Humantenna

Using the Human Body as an Antenna for Real-Time Whole-Body Interaction

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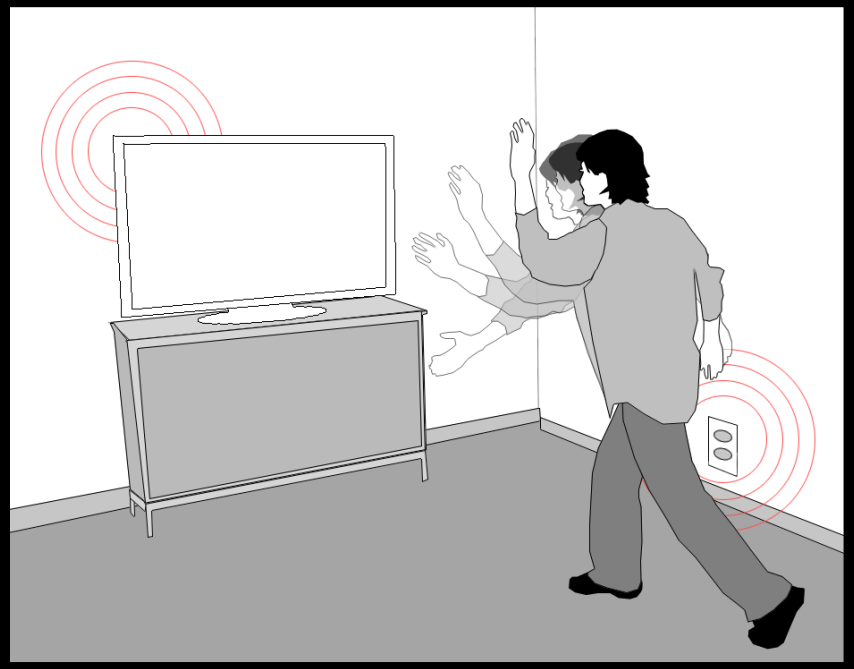


MSR Faculty Summit – July 16, 2012

Microsoft Research

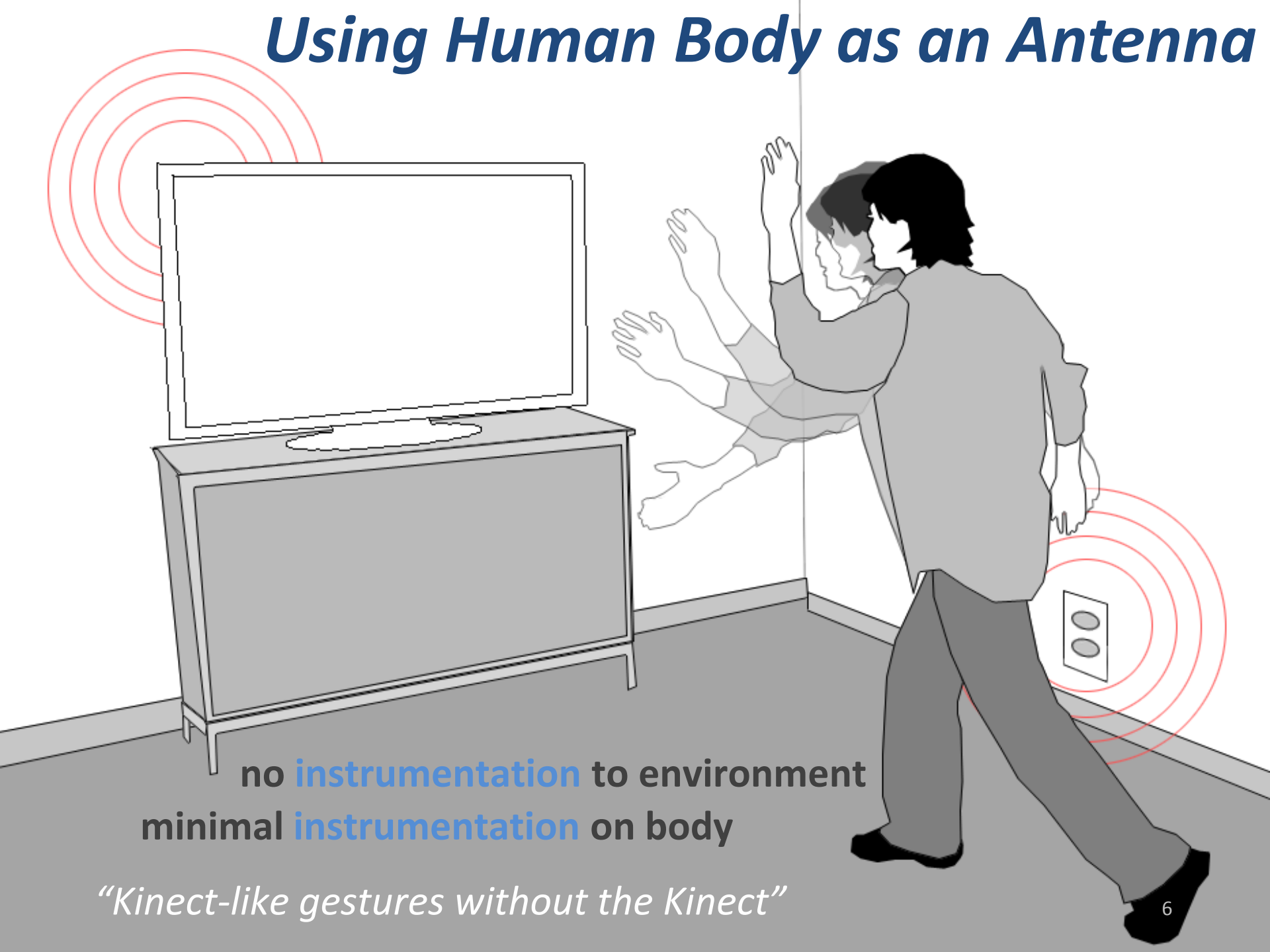
dub design: use: build: university of washington

