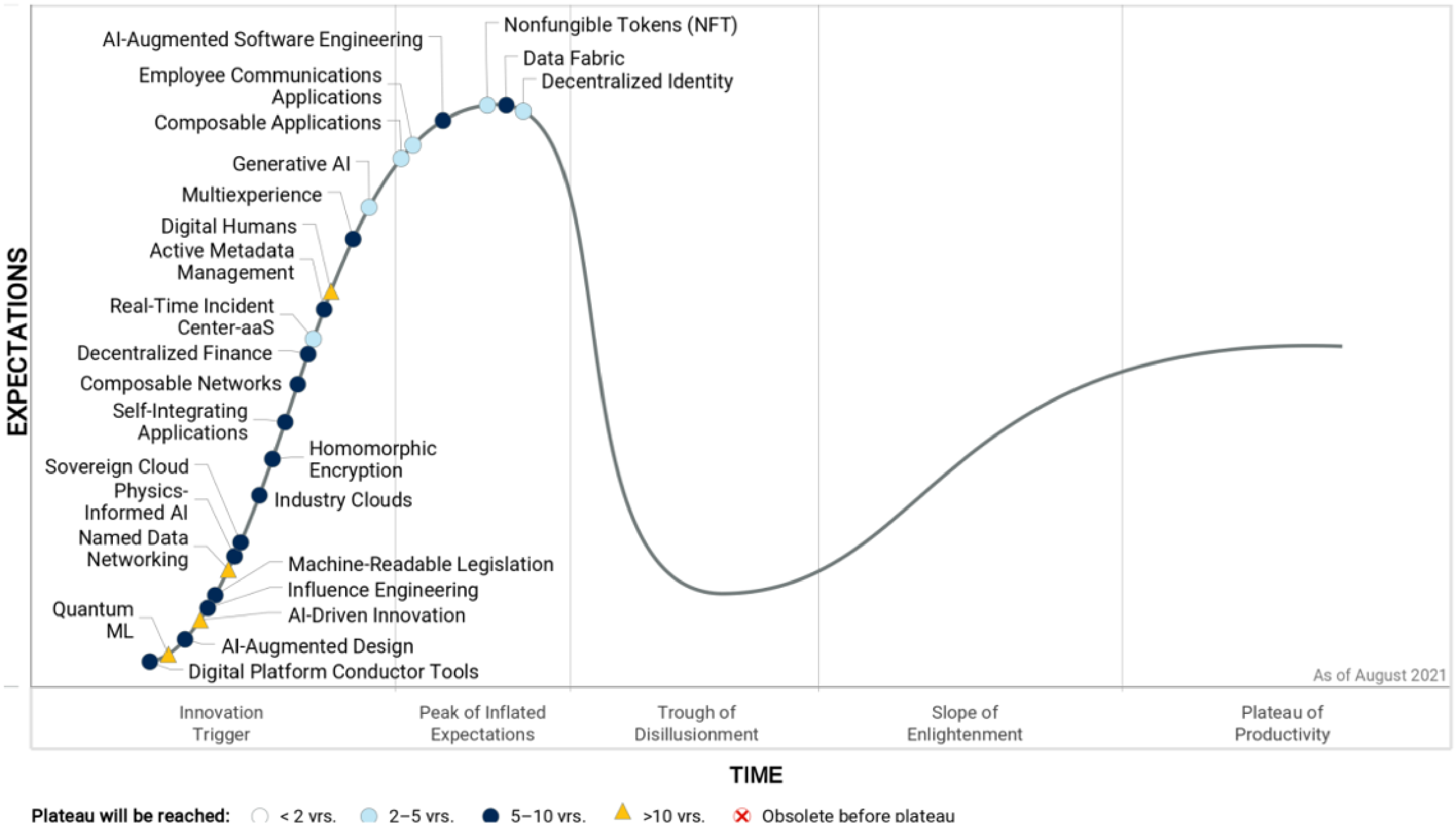
ARTIFICIAL INTELLIGENCE

DR SALEEM AHMED

Gartners Hype Graph for Emerging Tech



Source: Gartner (August 2021)

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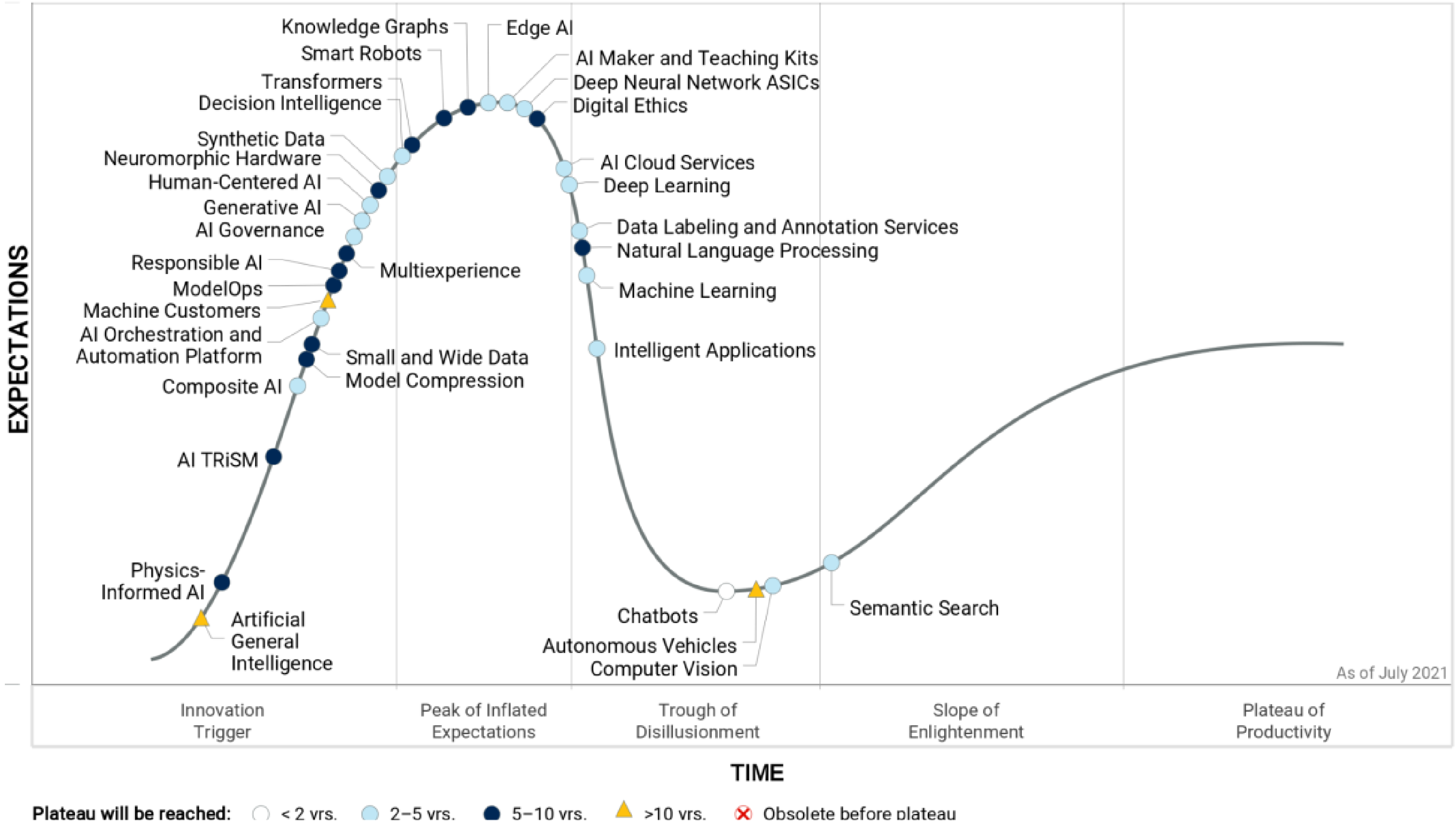
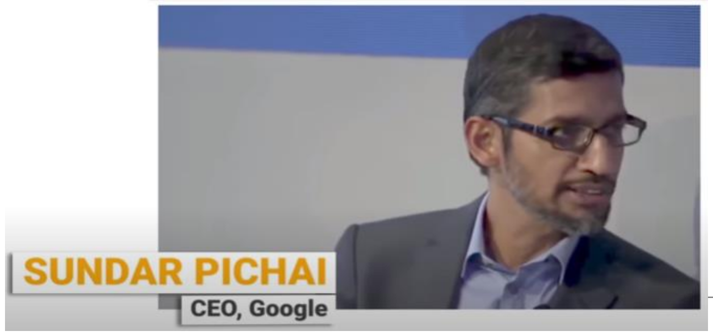
Gartners Hype Graph for Emerging Tech



Gartner



AI is the main tool behind new-age innovation and discoveries like driverless cars or disease detecting algorithm

Generalized AI is worth thinking about because it stretches our imaginations and it gets us to think about our core values and issues of choice

Artificial Intelligence will be ‘vastly smarter’ than any human and would overtake us by 2025.

We are now solving problems with machine learning and AI that were…in the realm of science fiction for the last several decades

Artificial Intelligence and Machine Learning

Artificial Intelligence

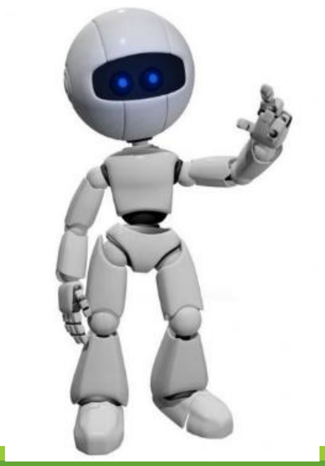
Machine Learning

AI is trained final output machine which mimic like human brain
Ex: Amazon Alexa

ML is a subset of AI. It is a technique to achieve AI. Ex: Spam Detection

Data volumes driving AI

Only AI has the power to analyze this data to solve grand challenges and problems guiding our future.



44 ZB 2020, 50x 2010

2015/16 entire human history

26 billion IoT devices 2020

Artificial Intelligence and Machine Learning in Industry 4.0

Breakdowns of industrial development and the great changes in related categories

Industry 1.0
1760-1830
Mechanization, stream and water power

Industry 2.0
1870-1914
Mass production and Electricity

Industry 3.0
1970-2000
Electronic and IT systems, Automation

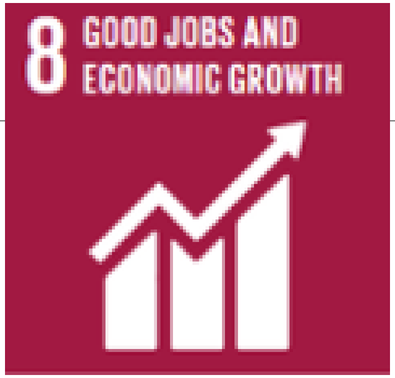
Industry 4.0
2015 -2050?
Artificial intelligence

AI and SDGs

Tracking poverty (SDG1)

Diagnosis (SDG3)

Causal influences development programs education (SDG4)



Micro-finance (SDG8)

Greenhouse emissions and smart cities (SDG11&13)

Global partnerships (SDG17)

Applications

Engineering:

- Computer Vision (e.g. image classification, segmentation)
- Speech Recognition
- Natural Language Processing (e.g. sentiment analysis, translation)

Science:

- Biology (e.g. protein structure prediction, analysis of genomic data)
- Chemistry (e.g. predicting chemical reactions)
- Physics (e.g. detecting exotic particles)

and many more

Machine Learning

What is Learning?

Learning is any process by which a system improves performance from experience.

What is Machine Learning?

Machine learning is concerned with computer programs that automatically improve their performance through experience.

