Advanced Machine Learning

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Introduction

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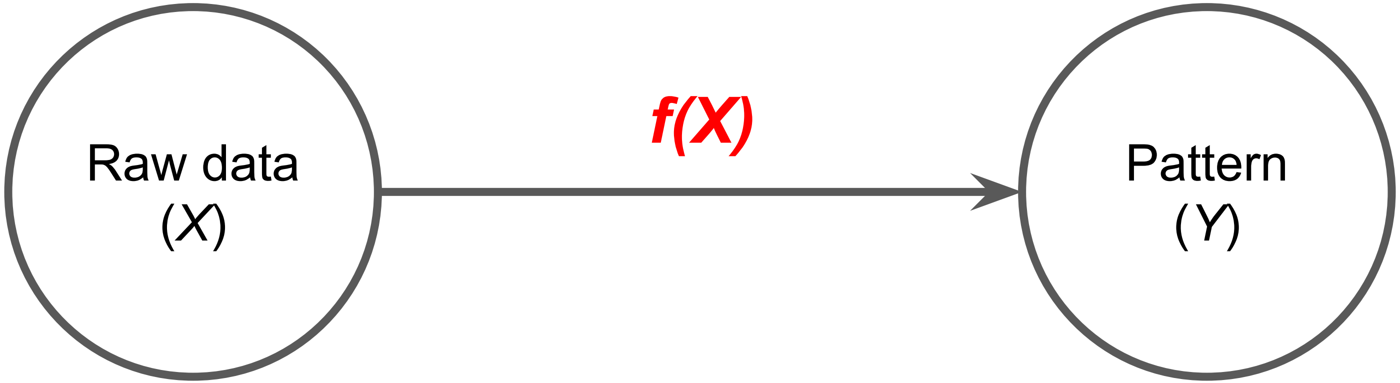
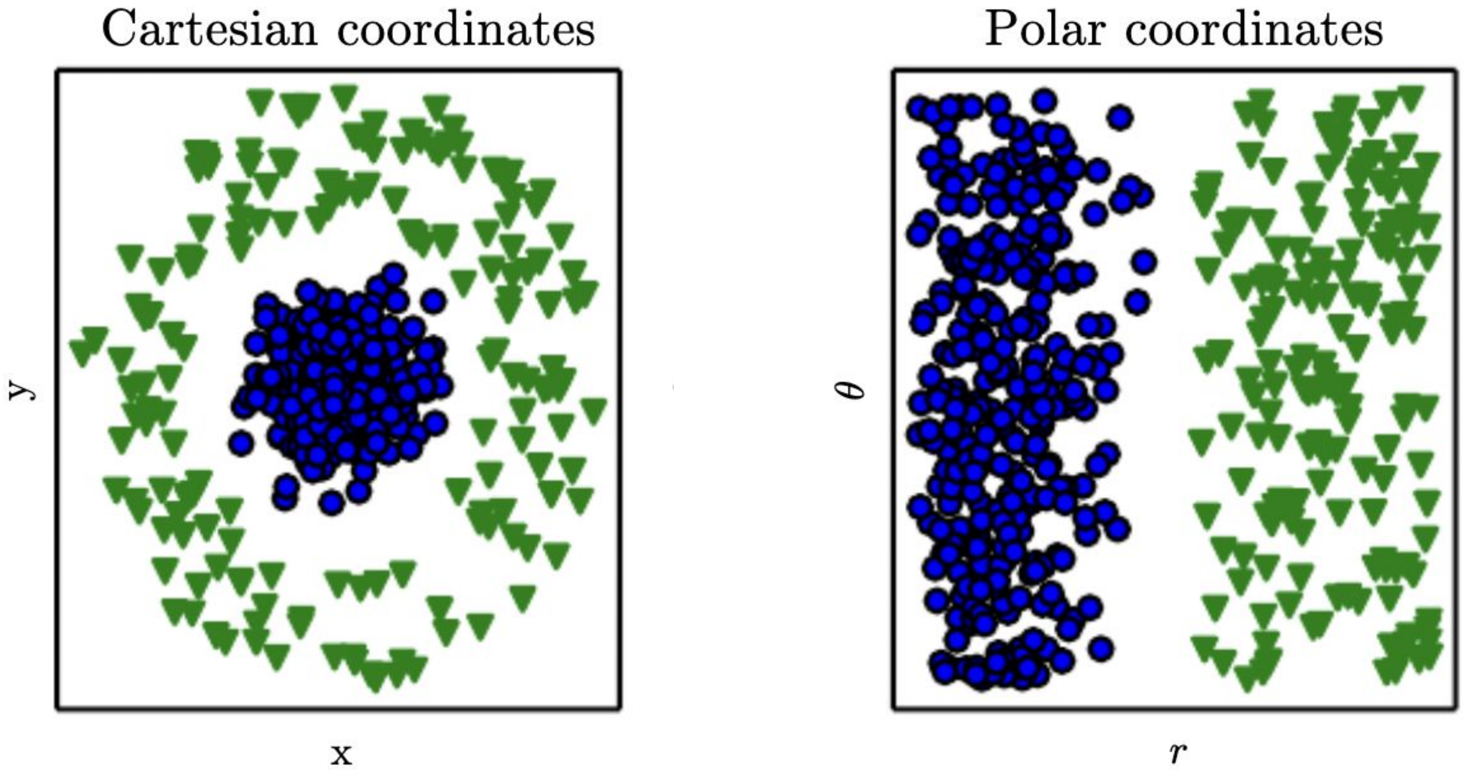
What is Machine Learning?

