Autoencoder

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Slides prepared based on the Lectures slides of Autoencoders from
https://www.deeplearningbook.org/lecture_slides.html

Structure of an Autoencoder

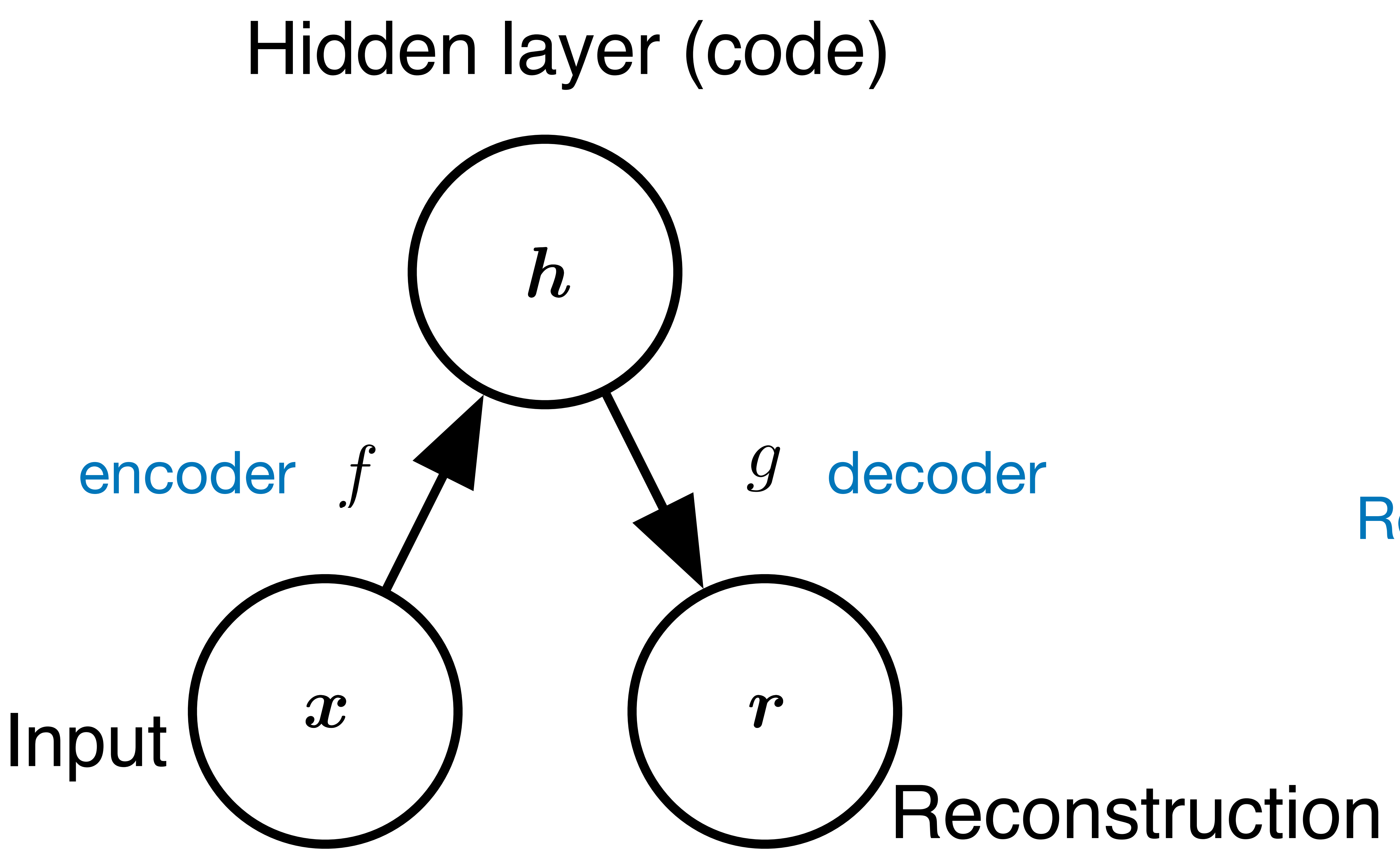


Figure 14.1

Reconstruction $r = g(h(x))$

(Goodfellow 2016)

