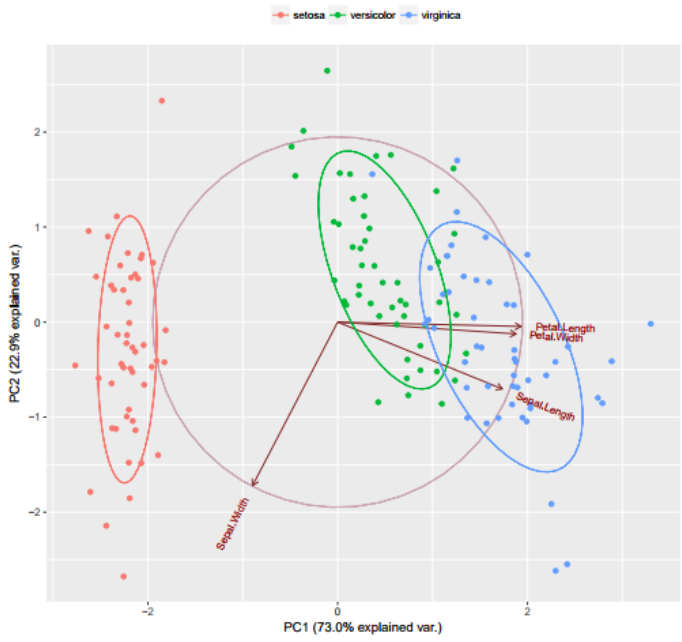
Deep Learning

Unsupervised Learning

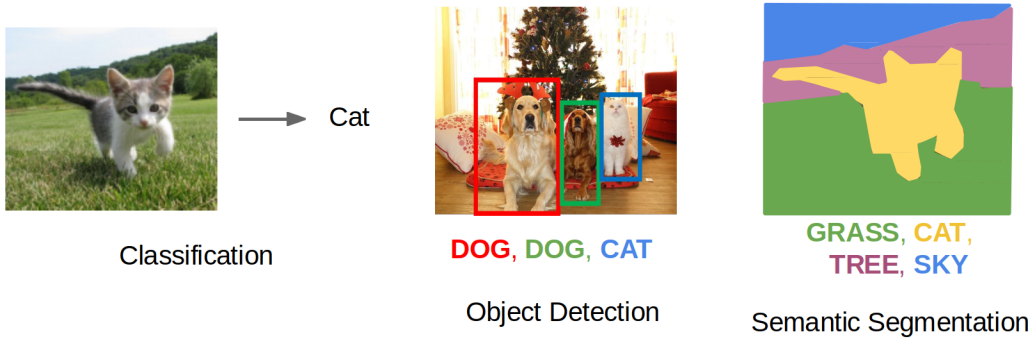


Learning goals

- Unsupervised learning tasks
- Unsupervised deep learning

UNSUPERVISED LEARNING

- So far, we have described the application of neural networks to **supervised learning** in which we have labeled training data $(\boldsymbol{x}^{(1)}, \boldsymbol{y}^{(1)}), \ldots, (\boldsymbol{x}^{(n)}, \boldsymbol{y}^{(n)})$.
- In supervised learning scenarios we exploit label information (i.e. class memberships or numeric values) to train our algorithm.
- The model learns a function to map $\boldsymbol{x}$ to $\boldsymbol{y}$.
- Examples are: classification, regression, object detection, semantic segmentation, image captioning, etc.



UNSUPERVISED LEARNING

- In **unsupervised learning** scenarios training data consists of unlabeled input points $\boldsymbol{x}^{(1)}, \ldots, \boldsymbol{x}^{(n)}$.
- Our goal is to learn some underlying hidden structure of the data.
- Examples are: clustering, dimensionality reduction, feature learning, density estimation, etc.

