

# Machine Learning: An Introduction

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# ML: From Rules to Data

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# Example: Activity Recognition

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# Example: Activity Recognition



```
0101001010100101010
1001010101001011101
0100101010010101001
0101001010100101010
```

Label = WALKING



```
1010100101001010101
0101010010010010001
0010011111010101111
1010100100111101011
```

Label = RUNNING



```
1001010011111010101
1101010111010101110
1010101111010101011
1111110001111010101
```

Label = BIKING



```
1111111111010011101
0011111010111110101
0101110101010101110
1010101010100111110
```

Label = GOLFING

# Demo: WAP

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- Please choose one correct answer:
- 1 | 3 | 5 | 7 | 9 | ?
  - ?
  - $y = 2x - 1$
- 3 | 8 | 15 | 24 | 35 | ?
  - Quiz1=  
<https://forms.gle/U5MFgeYPfMKfuYBd9>
  - $y = x^*(x+2)$

# Training and Testing

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Training Phase

# What is ML?

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- Term “Machine Learning” coined by Arthur Samuel in 1959.
  - [Samuel Checkers-playing Program](#)
- Common definition (by Tom Mitchell)
  - Machine Learning is the study of computer algorithms that improve automatically through experience

# More details

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- Study of algorithms that
  - improve their performance  $P$
  - at some task  $T$
  - with experience  $E$
- Well-defined learning task:  $\langle P, T, E \rangle$





# Task (T)

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- Classification or Pattern Recognition
- Regression or Prediction
- Clustering
- Synthesis or Sampling
- Ranking
- Recommendation Systems
- Anomaly Detection
- Data Mining etc.



# Performance (P)



- A quantitative measure to evaluate performance
  - Usually Task specific
- Classification

		Predicted Class		
		Positive	Negative	
Actual Class	Positive	True Positive (TP)	False Negative (FN) <b>Type II Error</b>	<b>Sensitivity</b> $\frac{TP}{(TP + FN)}$
	Negative	False Positive (FP) <b>Type I Error</b>	True Negative (TN)	<b>Specificity</b> $\frac{TN}{(TN + FP)}$
		<b>Precision</b> $\frac{TP}{(TP + FP)}$	<b>Negative Predictive Value</b> $\frac{TN}{(TN + FN)}$	<b>Accuracy</b> $\frac{TP + TN}{(TP + TN + FP + FN)}$

# Performance (P)

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- Regression
  - Error measure such as ‘mean squared error’



# Experience (E)

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- Supervised Learning
  - Labelled data – (Data, target value)
  - Target value could be category/class labels, real value, real vector, etc.
  - Classification, Regression
- Unsupervised Learning
  - Only data, no labels
  - Dimensionality Reduction, ICA, Clustering
- Reinforcement Learning
  - No examples, but a reward function
  - Payoff based on actions

# An Incomplete History of Learning



- Turing Test (1950)
  - Machines do very poorly
- Rosenblatt's Perceptron (1960's)
  - Kick started the mathematical analysis of the learning process
  - Key idea behind Support Vector Machines (SVMs) and Neural Networks
- Construction of Fundamentals of Learning Theory (1960-70's)
  - Focus on generalization capability of learning machines
    - Performance on unseen data
  - Regularization for ill-posed problems
    - e.g., linear equations for ill-conditioned matrices
- Neural Networks (1980's)
  - Connectionism
  - Back-propagation [LeCun, '86]
  - CNNs, RNNs
- SVMs (1990's)
  - Margin Maximization
  - Kernel Methods to handle non-linearity
- Deep Learning (>2006)
  - Hinton, Bengio, LeCun at forefront
  - Abstract Representations
- (>2012) Crazyess!!

# Most Amazing Milestones So Far



- 1997 – Deep Blue defeats world chess champion Garry Kasparov
- 2005 – The DARPA Grand Challenge
- A \$2 million prized race for autonomous vehicles across 100+ kms off-road terrain in the desert.

Deep Blue vs. Kasparov



Deep Blue  
IBM chess computer



Garry Kasparov  
World Chess Champion



Stanford Racing Team's leader Sebastian Thrun

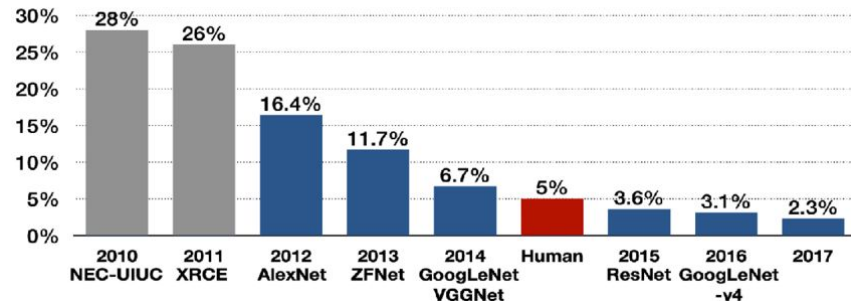
# Most Amazing Milestones So Far



- 2011 – IBM Watson’s Jeopardy! Victory
- The final tally was \$77,147 to Mr. Jennings’s \$24,000 and Mr. Rutter’s \$21,600.



- 2015 – Machines “see” better than humans
- Largescale image recognition contest for classifying 50,000 high-resolution color images into 1,000 categories.
- The model is considered to have classified a given image correctly if the target label is one of the model’s top 5 predictions.





# Most Amazing Milestones So Far



- 2016 – AlphaGo created by Deep Mind (now a Google subsidiary) defeated world Go champion Lee Sedol over five matches.
- There are over 100,000 possible opening moves in Go, compared to 400 in Chess, make the brute force approach impractical.





# Recent Progress

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- Google Search
- Computer Vision / Image Recognition
  - ImageNet
  - Convolutional Neural Networks
- Autonomous driving
- Speech Recognition
- Voice assistants
  - Apple's Siri, Microsoft's Cortana, Amazon's Echo
- Language Translation
  - Google Translate
  - Unsupervised Translation
- Game Playing / Deep Reinforcement Learning
  - AlphaGo

# ML vs DL



## Traditional Machine Learning



Requires handcrafted features

Car ✓  
Truck ✗  
•  
Bicycle ✗

## Deep Learning

### Convolutional Neural Network (CNN)



End-to-end learning

Feature learning + Classification

Car ✓  
Truck ✗  
•  
Bicycle ✗

# Next Class



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- Learning Problems and the Empirical Risk Minimization Framework
  - Loss Functions for Classification and Regression
  - Evaluation Metrics for Classification

# References



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1. Introduction to TensorFlow for Artificial Intelligence, Machine Learning, and Deep Learning: DeepLearning.AI

