Cagri Ozcinar, PhD

LTTI.00.032 - Machine Learning in Synthetic Biology

Content

- **DL**
- **Multilayer perception**
- **Convolutional neural networks (CNNs)**
- **Recurrent neural networks (RNNs)**
- **Generative adversarial networks (GANs)**

What should you expect?

- **Theory**
- **Tutorials**
- **Applications**

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Deep Learning

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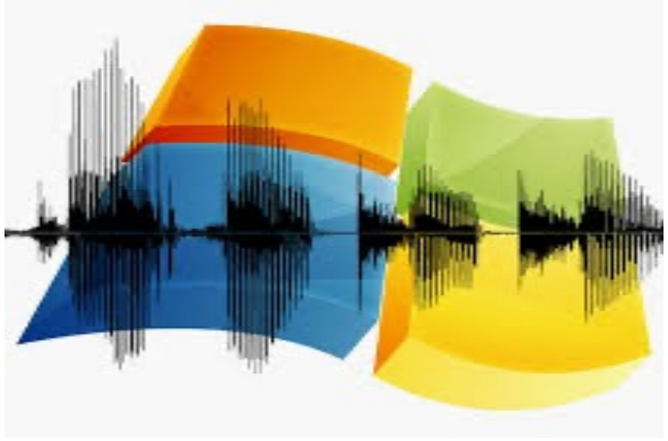
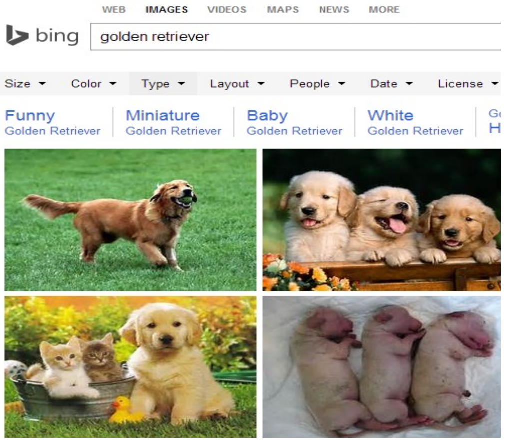
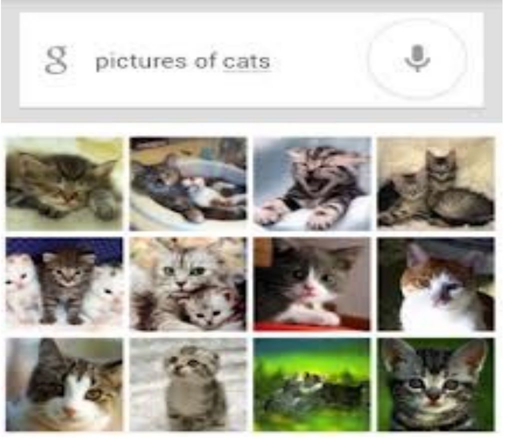
Deep Learning – from Research to Technology





Translate Google



Deep Learning - breakthrough in visual and speech recognition

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Classical Computer Vision Pipeline

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Classical Computer Vision Pipeline

CV experts

1. Select / develop features: SURF, HoG, SIFT, RIFT, …
2. Add on top of this Machine Learning for multi-class recognition (SVM, DT, etc.) and train classifier

Feature Extraction: SIFT, HoG...

Detection, Classification Recognition

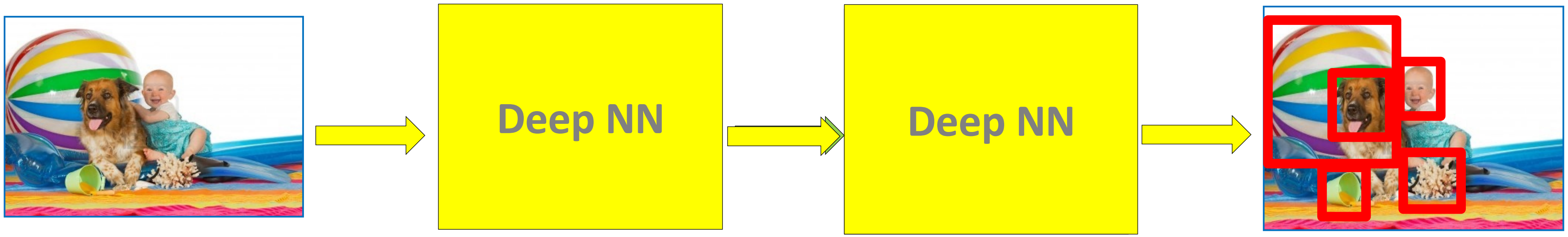
Classical CV feature definition is domain-specific and time-consuming

Deep Learning –based Vision Pipeline

Deep Learning:

- Build features automatically based on training data
- Combine feature extraction and classification

DL experts: define NN topology and train NN



Deep Learning promise:
train good feature automatically,
same method for different domain

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Computer Vision +Deep Learning + Machine Learning

