PCA and VAE

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Dimensionality reduction techs.

PCA

- a statistical technique used to reduce the dimensionality of large data sets while preserving as much variance as possible.
- reduces number of features in a data set while keeping the most important information
- it changes complex data sets by transforming correlated features into smaller sets of uncorrelated components.

- it helps us remove redundancy and improve computational efficiency while making the data easier to visualize.

- It uses linear algebra to transform data into principal components
- it does this by calculating eigen vectors (directions) and eigen values (importance) from the covariance matrix

- Step 1 standardize the data
- Step 2 Calculate covariance matrix
- Step 3 find the principal components.
- Step 4 Pick the top Directions and Transform Data

- Can be done in python using Sklearn

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1. multicollinearity Handling: Creates NEW uncorrelated variables to address issues when original features are highly correlated.
2. Noise Reduction: reduces components with low variance thus increasing data clarity.
3. Data Compression: Reduces data size
4. Outlier detection: identifies outliers.

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1. Interpretation challenges: Principal components are combinations so can be hard to explain
2. Data scaling sensitivity: Requires proper scaling of data or results will be misleading.
3. Information loss: may lead to loss if too few components are kept.
4. Assumption of linearity: May struggle with non linear data
5. Computational complexity: Can be slow and resource intensive on large datasets
6. Risk of overfitting.

Variational auto encoders.

are generative models that learn a smooth, probabalistic latent space.

- VAE's capture the underlying structure of a dataset and produce outputs that closely resemble the original data.

- learns a continuous latent representation
- Enable controlled and meaningful data generation
- widely used in image synthesis, anomaly detection and representation learning

- Step 1 Encoder (understand the input)
- Step 2 Latent space (adding some randomness)
- Step 3 Decoder (Re constructing / creating new dataset)

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- Generative modelling
- Anomaly detection
- Data imputation and denoising