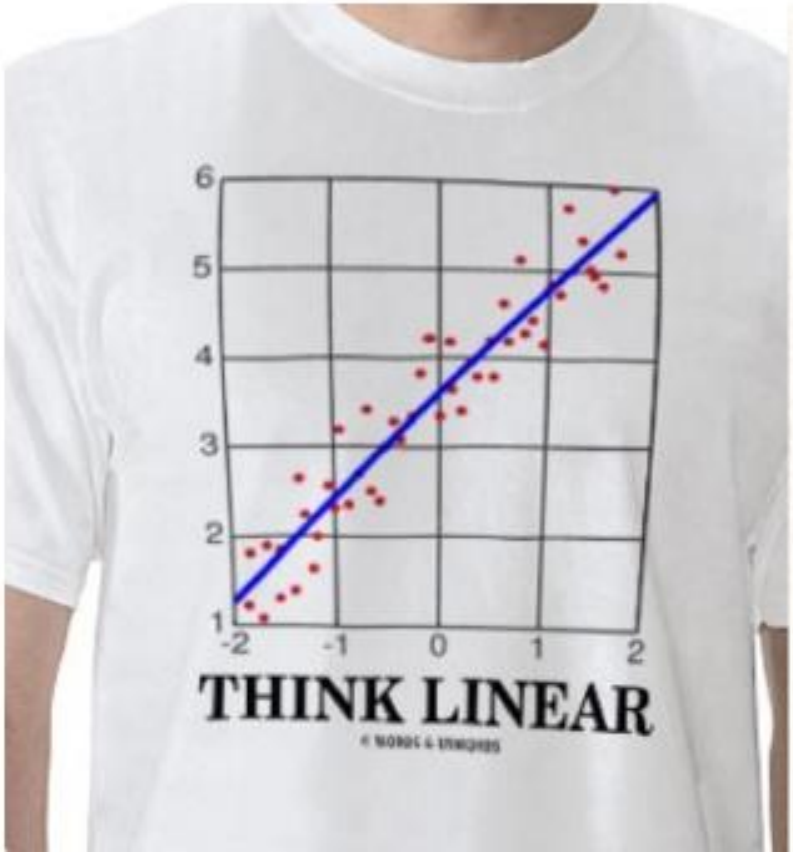
Pakistan Institute of Engineering and Applied Sciences(PIEAS),Islamabad

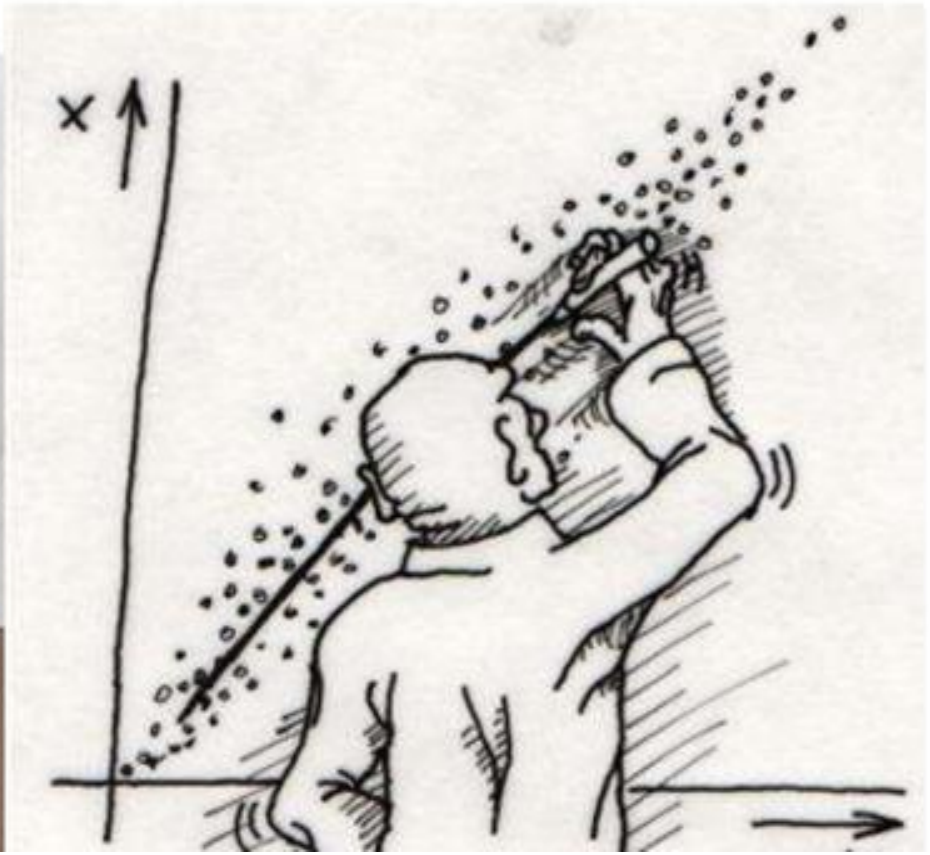
REGRESSION

Presented By:

Rao Muhammad Umer

REGRESSION





REGRESSION

- Section-I:
  - Motivation
- Section-II:
  - Theoretical Bases
- Section-III:
  - Implementation

REGRESSION

PART-I:

Motivation

Outline

- What?
- Why?
- Who?
- How?

Outline

- **What?**
- **Why?**
- **Who?**
- **How?**

Regression

- What about **Machine Learning**?
- What about **Deep Learning**?
- What about **Data Science**?
- What about **Big Data Analysis**?
- What about **Predictive Analytics** ?

Regression

- Predicting a real numeric value for an entity with a given set of features

Deterministic Vs Probabilistic Modeling

- $\mathbf{Y_i = a + b X_i}$
  - Substituting a value of X in the equation, we can completely determine a unique value of Y.(Exact relationship)
  - Examples: **F = 32 + (9/5) C** , $A = \pi r^2$

- $\mathbf{Y_i = a + b X_i + e_i}$
  - Inexact relationship b/w variables
  - $\mathbf{e_i}$ is known as random error

Types of Regression

- Simple Linear Regression
- Multiple Regression
- Polynomial Regression
- Logistic Regression

Outline

- What?
- **Why?**
- Who?
- How?

Predicting House Price

Predicting House Price

Predicting which Television Show will have more viewers for next week

What Causes Retweets?

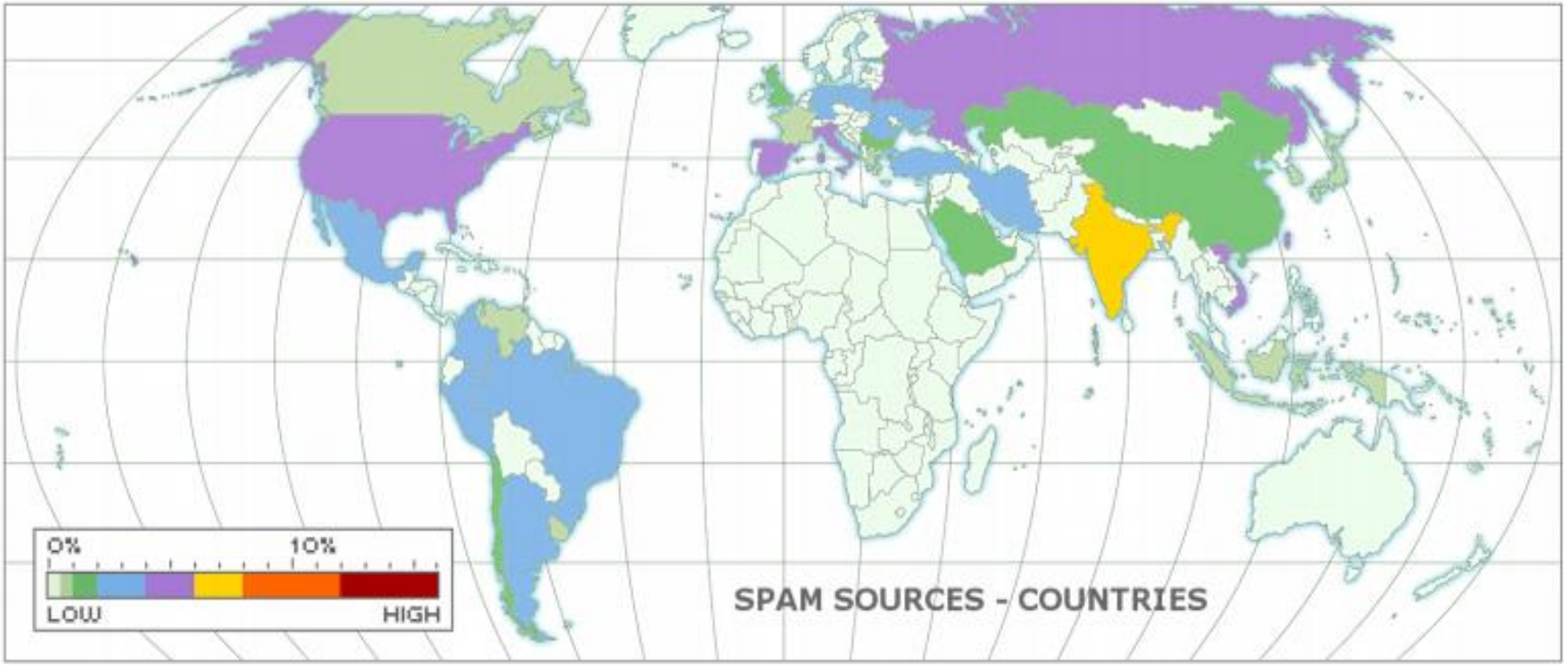
- How can we help marketers use Twitter data to influence the number of times a tweet is retweeted?
- With over 555 MM registered users who tweet 58 MM times per day, Tweeting is potentially big business.
- We selected the top 30 entertainment industry related accounts to find out, ranging from rock stars, actors, to famous sports figures.
- In particular, we are attempting to understand the factors that contribute to a “retweet”, i.e. an instance where a Twitter account holder’s tweet is shared by another Twitter user.
- This has important implications for marketers.
- By understanding the factors that contribute to a retweet a marketer can maximize the potential audience and can better engage with target audiences.

SPAM CLASSIFICATION

>67%

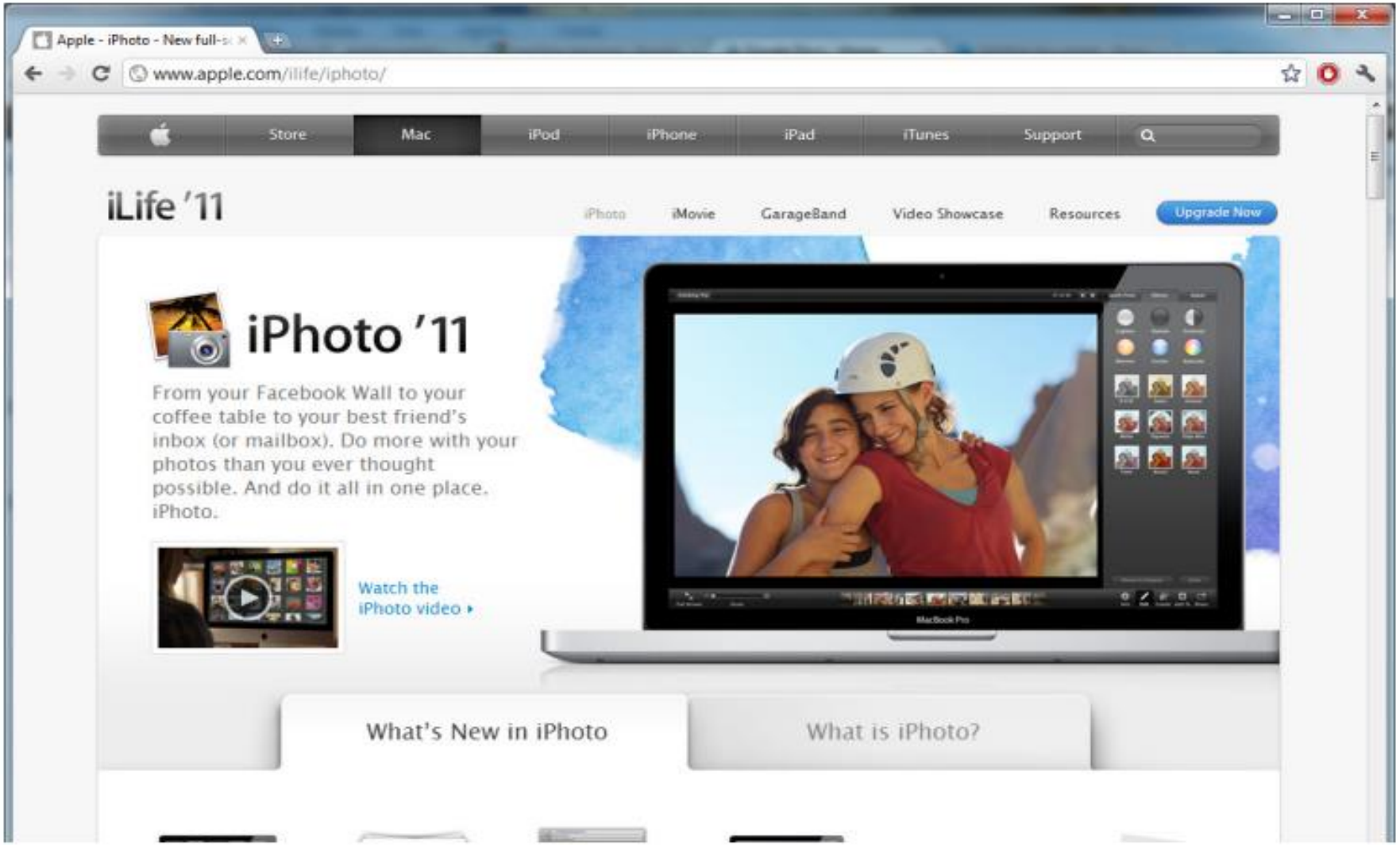
Of all inbound email is spam

"If you are tired of spam email, imagine if there were no spam filters"



SPAM CLASSIFICATION

Tagging a Photo!!!



