

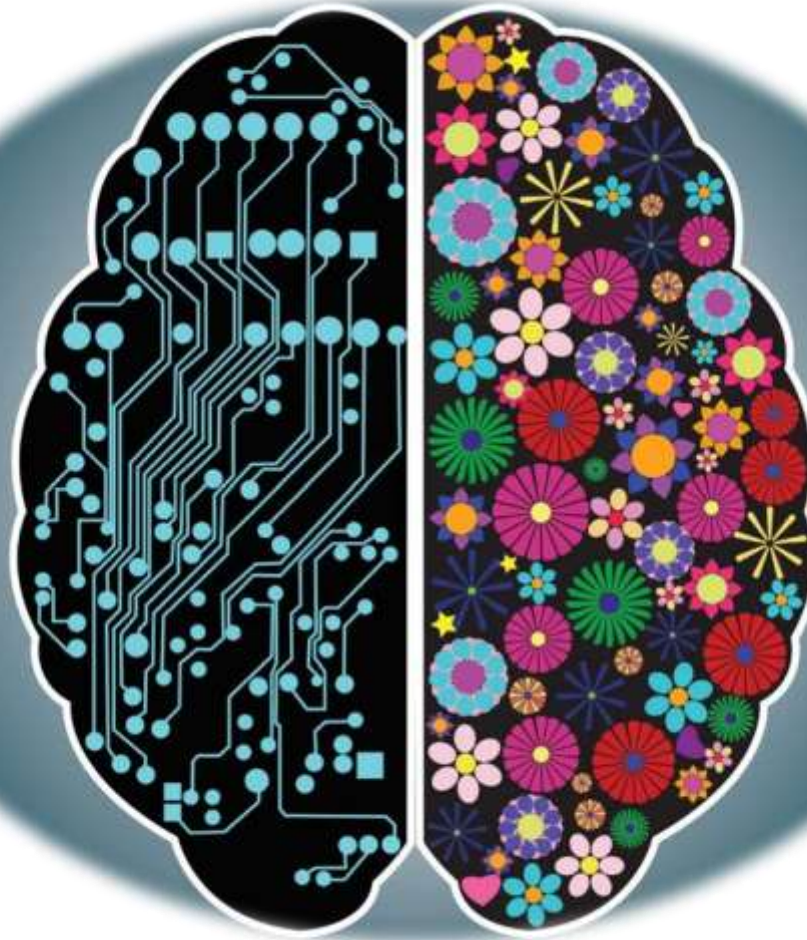
# ARTIFICIAL INTELLIGENCE



# Human Cognition Abilities

## LEFT BRAIN FUNCTIONS

Logic  
Analysis  
Sequencing  
Mathematics  
Language  
Facts  
Words of  
songs  
Computation



## RIGHT BRAIN FUNCTIONS

Creativity  
Imagination  
Holistic Thinking  
Intuition  
Arts (Motor Skill)  
Rhythm (beats)  
Visualization  
Tune of songs  
Daydreaming

*Symbolic methods: Classical AI*

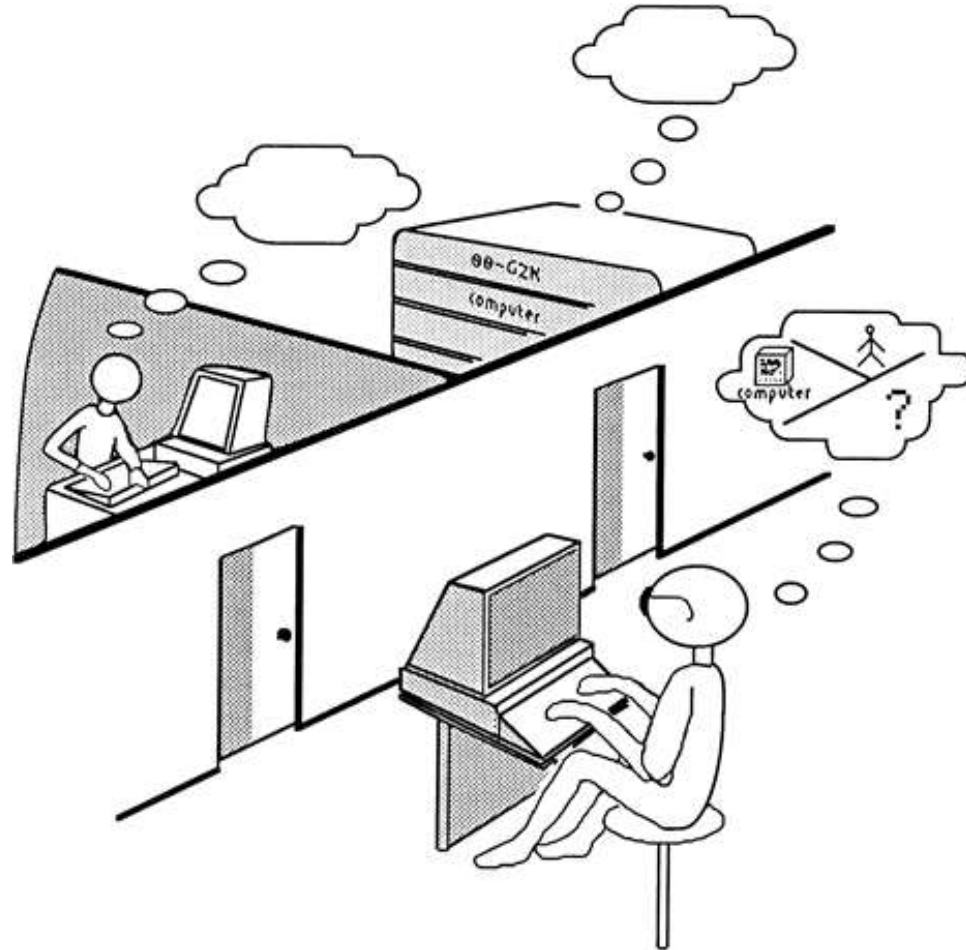
Modern AI is the  
convergence of these two

