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# From Curse to Cure: Dimensionality Reduction Techniques in Machine Learning

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**Abstract**

The growth of high-dimensional data has greatly advanced machine learning, allowing it to capture and understand complex phenomena. However, it has also introduced a host of challenges, commonly referred to as the curse of dimensionality. As the number of dimensions increases, data points often become sparse, making it difficult to identify meaningful patterns. Additionally, high dimensionality leads to exponential growth in computational complexity, requiring significant resources to process and analyze data. It also increases the risk of overfitting, as models struggle to generalize well in the presence of numerous, potentially irrelevant features. Addressing these challenges is crucial for effective machine learning. Dimensionality reduction techniques play a pivotal role by simplifying high-dimensional data into a more manageable form without sacrificing critical information. These methods not only improve computational efficiency but also enhance the interpretability of data, enabling researchers and practitioners to focus on the most relevant features. In this talk, we will discuss the adverse effects of high dimensionality and how it complicates tasks such as clustering, classification and visualization. Following this, we will introduce essential dimensionality reduction techniques, from classical methods like Principal Component Analysis (PCA) to modern nonlinear approaches like t-SNE and UMAP

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