Self Customizing Programs

- Self customizing programs
  - Netflix
  - Amazon

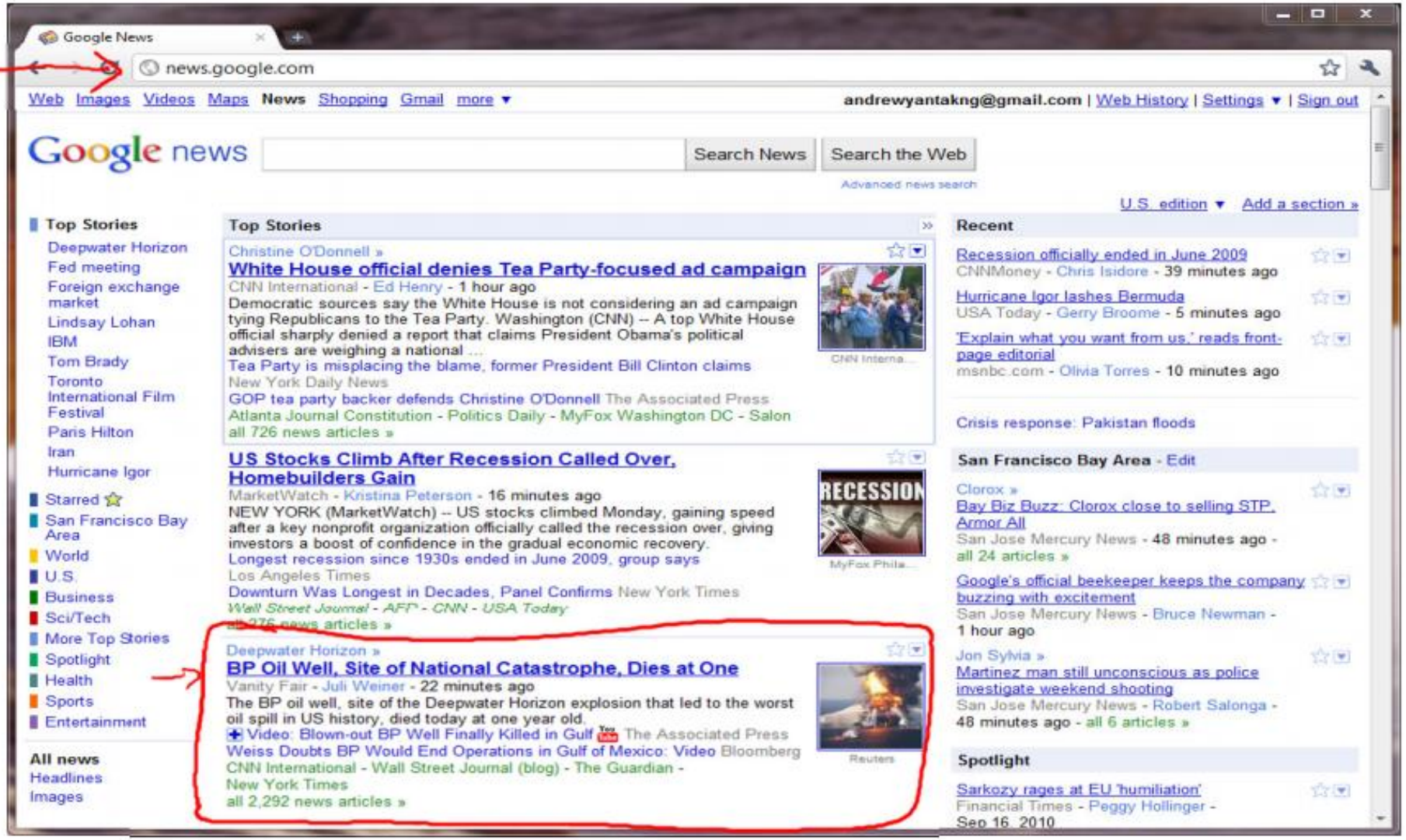
Stock Exchange Price Prediction

- Predicting a continuous response like stock price

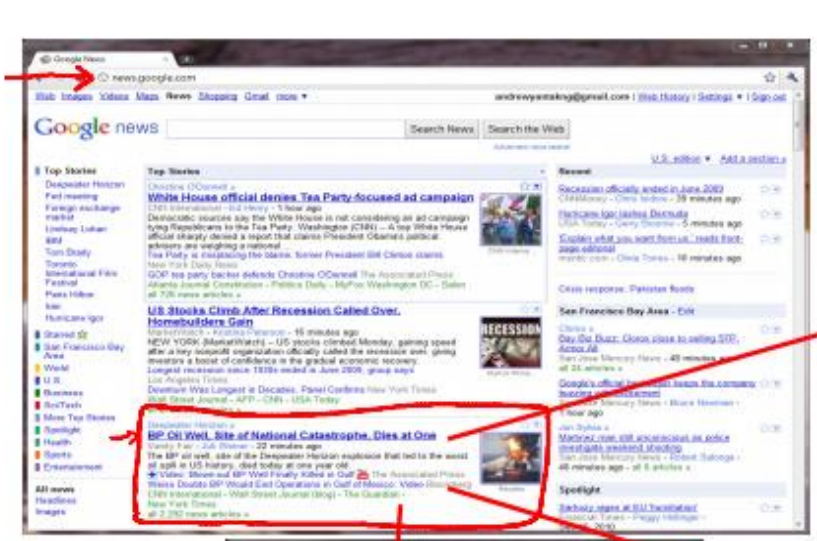
Detecting Fraudulent Transaction

- Online Transactions:
    - Fraudulent((Yes(/(No)?
- Credit card fraud
- Online payment fraud
- Spam instant messages etc.

Clustering


Google News
news.google.com
Web Images Videos Maps News Shopping Gmail more
andrewyantakng@gmail.com | Web History | Settings | Sign out
Google news
Search News
Search the Web
Advanced news search
U.S. edition
Add a section
Top Stories
Deepwater Horizon
Fed meeting
Foreign exchange market
Lindsay Lohan
IBM
Tom Brady
Toronto International Film Festival
Paris Hilton
Iran
Hurricane Igor
Starred
San Francisco Bay Area
World
U.S.
Business
Sci/Tech
More Top Stories
Spotlight
Health
Sports
Entertainment
All news
Headlines
Images
Top Stories
Christine O'Donnell »
White House official denies Tea Party-focused ad campaign
CNN International - Ed Henry - 1 hour ago
Democratic sources say the White House is not considering an ad campaign tying Republicans to the Tea Party. Washington (CNN) -- A top White House official sharply denied a report that claims President Obama's political advisers are weighing a national ...
Tea Party is misplacing the blame, former President Bill Clinton claims New York Daily News
GOP tea party backer defends Christine O'Donnell The Associated Press
Atlanta Journal Constitution - Politics Daily - MyFox Washington DC - Salon
all 726 news articles »
US Stocks Climb After Recession Called Over, Homebuilders Gain
MarketWatch - Kristina Peterson - 16 minutes ago
NEW YORK (MarketWatch) -- US stocks climbed Monday, gaining speed after a key nonprofit organization officially called the recession over, giving investors a boost of confidence in the gradual economic recovery.
Longest recession since 1930s ended in June 2009, group says Los Angeles Times
Downturn Was Longest in Decades, Panel Confirms New York Times
Wall Street Journal - AFP - CNN - USA Today
all 276 news articles »
RECESSION
MyFox Phila...
Deepwater Horizon »
BP Oil Well, Site of National Catastrophe, Dies at One
Vanity Fair - Juli Weiner - 22 minutes ago
The BP oil well, site of the Deepwater Horizon explosion that led to the worst oil spill in US history, died today at one year old.
Video: Blown-out BP Well Finally Killed in Gulf The Associated Press
Weiss Doubts BP Would End Operations in Gulf of Mexico: Video Bloomberg
CNN International - Wall Street Journal (blog) - The Guardian - New York Times
all 2,292 news articles »
Reuters
Recent
Recession officially ended in June 2009
CNNMoney - Chris Isidore - 39 minutes ago
Hurricane Igor lashes Bermuda
USA Today - Gerry Broome - 5 minutes ago
'Explain what you want from us,' reads front-page editorial
msnbc.com - Olivia Torres - 10 minutes ago
Crisis response: Pakistan floods
San Francisco Bay Area - Edit
Clorox »
Bay Biz Buzz: Clorox close to selling STP, Armor All
San Jose Mercury News - 48 minutes ago - all 24 articles »
Google's official beekeeper keeps the company buzzing with excitement
San Jose Mercury News - Bruce Newman - 1 hour ago
Jon Sylvia »
Martinez man still unconscious as police investigate weekend shooting
San Jose Mercury News - Robert Salonga - 48 minutes ago - all 6 articles »
Spotlight
Sarkozy rages at EU 'humiliation'
Financial Times - Peggy Hollinger - Sep 16, 2010

Clustering


Google news
White House official denies Tea Party-focused ad campaign
US Stocks Climb After Recession Called Over, Homebuilders Gain
BP Oil Well, Site of National Catastrophe, Dies at One


THE WALL STREET JOURNAL.
THE SOURCE
BP Kills Macondo, But Its Legacy Lives On


CNN
Allen: Well is dead, but much Gulf Coast work remains
Click to play


guardian.co.uk
BP oil spill cost hits nearly $10bn

Outline

- What?
- Why?
- **Who?**
- How?

