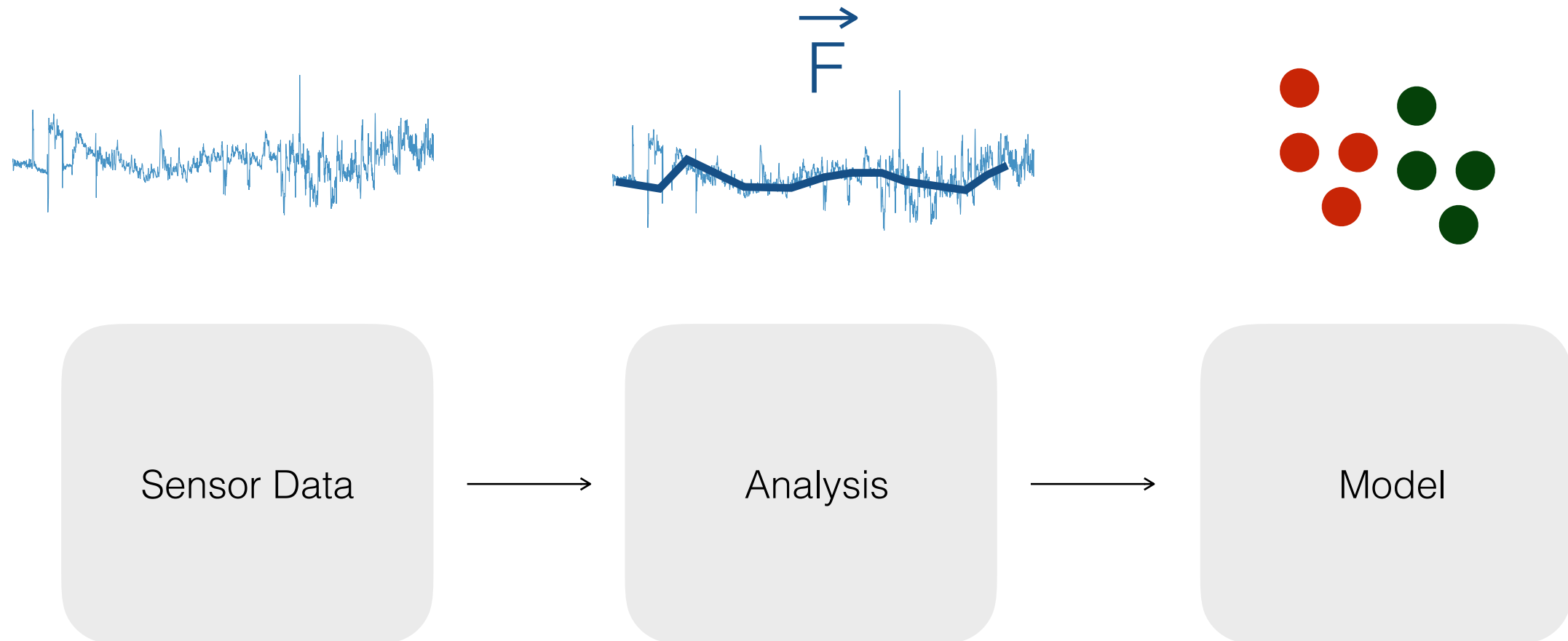


# Activity Recognition Concepts

EE382V Activity Sensing and Recognition

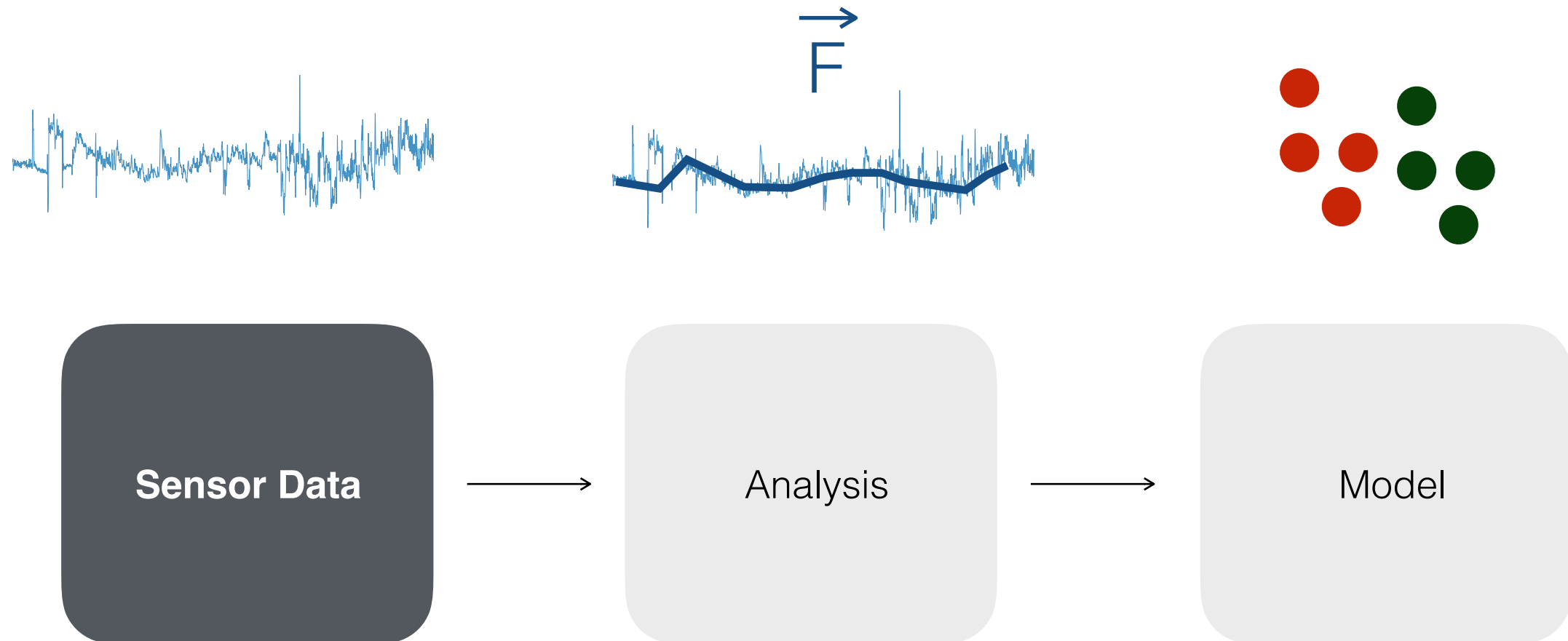
# Activity Recognition Pipeline

---



# Activity Recognition Pipeline

---



# Two Predominant Sensing Approaches

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Environmental Sensors



On-Body Sensors

# Two Predominant Sensing Approaches

---

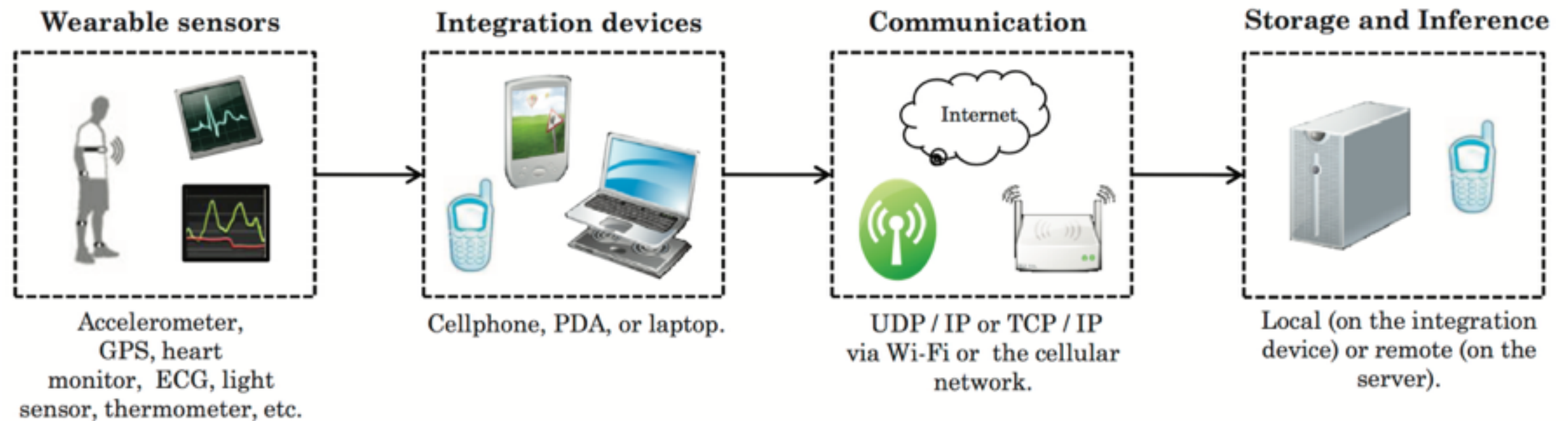


Run Studies with Participants



# Sensor Data Acquisition

---



Aggregation

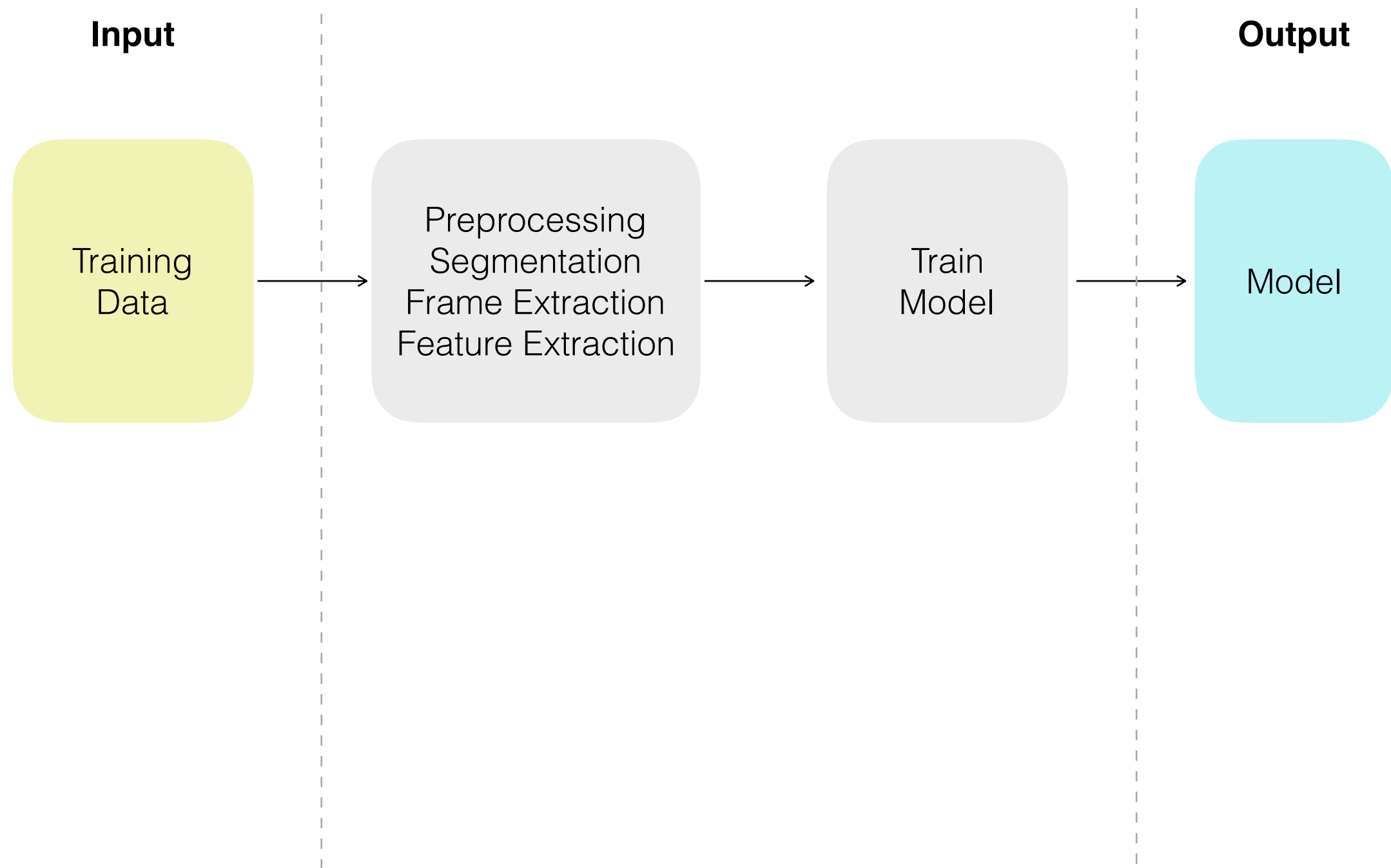
Storage (Local vs. Server)