*Statistical methods: ML*

# What is “Artificial Intelligence”?

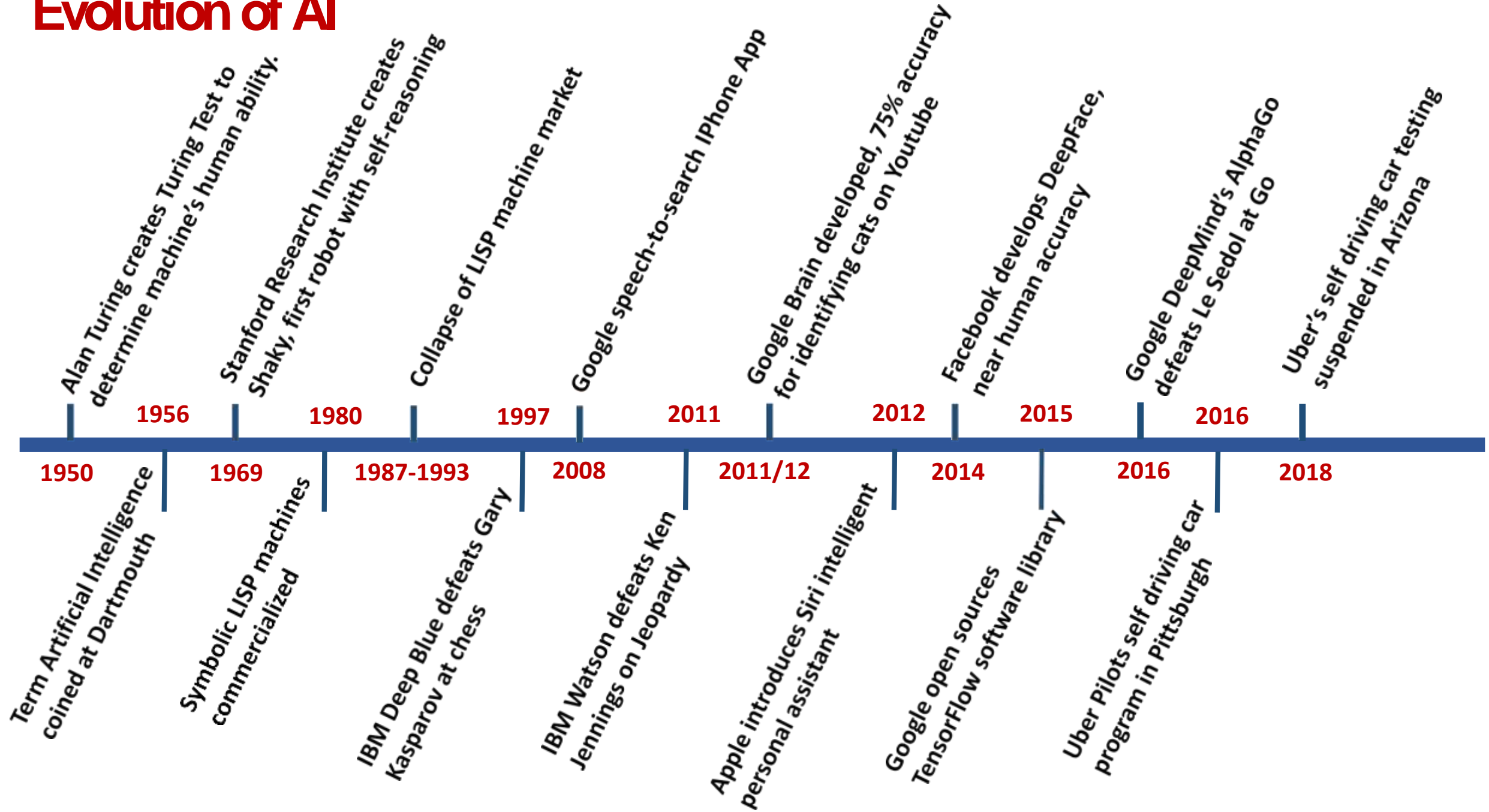
## Turing Test (1950)

- The computer is interrogated by a human via a teletype.
- It passes if the human cannot tell if there is a computer or human at the other end





# Evolution of AI



# Kasparov versus Deep Blue



On May 11, 1997, it won a 6-game match by 2 wins to 1 with 3 draws

Today, we have power to evaluate  
200 million moves per second !!



