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Artificial Intelligence & Smart Healthcare

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Institute of Management of Technology, National Yang Ming Chiao Tung University, Taiwan

Academic Background

- **PhD** in Computer Science (Machine Learning & Optimization), U. of Manchester, U. K.

- **MPhil** in Technology Policy, U. of Cambridge, U. K.

- **MSc(Eng)** in Advanced Software Engineering, U. of Sheffield, U. K.

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Research

- Machine Learning
- Computational Intelligence and Decision Support System
- Pattern Recognition
- Artificial Intelligence – Smart Healthcare & Fintech
- Technology Policy (Climate Change Issues and Energy Prediction)

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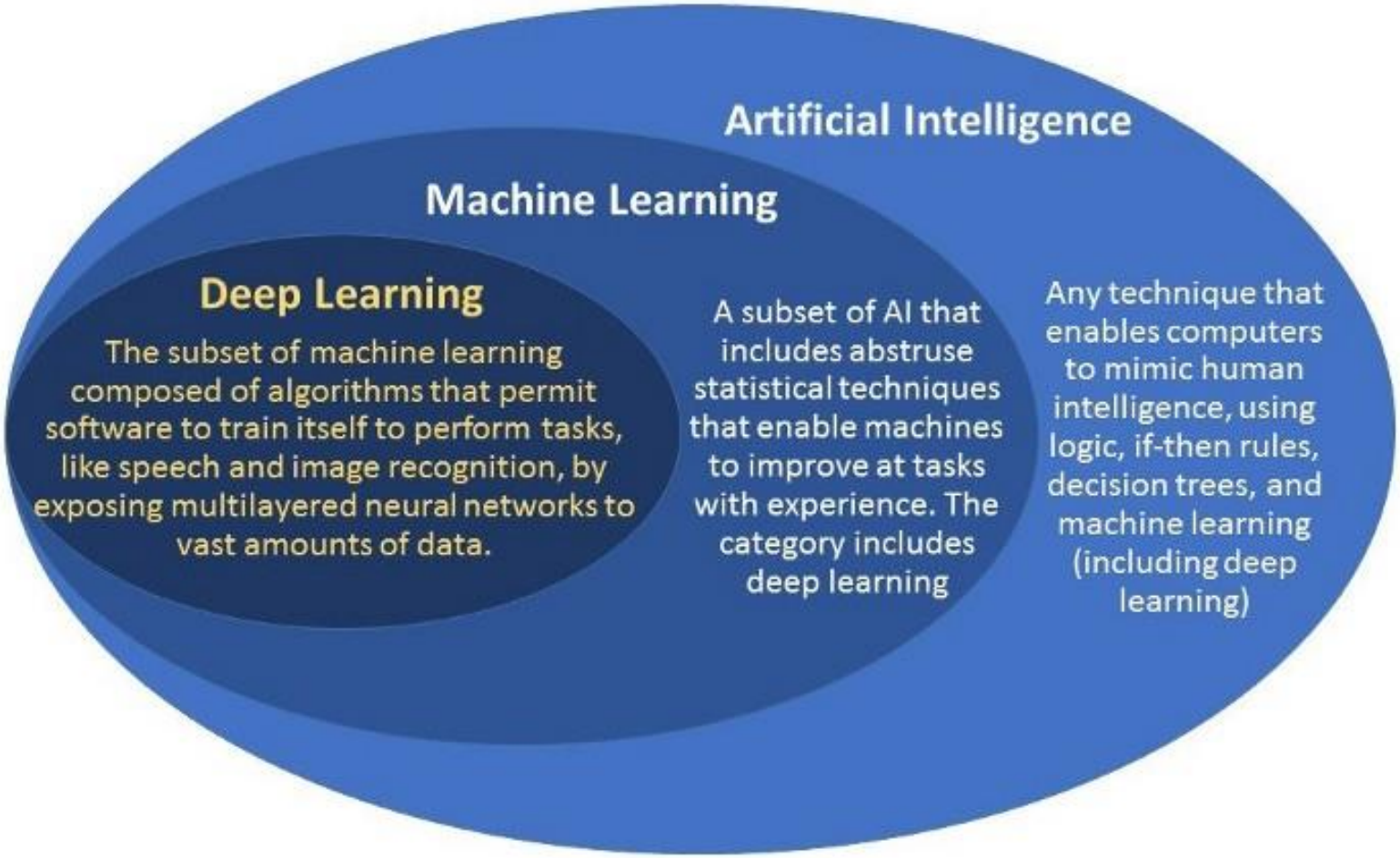

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What is Artificial Intelligence A.I. ?

Problem Define?

Reasoning?

Knowledge Presentation?

Learning?

Problem Recognized !

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Weak AI

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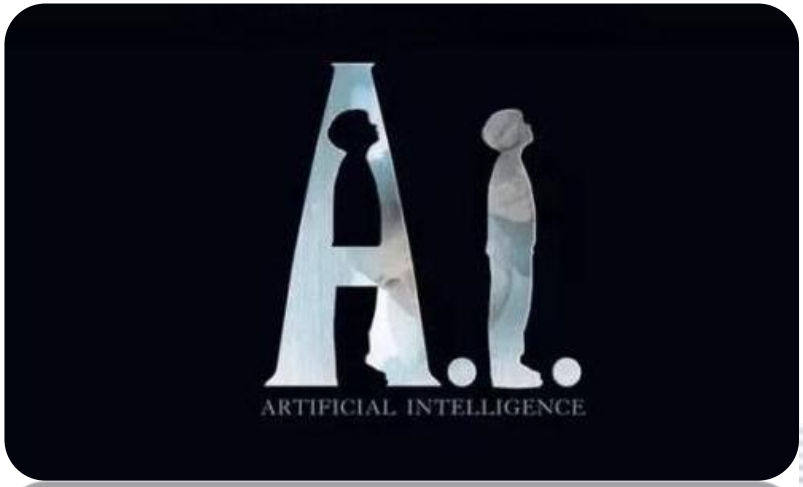
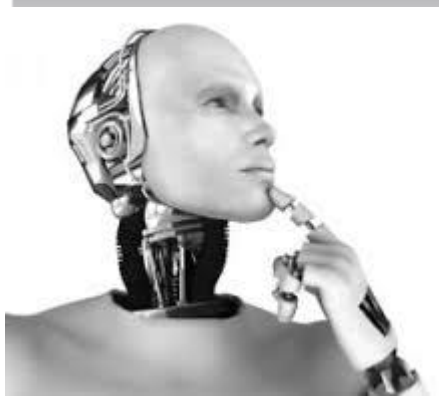
Strong AI





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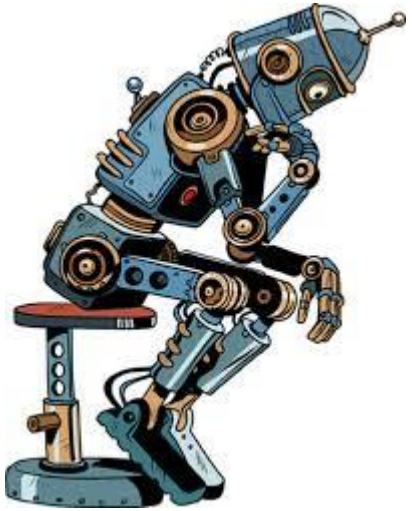
Can Robot really think?

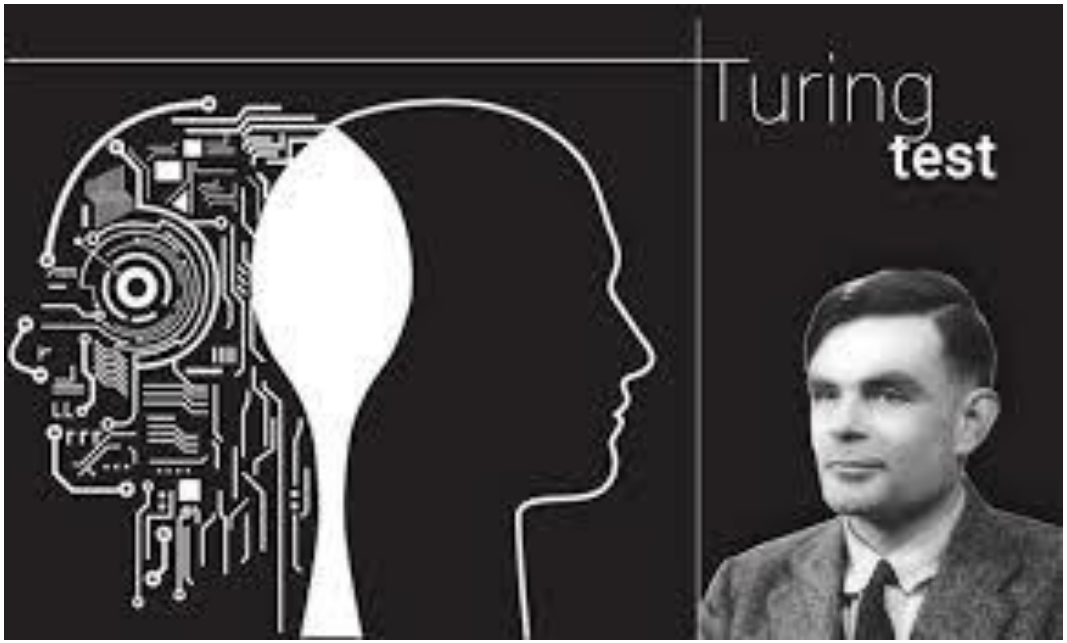
"The New York Times" said: "The navy's computer displayed today will be able to walk, talk, see and write in the future, be able to copy itself, and be aware of its own existence."

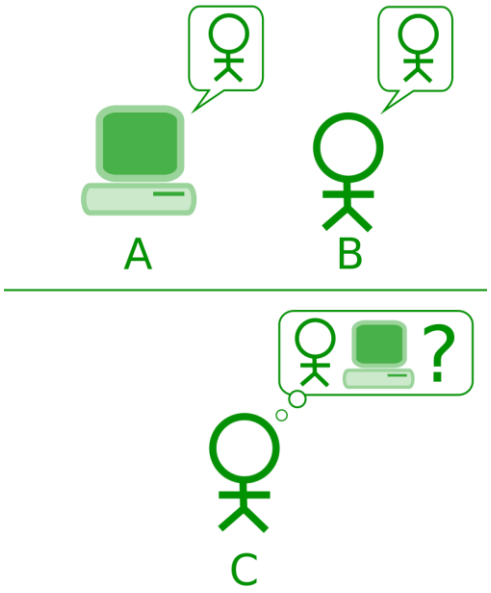
Deep Blue can calculate the subsequent possible development of 200 million chess games every second, and compare it with the record of 700,000 chess masters in the past. It's not "really able to think".



Turing Test

If a machine can start a dialogue with humans (through telex equipment) and cannot be identified as the machine, then the machine is said to be intelligent.





The Turing test, originally called the imitation game by Alan Turing in 1950 is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human.

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How to Apply Big Data under the Uncertainty?

- Practical Data in the Real World: Industrial Data、Medical Data、Financial Data, and etc.
- Uncertainty -> Risk
- Analyzing, Mining or Prediction?
- Statistics & Machine Learning

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By Statistics

Statistics

The branch of mathematics that transforms data into useful information for decision makers.

Descriptive Statistics

Collecting, summarizing, presenting and analyzing data

Inferential Statistics

Using data collected from a small group to draw conclusions about a larger group

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By Machine Learning

- *A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E. (Mitchell, 1997)*

- **Machine Learning**

- The process of extracting patterns from data, which plays an important role in discovering knowledge from data by machine learning algorithms

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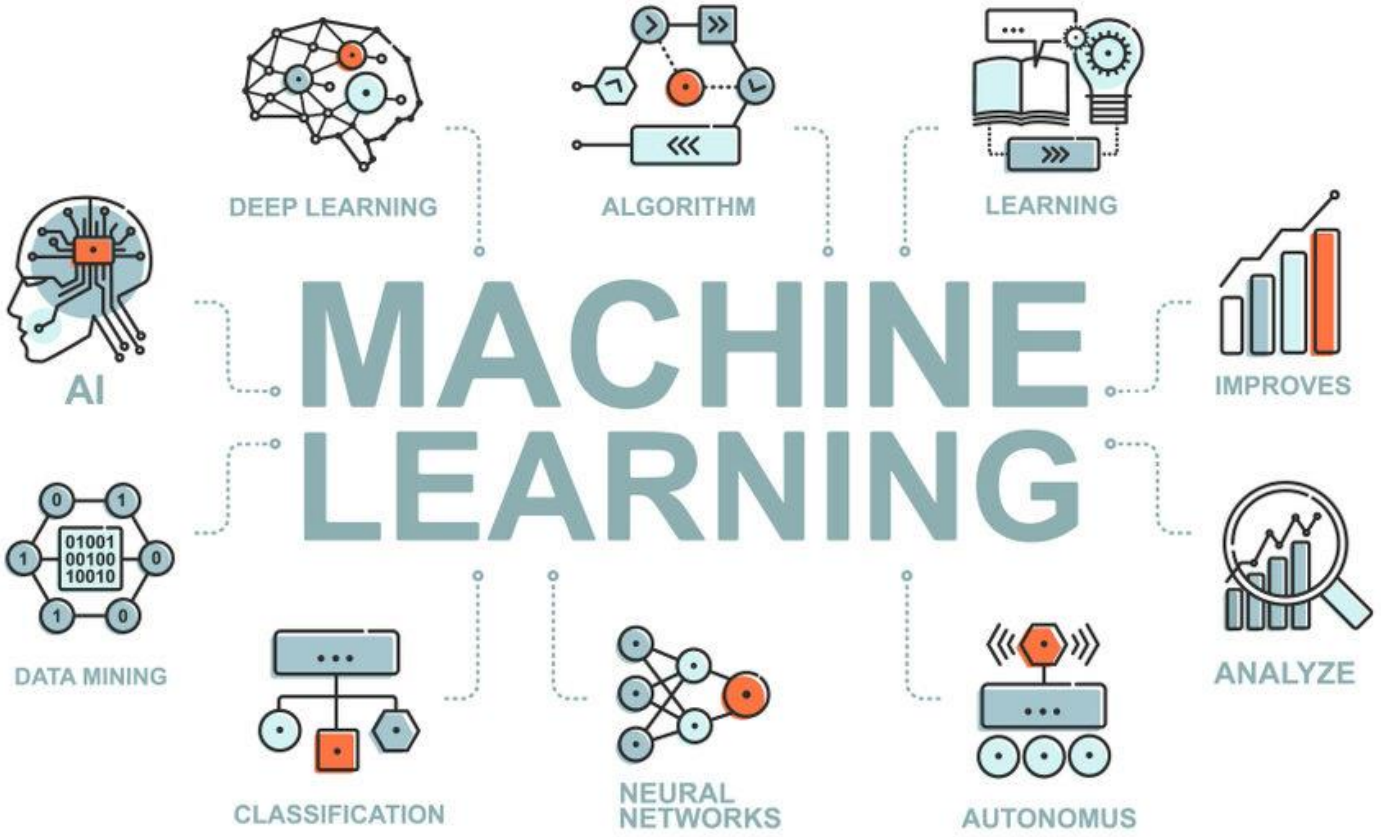

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Types of Machine Learning Algorithms

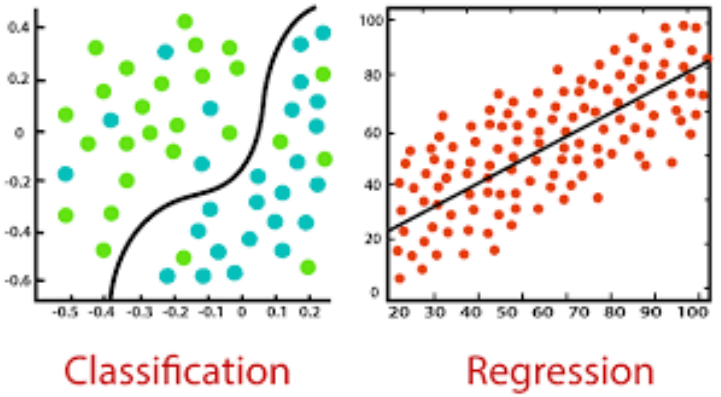
- Supervised Learning
- Unsupervised Learning
- Semi-Supervised Learning
- Reinforcement Learning
- Transfer Learning

