Date:

Artificial Intelligence and Expert Systems

Artificial Intelligence:

John Mccarthy First used the term A.I in 1958. He said machine can be more intelligent by combining mechanical machines with A.I.

Alan Turing created a design test called "Turing test" in which he said that a machine is intelligent if it posses this test.

Purpose of A.I: To make machine intelligent

A.I is the development/achievement of digital brain.

A.I: Study of those theories, algos, technologies by which we can make a machine intelligent is called A.I.

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The digital brain uses digits for computation. if there is an image input it will translate it into matrix consisting of digits (image processing).

Algorithm for A.I include A*, BFS, DFS

Q. What do you mean by digital brain?

In A.I digital brain is an evolving term which refers to a conceptual representation of the computational and cognitive capabilities of A.I systems. Just as the human brain processes information, learn from experience and make decisions a digital brain refers to the collection of algorithms, models and computational processes that enable A.I systems to perform tasks such as natural language understanding pattern recognition, problem-solving and decision making. These A.I systems are designed to process vast amounts of data, learn from experience and adopt their behaviour based on feedback, similar to how neurons in human brain form connections and adjust their activity according to stimuli.

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Artificial Intelligence: A.I is basically a super smart computer system that can imitate humans How they talk, understand, analyze problems.

Types of A.I:

1) ANI (Artificial narrow Intelligence):
Lots of progress, includes face recognition, replication of data, drones. Most work done in A.I right now.

2) AGI (Artificial General Intelligence): Creation of almost human like style. Includes chat Gpt or Generative A.I.

Generative A.I: A machine being able to create a similar machine by itself.

Generative A.I can be text (Chat GPT) can create images by GAN (Generative Adhesive Network). GAN uses pixel and create images from it.

GI tools for images, Text: Mid Journey, ideogram AI

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Task

Q: Write about Narrow A.I and General A.I?

Artificial Narrow Intelligence (ANI):

Also known as weak A.I. It is the only type of A.I we have successfully realized to date. Narrow A.I refers to goal-oriented version of A.I designed to perform a single task such as tracking weather updates or generating data science reports by analyzing raw data. Unlike general A.I, narrow A.I lacks self awareness consciousness, emotions and genuine intelligence that can match human intelligence.

Artificial General Intelligence (AGI):

It is a field of theoretical A.I research that attempts to create software with human like intelligence and the ability to self-teach. The aim is for the software to be able to perform tasks that it is not necessarily trained or developed for. An AGI system can solve problems in various domain like humans without manual intervention.

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Object Detection: used to detect whether object exists or not:

Based on Binary → Yes
→ No

Object Classification: Find class group of the object. Class group could be:

Type → Binary → 0 (Object does not exist)
→ 1 (object exists)
→ Multi-Class → output will be any no (1, 2 ... 3)

These numbers will be labelled eg 1=people, 2=vehicle and so on. These are classes.

Machine Learning: Creating Models in which data is learned by these models to train them to identify patterns and trends.

E.G: K-means algorithm.

We want to classify this data based on some conditions.

Data	Label
100	3
150	1
20	2
85	3

We will do it using a machine learning algorithm E.G K-means algo

[Label, cent] = K-means (data, 3)

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What do we need for object detection?

1) Data set → Training data set
   → Test data set

2) Object of interest. Object for which we are training our model. For. This is called our foreground.

could be anything specific. Object can be detected based on 1 or more feature.

Training Data set

→ set of positive examples
↓
Those that contains object of interest

→ set of negative examples.
↓
Must not contain object of interest

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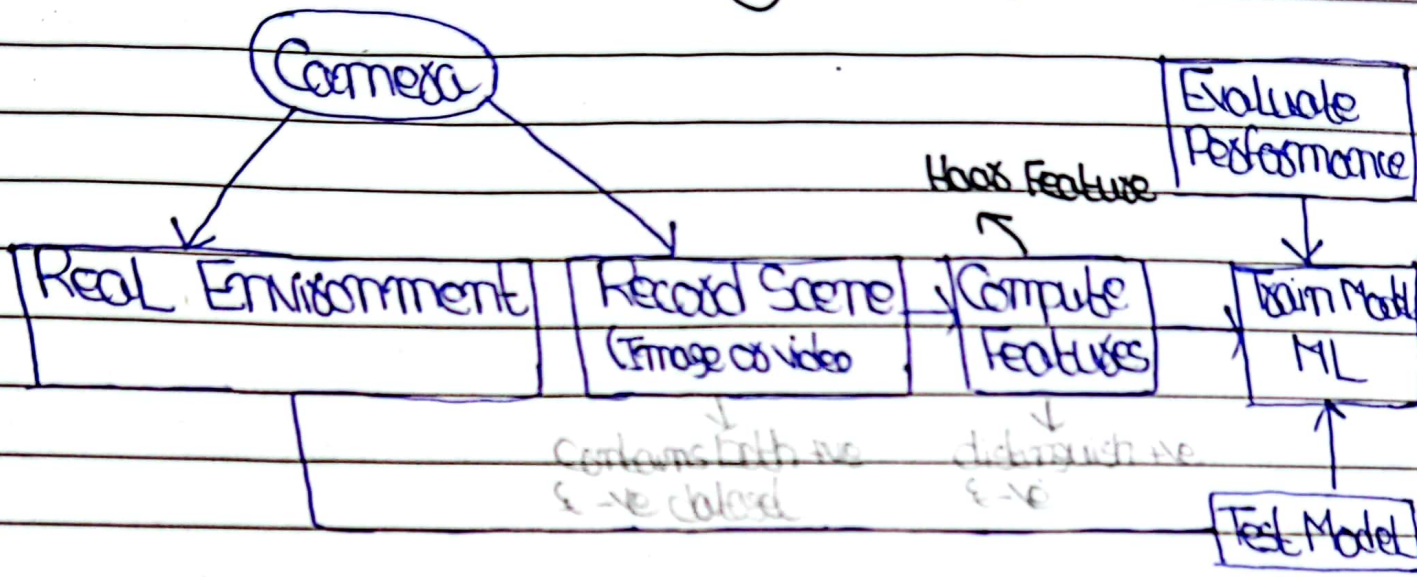
Machine Learning Concept



For now we focus on foreground with static background. We need to ensure static background.

