JOIN LIVE

Making Machine's to Reason with Neuro-Symbolic AI

LEARN TO UNDERSTAND HOW TO MAKE MACHINES TO REASON

LIVE ONLINE SESSION

ON 29-OCT-2022 @ 7.00 - 08.30 PM IST (SATURDAY)
@ 9.30 - 11.00 AM EST
@ 2.30 - 04.00 PM LONDON

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HTTPS://FORMS.GLE/ARWBMXU7H9LKDRC3A

BY PRASANNA VENKATESH J

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AGENDA

- Problem with current AI and ML Approaches
- Understanding how Reasoning works
- Introduction to Symbolic AI
- Introduction to the Combination of th Neural Network and Symbolic AI
- Introduction to Neuro Symbolic AI
- Current Progress - LNN – Logic Neural Network

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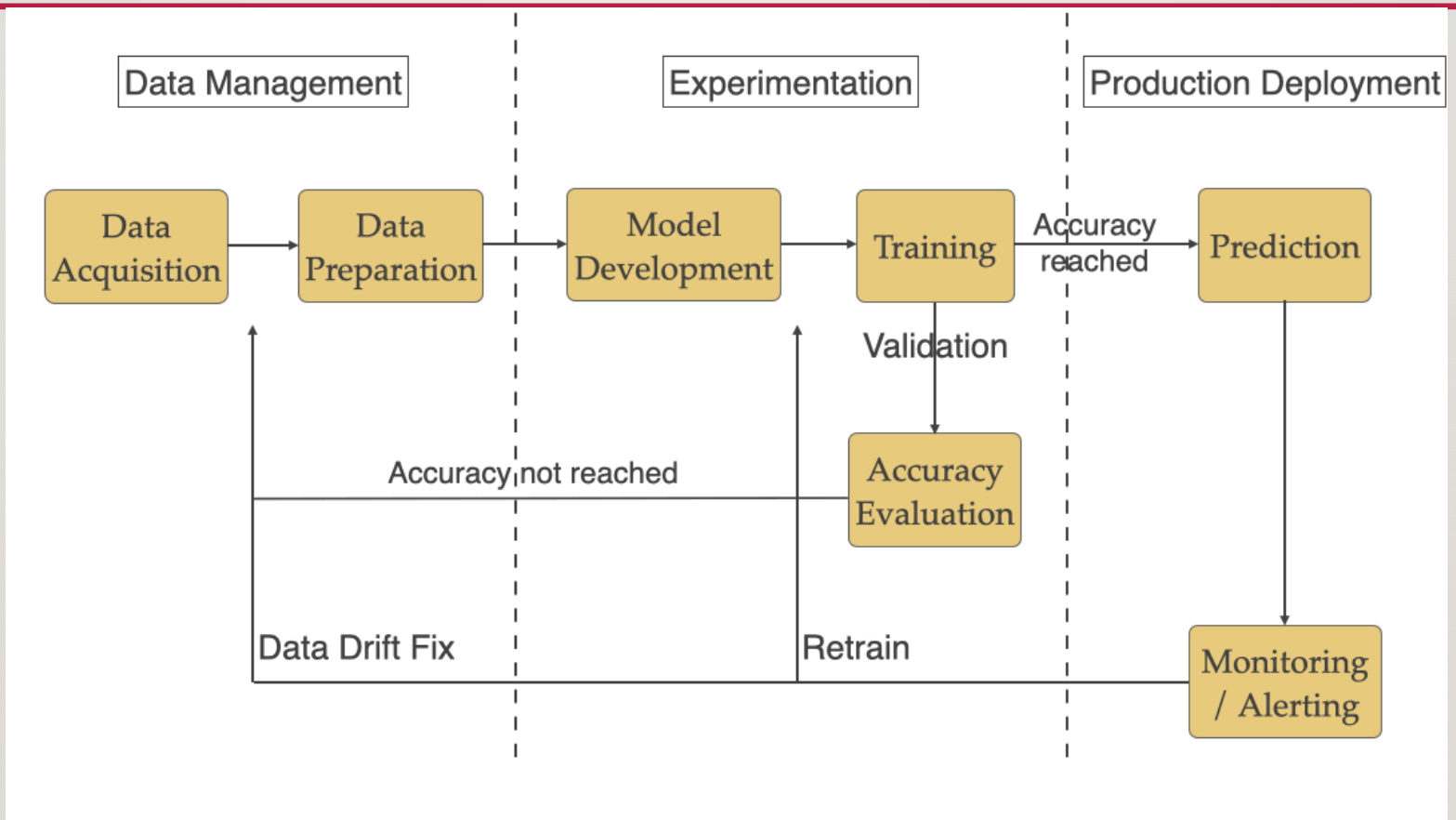
CURRENT APPROACH OF MACHINE LEARNING PROBLEM SOLVING



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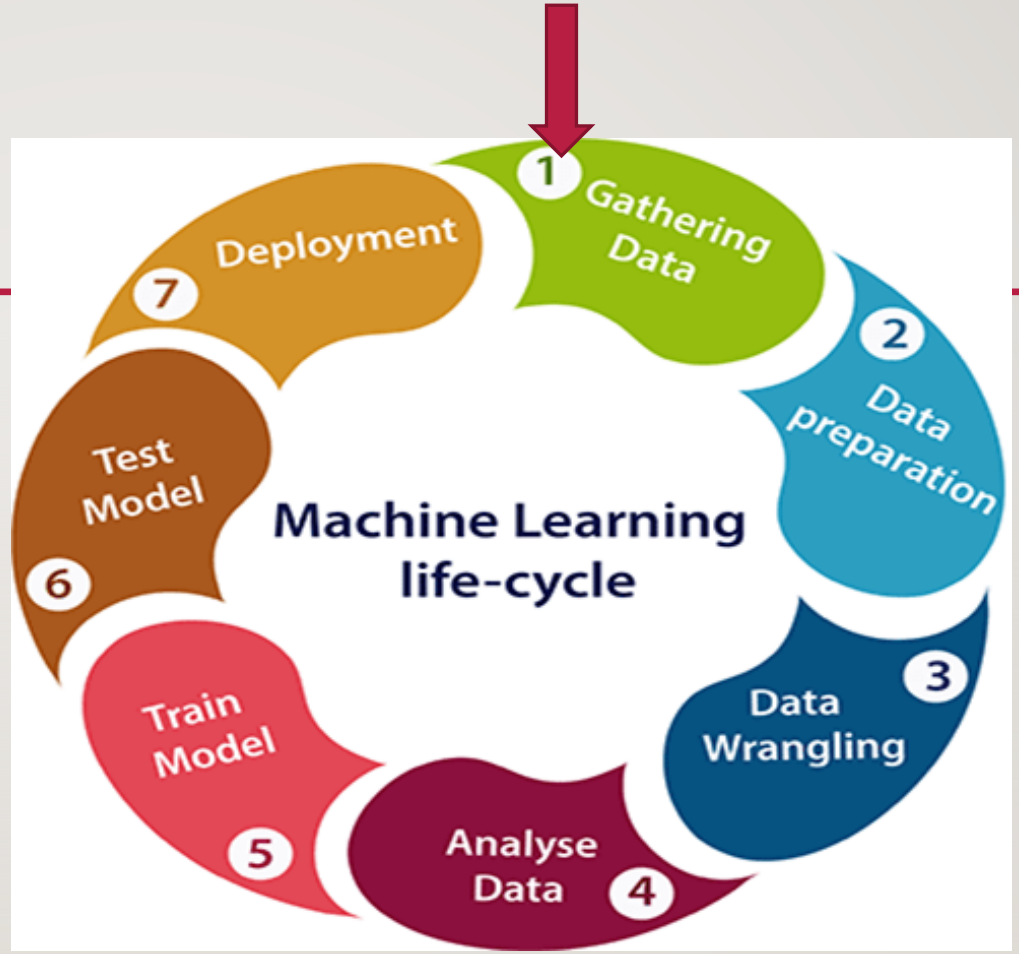
MACHINE LEARNING LIFECYCLE



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Use case	AI Implementation
Build AI to process the Loan application and decide to approve / Reject Loan Application.	Identify a problem
Collect past loan Approval / rejection detailed data sets	Collect data specific to it
Perform EDA and get proper data and apply vairous ML alogiorithm which can help get better result.	Apply various algorithms to find a best fit
Find best algorithm providing highest score	Build a model using the best algorithm
Use the Model to serve / predict new Loan application processing.	Use the model to serve the purpose.

CURRENT STAGE OF AI AS WE KNOW IT

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AI SHORT-COMING

Low Reusability

- Cannot reuse the model for new problem?
- If the data change / feature change the model fails?

Not much inteligent

- Does not describe how it works? how it has done prediction?

Current Stage of AI = ANI (Artificial Narrow Intelligence)

No much reasoning capability

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WHAT IS REASONING?

Simple example:

- **Premise-1: All the human eats veggies**
- **Premise-2: Suresh is human.**

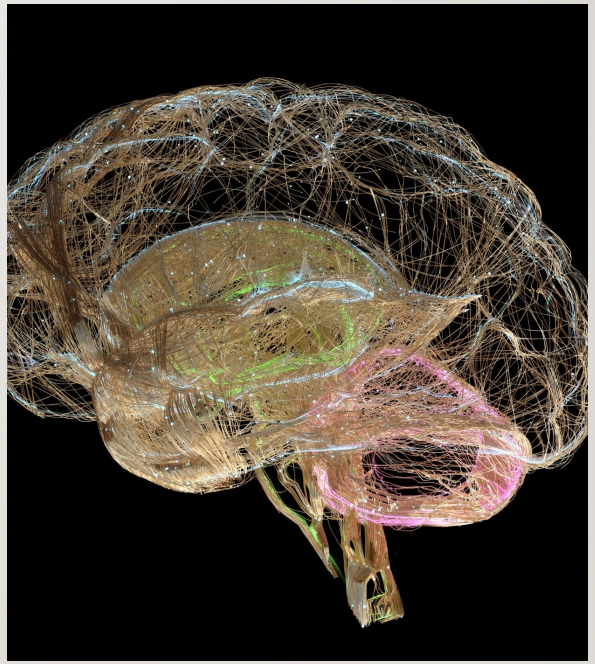
AI Conclusion: Suresh eats veggies.

It is very hard for the current ML Approach to derive from the existing knowledge.

What is the best approach?

