

Exploring sex-based brain morphometry differences through Explainable Artificial Intelligence: Insights for Digital Health Innovation

The rapid advancement of Artificial Intelligence (AI) and Machine Learning (ML) is revolutionizing the field of digital health, offering innovative approaches to complex medical challenges. A particularly promising area of interest is the exploration of sex-based brain morphometry differences, which holds profound implications for personalized medicine and tailored interventions for neurological conditions.

Traditionally, brain morphometry studies have identified structural differences between male and female brains, yet the underlying causes and implications for health and disease remain inadequately understood. To address this gap, the application of Explainable Artificial Intelligence (XAI) techniques has become crucial.

This research leverages XAI to uncover hidden patterns and correlations in brain imaging data that might be overlooked by conventional methods, providing interpretable insights into which specific features or regions of the brain contribute most to observed sex-based differences. Specifically, we compared two XAI classifiers: XGBoost (XGB) with Shapley Additive Explanations (SHAP) and Explainable Boosting Machines (EBM) trained on FreeSurfer morphological features from the HCP Young Adult dataset. Both models demonstrated high accuracy, with XGB achieving 87% and EBM achieving 85% and 86% (without and with 20 interactions, respectively). Notably, global explanations from SHAP and EBM showed consistency in feature importance rankings, highlighting bilateral amygdala volume as a key predictor, which was also significant in local explanations of individual predictions.

The explainability provided by XAI is particularly valuable in this context, as it allows researchers to trace the decision-making process of AI models. This, in turn, offers insights into the specific features or regions of the brain that contribute most to observed differences between sexes.

The implications of these findings are significant for the development of more precise diagnostic tools and therapeutic strategies. For instance, understanding sex-specific brain morphometry could lead to better-targeted treatments for neurological and psychiatric conditions, which often present differently in males and females. Moreover, the integration of XAI ensures that models used are not only accurate but also interpretable and reliable, addressing one of the key challenges in the application of AI in healthcare.