Using attention to model long-term dependencies in occupancy behavior

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<u>Max Kleinebrahm</u>
Chair of Energy Economics
Karlsruhe Institute of Technology
Karlsruhe, Germany
max.kleinebrahm@kit.edu

Jacopo Torriti
School of the Built Environment
University of Reading
Reading, United Kingdom
j.torriti@reading.ac.uk

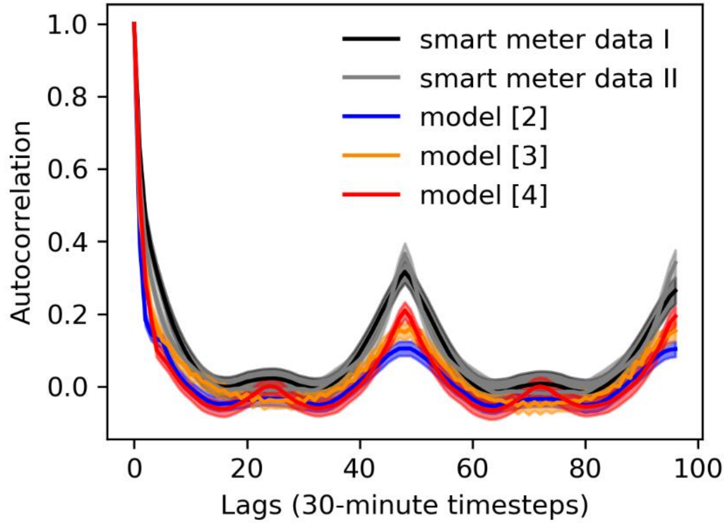
Russell McKenna
Chair in Energy Transition
University of Aberdeen
Aberdeen, United Kingdom
russell.mckenna@abdn.ac.uk

Armin Ardone
Chair of Energy Economics
Karlsruhe Institute of Technology
Karlsruhe, Germany
armin.ardone@kit.edu

Wolf Fichtner
Chair of Energy Economics
Karlsruhe Institute of Technology
Karlsruhe, Germany
wolf.fichtner@kit.edu

Motivation & objective

Why is it important to capture long-term behavioral dependencies in occupant behavior models to tackle climate change?

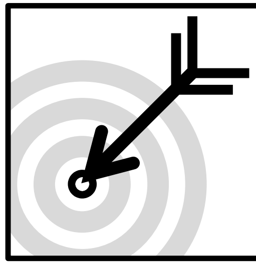


- Occupant behavior has a significant impact on the dynamics of household energy consumption [1]
- Existing studies try to simulate occupant behavior to explain aggregated energy demand [2,3,4]

⇨ **Low quality individual occupant activity schedules**

- Decarbonisation of domestic energy demand (electricity, heat, mobility)
- New technologies: heat pumps, electric vehicles, batteries,…