Feature: It is an attribute by which we can distinguish an object.

* Feature could be 1 or more by which we can distinguish
* Feature should be robust (meaning same feature in similar objects).
* Computer computes haar feature in which it will detect rapid change in our dataset.

Object detection using that Haar feature:
It was first introduced by Viola and Jones in form of 4 rectangular features

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Haar features are computed in which positive examples are translated into matrices for the computer and this is used to train model.

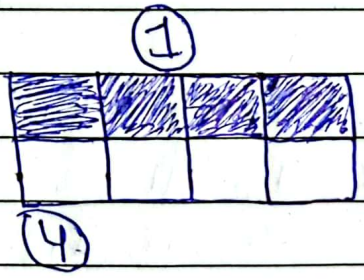
Haar feature is also known as rectangle feature.

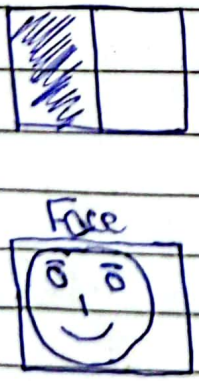
Aim of ML is to obtain a mathematical model that satisfies the positive and negative examples of our data.

Haar feature may not be suitable for.

1) very small objects
2) Great variation in object (no robustness)
3) No significant change.

initially ⇒ 4 haar rectangular features :





stored in computer in form of matrix →

50	53	100
51	54	150
52	56	200

Eyeglasses Forehead

Features of Haas Features? When is it used?

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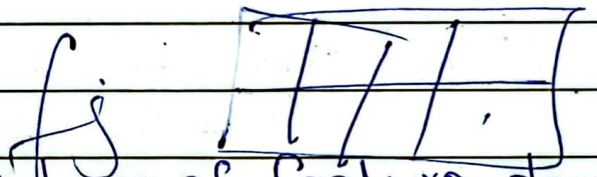
Computation of haas feature $h_1 = \Sigma Dark - \Sigma White$

if $h_1 \approx 0$ it shows skin of same color meaning same feature here. (Forehead)

However when moving from forehead to eyebrows h_2 will be greater e.g $h_1 \approx 150$ which show change in skin colour.

Q: What is Haas Feature? how to compute it?

Haas Feature:



Haas Feature are a type of feature descriptor used in computer vision and image processing for object detection. Haas features are simple rectangular pattern that are defined over rectangular regions of an image. These patterns are used to capture various visual characteristics such as edges, Lines and textures within image.

Computation of haas feature involves:

1) Feature Selection: Haas features are typically defined as rectangular regions with light and dark intensities. These features can vary in size and position within an image.

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2) Integral Image: To efficiently compute haar feature, an integral image is computed from the original image. The integral image allows for rapid calculations of the sum of pixel values within any rectangular region of the image.

3) Feature Evaluation: For each haar feature, the difference in the sum of pixel values between the light and dark rectangle is computed using integral image.

4) Feature thresholding: Haar features are often used as binary classifiers, where a threshold is applied to the computed feature value to determine whether the feature is present or not.

5) Feature detection: The computed haar feature are then used as input to a ML algorithm to train a classifier for object detection tasks.

Write 3 definitions of A.I according to scientist John Mccarthy, Alan Turing.