Machine Learning

Supervised: Given input samples (X) and output samples (y)

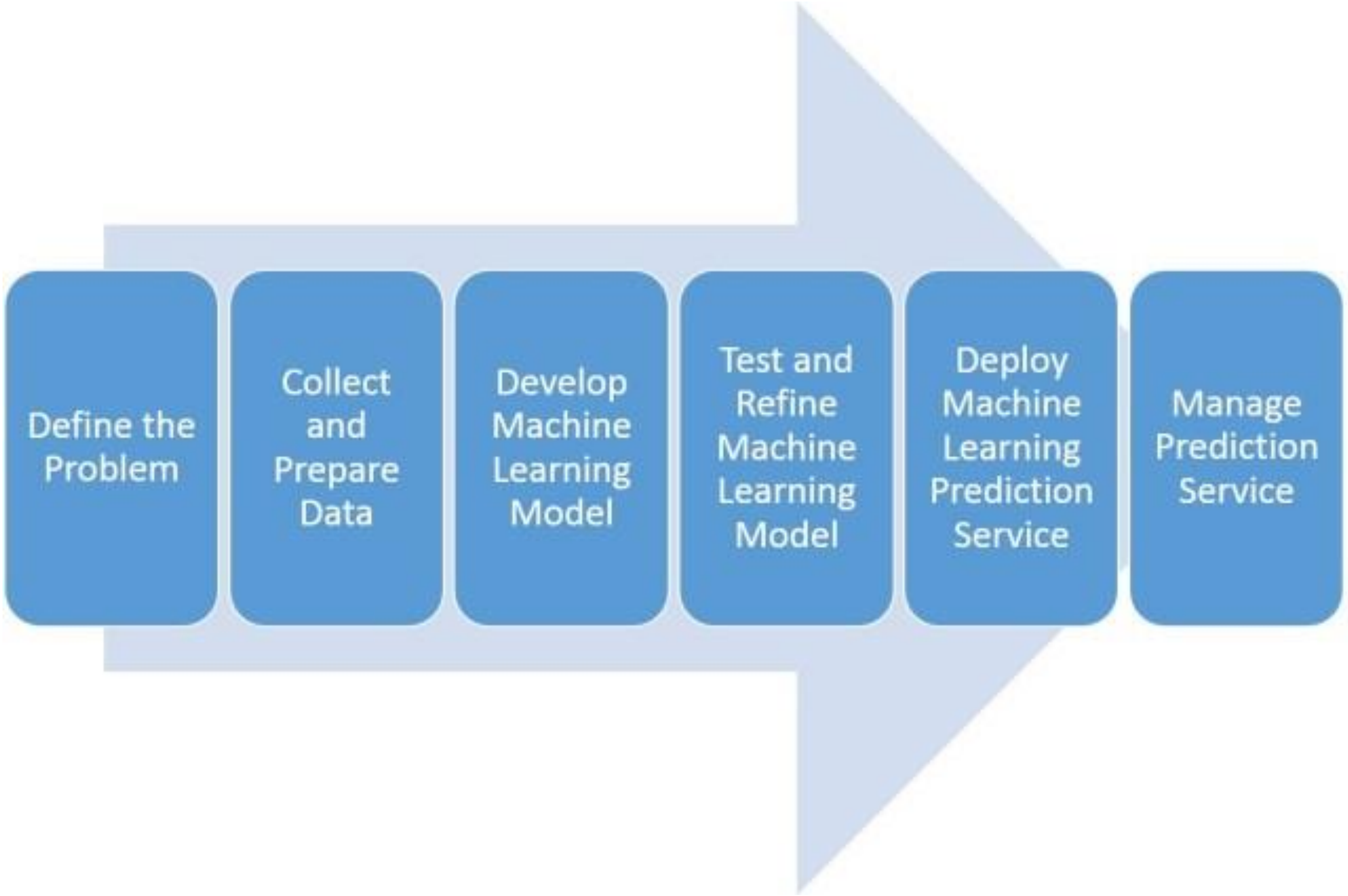
y = f(X). We would like to "learn" f, and evaluate it on new data. Types:

- **Classification:** y is discrete (class labels).
- **Regression:** y is continuous, e.g. linear regression.

Unsupervised: Given only samples X of the data, we compute a function f such that y = f(X) is "simpler".

- **Clustering:** y is discrete
- Y is continuous: **Matrix factorization, Kalman filtering, unsupervised neural networks**.

Machine Learning Process



Regression

- In statistics, regression analysis includes many techniques for modeling and analyzing several variables when the focus is on the relationship between a dependent variables and one or more independent variables.

- Regression analysis is widely used for prediction and forecasting.

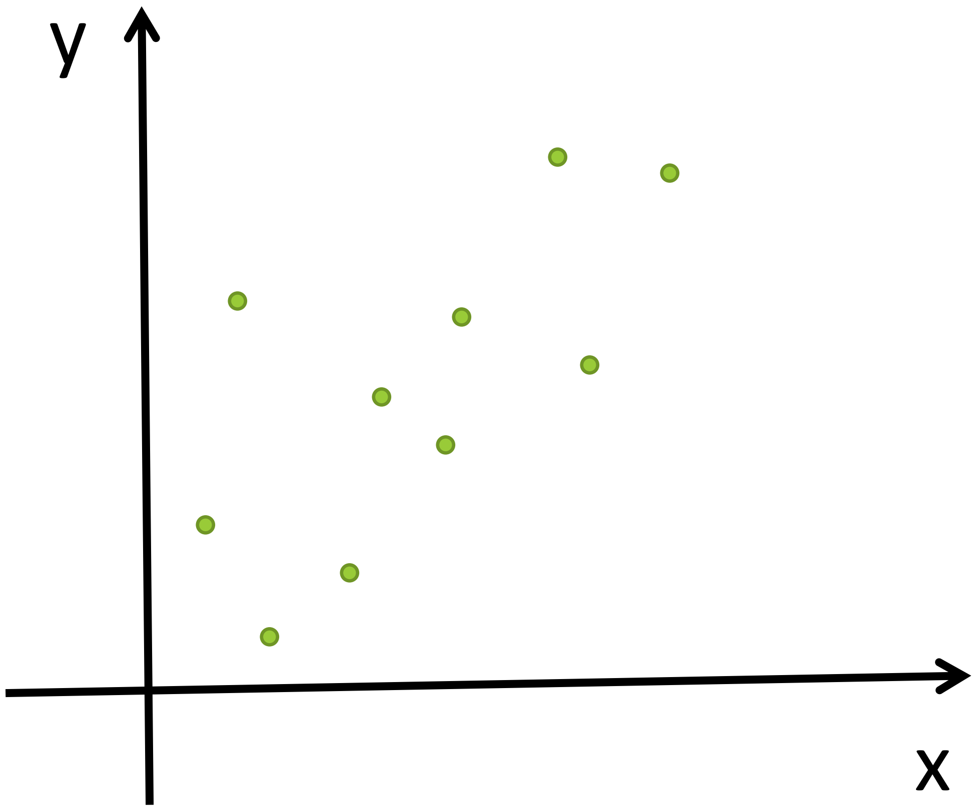
Regression

Dependent & independent variables

- Independent variables are regarded as inputs to a system and may take on different values freely. They are also called as predictors or explanatory variables and denoted by **X**.

- Dependent variables are also called as response variables and denoted by **Y**.

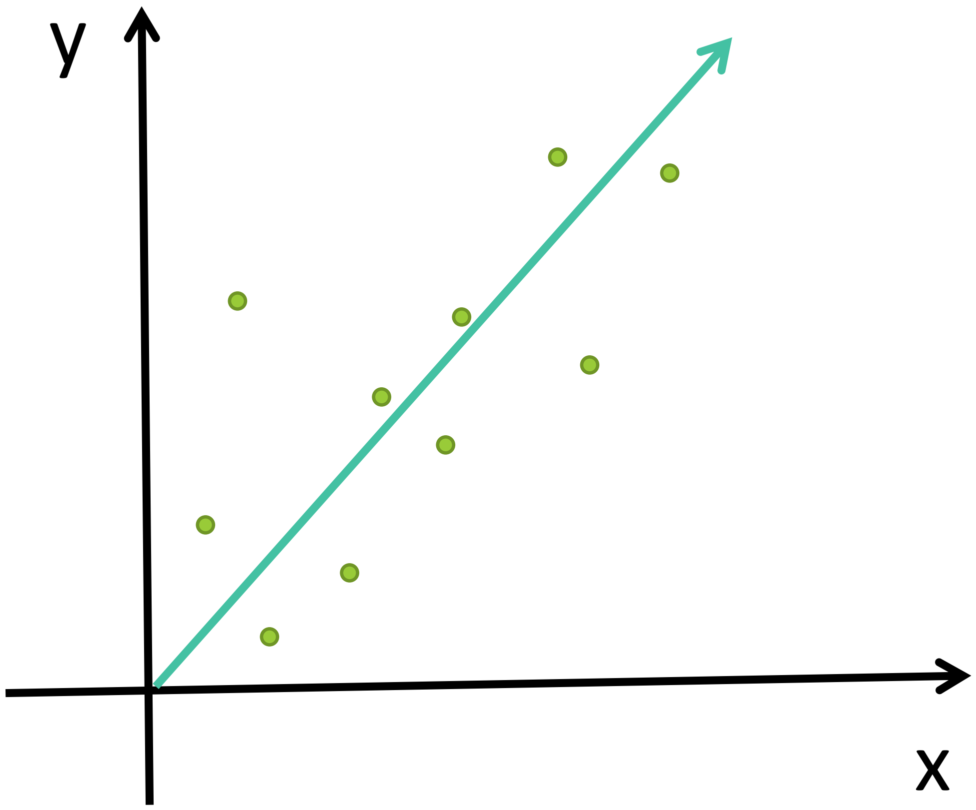
Linear Regression



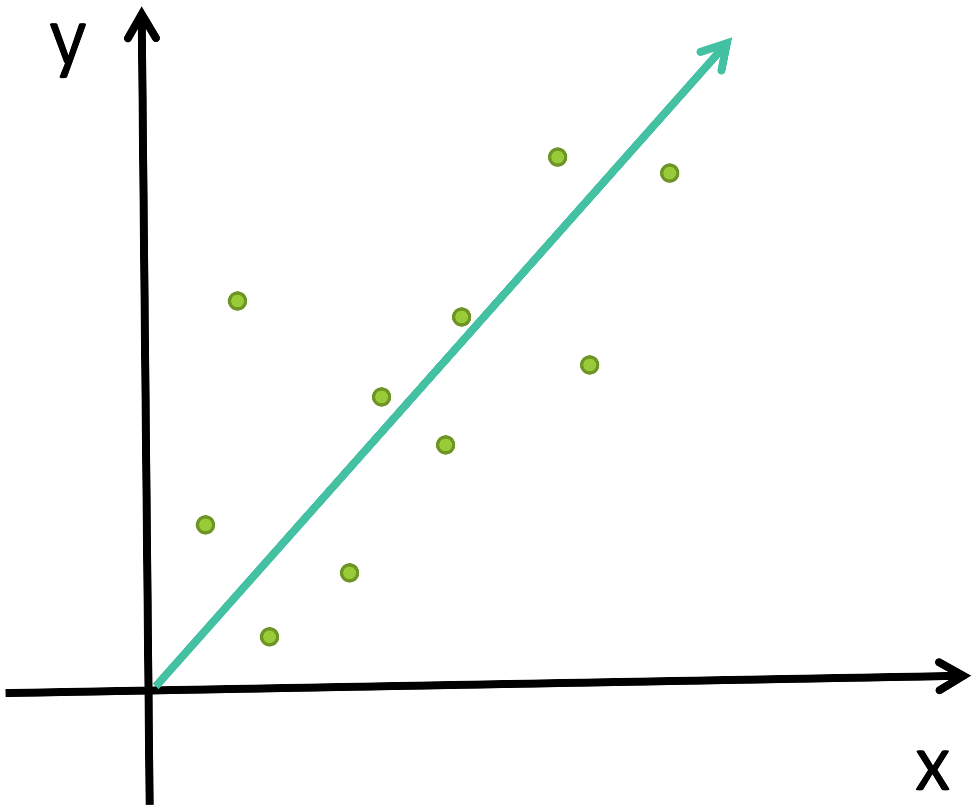
The Simplest mathematical relationship between two variables X and Y is a linear relationship

x	y
0.056	0.848
0.038	0.806
0.014	0.738
0.034	0.738
0.066	0.726
0.112	0.632
0.16	0.678
0.26	0.67
0.22	0.766
0.142	0.764
0.132	0.714
0.196	0.668

