# Hips do lie! A position-aware mobile fall detection system

Christian Krupitzer, Timo Sztyler, Janick Edinger, Martin Breitbach,
Heiner Stuckenschmidt, and Christian Becker

AACSB ACCREDITED
EFMD EQUIS ACCREDITED
Accredited by Association of MBAs
UNIVERSITY OF MANNHEIM

# Proposition

> *So be wise and keep on*
> *Reading the signs of my body*
> *And I'm on tonight you know*
> *my **hips don't lie.***

SHAKIRA: "HIPS DON'T LIE" (2005)

# Alternative Proposition

Observation:

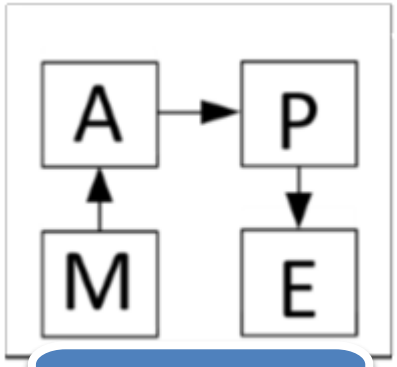
*Hips might not be the most reliable source of information*

# Research Question

*How can a mobile fall detection system react to changes in the sensor position?*

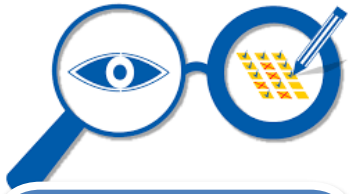
# What to Expect from this Presentation?

Fall Detection in a Nutshell

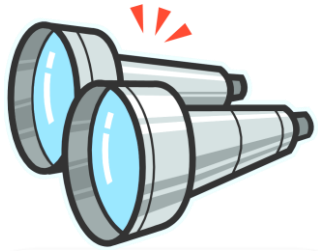



Self-Adaptive Fall Detection

Implemen-tation

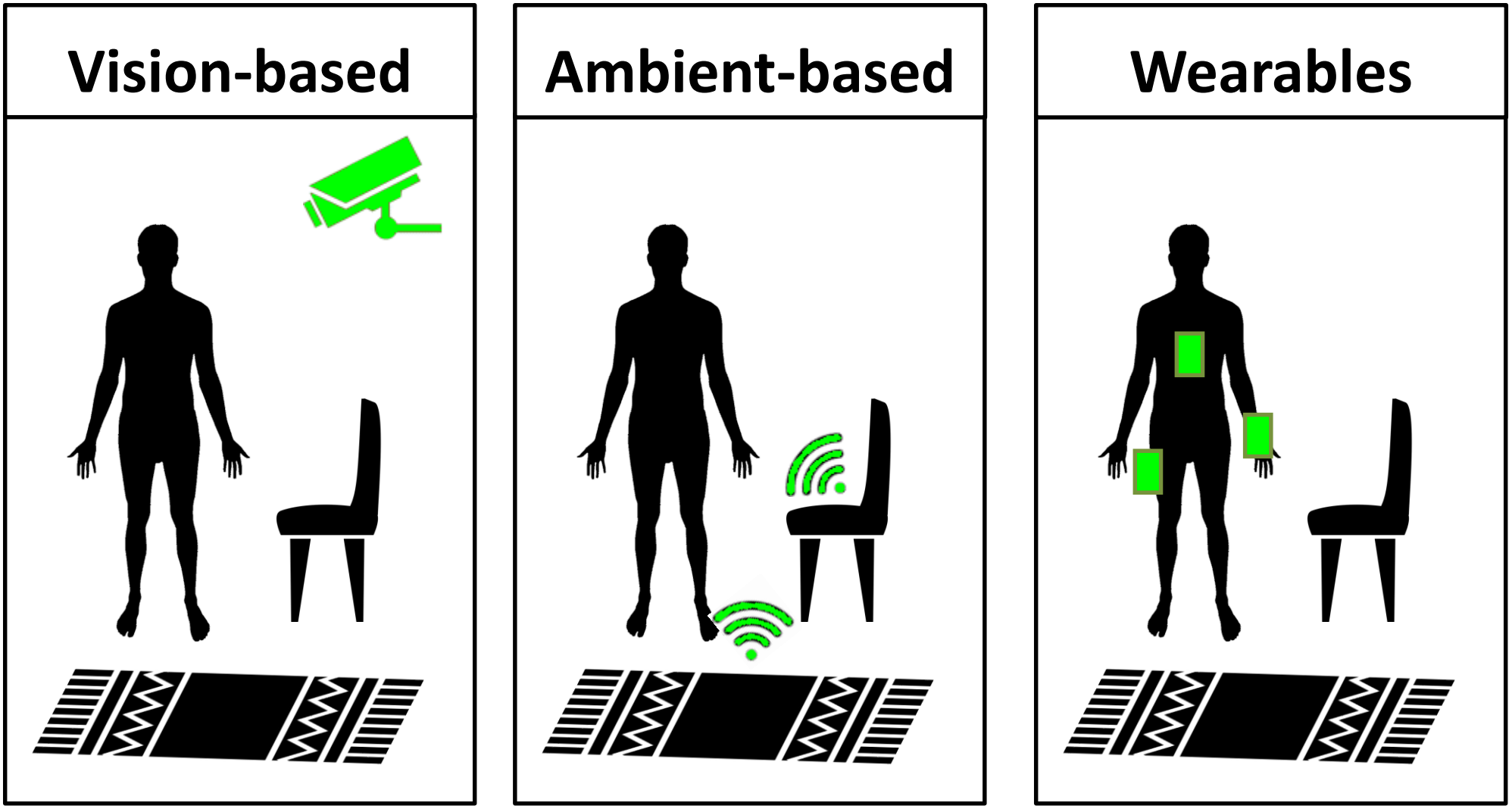


Case Studies



Future Work

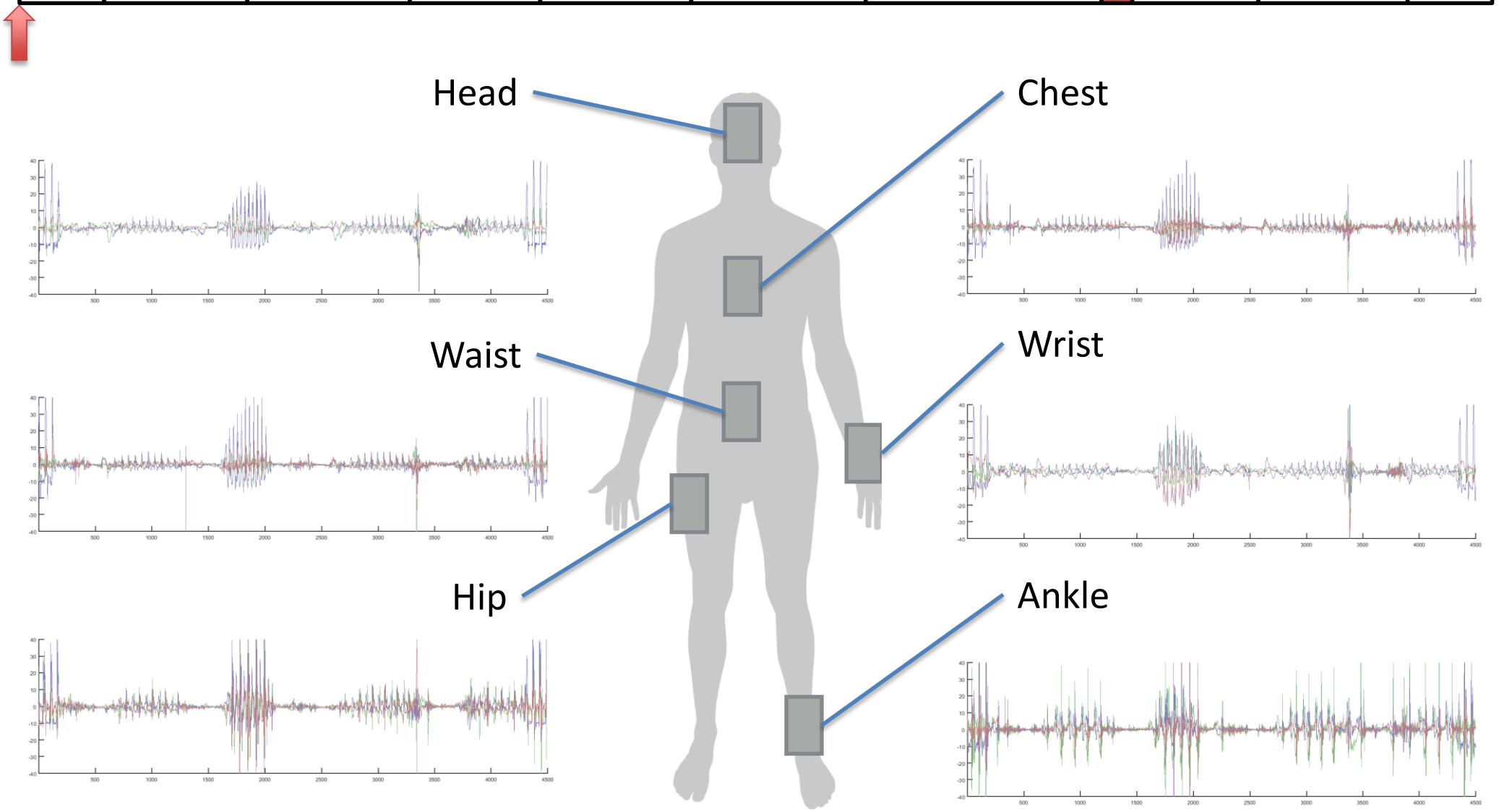
# Fall Detection Systems



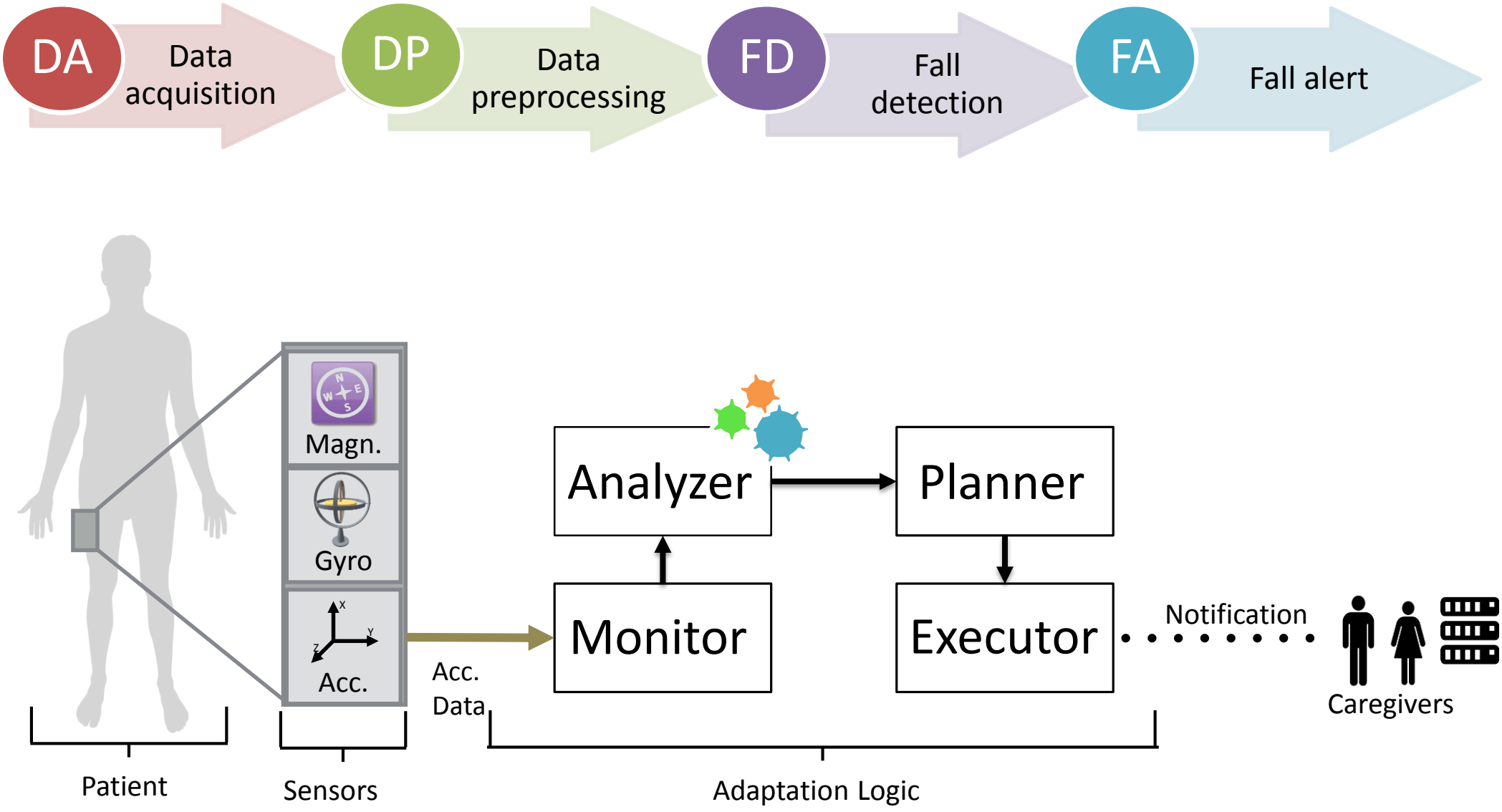

Mubashir, Shao & Seed: A survey on fall detection: Principles and approaches. In: Neurocomputing, Volume 100, 2013, Pages 144-152.

