# Mobile Application (Design and) Development

12th class

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# Today

- Q&A
- Project idea observations
- Acceleration data
- Mention of other sensors
- Web connection
- Design paper presentations
  - Case Studies
    Presenter: Rahul Trivedi
  - Case Studies
    Ben Johnson
  - The Future of Persuasion and Persuasive Games
    Robert Steinbach

# Schedule

- Tomorrow: Project presentations (start)
  - Please be on time
  - Fast paced
- Thu: Finish project presentations
  - Start SQLite
- Sunday: Programming assignment 4 due
  - "Boggle Health Game"

# Q&A

# Project idea observations

- Most teams: be much more clear about how it works. Too many missing screens, etc.

- If people don't do it already, do they really *need* to do it? Think like a business person: where do they feel pain?

# Project idea observations

- Why is what you propose likely to be addictive? Describe what is fun and WHY. What will pull in the skeptics? Think about the theory behind it? E.g., does it have cleverly balanced reward/challenge as all good games do? Does it do that at multiple levels? Does it lead people into the cognitive model? (See the Angry Birds article for inspiration)

# Project idea observations

- Some projects are promising way too much complexity in terms of databases and data entry. Think smaller but more clever. You are not going to do the same-old, same-old food tracking better. Or, if you think you are, you need to demonstrate why you have a breakthrough in simplicity!

# Project idea observations

- Not nearly enough detail in may paper prototypes

- Game will make it “fun and exciting.” Why? Show that what you are doing has the flavor of other games that are already known to be hugely popular.

# Project idea observations

- Do people actually CARE about the problem you are solving? Or is it just that they SHOULD care? If only the latter, you are fighting an uphill battle unless you have a something that will make the app have an engaging pull.

# Project idea observations

- Error in the measurement: watch out! Impacts your apps credibility. You need to assume error and deal with it, not assume perfect measurement or behavior. If user figures out your app is not perfect, why should they take time to give it info?

- Do I have to remember to use it? If I forget, can I use it afterwards?

# Project idea observations

- Can I correct information if I think the app was not correct (or better, is the design forgiving of this and doesn't make me mad if it misses something)

# Project idea observations

- Not much use of friends (or better, other users that user doesn't know) in clever ways. Think about if you can make the app more compelling by exploiting human creativity and ingenuity.

- Think about synchronous vs. asynchronous communication.

# Project idea observations

- I particularly like the apps that are measuring something in a new way ... that gives the app a sense of freshness vs potential competition and also may make it seem more unusual.
- Beware of reminding to do exercise ... remember that **TIME IS THE MOST VALUABLE RESOURCE** people have ... if you are asking their time, you are asking a great deal.

# Project idea observations

- Best, where possible, to wait until they do something and positively reward. Integrate into everyday life.

# Project idea observations

- "Friend" or "buddy" type applications … what can do you do to make it unique/special? E.g., only one buddy? Clever way of getting buddies? Competition to get buddies? Some type of "secret" communication channels? BE CREATIVE! Think hard about how to make the app feel different than all others … it's mostly NOT about programming. It's about design.

# Project idea observations

- Where is the POINT OF DECISION? (Example, food in the kitchen; doing exercises at the gym; watching a new television show)

- Beware of ideas that require practive action for what should be background monitoring.

# Project idea observations

- If you need art, where will you get it so the apps looks professional? (Suggest you find a friend who is in the arts/graphic design)
- Be sure to include a mechanism in your app where you users can provide you with feedback about how to improve it. This is a GOLD MINE for you. It is also a feature that users greatly appreciate if they think you, the developer, are listening to them. Don't squander the opportunity.

# Project idea observations

- Sensor noise. Accept it. Embrace it. Design around it.

- Animated agents are very challenging to make well. Anthropomorphization is tricky territory to be in and confuses many users. Is it a computer? Is it supposed to be real? Why isn't it smarter? Can you accomplish what you want without requiring AI?

# Project idea observations

- What about cheating? Some apps may fail because users will be distrustful of other people cheating.

- Graphs are a reasonable amount of work to implement. They seem like a good idea at first, but they aren't particularly fun. Can you make the graphs fun in some way? What is the PURPOSE of the graphs?

# Project idea observations

- Think through all the types of rewards you could offer: Badges? Avenues of communication? You may not use money as a reward because it will not scale to large numbers of people (unless you can figure out a way to do that without spending your own money)

# Project idea observations

- Many apps do not clearly show how someone would get started using it ... this should come out if you are doing paper prototyping. Think very hard about the learning curve for the cognitive model and how to increase cognitive complexity gradually. Good games do this.

# Project idea observations

- Databases ... some are requiring them but will you have what you need? If the DB you need is not available (ask me if I'm aware of something) or would require a lot of work to create, move on to a new idea.

# Project idea observations

- Said this before but want to reemphasize: don't just say your idea is better than the competition because someone is playing a game. Saying that you have a "fun and addictive game format" doesn't tell the user anything. Many games are junk. What designs of the game make it good, and you should be able to justify that via comparison with games that you know are good. (DropWords example)

# Project idea observations

- Think carefully about what burden you are putting on the user based on how they must carry the phone. Is what you are asking them to change reasonable given what your app actually gives them in terms of benefits?
- Think carefully about the interaction/interruption burden your app imposes. Is it reasonable?

# Project idea observations

- Tracking behavior is not fun. So, if you are asking people to do tracking, does it (1) lead to something fun? (2) save time? (3) lead to more interesting communication? (4) ????
- Unless your app really is only designed for one gender, be careful in your descriptions that you are not excluding 50% of the Market! Some have examples that are quiet gender specific.

# Project idea observations ***

- I am putting heavy weight on creativity and use of the special capabilities of mobile devices and simplicity and robustness! Why?

# Project idea observations ***

- I am putting heavy weight on creativity and use of the special capabilities of mobile devices and simplicity and robustness! Why?
- **I want to see more detail in paper prototypes and more evidence that teams are really doing it! Generally it comes through loud and clear if you are serious about it.**

