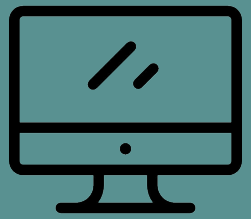
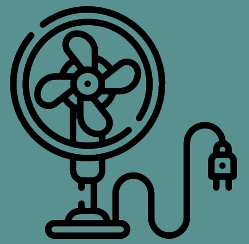
# MotionSync: Personal Energy Analytics through Motion Tags and Wearable Sensing

Josiah Jee, Aveek K. Das, Parth H. Pathak, and Prasant Mohapatra
**Presented by: Peter Wei**

# The Problem

# Energy Apportionment





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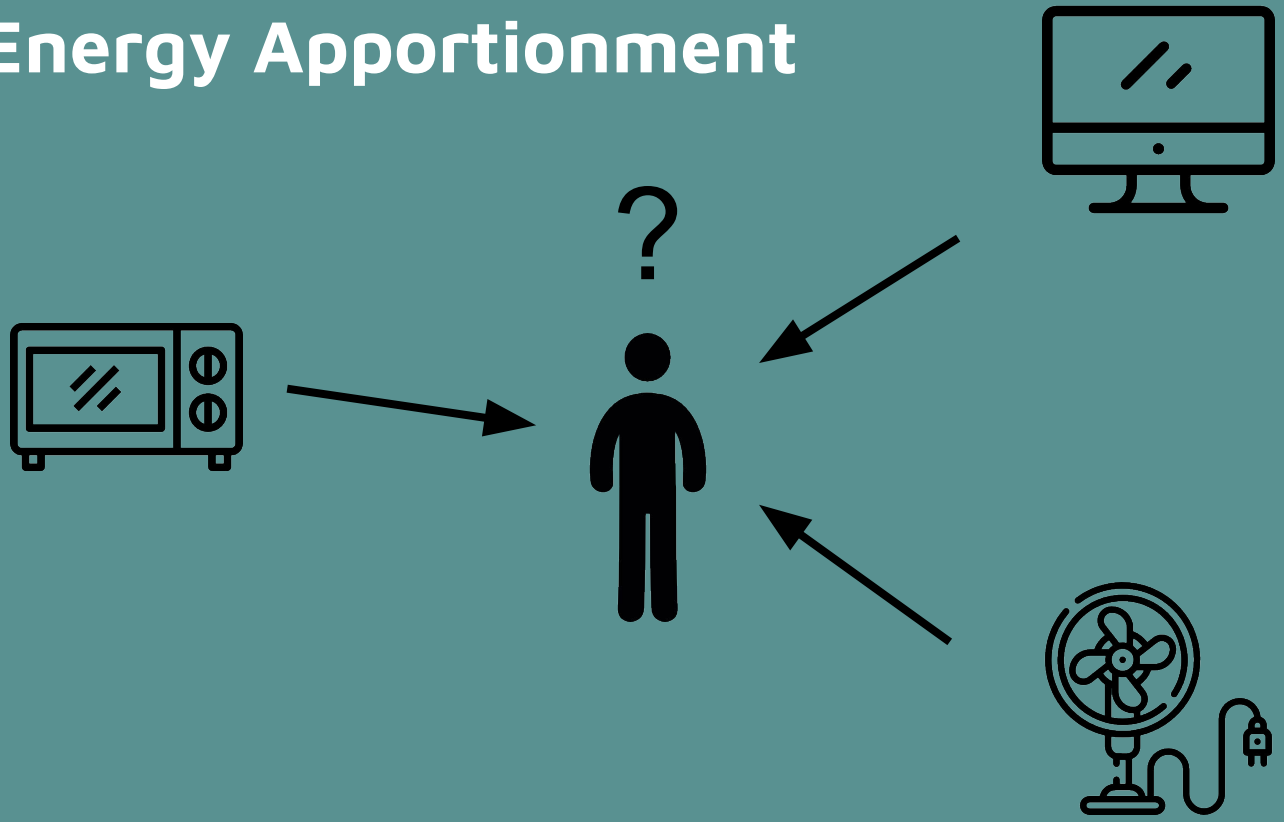

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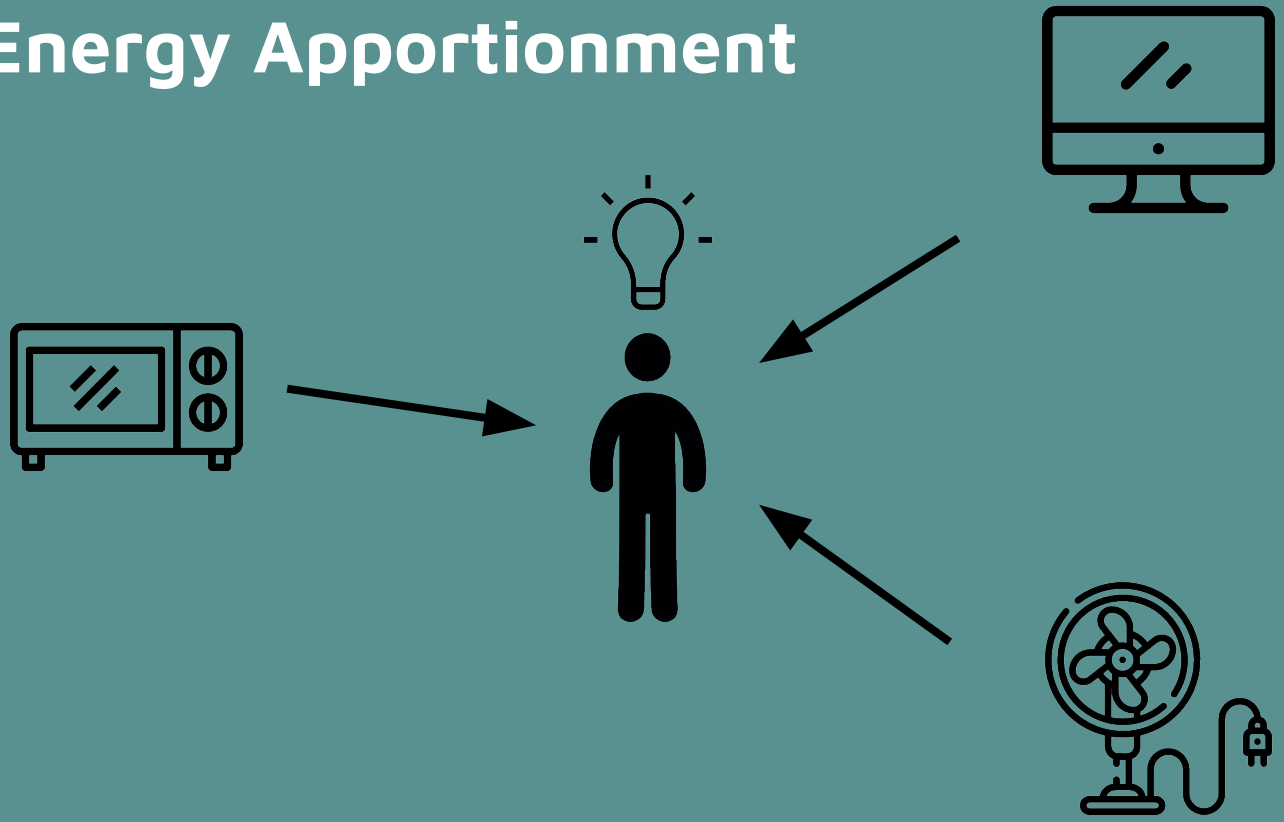
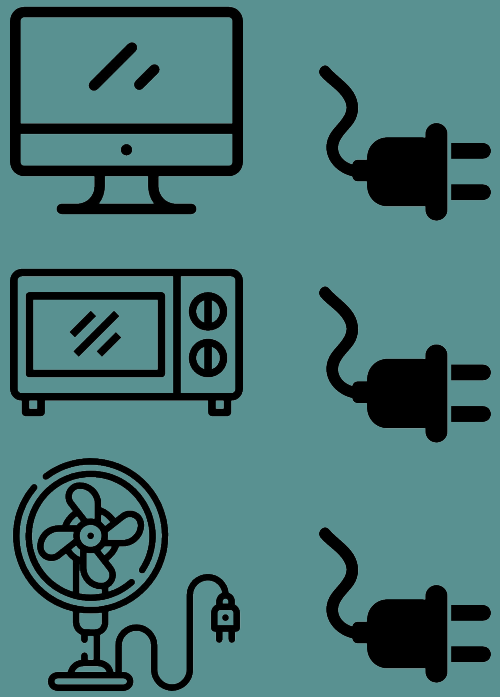