Supervised Learning

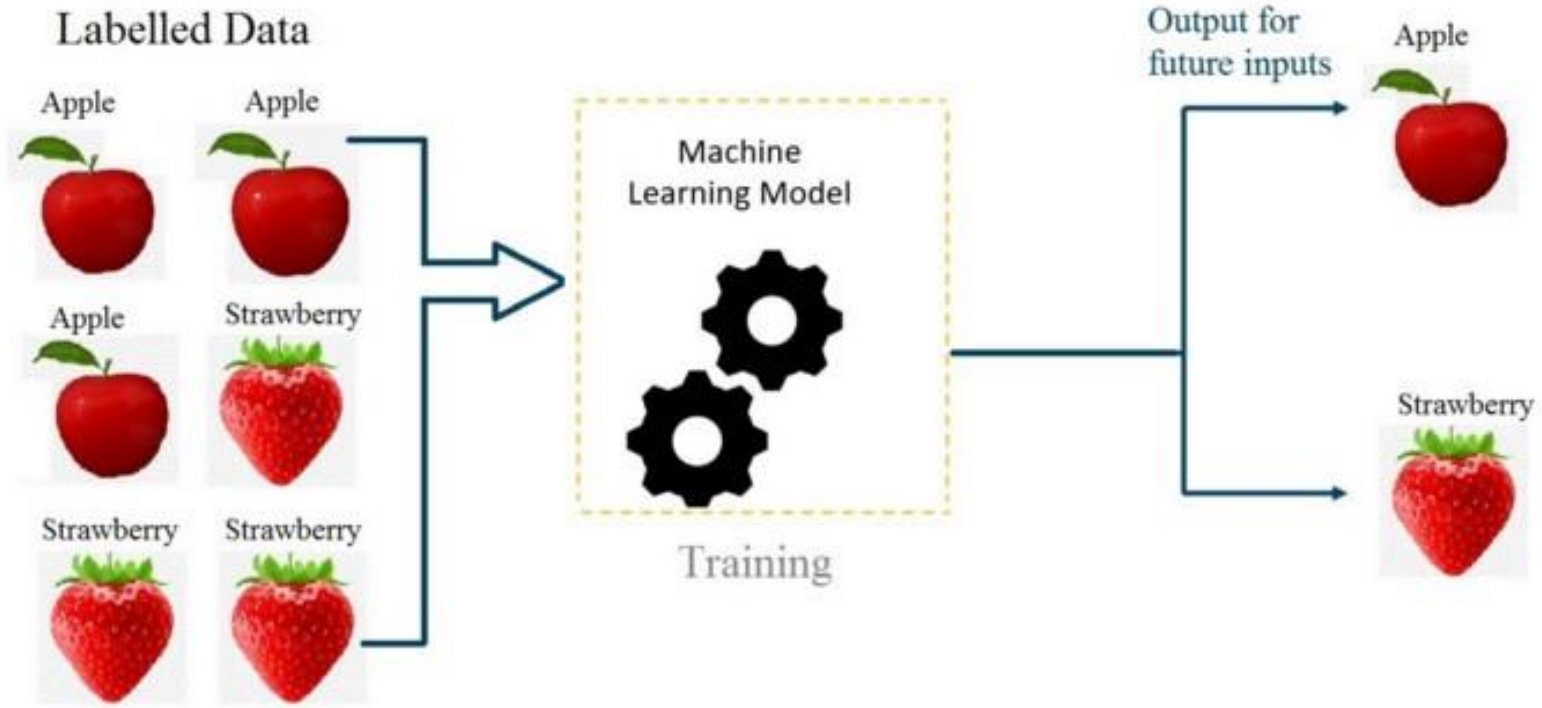
- Generates a function that maps inputs to desired outputs. In a classification problem, the learner approximates a function mapping a vector into classes by looking at input-output examples of the target function

- The Problem of Supervised Learning is divided into two types:
- A) Classification Problem
- B) Regression Problem

Simply, we know the output !



Classification Problem



Simply, we know the "label".

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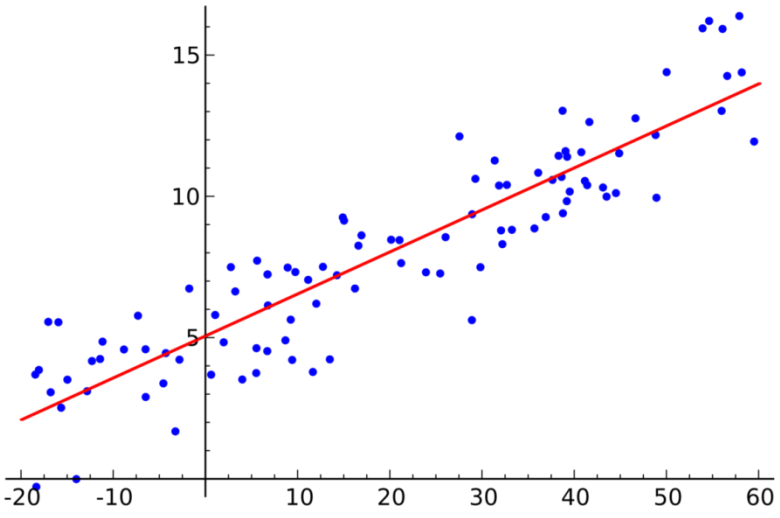
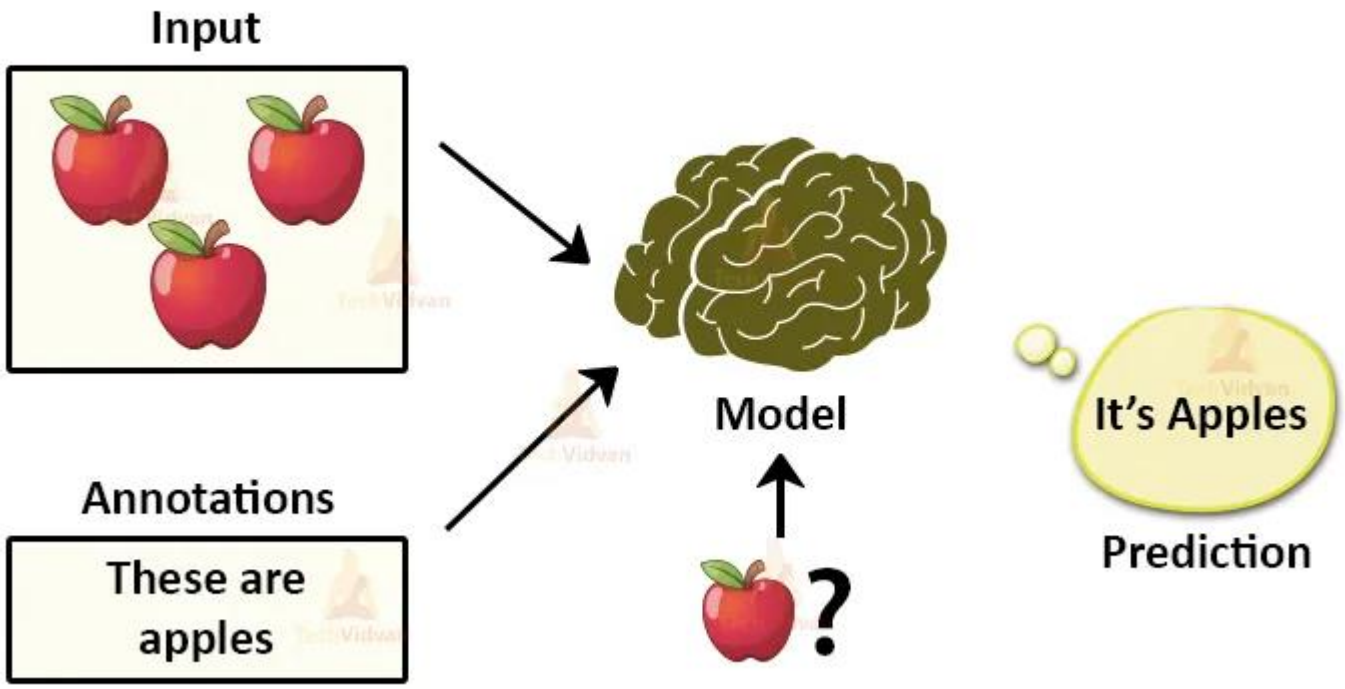
Regression Problem



A	B	C	D	E
R&D Spend	**Administration**	**Marketing Spend**	**State**	**Profit**
165349.2	136897.8	471784.1	New York	192261.83
162597.7	151377.59	443898.53	California	191792.06
153441.51	101145.55	407934.54	Florida	191050.39
144372.41	118671.85	383199.62	New York	182901.99
142107.34	91391.77	366168.42	Florida	166187.94
131876.9	99814.71	362861.36	New York	156991.12
134615.46	147198.87	127716.82	California	156122.51
130298.13	145530.06	323876.68	Florida	155752.6
120542.52	148718.95	311613.29	New York	152211.77
123334.88	108679.17	304981.62	California	149759.96
101913.08	110594.11	229160.95	Florida	146121.95
100671.96	91790.61	249744.55	California	144259.4

Simply, we know the "output value".

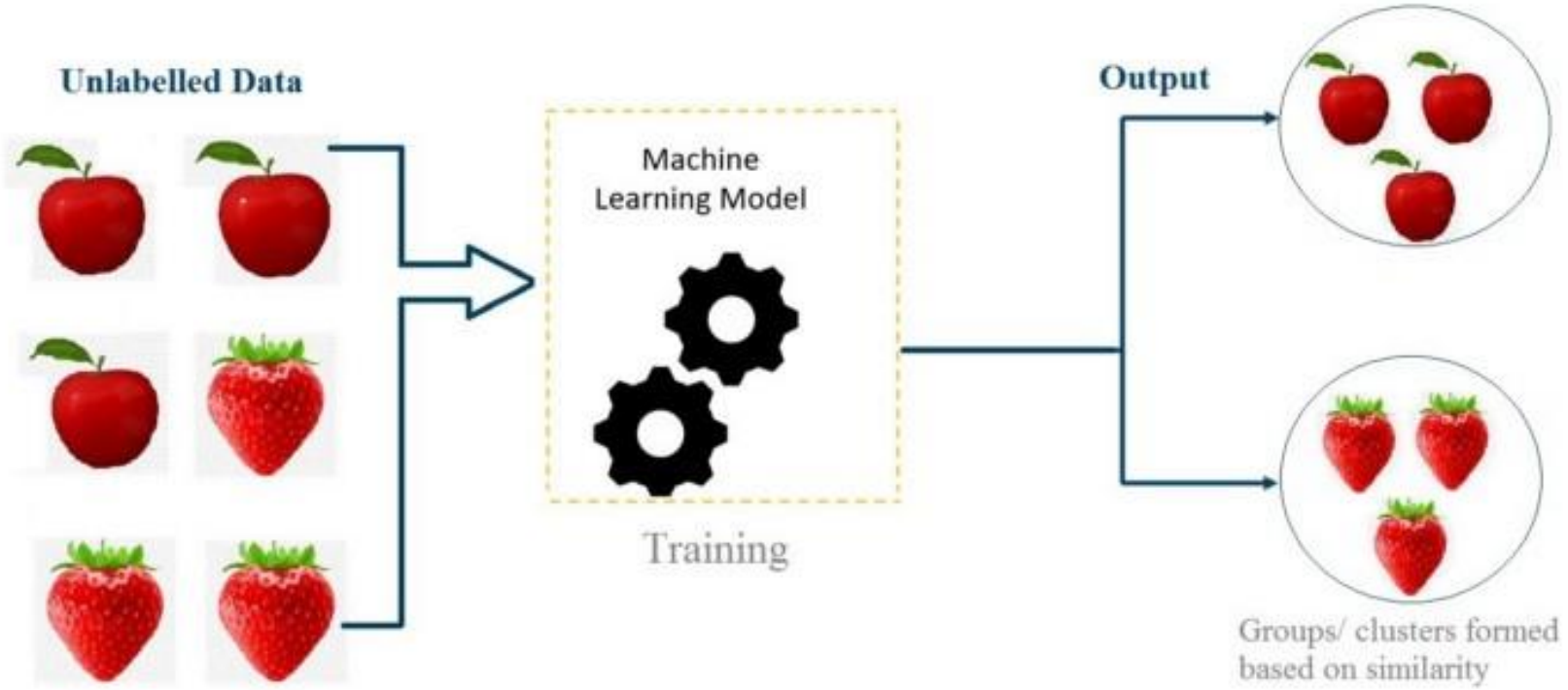
Supervised Learning in ML



Unsupervised Learning

- Different from supervised learning, unsupervised learning models a set of inputs and seeks to summarize and explain key features of the data, such as clustering
- Clustering Problem
- We don’t know the output at all.

Clustering Problem



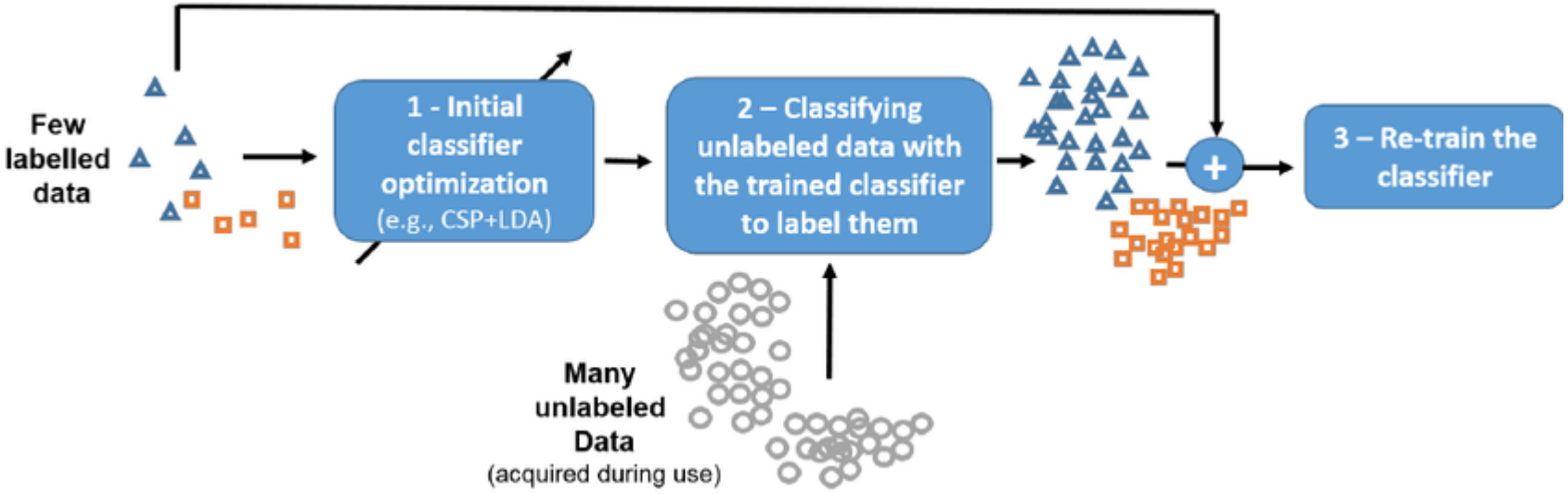
We don’t have information of labels.