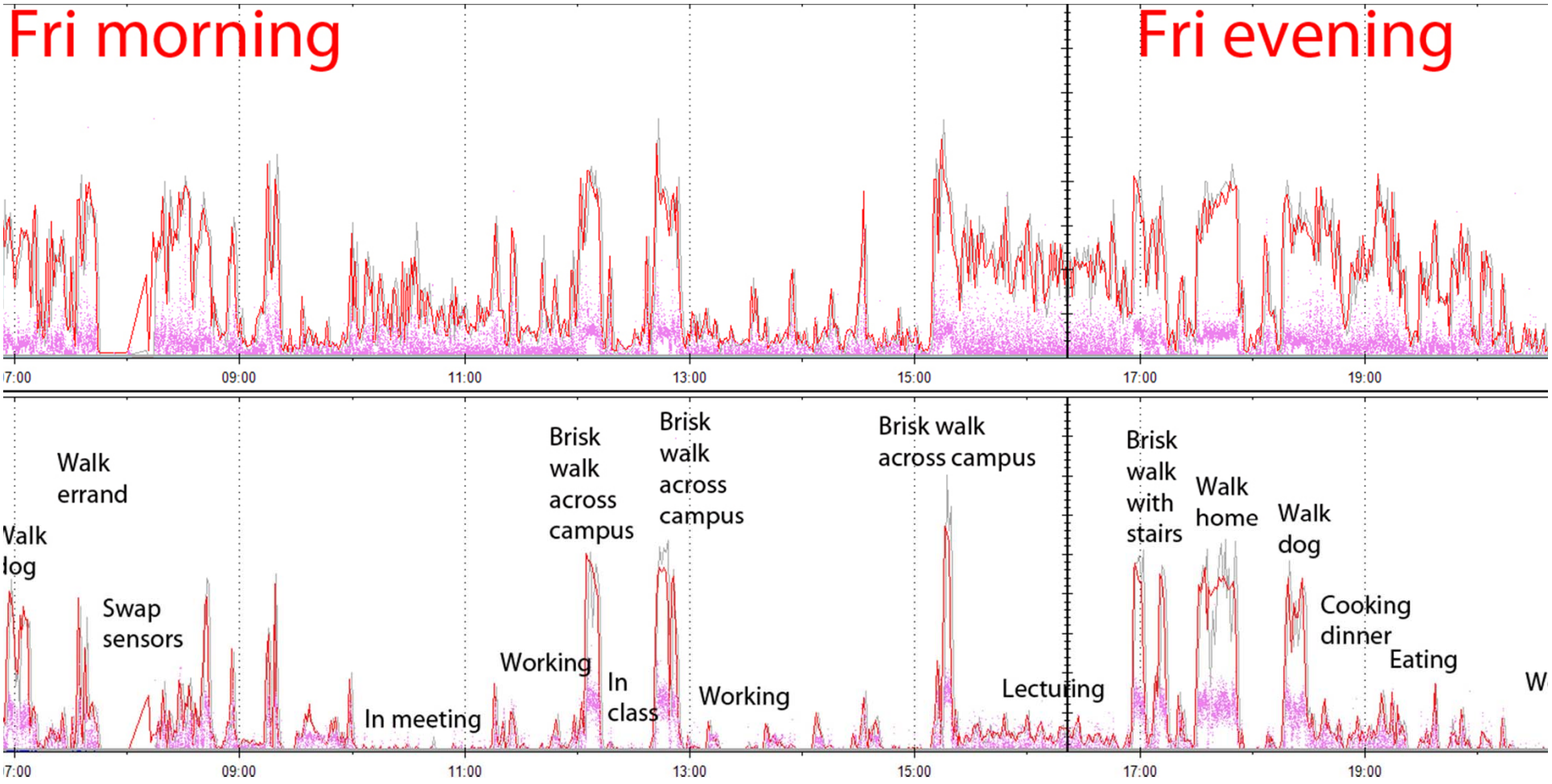
# A bit about accelerometer data

- Lateral (x)
- Longitudinal (y)
- Vertical (z) (out of screen)

# Using accelerometer data

- Computing "counts"
  - Area under the curve
  - Filtering out DC component of signal
  - Filtering out high frequency spikes
  - "Epoch"

# Counts


Fri morning
Fri evening
7:00
09:00
11:00
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15:00
17:00
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Walk
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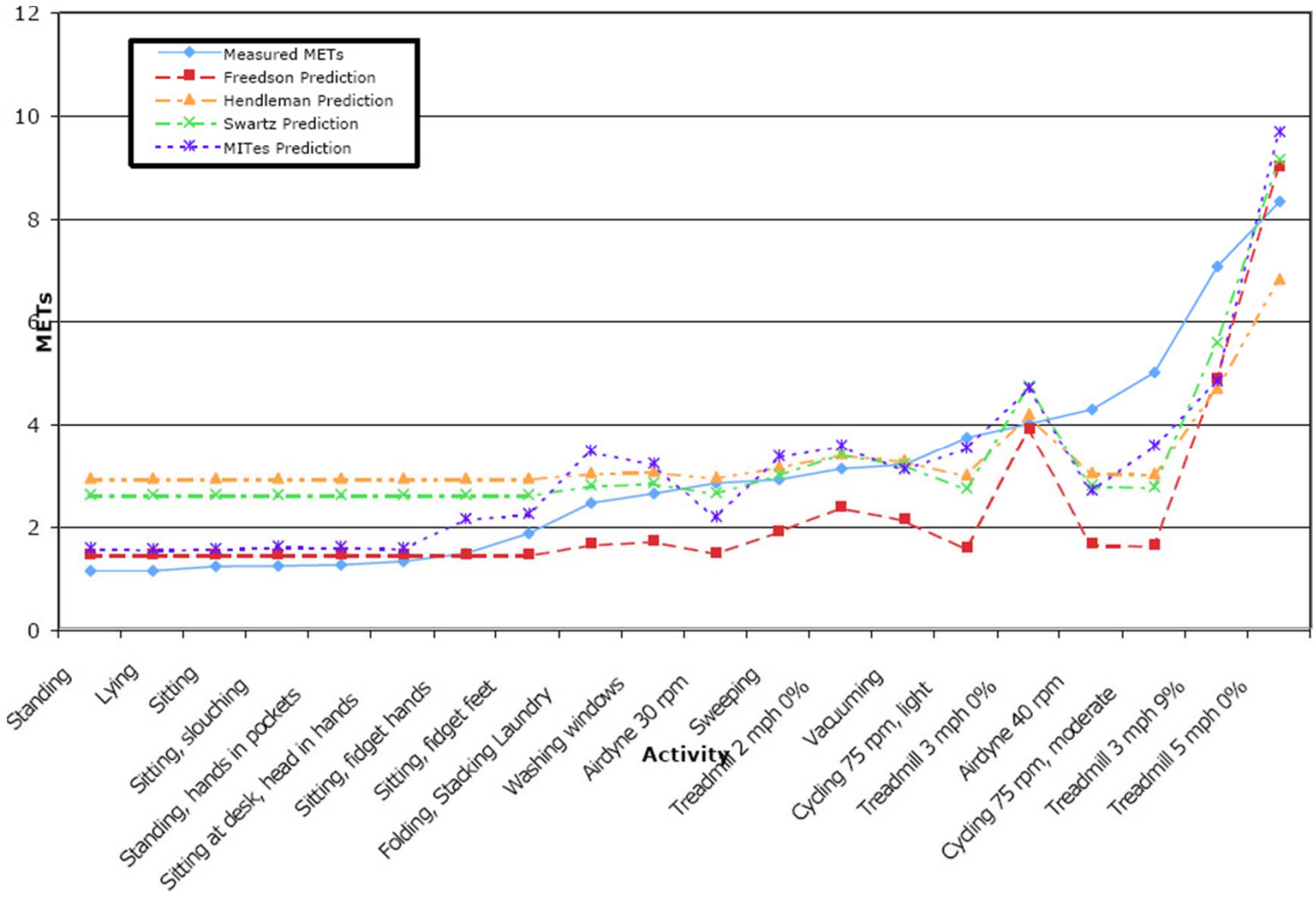
Swap
sensors
In meeting
Working
Brisk
walk
across
campus
In
class
Brisk
walk
across
campus
Working
Brisk walk
across campus
Lecturing
Brisk
walk
with
stairs
Walk
home
Walk
dog
Cooking
dinner
Eating