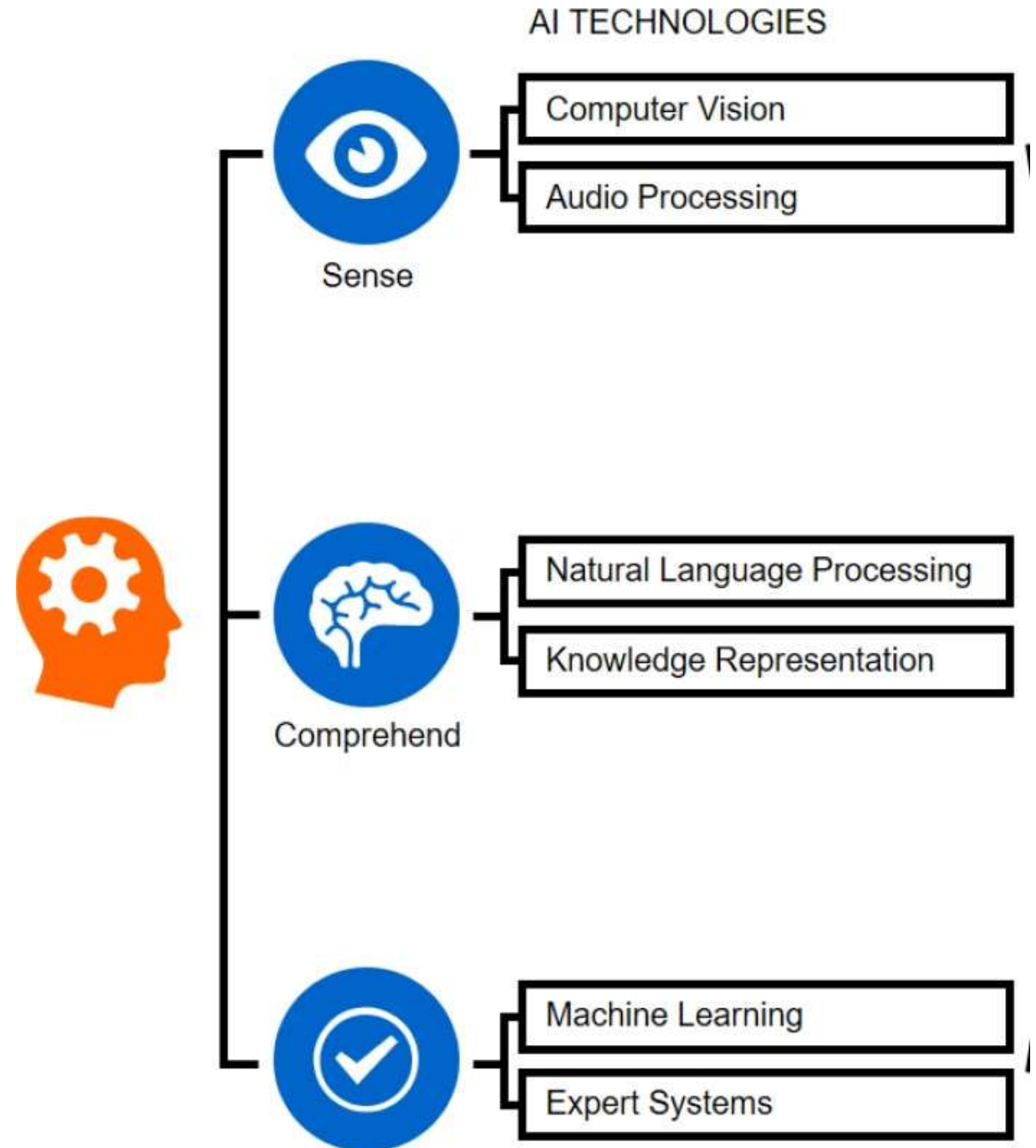
# What are the green fields for AI in India?

