Machine Learning : Lecture -1

Introduction

Topics (Part -1)

Tutorials: (Mon 5.00 PM -6.30 PM)

R-102 – Batch 1
R-104 – Batch 2
R-105 – Batch 3
R-110 – Batch 4

1. Linear modelling:

Least square (LS)
Non-linear response from linear models
Generalization versus overfitting
Regularized Least Squares:
L2, L1 regularization (LASSO)

2. Maximum likelihood (ML) approach

3. Classifiers:
Probabilistic Classifier: Bayes classifier, Logistic regression
Non-Probabilistic classifier: K-nearest neighbours

4. Decision Trees

5. Random Forests

6. Gradient Boosting

Text Books:
1 , 2, 3: A first Course on Machine Learning by Simon Rogers
4,5,6 : Multiple references, will be mentioned on slides.

Reference:
Machine Learning: Foundations, Methodologies, and Applications by Alexander Jung

Assessment Plan: Part 1 (50 Marks)

Class Quiz (After Aug 31) : 10 Marks

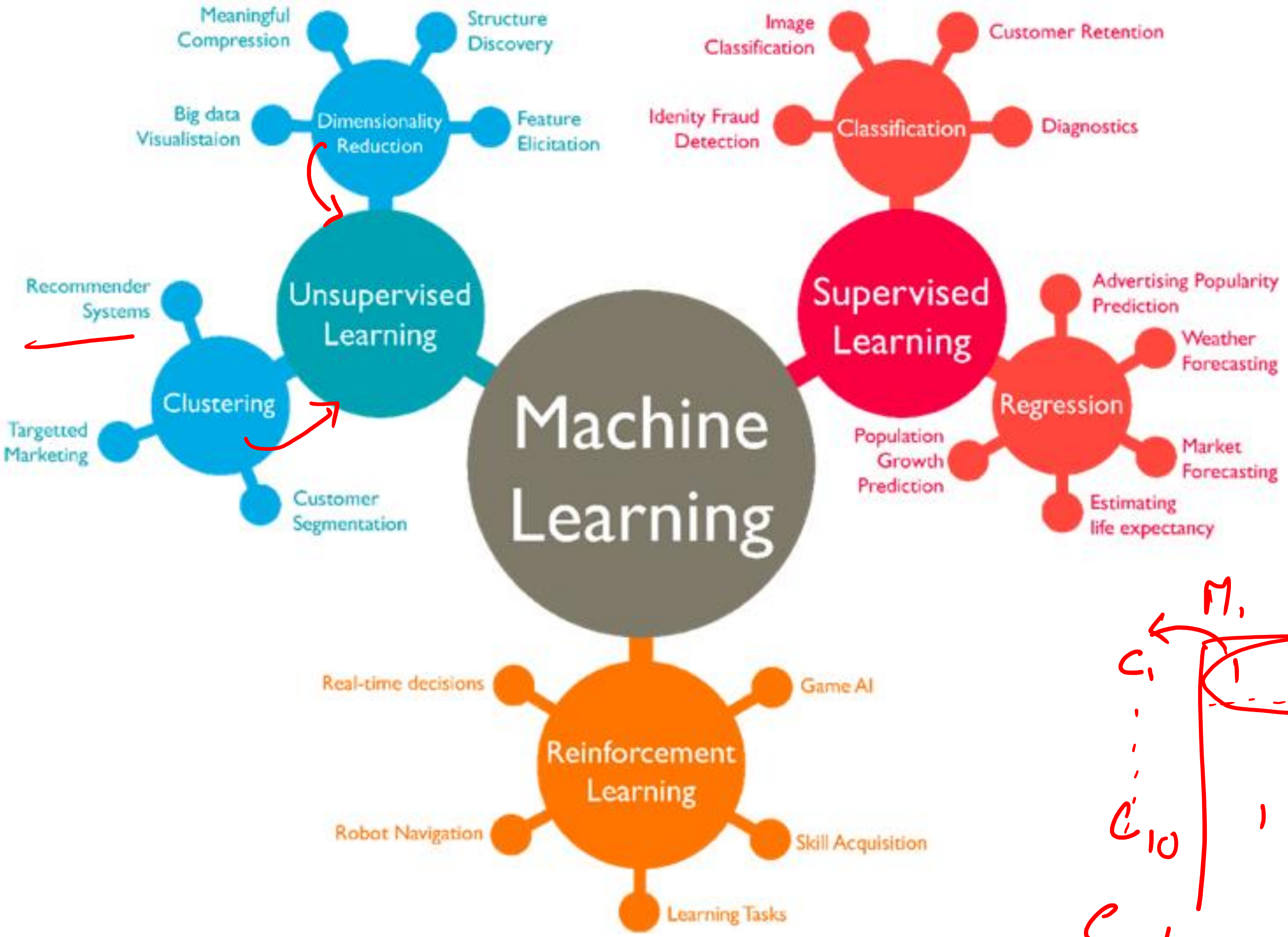
Assignment – 1 (After Sep 15) : 10 Marks

