Object Motion MITes

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Object motion MITes

GOAL: Measure people's interaction with objects in the environment

We consider that someone uses an object whenever the person has been in direct contact with the object by manipulating it either by touching, moving, or holding it.

Passive RFIDs

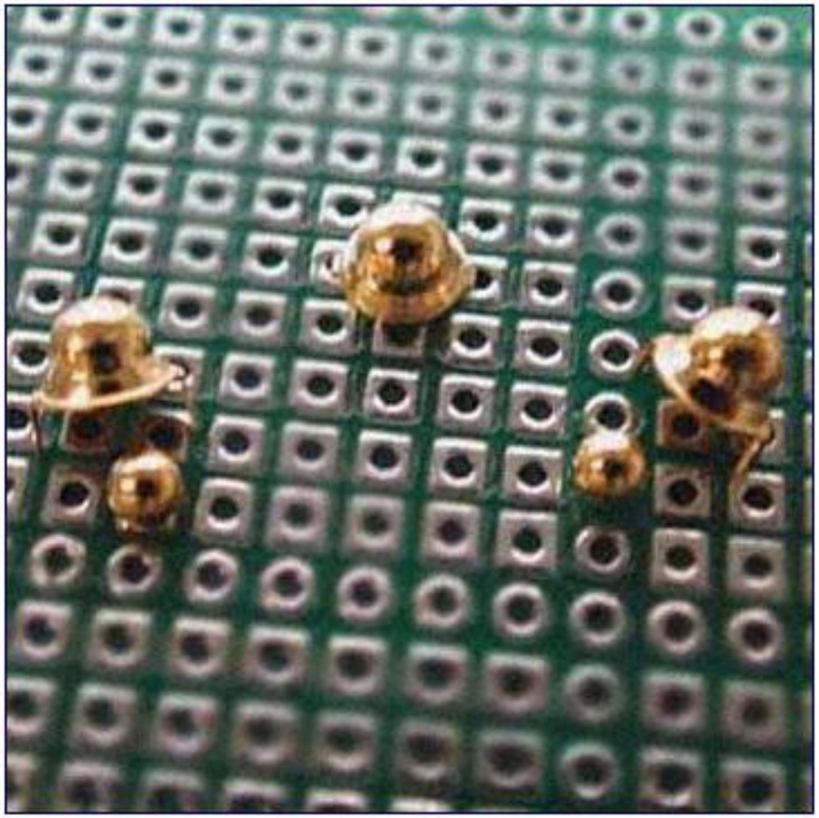
Passive RFIDs

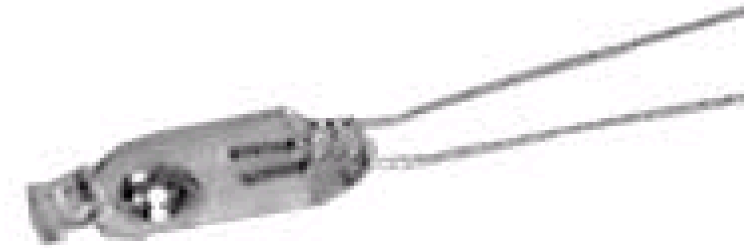
Problems: (1) metal objects, (2) alignment between reader and tag, (3) battery life and (4) wearable glove is intrusive

Magnetic Reed Switches

Problems: (1) Installation is complicated and time consuming and (2) not possible to install in every object

Vibration/Tilt sensors





Problems: (1) Sensitivity to motion cannot be adjusted and (2) orientation sensitive.

