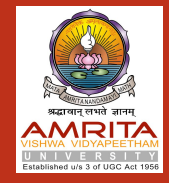


From Regression to Deep Learning

ICMR Sponsored Seminar On Deep Learning Techniques and Tools for Medical Applications

Practice **LESS** Deep Learning

Learn - **E**xperiment - **S**hare - **S**eek

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

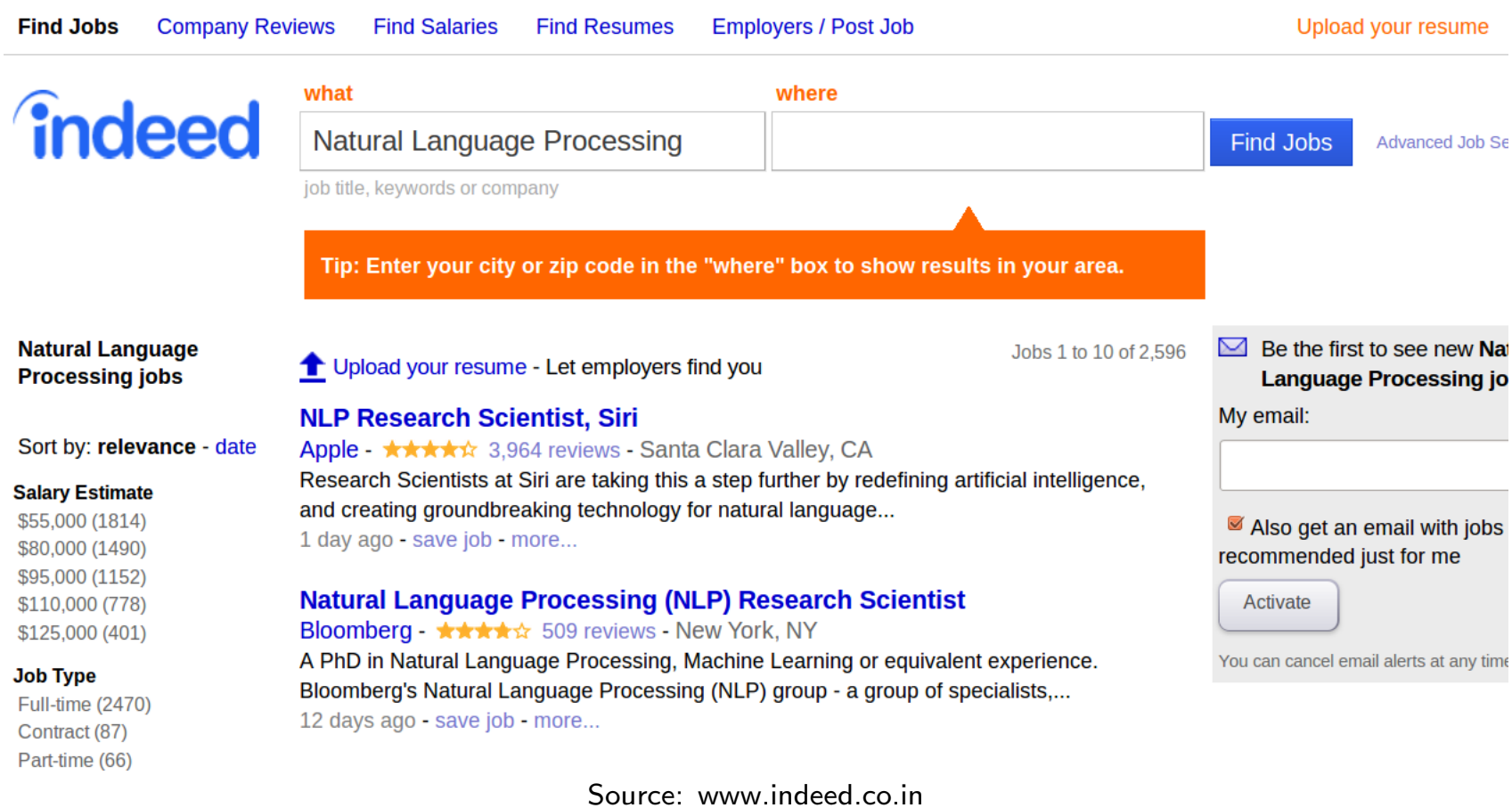
ML Introduction

Regression to Deep Learning

Need of Deep Learning

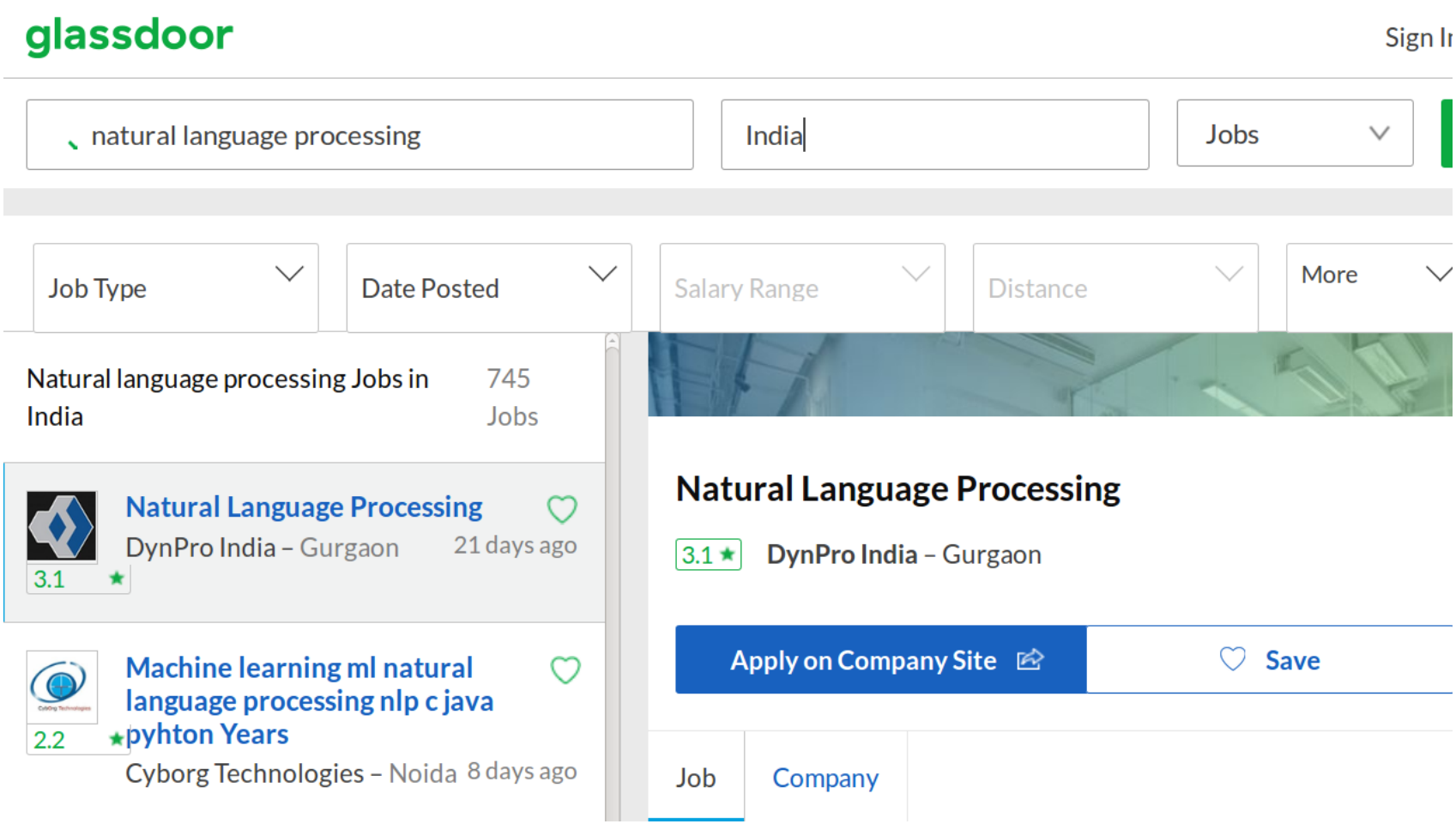
Matrix Representation

Opportunities



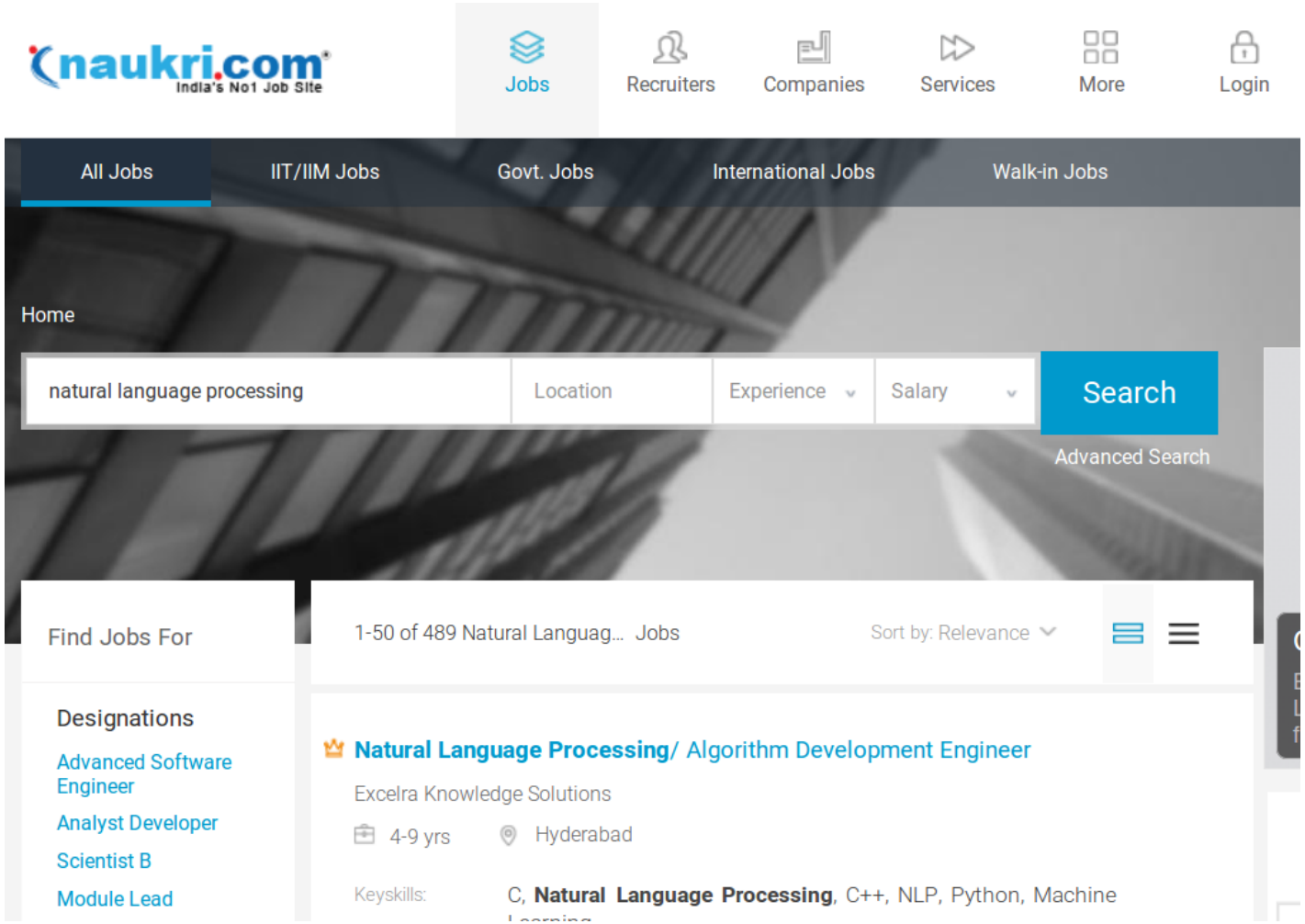
Source: www.indeed.co.in

Opportunities



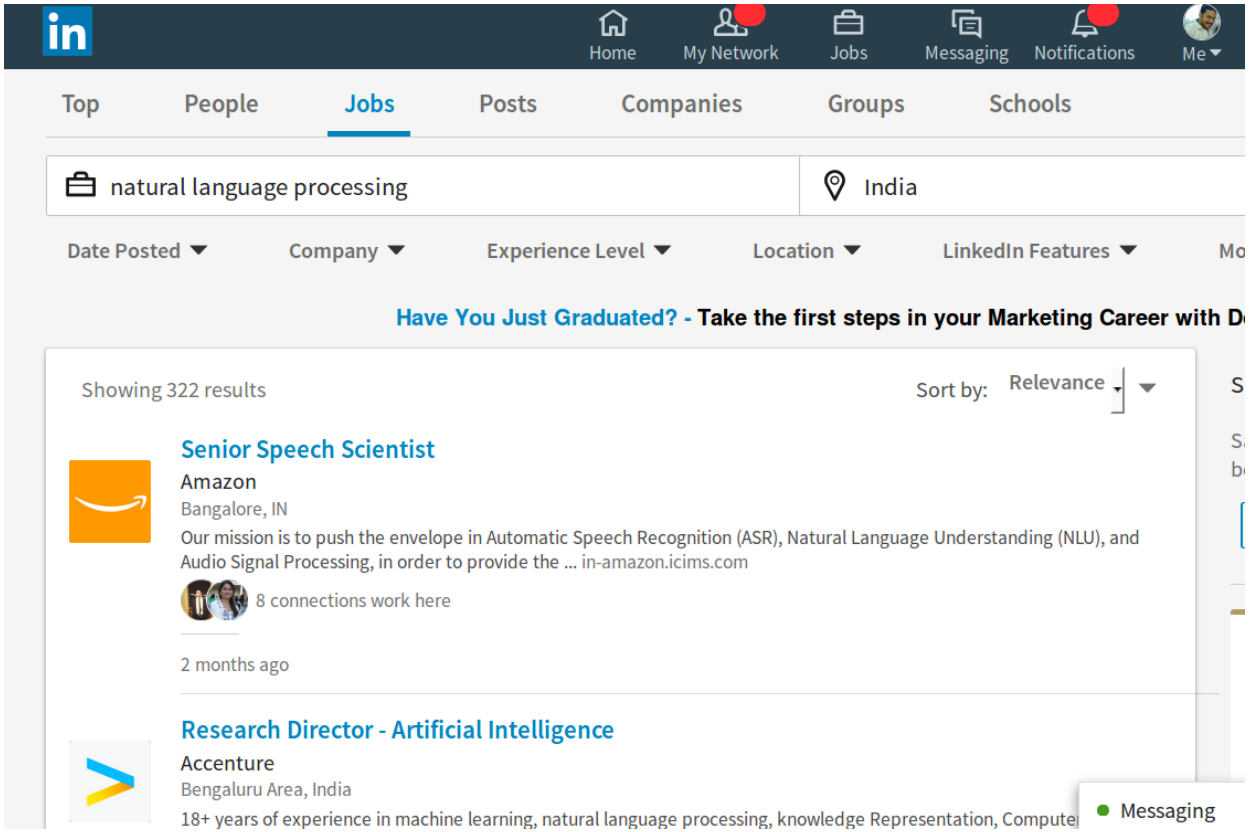