Avoiding Trivial Identity

- Undercomplete autoencoders
  - *h* has lower dimension than *x*
  - *f* or *g* has low capacity (e.g., linear *g*)
  - Must discard some information in *h*
- Overcomplete autoencoders
  - *h* has higher dimension than *x*
  - Must be regularized

(Goodfellow 2016)

Undercomplete autoencoder for nonlinear dimensionality reduction

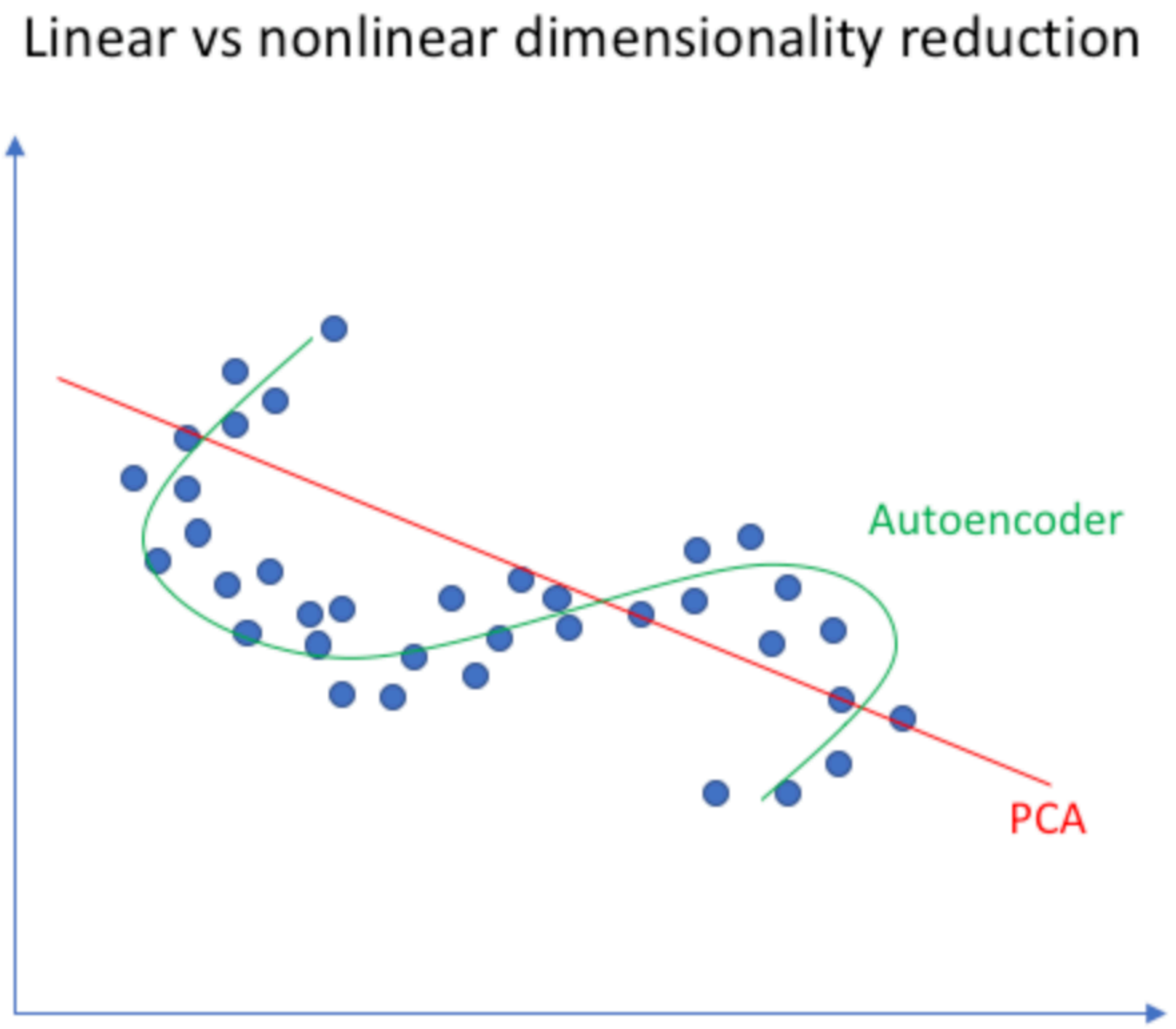
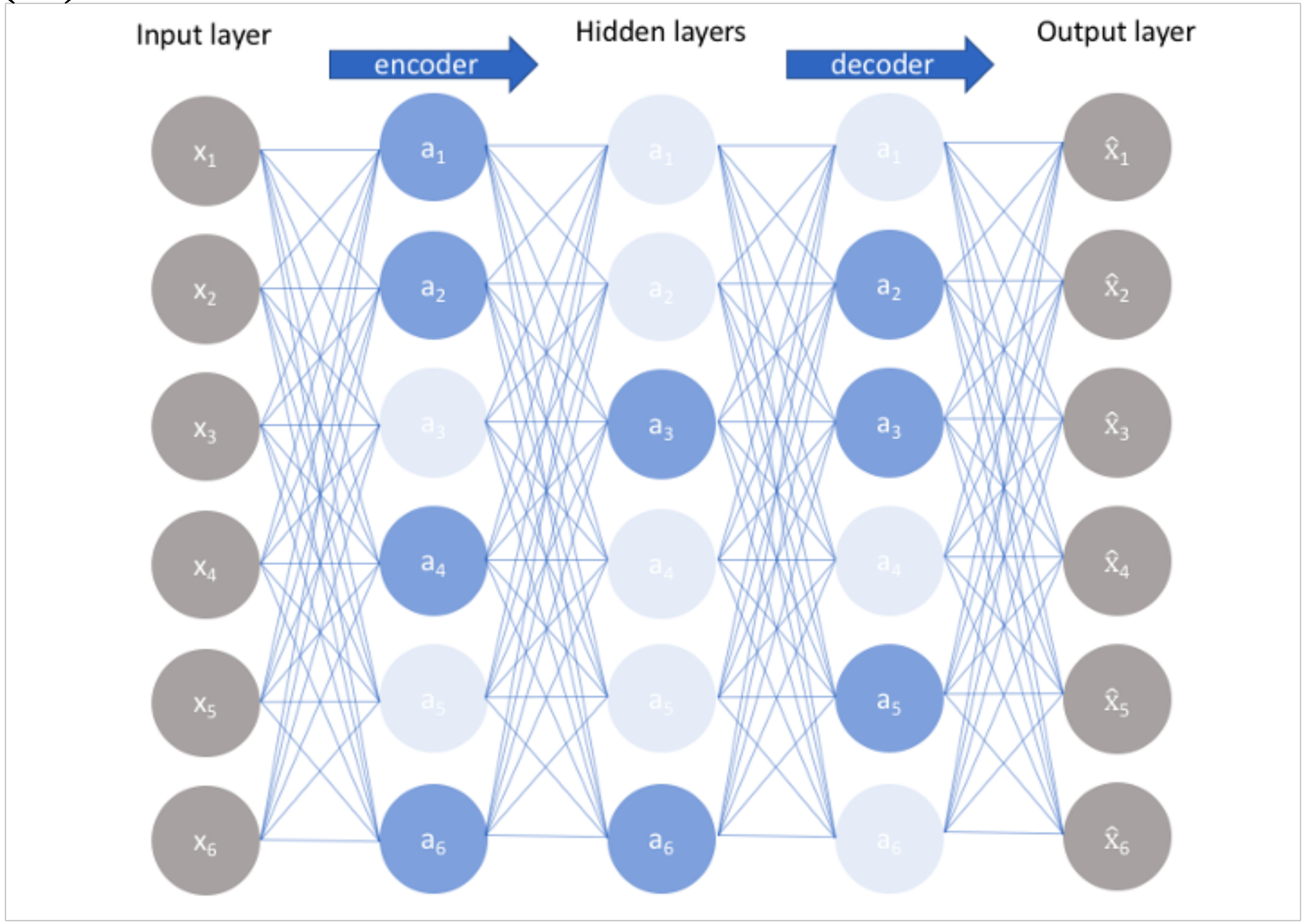