Summary of challenges

- Installation complexity
- Installation time
- Sensitivity to motion
- Orientation dependence
- Battery life
- Wearable technologies are intrusive

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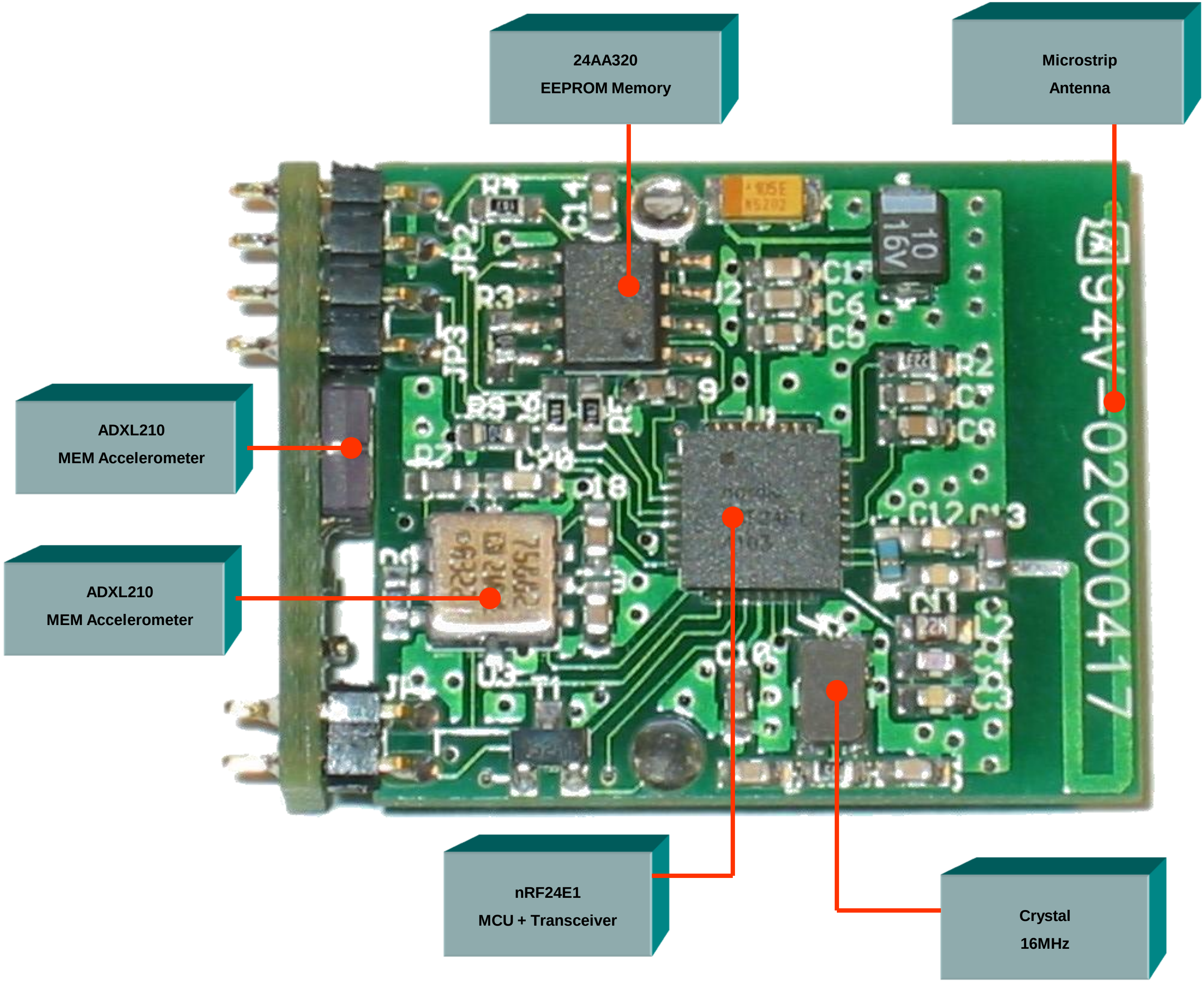
Measure people’s interaction with objects in the environment

- Stick-on and forget devices
- Single sensor (2-axis accelerometer) to measure movement, tilt, and vibration
- Active RFID tags that sense movement
- Low cost ~$29
- Wireless at 2.4GHz
- Tx/Rx range 106m outdoors line of sight and 38m random disposition,


24AA320
EEPROM Memory
Microstrip
Antenna
ADXL210
MEM Accelerometer
ADXL210
MEM Accelerometer
nRF24E1
MCU + Transceiver
Crystal
16MHz