Unsupervised Learning in ML

Semi-supervised Learning

- Combines both supervised learning (labelled training data) and unsupervised learning (unlabeled training data) to generate an appropriate function or classifier

- Hybrid Learning Problem



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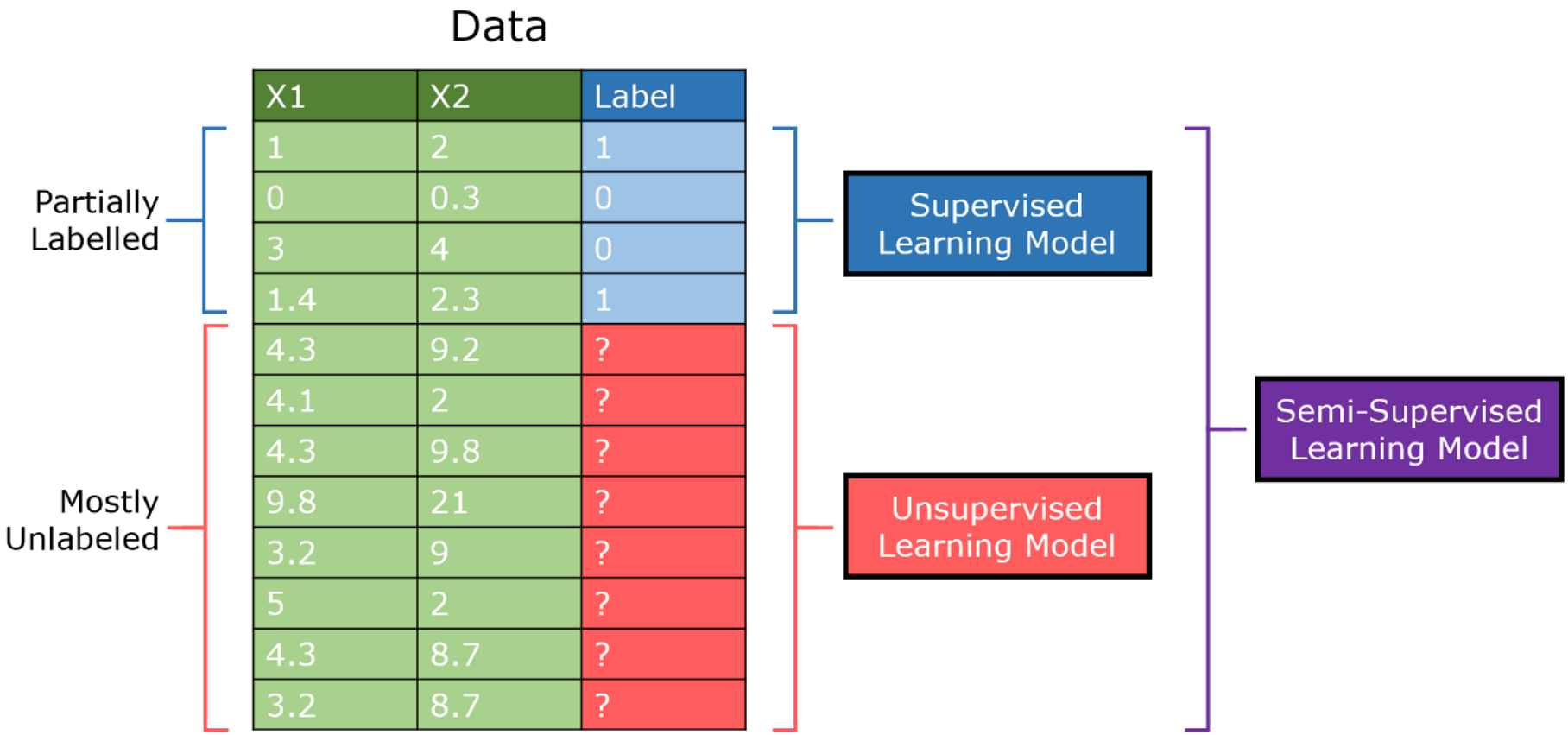
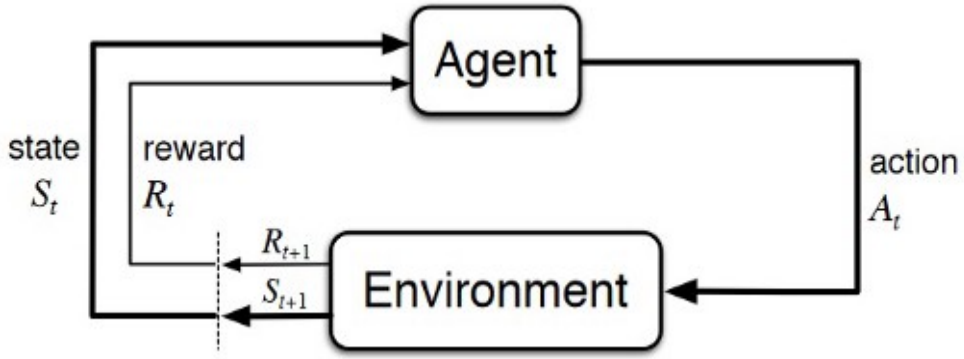
Hybrid Learning Problem

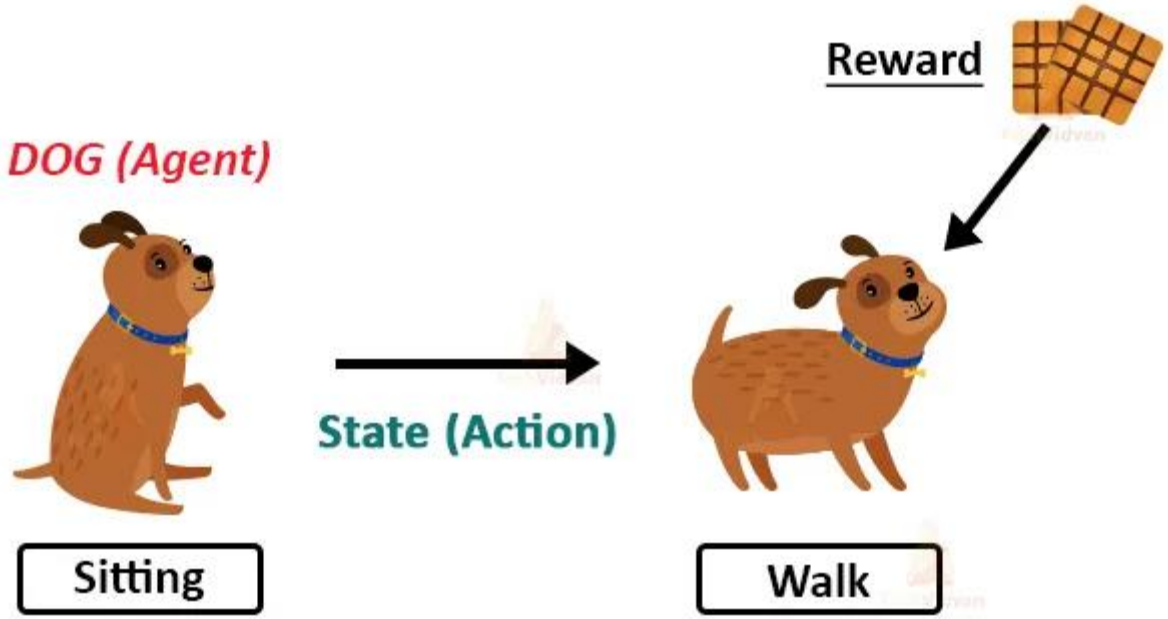


Reinforcement Learning

- Learns to take action through the observation of the environment, and which reinforces learning algorithms by the feedback given by the impact in the environment

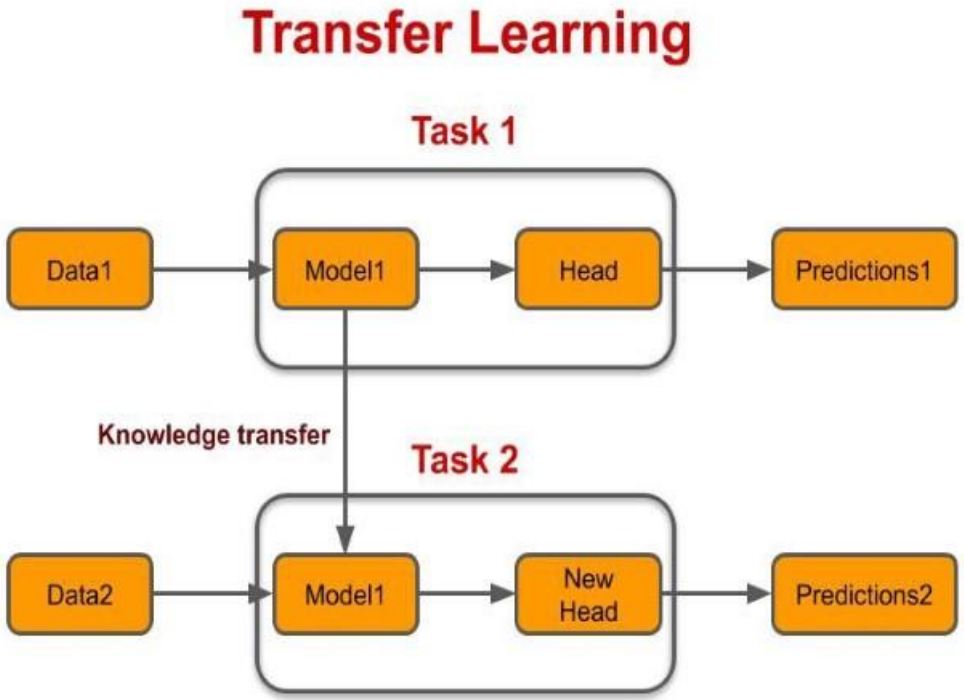


Reinforcement Learning in ML



Transfer Learning

- Transfer Learning is a research problem in ML that focuses on storing knowledge gained while solving one problem and applying it to a different but related problem.



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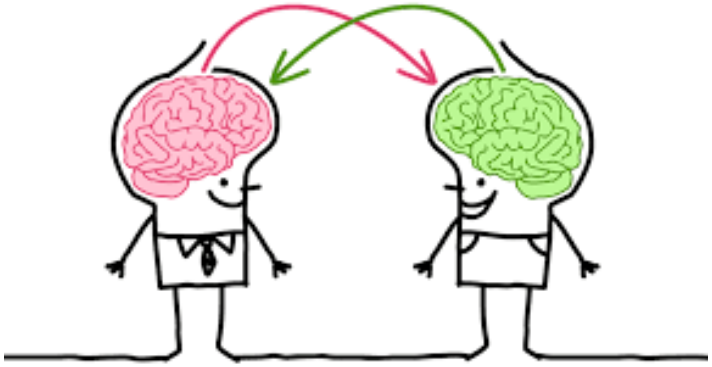