Linear Regression



Linear Regression



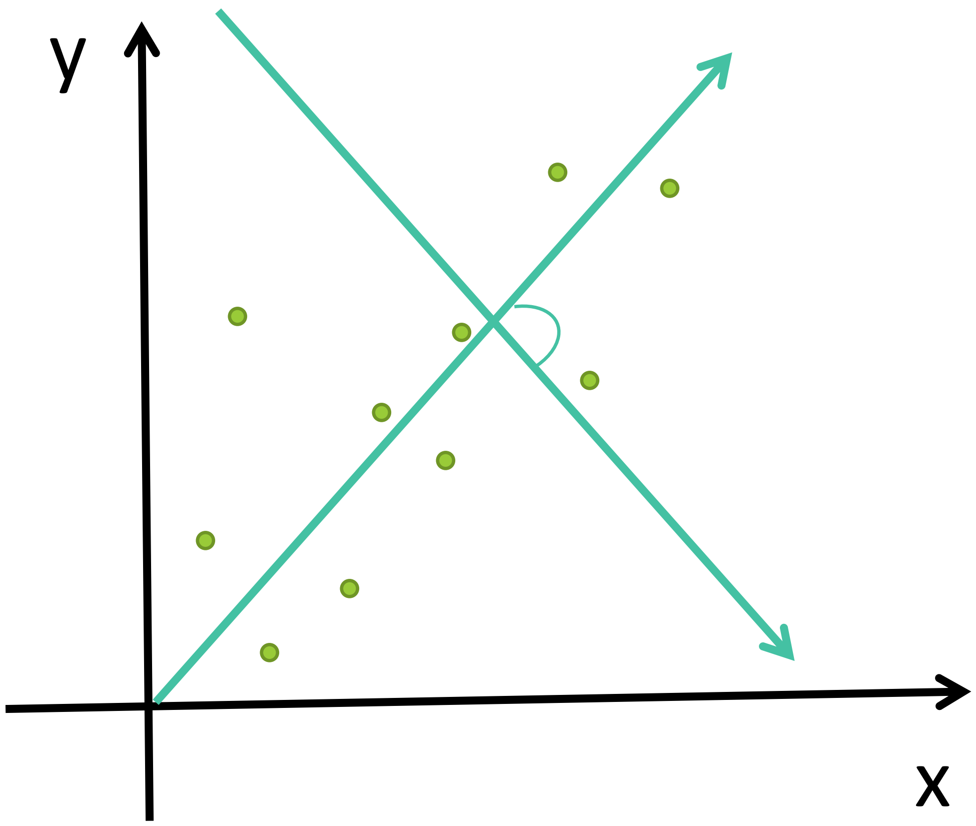
EQUATION OF THE LINE

$$\boxed{y = mx + c}$$

- The value of m is called the slope constant

- The value of C is called the Y-intercept

Linear Regression

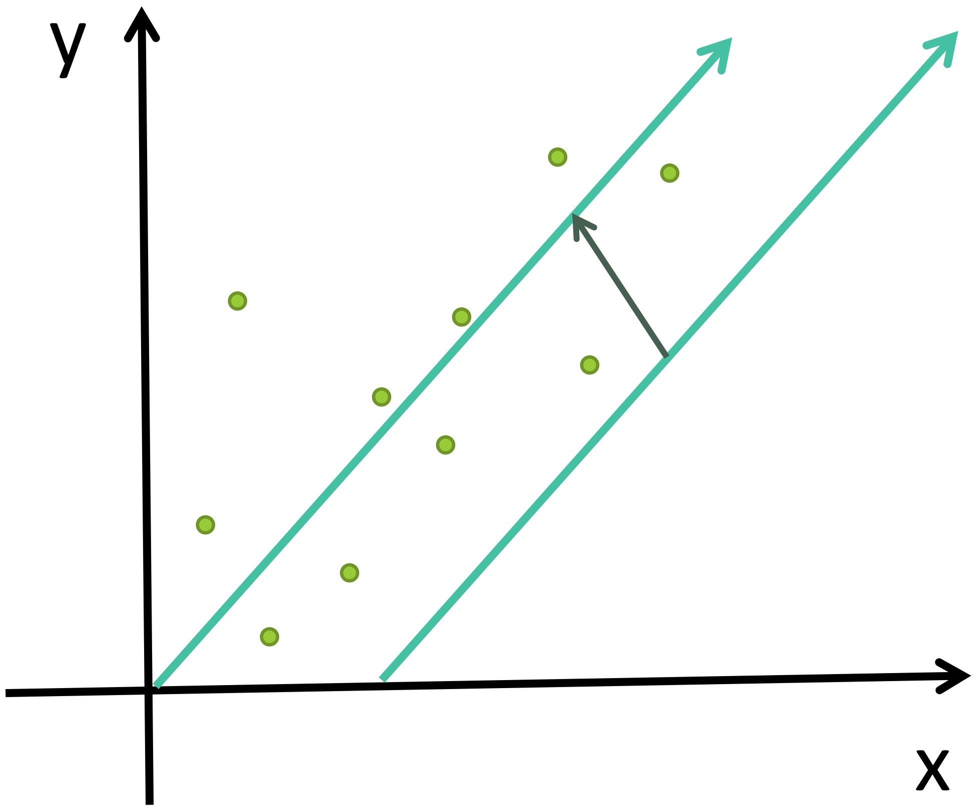


$$\boxed{y = mx + c}$$

$$\boxed{\Delta m}$$

Determines the direction and degree to which the line is tilted

Linear Regression

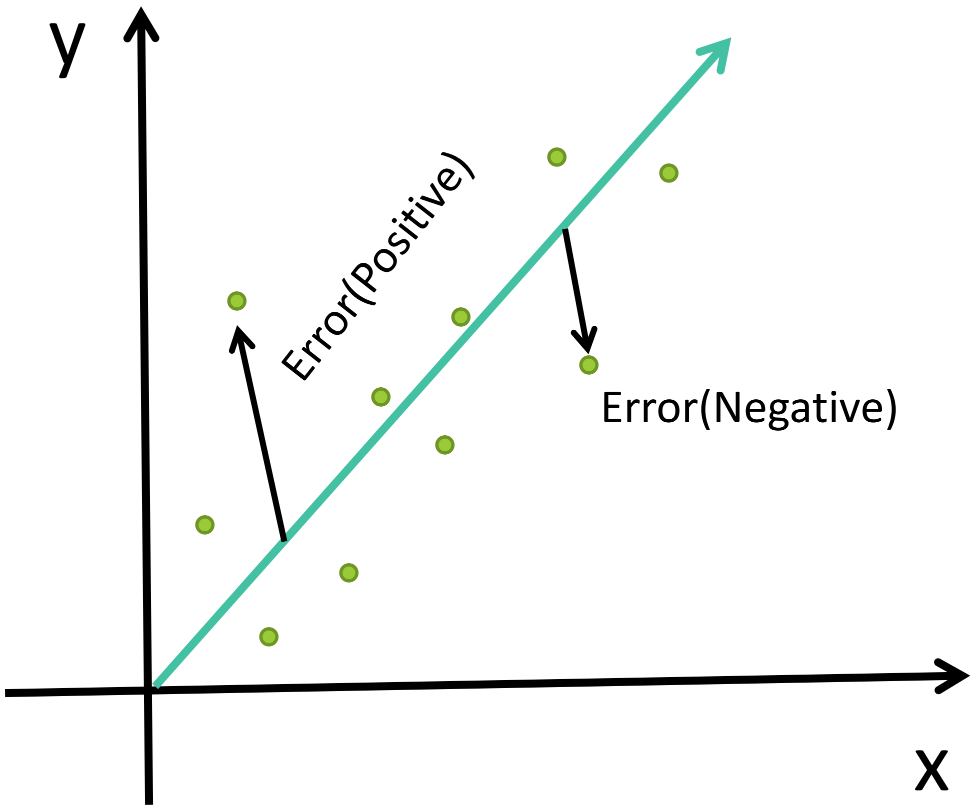


$$\boxed{Y = mX + c}$$

$$\boxed{\Delta c}$$

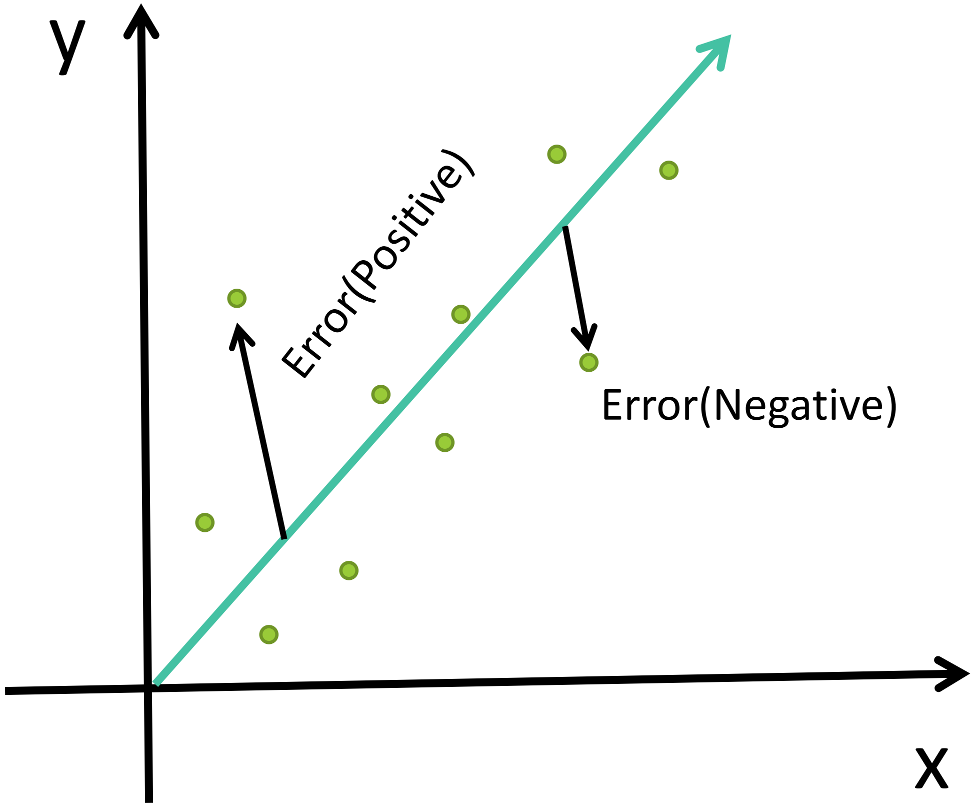
Determines the point where the line crosses the Y-axis.

Linear Regression



$$\boxed{\textbf{Error} = y-(mx + c)}$$

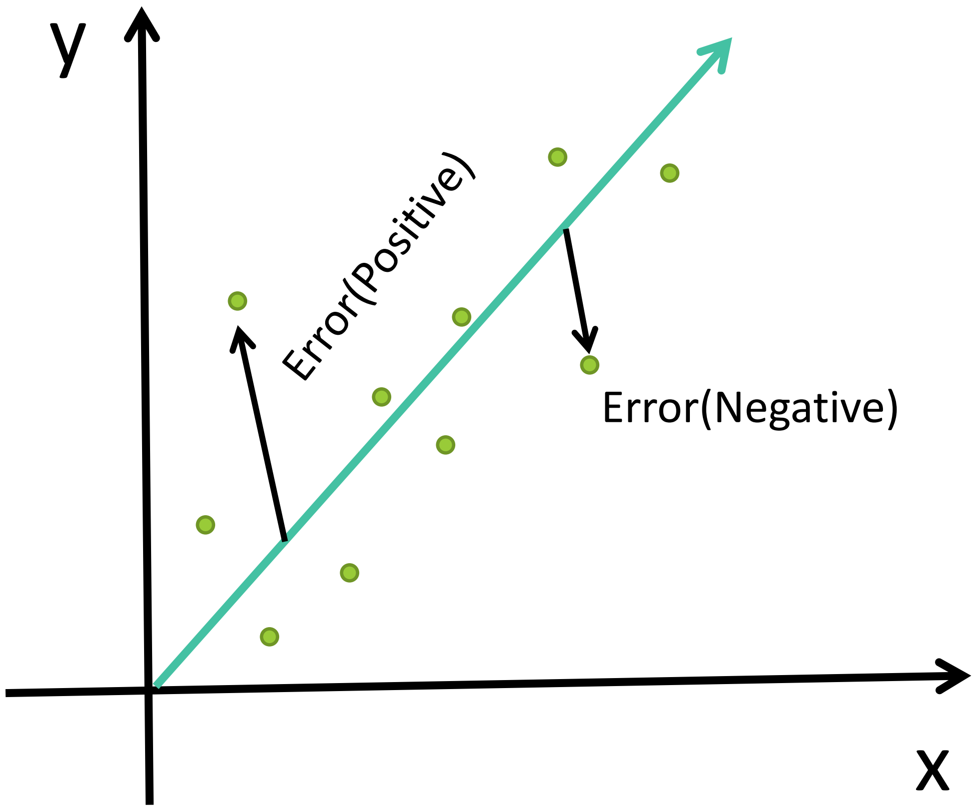
Linear Regression



$$\boxed{\textbf{Error} = y-(mx + c)}$$

$$\boxed{\Delta m = \textbf{learning rate} * \textbf{error}*x}$$

Linear Regression



Error = y-(mx + c)

Δm = learning rate * error*x

Δc = learning rate * error

learning rate = 0.01

K-Nearest Neighbor

The KNN Model

- Accuracy generally improves with more data.
- Matching is simple and fast (and single pass).
- Usually need data in memory, but can be run off disk.

Minimal Configuration:

- Only parameter is k (number of neighbors)
- Weighting of neighbors.

K-Nearest Neighbor

Euclidean Distance: Simplest, fast to compute

$$d(x, y) = \|x - y\|$$

Cosine Distance: Good for documents, images, etc.

$$d(x, y) = 1 - \frac{x \cdot y}{\|x\|\|y\|}$$

Jaccard Distance: For set data:

$$d(X, Y) = 1 - \frac{|X \cap Y|}{|X \cup Y|}$$

Hamming Distance: For string data:

$$d(x, y) = \sum_{i=1}^{n} (x_i \neq y_i)$$

Random Forest

- Random Forest is method that operates by constructing multiple decision trees during training phase.

- The decision of the majority of the trees is chosen by the random forest as the final decision.