AI GOAL

- Move from
  - **Artificial Narrow Intelligence -> Artificial General Intellgence (at par with Human)**
- Goal is to
  - **Artificial General Intelligence -> Artificial Super Intelligence (Beyond Human capability)**



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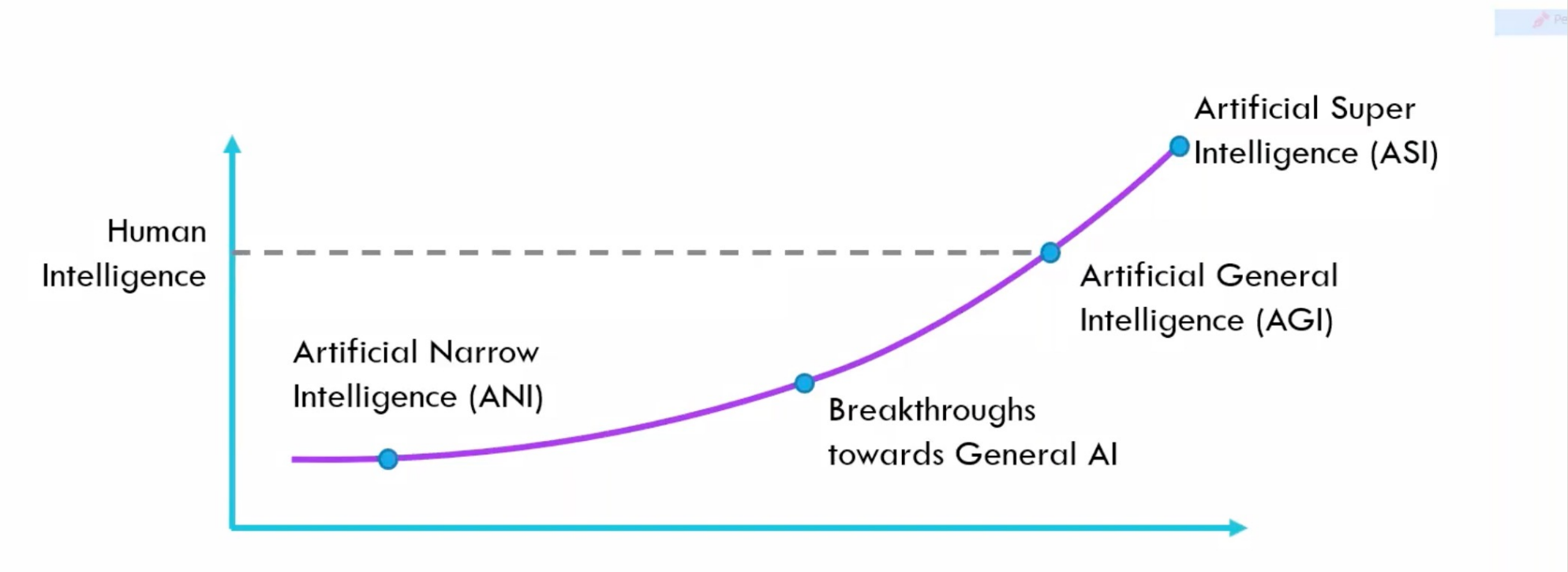
AI GOAL



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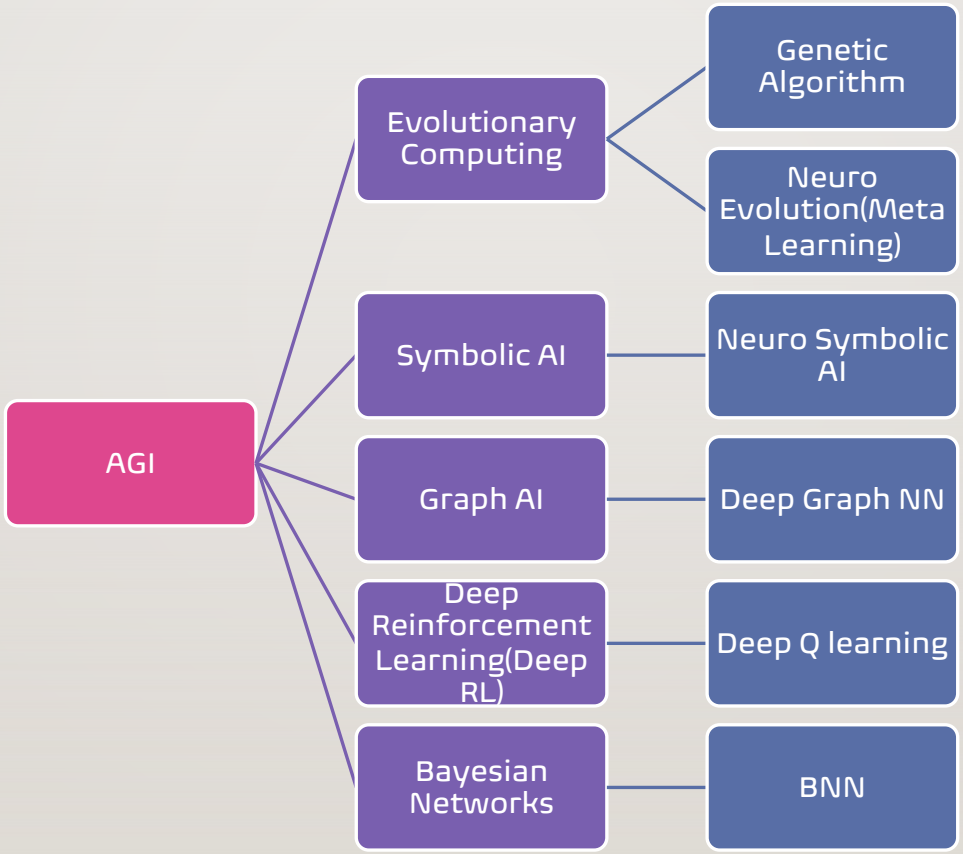
APPROACHES TO REACH AGI (ARTIFICIAL GENERAL INTELLIGENCE)



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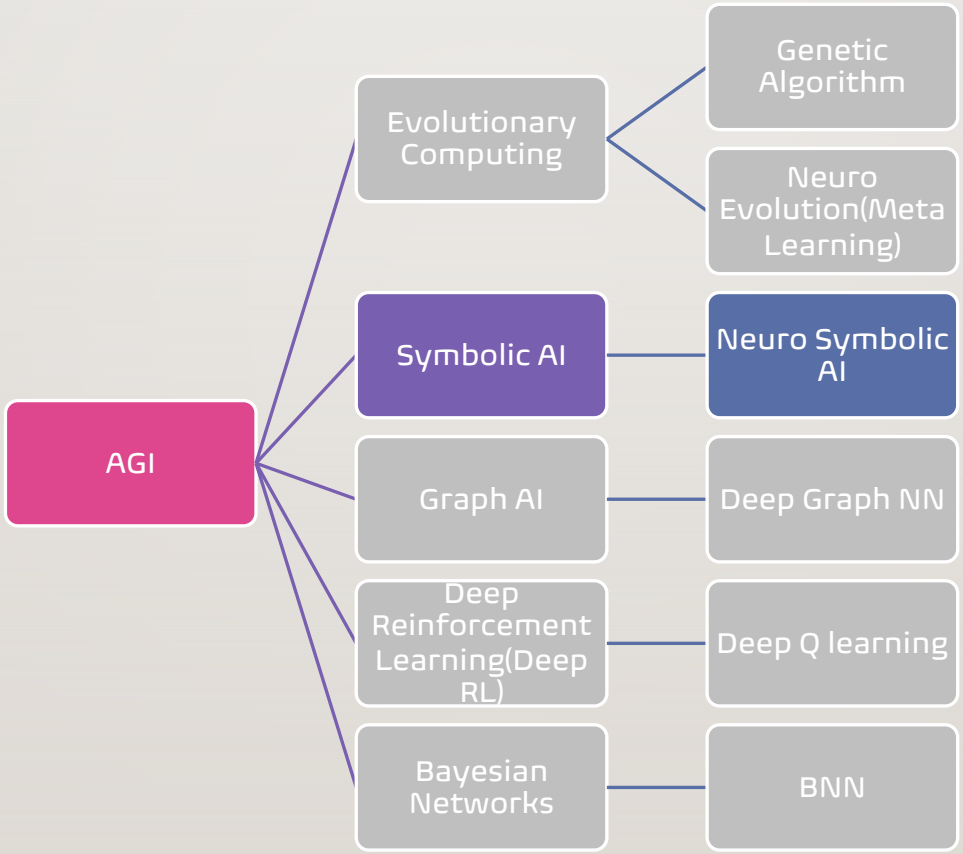
WE SHALL BE DISCUSSING ON THE APPROACH OF



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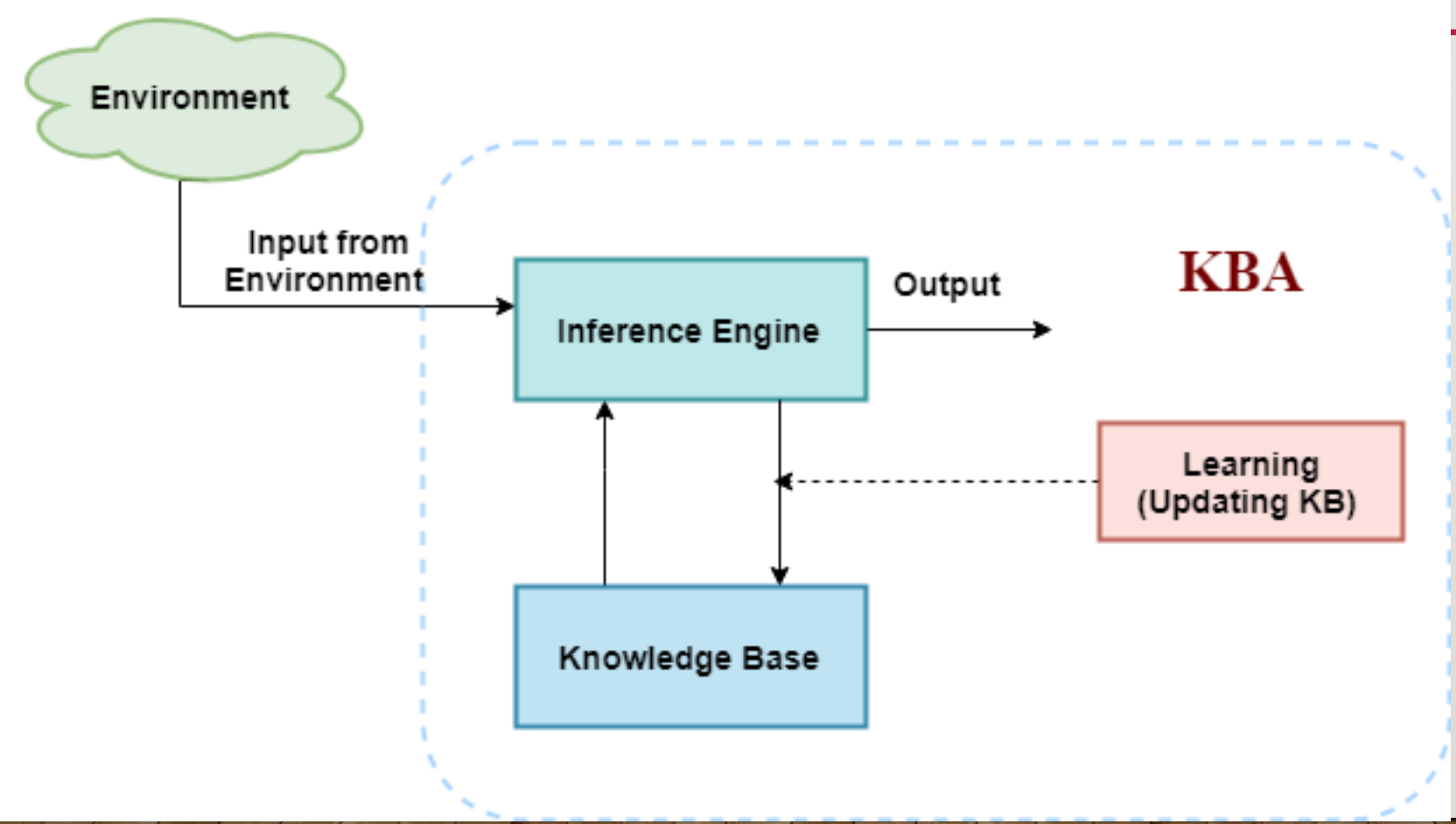
EXPECTATION OF AN AI SYSTEM / AI AGENT

- An intelligent agent needs **knowledge** about the real world for taking decisions and **reasoning** to act efficiently.

KNOWLEDGE BASED AGENTS



i.e:

AI ROBOT as "Knowledge Based Agent".