# Using accelerometer data

- Computing “counts”
- Computing energy expenditure

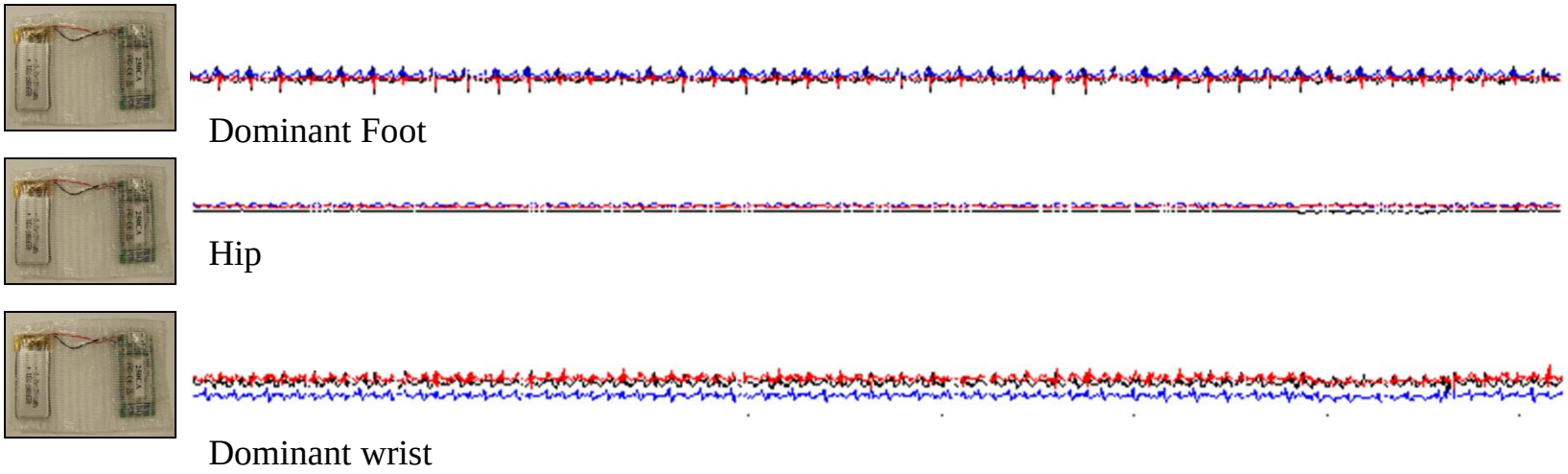
# MITes v. Actigraphs EEE (single linear regression)



# Using accelerometer data

- Computing "counts"
- Computing energy expenditure
- Computing activity type
  - Filter raw data (Note: ALL sensors are noisy!)