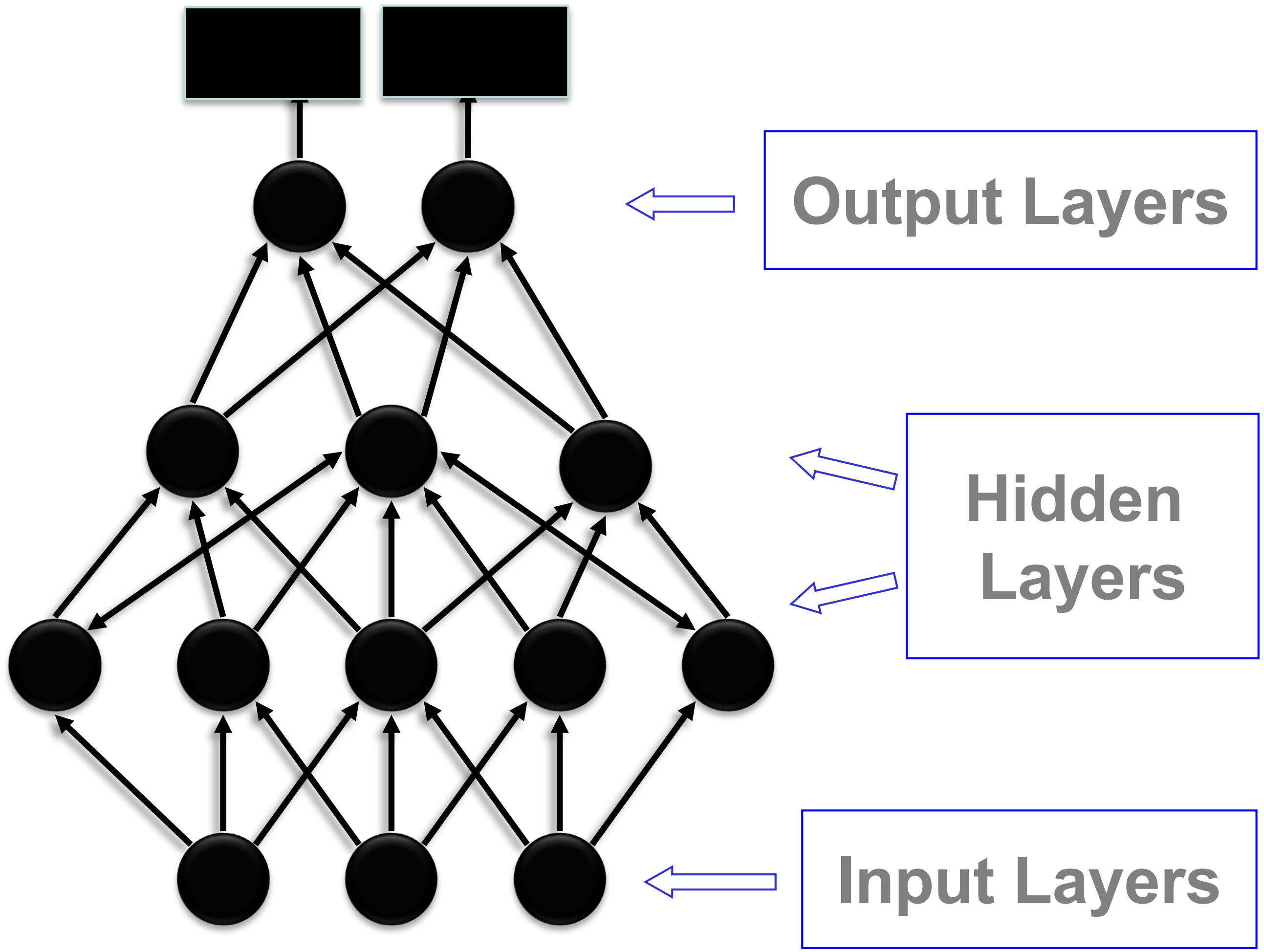
- Combine pre-defined features with learned features;
- Use best ML methods for multi-class recognition

CV+DL+ML experts needed to build the best-in-class

Combine best of Computer Vision
Deep Learning and Machine Learning

Deep Learning Basics

Deep Learning – is a set of machine learning algorithms based on multi-layer networks



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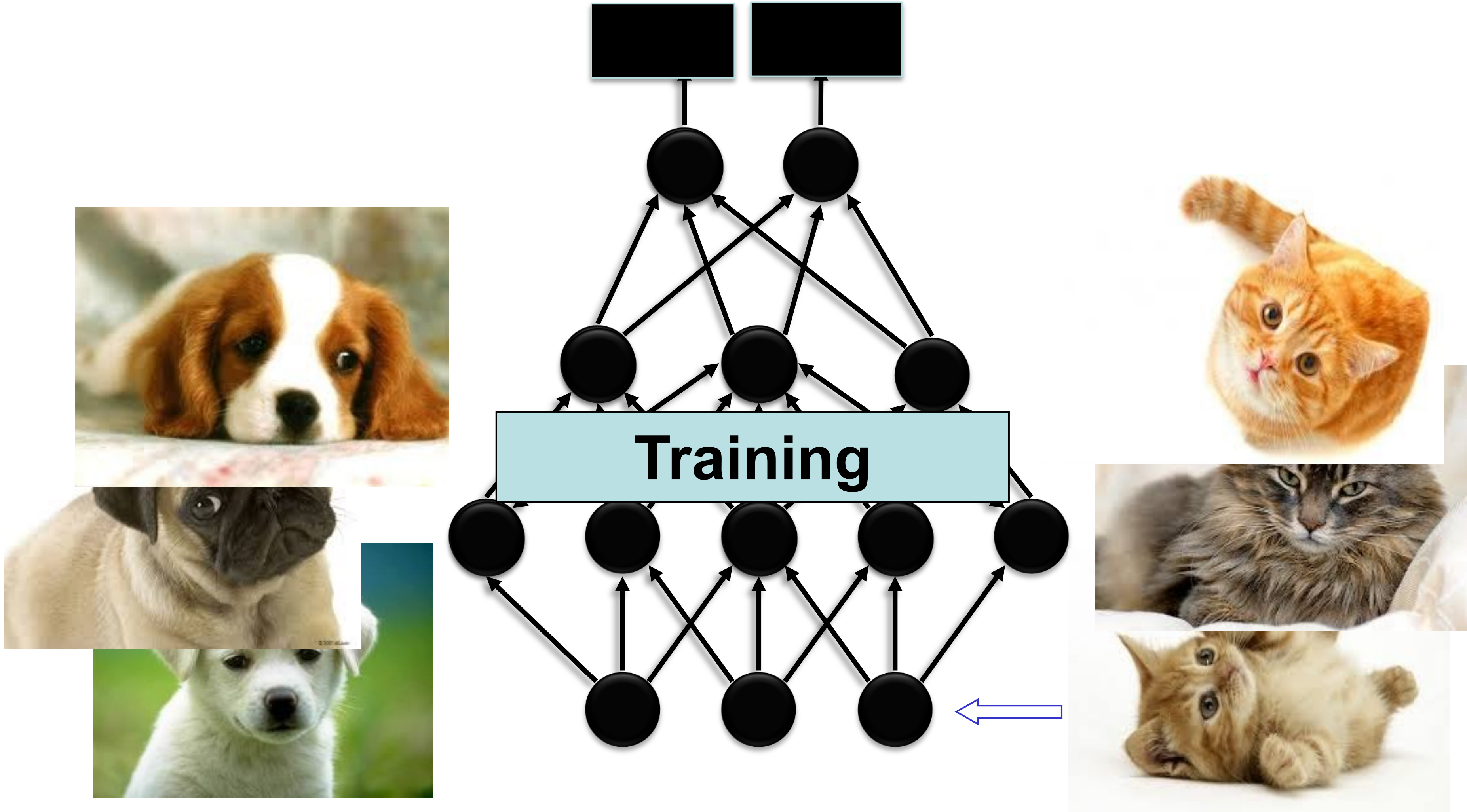