# Related Work

# Foundation: Appliance Load Monitoring ILM



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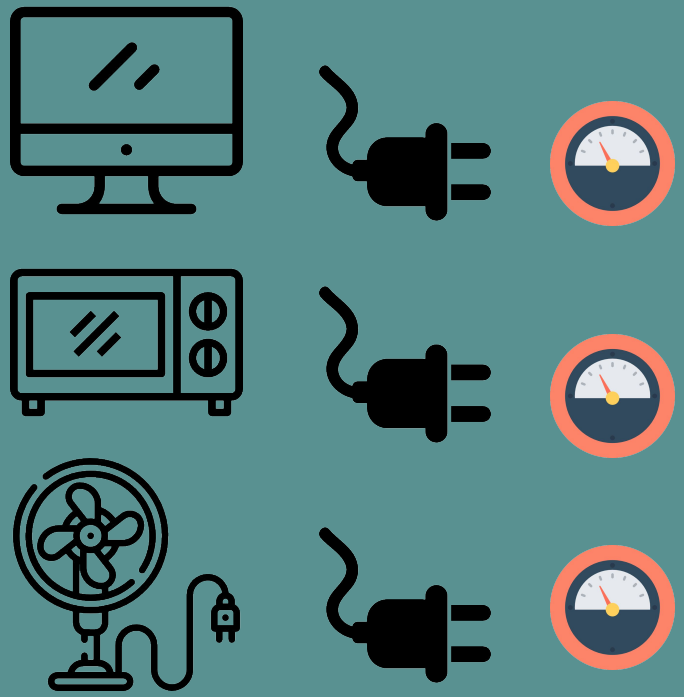
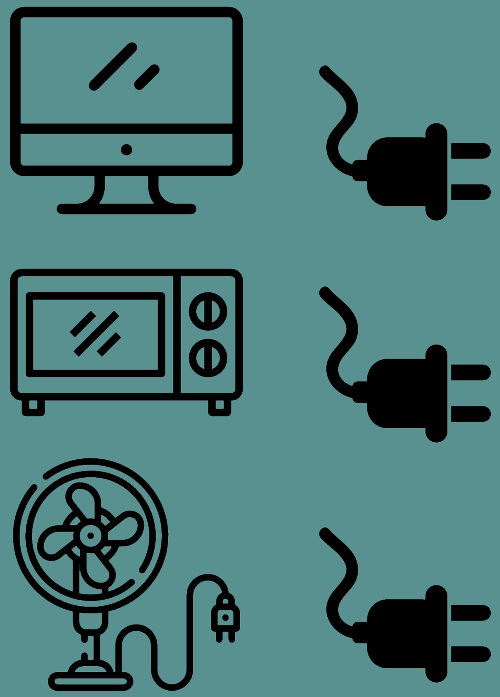


