

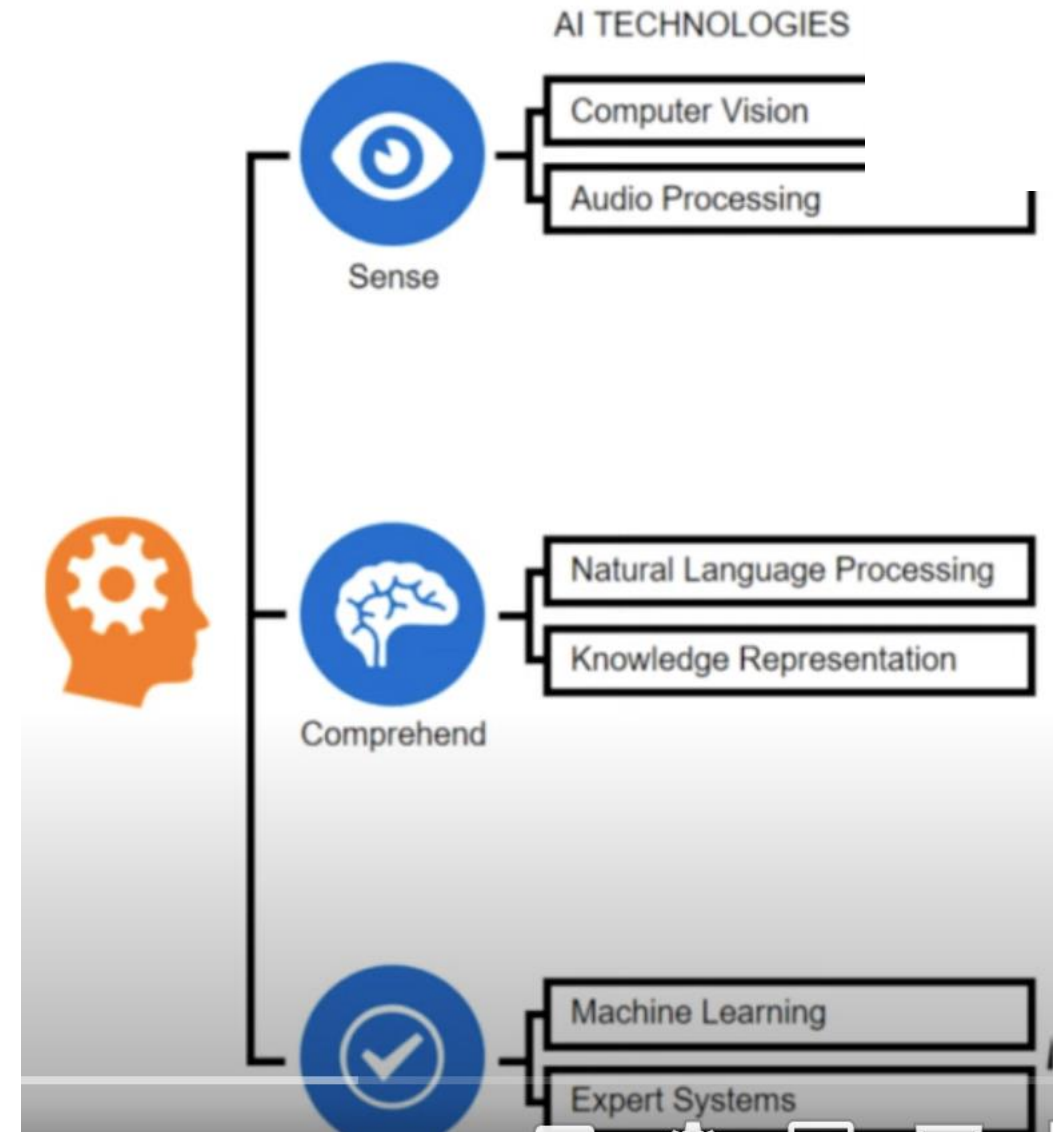
# AI: Areas

06/01/2025

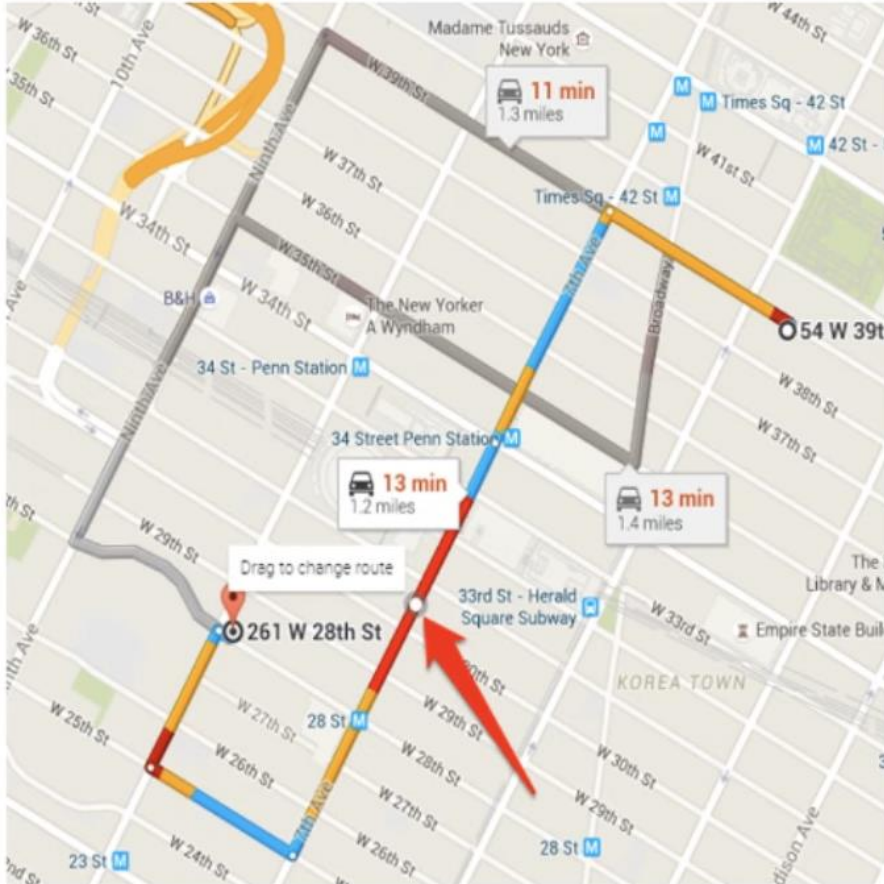
Koustav Rudra

# Artificial Intelligence

- Core capabilities
- The ability to solve problems
  - Constraint satisfaction
  - Optimization
  - Search
- The ability to plan
  - Abstraction
- The ability to deduce
  - Logic, reasoning algorithm
- The ability to learn
  - Models, data, learning algorithms
- The ability to handle uncertainty
- The ability to interface with the real world