Source: www.glassdoor.com

Opportunities



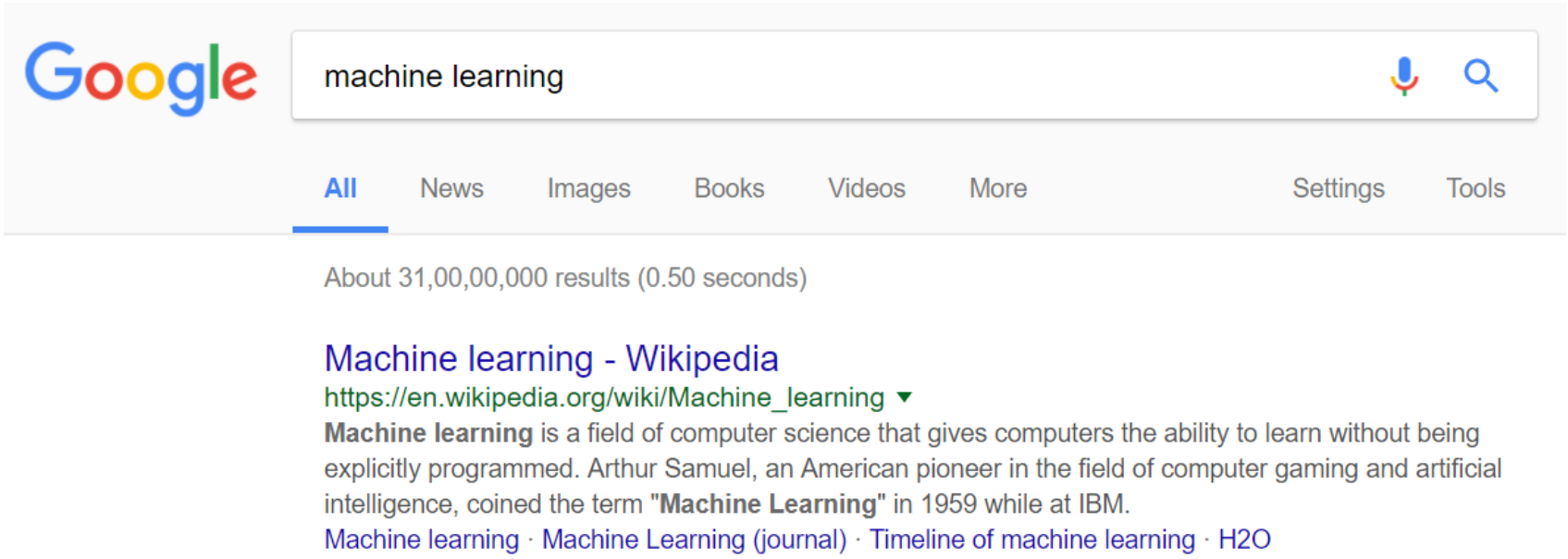
Source: www.naukri.com

Opportunities



Source: in.linkedin.com

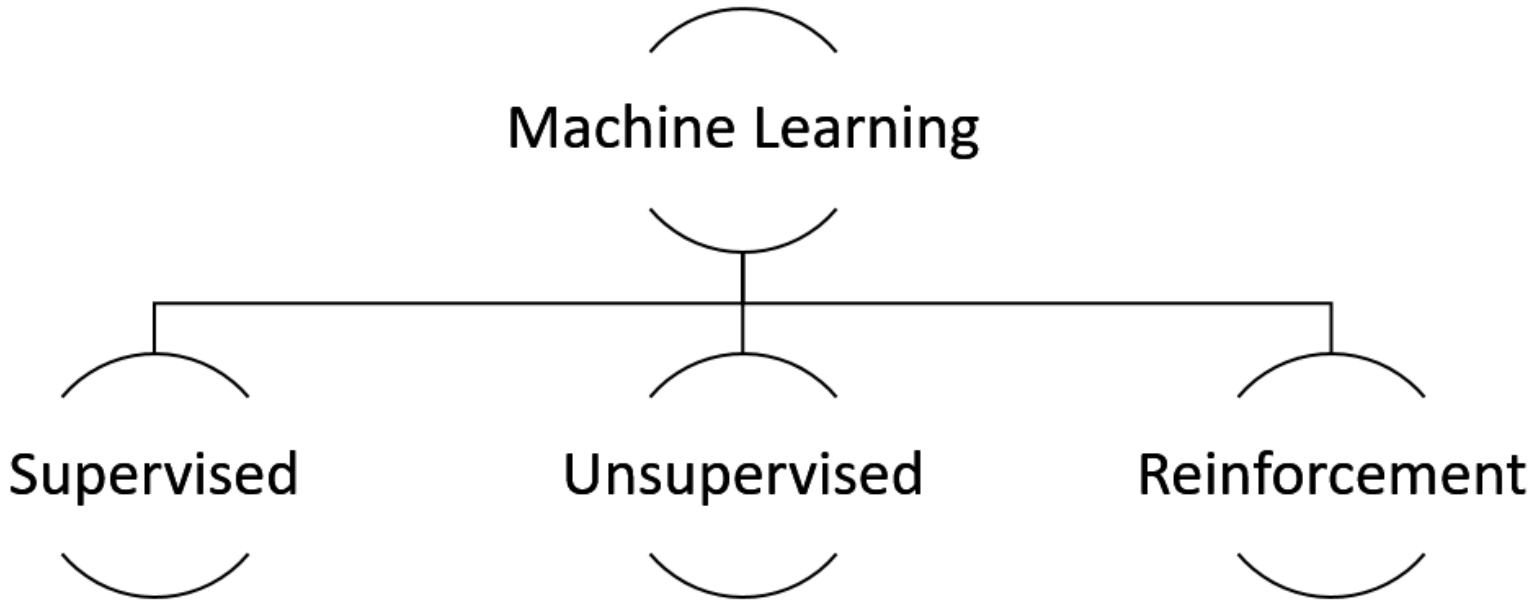
Machine Learning Introduction


Google
machine learning
All
News
Images
Books
Videos
More
Settings
Tools
About 31,00,00,000 results (0.50 seconds)
Machine learning - Wikipedia
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

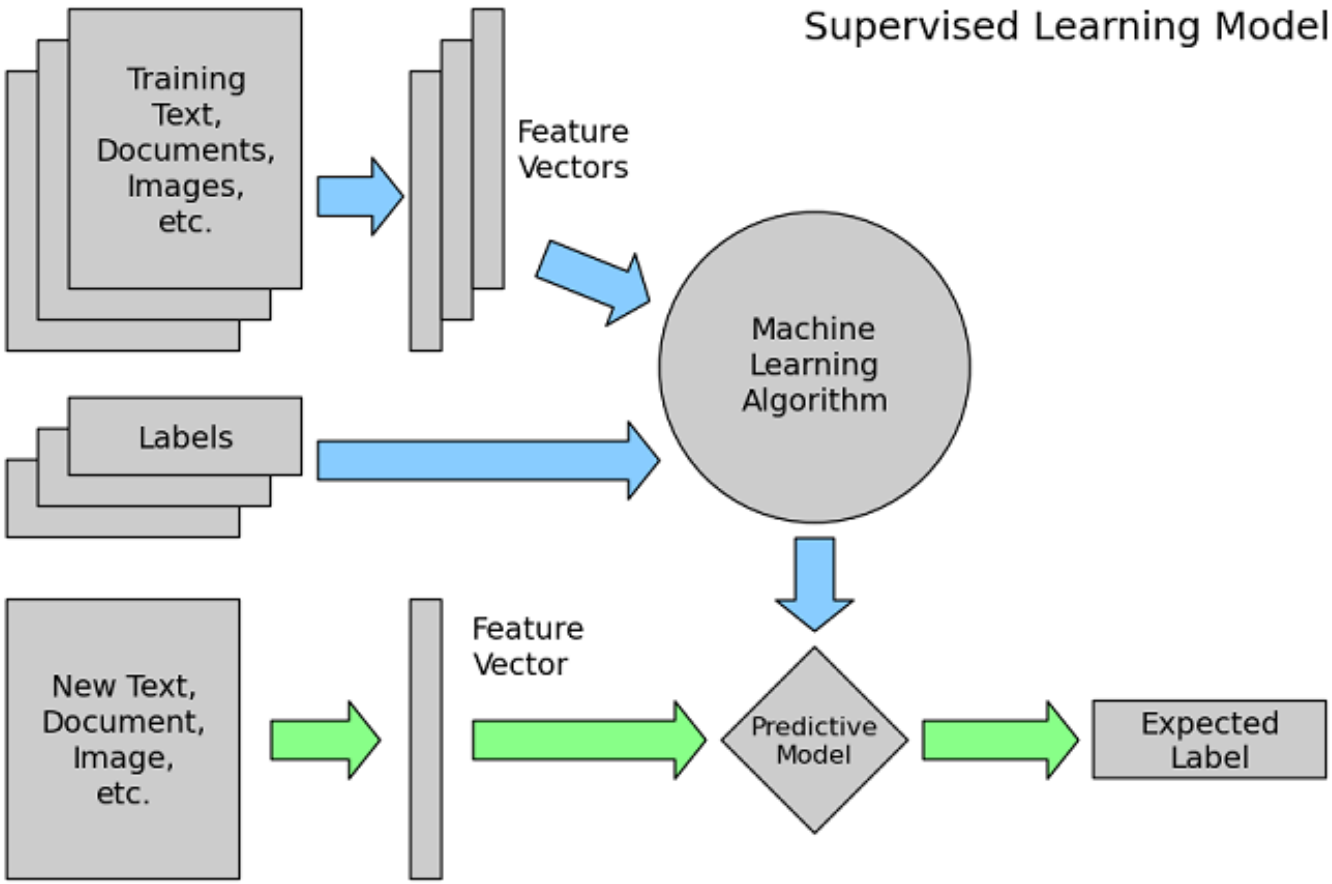
- Reducing human/machine efforts required to perform a task (time optimization).
- Increasing the performance of a task (efficiency optimization).