UNSUPERVISED LEARNING - EXAMPLES

1. Clustering.

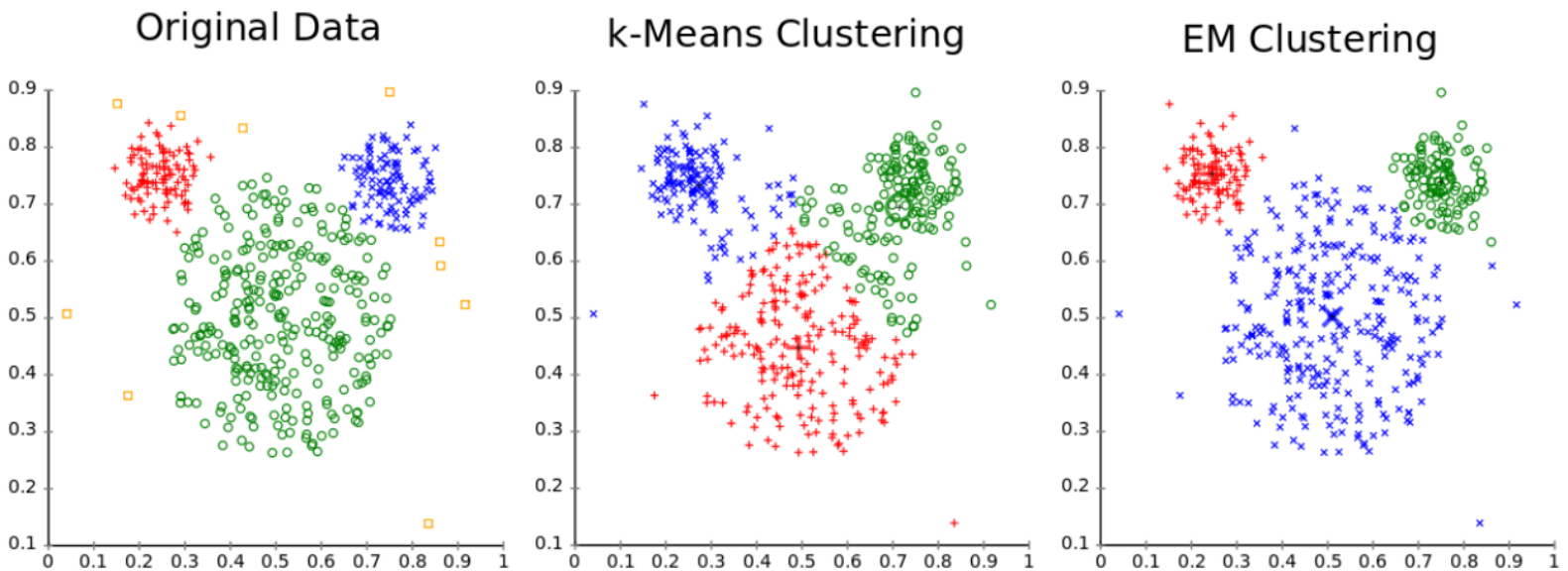


Figure: Cluster analysis results for different algorithms. Different clusters are indicated by different colors. (Source : Wikipedia)

UNSUPERVISED LEARNING - EXAMPLES

2. Dimensionality reduction/manifold learning.

- E.g. for visualisation in a low dimensional space.