- Preventive and affordable Healthcare
- Agriculture and Rural Development
- Smart Mobility and Intelligent Transportation Systems
- Retail
- Manufacturing
- Energy management
- Smart Cities
- Education and Skilling

# Artificial Intelligence

## CORE CAPABILITIES

- **The ability to solve problems**
  - Constraint satisfaction, Optimization, Search
- **The ability to plan**
  - Abstraction
- **The ability to deduce**
  - Logic, Reasoning algorithms
- **The ability to learn**
  - Models, Data, Learning algorithms
- **The ability to handle uncertainty**
- **The ability to interface with the real world**



Source: Accenture



# Constraints and Optimization



## Path Finding

- I wish to find a shortest path
- I wish to find a path with minimum congestion
- I wish to find a path with combination of transportation options (metro, bus, taxi)
- I wish to find a path which goes past a medicine shop
- I wish to find a path which minimizes energy consumption from my battery in a e-vehicle

When the size and complexity becomes too big we use “heuristic functions” to cut out unnecessary parts.

In the lack of domain knowledge, we can statistically learn the best way (reinforcement learning) by exploration.

Modern AI aims to combine learning from data with structured use of domain knowledge.



# AI Planning

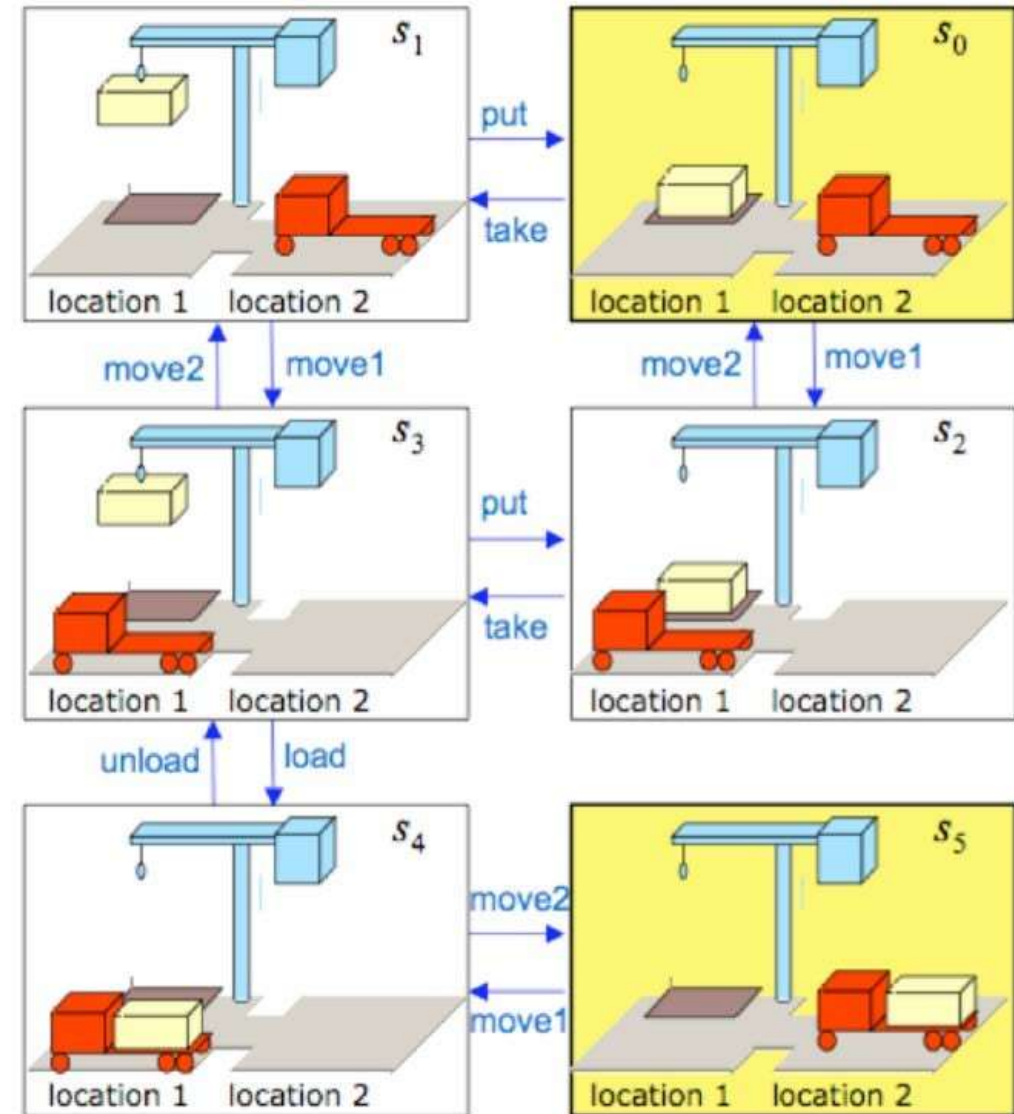
## Elements of a Planning Problem

- A set of states (worlds) described in terms of predicates
- A set of actions which transforms some parts of one world to take us to another world
- An initial world
- A goal in terms of the predicates that must hold in the final world

Planning is widely used in robotics and automated control

Modern AI explores techniques that combine planning with machine learning

- Autonomous driving is one of many areas where such combinations are highly relevant



# Logical Reasoning

- Automated ways to use what is known to reason about something which is not explicitly known.