Image credit: https://www.jeremyjordan.me/autoencoders/

Autoencoder with regularization: sparse autoencoder

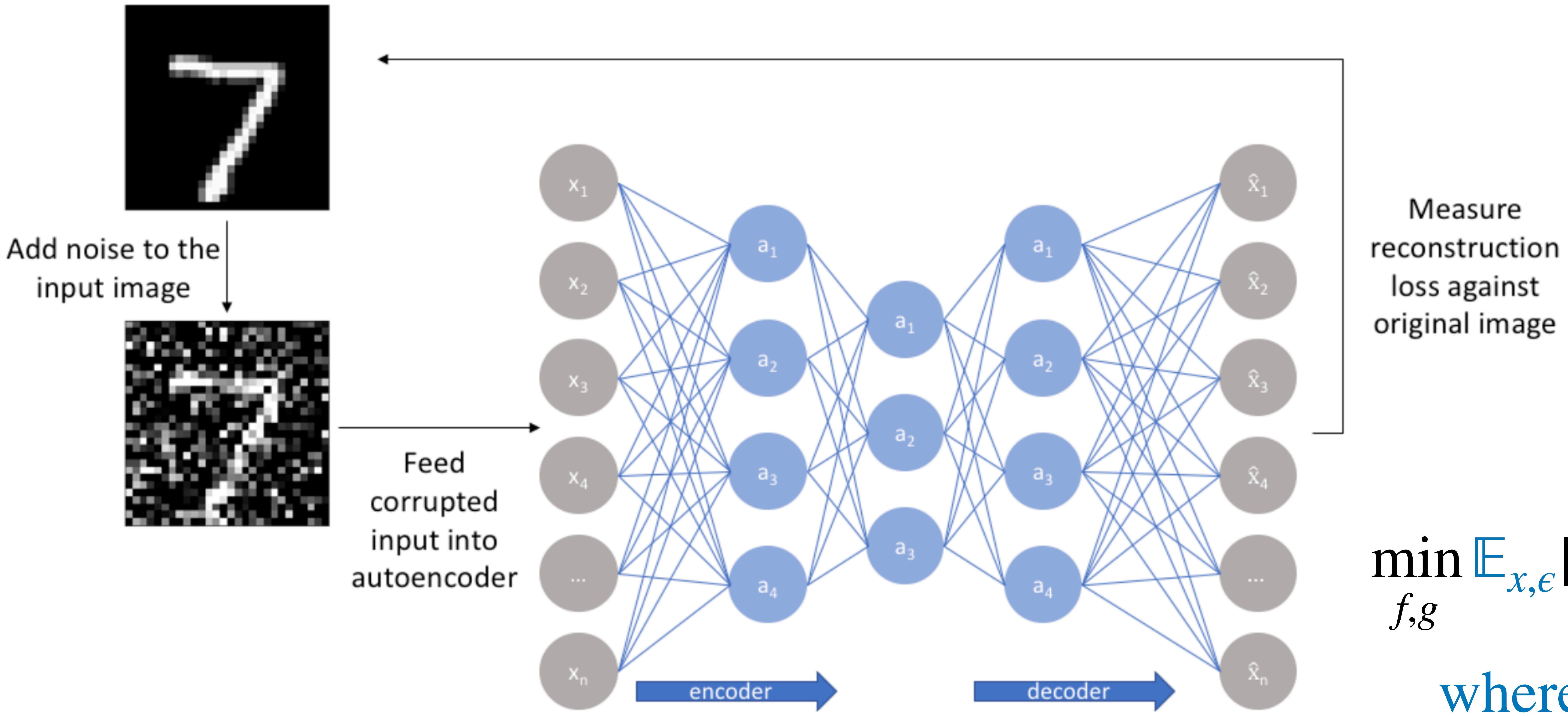
- Sparsity regularization: $\mathscr{L}(\mathbf{x}, \mathbf{r}) + \lambda\Omega(\mathbf{h})$
  - ℓ_1-norm regularization