Visualization

**Challenge in Field Studies**

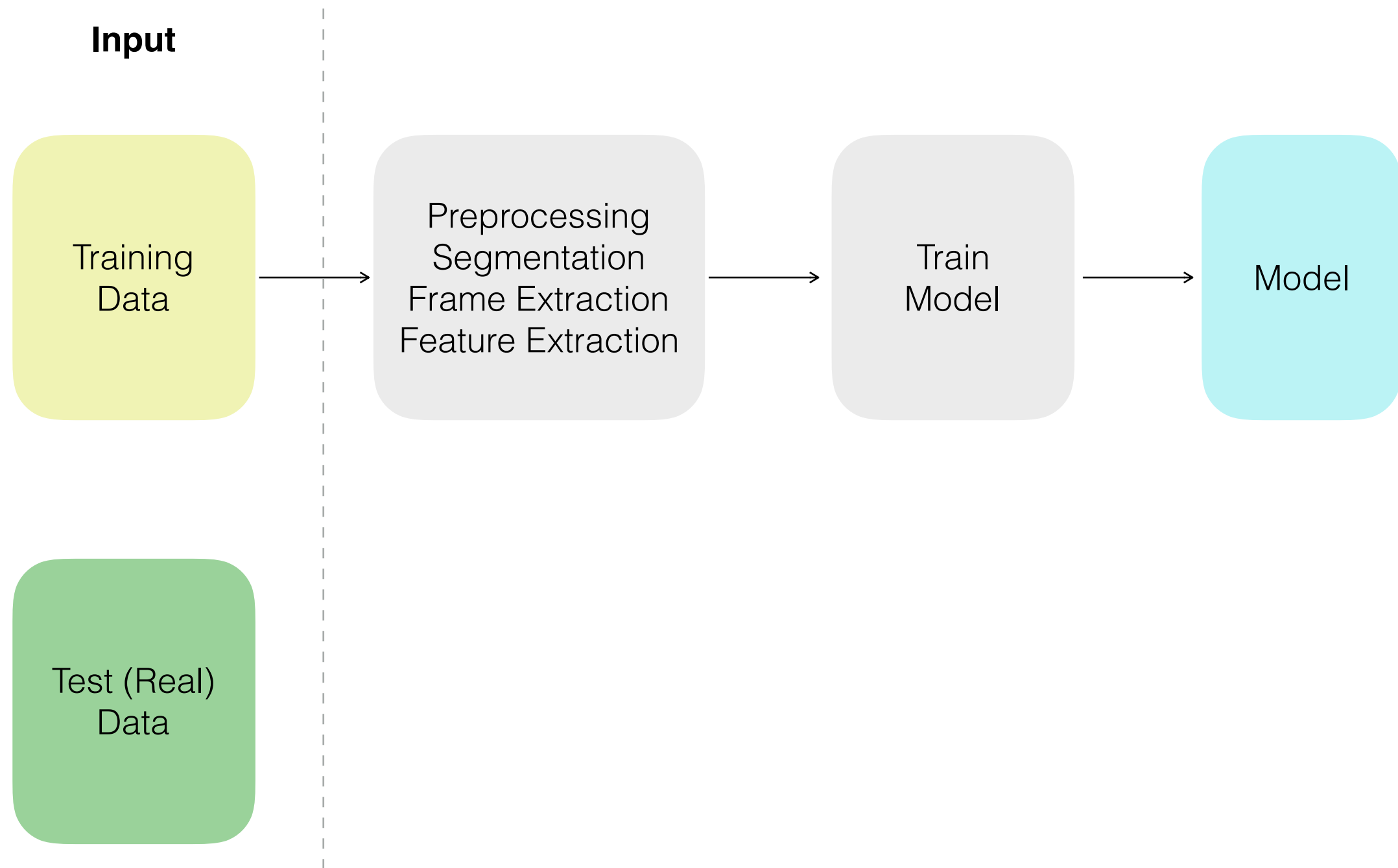
# Activity Recognition Pipeline

---



# Activity Recognition Pipeline

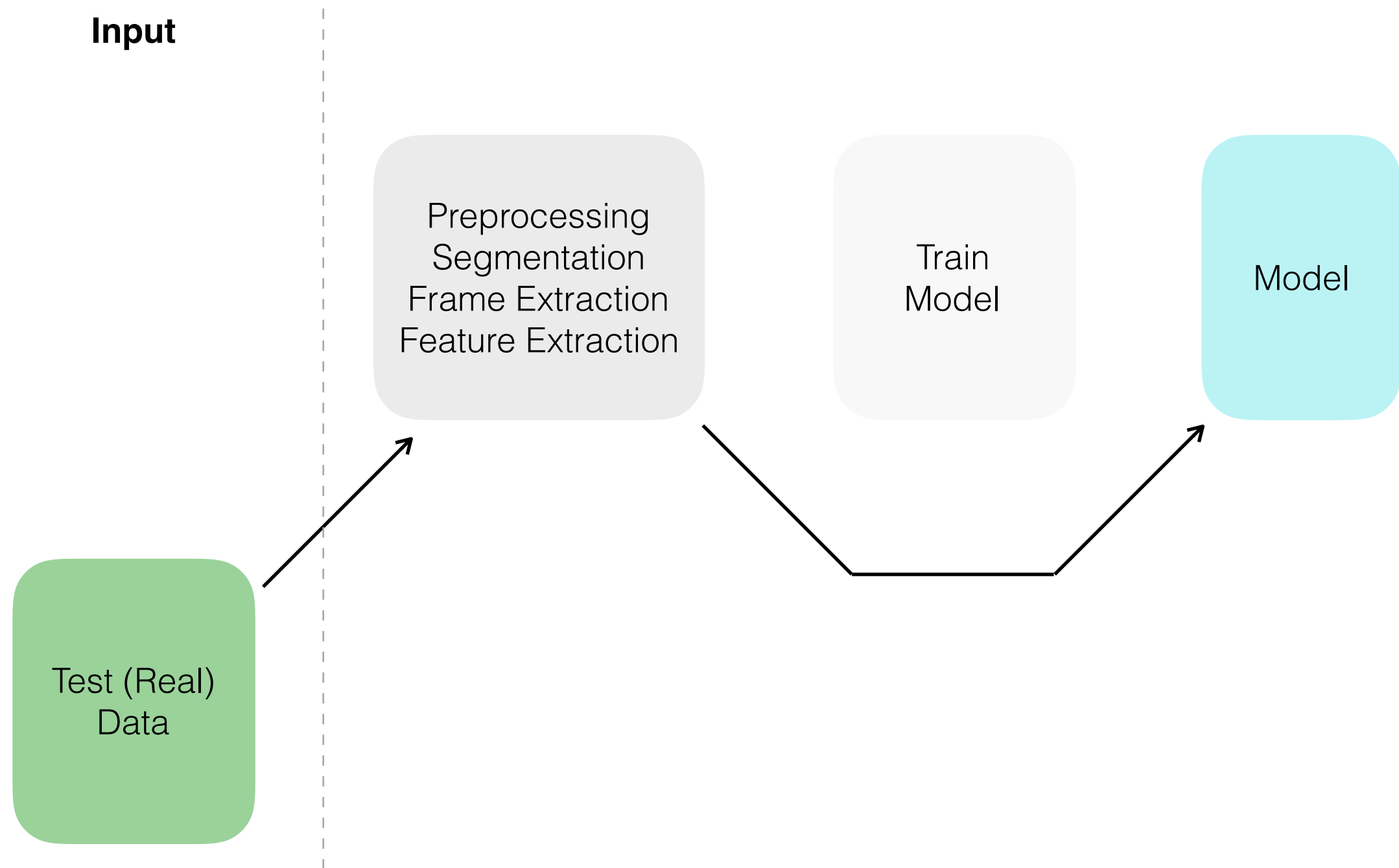
---





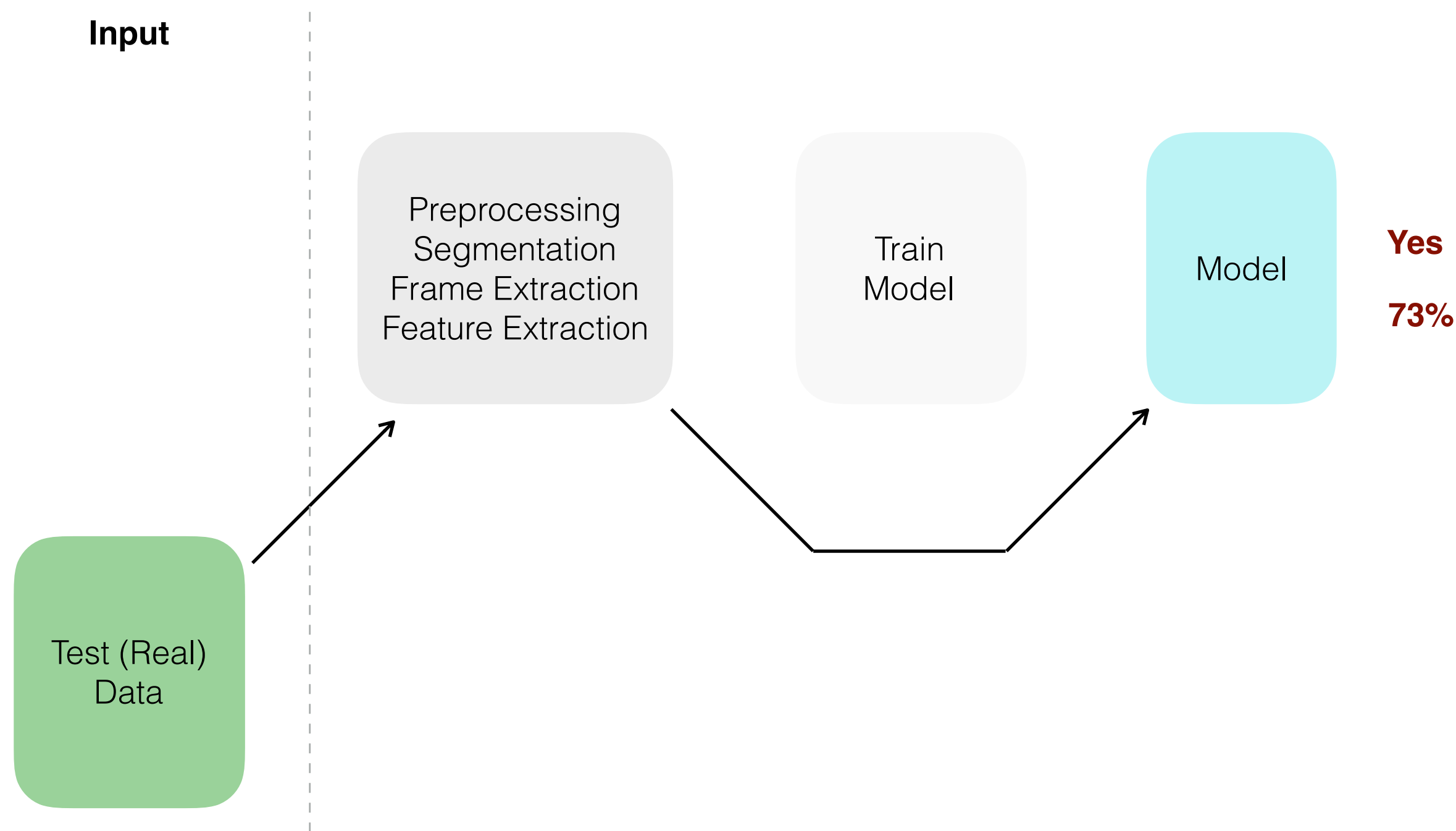
# Activity Recognition Pipeline

---



# Activity Recognition Pipeline

---



# Preprocessing

---

Synchronisation

Validate Sensing Specs

Remove undesirable artifacts

Downsampling

Encoding