- Automated Reasoning:

- **Deduction**

Rule: *All the marbles in this bag are blue*

Case: *These marbles are from this bag*

Inference: *These marbles are blue*

- **Abduction**

Rule: *All the marbles in this bag are blue*

Observation: *These marbles are blue*

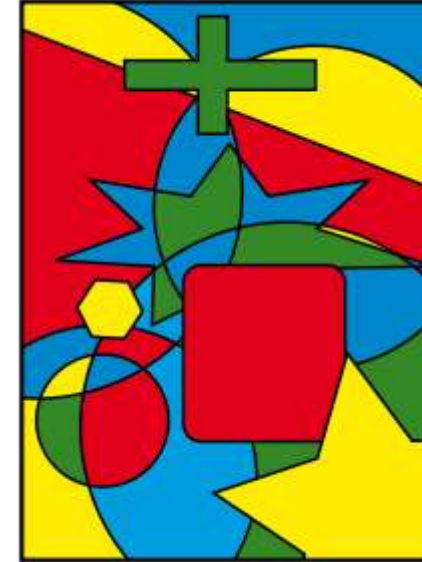
Case: *These marbles are from this bag*

- **Induction**

Case: *These marbles are from this bag*

Observation: *These marbles are blue*

Rule: *All the marbles in this bag are blue*



**Five color theorem:** All maps can be colored with five colors, where neighboring countries get different colors [Proved in 1800s]

**Four color theorem:** All maps can be colored with four colors, where neighboring countries get different colors [Proved in 1976 with help of computers]

## Applications of Logical Reasoning

- Automated Theorem Proving
- Rule-based Systems
- Complexity Analysis

# Logical Reasoning with Other Fun Things

$\text{father}(x, z), \text{father}(z, y)$   
 $\Rightarrow \text{grandfather}(x, y)$

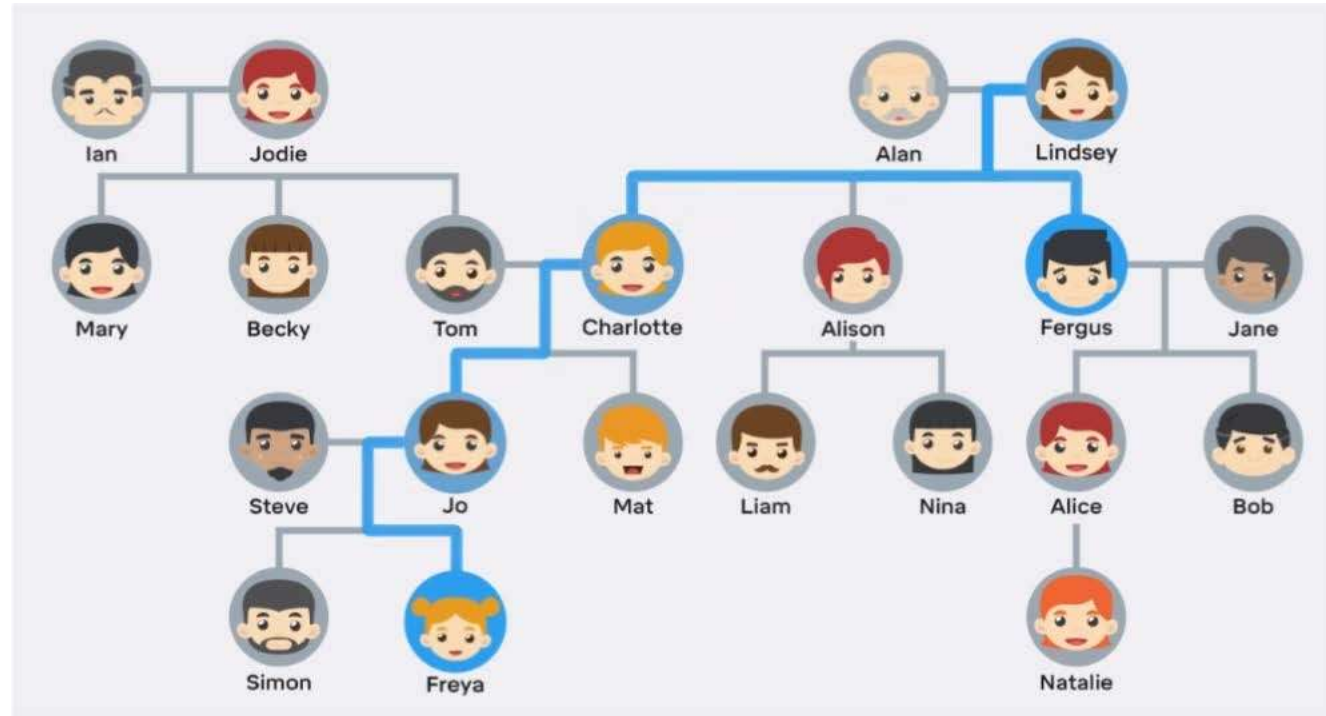
$\text{mother}(x, z), \text{father}(z, y)$   
 $\Rightarrow \text{maternalgrandfather}(x, y)$