Example

# Foundation: Appliance Load Monitoring NILM



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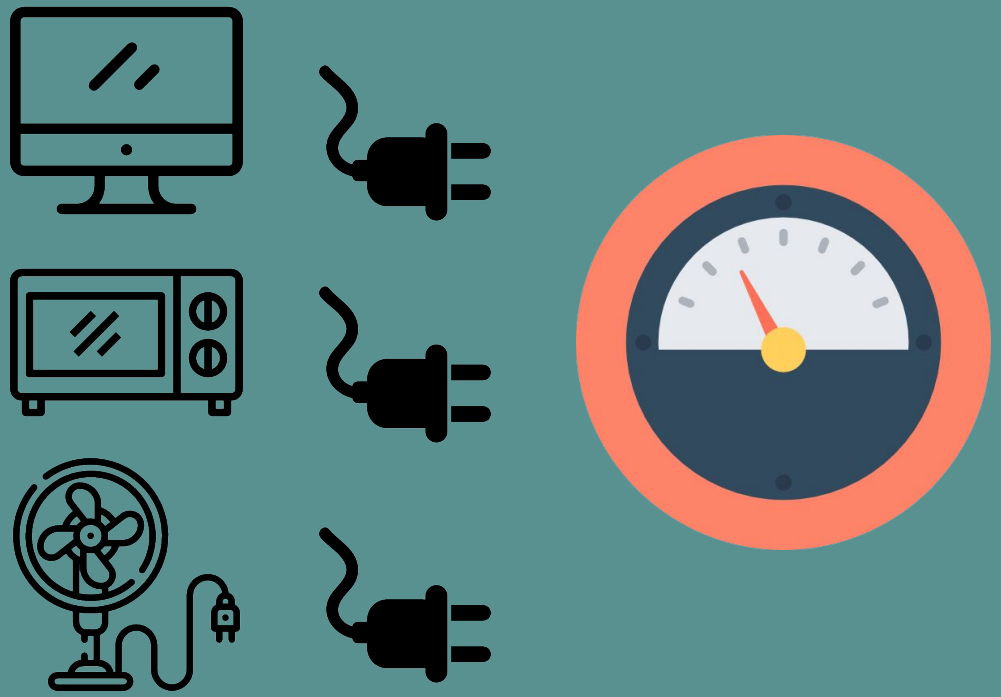
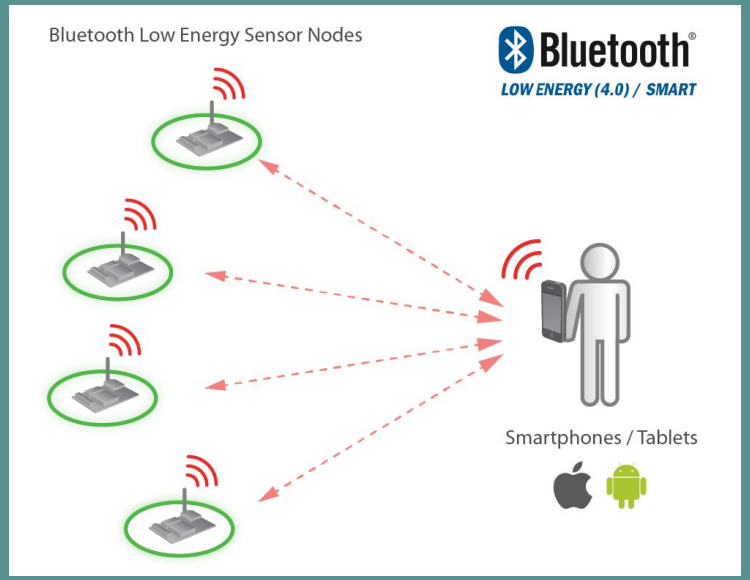
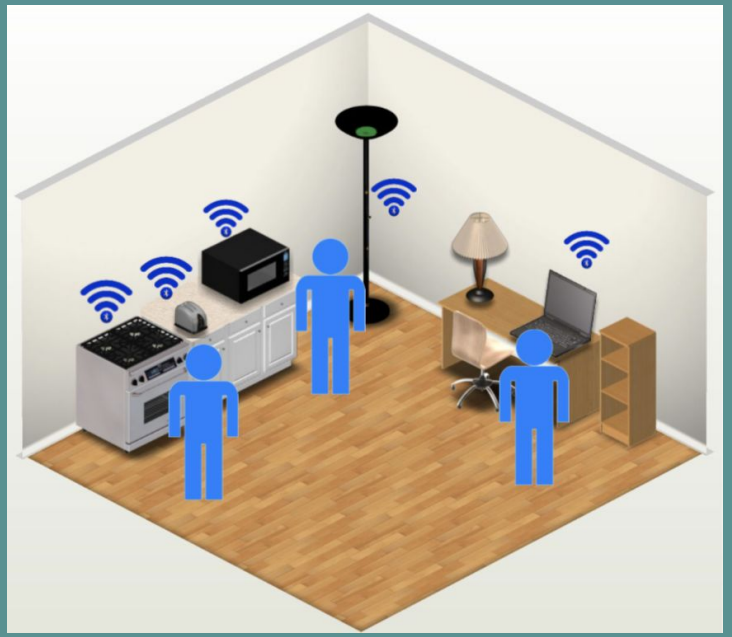
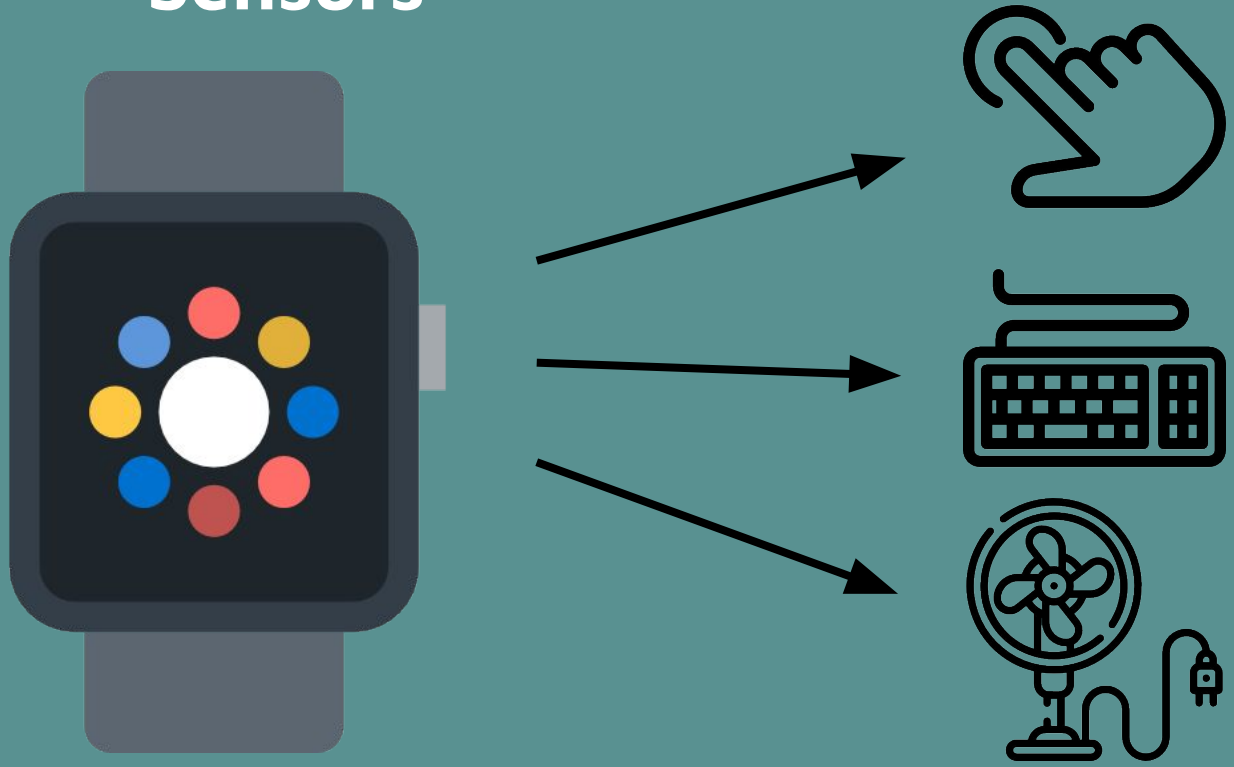