My Background

- **Rao Muhammad Umer**
- MS Computer Science (Continue…)
- Email address: engr.raoumer943@gmail.com
- Web: https://raoumer.github.io

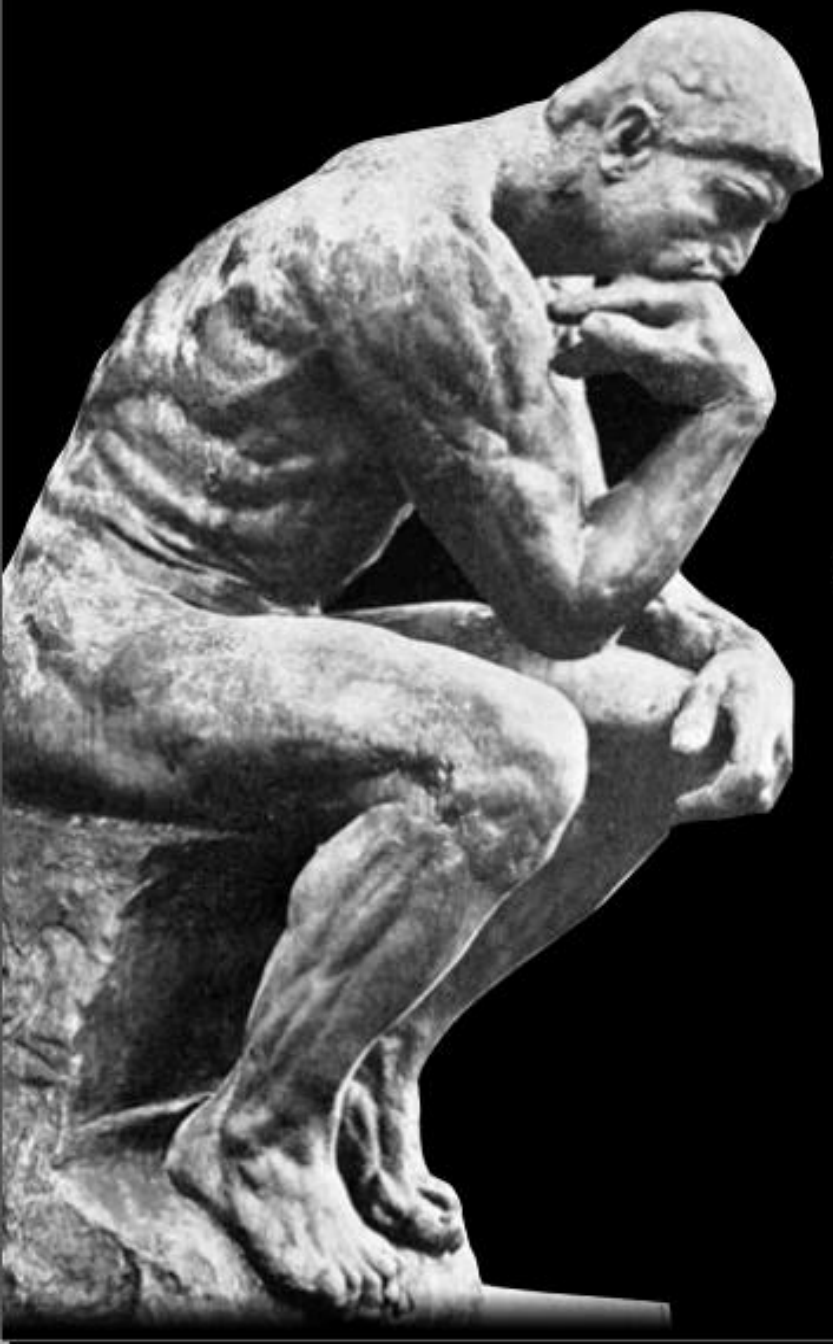
- Github:

  http://raoumer.github.io/GPU-Workshop-PIEAS-2016

About You

Outline

- What?
- Why?
- Who?
- **How?**



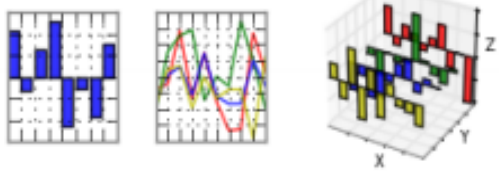
Abstractions...

...and Tools

IP[y]: IPython
Interactive Computing

pandas

$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



scikits learn
machine learning in Python

NumPy

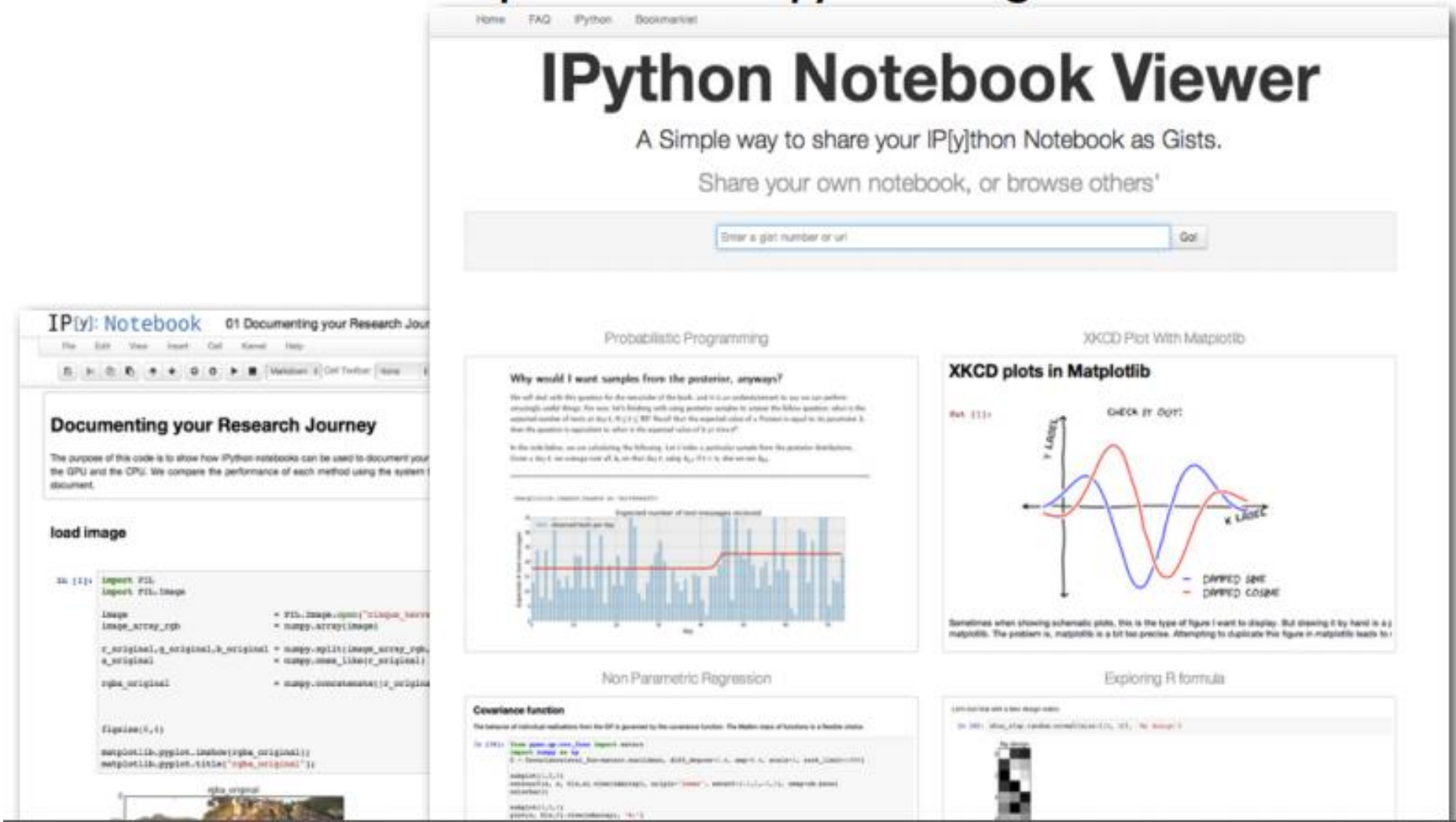
SciPy.org Sponsored By ENTHOUGHT

matplotlib

mrjob

IPython Notebooks

http://nbviewer.ipython.org/



Is this possible for me ???

Prerequisites

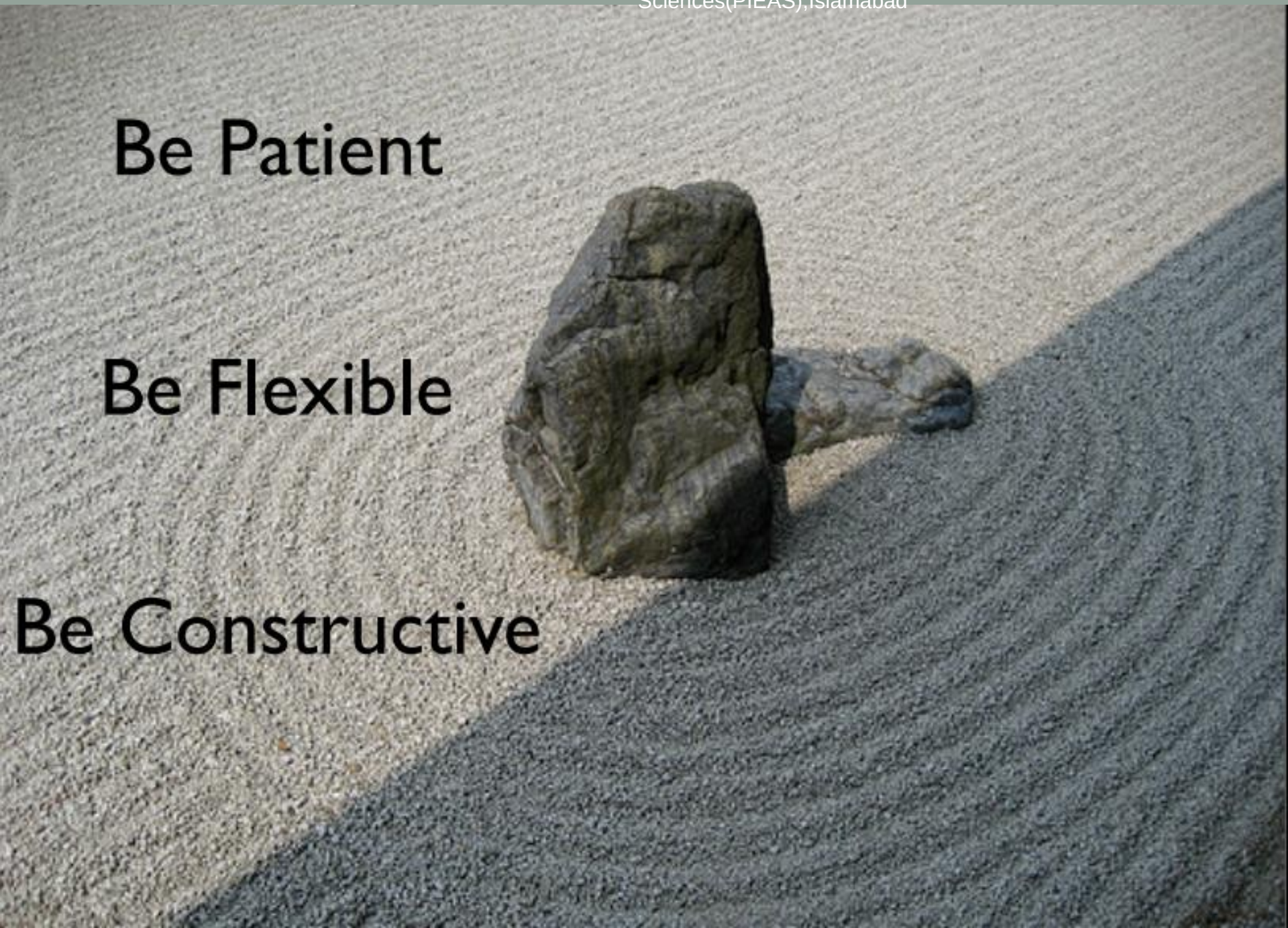
- Programming experience

  C, C++, Java, Python, **Cuda C** etc.

- Basic statistical knowledge

  Mean, Standard Deviation, Probability etc.