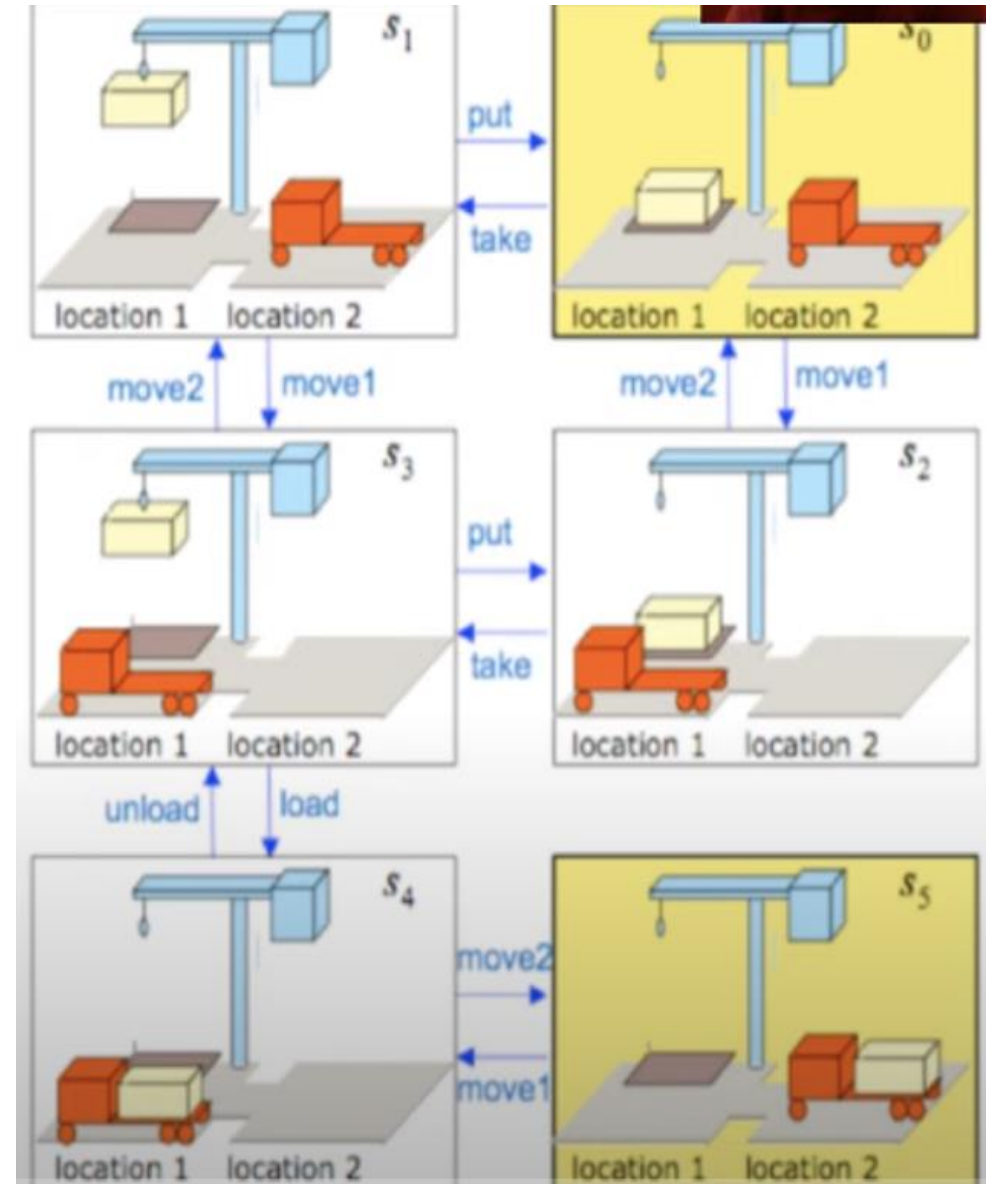
# Constraints and Optimization



- **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 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



# 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: [1800]**
  - All maps can be coloured with five colours
  - Neighbouring maps have different colours
- **Four Color Theorem: [1976]**
  - All maps can be coloured with five colours
  - Neighbouring maps have different colours
- **Applications of Logical Reasoning:**
  - Automated Theorem Proving
  - Rule based Systems
  - Complexity Analysis