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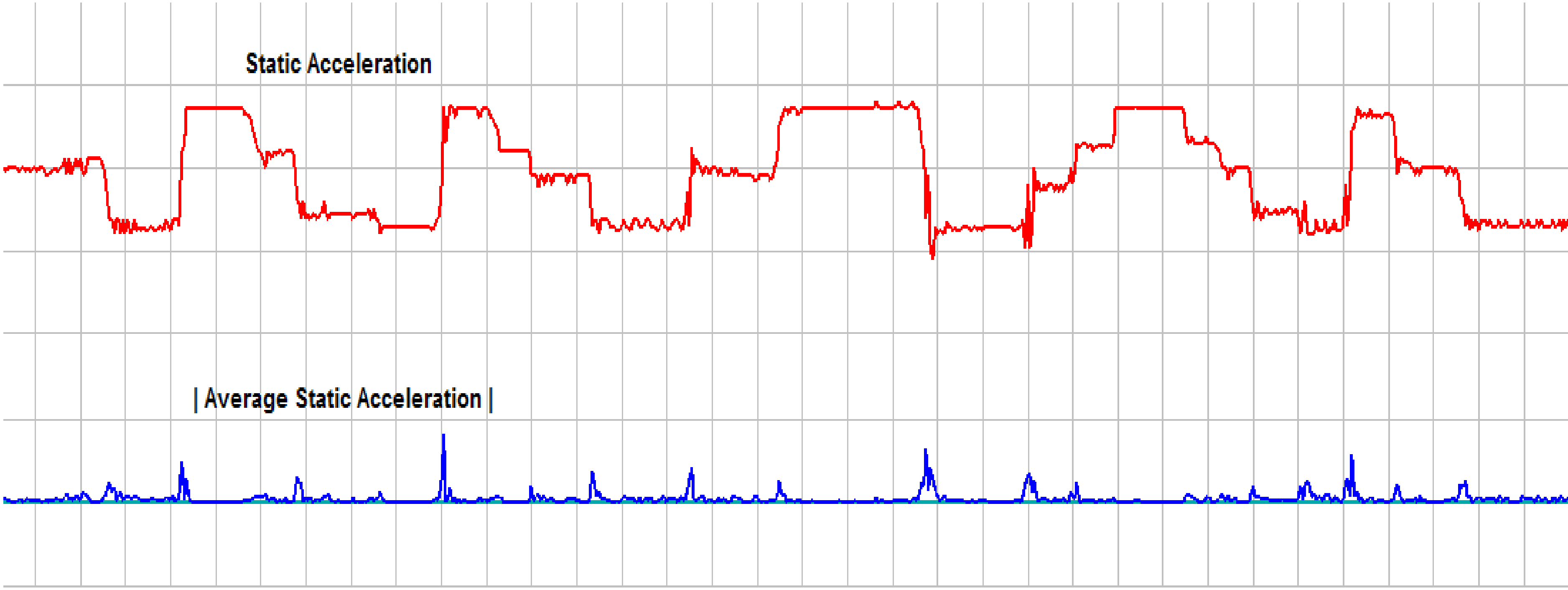

MITes measure dynamic acceleration (movement and vibration) as well as static acceleration (rotation and inclination)

