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Machine Learning to Analyze SCED Data

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Objectives

1. Describe the basic methodology underpinning machine learning research
2. Train simple machine learning models using Python
3. Apply machine learning to single-case datate

What to Expect

- Brief lecture
- Modeling
- Practice, more practice and even more practice
- Remote prompting
- Feedback

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Artificial Intelligence

"… the study of how to make computers do things at which, at the moment, people are better." (Rich, 1991)

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Machine Learning

- Subfield of artificial intelligence
- Detect patterns
- Predictions and support decision-making
- Three main types:
  - Supervised learning
  - Unsupervised learning
  - Reinforcement learning

Dataset

- Samples: Exemplars
- Features: Discriminative stimuli/Salient characteristics
- Class label: Correct response

Dataset – AB Graphs

- 8,000 samples
- Eight features:
  - Mean and standard deviation
  - Intercept and slope
- One class label: Change vs no change

Transforming Data

- Transform continuous feature values to z scores
- (value – mean) / SD

Step 1 – Extract graph data

A	A	A	B	B	B	B	B
7.0	3.2	10.1	1.1	0.2	2.1	2.1	2.1

Expected direction of change: -1 (decrease)
Label: 1 (clear change)

Step 2 – Multiply by -1 (as expected direction of change is to decrease)

A	A	A	B	B	B	B	B
-7.0	-3.2	-10.1	-1.1	-0.2	-2.1	-2.1	-2.1

If the expected direction of change is to increase, skip this step (or multiply by 1).

Step 3 – Normalize the data by subtracting the mean (-3.49) and then dividing the difference by the standard deviation (3.13)

A	A	A	B	B	B	B	B
-1.12	0.09	-2.11	0.76	1.05	0.44	0.44	0.44

Now, the graph data has a mean of 0 and a standard deviation of 1.

Step 4 – Extract eight features from the normalized data

Mean A	Mean B	*SD* - A	*SD* - B	Intercept A	Slope A	Intercept B	Slope B
-1.05	0.63	.90	0.24	-0.55	-0.50	1.25	-0.12

Practice

Manipulating data

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Algorithms

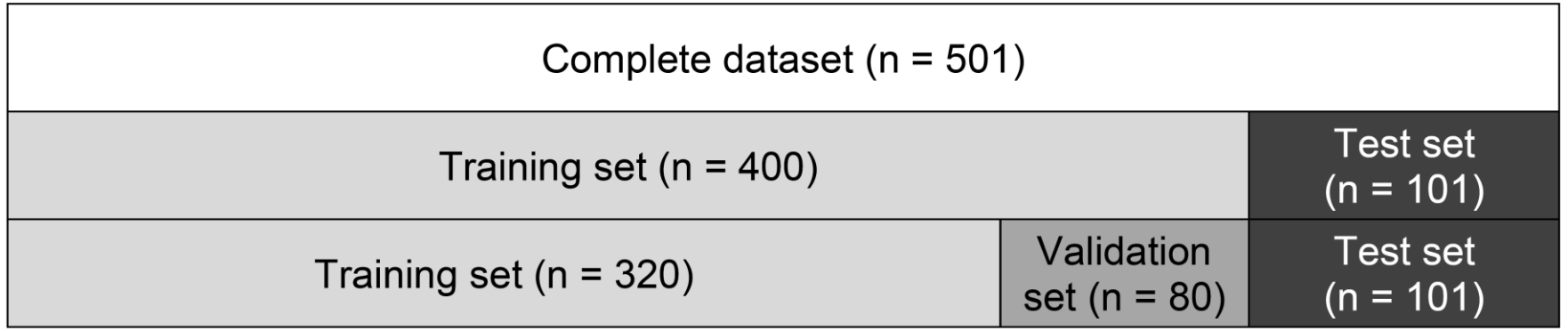
- Algorithm: Teaching method
- Model: Learner
- Predictions: Learner's response
- Hyperparameters: Teaching parameters