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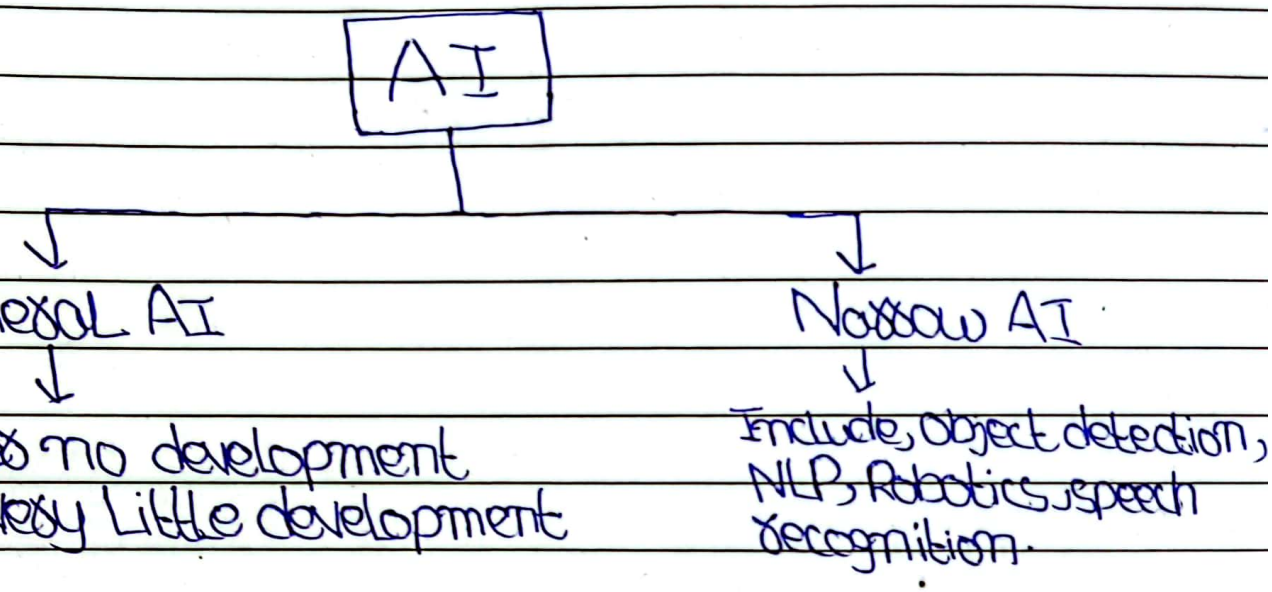
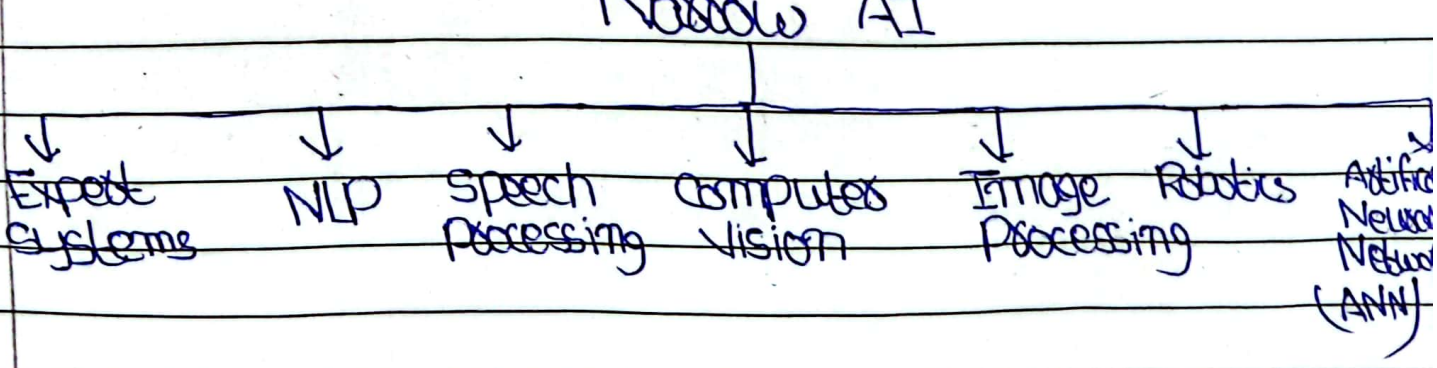
AI & Its Branches:

AI → to develop Intelligent Machine
OR
to develop digital brain.



General AI:

Target of general AI is to stimulate complete human simulation to think rationally like humans.



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Expert system:

Experts are human who have significant knowledge in a particular domain and are able to solve complex problems.

Expert system is a computer program that stimulate Human Expert.

3 components of Expert System.

1) UI
2) Knowledge base
3) Inference Engine

Expert system → Prolog Language

Natural Language Processing (NLP):

NLP Concerning with only → Speech, Written, Gesture, Emotion

Scientists are trying to enable computer that they could recognize written form of our language as well as give response in written form.

NLP is concerned with written form only.

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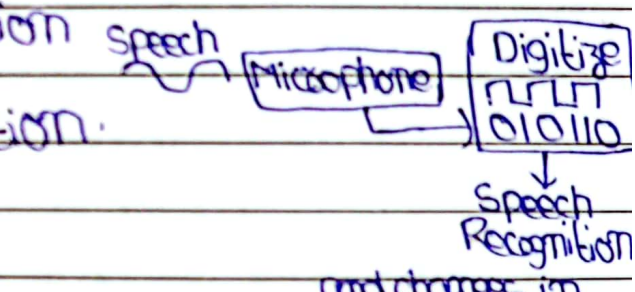
Branches of NLP.

1) Natural Language Understanding
2) Natural Language Generation.

Speech Processing

To enable computer in a way that they could recognize human spoken language.

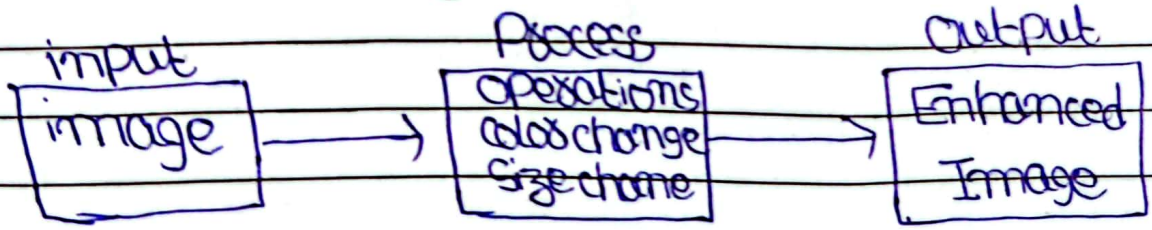
Branches → Speech recognition
→ Speech Generation.



Computer Vision:

Scientists are trying to evolve computer that they recognize their external environment by using visual (camera) systems as well as give response and changes in environment on comput vision output is action.