Steps in Machine Learning

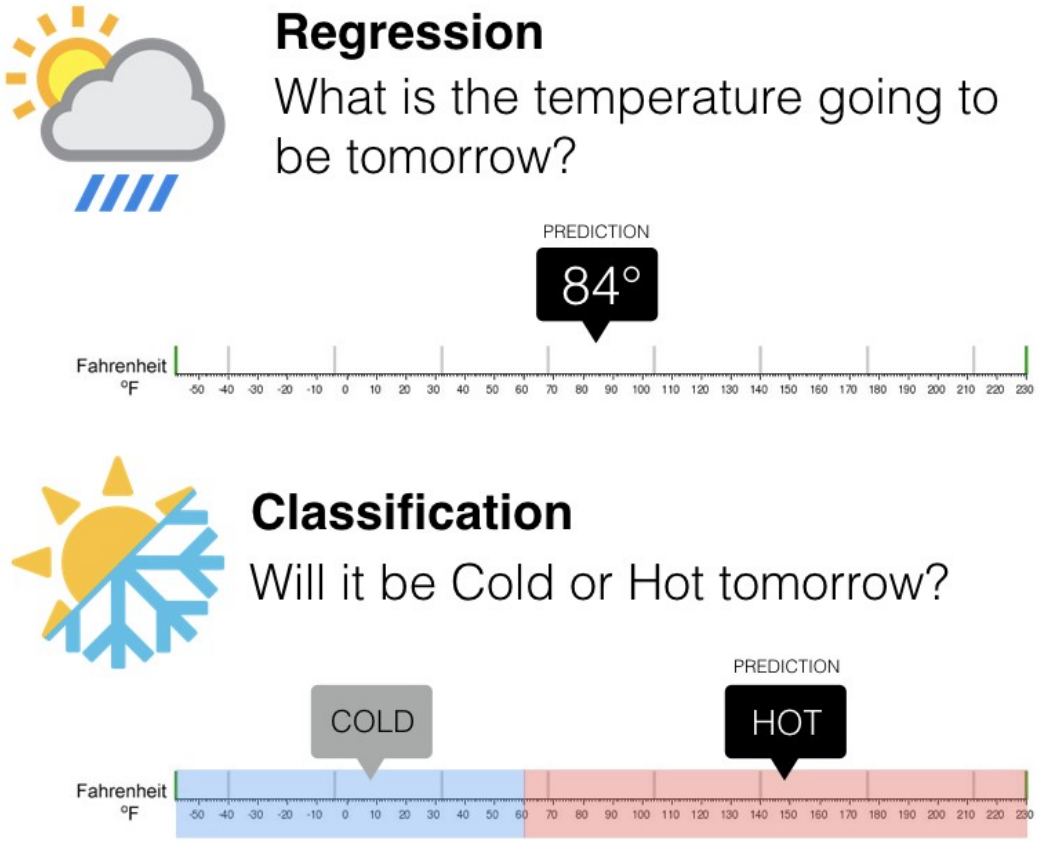
- Collecting data
- Preparing the data
- Training a model
- Evaluating the model
- Improving the performance


Machine Learning
Supervised
Unsupervised
Reinforcement

Supervised Learning



source: www.allprogrammingtutorials.com/tutorials/introduction-to-machine-learning.php

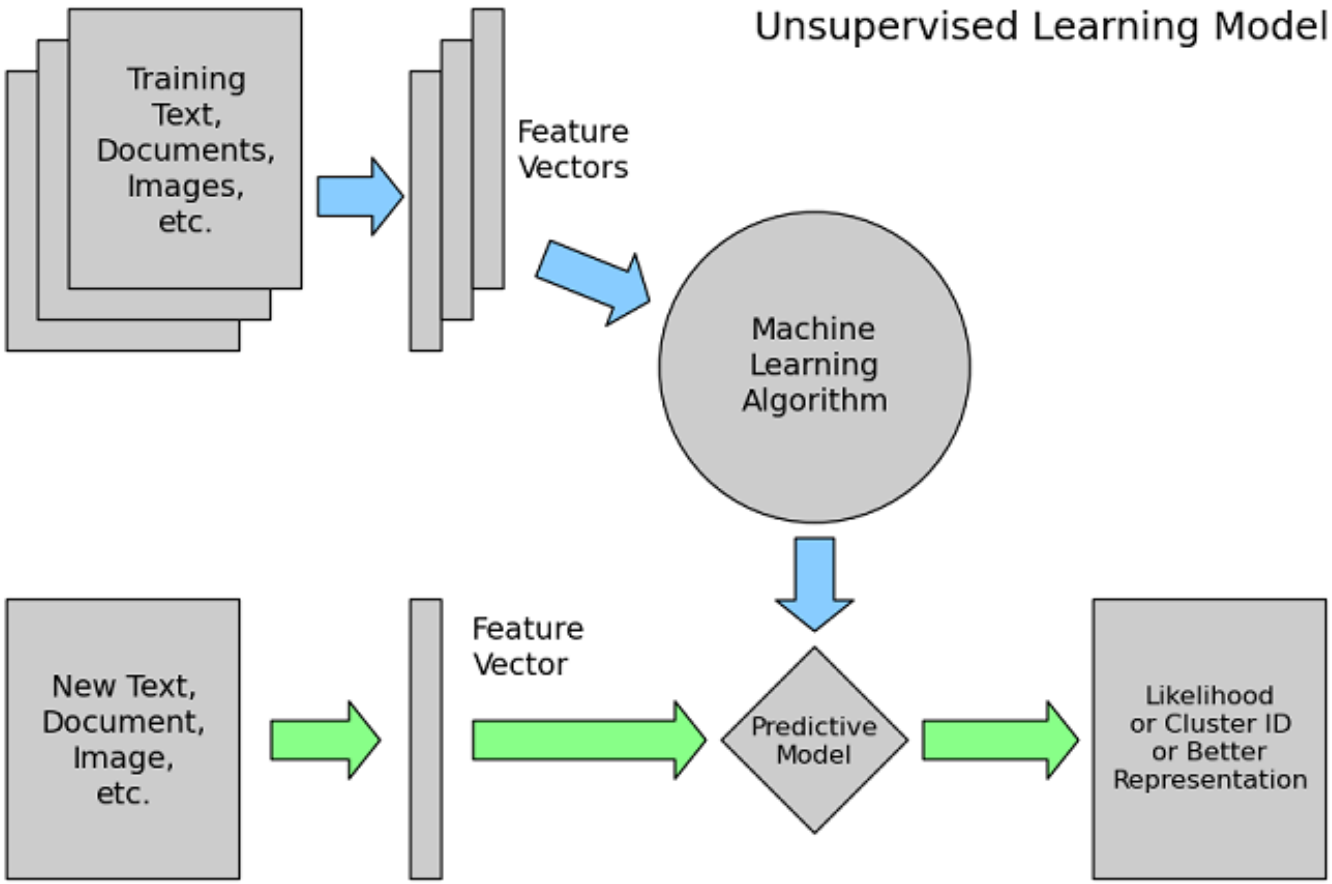


source: https://medium.com/@ali_88273/regression-vs-classification-87c224350d69

Common Supervised Learning Algorithms

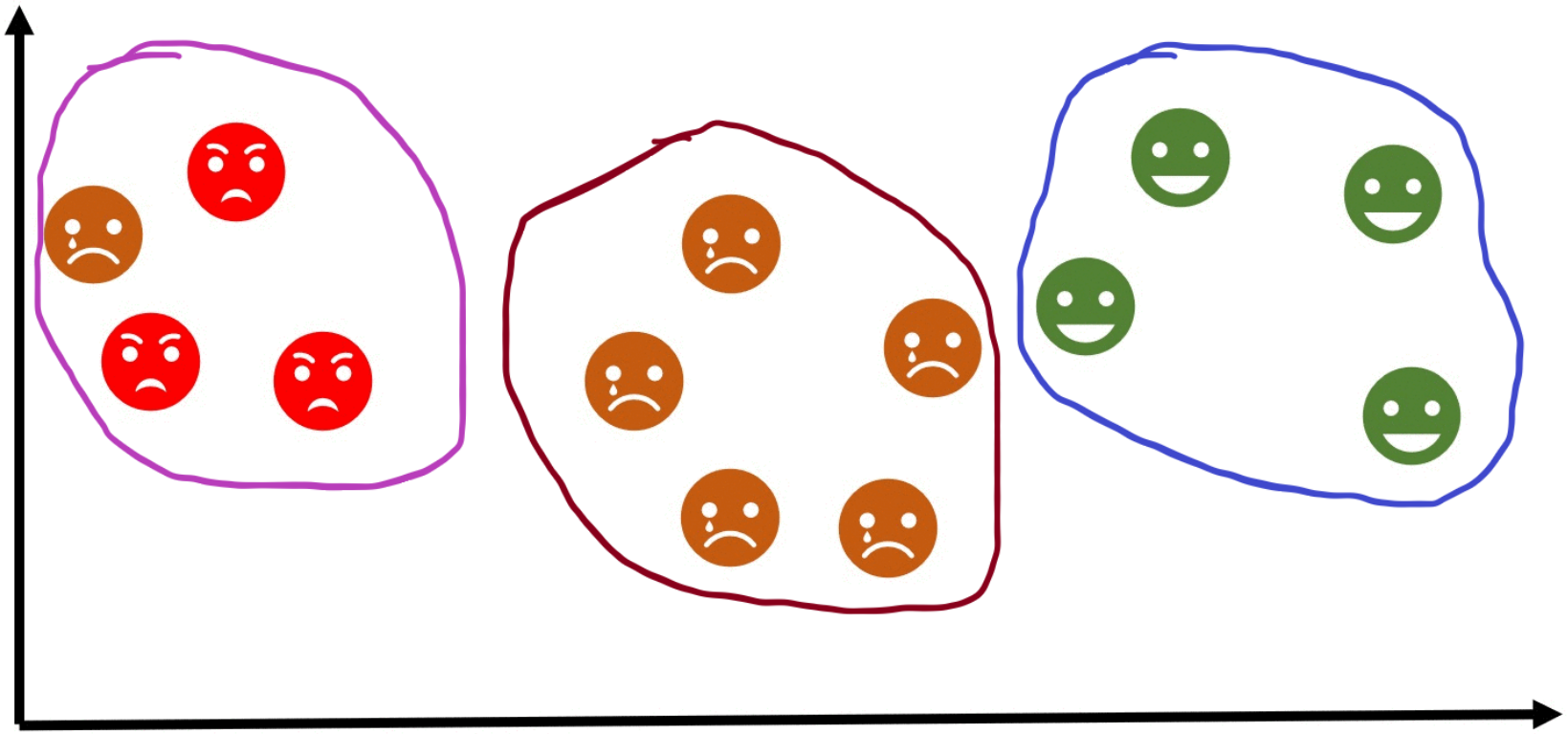
- Linear Regression
- Logistic Regression
- Support Vector Machines
- Support Vector Regression
- Decision Trees
- Random Forest Tree
- Naive Bayes