Mid-term: 20 Marks

Tutorial Assessment (Multiple assessments spread across random tutorial days): 5 Marks

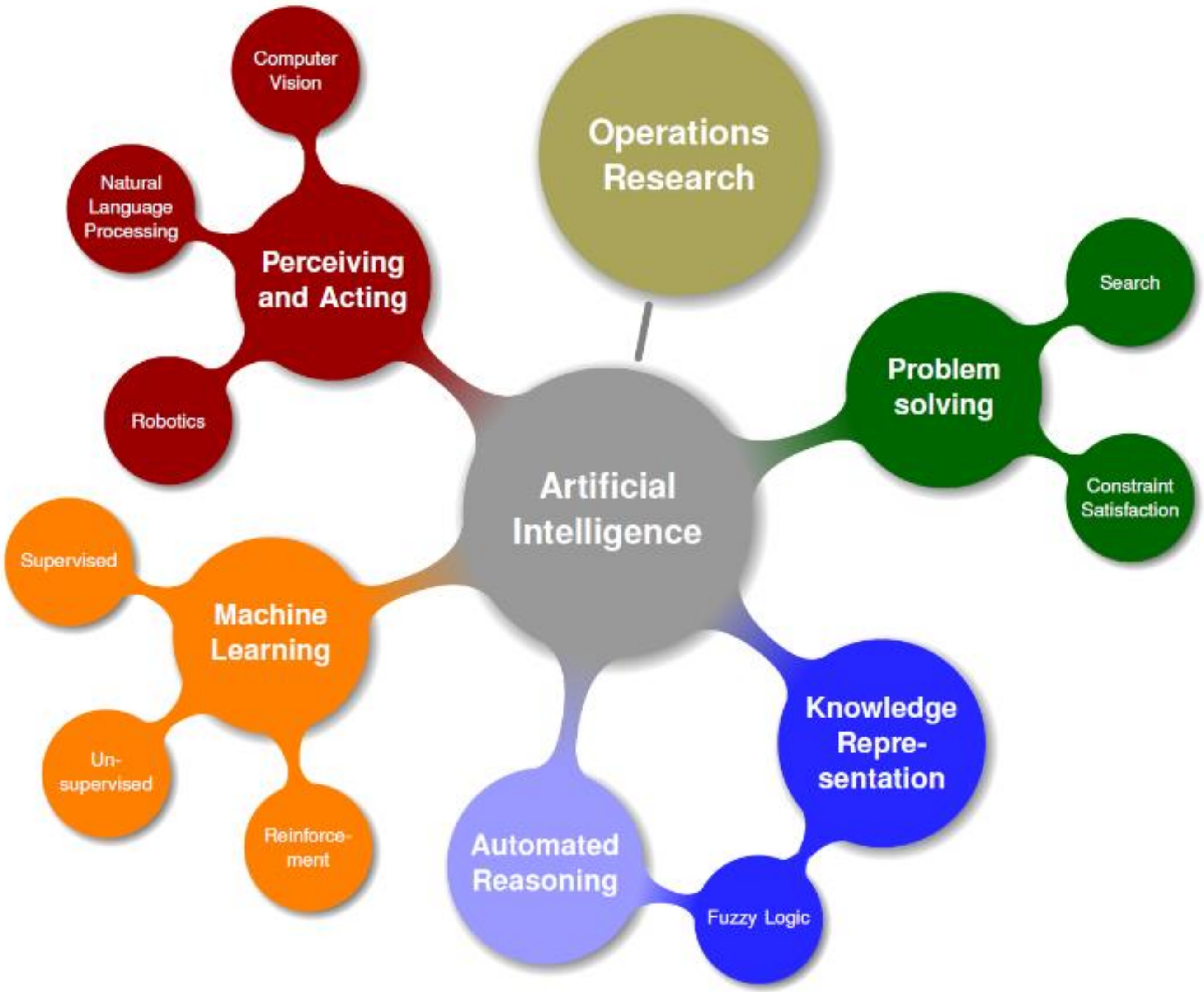
Class Participation: 5 Marks

Machine Learning



$$
\begin{array}{c|ccccc}
 & M_1 & M_2 & \dots & M_{100} & M_{1000} \\
\hline
C_1 & 1 & & 1 & & \\
\vdots & & & & & \\
C_{10} & 1 & \dots & 1 & 0 & \dots \\
C_{10^6} & & & & &
\end{array}
$$