$\text{mother}(x, z), \text{mother}(z, y)$   
 $\Rightarrow \text{maternalgrandmother}(x, y)$

$\text{father}(x, z), \text{mother}(z, y)$   
 $\Rightarrow \text{grandmother}(x, y)$

$\text{maternalgrandmother}(x, z),$   
 $\text{mother}(z, p), \text{son}(p, y)$   
 $\Rightarrow \text{maternalgreatuncle}(x, y)$

*Who is the maternal great uncle of Freya?*

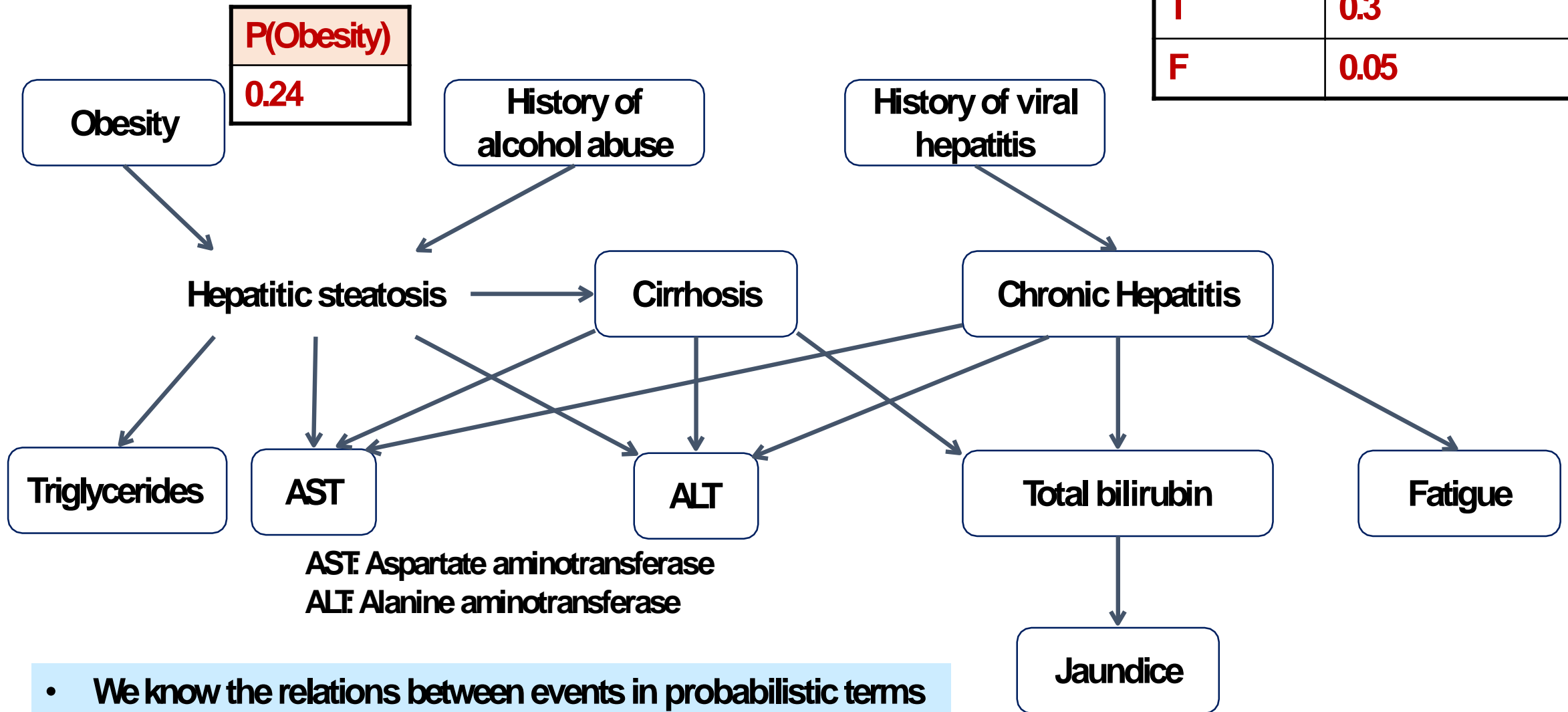


*$\text{maternalgrandmother}(\text{Freya}, \text{Charlotte}),$   
 $\text{mother}(\text{Charlotte}, \text{Lindsey}), \text{son}(\text{Lindsey}, \text{Fergus})$   
 $\Rightarrow \text{maternalgreatuncle}(\text{Freya}, \text{Fergus})$*

We could build this into a social media platform which suggests Freya to post a picture of Fergus on the Maternal-Great-Uncle day !!