Unsupervised Learning



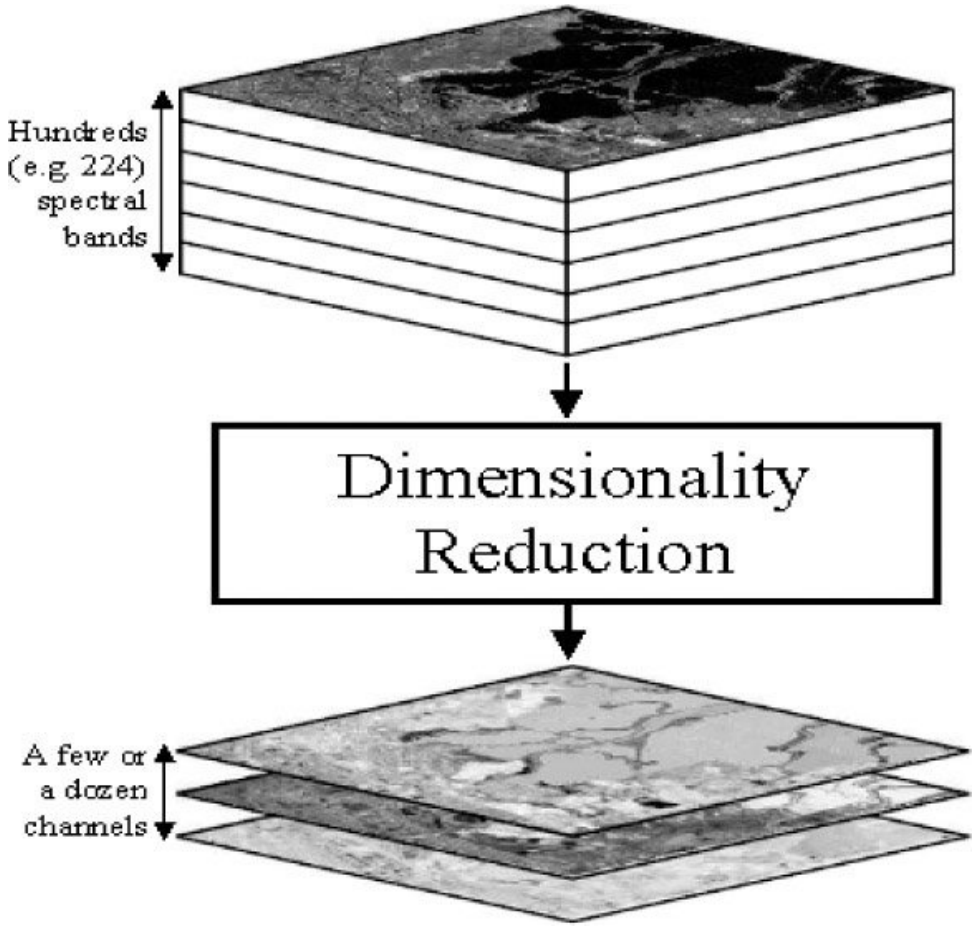
source: www.allprogrammingtutorials.com/tutorials/introduction-to-machine-learning.php

Clustering



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

Dimensionality Reduction



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

Common Unsupervised Learning Algorithms

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

You have already learned the Machine Learning. When?

?

You have already learned the Machine Learning. When?

$$2x = 6 \tag{1}$$

$$(2x - 6) = 0 \tag{2}$$

$$x = ? \tag{3}$$

You have already learned the Machine Learning. When?

$$2x = 6 \tag{4}$$

$$(2x - 6) = 0 \tag{5}$$

$$x = ? \tag{6}$$

$$x = 6/2 = 3 \tag{7}$$

$$2(3) - 6 = 0 \tag{8}$$

You have already learned the Machine Learning. When?

$$2a + b + c = 4 \tag{9}$$

$$a + 3b + 2c = 5 \tag{10}$$

$$a = 6 \tag{11}$$

You have already learned the Machine Learning. When?

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

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?

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

$$Ax = b \tag{15}$$

$$(Ax - b) = ? \tag{16}$$

You have already learned the Machine Learning. When?

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

$$Ax = b \tag{18}$$

$$(Ax - b) = 0 \tag{19}$$

$$x = \begin{bmatrix} a \\ b \\ c \end{bmatrix} = ? \tag{20}$$

What is Regression

Regression?

What is Regression

$$x + y = z$$

Solving Ax=b

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

$$X\ W = Y \tag{22}$$

$$(X\ W - Y) = 0 \tag{23}$$

$$W = \begin{bmatrix} a \\ b \\ c \end{bmatrix} = ? \tag{24}$$

$$X^{-1}\ X\ W = X^{-1}\ Y \tag{25}$$

$$I\ W = X^{-1}\ Y \tag{26}$$

$$W = X^{-1}\ Y \tag{27}$$

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**

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

$$X\ \mathbf{w} = \mathbf{y} \tag{29}$$

$$X^{-1}\ X\ \mathbf{w} = X^{-1}\ \mathbf{y} \tag{30}$$

$$\mathbf{w} = X^{-1}\ \mathbf{y} \tag{31}$$

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

$$X\ \mathbf{w} = \mathbf{y} \tag{33}$$

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

$$X\ \mathbf{w} = \mathbf{y}^{pre} \tag{35}$$

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

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

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

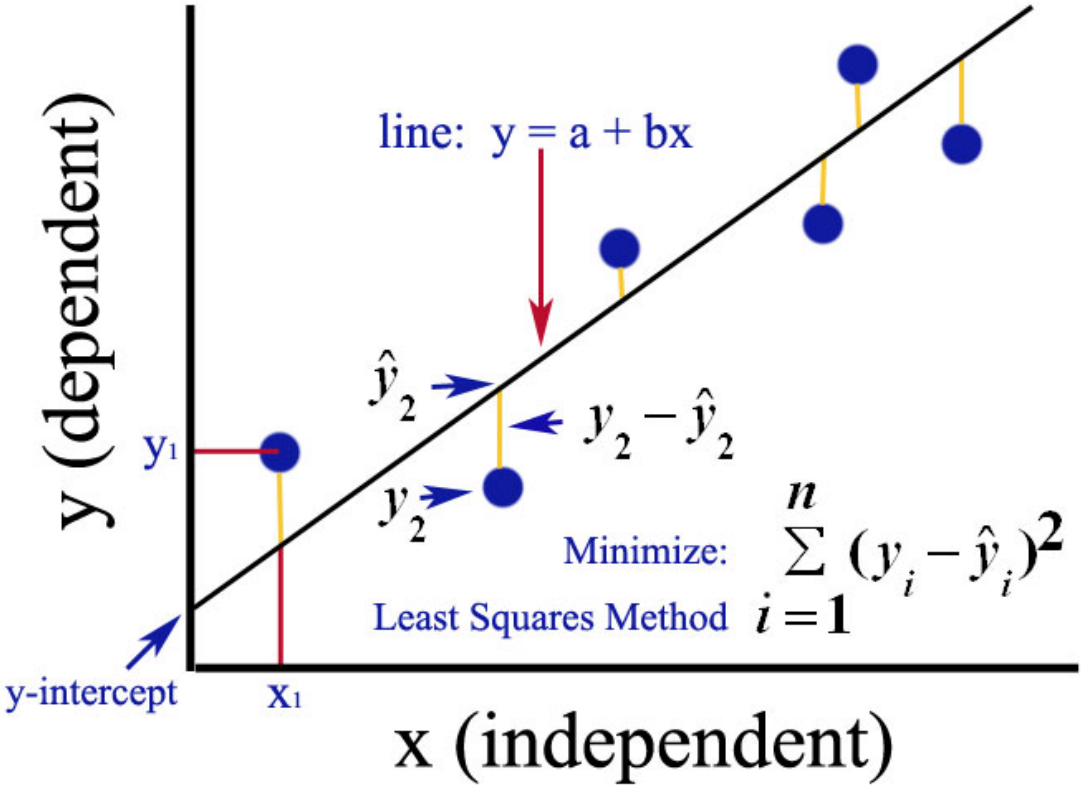
$$\begin{bmatrix} digit1 & digit2 & digit1 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = [value] \tag{39}$$

$$\textbf{digit1 * w1 + digit2 * w2 + digit3 * w3 = value} \tag{40}$$

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

$$\textbf{digit1 * 4 + digit2 * 2 + digit3 * 1 = value} \tag{42}$$

Linear Regression



source: solutions4statistics.com

Decimal Value Prediction

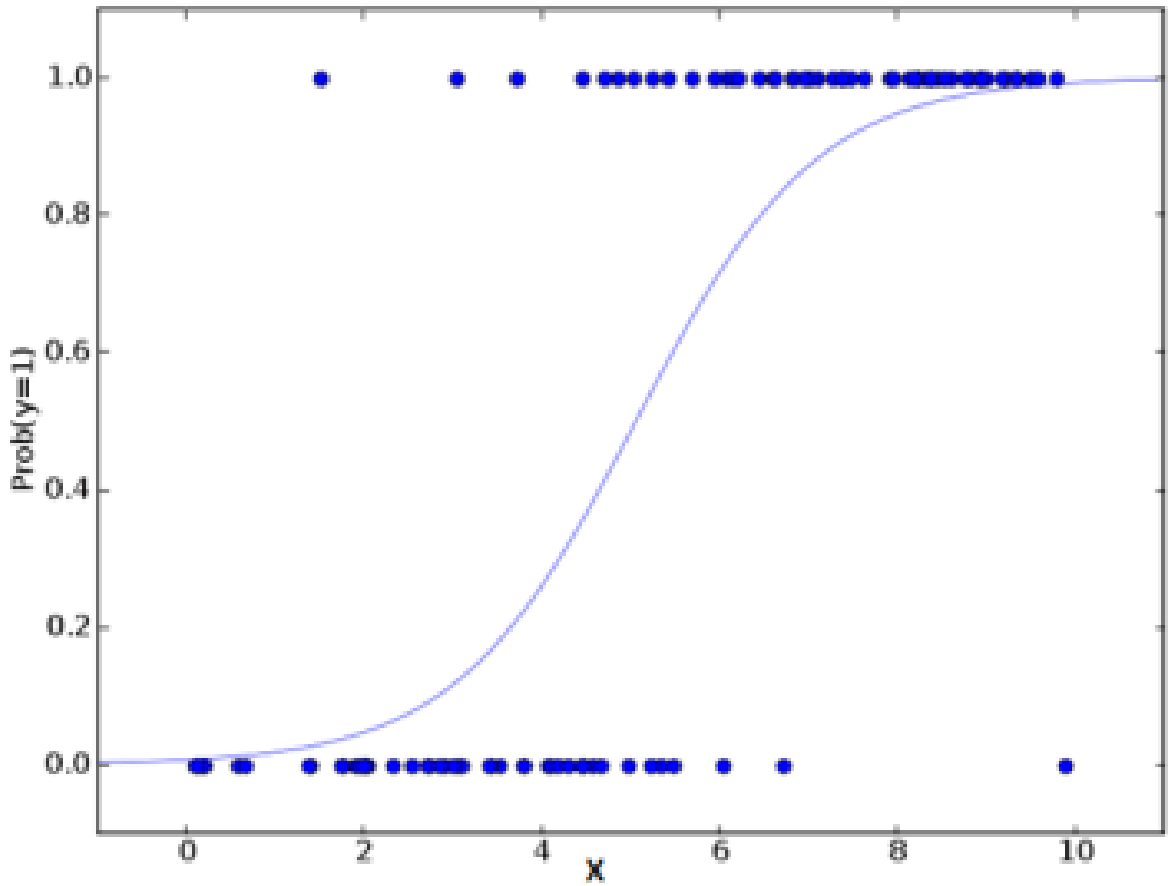
ID	digit1	digit2	digit3	value	decision
1	0	0	0	**0**	**0**
2	0	0	1	**1**	**0**
3	0	1	0	**2**	**0**
4	0	1	1	**3**	**0**
5	1	0	0	**4**	**1**
6	1	0	1	**5**	**1**
7	1	1	0	**6**	**1**
8	1	1	1	**7**	**1**

$$\begin{bmatrix} digit1 & digit2 & digit1 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = [value] \tag{43}$$

