8.1 Introduction to Autoencoders:

Autoencoders are a type of unsupervised deep learning model that use hidden layers to decompose & then recrate their input. They have several applications:

- Dimensionality Reduction   - Preprocessing for classifical
- Identifying, "essential" elements of input data, & filtering out noise.
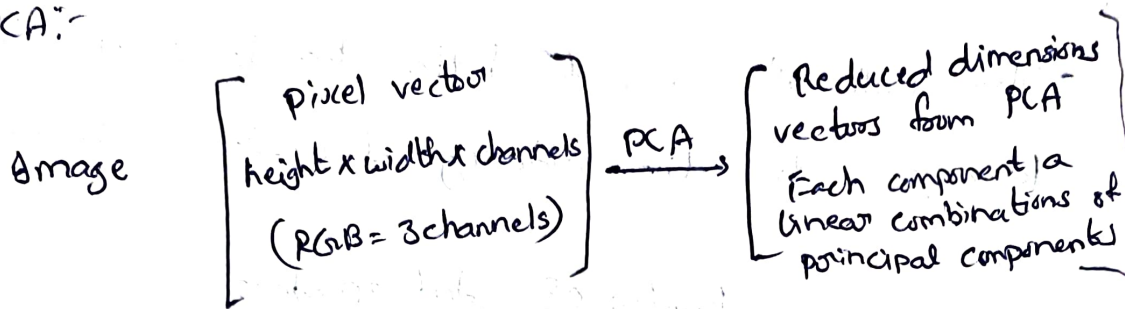
Data Representation: Motivation:-

Suppose we want to find whether 2 images are 'similar':-
we could not look at every pixel wise & distinguish if 2 images are both or different.

But we want to the capture the image content of 2 images & check the similarity. The we can say that 2 images are similar or different

Non-Deep Learning Techniques:-

One approach could be Principal Component Analysis

PCA:-

$$\text{Image} \begin{bmatrix} \text{pixel vector} \\ \text{height} \times \text{width} \times \text{channels} \\ (RGB = 3 \text{ channels}) \end{bmatrix} \xrightarrow{PCA} \begin{bmatrix} \text{Reduced dimensions} \\ \text{vectors form PCA} \\ \text{Each component ia} \\ \text{linear combinations of} \\ \text{principal components} \end{bmatrix}$$

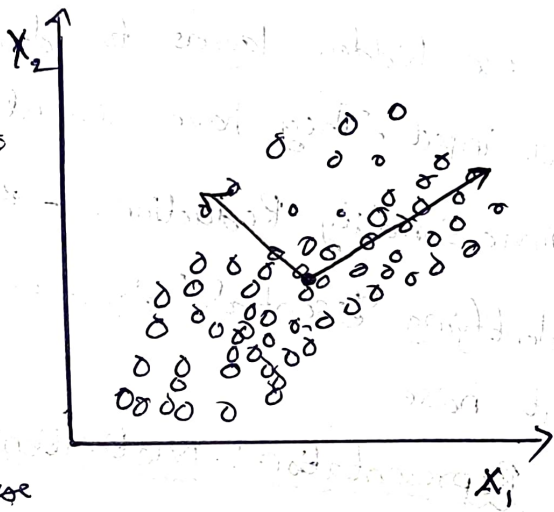PCA :- find dimensions that capture most variance in
   original data
      It usually reduces the dimensions of original image

- Two Dimensonal eg:

- Direction of arrows represent
  principal components

- Length of arrows correspond
  to variance in original data

- Notice that both arrows are
  combination of original feature

Limitations of PCA:-

- Learned features are linear combinations of original
  features

- These may be complex, non-linear relationship between
  original feature (pixels) & best lower dimensional representation

- The best representation can be defined in many
 different ways.

Autoencoders are a neural networks architecture that forces the learning, of a lower dimensional representation of data, commonly images.

Autoencoders, step by step,: Step-1 : Feed image though encoder network.

Autoencoders, step 2 :- Lower-dimensional embedding generated.

Autoencoders, step 3 :- Embedding feed though decoder network

Auto encoders, step 4:- Reconstructed version of original data generated

Image → → [ ] → → Output

Step-01   Step-02   Step 03   Step 04
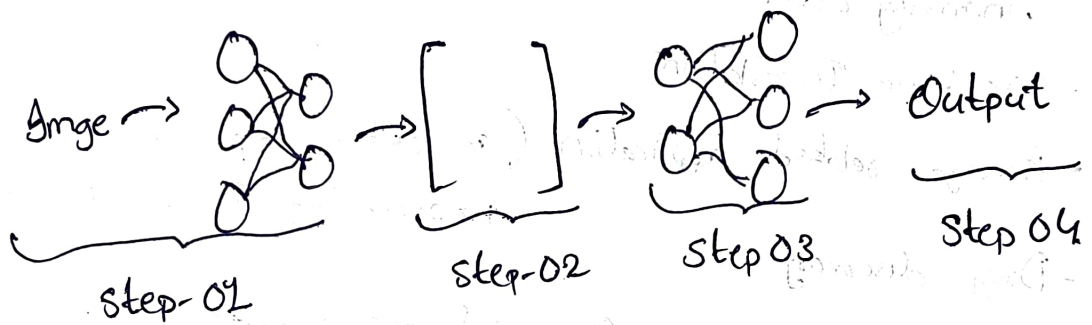
Autoencoders, Step 5:- Compare results to original (compute loss)

• Results:

Network will learn lower dimensional space representing original data

Application:- Auto encoders can be used to find image similarity. The decoder networks maps vectors from the lower-dimensional space to images

The decoder model can be used as a generative model once it is trained.

This isnot offtenly done:-

- To get reasonable results, deep convolutional architecture is required
- Generally inferior to using GANs for image generation

They have a wide variety of enterprise applications:

- Dimensionality reduction as preprocessing for classification

- Information retrieval

- Anomaly detection

- Machine Translation

- Image related application (generation, denoising, preprocessing & compression)

- Drug discovery

- Popularity prediction for social media posts

- Sound & music synthesis

While most autoencoders use deep layers, autoencoders are often trained with a single layer each for the encoding & decoding step. An example is sparse autoencoders, which have been used successfully in recommender systems