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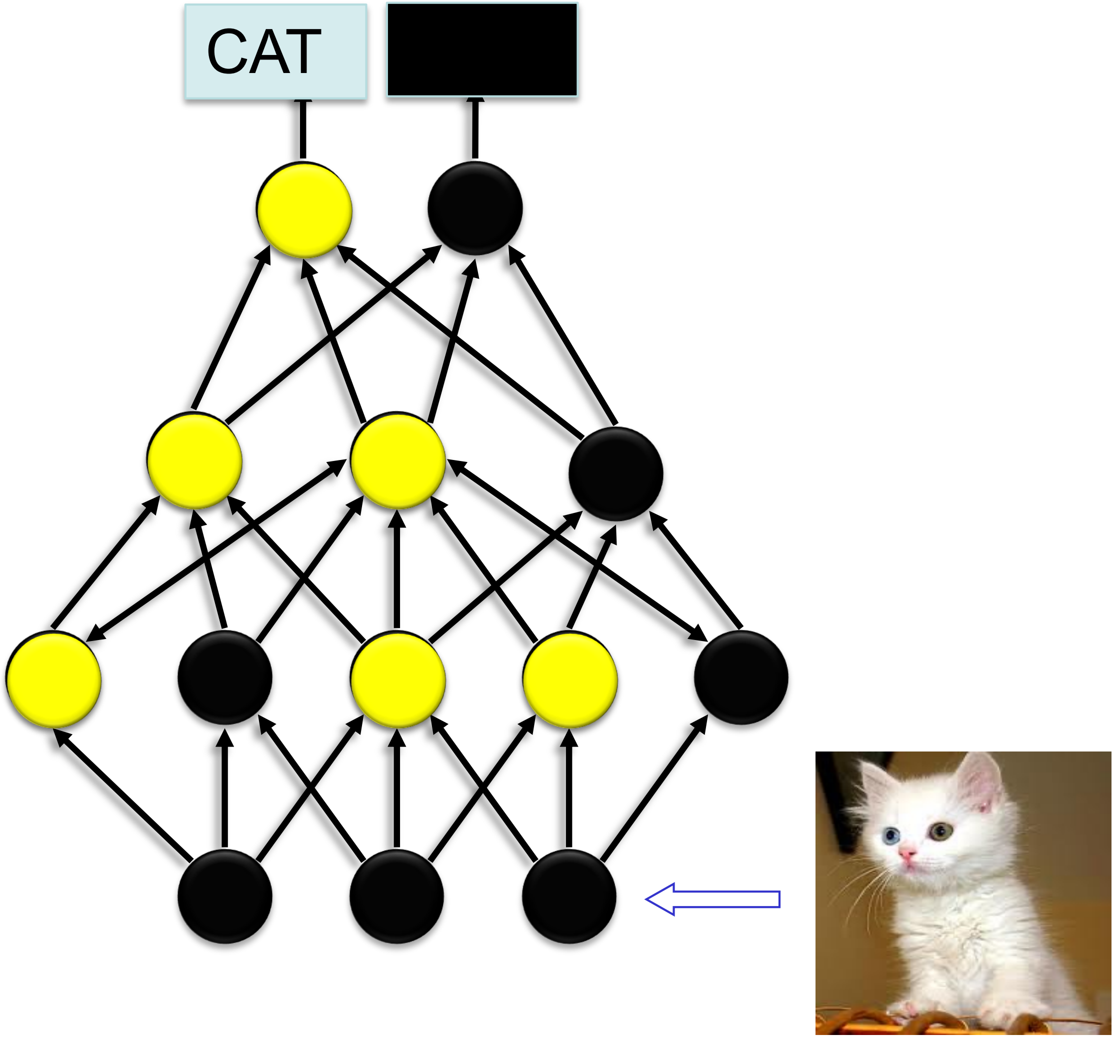

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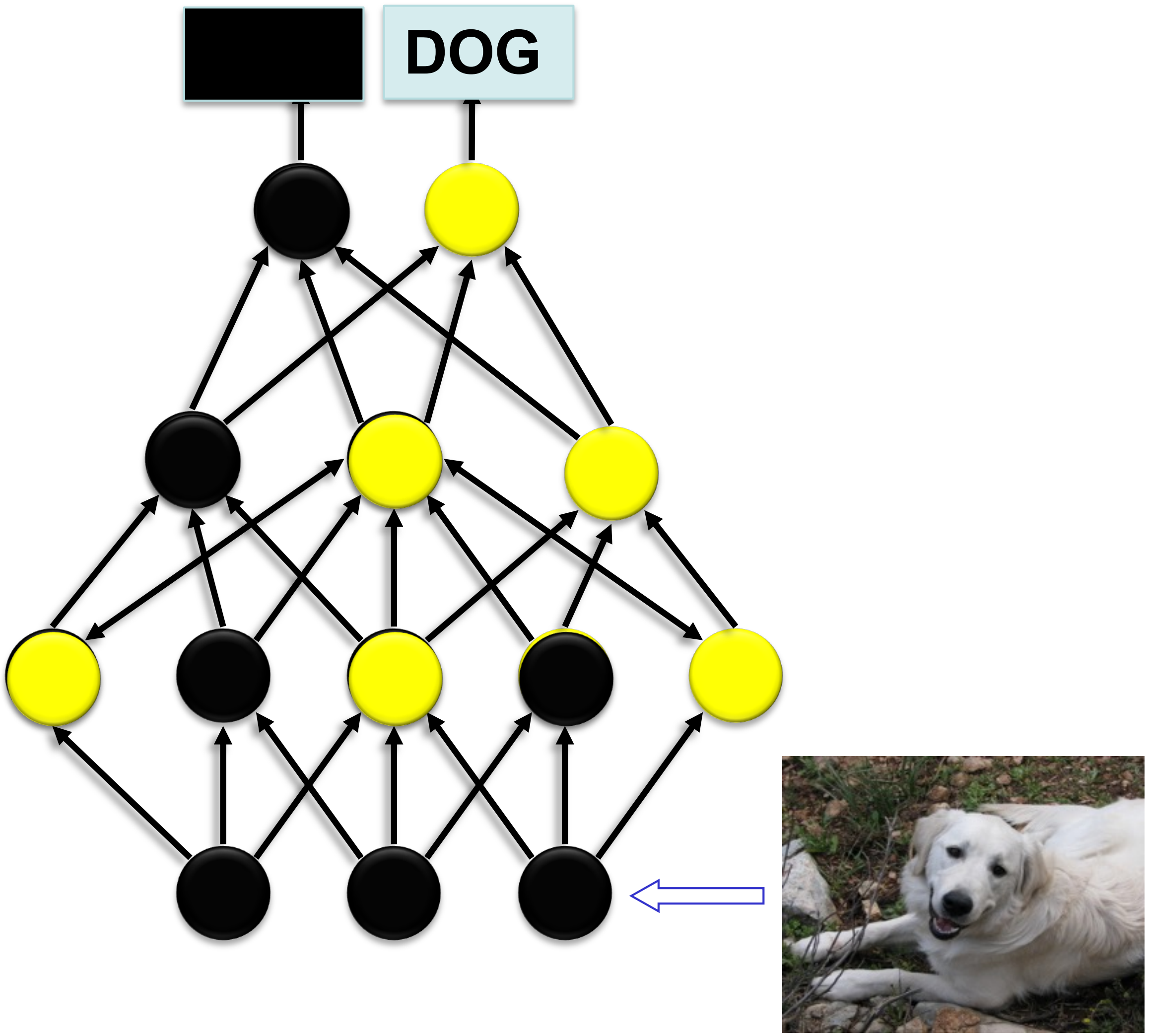

