

# Machine Learning & Deep Learning Basics

ICMR Sponsored Seminar On Deep Learning Techniques and  
Tools for Medical Applications  
Practice **LESS** Deep Learning  
Learn - Experiment - Share - Seek

Barathi Ganesh HB

Centre for Excellence in Computational Engineering and Networking (CEN)  
Amrita School of Engineering, Coimbatore  
Amrita Vishwa Vidyapeetham, India  
email: barathiganesh.hb@gmail.com



# Outline

Opportunities - NLP

ML Introduction

Regression to Deep Learning

Need of Deep Learning

Matrix Representation

# Opportunities

[Find Jobs](#) [Company Reviews](#) [Find Salaries](#) [Find Resumes](#) [Employers / Post Job](#)

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what

where

Natural Language Processing

Find Jobs

Advanced Job Se

job title, keywords or company

Tip: Enter your city or zip code in the "where" box to show results in your area.

## Natural Language Processing jobs

Sort by: **relevance** - date

### Salary Estimate

\$55,000 (1814)  
\$80,000 (1490)  
\$95,000 (1152)  
\$110,000 (778)  
\$125,000 (401)

### Job Type

Full-time (2470)  
Contract (87)  
Part-time (66)

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Jobs 1 to 10 of 2,596

### NLP Research Scientist, Siri

Apple - ★★★★★ 3,964 reviews - Santa Clara Valley, CA

Research Scientists at Siri are taking this a step further by redefining artificial intelligence, and creating groundbreaking technology for natural language...

1 day ago - [save job](#) - [more...](#)

### Natural Language Processing (NLP) Research Scientist

Bloomberg - ★★★★★ 509 reviews - New York, NY

A PhD in Natural Language Processing, Machine Learning or equivalent experience. Bloomberg's Natural Language Processing (NLP) group - a group of specialists,...

12 days ago - [save job](#) - [more...](#)

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Source: [www.indeed.co.in](http://www.indeed.co.in)

# Opportunities

**glassdoor** Sign In



Natural language processing Jobs in India 745 Jobs

**Natural Language Processing**   
DynPro India - Gurgaon 21 days ago  
3.1 ★

**Machine learning ml natural language processing nlp c java pyhton Years**   
Cyborg Technologies - Noida 8 days ago  
2.2 ★

## Natural Language Processing

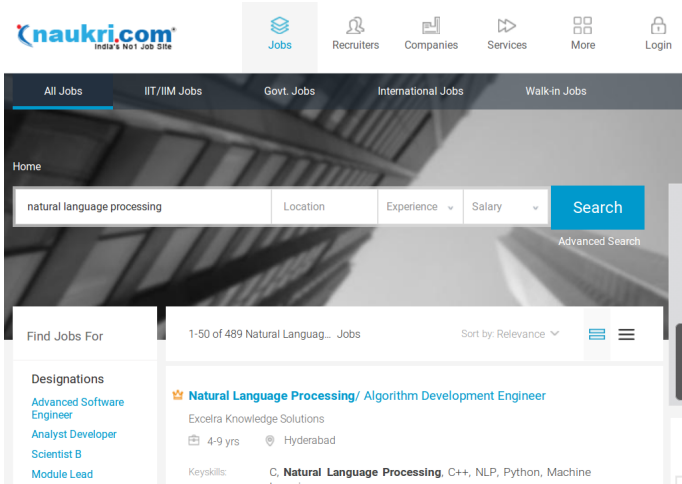
3.1 ★ DynPro India - Gurgaon

[Apply on Company Site](#)   [Save](#)

[Job](#) [Company](#)

Source: [www.glassdoor.com](http://www.glassdoor.com)

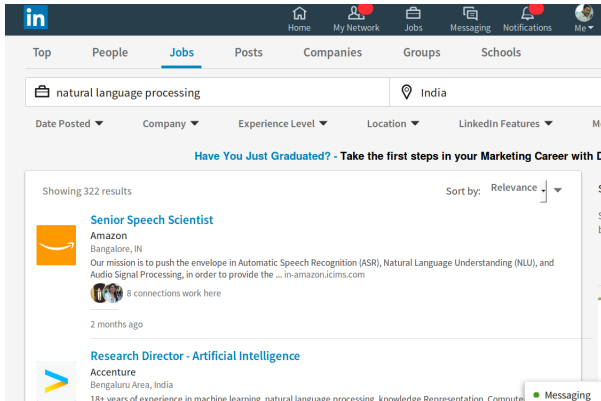
# Opportunities



The screenshot shows the naukri.com website interface. At the top, there's a navigation bar with icons for Jobs, Recruiters, Companies, Services, More, and Login. Below this is a category bar with links for All Jobs, IIT/IIM Jobs, Govt. Jobs, International Jobs, and Walk-in Jobs. The main search area has a search bar with the text 'natural language processing', and filters for Location, Experience, and Salary. A blue 'Search' button is next to it. Below the search bar, there's a section for 'Find Jobs For' with a list of designations: Advanced Software Engineer, Analyst Developer, Scientist B, and Module Lead. To the right, the search results show '1-50 of 489 Natural Language... Jobs' sorted by Relevance. The first result is for 'Natural Language Processing/ Algorithm Development Engineer' at 'Excelra Knowledge Solutions' in 'Hyderabad' with '4-9 yrs' experience. The key skills listed are 'C, Natural Language Processing, C++, NLP, Python, Machine Learning'.