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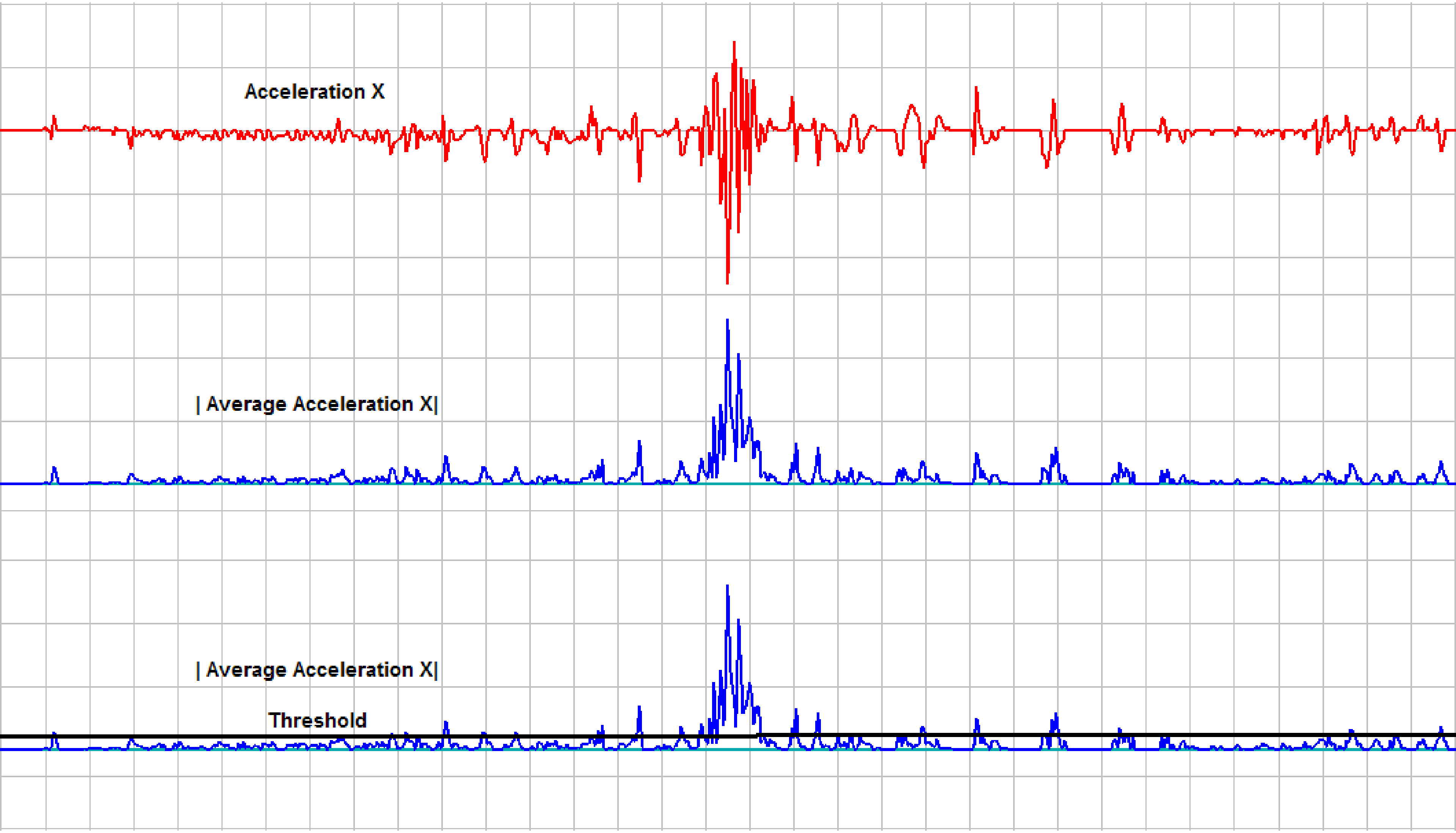

Algorithm running inside MITes to detect movement

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Installation procedure for stick-on MITes

Object Motion Installation

Object Motion Installation

In some objects, RFID tags would just not work!