Deep Learning Basics

Steps are as follows:

1. Sample a batch of data
2. Forward propagate it through the graph
3. Backpropagate to calculate the gradients
4. Update the parameters using gradients

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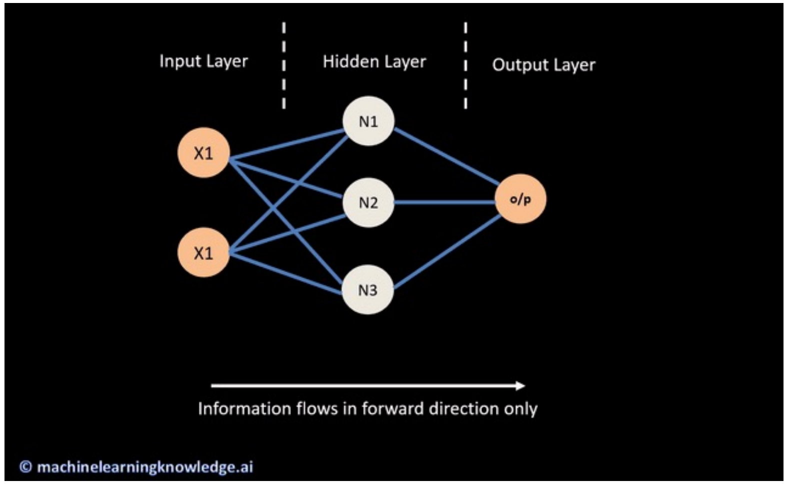

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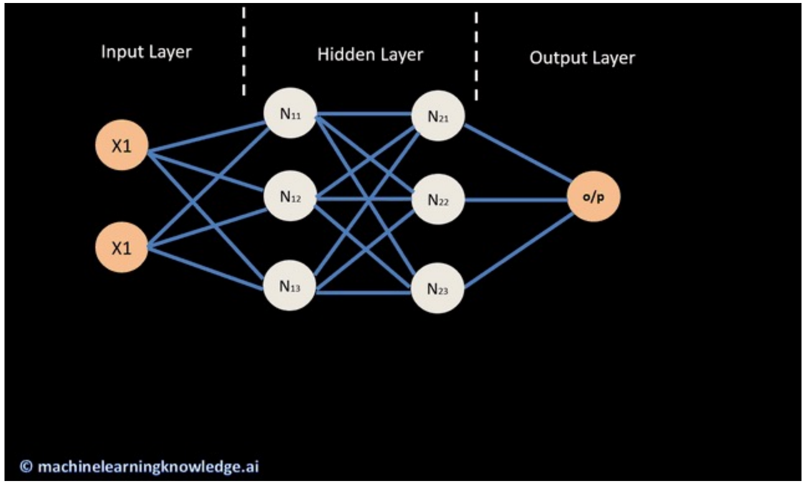

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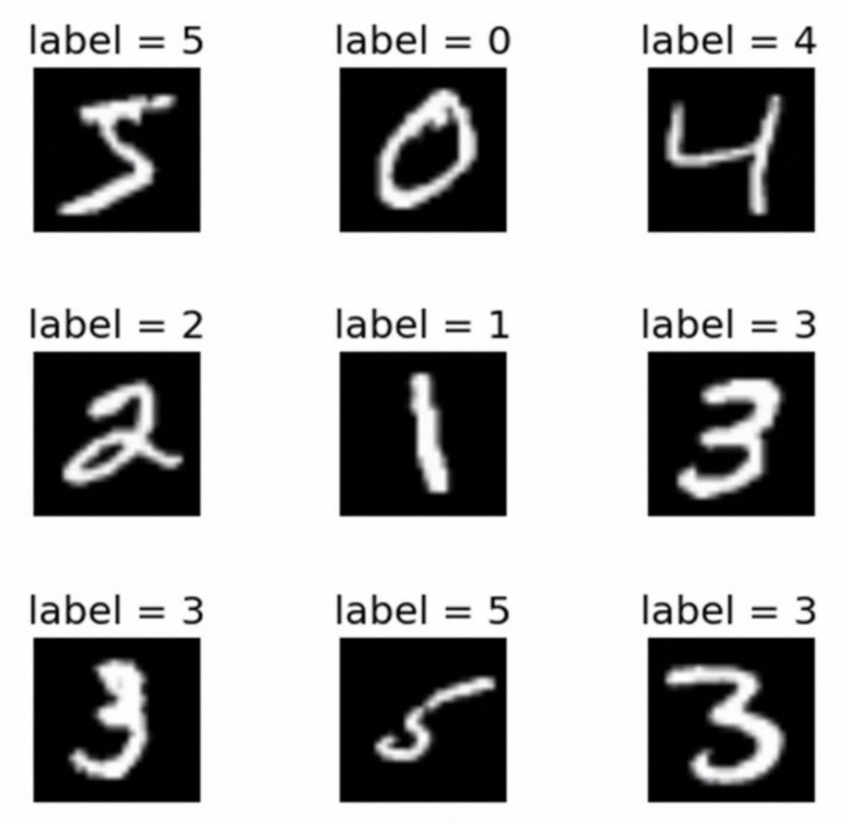
Practical example: MNIST

- MNIST dataset
  - Handwritten digits
  - 70,000 28x28 b/w images
  - Represent the digits from zero through nine

