University of Bristol

Pervasive Health Monitoring: An Overview

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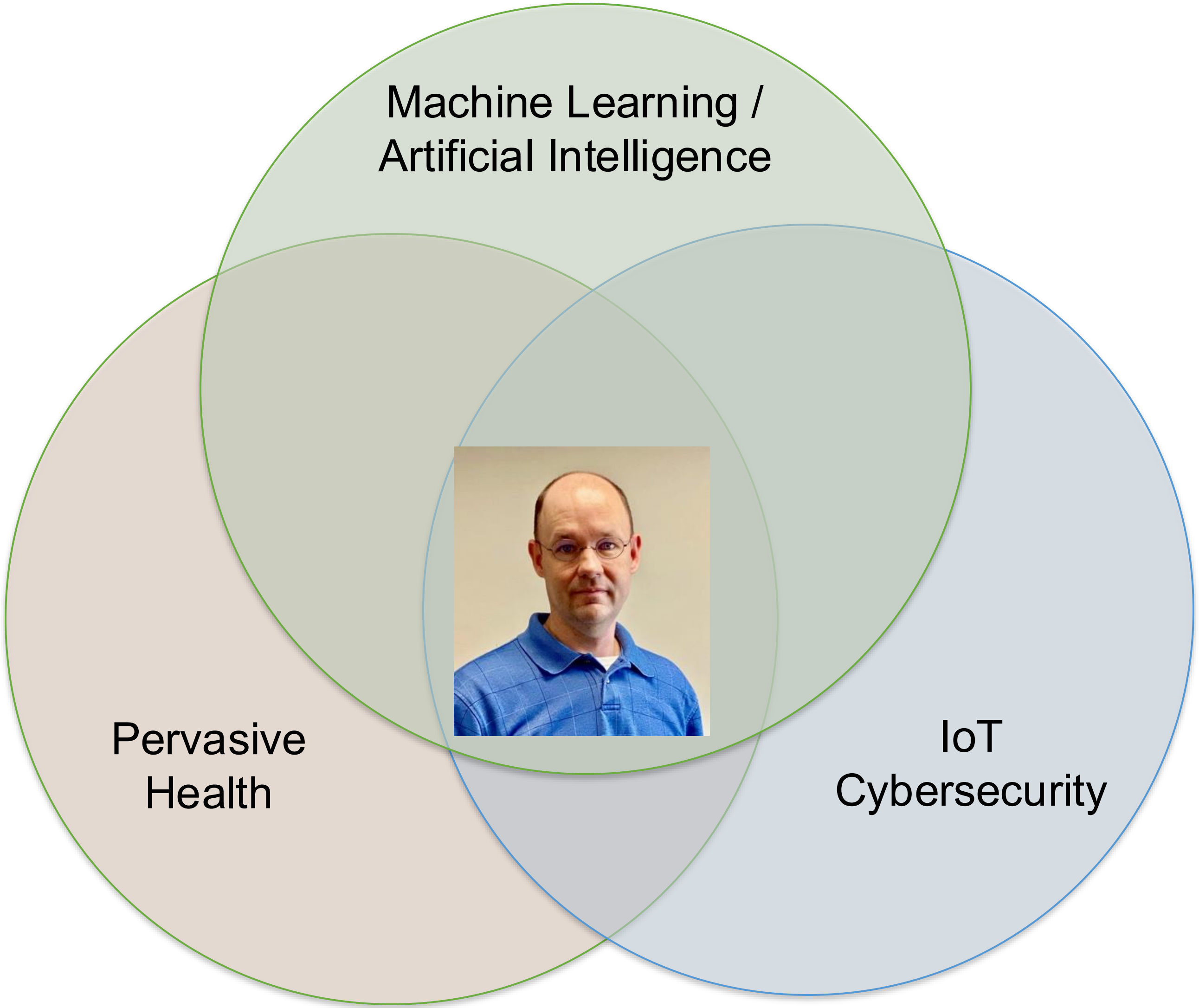
About Me


Machine Learning / Artificial Intelligence
Pervasive Health
IoT Cybersecurity

Pervasive Health Monitoring (PHM)

- Pervasive health monitoring refers to the continuous and unobtrusive tracking of an individual's health status using embedded, wearable, or ambient technologies integrated into everyday life.

- Keywords: Smart Home, Wearables, Indoor Localisation, Human Activity Recognition

- Key aspect: Monitoring fades into background, individuals forget that it's there (avoid Hawthorne effects).