ubicomp lab university of washington

Computer Vision and Depth Cameras


750
stretch-rite

Using Human Body as an Antenna

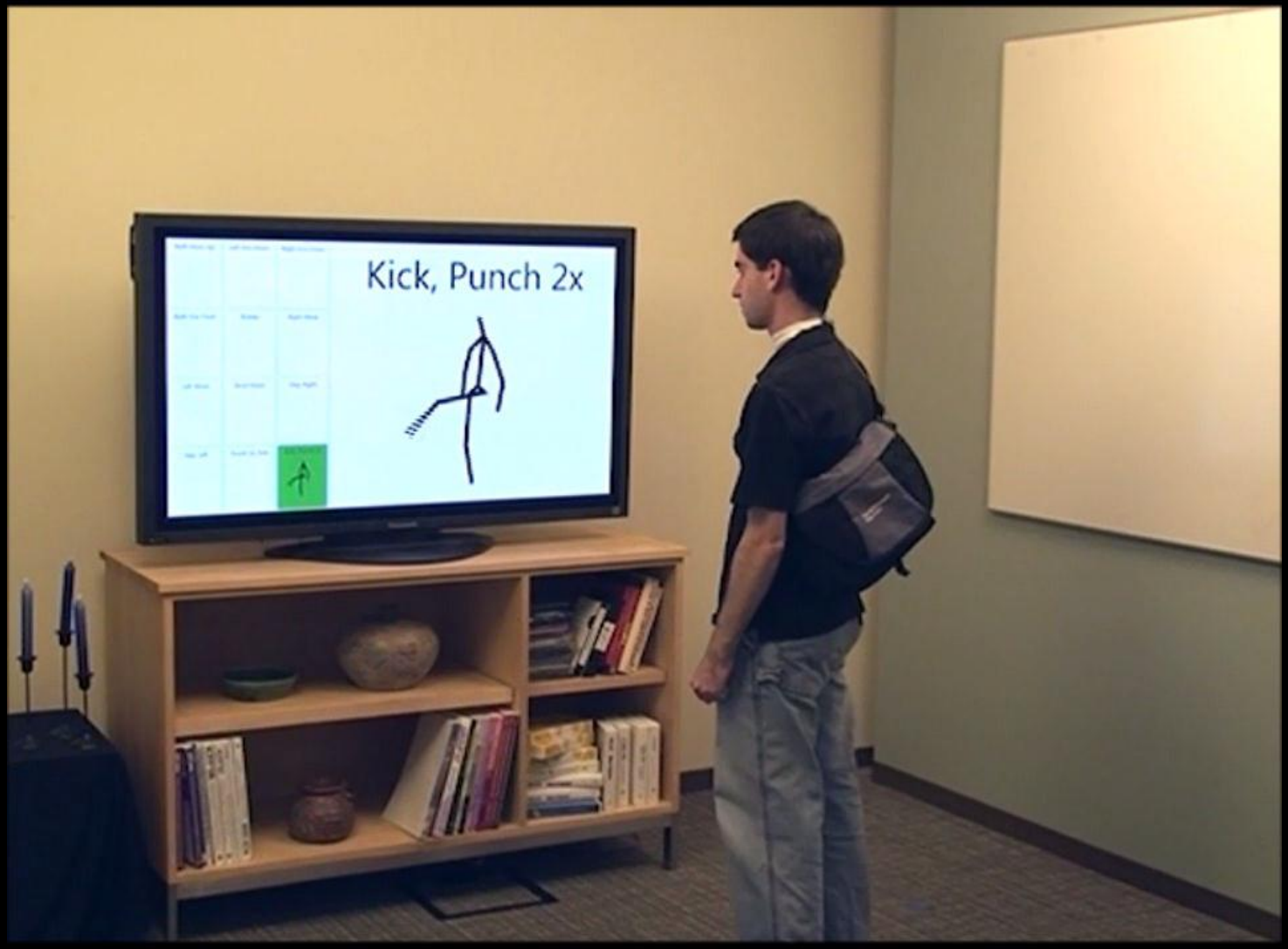


no instrumentation to environment

minimal instrumentation on body

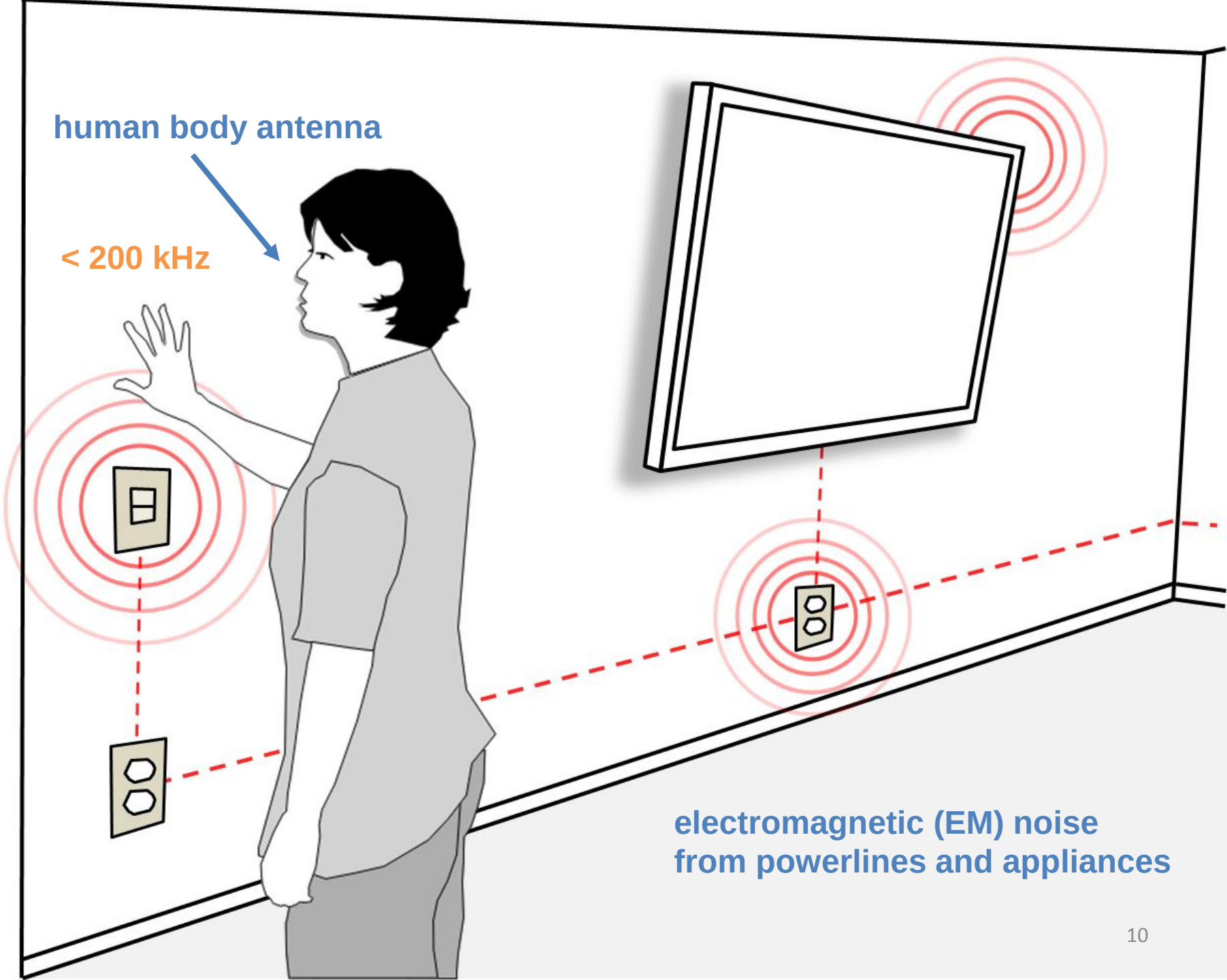
"Kinect-like gestures without the Kinect"

Humantenna

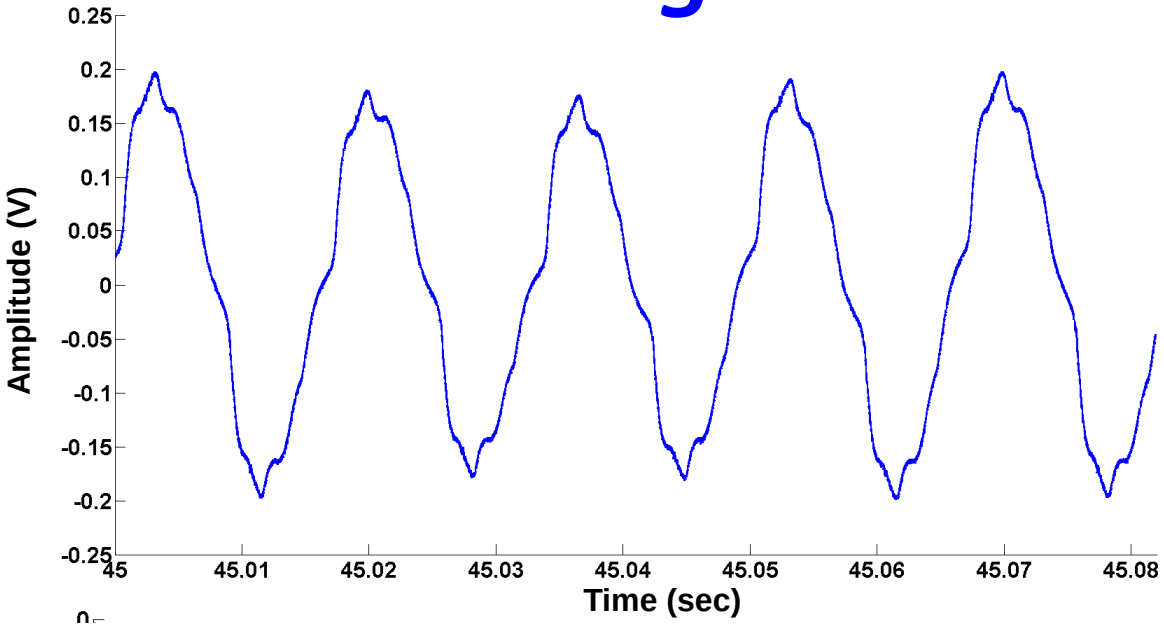


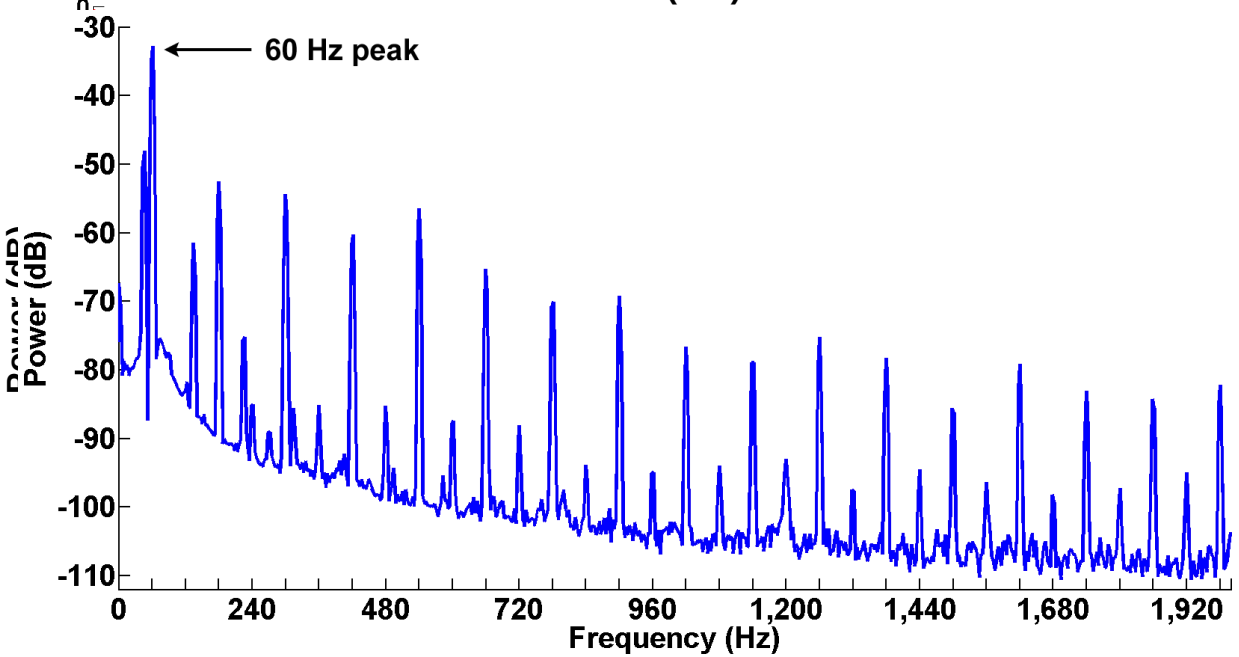

Typical
“bunny ears”
TV antenna


Typical
“teenager”
human antenna
dielectric with
complex geometry
40 Hz – 400 MHz
“body antenna effect”
- body area networks (BAN)
- analyzing electrical activity on body

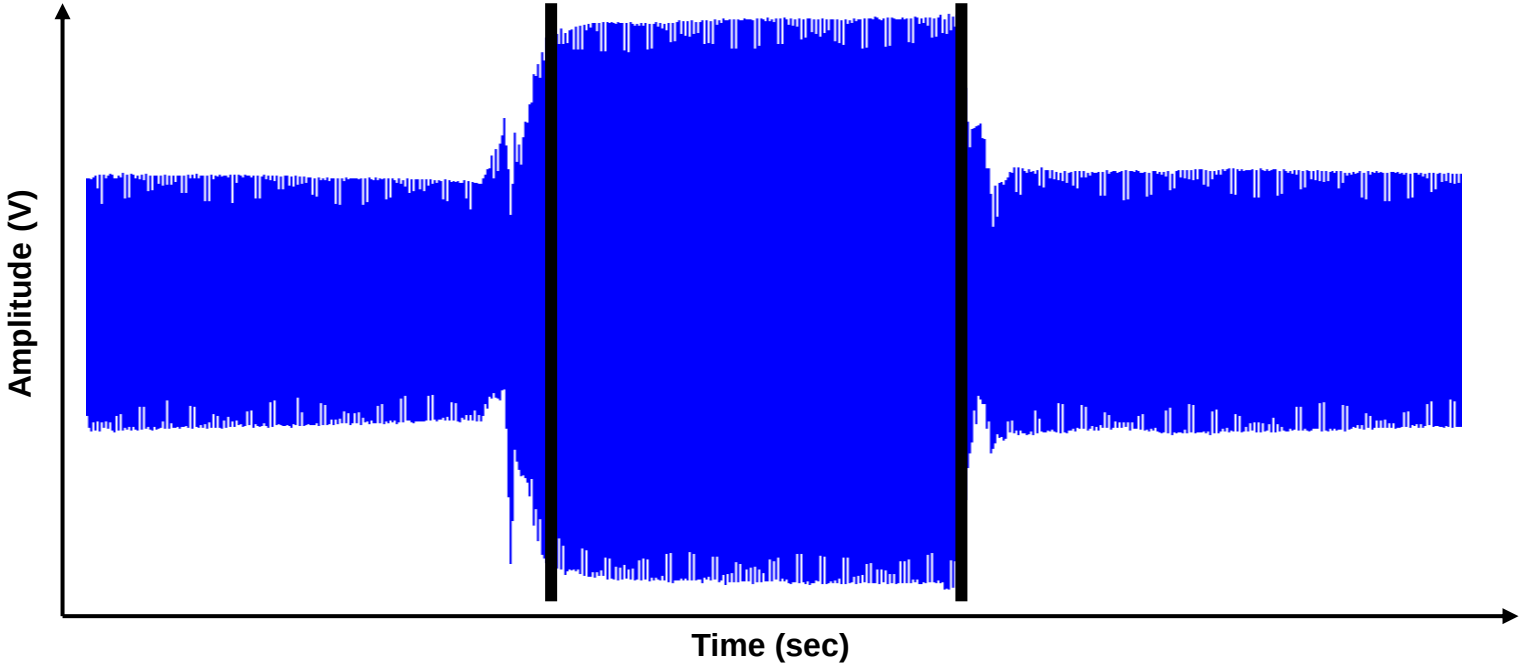

human body antenna
< 200 kHz
electromagnetic (EM) noise
from powerlines and appliances

