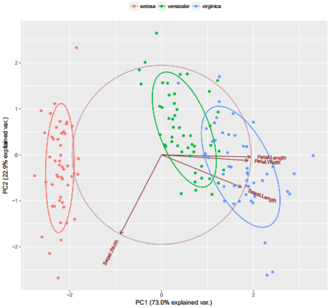
Deep Learning

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.

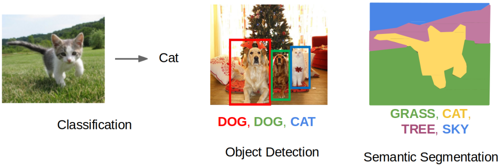


Figure: Examples of unsupervised learning (Li, 2023).

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.

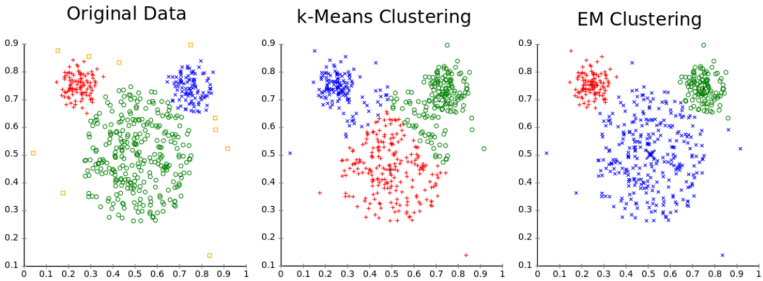


Figure: Cluster analysis results for different algorithms. Different clusters are indicated by different colors (Bullibabu et al., 2016).

UNSUPERVISED LEARNING - EXAMPLES

2. Dimensionality reduction/manifold learning.

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

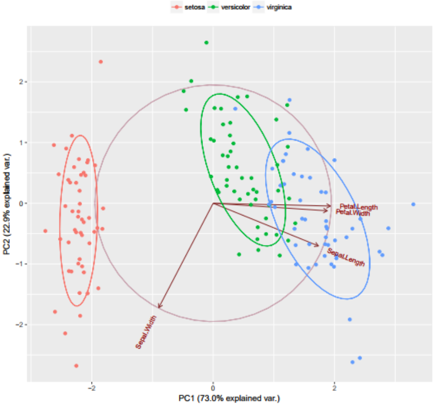


Figure: Principal Component Analysis (PCA) (Finnstats, 2021).

UNSUPERVISED LEARNING - EXAMPLES

2. **Dimensionality reduction/manifold learning.**
   - E.g. for image compression.

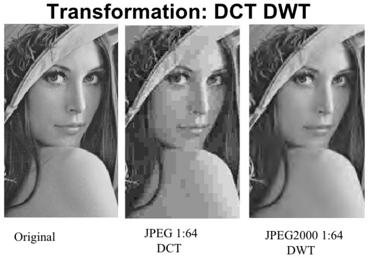


Figure: Example of image compression (Cycon, 2009).

UNSUPERVISED LEARNING - EXAMPLES

3. Feature extraction/representation learning.

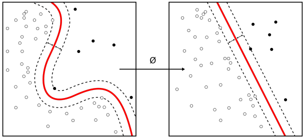


Figure: Use of kernel machines to obtain a linearly separable function (Matzer, 2019).

- 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.

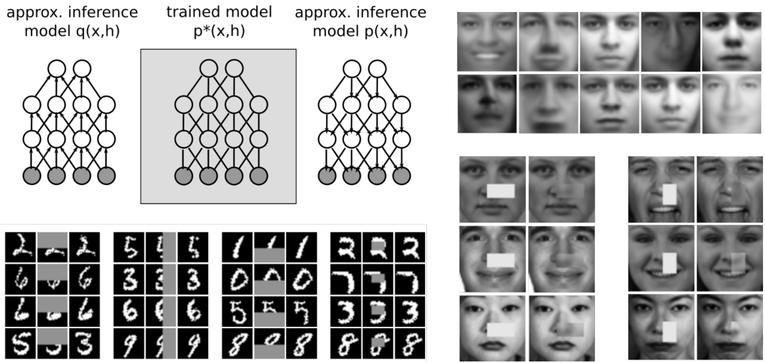


Figure: A generative model can reconstruct the missing portions of the images (Bornschein et al., 2016).

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, ...).

REFERENCES

- Bornschein, J., Shabanian, S., Fischer, A., & Bengio, Y. (2016). *Bidirectional Helmholtz Machines*.
- Cycon. (2009, May 4). *Bildkompression*. PPT. https://de.slideshare.net/hcycon/bildkompression
- Matzer, M. (2019, April 29). *Optimale clusteranalyse und segmentierung mit dem k-means-algorithmus*. BigData. https://www.bigdata-insider.de/optimale-clusteranalyse-und-segmentierung-mit-dem-k-means-algorithm
- Finnstats. (2021, May 7). *Principal Component Analysis (PCA) in R: R-bloggers. R-bloggers*. https://www.r-bloggers.com/2021/05/principal-component-analysis-pca-in-r/
- Bullibabu, Rasamsetty & Snehal, G. & Kiran, P.. (2016). *Detection of Crimes using Unsupervised Learning Techniques*. Indian Journal of Science and Technology.
- Li, F.-F. (2023). *Lecture 11: Detection and segmentation - Stanford University*. CS231n. http://cs231n.stanford.edu/slides/2017/cs231n_2017_lecture11.pdf