Parameters to Evaluate Model

R-Squared:

$$R^2 = 1 - \frac{\sum(y_i - \widehat{y_i})^2}{\sum(y_i - \bar{y})^2}$$

Mean Square Error

$$\mathrm{MSE} = \frac{1}{\mathrm{n}} \sum_{\mathrm{i}}^{\mathrm{n}} (\mathrm{y_i} - \hat{\mathrm{y}}_{\mathrm{i}})^2$$

Root Mean Square Error:

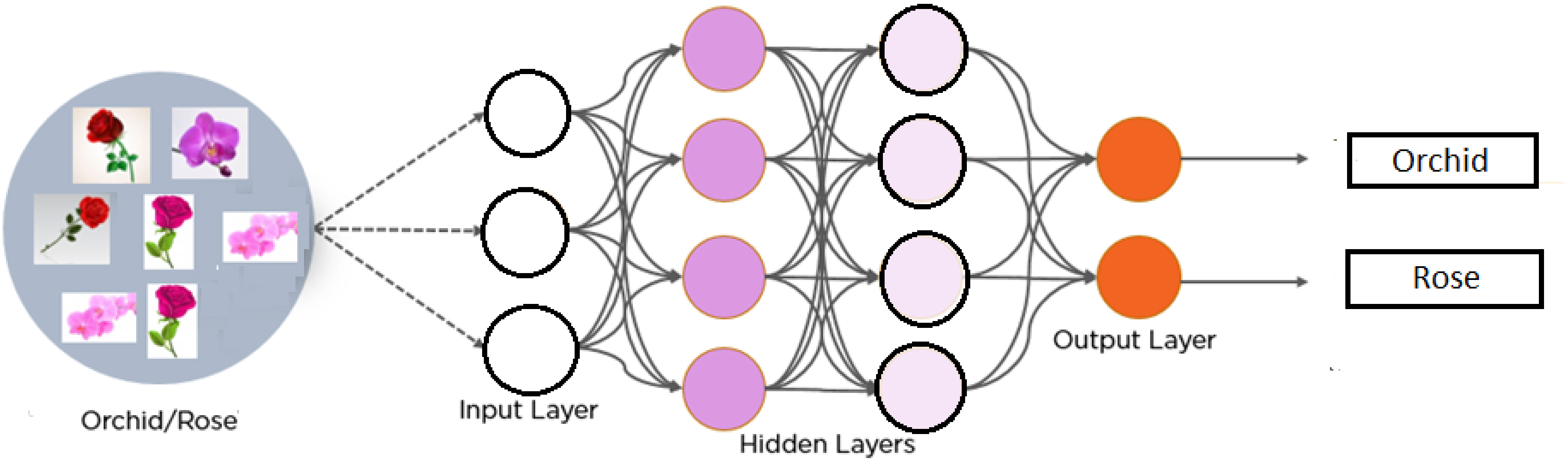
$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n}}$$

Mean Absolute Error:

$$MAE = \frac{\sum_{i=1}^{n}|y_i - \hat{y}_i|^2}{n}$$

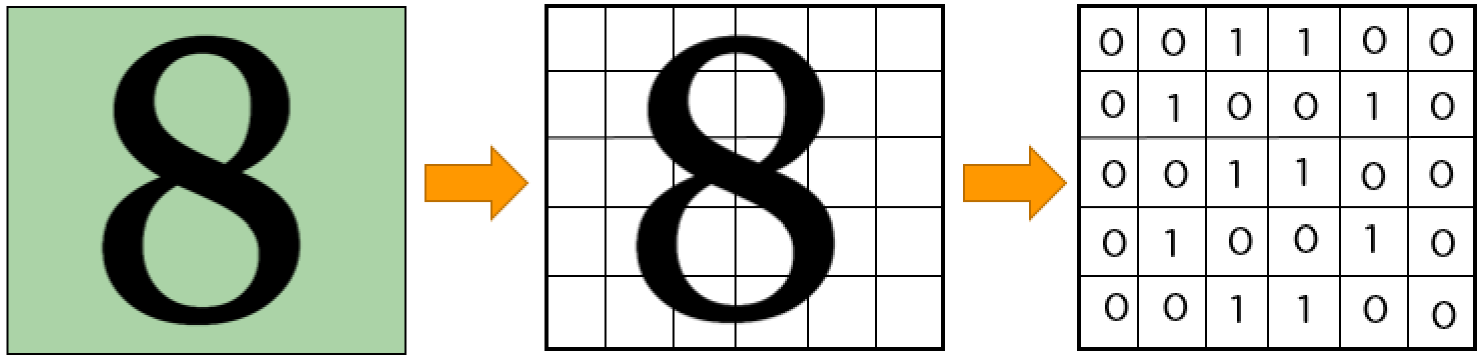
Convolutional Neural Network

- A convolutional neural network is a feed-forward neural network that is generally used to analyze visual images by processing data with grid-like topology. It's also known as a ConvNet. A convolutional neural network is used to detect and classify objects in an image.



Convolutional Neural Network

In CNN, every image is represented in the form of an array of pixel values.



Real Image of the digit 8

Represented in the form of an array

Digit 8 represented in the form of pixels of 0's and 1's

Convolutional Neural Network

Layers in a Convolutional Neural Network

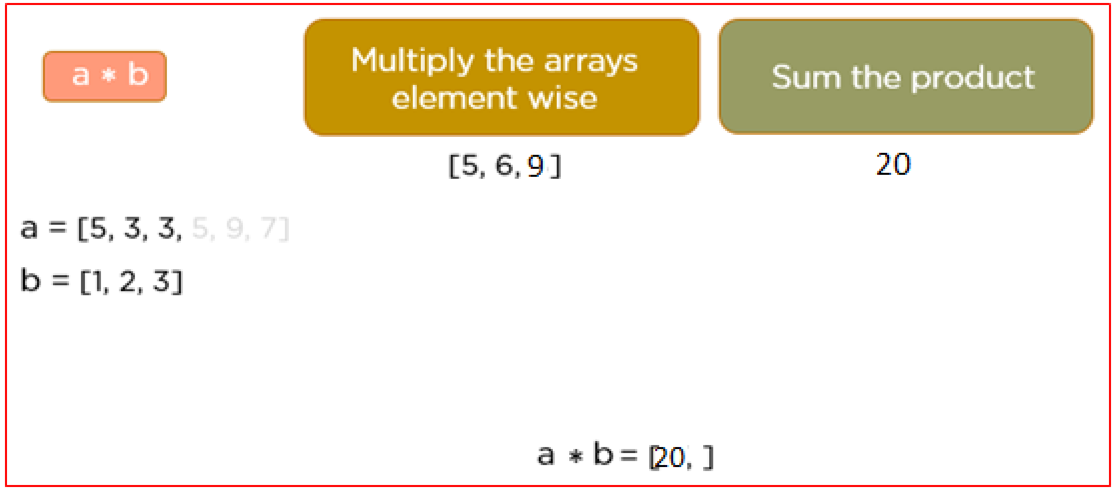
A convolution neural network has multiple hidden layers that help in extracting information from an image. The four important layers in CNN are:

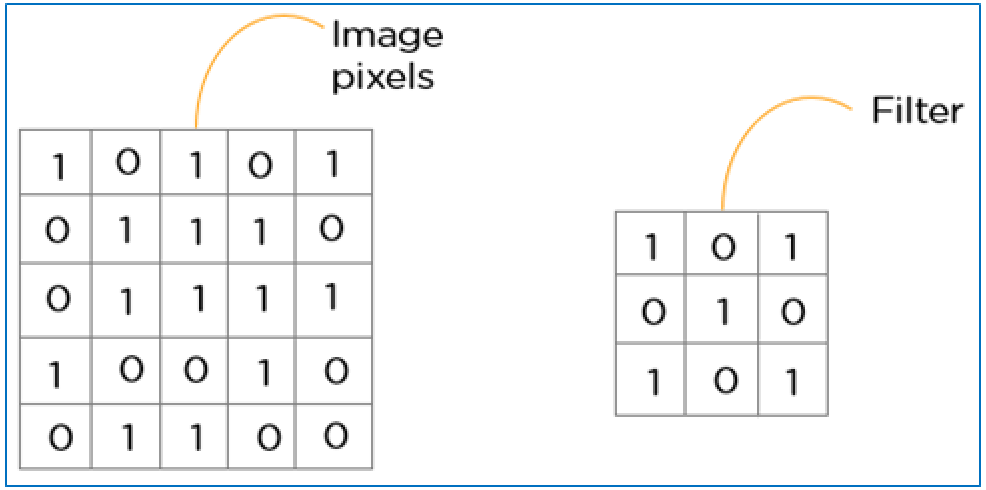
1. Convolution layer
2. ReLU layer
3. Pooling layer
4. Fully connected layer

Convolutional Neural Network

Convolution Layer

This is the first step in the process of extracting valuable features from an image. A convolution layer has several filters that perform the convolution operation. Every image is considered as a matrix of pixel values.

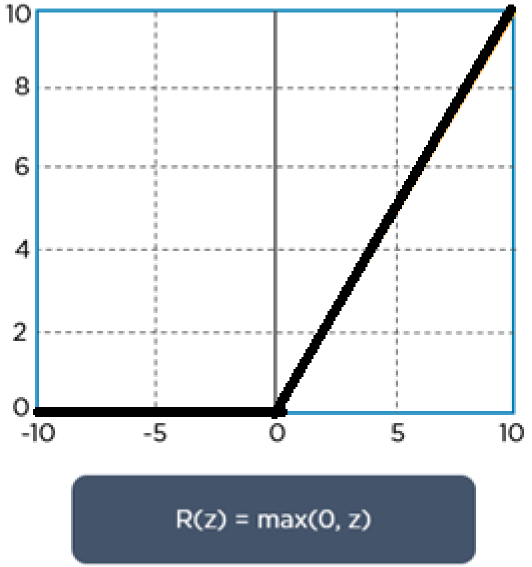




Convolutional Neural Network

ReLU layer

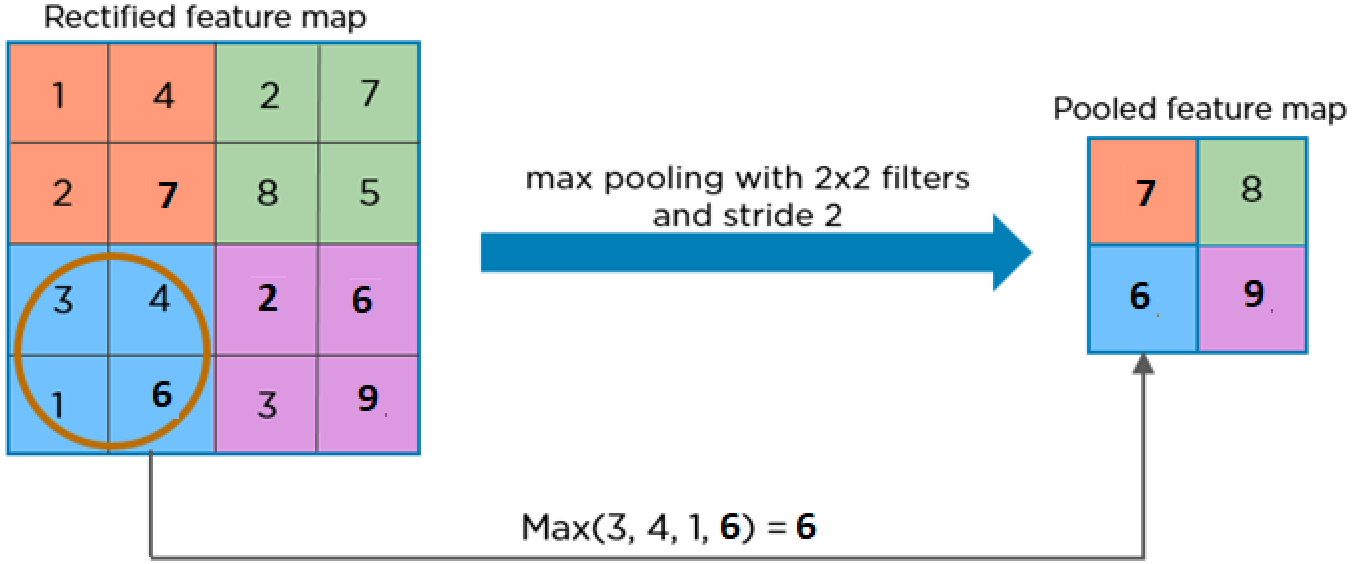
ReLU performs an element-wise operation and sets all the negative pixels to 0. It introduces non-linearity to the network, and the generated output is a rectified feature map. Below is the graph of a ReLU function:



Convolutional Neural Network

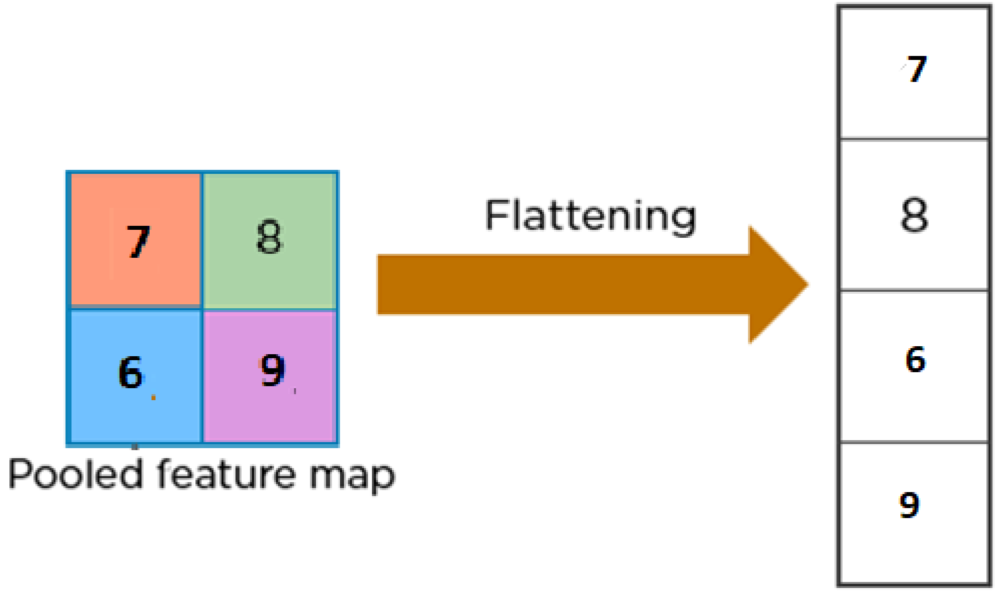
Pooling Layer

Pooling is a down-sampling operation that reduces the dimensionality of the feature map. The rectified feature map now goes through a pooling layer to generate a pooled feature map.