Machine Learning and Artificial Intelligence



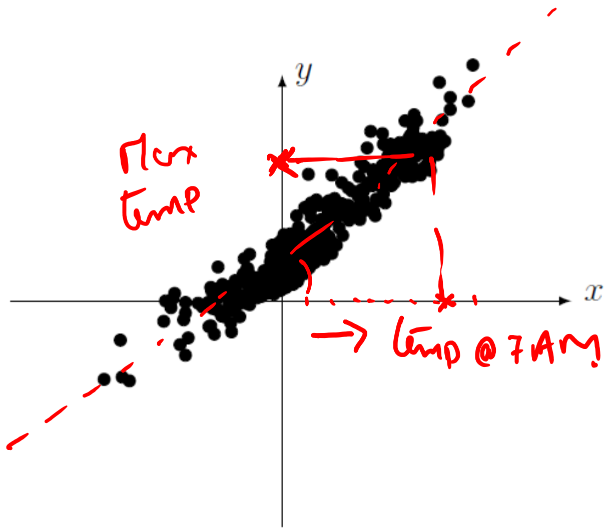
Artificial intelligence is a set of technologies implemented *in* a system to enable it to reason, learn, and act to solve a complex problem.

A Simple Learning Example

$w \in \mathbb{R}$ $\quad x \in \mathbb{R}^2$

Objective: Predict the maximum day temperature after observing the temperature at 7 AM.

Observations:

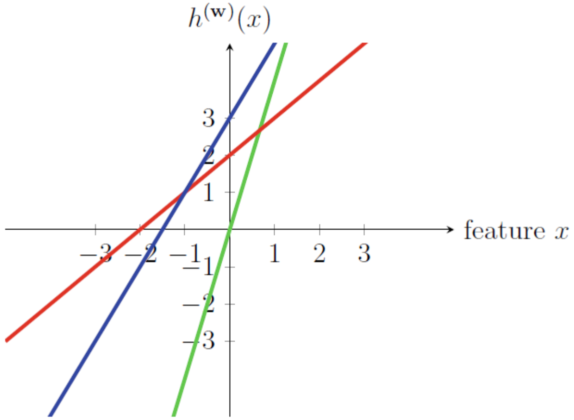


x : Temperature at 7 AM

y : Maximum Day Temperature

How can we find suitable w_1 and w_0?

Sample hypotheses: $h(x) := w_1 x + w_0 \quad w_1 \in \mathbb{R}_+, w_0 \in \mathbb{R}.$



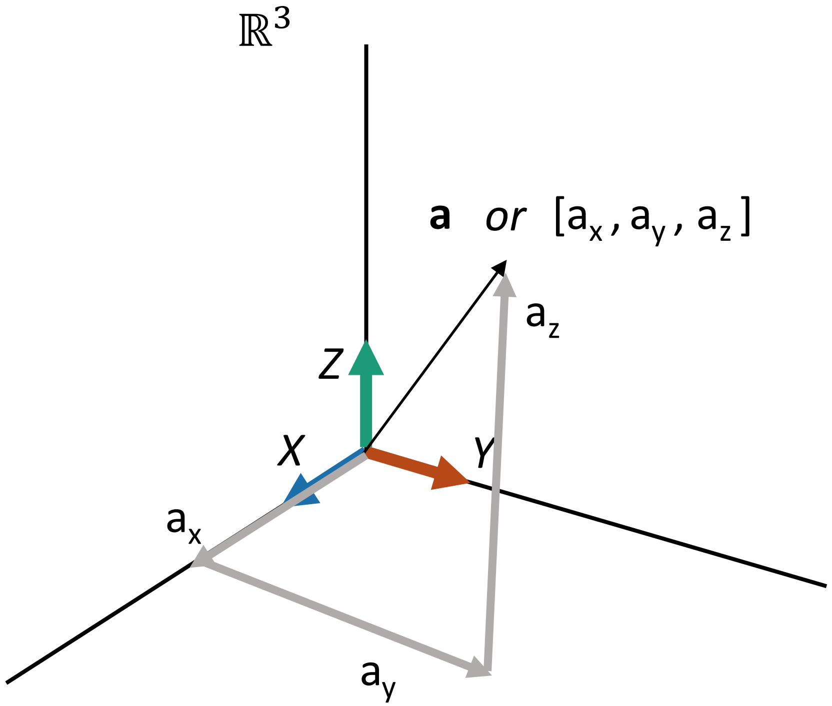
Model:

$$y \approx w_1 x + w_0$$

$y = x^3 + x^2 + \dots x + \dots$

ML Objective: Find the "best" hypothesis from the set of feasible hypotheses

[ML & Linear Algebra] : Vector Representation



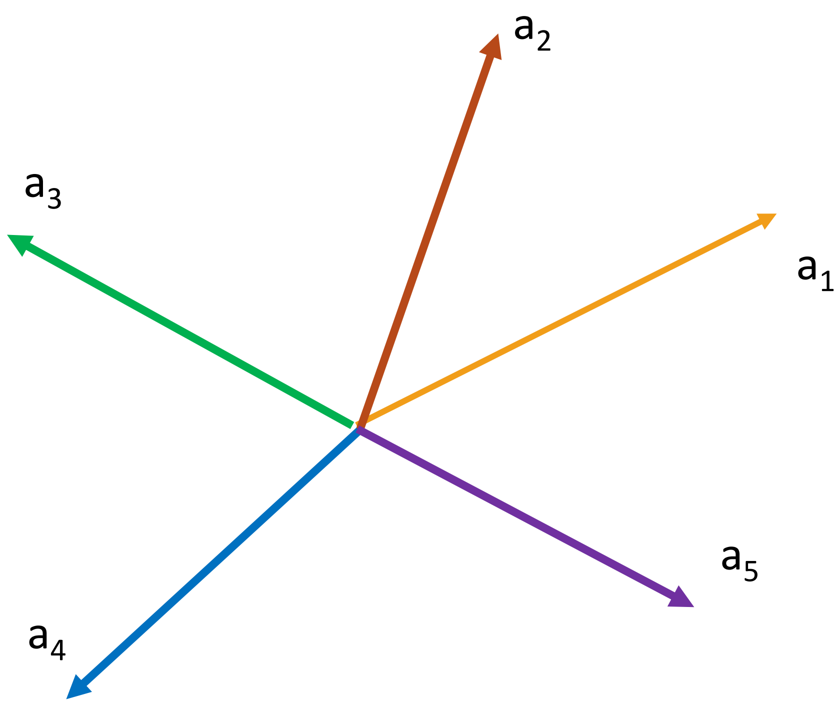
$a \in \mathbb{R}^3$

$[a_x, a_y, a_z]$ ➡ Point in 3- dimensional Space / 3-dimensional Vector / Data

[ML & Linear Algebra] : Data in Multi-Dimensional Space

5 –Dimensional Space ($\mathbb{R}^5$)

(Do not bother to Imagine !
Look only Algebraic way)



$$a_1 = \begin{bmatrix}1\\0\\0\\0\\0\end{bmatrix} \quad a_2 = \begin{bmatrix}0\\1\\0\\0\\0\end{bmatrix} \quad a_3 = \begin{bmatrix}0\\0\\1\\0\\0\end{bmatrix}$$

$$a_4 = \begin{bmatrix}0\\0\\0\\1\\0\end{bmatrix} \quad a_5 = \begin{bmatrix}0\\0\\0\\0\\1\end{bmatrix}$$

Dimension	Meaning	Value
a_1	Height (ft)	6
a_2	Age	30
a_3	Weight (kg)	70
a_4	Waist-Size(in)	32
a_5	Gender	1