Image Processing:



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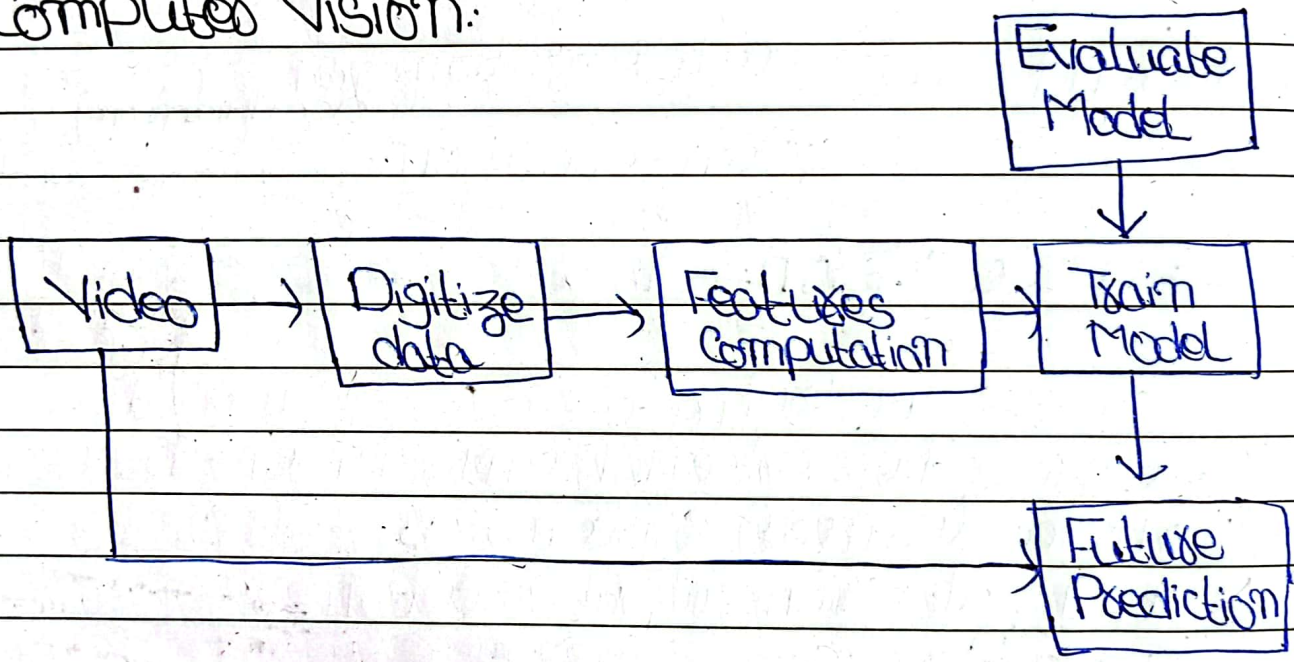
3 characteristics by which analog speech is transformed into digital:

1) Syllable
   - Basic sound of Alphabet
2) Allophones
   - No of clear sound in a word.
   - E.G Knifeshonous
3) Phonem
   - Actual sound of single or combined letters
   - E.G t and th have different sounds

Computer Vision:



Enable computers to recognize their External environment using virtual inputs.

Train Model: Models include Algorithm e.g SVM, ANN, CNN, K-means, LLM. The functionality of these algorithm is to identify patterns.

1)
2)
3)

Date:

Future Prediction: using the trained model, we identify the target item from our dataset

To minimize noise in our target object, the box around your target should be small, so it does not contain any unrecognized objects.

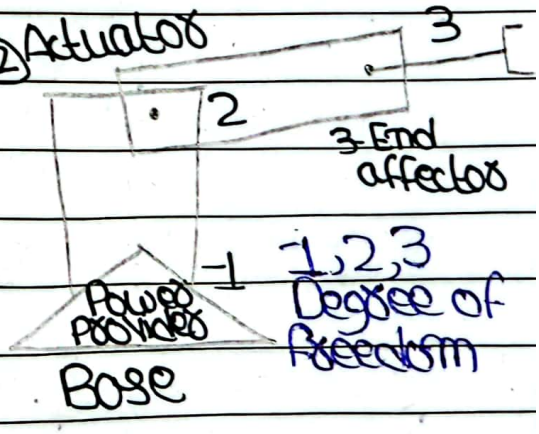
Branches of A.I (Continued)

Robotics: Robot is an electromechanical device. Robotic is the study of Robots.
The word 'Robot' come from Czech word 'Robotit' which means 'forced Labour'

In 1920, stage play named 'Rosseums' Universal Robot (RUR) was done, from which this name came.

A simple Robot has 3 parts.

1) Base
2) Actuator
3) End Affector



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1) Base: It is the power provider which provides power to the Robot to perform specific tasks.

There are 3 types of power providers:

1) Electric: Electricity used.
2) Pneumatic: Produce power using air pressure. These are compressors. They are cheaper but do not produce very high pressure.
3) Hydraulic: Produce power using Liquid.

2) Actuator: It is the arm of the robot. These are 3 degree of freedom in an Actuator, similar to human arm (shoulder, elbow & wrist)

3) End Effector: The end point of the robot by which robot may perform specific task including drilling, Suction cups. End point is replaceable according to your need.

There are 3 types of motion in end effector:

1) Pitch: Left & right (↔)
2) Yaw: up & down (↕)
3) Roll: Rotation

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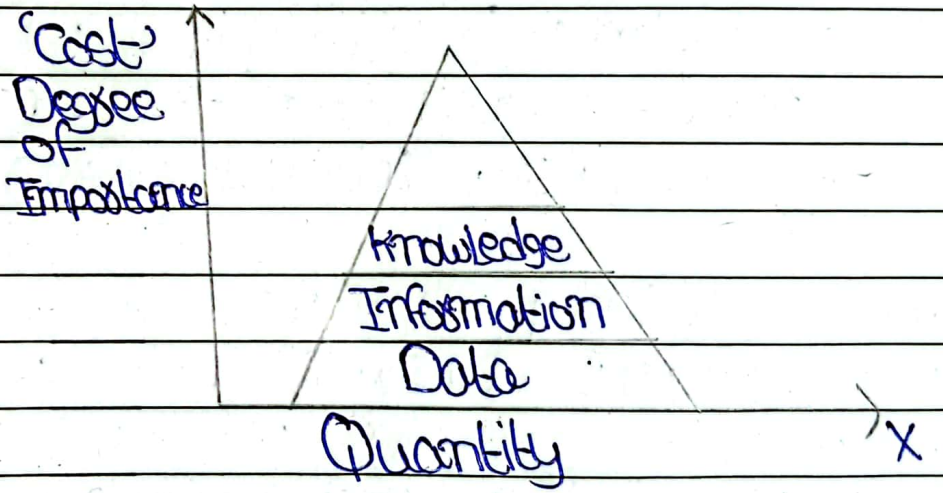
In 1940, Asimove stated 3 laws of Robotics:

1) Machine should obey instructions of human, unless it is an instruction which causes self-harm.
2) Follow law 1 until it is harmful for other human.
3) Machine should protect humans until it is harmful for Machine itself.