The Signal

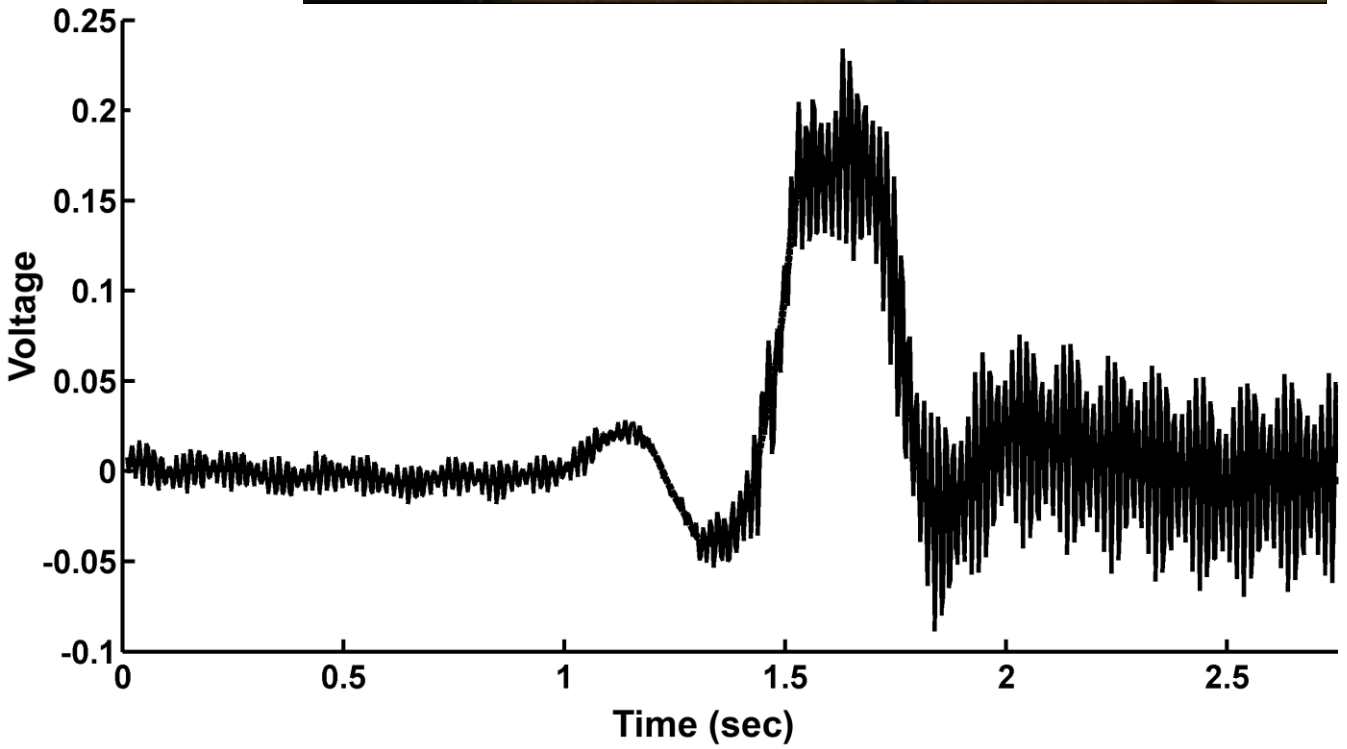

Amplitude (V)
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
45
45.01
45.02
45.03
45.04
45.05
45.06
45.07
45.08
Time (sec)


60 Hz peak
Power (dB)
-30
-40
-50
-60
-70
-80
-90
-100
-110
0
240
480
720
960
1,200
1,440
1,680
1,920
Frequency (Hz)

Wall Touch

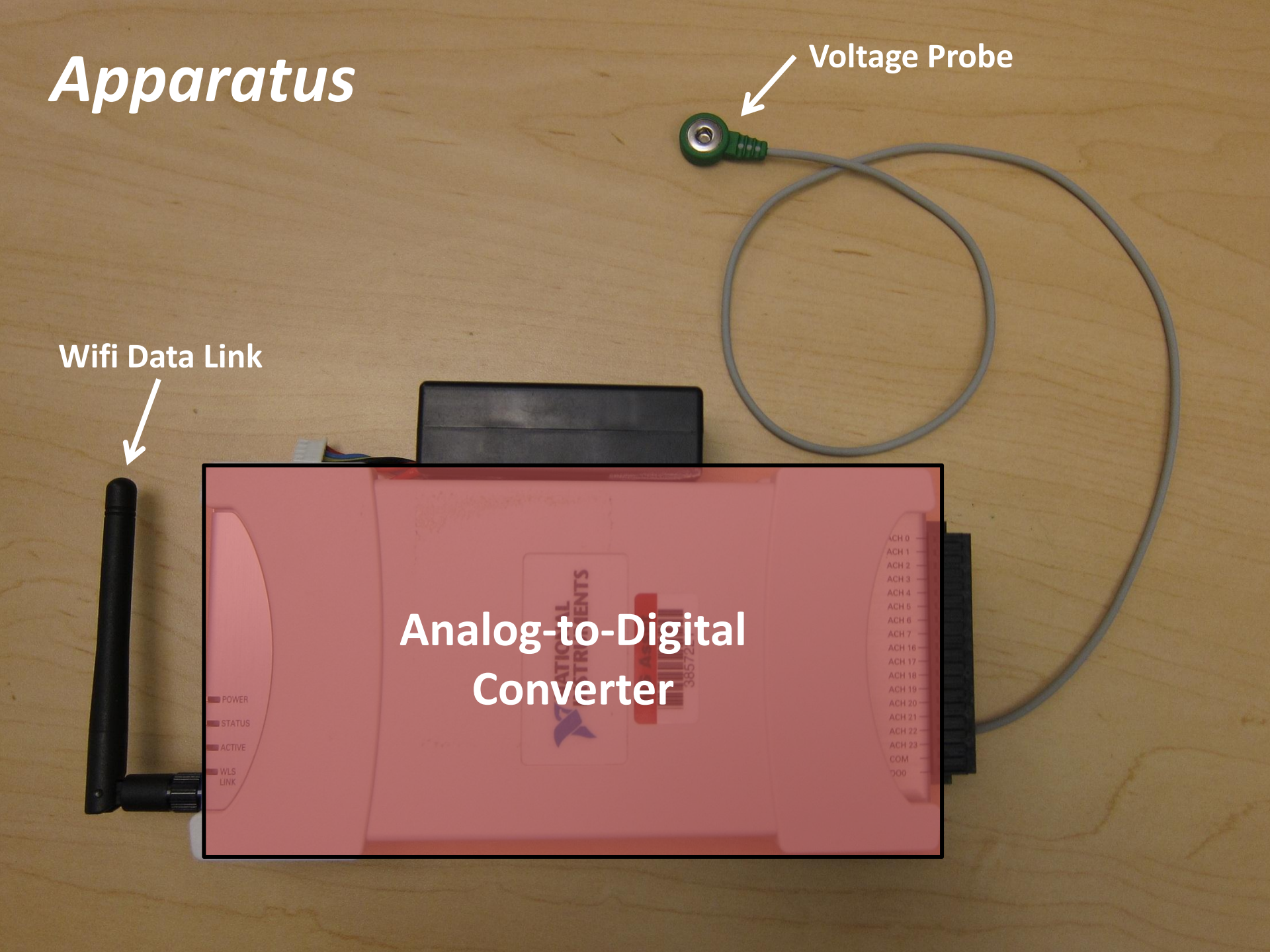


User Motion



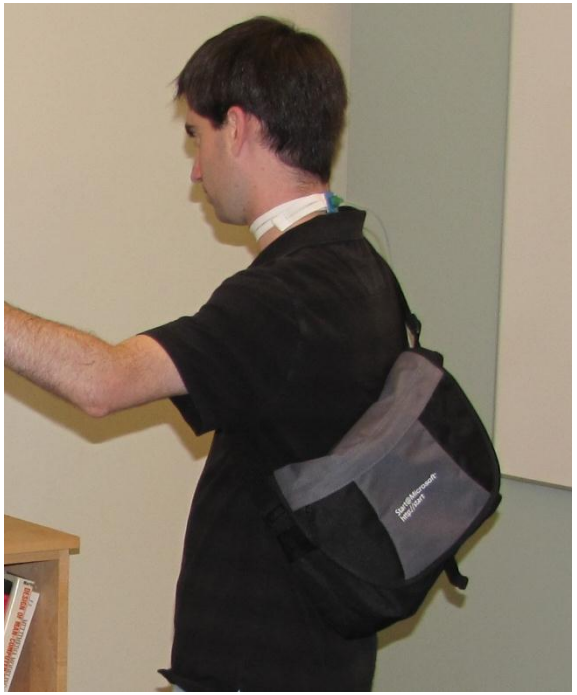
Is this signal useful?

Apparatus

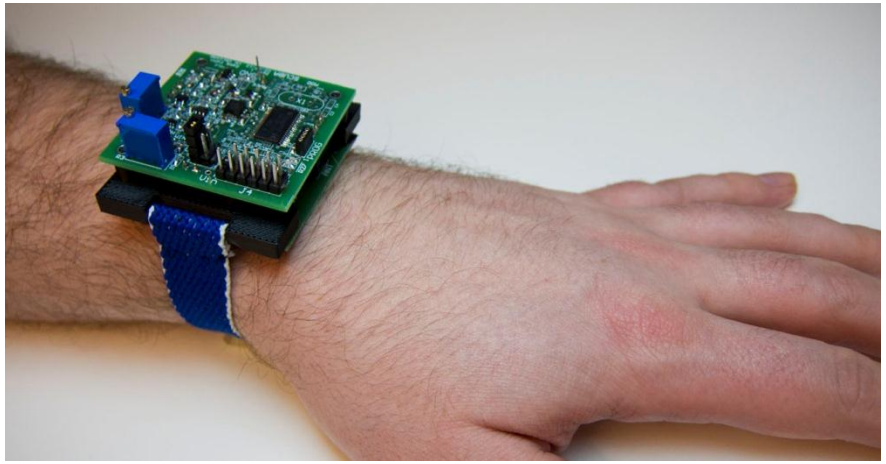

Voltage Probe
Wifi Data Link
Analog-to-Digital Converter
POWER
STATUS
ACTIVE
WLS LINK
ACH 0
ACH 1
ACH 2
ACH 3
ACH 4
ACH 5
ACH 6
ACH 7
ACH 16
ACH 17
ACH 18
ACH 19
ACH 20
ACH 21
ACH 22
ACH 23
COM

