Autoencoders

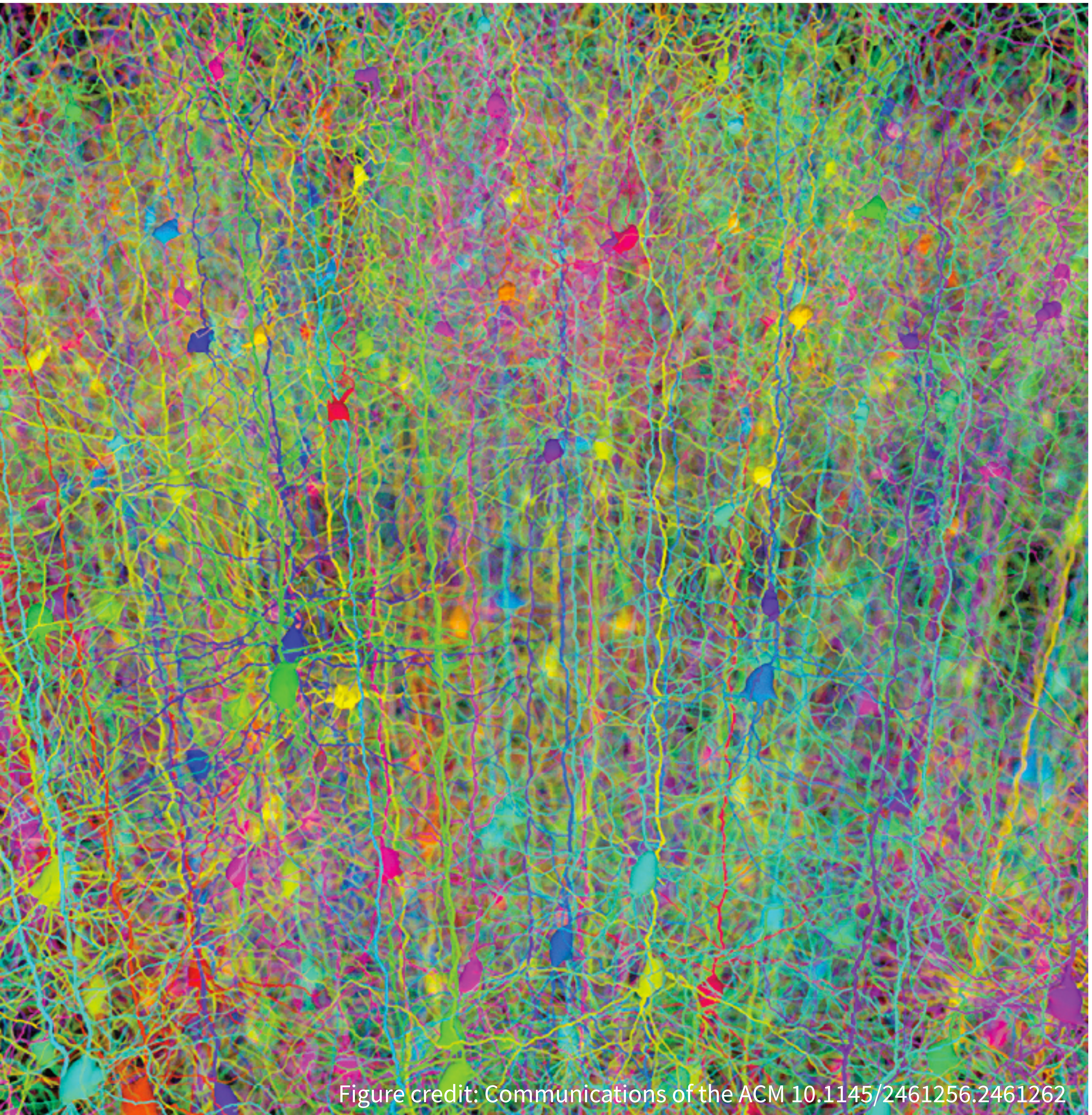


Figure credit: Communications of the ACM 10.1145/2461256.2461262

GRAHAM TAYLOR