Ability of a machine to extract patterns from raw data

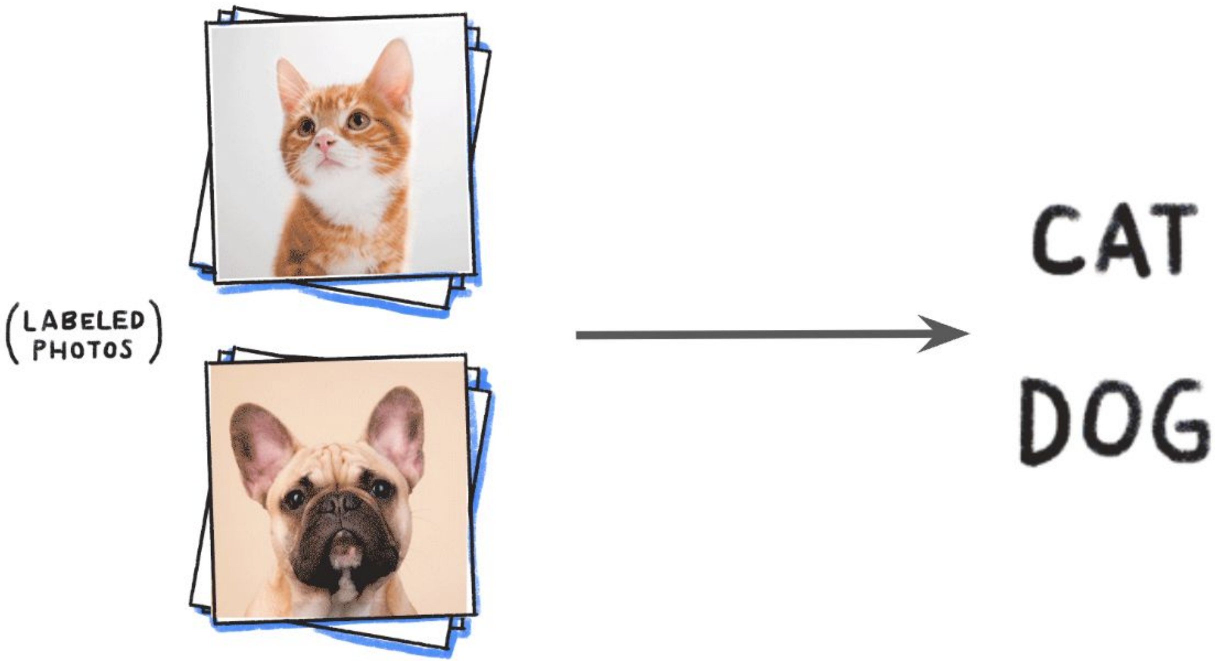


What is Machine Learning?



What is Deep Learning?

Sometimes, it can be very difficult to extract high-level, abstract features directly from raw data.



What is Deep Learning?

Quintessential example of deep learning model is **multilayer perceptron (MLP)**

Definition of MLP:

A **feedforward** artificial neural network, consisting of **fully connected** neurons with a **nonlinear** activation function, that is trained using **backpropagation**

Feedforward - The flow of information is unidirectional, i.e, in the forward direction from the input neurons, through the hidden neurons, and to the output neurons.