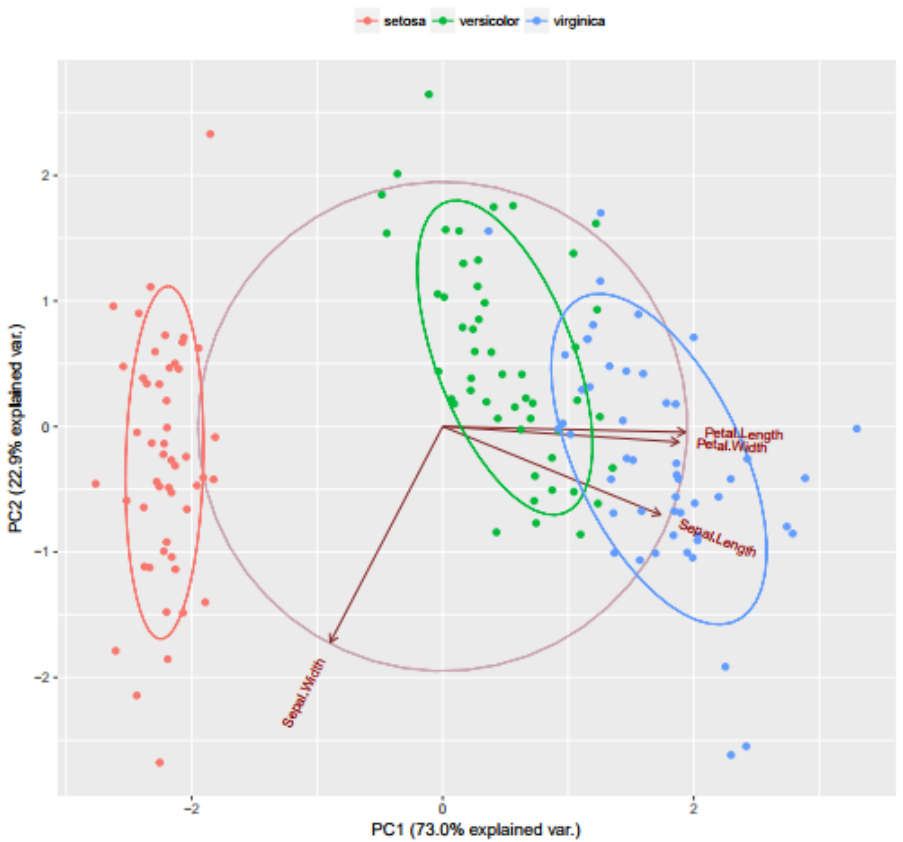


Figure: Principal Component Analysis (PCA)

UNSUPERVISED LEARNING - EXAMPLES

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- E.g. for image compression.

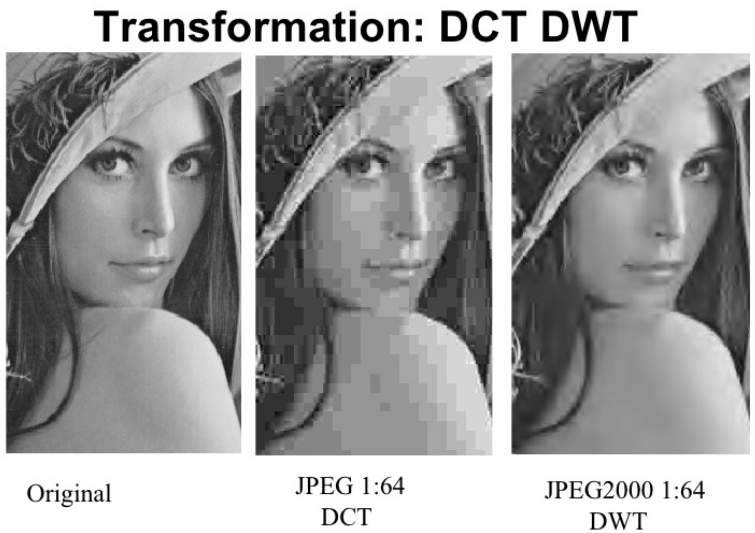

Figure: from `https://de.slideshare.net/hcycon/bildkompression`

UNSUPERVISED LEARNING - EXAMPLES

3. Feature extraction/representation learning.

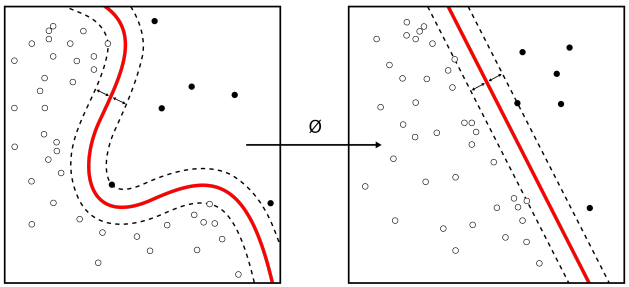

Figure: Source: Wikipedia

- E.g. for **semi-supervised learning**: features learned from an unlabeled dataset are employed to improve performance in a supervised setting.