Missing Values

Unit Conversion

Quantization

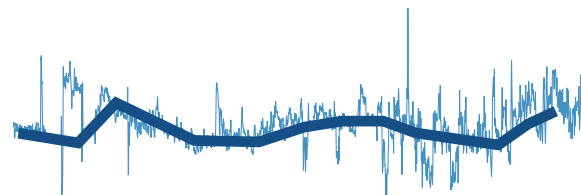
---

Scaling to Range

Mean Removal

Normalization

Smoothing

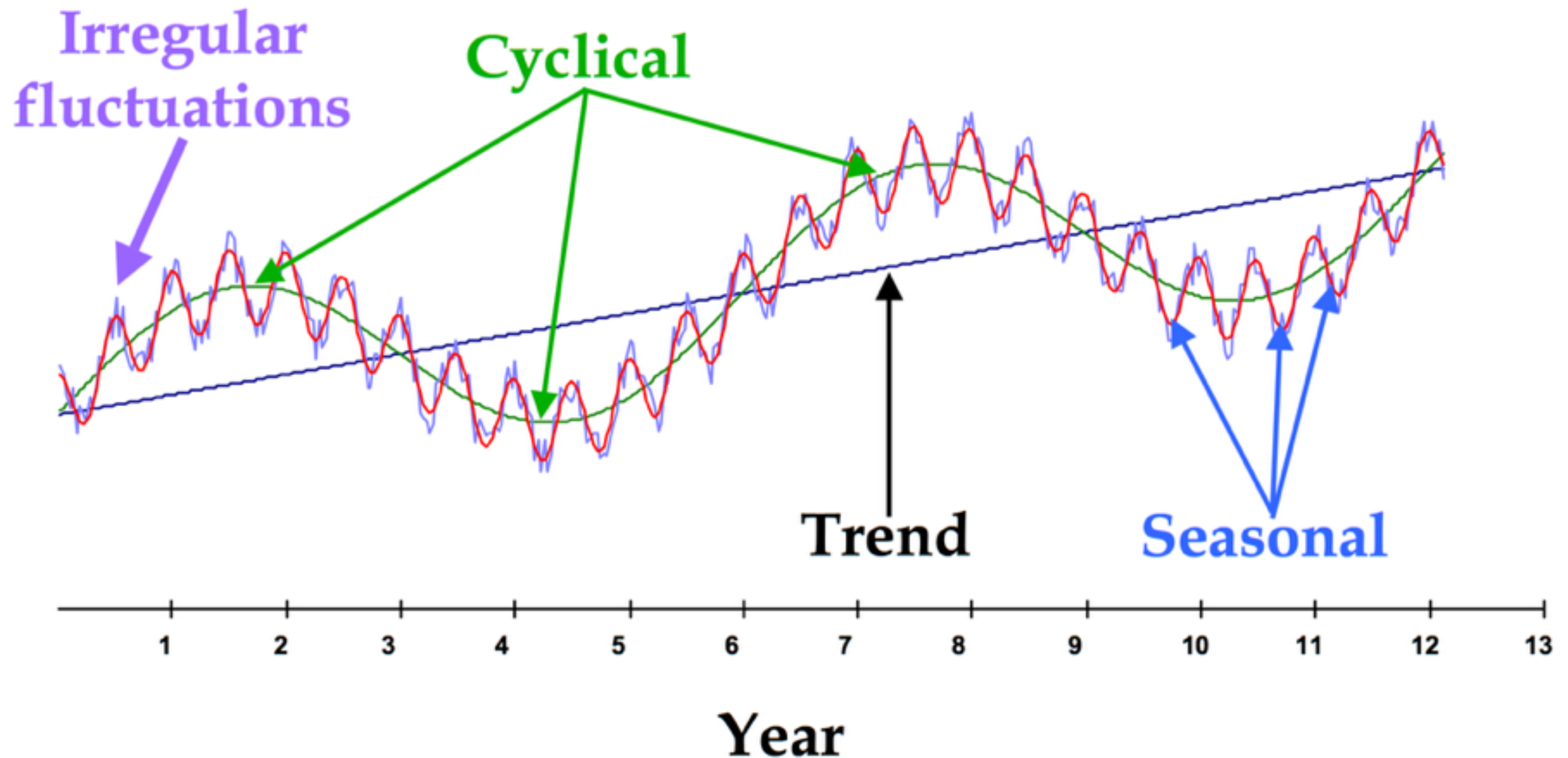


Moving Average

Exponential Smoothing

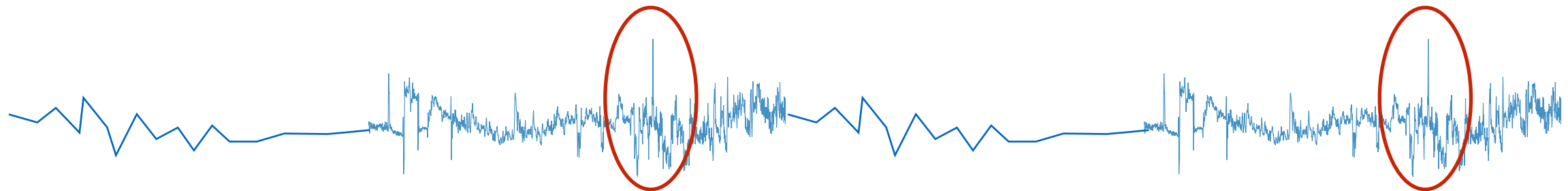
Low-Pass Filter

# Data and Preprocessing



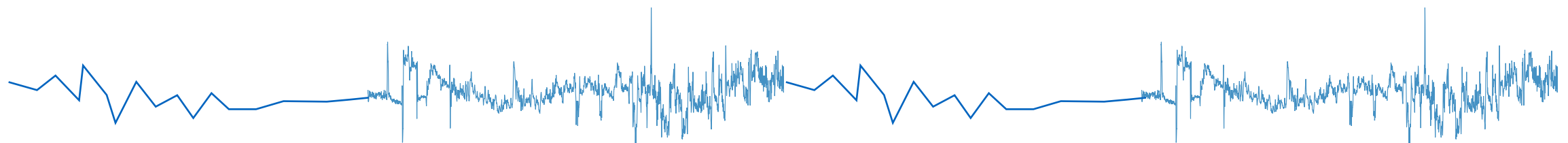
# Segmentation

---



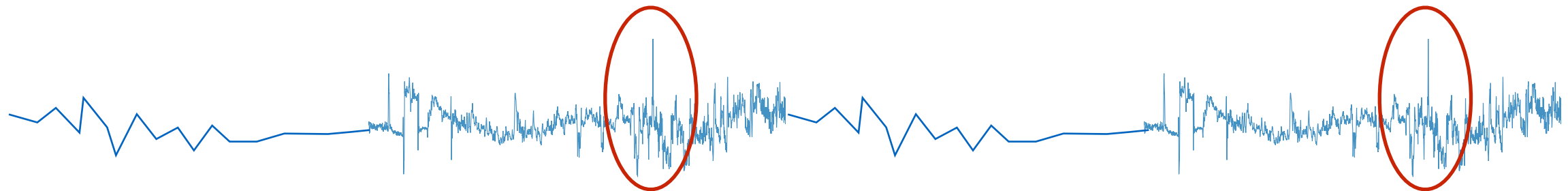
Need to run classifier continuously?