$$\min_{f,g} \mathbb{E}_x[L(x, g(f(x)))] + \lambda \|f(x)\|_1$$



https://www.jeremyjordan.me/autoencoders/

Autoencoder with regularization: <u>denoising autoencoder</u>



$$\min_{f,g} \mathbb{E}_{x,\epsilon}[L(x, g(f(x+\epsilon)))]$$

$$\text{where } \epsilon \sim \mathcal{N}(\mu, \sigma I)$$

Image credit: https://www.jeremyjordan.me/autoencoders/

Stochastic Autoencoders

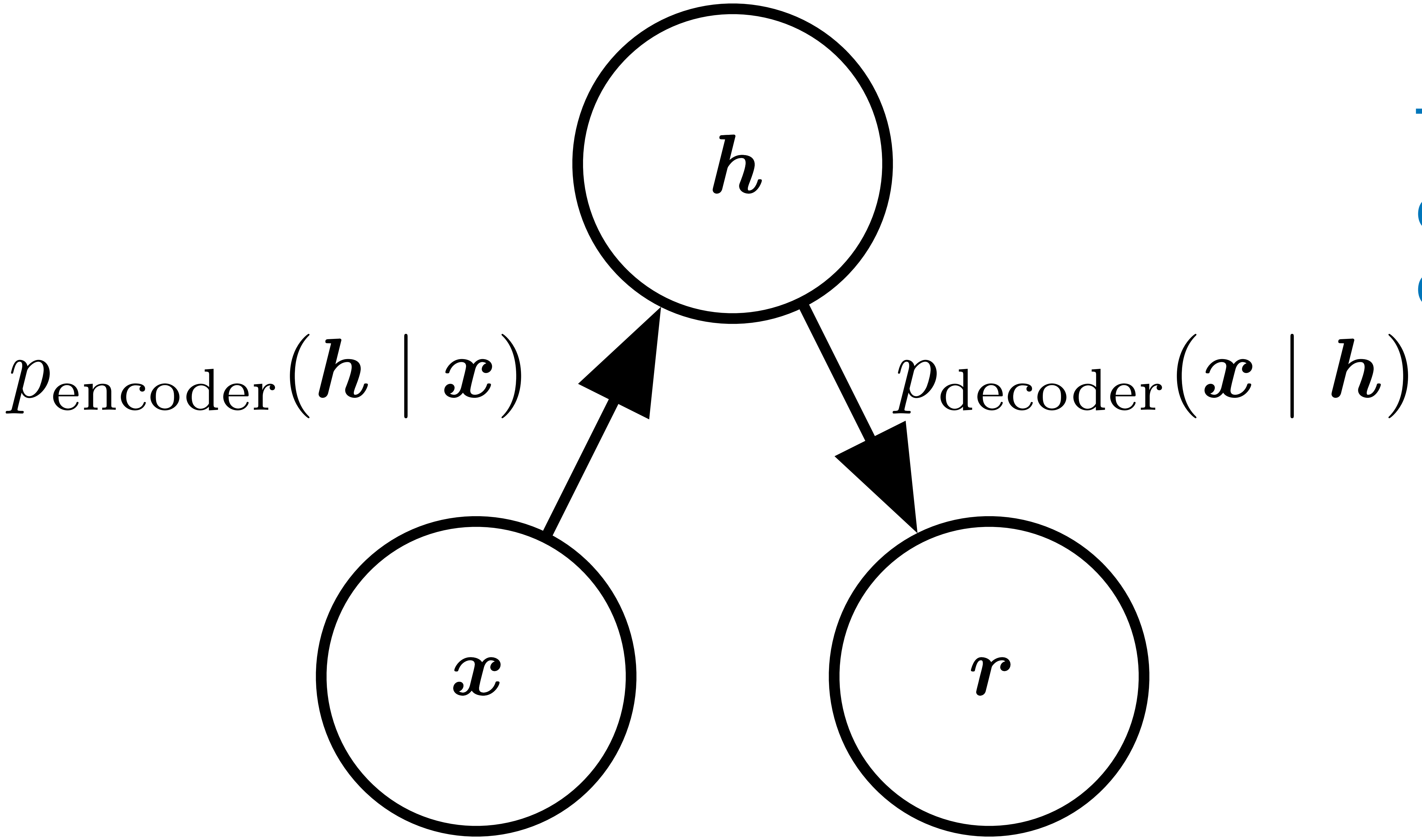


Figure 14.2

The outputs are **distributions** instead of a point: encoder/decoder learns the distribution parameters

$$p_{encoder}(h \,|\, x) = \mathcal{N}(h; \mu = f(x), \Sigma = I)$$

$$p_{encoder}(x \,|\, h) = \mathcal{N}(x; \mu = g(h), \Sigma = I)$$

Example: Variational Autoencoder

(Goodfellow 2016)