Source: [www.naukri.com](http://www.naukri.com)

# Opportunities



The screenshot shows the LinkedIn Jobs interface. The search bar contains 'natural language processing' and the location is set to 'India'. The results are sorted by 'Relevance'. The first job listing is for 'Senior Speech Scientist' at Amazon, Bangalore, IN. The description mentions 'Automatic Speech Recognition (ASR), Natural Language Understanding (NLU), and Audio Signal Processing'. The second job listing is for 'Research Director - Artificial Intelligence' at Accenture, Bengaluru Area, India. The description mentions '18+ years of experience in machine learning, natural language processing, knowledge Representation, Compute'.

in

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natural language processing India

Date Posted Company Experience Level Location LinkedIn Features Mo

Have You Just Graduated? - Take the first steps in your Marketing Career with D

Showing 322 results Sort by: Relevance

**Senior Speech Scientist**  
Amazon  
Bangalore, IN  
Our mission is to push the envelope in Automatic Speech Recognition (ASR), Natural Language Understanding (NLU), and Audio Signal Processing, in order to provide the ... in-amazon.icims.com  
8 connections work here  
2 months ago

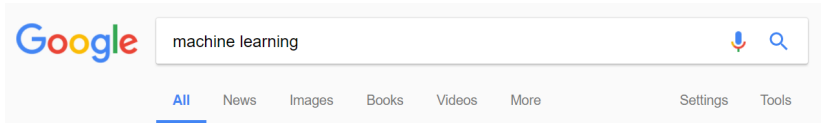
**Research Director - Artificial Intelligence**  
Accenture  
Bengaluru Area, India  
18+ years of experience in machine learning, natural language processing, knowledge Representation, Compute

Messaging

Source: in.linkedin.com



# *Machine Learning Introduction*



About 31,00,00,000 results (0.50 seconds)

### Machine learning - Wikipedia

[https://en.wikipedia.org/wiki/Machine\\_learning](https://en.wikipedia.org/wiki/Machine_learning) ▼

**Machine learning** is a field of computer science that gives computers the ability to learn without being explicitly programmed. Arthur Samuel, an American pioneer in the field of computer gaming and artificial intelligence, coined the term "**Machine Learning**" in 1959 while at IBM.

[Machine learning](#) · [Machine Learning \(journal\)](#) · [Timeline of machine learning](#) · [H2O](#)



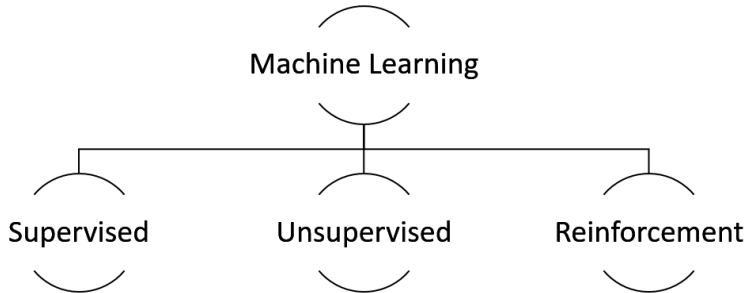


- Reducing human/machine efforts required to perform a task (time optimization).
- Increasing the performance of a task (efficiency optimization).

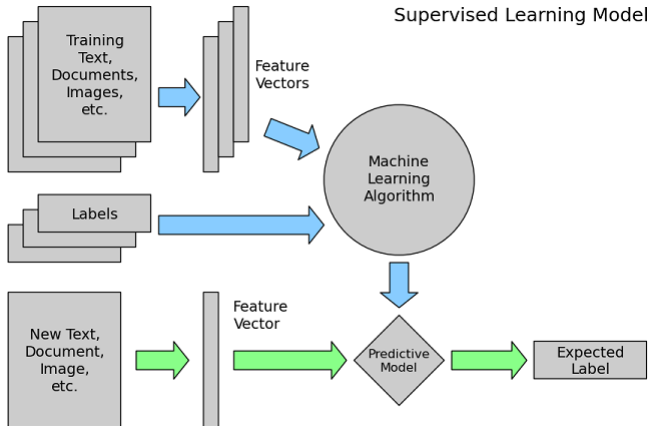


# Steps in Machine Learning

- Collecting data
- Preparing the data
- Training a model
- Evaluating the model
- Improving the performance



# Supervised Learning



source: [www.allprogrammingtutorials.com/tutorials/introduction-to-machine-learning.php](http://www.allprogrammingtutorials.com/tutorials/introduction-to-machine-learning.php)



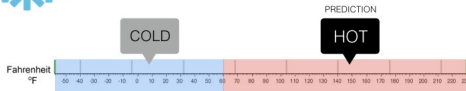
## Regression

What is the temperature going to be tomorrow?



## Classification

Will it be Cold or Hot tomorrow?



