WHOAMION : A Technique To Determine Whether All Devices Are Being Used By The Same Person

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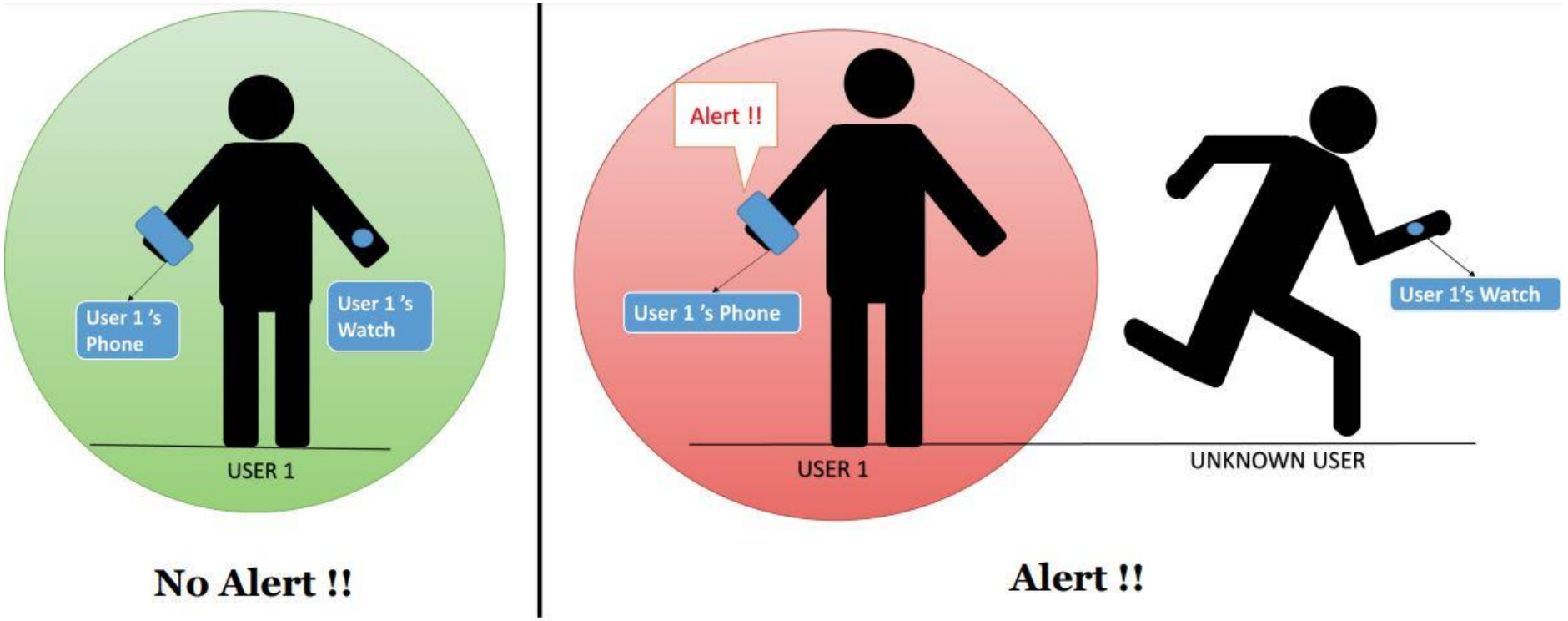
IEEE UIC @ IEEE Smart World Congress 2024

Background

Motivation



"Can multiple devices of the owner collaborate to determine whether the devices' owner is using them?"

Related Work

- Researchers used inertial sensors for movement-based correlation.
- **Two accelerometers produce similar signals when shaken together.**
- These inertial sensors may not be correlated if placed on different body positions.
- For e.g. Inertial sensor reading from smartwatch may be different from the smartphone in the pocket while typing.
- Researchers used barometer data along with accelerometer data to synchronize various devices [1].

1. Meier, Manuel, and Christian Holz. "BMAR: barometric and motion-based alignment and refinement for offline signal synchronization across devices." *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 7.2 (2023): 1-21.

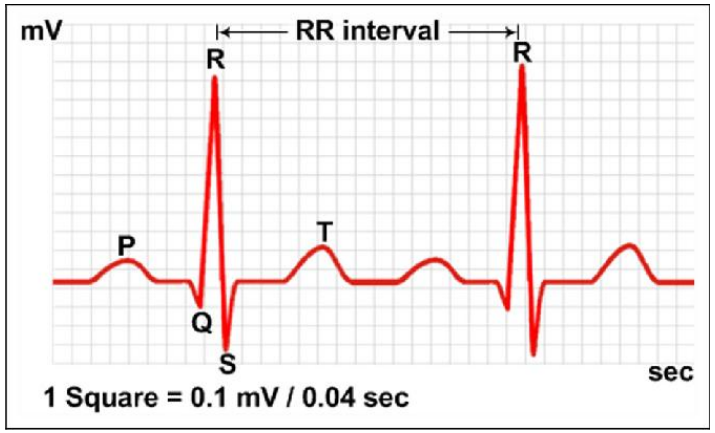
Challenges

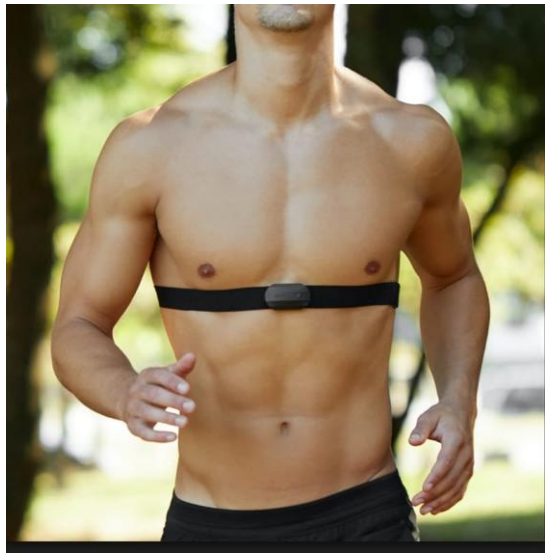
1. Device's on body position should not affect the system performance.
2. Sensitivity and resolution of the sensor might vary.
3. Prone to motion artifacts.
4. Correct logging to the data with owner.

We developed a system **WHOAMION,** a technique that determines if all the devices are with the same person.

Why Heart Rate?

Can body-generated physiological signals be used for continuous authentication?



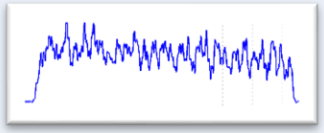
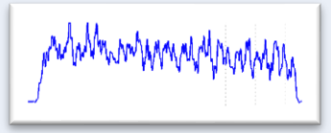