PHM Key Characteristics

- **Continuous**: Health parameters are monitored in real-time or at frequent intervals, not just during clinical visits.
- **Unobtrusive**: Devices are designed to be minimally invasive—often wearable or embedded in the environment—to avoid disrupting daily life.
- **Context-aware**: Monitoring systems can interpret health data in relation to context (e.g., activity, location, time).
- **Remote accessibility**: Data can be transmitted to healthcare providers or caregivers, enabling remote care and early intervention.

PHM Technologies Involved

- **Wearables**: Smartwatches, fitness trackers, ECG patches.
- **Ambient sensors**: Sensors embedded in home environments.
- **Mobile health** (mHealth): Smartphone-based apps and tools.
- **IoT and cloud computing**: For integration, storage, analysis.
- **AI/ML**: anomalies, predicting conditions, and personalizing.

PHM Benefits

- Enables preventive healthcare, personalised, early diagnosis.
- Reduces hospital visits and costs through remote patient management.
- Improves quality of life, especially for elderly and chronically ill patients.
- Shifts focus from reactive, clinic-based care to proactive, patient-centered wellness.

PHM and AI Challenge

- Supervised performs well, better understood -> requires annotations/labels
- PHM often lack annotations/labels

Who "owns" the data? Who "stores/controls" the data?

PHM Use Cases

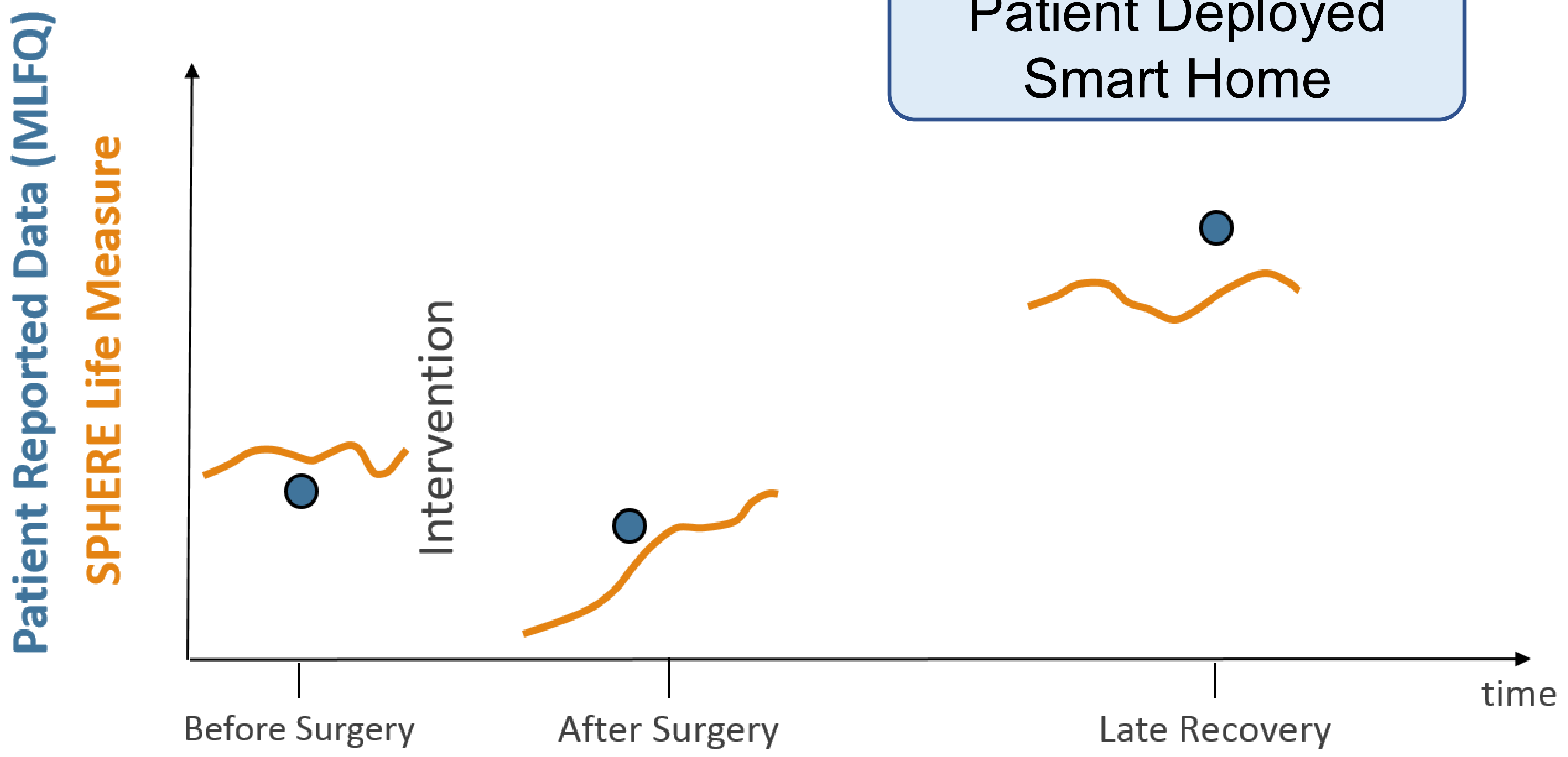
- Smart-home Systems
  - EurValve (Cardiac)
  - Parkinsons' Disease (PD) SENSORS / TORUS
  - Stroke Rehabilitation
- Mobile Systems
  - REST, using sleep and activity to measure mood (Hanna Kristiina Isotalus)
  - Skin Tone Bias (JGI, Mingmar Sherpa)
- Vital signs (PHM?)
  - Peri-operative Mortality Prediction (INSPIRE Dataset, Surgeon at UHBW)
- Population health
  - Health Camps in Nepal (PhD Candidate Cornell, Mingmar Sherpa)

