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Privacy-Aware and Acceptable Video-Based Technologies and Services for Active and Assisted Living

ESR12. AI for Dementia Care

1st Doctoral Seminar

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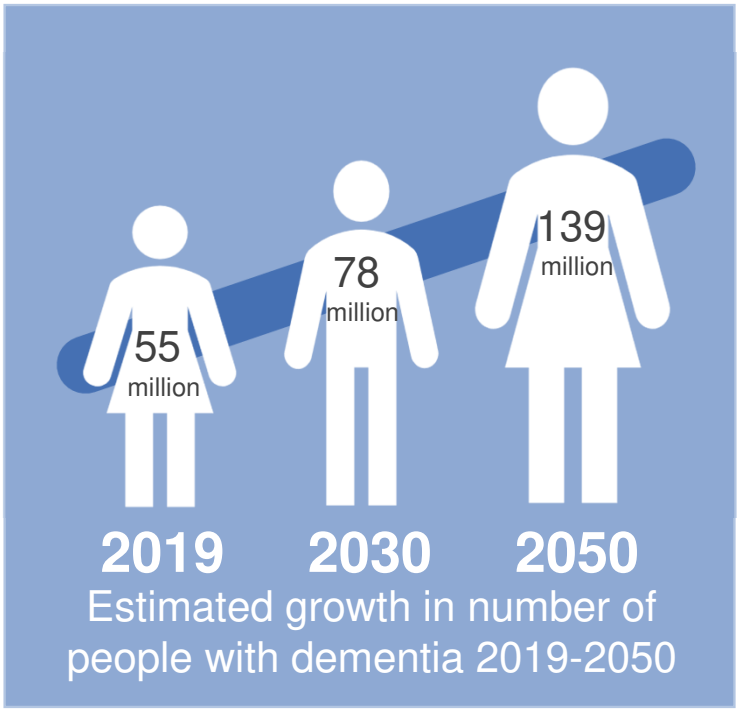
Overview

1. Introduction: **AI for Dementia Care**
2. **Toilet Module**
   - Progress report
   - Next steps
3. PhD: **Machine Learning for Measuring Behavioural and Cognitive Changes**
   - Problem addressed and contribution
   - Research questions
   - Methodology
   - Data exploration and preliminary analysis
   - Next steps

What's dementia?

- Syndrome in which there is a **deterioration in cognitive functioning beyond what might be expected from normal ageing** [1]

- One of the **major causes of dependency** among older people [2]
- Prevalence is expected to increase in the future years
- We need solutions to ensure the **quality of life** of people with dementia



Data source: WHO [1]

[1] World Health Organization https://www.who.int/news-room/fact-sheets/detail/dementia (accessed April 25, 2022)
[2] **Global status report on the public health response to dementia**. World Health Organization (2021)

AI for Behaviour Analysis

- Activity recognition and assessment
- Routine discovery
- Detection of dementia-related behaviours (e.g. twisted day-night rhythms, reduced level of activity, aggressivity)

Time horizons

- *Short-term*: **assistance** with the activities of the daily living (e.g., toileting), **critical event monitoring** (e.g., falls)
- *Long-term*: detecting early signs of dementia, disease progression **monitoring**

Goal

Step-by-step guidance for people with mild dementia in the toilet using a depth camera

What has been done until now?

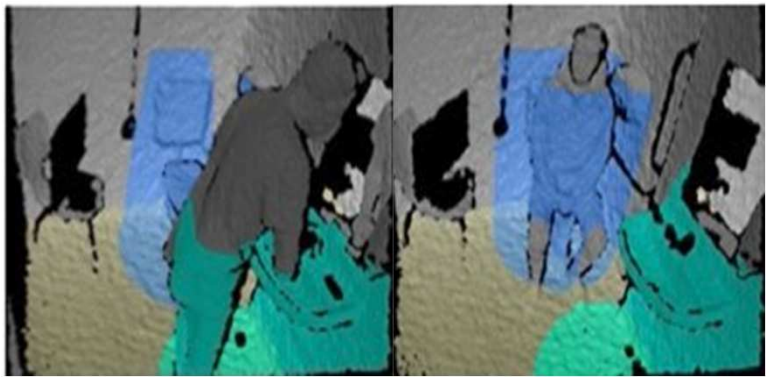
1. **Focus groups** with health professionals:
   How the system should communicate with people with dementia?