VECTOR INSTITUTE

SCHOOL OF ENGINEERING
UNIVERSITY OF GUELPH

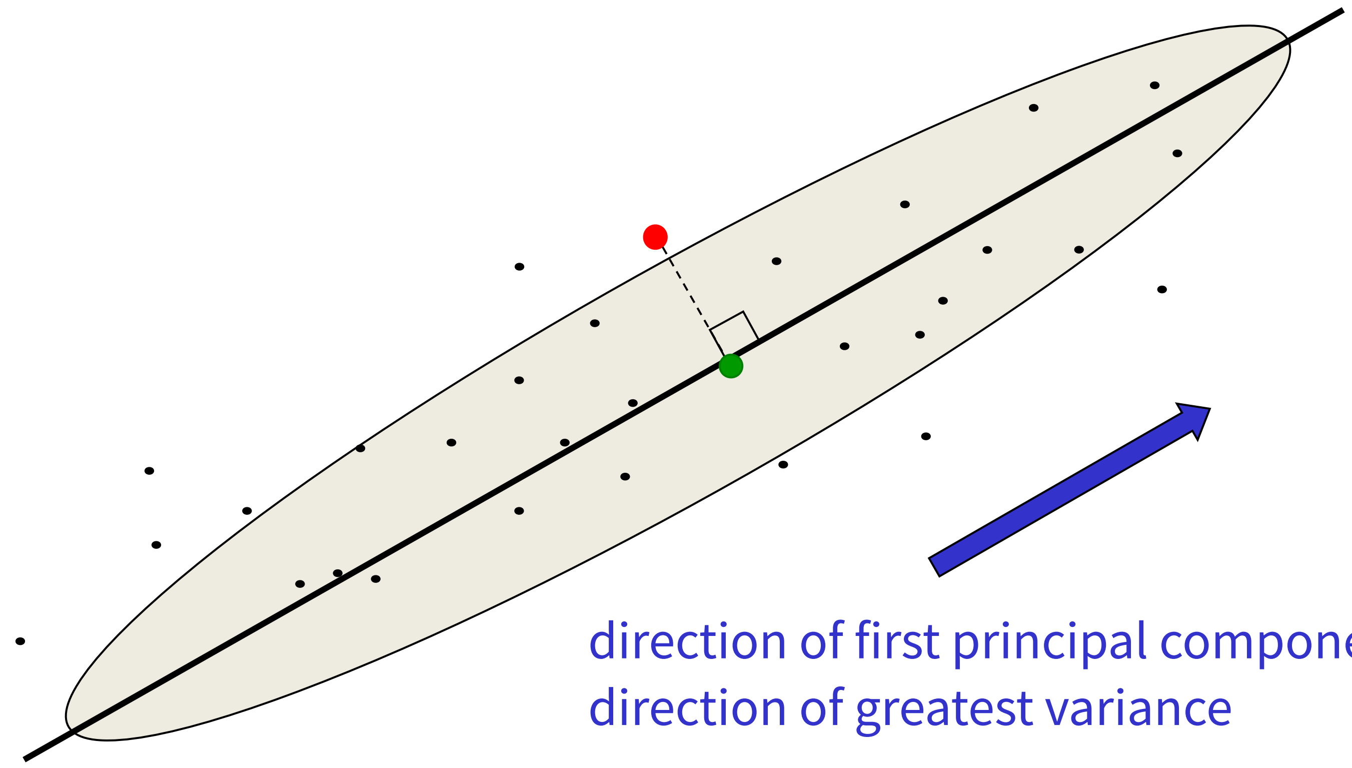
CANADIAN INSTITUTE
FOR ADVANCED RESEARCH