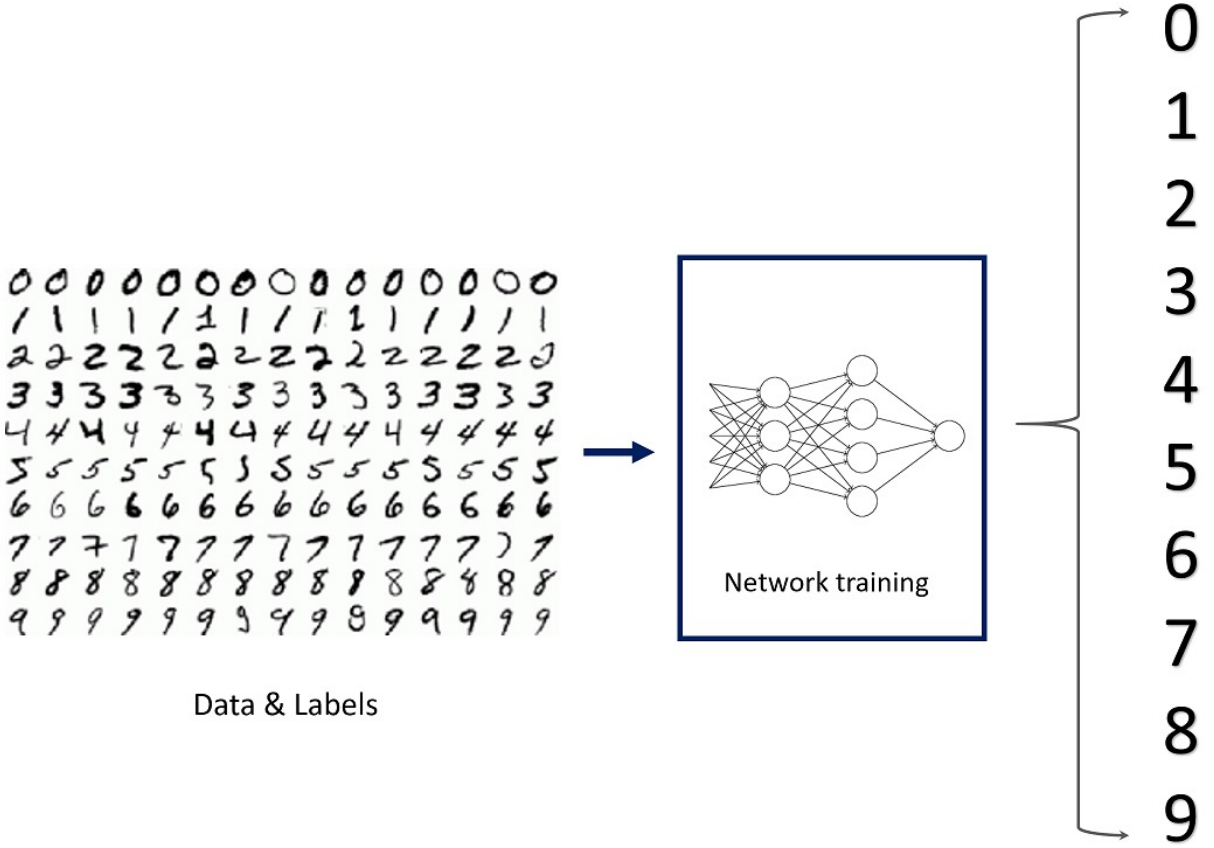
Practical example: MNIST

- Each letter can be written with different style



Practical example: MNIST

- Deep neural networks allow us to train a computer effectively
- Classification to handwritten digits



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Practical example: MNIST

- **SoftMax activation** function can be used for multi-class data classification
- Sigmoid activation function can be used for binary classification

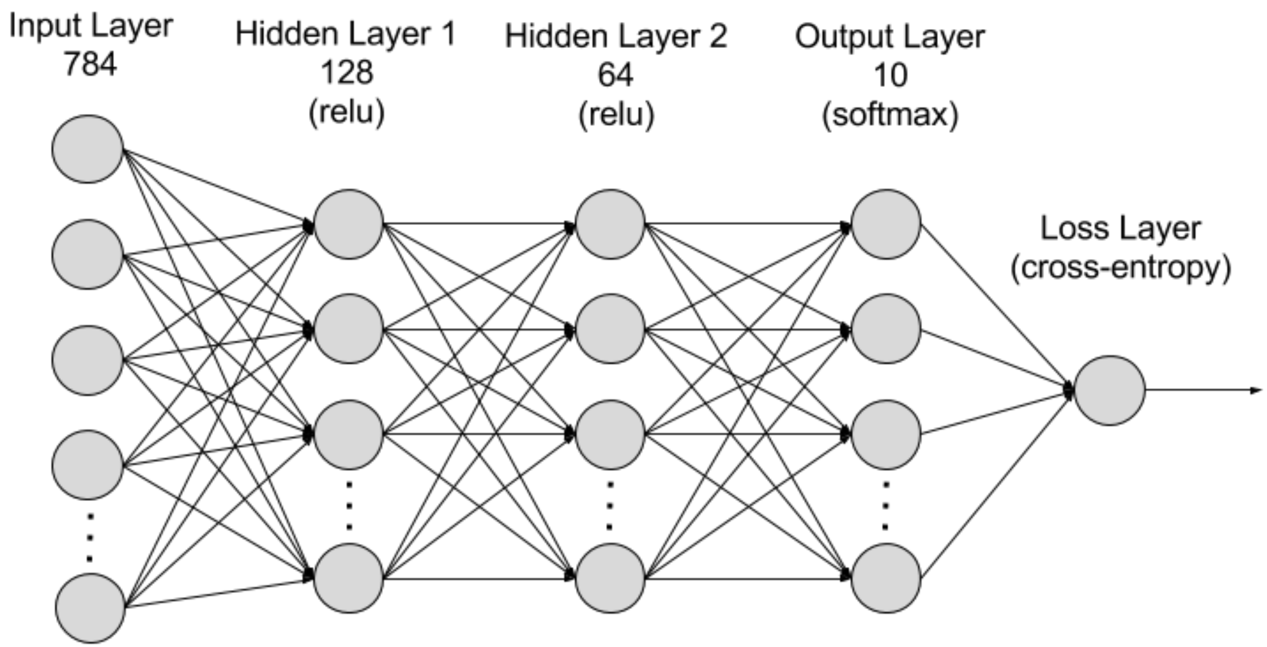
Multi-class

Practical example: MNIST

- Multi-layer perception: we need to flatten a given 28x29 images into

a flat 1-D structure of 784 (28*28) pixel value

- SoftMax (output layer) maps its input to a probability score for each class of output



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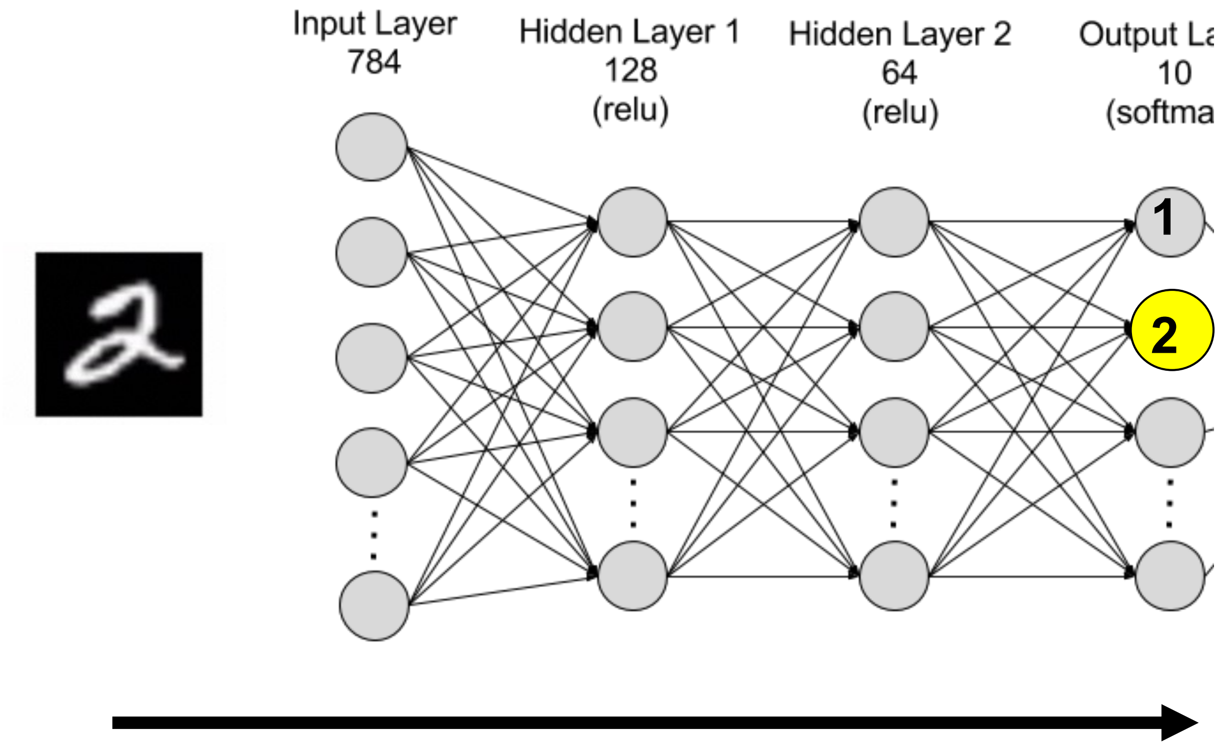
Practical example: MNIST