---

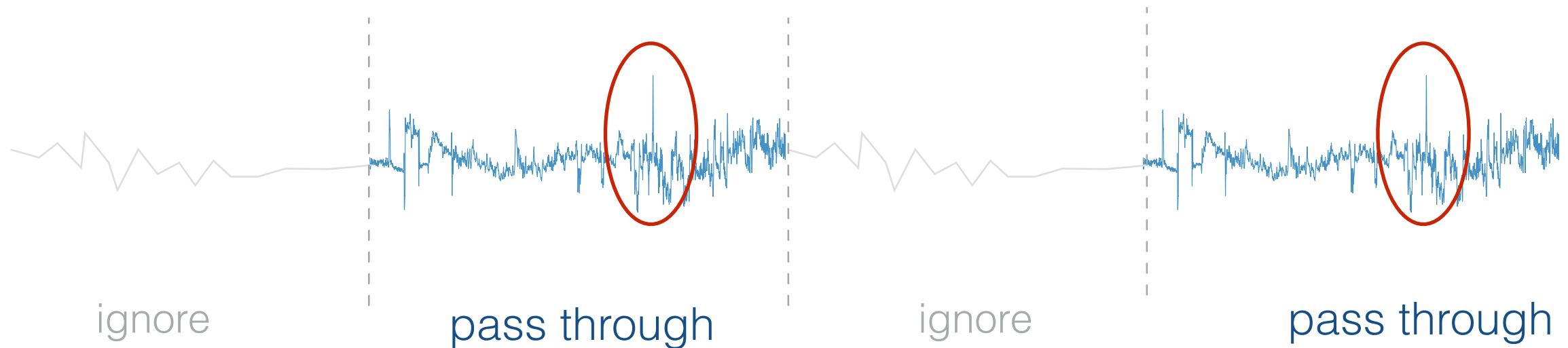


# Segmentation

---



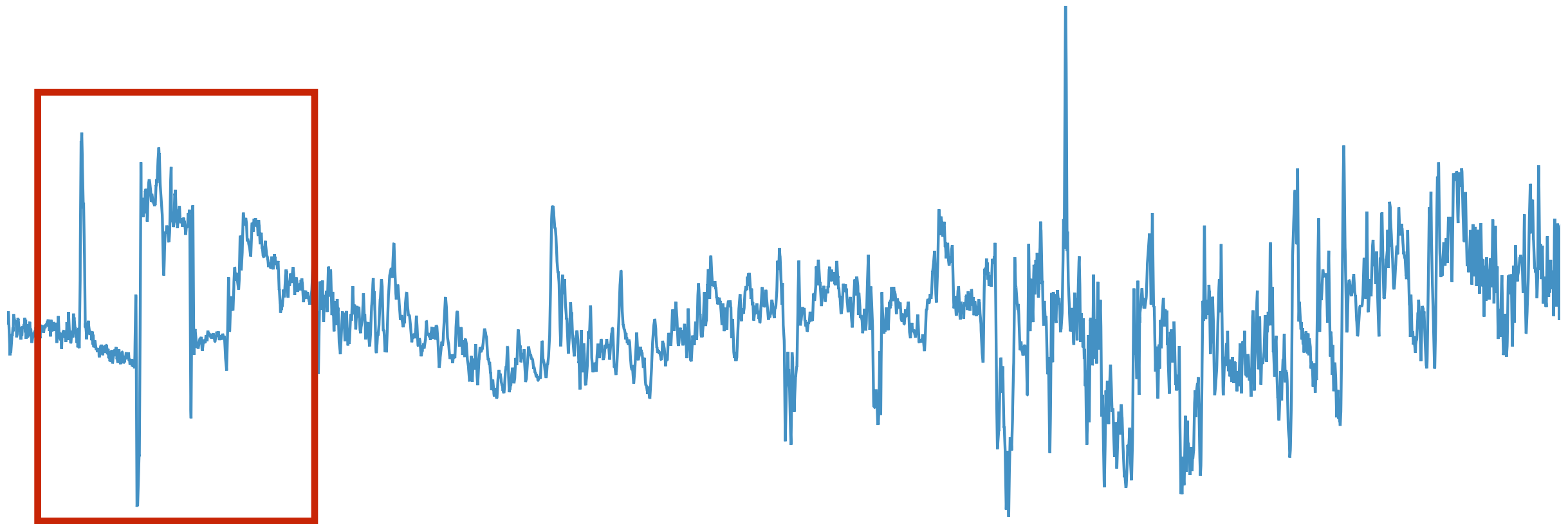
Need to run classifier continuously?



Segment It

# Frame and Feature Extraction

---



$F_1$

$f_1$

$f_2$

$f_3$

$f_4$

$f_5$

$F_2$

$f_1$

$f_2$

$f_3$

$f_4$

$f_5$

$F_3$

$f_1$

$f_2$

$f_3$

$f_4$

$f_5$

Mean

Variance

Kurtosis

Skewness

RMS



# Feature Selection

---

## Signal-based

Statistical: mean, variance, kurtosis, skewness

Frequency Domain: MFCC, FFT, Spectral, DCT

## Physical model

Limb Trajectories

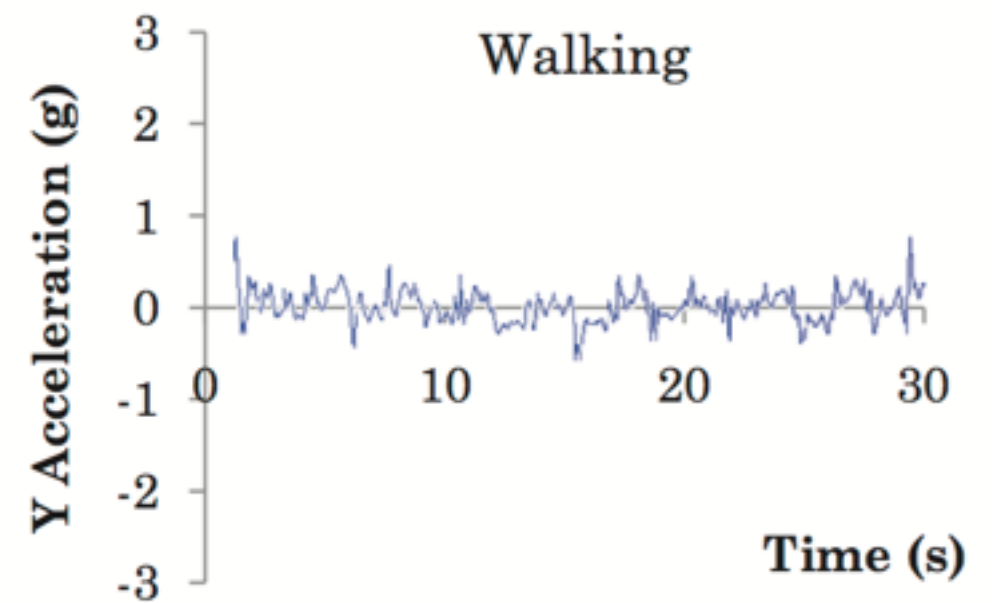
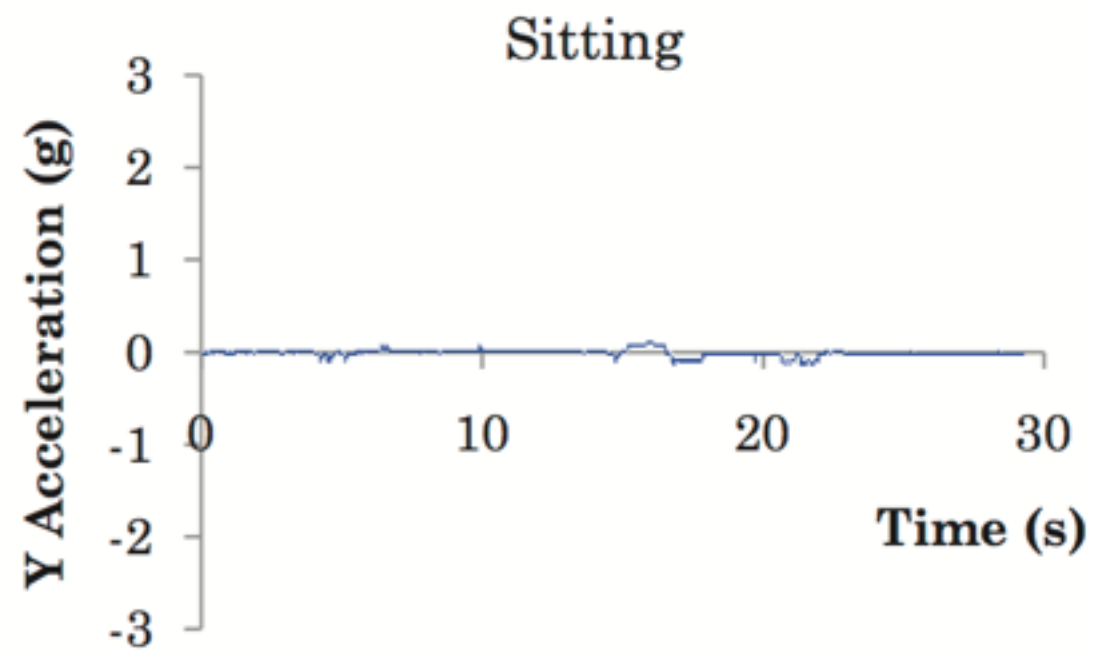
## Extract from Data

Clustering, PCA, LDA

```
> yaafe.py -l
Available features:
- AmplitudeModulation
- AutoCorrelation
- ComplexDomainOnsetDetection
- Energy
- Envelope
- EnvelopeShapeStatistics
- Frames
- LPC
- LSF
- Loudness
- MFCC
- MagnitudeSpectrum
- OBSI
- OBSIR
- PerceptualSharpness
- PerceptualSpread
- SpectralCrestFactorPerBand
- SpectralDecrease
- SpectralFlatness
- SpectralFlatnessPerBand
- SpectralFlux
- SpectralRolloff
- SpectralShapeStatistics
- SpectralSlope
- SpectralVariation
- TemporalShapeStatistics
- ZCR
Available feature transforms:
- AutoCorrelationPeaksIntegrator
- Cepstrum
- Derivate
- HistogramIntegrator
- SlopeIntegrator
- StatisticalIntegrator
Available Output formats:
- csv
- h5
```

# Simple Example

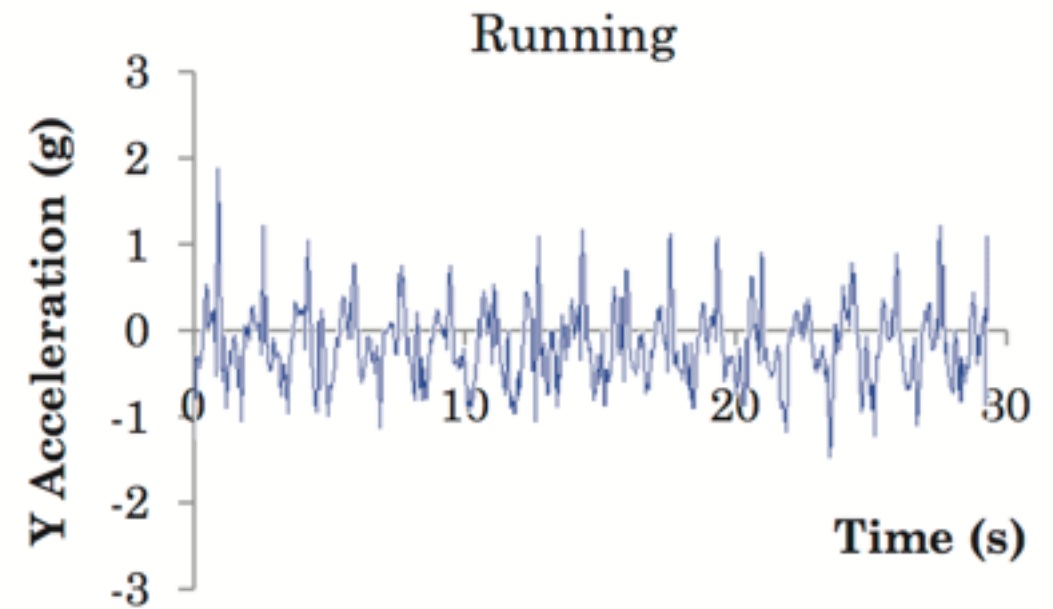
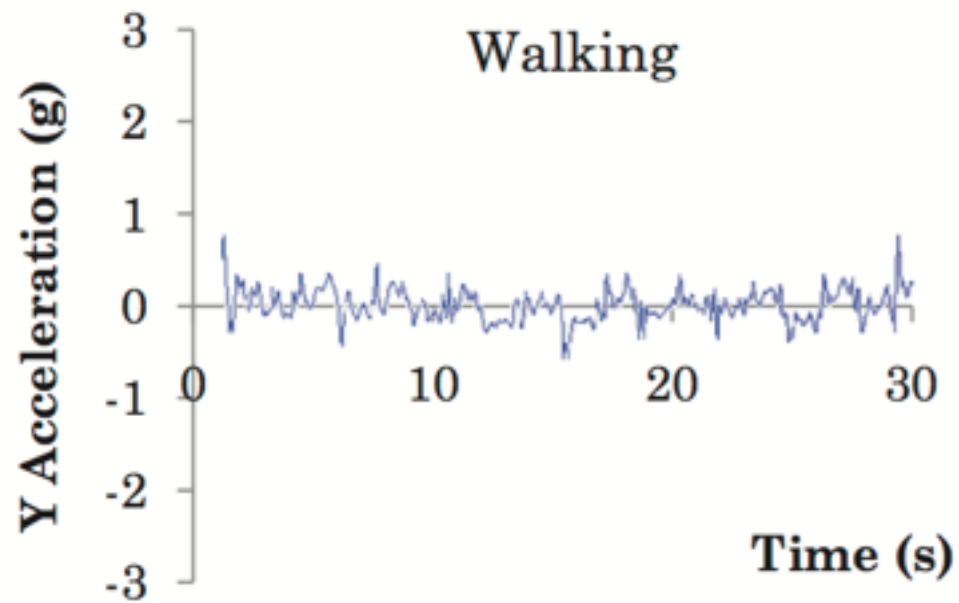
---