Testing Models

- Training set
- Testing set

Holdout Cross-Validation

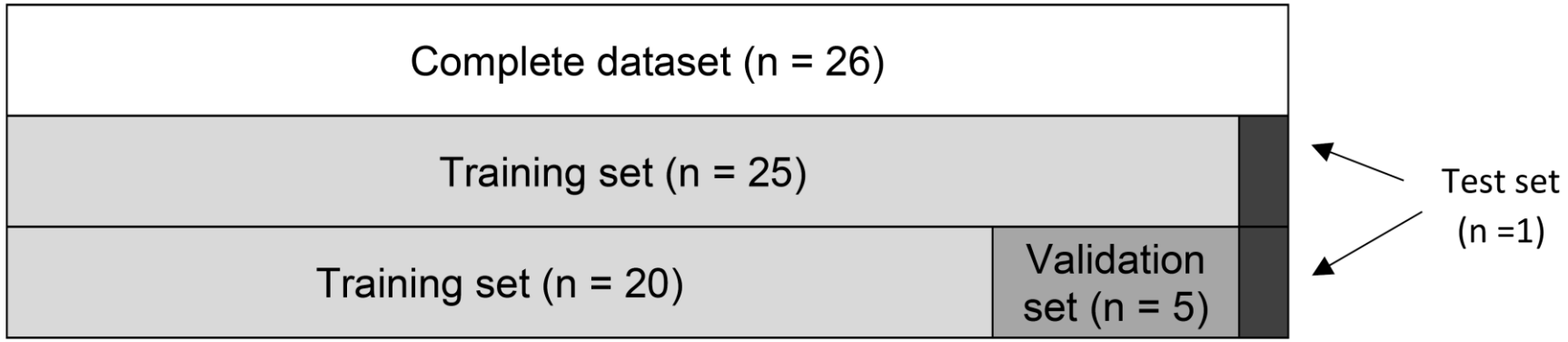
Holdout Cross-Validation



Note. This process runs only once with each set being sampled randomly without replacement.

