Adaptive system for autoencoder-based anomaly detection in daily routines D. Gibietz, D. Helmer, E. Godehardt, H. Hinkelmann, T. Hollstein. *Gerontechnology* 25(s)

Purpose Demographic change and the increasing number of elderly people living alone create rising demands for safety, prevention, and continuous health support in home environments. Elderly people are increasingly affected by structural developments associated with rising healthcare and long-term care expenditures, which place growing pressure on formal care systems [1]. Many everyday-relevant changes, such as prolonged inactivity, disorientation, or atypical activity patterns, often remain unnoticed. Digital technologies offer new opportunities to detect such changes at an early stage and to promote independence in later life. For example, continuous observation of daily routines has been shown to reveal behavioral characteristics that may indicate cognitive decline before clinical symptoms appear [2]. Against this background, the present work focuses on data-driven, self-learning approaches capable of reliably modeling individual daily routines and automatically identifying relevant deviations through edge-based data processing that can inform caregivers and family members as early indicators of emerging risks. The overarching aim is the early detection of health- and age-related changes in behavior patterns, enabling preventative interventions and thereby promoting independence and a sense of safety among elderly people while reducing the burden on caregivers and family members. **Method** Publicly available CASAS smart home datasets [3] are used for developing and testing the anomaly detection system, focusing on recordings of elderly people living alone. From the recorded motion sensor streams, three behavioral features are extracted for each room and hour, capturing how long the person stayed in a room, how active they were there, and how often a room was entered. During preprocessing, sensor events are temporally aggregated and mapped to these features. The data are normalized per room using that room's maximum observed value. This scales the features to personal behavioral baselines, making significant deviations more detectable. An unsupervised reconstruction-based anomaly detection approach is applied using an autoencoder that learns characteristic daily routines of a person by training the model with each new non-anomalous daily routine. Deviations from these patterns are detected based on the reconstruction error between expected and observed behavior [4]. **Results and Discussion** Previous results demonstrate that the autoencoder can reliably detect most unusual daily routines and achieves an F1 score of up to 83.6 %, reflecting detection reliability, on the CASAS HH101 dataset. Through continuous learning and dynamic updating of room-specific maximum values, the system was able to adapt to the resident's normal behavior [4]. Extending the normalization by separating room-specific maximum values into four time-of-day phases and introducing a sliding-window-based threshold over the most recent 14 non-anomalous days increased detection performance, resulting in F1 scores of up to 89 % on the same dataset. These adjustments allow unusual behavioral changes to be detected within finer temporal segments of daily routines. In addition, the adaptive threshold supports tracking the current behavioral trend. In future work, the system will be tested on additional datasets to evaluate adaptability, and gradual change detection will be incorporated to capture long-term deviations.

References

1. European Commission (2024). *2024 Ageing Report: Economic and budgetary projections for the EU Member States (2022–2070)*. Publications Office of the European Union. https://doi.org/10.2765/022983
2. Botros, A., Schütz, N., Röcke, C., Weibel, R., Martin, M., Müri, R., et al. (2021). Eigenbehaviour as an indicator of cognitive abilities. https://arxiv.org/abs/2110.09525
3. Cook, D., Crandall, A., Thomas, B., & Krishnan, N. (2013). CASAS: A smart home in a box. *IEEE Computer*, 46(7):62-69, 2013. https://doi.org/10.1109/MC.2012.328
4. Gibietz, D., Helmer, D., Godehardt, E., Hinkelmann, H., Hollstein, T. (2025). Continuous learning system for detecting anomalies in daily routines using an autoencoder. In: Yang, XS., Sherratt, R.S., Dey, N., Joshi, A. (eds). Proceedings of Tenth International Congress on Information and Communication Technology (ICICT 2025). *Lecture Notes in Networks and Systems*, vol. 1440. Springer, Singapore. https://doi.org/10.1007/978-981-96-9709-0_13

Affiliation: Frankfurt University of Applied Sciences, Germany
Email: dominic.gibietz@fra-uas.de; **ORCID iD:** Dominic Gibietz (0000-0002-7340-2794)