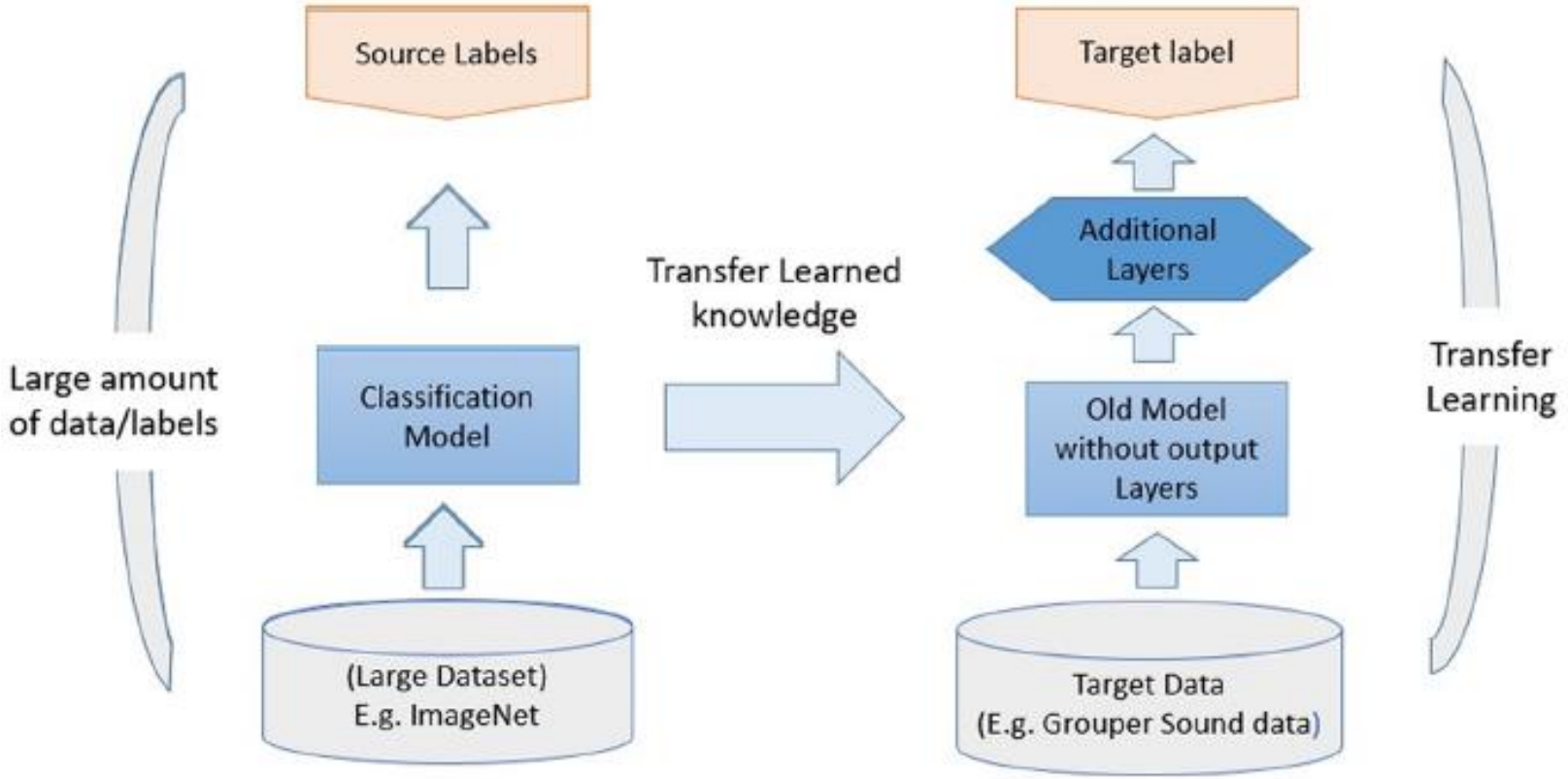

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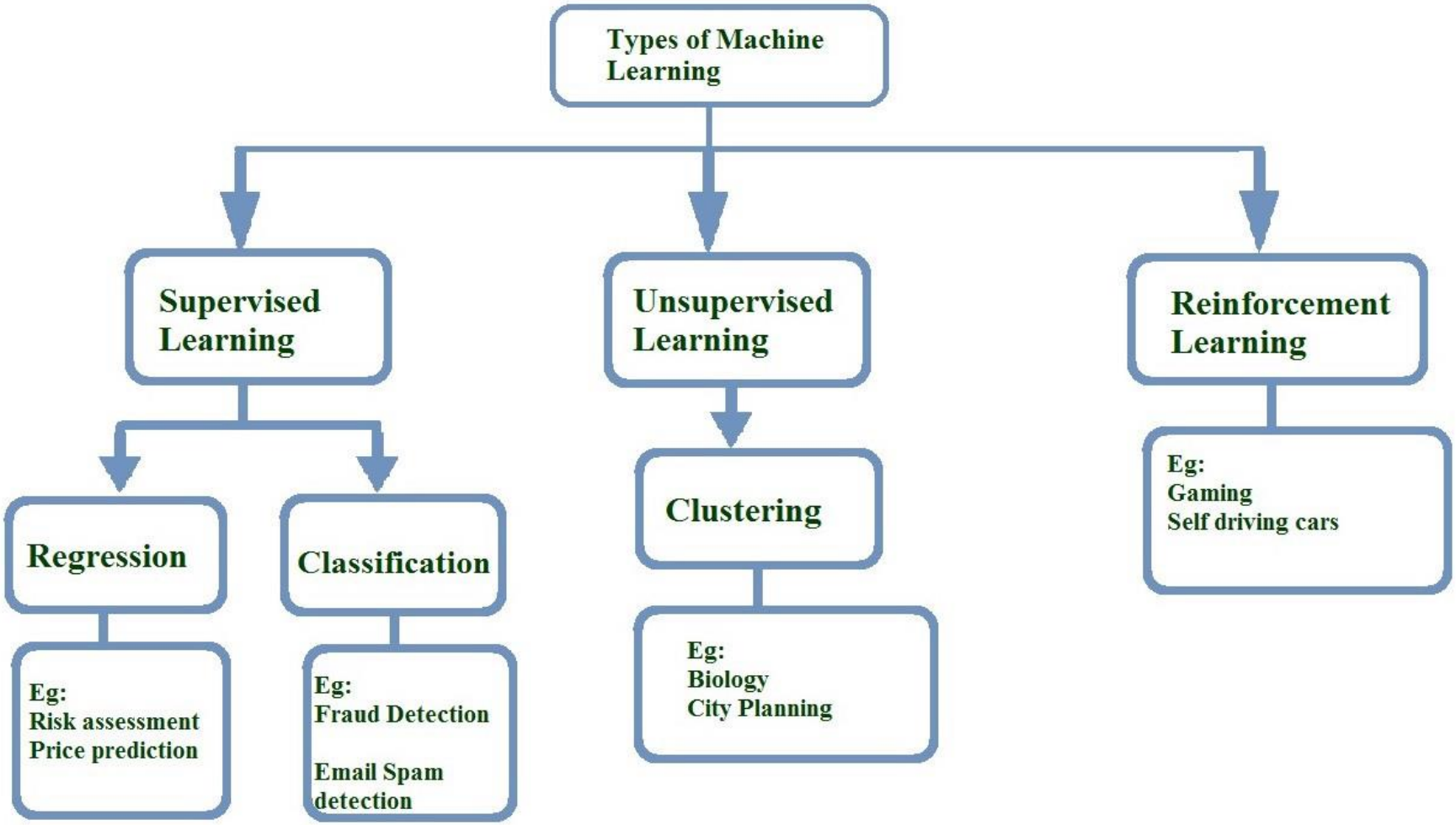
Flow chart recap for Types of Machine Learning



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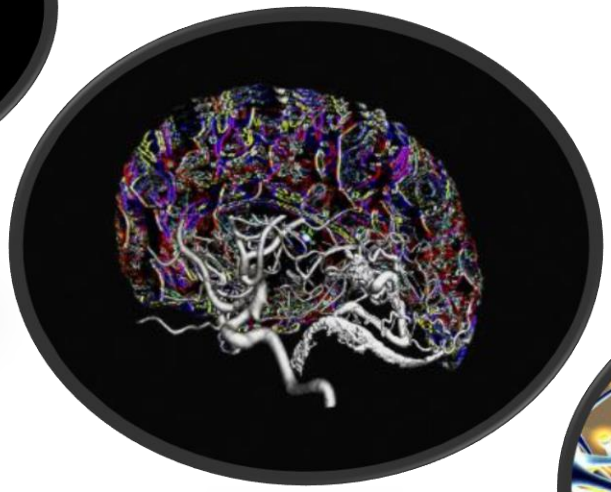
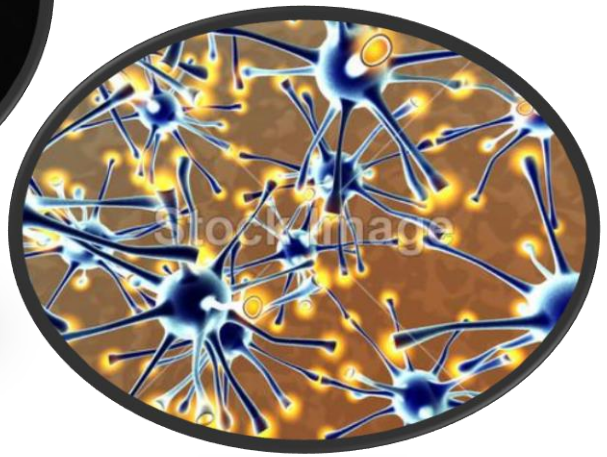
Machine Learning Inference Model

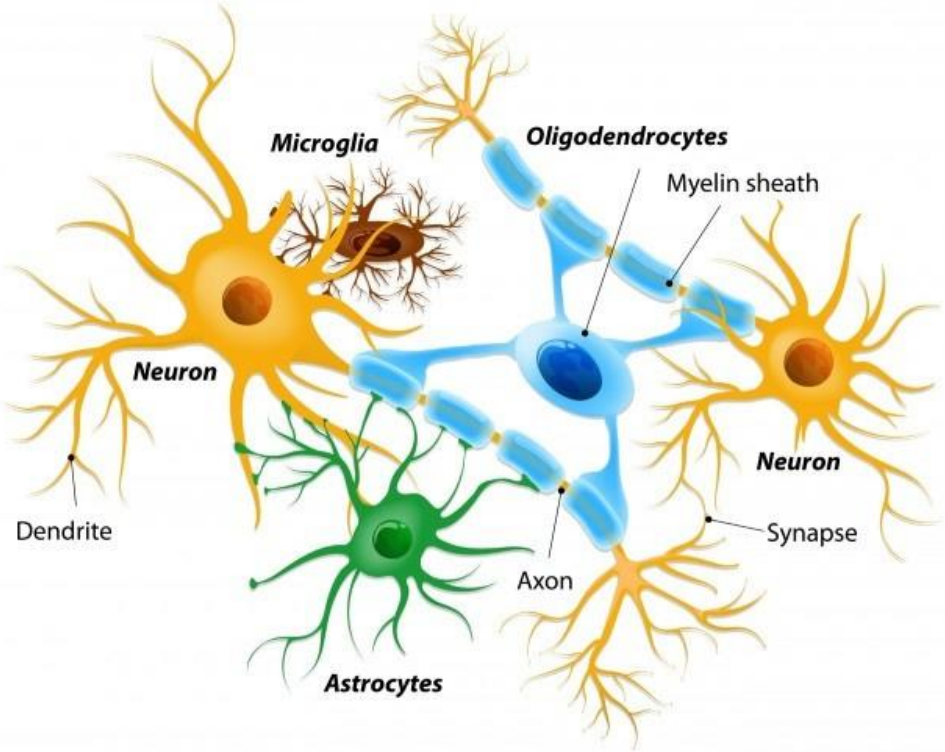
- Artificial Neural Networks (ANNs)
- Bayesian Network
- Decision Tree
- Support Vector Machine
- Fuzzy Systems

Artificial Neural Networks – How does the Brain work?





NEURONS AND NEUROGLIAL CELLS



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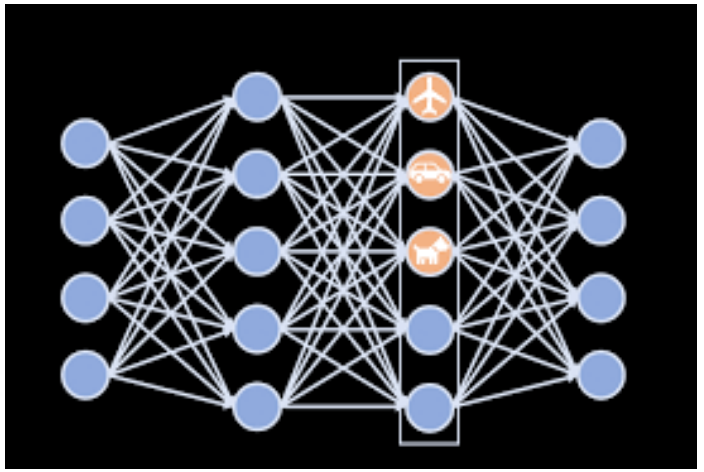
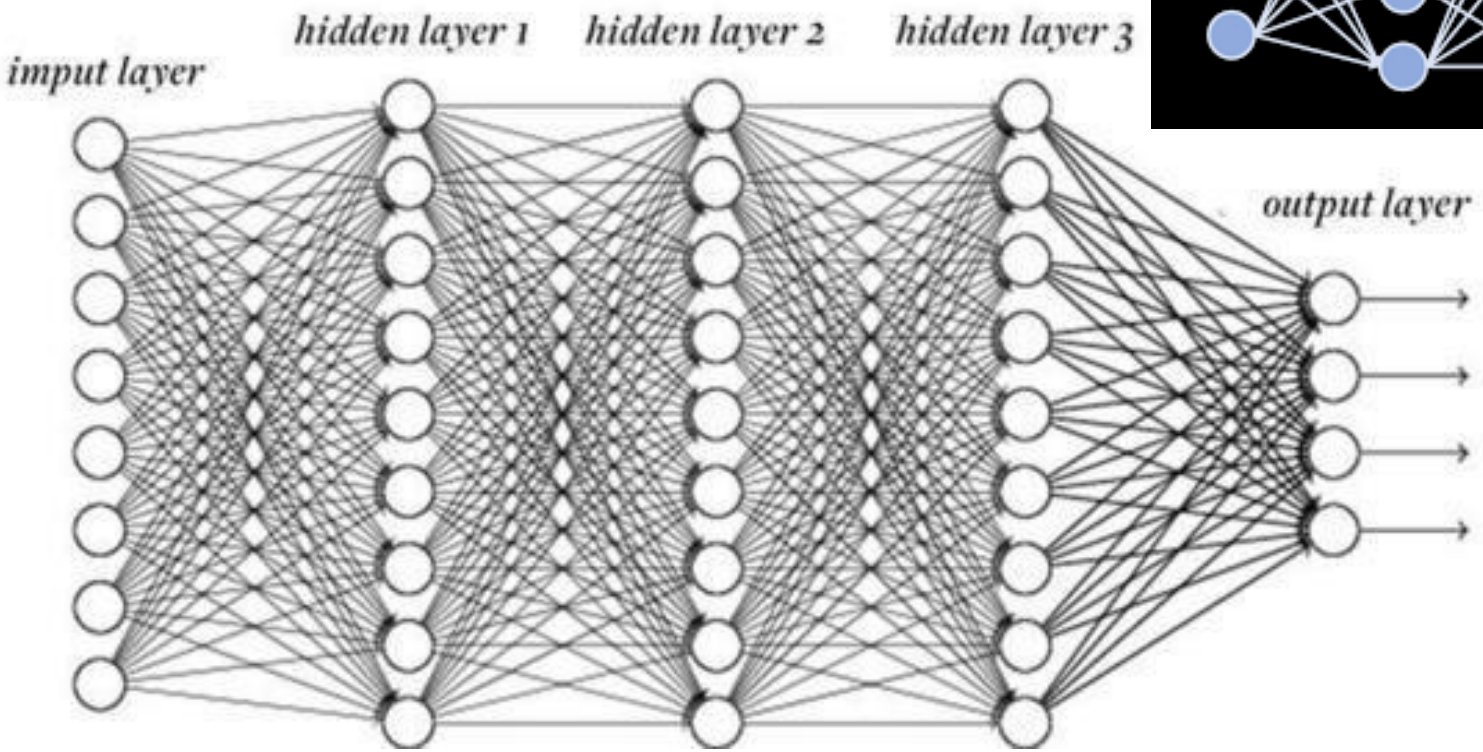
The Mechanism of ANNs





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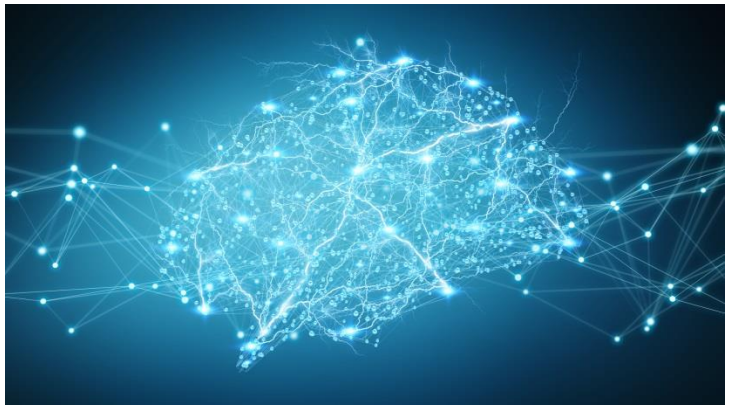
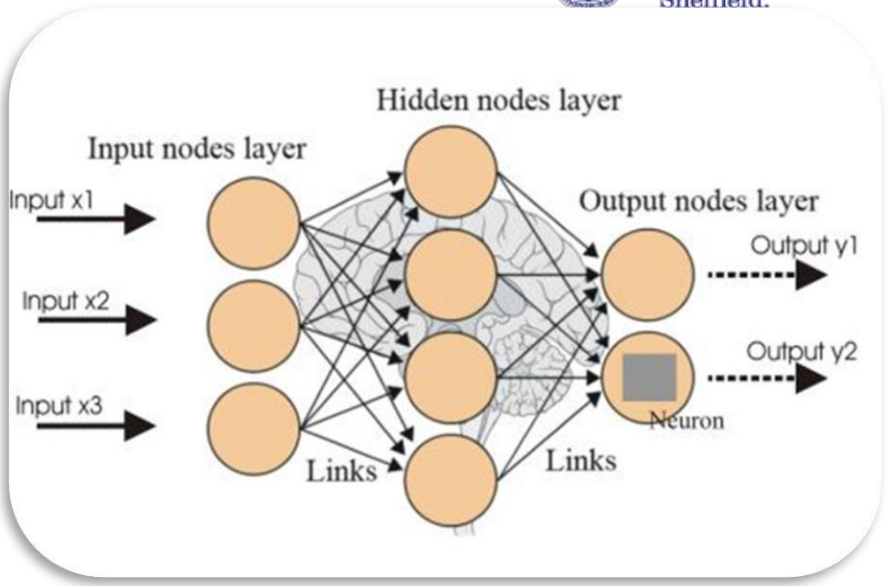
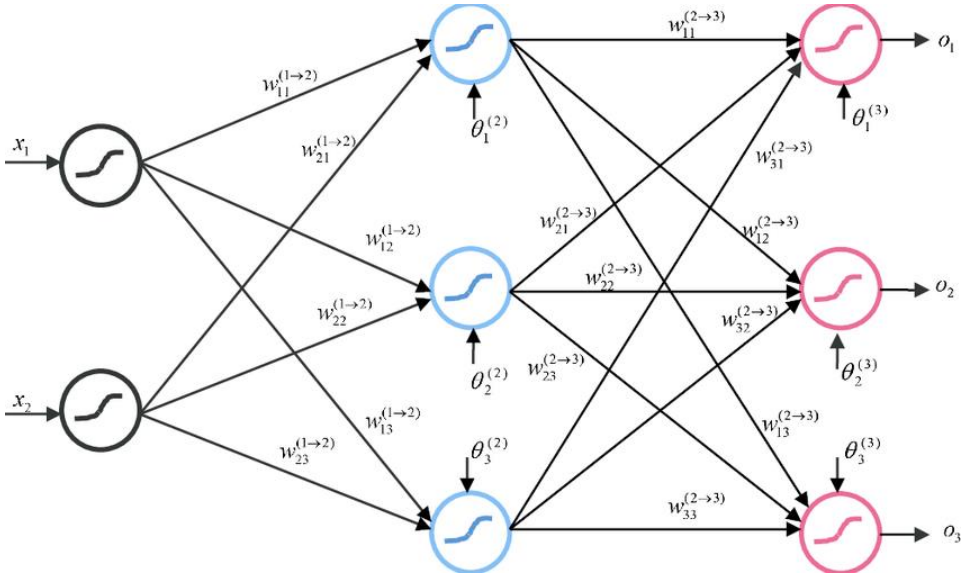






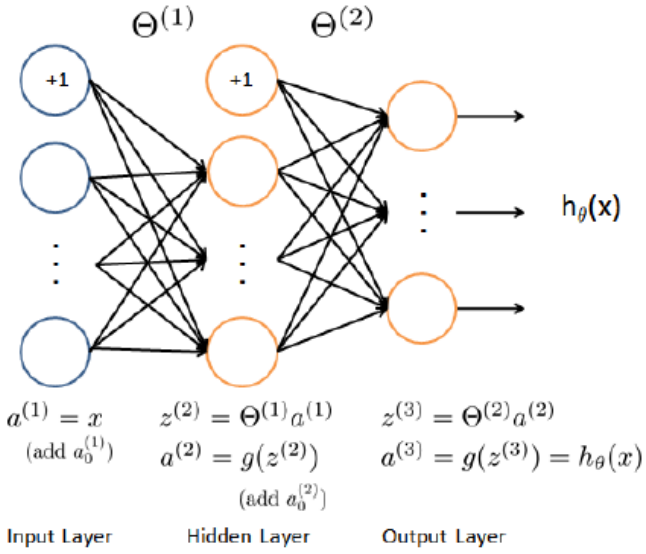


Figure 2: Neural network model.