Apparatus

CHI 2011



CHI 2012



Ubicomp 2012

In-Home Data Collection

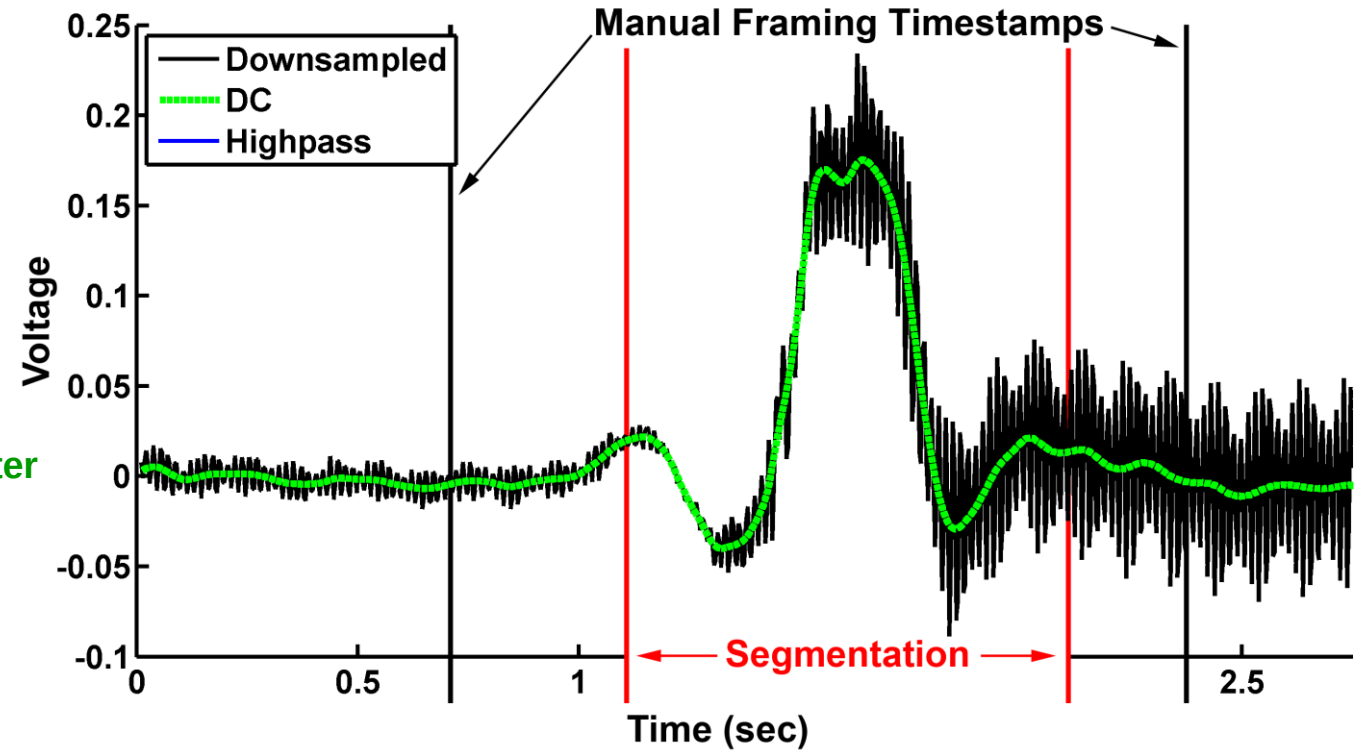
Analysis

1. segmentation
2. feature extraction
3. classification

Analysis

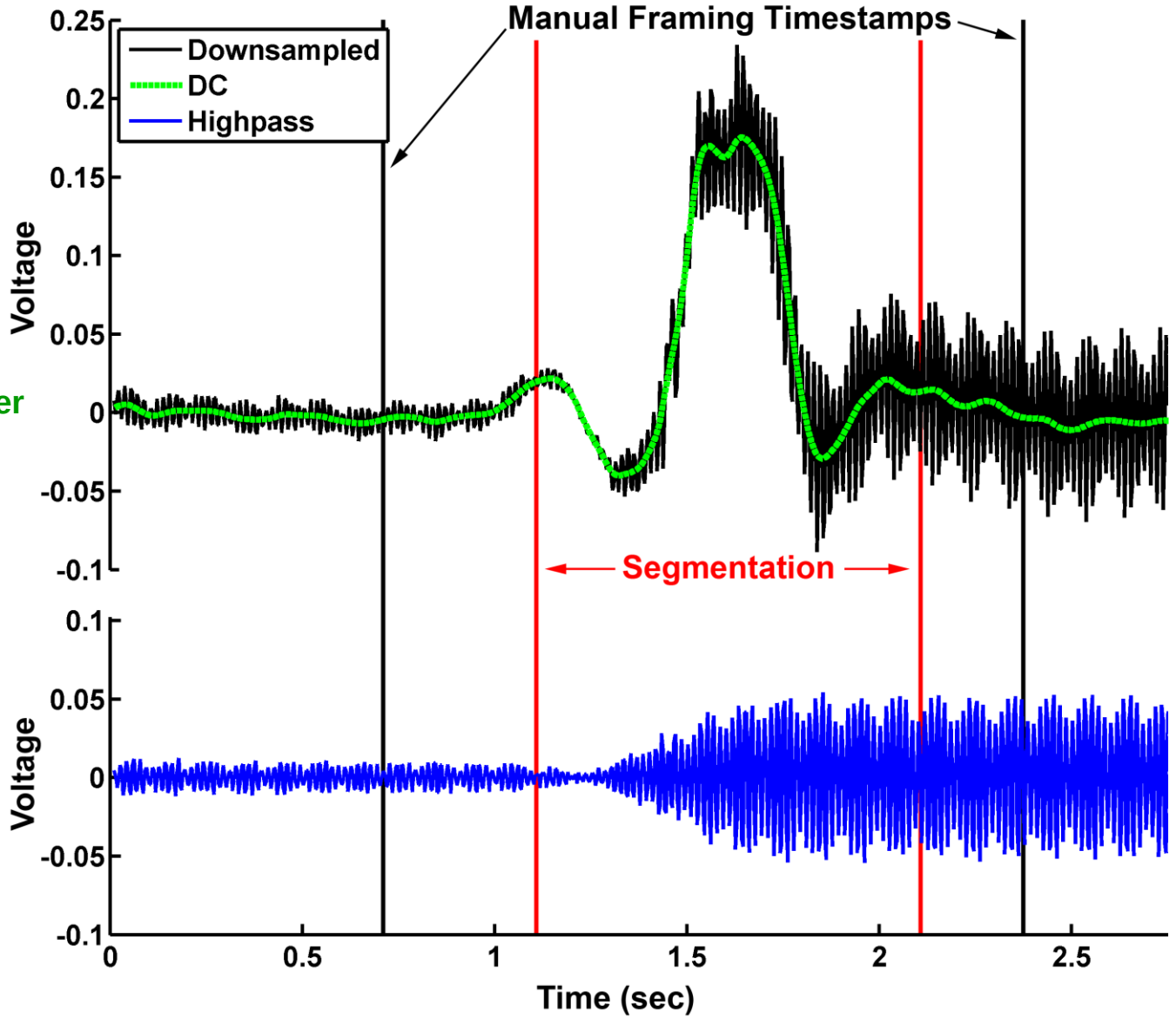
Segmentation

Lowpass Filter at 10 Hz



Analysis

Feature Extraction



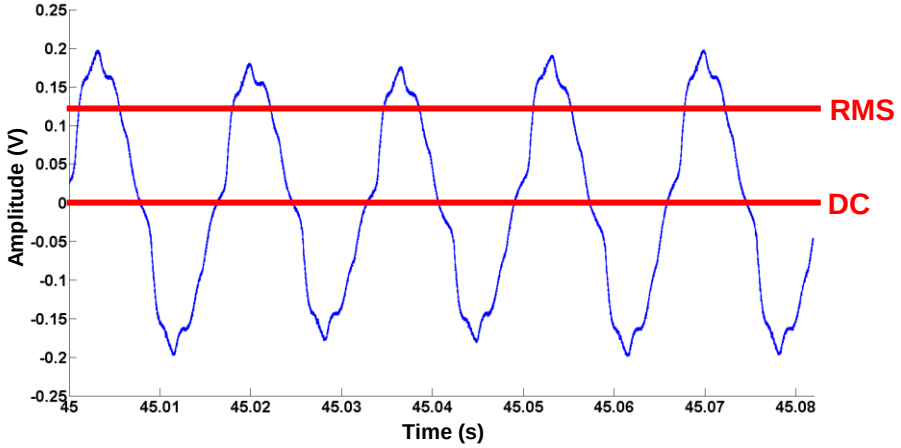
Lowpass Filter at 10 Hz

Highpass Filter at 40 Hz

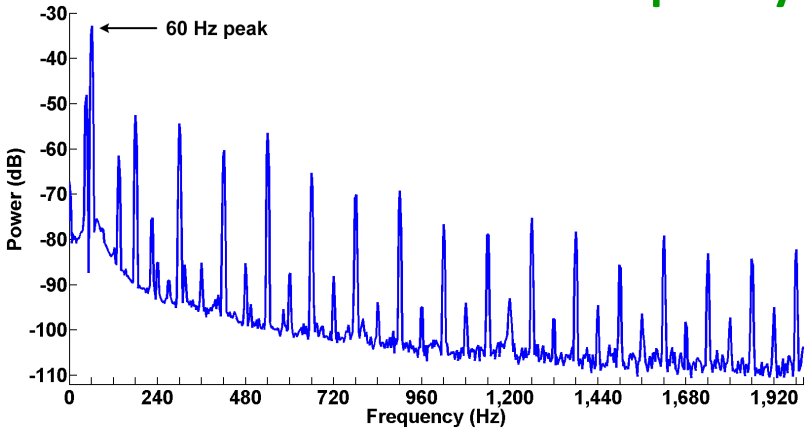
Analysis

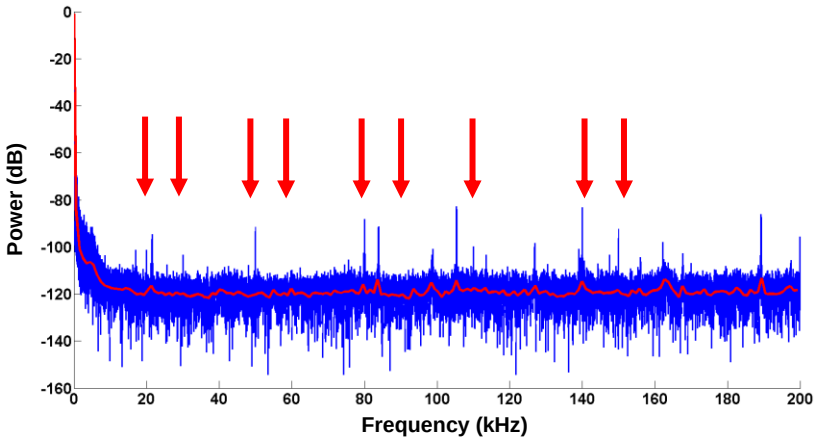
Feature Extraction

Time Domain Features



Frequency Domain Features





Analysis

Classification

classification using the Weka SVM

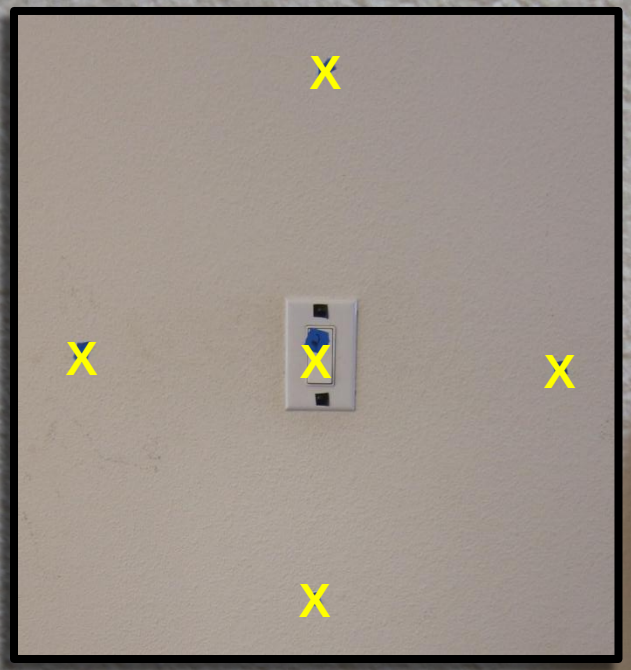
cross-validation in which we fold by "session" to avoid over-fitting