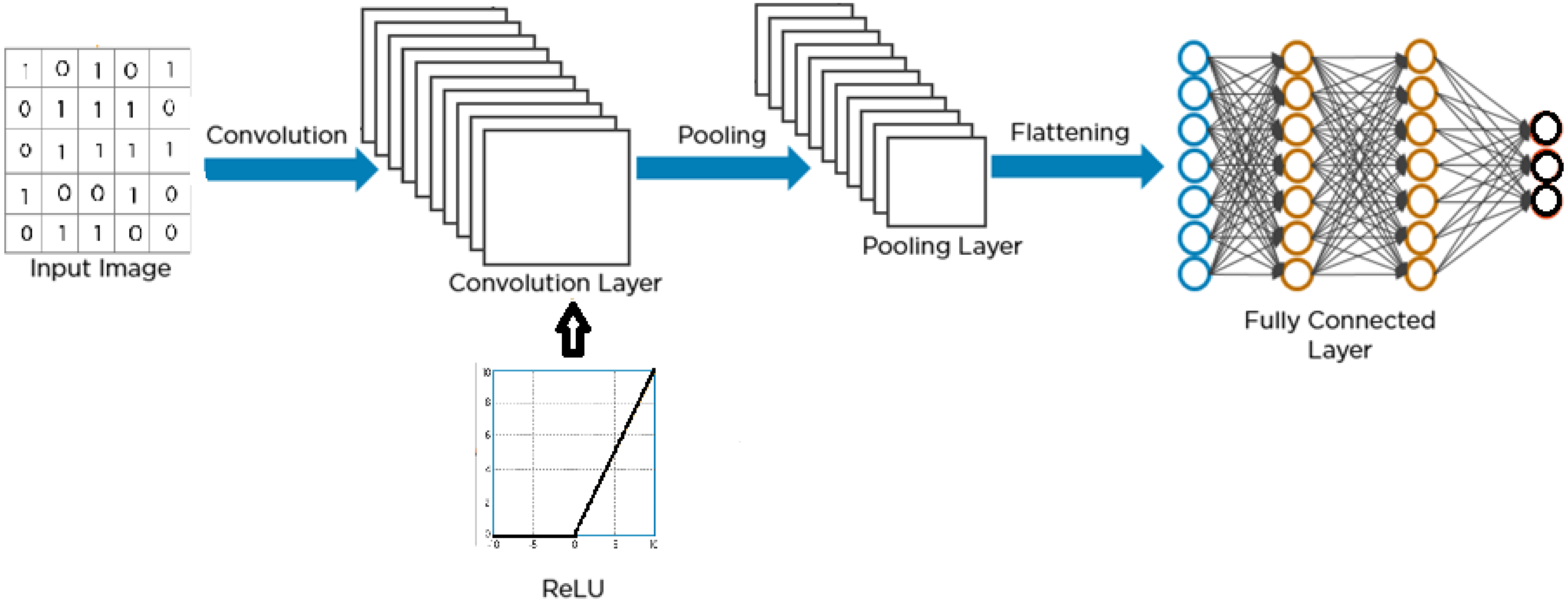
Convolutional Neural Network

The next step in the process is called flattening. Flattening is used to convert all the resultant 2-Dimensional arrays from pooled feature maps into a single long continuous linear vector.

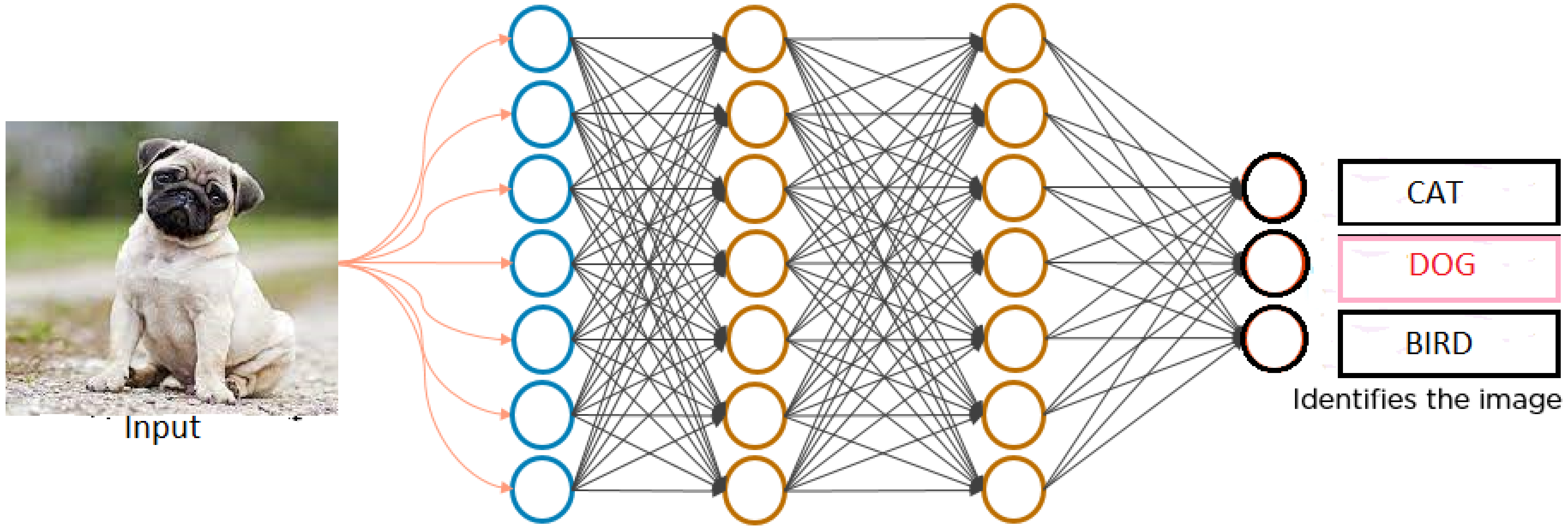


Convolutional Neural Network

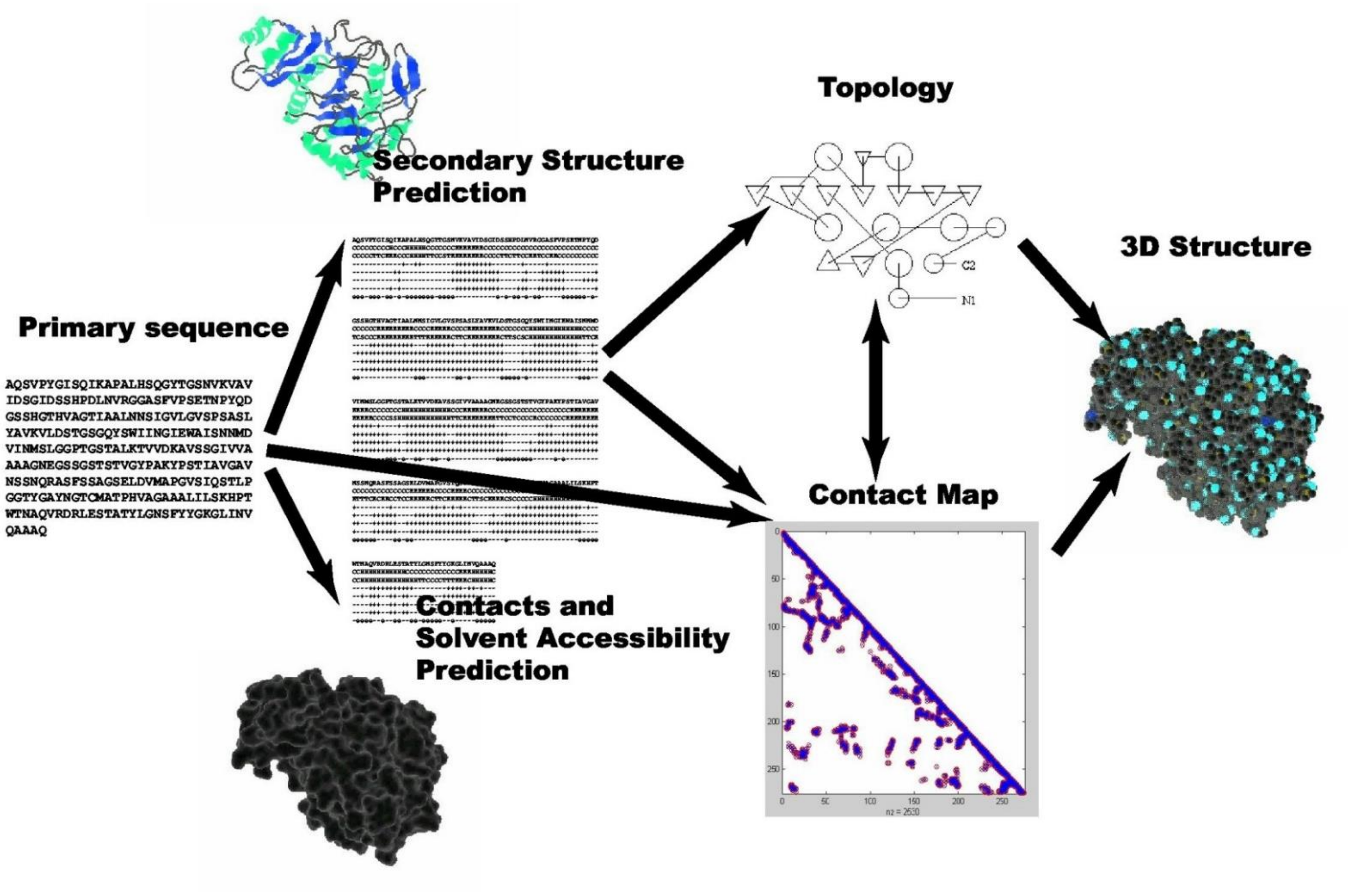
The flattened matrix is fed as input to the fully connected layer to classify the image.