Bayesian Networks

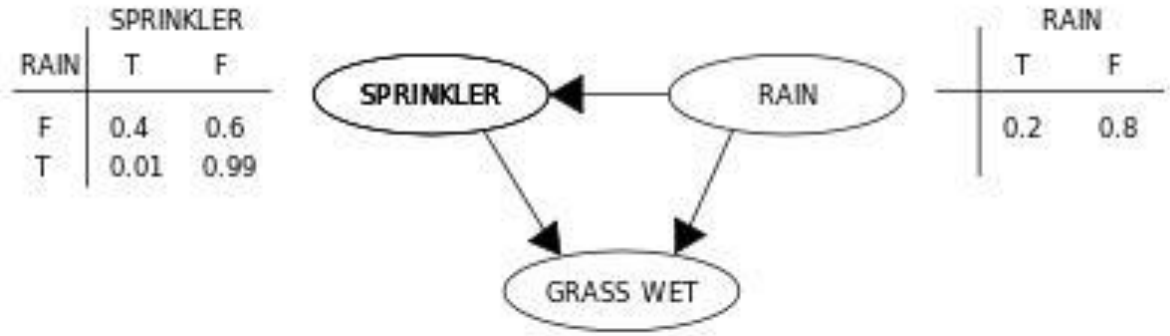
Bayesian Law $$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

$$P(A|B) = \frac{P(A \cap B)}{P(B)}$$

$$P(B|A) = \frac{P(A \cap B)}{P(A)}$$

$$P(A \cap B) = P(B|A)\,P(A)$$

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

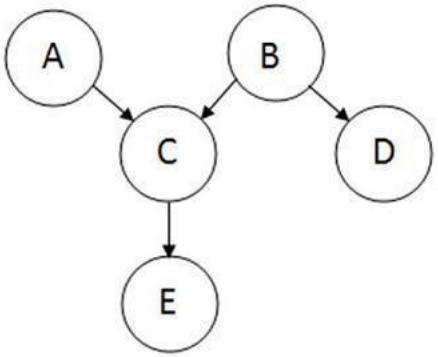


RAIN	SPRINKLER T	SPRINKLER F
F	0.4	0.6
T	0.01	0.99

RAIN T	RAIN F
0.2	0.8

SPRINKLER	RAIN	GRASS WET T	GRASS WET F
F	F	0.0	1.0
F	T	0.8	0.2
T	F	0.9	0.1
T	T	0.99	0.01

$$Pr(G, S, R) = Pr(G|S, R)\, Pr(S|R)\, Pr(R)$$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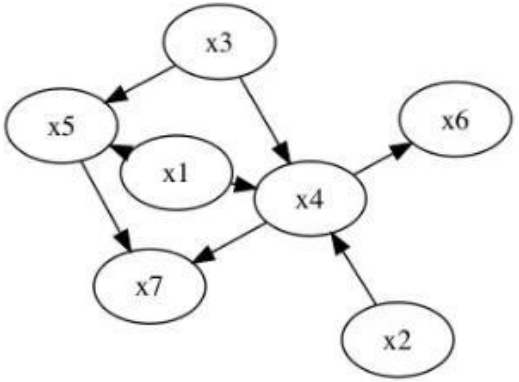
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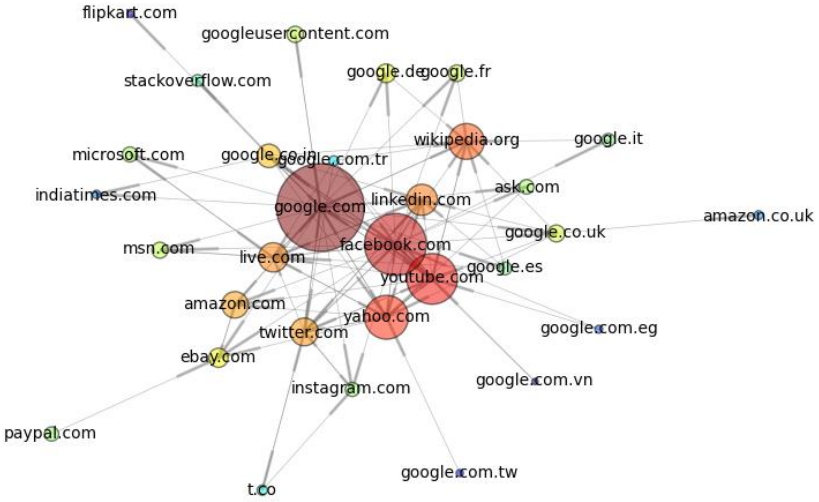
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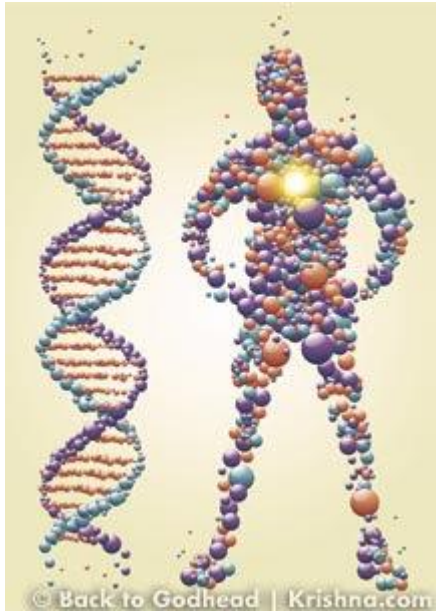
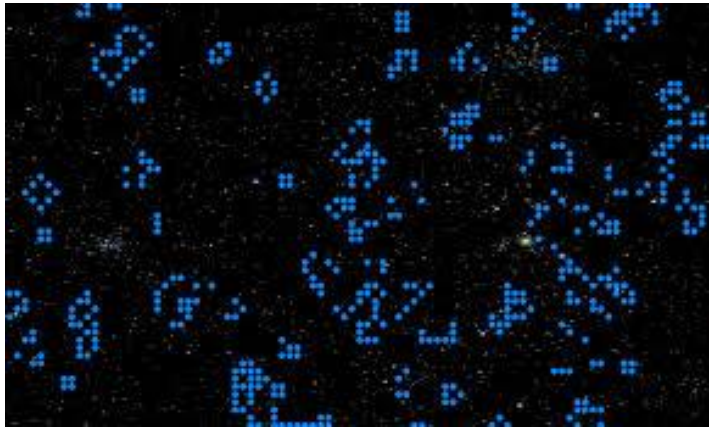
Artificial Life

"Artificial life (also known as AL, A-Life, or Alife) is an interdisciplinary study of life-like processes using a synthetic methodology"





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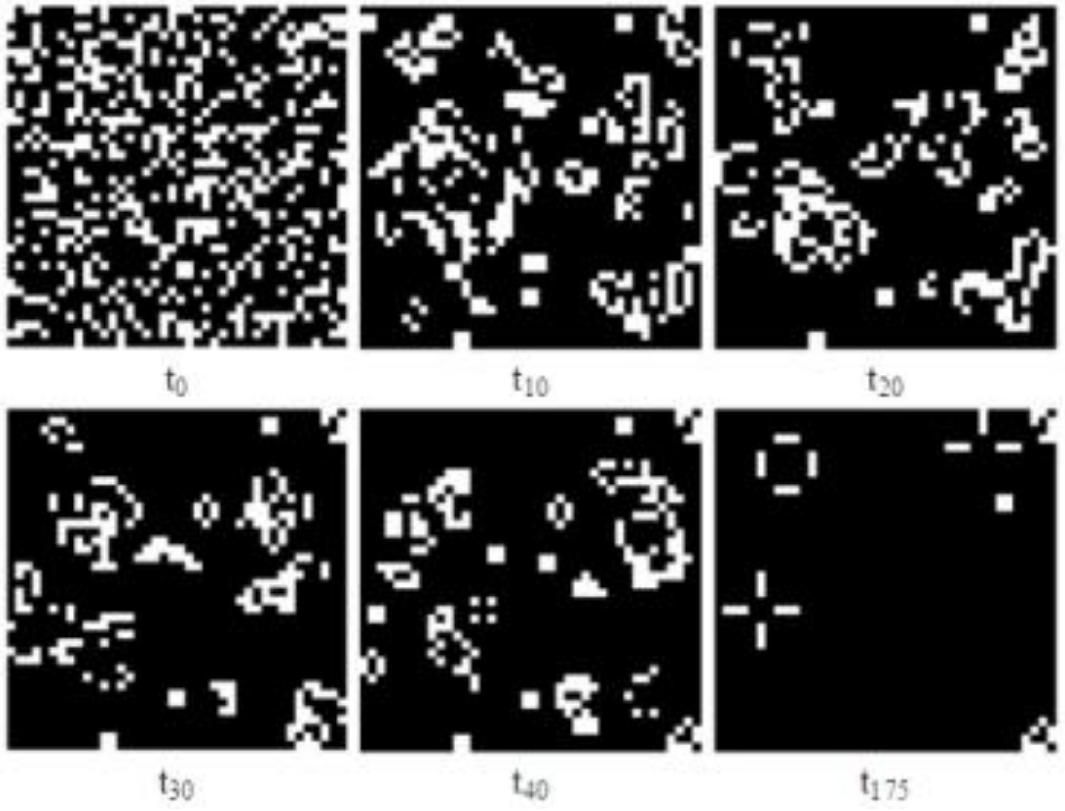
The evolving process of 'life-forms'



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Strong AL vs. Weak AL

- **The strong alife** - "life is a process which can be abstracted away from any particular medium"
- **The weak alife** - denies the possibility of generating a "living process" outside of a chemical solution, and tries to understand the underlying mechanics of biological phenomena.

Conway's Game of Life

- The universe of the Game of Life is an infinite 2-D orthogonal grid of square *cells*, each cell with two states, *alive* or *dead*, or "populated" or "unpopulated"

- If live neighbours < 2, then dies. (underpopulation)
- If live neighbours = 2, 3, then stay.
- If live neighbours > 3, then dies. (overpopulation)
- If a dead cell with three live neighbours, then becomes a live cell. (reproduction)

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Original Life-Form

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A Reward Policy of Game of Life

- Each cell has 250 points energy initially.
- If cell maintains or changes to "active" in the crowded state will reduce 5 points energy.
- Cells are activated in the non-crowded state will get 3 points energy.
- Cells will reduce 1 point energy when it is "inactive".
- When the cell's energy decreased to 0, it will change and still remain dormant (means dead).

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Life-Form with Reward Policy

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Original Life-Form

Life-Form with Reward Policy

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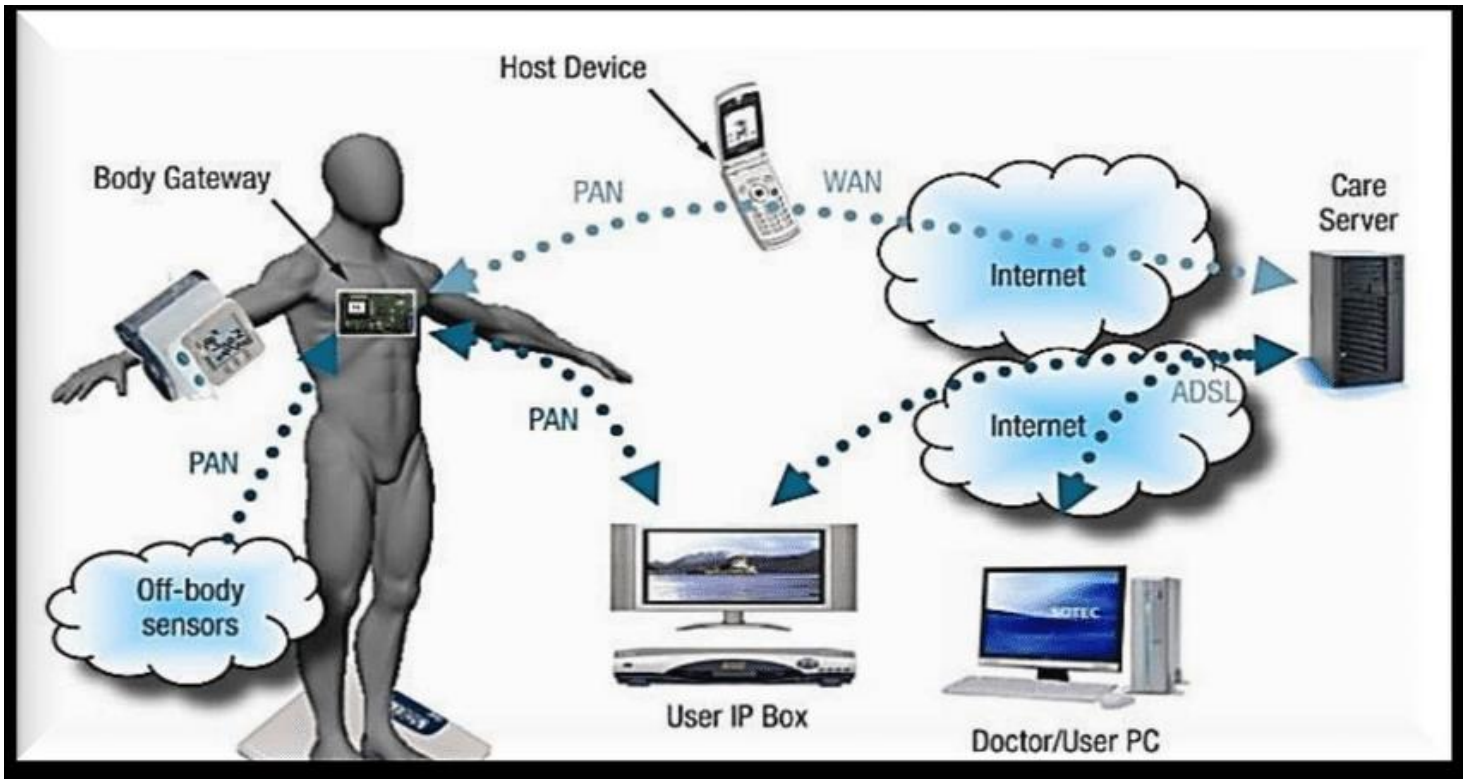
Smart Healthcare Powered by AI