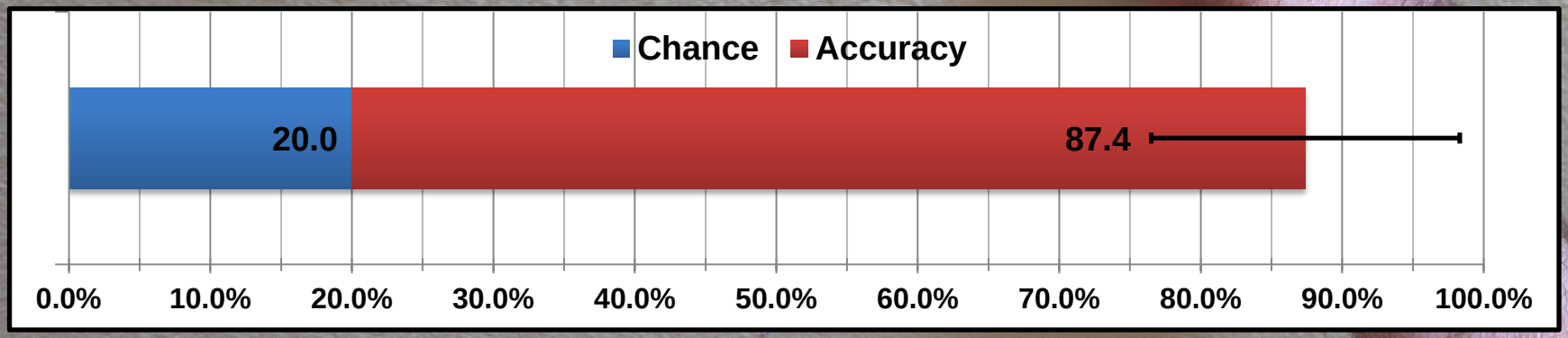
training/testing sets in different "sessions" (separated in time)