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Definition of MLP:

A **feedforward** artificial neural network, consisting of **fully connected** neurons with a **nonlinear** kind of activation function, that is trained using **backpropagation**

Fully connected - Each neuron of a layer is connected to each neuron of the next layer

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Nonlinear activation function - A nonlinear function applied to the output of each neuron before it is fed to the next layer. Eg, ReLU, sigmoid, etc.

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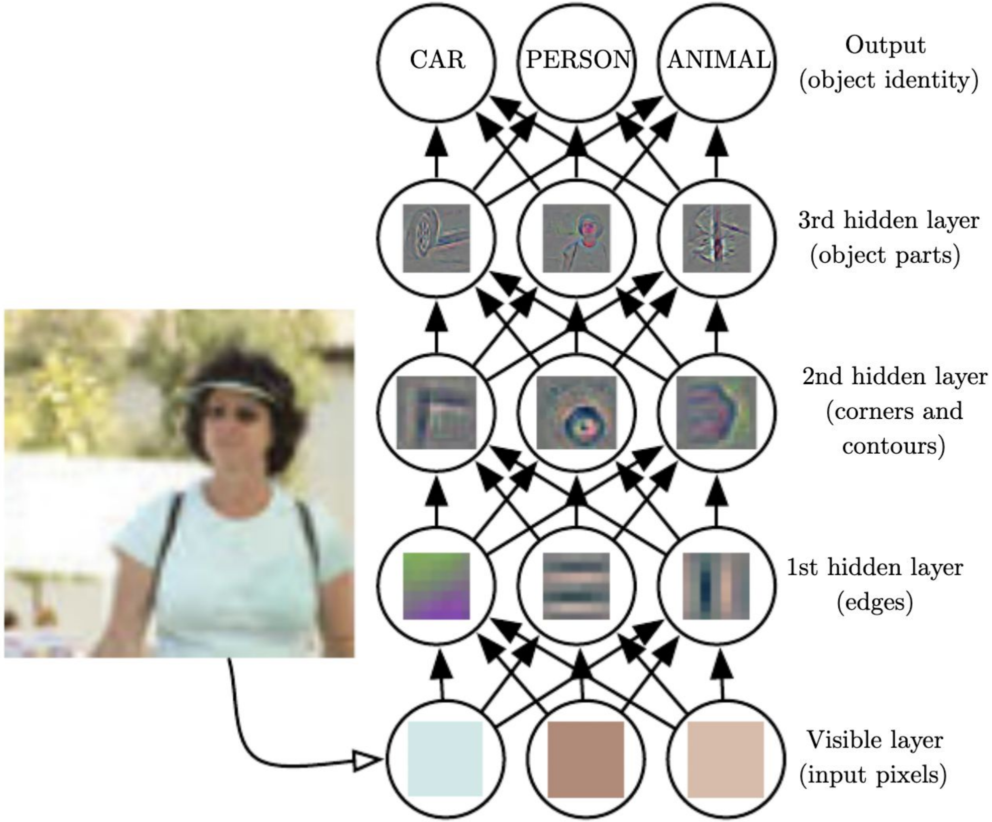
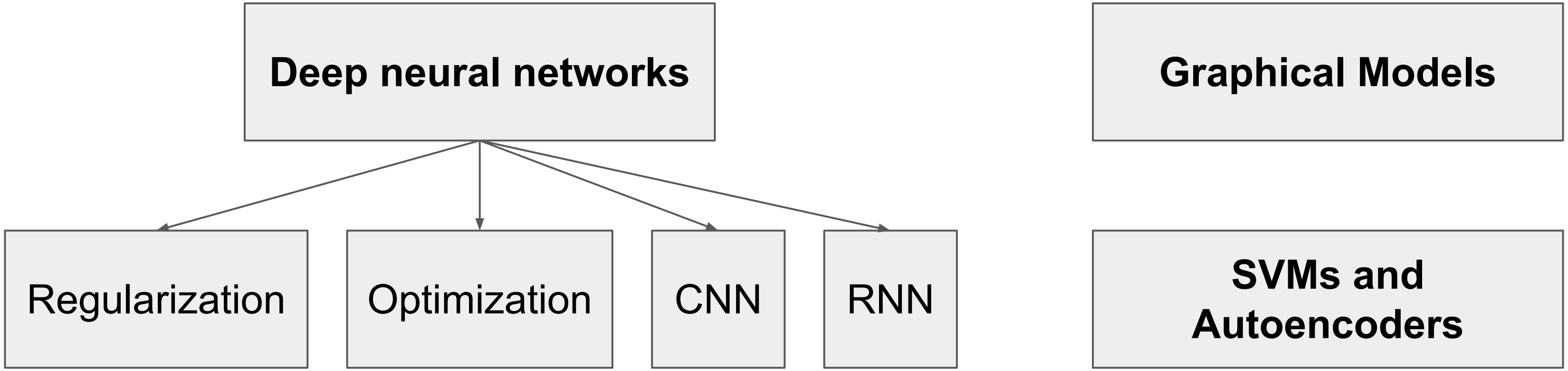
Backpropagation - Adjustment of the weights/parameters in such a way as to minimize the mean squared error (MSE) between the actual labels and predicted labels. Eg. gradient descent.