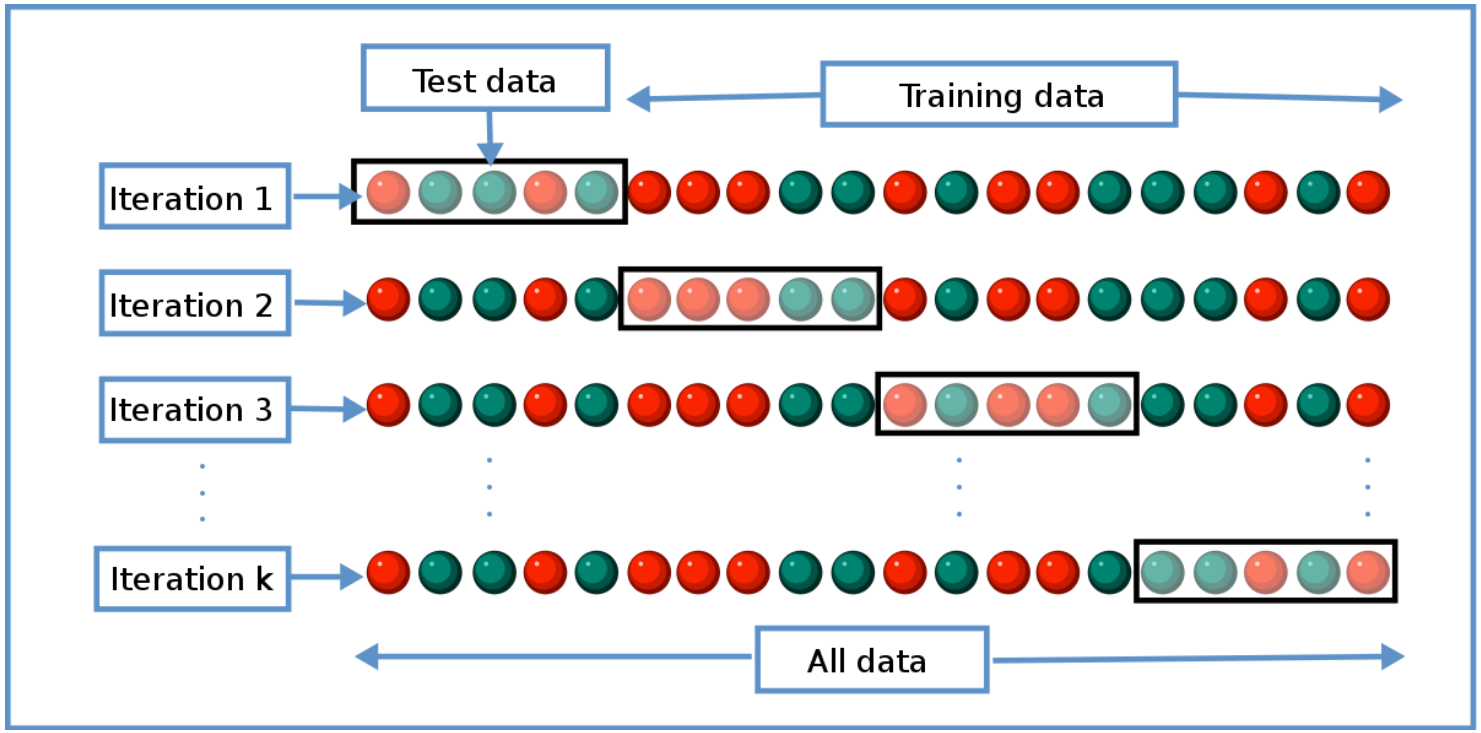
Leave-One Out Cross-Validation

Leave-One Out Cross-Validation



Note. This process runs 26 times so that each sample is in the test set once.

K-Fold Cross-Validation



Source: https://en.wikipedia.org/wiki/Cross-validation_(statistics)

Practice

Splitting the data

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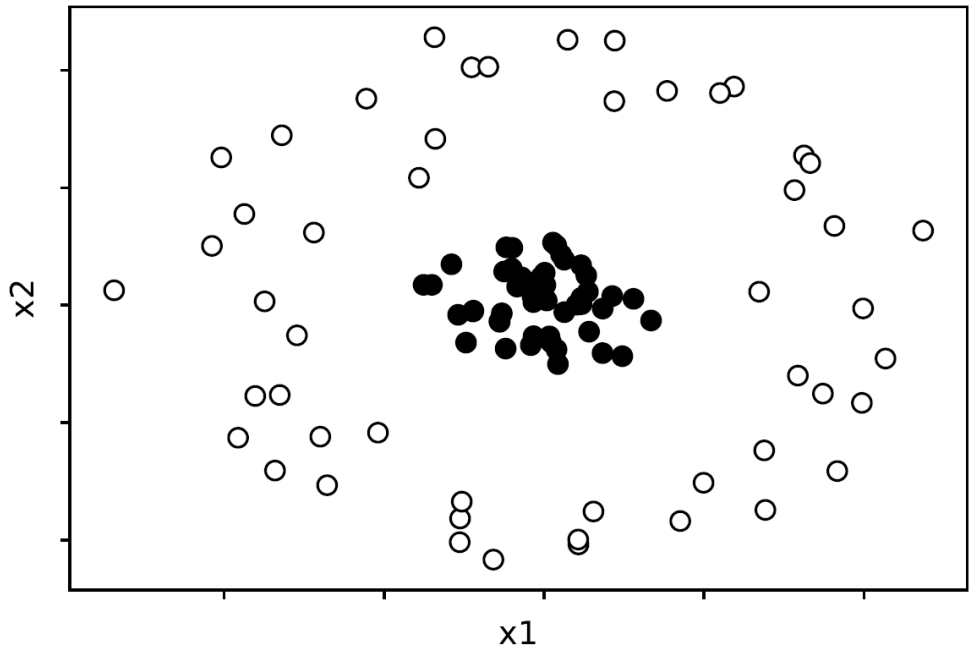
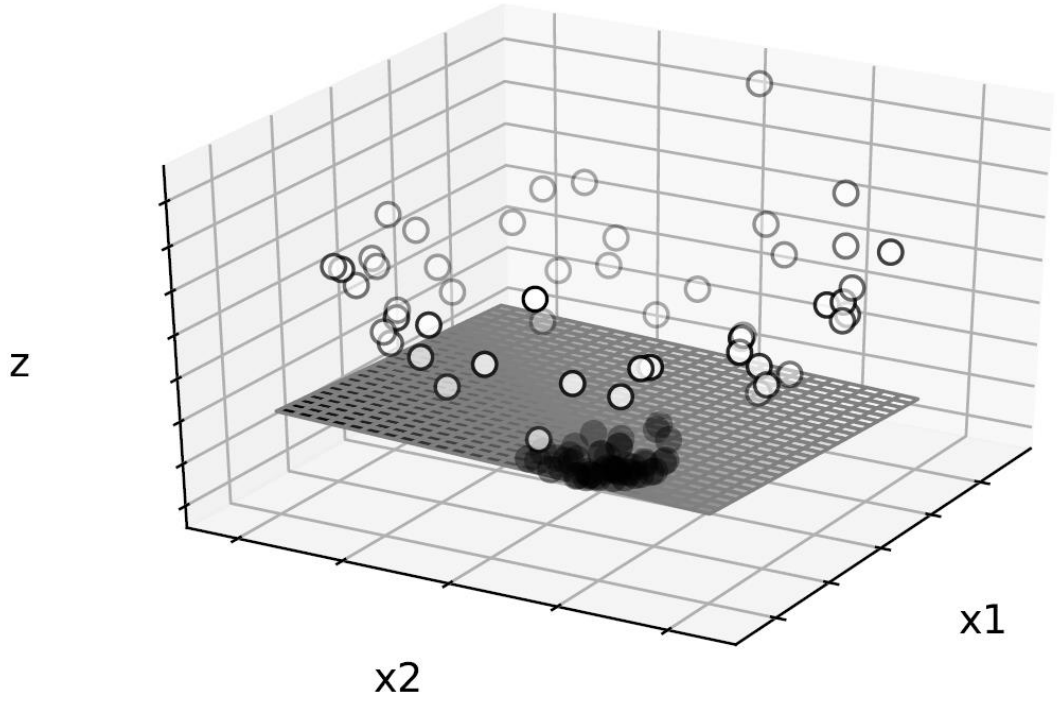
Support Vector Classifier