X ——— X

Knowledge: Refined form of information required to perform specific task.



Levels of Knowledge:

1) Shallow level: Easily Available. Basic Knowledge used to solve simple problem.

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1) Deep Level: Connection b/w different components of knowledge e.g doctors can link Glucose, CBC report to diagnose a patient, follo rules, procedures to give a solution used to solve complex problem.

Types of Knowledge:

1) Declerative Knowledge 2) Procedural Knowledge 3) Heuristic Knowledge 4) Meta Knowledge

2) Declerative Knowledge: Simple Knowledge same as Shallow Level can be used to solve simples problems. Anything that we declare is called declerative knowledge. It is known to be either true or false. They create/form a databas

3) It is also called passive knowledge (will not generate any new answers on its own. They onl give feeded answers. They will answer only those or provide knowledge which is pre-defined in it.

How can we program this knowledge into computer?

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Deep Knowledge can be programmed into computers using PROLOG
↳ Programming in Logic.

LISP : List Programming

PROLOG: Prolog syntax is known as 'Predicate calculus' (study of change or calculus) (computation of change)

Syntax: Predicate (Obj) or Predicate (Obj1, Obj2, Obj3)

EG: Apples are green so
Predicate (Obj) = Green (Apples)

Procedural Knowledge: Contains Knowledge rule. Step by step knowledge to perform a task.

It is dynamic knowledge. i.e it may give answers of that queries which are not explicitly defined before.

Procedural Knowledge can be written using IF - THEN Rule:
In Prolog it can be defined as:

THEN :- If condy1, condy2, condy3 ....

Task: Create Family Tree.

Date:

1. Rule For Brothers:

brother(X,Y) :- parent(Z,X), parent(Z,Y), male(X)

Procedural Knowledge form Knowledge base. Knowledge base consist of Procedural + Declarative Knowledge.

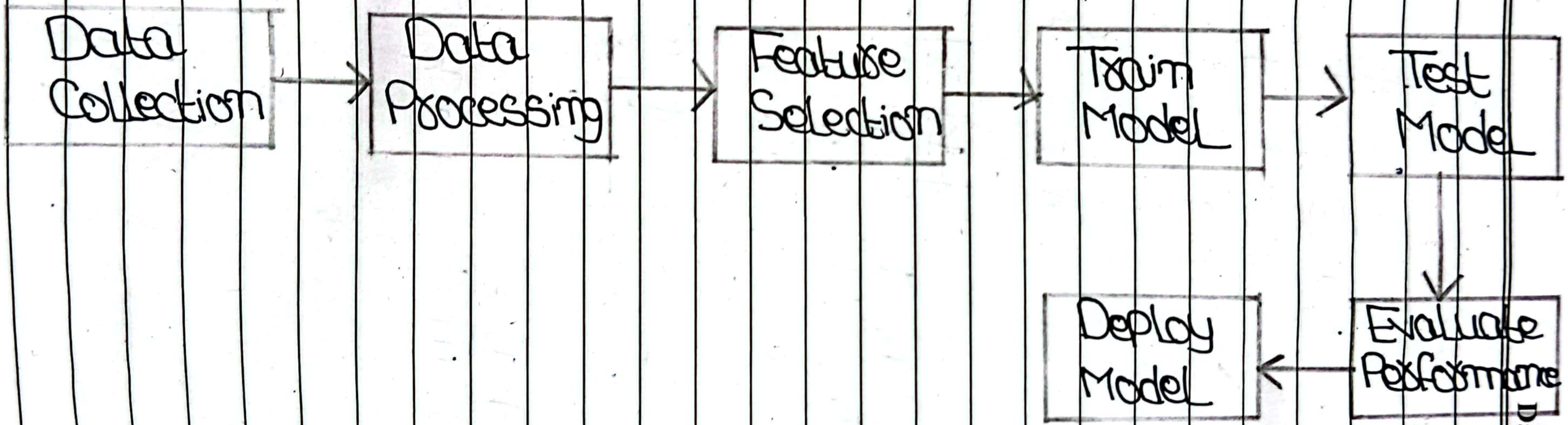
Heuristic Knowledge: Knowledge of Judgement, tricks, Logic and common sense.

Mathametically, heuristic Knowledge can be defined by A* Algorithm / Heuristic Search

$$h(n) = g(n) + f(n)$$

h(n) → decision node / state
g(n) → Distance from initial node (initial always 0)
f(n) → Distance from Final (Goal) node. (Generally it decreases on each step but not necessary)

This Knowledge doesn't give guaranteed solution. Used to solve game playing and other daily problems


Data Collection
Data Processing
Feature Selection
Train Model
Test Model
Evaluate Performance
Deploy Model

Date:

1		3
4	2	6
7	5	8

Initial

1	2	3
4	5	6
	7	8

Goal

Move 1:

	1	3
4	2	6
7	5	8

g(m) = 1
f(m) = 4
h = 5

Move 2:

1	2	3
4		6
7	5	8

g(m) = 1
f(m) = 2
h = 3

Move 3:

1	3	
4	2	6
7	5	8

g(m) = 1
f(m) = 4
h = 5

Continue move 2:
Move 4

1	2	3
	4	6
7	5	8

g(m) = 2
f(m) = 3
h = 5

Move 6:

1	2	3
4	6	
7	5	8

g(m) = 2
f(m) = 3
h = 5

Move 5:

1	2	3
4	5	6
7		8

g(m) = 2
f(m) = 1
h = 3

Date:

Continue Move 5:

Move 7:

1	2	3
4	5	6
	7	8

We consider puzzle with Lesser h(n).