What is Deep Learning?



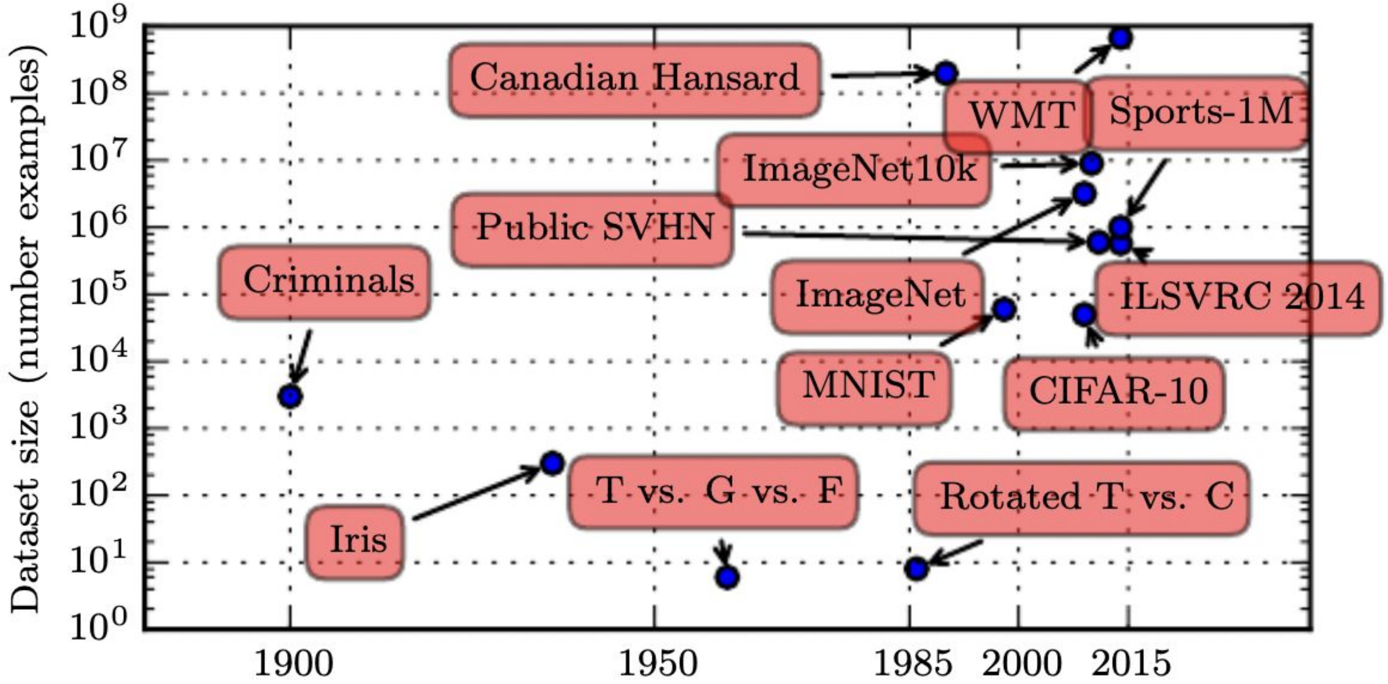
Course Objectives

Learn about deep neural networks, probabilistic graphical models, dimensionality reduction, etc., and their applications in solving real-world problems.