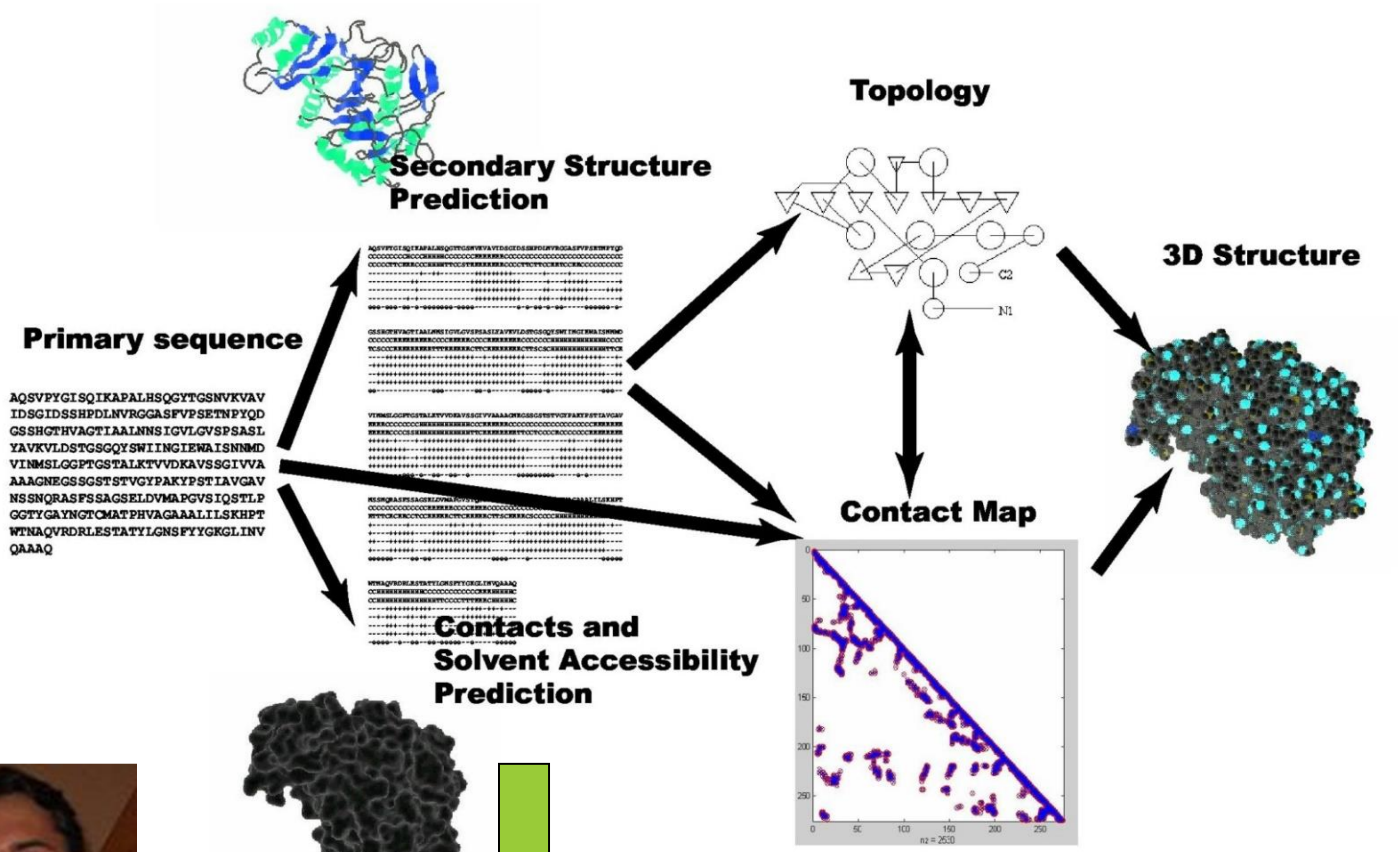
Convolutional Neural Network



Deep Learning in Biology: Mining Omic Data



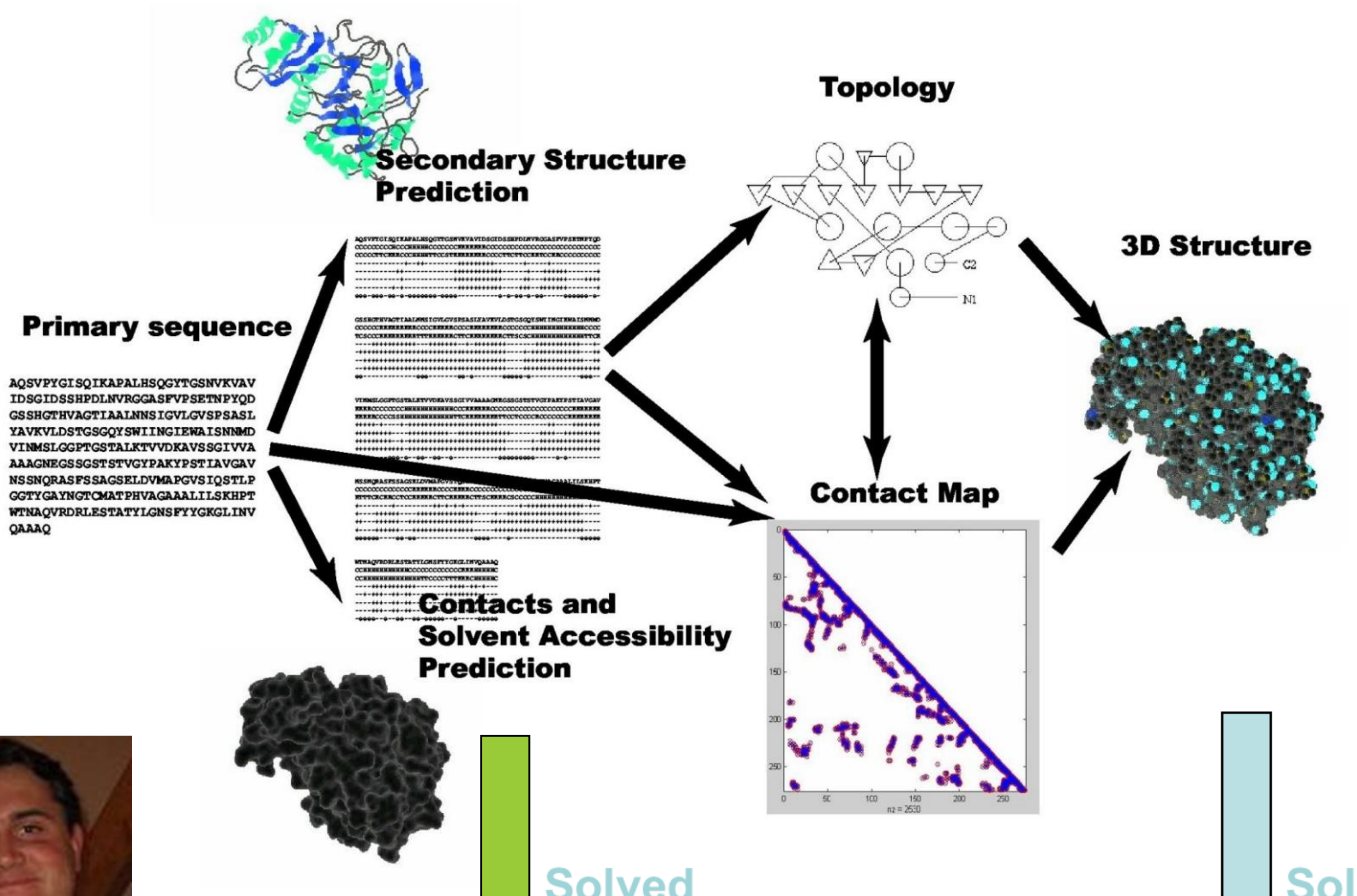
Deep Learning in Biology: Mining Omic Data



Solved

C. Magnan and P. Baldi. Sspro/ACCpro 5.0: Almost Perfect Prediction of Protein Secondary Structure and Relative Solvent Accessibility. Problem Solved? *Bioinformatics*, (advance access June 18), (2014).

Deep Learning in Biology: Mining Omic Data



Solved

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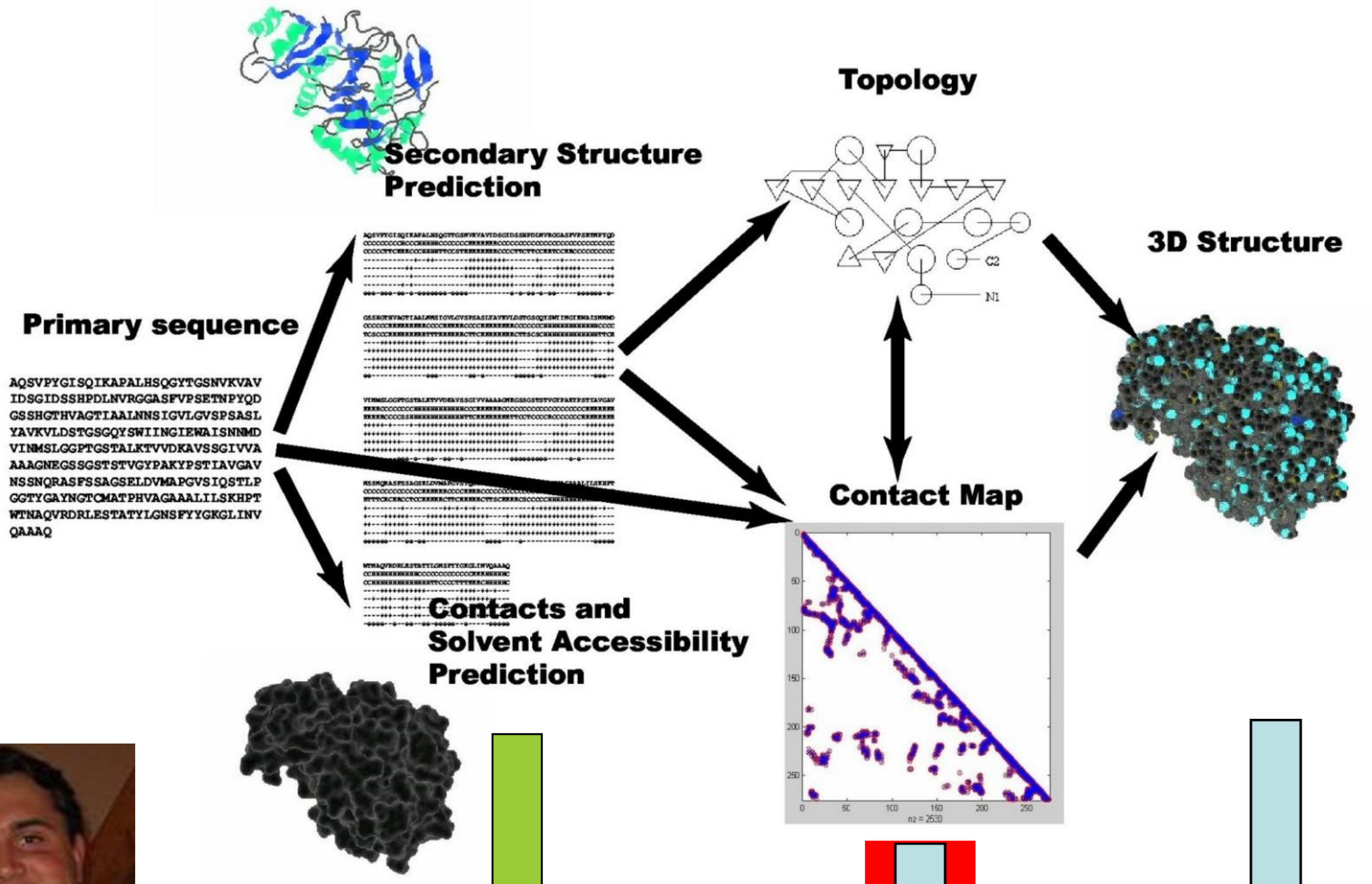
Deep Learning in Biology: Mining Omic Data



C. Magnan and P. Baldi. Sspro/ACCpro 5.0: Almost Perfect Prediction of Protein Secondary Structure and Relative Solvent Accessibility. Problem Solved? *Bioinformatics*, (advance access June 18),.

RR Results Summary - CASP10

10th Community Wide Experiment on the Critical Assessment of Techniques for Protein Structure Prediction

P. Di Lena, K. Nagata, and P. Baldi. Deep Architectures for Protein Contact Map Prediction. *Bioinformatics*, 28, 2449-2457, (2012)

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RR Analysis

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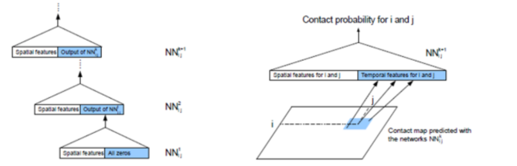
The table summarizes the evaluation of predictions in 'RR' category.
The analysis was performed at per domains basis; only predictions for domains classified as "FM", "TBM/FM", "TBM hard" were considered.
The groups were ranked according to sum of average Z-scores for two measures Acc and Xd.
The per target Z-scores were recalculated from the "cleaned" distributions, where the outlier predictions (below mean - 2 std dev) were eliminated.

- **Domain classification:**
  - FM
  - TBM/FM
  - TBM hard (max gdt_ts < 50)
- **Contact Range:** long
- **List Size:** L/5



(a) DST-NN architecture (b) Temporal input features for NN_{ij}^k

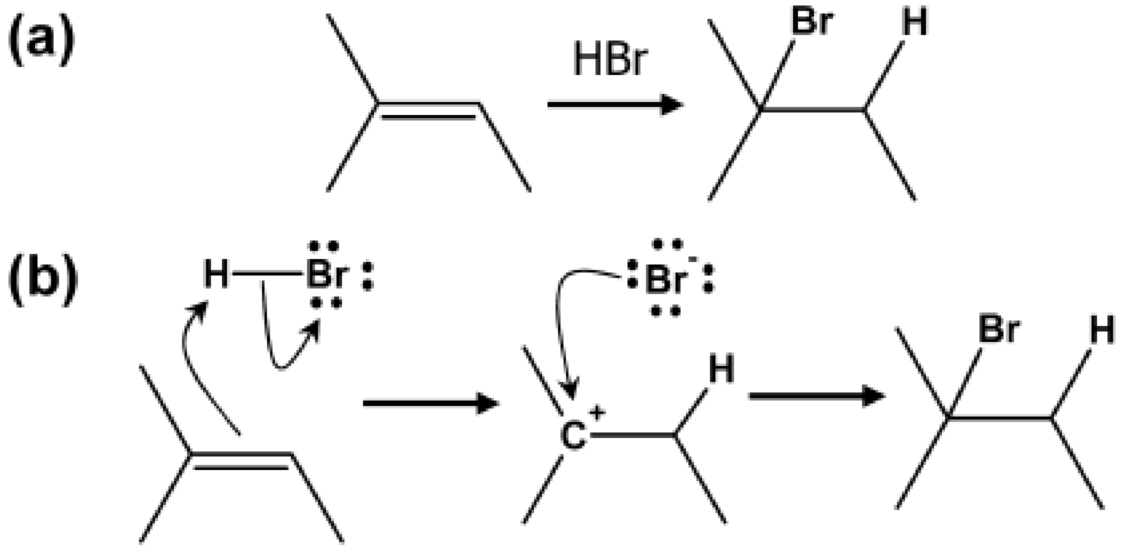
Figure 1: DST-NN architecture. (a) Overview. Each NN_{ij}^k represents a feed-forward neural network trainable by back-propagation. (b) For a pair of residues (i, j), the temporal inputs into NN_{ij}^{k+1} consist of the contact probabilities produced by the network at the previous level over a neighborhood of (i, j).