$$\mathbf{digit1 * w1 + digit2 * w2 + digit3 * w3 = value} \tag{44}$$

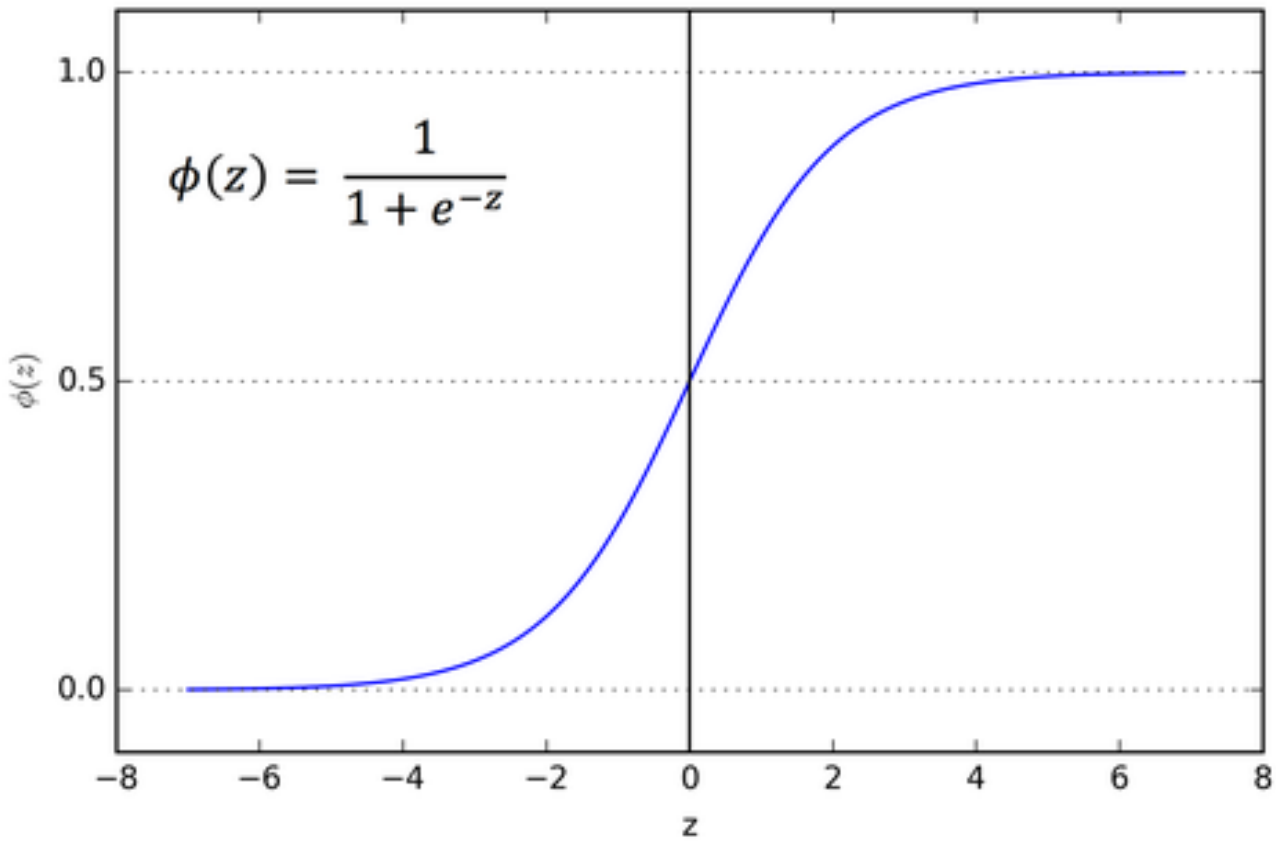
$$Prediction = \begin{cases} 1 & if\ 4 \geqslant value \\ 0 & else \end{cases} \tag{45}$$

Logistic Regression



source: solutions4statistics.com

Logistic - Sigmoid Function



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

Logistic - Sigmoid

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

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

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

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

Logistic Regression

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

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

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} w1 \\ w2 \\ w3 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \tag{52}$$

$$X\ \mathbf{w} = \mathbf{y} \tag{53}$$

$$X^{-1}\ X\ \mathbf{w} = X^{-1}\ \mathbf{y} \tag{54}$$

$$\mathbf{w} = X^{-1}\ \mathbf{y} \tag{55}$$

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

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

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

$$sigmoid\left(\begin{bmatrix} 0.0 \\ -0.11269202 \\ -0.11269202 \\ -0.22538404 \\ 1.24054754 \\ 1.12785552 \\ 1.12785552 \\ 1.0151635 \end{bmatrix}\right) = \begin{bmatrix} 0.5 \\ 0.47185 \\ 0.47185 \\ 0.44389 \\ 0.77565 \\ 0.75544 \\ 0.75544 \\ 0.73402 \end{bmatrix} \tag{59}$$

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

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

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

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

$$training\ \ error = 0 \tag{64}$$

$$\begin{bmatrix} 0.5 \\ 0.47185 \\ 0.47185 \\ 0.44389 \\ 0.77565 \\ 0.75544 \\ 0.75544 \\ 0.73402 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \tag{65}$$

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

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

$$\mathbf{digit1 * w1 + digit2 * w2 + digit3 * w3 = value} \tag{68}$$

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

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

Evaluating the model

- Accuracy

$$Accuracy = \frac{\#\ correctly\ classified\ instances}{total\#\ instances} \tag{71}$$

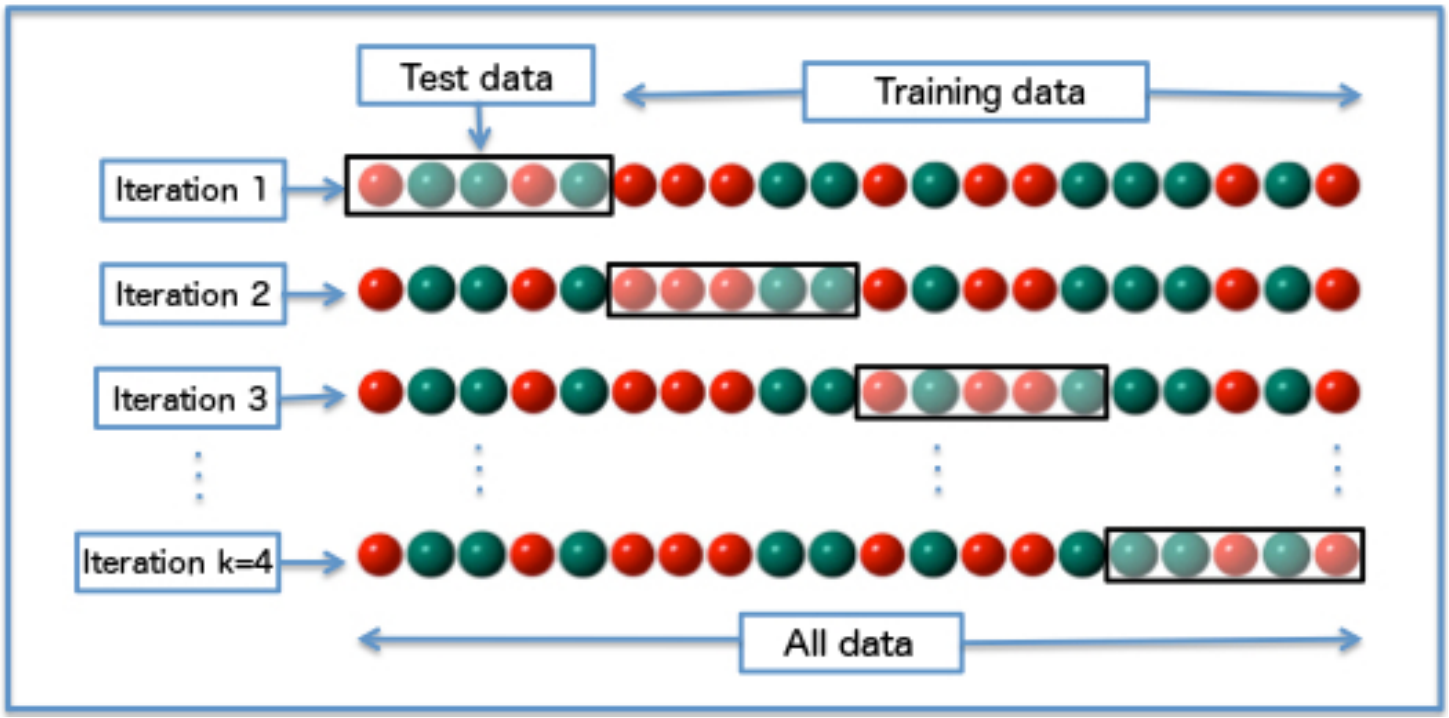
Evaluating the model

$$\begin{bmatrix}1\\0\\0\\0\\1\\1\\1\\0\end{bmatrix} == \begin{bmatrix}0\\0\\0\\0\\1\\1\\1\\1\end{bmatrix} = \begin{bmatrix}False\\True\\True\\True\\True\\True\\True\\False\end{bmatrix} \tag{72}$$