# Positions of Wearables for Fall Detection

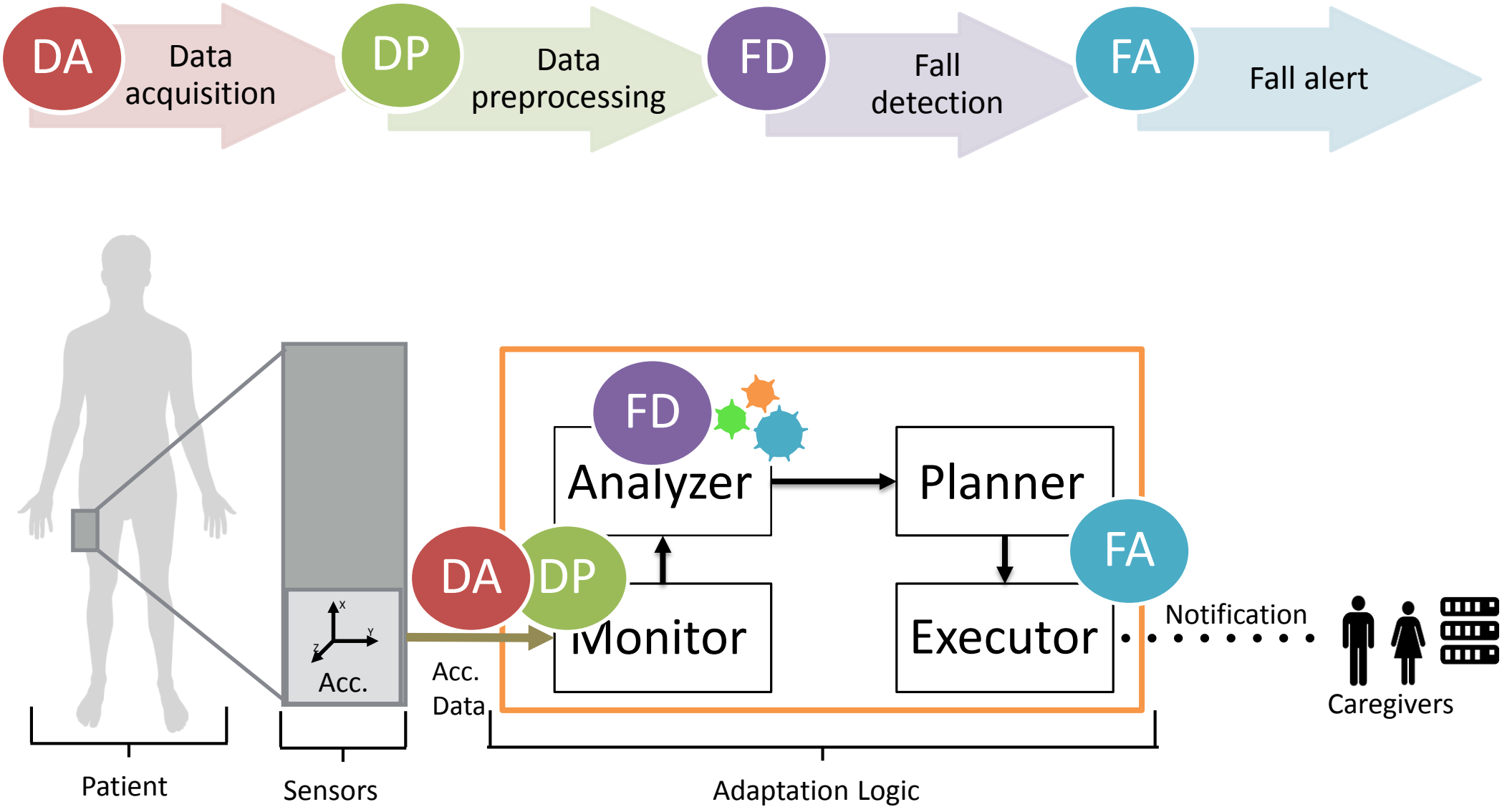
| Jump | Sit | Walk | Bend | Run | Sit | Walk | Fall | Get up | Walk | Jump |
|---|---|---|---|---|---|---|---|---|---|---|