Distinguish Sitting from Walking

# Slightly Harder...

---



Distinguish Walking from Running

# Classification

---

Decision Trees

kNN

SVM

Bayesian Networks

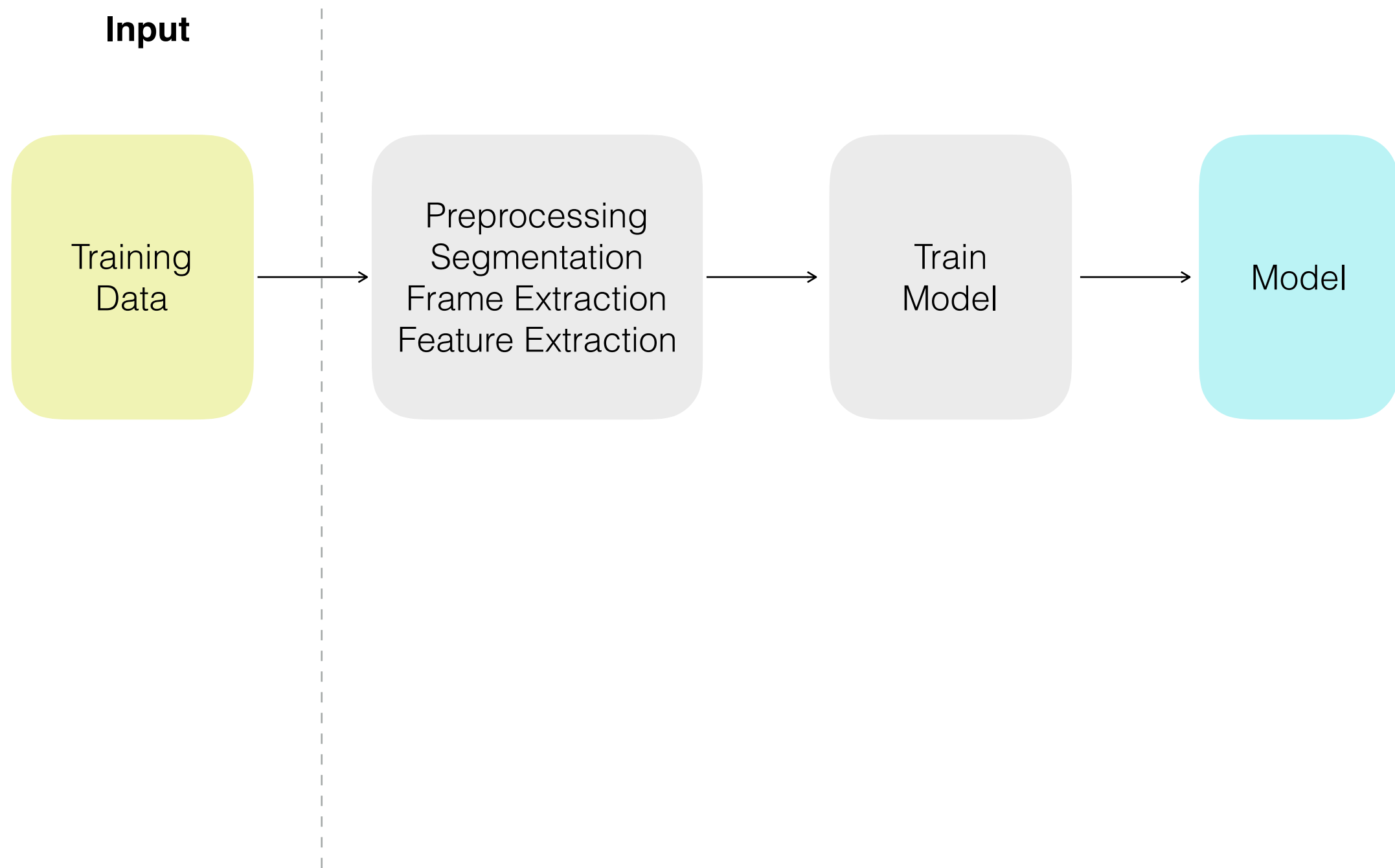
Graphical Models (HMM, CRF)

Symbolic Representations (Vector Space Model)