UNIVERSITY of GUELPH
CHANGING LIVES IMPROVING LIFE

CIFAR
CANADIAN INSTITUTE FOR ADVANCED RESEARCH

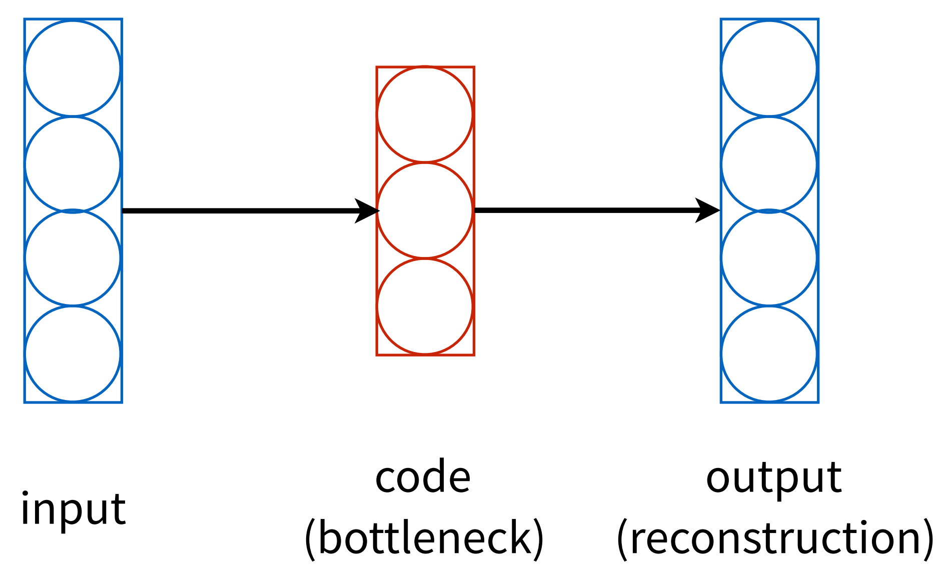
Principal Components Analysis

- PCA works well when the data is near a linear manifold in high-dimensional space
- Project the data onto this subspace spanned by principal components
- In dimensions orthogonal to the subspace the data has low variance



Credit: Geoff Hinton

An inefficient way to fit PCA



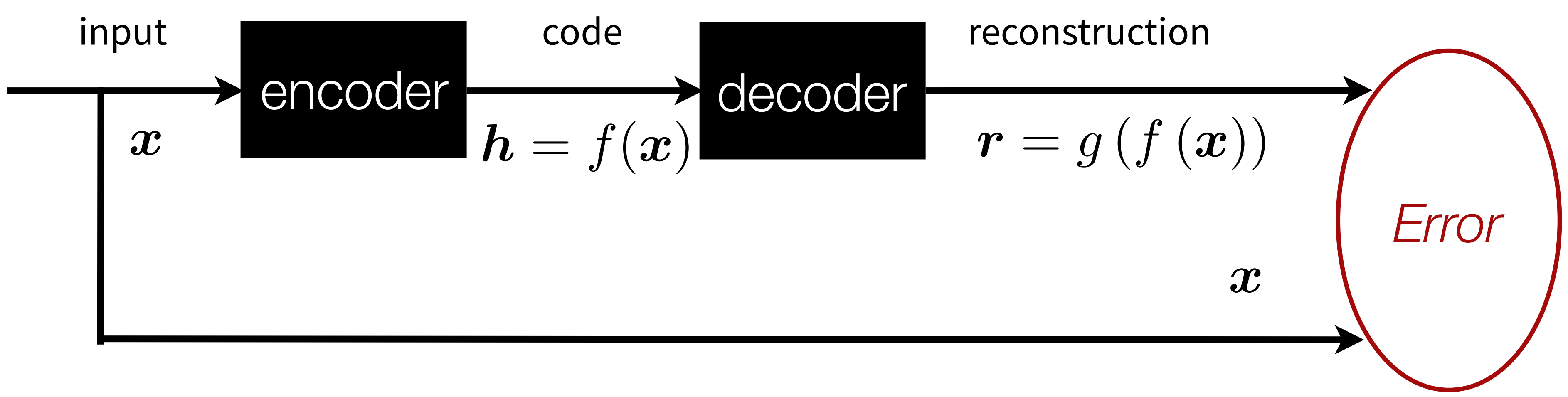
- Train a neural network with a “bottleneck” hidden layer

- Try to make the output the same as the input

- If the hidden and output layers are linear, and we minimize squared reconstruction error:
  - The M hidden units will span the same space as the first M principal components
  - But their weight vectors will not be orthogonal
  - And they will have approximately equal variance