Problem 1: Adjacencies

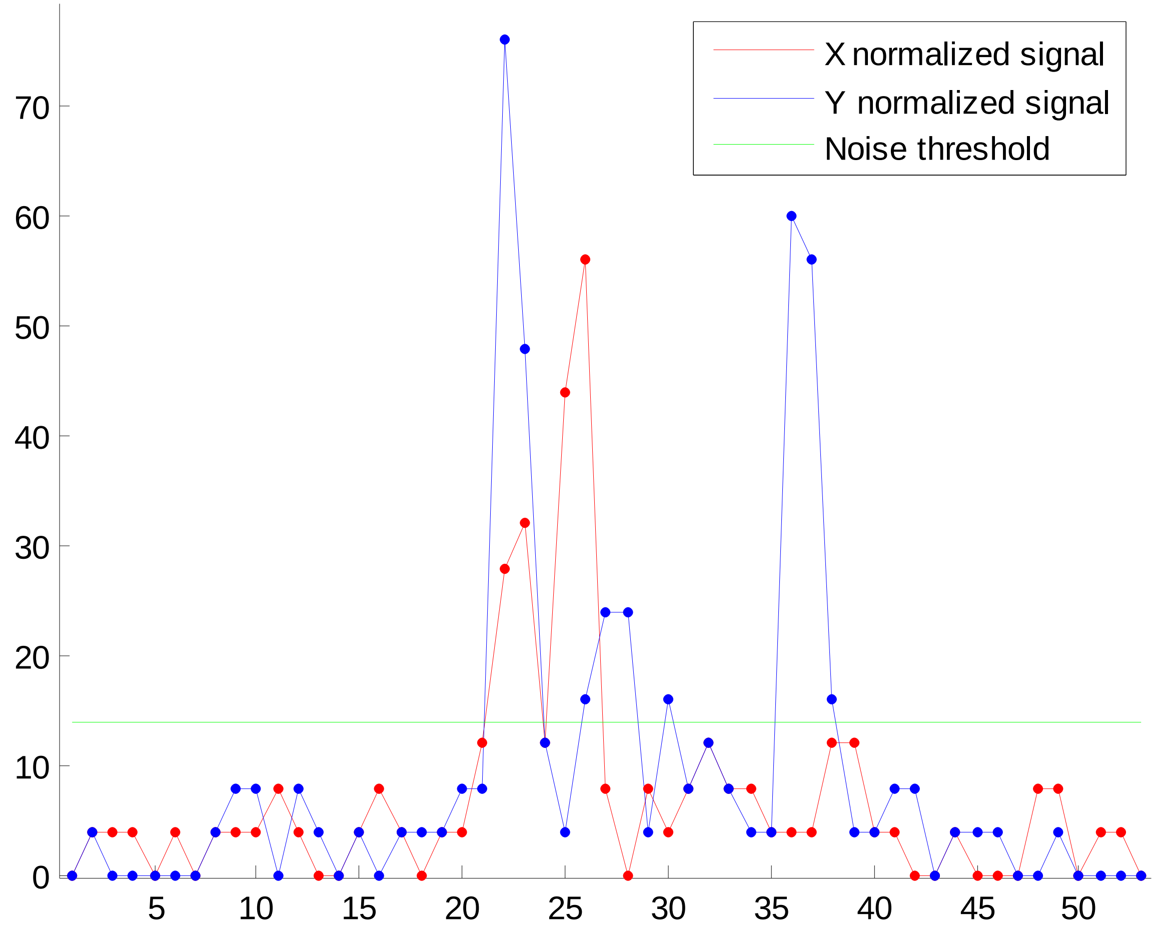
- Sensors in the neighborhood of the moved sensor/object will fire
- We need a way to distinguish between “real motion” and “adjacent motion”

Not a simple problem!

Classification problem: real vs. adjacent motion

Object	Examples
Drawer	50
Drawer adjacent	50
Cabinet	50
Cabinet adjacent	50
Door	50
Couch	50
Couch adjacent	50
Chair	50
Table	25
Cup	25
Remote control	25
Toilet cover	25
Faucet	25
Bed	25

Acceleration signal for ‘opening a drawer’



Features extracted

1. Min value above noise threshold
2. Max value above noise threshold
3. Area under curve
4. Duration of the motion (number of samples greater than the noise threshold)
5. Average of the signal
6. Variance of the signal

Classification algorithms

RULE BASED ALGORITHMS	TREE-BASED ALGORITHMS
1.ZeroR 2.OneR 3.Rules PART 4.Single conjunctive rule learner 5. Ridor 6. Jrip	1. Decision stump 2. J48 3. NB tree

Why these?