Results

Touch Position on Wall

5-position classification

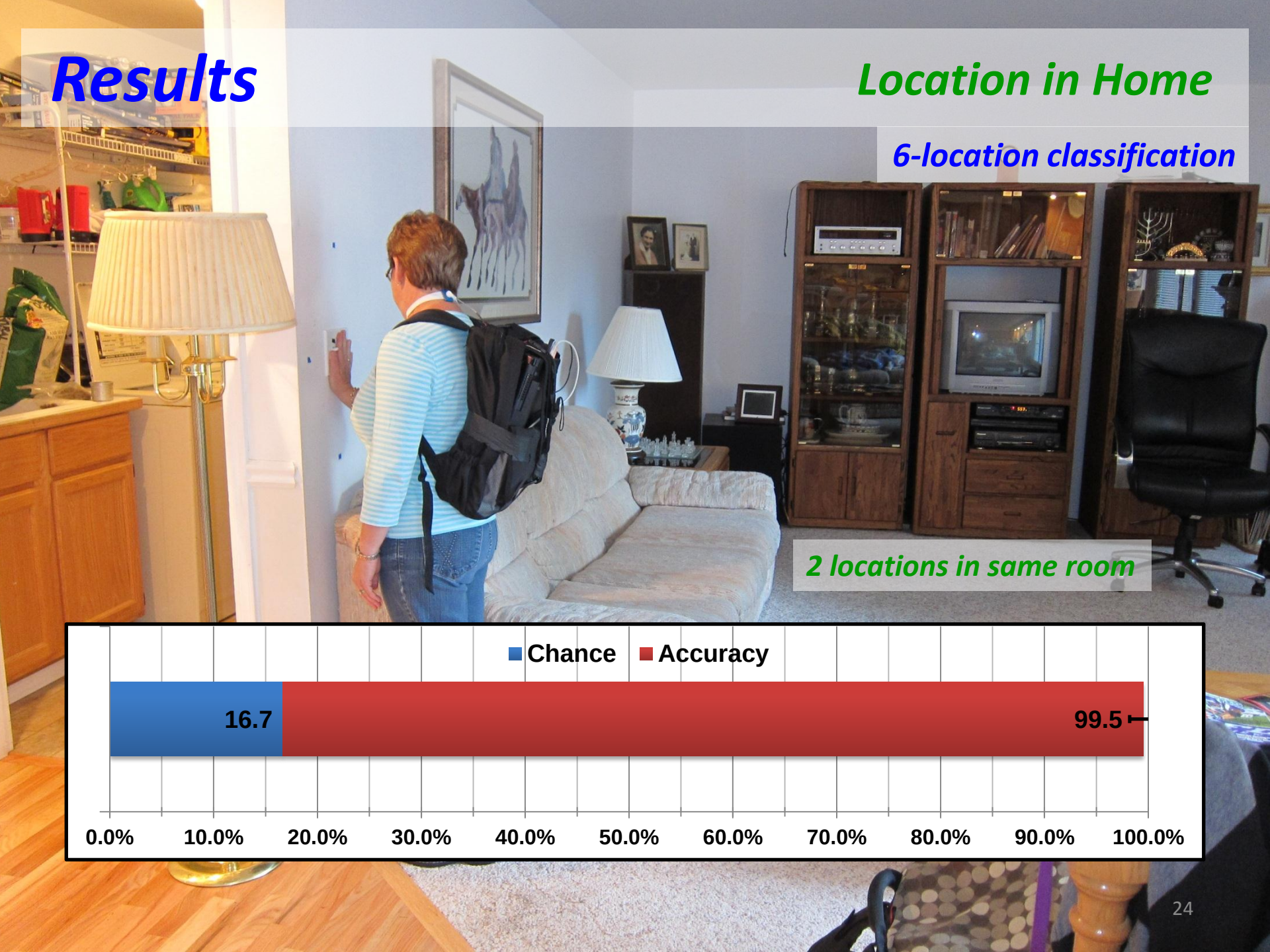




Results

Location in Home

6-location classification

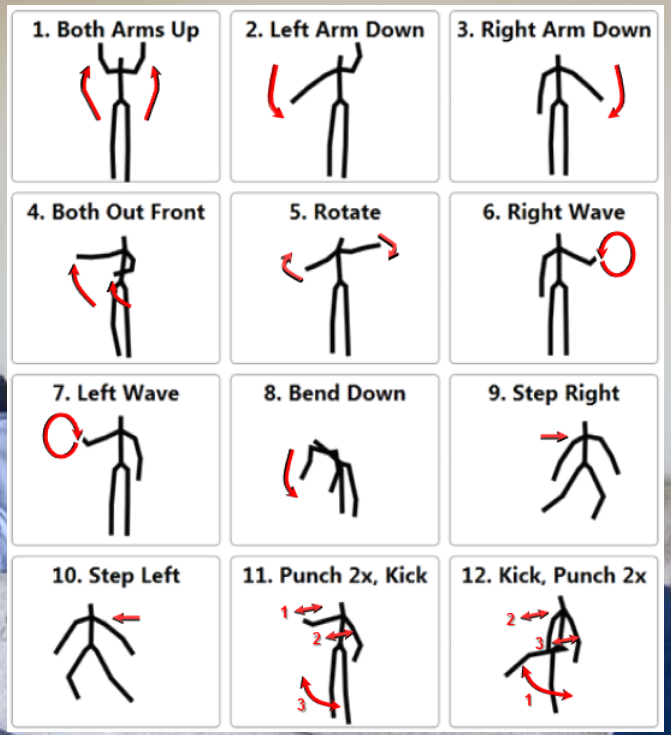


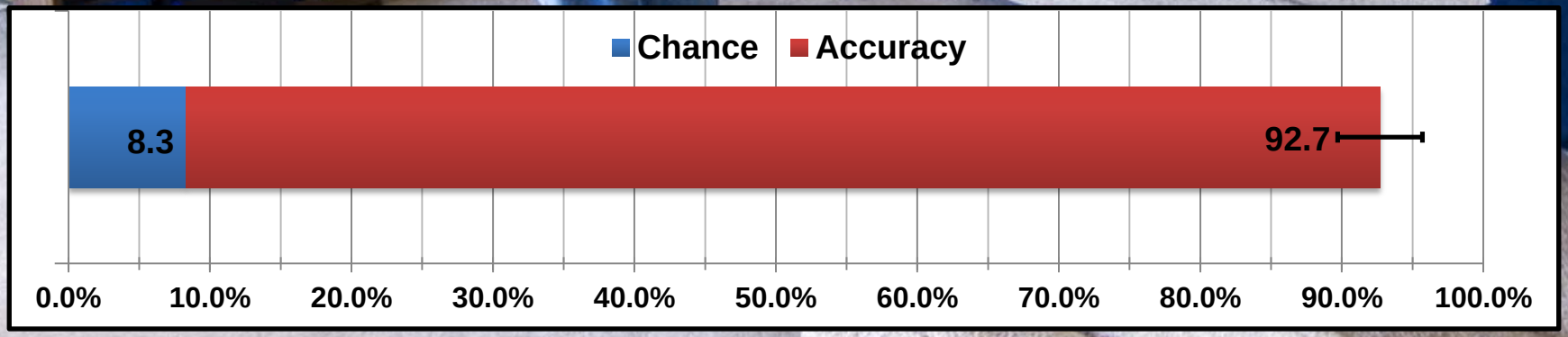
2 locations in same room

Results

Whole-Body Gestures

12-gesture classification





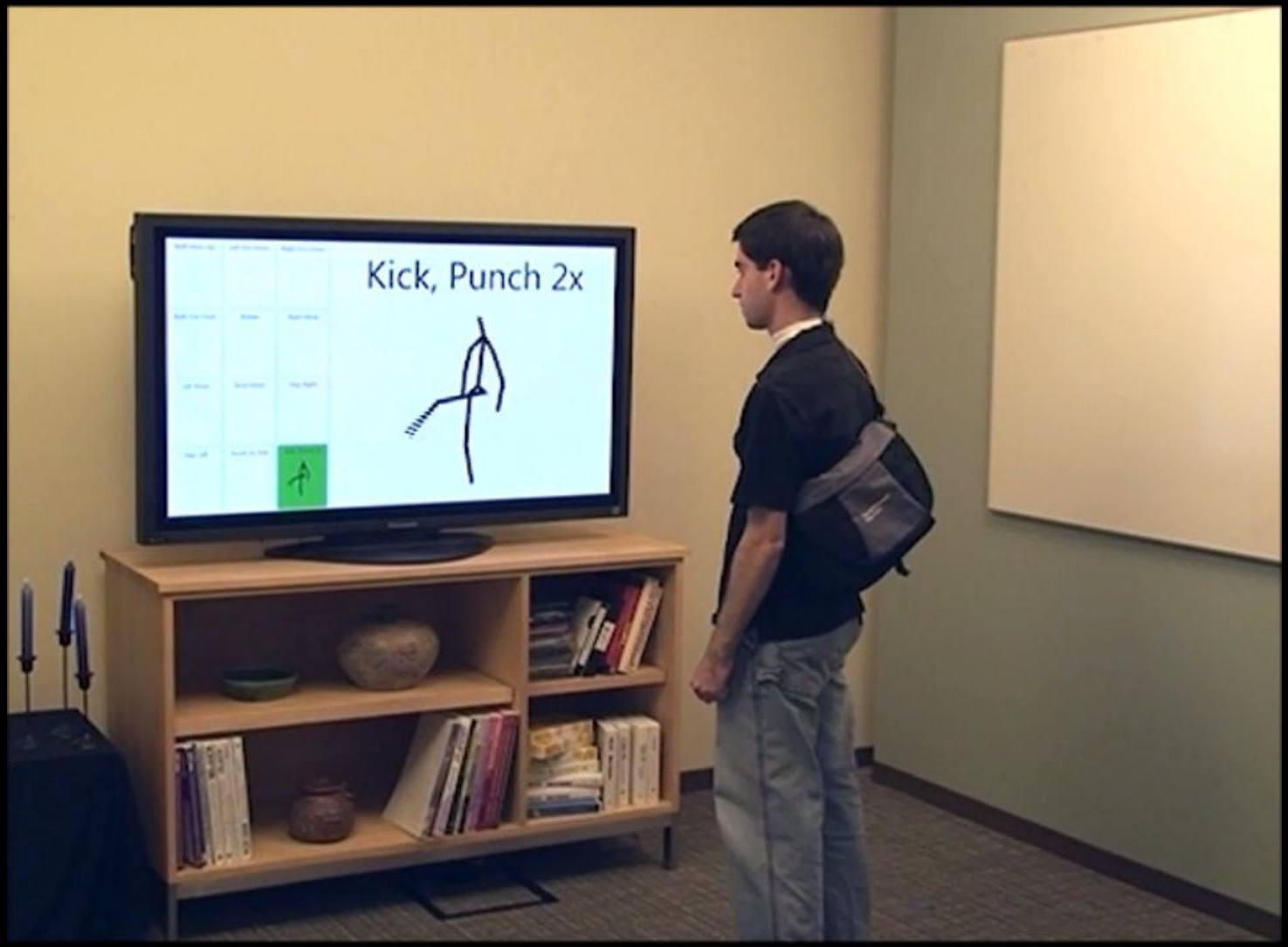
Results Summary

location of user in home **100%**

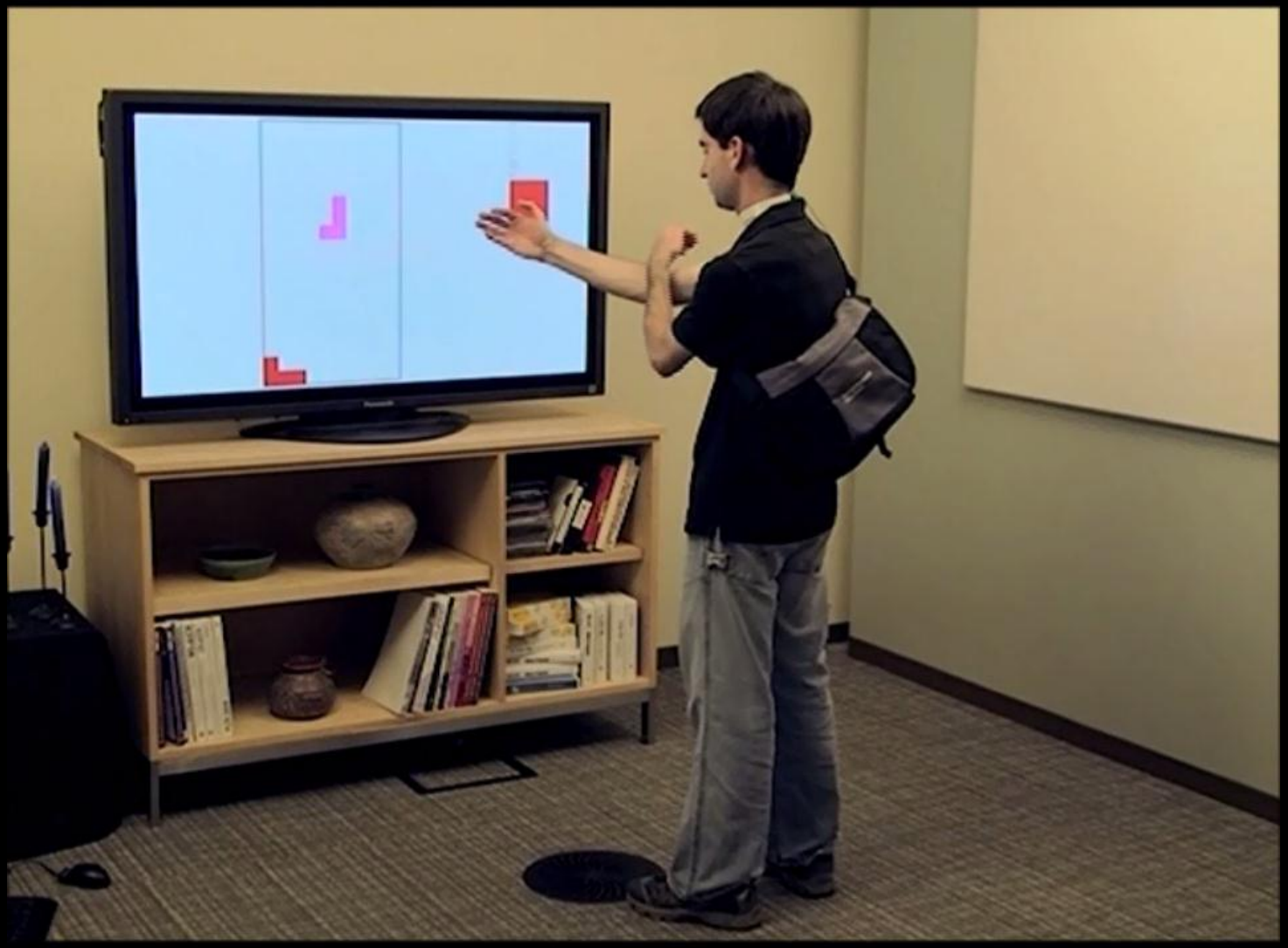
whole-body gesture **93%**

touch position on wall **87%**

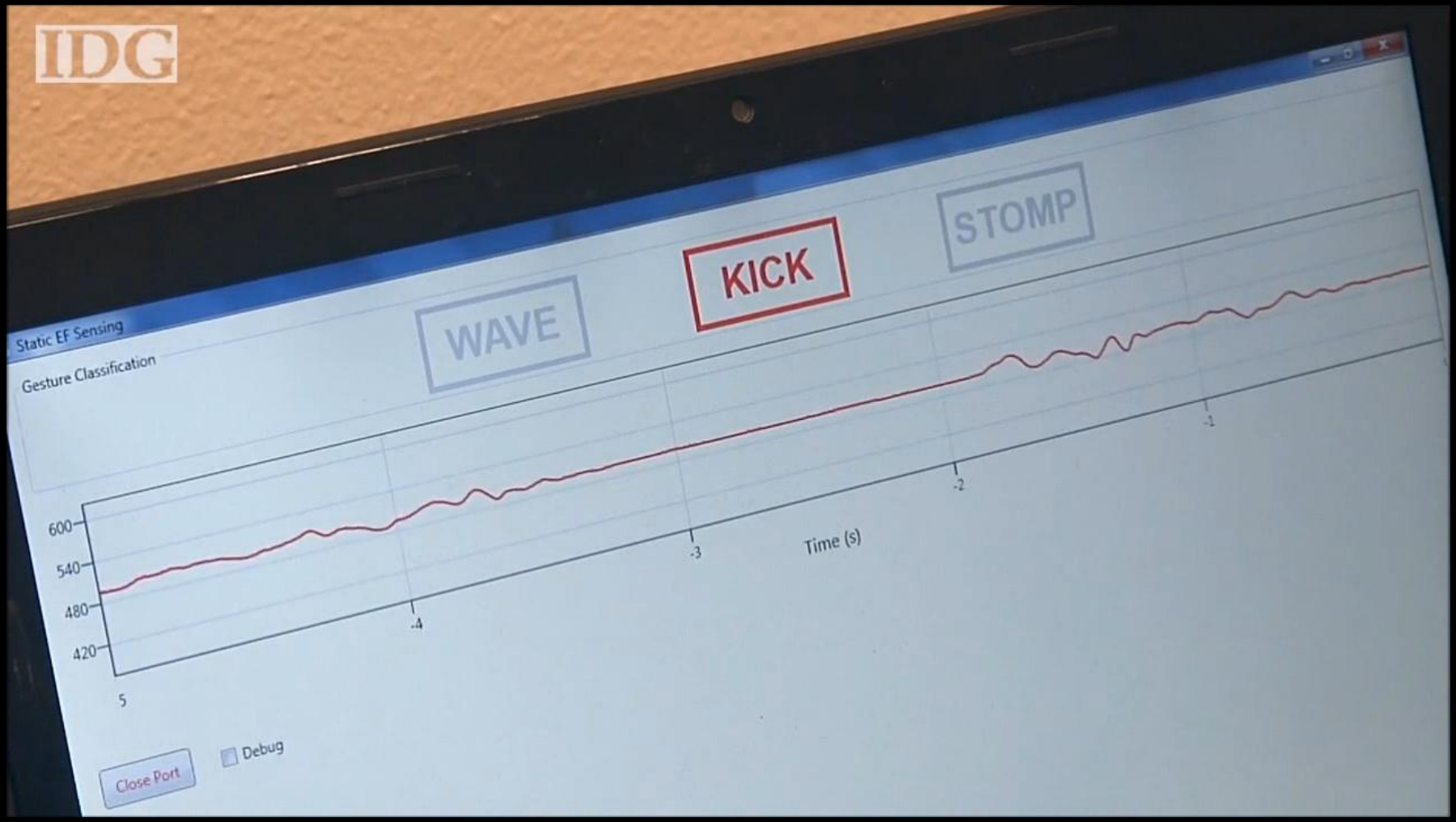
Real-Time Implementation



Tetris Demo Application



Slide Changer Demo Application



Sensing Gestures Using the Body as an Antenna

Your Noise is My Command

CHI 2011

***feasibility* of sensing:**

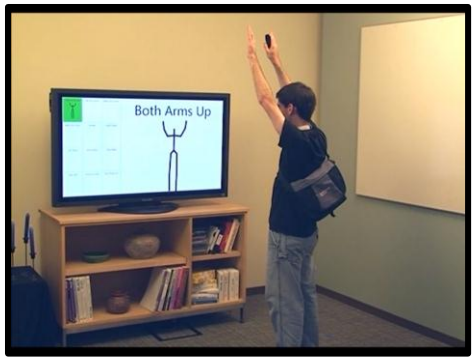
location of user

position of wall touches

***offline* post-processing**

Humantenna

CHI 2012



***demonstrates* sensing:**

whole-body,

free-space gestures

in a real-time system

Future Work

Generalizability of noise signals
- *Training procedure*
- *Signal variation with location*
- *Appliances switched on/off*
- *Variation in gestures*

Improved feature set
Continually adaptive classifier
Signal injection
- *on-body*
- *into power line*

Explore gesture set
Explore application space

Humantenna

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Thank You!