# Logical Reasoning

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

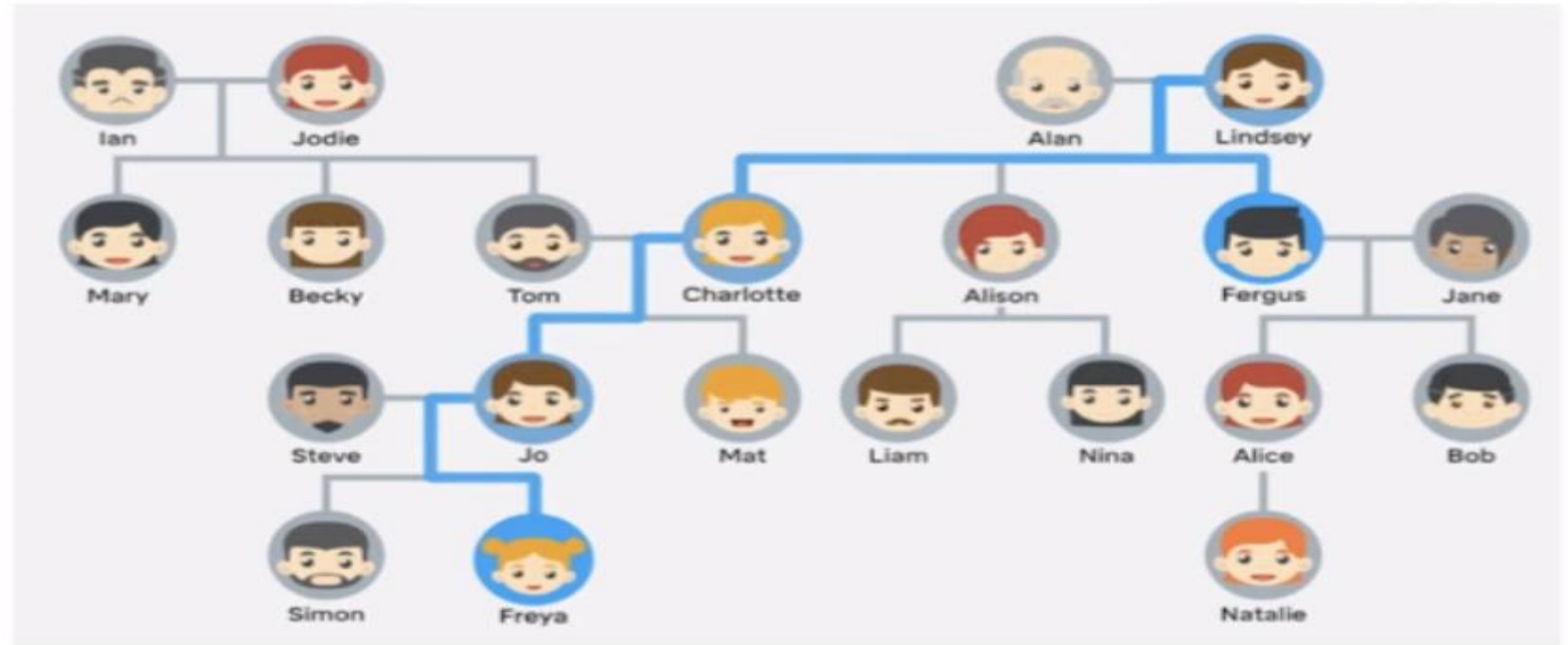
$\text{mother}(x, z), \text{father}(z, y)$   
 $\Rightarrow \text{maternalgrandfather}(x, y)$

