# CDS503: Machine Learning

## *Topic 3*

## Parametric and Non-Parametric Algorithms

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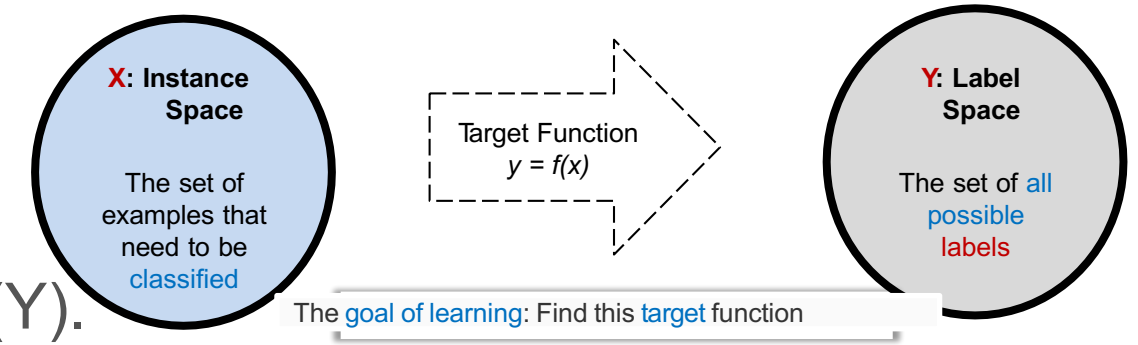
- Parametric versus Non-Parametric
- Benefit and Limitation

https://machinelearningmastery.com/parametric-and-nonparametric-machine-learning-algorithms/

# Learning a Function

- Non-parametric algorithm does not mean that they have NO parameters!
- Non-parametric models (can) become more and more complex with an increasing amount of data.
- Machine learning can be summarized as learning a function (f) that maps input variables (X) to output variables (Y).




$$Y = f(x)$$

- An algorithm learns this target mapping function from training data.
- Different algorithms make different assumptions or biases about the form of the function and how it can be learned.

# Parametric
# Machine Learning Algorithms

- Algorithms that simplify the function to a known form

  (make strong assumptions about the data*)

  - *A learning model that summarizes data with a set of parameters of fixed size (independent of the number of training examples).*
  - ***Fixed number of parameters***
  - *No matter how much data you throw at a **parametric** model, it **won't change its mind** about how many parameters it needs.*
- Has a fixed number of parameters
- The algorithms involve two steps:
  1) Select a form for the function
  2) Learn the coefficients for the function from the training data

- the algorithm may work well if the assumptions turn out to be correct, but it may perform badly if the assumptions are wrong.

# Benefit and Limitation

## Benefit

- **Simpler**: Easier to understand and interpret results
- **Speed**: Very fast to learn from data
- **Less Data**: Do not require as much training data and can work well even if the fit to the data is not perfect

## Limitation

- **Constrained**: By choosing a functional form these methods are highly constrained to the specified form
- **Limited Complexity**: More suited to simpler problems
- **Poor Fit**: In practice the methods are unlikely to match the underlying mapping function

# Non-Parametric Machine Learning Algorithms

- Algorithms that **do not** make strong assumptions about the data (free to learn any functional form from training data)
- Has a flexible number of parameters - number of parameters often grows as it learns from more data.
- Good when have a lot of data and no prior knowledge, and when don't want to worry too much about choosing just the right features
- Nonparametric methods seek to best fit the training data in constructing the mapping function, whilst maintaining some ability to generalize to unseen data. As such, they are able to fit a large number of functional forms.

# Benefit and Limitation

## Benefits

- **Flexibility**: Capable of fitting a large number of functional forms
- **Power**: No assumptions (or weak assumptions) about the underlying function
- **Performance**: Can result in higher performance models for prediction

## Limitations

- **More data**: Require a lot more training data to estimate the mapping function
- **Slower**: A lot slower to train (have far more parameters to train)
- **Overfitting**: More of a risk to overfit training data and harder to explain why specific predictions are made

# Parametric versus Non-Parametric Algorithms

Make strong assumptions about the data

**Parametric**
**ML Algorithms**

- Logistic Regression
- Linear Discriminant Analysis
- Perceptron
- Naive Bayes
- Simple Neural Networks

Do not make strong assumptions about the data

**Non-Parametric**
**ML Algorithms**

- k-Nearest Neighbors
- Decision Trees like CART and C4.5

What about:
ANN – Parametric/Non-parametric
SVM - Non-parametric

To summarize, the **trade-offs** between parametric and non-parametric algorithms are in **computational cost** and **accuracy**.

# Thank you