#	GR#	GR Name	Count domains	AVG Acc	AVG Zscore Acc	AVG Xd	AVG Zscore Xd	Zscore Acc + Zscore Xd
1.	222 s	MULTICOM-CONSTRUCT	14	19.41	0.58	12.08	0.77	1.35
2.	305 s	IGBteam	15	19.22	0.72	10.19	0.58	1.30
3.	424 s	MULTICOM-NOVEL	14	20.39	0.50	10.32	0.72	1.22
4.	125 s	MULTICOM-REFINE	14	21.35	0.51	10.29	0.70	1.21
5.	413 s	ZHOU-SPARKS-X	12	12.26	0.62	8.26	0.59	1.21
6.	113 s	SAM-T08-server	11	16.13	0.72	9.44	0.47	1.19
7.	358 s	RaptorX-Roll	8	12.07	0.58	8.23	0.55	1.13
8.	314 s	ProC_S4	14	17.91	0.59	9.76	0.47	1.05
9.	087 s	Distill_roll	15	13.97	0.60	8.57	0.36	0.96
10.	489	MULTICOM	14	12.96	0.43	8.19	0.40	0.83
11.	184 s	ICOS	14	17.03	0.40	9.72	0.39	0.78
12.	396 s	ProC_S5	14	16.51	0.36	9.10	0.36	0.72
13.	381 s	SAM-T06-	10	10.98	0.37	7.94	0.31	0.68

Deep Learning

Deep Learning Chemical Reactions

RCH=CH2 + HBr → RCH(Br)–CH3



Deep Learning Chemical Reaction: ReactionPredictor

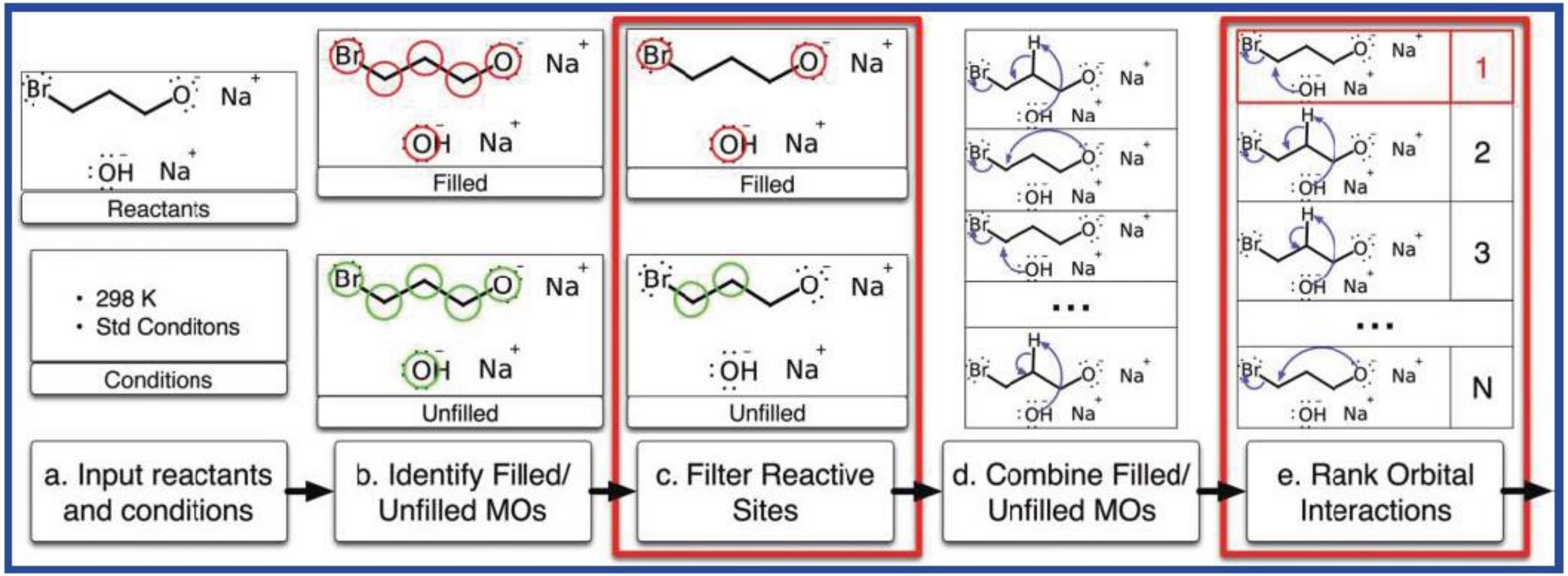
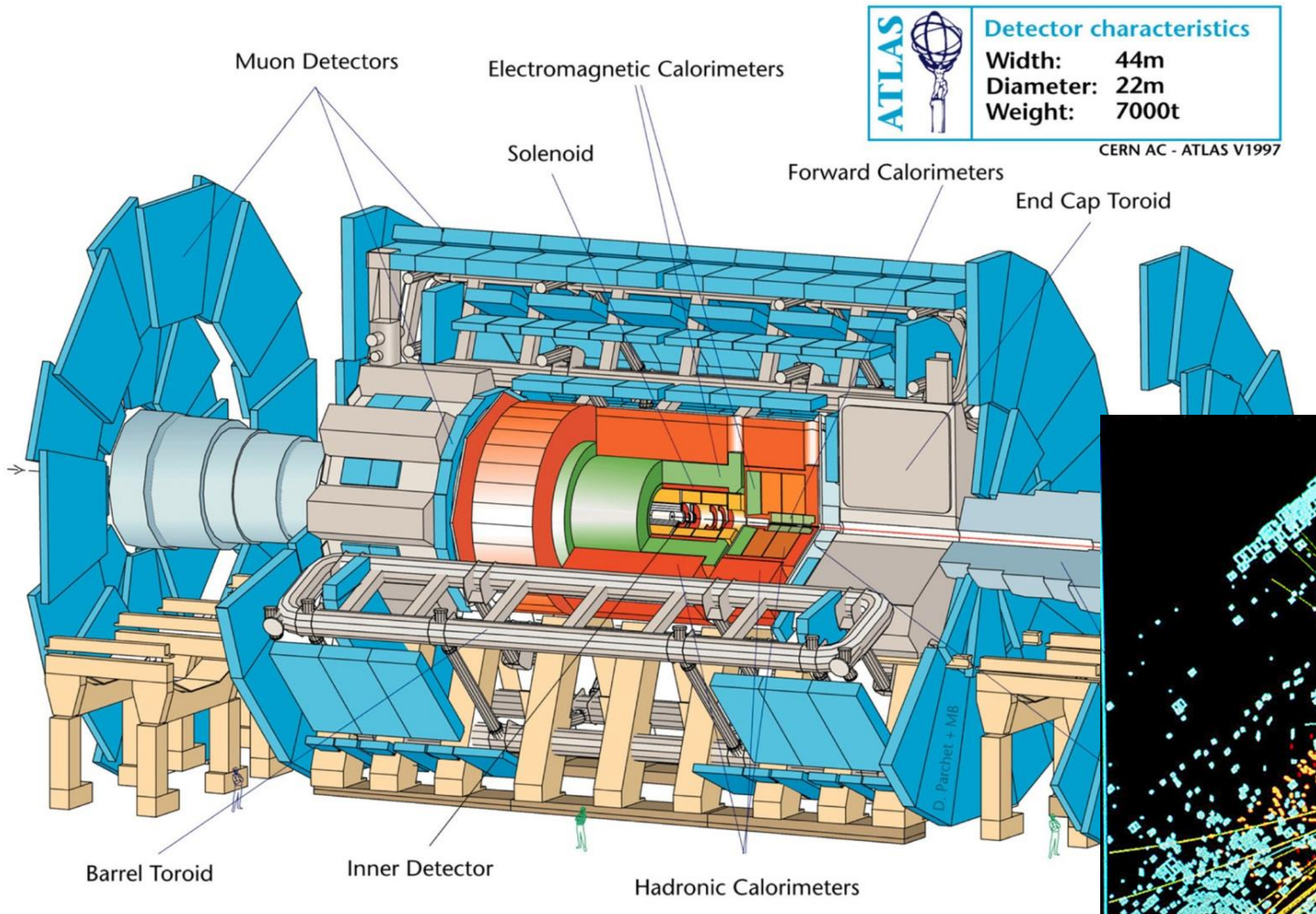


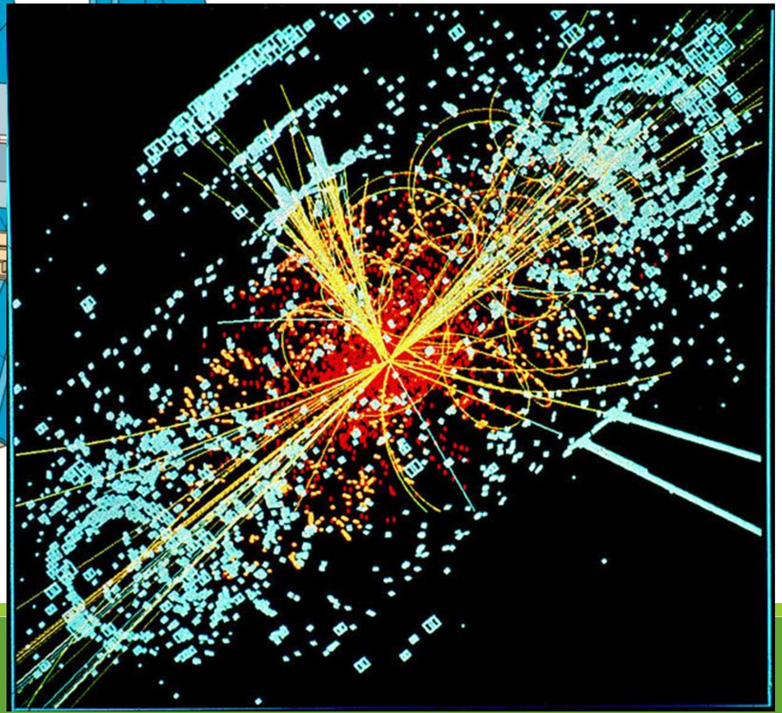
Figure 2. Overall reaction prediction framework: (a) A user inputs the reactants and conditions. (b) We identify potential electron donors and acceptors using coarse approximations of electron-filled and -unfilled MOs. (c) Highly sensitive reactive site classifiers are trained and used to filter out the vast majority of unreactive sites, pruning the space of potential reactions. (d) Reactions are enumerated by pairing filled and unfilled MOs. (e) A ranking model is trained and used to order the reactions, where the best ranking one or few represent the major products. The top-ranked product can be recursively chained to a new instance of the framework for multistep reaction prediction.