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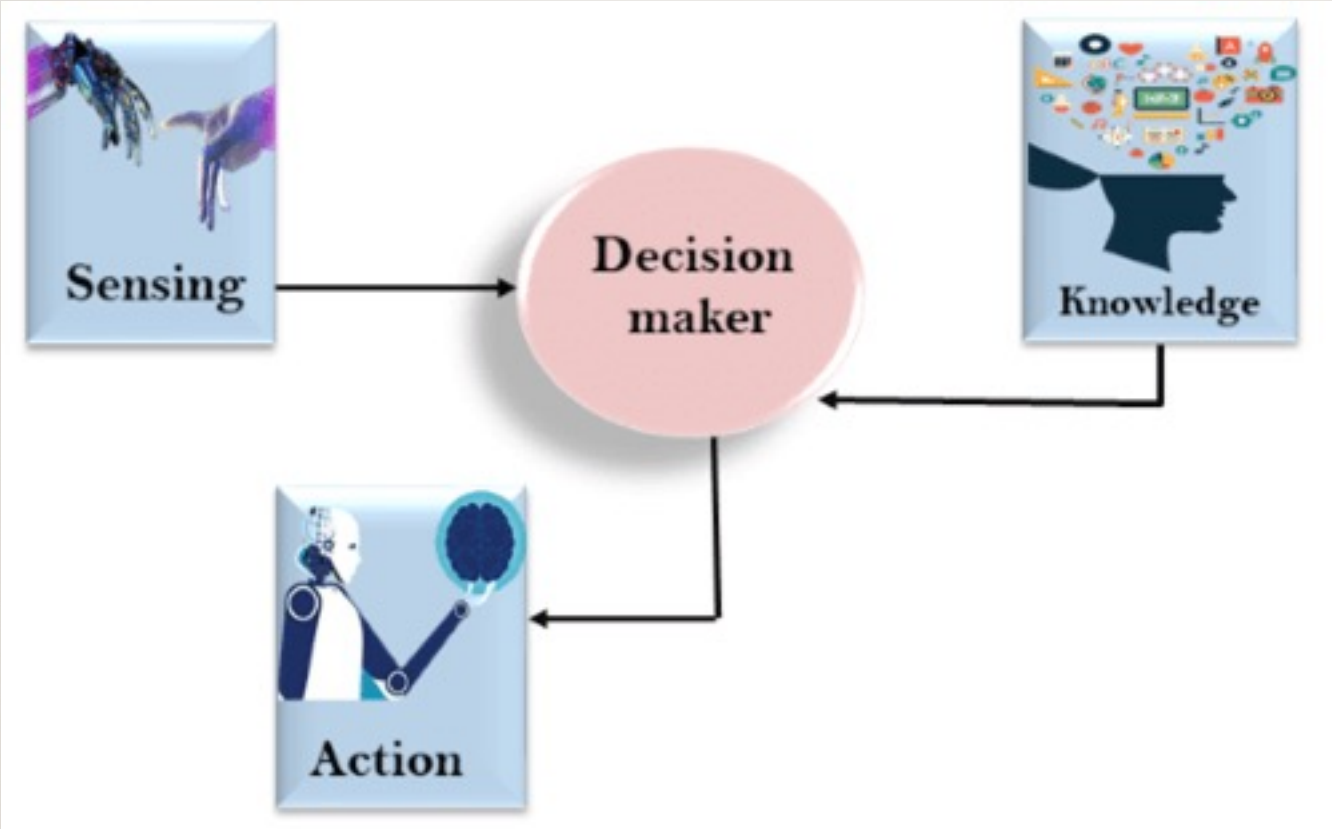
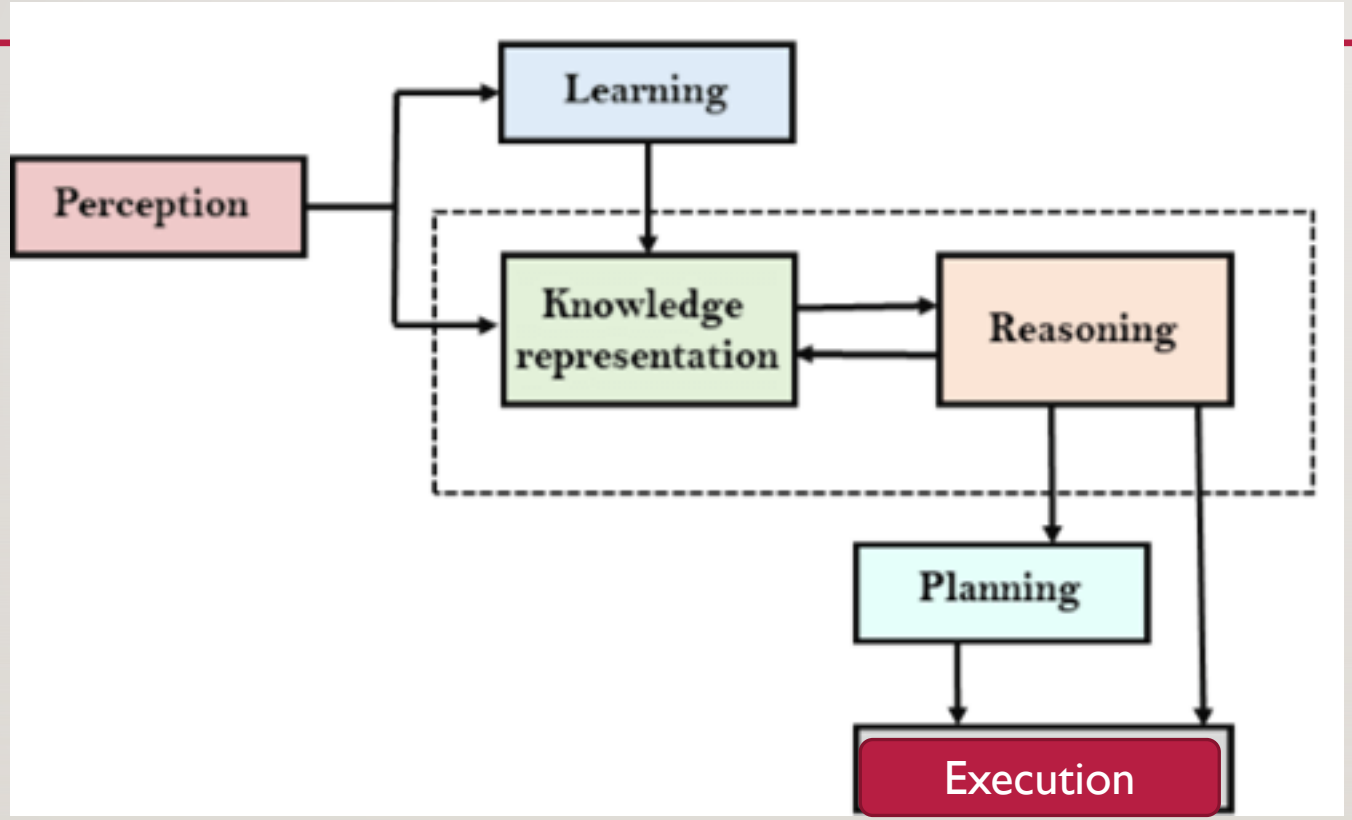
RELATIONSHIP BETWEEN KNOWLEDGE AND INTELIGENT



AI KNOWLEDGE CYCLE



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AI GOAL OF AN IDEAL AI AGENT

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AI GOAL OF AN IDEAL AI AGENT

KNOWLEDGE REPRESENTATION

1- Simple Relational Knowledge

2 - Inheritable Knowledge

3 - Inferential Knowledge

4 - Procedural Knowledge

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1-RELATIONAL KNOWLEDGE

1- Simple Relational Knowledge
2 - Inheritable Knowledge
3 - Inferential Knowledge
4 - Procedural Knowledge

- Database Tables are example for relational knowledge representation

Player	Weight	Age
Player1	65	23
Player2	58	18
Player3	75	24

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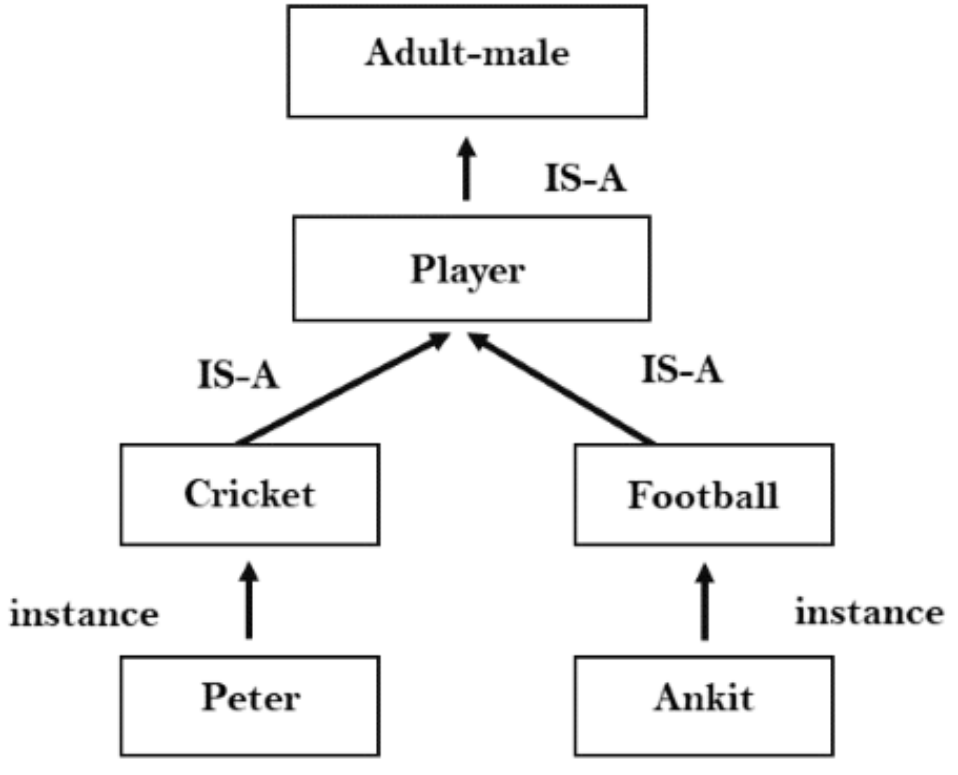
2-INHERITABLE KNOWLEDGE

1- Simple Relational Knowledge
2 - Inheritable Knowledge
3 - Inferential Knowledge
4 - Procedural Knowledge



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3-INFERENTIAL KNOWLEDGE

1- Simple Relational Knowledge
2 - Inheritable Knowledge
3 - Inferential Knowledge
4 - Procedural Knowledge

- nferential knowledge approach represents knowledge in the form of formal logics.
- This approach can be used to derive more facts.
- It guaranteed correctness.
- **Example:** Let's suppose there are two statements:
  - Marcus is a man
  - All men are mortal
    Then it can represent as;

    man(Marcus)
    ∀x = man (x) ----------> mortal (x)s

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4-PROECEDURAL KNOWLEDGE

- Procedural knowledge approach uses small programs and codes which describes how to do specific things, and how to proceed.
- In this approach, one important rule is used which is **If-Then rule**.
- In this knowledge, we can use various coding languages such as **LISP language** and **Prolog language**.
- We can easily represent heuristic or domain-specific knowledge using this approach.
- But it is not necessary that we can represent all cases in this approach.

