

# Exploring Dimensionality Reductions with Forward and Backward Projections

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## ABSTRACT

Dimensionality reduction is a common method for analyzing and visualizing high-dimensional data across domains. Dimensionality-reduction algorithms involve complex optimizations and reduced dimensions but generally lack clear relation to the initial data dimensions, so that interpreting and reasoning about dimensionality reductions can be difficult. In this work, we introduce two interaction techniques, *forward projection* and *backward projection*, for reasoning dynamically about scatter plots of dimensionally reduced data. We also contribute two related visualization techniques, *prolines* and *feasibility map*, to facilitate and enrich the effective use of the proposed interactions, which we integrate in a new tool called *Praxis*. To evaluate our techniques, we first analyze their time and accuracy performance across varying sample and dimension sizes. We then conduct a user study in which twelve data scientists use *Praxis* so as to assess the usefulness of the techniques in performing exploratory data analysis tasks. Results suggest that our visual interactions are intuitive and effective for exploring dimensionality reductions and generating hypotheses about the underlying data.

## KEYWORDS

Dimensionality reduction, interaction, bidirectional binding, visual embedding, forward projection, backward projection, PCA, autoencoder, prolines, feasibility map, what-if analysis, Praxis

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