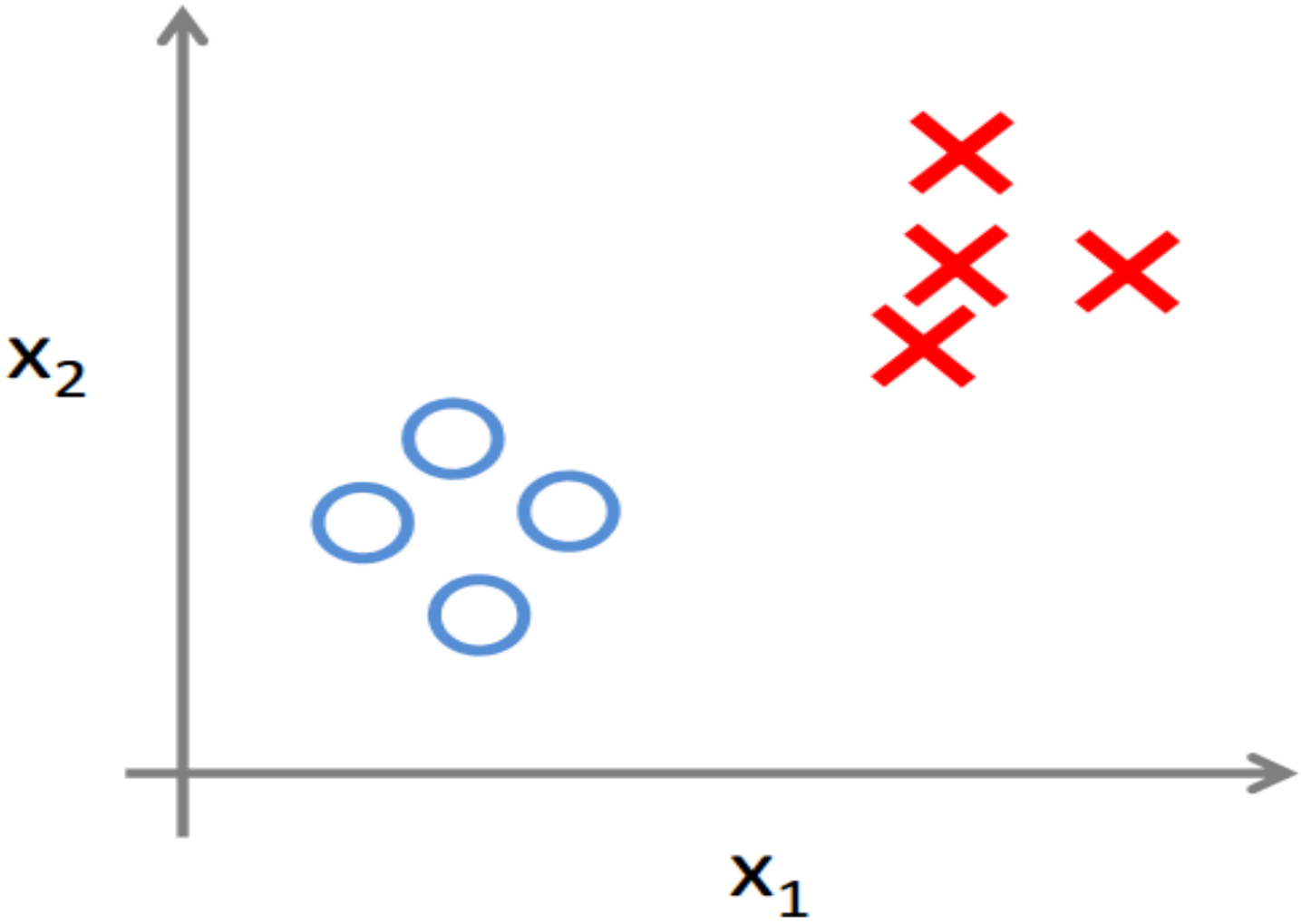
- Willingness to learn new software & tools
  - This can be time consuming
  - You will need to read online documentation


Be Patient
Be Flexible
Be Constructive

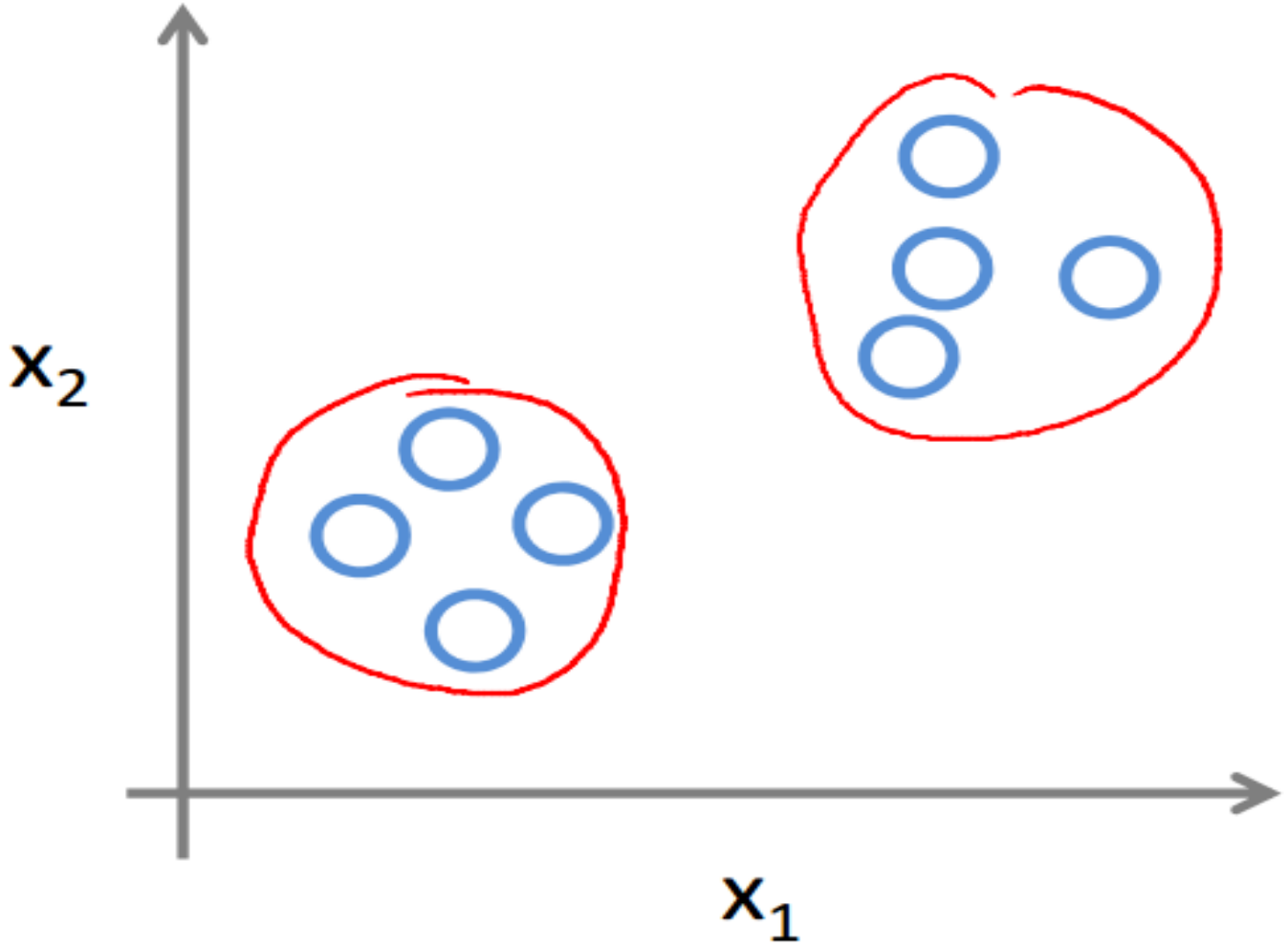
REGRESSION

PART-II:
Theoretical Basics

Supervised Learning



Unsupervised Learning



Linear Regression

Housing Price Prediction

- Supervised Learning
  - “right answers” given
- Regression: Predict continuous valued output (price)

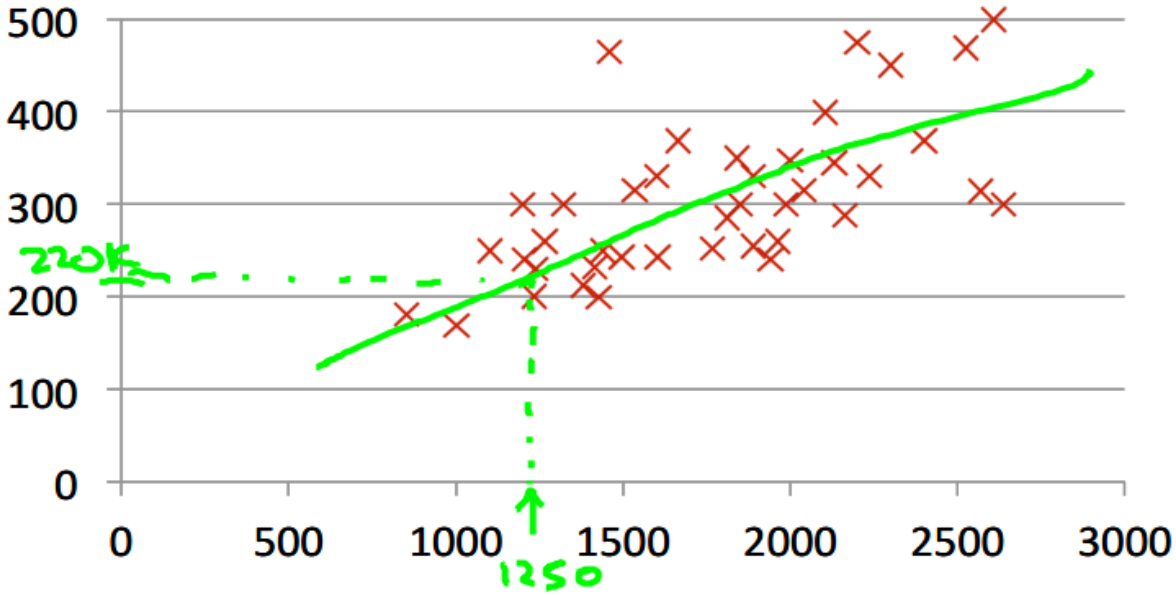
Training set of Housing Prices

Size in feet² (x)	Price ($) in 1000's (y)
2104	460
1416	232
1534	315
852	178
...	...

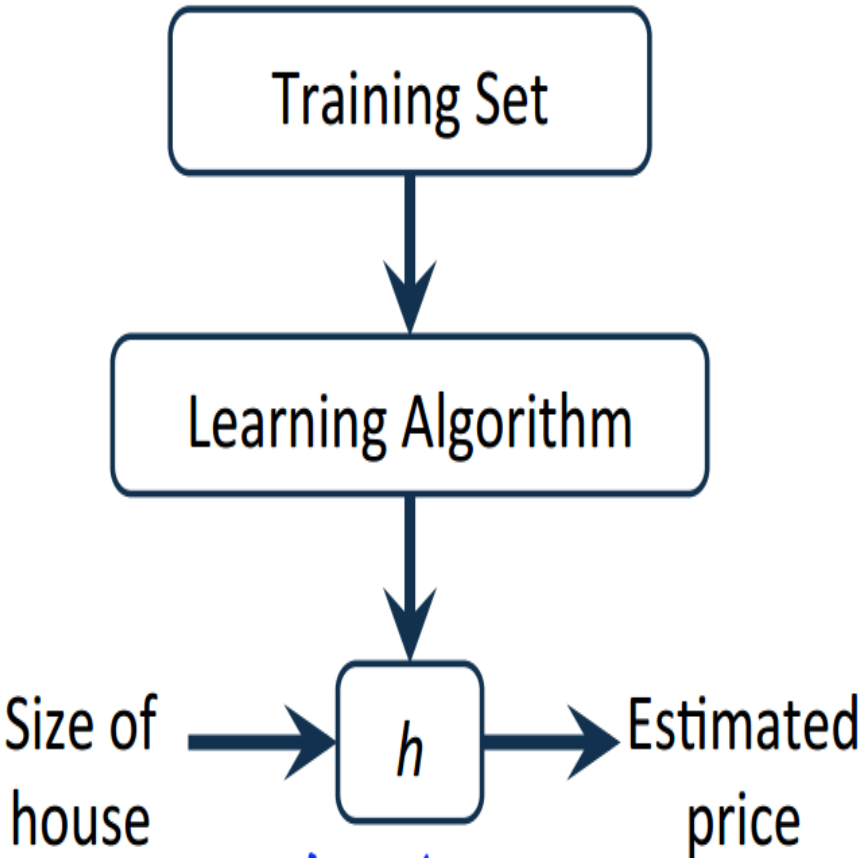
$m = 47$

Simple Linear Regression

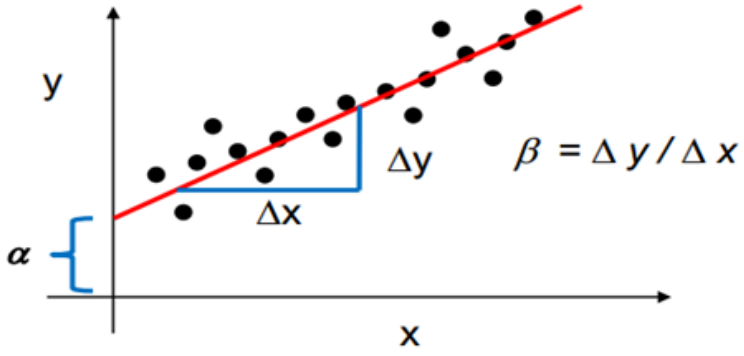
- Housing Prices



- Supervised Learning
  - Given the “right answer” for each example in the data
- Regression Problem
  - Predict real-valued output