DeepNets

# Unimodal Input

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# Multimodal Input

---

## Input

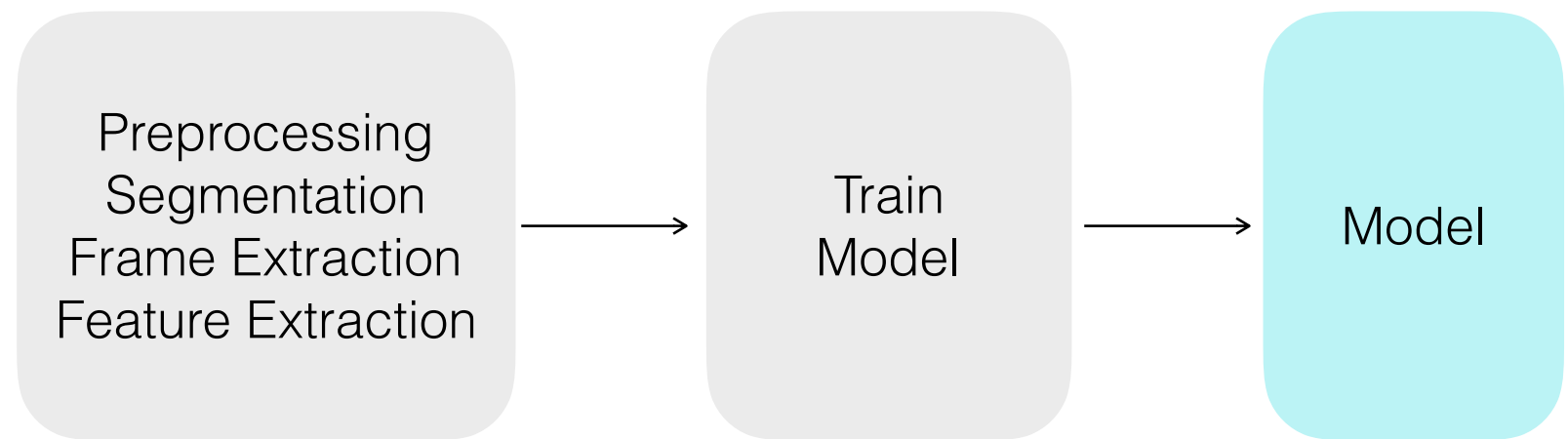
Inertial

Audio

Location

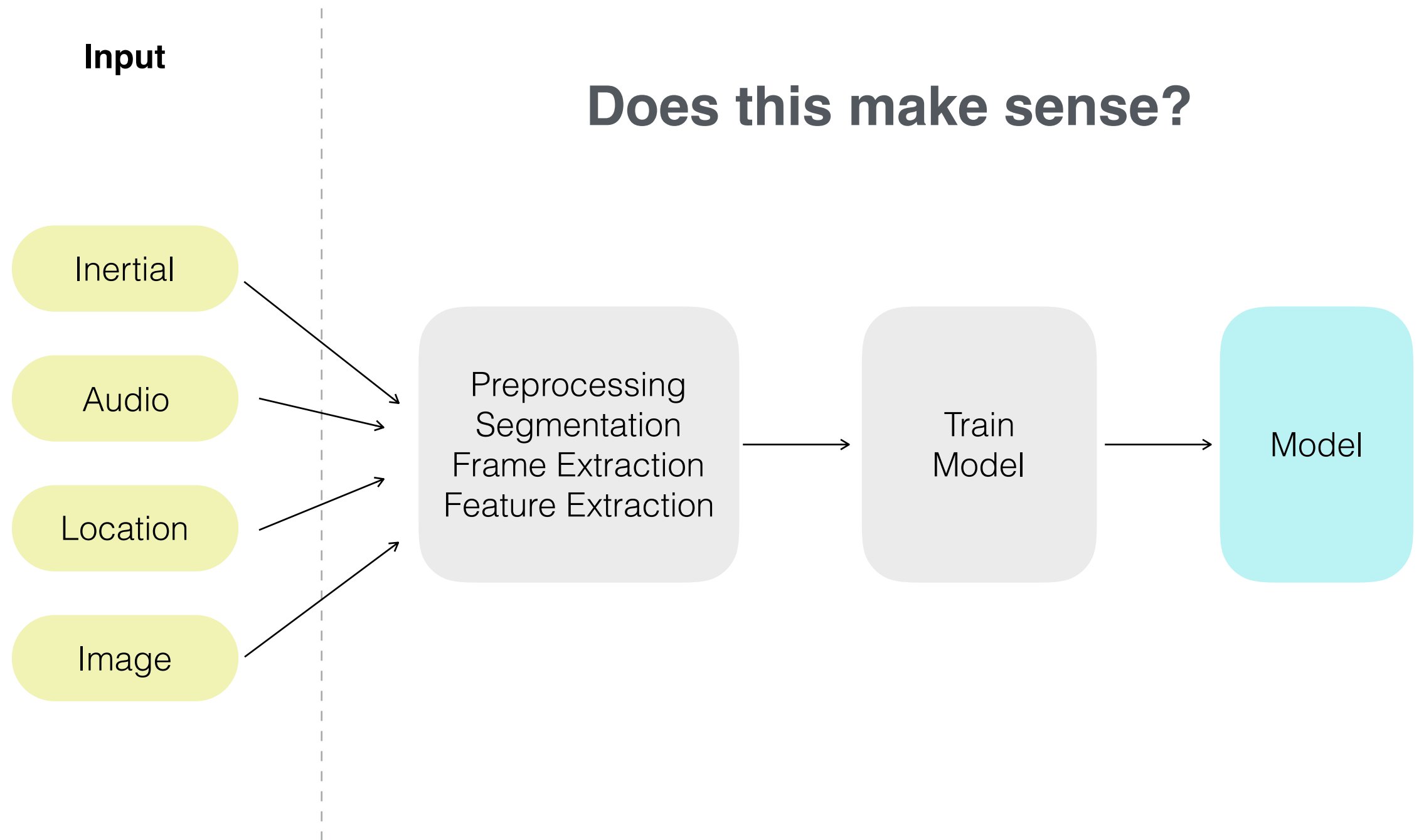
Image

## How to train a model with multimodal input?



# Multimodal Input

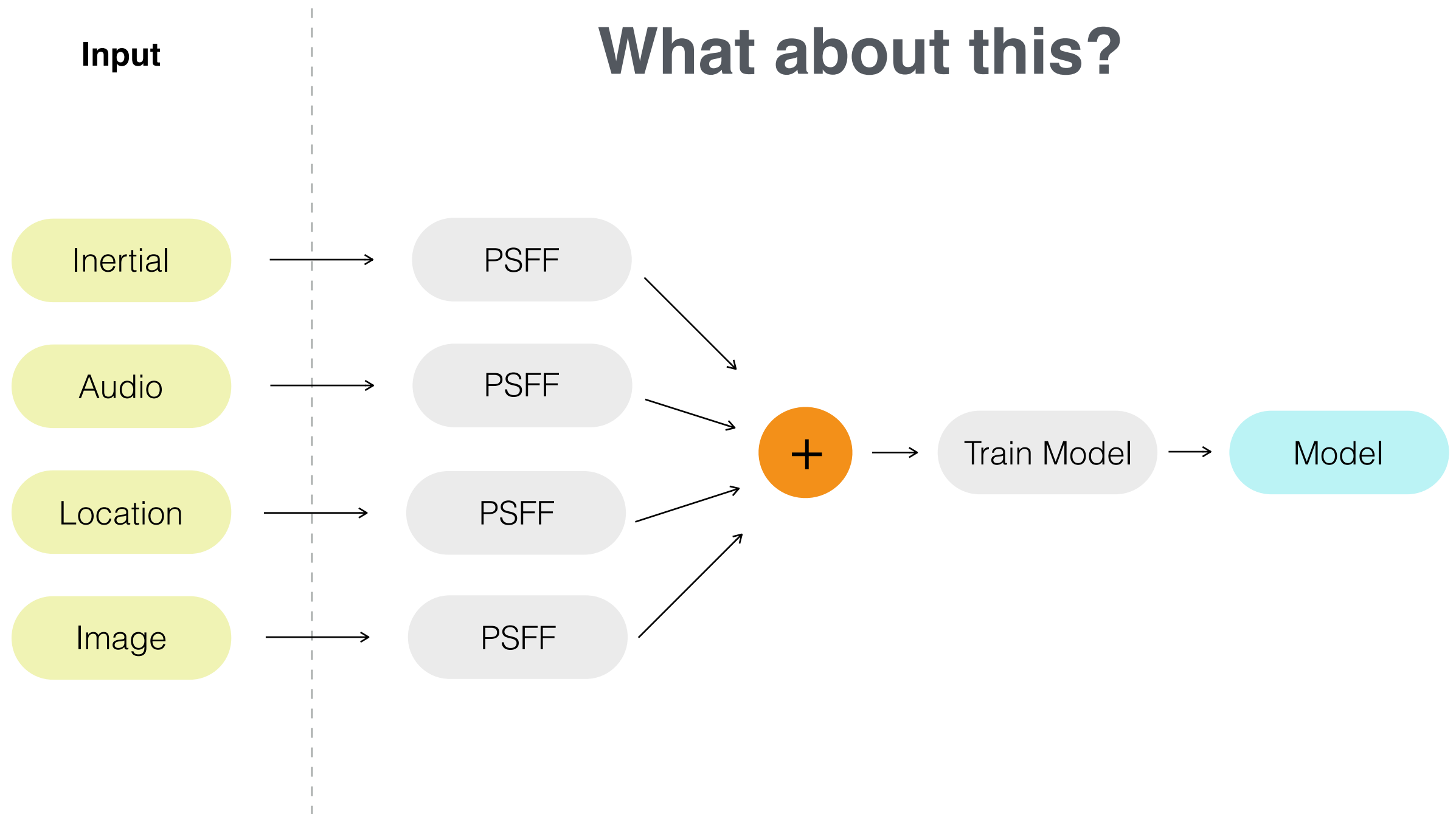
---





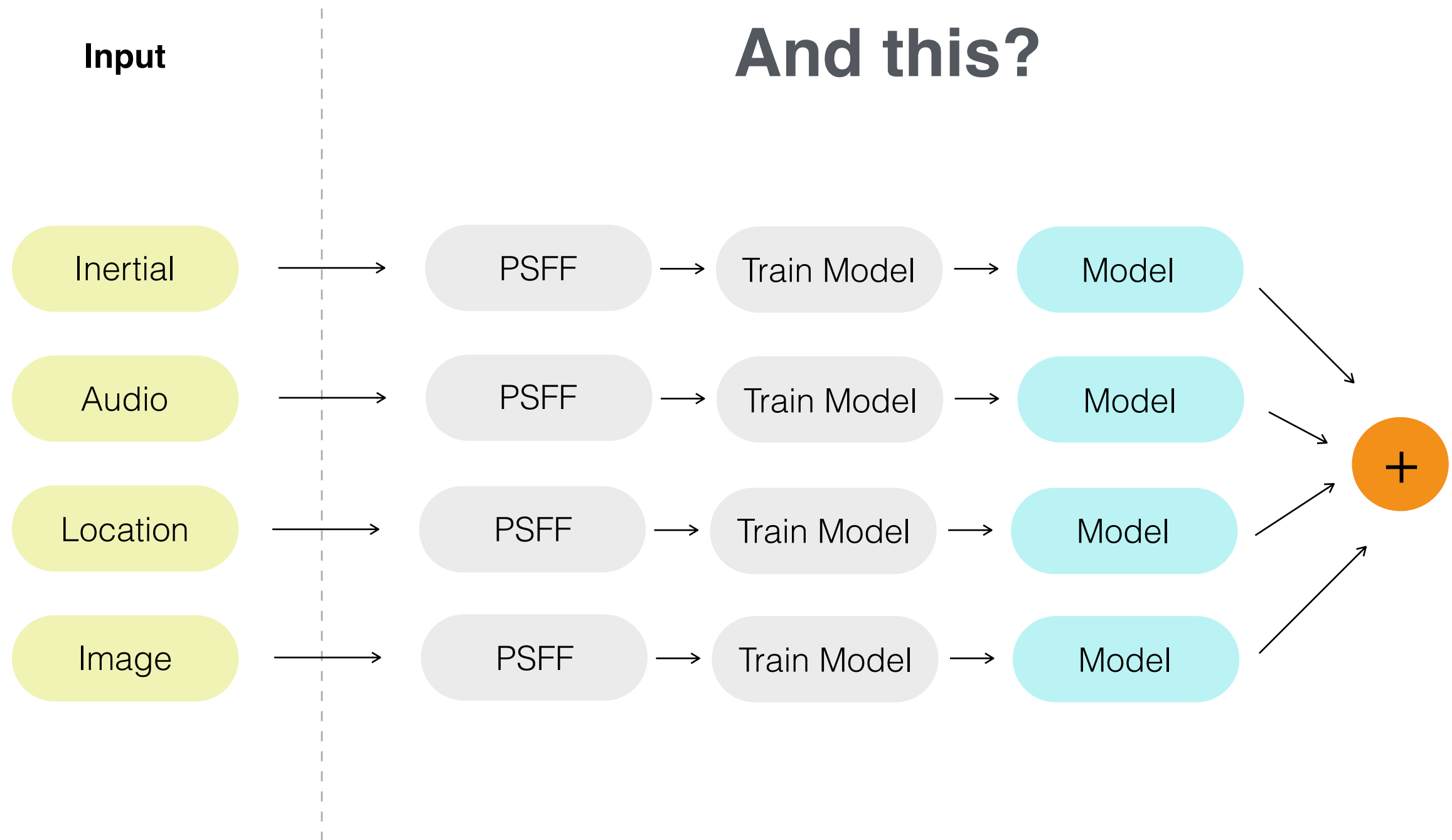
# Multimodal Input

---



# Multimodal Input

---



# Performance Evaluation

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## Eating Detector



# Performance Evaluation

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Apple Watch 2 comes with Eating Detector!



Runs at the end of every hour, from 8AM to 8PM

Outputs **Eat/No Eat** for every minute

Claimed Accuracy of 87.5%

Is this good?