- **PRECISION MEDICINE** – PERSONALIZED MEDICINE
- **MEDICAL IOT SYSTEM** – MIOT SYSTEM



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MEDICAL DATA TYPE

- **VALUE** – BIOMETRIC MEASUREMENTS, BLOOD PRESSURE、CHOLESTEROL、BLOOD SUGAR
- **SIGNAL** – ELECTROCARDIOGRAM(ECG)、ELECTROENCEPHALOGRAPHY(EEG)
- IMAGE –
- A. IN VIVO: X-RAY、ULTRASOUND、COMPUTED TOMOGRAPHY(CT)、MAGNETIC RESONANCE IMAGE(MRI)
- B. IN VITRO: SKIN CANCER
- **TEXT** – MEDICAL RECORD
- **OTHERS** – VOICE

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Relevant Cases

- 1. Risk Prediction of Thyroid Cancer on Ultrasound
- 2. Risk Prediction with Pediatric Echocardiography
- 3. Fundus photograph-based deep learning algorithms in detecting diabetic retinopathy
- 4. Glaucoma Detection by generative network
- 5. Analysis of the Severity of Sleep Apnea Based on PSG Physiological Parameters

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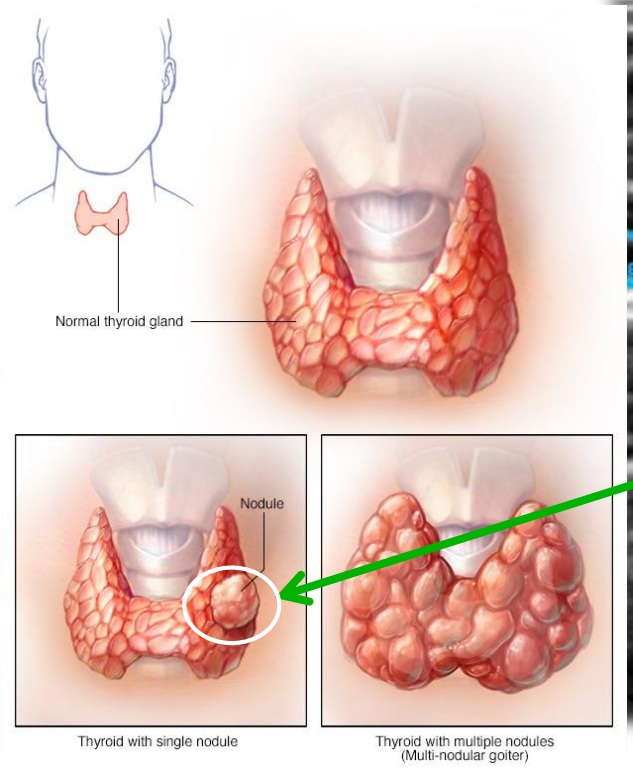
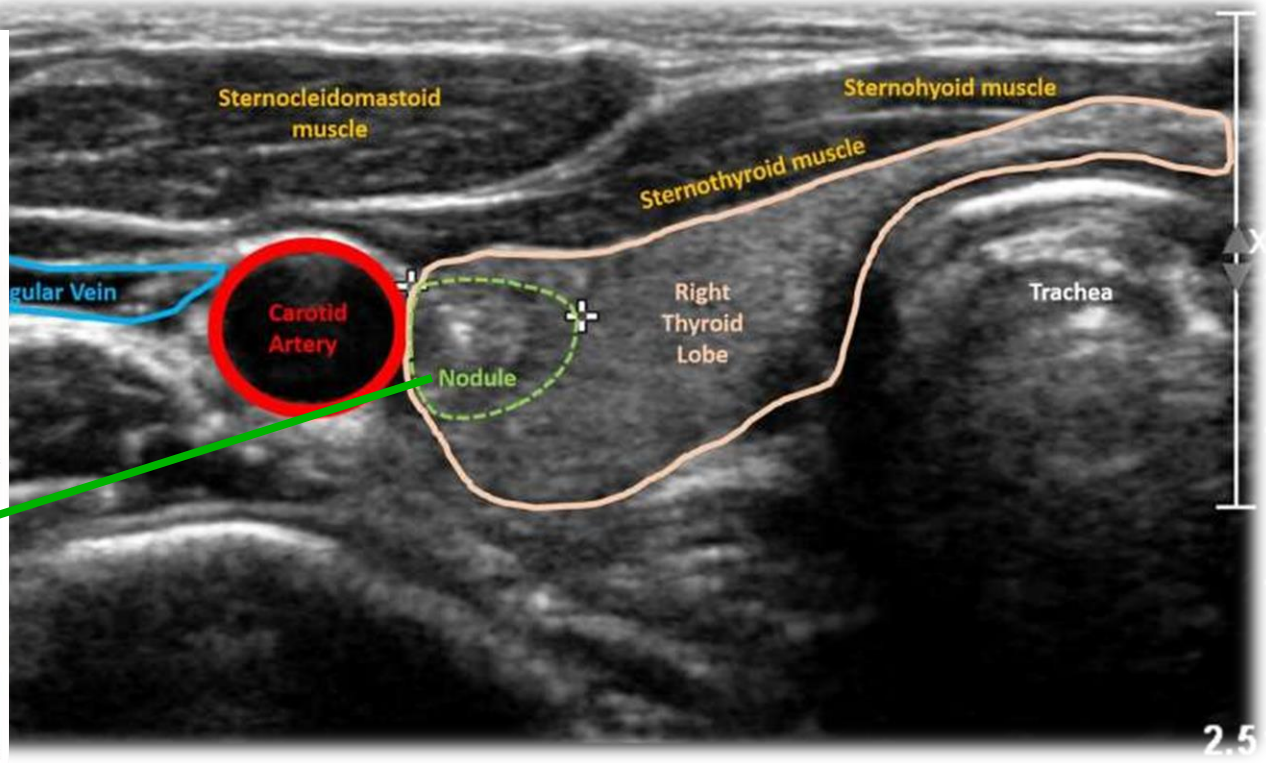
1. Risk Prediction of Thyroid Cancer on Ultrasound

1. Extracting the lesion boundaries of nodules
2. Extracting nodular lesion features
3. Predicting Malignant or Benign Classification of Thyroid Nodules Using Deep Learning





Ultrasound imaging of thyroid nodules

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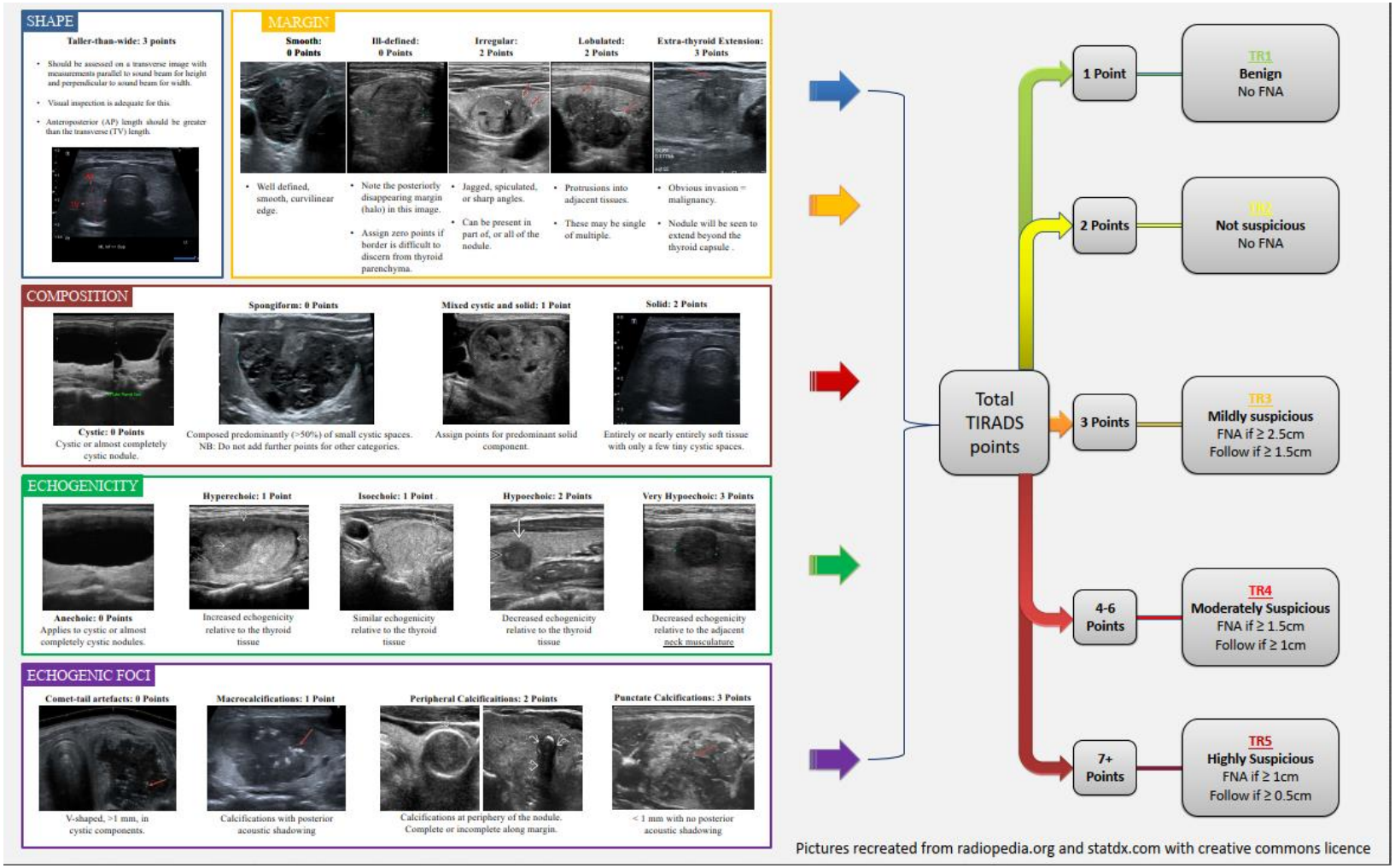
TI-RADS

Thyroid Imaging Reporting & Data System



Pictures recreated from radiopedia.org and statdx.com with creative commons licence

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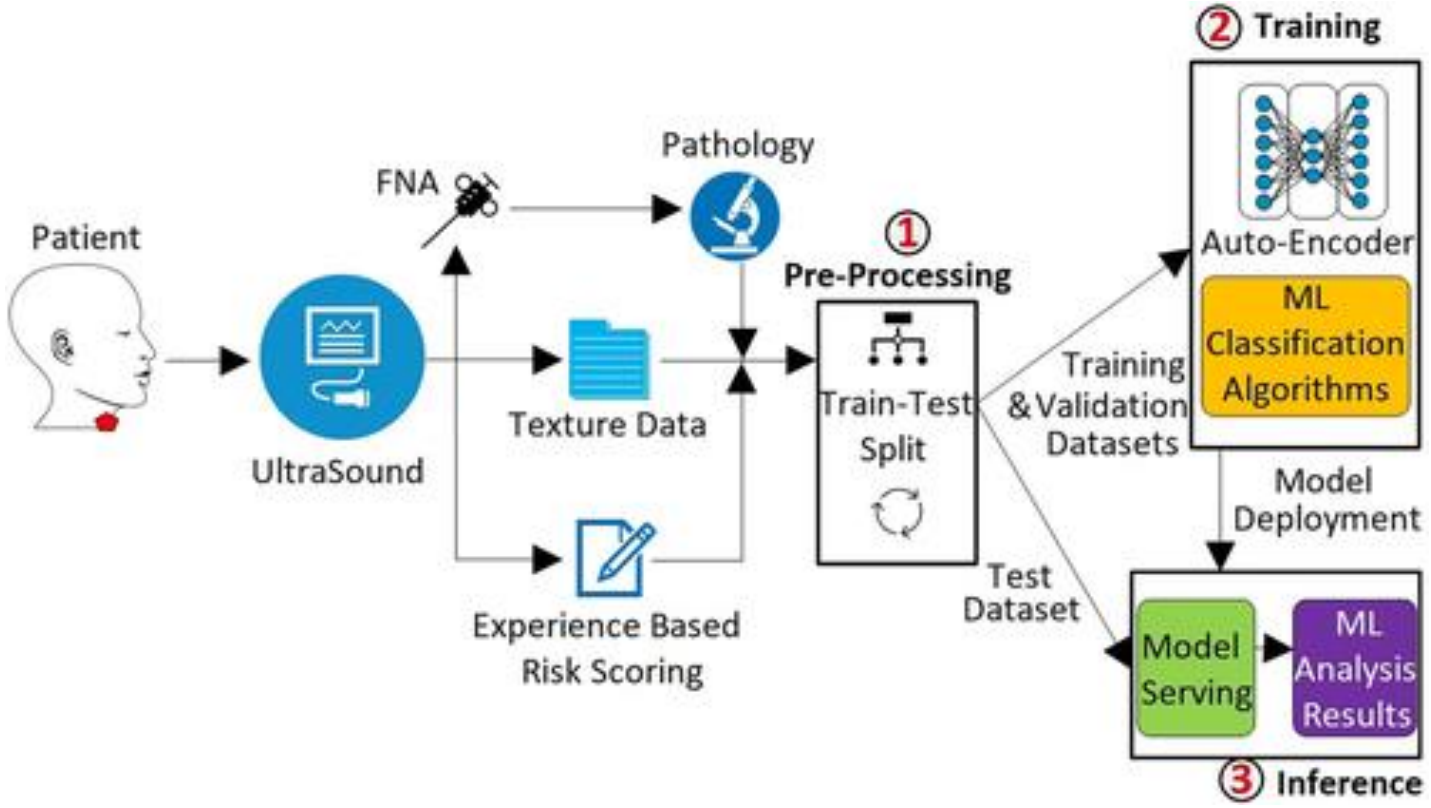
INCORPORATION OF AN ML APPROACH WITH OBJECT DETECTION AND DATA REPORTING SYSTEM TO IMPROVES THE DIAGNOSIS OF RISK STRATIFICATION OF THYROID NODULES



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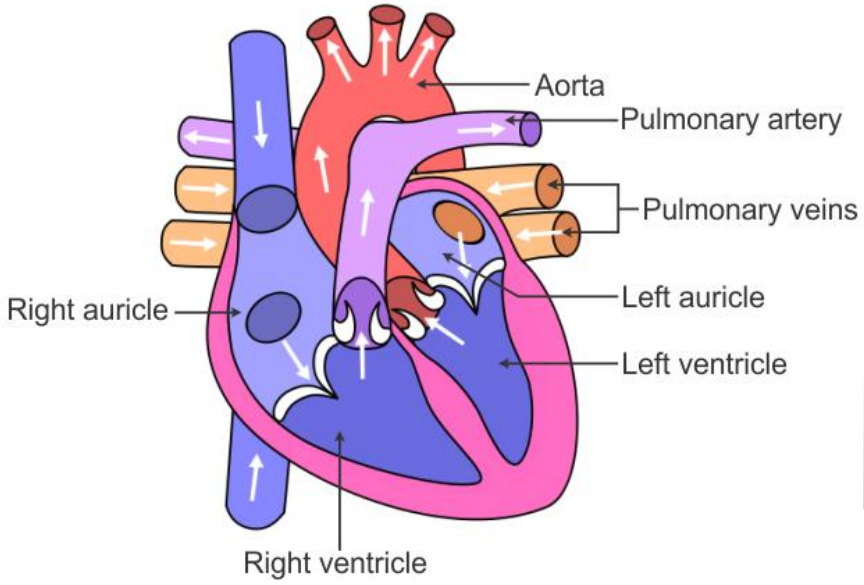
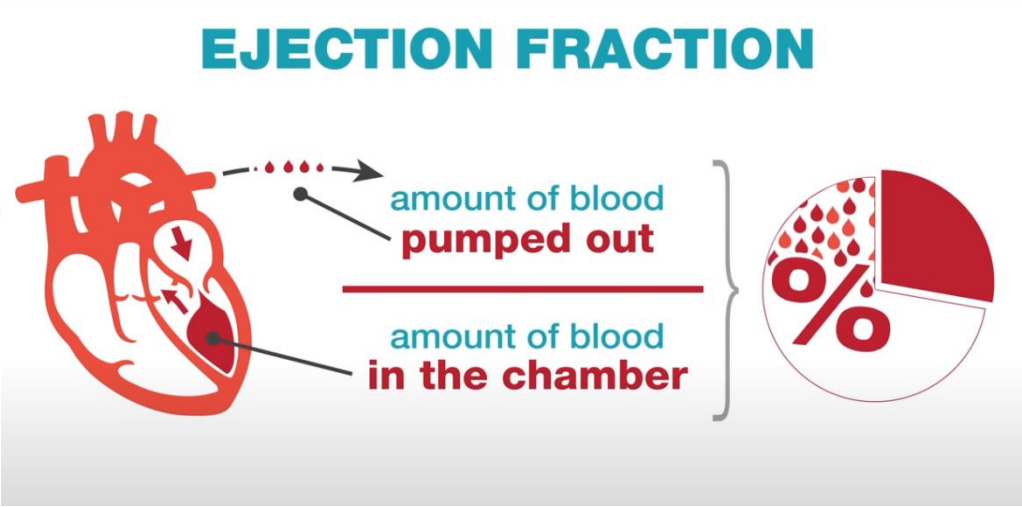
2. RISK PREDICTION WITH PEDIATRIC ECHOCARDIOGRAPHY