Applications of Autoencoder: Image Inpaiting

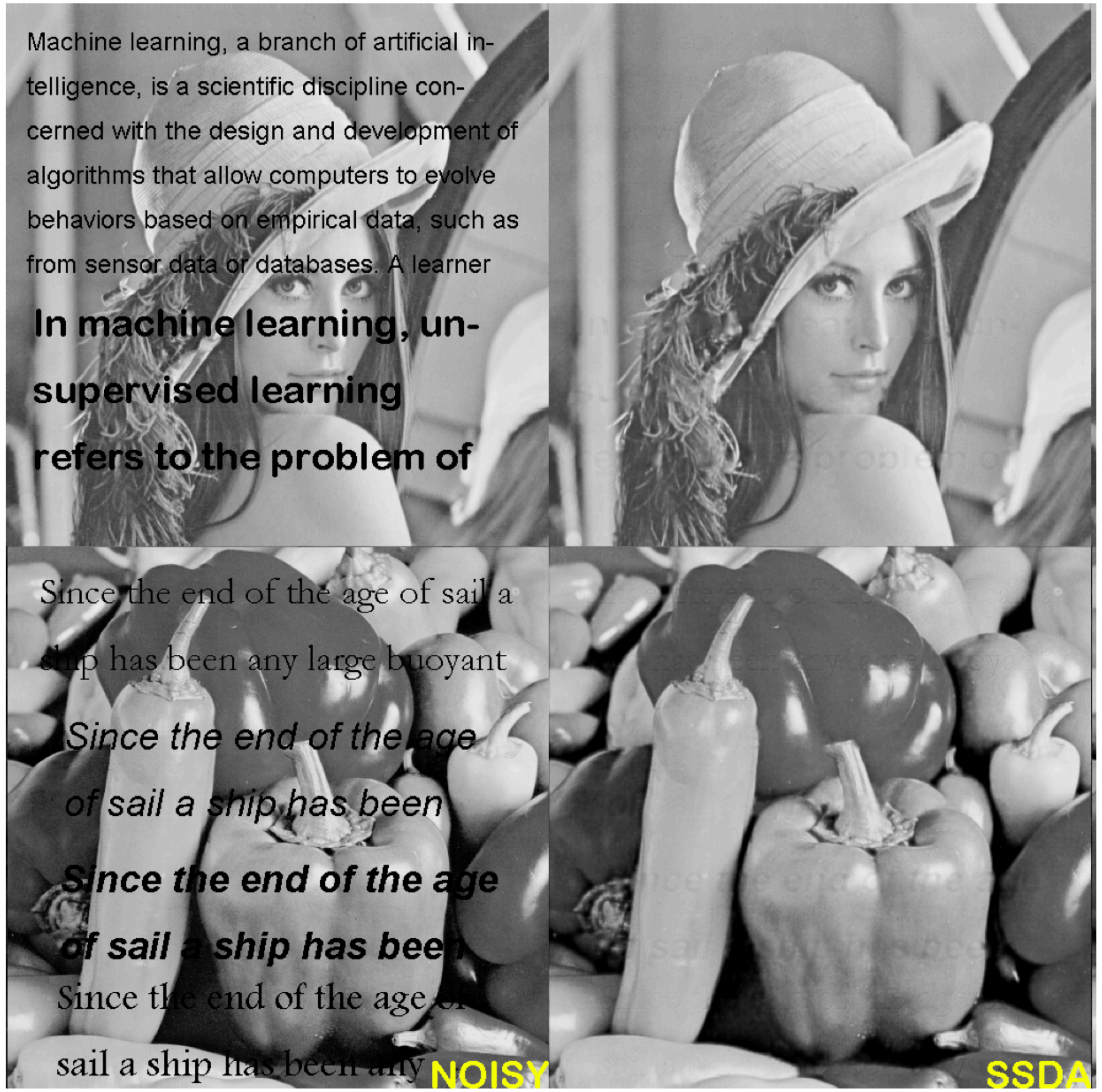


Image credit: Xie, J., Xu, L., & Chen, E. (2012).