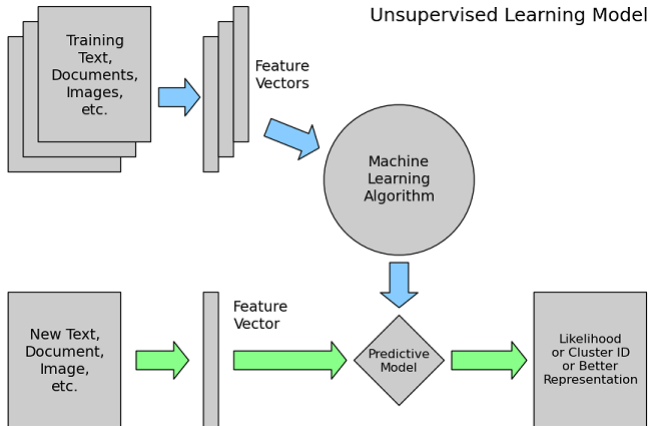
source: [https://medium.com/@ali\\_88273/regression-vs-classification-87c224350d69](https://medium.com/@ali_88273/regression-vs-classification-87c224350d69)



# Common Supervised Learning Algorithms

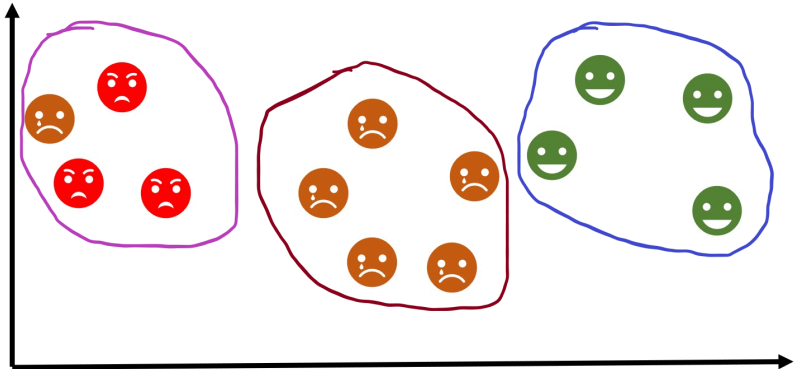
- Linear Regression
- Logistic Regression
- Support Vector Machines
- Support Vector Regression
- Decision Trees
- Random Forest Tree
- Naive Bayes

# Unsupervised Learning



source: [www.allprogrammingtutorials.com/tutorials/introduction-to-machine-learning.php](http://www.allprogrammingtutorials.com/tutorials/introduction-to-machine-learning.php)

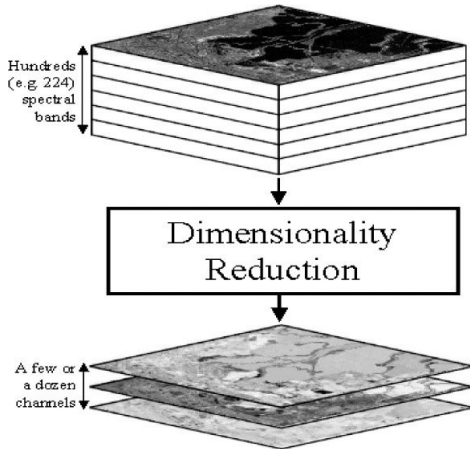
# Clustering



source: <https://towardsdatascience.com/clustering-unsupervised-learning-788b215b074b>



# Dimensionality Reduction



source: <http://spie.org/newsroom/3560-dimensionality-reduction-of-multidimensional-satellite-imagery?SS0=1>



# Common Unsupervised Learning Algorithms

- K-means
- Affinity Propagation
- Singular Value Decomposition
- Non-negative matrix factorization



# You have already learned the Machine Learning. When?

?



# You have already learned the Machine Learning. When?

$$2x = 6 \quad (1)$$

$$(2x - 6) = 0 \quad (2)$$

$$x = ? \quad (3)$$



# You have already learned the Machine Learning. When?

$$2x = 6 \quad (4)$$

$$(2x - 6) = 0 \quad (5)$$

$$x = ? \quad (6)$$

$$x = 6/2 = 3 \quad (7)$$

$$2(3) - 6 = 0 \quad (8)$$



You have already learned the Machine Learning. When?

$$2a + b + c = 4 \quad (9)$$

$$a + 3b + 2c = 5 \quad (10)$$

$$a = 6 \quad (11)$$



You have already learned the Machine Learning. When?

$$\begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (12)$$



You have already learned the Machine Learning. When?

$$A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix}, x = \begin{bmatrix} a \\ b \\ c \end{bmatrix}, b = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (13)$$





You have already learned the Machine Learning. When?