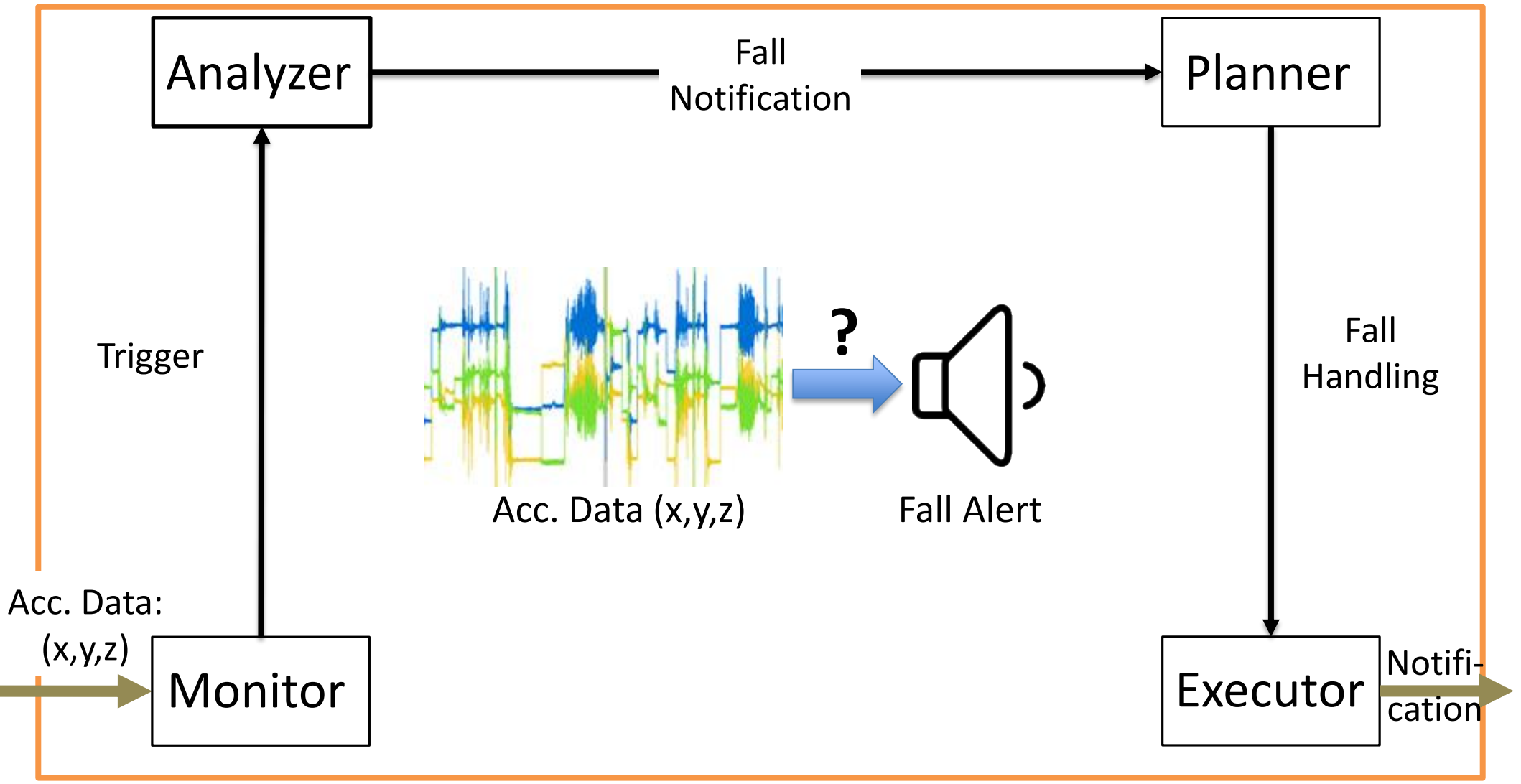
# Self-Adaptive Fall Detection



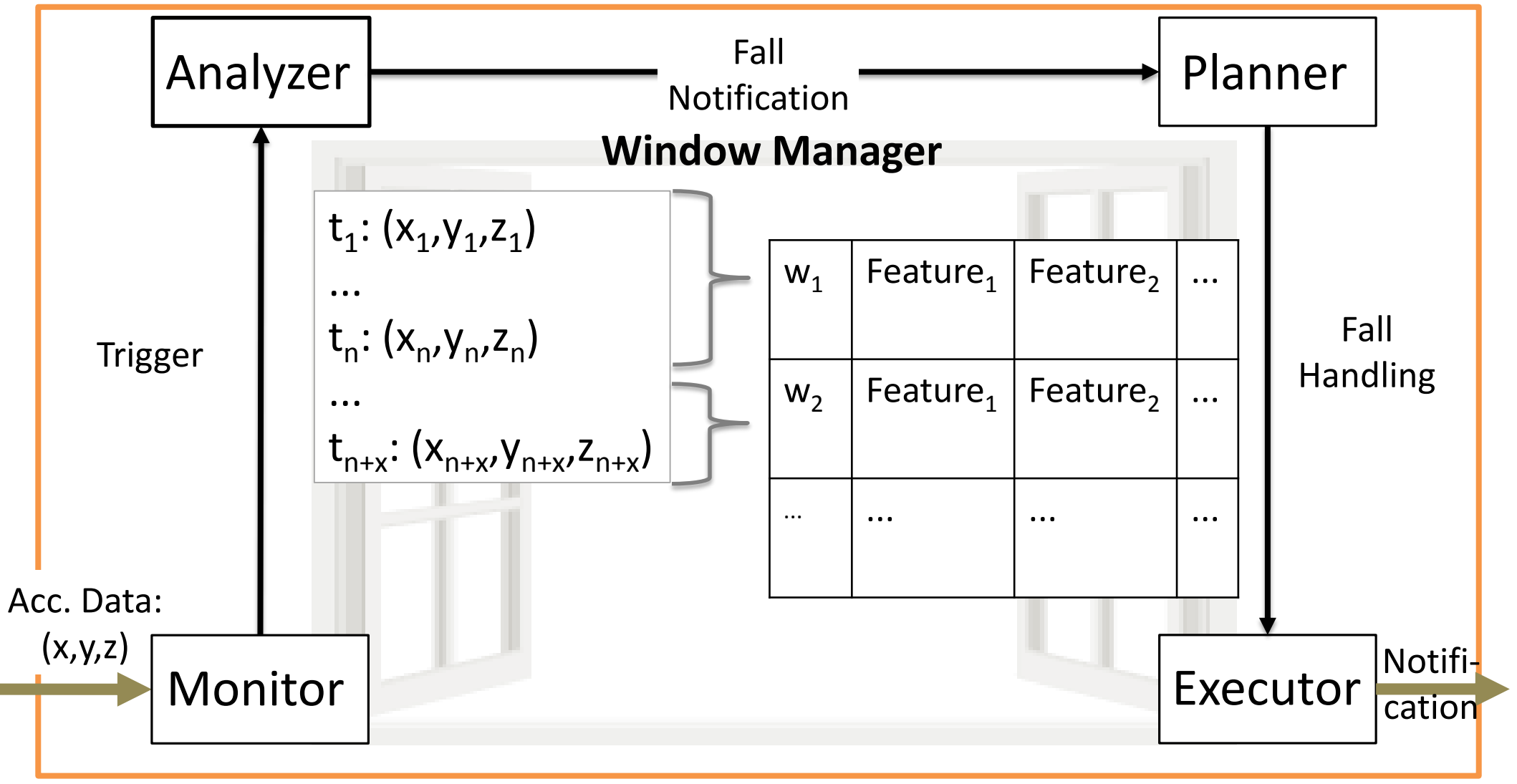
# Self-Adaptive Fall Detection



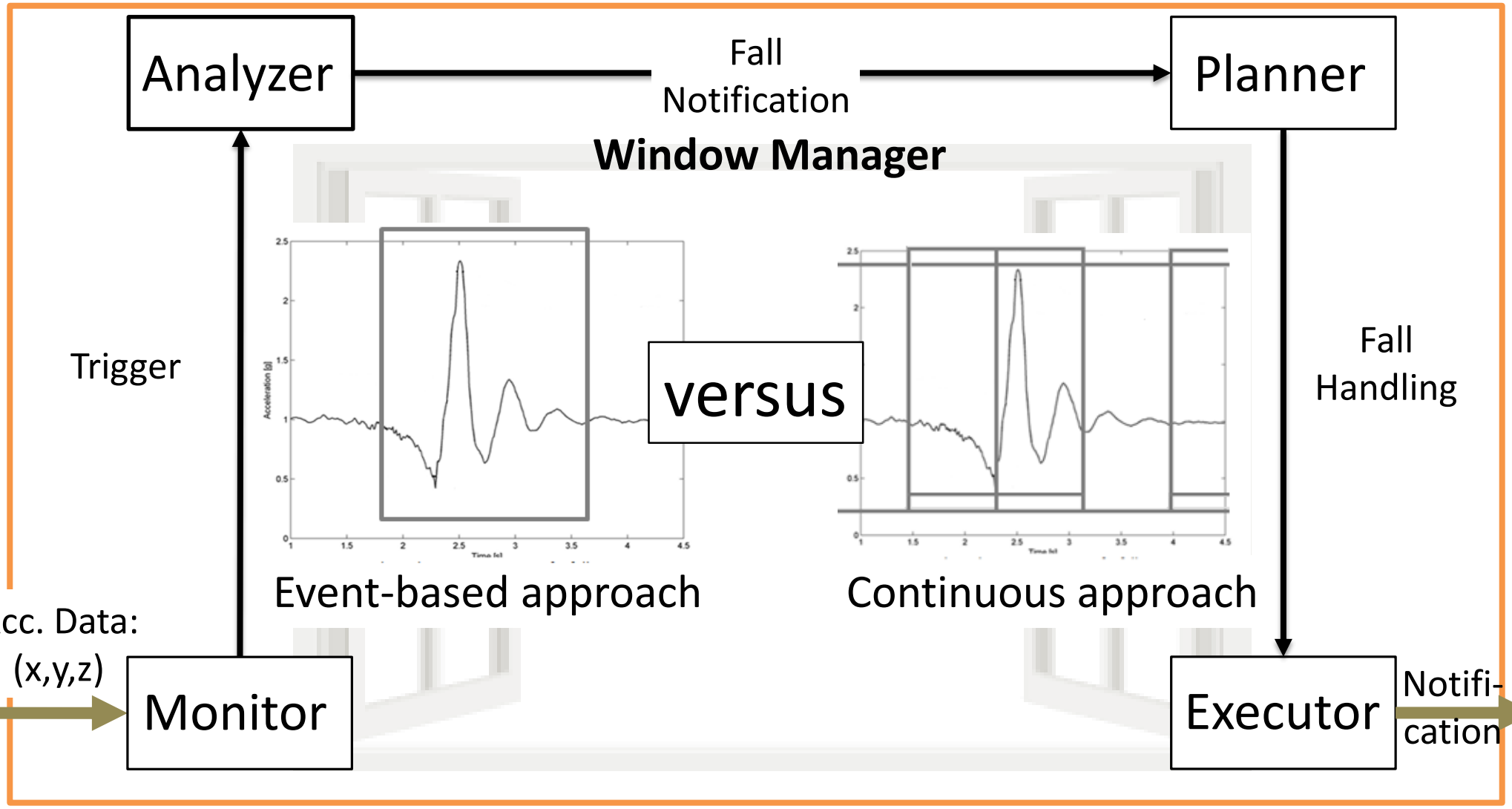
# Implementation: Adaptation Logic



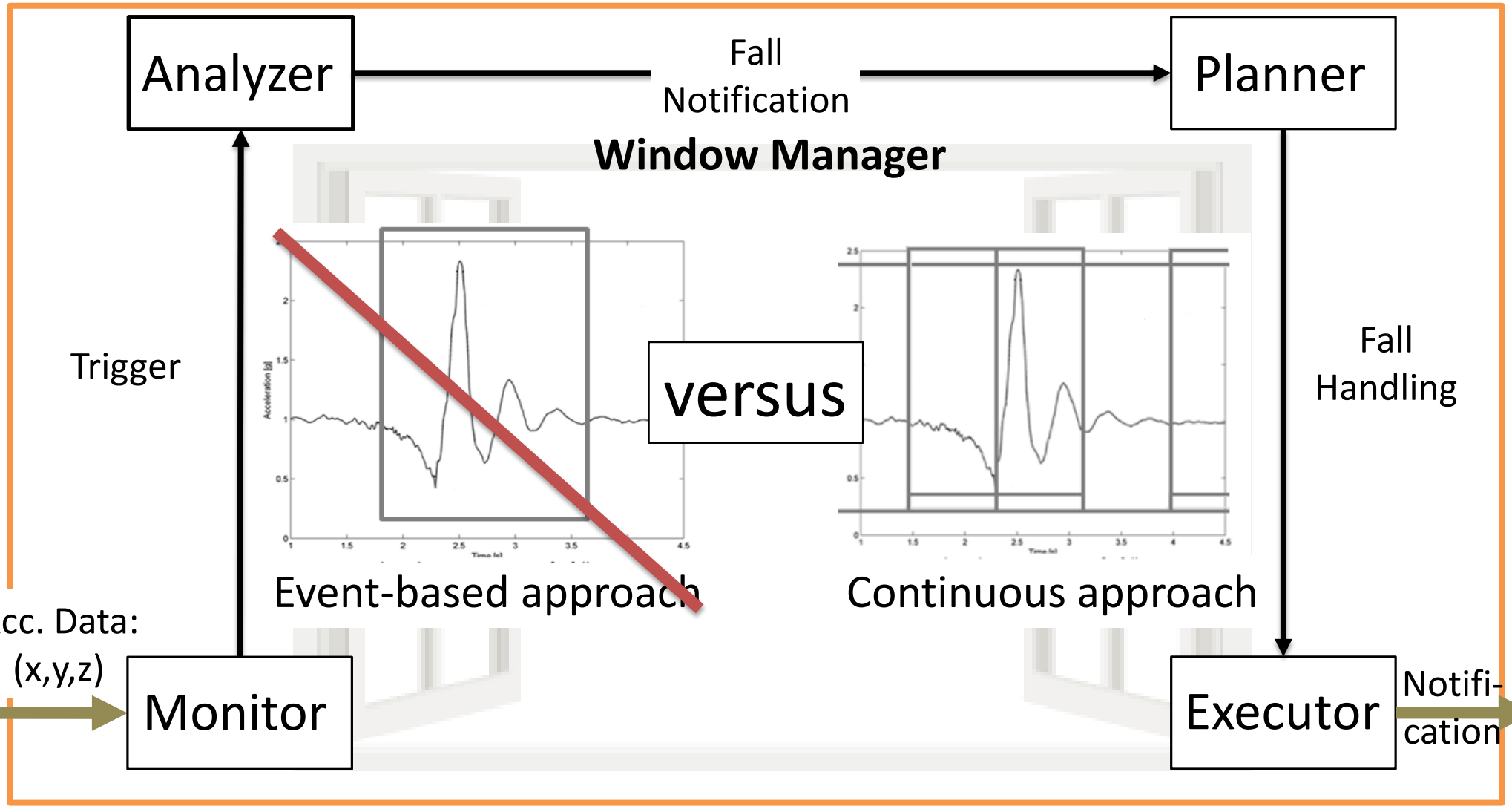
# Implementation: Adaptation Logic



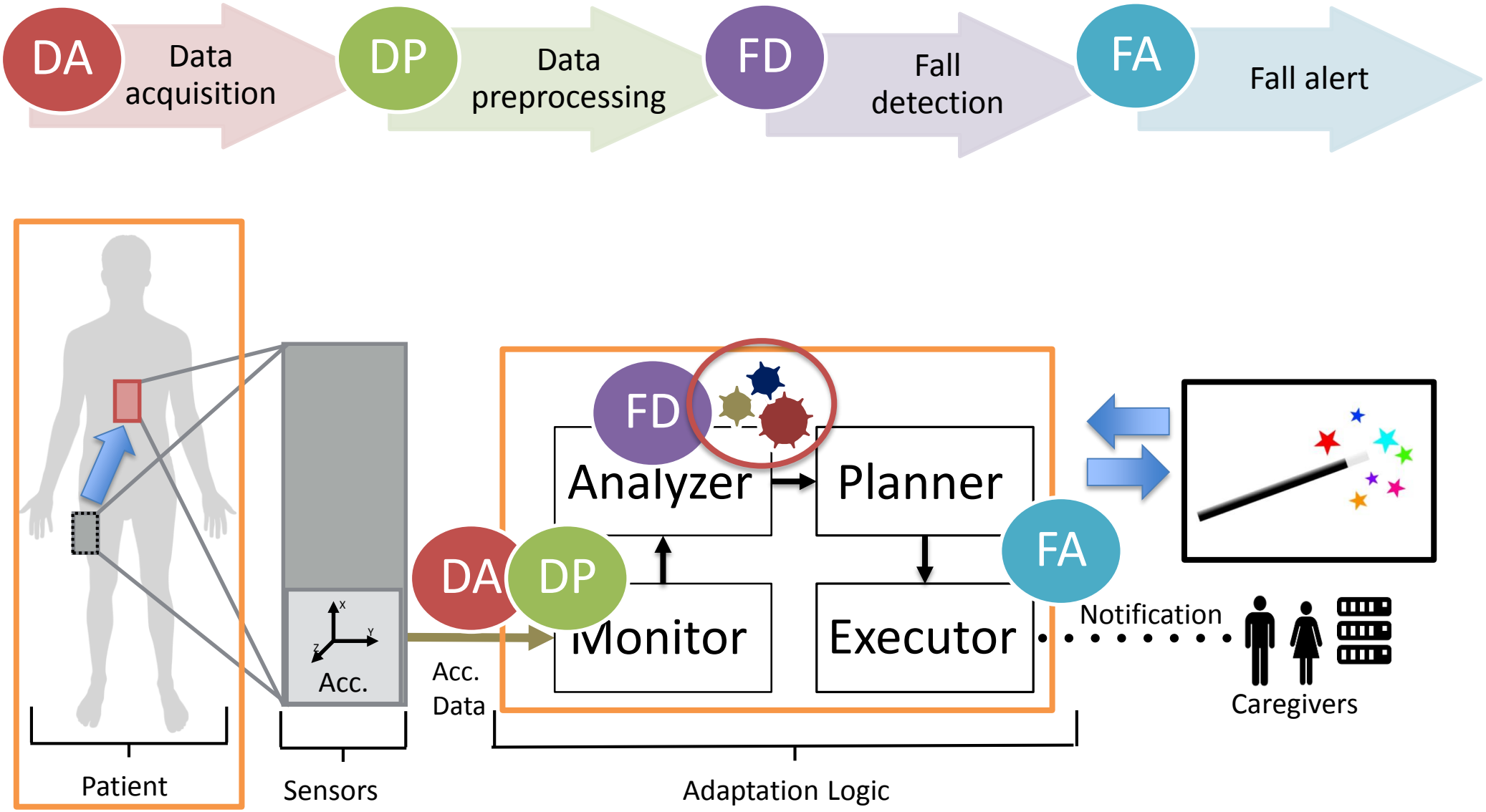
# Implementation: Adaptation Logic



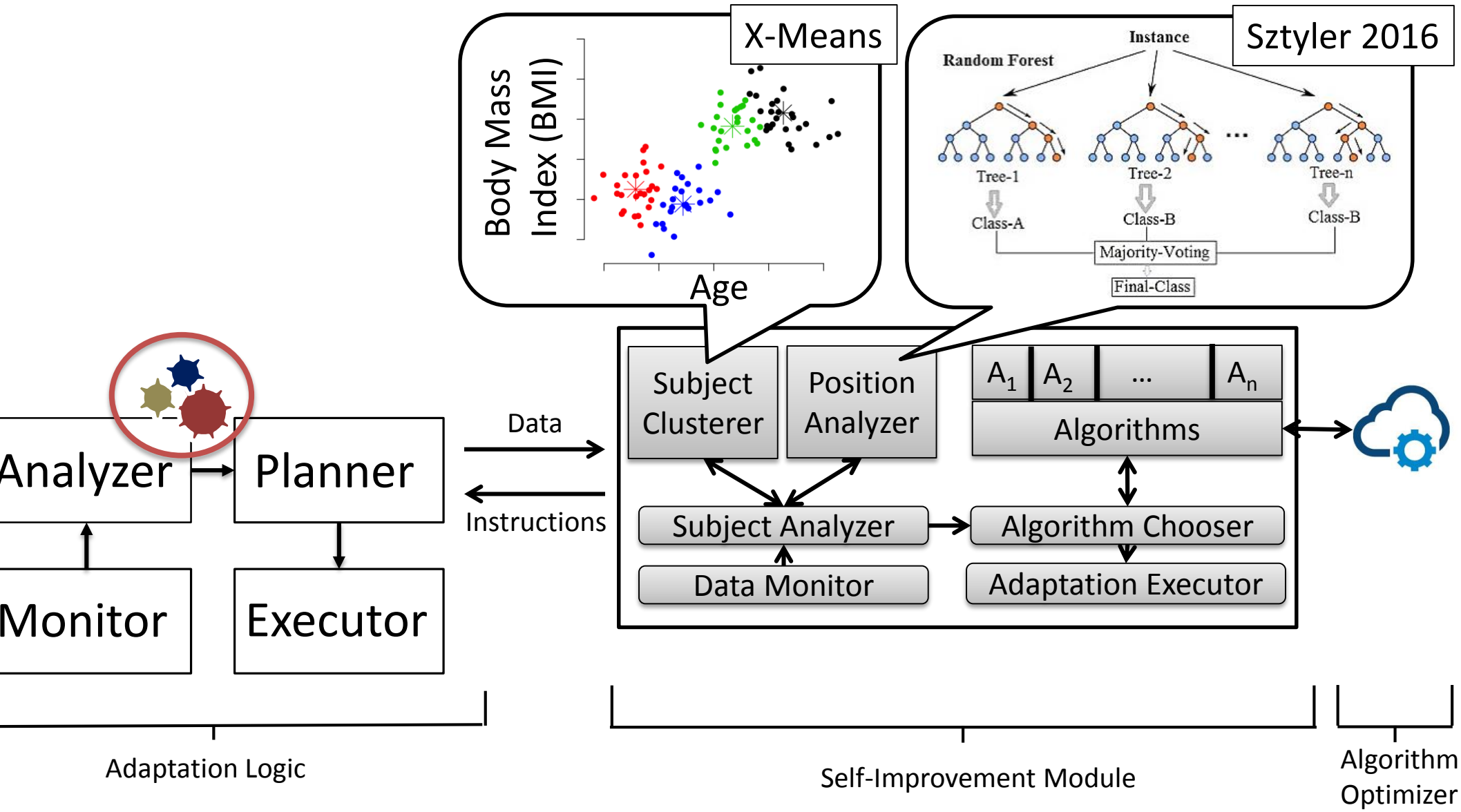
# Implementation: Adaptation Logic



# Self-Adaptive Fall Detection



# Self-Improving Fall Detection



# Evaluation Setting

Propositions:

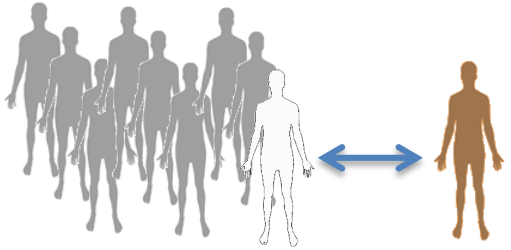
1. Origin of data matters
2. Position matters
3. Self-Improvement matters

Algorithms:

- Classification-based:
  SVM, ANN, Random Forest, k-NN,
  J48 Decision Tree
- Threshold-based (params learned)
- Supports deep learning,
  but dataset is too small

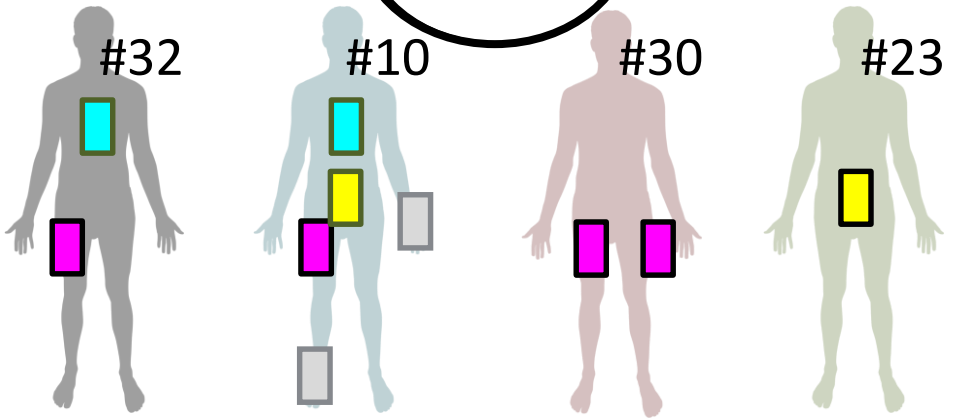
Training of models / evaluation:
Leave-one-subject-out approach

Training Set

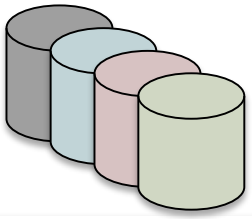


Testing Set

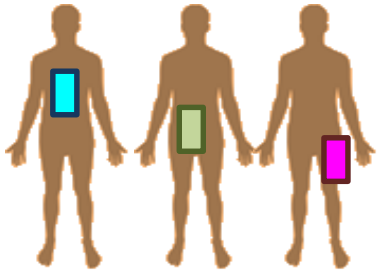
Data:



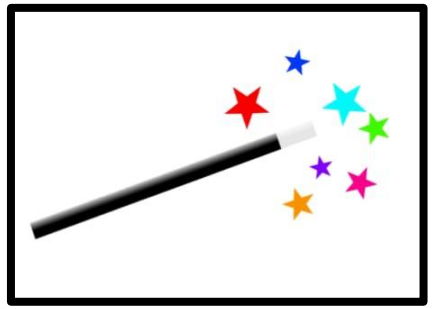
# Evaluation Overview



Experiment 1: Cross dataset analysis

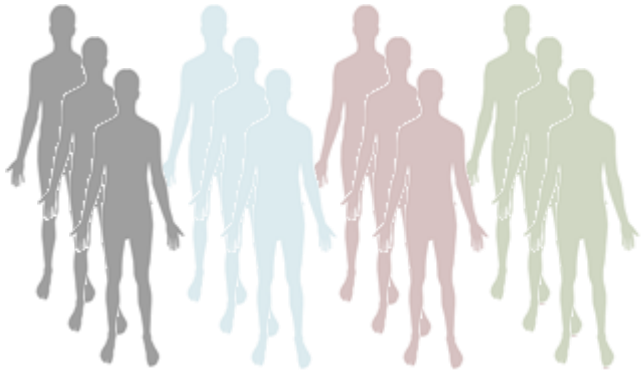


Experiment 2: Position-aware fall detection



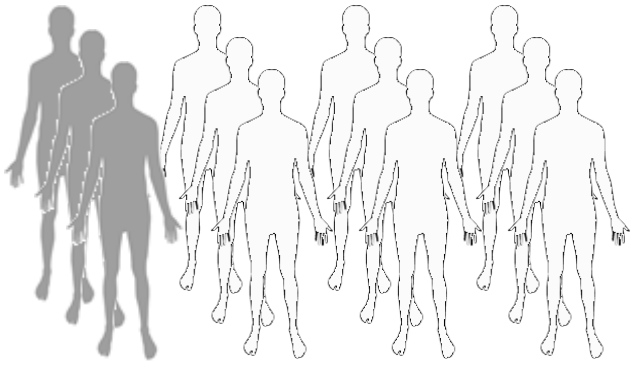
Experiment 3: Self-improving fall detection

# Experiment 1: Cross-Datasets Fall Detection

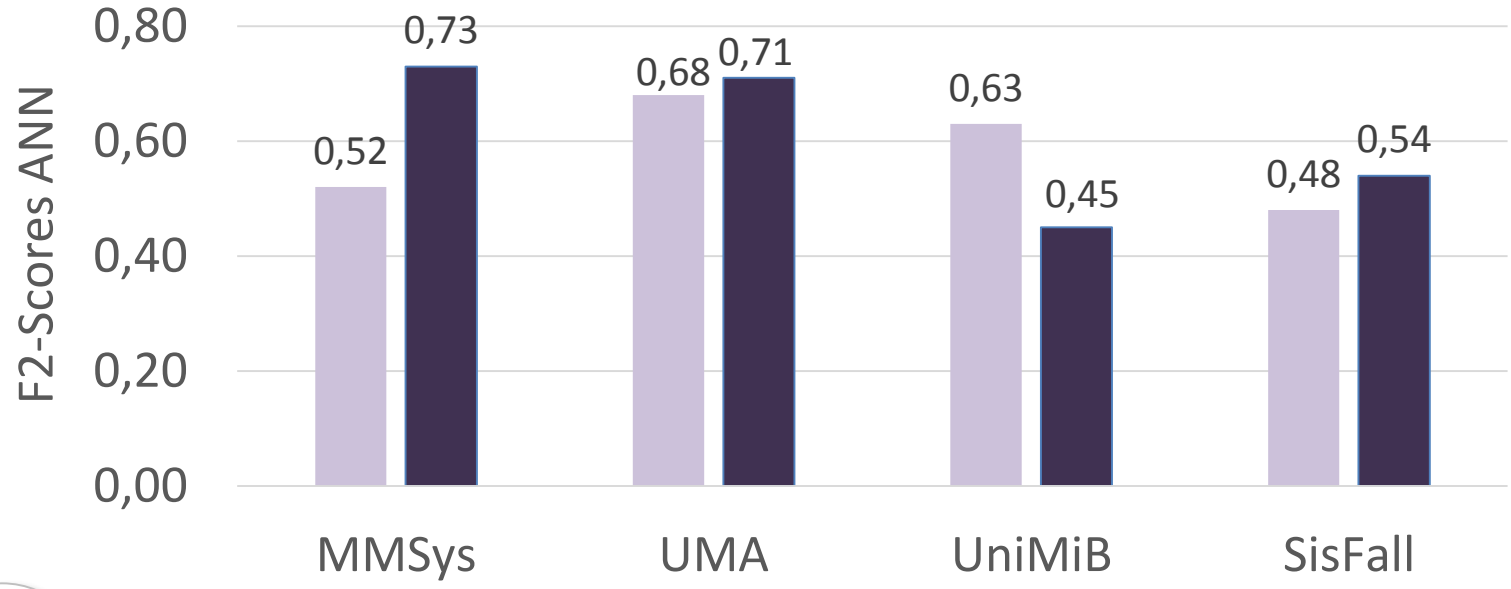


Trained across datasets

Tested on

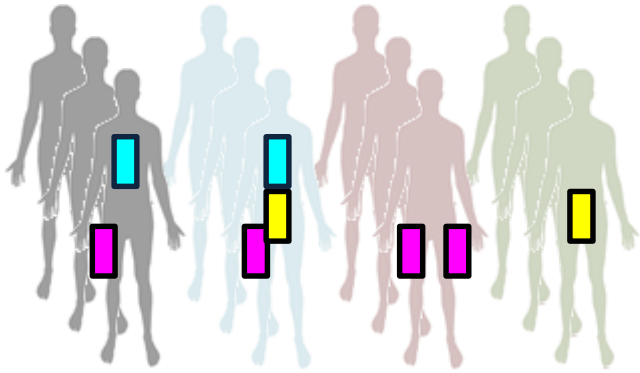


Trained on same dataset

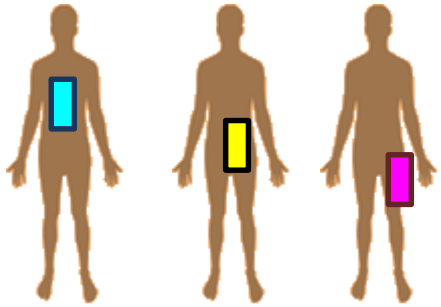



- Proposition 1: Origin of data matters
- The results indicate issues in labeling and setup of capturing data

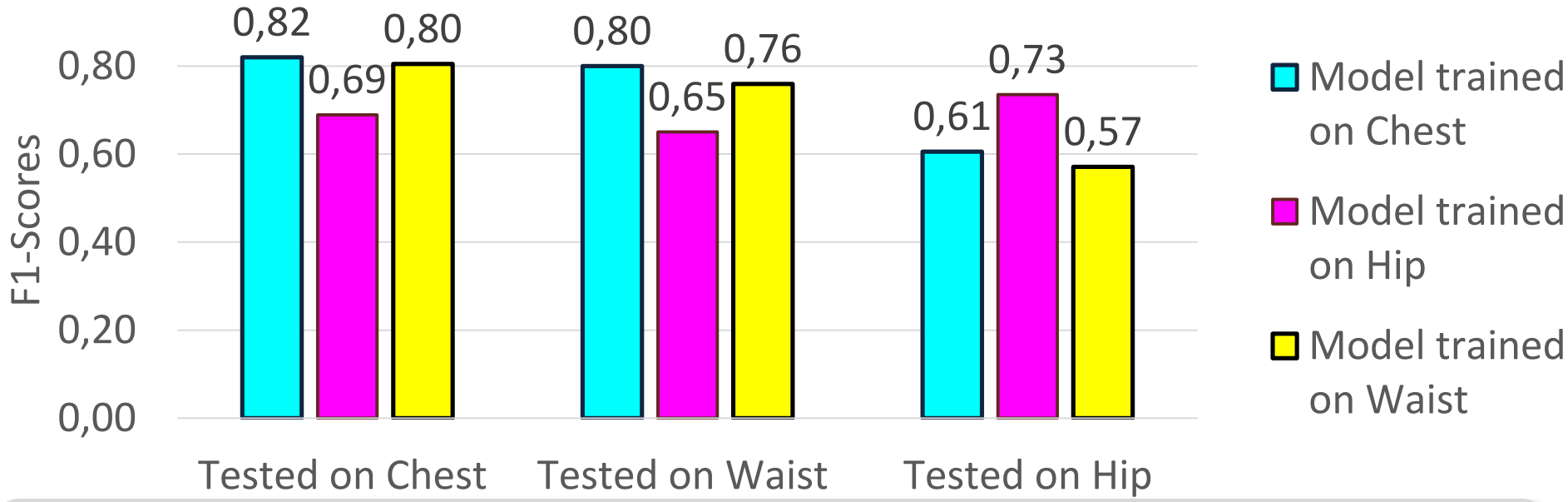
# Experiment 2: Position-Aware Fall Detection