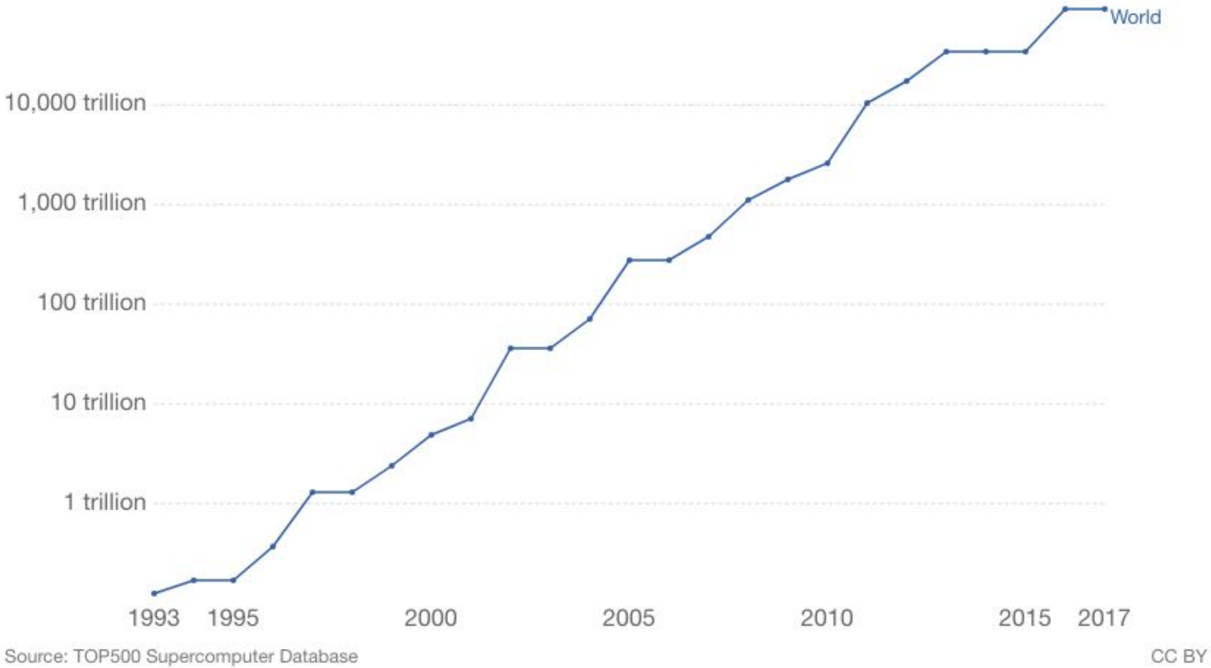
Why is Deep Learning important today?

1. Increasing Dataset Sizes



Why is Deep Learning important today?