EX2:

1	2	3
	4	6
7	5	8

Initial

Goal

1	2	3
4	5	6
7	8	

Meta Knowledge:

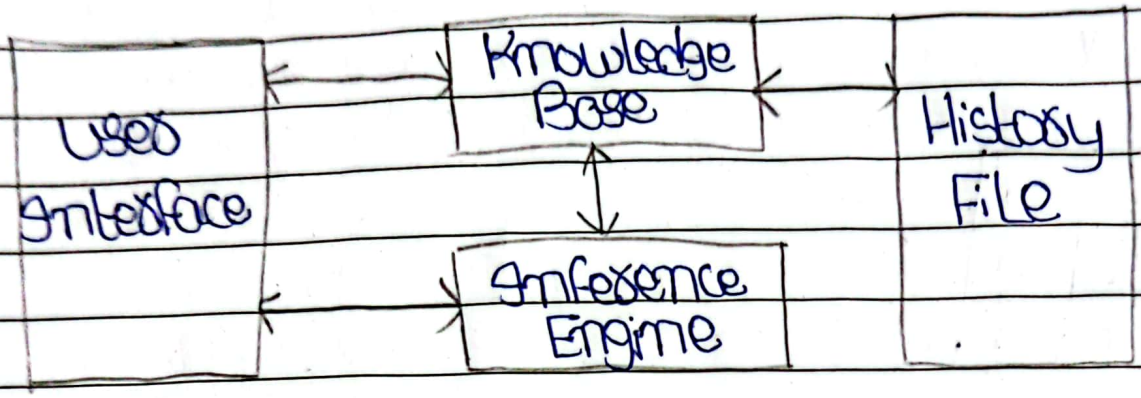
Knowledge about Knowledge. E.G index page in books

Expert system contains a section called meta knowledge which tells another specific information requested for expert system is present in its knowledge base. or not. It tells which problem can be solved by this software.

Expert System

Date:

Block diagram for a Rule-Based Expert System



Expert system: A software that is able to solve complex problem in a particulars domain.

Components of Expert System:

1) User Interface
2) Knowledge Base.
3) Inference Engine:

The person involved in ~~delivering~~ developing an expert system are:

Domain Expert: A person with significant knowledge of a domain. E.G doctors, mathematician

Knowledge Engineer: Computer Programmers as software Engineer acquires knowledge from domain expert and write it in proper way

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User interface: Component of expert system by which user can communicate with the system. It works bi directionally or in between user and system.

There are multiple types of user interface. GUI, CLI, Menu driven, Gesture recognizer, voice recognizer.

Knowledge Base: It is a component of expert system that contain knowledge about the specific domain for which the expert system been developed. It contain two types of knowledge.

1) Declarative knowledge
2) Procedural knowledge

Inference Engine: It is the main component of expert system infact it runs the expert system it try to find the answer if exist of a query asked by the user.

It works using following 3-step.

1) Match 2) Select 3) Run

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Knowledge Representation Techniques:

AI Techniques to represent Knowledge.

1) Frames 2) Scripts 3) Semantics Net

Frames: The term Frame coined by Marvin Minshy. According to him frames are comp of slots, Attributes, values.

Slot: A complete information about a component of obj.

Attribute: entity of Property, characteristics

Value: Value against an entity.

Frame: chair
Specification: Sitting item
Components: Seat, back, Legs, Arms etc
Size:
Seat: 2-3 ft
Legs: 04 Legs: each 3 to 4 ft.
Material: Plastic
Type: office, Recliner, Dining, wheel
Rules: if 2-arms the office chair, no arm dinning chair, if wheels so wheel chair

Vehicle Frame

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Frame : Cake
Specification: Food item, sweet
Components: whip cream, sugar, flour
eggs
Size: 1 Pound, 2 Pound, 3 Pound
Type:
Size: small, medium, large
Rules: If 1 pound so small, If 2 pound so medium, If 3 pound so large
Flavors: strawberry, chocolate, pineapple
Rule: if chocolate filling then chocolate cake, if pineapple filling then pineapple cake
Type:

Frames are static databases contains knowledge about objects and their properties.

2) Scripts: Scripts are used to represent knowledge about events. Events which are composed of dynamic (Time dependent) activities.

The concept of script given by Schank & Abelson in 1977 for a dynamic database

Event: An event is set of Activities involving some people, object fulfilling basic requirements

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The component of Scripts are:

1) Entry Condition: basic/necessary requirement for activity to be performed.

2) Mode or Track: Mode of Activity eg: Final exam can be computer based, paper based, oral etc.

3) Role: People perform different roles in the activity

4) Props: Objects required in the activity.

5) Scene: Scene contains a complete activity. An event may contain multiple scenes.

6) Results: Overall outcome of the activity

EG Dinner in Restaurant (Event)

1) Entry Condition: Money, Restaurant is open
2) Mode or Track: cafe, Ala carte, Food court
3) Role: Waiter, chef, Manager, other customer
4) Props: Table, Chair, crockery, Food items.
5) Scenes:

Scene 1: Entering Scene
* enter into the hall
* Look at tables.