12hrs = 720mins

Assume meal lasts 20 minutes

3 meals a day, for total of 60 minutes of eating

**Misses them all!**

$660/720 = 91.7\%$  Accuracy

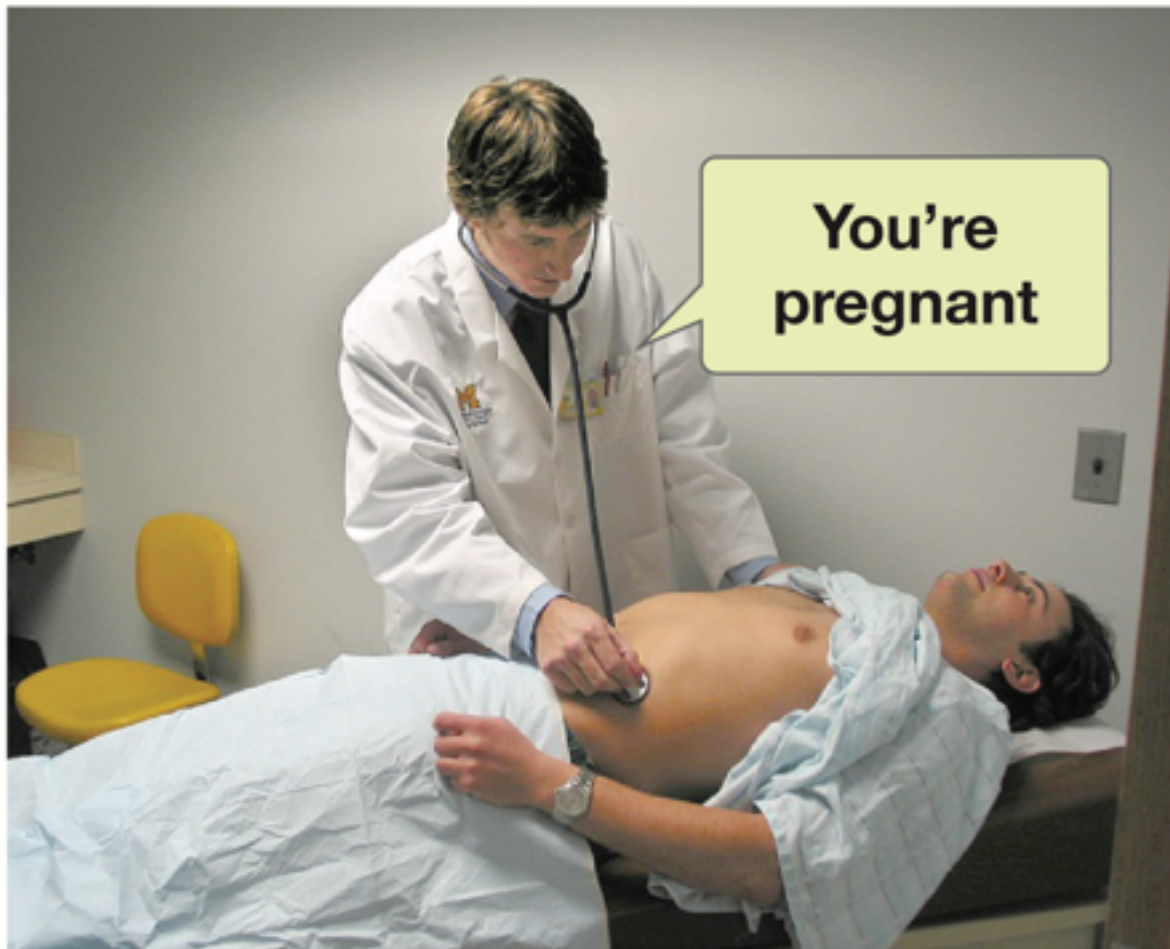


# Performance Evaluation

---

FP, TP, FN, TN

**Type I error**  
(false positive)



**Type II error**  
(false negative)



# Performance Evaluation: Metrics

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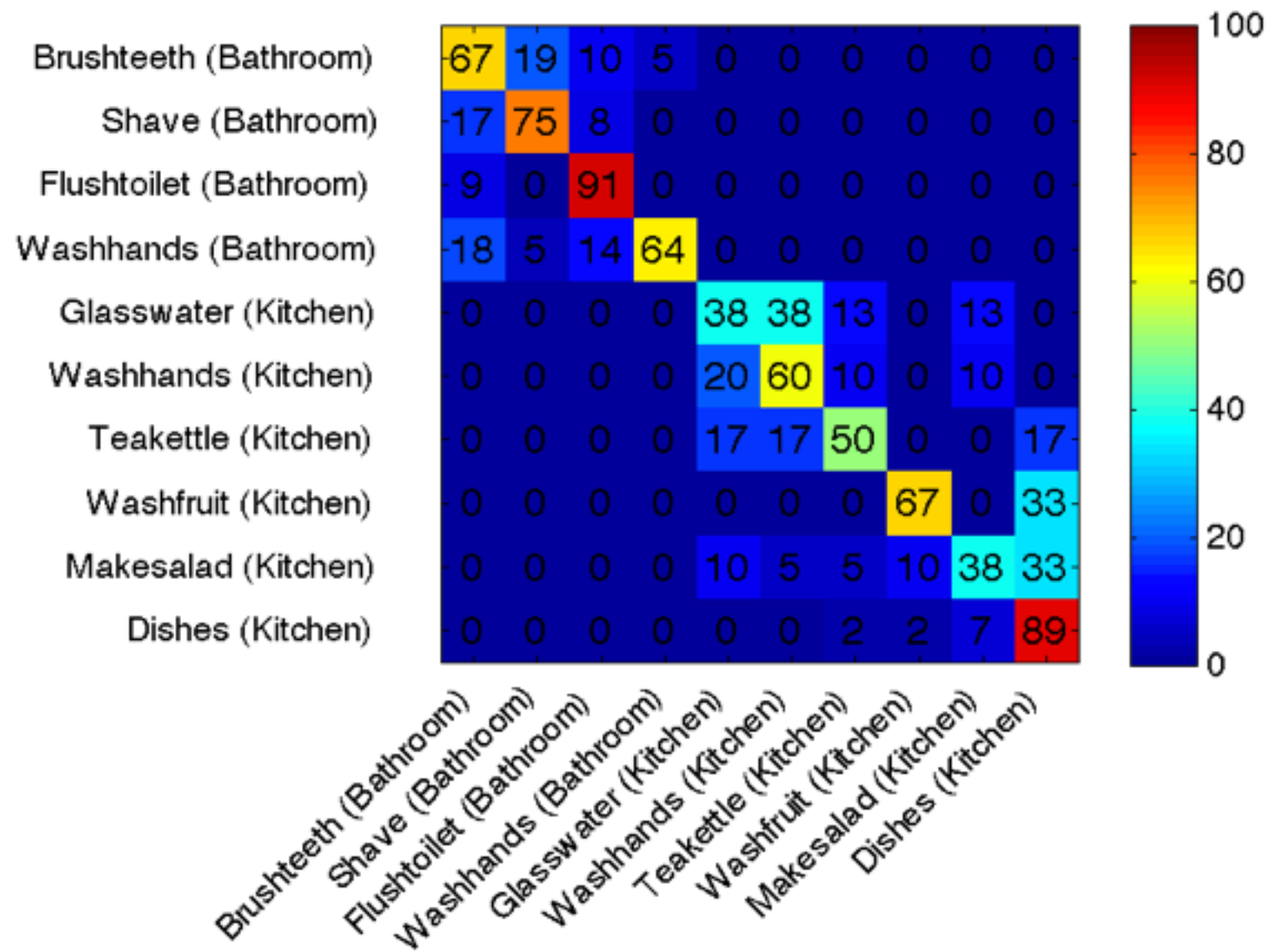
$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

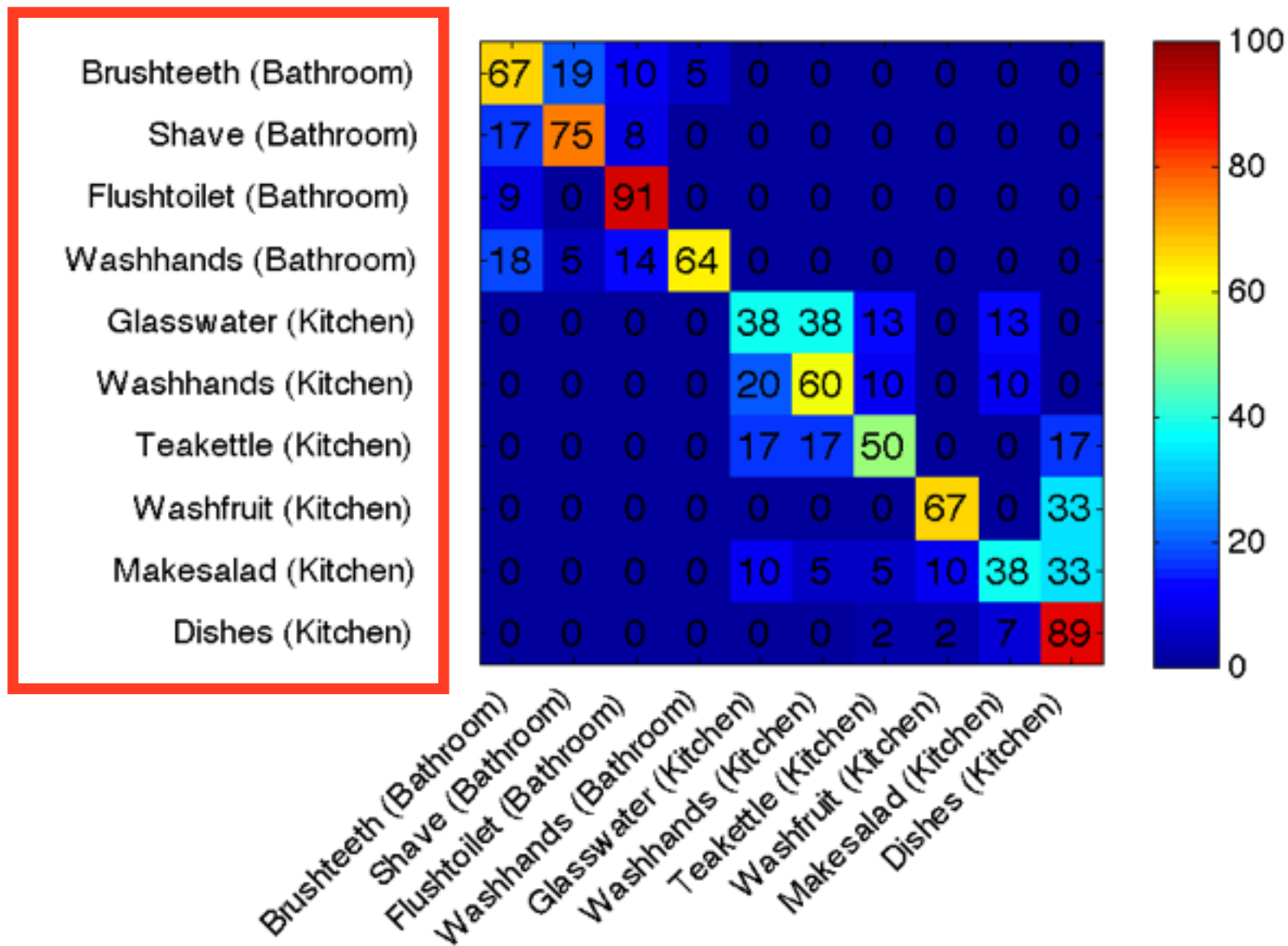
$$F - measure = 2 \cdot \frac{Precision \cdot Recall}{Precision + Recall}$$