SMART HOMES

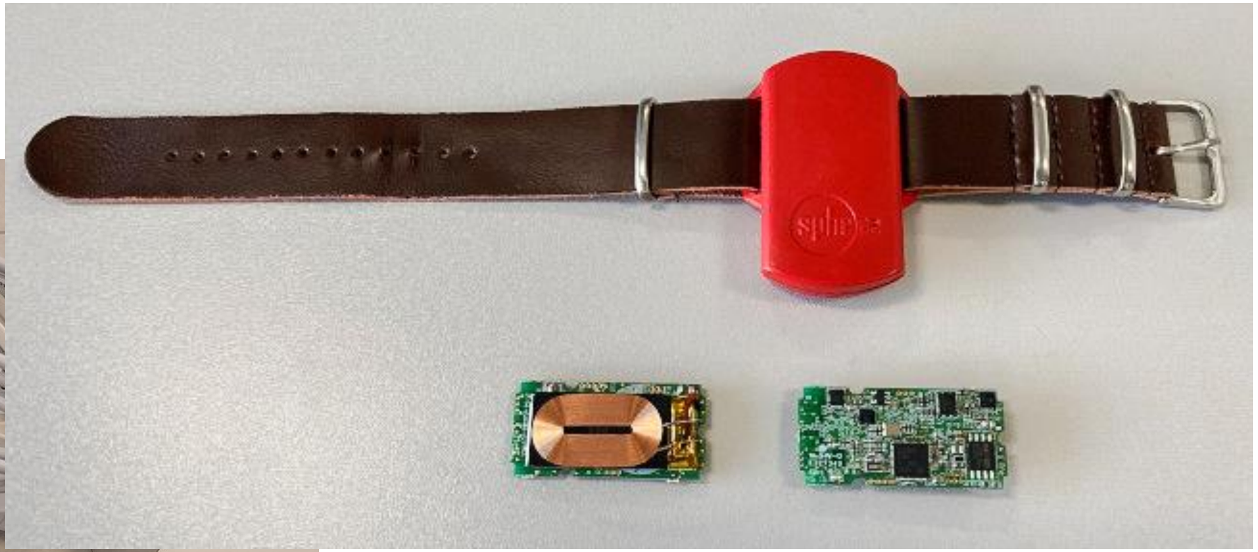
Wearables, Smart Home, Localisation, Human Activity Recognition

EurValve (HE 2020)

