A Framework for Predicting Fine-grained Behavioral and Psychological Symptoms of Dementia Using Machine Learning Techniques and Smart Wearable Devices Vincent S. Tseng, Oscar Tai-Yuan Chen, Bo-Wei Yao, Yuan-Han Yang. *Gerontechnology 25*(s)

Purpose Behavioral and Psychological Symptoms of Dementia (BPSD) consist of a wide variety of non-cognitive symptoms that tend to appear in individuals with dementia [1]. Managing BPSD is highly challenging in clinical practice. Therefore, early prediction and appropriate management of BPSD become essential for delivering timely interventions and support that improve patient outcomes. Cho et al. [2] presented a machine learning-based approach for the next-day BPSD prediction. However, with such a large time frame for predicting whether BPSD will occur the next day, it does not effectively aid caregivers in early intervention for real-world applications. Based on the above, this study proposed a personalized fine-grained BPSD prediction framework for predicting BPSD that occurs within the next four hours (Figure 1). **Method** The input data includes physiological signals collected from dementia patients wearing smart wearable devices, such as heart rate, heart rate variability, blood pressure, body temperature, and blood oxygen, together with demographic information, derived from a cohort of 183 clinically confirmed dementia patients, consisting of 101 females and 82 males, with a mean age of 77.9 ± 10.2 years (female 77.7 ± 8.8; male 78.2 ± 11.7) and an average education level of 6.6 ± 4.5 years (female 5.0 ± 4.2; male 8.6 ± 4.1). We developed a two-stage framework, comprising personalized and generalized models, since not all patients exhibit the same types of BPSD, making it impractical to develop a separate multiclass BPSD model for each individual. The personalized model captures each patient's distinctive representations, while the generalized model focuses on distinguishing among fine-grained BPSD types by utilizing data aggregated from all patients. For personalized model training, we employed a separate model for each patient to predict whether the patient exhibits BPSD, utilizing Extremely Randomized Trees (ERT) [3]. Additionally, the generalized model comprises three components: First, the Raw-Data-based Generalized model (RDG) trained on all patients' data is also an ERT model; Second, we used a Temporal Convolutional Network (TCN), an effective approach for processing time-series data, to construct the generalized model for extracting temporal features from the raw signals; Third, we utilized an Individual Representation-based Generalized (IRG) model, which incorporates each patient's unique feature during training. The generalized model aims to predict the fine-grained BPSD symptom type that will arise within the next four hours, following the abnormal prediction made by the personalized model. **Results and Discussion** Our proposed framework demonstrated excellent performance with a notable 16% increase in AUC (0.813) compared to the conventional generalized model, and 57% and 33% improvements for sensitivity (0.741) and specificity (0.858), respectively. In ablation studies, our proposed framework, which incorporates the full integration of RDG, TCN, and IRG into the generalized model, outperforms other ablation combinations, including those using only the RDG component, achieving superior results. This highlights the effect of integrating temporal contextual information and individualized representations with raw data-based modeling. In conclusion, this work presents promising potential for transforming dementia care by advancing personalized healthcare in geriatric medicine using machine learning techniques and wearable devices.

References

1. Cerejeira, J., Lagarto, L., & Mukaetova-Ladinska, E. B. (2012). Behavioral and psychological symptoms of dementia. *Frontiers in Neurology, 3*, 73. https://doi.org/10.3389/fneur.2012.00073
2. Cho, E., Kim, S., Heo, S. J., Shin, J., Hwang, S., Kwon, E., et al. (2023). Machine learning-based predictive models for the occurrence of behavioral and psychological symptoms of dementia: Model development and validation. *Scientific Reports, 13*(1), 8073. https://doi.org/10.1038/s41598-023-35289-6
3. Geurts, P., Ernst, D., & Wehenkel, L. (2006). Extremely randomized trees. *Machine Learning, 63*, 3–42. https://doi.org/10.1007/s10994-006-6226-1

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Affiliation: Department of Computer Science, National Yang Ming Chiao Tung University, Taiwan
Email: vtseng@cs.nycu.edu.tw

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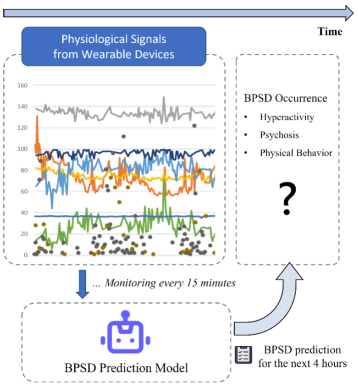

Figure 1. Overview of the proposed workflow for BPSD prediction