Trained on one position

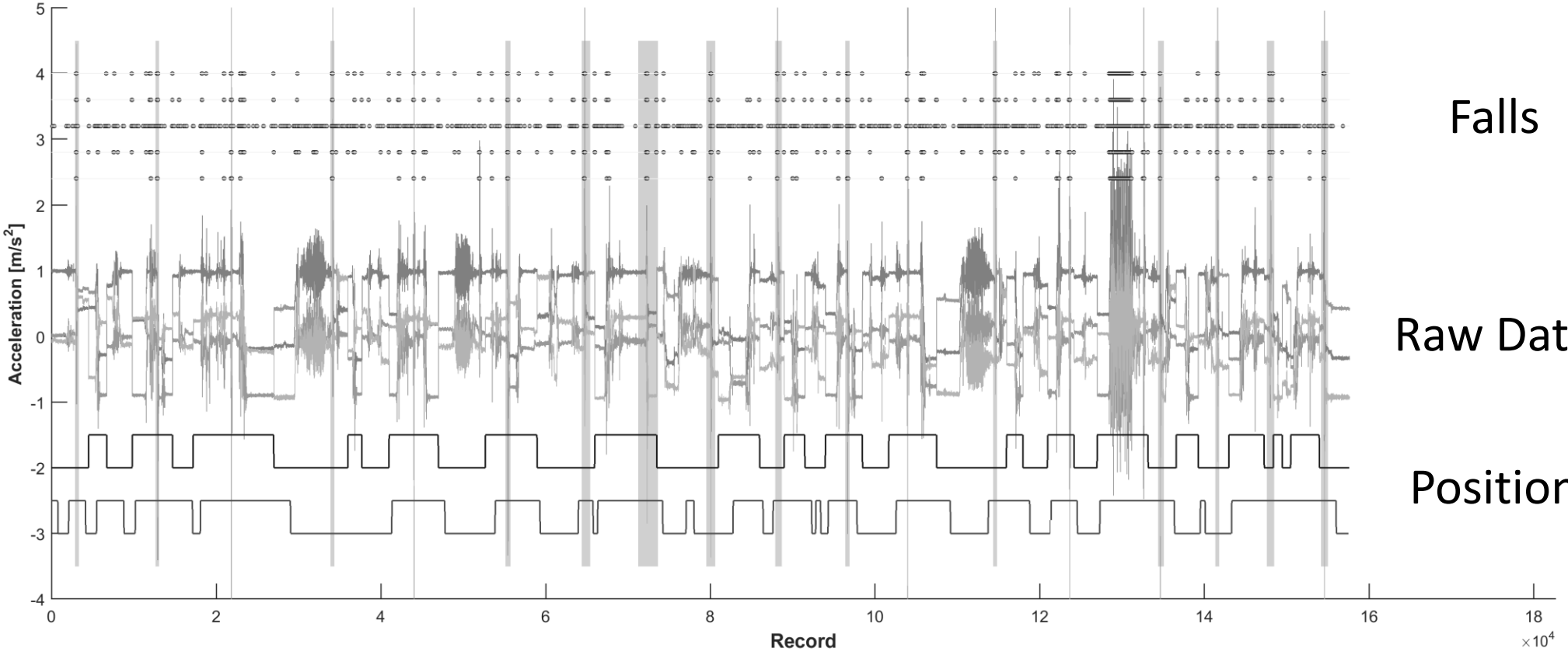


Tested on all positions




- Proposition 2: Position matters
- The results indicate that hips performed worst