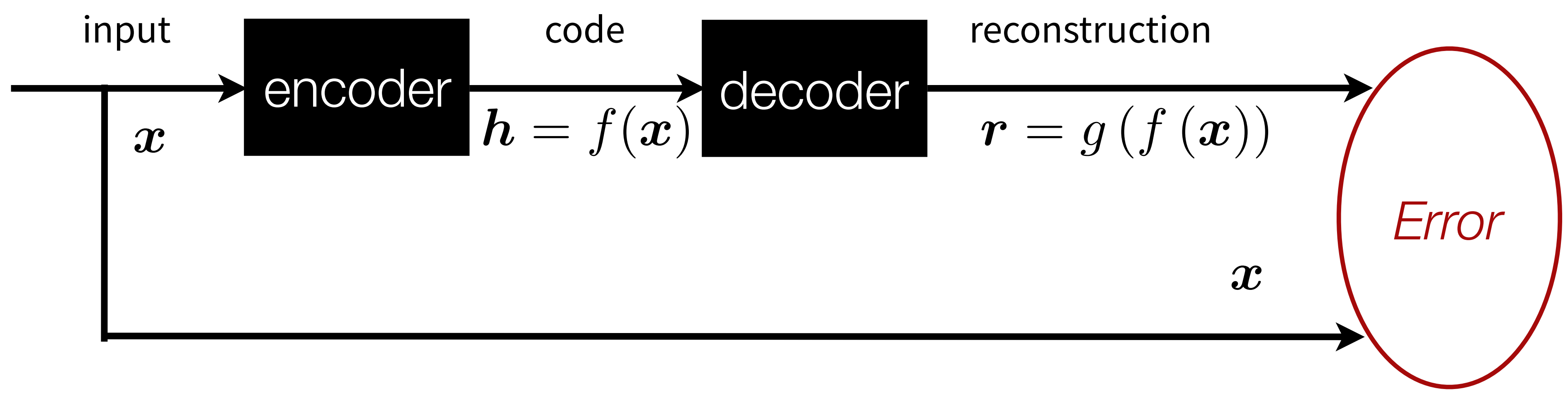
Credit: Geoff Hinton

Why fit PCA inefficiently?



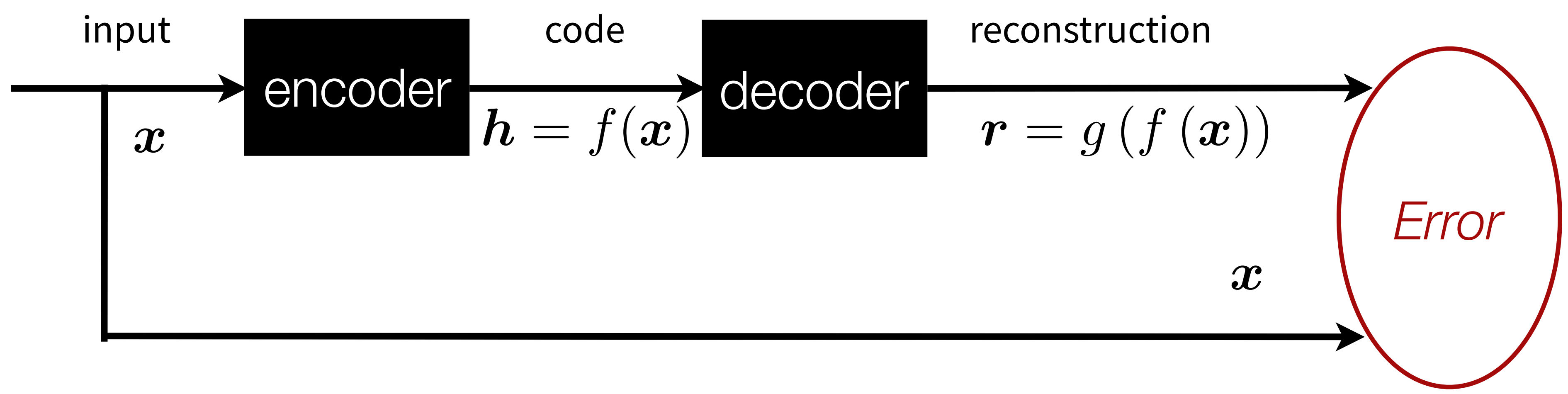
- With nonlinear layers before and after the code, it should be possible to represent data that lies on or near a nonlinear manifold
  - the encoder maps from data space to co-ordinates on the manifold
  - the decoder does the inverse transformation
- The encoder/decoder can be rich, multi-layer functions