Accuracy $= 8\ /10\ *\ 100 = 80\ \%$

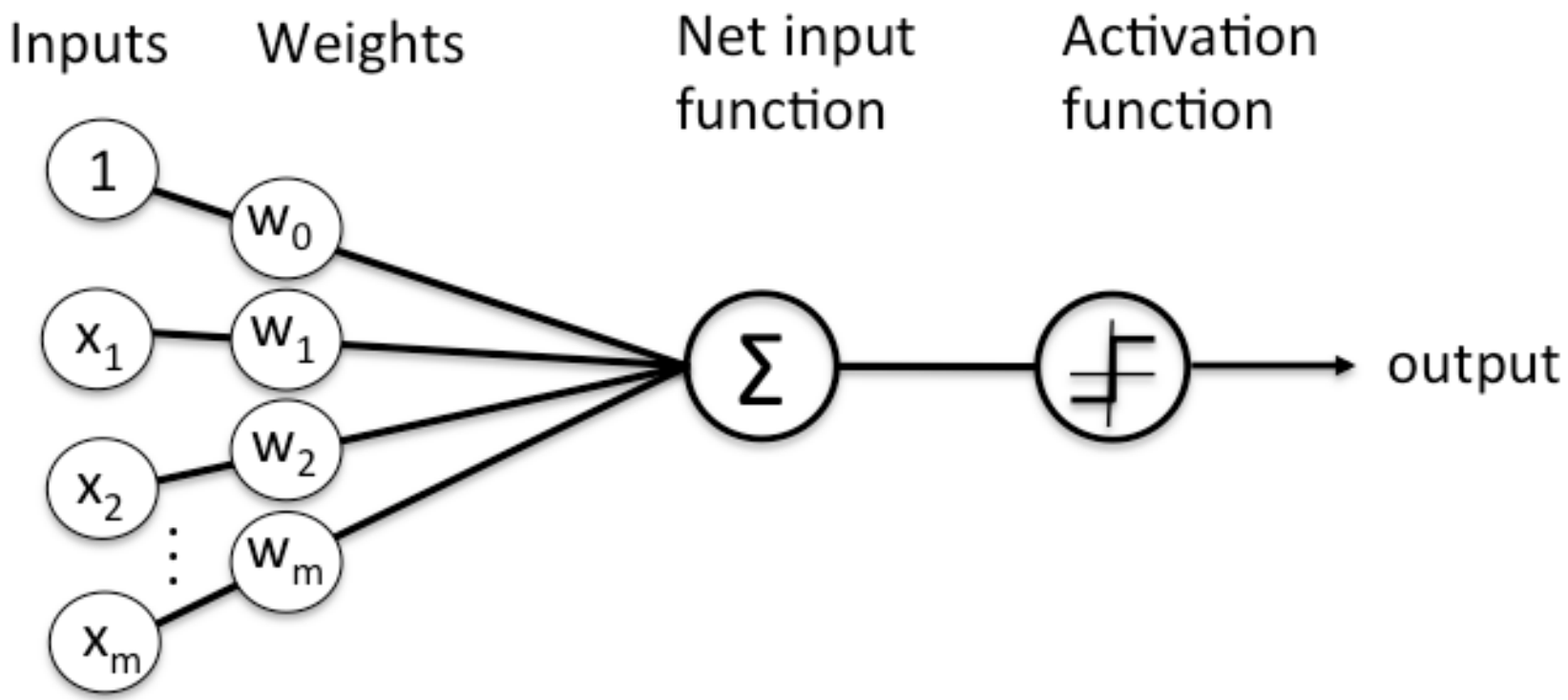
Improving the performance

10 - fold 10-cross validation



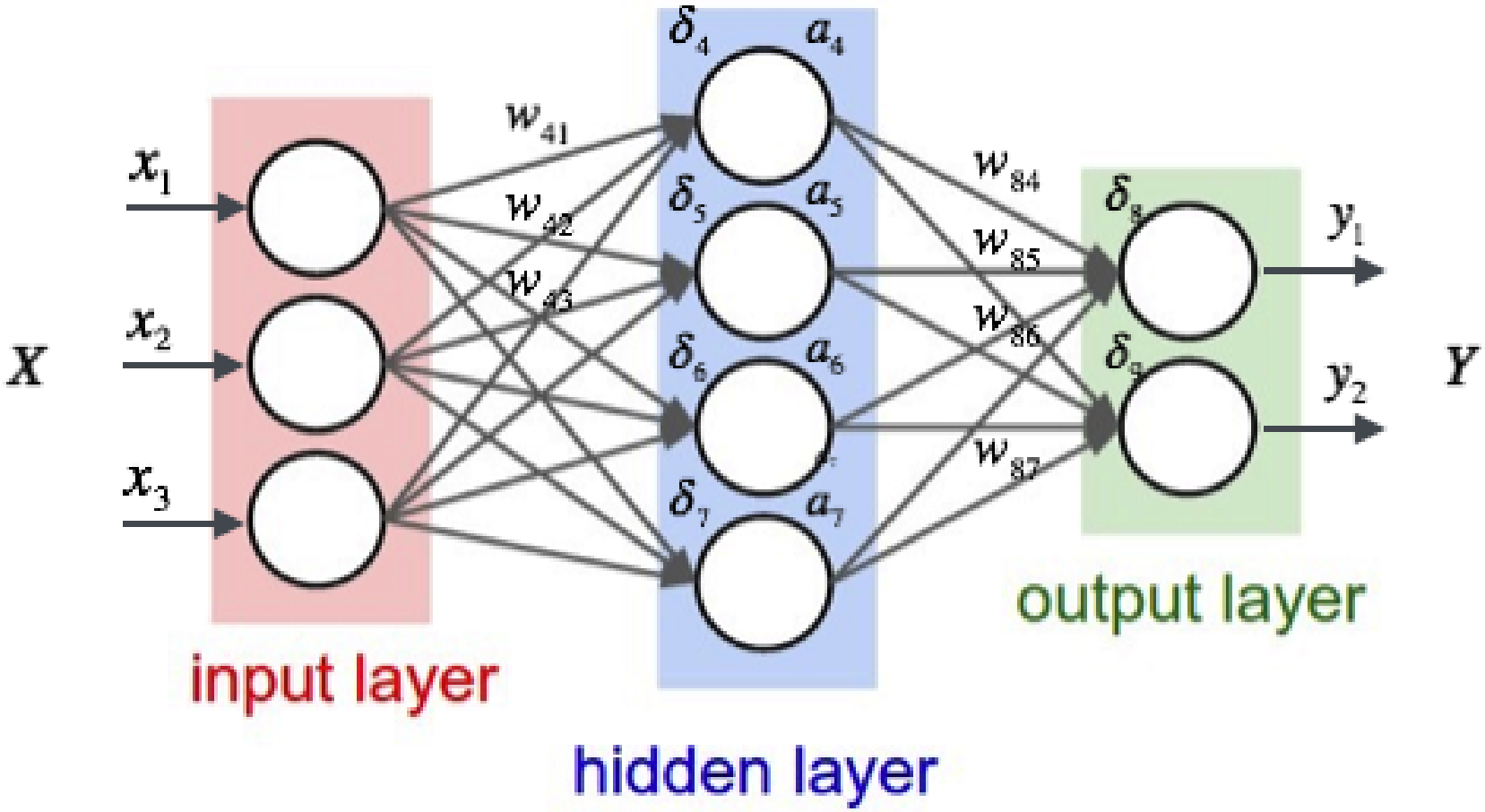
Source: wikipedia

Logistic Regression as a Neuron



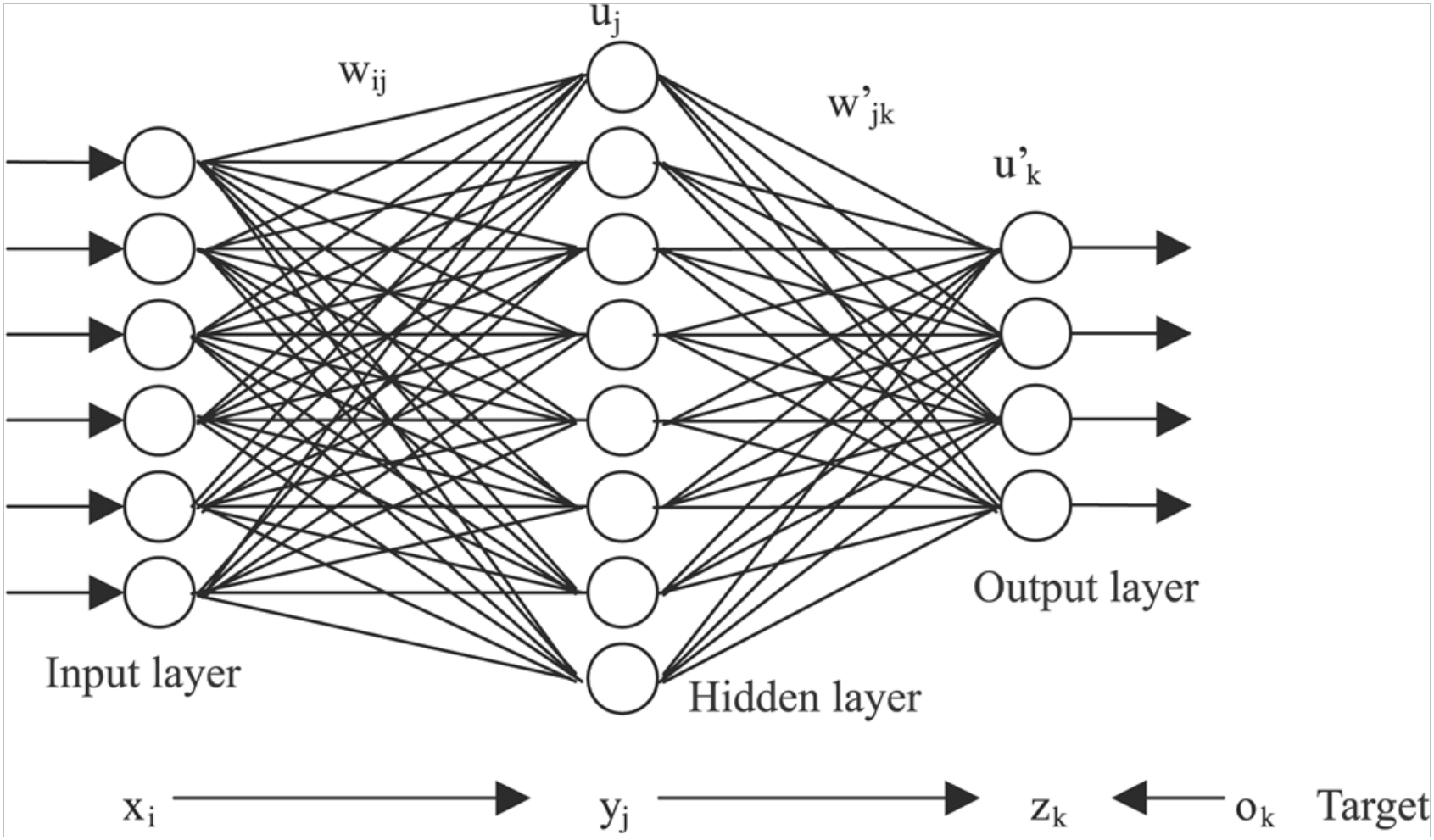
www.techmaru.com/technology/artificial-neural-networks/neural-network-elements

Neuron to Neurons



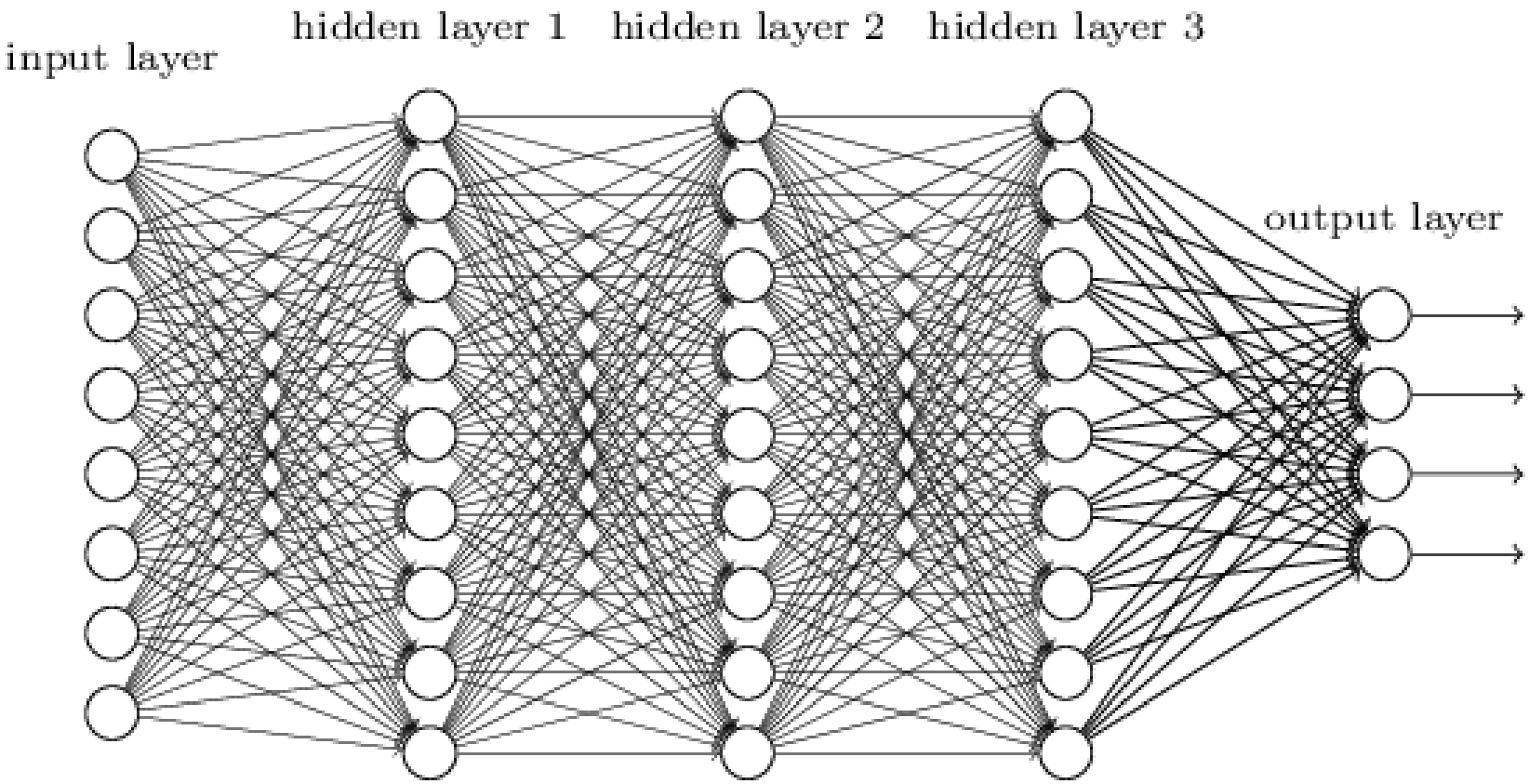
medium.com/@curiousily/tensorflow-for-hackers-part-iv-neural-network-from-scratch-1a4f504dfa8