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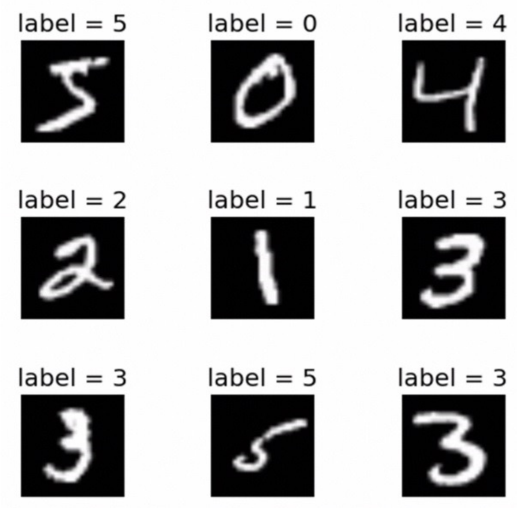
Practical example: MNIST

- Datasets in deep learning can be slip into **training set** and **test set**.

- Training set consists of inputs each corresponding to some answer/label.



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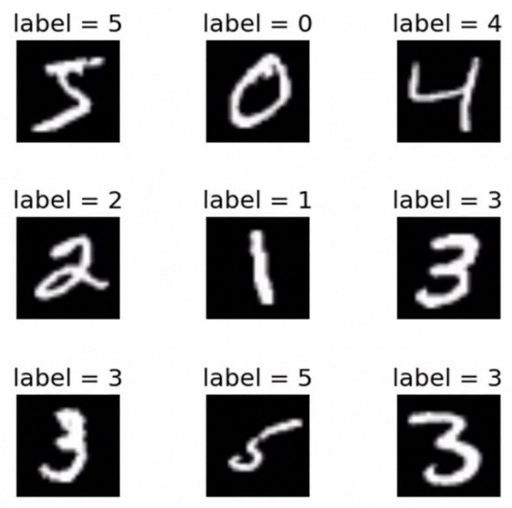

Practical example: MNIST

- Test set consists of inputs each corresponding to some answer/label. It consists of new images that never seen before

- In ML, we are interested in how well the ML algorithm performs on data that its never seen before

- It determines the performance in the real world.

Practical example: MNIST

- During the training we also require the test error
- When we train our deep neural network, the model tends to memorize the training data.
- Generalization

Generalization

- Small training error
- The gap between the training error and the test error should be small

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Generalization

- Large training error

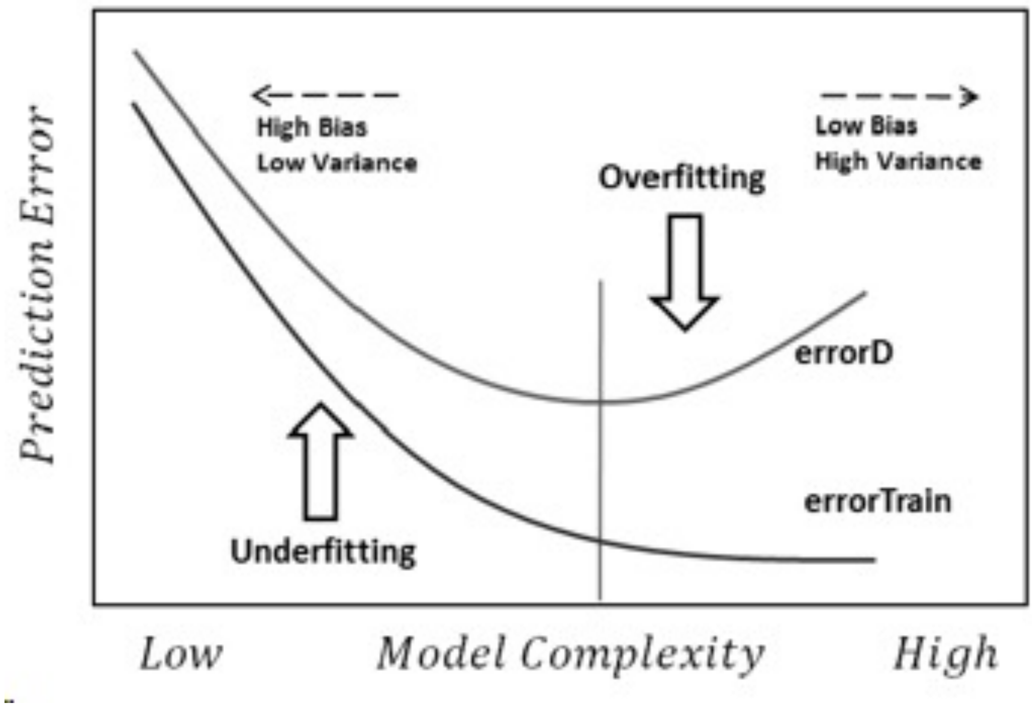
Challenge: under fitting

- Gap between test and training error grows larger

Challenge: over fitting

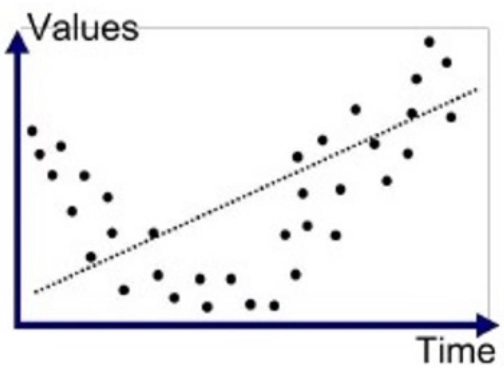
Generalization

- At the beginning, the function is too simple to capture the underlying trend of the data