2. Increasing Computational Speed

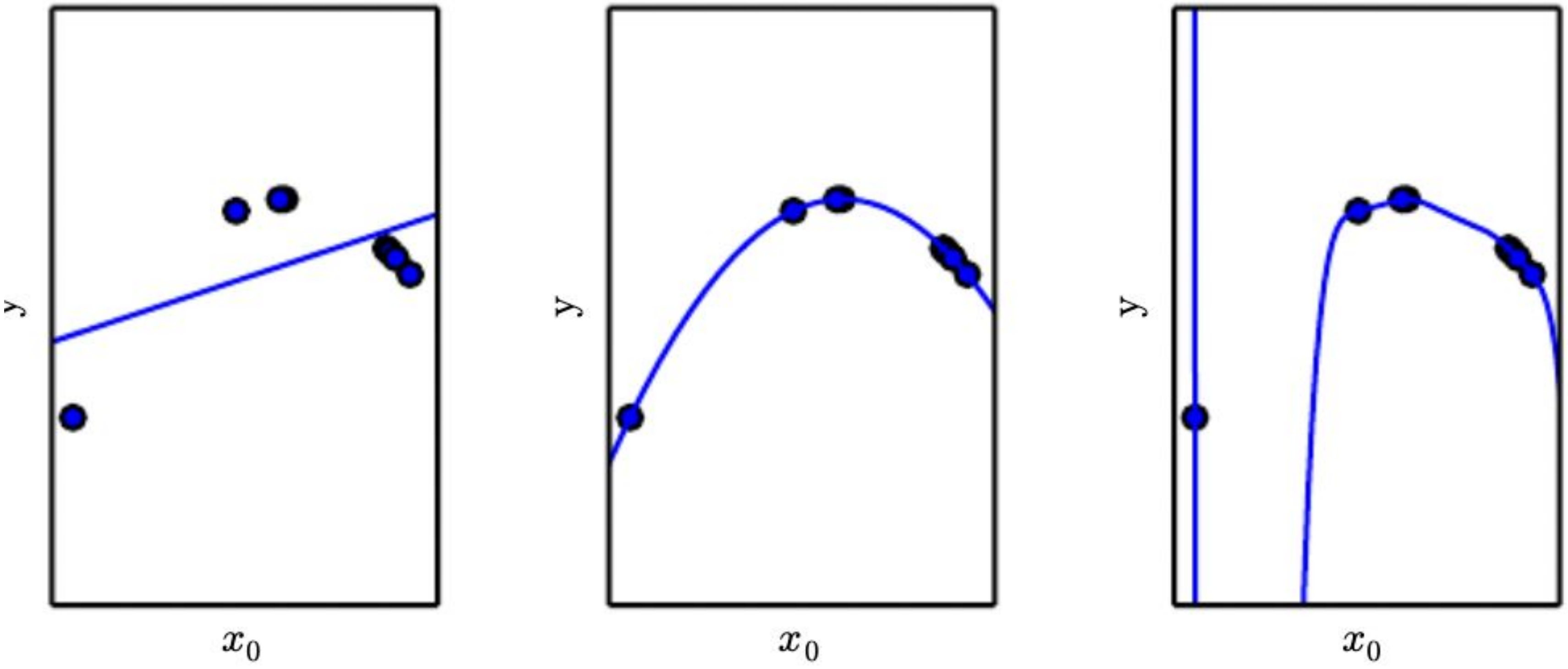


Review of basic concepts

Generalization - Ability of a machine learning model to perform well on new, previously unobserved inputs—not just those on which the model was trained.

1. Using a training set, we compute some error measure on it, called the **training error** and we aim to minimize it.
2. In addition, we also minimize the error on a new and unseen set of inputs, called the test set. This error is called the **testing error or generalization error.**