ECG

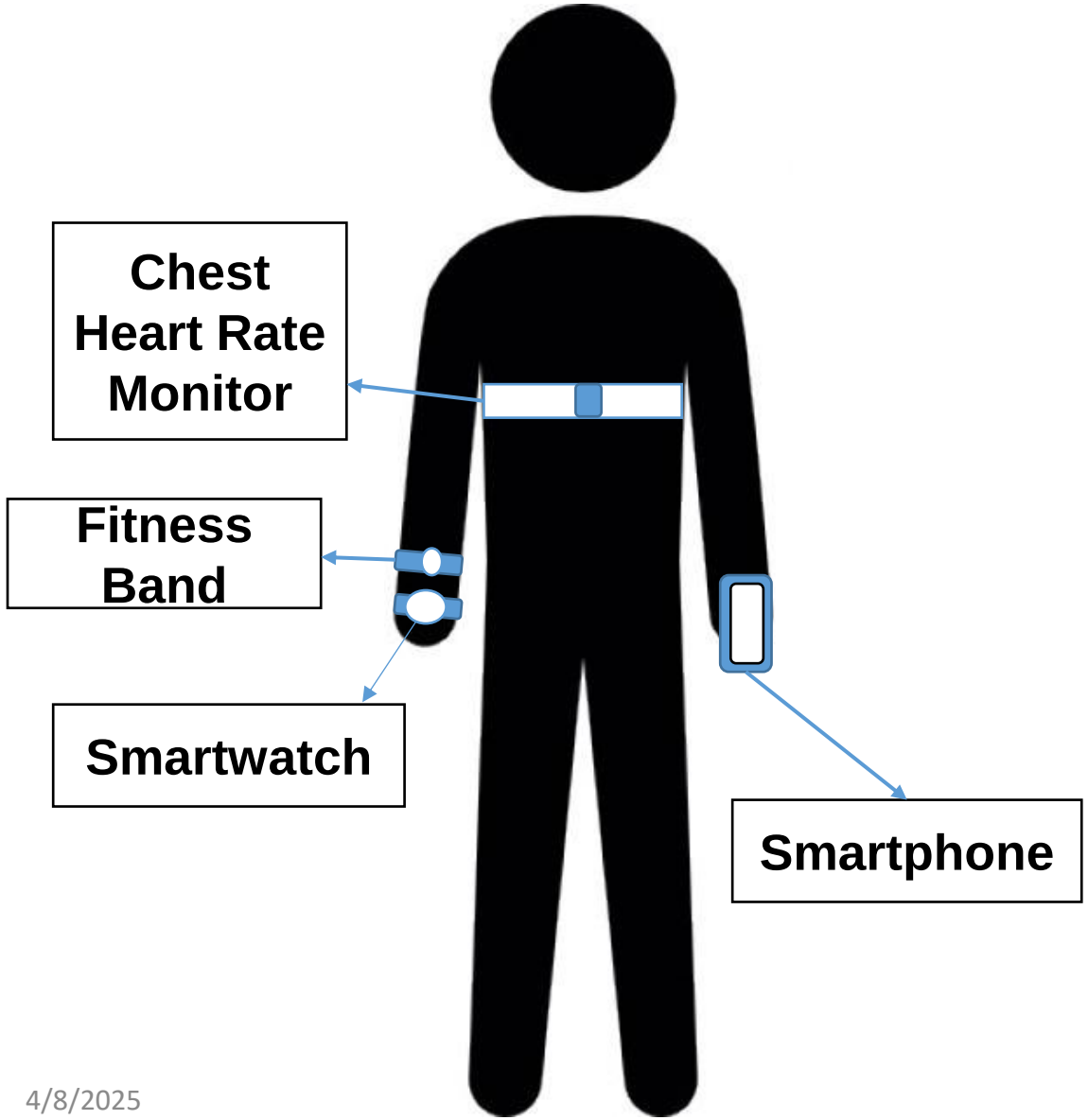
PPG

Heart Rate is similar even for different body positions.

Datasets

	Extrasensory Dataset (Publicly Available)	Multi-Device Dataset (Collected Dataset)
No. of participants	60 participants	12 participants
Duration	125 Hours	40 Minutes(per participant)
Devices	Smartphone , Smartwatch	Chest Heart Rate monitor, Fitness Band, Smartwatch, Smartphone
Sensor Signals		 
Activities	Walking , Running (Physical Activities)	Resting, Physical Activities, Psychological Activities