Patient Deployed Smart Home



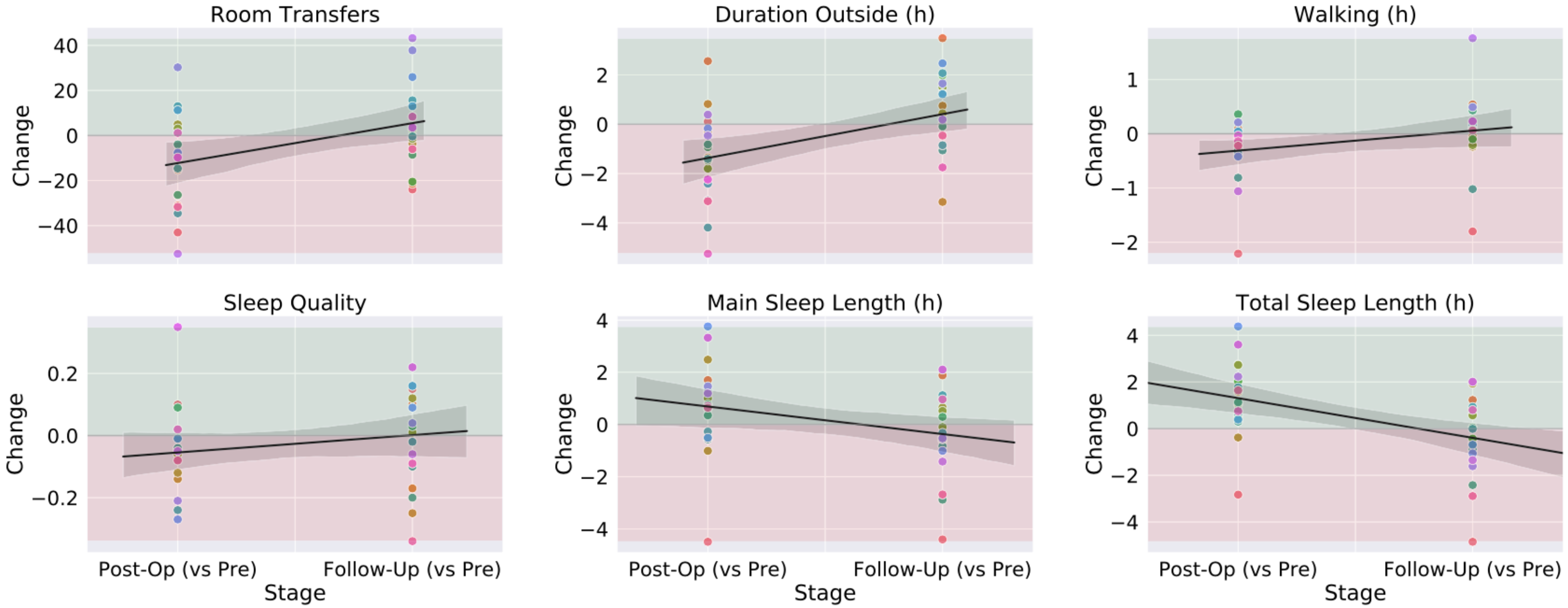
EurValve: Kit

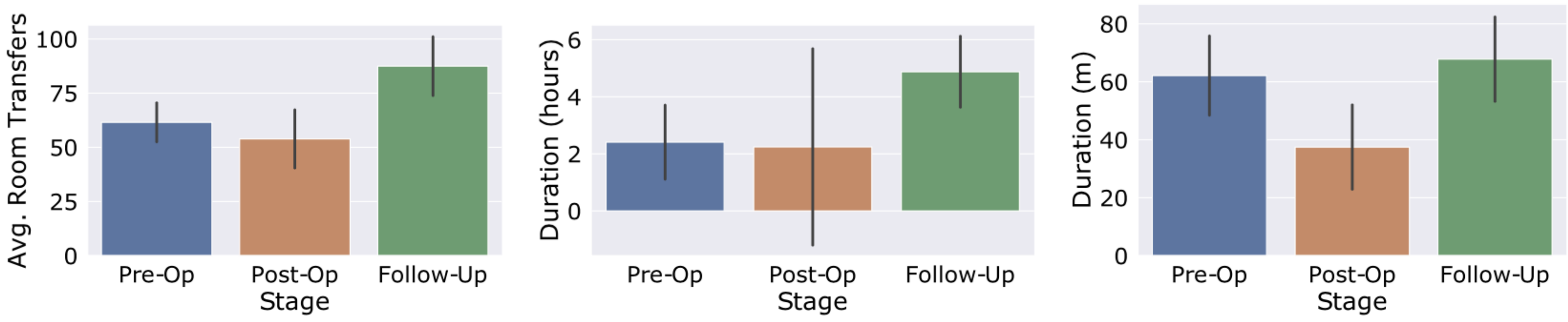


3-axis Accelerometer
4 RSSI for each Anchor

EurValve:

- Successful Intervention



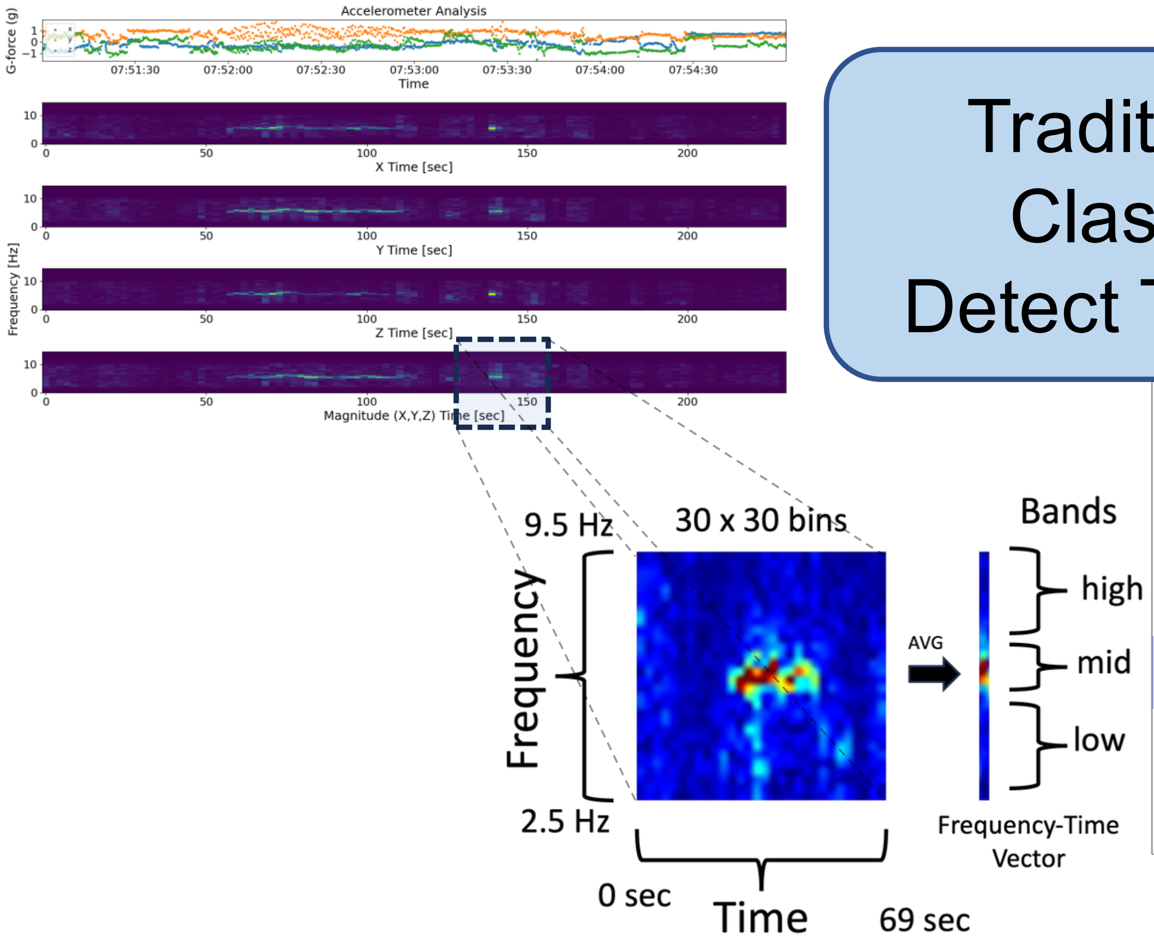


(a) Average daily room transfers (with standard deviation) for patient A.

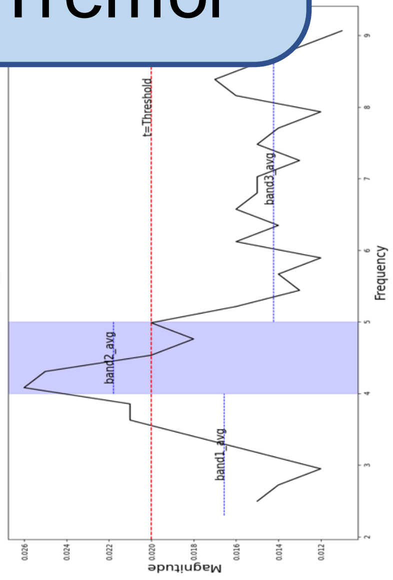
(b) Average daily hours outside (with standard deviation) for patient A.

(c) Average daily walking (with standard deviation) for patient A.