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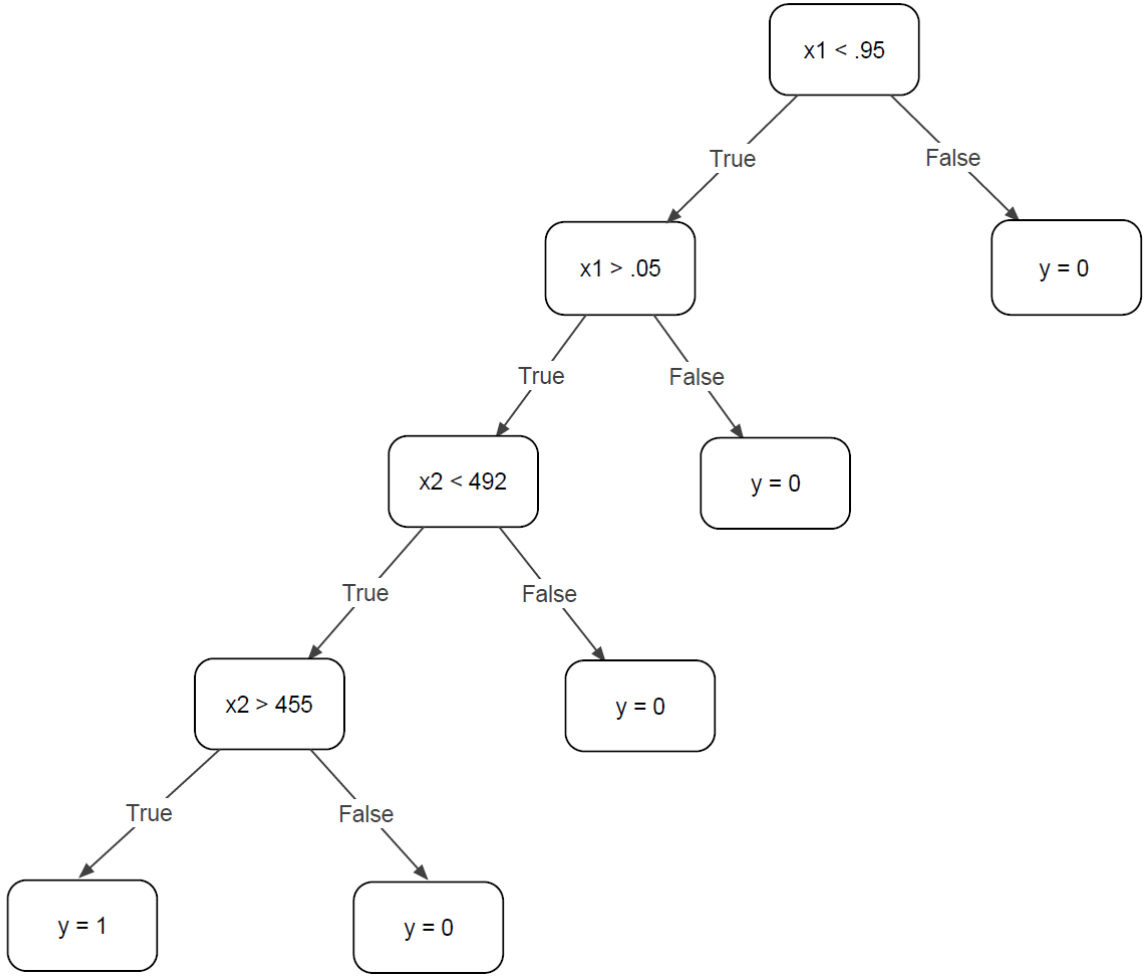
Random Forest