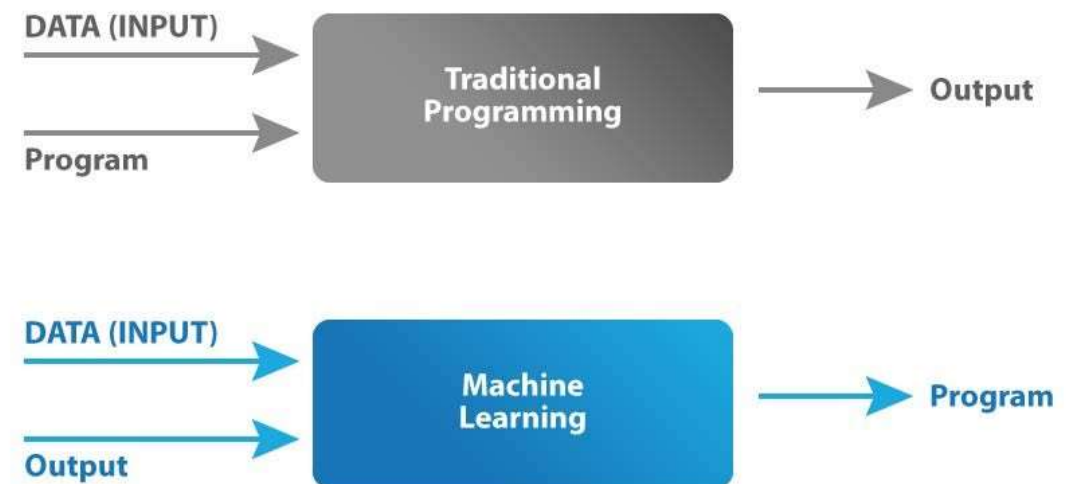
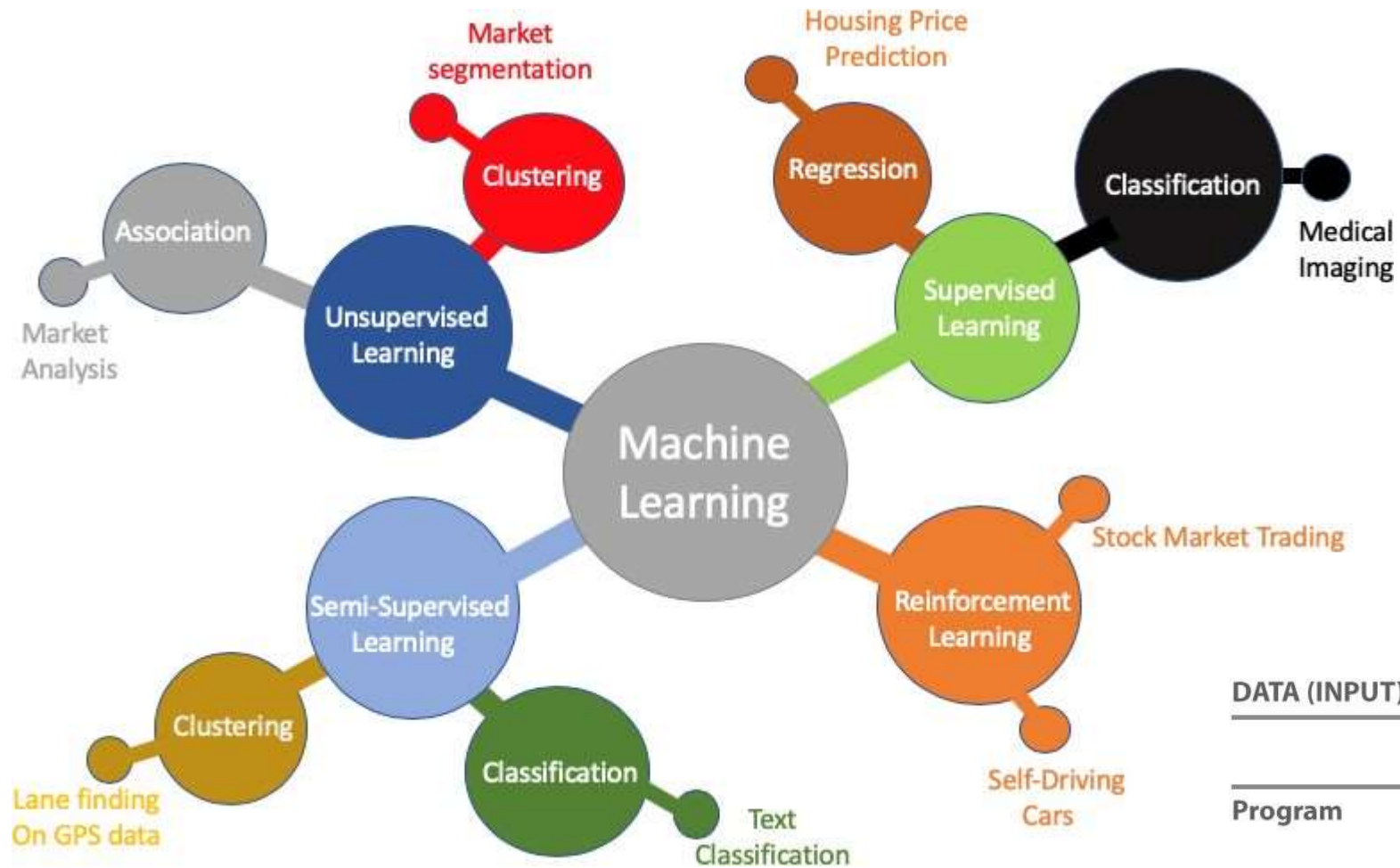
# Reasoning under Uncertainty