  - Compute features
  - Match features to models
  - Models created from training data

# Walking treadmill 4mph 0%



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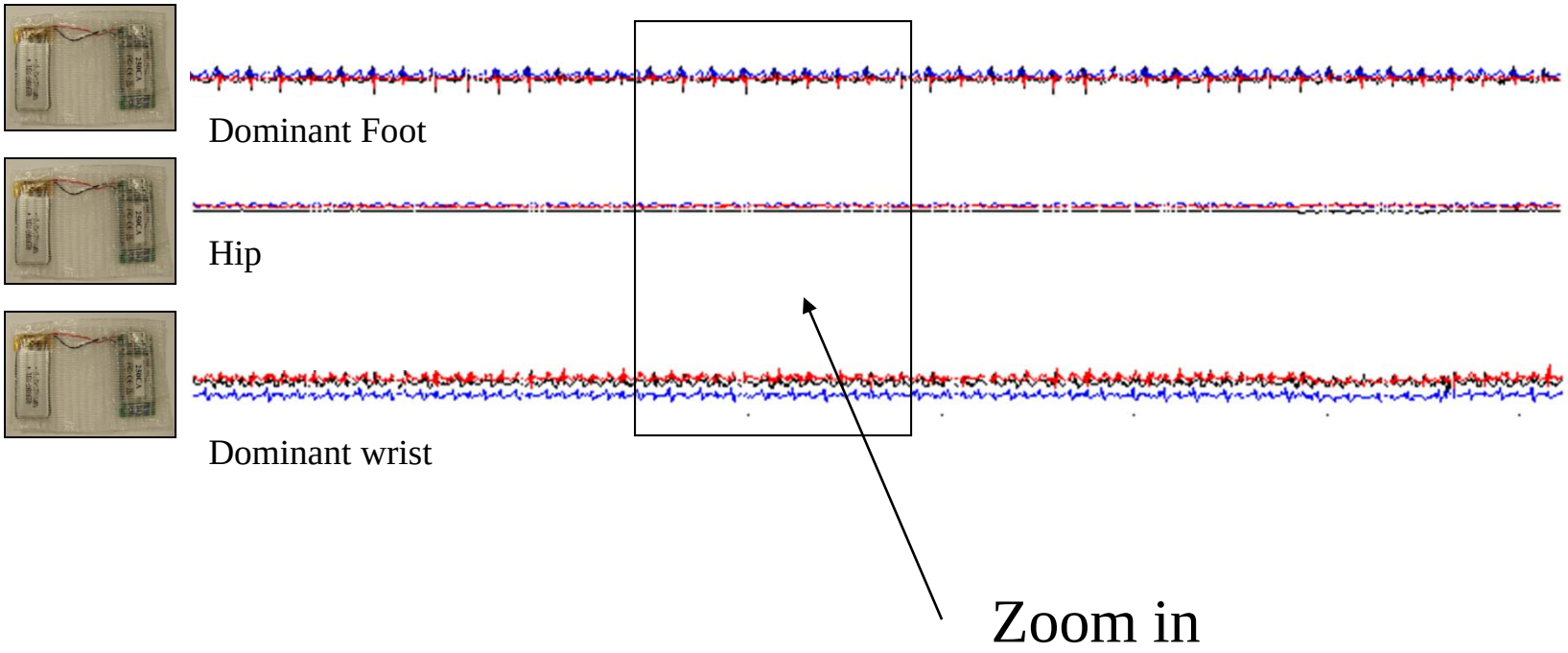
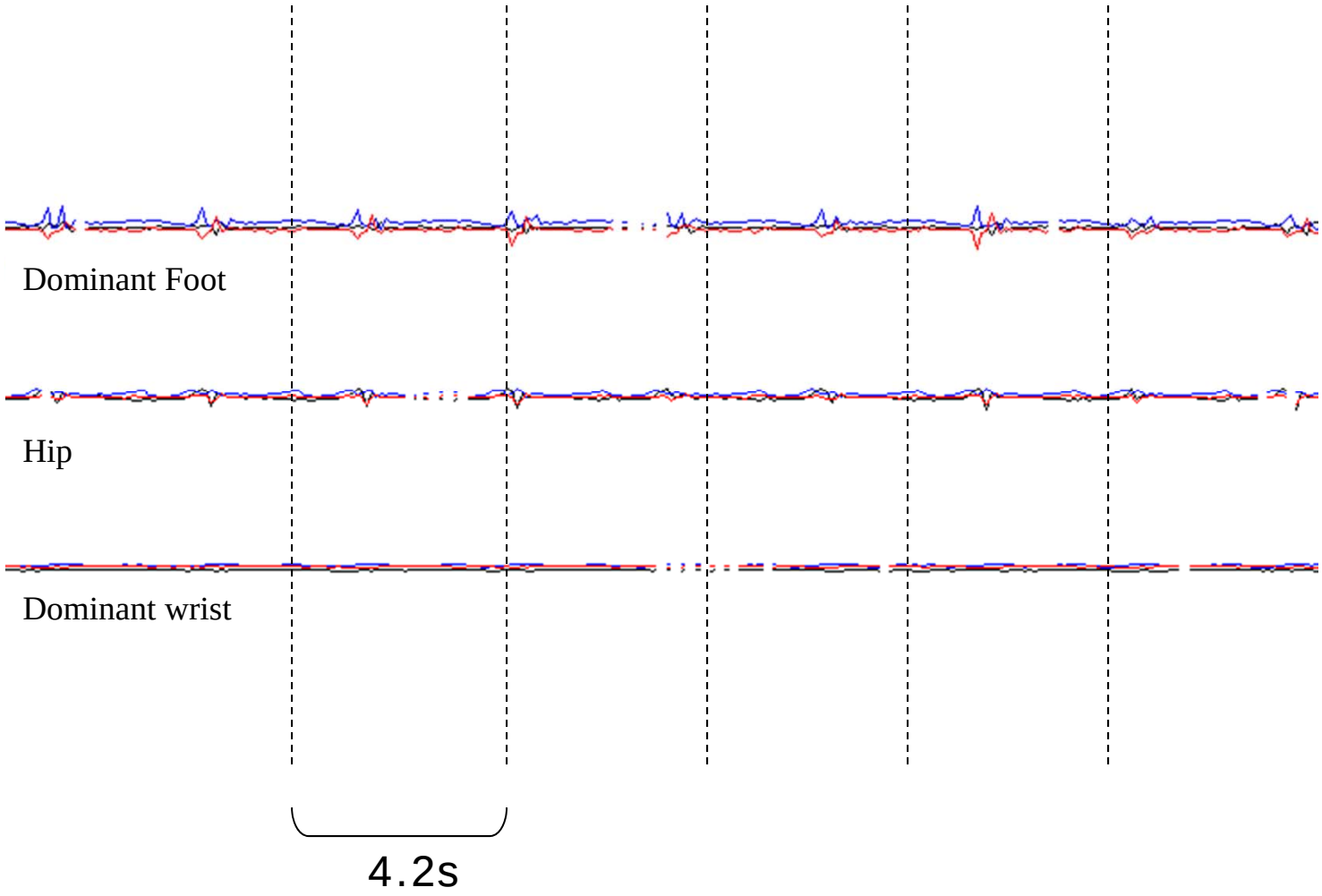
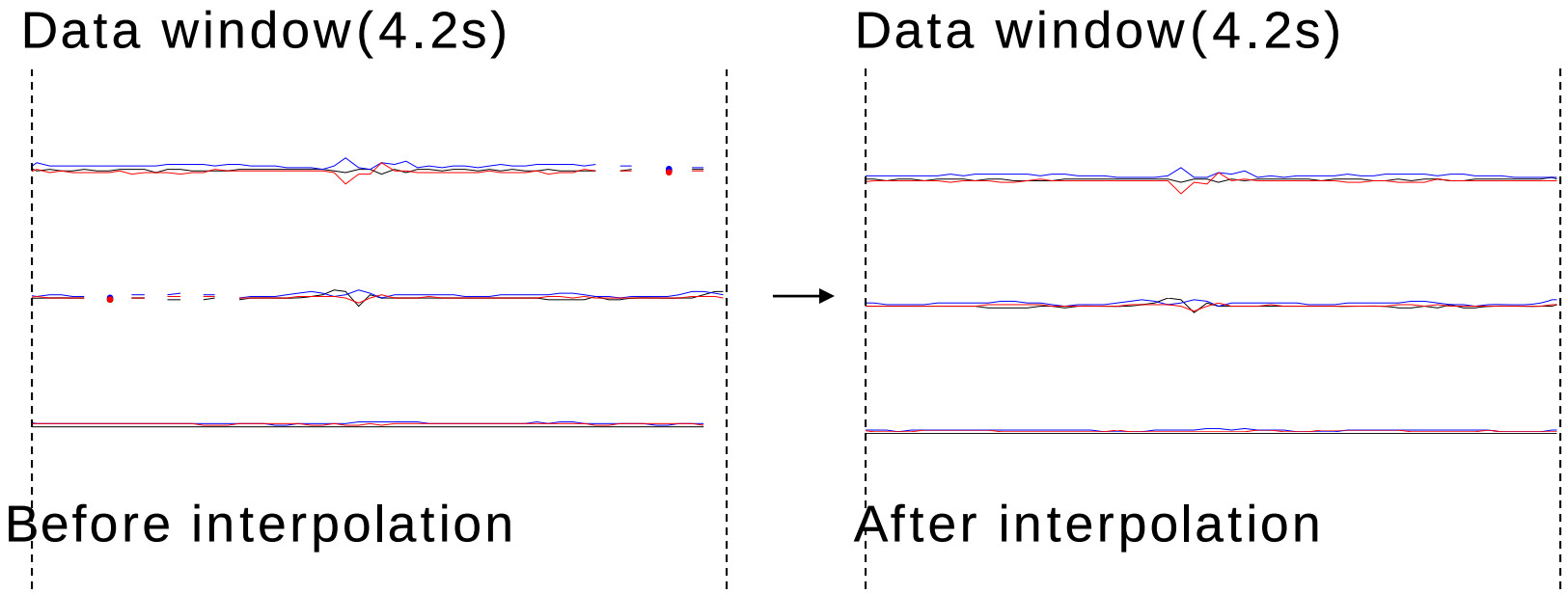