# Performance Evaluation: Confusion Matrix

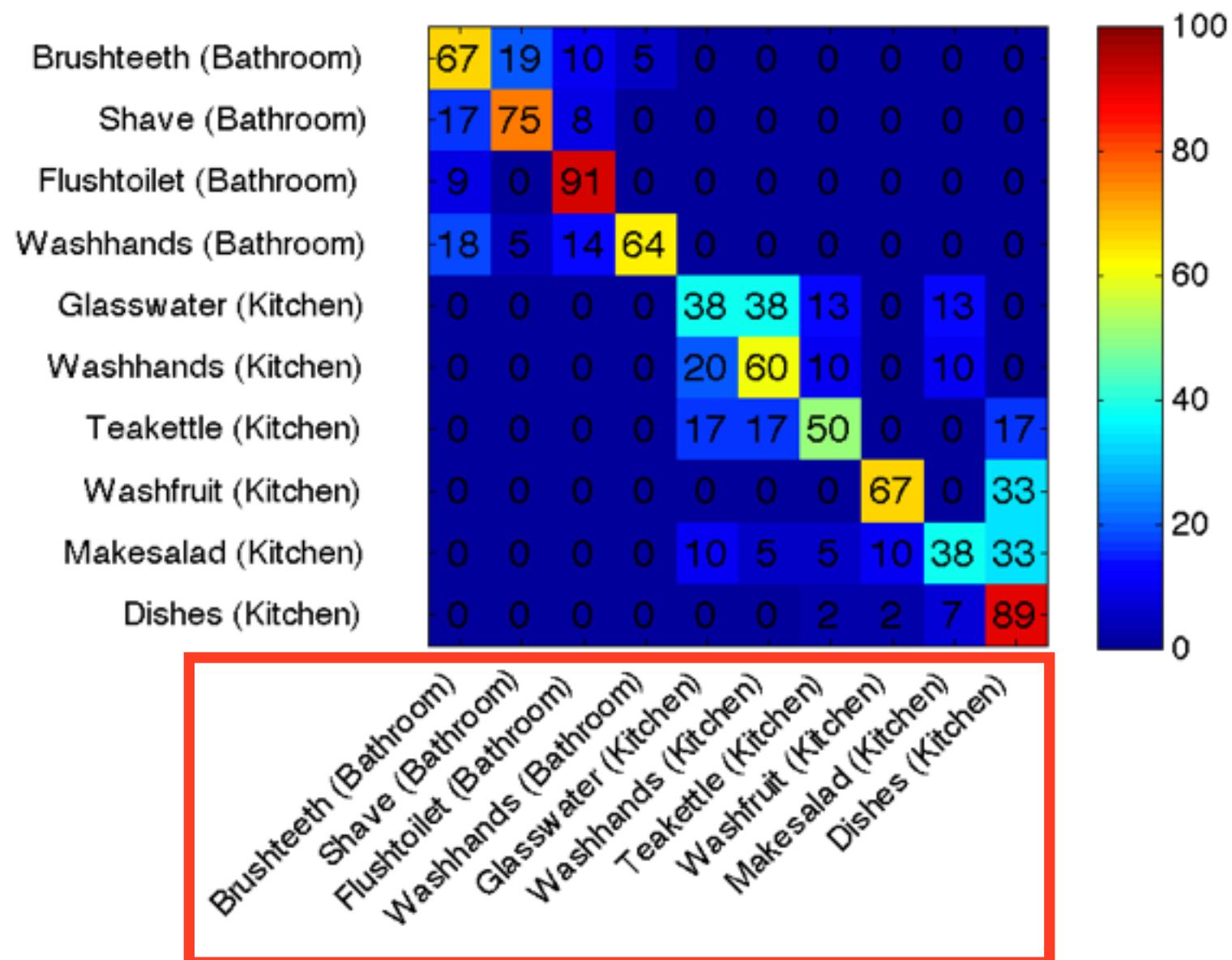




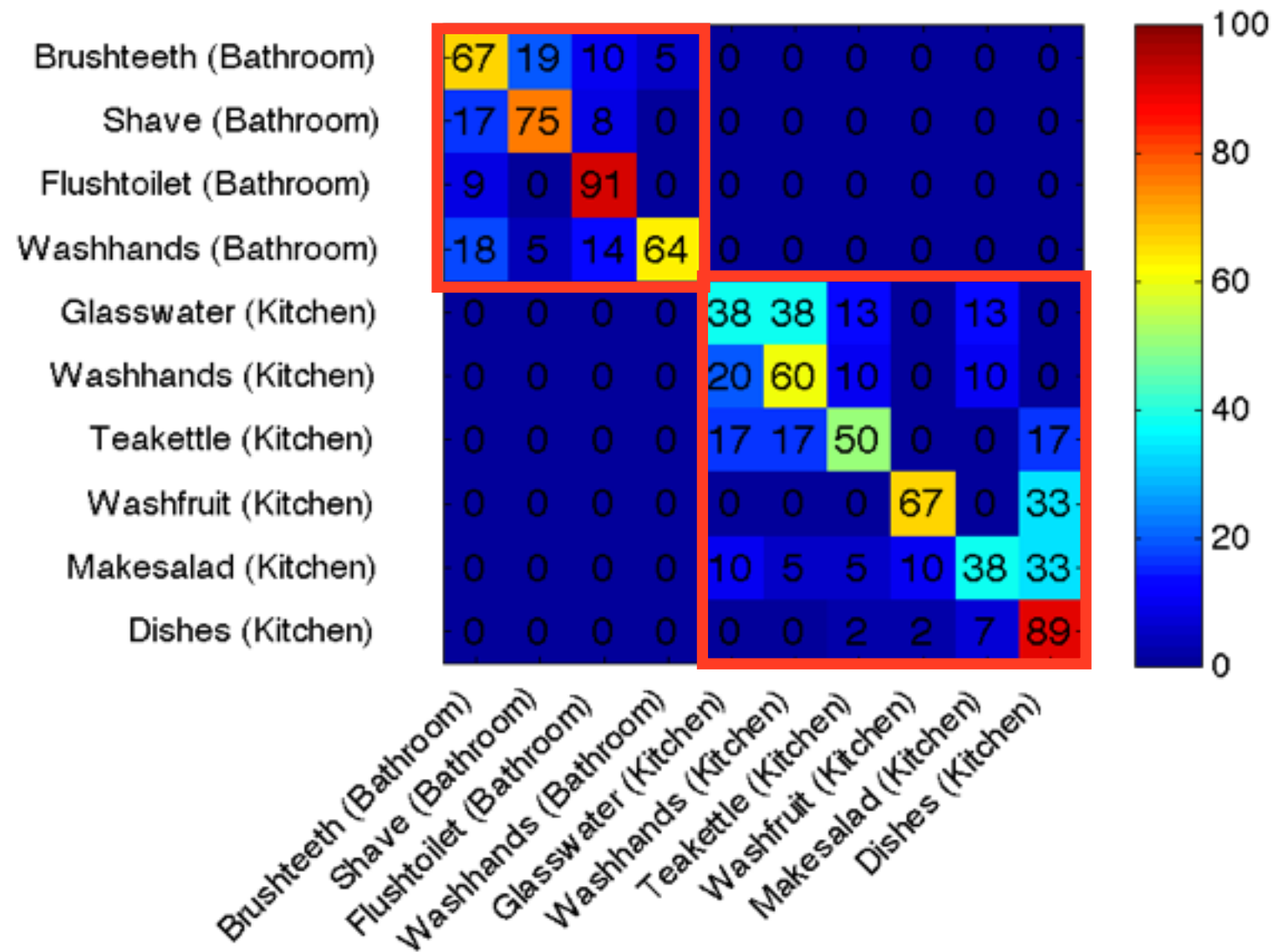
# Performance Evaluation: Confusion Matrix



# Performance Evaluation: Confusion Matrix



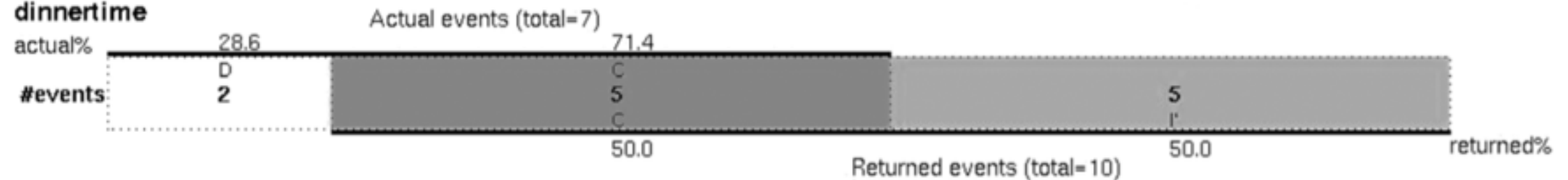
# Performance Evaluation: Confusion Matrix



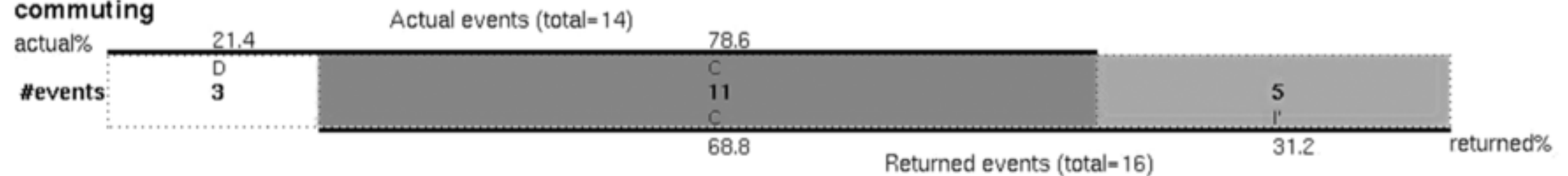
# Performance Evaluation: Time-Based

D2:

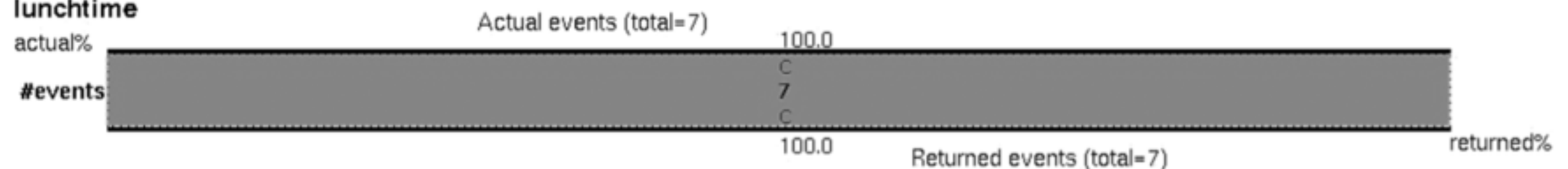
## dinnertime



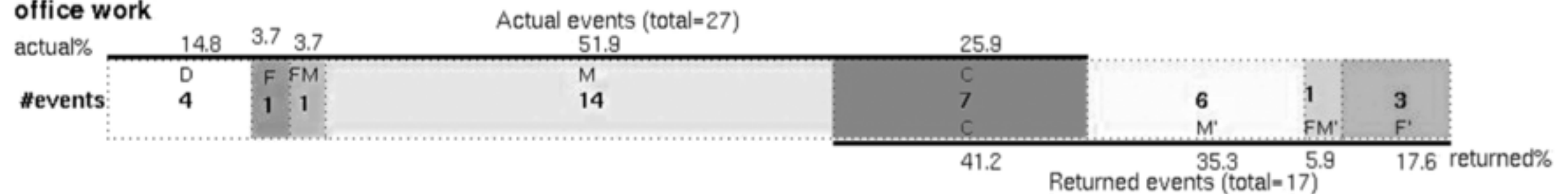
## commuting



## lunchtime



## office work

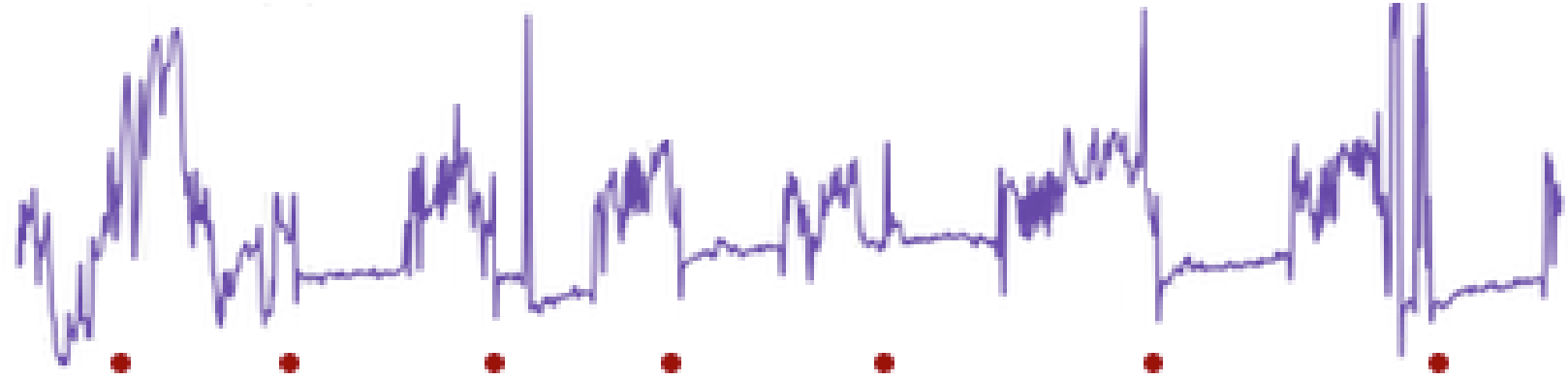


# Activity Recognition Challenges

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Intra-Class Variability

P4



# Activity Recognition Challenges

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Intra-Class Variability

Variability in Sensor

Inter-Class Similarity

Operating Requirements

NULL Class Problem

Sensor Fusion

Class Imbalance

Ground Truth Annotation

Extracting Qualitative Information



# Projects

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~10 Teams of 3/4 Students (Space in Canvas)

Project Proposal

Project Progress Report

Project Final Presentation

Project Final Report

Will be able to present ideas for projects on Sept 13th

Teams formed by Sept 20th

# Projects

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Swimming style and form detection

Identify different types of cooking gestures

Sensor to detect dog activities

Identify when text and driving is happening

Hand washing detection with wrist sensors

Activity recognition with physiological signals

Detect stress from gestural data

Activity recognition models from media

**Project report should be of publishable quality**

# Upcoming Class(es)

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Readings Assigned

Python + Scipy/Numpy + Scikit-Learn

Install in your computer (you will bring it to class next week)

Anaconda is a good install package for all you will need

Talk to me or TA in case if you have issues

Next week: Machine Learning