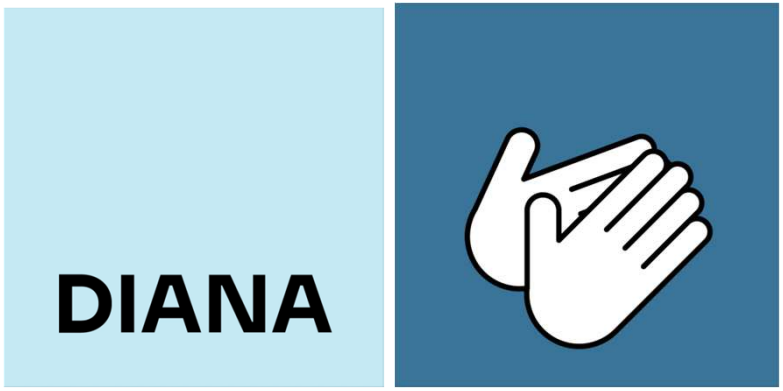
2. **Prototype developed**

Results in: "**RITA: A privacy-aware toileting assistance designed for people with dementia**" by Irene Ballester, Tamar Mujirishvili and Martin Kampel, In *Proceedings of the 15th EAI International Conference on Pervasive Computing Technologies for Healthcare,* 2021

What has been done until now?

- **Hand-washing and acknowledgement**
- **Validation in the lab:** functional testing
  - 98.5% avg. accuracy in action recognition
  - Interaction: 100% in fixed scenarios, 8/10 correct in open scenarios
- **New visualizations and audio**





Results in: "**Automated vision-based toilet assistance for people with dementia**" by Irene Ballester and Martin Kampel, AHFE 2022 - *13th International Conference on Applied Human Factors and Ergonomics,* July 24-28, 2022, New York, USA (*Accepted*)

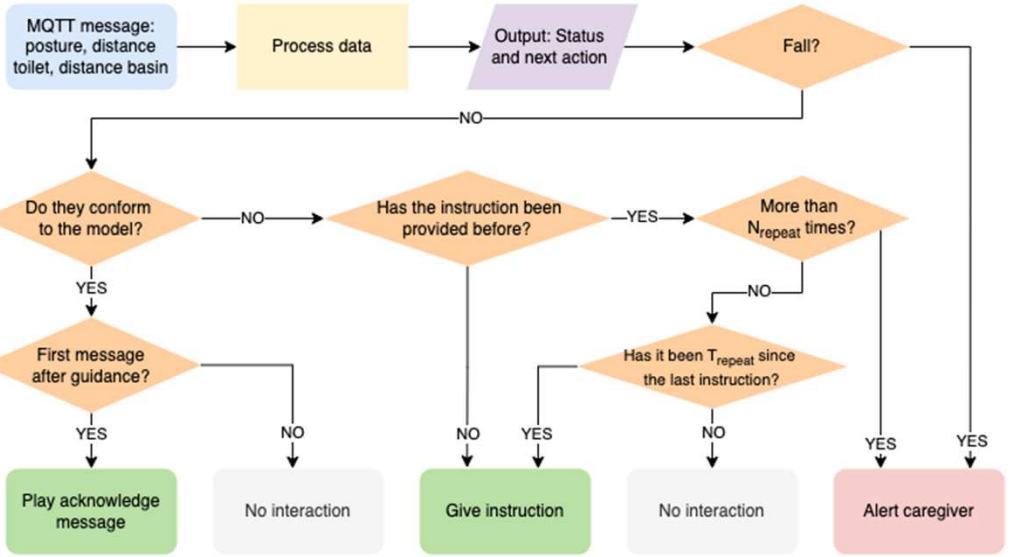
Next steps

Evaluation of the system with **real data**

1. Collection of depth videos of residents using the toilet in CH *(in progress)*

   → **validate action recognition** with real data

2. Validation of the interaction system in pilot sites *(to be defined)*



Problem Addressed

- Neurocognitive disorders: not only cognitive deficits but also **behavioural symptoms** [3]
- Measurement of behaviour and its changes: **valuable** for research and clinical practice:
  - Detecting **early signs** in care home residents
  - Disease **progression monitoring**
  - Monitoring the **effect of drugs** on residents

[3] Moyra E Mortby, Richard Burns, Ranmalee Eramudugolla, Zahinoor Ismail, and Kaarin J Anstey. **Neuropsychiatric Symptoms and Cognitive Impairment: Understanding the importance of co-morbid symptoms**. *Journal of Alzheimer's Disease*, 59(1):141–153, 2017