- **How do we represent h?**



- Linear regression with one variable
- Univariate linear regression

Cost function

Hypothesis:

$$h_\theta(x) = \theta_0 + \theta_1 x$$

Parameters:

$$\theta_0, \theta_1$$

Cost Function:

$$J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)}\right)^2$$

Goal: $\underset{\theta_0, \theta_1}{\text{minimize}}\ J(\theta_0, \theta_1)$

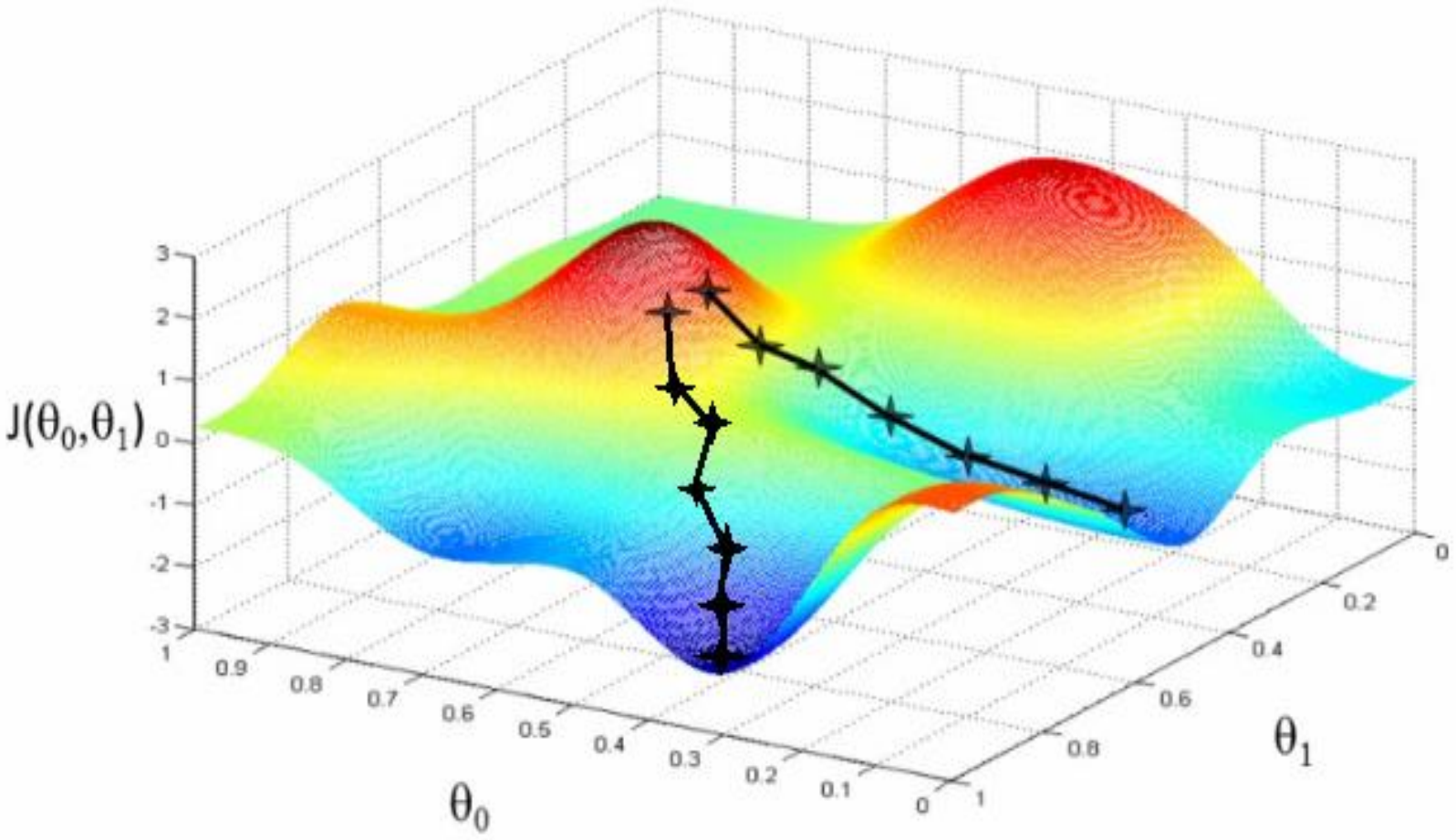
Gradient Descent

- Repeat until convergence {

$$\theta_j := \theta_j - \alpha \frac{\partial}{\partial \theta_j} J(\theta_0, \theta_1) \quad (\text{for } j = 0 \text{ and } j = 1)$$

}

Gradient Descent



Gradient Descent for Linear Regression

Gradient descent algorithm

repeat until convergence {

$$\theta_j := \theta_j - \alpha \frac{\partial}{\partial \theta_j} J(\theta_0, \theta_1)$$

$$(\text{for } j = 1 \text{ and } j = 0)$$

}

Linear Regression Model

$$h_\theta(x) = \theta_0 + \theta_1 x$$

$$J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

Multiple Linear Regression

- Linear Regression with Multiple variables

Size (feet²) x_1	Number of bedrooms x_2	Number of floors x_3	Age of home (years) x_4	Price ($1000) y
2104	5	1	45	460
1416	3	2	40	232
1534	3	2	30	315
852	2	1	36	178

$$h_\theta(x) = \theta_0 + \theta_1 x_1 + \theta_2 x_2 + \cdots + \theta_n x_n$$

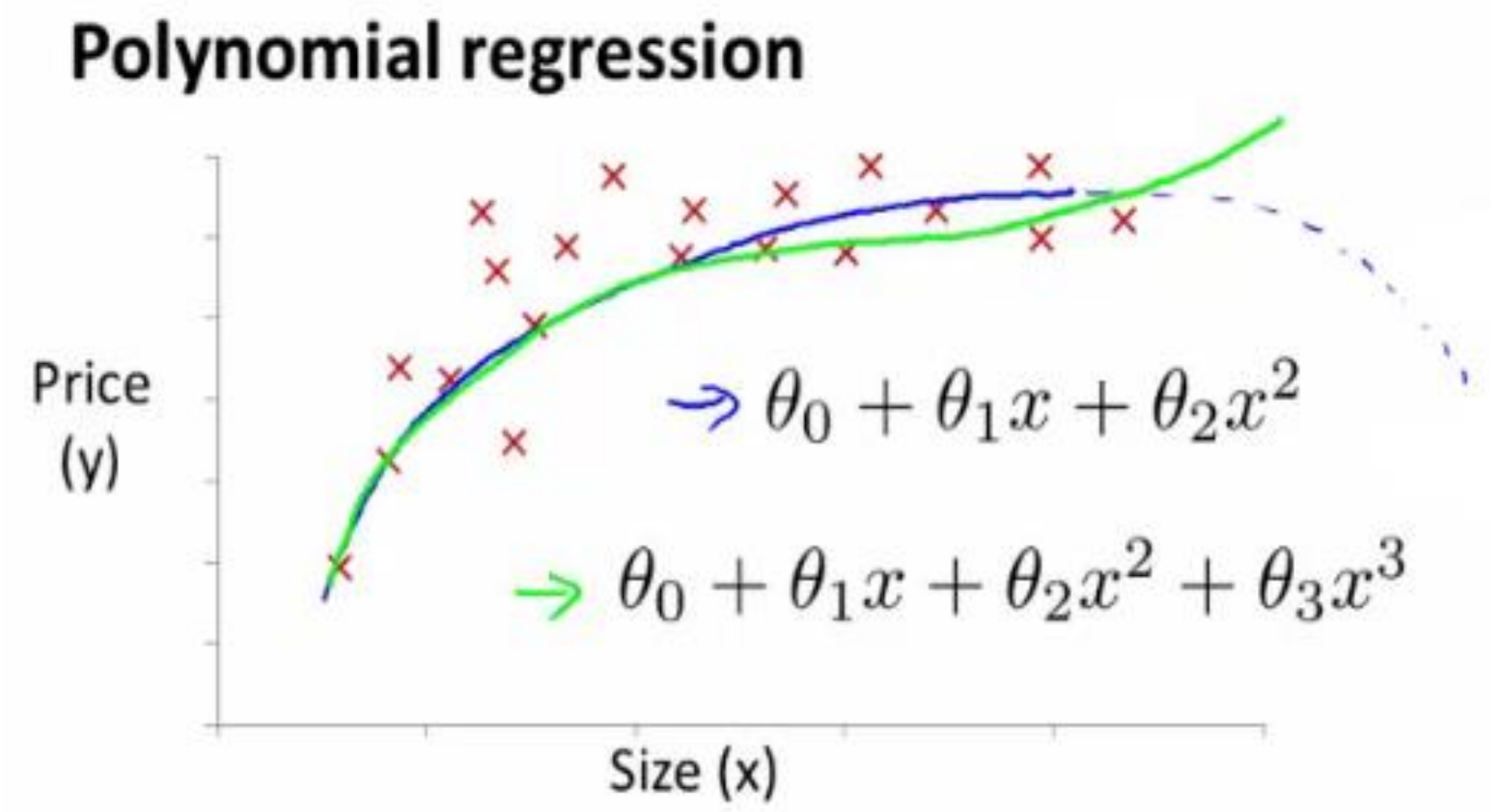
Polynomial Regression

- Housing Price Prediction

$$h_\theta(x) = \theta_0 + \theta_1 \times frontage + \theta_2 \times depth$$

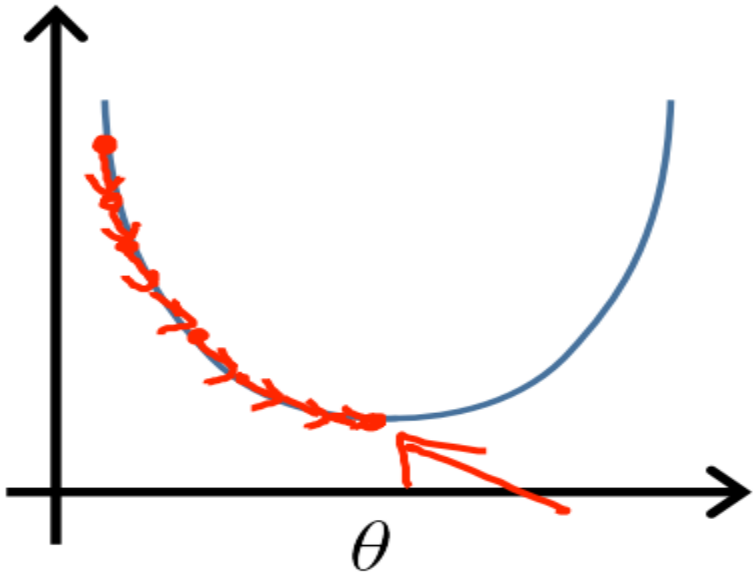
x_1 x_2

Polynomial Regression



Normal Equation

- Gradient Descent



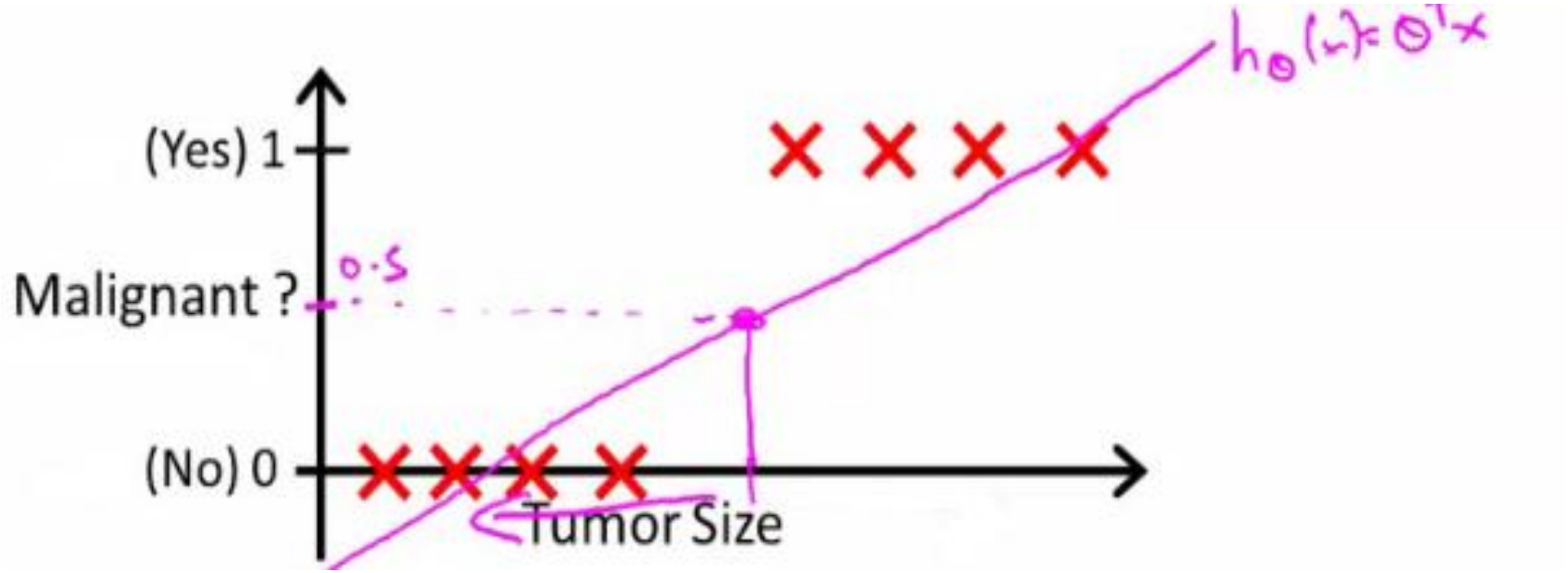
- Normal equation
  - Method to solve for θ analytically