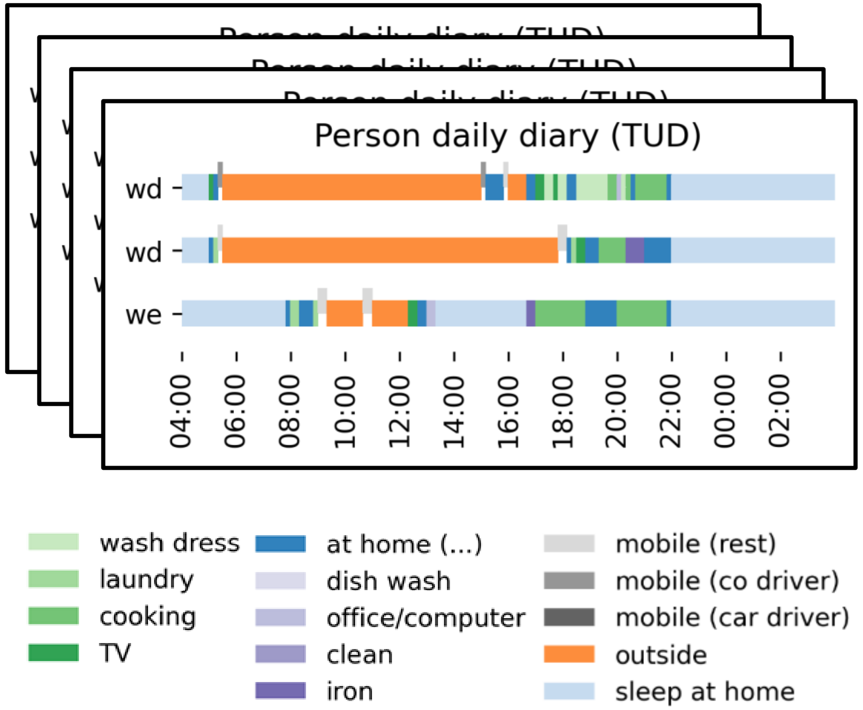
⇨ **Flexibility potential**



Representing long-term dependencies in occupant behavior models in order to generate high quality synthetic activity schedules