Dementia as a case study

- Prevalence of behavioural disturbances up to **90%** [4]
- **Strong correlations** between the behavioural changes and the degree of cognitive impairment [4]

- Behavioural and Psychological Symptoms of Dementia (BPSD):

  E.g.: agitation, aberrant motor behaviour, anxiety, irritability, depression, apathy and changes in sleep or appetite [4]

[4] Joaquim Cerejeira, Luísa Lagarto, and Elizabeta Blagoja Mukaetova- Ladinska. **Behavioral and psychological symptoms of dementia**. *Frontiers in Neurology*, 3:73, 2012

Contribution

Development of a framework for **identifying** and **measuring behavioural changes** indicative of a neurocognitive disorder through **unobtrusive sensing** for care facility residents.

Related work

- Detection of **abnormal behaviour** by modelling “normal” activity and room occupancy and checking against this baseline model [5]
  - 22 residents, PIR sensors, 3-12 months

- Public available datasets for cognitive assessment:
  - CASAS [6]
  - Simulated data [7] [8]

[5] Gilles Virone et al. **Behavioral patterns of older adults in assisted living**. *IEEE transactions on information technology in biomedicine,* 12(3):387–398, 2008.
[6] Cook DJ et al. **Collecting and disseminating smart home sensor data in the CASAS project**. In *Proceedings of the CHI Workshop on Developing Shared Home Behavior Datasets to Advance HCI and Ubiquitous Computing Research,* 2009.
[7] Damla Arifoglu et al. **Detecting indicators of cognitive impairment via Graph Convolutional Networks**. *Engineering Applications of Artificial Intelligence*, 89, 103401, 2020.
[8] ARM Forkan et al**. A context-aware approach for long-term behavioural change detection and abnormality prediction in ambient assisted living**. *Pattern Recognition* 48 (3), 628–641, 2015.

Research questions

RQ1. Measuring behaviours and changes

- How can behaviours associated with cognitive decline (e.g., agitation, aberrant motor behaviour, depression, apathy, sleep disturbances, changes in gait) be captured in a model and **measured** from data collected continuously by non-intrusive sensors?
- Which **metrics** can be used to quantify those behaviours?
- How can **changes** in these behaviours be measured?

Research questions

RQ2. Role of time

- How are **time horizons** defined for the detection of behavioural changes in the context of dementia through data collected continuously by unobtrusive sensors?
- How long does an individual have to be observed in order for their statistically "**normal**" **behaviour** to be modelled?
- How long does a trend have to be **consistent over time** to be considered statistically a change in the behaviour?

Research questions

RQ3. AI methods and data

- Which **AI methods** are the most suited to model the different behaviours and their changes?
- How can AI methods be designed to allow **inter-resident variabilities** to be taken into account in the model to be able to generalize to other residents?
- What **type of data** is best suited for modelling each behaviour?

Methodology

Part I. **Time series analysis methods** to model and measure changes in behaviour

- Time Series Modelling and Time Series Forecasting for Anomaly Detection in Behaviour

Part II. Agitated and Aggressive Behaviour Detection

- **Deep learning methods** for behavioural analysis from depth videos

+ Close collaboration with care facilities and health professionals

Part I. Dataset

47 residents from 4 care facilities in Austria

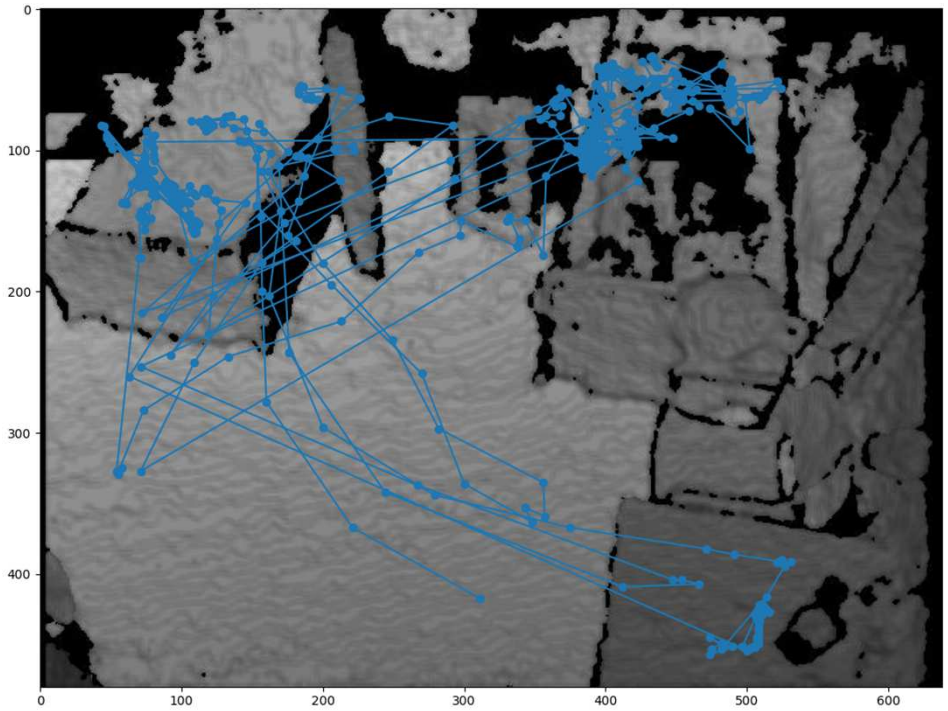
- 36 *with dementia*
- 11 *without dementia*