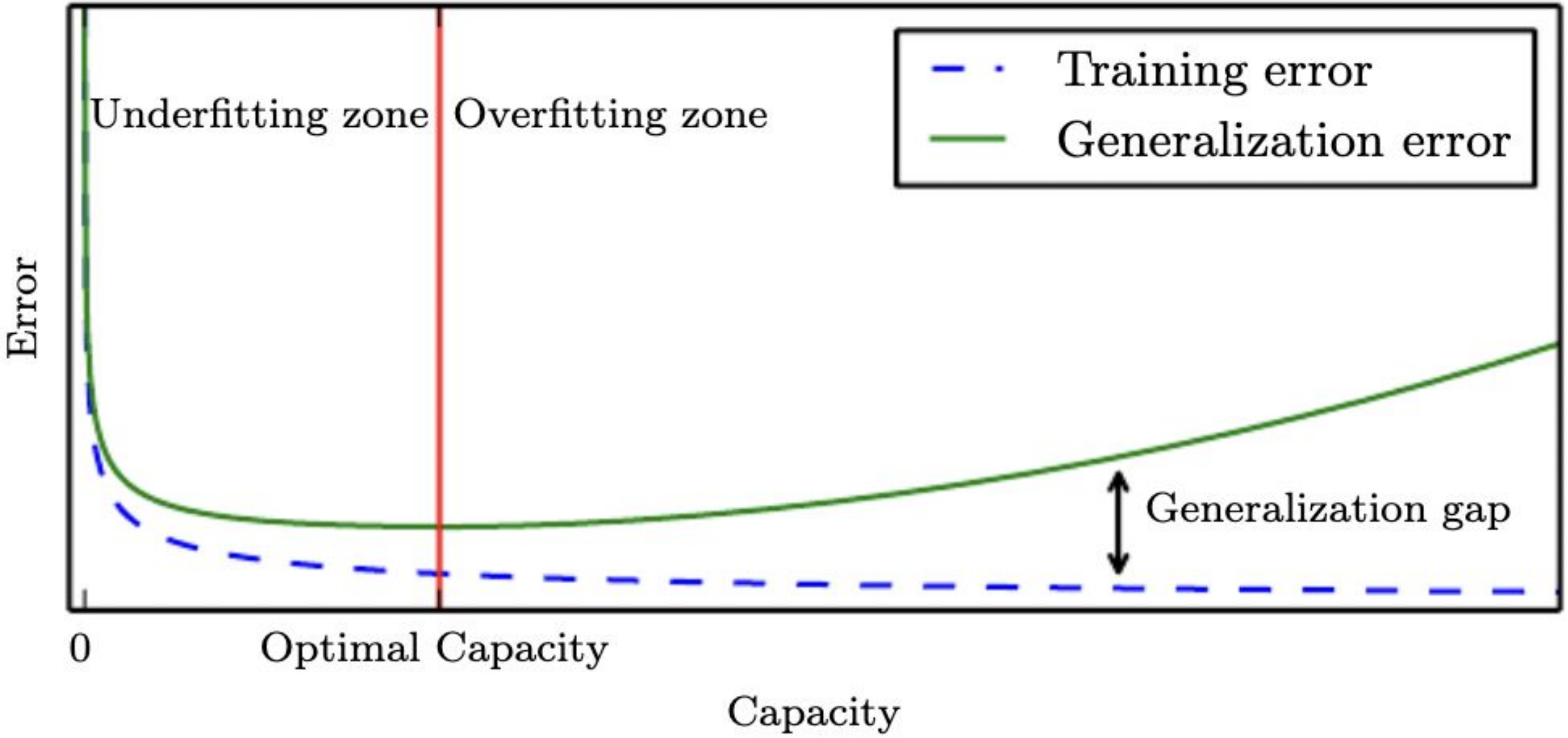
Underfitting and Overfitting



Underfitting

Overfitting

Underfitting and Overfitting



Regularization

Definition:

Regularization is any modification we make to a learning algorithm that is intended to reduce its generalization error but not its training error. This is achieved by lowering the **variance** of an estimator without increasing its **bias.**

Bias: How well the estimator represents the true/actual value?

$$\mathrm{bias}(\hat{\boldsymbol{\theta}}_m) = \mathbb{E}(\hat{\boldsymbol{\theta}}_m) - \boldsymbol{\theta}$$

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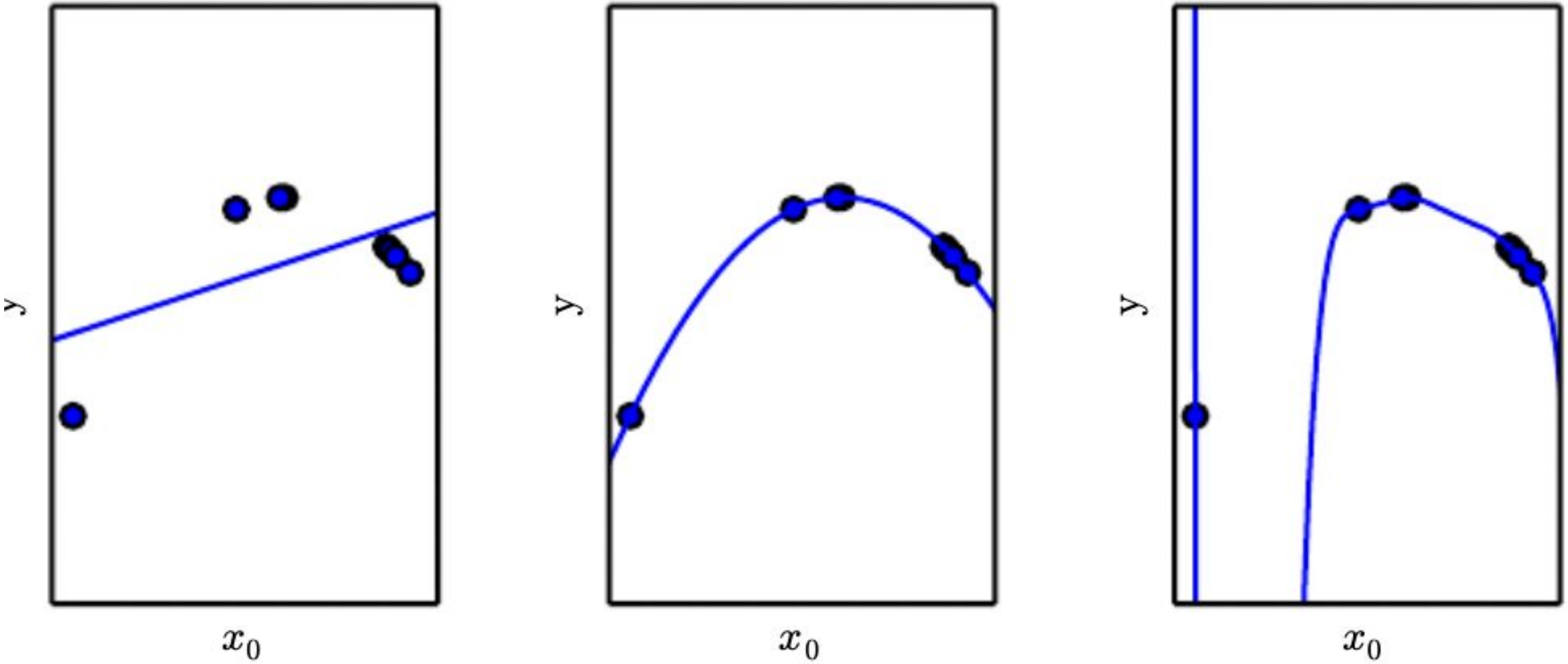
Variance: How does the estimator vary as a function of the data sample?