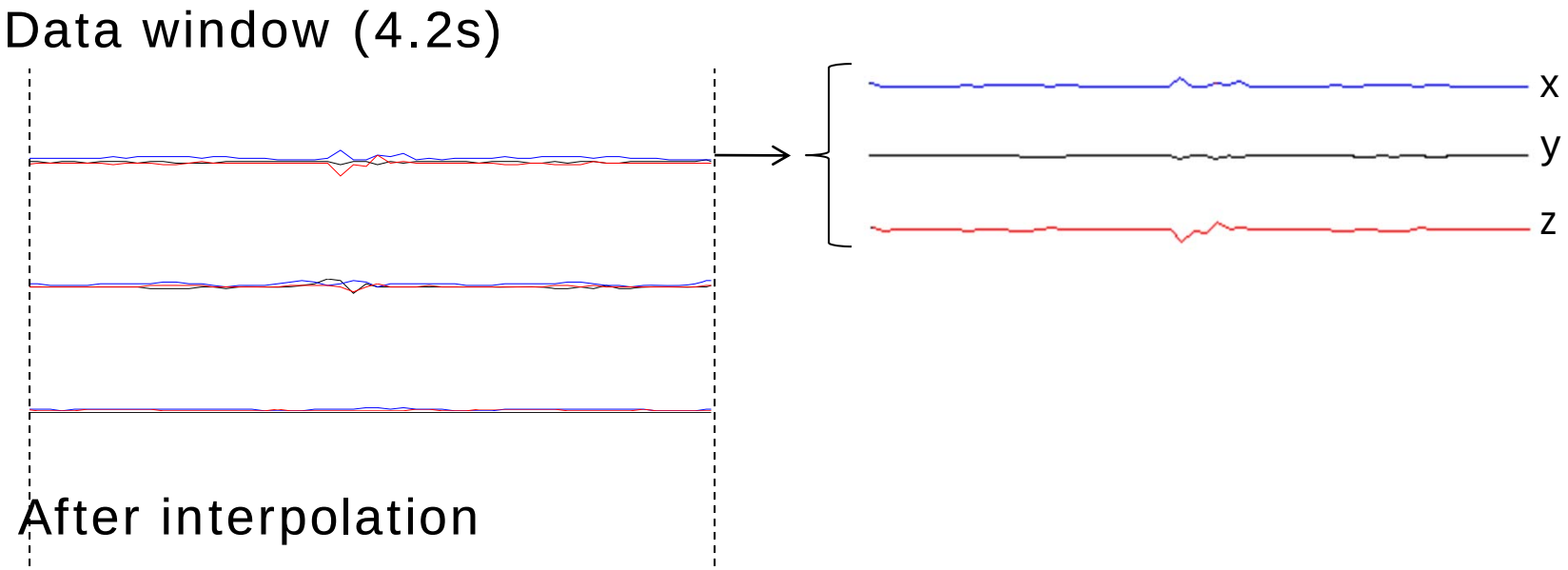
# Segmentation: Sliding windows



# Interpolation: Cubic splines



# Signal processing: Filtering



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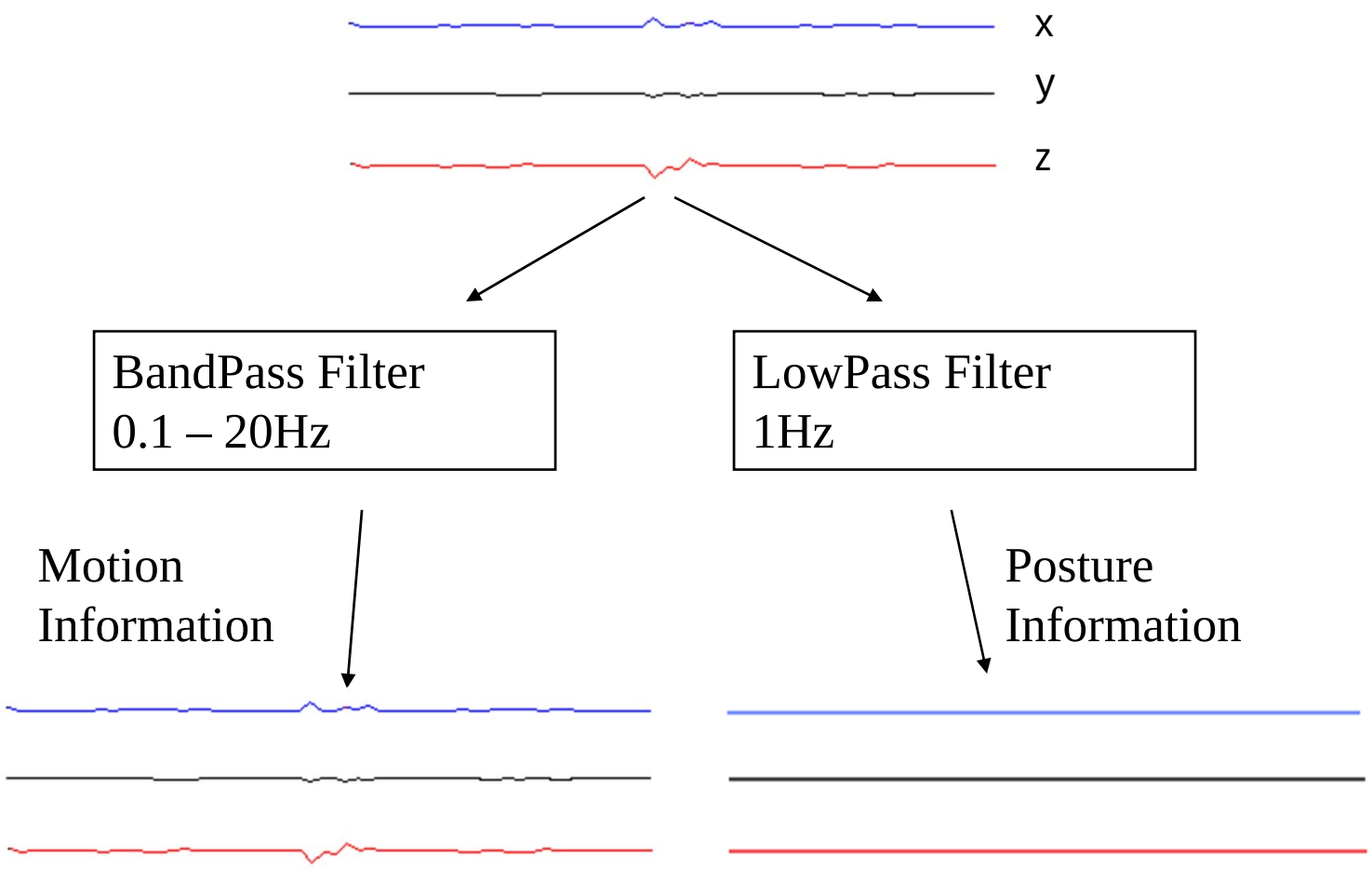


# Feature computation

For each axis, compute features such as...

**Signal variability**
- Variance

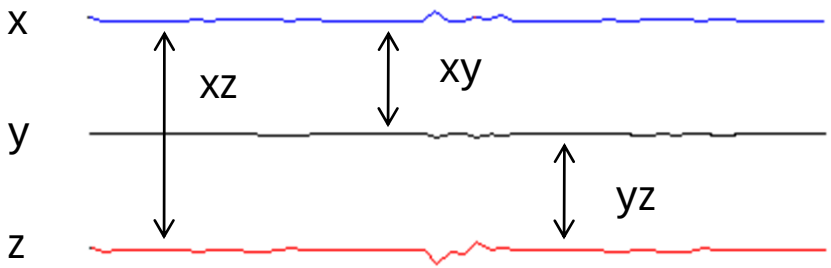
**Posture information**
- Posture distances