UNSUPERVISED LEARNING - EXAMPLES

4. Density fitting/learning a generative model.

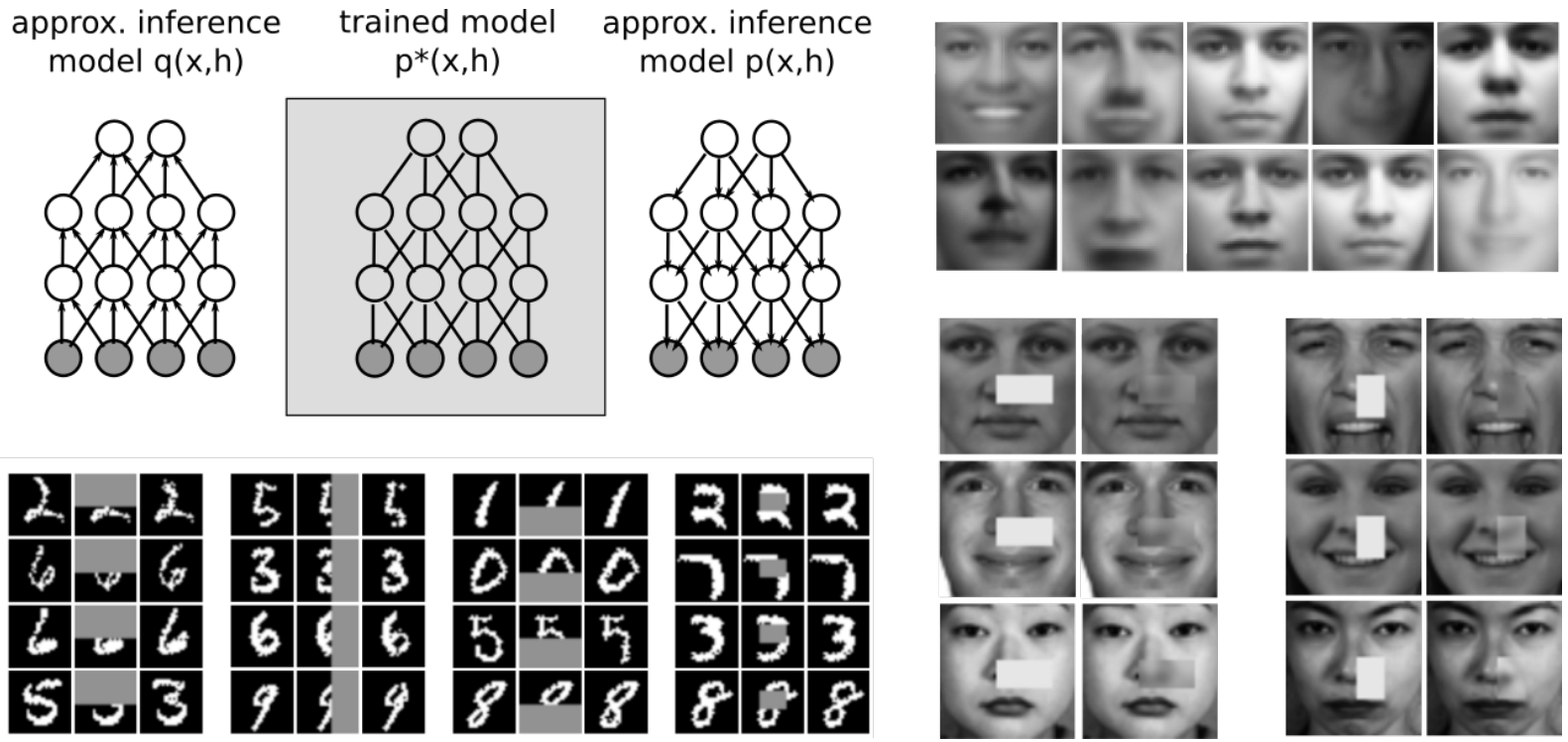

Figure: A generative model can reconstruct the missing portions of the images. (Bornschein, Shabanian, Fischer & Bengio, ICML, 2016)

UNSUPERVISED DEEP LEARNING

Given i.i.d. (unlabeled) data $\mathbf{x}_1, \mathbf{x}_2, \ldots, \mathbf{x}_n \sim p_{\text{data}}$, in unsupervised deep learning, one usually trains :

- an autoencoder (a special kind of neural network) for **representation learning** (feature extraction, dimensionality reduction, manifold learning, ...), or,

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- an autoencoder (a special kind of neural network) for **representation learning** (feature extraction, dimensionality reduction, manifold learning, ...), or,
- a **generative model**, i.e. a probabilistic model of the data generating distribution p_{data} (data generation, outlier detection, missing feature extraction, reconstruction, denoising or planning in reinforcement learning, ...).