Normal Equation

$$\theta = (X^T X)^{-1} X^T y$$

- **pinv(X' * X) *X' * y**

Logistic Regression



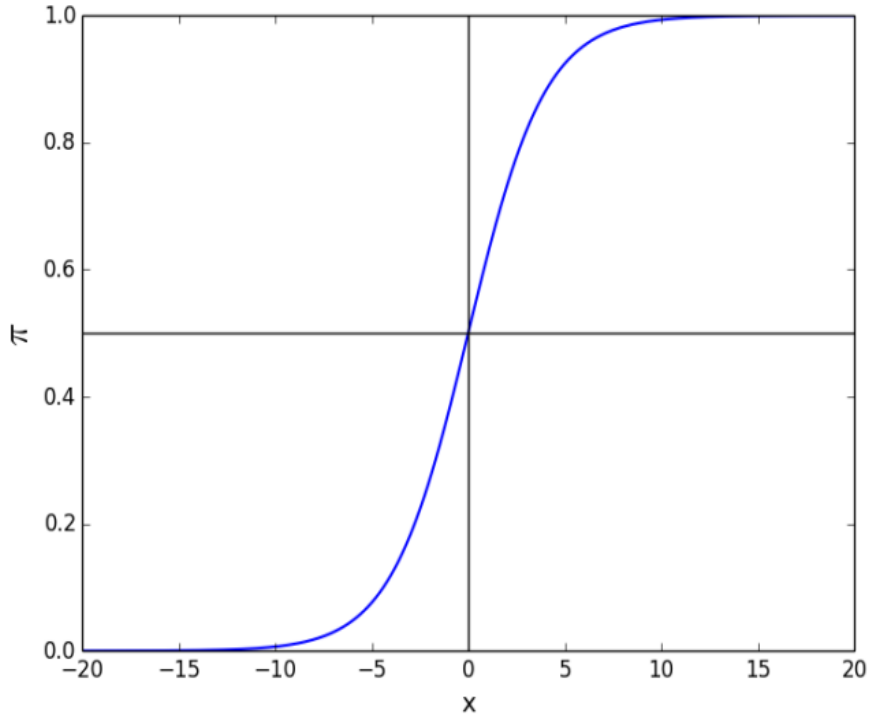
Threshold classifier output $h_\theta(x)$ at 0.5:

If $h_\theta(x) \geq 0.5$, predict "y = 1"

If $h_\theta(x) < 0.5$, predict "y = 0"

Logistic Regression Model

- Sigmoid Function
- Logistic Function



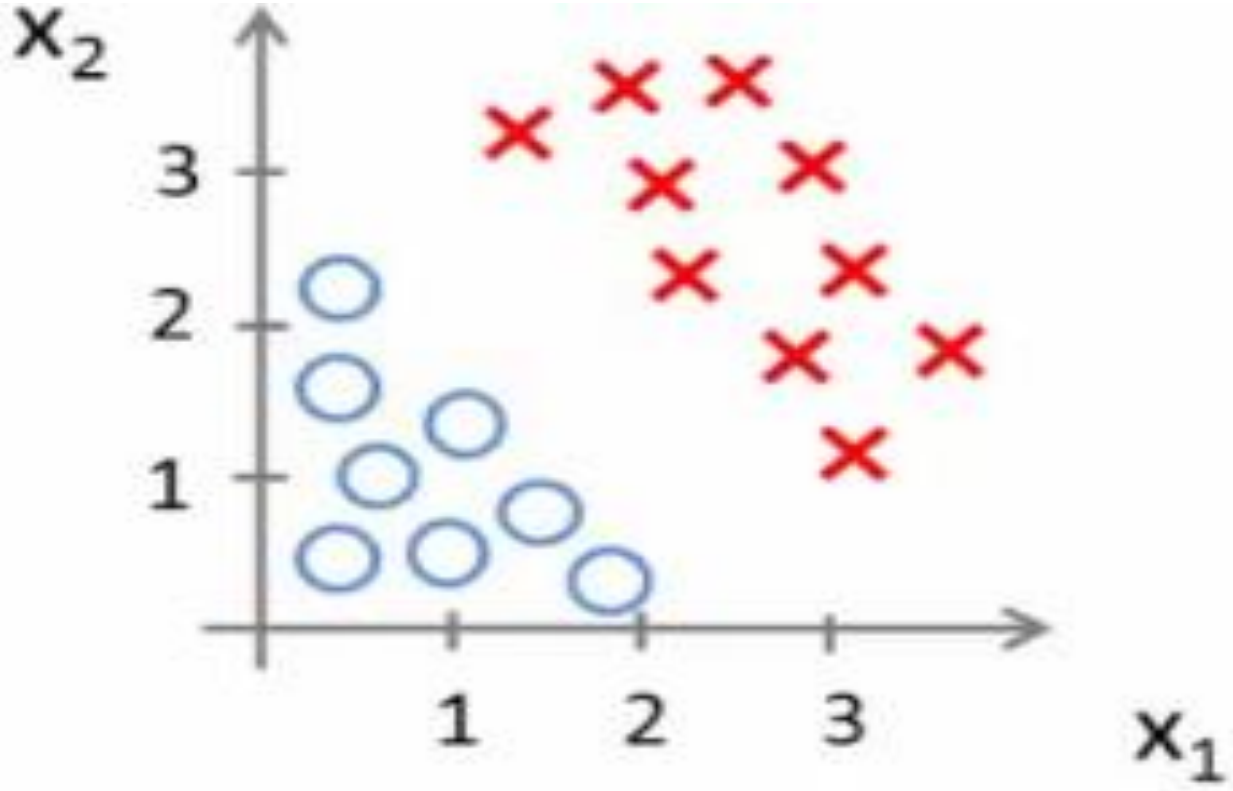
$$h_\theta(x) = g(\theta^T x)$$

$$g(z) = \frac{1}{1+e^{-z}}$$

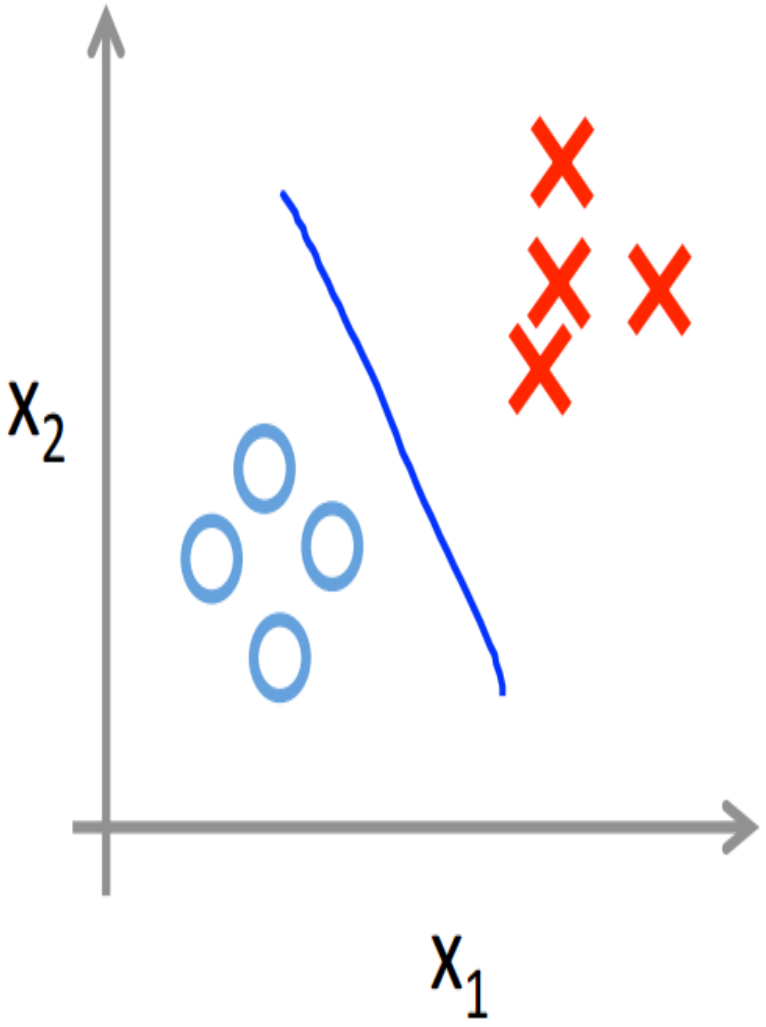
Suppose predict "$y = 1$" if $h_\theta(x) \geq 0.5$

predict "$y = 0$" if $h_\theta(x) < 0.5$

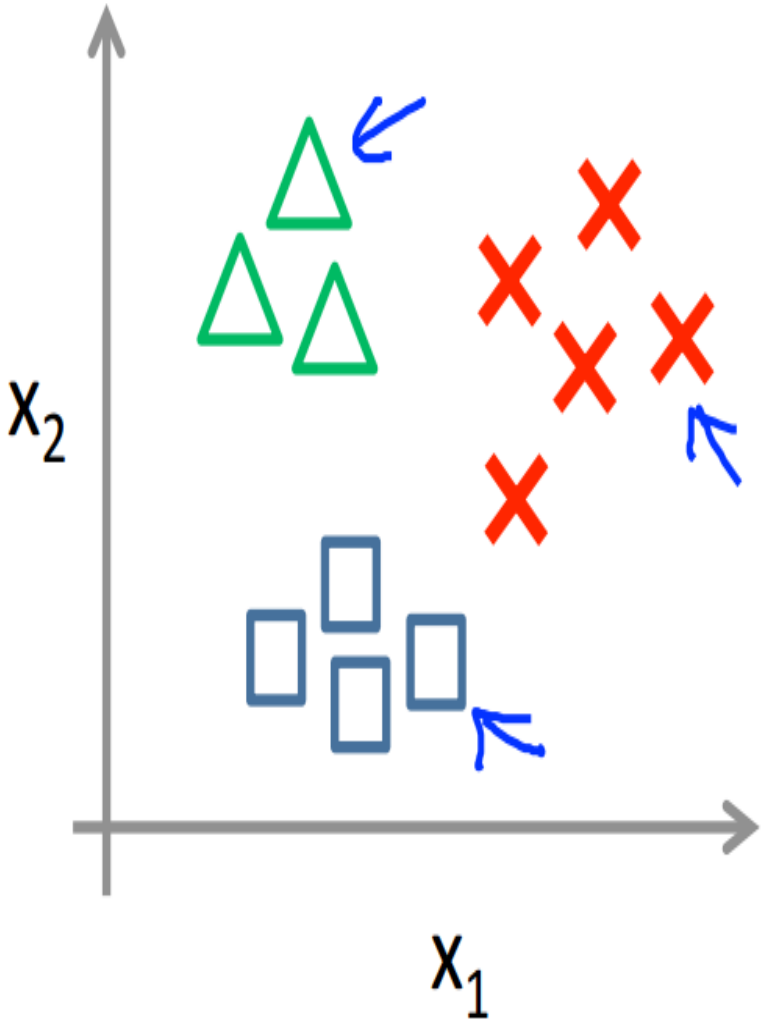
Classification



Binary classification:



Multi-class classification:



REGRESSION

PART-III: Implementation

Predicting House Price

LINEAR REGRESSION EXAMPLE

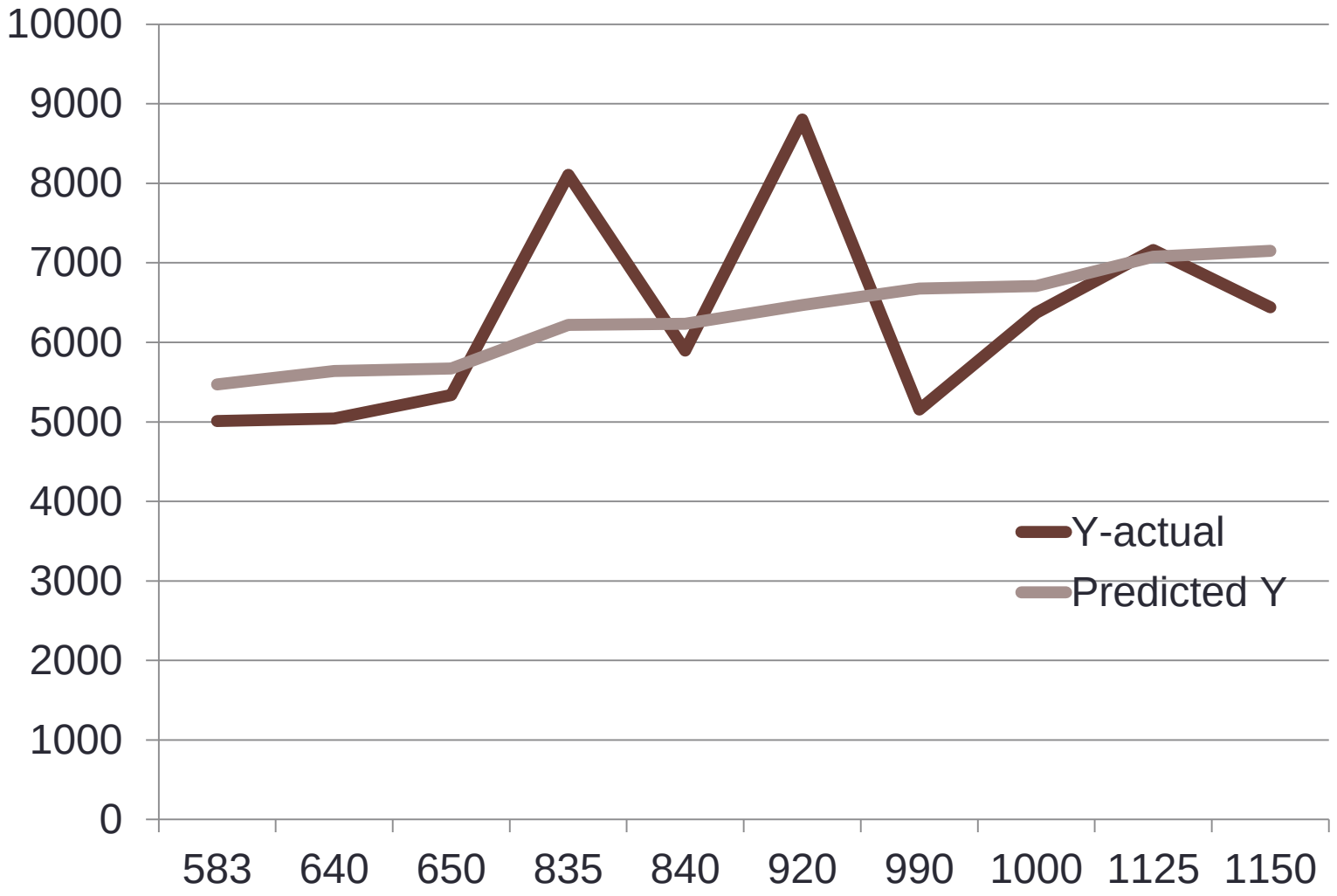
X	Y	XY	X^2
1125	7160	8055000	1265625
920	8804	8099680	846400
835	8108	6770180	697225
1000	6370	6370000	1000000
1150	6441	7407150	1322500
990	5154	5102460	980100
840	5896	4952640	705600
650	5336	3468400	422500
640	5041	3226240	409600
583	5012	2921996	339889
ΣX	ΣY	ΣXY	ΣX^2
8733	63322	56373746	7989439

X-mean	Y-mean
873.3	6332.2
b0	b1
3746.198	2.961183

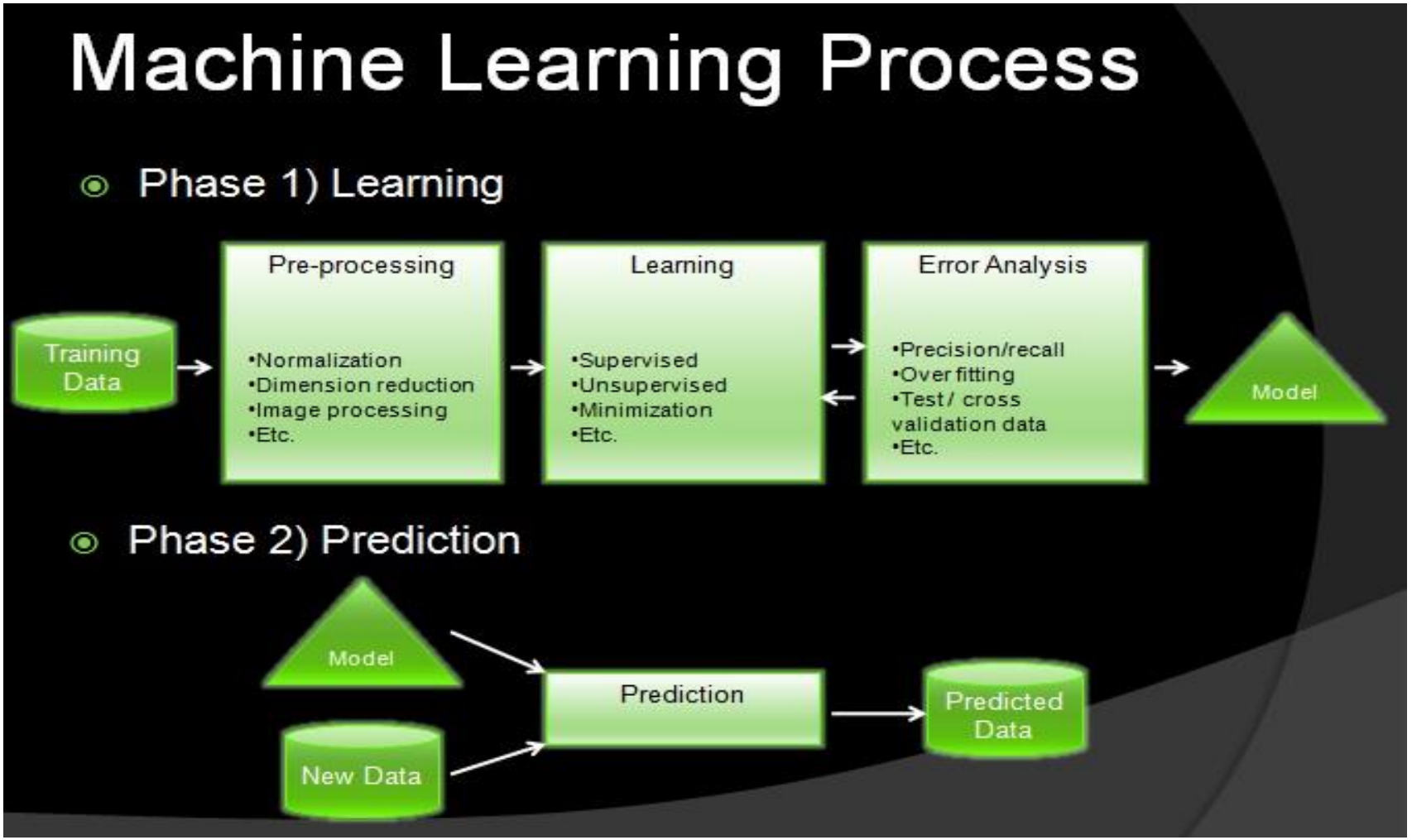
$$\beta_0 = \frac{(\sum X^2)(\sum Y) - (\sum X)(\sum XY)}{n\sum X^2 - (\sum X)^2}$$

$$\beta_1 = \frac{n\sum XY - (\sum X)(\sum Y)}{n\sum X^2 - (\sum X)^2}$$

LINEAR REGRESSION EXAMPLE



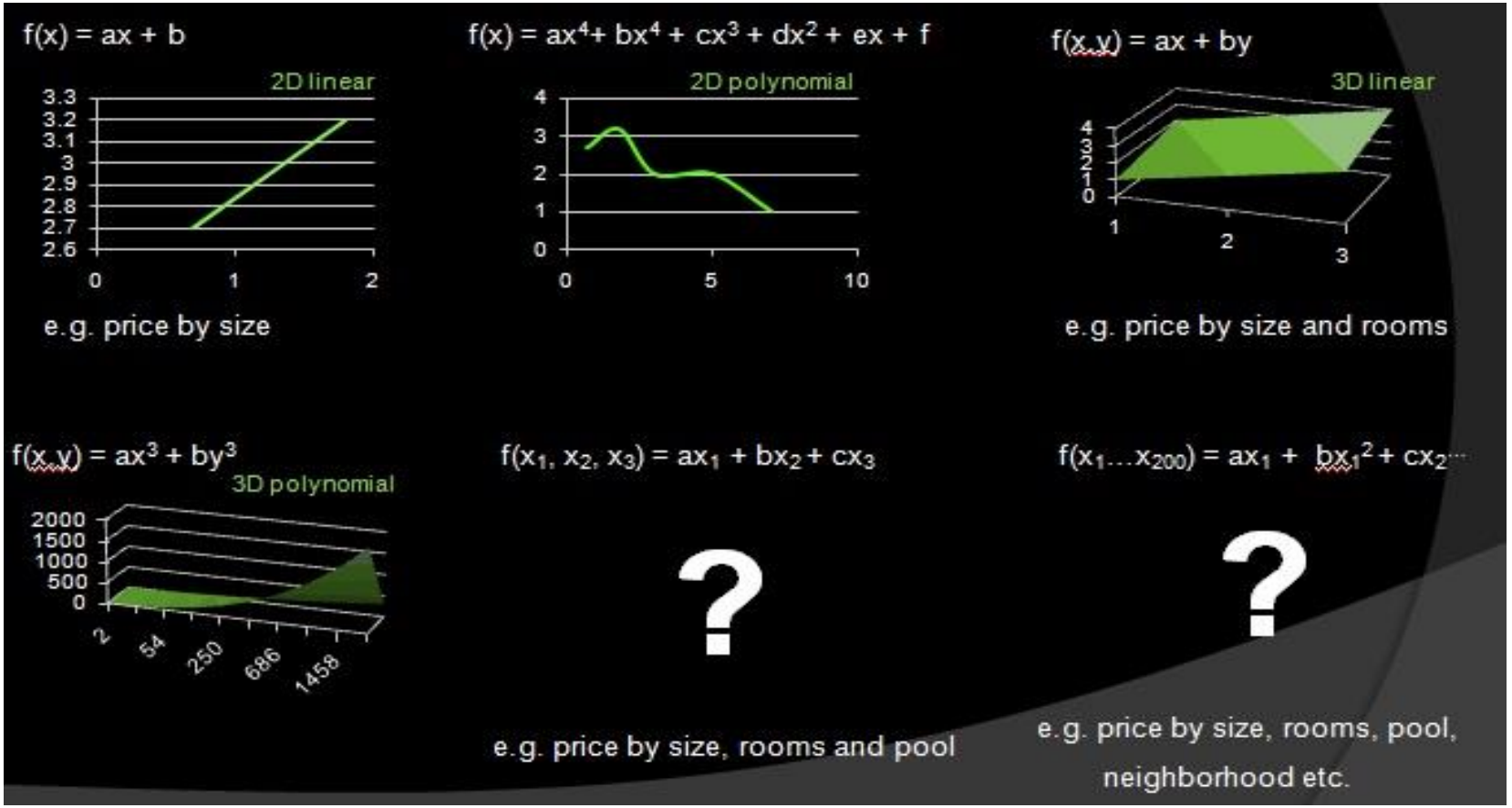
Machine Learning



Machine Learning

Figure shows how one feature can be used on a linear regression problem to predict new house prices