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

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

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

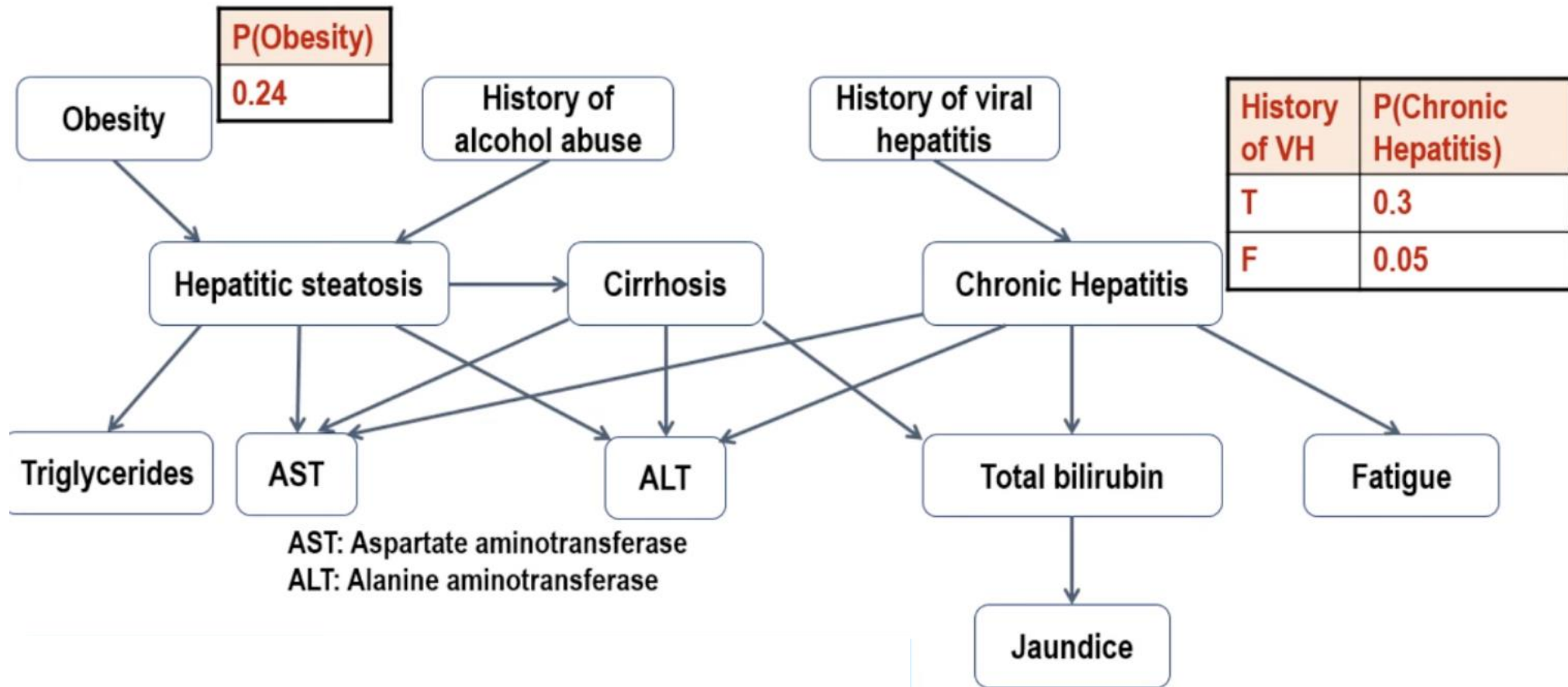
*Who is the maternal great uncle of Freya?*