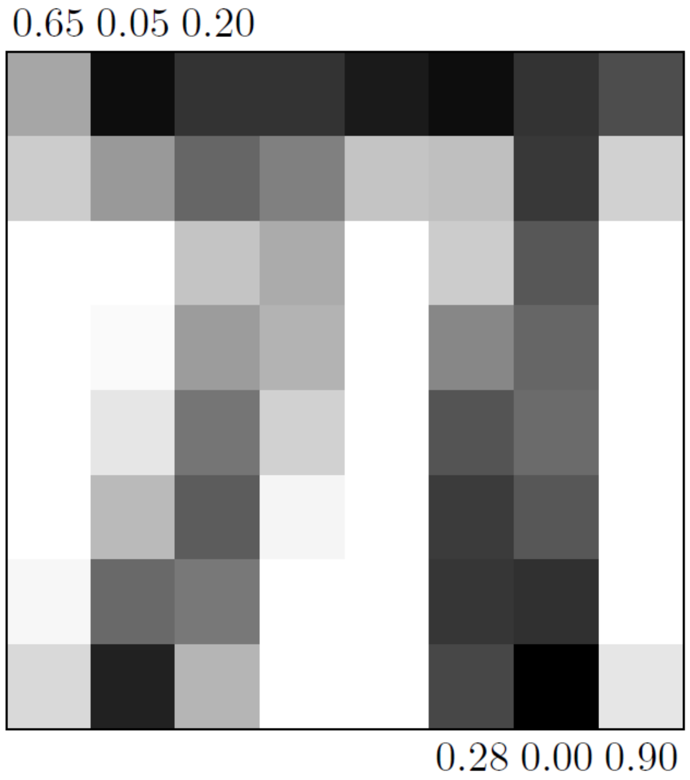
5- Dimensional Data

a = [6 , 30 , 70 , 32, 1] $\Rightarrow$ **a** = $6\mathbf{a_1} + 30\mathbf{a_2} + 70\mathbf{a_3} + 32\mathbf{a_4} + \mathbf{a_5}$

[ML & Linear Algebra] : Image Representation

$x \in \mathbb{R}^{64\times 32}$

$x \in \mathbb{R}^{32\times 64}$



8×8 image

8×8 image can be represented as 64 dimensional vector

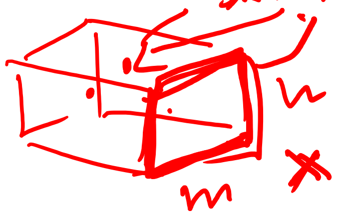
$x(3,2)$

$x(3)$

$x = [0.65\ \ 0.05\ 0.20\ \ \ldots\ldots\ldots.0.28\ 0.00\ 0.90\ ]$

$x(3)$

x is a point in 64-dimension space, $x \in \mathbb{R}^{64}$



What does $x \in \mathbb{R}^{8x8}$ mean ?

$n = x(3,2,1)$

$x(:,:,1)$

Videos:

k frames in a video of resolution $m \times n$ can be represented as as $m \times n \times k$ vector

$x \in \mathbb{R}^{m\times n\ \times k}$

Poll :	$x \in \mathbb{R}^{m\times n\ \times k}$ & $x \in \mathbb{R}^{m\times k\ \times n}$ represents the same video ?

[ML & Linear Algebra] : Document Representation

Documents:

D1 : I like deep learning

D2 : I like NLP

D3 : I enjoy flying

$D1 \in \mathbb{R}^{3000}$ $D2 \in \mathbb{R}^{3000}$

3K

$|V|$

D1 : [1 ... 0 ... 1 ... ... 0 ... 1]

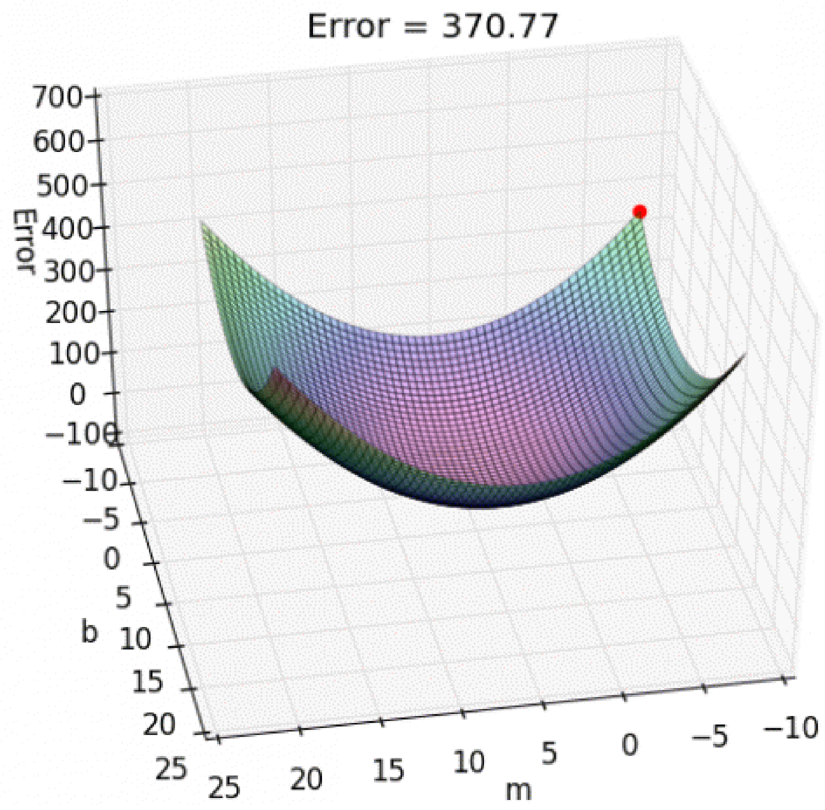
D2 : [1 ... 0 ... ... 1]