Single Layer Network



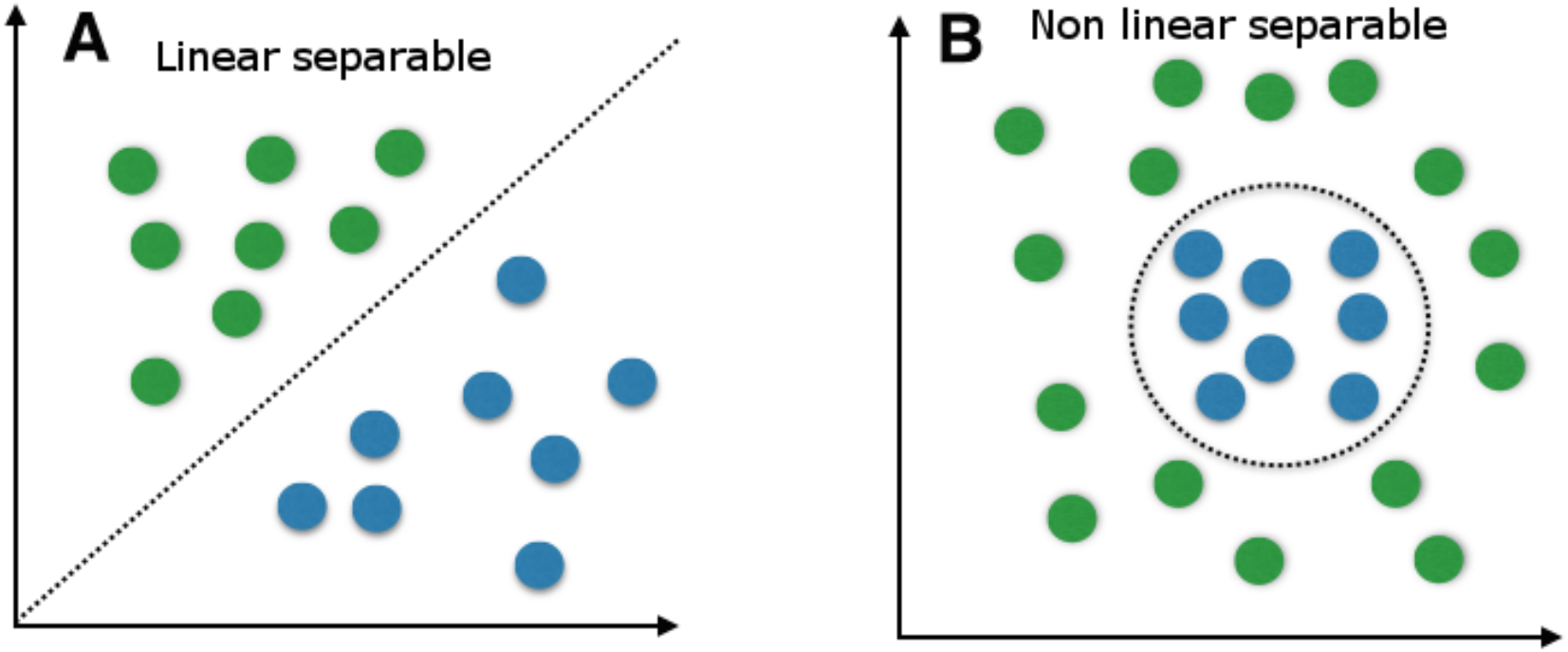
www.extremetech.com/extreme/
215170-artificial-neural-networks-are-changing-the-world-what-are-they

Multi Layer Network



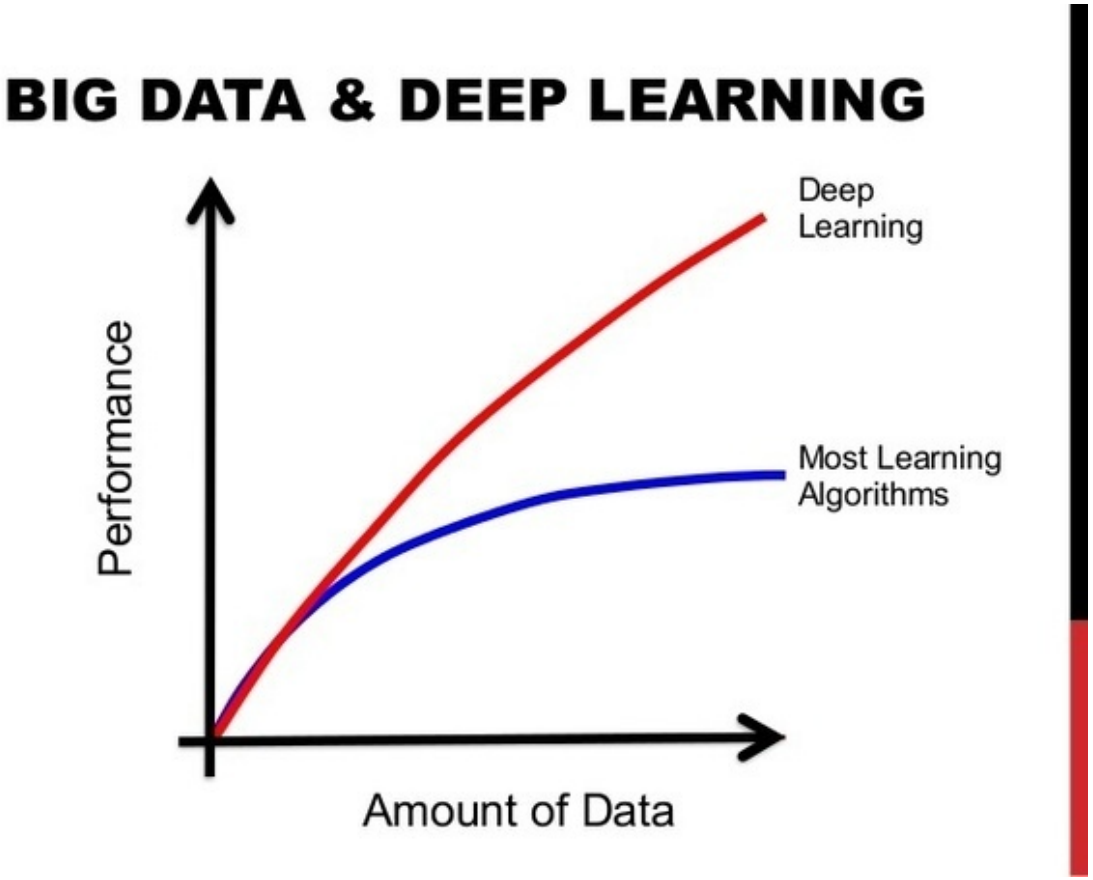
in.mathworks.com/matlabcentral/fileexchange/64247-simple-neural-network

Why Deep Learning?



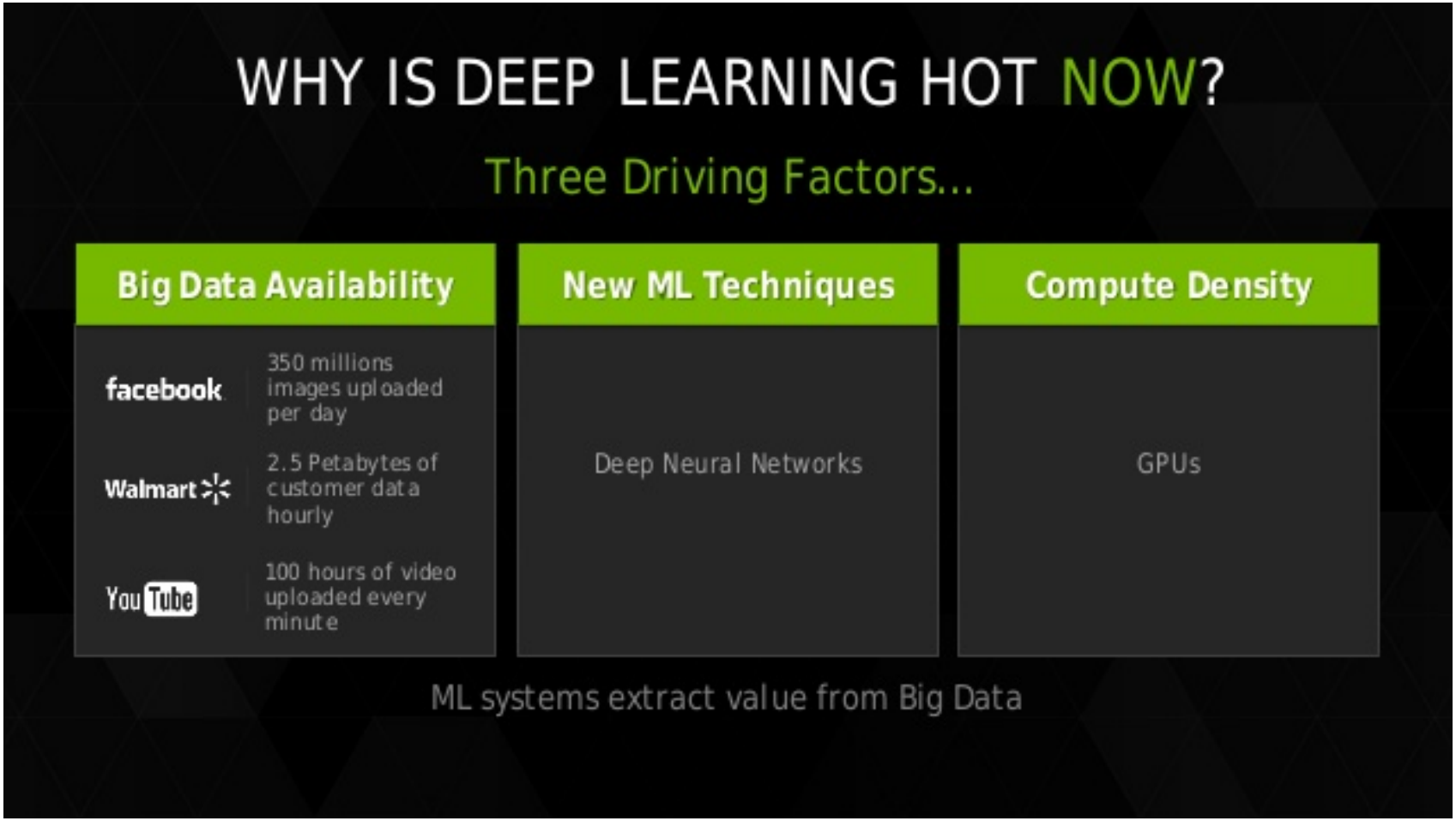
Source: https://leonardoaraujosantos.gitbooks.io/artificial-inteligence/content/linear_classification.html

Why Deep Learning?



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

Why now Deep Learning?



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

$$2a + b + c = 4 \tag{73}$$

$$a + 3b + 2c = 5 \tag{74}$$

$$a = 6 \tag{75}$$

Linear Equations to Matrix

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

Linear Equations to Matrix

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

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.

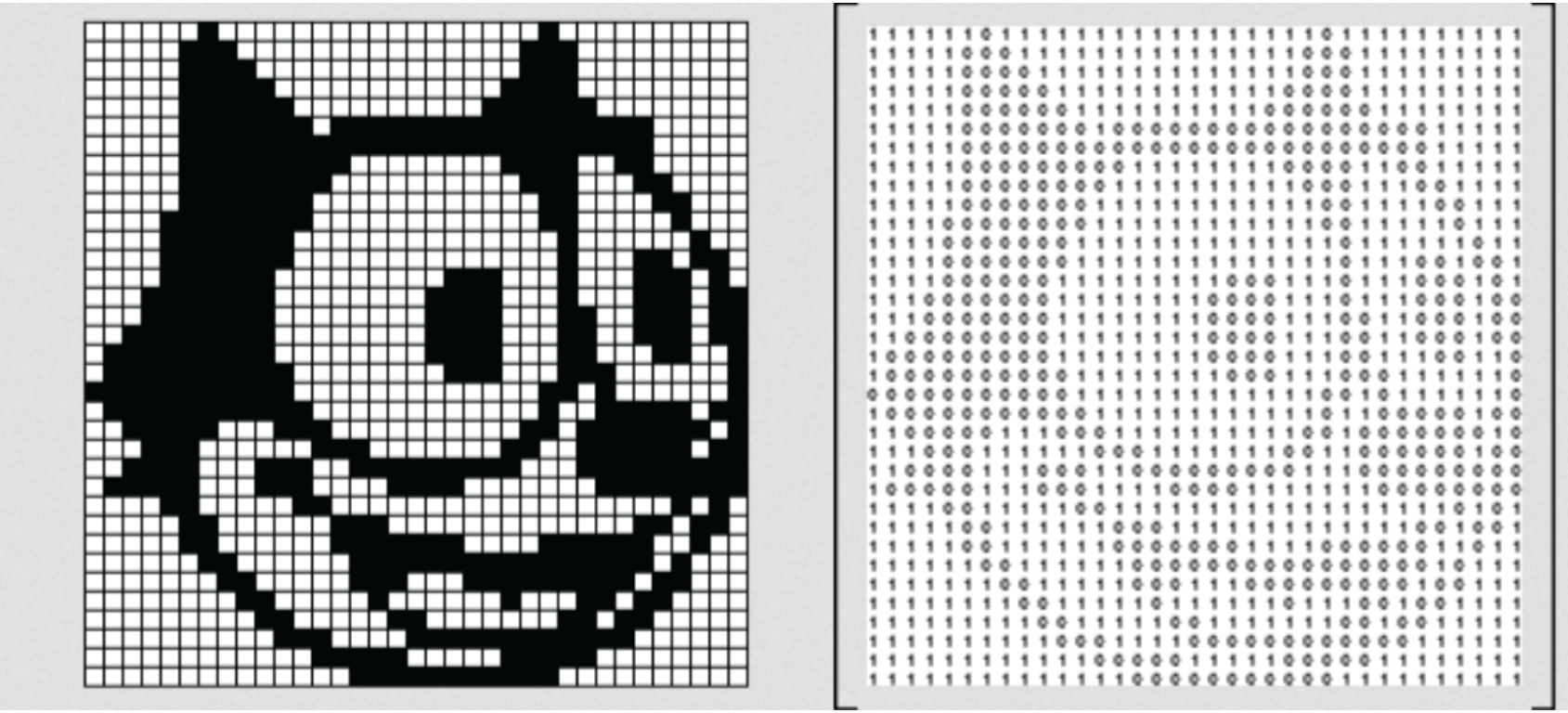
Vocabulary = amrita, are, cen, cbe, in, is, we