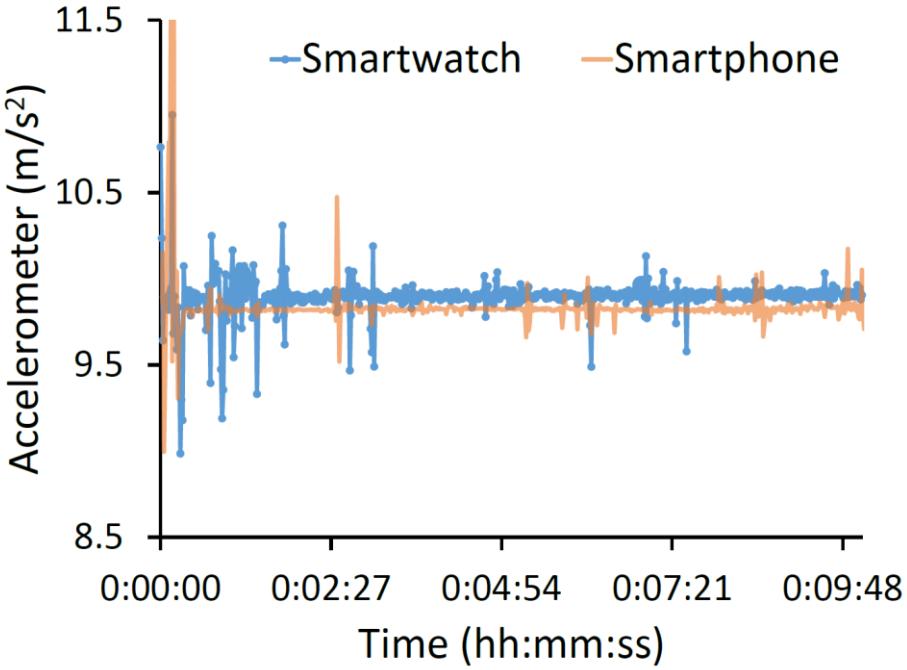
Multi-Device Dataset

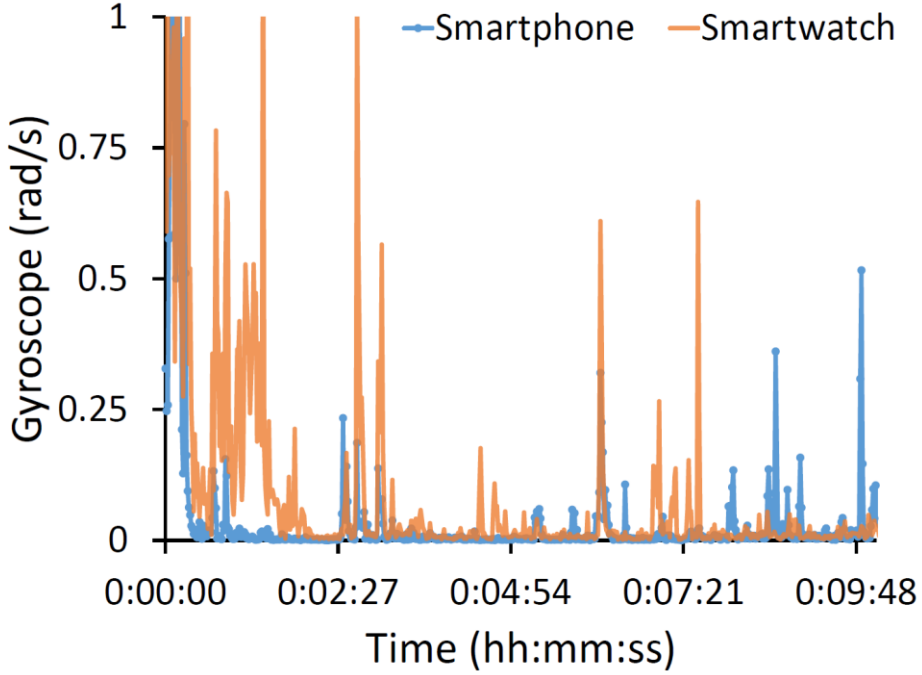


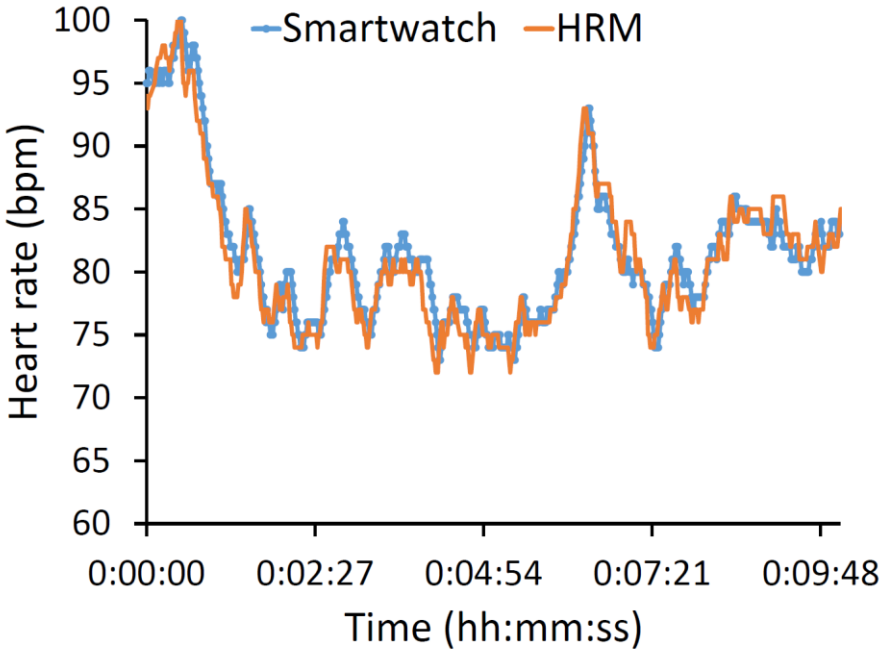
Activities

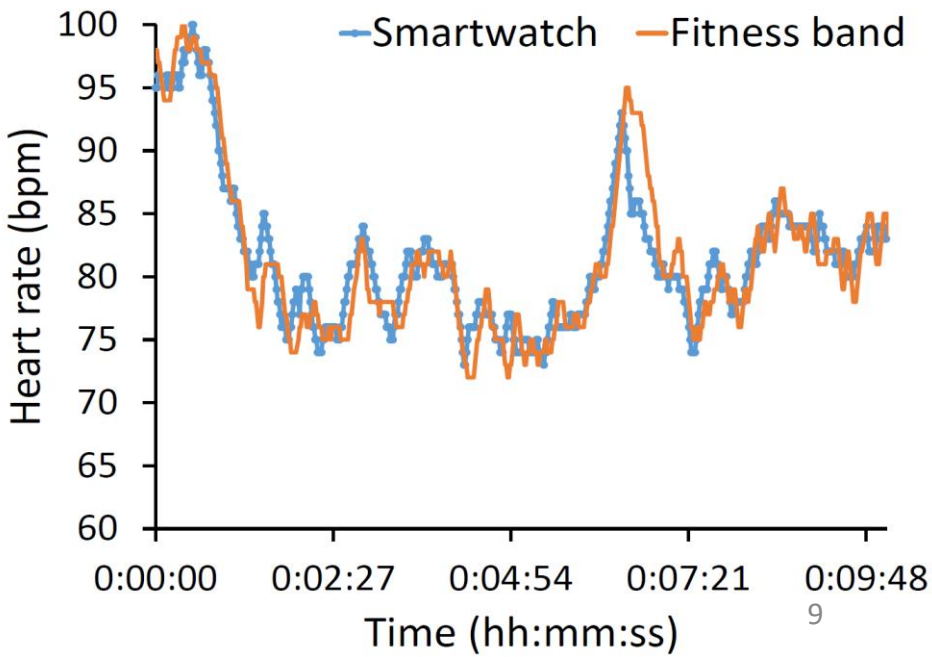
- Resting (5 minutes)
- Physical Activities (5 minutes)
  - Walking
  - Running
- Psychological Activities
  - Public Speaking (5 minutes)
  - Mental Arithmetic (5 minutes)

Feasibility Study









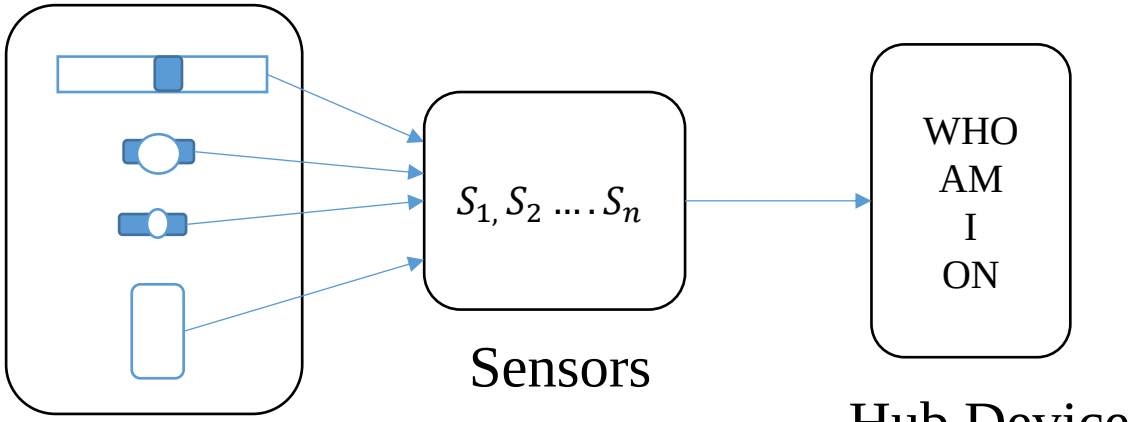
Feasibility Study

Pearson's Correlation

Sensor	Sensor1 (Device1)	Sensor2 (Device2)	Average Correlation
Accel	Accel. (Samsung Watch 4)	Accel. (Smartphone)	0.18
Gyro	Gyro. (Samsung Watch 4)	Gyro. (Smartphone)	0.60
Heart Rate	PPG (Garmin Vivosmart 4)	PPG (Samsung Watch 4)	**0.77**
	ECG (Polar H10 HRM)	PPG (Garmin Vivosmart 4)	**0.76**
	ECG (Polar H10 HRM)	PPG (Samsung Watch 4)	**0.80**