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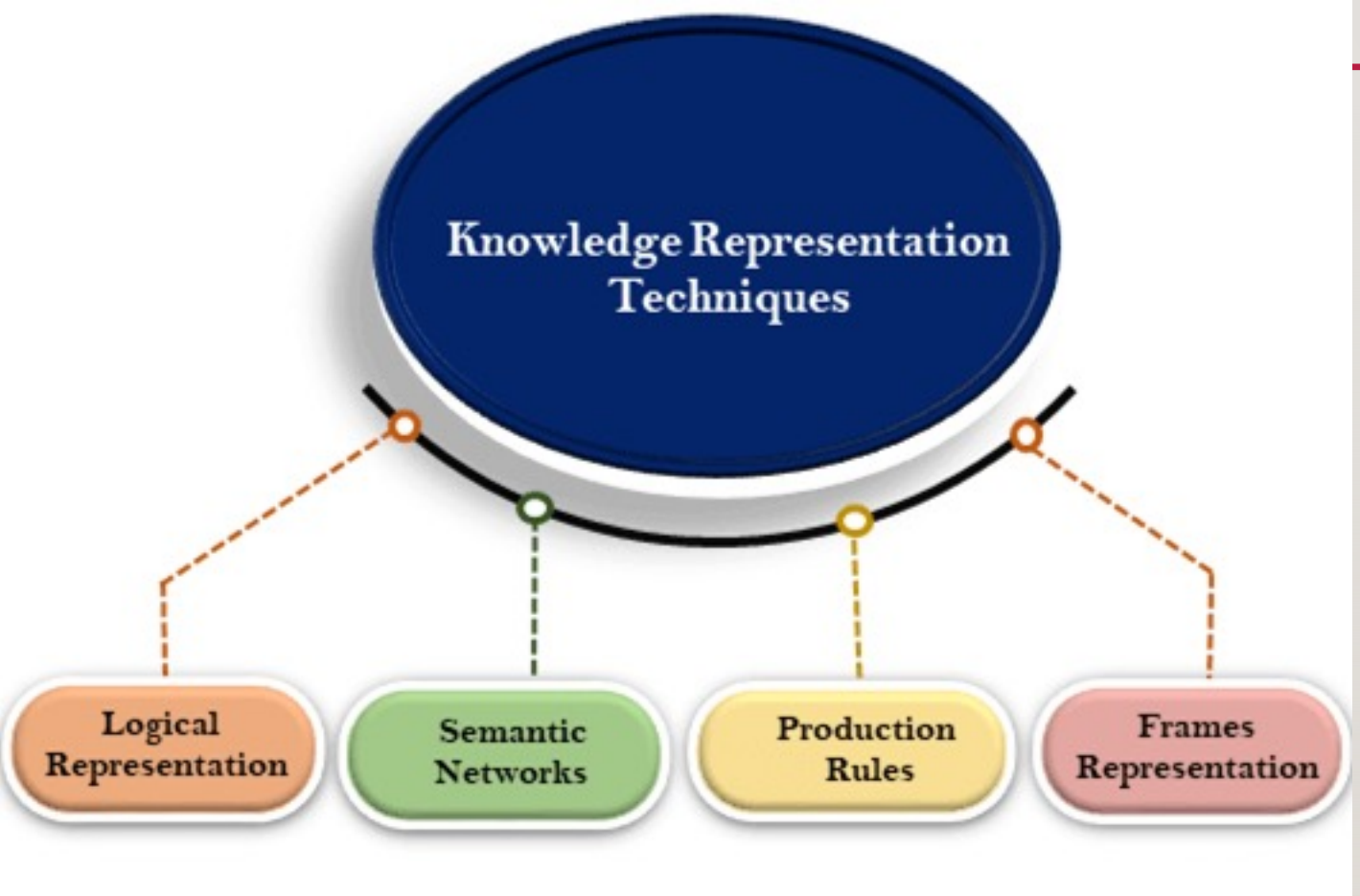
AI GOAL OF AN IDEAL AI AGENT

KNOWLEDGE REPRESENTATION TECHNIQUES



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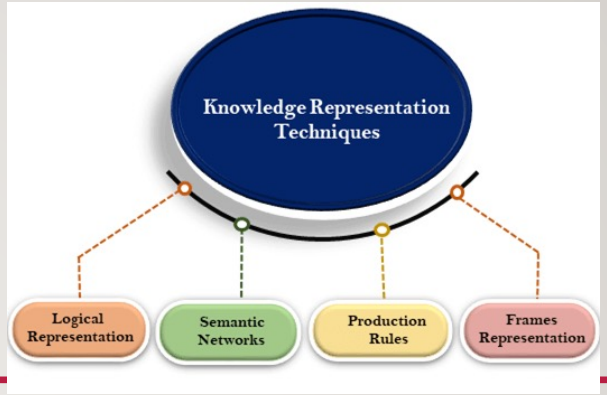
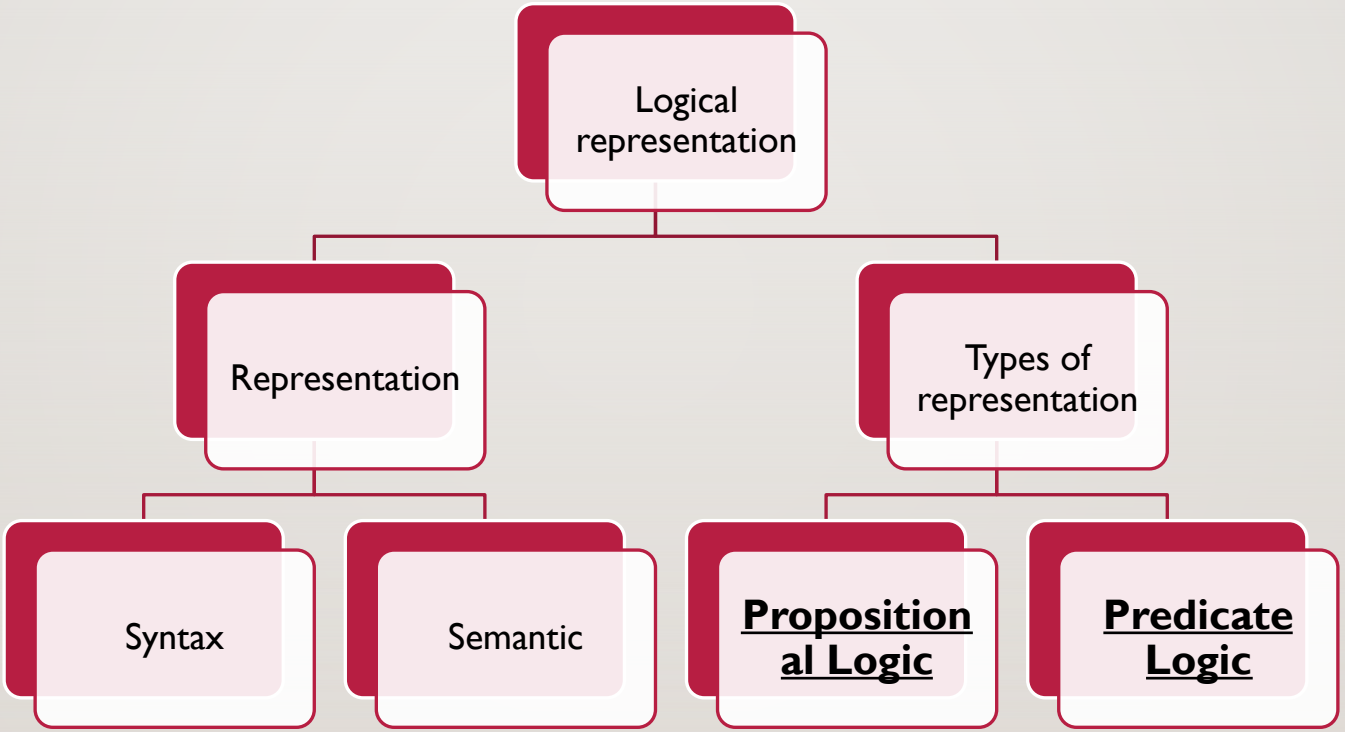
LOGICAL REPRESENTATION





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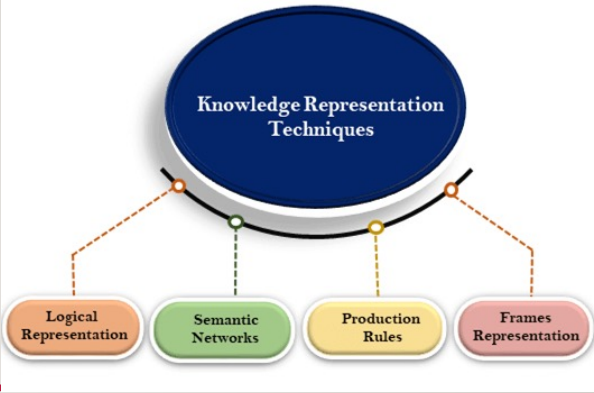
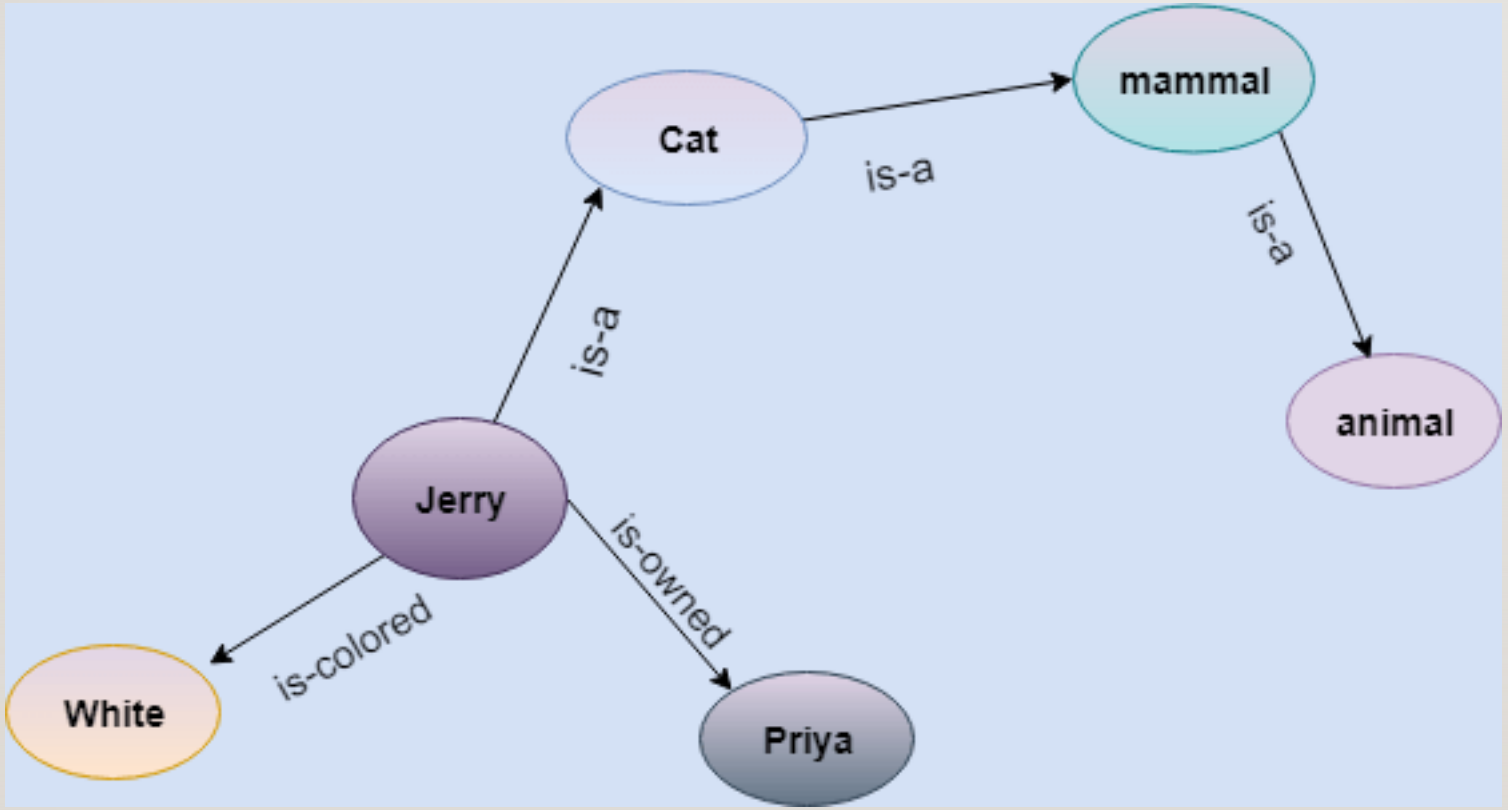
SEMANTIC NETWORK REPRESENTATION





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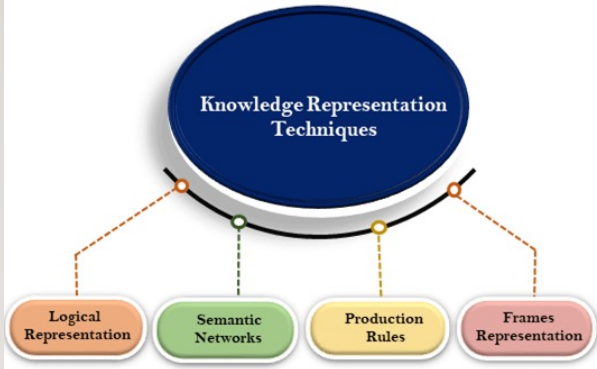
FRAMES REPRESENTATION



Frames Presentation of a Book.