**Activity intensity**
- Energy between 0.3-3.5Hz

**Frequency/periodicity of motion**
- Top 5 peaks of the FFT

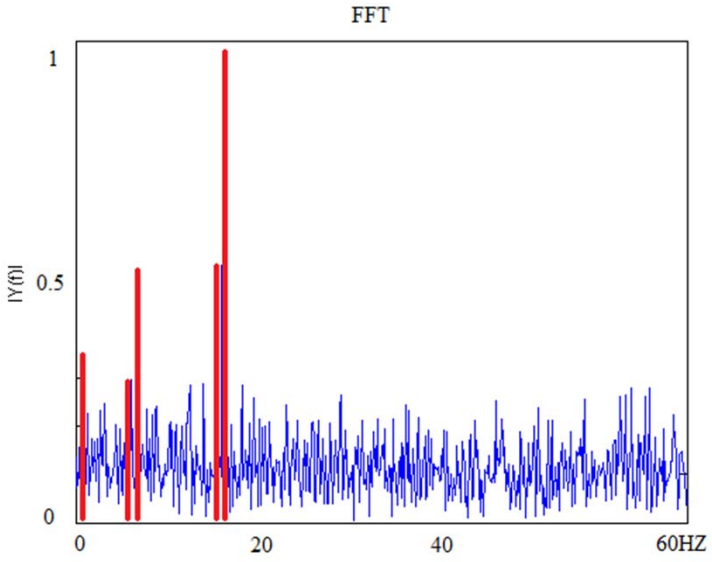
# Time domain features

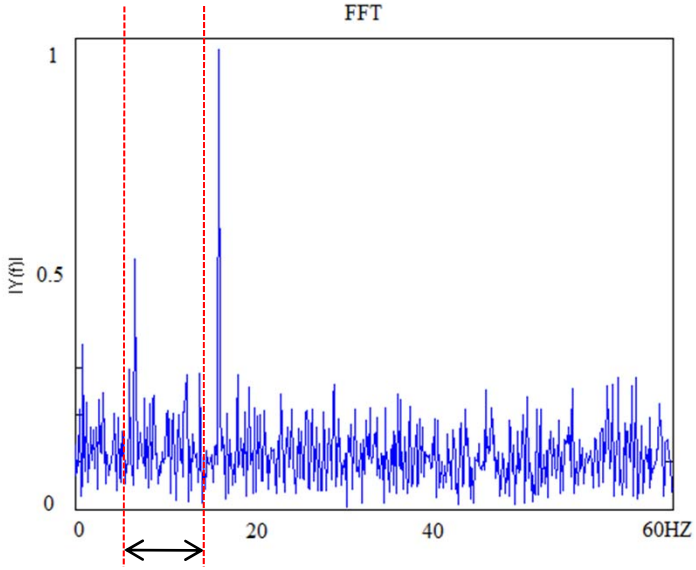

Variance




Posture distances

# Frequency domain features


5 FFT peaks

Freq1,Mag1
Freq2,Mag2,
Freq3,Mag3,
Freq4,Mag4,
Freq5,Mag5

0.3 - 3.5Hz

Band energy

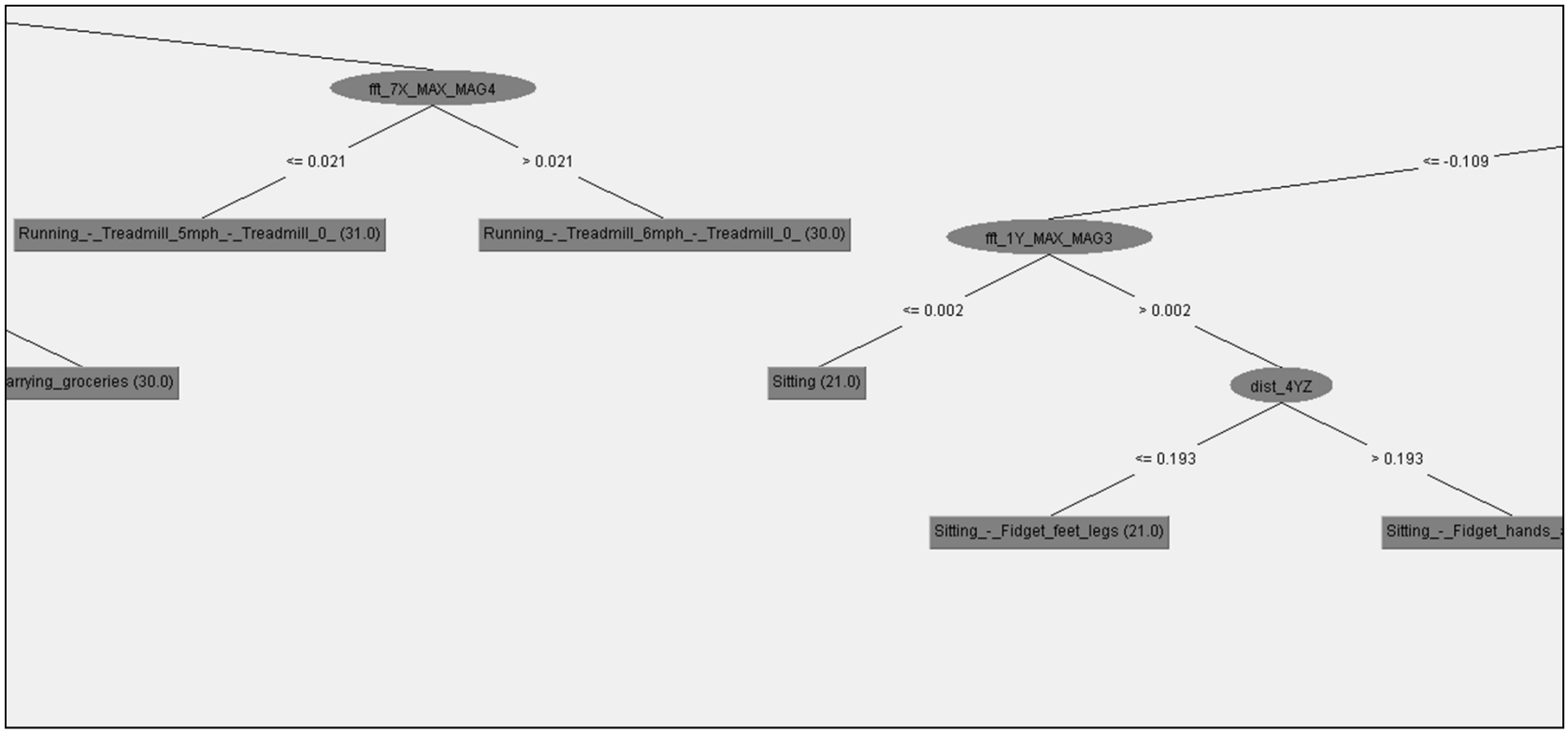
# Training of classifier

ACVar (9)
ACFFTPeaks (90)
ACBandEnergy (9)
DCPostureDist (9)

C4.5
Decision Tree
Classifier

[val_1 val_2 … val_117]
Vector size: 117

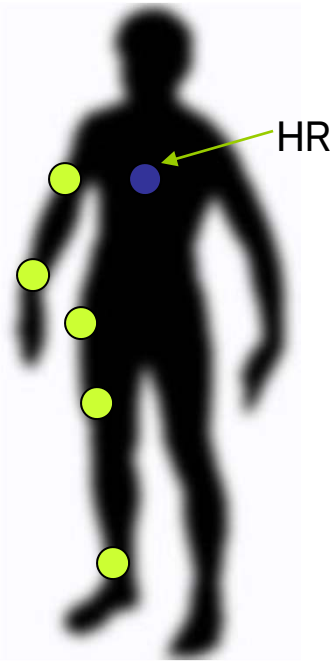
# C4.5 decision tree



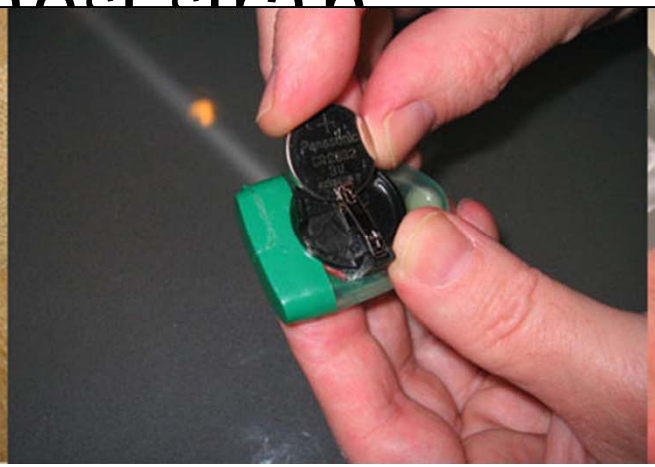

- Fast to run, works reasonably well
- Modest explanatory power (used in ongoing work)

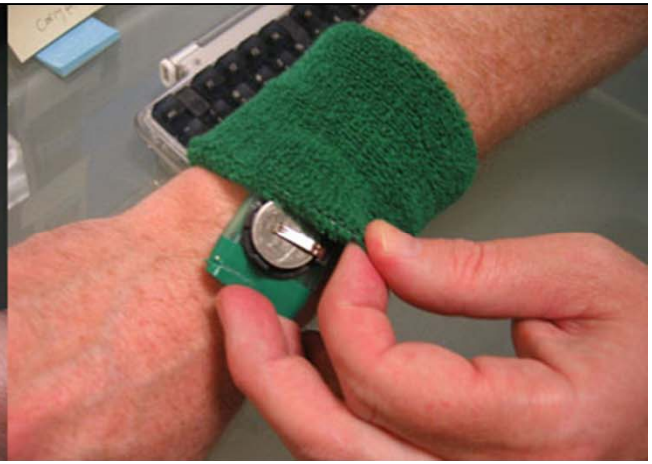
# Experiments: A superset of sensors

- Wrists (1)
- Forearm (1)
- Thigh (1)
- Waist (1)
- Ankle (1)
- Polar HR chest strap