# Foundation: Appliance Association



# Foundation: Wrist-Worn Motion Sensors



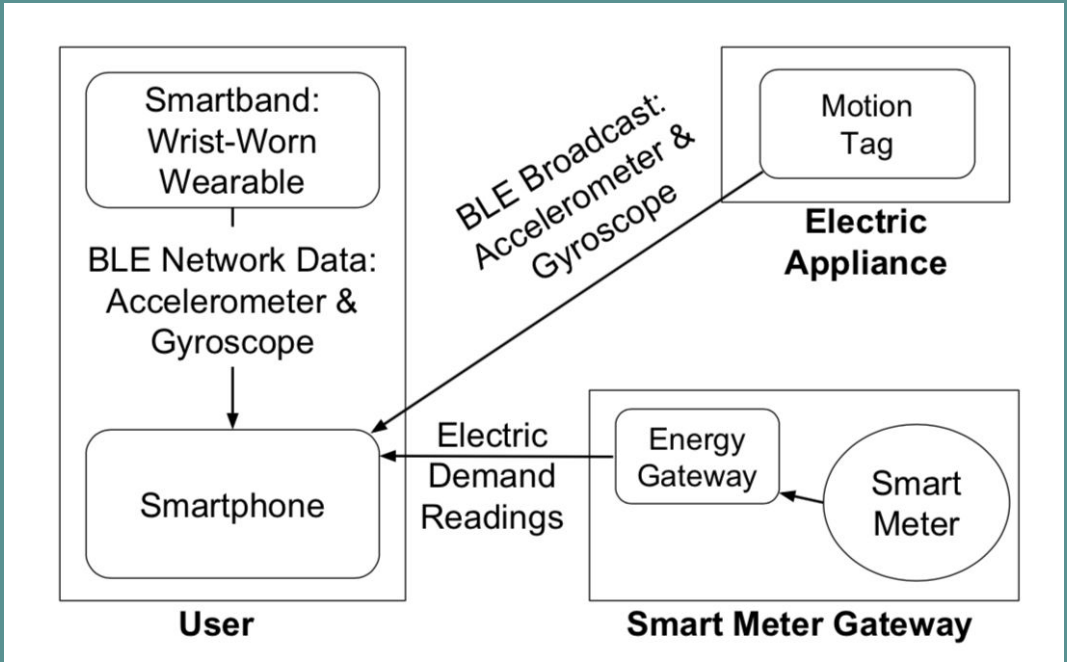
# Approach/Design

# Design Goals: Training

# Design Goals: Privacy (Location)

# Design Goals: Multiple Users

# System Concept

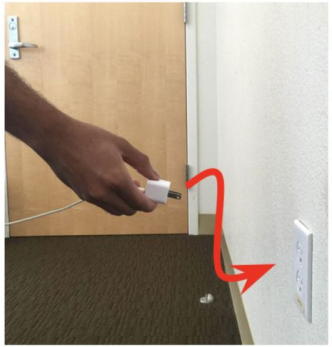


# Implementation

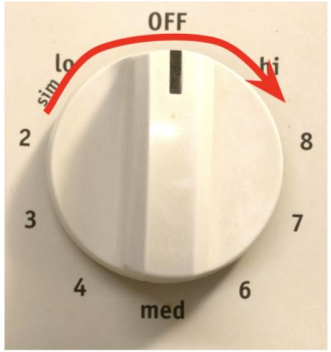
# Implementation

Button

Door



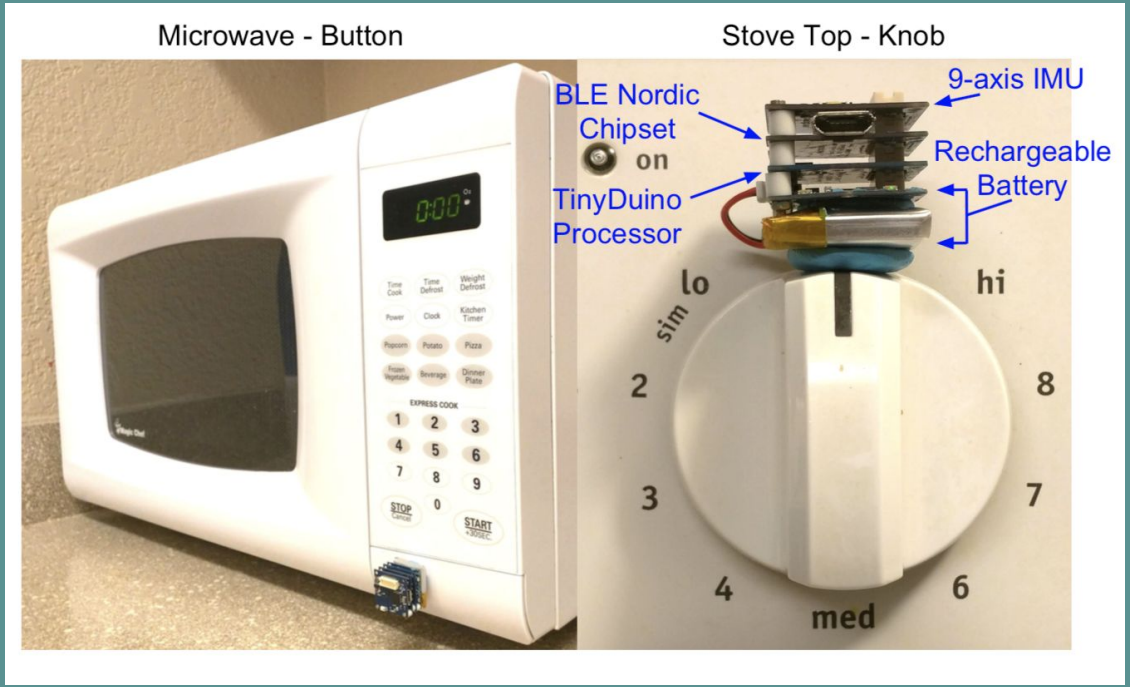
Free Floating



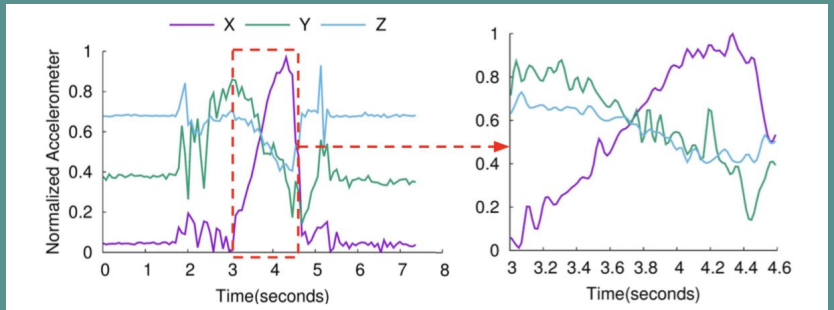

Knob

Switch

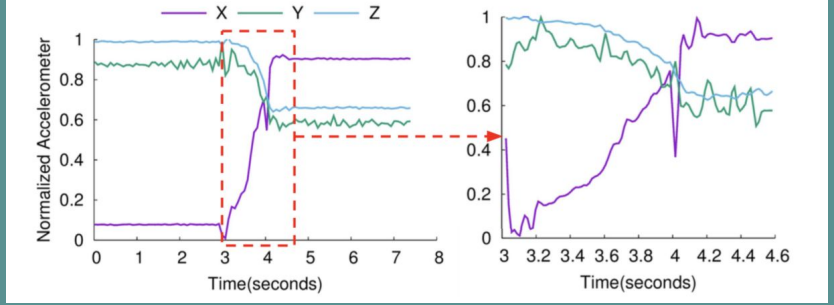
# Motion Tag


Microwave - Button
Stove Top - Knob
BLE Nordic
Chipset
on
TinyDuino
Processor
9-axis IMU
Rechargeable
Battery
lo
hi
sim
2
8
3
7
4
6
med