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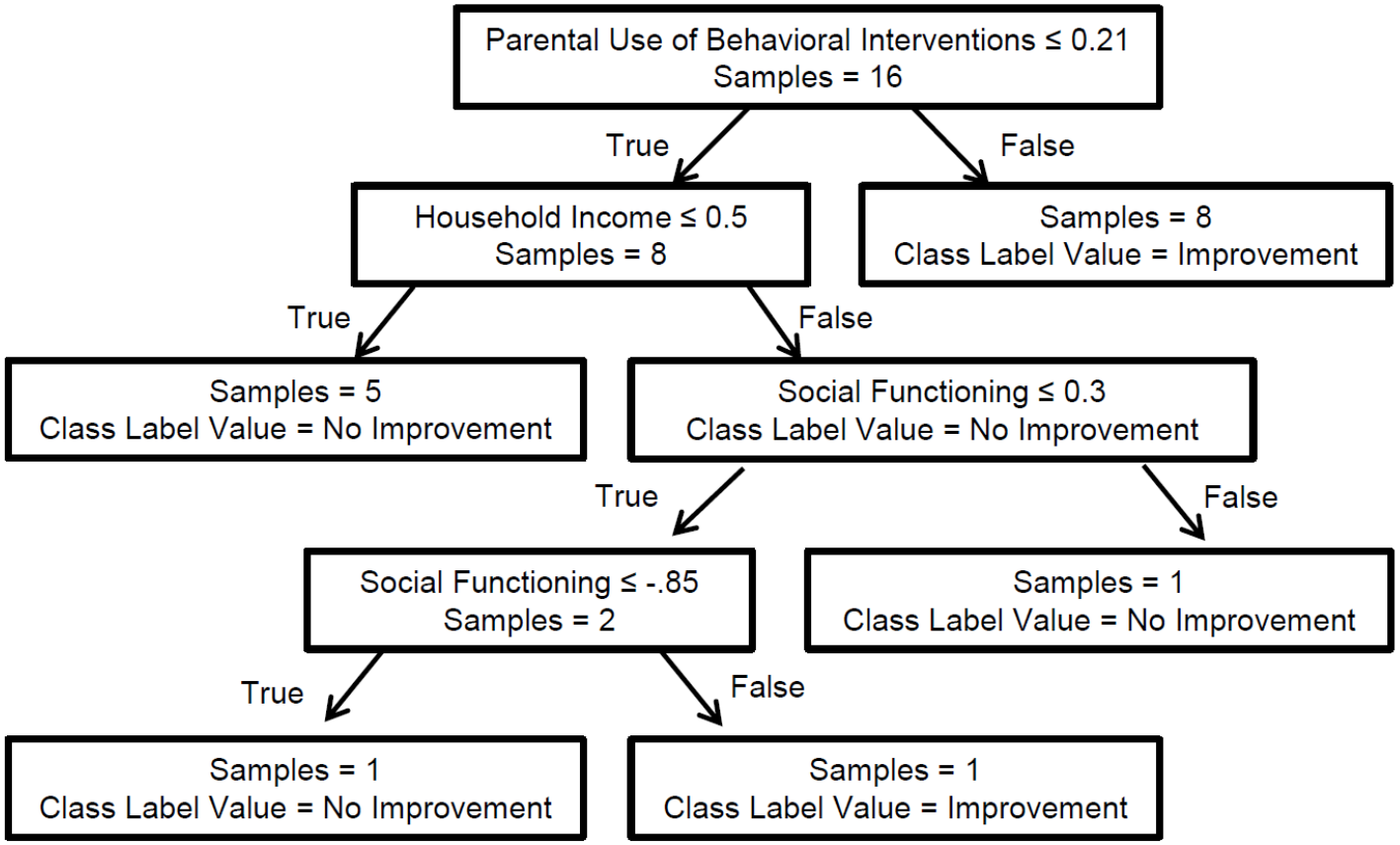
Random Forest