$$\begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (14)$$

$$Ax = b \quad (15)$$

$$(Ax - b) = ? \quad (16)$$



# You have already learned the Machine Learning. When?

$$\begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (17)$$

$$Ax = b \quad (18)$$

$$(Ax - b) = 0 \quad (19)$$

$$x = \begin{bmatrix} a \\ b \\ c \end{bmatrix} = ? \quad (20)$$



# What is Regression

*Regression?*



# What is Regression

$$x + y = z$$



## Solving $Ax=b$

$$\begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (21)$$

$$X W = Y \quad (22)$$

$$(X W - Y) = 0 \quad (23)$$

$$W = \begin{bmatrix} a \\ b \\ c \end{bmatrix} = ? \quad (24)$$

$$X^{-1} X W = X^{-1} Y \quad (25)$$

$$I W = X^{-1} Y \quad (26)$$

$$W = X^{-1} Y \quad (27)$$



## Decimal Value Prediction

ID	digit1	digit2	digit3	value
1	0	0	0	0
2	0	0	1	1
3	0	1	0	2
4	0	1	1	3
5	1	0	0	4
6	1	0	1	5
7	1	1	0	6
8	1	1	1	7

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{bmatrix} \quad (28)$$

$$X \mathbf{w} = \mathbf{y} \quad (29)$$

$$X^{-1} X \mathbf{w} = X^{-1} \mathbf{y} \quad (30)$$

$$\mathbf{w} = X^{-1} \mathbf{y} \quad (31)$$



$$\mathbf{w} = X^{-1} \mathbf{y} = X^{-1} \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{bmatrix} = \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} \quad (32)$$





$$X \mathbf{w} = \mathbf{y} \quad (33)$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{bmatrix} \quad (34)$$

$$X \mathbf{w} = \mathbf{y}^{pre} \quad (35)$$

$$training \ error = abs(\mathbf{y} - \mathbf{y}^{pre}) \quad (36)$$

$$\text{training error} = \text{sum}(\text{abs}(\mathbf{y} - \mathbf{y}^{pre})) \quad (37)$$

$$\mathbf{y} - \mathbf{y}^{pre} = \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{bmatrix} - \begin{bmatrix} 0 \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \end{bmatrix} = \text{sum} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} = 0 \quad (38)$$



$$\begin{bmatrix} digit1 & digit2 & digit1 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = [value] \quad (39)$$

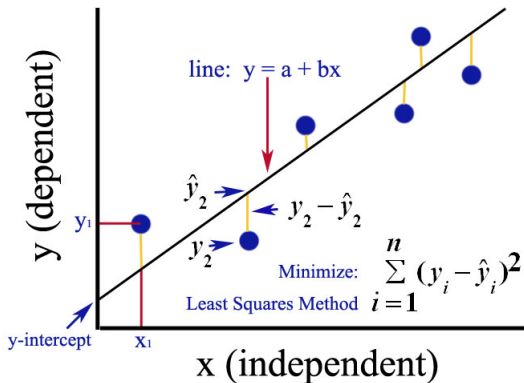
$$digit1 * w1 + digit2 * w2 + digit3 * w3 = value \quad (40)$$

$$\begin{bmatrix} digit1 & digit2 & digit1 \end{bmatrix} \begin{bmatrix} 4 \\ 2 \\ 1 \end{bmatrix} = [value] \quad (41)$$

$$digit1 * 4 + digit2 * 2 + digit3 * 1 = value \quad (42)$$



# Linear Regression



source: solutions4statistics.com



## Decimal Value Prediction

ID	digit1	digit2	digit3	value	decision
1	0	0	0	0	0
2	0	0	1	1	0
3	0	1	0	2	0
4	0	1	1	3	0
5	1	0	0	4	1
6	1	0	1	5	1
7	1	1	0	6	1
8	1	1	1	7	1

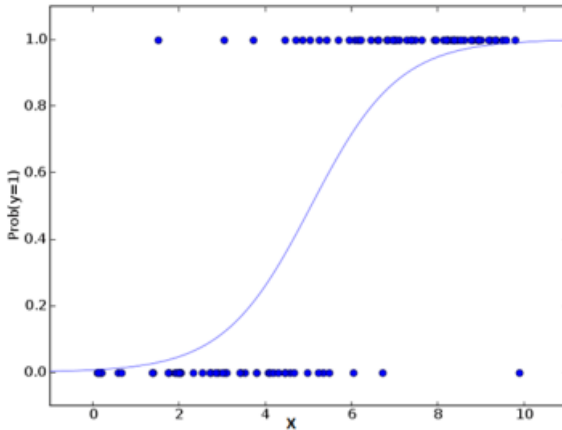


$$\begin{bmatrix} digit1 & digit2 & digit3 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = [value] \quad (43)$$

$$digit1 * w1 + digit2 * w2 + digit3 * w3 = value \quad (44)$$

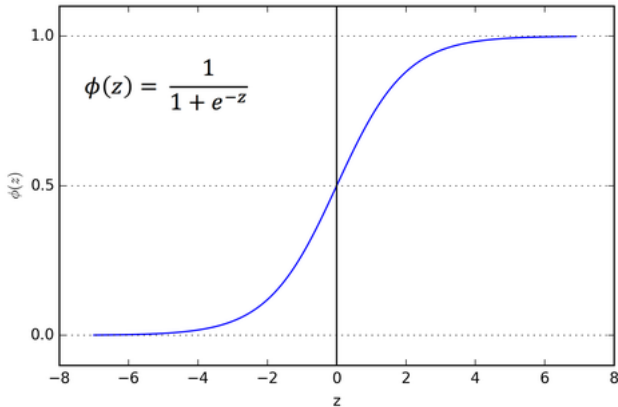
$$Prediction = \begin{cases} 1 & \text{if } 4 \geq value \\ 0 & \text{else} \end{cases} \quad (45)$$