They generate a set of simple decision rules that can be easily implemented as if-then clauses in a microprocessor

Results

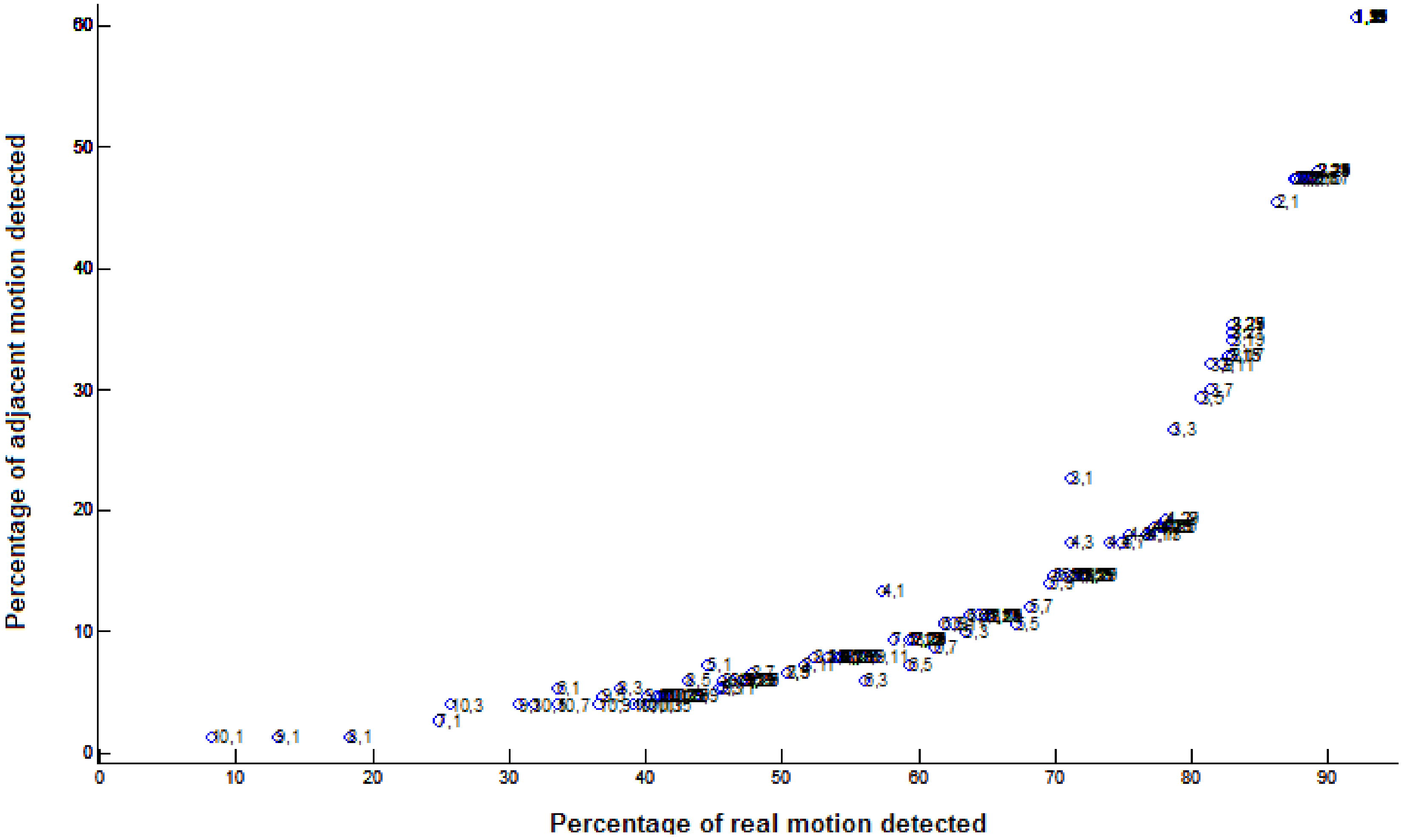
- Best feature to use is the duration of motion.
- Best algorithm to use is Rules PART which generates the simple classification rule