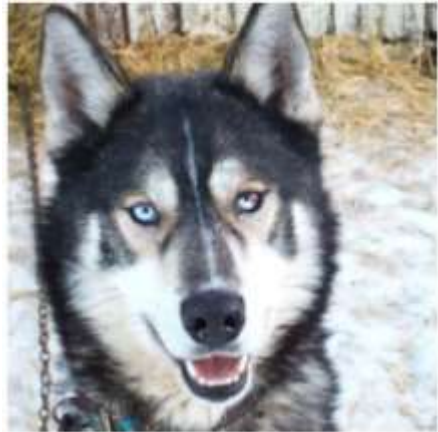
- We know the relations between events in probabilistic terms
- We are given a set of known events
- Goal: *Find the probability of some other event*

**Challenge:** Sometimes we do not know which is the cause and which is the effect.

# Machine Learning



# Deep Learning and the Problem of Explainability



Husky Classified  
as Wolf



Explanation  
based on  
saliency



Test Image



Evidence of Husky



Evidence of Flute

**Same pixels used to explain two different classifications !!**

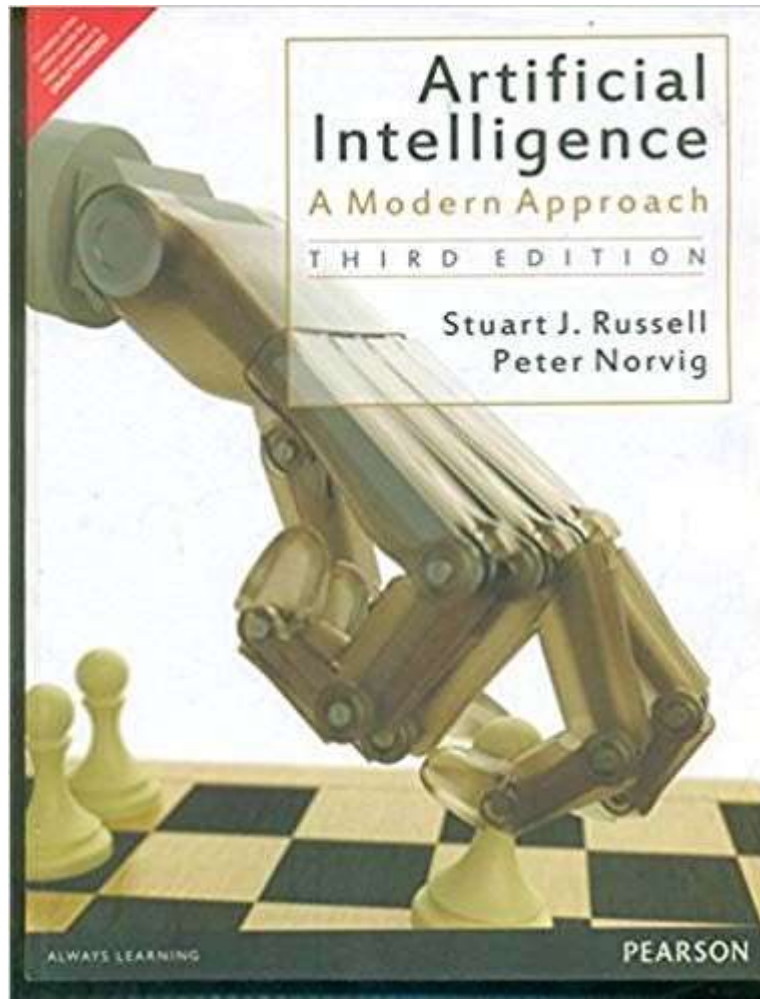


It has evidence for cat as well as  
evidence for bird, but it is neither



...but it is also not easy to define the features that  
separate a dog from a cat, even if we can paint both





The book that we will follow mostly for this and many other topics:

**Artificial Intelligence – A Modern Approach**  
Stuart J Russell, Peter Norvig

Pearson Education India