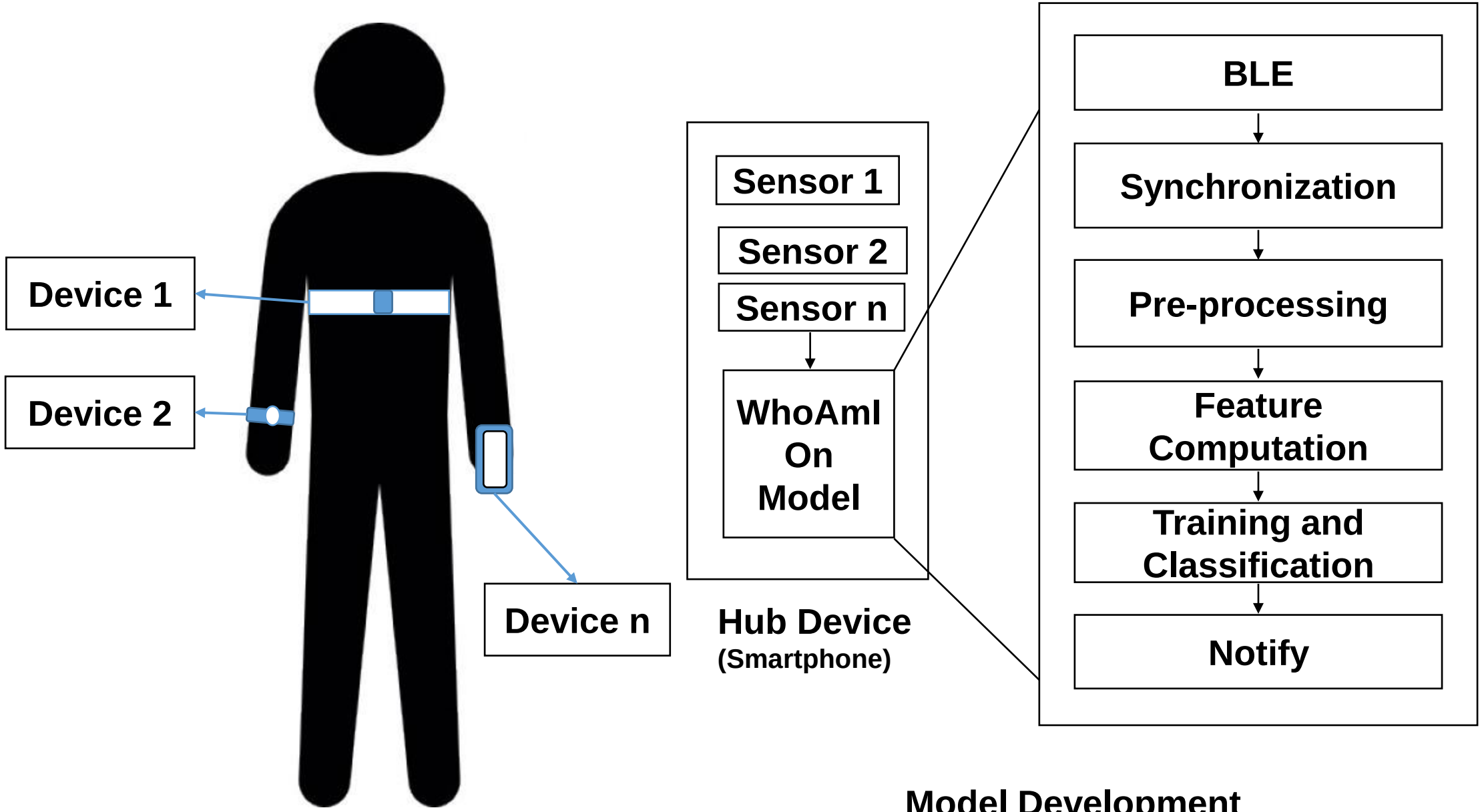
WHOAMION System

- Concern is about the misuse of personal devices.
- Aligns two sensor signals obtained from various on-body wearable devices.
- WHOAMION consists of

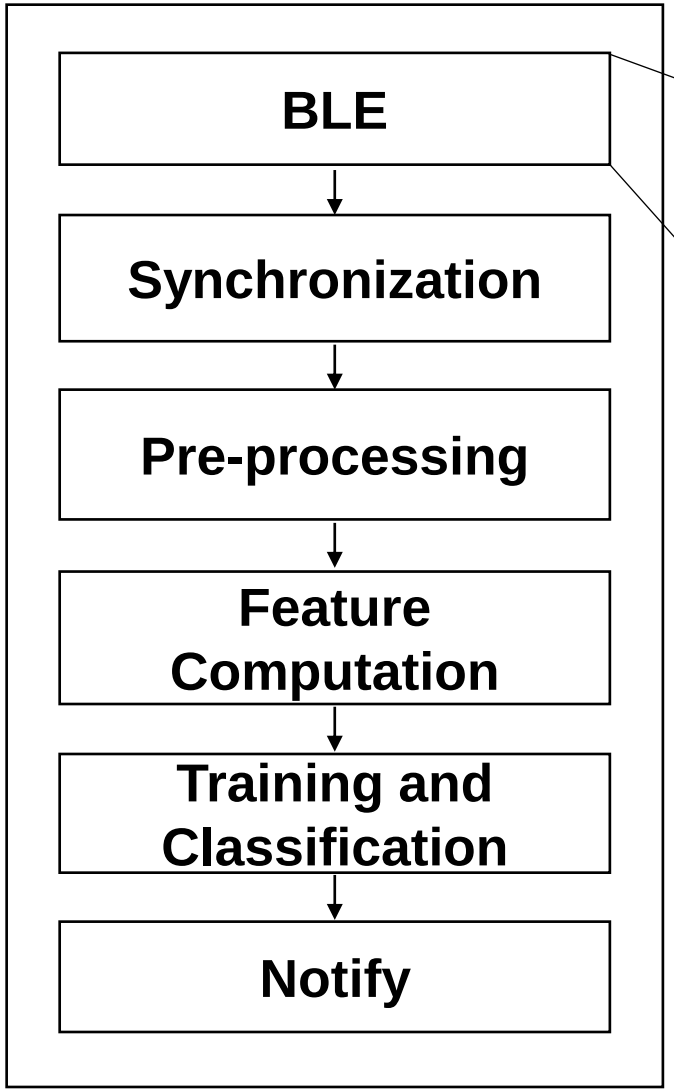


- Assumptions
  - User has done prior authentication (bonding and pairing) of devices.
  - Hub device is always with owner.