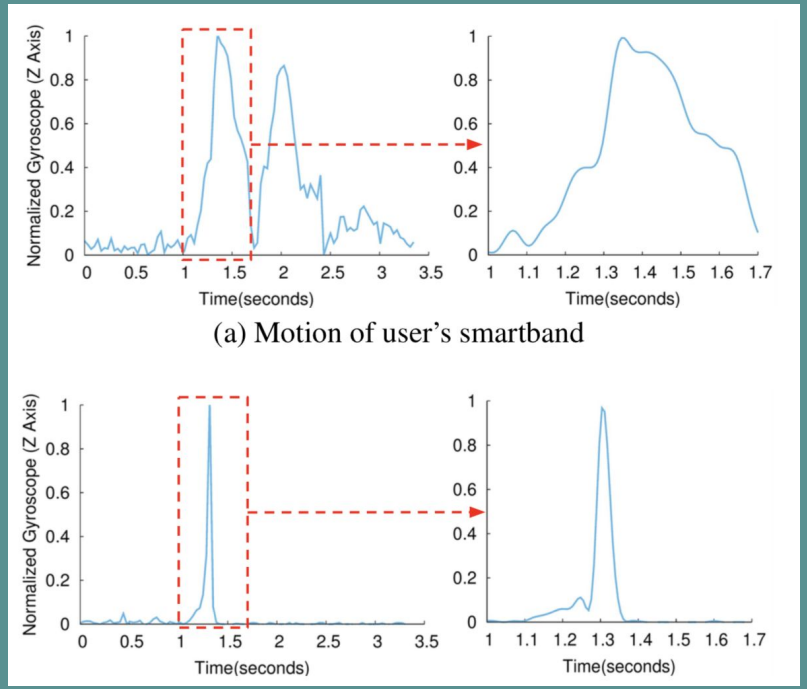
# Example




(a) User smartband motion

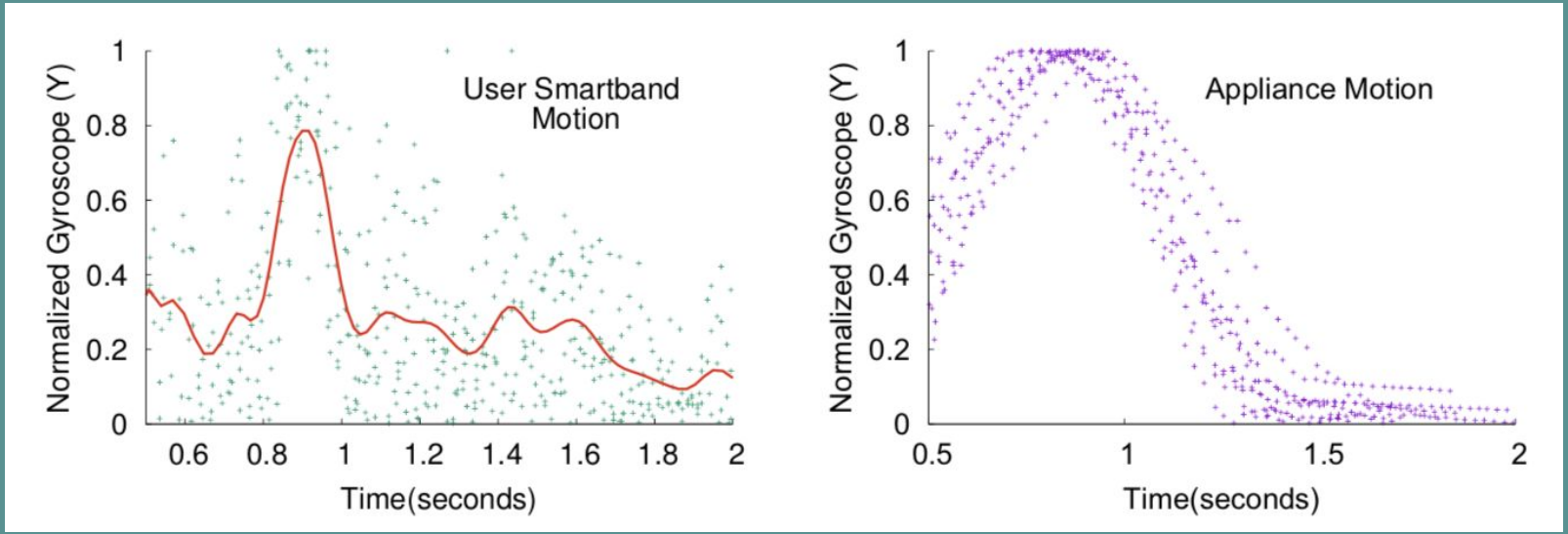


# Example

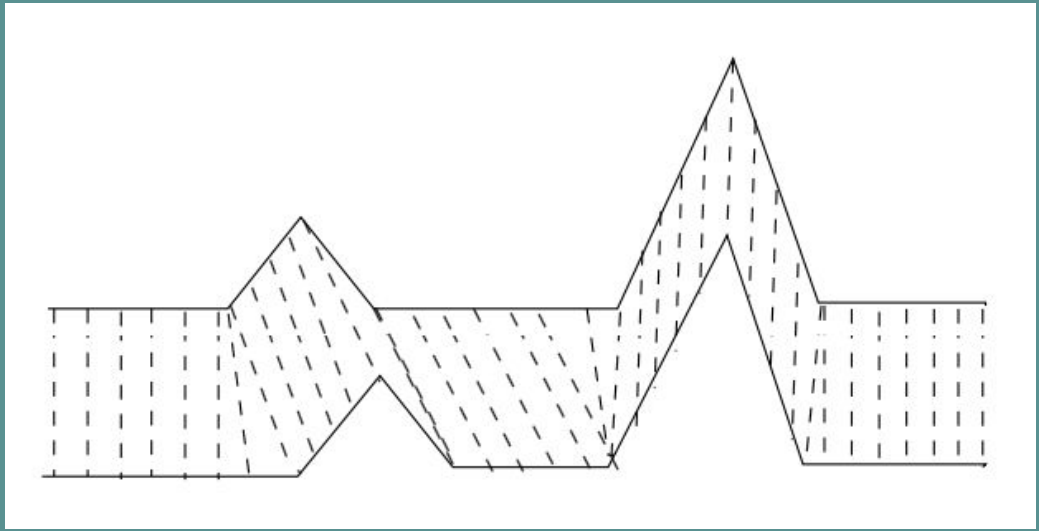


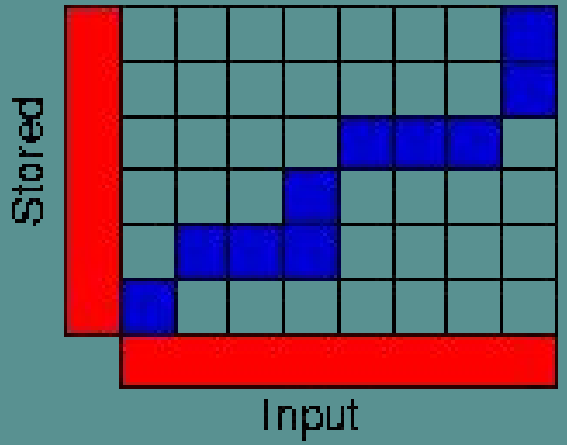

(a) Motion of user's smartband

# Example


User Smartband Motion
Normalized Gyroscope (Y)
Time(seconds)