# Experiment 3: Self-Improving Fall Detection

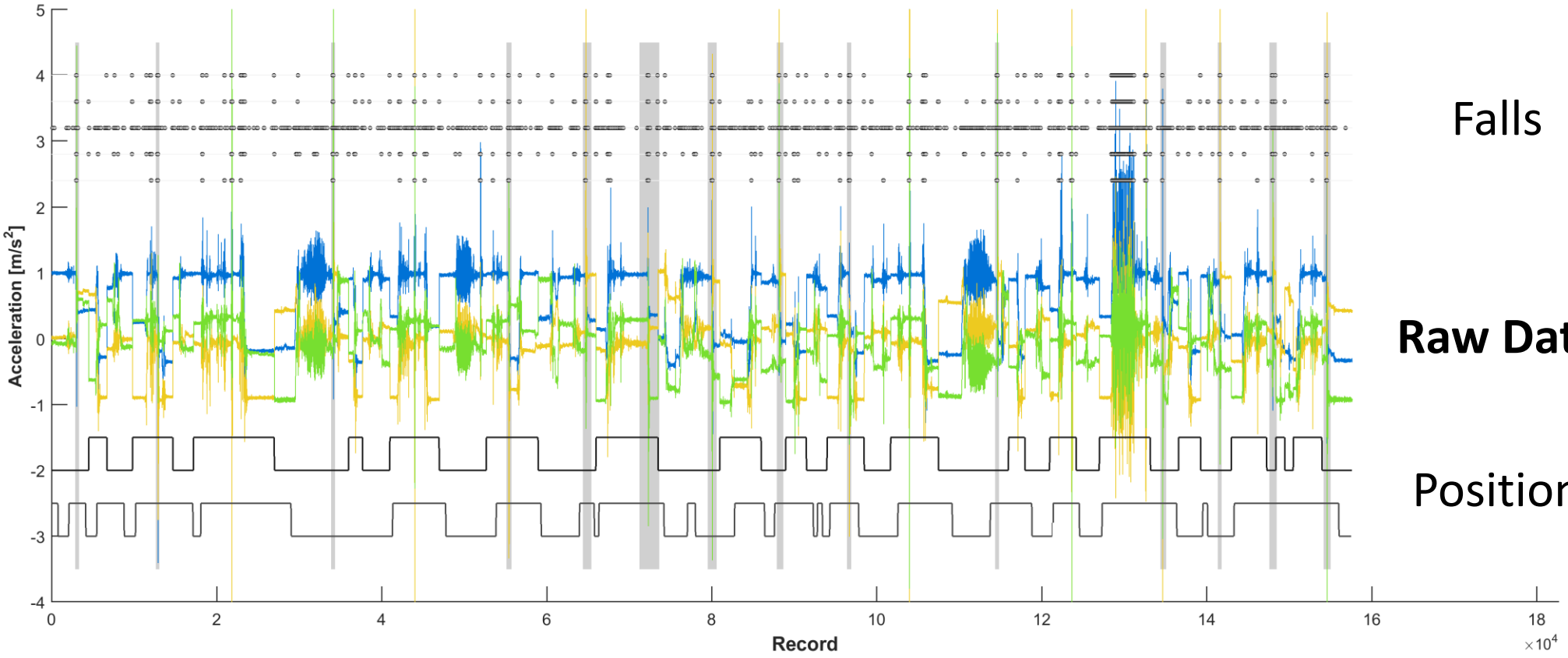



Falls

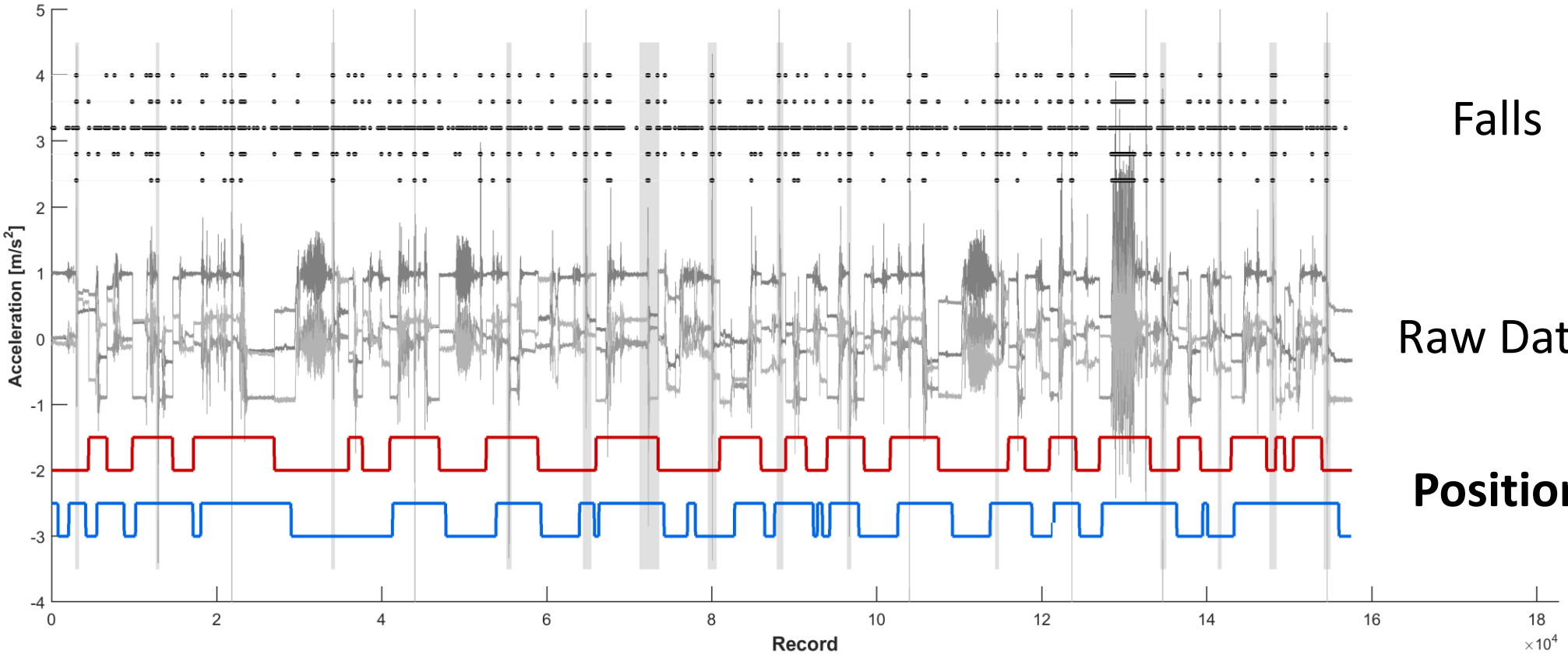
Raw Data

Position

# Experiment 3: Self-Improving Fall Detection



# Experiment 3: Self-Improving Fall Detection

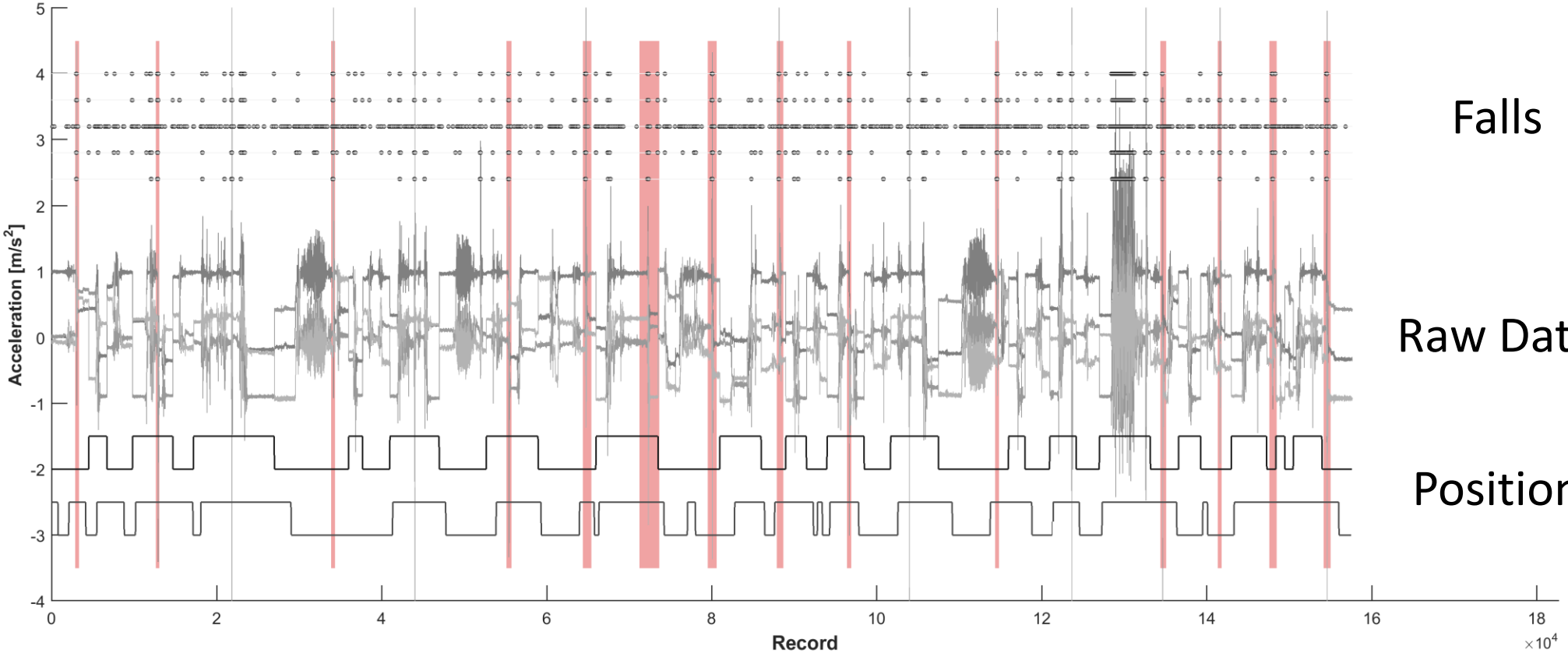



Falls

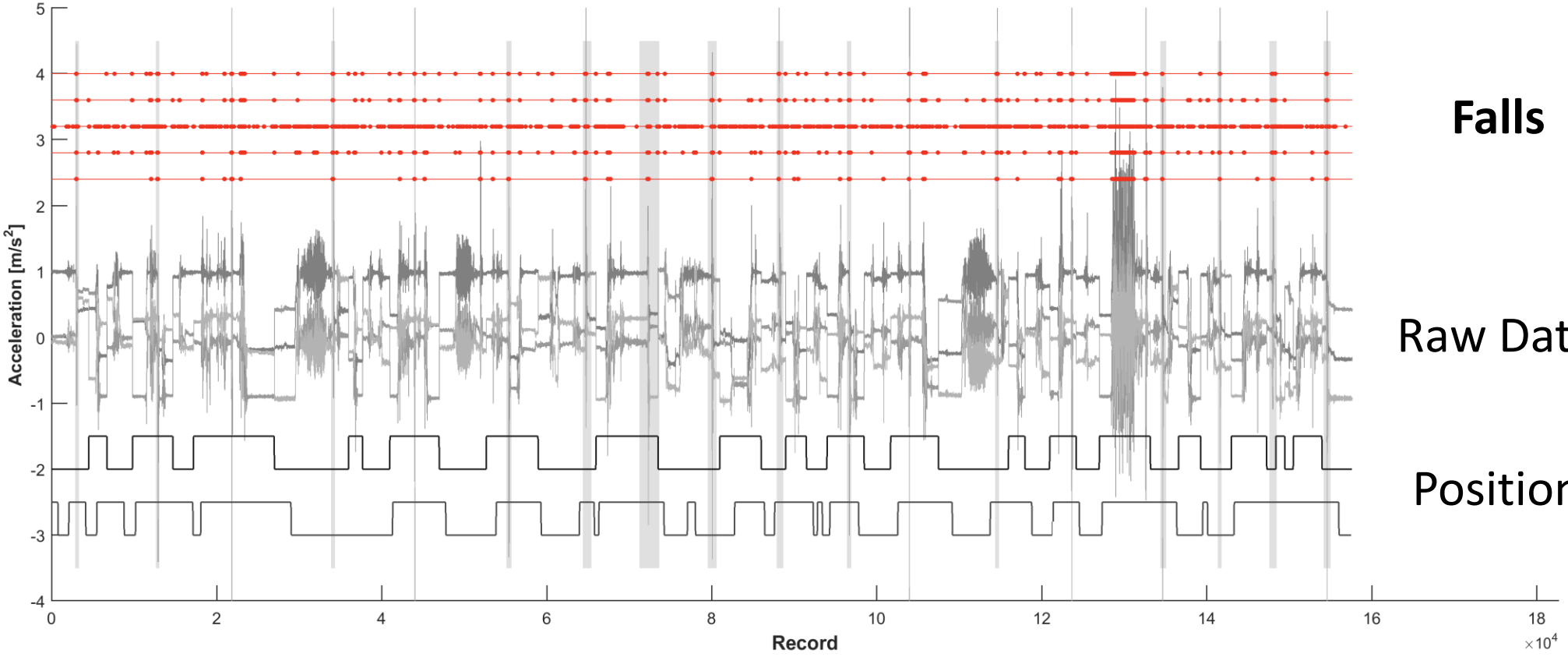
Raw Data

**Position**

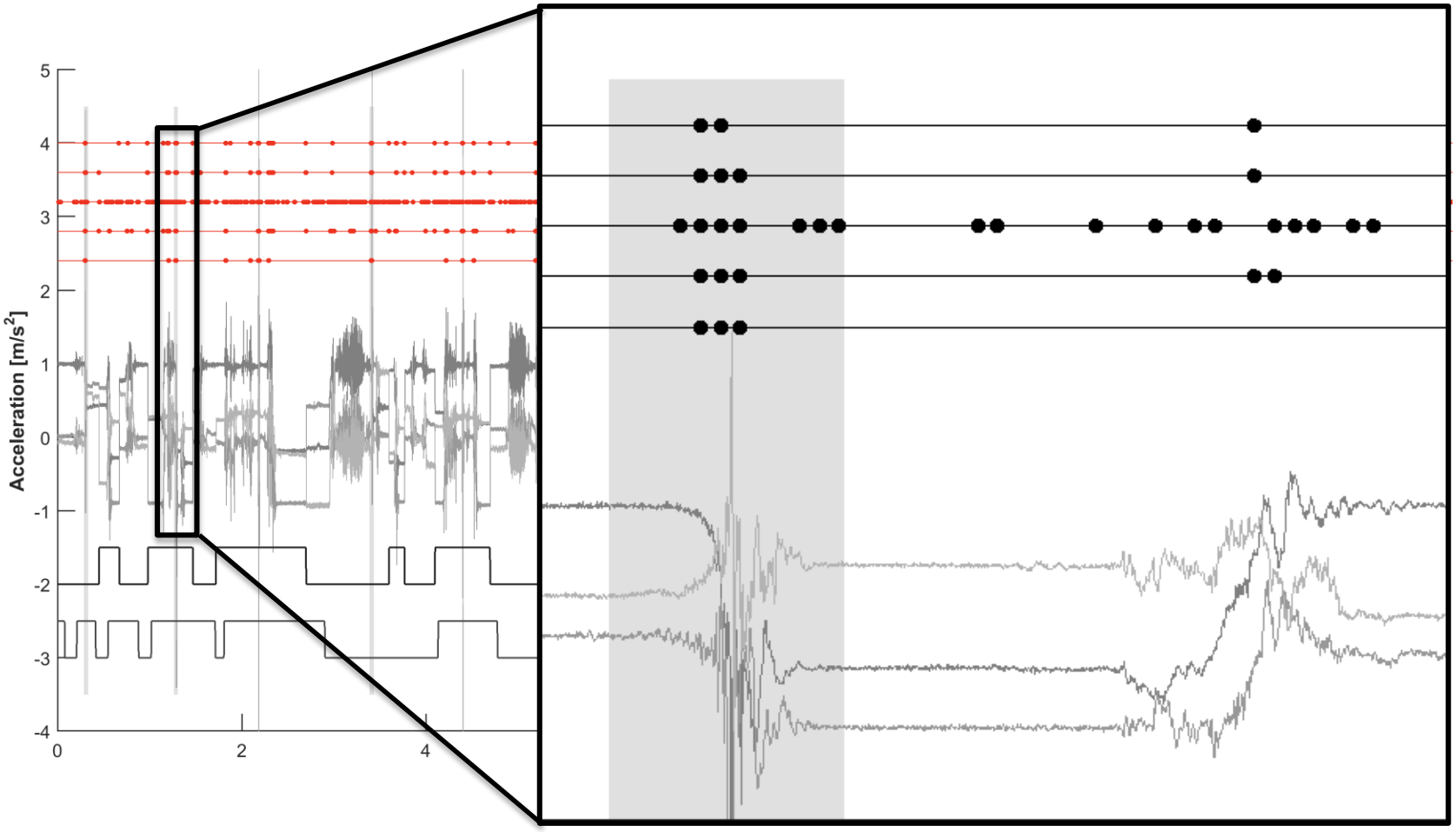
# Experiment 3: Self-Improving Fall Detection



# Experiment 3: Self-Improving Fall Detection



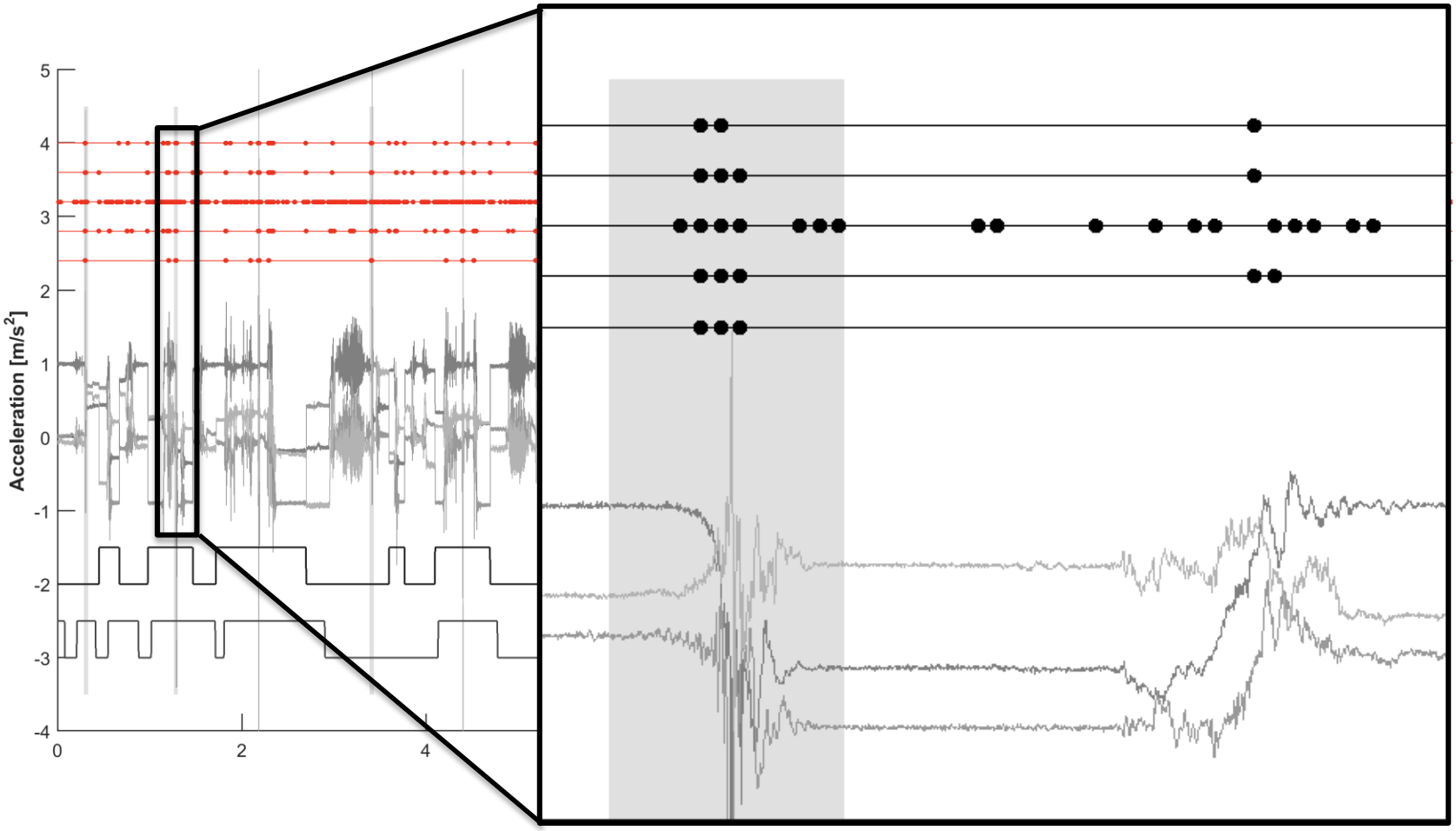
# Experiment 3: Self-Improving Fall Detection




**Detected falls:**
ANN
J48
KNN
Random Forest
Self-Improving

- Recall: 0.93 - Any falls missed?
- No: We missed fall windows, but for each fall we detected at least one window!

