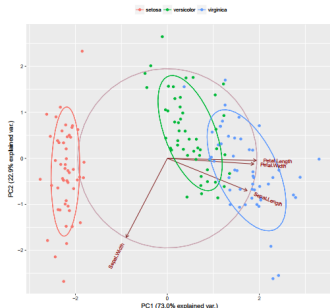


# Deep Learning

## Unsupervised Learning

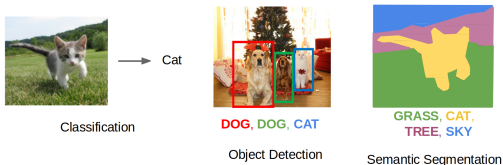


### Learning goals

- 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  $(\mathbf{x}^{(1)}, \mathbf{y}^{(1)}), \dots, (\mathbf{x}^{(n)}, \mathbf{y}^{(n)})$ .
- 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  $\mathbf{x}$  to  $\mathbf{y}$ .
- Examples are: classification, regression, object detection, semantic segmentation, image captioning, etc.

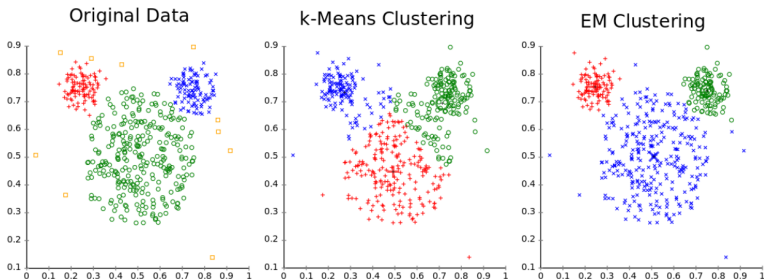


# UNSUPERVISED LEARNING

- In **unsupervised learning** scenarios training data consists of unlabeled input points  $\mathbf{x}^{(1)}, \dots, \mathbf{x}^{(n)}$ .
- 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.

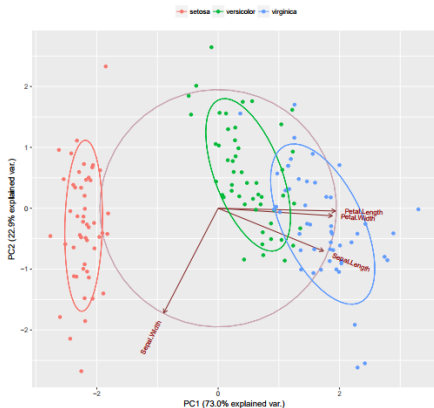


**Figure:** Cluster analysis results for different algorithms. Different clusters are indicated by different colors. (Source : Wikipedia)

# UNSUPERVISED LEARNING - EXAMPLES

## 2. Dimensionality reduction/manifold learning.

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

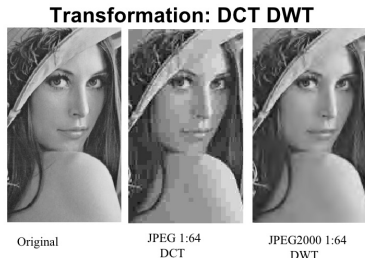


**Figure:** Principal Component Analysis (PCA)

# UNSUPERVISED LEARNING - EXAMPLES

## 2. Dimensionality reduction/manifold learning.

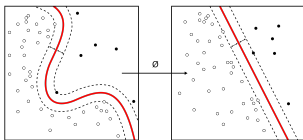
- E.g. for image compression.



**Figure:** from <https://de.slideshare.net/hcycon/bildkompression>

# UNSUPERVISED LEARNING - EXAMPLES

## 3. Feature extraction/representation learning.

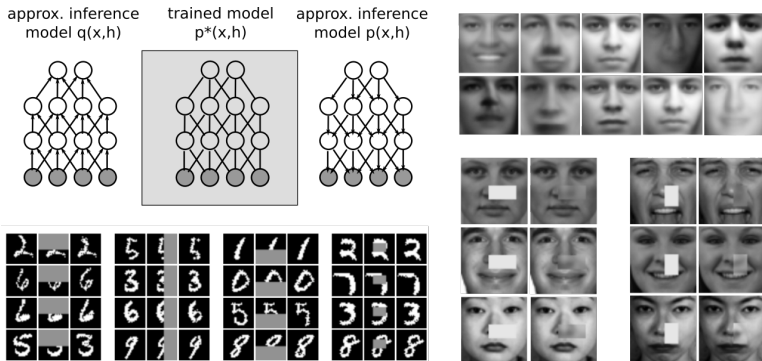


**Figure:** Source: Wikipedia

- 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  $\mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_n \sim p_{\text{data}}$ , 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,

# UNSUPERVISED DEEP LEARNING

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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  $p_{\text{data}}$  (data generation, outlier detection, missing feature extraction, reconstruction, denoising or planning in reinforcement learning, ...).