PURPOSE: CALCULATE THE PRECISE LEFT VENTRICULAR EJECTION FRACTION(LVEF)

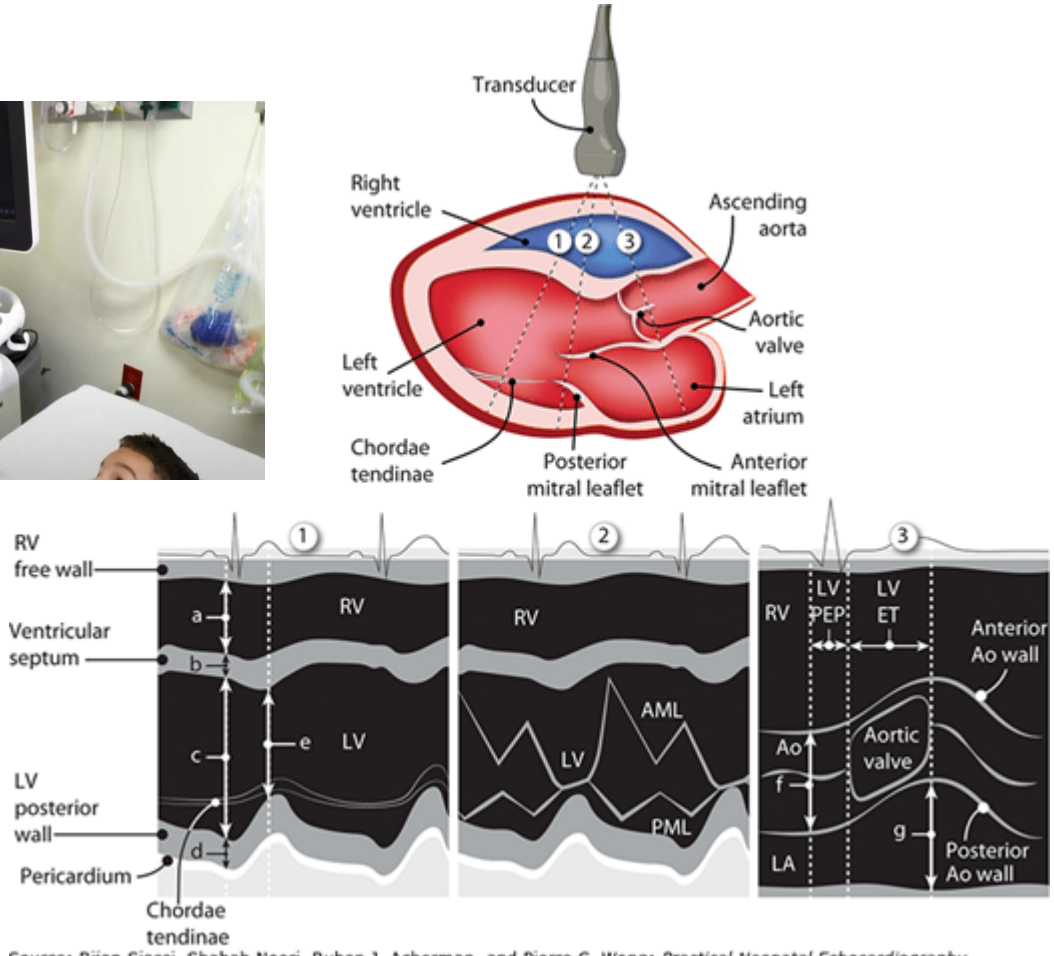


CROSS-SECTION VIEW OF A HUMAN HEART



Left ventricular ejection fraction (LVEF

M-MODE ECHOCARDIOGRAPHY



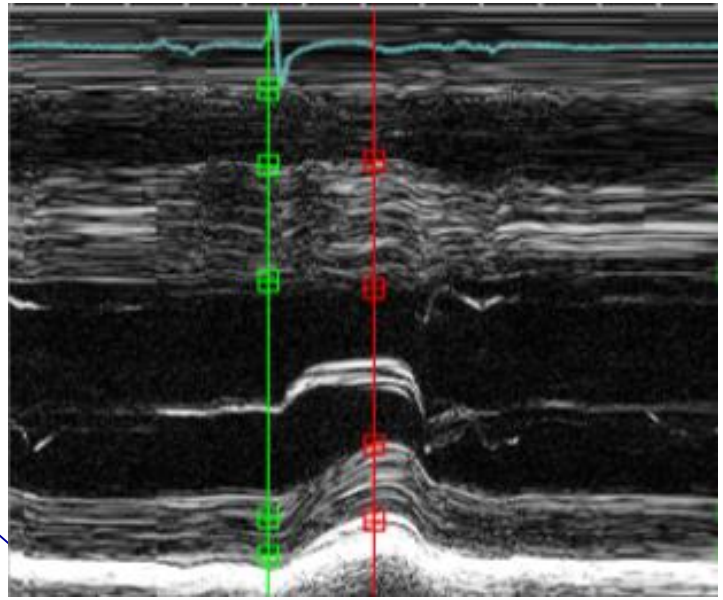
Source: Bijan Siassi, Shahab Noori, Ruben J. Acherman, and Pierre C. Wong: *Practical Neonatal Echocardiography*

https://thoracickey.com/m-mode-echocardiography-and-2d-cardiac-measurements/

Schematic drawings showing the 2D parasternal long-axis view of the heart and M-mode tracing at the levels of the papillary muscles (A), the mitral valve tips (B), and the aortic valve (C). Abbreviations: AML, anterior mitral valve; PMV, posterior mitral valve; PEP, pre-ejection period; ET, ejection time; Ao, aorta.

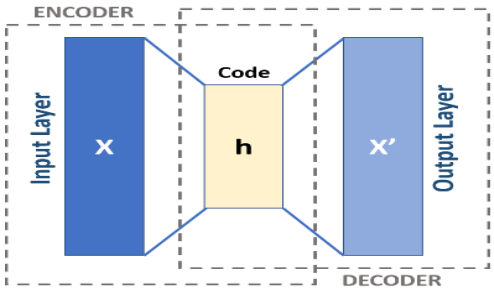
GOAL :

1. SIMPLIFY THE PEDIATRIC ECHOCARDIOGRAPHY EXAMINATION
2. RISK PREDICTION



IMAGES CAPTURE AND NUMERICAL MEASUREMENT NEED TO BE DONE IN A SHORT TIME

AI approaches



THE AUTOMATION OF MEASUREMENT AND NUMERICAL CALCULATION WILL MAKE THE INSPECTION PROCESS SMOOTH AND GET BETTER QUALITY INFORMATION.

FIG 5. AUTOMATED MEASUREMENT WITH AI APPROACH TO REDUCE THE BURDEN ON PEDIATRICIANS

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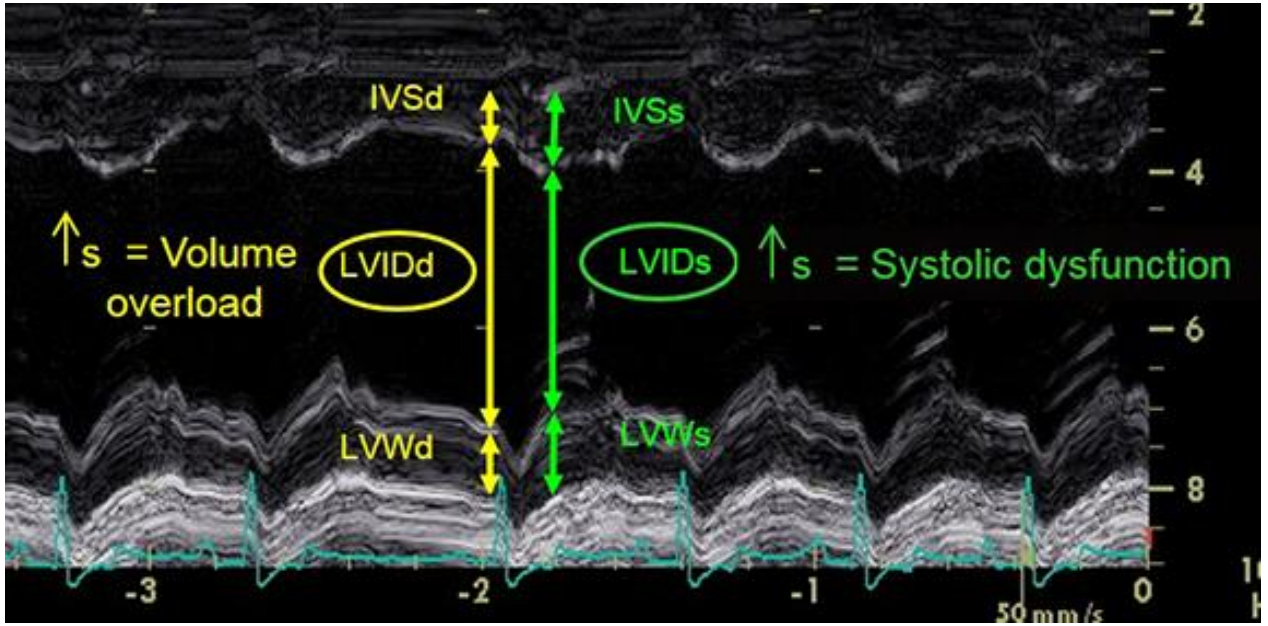
PURPOSE –CALCULATE LVEF

THE DEEP-LEARNING NETWORK FOR EDGE DETECTION AND QUANTITATIVE ANALYSIS OF PEDIATRIC ECHOCARDIOGRAPHY

1. EDGE DETECTION
2. QUANTITATIVE ANALYSIS
3. RISK PREDICTION



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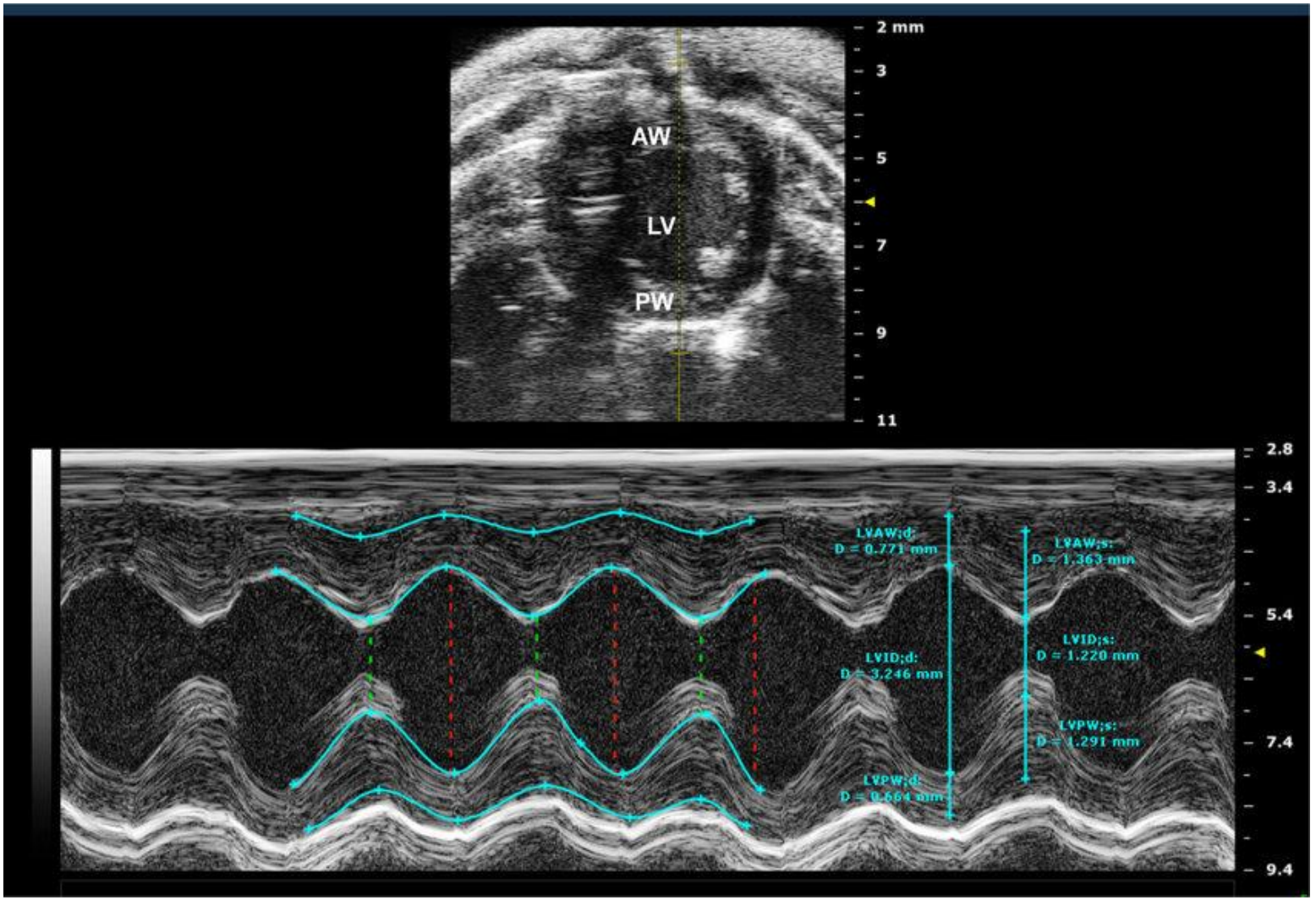
INSTANCE SEGMENTATION