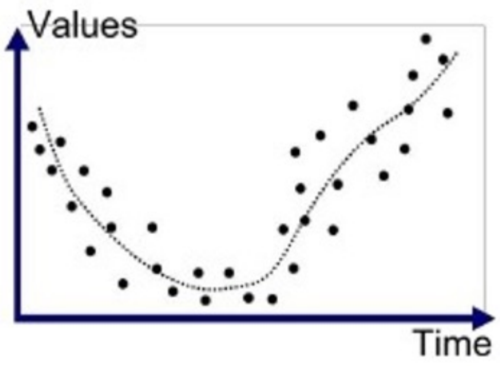


Under fitting

- It is not able to fit the training set
- The network does not have enough capacity to fit the training data



Underfitting



Good fit

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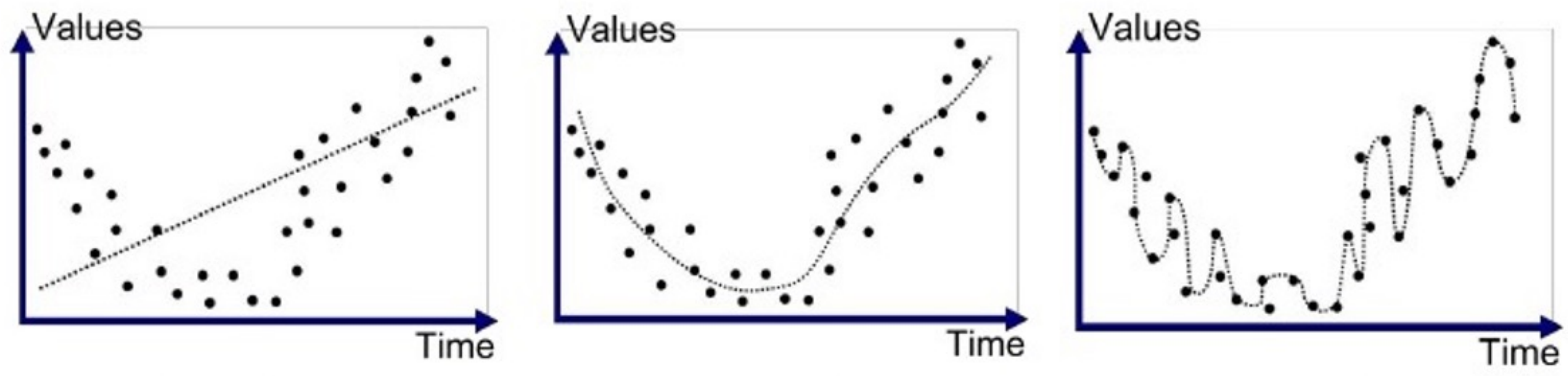
Over fitting

- If the capacity is too high, the network might over fit which introduce the concept of <u>**over fitting**</u>
- It memorize the training data, so when there is a new data, it is not able to effectively generalize to new data



Underfitting **Good fit** **Overfitting**

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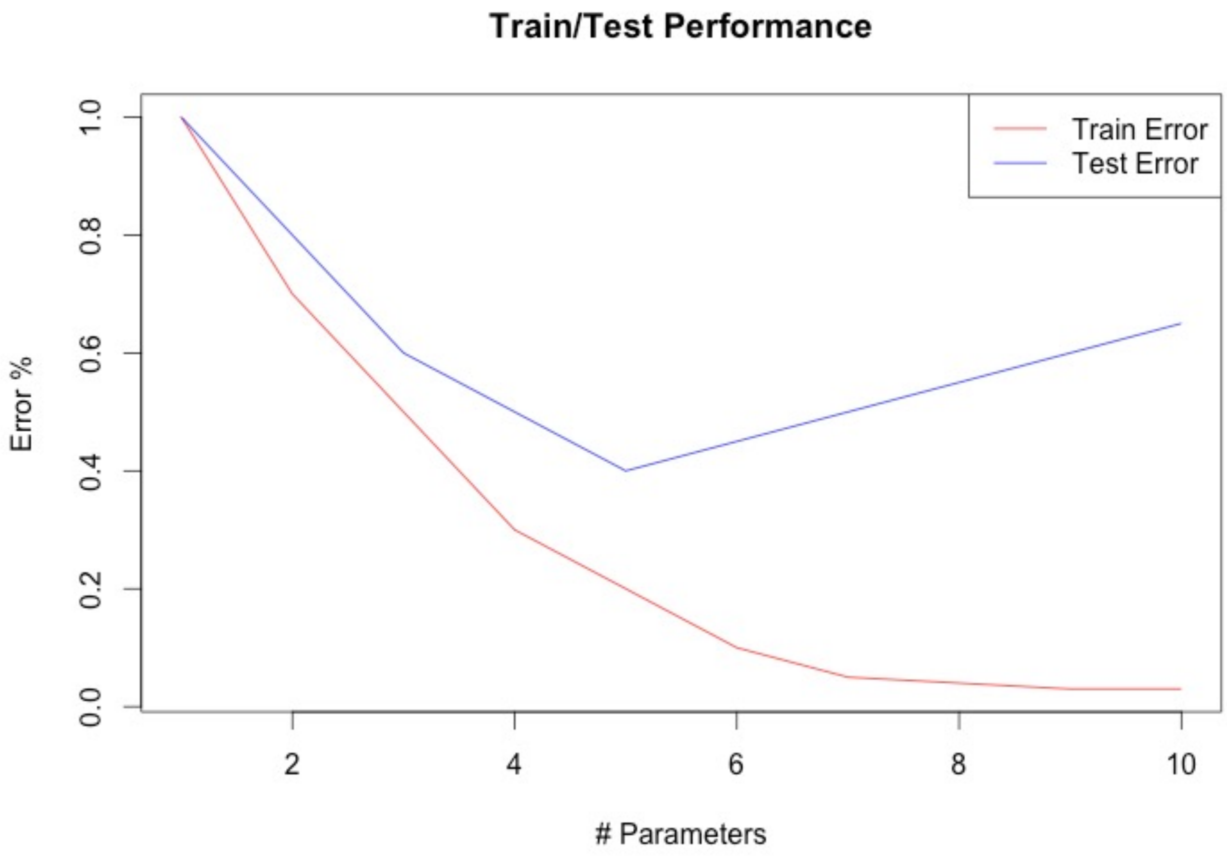
Generalization