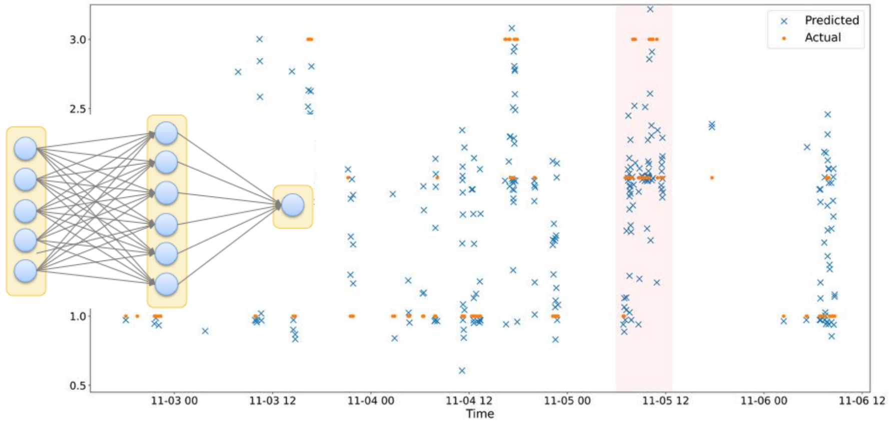
PD SENSORS: Parkinson's Disease



Traditional
Classify
Detect Tremor



Machine Learning
Regression
Tremor Severity



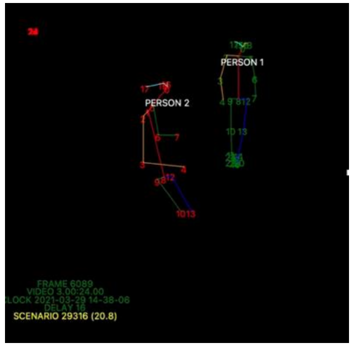
PD SENSORS: Human Activity Recognition

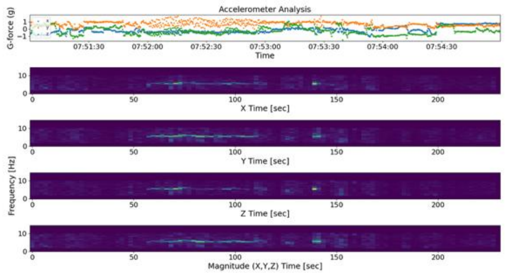
- Lying Down
- Sitting
- Standing
- Walking
- Sit-to-Stand duration
- Turning duration

PD SENSORS: Wearables, Cameras

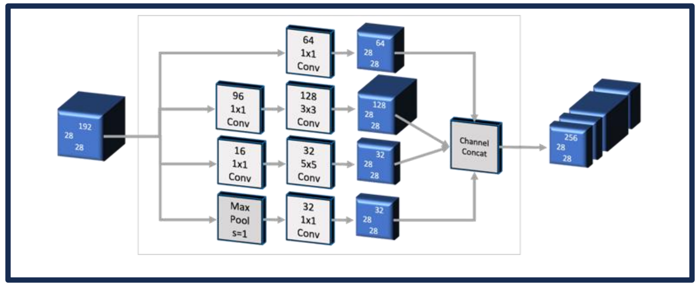
PhD Student Dina Molnar

Input





AI Model



Combine with camera/pose,
multi-modal HAR
TORUS Project

Output

- Lying Down
- Sitting
- Standing
- Walking
- Sit-to-Stand duration
- Turning duration

Stroke Rehab: Exercise Program

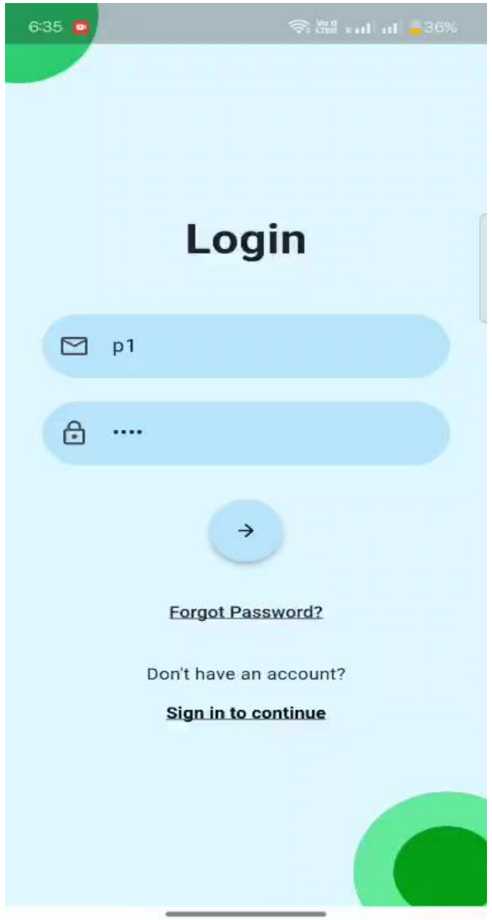
MSc Student Thrisha Rajkumar, "Codesign of Artificial Intelligence Algorithm for Personalised Exercise Videos to Enhance Community-Based Rehabilitation for People with Stroke"

App Overview

- Built using **Flutter** (Android, iOS, Web)
- **Co-designed** with clinicians, PwS, and digital health experts
- Goal: Deliver personalised home rehab support for people with stroke

