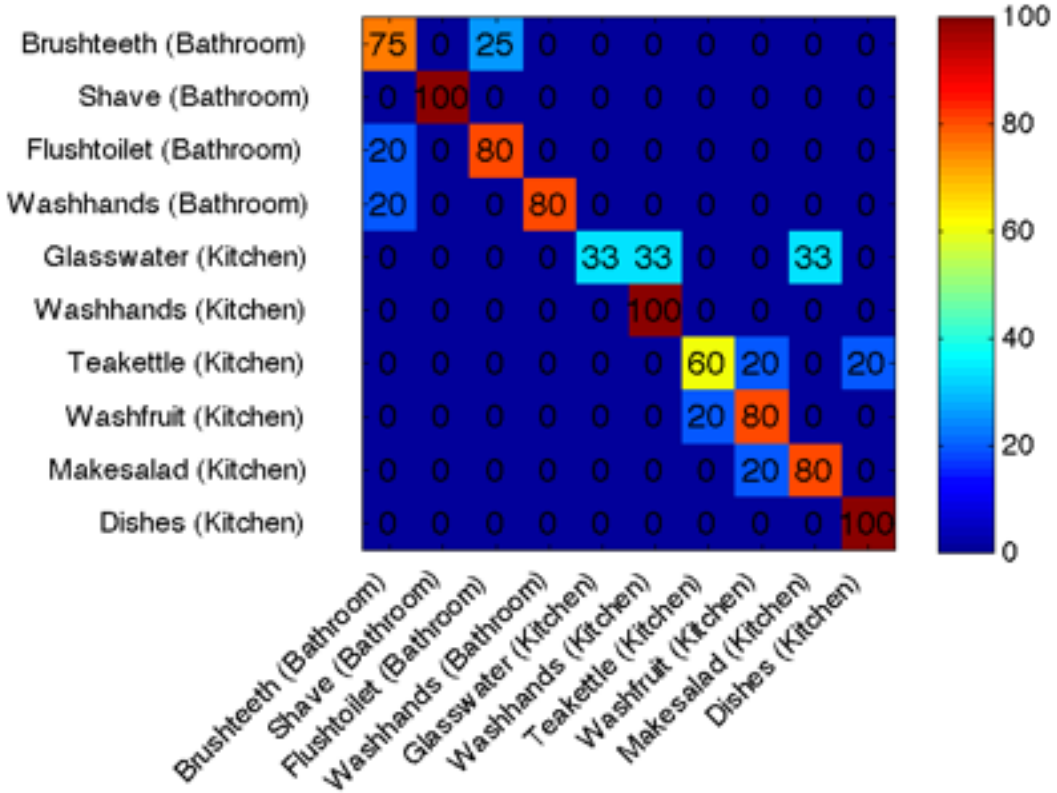
User Study :: Challenges



High Variability

Individuals carry out tasks differently

User Study :: Results (1 participant)



82.69%

Overall Accuracy

(54 Samples, 5 Examples)

(LOOCV)

Discussion & Insights

Infrastructure challenges

Could not leverage differentiation between hot/cold water sensors

Scripted scenario

Facilitated collection of ground truth data

Health applications

Good for holistic, entire-home monitoring

Future Work

Future Work

Aware Home

Real Home

Future Work

Ground truth

Label examples of human activities in a real world setting

Extend IMS to other home types

Multi-family homes, apartments

Compound water-events

Parallel events occur frequently

Contribution

A water-based, single-point IMS jointly with a VSM learning approach can be successfully used for high-level activity recognition in a home setting

Building a Bridge...

Questions

Comments