# Logistic Regression



source: solutions4statistics.com

# Logistic - Sigmoid Function



<https://sebastianraschka.com/images/faq/logisticregr-neuralnet/sigmoid.png>





## Logistic - Sigmoid

$$\Phi(z) = \frac{1}{1 + \exp^{-z}} \quad (46)$$

$$\Phi(-6) = \frac{1}{1 + \exp^{-(-6)}} = \frac{1}{1 + 403.42} = 0.0024 \quad (47)$$

$$\Phi(0) = \frac{1}{1 + \exp^0} = \frac{1}{1 + 1} = 0.5 \quad (48)$$

$$\Phi(6) = \frac{1}{1 + \exp^{-(6)}} = \frac{1}{1 + 0.0024} = 0.997 \quad (49)$$



# Logistic Regression

$$\Phi(z) = \frac{1}{1 + \exp^{-z}} \quad (50)$$

$$\mathbf{y} = \Phi(\mathbf{X} \mathbf{w}) = \frac{1}{1 + \exp^{-(\mathbf{X} \mathbf{w})}} \quad (51)$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \quad (52)$$

$$X \mathbf{w} = \mathbf{y} \quad (53)$$

$$X^{-1} X \mathbf{w} = X^{-1} \mathbf{y} \quad (54)$$

$$\mathbf{w} = X^{-1} \mathbf{y} \quad (55)$$

$$\mathbf{w} = X^{-1} \mathbf{y} = X^{-1} \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 1.24054754 \\ -0.11269202 \\ -0.11269202 \end{bmatrix} = \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} \quad (56)$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} 1.24054754 \\ -0.11269202 \\ -0.11269202 \end{bmatrix} = \text{sigmoid} \left( \begin{bmatrix} 0.0 \\ -0.11269202 \\ -0.11269202 \\ -0.22538404 \\ 1.24054754 \\ 1.12785552 \\ 1.12785552 \\ 1.0151635 \end{bmatrix} \right) \quad (57)$$

$$X \mathbf{w} = \text{sigmoid}(\mathbf{y}^{pre}) \quad (58)$$

$$\text{sigmoid} \left( \begin{bmatrix} 0.0 \\ -0.11269202 \\ -0.11269202 \\ -0.22538404 \\ 1.24054754 \\ 1.12785552 \\ 1.12785552 \\ 1.0151635 \end{bmatrix} \right) = \begin{bmatrix} 0.5 \\ 0.52814323 \\ 0.52814323 \\ 0.55610869 \\ 0.22434069 \\ 0.24455707 \\ 0.24455707 \\ 0.26597056 \end{bmatrix} \quad (59)$$

$$X \mathbf{w} = \text{sigmoid}(\mathbf{y}^{pre}) \quad (60)$$

$$\text{training error} = \text{sum}(\text{abs}(\mathbf{y} - \text{sigmoid}(\mathbf{y}^{pre}))) \quad (61)$$

$$\text{training error} = \text{sum}(\text{abs}(\mathbf{y} - \text{sigmoid}(\mathbf{y}^{\text{pre}}))) \quad (62)$$

$$\text{abs}(\mathbf{y} - \text{sigmoid}(\mathbf{y}^{\text{pre}})) = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (63)$$

$$\text{training error} = 0 \quad (64)$$



$$\begin{bmatrix} 0.5 \\ 0.52814323 \\ 0.52814323 \\ 0.55610869 \\ 0.22434069 \\ 0.24455707 \\ 0.24455707 \\ 0.26597056 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \quad (65)$$

$$Prediction = \begin{cases} 0 & \text{if } sigmoid(\mathbf{y}^{pre}) \geq 0.5 \\ 1 & \text{else} \end{cases} \quad (66)$$



$$\begin{bmatrix} digit1 & digit2 & digit3 \end{bmatrix} \begin{bmatrix} 1.24054754 \\ -0.11269202 \\ -0.11269202 \end{bmatrix} = [value] \quad (67)$$

$$digit1 * w1 + digit2 * w2 + digit3 * w3 = value \quad (68)$$

$$sigmoid(\mathbf{y}^{pre}) = \frac{1}{1 + \exp^{-(digit1 * w1 + digit2 * w2 + digit3 * w3)}} \quad (69)$$

$$Prediction = \begin{cases} 0 & \text{if } sigmoid(\mathbf{y}^{pre}) \geq 0.5 \\ 1 & \text{else} \end{cases} \quad (70)$$



# Evaluating the model

- Accuracy

$$Accuracy = \frac{\# \text{ correctly classified instances}}{\text{total} \# \text{ instances}} \quad (71)$$