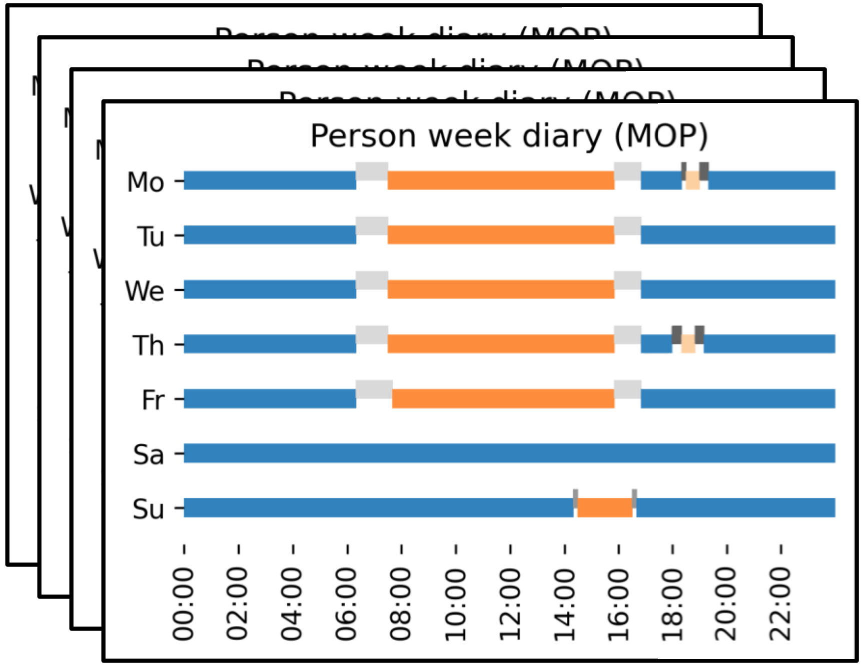
Input data

Activity data



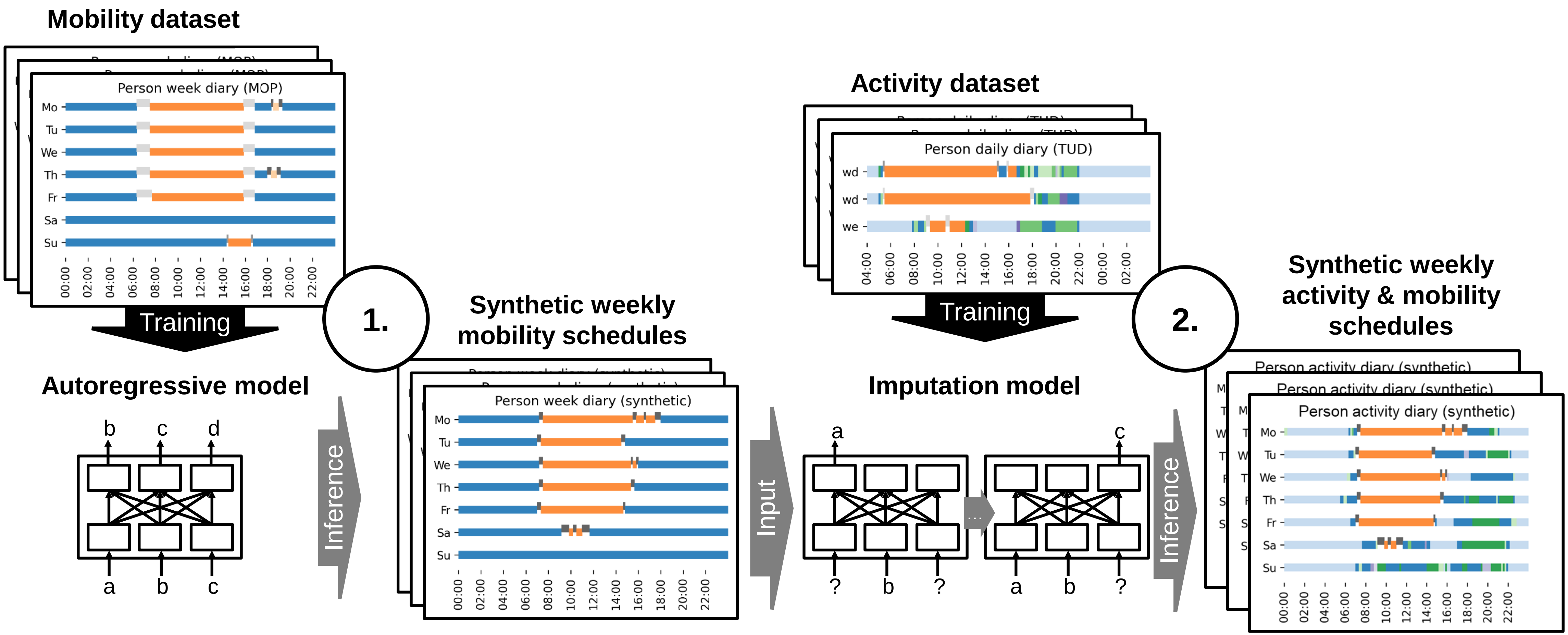
- National representative samples (30 countries)
- Highly differentiated states of activity
- Information about two to three individual days
- This study: German TUD [5]