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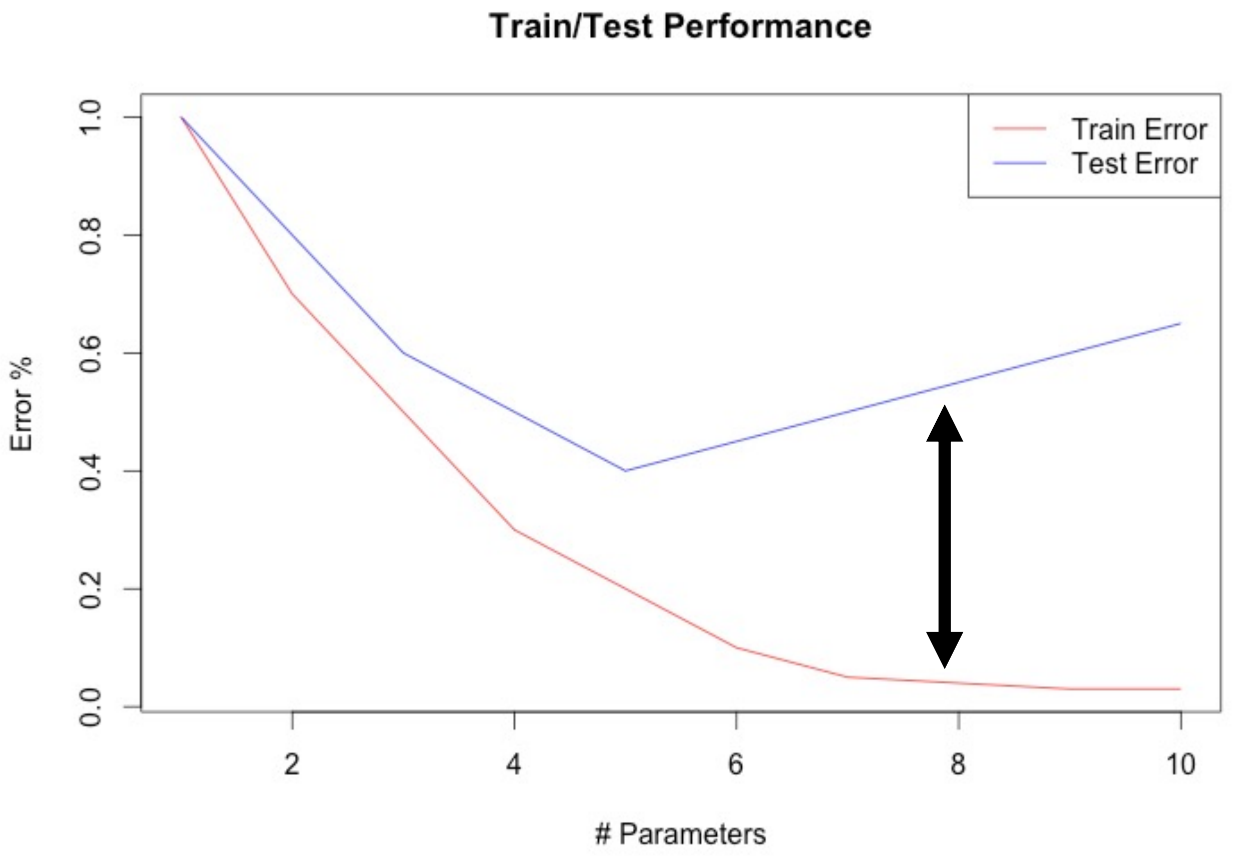

1. **Small training error**
2. **Gap between test and training error grows larger**

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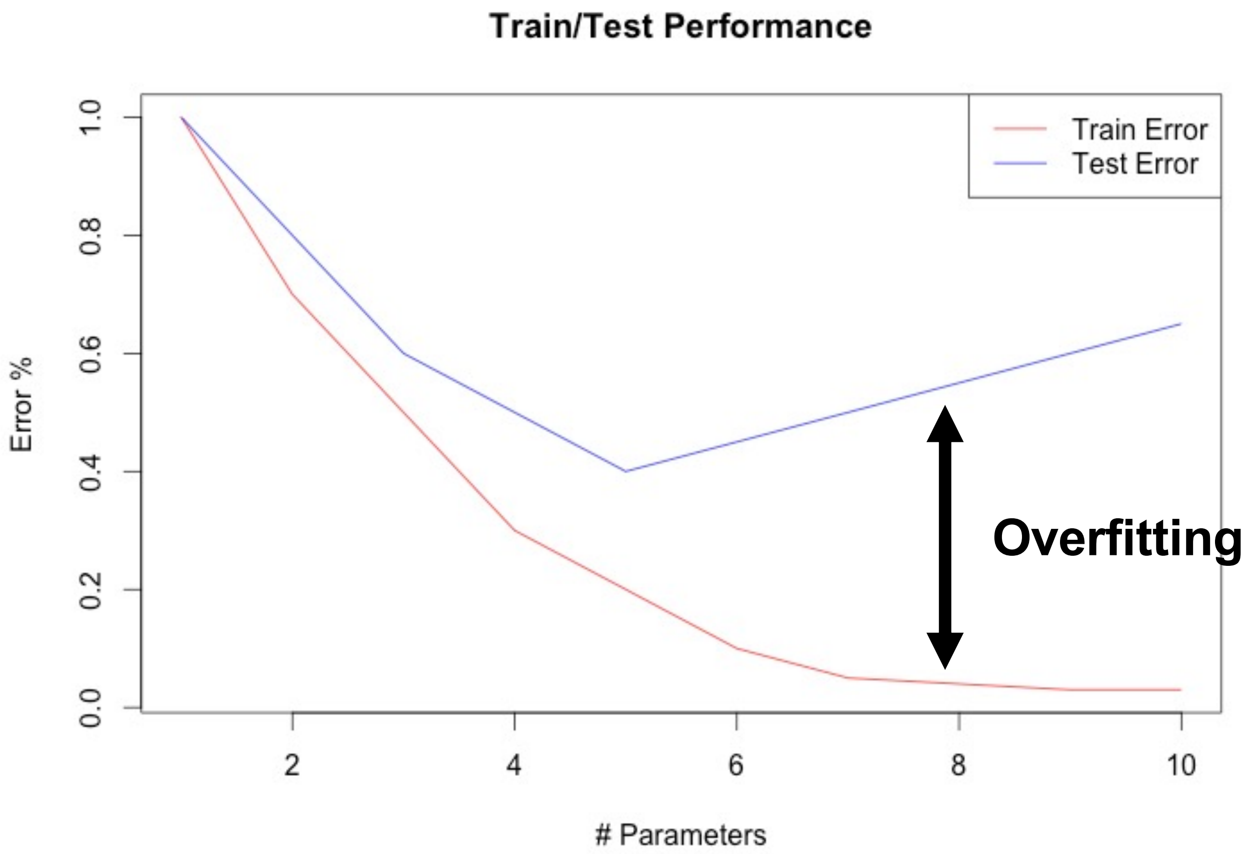
Generalization



1. **Small training error**
2. **Gap between test and training error grows larger**

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How can we fix over fitting?

- Reduce model complexity
- Reduce number of features
- Less epochs
- Mora data (clean and relevant)
- ….

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How can we fix under fitting?

- Increase model complexity
- Increase number of features
- More epochs (increase number of epochs)
- Remove noise from the data
- ….