# Target activities (51)

| Type | Intensity |
|---|---|
| Lying down | Not applicable |
| Standing | Not applicable |
| Sitting | Not applicable |
| Sitting | Fidget feet legs |
| Sitting | Fidget hands arms |
| Kneeling | Not applicable |
| Walking | Treadmill 2mph 0% grade |
| Walking | Treadmill 3mph 0% grade |
| Walking | Treadmill 3mph at 3% grade |
| Walking | Treadmill 3mph at 6% grade |
| Walking | Treadmill 3mph at 9% grade |
| Running | Treadmill 4mph at 0% grade |

| Type | Intensity |
|---|---|
| Running | Treadmill 5mph at 0% grade |
| Running | Treadmill 6mph at 0% grade |
| Stairs Ascend stairs | Not applicable |
| Stairs Descend stairs | Not applicable |
| Cycling | 80 rpm, light, moderate, hard |
| Cycling | 60 rpm, light |
| Cycling | 100 rpm, light |
| Rowing | 30 spm, light, moderate, hard |
| Bicep curls | Light, moderate, hard |
| Bench weight lifting | Light, moderate, hard |
| Sit-ups | Not applicable |
| Crunches | Not applicable |

Gymnasium activity subset
3-4 minutes of example data per activity

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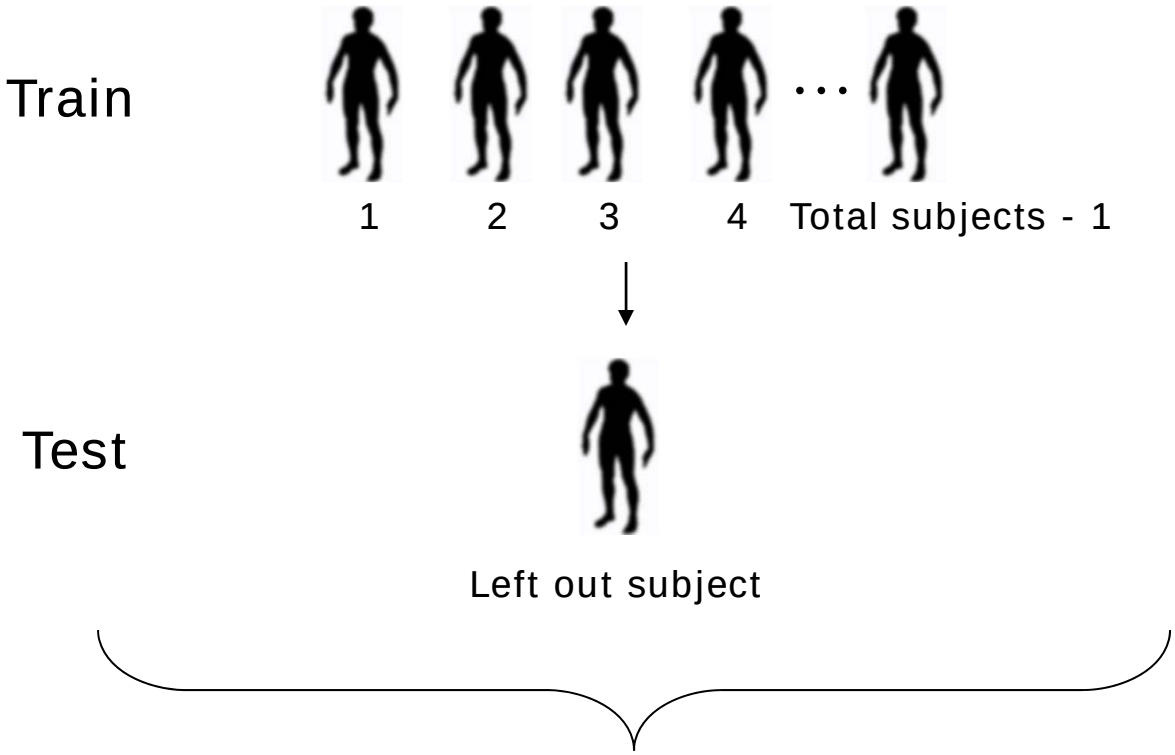
Gymnasium activity subset
3-4 minutes of example data per activity

# Target activities (51)

| Type | Type |
|---|---|
| Carrying groceries | Vacuuming |
| Doing dishes | Walking around block |
| Gardening | Washing windows |
| Ironing | Watching TV |
| Making the bed | Weeding |
| Mopping | Wiping/Dusting |
| Playing videogames | Writing |
| Scrubbing a surface | Taking out trash |
| Stacking groceries | |
| Sweeping | |
| Typing | |

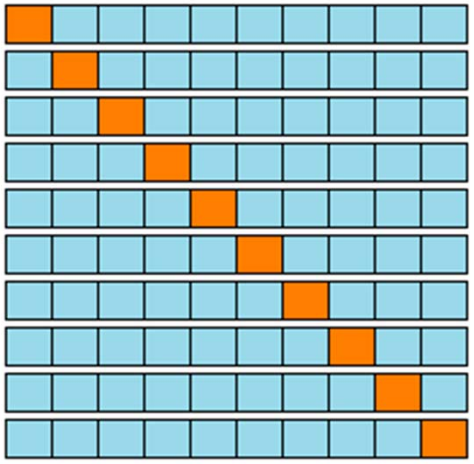
Household activities subset

# Subject independent evaluation



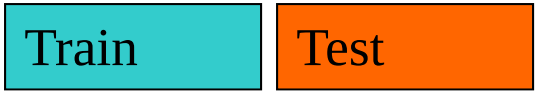

Repeat for as many subjects available and average results

# Subject dependent evaluation



Results

10-fold cross-validation




Repeat for as many subjects we have and average results

# Performance: 51 activities, 20 participants

| Evaluation Method | Accuracy (%) | TP Range (%) | FP Range (%) |
|---|---|---|---|
| Subject dependent | 87.9 | 80 - 93 | 0.1 – 0.2 |
| Subject independent | 50.6 | 34 – 77 | 0.5 – 1.3 |

Random guess: 1.96%

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# Performance: 51 activities

- Best: Postures and exercises
- Weakest: household and resistance activities
- Most confusion:
  - Intensity levels
  - Household
  - Activities involving upper body motion