PART decision list

xy_duration > 4: real

xy_duration <= 3: adjacent

Real vs. Adjacent motion trade-off



Problem 2: Battery life

Based on our experiments, we have found that the minimum sampling rate for distinguishing adjacencies is 10Hz

- At 10Hz, battery life is 46 days
- At 20Hz, battery life is 23 days

Problem 3 false positives are high

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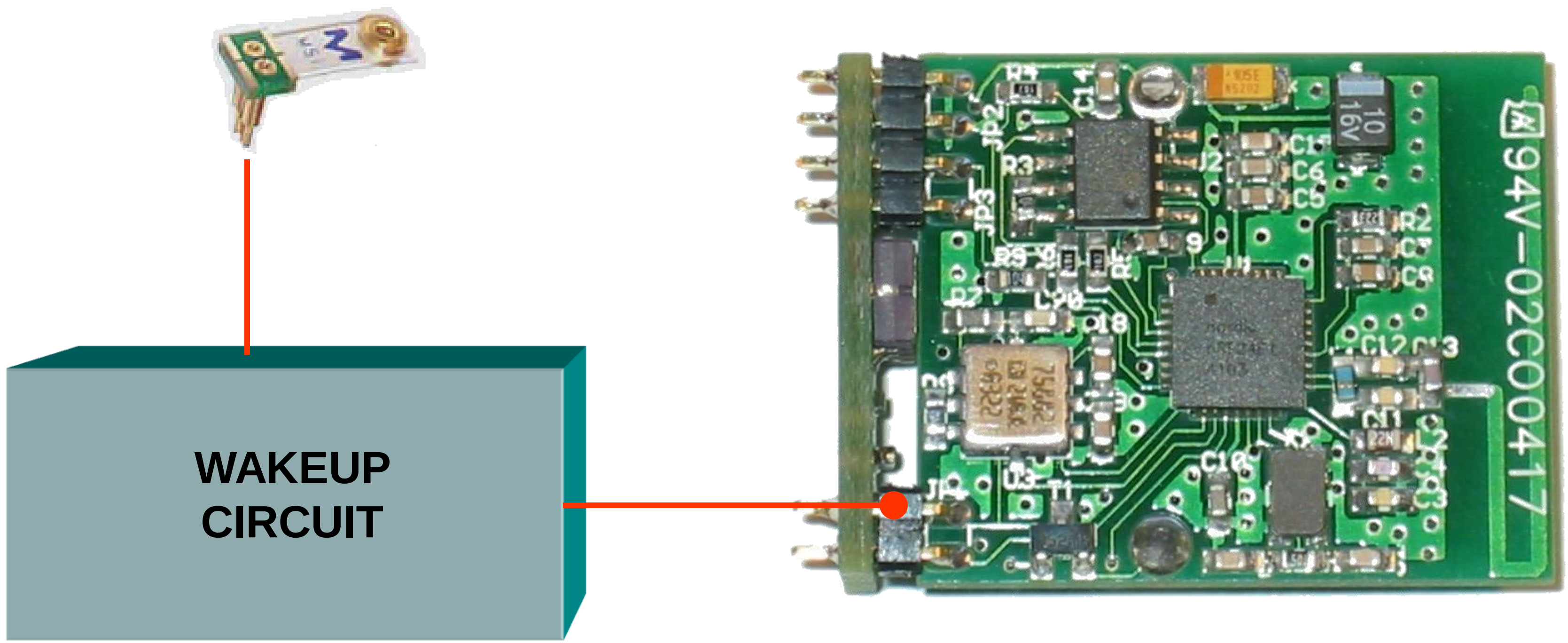
Piezofilm sensor



Extreme low power circuitry

Sleeping (power down mode) unless motion in external sensor is detected

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- New battery life is 6.3years (theoretical) but at least 1 year in practice based on measurements
- False positive activations is close to zero as measured over 21 days