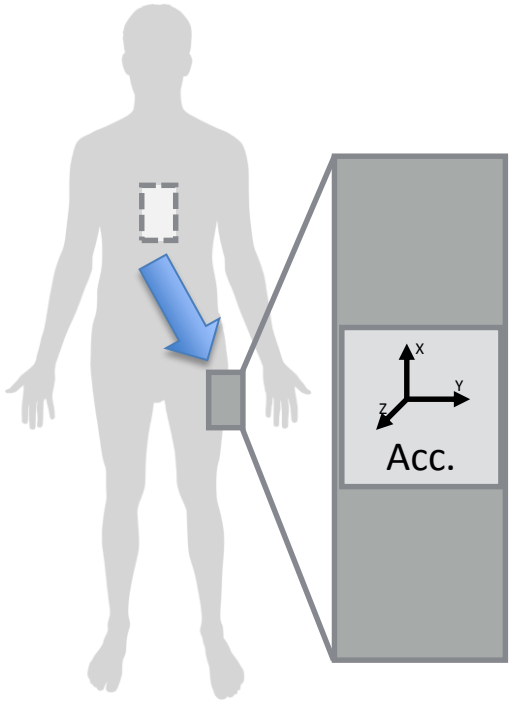
# Experiment 3: Self-Improving Fall Detection



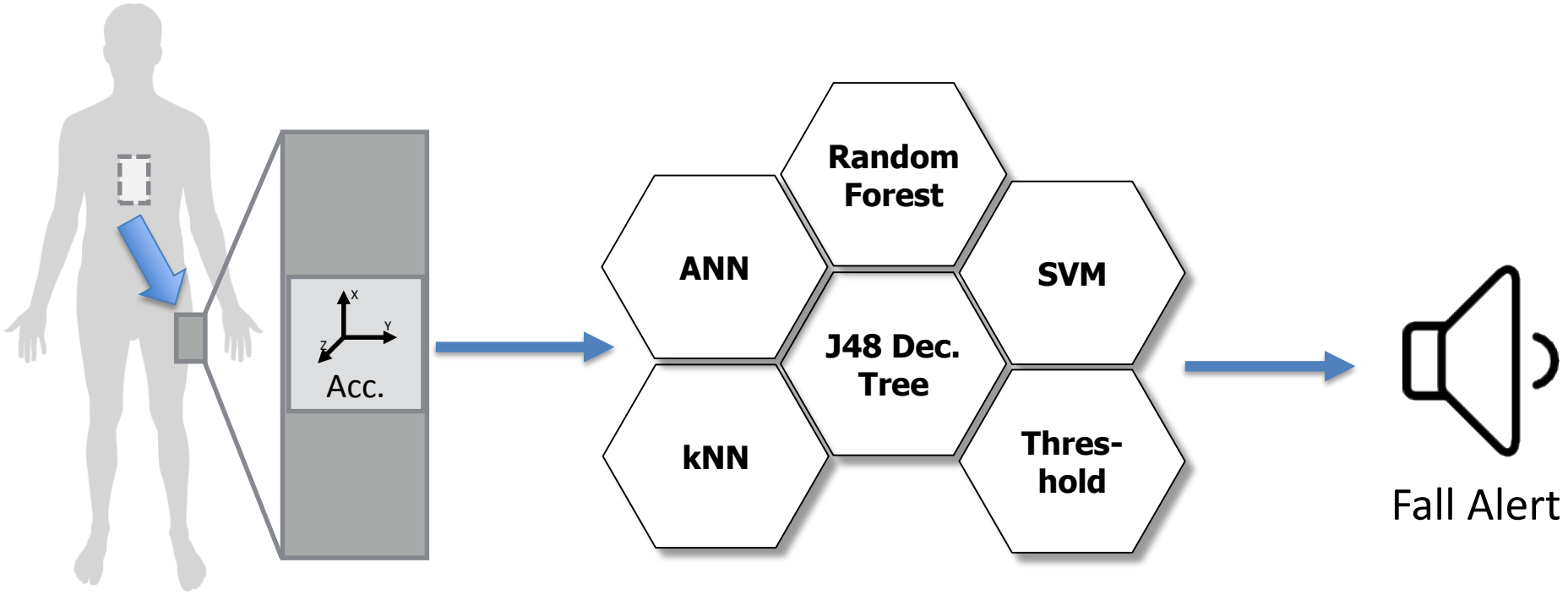

**Detected falls:**
ANN
J48
KNN
Random Forest
Self-Improving

- Proposition 3: Self-improvement matters
- Precision is improved → decreases false positives