Text to Matrix

Table: Text Representation

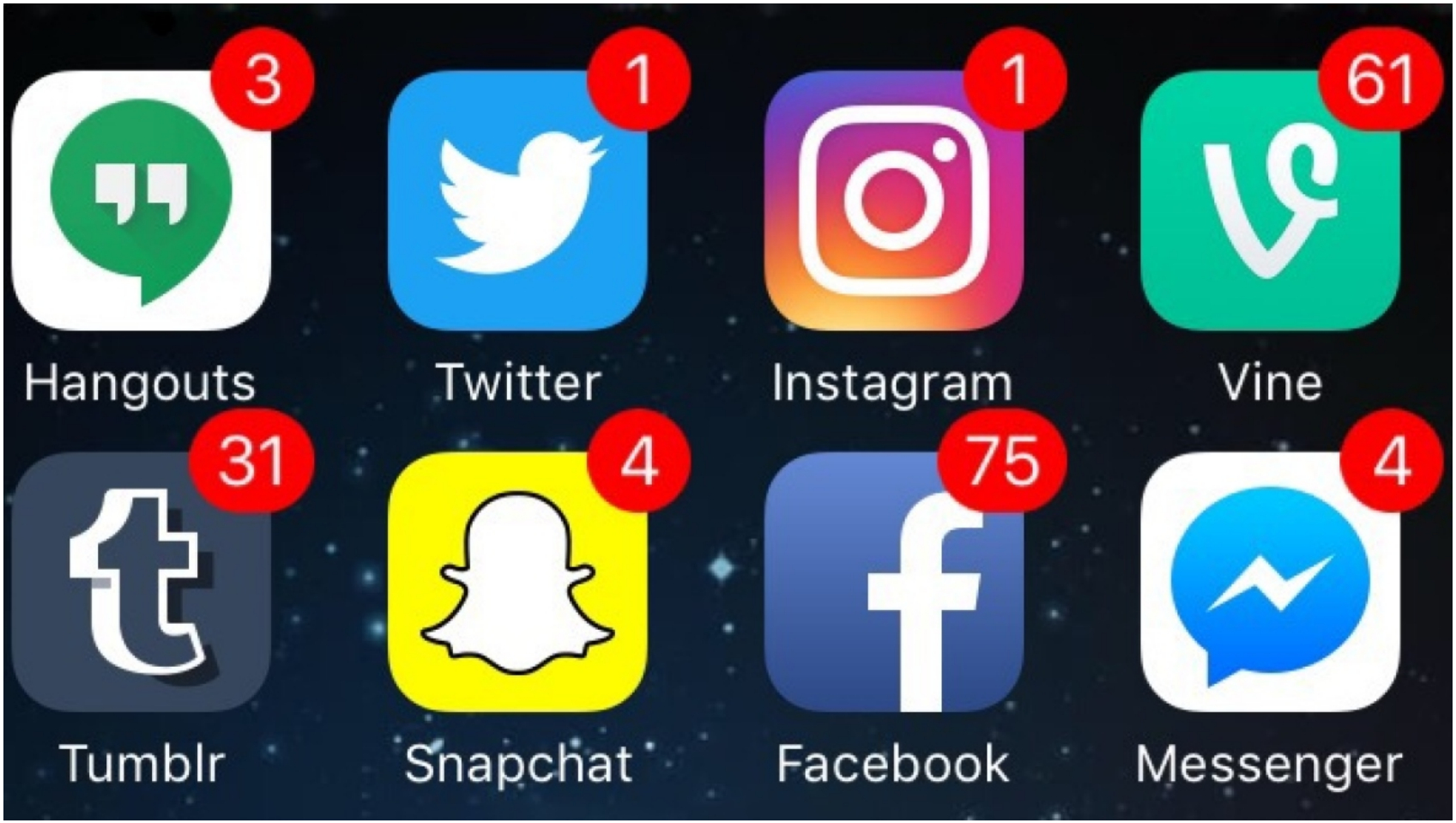
	amrita	**are**	**cen**	**cbe**	**in**	**is**	**we**
S1	0	1	1	0	1	0	1
S2	1	0	1	0	1	1	0
S3	1	0	0	1	1	1	0

Image to Matrix



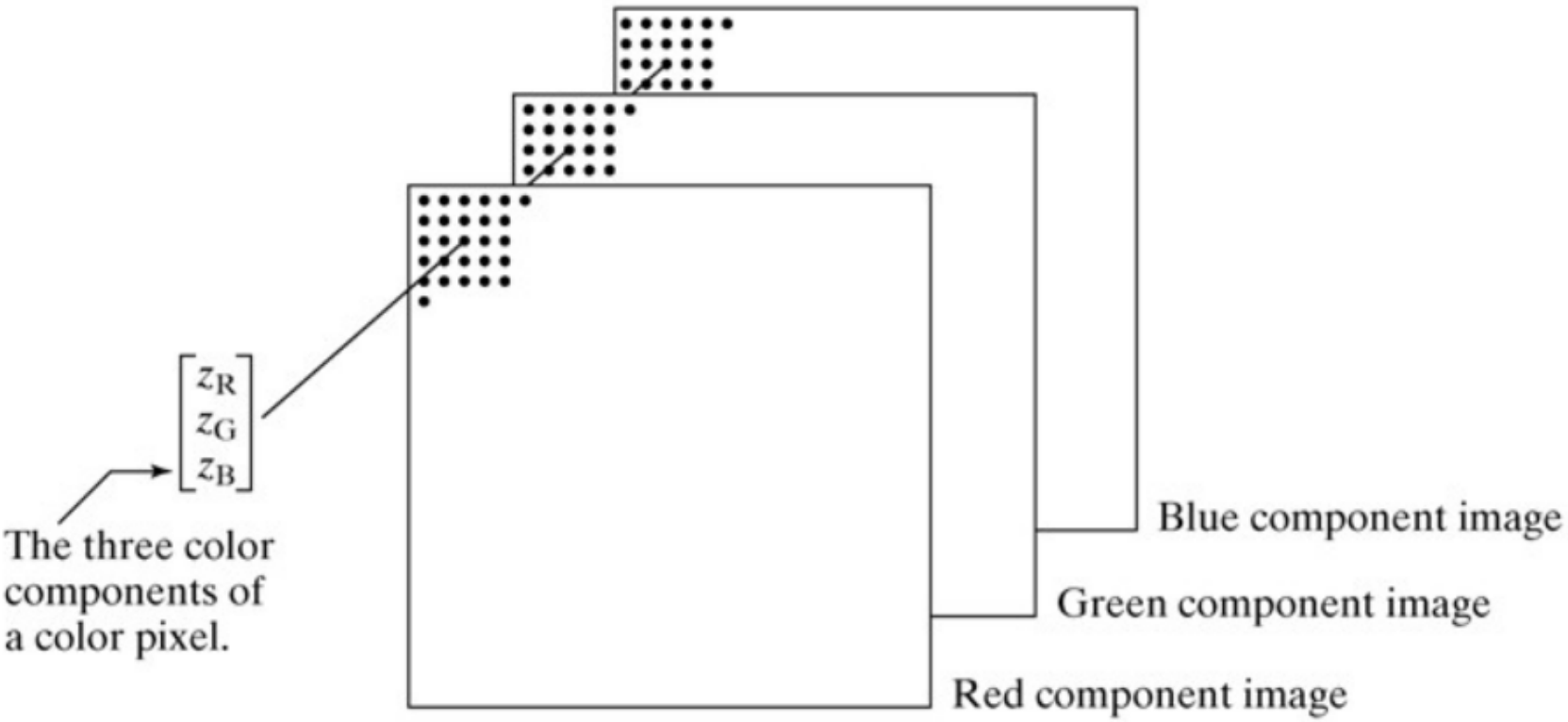
Source: blog.kleinproject.org/?p=588

Image to Matrix



Source: `www.cbc.ca/news/trending`

Image to Matrix



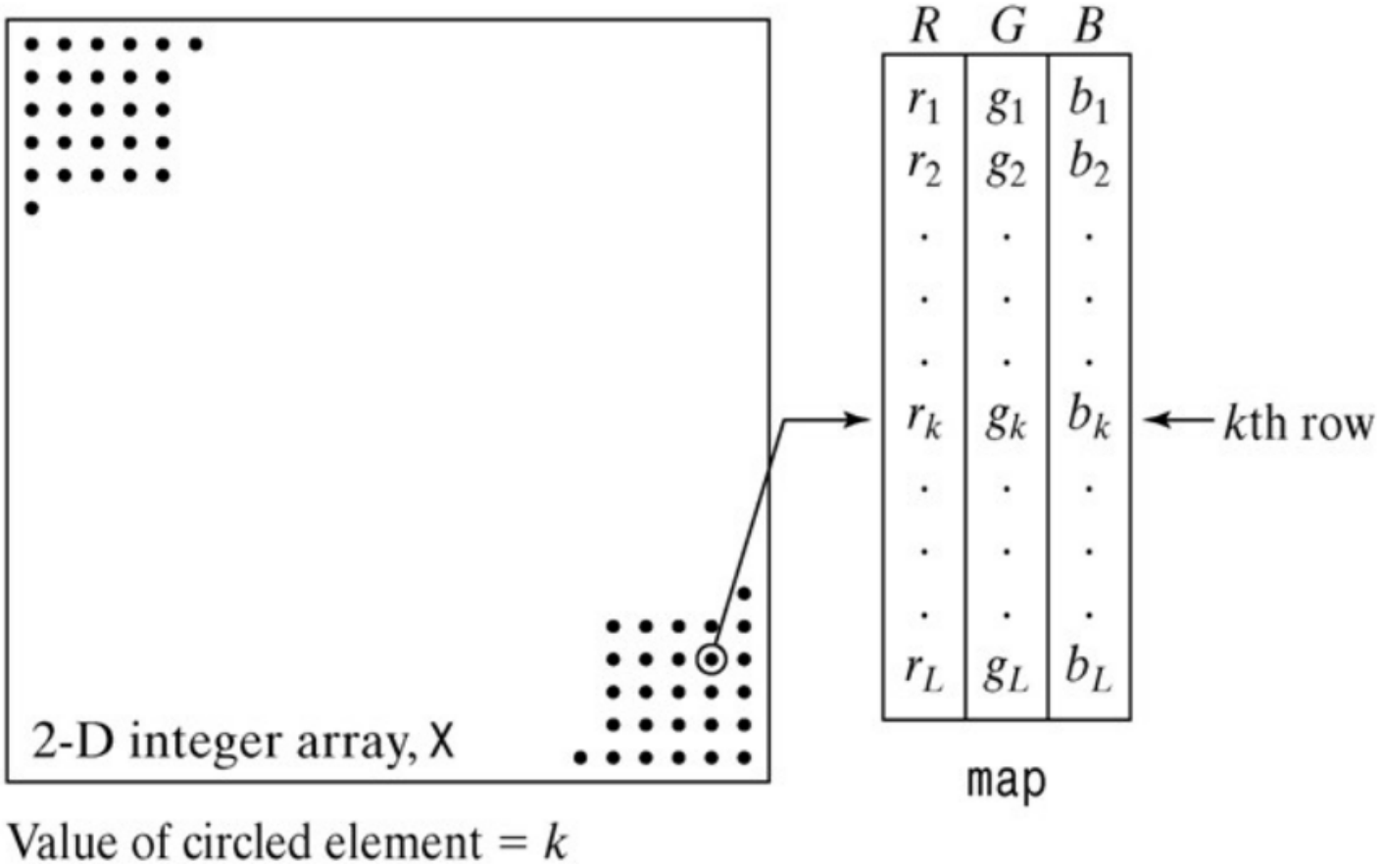
Source: http://slideplayer.com/slide/8752313/

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

Image to Matrix



Source: slideplayer.com/slide/8752313/

Thank You.

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