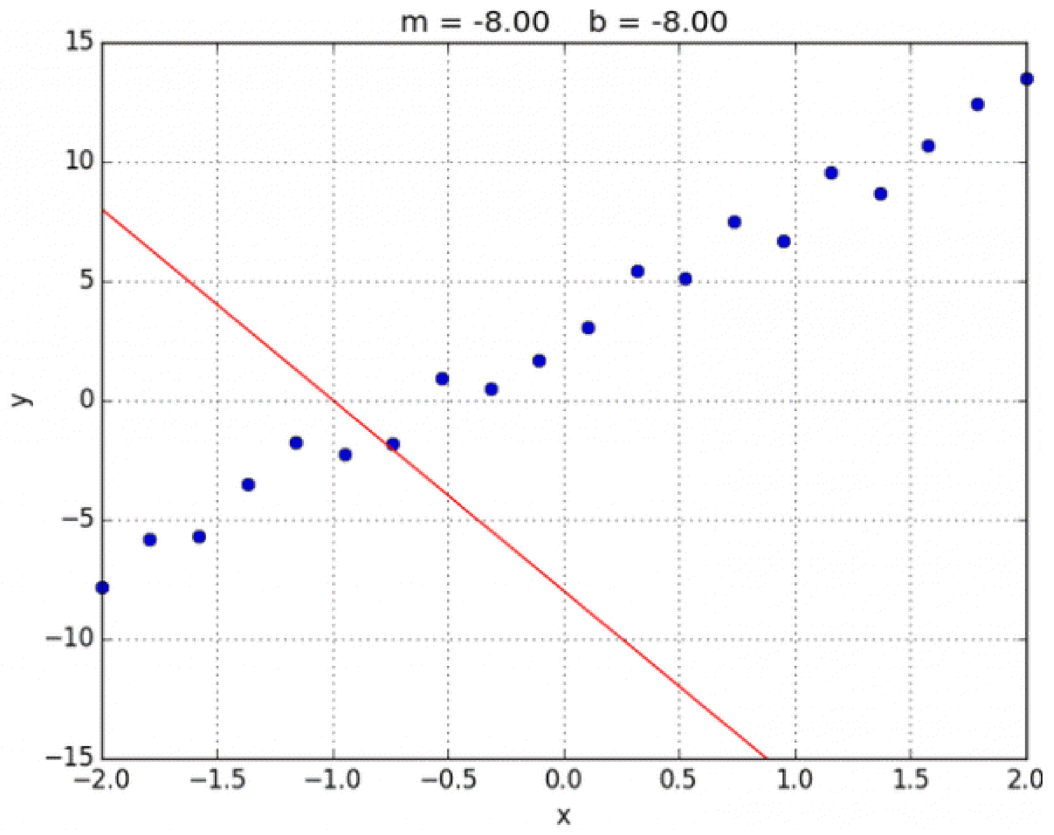
Word Count Histogram:

counts	D1	D2	D3
I	1	1	1
like	1	1	0
enjoy	0	0	1
deep	1	0	0
learning	1	0	0
NLP	0	1	0
flying	0	0	1
.	1	1	1

[ML & Optimization] Cost Function Minimization

$f(y|x)$





Line Fitting: Loss function minimization with two parameters

[ML & Probability]

What if we can model the joint probability distribution of data and labels ?

What if we can additionally sample new data from this joint distribution ?

Generative Models

7 AM Temperature vs. Max Day temperature:

$P(x,y)$

$\Downarrow$

$P(y|x)$

$\mathbf{z} = (x, y)$

joint distribution of Data & Label