0
0.2
0.4
0.6
0.8
1
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Appliance Motion
Normalized Gyroscope (Y)
Time(seconds)
0
0.2
0.4
0.6
0.8
1
0.5
1
1.5
2

# Dynamic Time Warping





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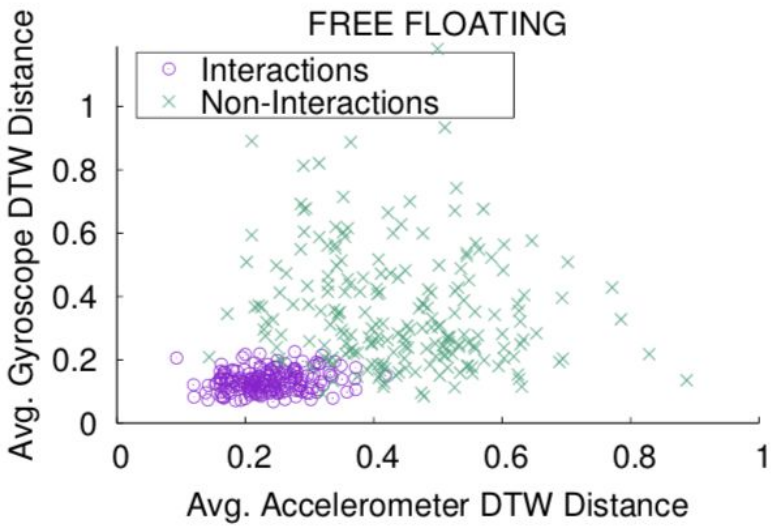
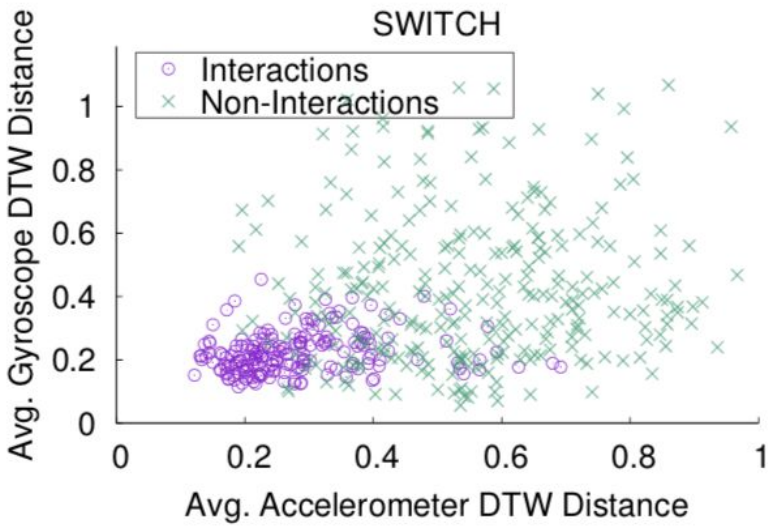



