Multi-Dimensional Interpretable Interaction Network (MDiiN) for Modeling Aging Health and Mortality

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Aging is the most important risk factor associated with many diseases such as cancer and Alzheimer's disease. While many studies focused on the prediction of aging cross-sectionally, few methodologies have been developed to model the longitudinal aging process. Modeling longitudinal data with a Stochastic Differential Equation (SDE) is an emerging area of aging research. There are frameworks that have been proposed but have only been implemented for 1-2 health variables or limited to binary health measures. I propose MDiiN (Multi-Dimensional Interpretable Interaction Network) to accurately predict an individual's trajectories of health states and survival. MDiiN features a three-dimensional interaction network that captures the strength of connections between 29 health variables and 19 background variables and results in interpretable models. MDiiN is applied to the English Longitudinal Study of Aging dataset of 27,365 participants. MDiiN outperforms the Elastic-Net in most metrics (C-Index = 0.9 vs 0.65 and Integrated Brier Score = 0.3 vs 0.6) and is comparable to it for D-Calibration (p = 0.9 vs 1.0). I also compare MDiiN to latent space models with varying dimensions to demonstrate that MDiiN is comparable to other high-dimensional models in prediction. Finally, I demonstrate MDiiN's interpretability through a visualized pairwise correlation network of the various health variables. MDiiN is the first three-dimensional interaction network to uncover high-dimensional interactions among health variables during the aging process while capturing its stochasticity in longitudinal data. It can be applied to a wide range of high-dimensional health data and ultimately improve our understanding of the aging process and benefit public health.