# Confusion matrix

CONFUSION MATRIX SUBJECT DEPENDENT INVARIANT FEATURES

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | [ | \ | ] | ^ | <-- Classified as |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 266 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | A |
| 1 | 259 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | B |
| 0 | 0 | 228 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | C |
| 1 | 0 | 0 | 234 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | D |
| 0 | 0 | 0 | 0 | 523 | 2 | 4 | 3 | 27 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | E |
| 0 | 0 | 0 | 0 | 0 | 586 | 1 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | F |
| 0 | 0 | 0 | 0 | 1 | 0 | 595 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | G |
| 0 | 0 | 0 | 0 | 13 | 0 | 6 | 1267 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | H |
| 0 | 0 | 0 | 0 | 27 | 3 | 0 | 52 | 533 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | I |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 515 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | J |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 688 | 6 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | K |
| 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 7 | 573 | 58 | 13 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 4 | 6 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | L |
| 1 | 1 | 4 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 56 | 574 | 15 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | M |
| 1 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 19 | 623 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | N |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 1 | 1 | 1 | 470 | 10 | 40 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | O |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 10 | 521 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | P |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 50 | 26 | 449 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Q |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 593 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | R |
| 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 601 | 5 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | S |
| 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 | 0 | 4 | 586 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | T |
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| 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 545 | 29 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | V |
| 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 | 482 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | W |
| 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 655 | 1 | 0 | 0 | 0 | 0 | 0 | X |
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| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 4 | 0 | 587 | 7 | 50 | 0 | [ |
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| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 656 | ^ |

Cycling

Moving weight

Rowing

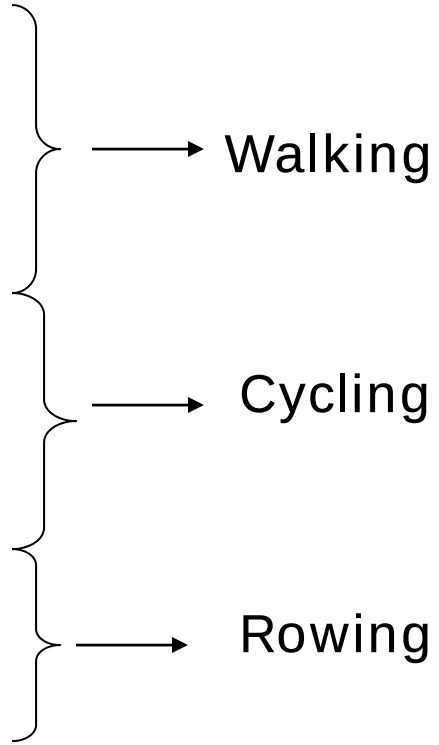
Walking

# Grouping intensities, performance improves

Walking Treadmill 2mph grade 0
Walking Treadmill 3mph grade 0
Walking Treadmill 3mph grade 4
Walking Treadmill 3mph grade 8
Walking Treadmill 3mph grade 12
Walking Treadmill 4mph Treadmill 0

Cycling light 60 rpm
Cycling light 80 rpm
Cycling light 100 rpm
Cycling mod 80 rpm
Cycling hard 80 rpm

Rowing light 30 spm
Rowing mod 30 spm
Rowing hard 30 spm



# Performance: Activity subsets

| Activities to recognize | Total | Activities Included |
|---|---|---|
| All | 51 | All 51 activities |
| All with no intensities | 31 | No intensity levels for<br>Bicep curls, bench weight lifting, walking, running, cycling, rowing, and sitting |
| Postures, ambulation and two MET intensity categories | 11 | Lying down, sitting, standing, kneeling, walking (2, 3mph), running (4,5, and 6 mph), moderate, vigorous |
| Postures and ambulation with no intensity | 8 | Lying down, sitting, standing, kneeling, walking, running, ascending stairs, descending stairs |
| Postures | 4 | Lying down, sitting, standing, kneeling |

# Performance: Activity subsets

| | | Subject Dependent | Subject Independent |
|---|---|---|---|
| **Activities to recognize** | **Random Guess (%)** | **Total Accuracy (%)** | **Total Accuracy (%)** |
| **All (51)** | 1.9% | 87.9 | 50.6 |
| **All with no intensities (31)** | 3.2% | 91.4 | 72.0 |
| **Postures, ambulation and two MET intensity categories (11)** | 9% | 96.5 | 81.3 |
| **Postures and Ambulation with no intensity (8)** | 12.5% | 98.4 | 92.9 |
| **Postures (4)** | 25% | 99.3 | 98.0 |

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If activity intensities are merged,
subject independent accuracy increases to 72%

# Performance: Activity subsets

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# 51 activities: Sensor subsets

| Sensor Combination | Subject Dependent Accuracy |
|---|---|
| All sensors | 87.9 ± 2.0 |
| Hip + DWrist + DFoot | -1.8 % |
| Hip + DFoot | -3.5 % |
| Hip + DWrist | -4.9 % |
| DWrist + DThigh | -7.2 % |
| DWrist + DFoot | -7.7 % |
| Hip | -8.4 % |
| DFoot | -14.9 % |
| DThigh | -15.1 % |
| DUpperArm | -15.4 % |
| DWrist | -19.6 % |

| Sensor Combination | Subject Independent Accuracy |
|---|---|
| All sensors | 50.6 ± 5.2 |
| Hip + DWrist + DFoot | -7.9 % |
| DWrist + DThigh | -8.1 % |
| DWrist + DFoot | -13.0 % |
| Hip + DWrist | -15.6 % |
| Hip + DFoot | -18.9 % |
| DUpperArm | -26.5 % |
| DWrist | -27.7 % |
| Hip | -28.5 % |
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| DFoot | -34.8 % |
| DThigh | -42.7 % |

Matches intuition: capture upper & lower body motion

# Listener for changes (accel)

```
public void setupSensorListener() {
  SensorManager sm = (SensorManager)getSystemService(Context.SENSOR_SERVICE);
  int sensorType = Sensor.TYPE_ACCELEROMETER;
  sm.registerListener(mySensorEventListener,
                      sm.getDefaultSensor(sensorType),
                      SensorManager.SENSOR_DELAY_NORMAL);
}

final SensorEventListener mySensorEventListener = new SensorEventListener() {
  public void onSensorChanged(SensorEvent sensorEvent) {
    if (sensorEvent.sensor.getType() == Sensor.TYPE_ACCELEROMETER) {
      float xAxis_lateralA = sensorEvent.values[0];
      float yAxis_longitudinalA = sensorEvent.values[1];
      float zAxis_verticalA = sensorEvent.values[2];
      // TODO apply the acceleration changes to your application.
    }
  }
};
```

# Orientation

```
field sensors
float[] accelerometerValues;
float[] magneticFieldValues;

final SensorEventListener myAccelerometerListener = new SensorEventListener() {
  public void onSensorChanged(SensorEvent sensorEvent) {
    if (sensorEvent.sensor.getType() == Sensor.TYPE_ACCELEROMETER)
      accelerometerValues = sensorEvent.values;
  }

  public void onAccuracyChanged(Sensor sensor, int accuracy) {}
};

final SensorEventListener myMagneticFieldListener = new SensorEventListener() {
  public void onSensorChanged(SensorEvent sensorEvent) {
    if (sensorEvent.sensor.getType() == Sensor.TYPE_MAGNETIC_FIELD)
      magneticFieldValues = sensorEvent.values;
  }

  public void onAccuracyChanged(Sensor sensor, int accuracy) {}
};
```

# Orientation

```
public void connectListeners() {
  SensorManager sm = (SensorManager)getSystemService(Context.SENSOR_SERVICE);
  Sensor aSensor = sm.getDefaultSensor(Sensor.TYPE_ACCELEROMETER);
  Sensor mfSensor = sm.getDefaultSensor(Sensor.TYPE_MAGNETIC_FIELD);

  sm.registerListener(myAccelerometerListener,
                      aSensor,
                      SensorManager.SENSOR_DELAY_UI);

  sm.registerListener(myMagneticFieldListener,
                      mfSensor,
                      SensorManager.SENSOR_DELAY_UI);
}
```

# Grabbing data from Internet

- WebKit
- Integration with javascript
- Standard network services

- Take a look at example code from text...