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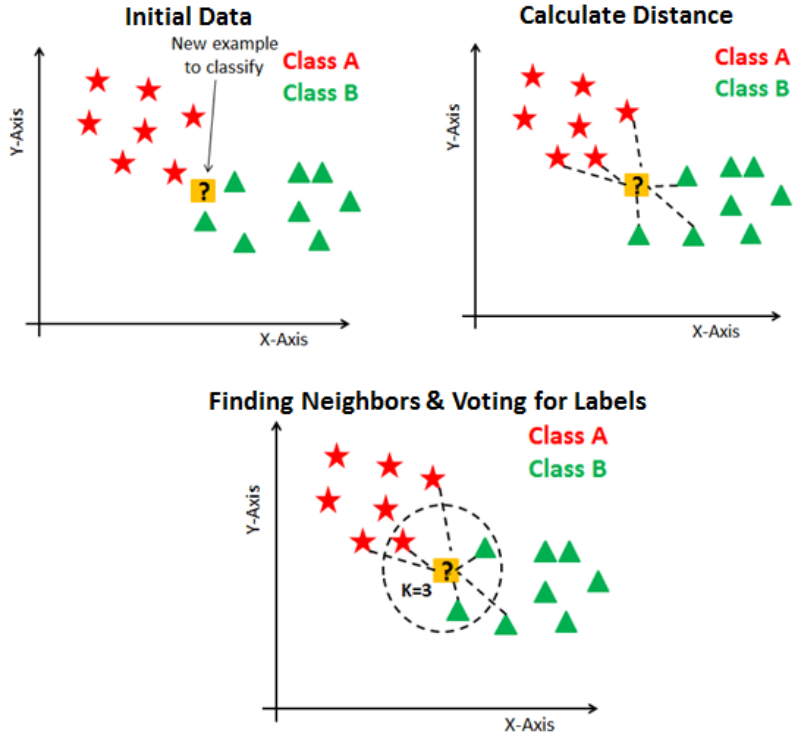
K-NEAREST NEIGHBORS



Source: https://www.datacamp.com/community/tutorials/k-nearest-neighbor-classification-scikit-learn