Slots	Filters
Title	Artificial Intelligence
Genre	Computer Science
Author	Peter Norvig
Edition	Third Edition
Year	1996
Page	1152

Sachin Tendulkar

Tendulkar in 2017

Personal information	
Full name	Sachin Ramesh Tendulkar
Born	24 April 1973 (age 49) Bombay, Maharashtra, India
Nickname	Little Master · Master Blaster [1][2]
Height	165 cm (5 ft 5 in)
Batting	Right-handed
Bowling	Right-arm leg break Right-arm off break
Role	Top-order batsman
Relations	Arjun Tendulkar (son) Ramesh Tendulkar (father)
Website	sachintendulkar.com

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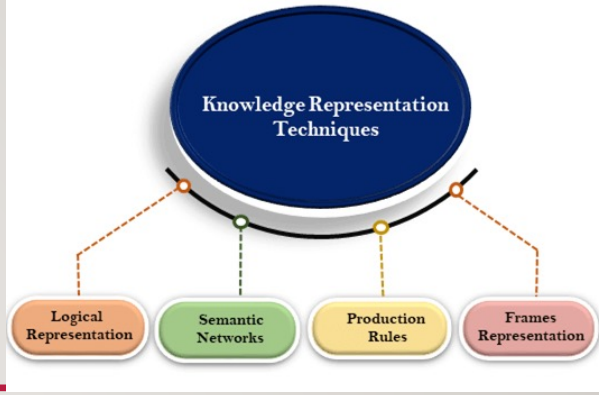
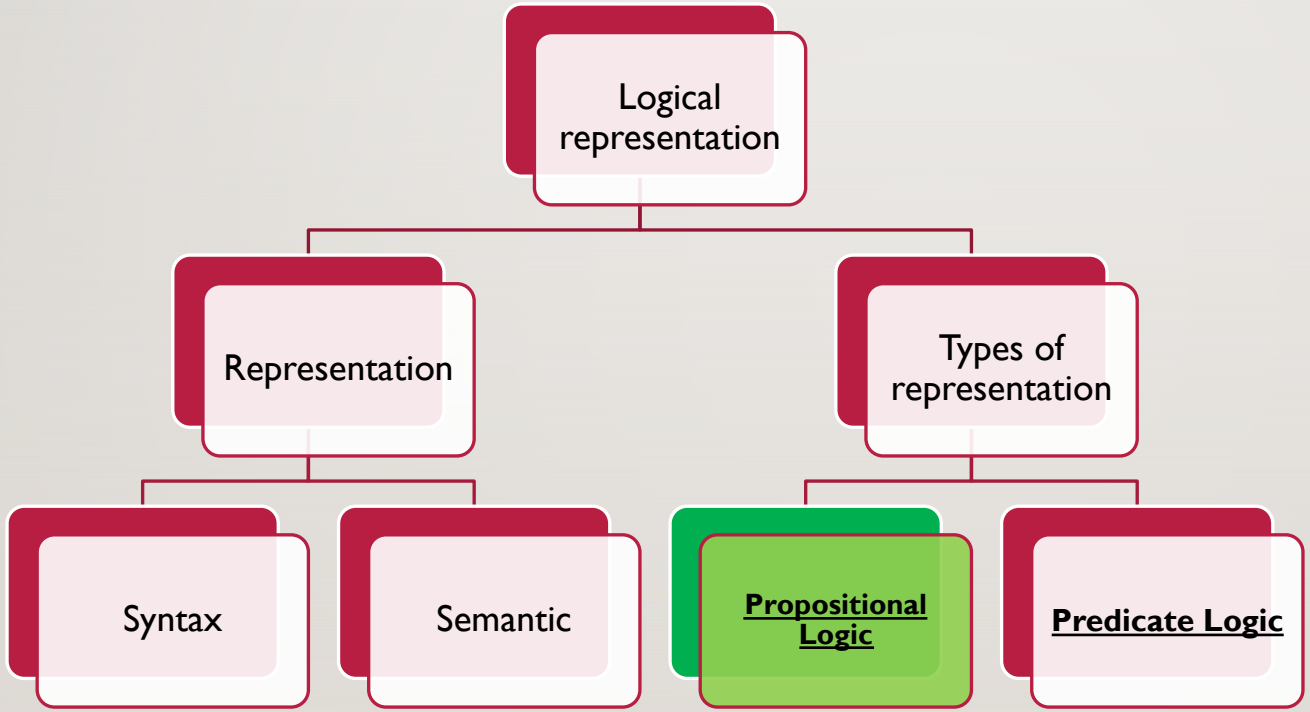
PRODUCTION RULES



- Example:
- **IF (at bus stop AND bus arrives) THEN action (get into the bus)**
- **IF (on the bus AND paid AND empty seat) THEN action (sit down).**
- **IF (on bus AND unpaid) THEN action (pay charges).**
- **IF (bus arrives at destination) THEN action (get down from the bus).**

PROPOSITIONAL LOGIC IN AI



- Propositional logic (PL) is the simplest form of logic where all the statements are made by propositions.
- A proposition is a declarative statement which is either **true or false**.
- Prominent form of knowledge presentation

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EXAMPLE OF PROPOSITIONAL LOGIC

a) It is Sunday.

b) The Sun rises from West (False proposition)

c) 3+3= 7(False proposition)

d) 5 is a prime number.

PROPOSITIONAL LOGIC

- Propositional logic is also called **Boolean logic** as it works on 0 and 1.
- In propositional logic, we use symbolic variables to represent the logic, and we can use any symbol for a representing a proposition, such A, B, C, P, Q, R, etc.
- Propositions can be either true or false, but it cannot be both.
- Propositional logic consists of an object, relations or function, and **logical connectives**.
- These connectives are also called logical operators.
- The propositions and connectives are the basic elements of the propositional logic.
- Connectives can be said as a logical operator which connects two sentences.
- A proposition formula which is always true is called **tautology**, and it is also called a valid sentence.
- A proposition formula which is always false is called **Contradiction**.
- Statements which are questions, commands, or opinions are not propositions such as "**Where is Rohini**", "**How are you**", "**What is your name**", are not propositions.

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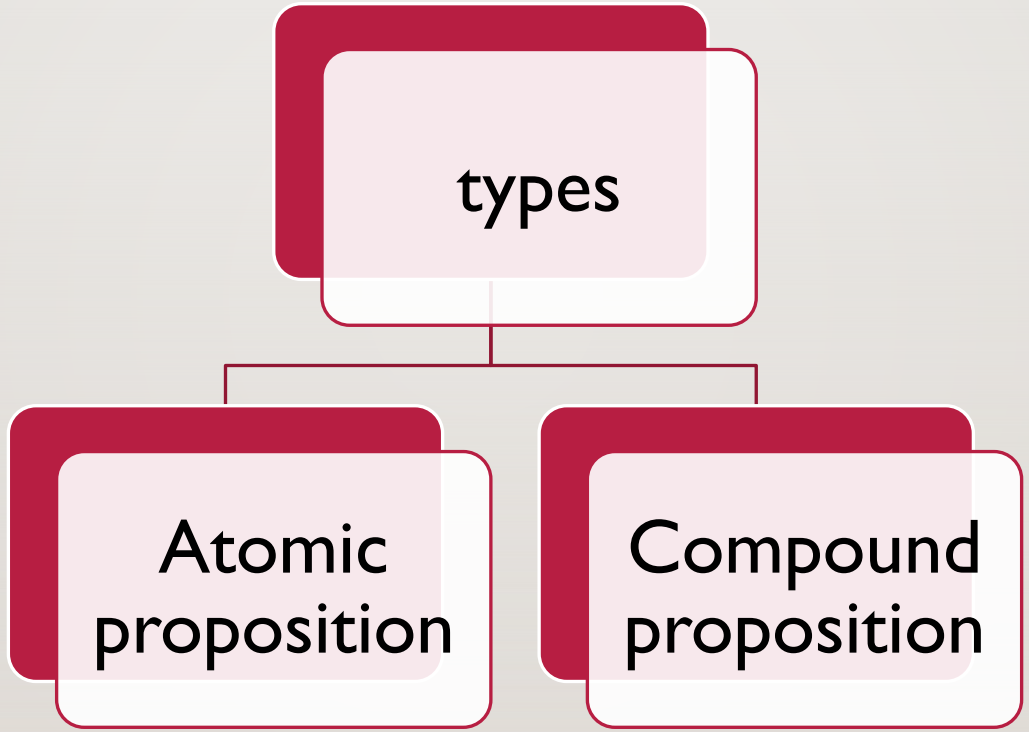
TYPES OF PROPOSITION LOGIC



1.a) 2+2 is 4, it is an atomic proposition as it is a **true** fact.
2.b) "The Sun is cold" is also a proposition as it is a **false** fact.

1.a) "It is raining today, and street is wet."
2.b) "Ankit is a doctor, and his clinic is in Mumbai."

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LOGICAL CONNECTIONS

Connective symbols	Word	Technical term	Example
∧	AND	Conjunction	A ∧ B
∨	OR	Disjunction	A ∨ B
→	Implies	Implication	A → B
⇔	If and only if	Biconditional	A⇔ B
¬ or ~	Not	Negation	¬ A or ¬ B

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TRUTH TABLES

Connective symbols	Word	Technical term	Example
∧	AND	Conjunction	A ∧ B
∨	OR	Disjunction	A ∨ B
→	Implies	Implication	A → B
⇔	If and only if	Biconditional	A⇔ B
¬ or ~	Not	Negation	¬ A or ¬ B

For Negation:

P	¬ P
True	**False**
False	**True**

For Conjunction:

P	Q	P∧ Q
True	True	**True**
True	False	**False**
False	True	**False**
False	False	**False**

For disjunction:

P	Q	P ∨ Q.
True	True	**True**
False	True	**True**
True	False	**True**
False	False	**False**

For Implication:

P	Q	P→ Q
True	True	**True**
True	False	**False**
False	True	**True**
False	False	**True**

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FIRST ORDER LOGIC S

- Problem with "Propositional logic" - can only take True or False statement.
- Real world consist of items which are beyond True or False statements
- i.e: **"Some humans are intelligent", or**

  "Sachin likes cricket."

  - **First Order Logic - also known as Predicate logic or First-order predicate logic.**

- First-order logic(FOL) is another way of knowledge representation in artificial intelligence. It is an extension to propositional logic.
- FOL is sufficiently expressive to represent the natural language statements in a concise way.

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FIRST ORDER LOGIC

- First-order logic (like natural language) does not only assume that the world contains facts like propositional logic but also assumes the following things in the world:
  - **Objects:** A, B, people, numbers, colors, wars, theories, squares, pits, wumpus, ...
  - **Relations: It can be unary relation such as:** red, round, is adjacent, **or n-any relation such as:** the sister of, brother of, has color, comes between
  - **Function:** Father of, best friend, third inning of, end of, ...
- As a natural language, first-order logic also has two main parts:
  - **Syntax**
  - **Semantics**

FOL - SYNTAX

BASIC ELEMENTS

Constant	1, 2, A, John, Mumbai, cat,....
Variables	x, y, z, a, b,....
Predicates	Brother, Father, >,....
Function	sqrt, LeftLegOf, ...
Connectives	∧, ∨, ¬, ⇒, ⇔
Equality	==
Quantifier	∀, ∃

Example:

Ravi and Ajay are brothers: => Brothers(Ravi, Ajay).

Chinky is a cat: => cat (Chinky).