Mobility data

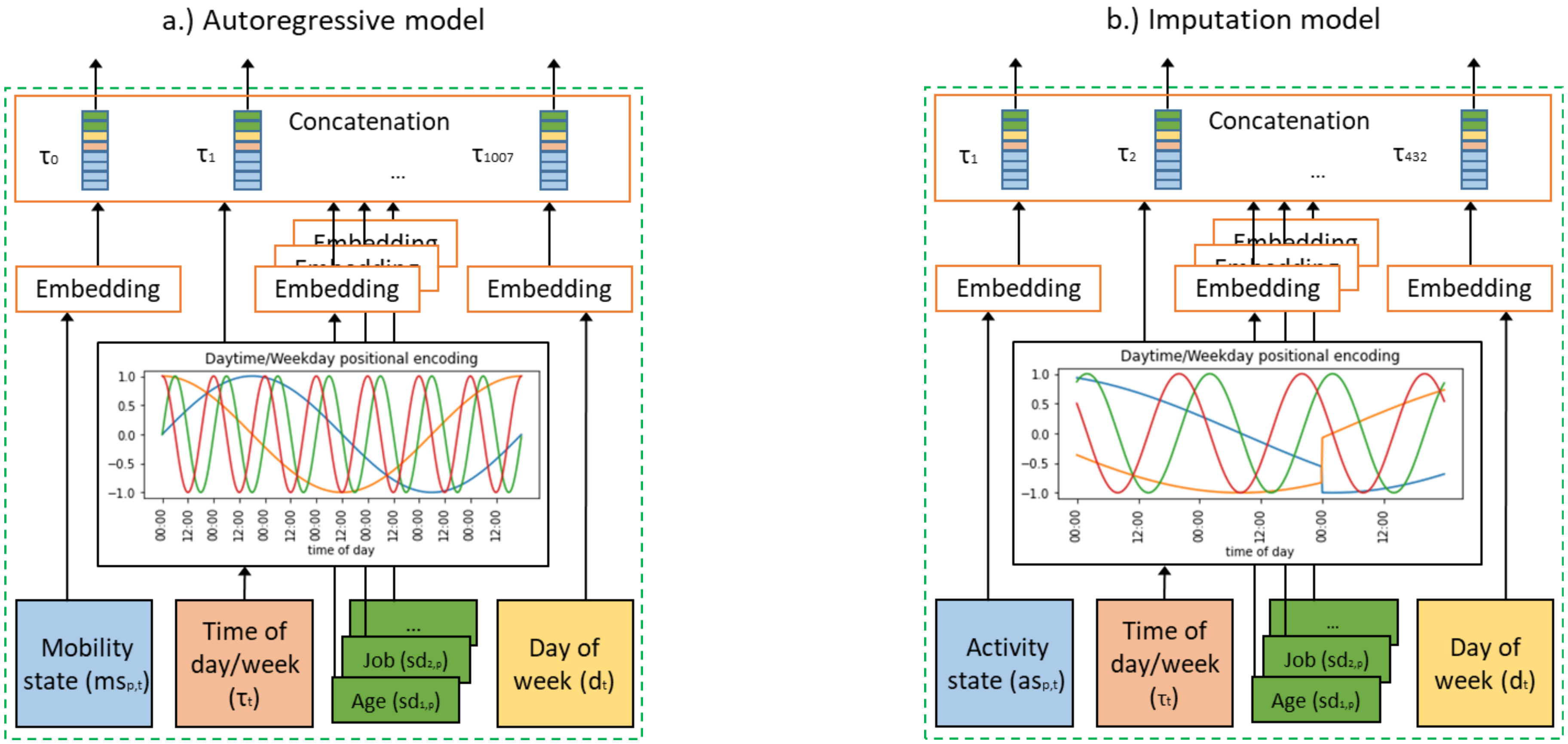


- National representative samples (DE, UK, …)
- Longitudinal mobility study
- Information about mobility patterns over one week
- This study: German Mobility Panel (MOP) [6]

