

Week 01

- Introduction
 - Wtf?
 - Supervised/ Unsupervised
 - Linear regression with one variable
 - Model and Cost Function
 - Model representation
 - Cost function
 - Parameter Learning
 - Gradient descent
 - Gradient descent for linear regression
 - Linear algebra
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I. Intro

1. Defintions:

- Arthur Samuel, 59' => ML gives computer ability to learn without being explicitly programmed;
- Tom Mitchell, 98': a computer is said to learn from experience (E) with respect to task (T) and some performances (P), if its performances on T as measured on by (P) improves (E).
- Example:
 - Email program watches you mark or no as Spam, and learns how to better filter Spam.
 - T = Classify emails
 - E = Watching you label emails as spam or not spam
 - P = The number of emails correctly classified
 - Playing checkers.
 - T = playing
 - E = play many games
 - P = Probablilty that program will win the next game
- ML algo.: Supervised and unsupervised learning + (bonus: reinforcement & recommender)

2. Supervised ML

Right answers are given and task of algorithm is to produce more right answers.

There's a relationship between the input and the output.

- Example:
- Breast cancer:
 - It is called classification problem: label sizes to 1 for malignant or 0 for benign.
 - pTo Predict results in a discrete output.
 - → classification is about predicting a label.
- Housing price prediction:
 - It is called regression problem to predict continuous valued output (prices).
 - Price as a function of size is a continuous output.
 - Map input variables to some continuous function.
 - → regression is about predicting a quantity.
 - Can turn to into classification problem: output whether the house "sells for more or less than the asking price."
 - Here we are classifying the houses based on price into two discrete categories.
- Age
 - Given a picture, predict the age.

3. Unsupervised ML

- Approach problems with little or no idea what our results should look like.
- Can derive results structure by clustering it based on relationships among the variables in the input.
- No feedback based on the prediction results.
- Example
 - Cocktail party problem: identify human voices and music => Non-clustering.
 - Discover market segments and group customers into different market segments.
 - Group articles into sets about the same stories.
 - Create groups from a collection of 1,000,000 different genes based on lifespan, location, roles, etc.

II. Model and cost function

1. Model representation:

- $\mathbf{x}^{(i)}$ = "input" variables = input features.
- $\mathbf{y}^{(i)}$ = "output" variables = target variable. => example: predict price (\mathbf{y}) from living area (\mathbf{x})
- couple $(\mathbf{x}^{(i)}, \mathbf{y}^{(i)})$ is called training example.
- couples $(\mathbf{x}^{(i)}, \mathbf{y}^{(i)}); i = 1..m$ is called training set.

- \mathbf{X} space of input values; \mathbf{Y} space of output values; $\mathbf{X} = \mathbf{Y} = \mathbb{R}$
- Supervised learning problem:
 - given a training set, to learn $\mathbf{h} : \mathbf{X} \rightarrow \mathbf{Y}$ so $h(x) \approx y$
 - \mathbf{h} is called **hypothesis**

[[An algorithm will learn from a training set how to predict \mathbf{y} when \mathbf{x} is provided using \mathbf{h}]]

Such as in our housing example, we call the learning problem a regression problem.

- Goal is to find \mathbf{h} and its parameters as $\mathbf{h}(\mathbf{x}) = \mathbf{ax} + \mathbf{b}$

2. Cost function

- Cost function = average difference of all results of all \mathbf{x} 's & \mathbf{y} 's
 - $J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=0..m} (h_{\theta}(x^{(i)}) - y^{(i)})^2$;
 - m is the number of training examples
- Hypothesis $\mathbf{h}_{\theta}(\mathbf{x}) = \theta_0 + \theta_1 \mathbf{x}$
 - Parameters: θ_0, θ_1
 - Choose these parameters so $\mathbf{h}_{\theta}(\mathbf{x})$ is close to \mathbf{y} for the training couple (\mathbf{x}, \mathbf{y})
- Goal: **minimize** $J(\theta_0, \theta_1)$

Intuition 1:

- Ideally, the line should pass through all the points of our training data set to minimize $J(\theta_0, \theta_1)$.
 - $\mathbf{h}_{\theta}(\mathbf{x})$ is plotted : a linear function passing through some points of the training set.
 - Plot $\mathbf{h}_{\theta}(\mathbf{x})$ and $J(\theta_0, \theta_1)$
 - $\theta_1 = 0 \Rightarrow J(0) = 2.3$
 - $\theta_1 = 0.5 \Rightarrow J(0.5) = 0.58$
 - $\theta_1 = 1 \Rightarrow J(1) = 0$
 - $\theta_1 = 1.5 \Rightarrow J(1.5) = 0.58$
 - $\theta_1 = 2 \Rightarrow J(2) = 2.3$
- Thus as a goal, try to minimize the cost function. In this case, $\theta_1 = 1$ is the global minimum.

III. Parameter learning

1. Gradient descent

- Have some function $J(\theta_0, \theta_1)$
- Want to **minimize** $J(\theta_0, \theta_1)$

- **Outline**

- Start with some θ_0, θ_1 .
 - Keep changing θ_0, θ_1 to reduce $J(\theta_0, \theta_1)$ to find up a minimum.
- Estimate the parameters in the hypothesis function \rightarrow Gradient descent