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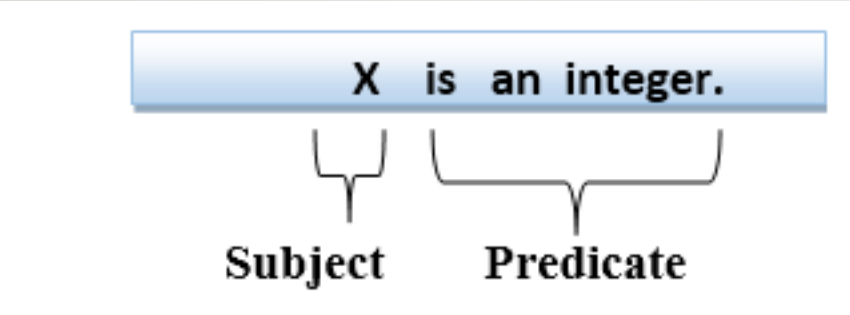
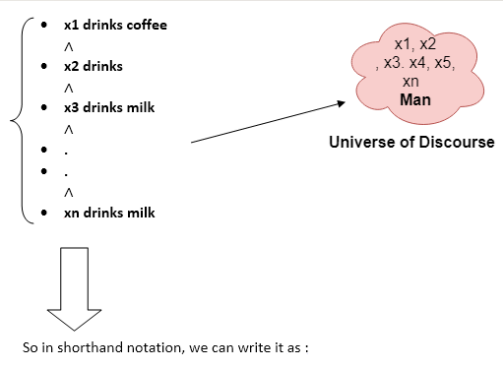
FIRST ORDER LOGIC - FOL – SUBJECT AND PREDICATE



All man drink coffee.



∀x man(x) → drink (x, coffee).

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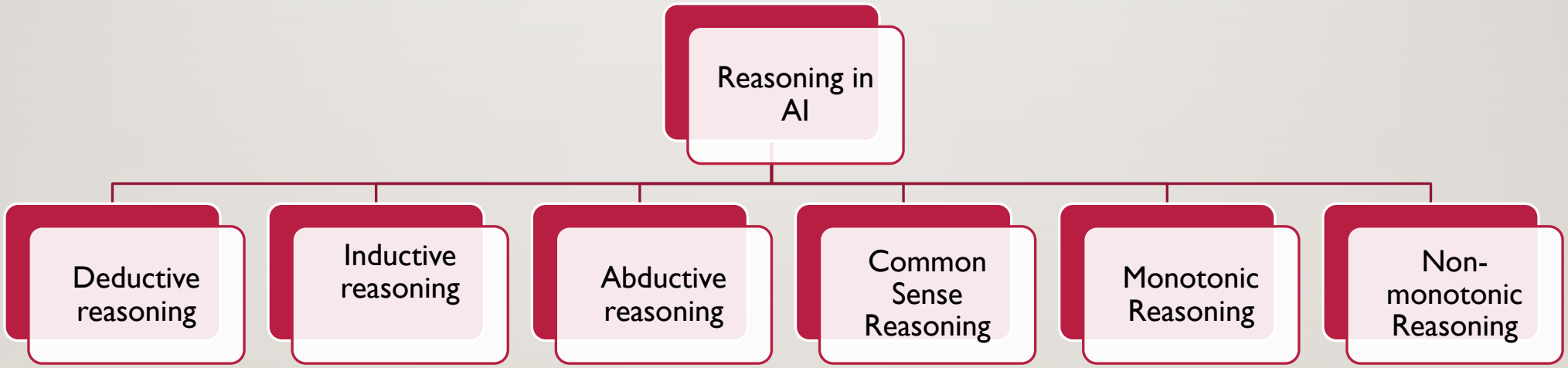
AI GOAL


Understanding knowledge
Represent Knowledge
Reason from Knowledge
Ideal AI Agent

REASONING IN AI

Simple example:
Premise-1: All the human eats veggies
Premise-2: Suresh is human.

AI Conclusion: Suresh eats veggies.



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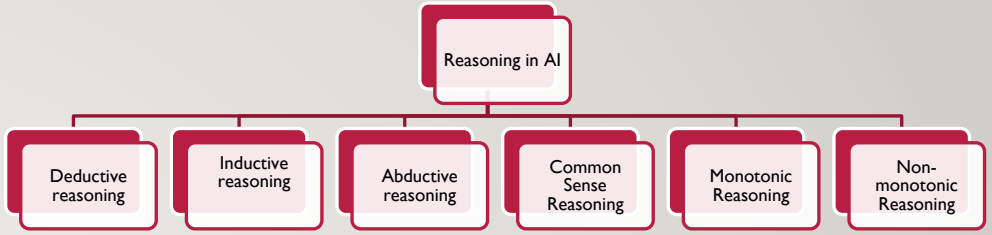
DEDUCTIVE REASONING



Deductive reasoning is deducing new information from logically related known information.

Example:

- **Premise-1: All the human eats veggies**
- **Premise-2: Suresh is human.**
- **Conclusion: Suresh eats veggies.**

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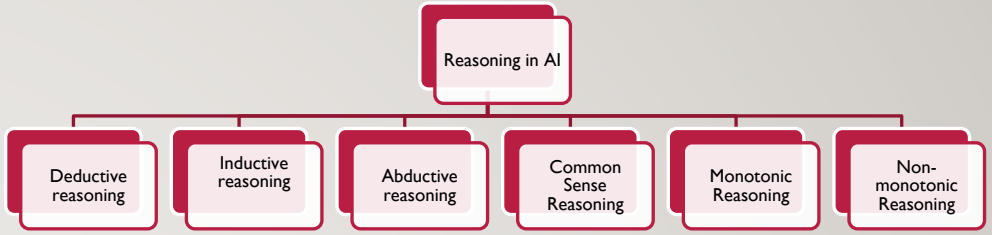
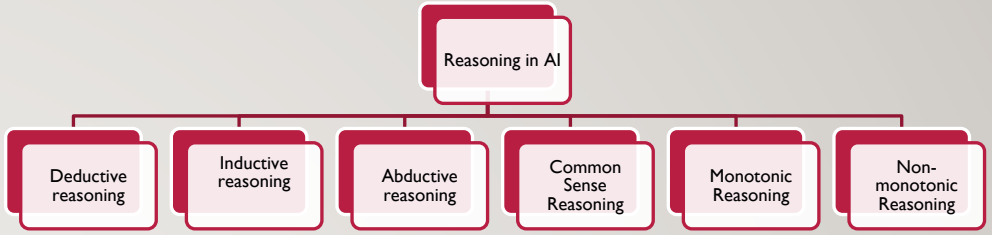
INDUCTIVE REASONING



- Inductive reasoning is a form of reasoning to arrive at a conclusion using limited sets of facts by the process of generalization.

- **Example:**
- **Premise: All of the pigeons we have seen in the zoo are white.**
- **Conclusion: Therefore, we can expect all the pigeons to be white.**

ABDUCTIVE REASONING



- Abductive reasoning is a form of logical reasoning which starts with single or multiple observations then seeks to find the most likely explanation or conclusion for the observation.

- **Example:**
- **Implication:** Cricket ground is wet if it is raining
- **Axiom:** Cricket ground is wet.
- Conclusion It is raining.

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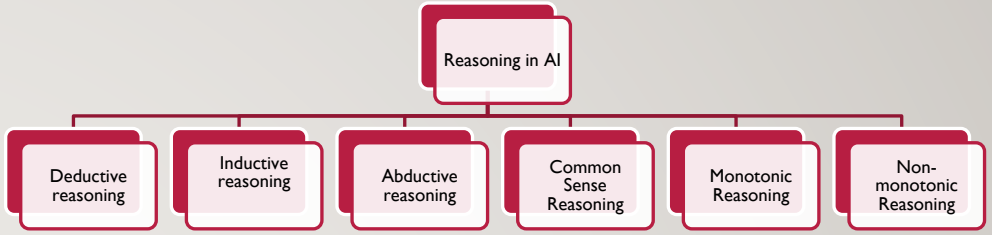
COMMON SENSE REASONING

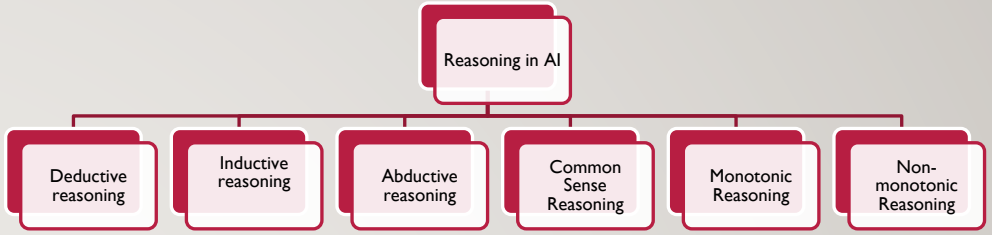


- Common sense reasoning is an informal form of reasoning, which can be gained through experiences.
-

- **Example:**

1. **One person can be at one place at a time.**
2. **If I put my hand in a fire, then it will burn.**

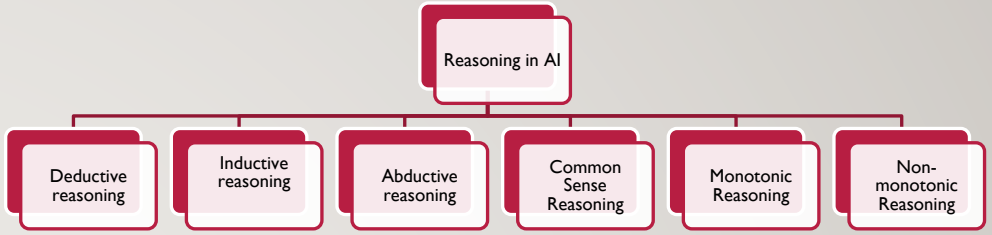
MONOTONIC REASONING



- Once the conclusion is taken, then it will remain the same **even if we add** some other information to existing information in our knowledge base.

- **Example:**
- **Earth revolves around the Sun.**
- It is a true fact, and it cannot be changed even if we add another sentence in knowledge base like, "The moon revolves around the earth" Or "Earth is not round," etc.

NON- MONOTONIC REASONING



- **Example:** Let suppose the knowledge base contains the following knowledge:
  - **Birds can fly**
  - **Penguins cannot fly**
  - **Pitty is a bird**

- So from the above sentences, we can conclude that **Pitty can fly**.
- However, if we add one another sentence into knowledge base "**Pitty is a penguin**", which concludes "**Pitty cannot fly**", so it invalidates the above conclusion.

PROBABILISTIC REASONING IN AI

- In Both First order logic and Propositional Logic it is expecthed that all the facts to be considered.
- There are cases we can expect that we may not know whether the fact is 100% True or False then comes the Probabilistic Reasoning.