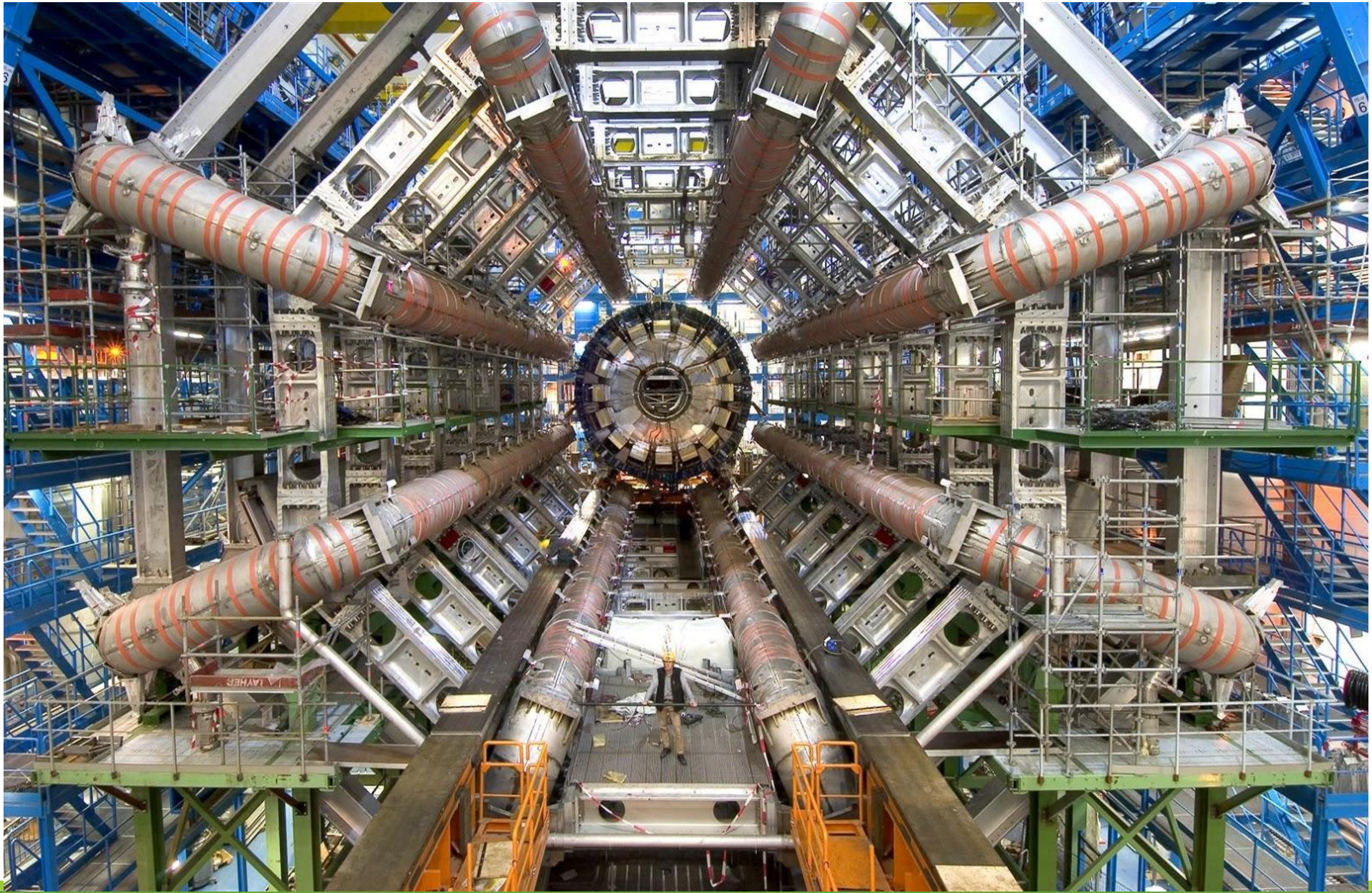
M. Kayala, C. Azencott, J. Chen, and P. Baldi. Learning to Predict Chemical Reactions. *Journal of Chemical Information and Modeling*, 51, 9, 2209–2222,.

M. Kayala and P. Baldi. ReactionPredictor: Prediction of Complex Chemical Reactions at the Mechanistic Level Using Machine Learning. *Journal of Chemical Information and Modeling*, 52, 10, 2526–2540,

Deep Learning in Physics:
Searching for Exotic Particles







nature COMMUNICATIONS

ARTICLE

Received 19 Feb 2014 | Accepted 4 Jun 2014 | Published 2 Jul 2014

DOI: 10.1038/ncomms5308

Searching for exotic particles in high-energy physics with deep learning

P. Baldi[1], P. Sadowski[1] & D. Whiteson[2]

Collisions at high-energy particle colliders are a traditionally fruitful source of exotic particle discoveries. Finding these rare particles requires solving difficult signal-versus-background classification problems, hence machine-learning approaches are often used. Standard approaches have relied on 'shallow' machine-learning models that have a limited capacity to learn complex nonlinear functions of the inputs, and rely on a painstaking search through manually constructed nonlinear features. Progress on this problem has slowed, as a variety of techniques have shown equivalent performance. Recent advances in the field of deep learning make it possible to learn more complex functions and better discriminate between signal and background classes. Here, using benchmark data sets, we show that deep-learning methods need no manually constructed inputs and yet improve the classification metric by as much as 8% over the best current approaches. This demonstrates that deep-learning approaches can improve the power of collider searches for exotic particles.

Daniel Whiteson

Peter Sadowski

World's biggest companies heavily relying on AI & ML

amazon web services

IBM Cloud

phrasee

salesforce

Alibaba Cloud

sift

Microsoft Azure

ANDURIL

Google Cloud Platform

nauto

certis Applied Cloud

people.ai

SIEMENS

DATAVISOR

AUTOMATION ANYWHERE

Rev

AEYE

AlphaSense

VERKADA

TEMPUS

SenSat

Suki

freenome

intel

NVIDIA

Orbital Insight

IRIS.AI

AI

x.

zebra
MEDICAL.VISION

clarifai

pymetrics

tamr

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sensetime

bigpanda

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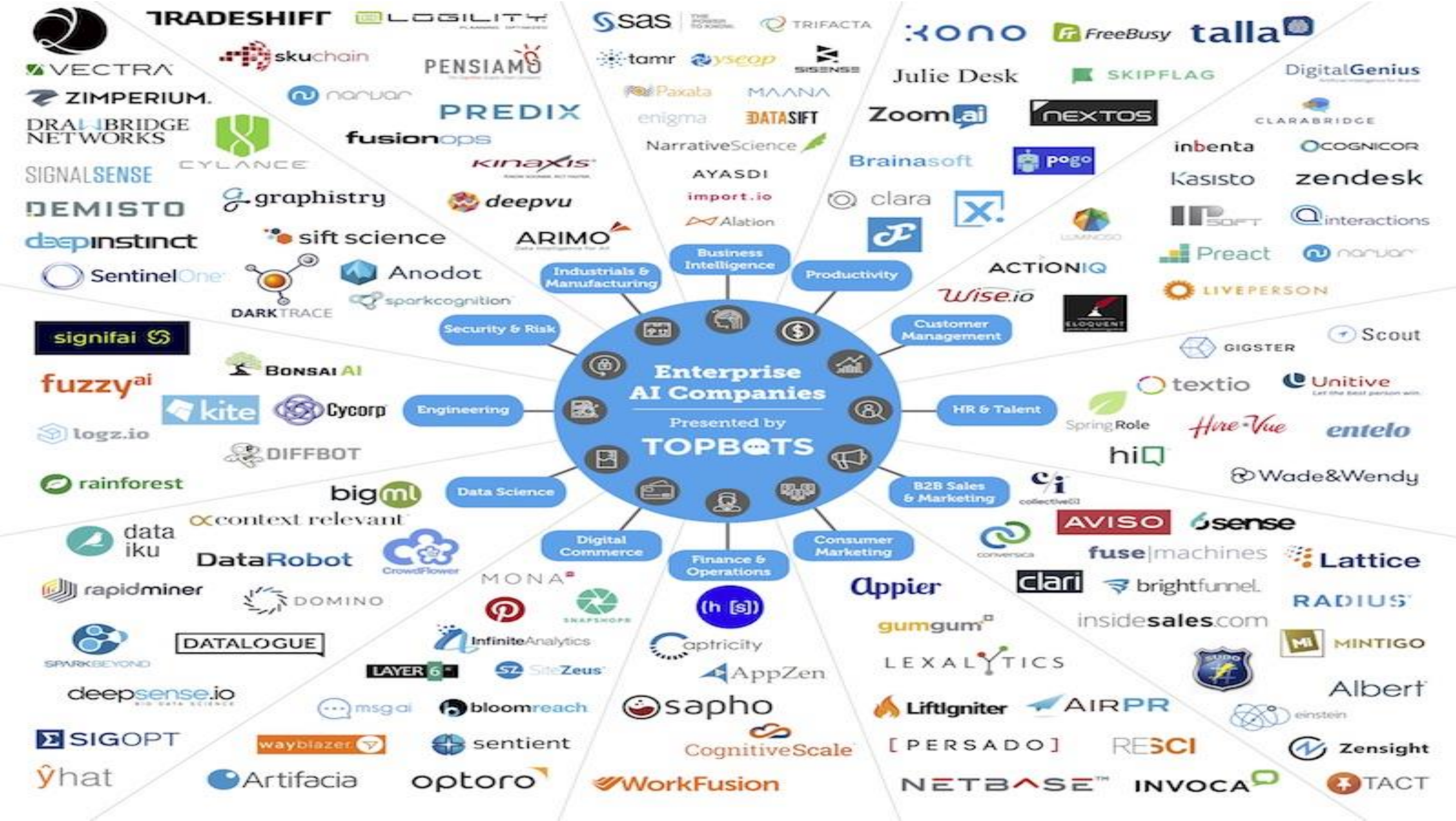
ELEMENT AI

C3.ai

directly

AI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Productivity
Customer Management
HR & Talent
B2B Sales & Marketing
Consumer Marketing
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Data Science
Engineering
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TRADESHIFT
LOGILITY
VECTRA
skuchain
PENSIAMO
ZIMPERIUM.
narvar
PREDIX
DRAWBRIDGE NETWORKS
CYLANCE
fusionops
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KINAXIS
graphistry
deepvu
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deepinstinct
sift science
ARIMO
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Anodot
sparkcognition
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TRIFACTA
tamr
yseop
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nextos
CLARABRIDGE
inbenta
COGNICOR
Brainasoft
pogo
Kasisto
zendesk
clara
IPsoft
interactions
Preact
narvar
ACTIONIQ
Wise.io
LIVEPERSON
ELOQUENT
signifai
BONSAI AI
fuzzyai
kite
Cycorp
logz.io
DIFFBOT
rainforest
bigml
GIGSTER
Scout
textio
Unitive
Spring Role
HireVue
entelo
hiQ
Wade&Wendy
collective[i]
AVISO
6sense
context relevant
data iku
DataRobot
CrowdFlower
MONA
rapidminer
DOMINO
SNAPSHOPR
SPARKBEYOND
DATALOGUE
InfiniteAnalytics
LAYER 6
SiteZeus
deepsense.io
msg.ai
bloomreach
SIGOPT
wayblazer
sentient
yhat
Artifacia
optoro
(h [s])
captricity
AppZen
sapho
CognitiveScale
WorkFusion
conversica
fuse|machines
Lattice
Appier
clari
brightfunnel
RADIUS
insidesales.com
gumgum
MINTIGO
LEXALYTICS
Albert
LiftIgniter
AIRPR
einstein
[PERSADO]
RESCI
Zensight
NETBASE
INVOCA
TACT

2020

Healthcare
RECURSION, zebra MEDICAL VISION, ProteinQure, Viz.ai, Eko, Healthy.io, CYCLICA, OWKIN, PAIGE, Atomwise, Butterfly Network, SUBTLE MEDICAL, Concerto HealthAI

Finance & Insurance
Comply Advantage, FEATURE SPACE, (h[s]) HYPERSCIENCE, zesty.ai, Lemonade, TRACTABLE

Transportation
GHOST, isee, KONUX, loadsmart, tusimple, HOLOMATIC 禾多科技, Aurora, voyage

Construction
ALICE technologies, BUILT ROBOTICS

Retail & Warehousing
grabango, THE YES, heuritech, [Sc] STANDARD COGNITION, OSARO, FAIRE, dorabot, AIFI, covariant

Govt. & City Planning
SHIELD AI, AMP ROBOTICS, Replica, Mapillary, SYNAPSE TECHNOLOGY CORPORATION

Media & Entertainment
SECOND SPECTRUM, FANAI, Synthesia, WELLSAID

Education
松鼠AI·智适应 Squirrel AI Learning, KORBIT

Manufacturing
noodle.ai, NAVVIS, dataprophet machine learning specialists, CITRINE INFORMATICS

Legal
lexion

Mining
razorlabs

Food & Agriculture
BENSON HILL, NotCo, BOWERY

AI 100

CBINSIGHTS

Energy
BEYOND LIMITS, INVENIA LABS, TACHYUS

Telecom
DEEPSIG, METAWAVE

Real Estate
CASPAR

CROSS-INDUSTRY TECH

AI Processors
SYNTIANT, LIGHTMATTER, GRAPHCORE, XANADU, Kneron

AI Model Development
DARWIN AI, H_2O.ai, PerceptiLabs, DataRobot, dotData

DevOps & Model Monitoring
ALGORITHMIA, snyk, ArthurAI

NLP, NLG, & Computer Vision
PRIMER, sherpa.ai, HUGGING FACE, 创新奇智 AInnovation, :) Affectiva

Cybersecurity
SentinelOne, OBSIDIAN, onfido, ABNORMAL SECURITY, BLUEHEXAGON

BI & Ops Intel
climacell, C3.ai, falkonry

Sales & CRM
CRESTA, integrate.ai, ZHUIYI 追一科技

Other R&D
sparkcognition, KYNDI, 4Paradigm 第四范式, InstaDeep, Deeplite, nnaisense, HACARUS

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AI

Conclusions

- As an Artificial Intelligence aspirant, you have ample of job opportunities in this field.
- Artificial intelligence will transform the global economy, and AI jobs are in high demand.
- According to International Data Corporation (IDC), the number of AI jobs is expected to globally grow 16 percent this year.
- AI careers are future-proof, meaning they are likely to survive well into the future.
- Getting an education in AI is challenging and requires persistence and personal initiative.

Thank you

Questions?