(a) Free-Floating




(b) Switch

# Logistic Regression

DTW- Accelerometer X

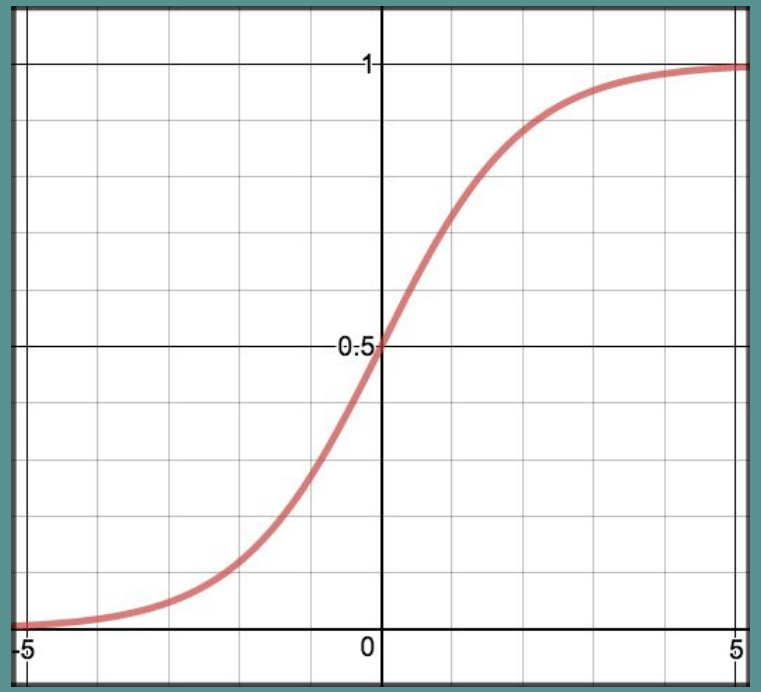
DTW- Accelerometer Y

DTW- Accelerometer Z

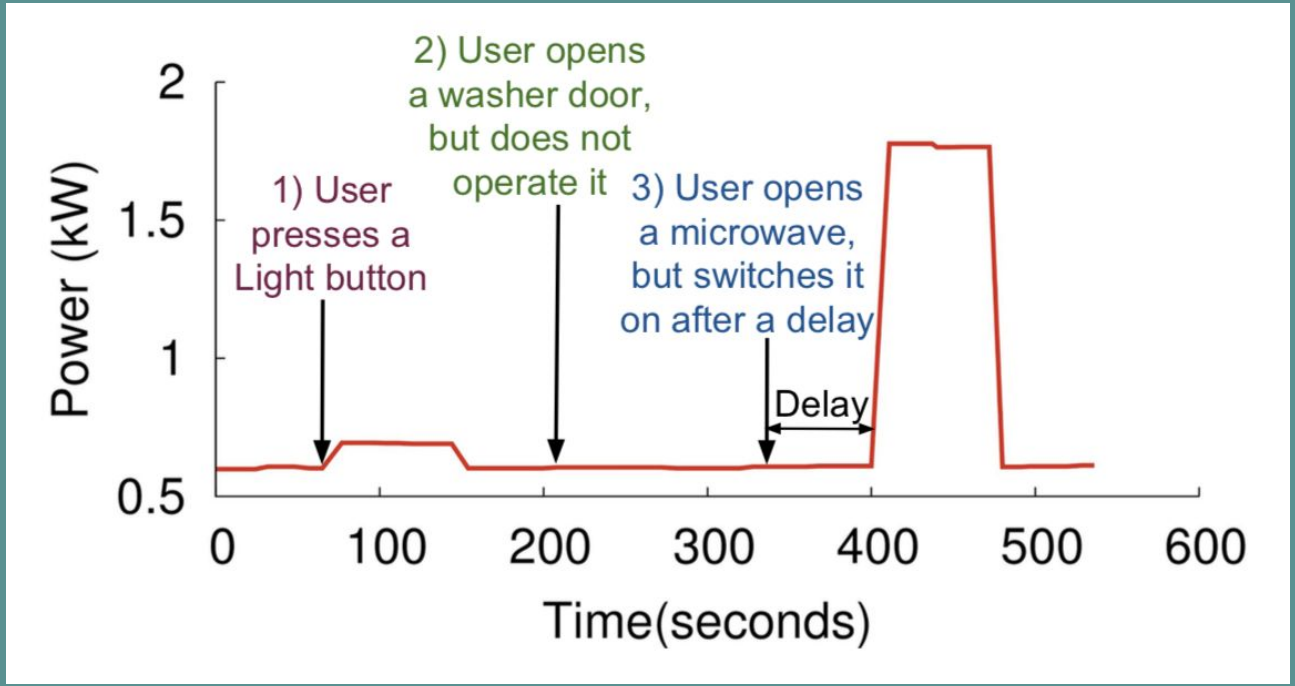
DTW- Gyroscope X

DTW- Gyroscope Y

DTW- Gyroscope Z



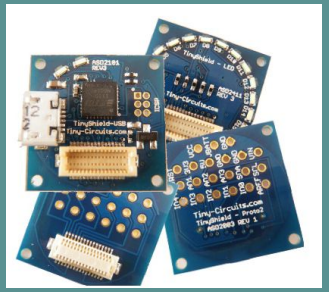
# Smart Meter Integration



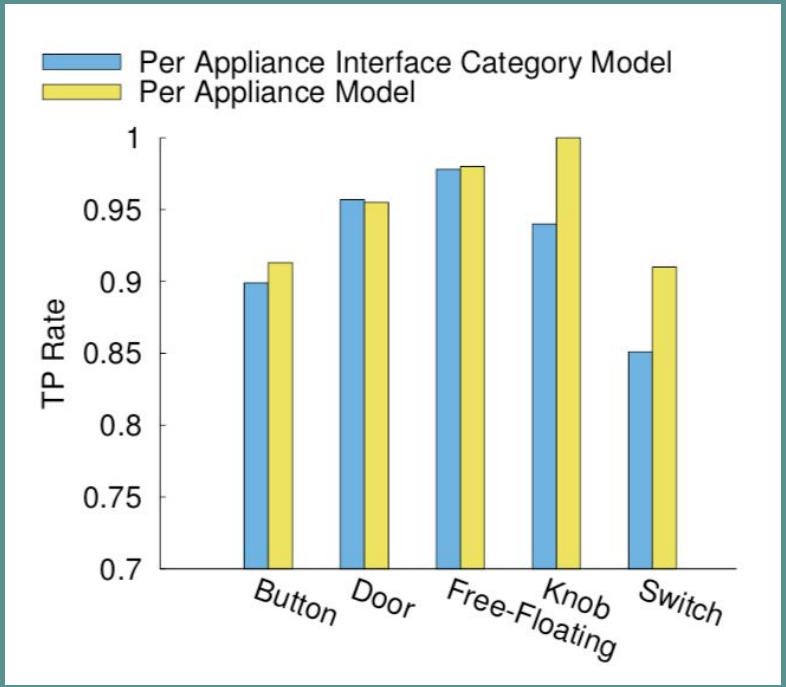
# Experiments/Results

# Experimental Setup

- Tag: TinyDuino
- Wearable: Google Nexus 5
- Bluetooth Sniffer: ComProbe BPA 600
- Laptop running MotionSync
- 4 appliances for each appliance type
- 3 users