# Current State

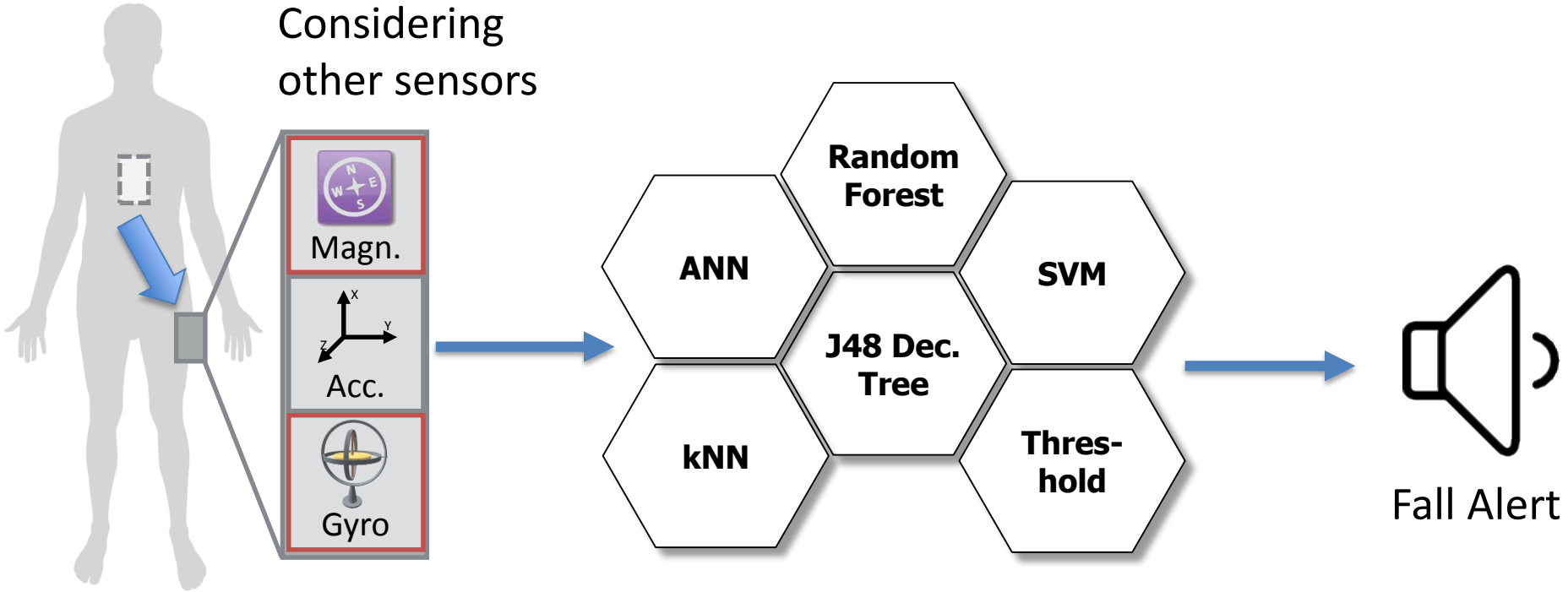


# Current State



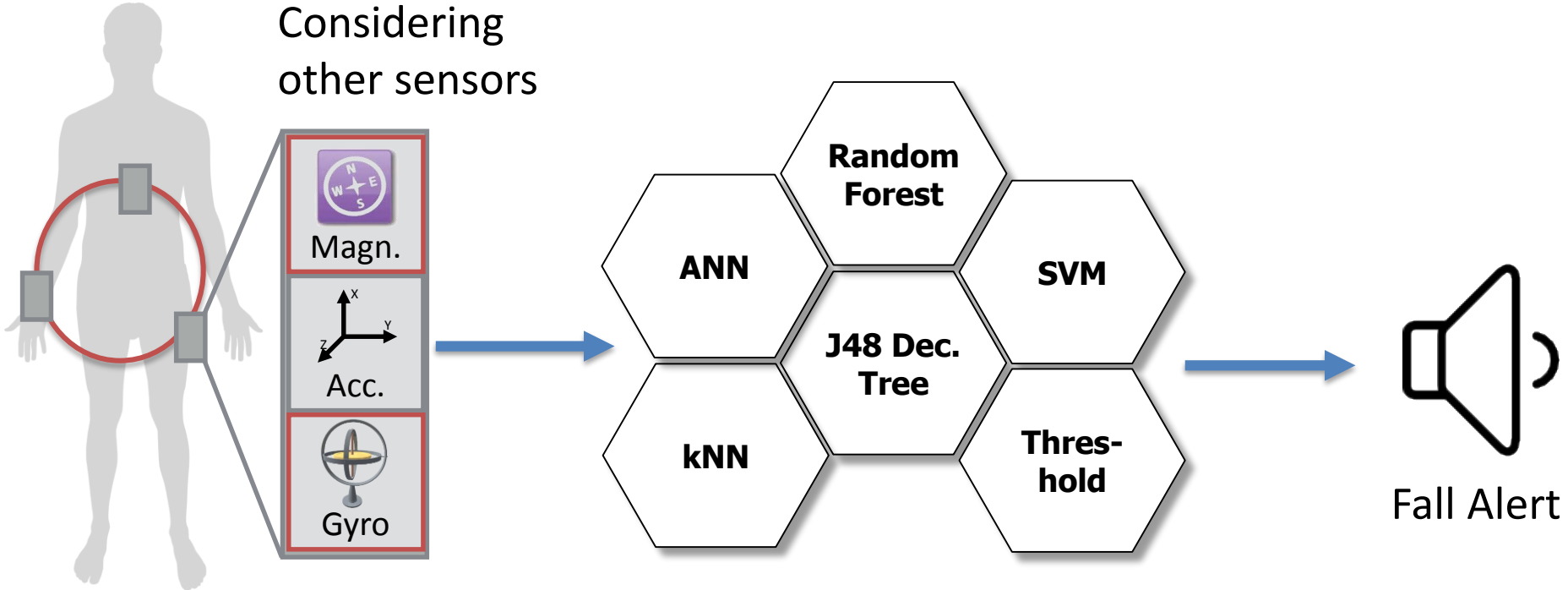
# Future Work

1. Extension: Considering other sensors



# Future Work

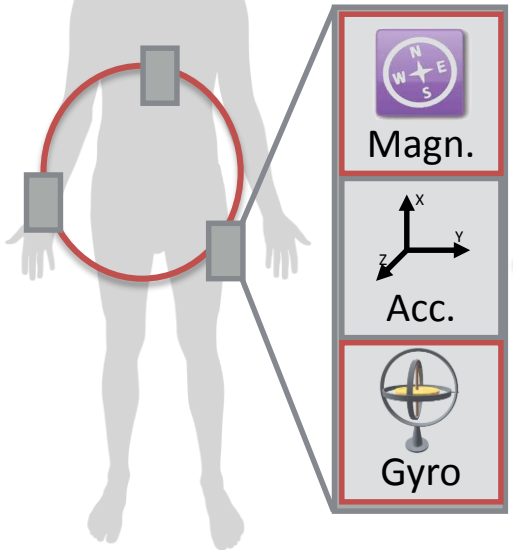
1. Extension: Considering other sensors




2. Extension: Cross-positional sensor fusion

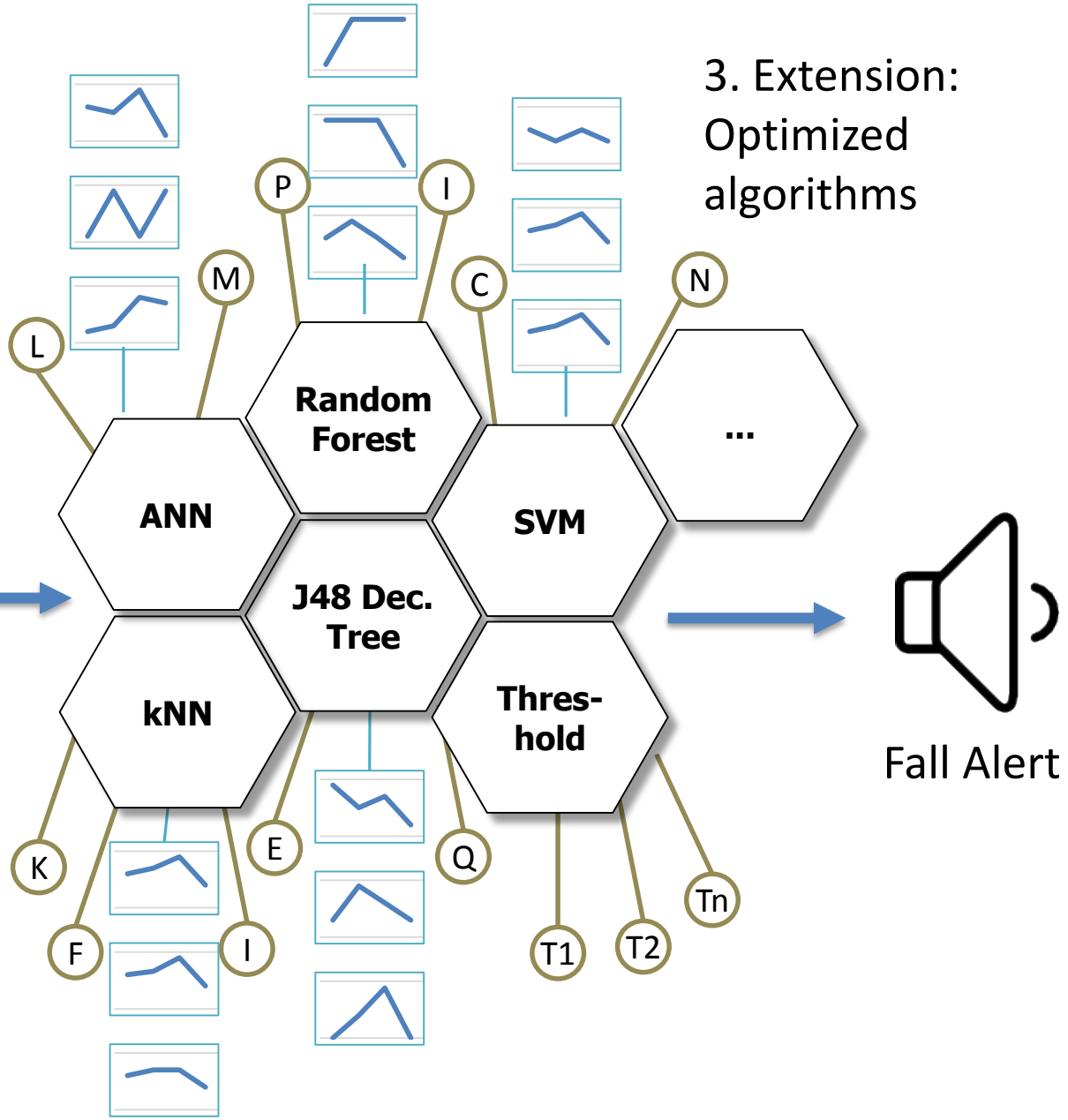
# Future Work

1. Extension: Considering other sensors




2. Extension: Cross-positional sensor fusion

3. Extension: Optimized algorithms

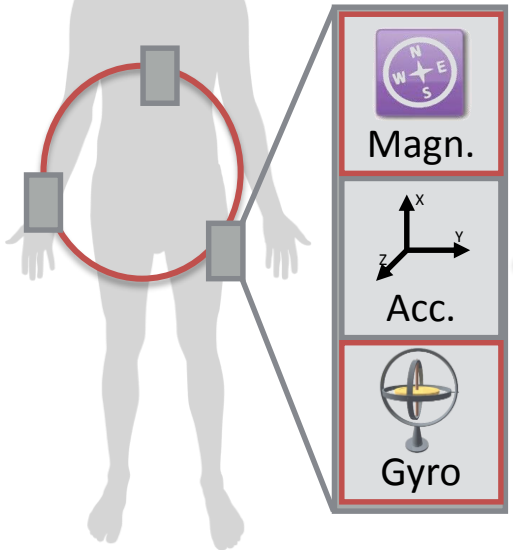




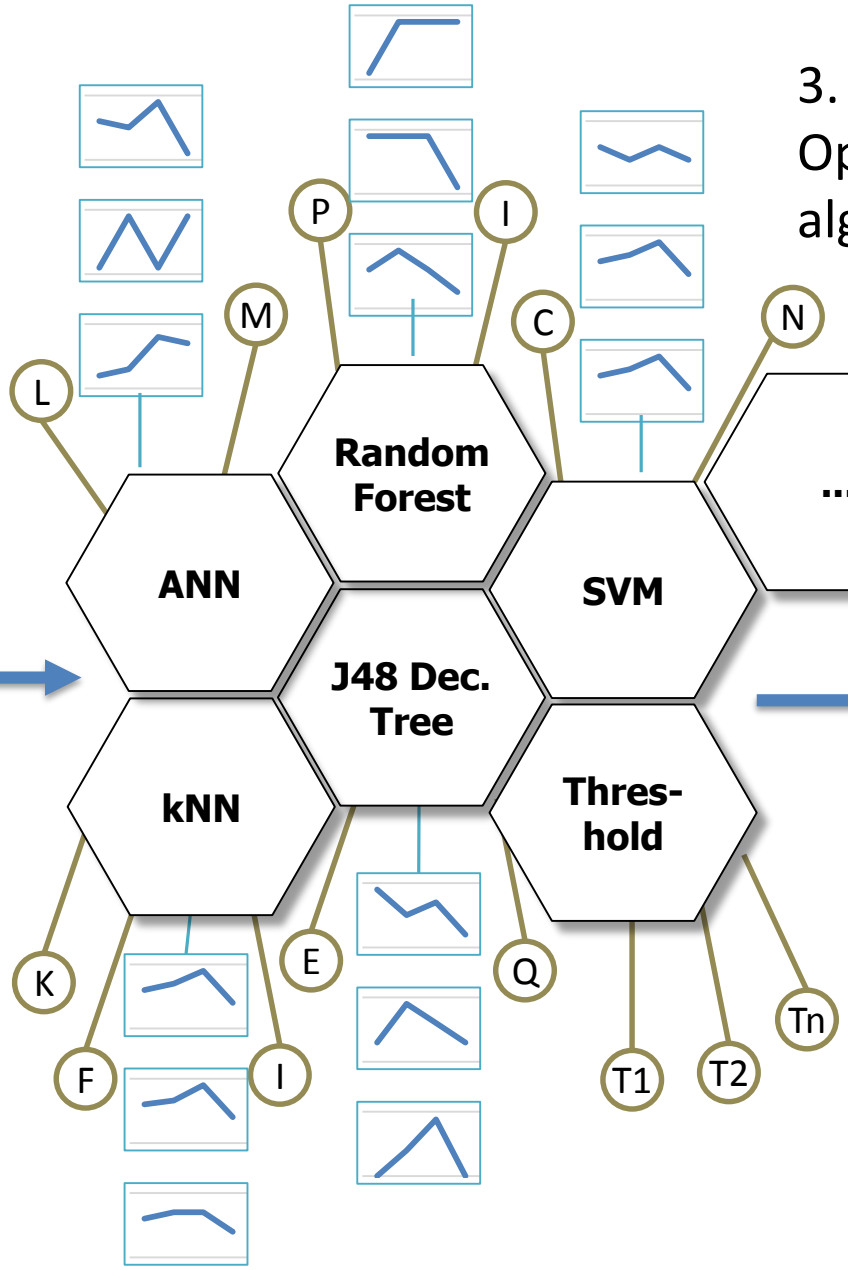

Fall Alert

# Future Work

1. Extension: Considering other sensors

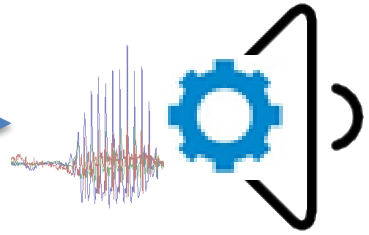



2. Extension: Cross-positional sensor fusion




3. Extension: Optimized algorithms

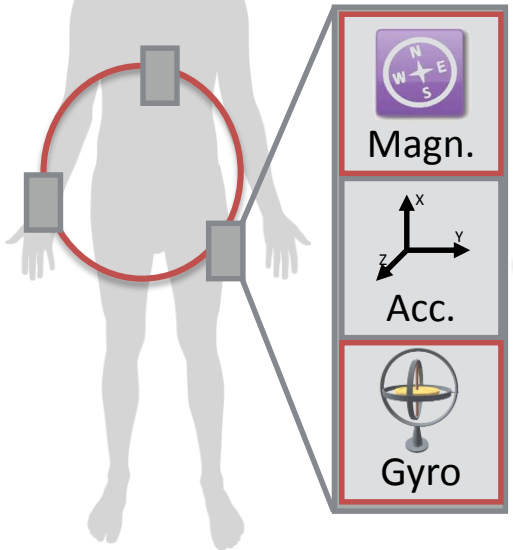
4. Extension: Intelligent fall alert



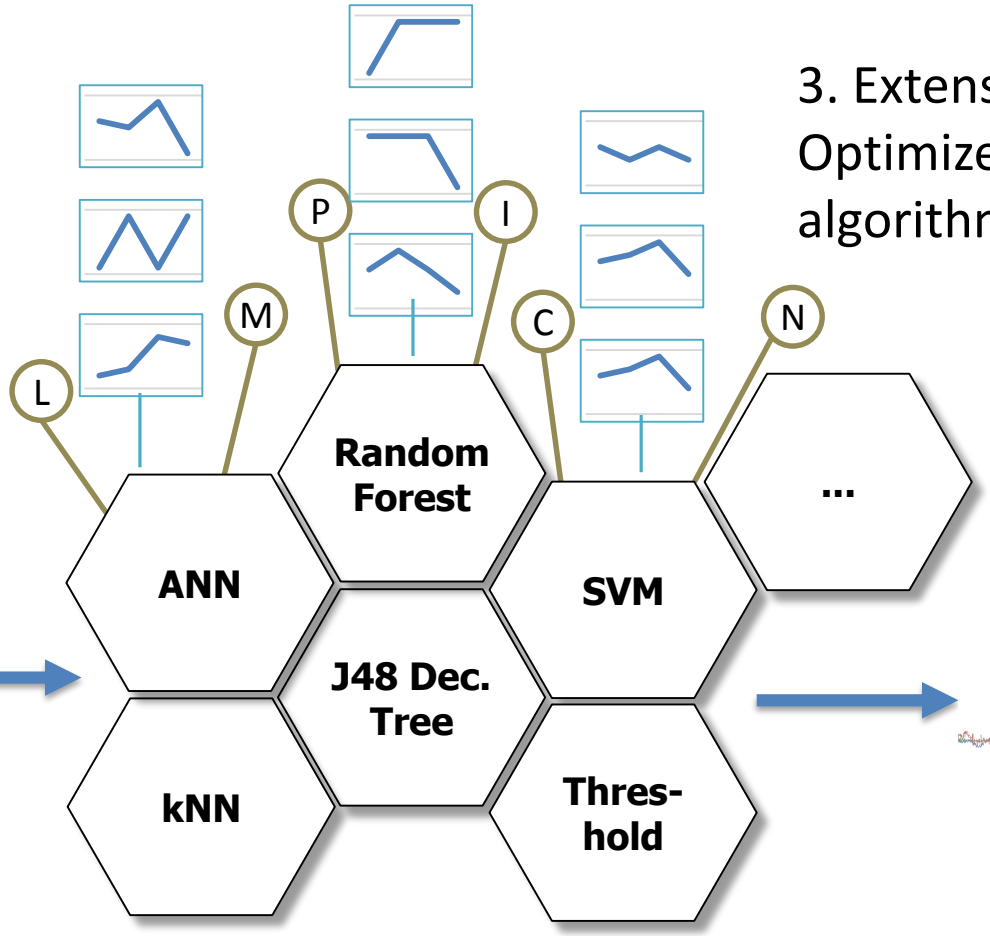
Fall Alert

# Future Work

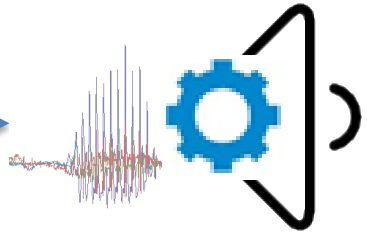
1. Extension: Considering other sensors




3. Extension: Optimized algorithms

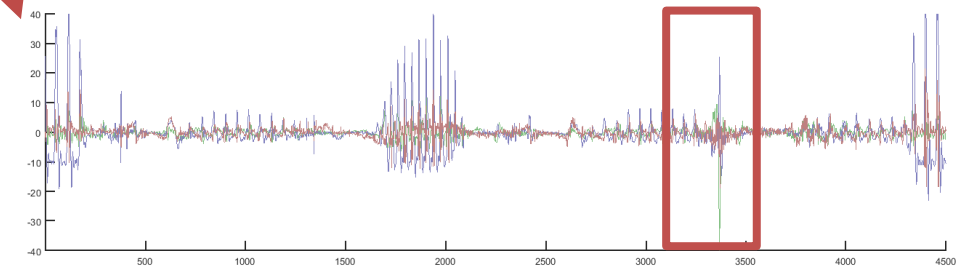



4. Extension: Intelligent fall alert



Fall Alert

2. Extension: Cross-positional sensor fusion

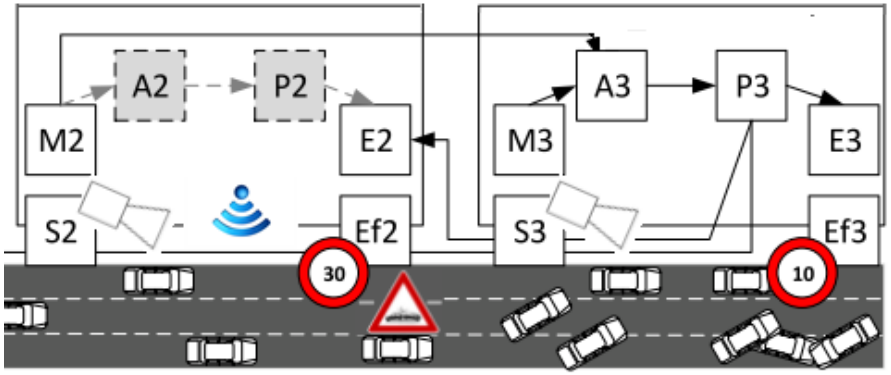


5. Extension: Outlier detection

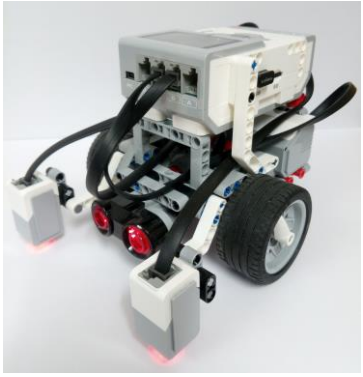
# Big Picture

Fall Detection

Intelligent Transportation Systems [ICAC17]




Self-Improvement for Pervasive Systems



Smart Vacuum Cleaner [PerIoT17]

Your project could appear here...

# The End

- Shakira: Hips don’t lie
- We: Hips do lie