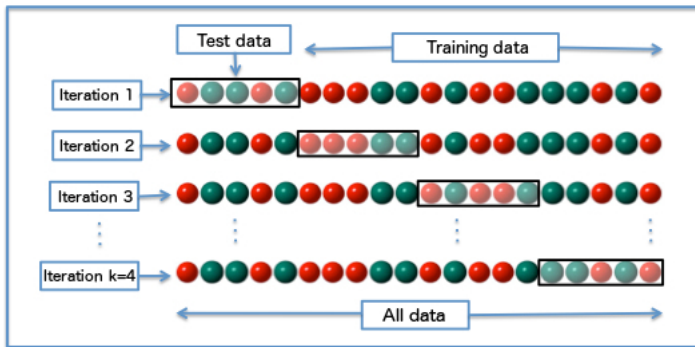
## Evaluating the model

$$\begin{bmatrix} 1 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 0 \end{bmatrix} == \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} False \\ True \\ True \\ True \\ True \\ True \\ True \\ False \end{bmatrix} \quad (72)$$

$$\text{Accuracy} = 8 / 10 \quad 100 = 80 \%$$

## Improving the performance

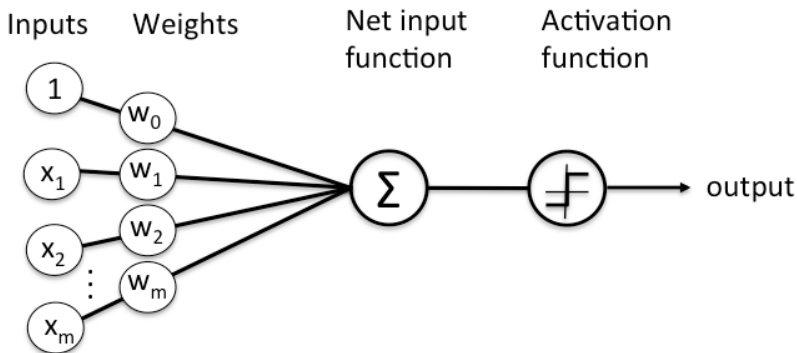
### 10 - fold 10-cross validation



Source: wikipedia

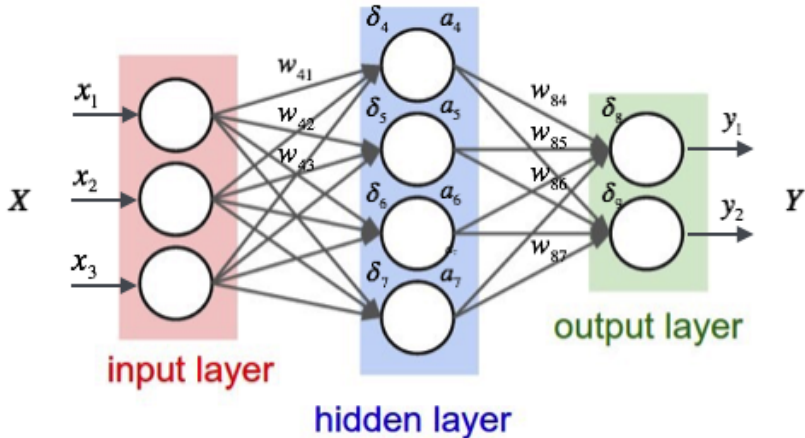


# Logistic Regression as a Neuron



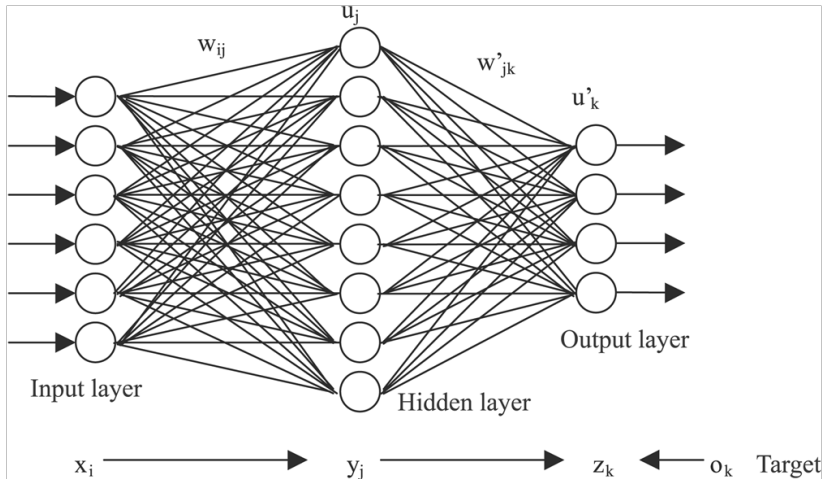
[www.techmaru.com/technology/artificial-neural-networks/neural-network-elements](http://www.techmaru.com/technology/artificial-neural-networks/neural-network-elements)

## Neuron to Neurons



[medium.com/@curiously/tensorflow-for-hackers-part-iv-neural-network-from-scratch-1a4f504dfa8](https://medium.com/@curiously/tensorflow-for-hackers-part-iv-neural-network-from-scratch-1a4f504dfa8)