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* Decide where to sit
* Sit at the table

Scene 2: Ordering Scene
Scene 3: Eating Scene
Scene 4: Exit Scene

⑥ Results: Food review, Ambience

Assignment: Visit to Doctor

1) Entry condition: Feeling Sick, Doctor is available appointment has been made

2) Mode or Track: Clinic, Hospital, Emegency Situation, Home appointment

3) Role: Doctor, Nurse, Patient, Receptionist

4) Probs: Stoethes, Thermometer, ECG Machine

5) Scenes:
Scene 1: Booking Appointment
Scene 2: Going to Hospital
*entering Hospital
*Entering doctor room
Scence 3: Doctor Diagnosis

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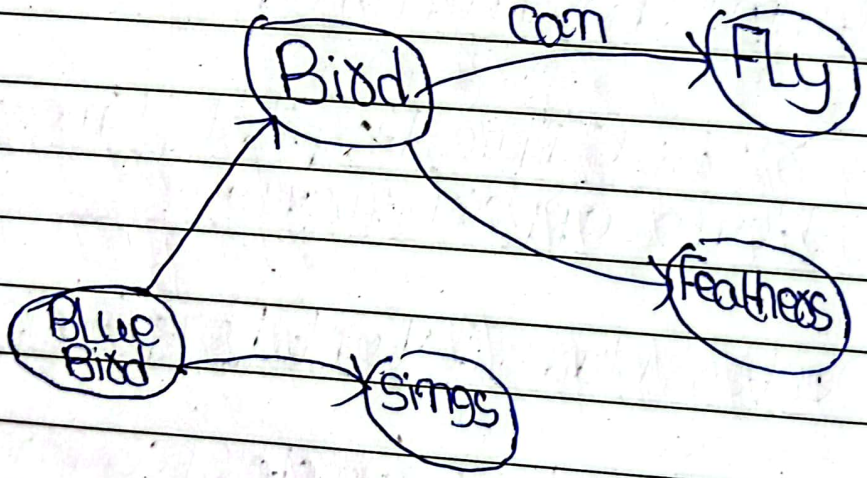
→ introduced by Ross Quillon

Semantic Net: Graphical representation of knowledge in terms of 'Nodes' and edges or arcs represents knowledge for computer.

Nodes represents objects, property, concept etc. where as edge represents relation between object and their properties.

Semantic Nets are used to represent Natural language understanding e.g Birds can Fly, They have feathers. Blue Bird is a bird, that sings a song.



The nodes in semantic nets are unique (not redundant). It shares information from other nodes.

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Tom is a cat. Tom is a pet of John. Cats Like milk. A cat is a Mammal. ALL mammals have skins and Fur. Dog is also a mammal.

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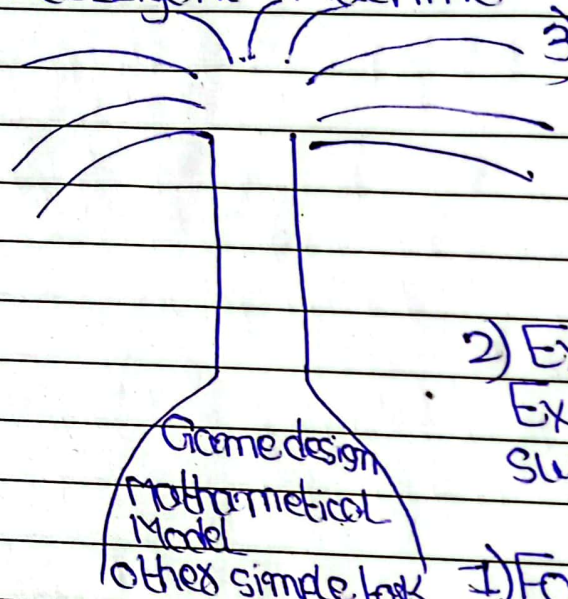
Development stages / Task of Intelligent Machine:

A.I Tree:

A.I scientist categorized / divided task in 3 stage by which we may make ~~machine~~ intelligent Machine.



1) Formal Tree: Those Task whose development can be done with the help of good programming skills. We do not need to learn the solution of such problem by a domain expert.

2) Expert Task: These Task are wise acquiring knowledge from domain experts. Then we start

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designing the system e.g medical domain expert system.

3) Mundane Task: Those Task whose solution are not available. Methods and algorithms are not defined. We have to study and research on these tasks to find solution of these Tasks. e.g fire, flame, identification.

Natuse Language understanding Problem:

Multiple words Meaning.
Ambiguity.
- Syntactic Ambiguity
- Use of Pronouns.

Impsecision.
Inaccuracy
Incompleteness.

We people commonly use written form of communication in our daily life. There are 3 Level/Stages of Natural Language understanding.

1) Completly not understand
2) Outcome: No-action. The person will not get anything what he/she requests.

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E.G Do you Ranchen
↳ word not understand

2) Incomplete or Misunderstand.
Out-Action: The other person may get some thing but ~~m~~ not exactly what he/she requested.
e.g رقعت جائے دو

3) Completly understand.

Output-Action: The other person may get exactly what he/she requested.
e.g what is your name?

Thus misunderstanding in NLP (written Form) may happen due to the following

1) Multiple words meaning - Homonyms.

eg: The Pitcher is angry.
The Pitcher is empty.

In every Language, there are some words having multiple meaning which may cause misunderstanding.

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A computer may have problem to recognize which pitches mean is meant what in each sentence's context.

2) Ambiguity

Due to ambiguity a sentence may interprate more than one way.
e.g I'm fine

Ambiguity may happen due to the following (2-reasons)
i) Syntactic Ambiguity
"I hit the man with the hammer".