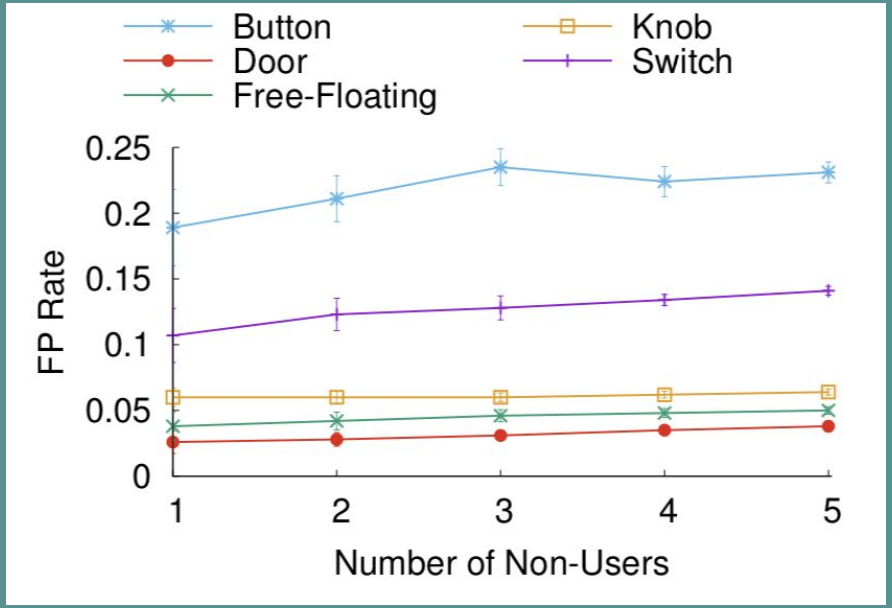


# System Accuracy



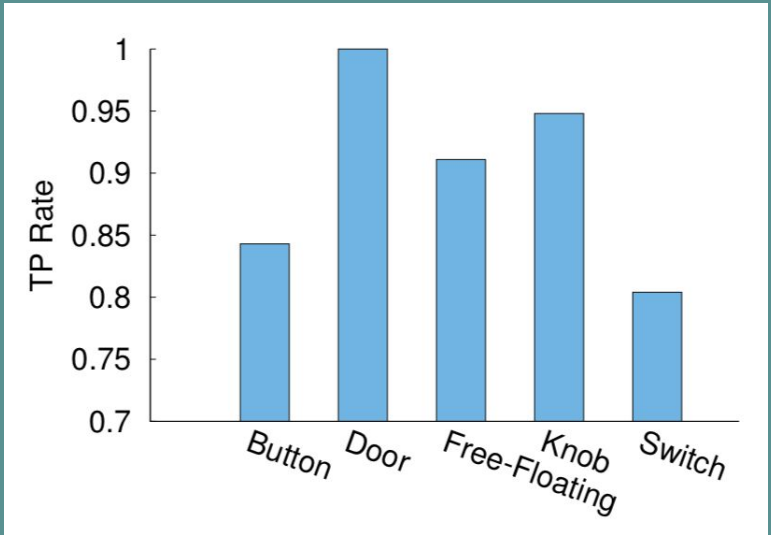

| Interface Class | Appliance | TP Rate | FP Rate |
|---|---|---|---|
| **Button** | Light Button | 0.873 | 0.190 |
| | Microwave | 0.842 | 0.088 |
| | Coffee Maker | 0.914 | 0.190 |
| | Desktop | 0.897 | 0.034 |
| | Fan Button | 0.968 | 0.190 |
| **Door** | Oven 1 | 0.931 | 0.026 |
| | Oven 2 | 1.00 | 0.051 |
| | Washer | 0.968 | 0.051 |
| | Dryer | 0.933 | 0.00 |
| **Free-Floating** | Phone Charger | 0.966 | 0.026 |
| | Laptop Charger | 0.969 | 0.00 |
| | Remote 1 | 1.00 | 0.051 |
| | Remote 2 | 0.952 | 0.051 |
| | Hair Dryer | 1.00 | 0.00 |
| | Hair Dryer 2 | 0.900 | 0.00 |
| **Knob** | Espresso Maker | 1.00 | 0.050 |
| | Stove Top 1 | 0.981 | 0.110 |
| | Stove Top 2 | 0.900 | 0.017 |
| | Toaster Oven | 0.948 | 0.052 |
| **Switch** | Toaster 1 | 1.00 | 0.067 |
| | Toaster 2 | 1.00 | 0.00 |
| | Rice Cooker | 1.00 | 0.25 |
| | Light Switch | 0.828 | 0.276 |
| | Water Heater | 1.00 | 0.032 |

# Multiple Users

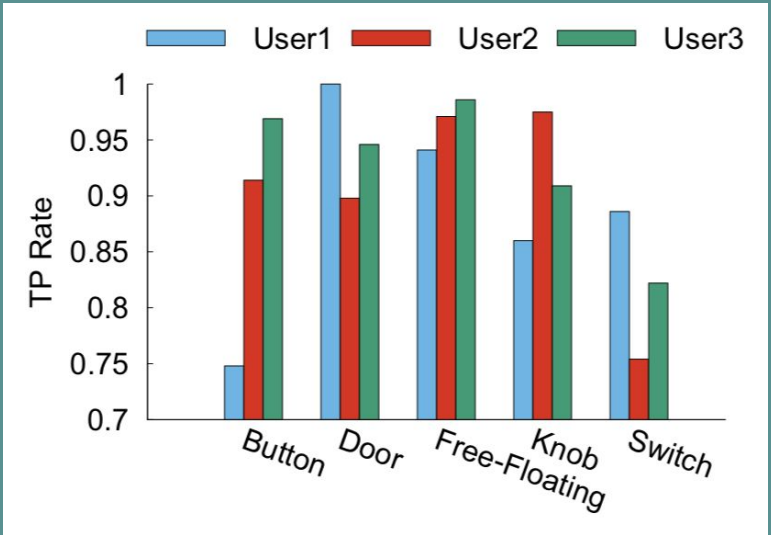


# New Appliances and Users

New Appliances




New Users



# Assessment

# Assessment

- Motion Matching

- Shared Resources
- Limited Experimental Data
- Last User Association