Applications of Autoencoder: 3D Shape Reconstruction

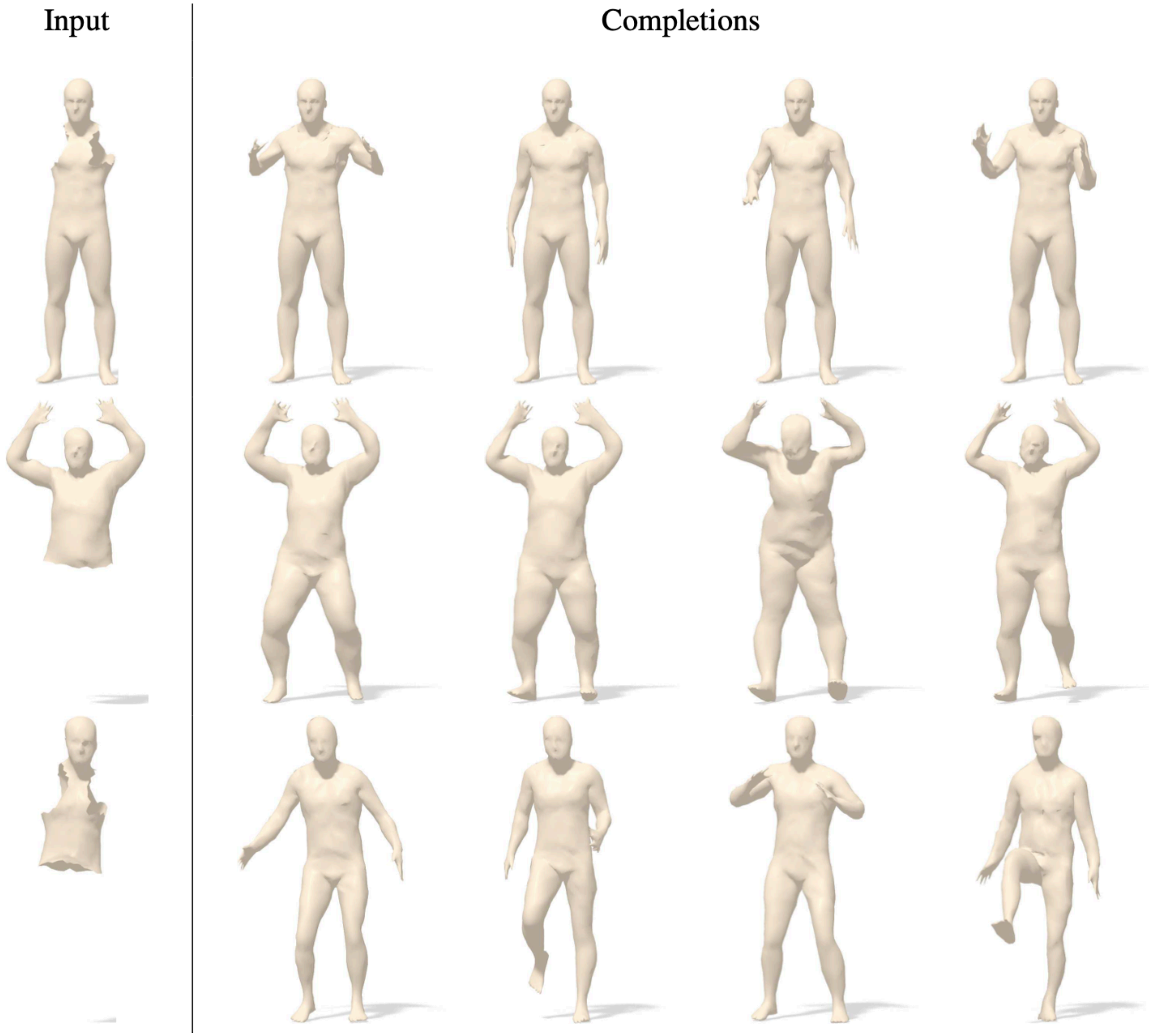


Image credit: Litany et al. (2018).