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AI GOAL OF AN IDEAL AI AGENT

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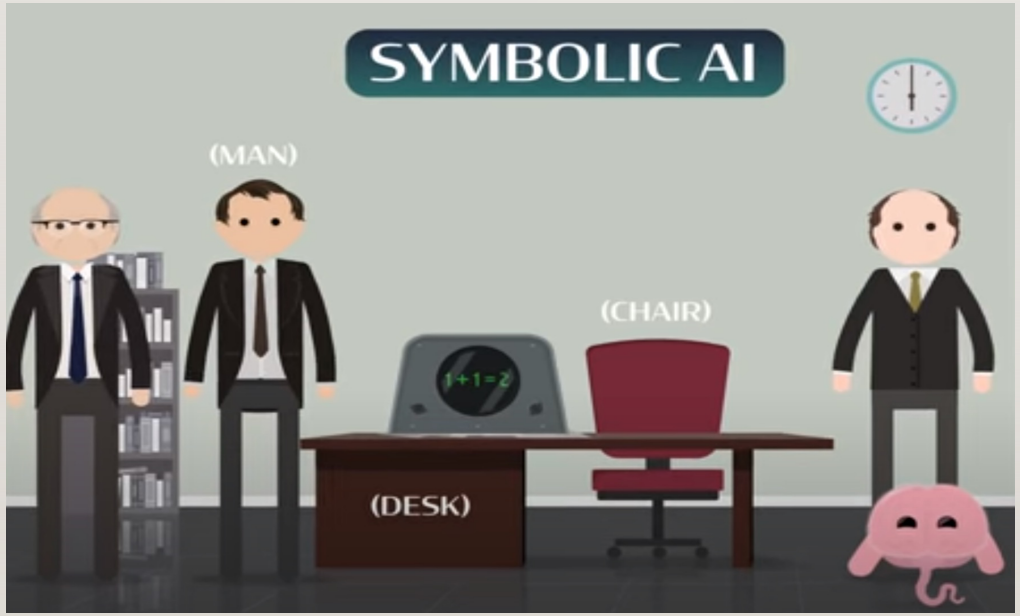
SYMBOLIC AI

- Human do not see things as 1 or 0
- Human sees things as – chair, objects, person, laptop etc



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LOGIC AND SYMBOLS

- Logics are how we are going to solve the problem.
- Symbols are how we are going to represent the problem in the computers.
- Knowledge base – huge set of symbols and relationship.
- Logical connection - And / OR / NOT
- Implication - If then Else
- Terms:

Relationship –	Logical Connection:	Implication:
Eat(person, bread) Person and bread – symbols Eat – relation ship	Eat(person) Eat(bread) Eat(person) and Eat(Bread)	IF Hungry(person) then Eat(Bread)

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APPLE SIRI

- Siri has huge set of knowledge base
- Huge knowledge base of all the various combinarions of symbols and relationship for the siri responses.

- **Advancement - Neuro symbolic AI**

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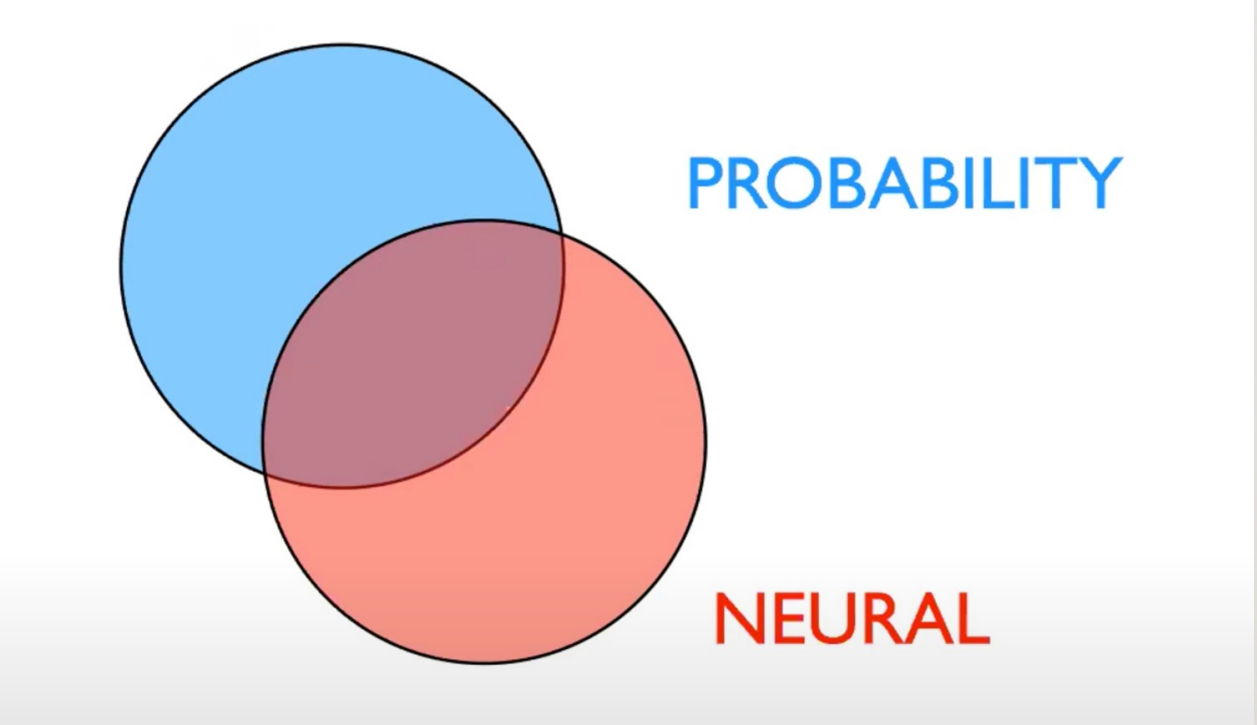
CURRENT DEEP LEARNING APPROACH



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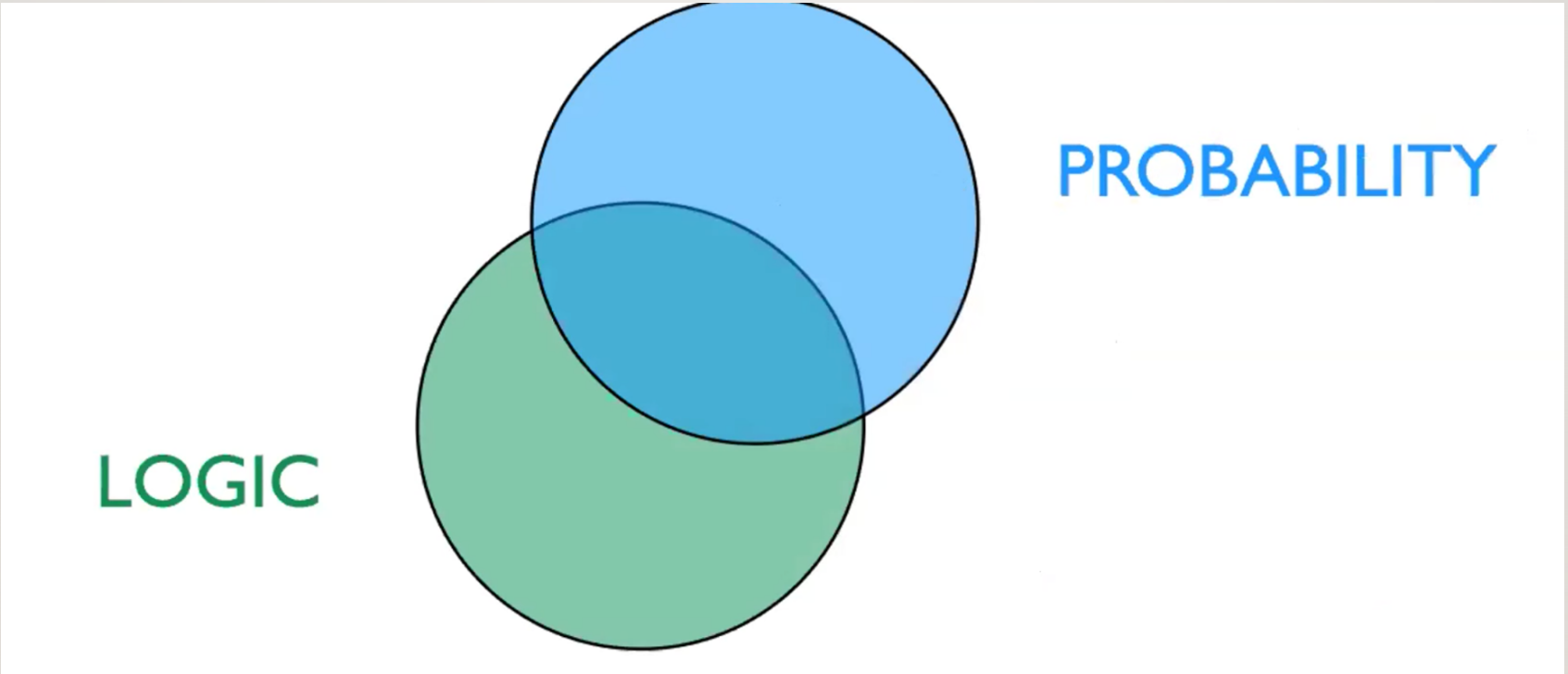
CURRENT SYMBOLIC AI APPROACH



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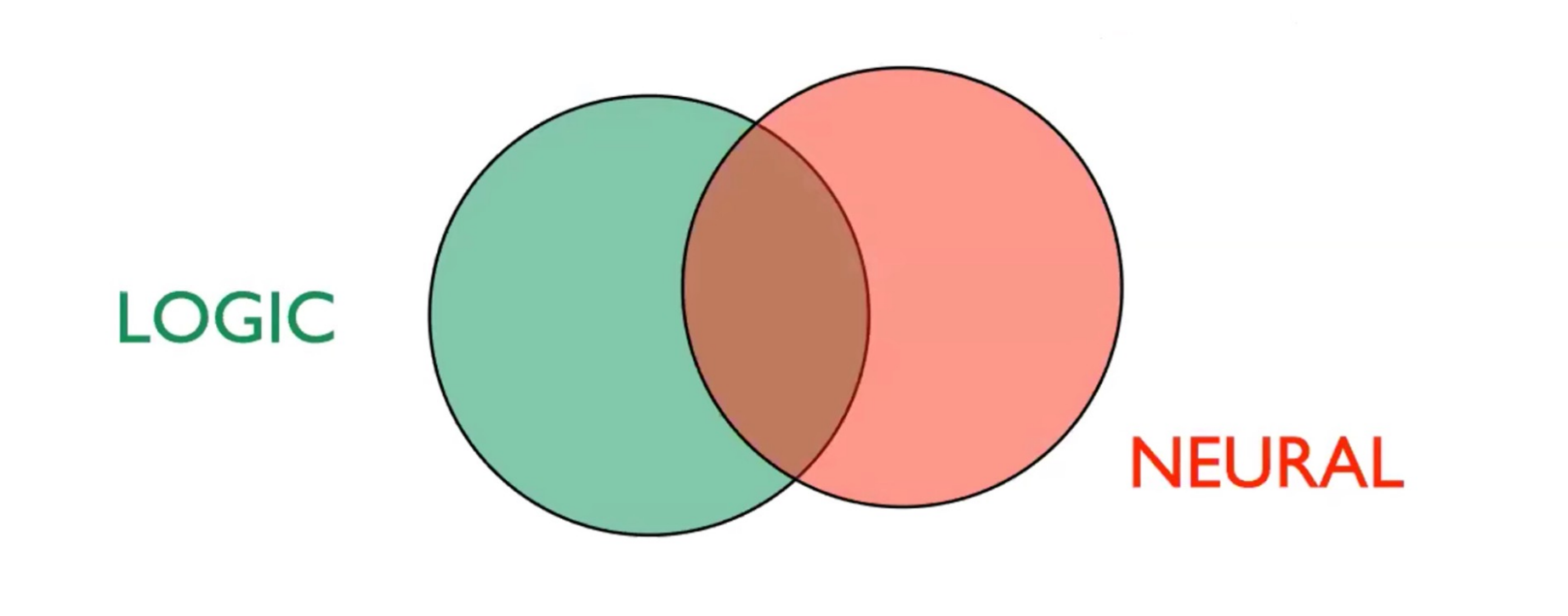
NEURO LOGIC APPROACH



