153

Frailty prediction using digital sensor data, an interpretable machine learning approach

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Gaizka Pérez
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Gaizka is a psychometrician and statistician based in Bilbao, Spain. He has a background in health psychology and data science. Gaizka has working experience on the validation of psychometric instruments. Recently, he has gained a special interest in the analysis of digitally derived measures and methodological innovation in the health industry.
Gaizka completed a master's degree in general health psychology and gerontology at the University of Deusto. Later, he also completed a master's degree in data science at UNED.

Aleksandra Sjöström-Bujacz
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Aleksandra is an experienced cross-disciplinary researcher, instructor, and consultant. She has a passion for psychometrics and a strong focus on health and well-being measurement, especially in a digital setting. Prior to joining IQVIA in 2023, Aleksandra worked both as a consultant in the field of work and organizational psychology and as a researcher investigating ways in which behavioral data can be used to optimize health interventions. Aleksandra has broad experience in scale development and psychometric validation of behavioral measurements for various purposes such as intervention and treatment assessment, measurement of change, recruitment, and selection. She has authored and co-authored several articles in peer-reviewed scientific journals.
Aleksandra earned her PhD in psychology with a focus on work and organizational psychology at the Johannes Gutenberg University in Germany, having previously completed a master of science in psychology at Adam Mickiewicz University in Poland. She is also an affiliated researcher at the Health Informatics Centre at Karolinska Institutet in Stockholm, Sweden.

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Multidimensional assessment of frailty in healthcare settings is often constrained by time, resources, and the lack of sensitive early detection measures. Continuous monitoring with digital health technologies (DHTs) is a promising alternative enabling real-life assessments. Deriving measures from DHT sensors typically involves machine learning (ML) and artificial intelligence (AI) models. Beyond the model's predictive ability, interpretability is crucial for stakeholders and regulatory bodies.

In this study we predict frailty using electrocardiogram (ECG) data gathered with commercially available sensor (Polar H10) from 80 post-open heart surgery patients. Two alternative methodological approaches were compared in terms of their prediction ability and interpretability. First, tabular features were extracted from the sensor data for the implementation of traditional ML models. These models were further analyzed utilizing SHapley Additive exPlanations (SHAP) values. Second, the sensor data were segmented, and a deep learning model for time series classification was employed as an alternative approach. For the deep learning model, local interpretation methods such as Agnostic Local

Explanation for Time Series Classification (LEFTIST) and Evolutionary Counterfactual Explanations for Time Series Classification (TSEvo) were used.

Based on the current analysis, traditional ML models are preferable due to their higher interpretability when useful features can be extracted from time series data. Alternatively, the use of deep learning models with post-hoc interpretation methods can offer a good balance between predictive ability and interpretability when it is of interest how the time series itself relates to the prediction.