Includes: Age, gender, dementia severity, fall risk, care level

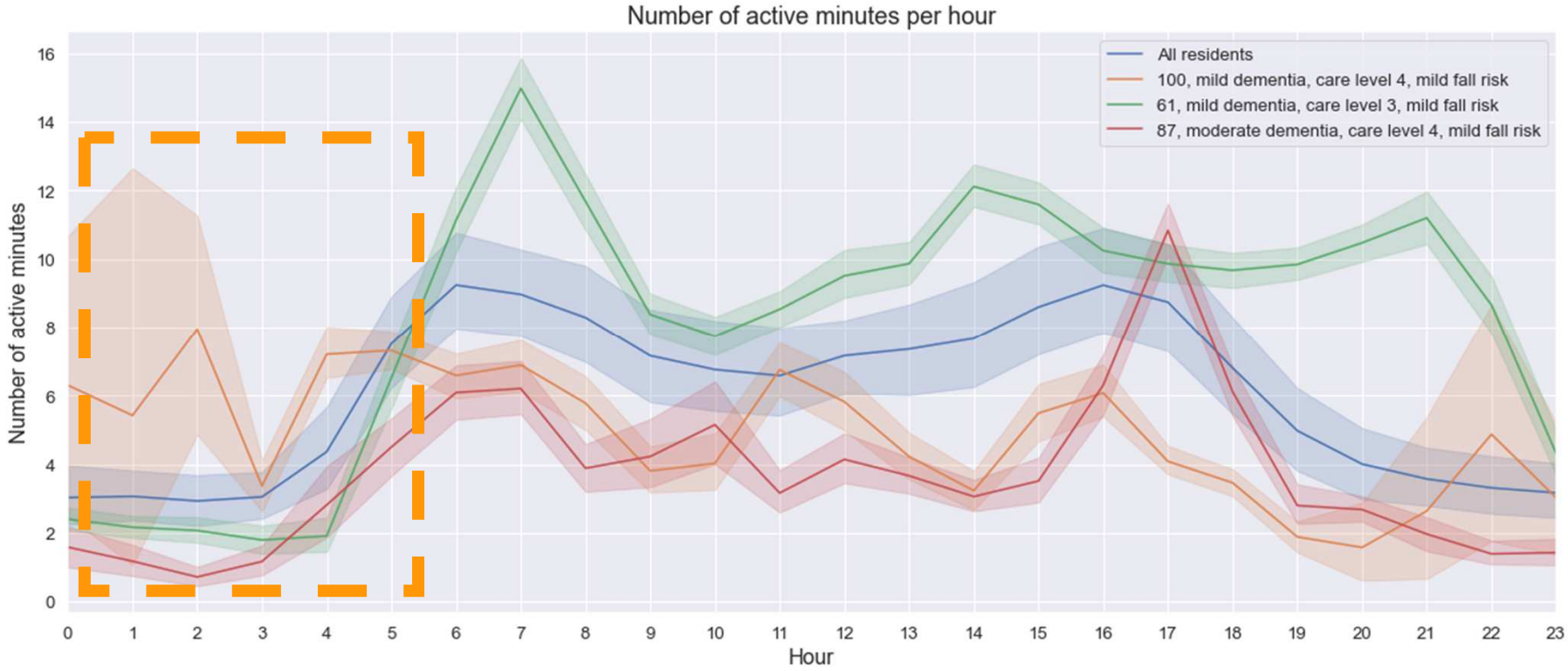
Timestamp, x, y, z

Single rooms