Applications of Autoencoder: Information Retrieval

Text: nikon, sky, blue, autumn, nikkor

Image credit: Feng, F., Wang, X., & Li, R. (2014, November).

Applications of Autoencoder: Image Generation

Image credit: Huang et al. (2018).

Applications of Autoencoder: Video Analysis

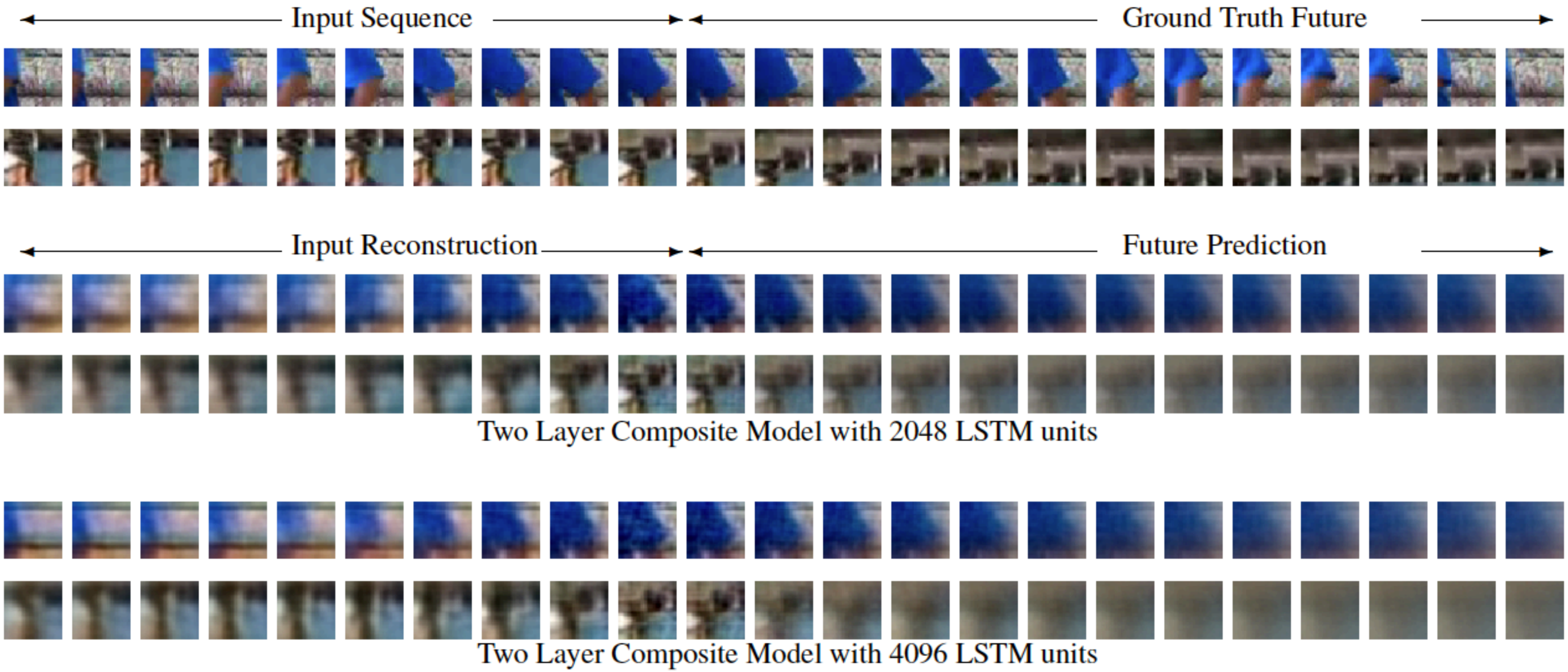


Image credit: Srivastava et al. (2016).