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A Deep Learning Approach for High-Dimensional Reliability Analysis with DBSCAN Clustering

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Abstract

Analyzing reliability in high-dimensional systems presents substantial difficulties due to their inherent complexity and the challenges posed by the curse of dimensionality. One existing solution is the High-Dimensional Data Abstraction (HDDA) method proposed by Li and Wang (2021), which uses deep learning for dimensionality reduction, maps high-dimensional data to latent variables and estimates reliability through Gaussian process regression (GPR). Due to cost constraints, it is necessary to optimize the increase in sample size while controlling expenses to enhance model performance. We adopt the DBSCAN method for exploring the latent space and replace GPR with commonly used classification models, such as SVM and Logistic Regression, to analyze their impact on classification prediction and performance. Compared to the original HDDA method, utilizing DBSCAN for outlier detection enables more effective exploration of the latent space, although occasional underestimation may occur. Future research will focus on optimizing DBSCAN techniques while further investigating the application of classification models to enhance the accuracy of reliability estimation and the robustness of the model.

Keywords：DBSCAN Clustering, Deep Learning, Dimensionality Reduction, High-dimensional Data, Reliability

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