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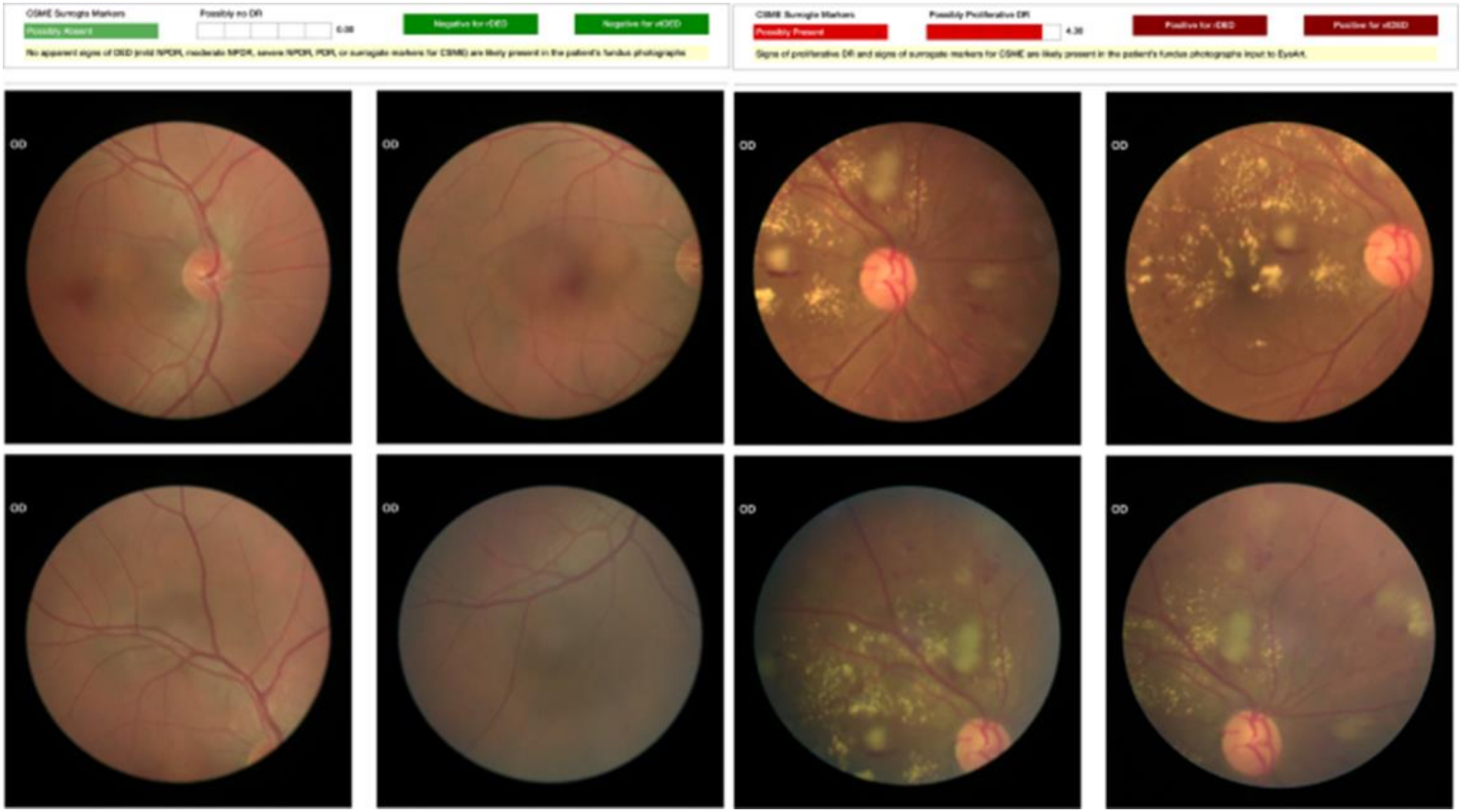
3. FUNDUS PHOTOGRAPH-BASED DEEP LEARNING ALGORITHMS IN DETECTING DIABETIC RETINOPATHY



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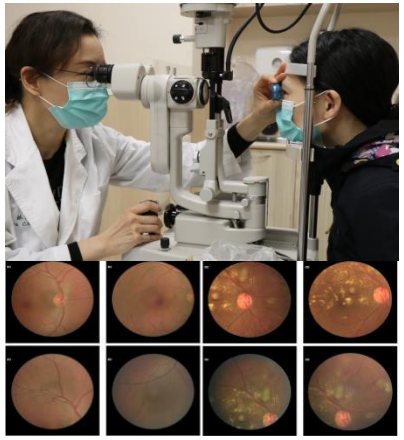
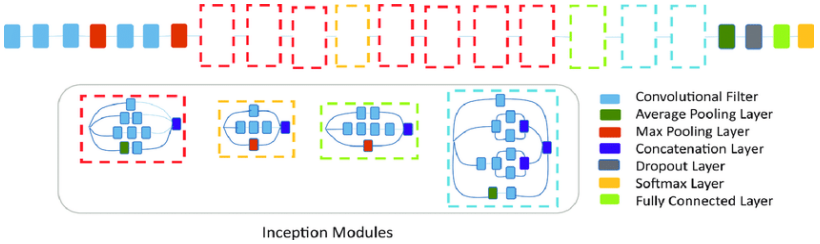
PURPOSE

GOAL : ACCURATELY DETECT DIABETIC RETINOPATHY BY AI APPROACH

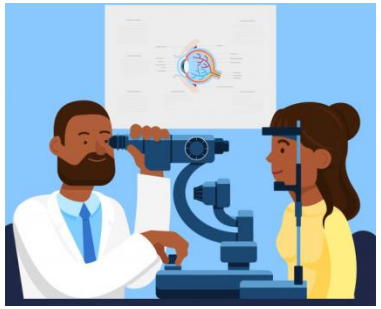




DEEP-LEARNING NETWORK

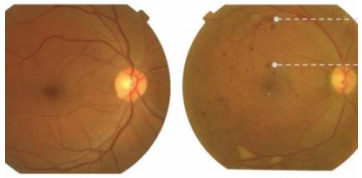
2000 DR SAMPLES

Establish a prediction model of the DR



OPHTHALMOLOGIST

LABELING the lesion LOCATIONS of DIABETIC RETINOPATHY



AI-ADDED OPHTHALMOSCOPE MEDICAL MATERIALS

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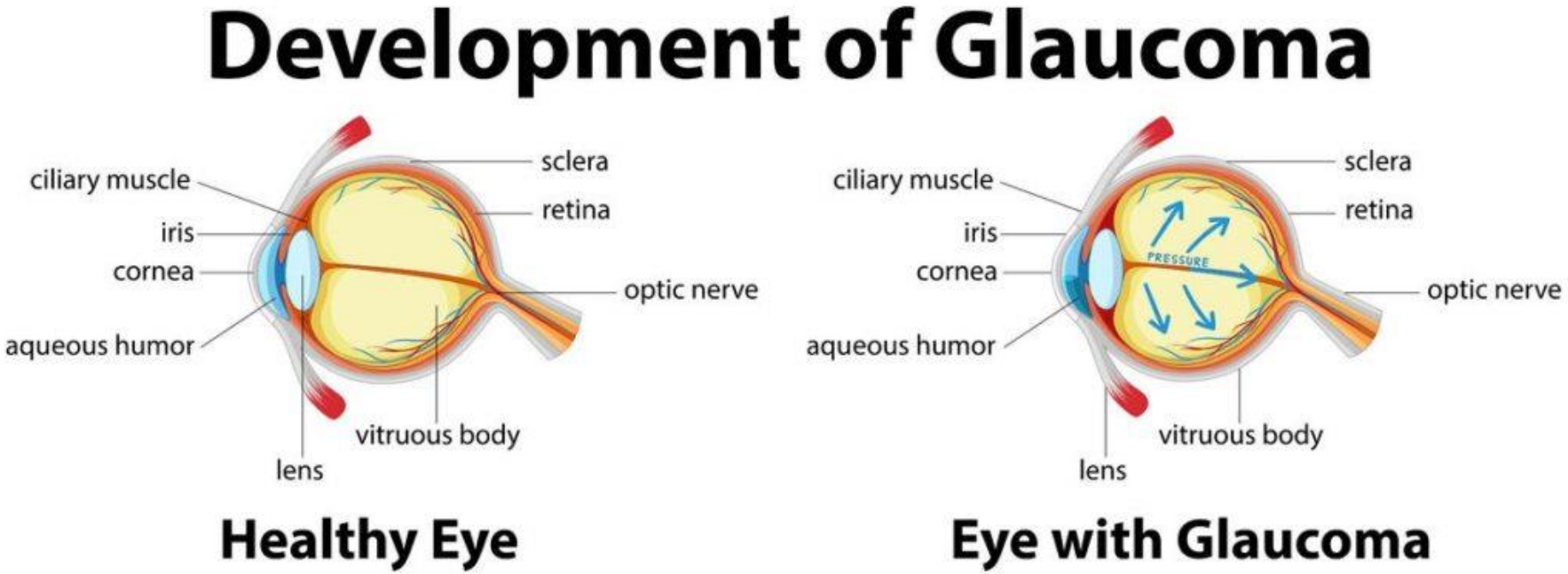
4. Glaucoma Detection by AI

Glaucoma is often described as a condition of high intraocular pressure (IOP), or pressure inside the eye, leading to damage of the optic nerve. However, some cases of glaucoma are Normal-Tension Glaucoma (NTG), with normal levels of pressure on the optic nerve. Treatment of glaucoma involve medication, surgery, or a combination.



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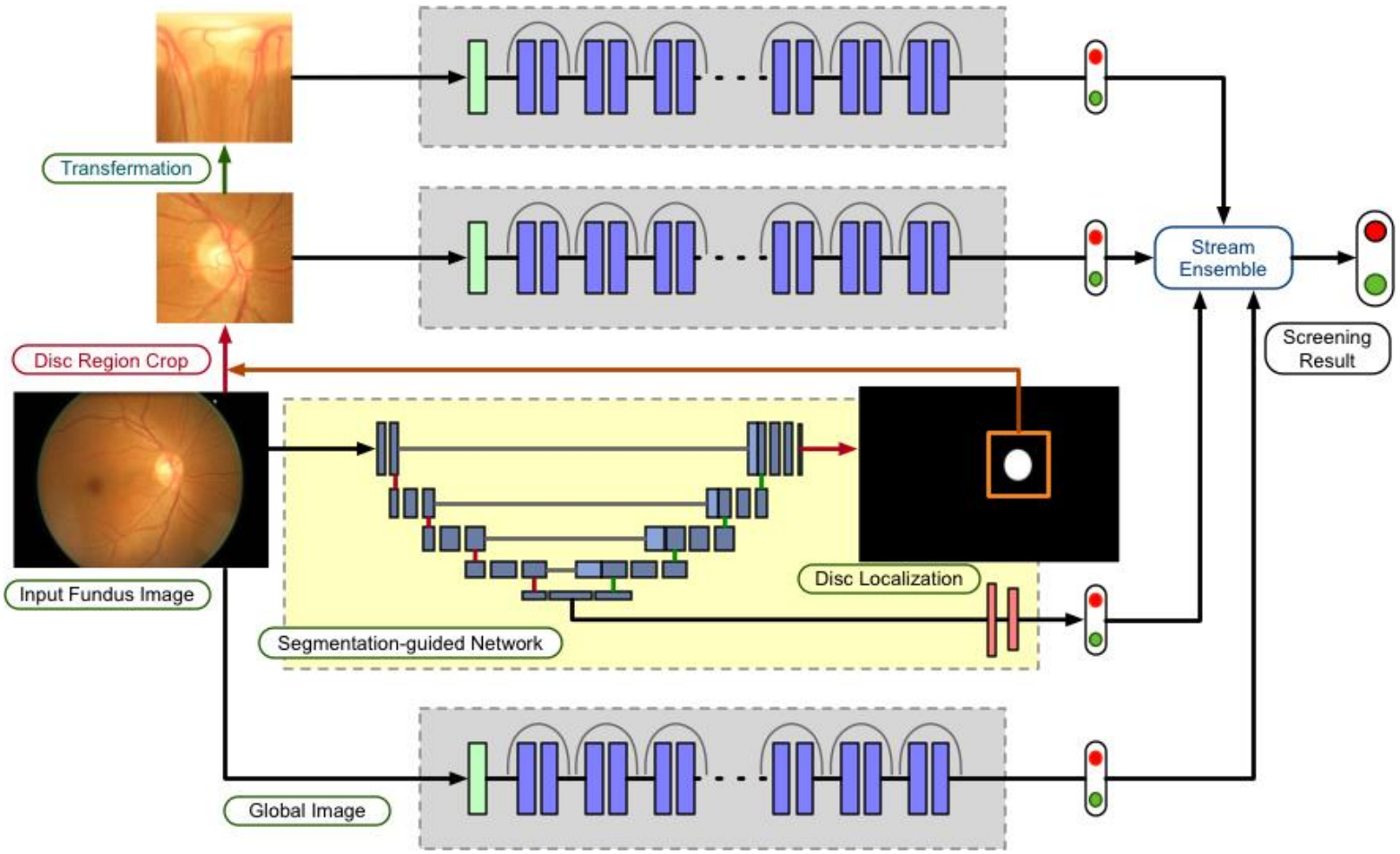
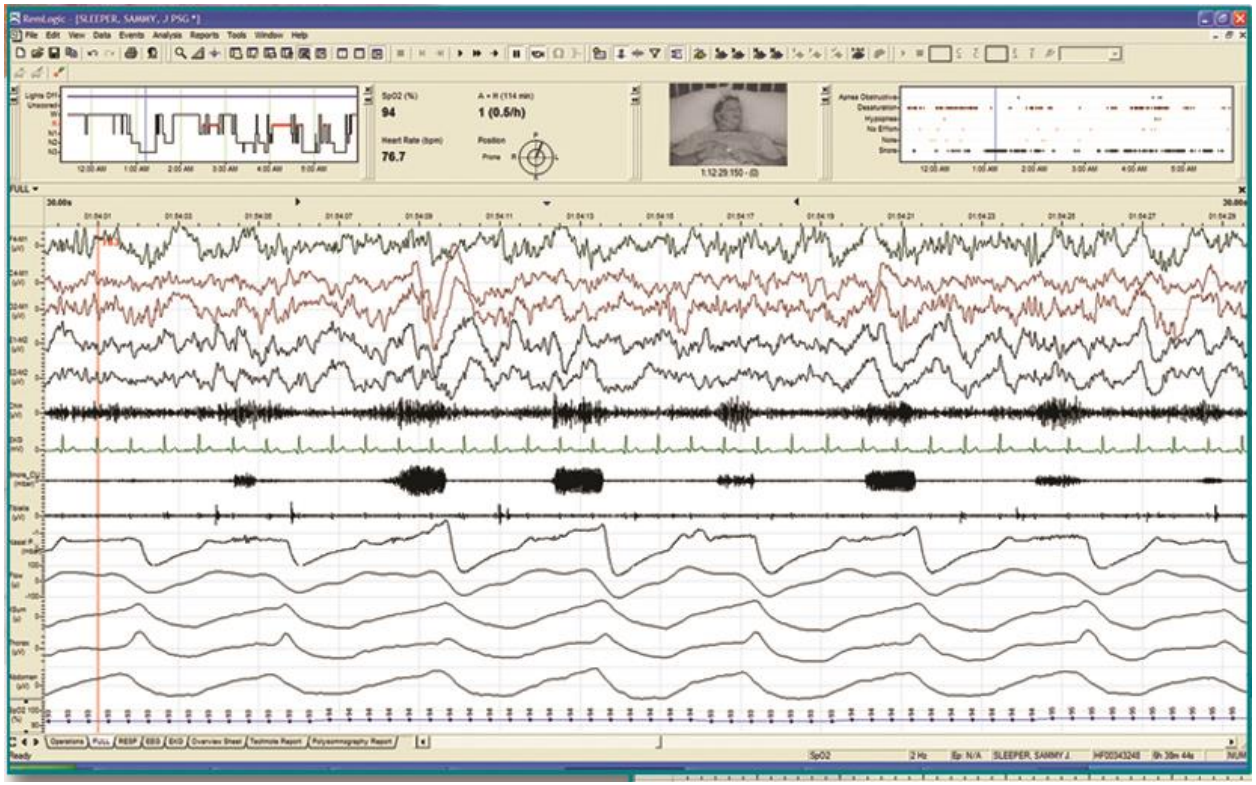
GOAL：ACCURATELY DETECT GLAUCOMA BY DEEP LEARNING



5. Analysis of the Severity of Sleep Apnea Based on PSG Physiological Parameters (by EEG)



Sleep Apnea Detection based on EEG

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Conclusion

Ultimately Strong AI !!

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Question?

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Thank You