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Dan Morris
Shwetak N. Patel
Desney S. Tan

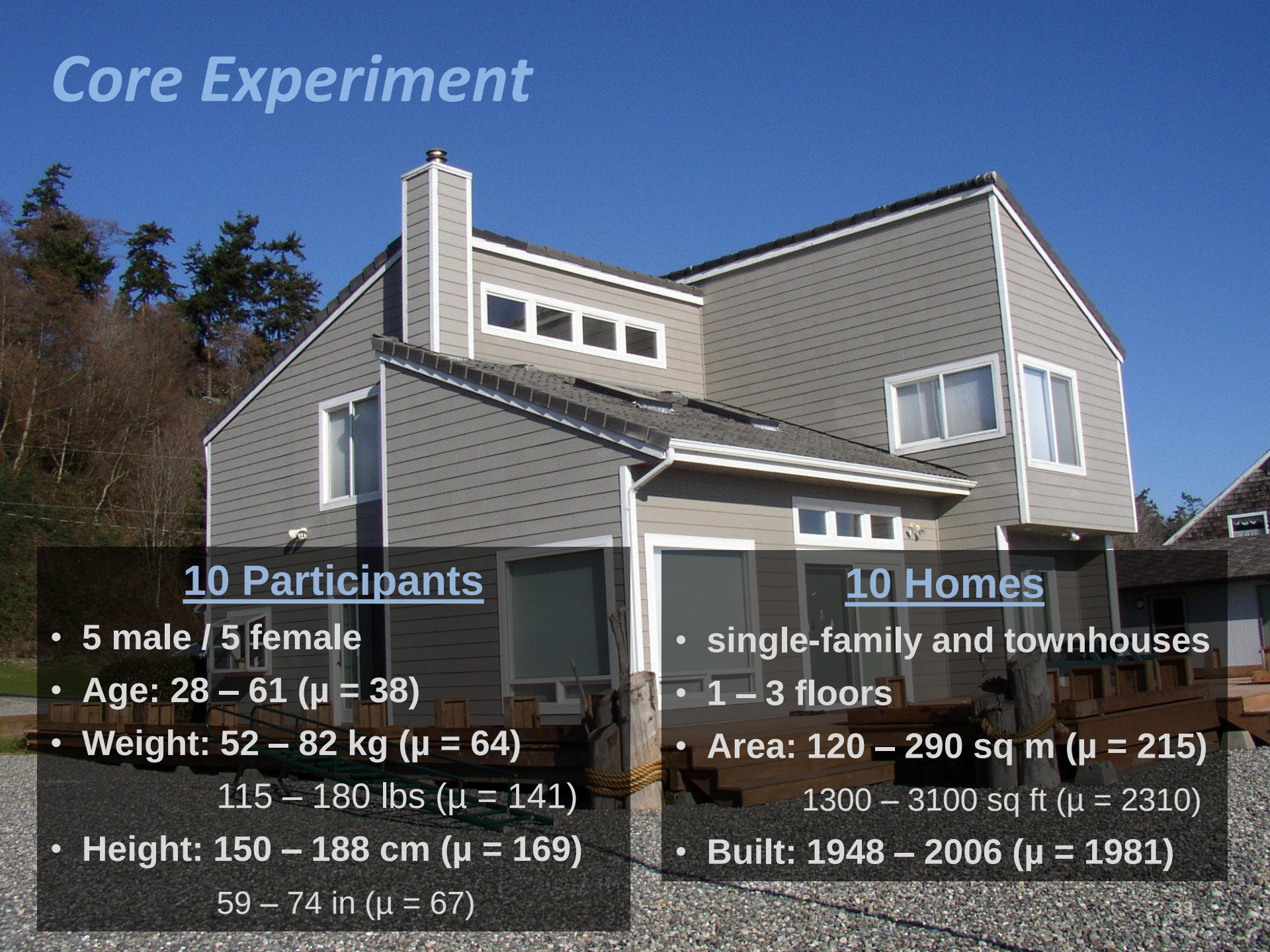
Microsoft Research

ubicomp lab

dub design: use: build: university of washington

Backup Slides

Core Experiment



10 Participants

- **5 male / 5 female**
- **Age: 28 – 61 (μ = 38)**
- **Weight: 52 – 82 kg (μ = 64)**
  115 – 180 lbs (μ = 141)
- **Height: 150 – 188 cm (μ = 169)**
  59 – 74 in (μ = 67)

10 Homes

- **single-family and townhouses**
- **1 – 3 floors**
- **Area: 120 – 290 sq m (μ = 215)**
  1300 – 3100 sq ft (μ = 2310)
- **Built: 1948 – 2006 (μ = 1981)**

Locations

6 locations in each home

5 light switches

2 in same room

1 blank wall above an outlet

Procedure

6 gestures per location

hold each for 6 seconds

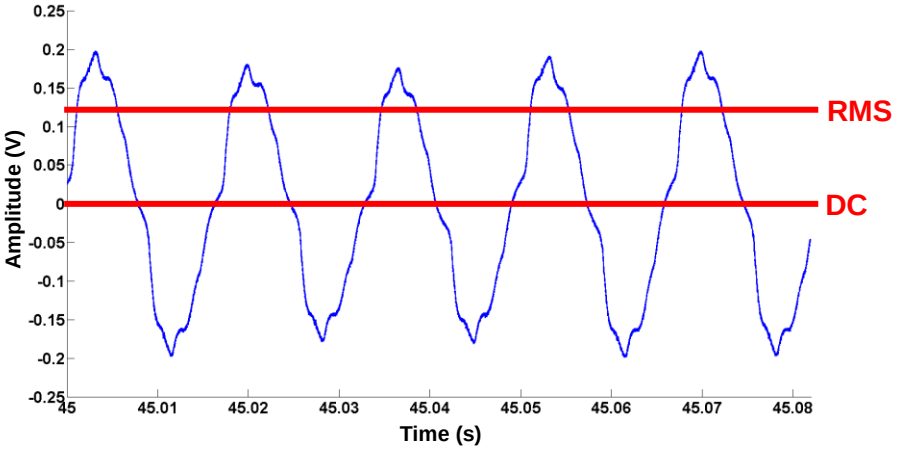
guided by computer commands

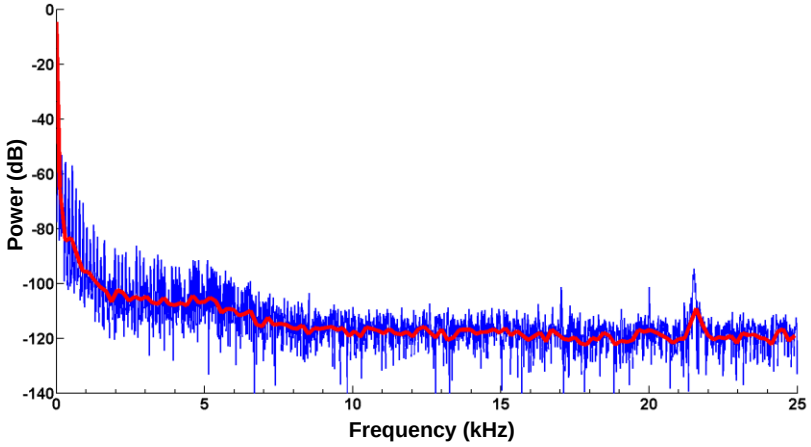
6 locations
6 gestures per location
4 “rounds” (repetitions)

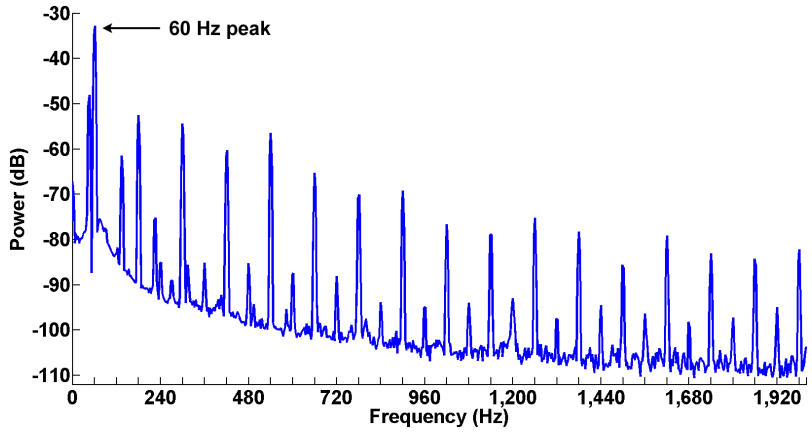
144 total gestures per participant

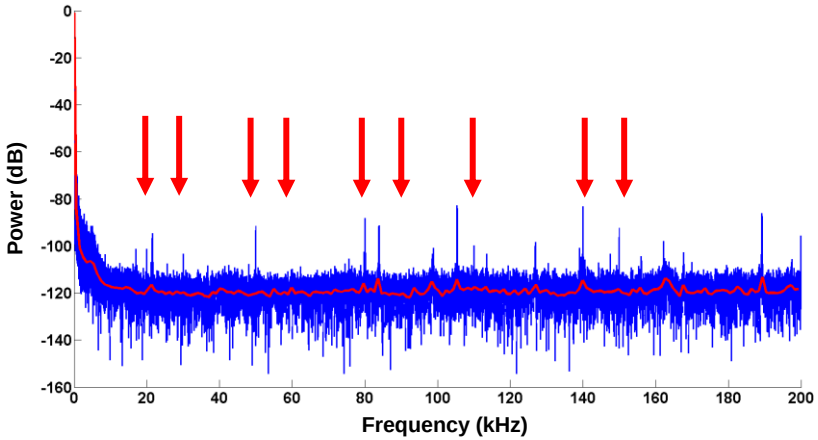
Analysis

Feature Extraction









Time Domain	2 Features
FFT 0 – 2 kHz	332 Features

FFT 0 – 25 kHz	250 Features
FFT 0 – 200 kHz	400 Features
High Freq. Peaks	18 Features

1002 Total Features per 82 ms window

Summary

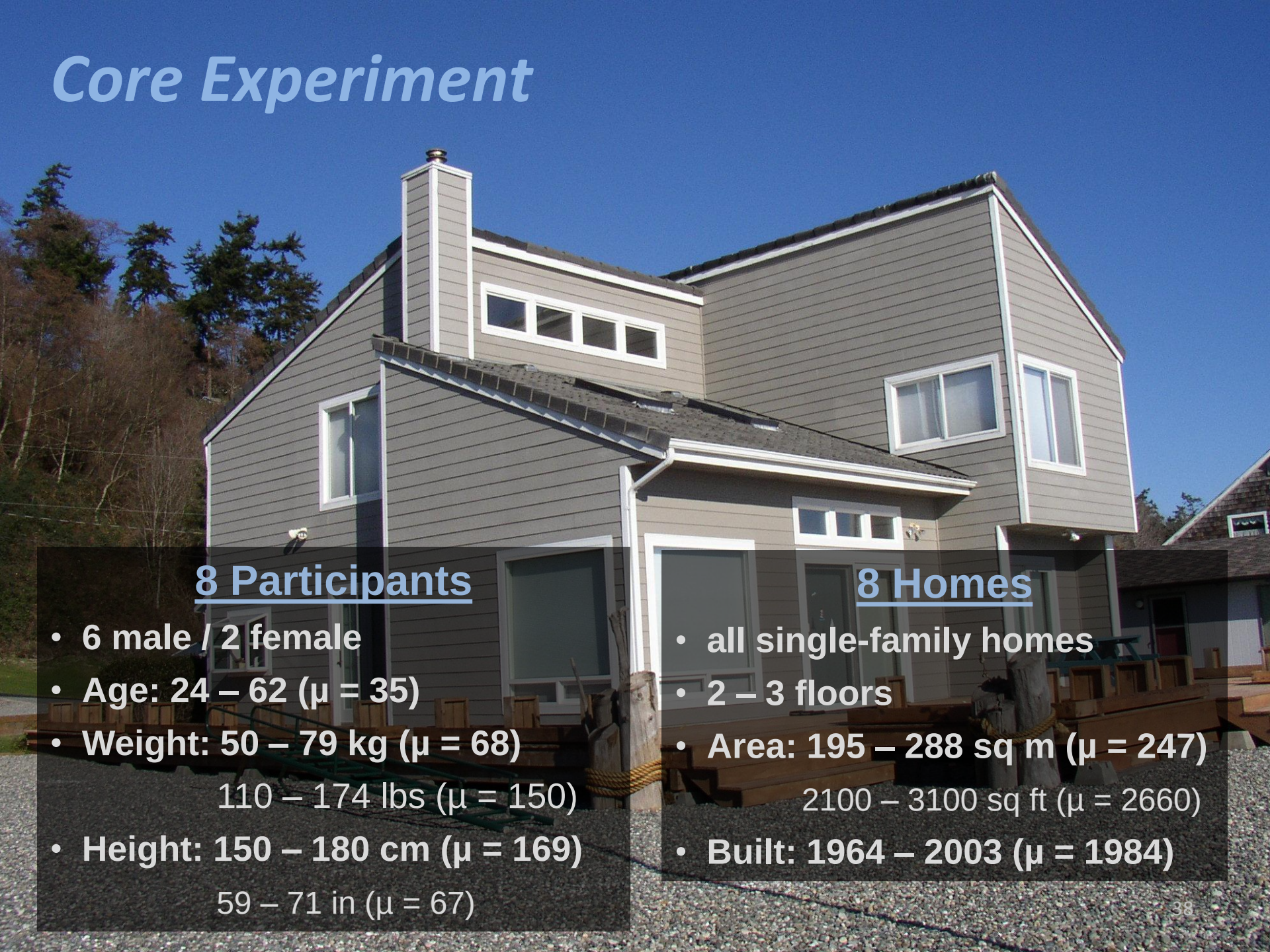
Core Experiment:

- Location in home - near 100%
- Position on around switch – 87%

Additional Exploration:

- Differentiate right/left hand
- Differentiate appliance touched
- Estimate proximity to wall
- Estimate continuous position on wall

Core Experiment



8 Participants

- **6 male / 2 female**
- **Age: 24 – 62 (μ = 35)**
- **Weight: 50 – 79 kg (μ = 68)**
  110 – 174 lbs (μ = 150)
- **Height: 150 – 180 cm (μ = 169)**
  59 – 71 in (μ = 67)

8 Homes

- **all single-family homes**
- **2 – 3 floors**
- **Area: 195 – 288 sq m (μ = 247)**
  2100 – 3100 sq ft (μ = 2660)
- **Built: 1964 – 2003 (μ = 1984)**

Locations

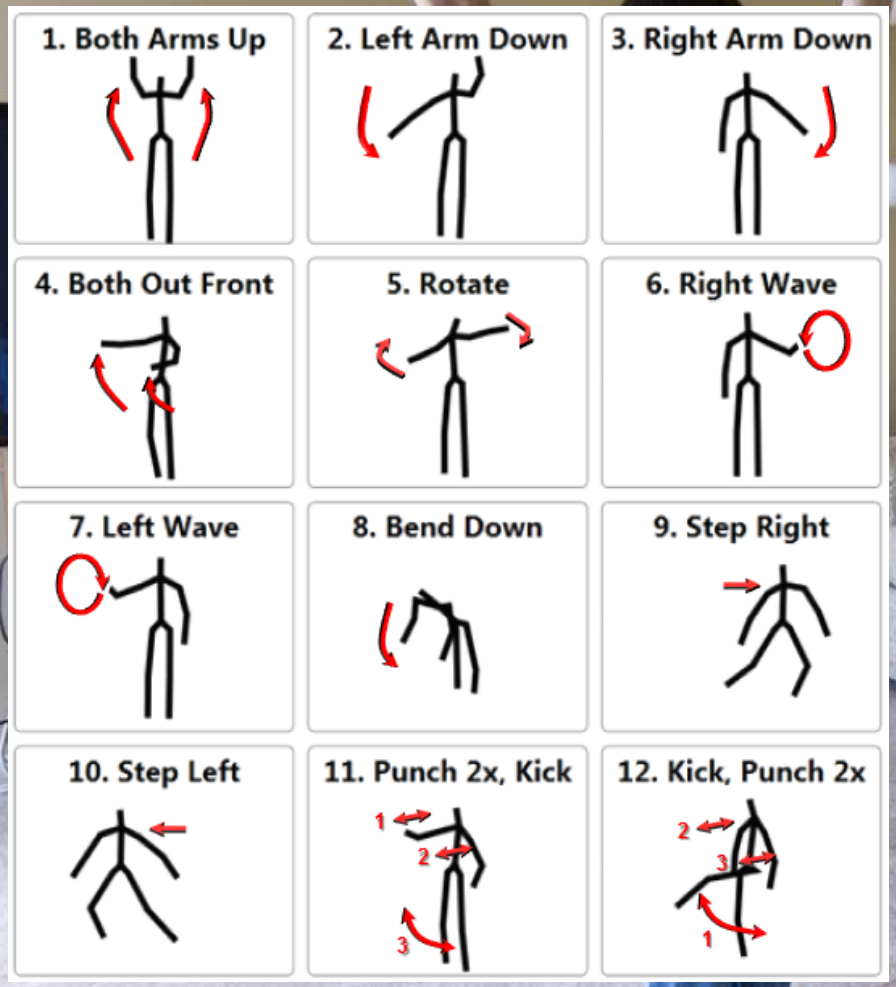
family room

large open space
few electronics (except TV)

kitchen

small space
many lights and appliances

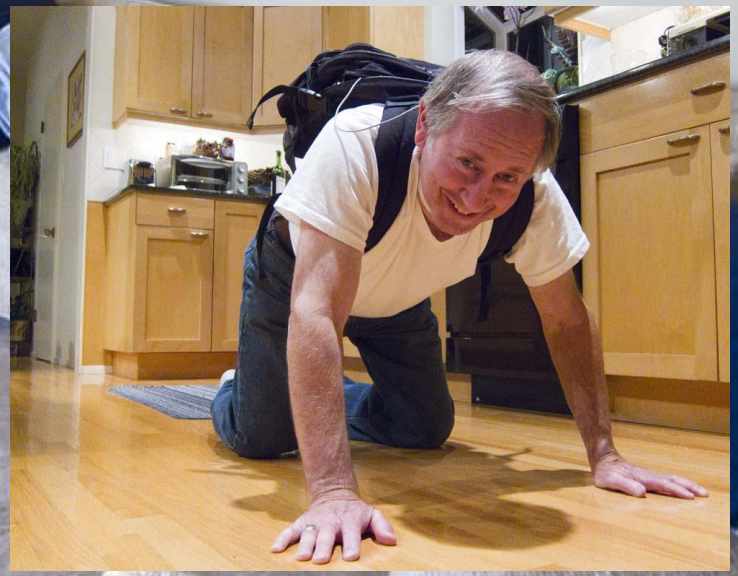
Procedure



12 gestures per location
1 *run*

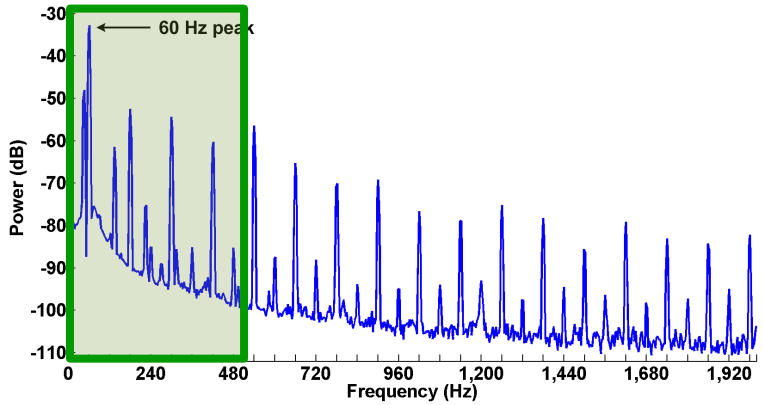
4 runs at each of 2 locations
1 *session*

10 sessions
40 examples of each gesture per location per participant



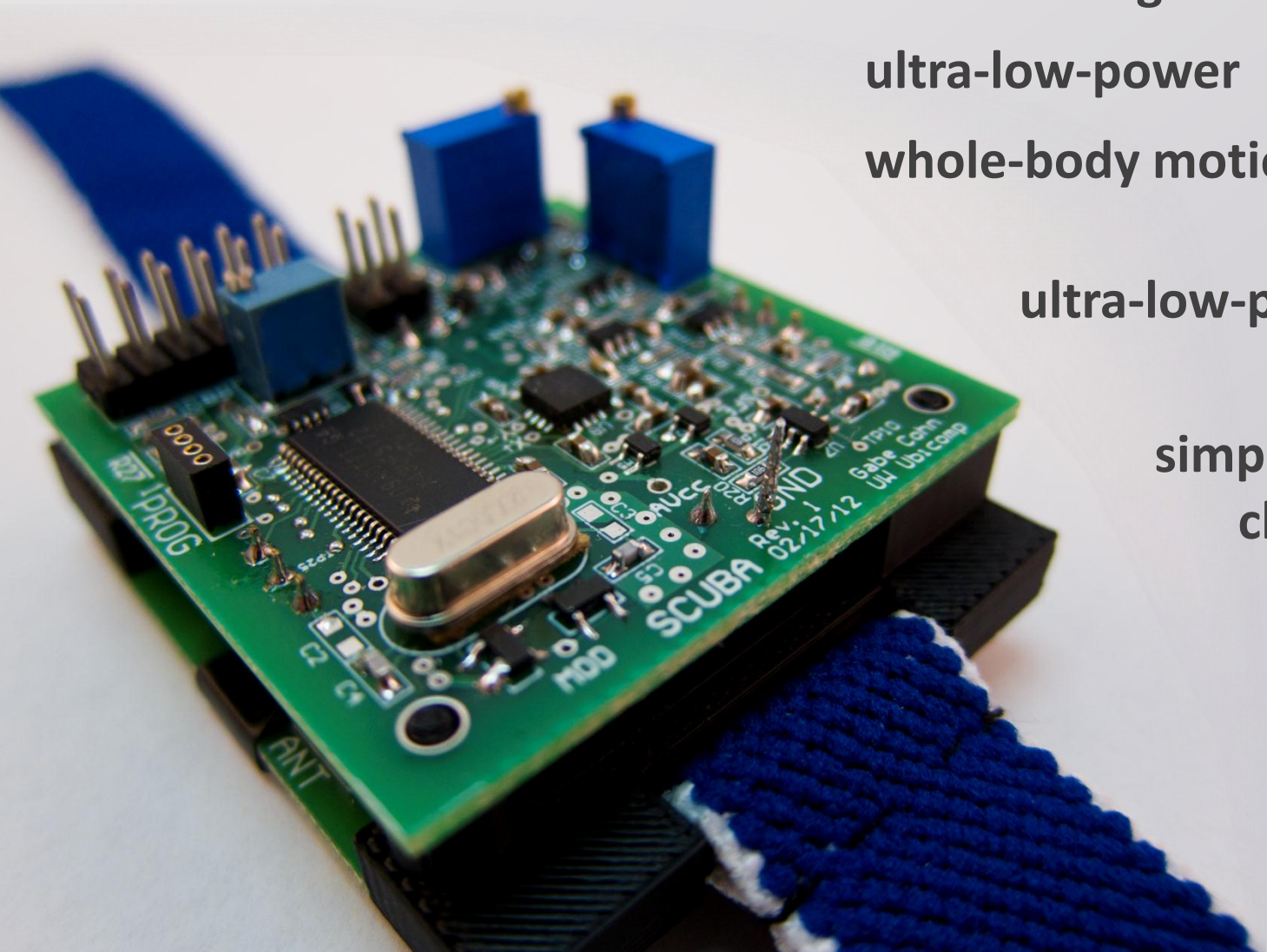
Analysis

Feature Extraction



Frequency Domain < 500 Hz

Summary



Static EF Sensing

ultra-low-power

whole-body motion

ultra-low-power wakeup

simple body motion classification