WHOAMION System

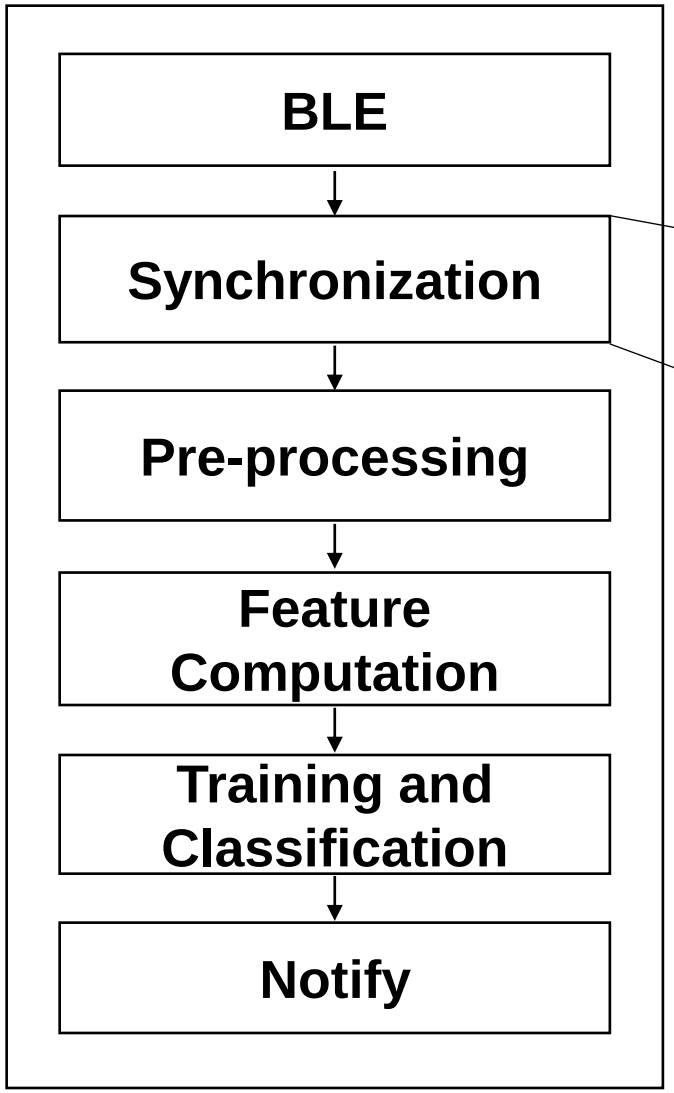


WHOAMION System



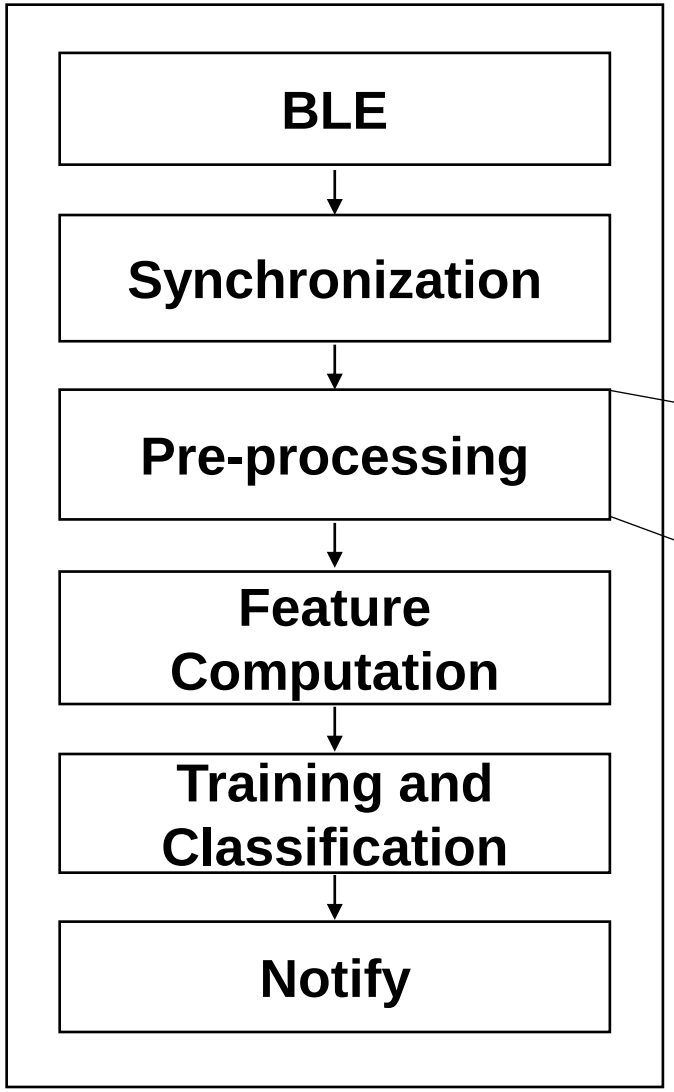
- Collects the sensor data from various devices over BLE.

WHOAMION System



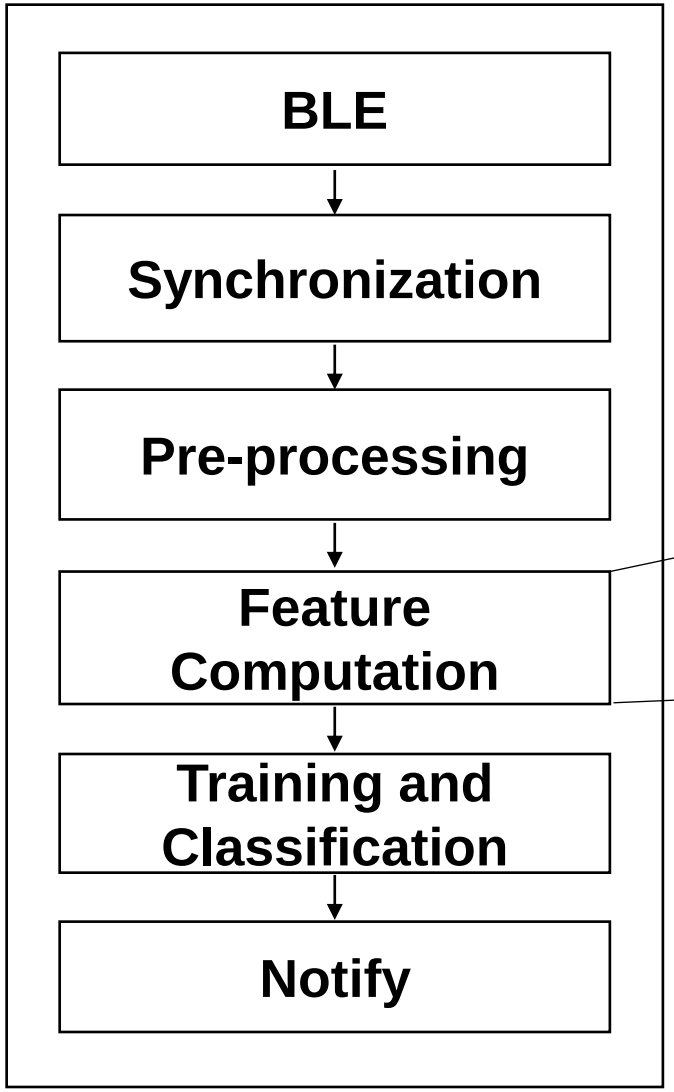
- Sync the data based on time.

WHOAMION System



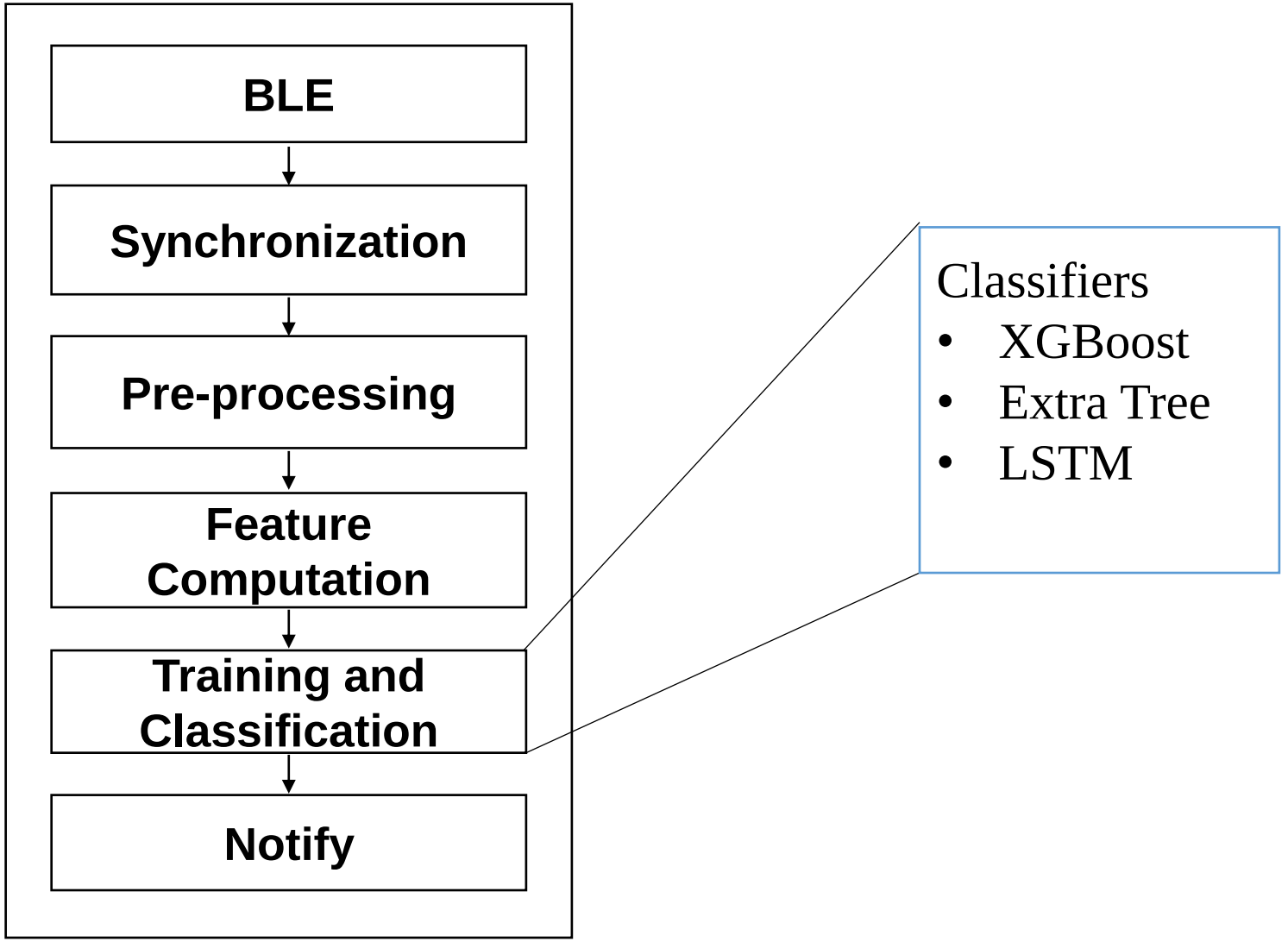
- NA are removed.
- Erroneous readings are removed

WHOAMION System



- Frame the sensor data into **Window.**
- Compute features**.**

WHOAMION System



Evaluation & Results

Comparison of the different sensing modalities for on-body detection

Classifier	Accuracy (Accel –Accel)
XGBoost	83%
Extra-Tree	**84%**
LSTM	56%

Extrasensory Dataset

Evaluation & Results

Classifier	Accuracy HR - HR	Accuracy Accel-Accel	Accuracy Gyro-Gyro
XGBoost	56%	51%	53%
Extra-Tree	65%	61%	67%
LSTM	**84%**	52%	74%

Multidevice Dataset

Conclusion

- WhoAmIOn, a technique to determine whether the devices of the owner are on the same body.
- We evaluated WhoAmIOn on two datasets, one publicly available dataset and another dataset that we collected in a controlled setting.
- We experimented with both inertial sensors and heart rate sensors.
- We observed the accuracy of 0.84 with inertial sensors from extrasensory dataset and 0.84 using heart rate sensor on Multidevice dataset.

