Variational Autoencoder as a Robust Clinical Classification Tool for Dementia

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The rising prevalence of neurodegenerative dementia highlights the need for improved diagnostic accuracy. Many proposed clinical decision support systems (CDSS) require multiple disparate data elements as input, which makes implementation difficult, and furthermore have a black-box nature leading to low interpretability of individual diagnosis. Fluorodeoxyglucose Positron Emission Tomography (FDG-PET) is an established modality for the diagnosis of dementia and a CDSS that uses only an FDG-PET image to produce a reliable and understandable result would ease both of these challenges to clinical application. I designed a deep variational autoencoder (VAE) to extract a latent representation of each image through prior training from FDG-PET brain images (n=2000). This unsupervised VAE reduces an FDG-PET image to 16 low-dimensional and interpretable classification features, where each dimension represents a pattern of brain activity. A logistic regression classifier was implemented to classify each image. The features from the model were analyzed in comparison to true neurodegenerative pathology and aligned with known clinical pathology and metabolic patterns. A logistic regression classifier of images embedded in the VAE latent space was evaluated and compared to a baseline principal component analysis architecture. The undirected graph illustrates a latent space comparison among dementia phenotypes. The VAE latent space and graph structure provide clear visual interpretability and achieved high accuracy, for instance, 90% accuracy in diagnosing Alzheimer’s disease. The use of a single brain FDG-PET allows this model to be implementable in the clinical setting and would be a robust CDSS to assist clinicians in diagnosing neurodegenerative diseases.

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