Humantenna

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

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Computer Vision and Depth Cameras
Using Human Body as an Antenna

no instrumentation to environment
minimal instrumentation on body

“Kinect-like gestures without the Kinect”
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) vs. Time (sec)

Frequency (Hz) vs. Power (dB)

60 Hz peak
Wall Touch

Amplitude (V) vs. Time (sec)
User Motion
Is this signal useful?
Analog-to-Digital Converter

Wifi Data Link

Voltage Probe
Apparatus
In-Home Data Collection
Analysis

1. segmentation
2. feature extraction
3. classification
Analysis

Lowpass Filter at 10 Hz
Analysis

Feature Extraction

Lowpass Filter at 10 Hz

Highpass Filter at 40 Hz
**Analysis**

**Feature Extraction**

**Time Domain Features**

![Time Domain Features Graph]

**Frequency Domain Features**

![Frequency Domain Features Graph]
Analysis

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

![Diagram showing touch positions on a wall with classification results]
Results

Location in Home

6-location classification

2 locations in same room

Chance  Accuracy

0.0%  10.0%  20.0%  30.0%  40.0%  50.0%  60.0%  70.0%  80.0%  90.0%  100.0%

16.7  99.5
Results

Whole-Body Gestures

12-gesture classification

Chance  Accuracy

8.3  92.7
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

 feasability of sensing:
location of user
position of wall touches
offline post-processing

demonstrates sensing:
whole-body,
free-space gestures
in a real-time system

Humanantenna
CHI 2012

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
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Thank You!

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Backup Slides
Core Experiment

10 Homes
- single-family and townhouses
- 1 – 3 floors
- Area: 120 – 290 sq m (µ = 215)
  1300 – 3100 sq ft (µ = 2310)

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)
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

1002 Total Features per 82 ms window
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 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)

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)
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

DC

RMS

Segmentation

Feature Windows

1 2 3 4 5 6 7
Summary

Static EF Sensing
ultra-low-power
whole-body motion
ultra-low-power wakeup
simple body motion classification