Thank You !!

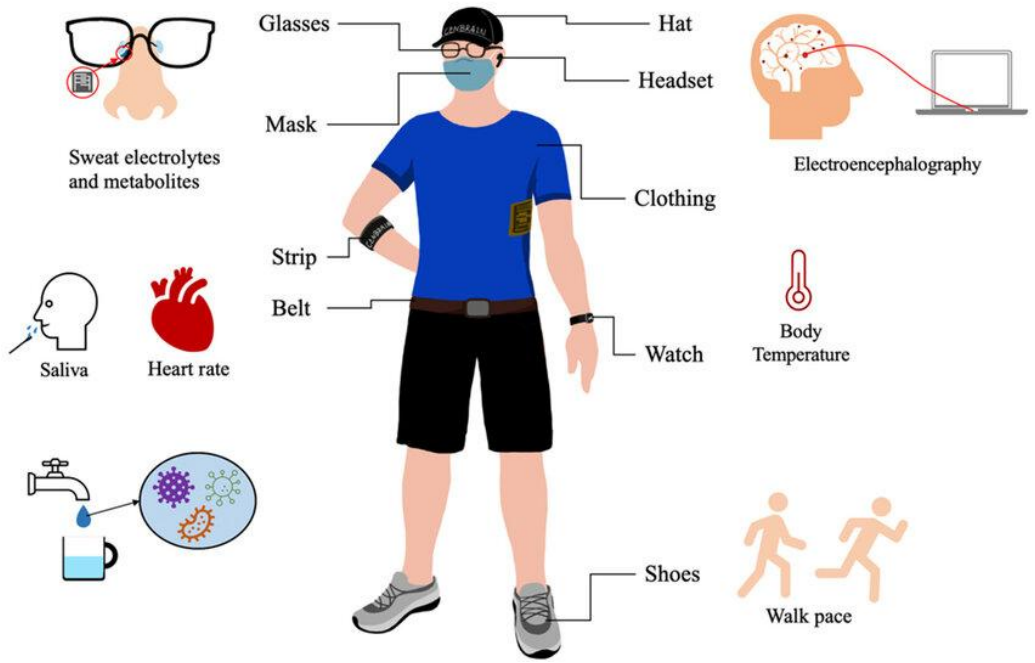
Evaluation & Results

Comparison of the different sensing modalities for on-body detection

Sensor Combination	Devices	Accuracy
PPG - PPG	Garmin Vivosmart 4, Samsung Watch 4	0.74
ECG- PPG	Polar H10 , Garmin Vivosmart 4	0.75
ECG-PPG	Polar H10, Samsung Watch 4	0.84

Challenges

- Device's on body position should not affect the system performance.



Energy Solutions for Wearable Sensors: A Review - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Wearable-medical-and-healthcare-devices-for-various-regions-of-the-body_fig1_352005714 [accessed 2 Dec 2024]

Challenges

- Sensitivity and resolution of the sensor might vary.
- Robust to variations in sensor data.
- Correct logging to the data with owner.

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Co-Supervisor : Dr. Dheryta Jaisinghani

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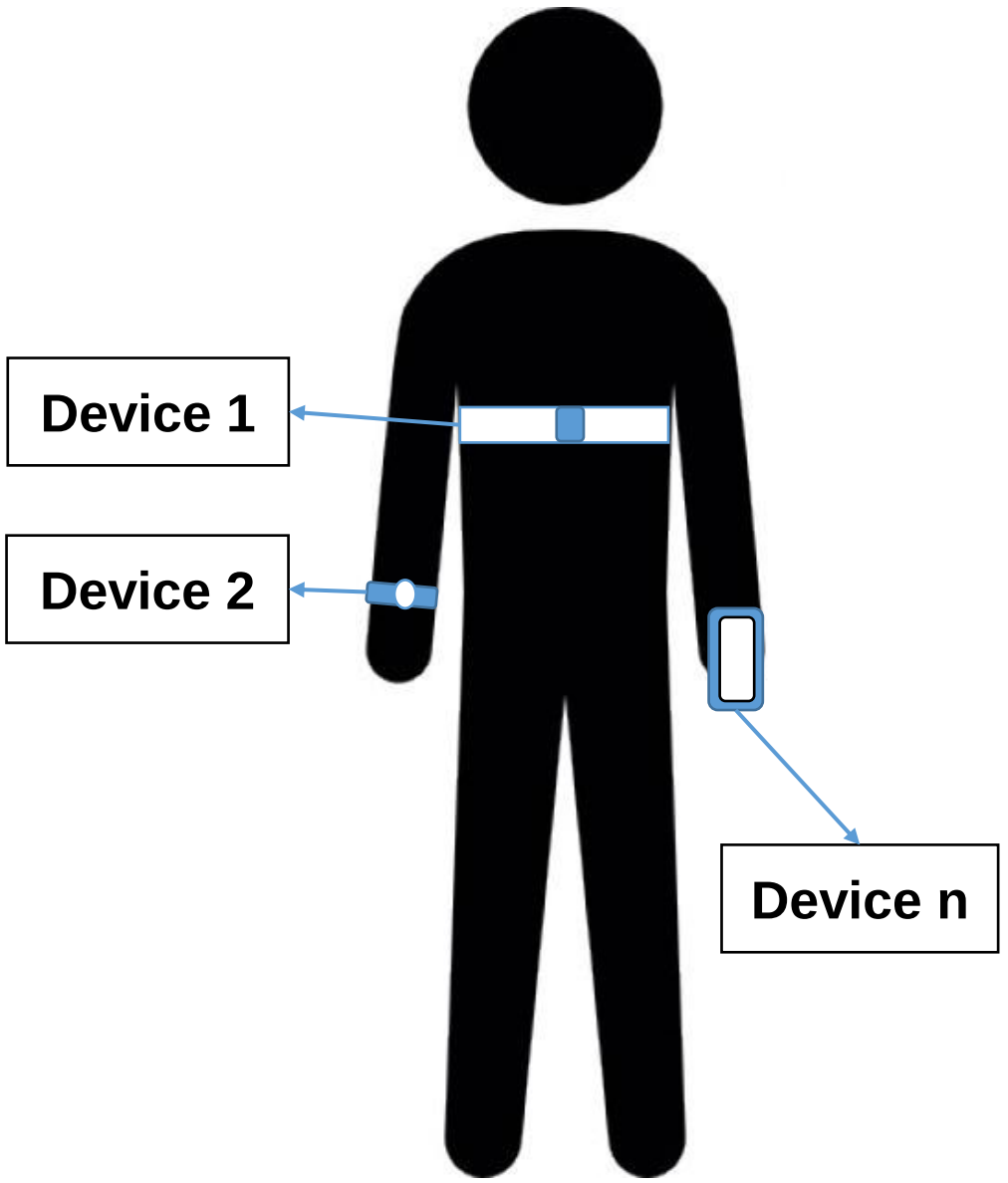