Auto-encoder



- Feed-forward architecture
- Trained to minimize reconstruction error
  - bottleneck or regularization essential

Auto-encoder



- Feed-forward architecture
- Trained to minimize reconstruction error
  - bottleneck or regularization essential

Example: real-valued data

Encoder

$$h_i = \sigma\left(\sum_j W_{i,j} x_j\right)$$

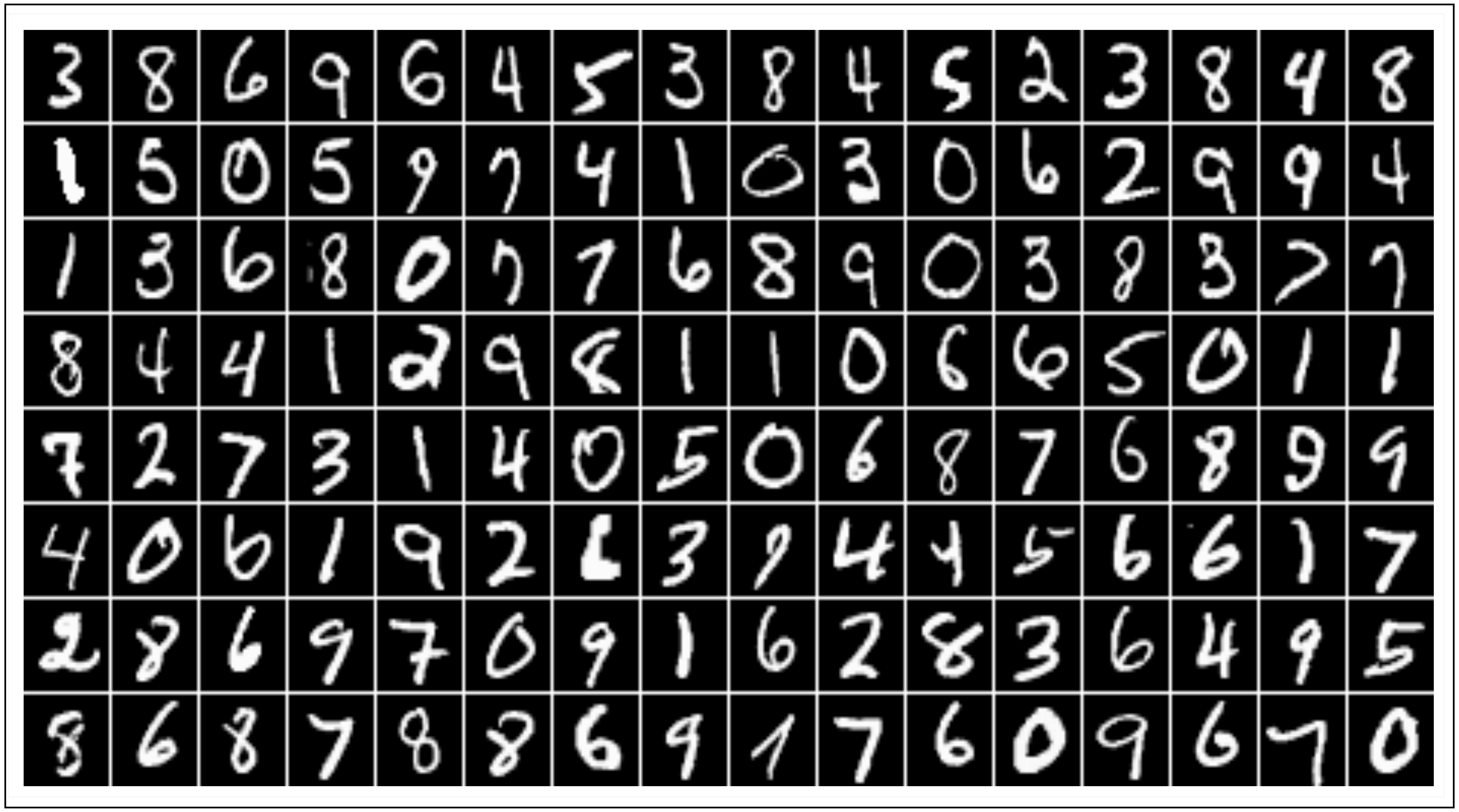
Decoder

$$r_j = \sum_i W_{i,j} h_i$$

Error

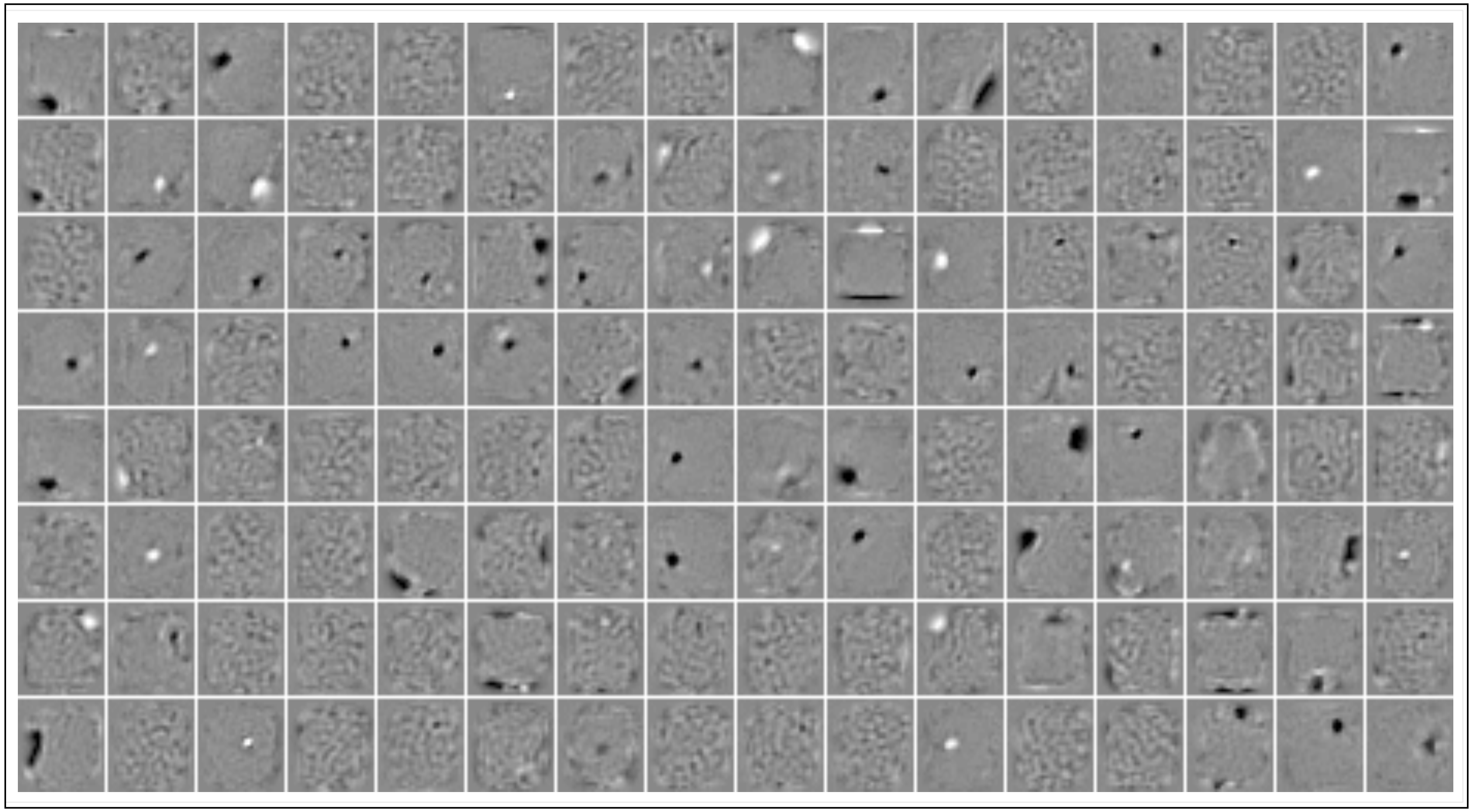
$$L = ||\boldsymbol{r} - \boldsymbol{x}||^2$$

Autoencoder: Example (MNIST)



Reproduced from Hugo Larochelle's slides

Autoencoder: Filters



Reproduced from Hugo Larochelle's slides