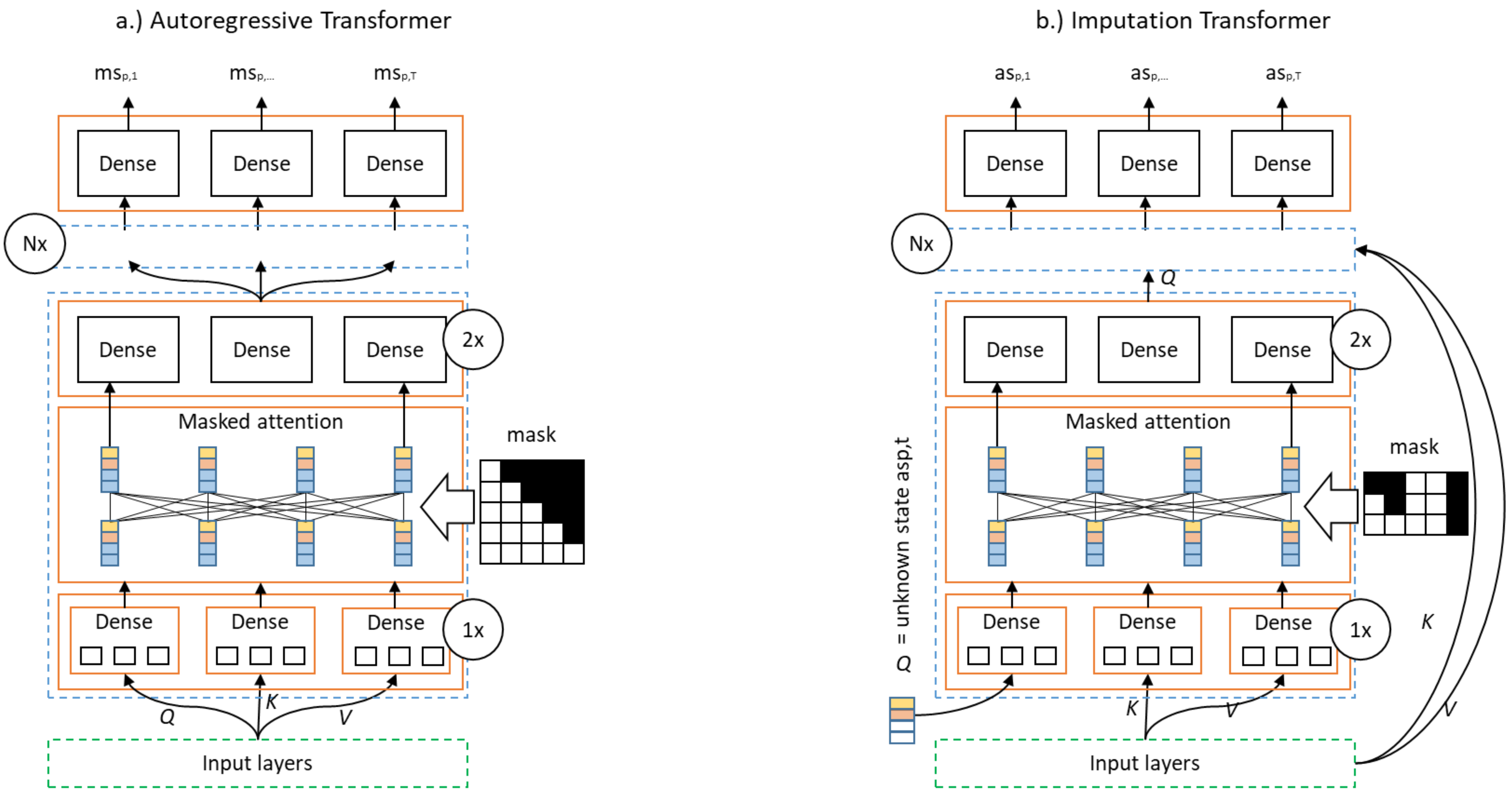
Model architecture



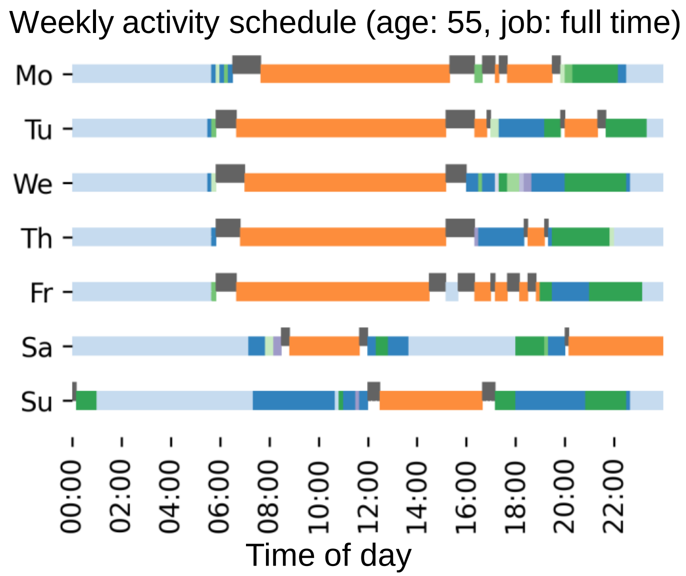
Input & first layers

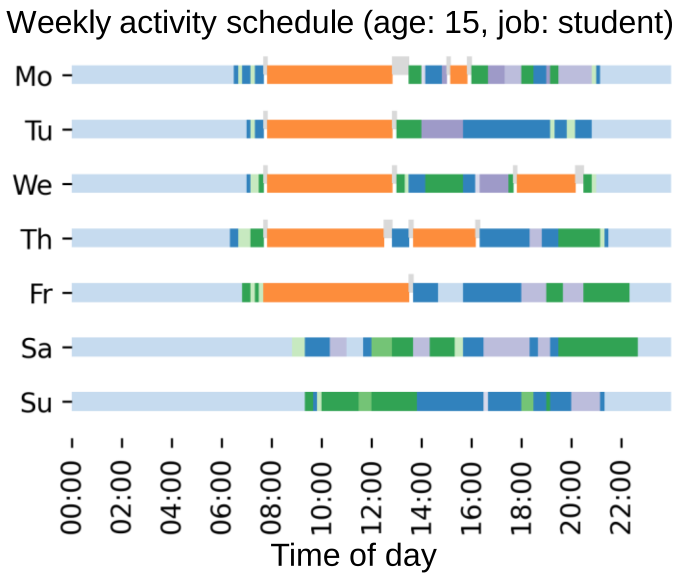


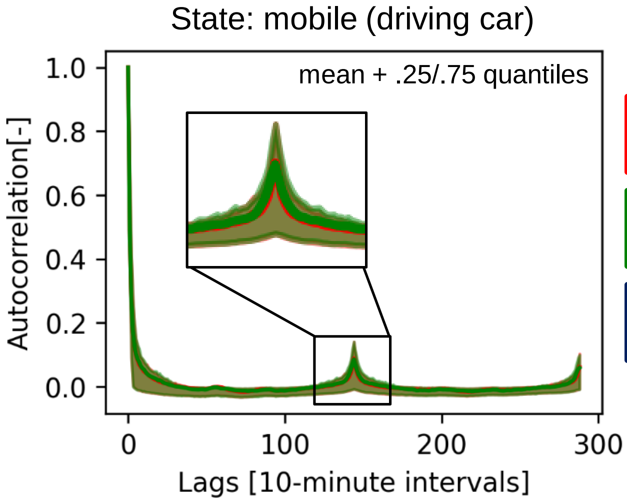
Autoregressive & imputation model

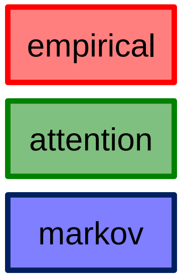


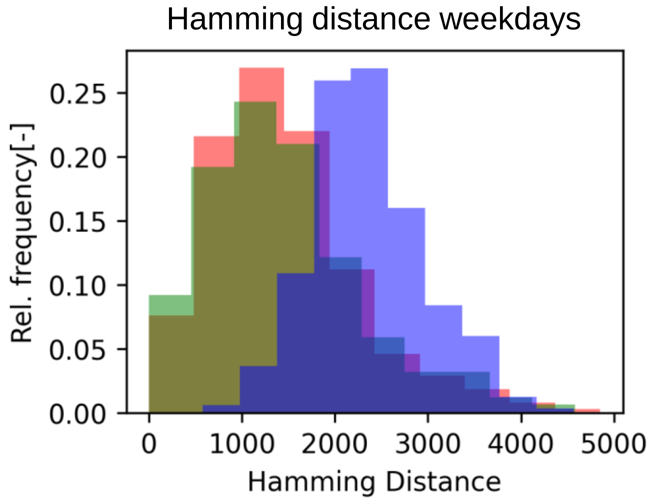
Exemplary results











- **Visual control:**
  - Interday dependencies are reproduced
  - Behavior of different socio-demographic groups is captured
- **Aggregated metrics:**
  - State probability
  - State duration
  - State autocorrelation
  - Weekly appearances of state
  - Hamming distance between weekdays:

$$hd_n = \sum_{d_1=1}^{5} \sum_{d_2=1}^{5} |\{t \in \{1, \dots, T_d\}|\, s_{d_1,t} \neq s_{d_2,t}\}| \quad \forall\, n \in N$$

Conclusion & outlook & challenges

Conclusion:

- Attention based models can capture complex long-term dependencies in occupancy behavior
- The diversity in behavior across the entire population and different socio-demographic groups is adequately reproduced by the presented approach
- The approach combines the advantages of two datasets and creates a new high quality synthetic dataset for energy system modelers

Outlook:

- Individual behavior → household behavior (*challenge*: quadratic memory and time complexity with sequence length)
- Open data → differential privacy (*challenge*: trade off between accuracy and privacy)

Thanks for your ~~attention~~!

$$\operatorname{softmax}\left(\frac{QK^T}{\sqrt{d_k}}\right)V!$$

Literature

[1] Koen Steemers and Geun Young Yun. Household energy consumption: A study of the role of occupants. Building Research & Information, 37(5-6):625–637, 2009.

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