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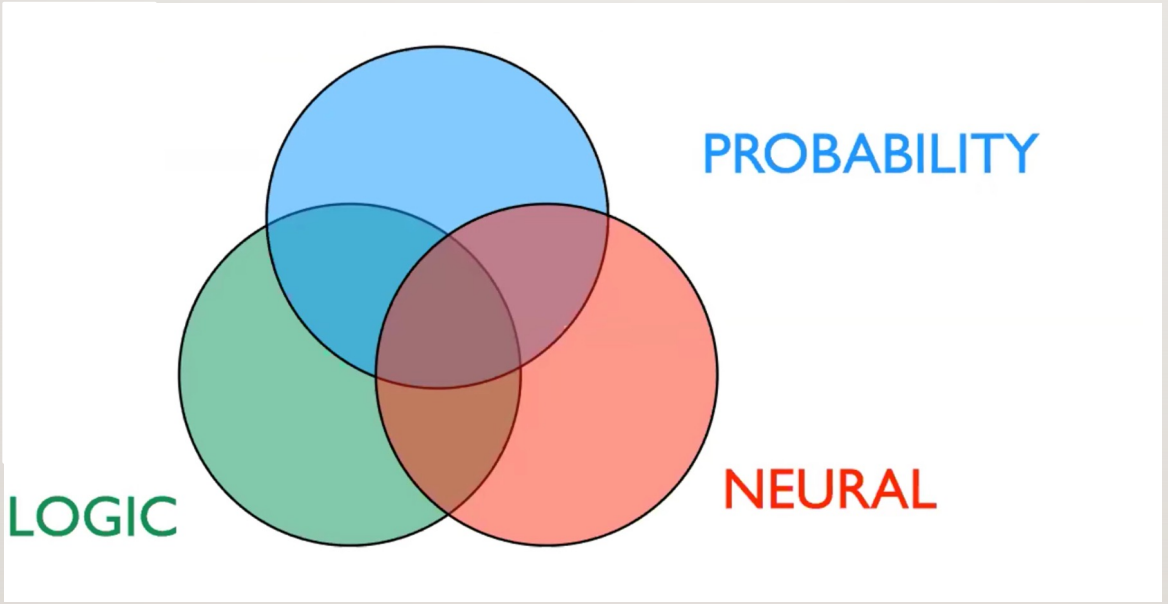
NEURO SYMBOLIC AI APPROACH



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KNOWLEDGE REPRESENTATION IN LOGIC

Advancement in Knowledge Representation in Logic – ULKB – Universal Logic Knowledge base

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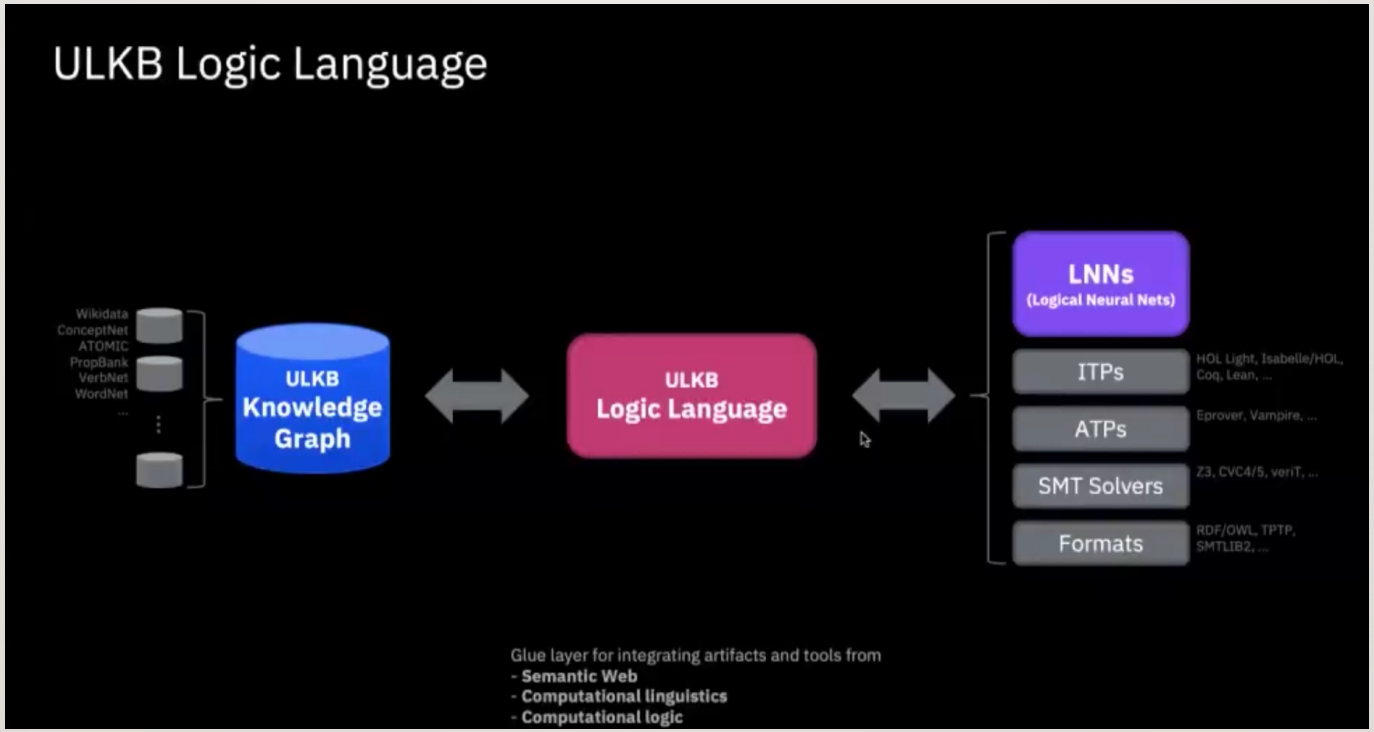
UNIVERSAL LOGIC KNOWLEDGE BASE – LOGIC LANGUAGE



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TOOLS FOR THE (MINIMAL RECURSIVE SEMANTIC) PARSING

- PyDelphin Library – Python library for the Parsing
- ACE Parser
- Demo:
- https://delph-in.github.io/delphin-viz/demo/

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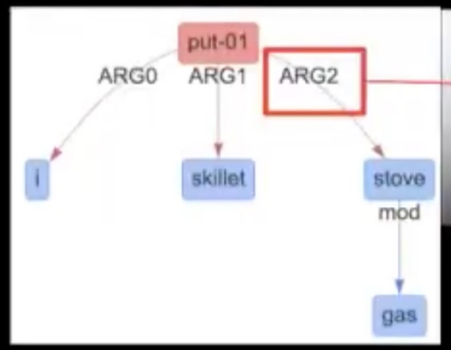
ULKB

- https://ibm.github.io/neuro-symbolic-ai/toolkit/ulkb

- https://github.com/IBM/ULKB

ULKB roadmap: a knowledge asset to bridge NLP and Logic

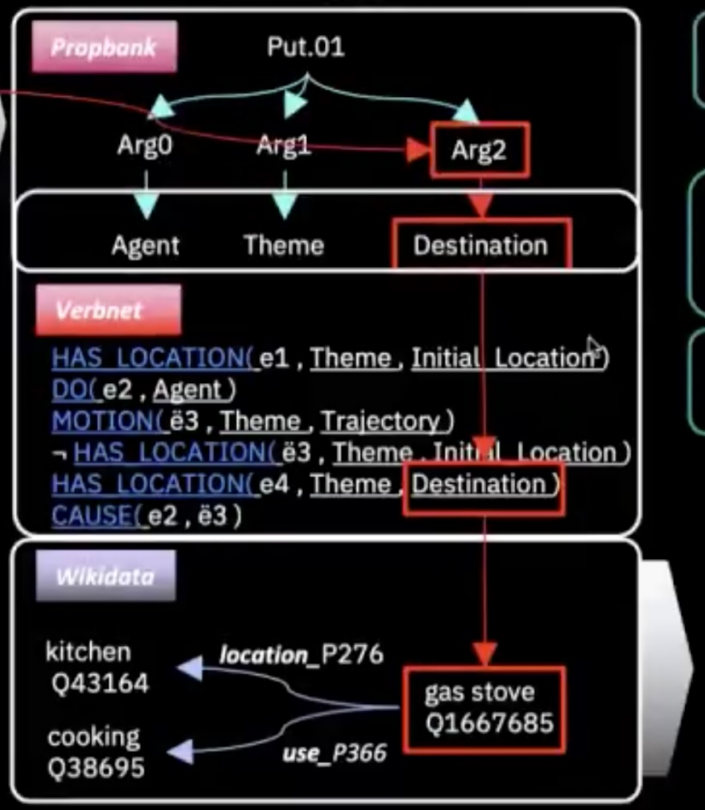
FROM an interpretation of text (MRS/AMR)



"I put the skillet on the gas stove"

What is a skillet, a gas stove?
What does it mean to put A on B?

we link to federated linguistic and ontologic knowledge (ULKB graph)



... And translate it into logic expressions for use in reasoners (ULKB logic)

e1 "The skillet was somewhere"
hasLocation skillet location0

...

e3 "After a trajectory, the skillet is somewhere else"
motion skillet trajectory ∧
¬(hasLocation skillet location0)

e4 "The Skillet is now on the stove"
hasLocation skillet gas_stove

reasoner

- "The gas_stove is in the kitchen"
  hasLocation gas_stove kitchen
- "I intend to cook"
  usedFor gas_stove cooking
- ~~The skillet was NOT in the kitchen~~

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Source IBM

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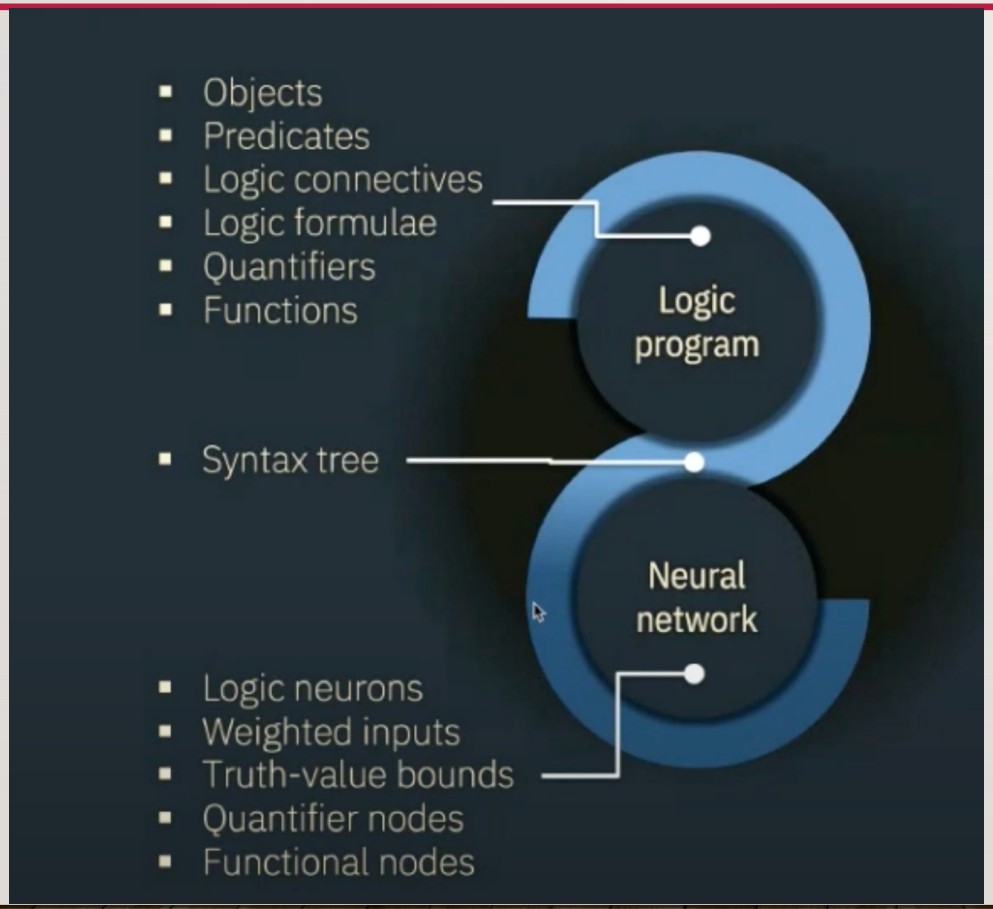
LNN – LOGIC NEURAL NETWORK



Open source initiative from IBM Extending the Neural Network with Symbolic Logic.

Link for LNN in Git Hub –

https://github.com/IBM/TensorLNN

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