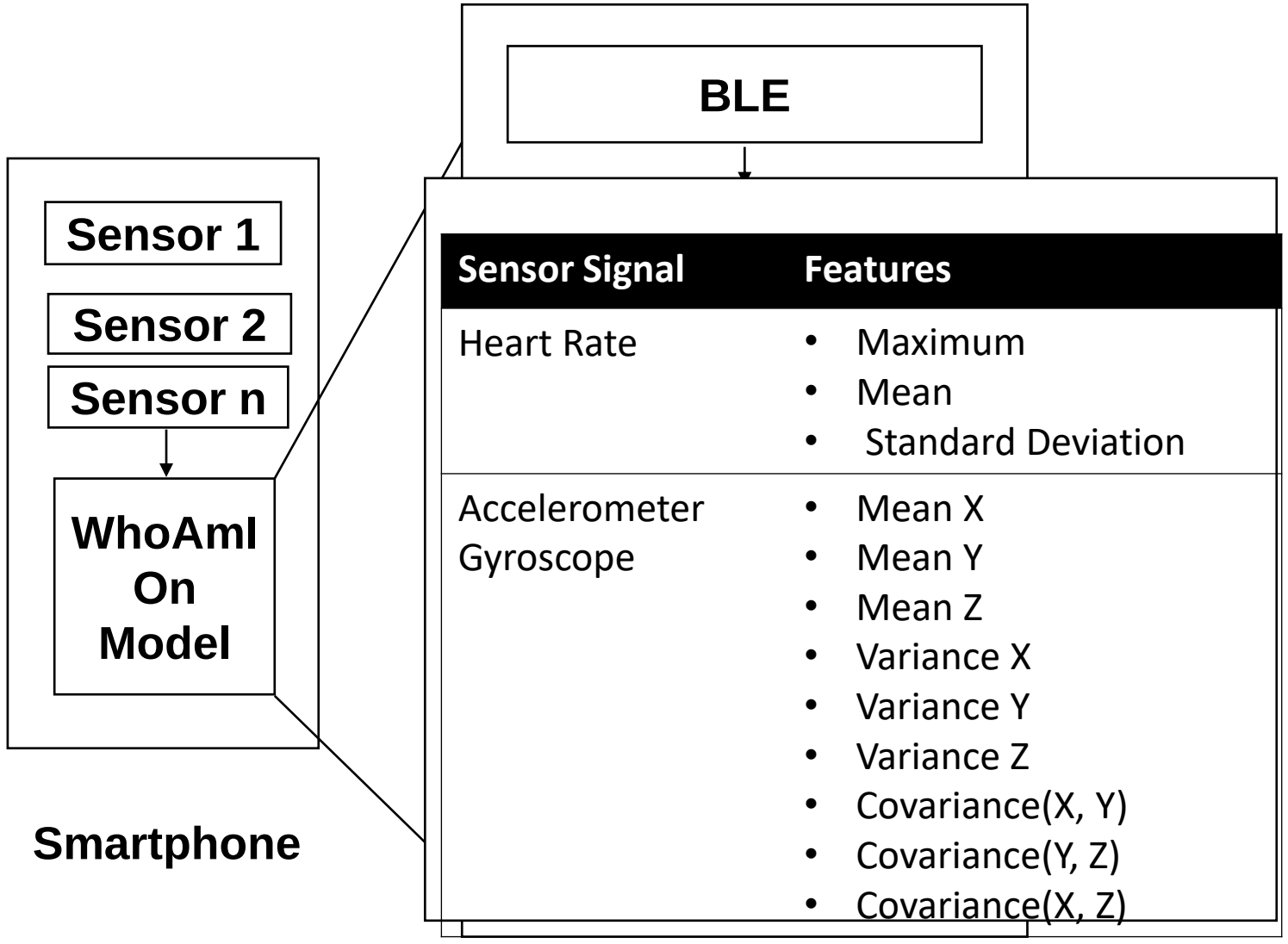

Sensor Signal	Features
Heart Rate	• Maximum • Mean • Standard Deviation
Accelerometer Gyroscope	• Mean X • Mean Y • Mean Z • Variance X • Variance Y • Variance Z • Covariance(X, Y) • Covariance(Y, Z) • Covariance(X, Z)

Model Development

How we overcome the challenges?

Challenges

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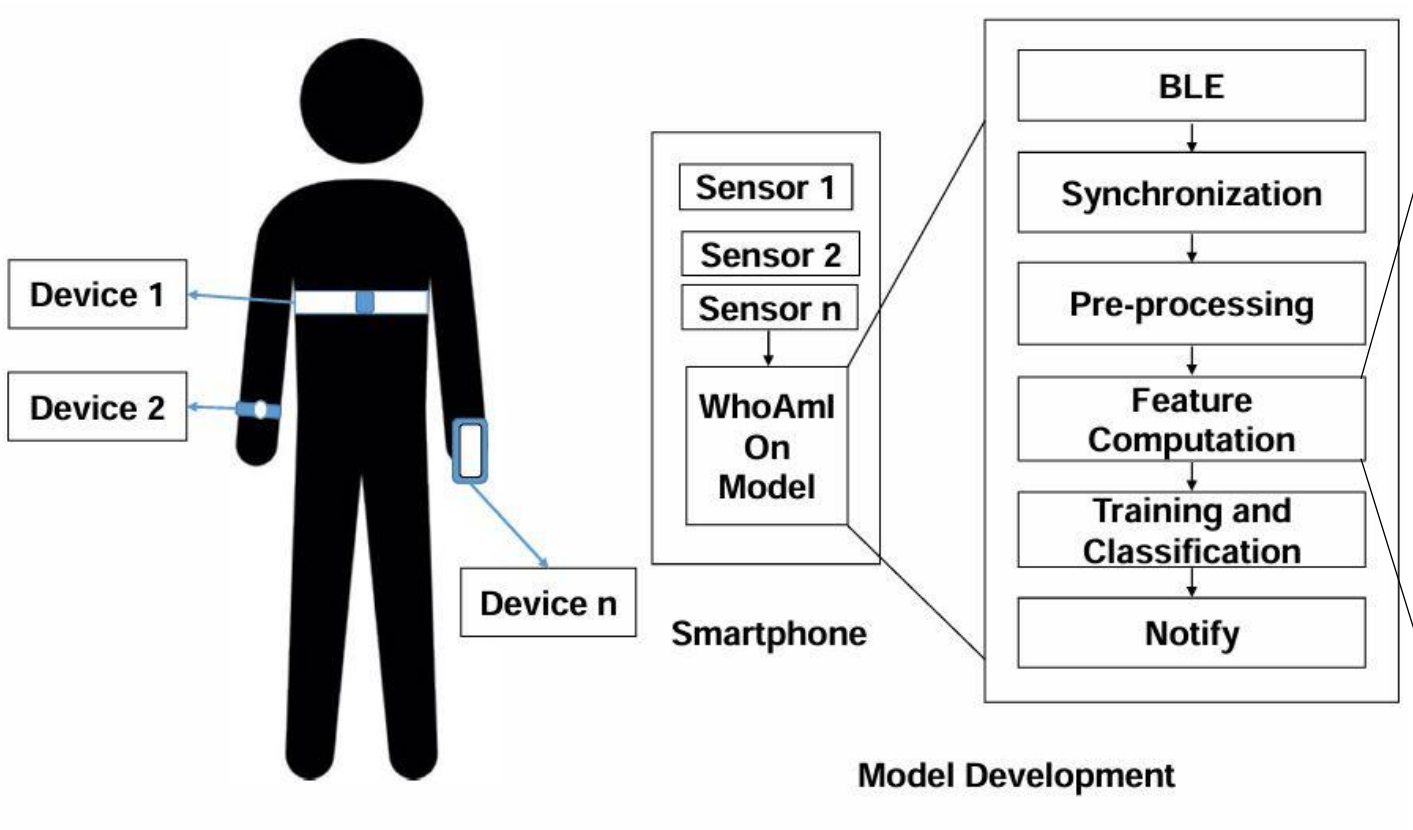