Personalised Routines

- Based on individual goals, stroke type, and recovery stage



Stroke Rehab: Exercise Program

Input Features

- Session/ Exercises
- Demographics
- Stroke diagnosis
- Clinical Reasoning

AI Model

- Natural Language Processing (NLP)
- Random Forest / Decision Trees

supervised learning and clinical reasoning embeddings

Output

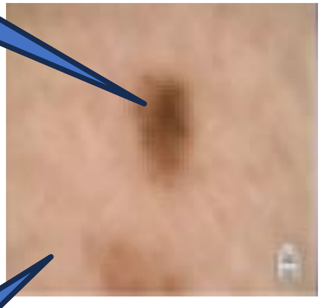
- Personalised **exercise routine recommendation**
- Adaptive routine **level (Easy / Moderate / Challenging)**
- Based on **progress and feedback**

Tone Bias: Skin Lesion Images

Huw Day, Will Chapman

Input

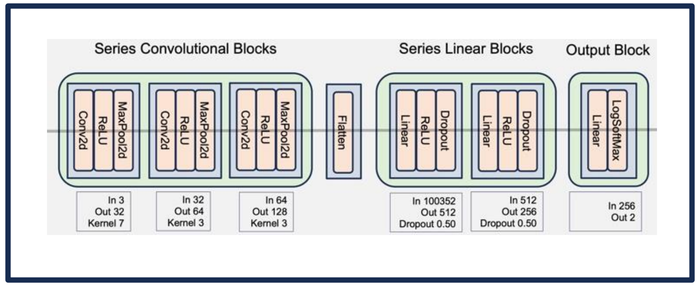
Mole



Skin Tone

How to map Fitzpatrick
Skin Type -> Skin Tone?