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

**How to use this?**

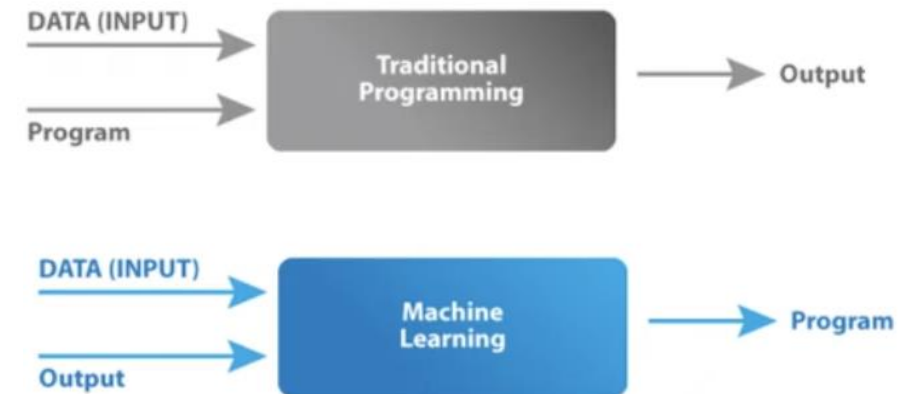
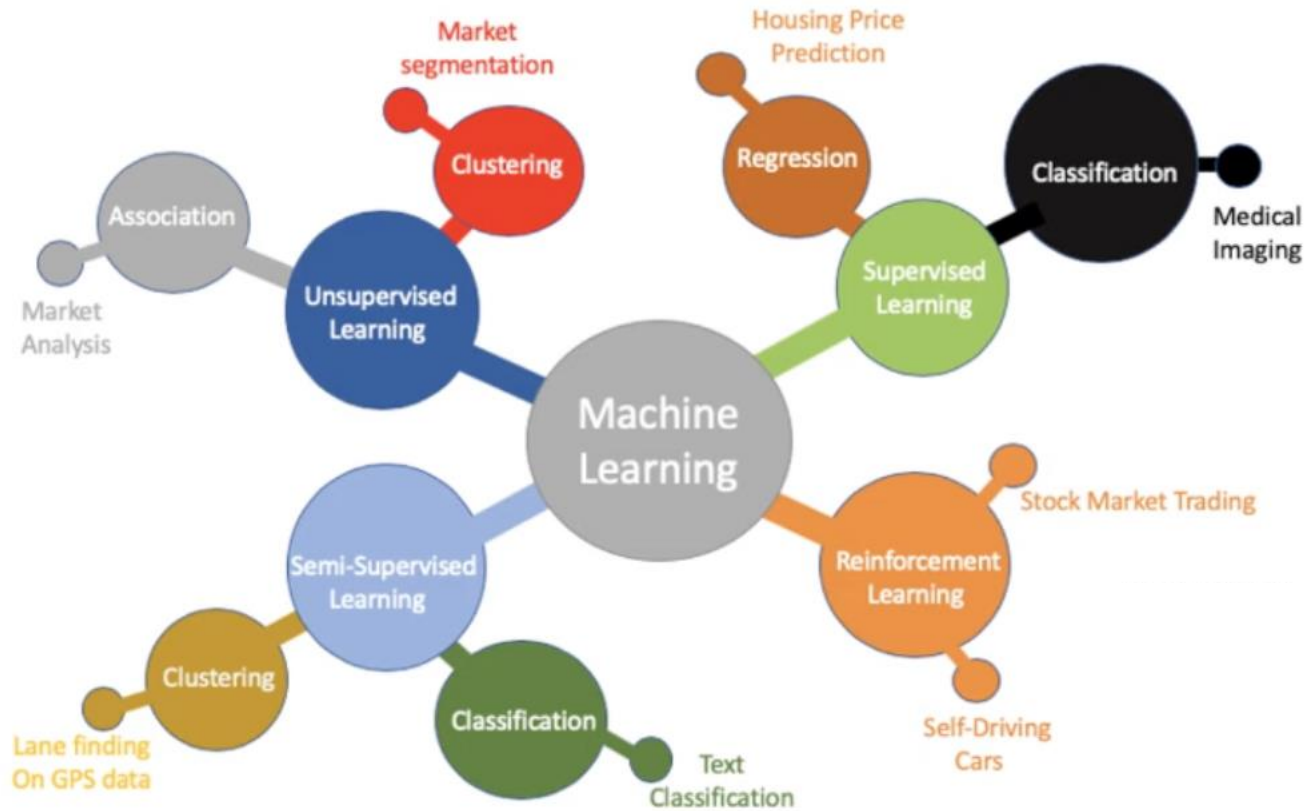
# Reasoning under Uncertainty



- 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 Problem of Explainability



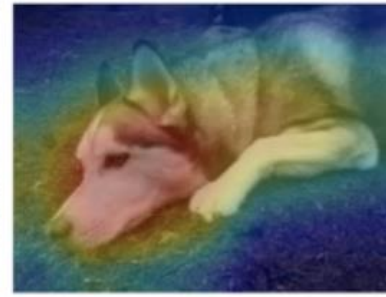
Husky Classified  
as Wolf



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

# Course Outline

- Problem Solving by Search
  - State space search
  - Problem reduction search
  - Game playing
- Logic and Deduction
  - Propositional Logic
  - First Order Logic
- Planning + CSP
- Prolog
- Reasoning Under Uncertainty
- Learning
- Genetic Programming

Thank You