This sentence can be interpreted in one than one way one above as I hit a man who was holding a hammer.

A computer may have a xxxx to solve this ambiguity.

ii) Use of Antedents (Pronoun).
e.g "John hit the Bill because he loved mary.

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We frequency use pronouns instead of using proper noun (eg: Rohan).
A computer may have problem in recognizing such pronouns eg it may have problem in recognizing John

3) Imprecision:

In English there are some words whose meaning or vague or their meaning may vary person-to-person. Situation to situation.

e.g: I have been waiting since long time in your office.

The Muslims were rule on Asia for long-time.

A computer may have difficulty in each of the above sentence either few hours or hundred of years due to the word long-time.

4) Accuracy:

The written communication we receive may

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have multiple excess due to the use of inaccurate english.

e.g use of transpose word, punctuation, grammar.

Being human we may ignore such mistakes using our intelligence However a computer may have difficulty to process inaccurate correspondense.

5) Incompleteness:

In our daily written communication we ignore much details based on understanding of sharing common information. without fear of misunderstanding. However a computer may have difficulty to process certain informatio

E.G: I will bring PCB in my next electronics class.

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Natural Language Understanding Techniques

Following are the characteristic techniques generally use to understand Natural Language.

1) Lexical Analysis:

Lexicon mean dictionary. In this technique we look up meaning of each word of the sentence in dictionary Based on meaning defined in dictionary, we interpret meaning of sentence.

Computer uses Lexical Analysis eg in MS word are in different programming editor.

2) Keyword Analysis:

In Keyword Analysis we Loop up one or more Keywords in the sentence & Based on these Keywords, we try to interpret the meaning of the sentence.

Computer also uses Keyword Analysis eg in search engine (Google) chatbots.

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3) Syntatic Analysis:

Syntatic Analysis require passing/breaking sentence to its component (Parts of speech)

e.g ALi Liked Apples

We also find the relation b/w each component

e.g The cat fast runs ×
Adv verbs

By syntatic Analysis we can identify grammatical mistake.

4) Semantic Analysis:

In this technique we do not care about the formation/structure of the sentence. Rather we focus on the meaning of the sentence.

e.g ALi bought a book from Sara. or Sara sold a book to ALi

Both sentences have different structure but same meaning.

Computer also uses semantic Analysis e.g search engine.

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5) Pragmatic Analysis:

In this technique, the meaning of sentence does not interpret on Lexical Analysis but rathes the meaning are interpreted with the owners of sentence and the situation in which the sentence delivered

Computer uses pragmatic analysis eg admin rights Based on admin rights, computer may process commands else it rejects them.

Date:

Machine Learning Vs Deep Learning Vs ANN

→ ∞ characteristic/feature

Machine Learning: Finding patterns in data and Learn a Mathematical Model

Results of a Model are checked by Model evaluation Technique. In this two values are measured to check Accuracy of model.

1) Precision & Recall 2) F-1 value

$$\text{Precision (P)} = \frac{T.P}{T.P + F.P} \qquad \text{Recall (R)} : \frac{T.P}{T.P + F.N}$$

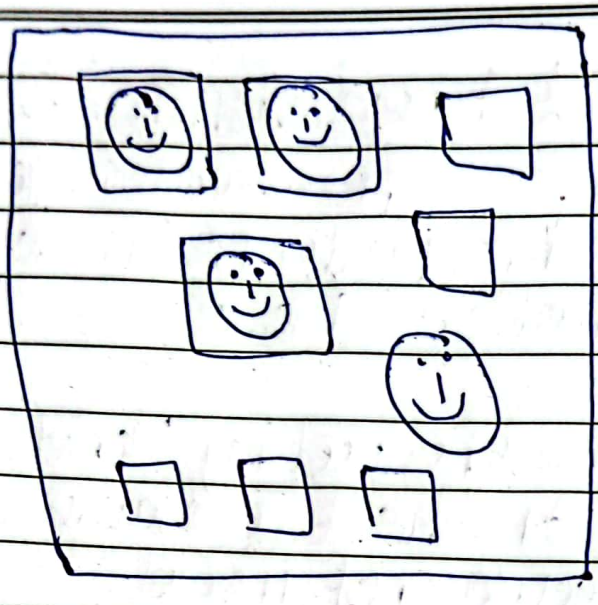
$$\text{F-1 value} : \frac{2PR}{P+R} \quad \text{(Harmonic Mean)}$$

where T.P: True Positive
F.P: False Positive
F.N: False negative
T.N: True negative

Fire Alarm System:

T.P → Correct detection → There is Fire & Alarm ON
F.P → Wrong detection → There is no fire but Alarm ON
F.N → Miss detection → There is Fire But Alarm NO

Date:



T.P = 3 , F.P = 5 , F.N = 1

$$\text{Precision} = \frac{T.P}{T.P + F.P} = \frac{3}{3+5} = \frac{3}{8} = 37\%$$

$$\text{Recall} = \frac{T.P}{T.P + F.N} = \frac{3}{3+1} = \frac{3}{4} = 75.1\%$$

$$\text{F1 value} = \frac{2PR}{P+R} = 0.5 = 50.1\%$$

Test data	Correct data	False data	Miss Data
Data 1	100	75	50	25
Data 2	300	200	150	(300-200=100)
Data 3	400	400-250=150	200	250

Date:

	P	R	F1
Dataset 1	60.1.	75.1.	66.67.1.
Data 2	57.1.	66.1.	61.1.
Data 3	42.1.	37.1.	40.1.

Precision tells rate of false positive
Recalls tell rate of Miss detection.

Recall and precision we cannot explain explicitly the result. (Draw back).

F1 value clearly says the result.

Precision → ratio of false Positive
Recall → ratio of miss detection.