Machine Learning

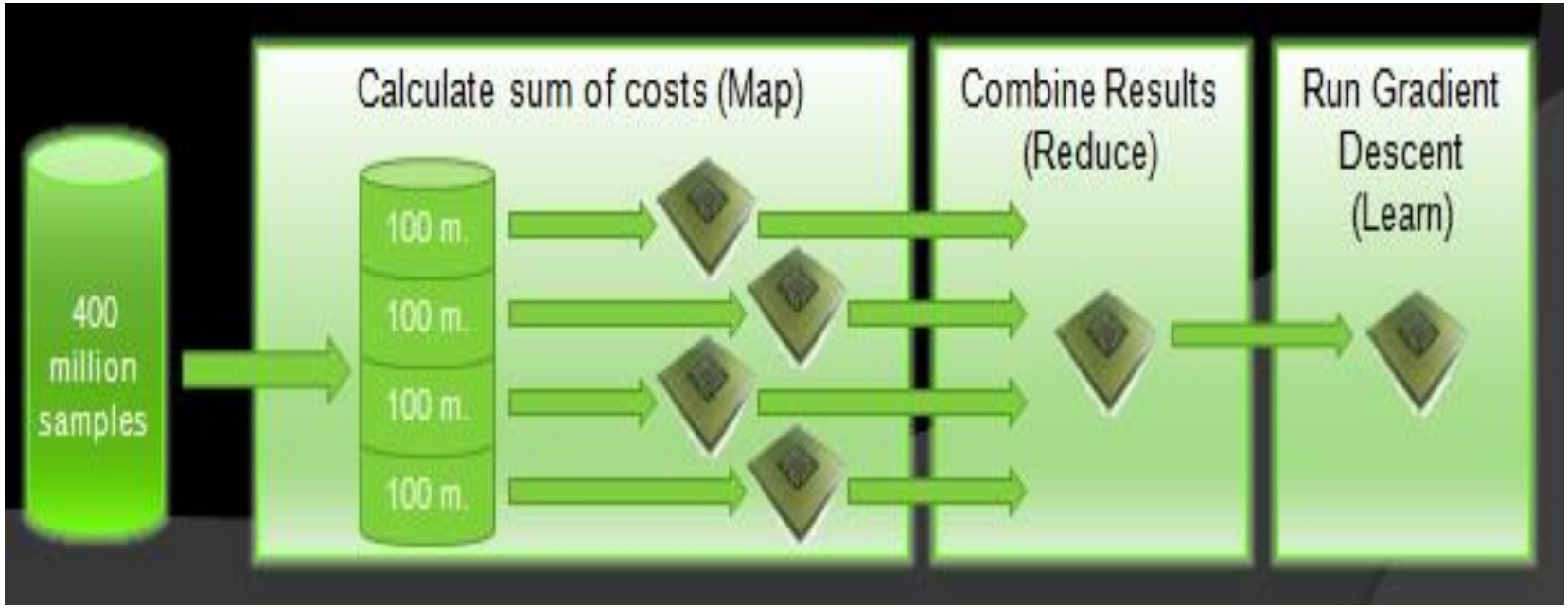


On Figure how the complexity can grow easily from 2 dimensions linear to hundreds of dimensions polynomial

Gradient Descent

Figure shows how a training data is plot and the error is calculated

Large Scale Machine Learning



In Figure we can see how the data is split into four parts and fed into four different processors

Large Scale Machine Learning

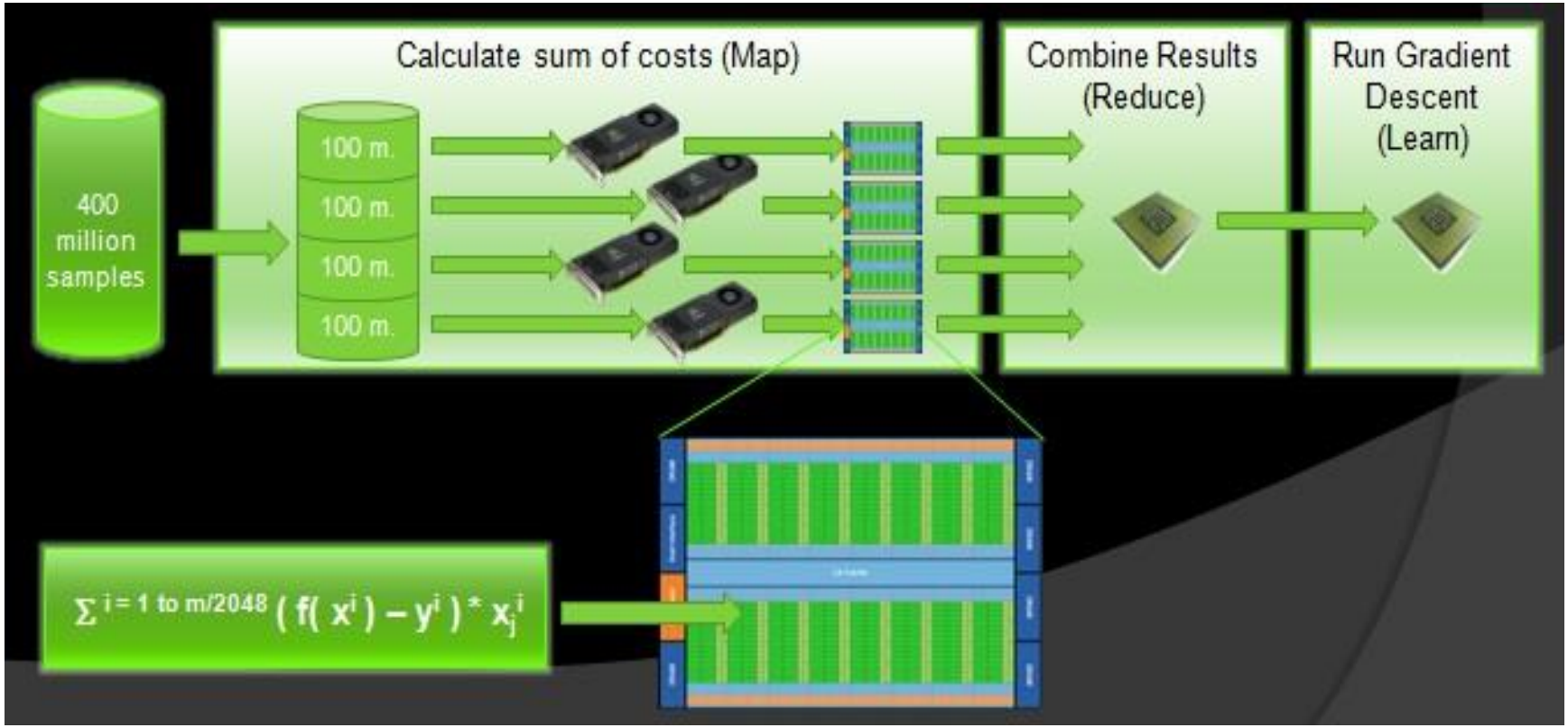
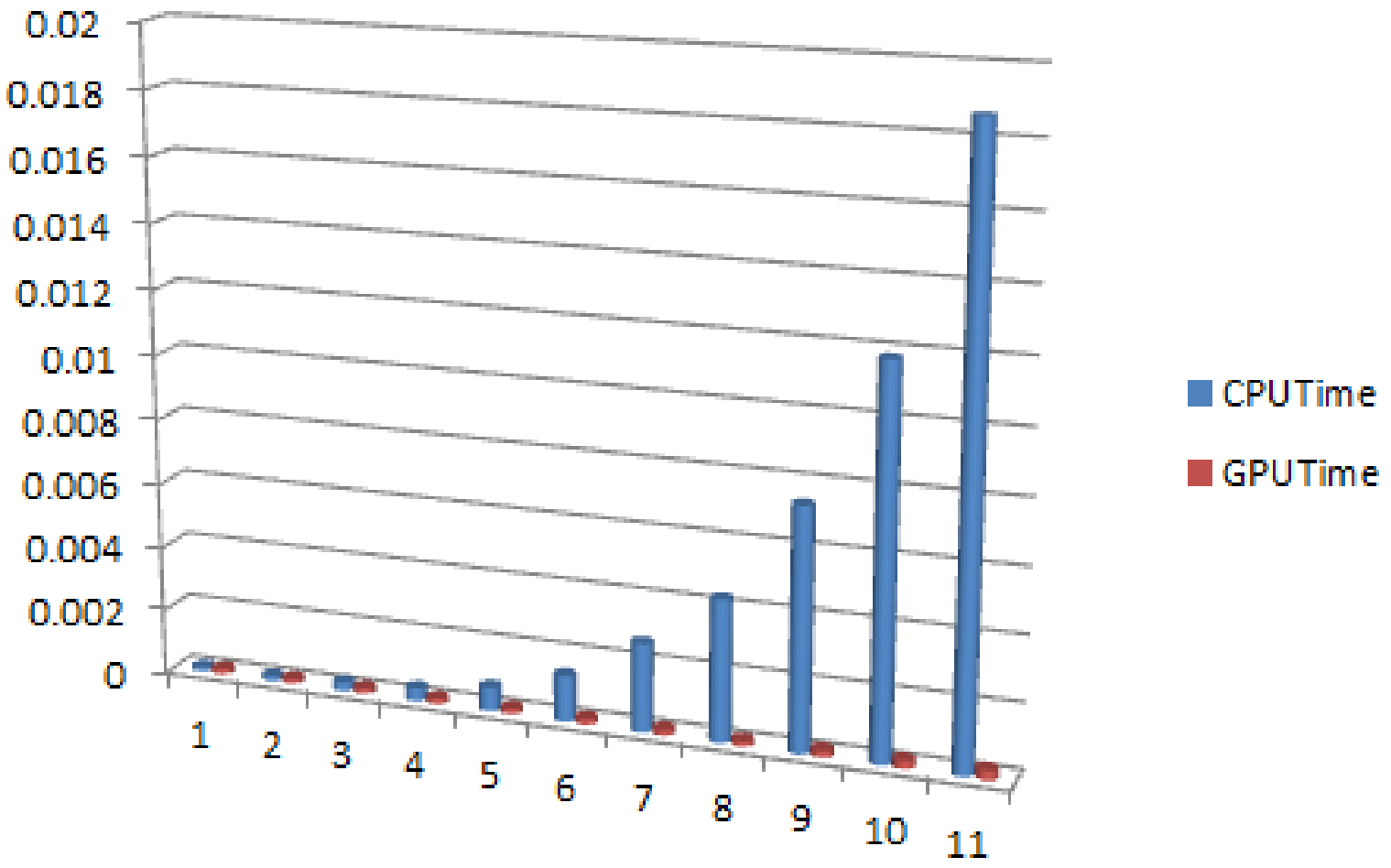


Figure shows this configuration along with the parallelized part on the GPU cores

GPGPU

- Utilizing GPUs to enable dramatic increases in computing performance of general purpose scientific and engineering computing is named GPGPU.
- NVIDIA is providing a parallel computing platform and programming model named CUDA to develop GPGPU software on C, C++ or Fortran which can run on any NVIDIA GPU.

CPU vs GPU Time



Conclusion

- **GPGPU**, **Machine Learning** and **Big Data** are three rising fields in the IT industry.
- As much as we get deeper into these fields ,we figure out how well they fit together.
- I hope this sample application gave you some basic idea and maybe just one perspective how you can use **NVIDIA CUDA** easily on machine learning problems.

References

- http://gpgpu.org/
- https://en.wikipedia.org/wiki/Linear_regression
- https://docs.nvidia.com/cuda/
- https://en.wikipedia.org/wiki/Polynomial_regression
- https://en.wikipedia.org/wiki/Gradient_descent
- https://en.wikipedia.org/wiki/Overfitting
- https://en.wikipedia.org/wiki/Regularization_(mathematics)
- http://www.nvidia.com/object/machine-learning.html
- https://developer.nvidia.com/nvidia-nsight-visual-studio-edition
- https://docs.nvidia.com/cuda/thrust/index.html
- https://adnanboz.wordpress.com/2012/02/25/large-scale-machine-learning-using-nvidia-cuda/

References

- http://statsmodels.sourceforge.net/
- http://www.nature.com/ejhg/journal/v17/n8/full/ejhg2009 5a.html
- http://www.alsharif.info/#!iom530/c21o7
- Some slides taken from Dr. Andrew Ng. Course of Machine Learning