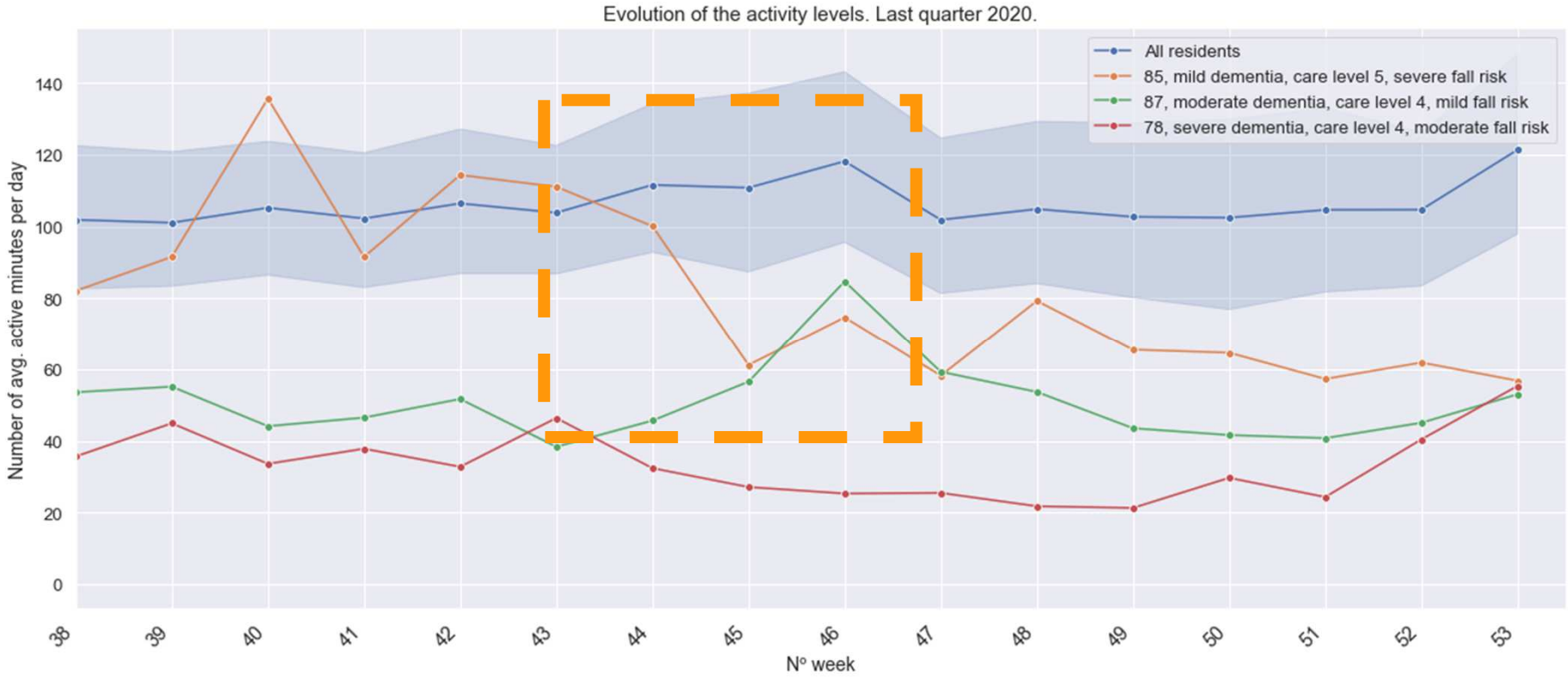
Duration: 9 months



Part I. Data exploration and preliminary analysis (I)



Part I. Data exploration and preliminary analysis (II)