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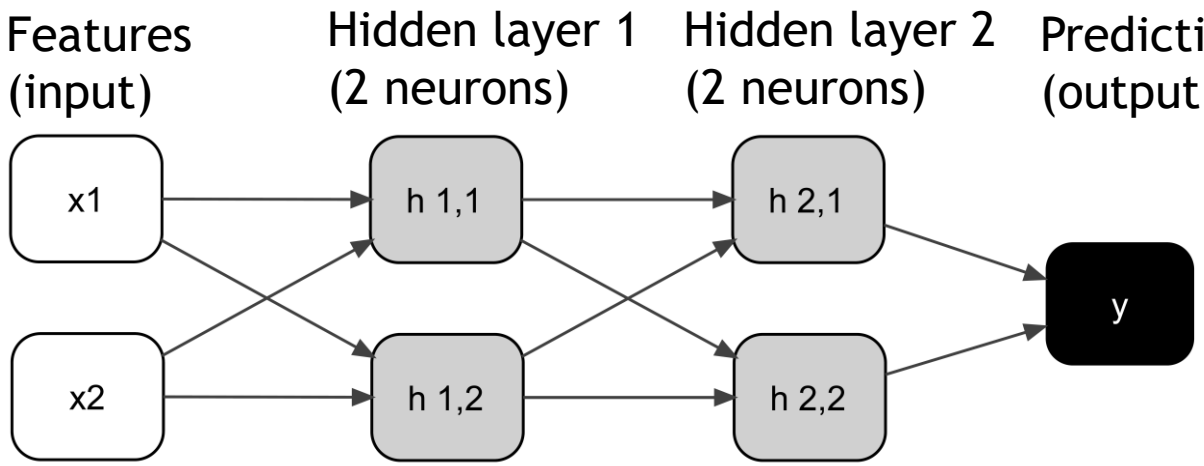
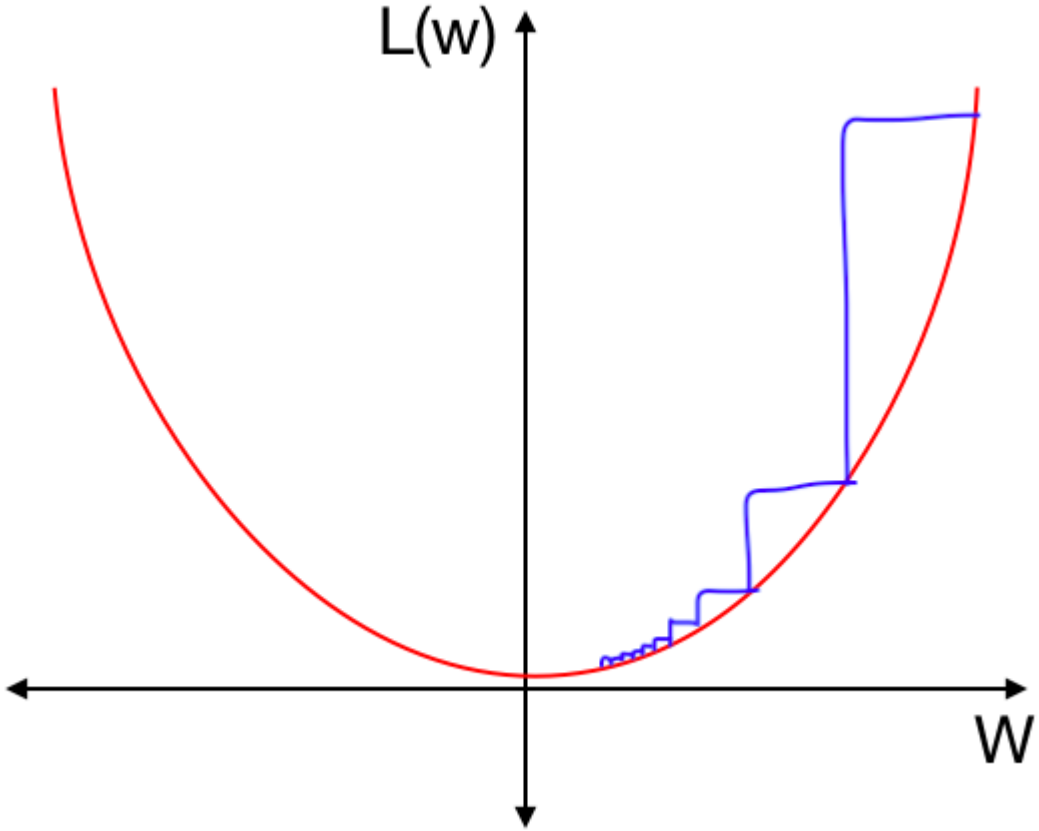
Dense Neural Network



Yes or no?

Backpropagation of the Errors



Source: https://towardsdatascience.com/https-medium-com-reina-wang-tw-stochastic-gradient-descent-with-restarts-5f511975163

Practice

Training a model

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Measures

- Outcomes
  - Accuracy
  - Type I error rate
  - Power
- Comparisons
  - Human observers
  - Best practice

Practice

Computing outcome measures

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Hyperparameter Tuning

- Number of trees
- Function parameters
- Learning rate
- Epochs
- Number of neighbors
- Loss function

Hyperparameter Tuning

- Epochs
- Number of neurons
- Number of layers
- Activation function
- Loss function
- Dropout

Practice

Hyperparameter tuning

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Selecting an Algorithm

- Number of samples
- Type of data
- Need to explain
- Stability
- Tuning requirements

Benefits

- Reliable decision-making
- Non linear relationships
- Unaffected by common MOs
- Improvements in accuracy

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Drawbacks

- Black box problem
- “Stupid” decisions
- Number of samples required
- Overtraining and overfitting

Other Considerations

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Feature Selection

- Filter-based methods
- Wrapper-based methods
- Embedded methods

Review Objectives

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Questions/Comments?

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