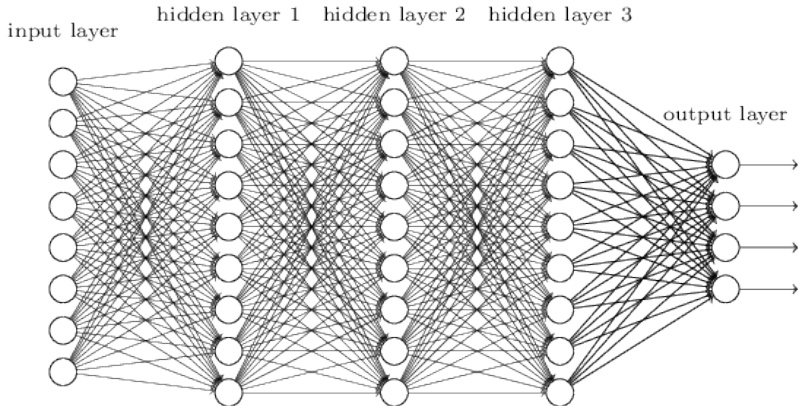
# Single Layer Network



[www.extremetech.com/extreme/](http://www.extremetech.com/extreme/)

215170-artificial-neural-networks-are-changing-the-world-what-are-they

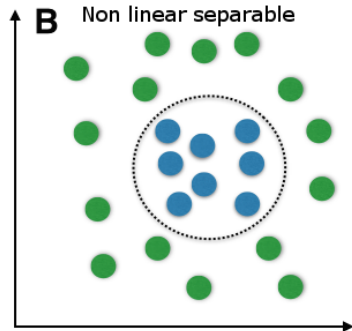
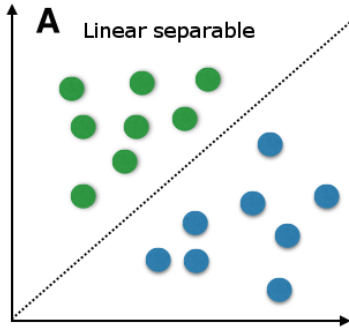
# Multi Layer Network



[in.mathworks.com/matlabcentral/fileexchange/64247-simple-neural-network](https://in.mathworks.com/matlabcentral/fileexchange/64247-simple-neural-network)



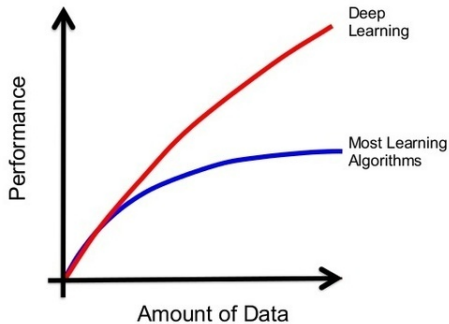
# Why Deep Learning?



Source: [https://leonardoraujosantos.gitbooks.io/artificial-intelligence/content/linear\\_classification.html](https://leonardoraujosantos.gitbooks.io/artificial-intelligence/content/linear_classification.html)

# Why Deep Learning?

## BIG DATA & DEEP LEARNING



Source: <https://qph.ec.quoracdn.net/main-qimg-bf69c291005e68620a1bef39ae8f029e-c>

# Why now Deep Learning?

## WHY IS DEEP LEARNING HOT NOW?

### Three Driving Factors...

Big Data Availability	New ML Techniques	Compute Density
<b>facebook</b> 350 millions images uploaded per day	Deep Neural Networks	GPUs
<b>Walmart</b> ✱ 2.5 Petabytes of customer data hourly		
<b>You Tube</b> 100 hours of video uploaded every minute		

ML systems extract value from Big Data

<https://www.slideshare.net/DataScienceMD/deep-learning-with-gpus>



# Common Deep Learning Algorithms

- Convolutional Neural Network
- Recurrent Neural Network
- Long-Short Term Memory Network
- Deep Neural Network
- Auto Encoders



## *Matrix Representation*



# Linear Equations to Matrix

$$2a + b + c = 4 \quad (73)$$

$$a + 3b + 2c = 5 \quad (74)$$

$$a = 6 \quad (75)$$



# Linear Equations to Matrix

$$\begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (76)$$



# Linear Equations to Matrix

$$A = \begin{bmatrix} 2 & 1 & 1 \\ 1 & 3 & 2 \\ 1 & 0 & 0 \end{bmatrix}, \mathbf{x} = \begin{bmatrix} a \\ b \\ c \end{bmatrix}, \mathbf{b} = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \quad (77)$$





## Text to Matrix

- **S1:** We are in CEN.
- **S2:** CEN is in Amrita.
- **S3:** Amrita is in CBE.



# Text to Matrix

- **S1:** We are in CEN.
- **S2:** CEN is in Amrita.
- **S3:** Amrita is in CBE.