AI Model



Output

1=Cancer

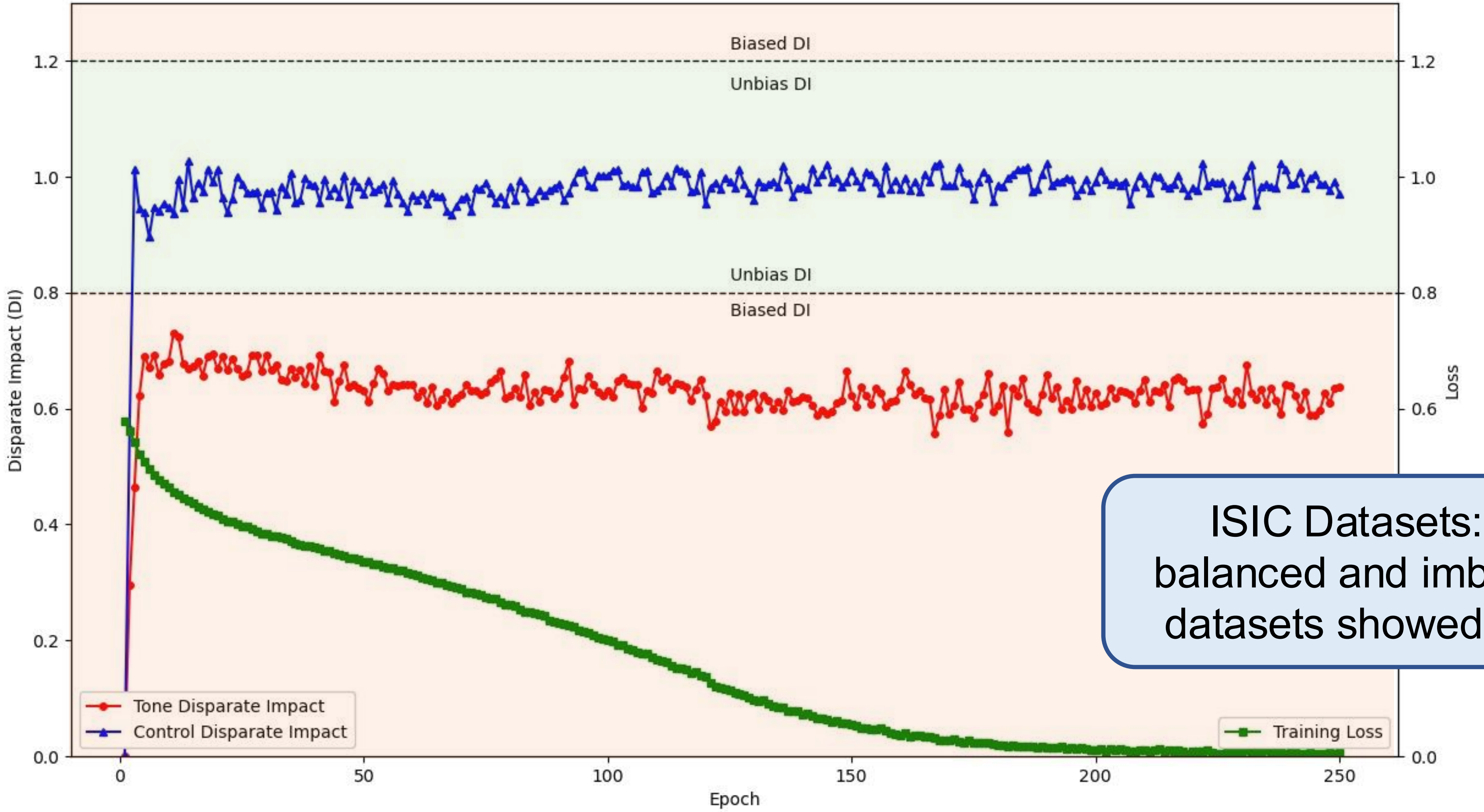
0=Benign

What did the model “learn”?

- Mole colour/shape
- Skin tone colour
- Mole/Skin Contrast

“Mind the Gap”
Darker Skin

Tone Bias: Disparate Impact



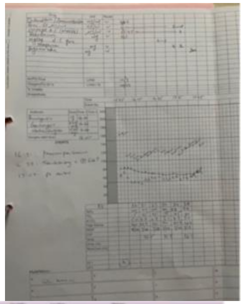
ISIC Datasets: Both balanced and imbalanced datasets showed DI bias

Peri-Operative Mortality Prediction (UHBW)

INSPIRE: https://physionet.org/content/inspire/1.3/

Input

Preop/Postop Vitals



Gas

Blood

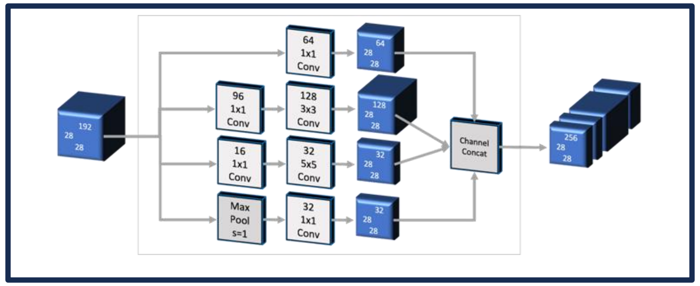
NEWS

Peri Vitals

NELA

Patient Info

AI Model



Combine (mostly) time series data
Integrate PHM data?

Output

- Dies during (or within 30 days) of operation
- Survives

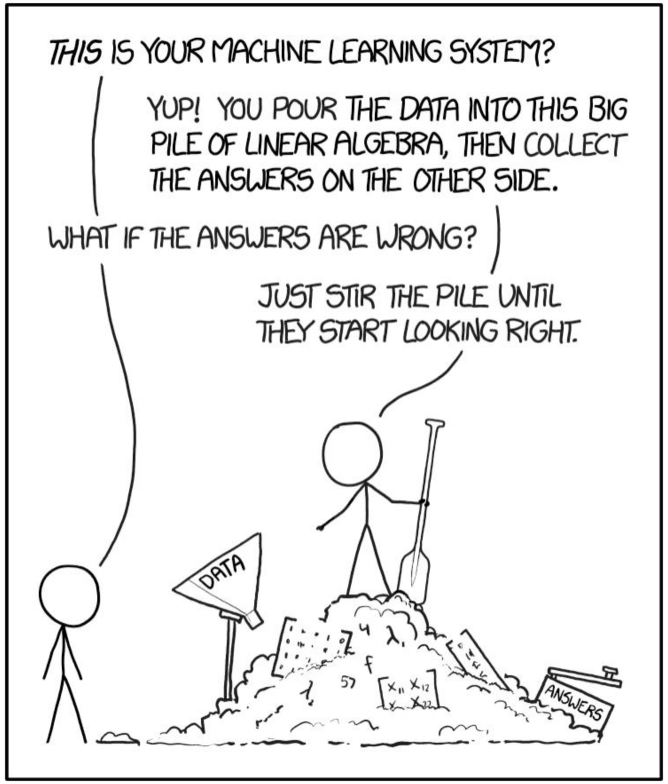
AI (and Health) Near-term Risks

- Fake images, voices and video
- Massive job losses
- Massive surveillance
- Model discrimination/bias
- End of humanity

- "Do not forget that AI will be immensely helpful in areas like healthcare" (why AI development should not be stopped)

Prof. Geoffrey Hinton - "Will digital intelligence replace biological intelligence?" Romanes Lecture
YouTube: https://www.youtube.com/watch?v=N1TEjTeQeg0 [last accessed 7 Jul 2025].

Thank You for Listening!!!



Source: https://xkcd.com/