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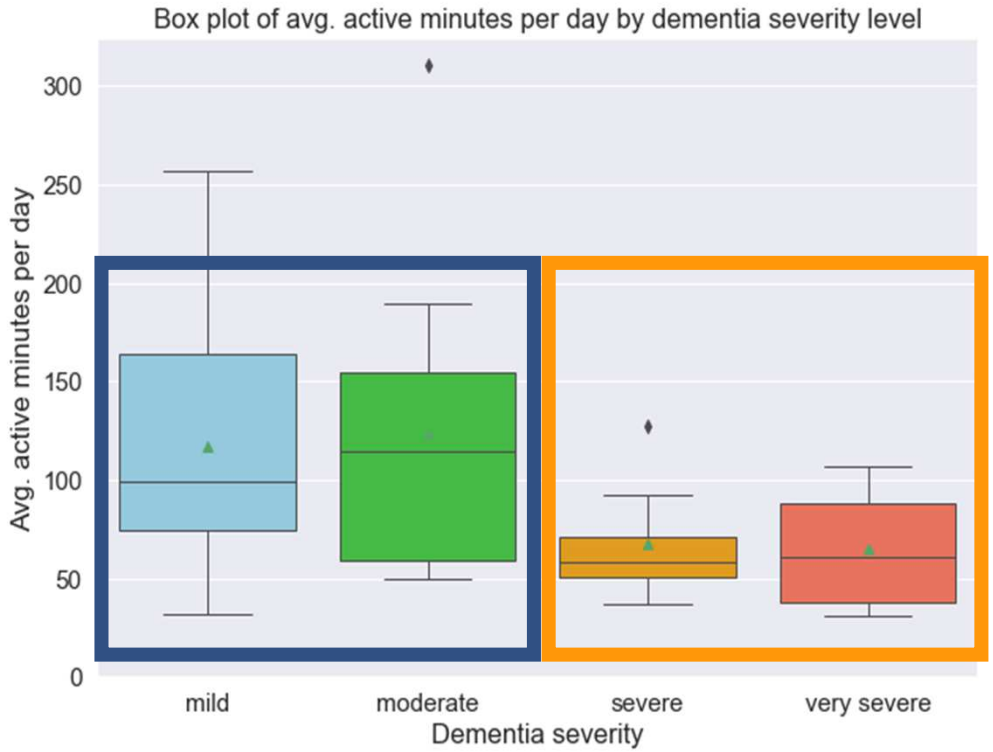
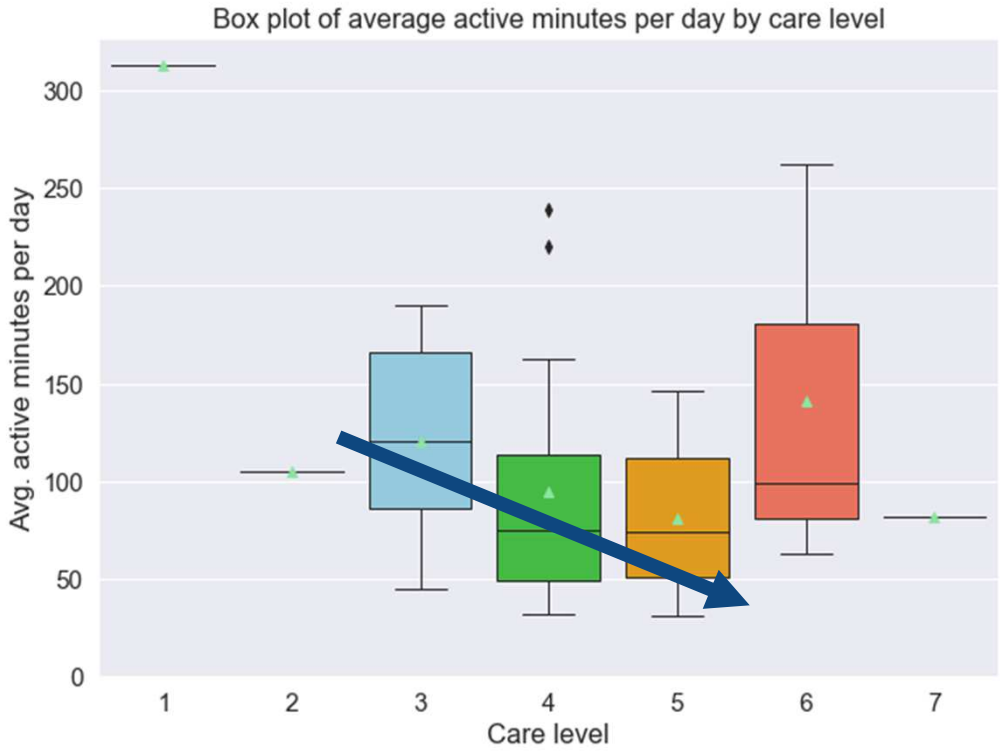
Part I. Data exploration and preliminary analysis (III)





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Part I. Next steps

- Proficiency evaluation
- Implement **bed** and **door location detection**
- **Noise mitigation** and **filtering** implementation:
  - False detections, lost tracking
  - More than one person in the room (nurses)
- Implement **time series analysis** methods:
  - Literature research on state-of-the-art time series analysis methods

Thank you!

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