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WHOAMION System

- Concern is about the misuse of personal devices.
- Aligns two sensor signals obtained from various on-body wearable devices.
- Can work with any time-series data.
- WHOAMION consists of
  - Set of devices D that are connected to Hub Device H.
  - Hub Device has set of sensors S_i.
  - Each device $d_j \in D$ and has set of sensor which belongs to set S_i.
- Assumptions
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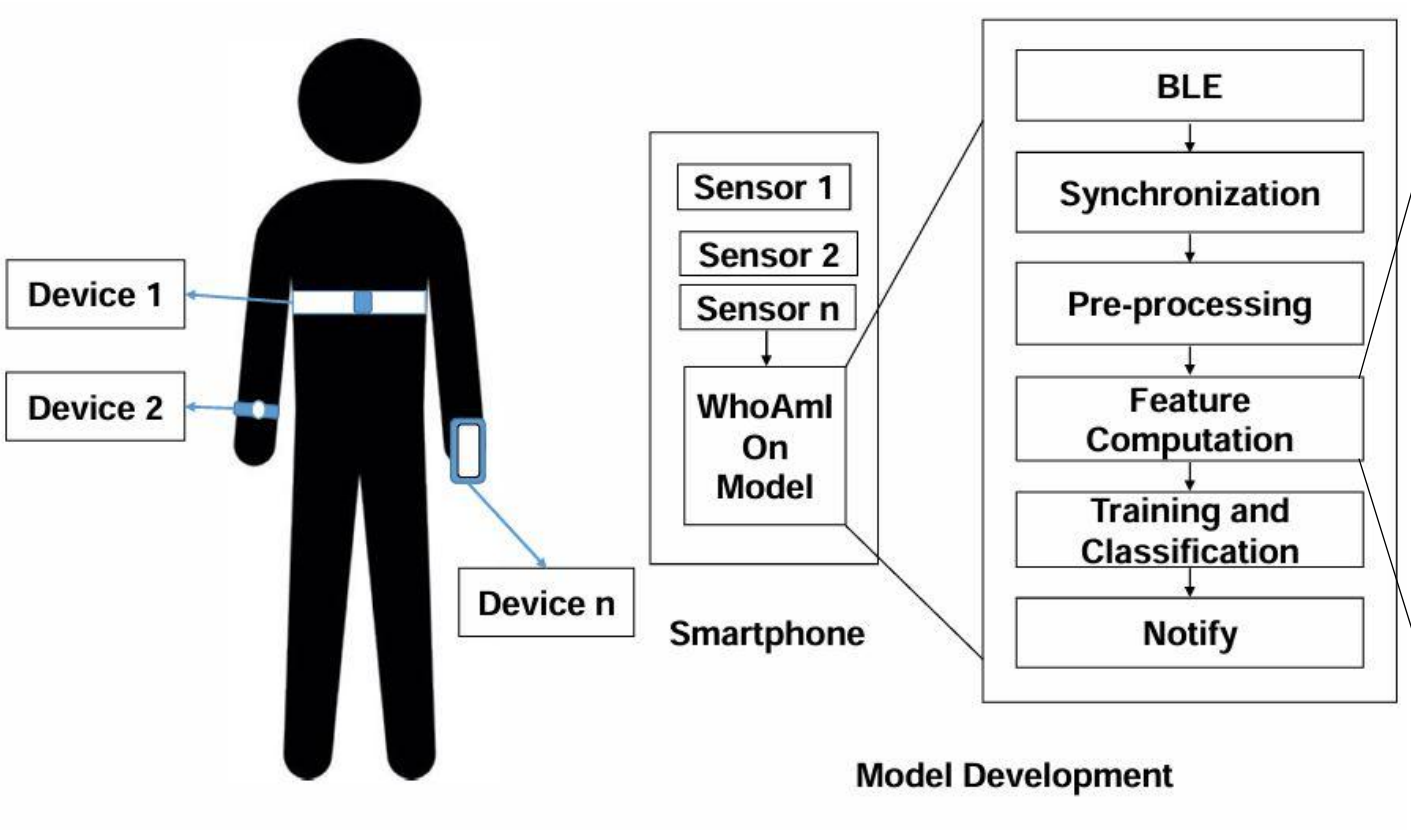

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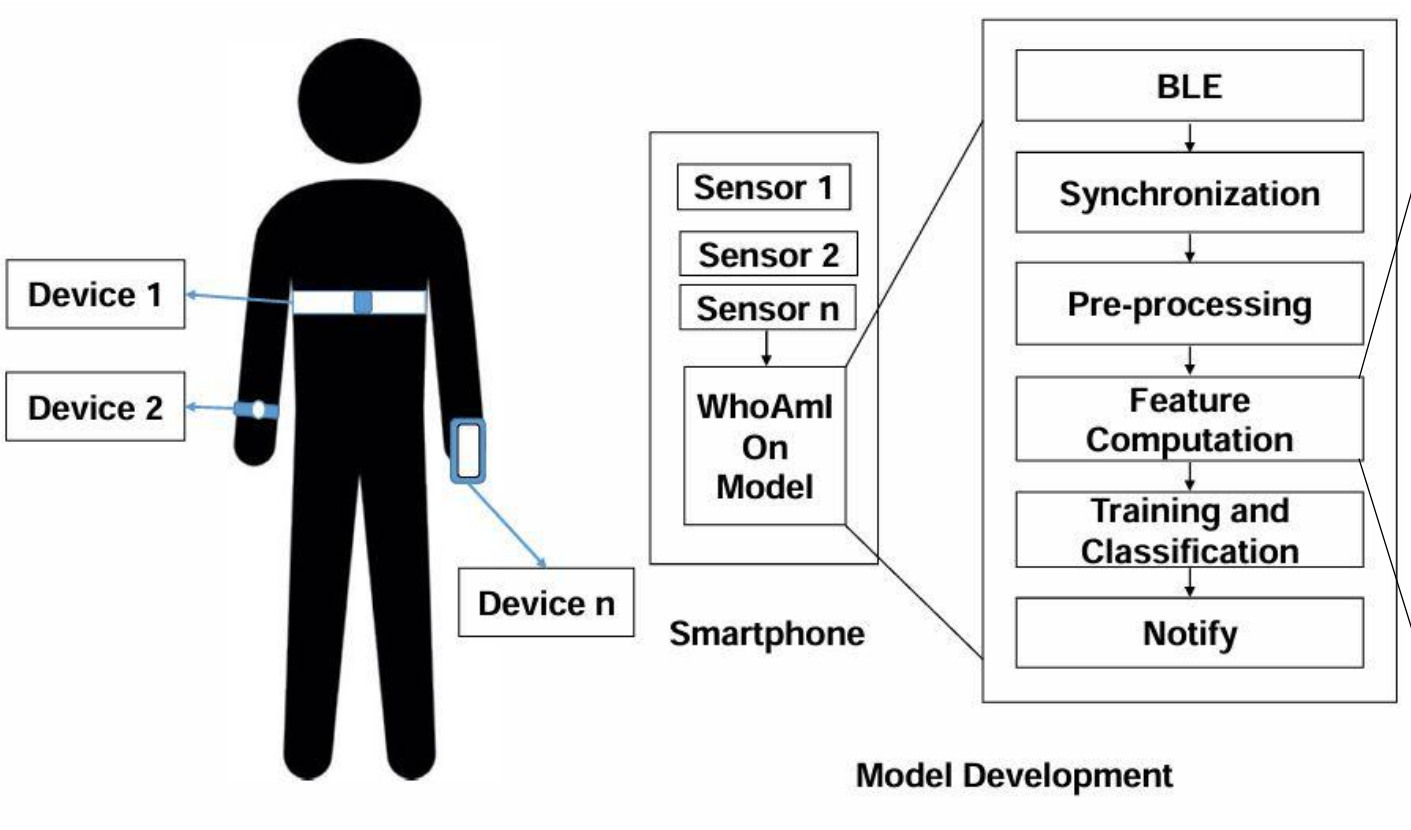

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