Analysis of Photoplethysmographic Signals in Low-Dimensional Latent Spaces

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Introduction. Physiological signals are inherently complex yet serve as a critical source of clinical knowledge. Integrating this data into artificial intelligence (AI) systems has shown promising capabilities in supplementing usual clinical practices. Nonetheless, the extent of applicability of these systems may be constrained by the lack of transparency of the used algorithms.

Materials and Methods. The input space of photoplethysmography (PPG) signals is sourced from a collection of representative datasets with diverse purposes and extraction techniques. These signals are projected into a viewable latent space using unsupervised (Autoencoders, AE), supervised (Fully Connected Neural Networks, FCNN), and semi-supervised methods (Uniform Manifold Approximation and Projection, UMAP). The optimal hyperparameters for the models are found with a grid search holdout cross-validation strategy based on the reconstruction error for the AE model, classification loss for the FCNN, and the Davies-Bouldin index for UMAP.

Experiments and Results. Among the evaluated algorithms, UMAP demonstrates a detailed geometry of the latent accounting for the periodicity of signals. AE produces a very compact representation, allowing reconstructions from the represented hidden variables, and FCNN provides insight into the classification framework affecting the latent space.

Conclusions. Reduced-dimensionality latent spaces retain amplitude, frequency, periodicity characteristics, and morphological insight about the PPG signals.

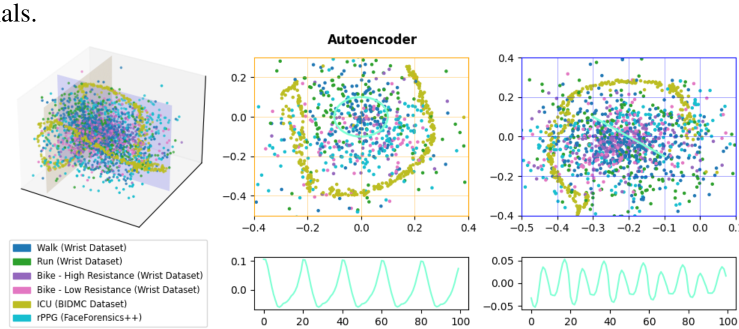

Figure 1: Latent space representation from AE for the complete test dataset with two perpendicular plane slices. Below each slice, a reconstruction of the PPG signal from the highlighted points is provided.