$$\mathrm{Var}(\hat{\theta})$$

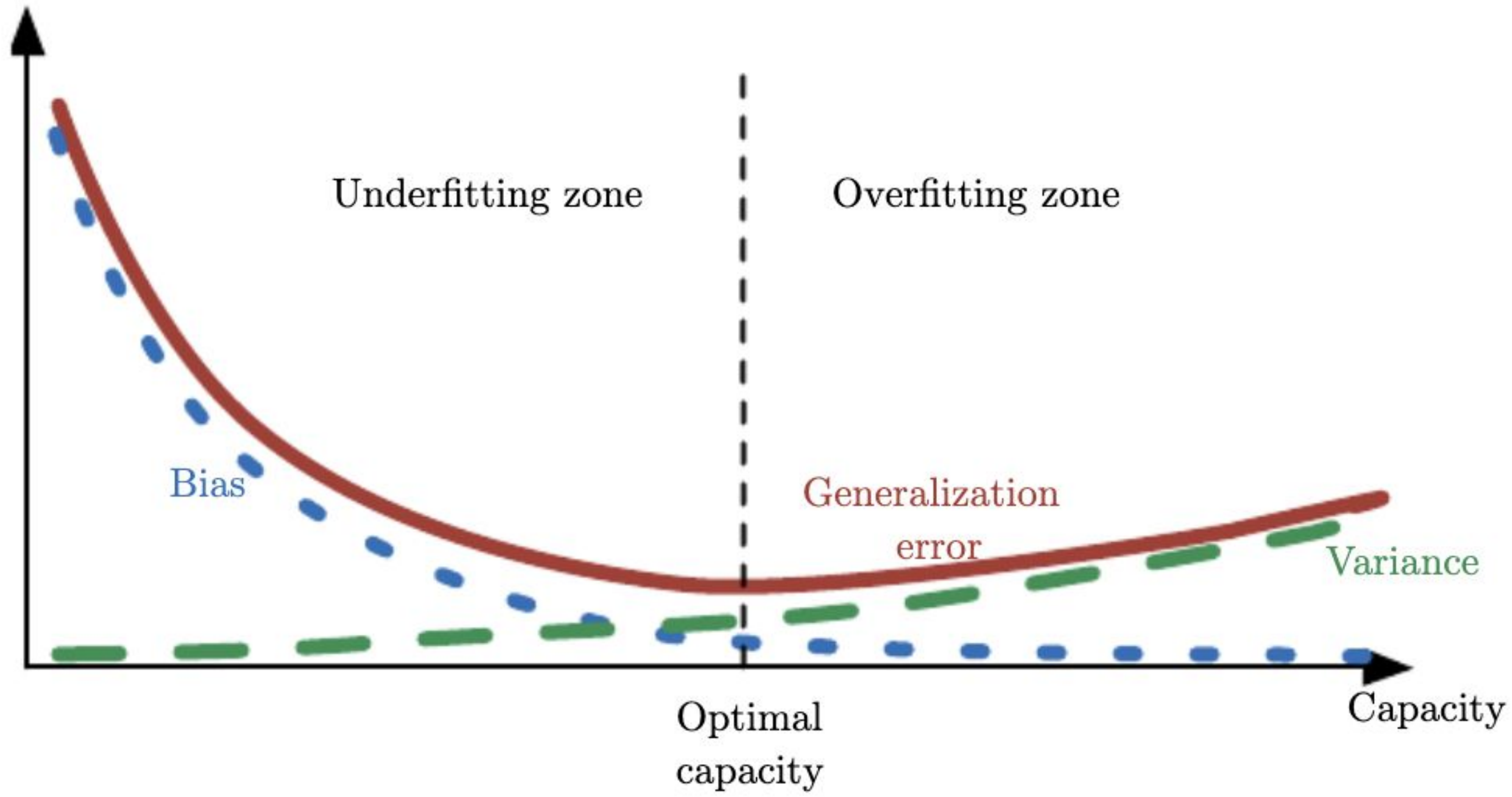
Regularization



High Bias

High Variance

Regularization



References

- Goodfellow, Ian, Yoshua Bengio, and Aaron Courville. Deep learning. MIT press, 2016.