**Vocabulary** = amrita, are, cen, cbe, in, is, we

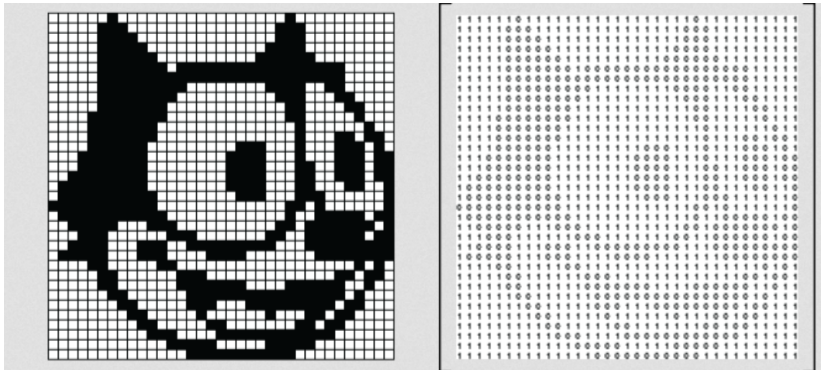


# Text to Matrix

Table: Text Representation

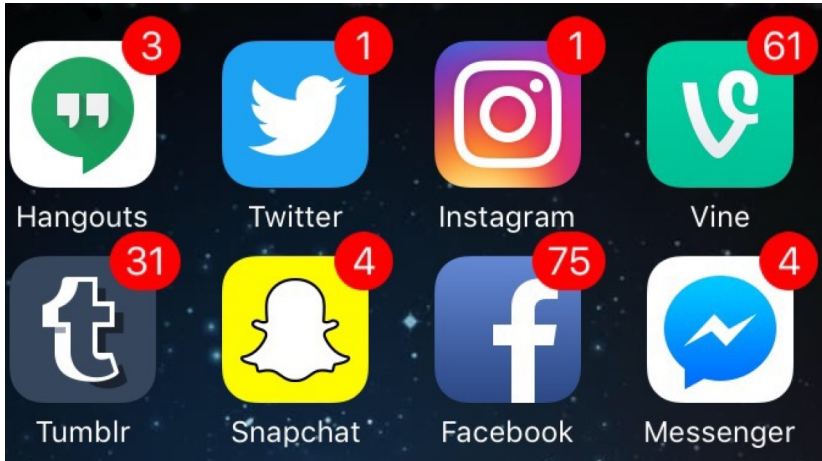
	amrita	are	cen	cbe	in	is	we
S1	0	1	1	0	1	0	1
S2	1	0	1	0	1	1	0
S3	1	0	0	1	1	1	0

## Image to Matrix



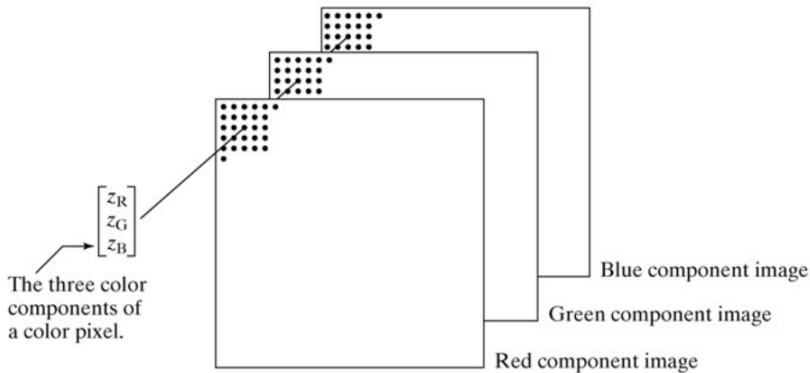
Source: [blog.kleinproject.org/?p=588](http://blog.kleinproject.org/?p=588)

## Image to Matrix



Source: [www.cbc.ca/news/trending](http://www.cbc.ca/news/trending)

# Image to Matrix



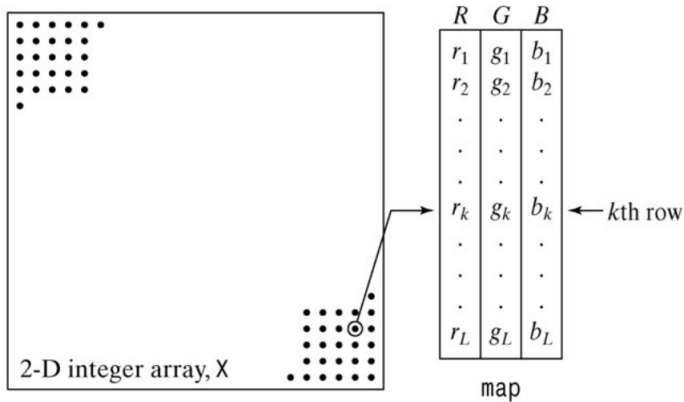
Source: <http://slideplayer.com/slide/8752313/>

## Image to Matrix

88	82	84	88	85	83	80	93	102
88	80	78	80	80	78	73	94	100
85	79	80	78	77	74	65	91	99
38	35	40	35	39	74	77	70	65
20	25	23	28	37	69	64	60	57
22	26	22	28	40	65	64	59	34
24	28	24	30	37	60	58	56	66
21	22	23	27	38	60	67	65	67
23	22	22	25	38	59	64	67	66

Source: [www1.adept.com/main/KE/DATA/ACE/AdeptSight\\_User/Vision\\_Basics\\_Mode.html](http://www1.adept.com/main/KE/DATA/ACE/AdeptSight_User/Vision_Basics_Mode.html)

# Image to Matrix



Value of circled element =  $k$

Source: [slideplayer.com/slide/8752313/](http://slideplayer.com/slide/8752313/)



*Thank You.*  
*you can follow me through:*  
*[www.linkedin.com/in/barathiganeshhb](http://www.linkedin.com/in/barathiganeshhb)*