

AIFA

Introduction

02/01/2024

Koustav Rudra

General Information

- **Class Timings**
 - Monday: 12-1 PM
 - Tuesday: 10-12 AM
 - Thursday: 8-9 AM
- **Venue**
 - NR 412
- Study Materials, Assignments, Class Schedule and other Information will be shared through *teams*
 - [Link to be provided by this week](#)

General Information

- Head TAs

- Mr. Dipankar Mondal (mdipankar960@gmail.com)
- Mr. Sayantan Saha (sayantan.saha@kgpian.iitkgp.ac.in)
- Mr. Asim Manna (asimmanna17@kgpian.iitkgp.ac.in)
- Mr. Dipayan Dewan

- References

- Artificial Intelligence – A Modern Approach
 - Stuart Russell and Peter Norvig
- Principles of Artificial Intelligence
 - N J Nilsson

Assessment/ Evaluation

- Overall Assessment

- Assignment, ...

- Class Test1

- Class Test2

Tentative 25-30%

- Mid Sem

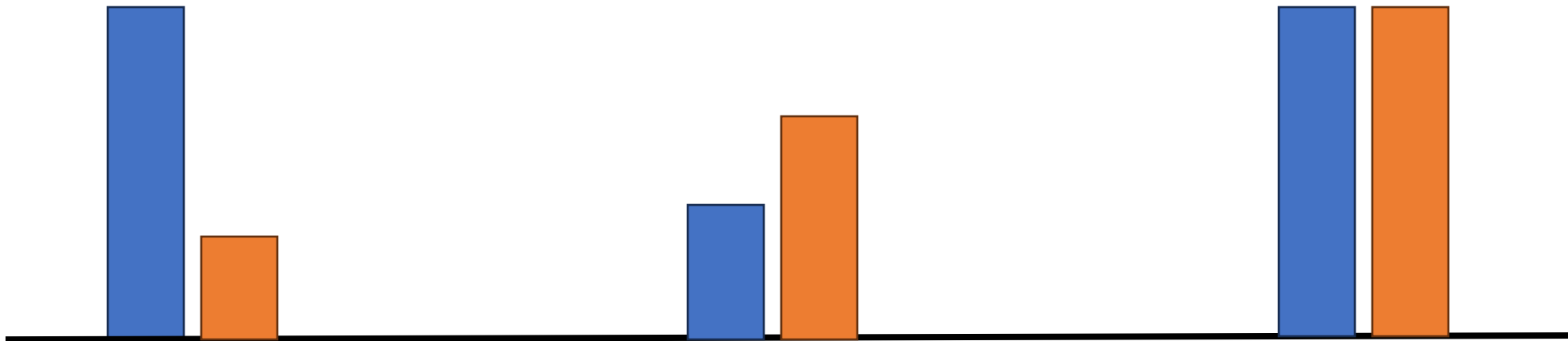
- End Sem

Tentative 75-70%

- Class Test1 Date: 05/02/2024

- Class Test2 Date: 01/04/2024

Progress



- Lots of AI Hype
- Limited Hardware

- Mostly known what could be done or not done
- Hardware support improves

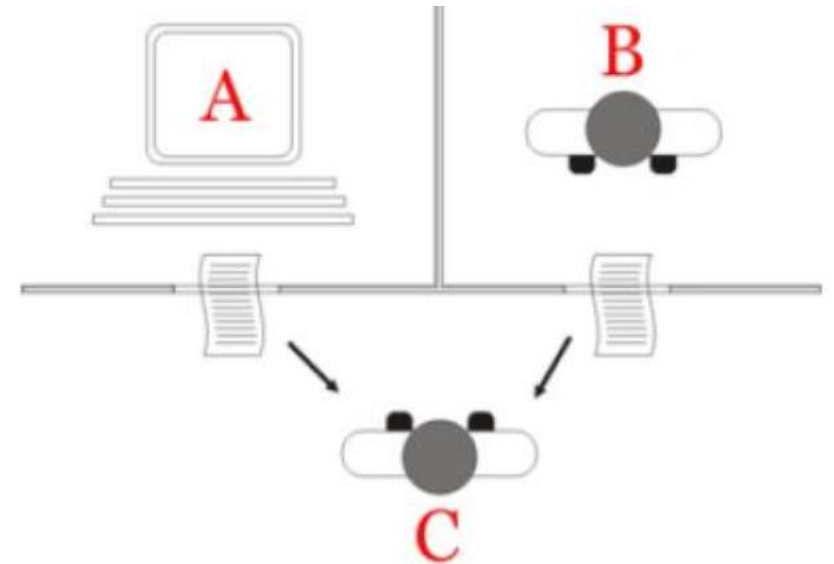
- AI Hype
- Hardware Support

What is an AI?

- An attempt to replicate human intelligence
- Think like a human or act like a human?
- Think like human – Cognitive modeling
 - Need to know how human brain functions - through introspection, psychological experiments, brain imaging, etc.
- Act like human – The ‘Turing test’

What is an AI?

- An attempt to replicate human intelligence
- Turing Test (1950)
 - The computer is interrogated by a human via a teletype
 - It passes if human cannot tell if there is a computer or human at the other end
 - Don't have NLP support like today



What is an AI?

- An attempt to replicate human intelligence
- Chinese Room Problem
 - Suppose, AI has succeeded in constructing a machine that understands Chinese
 - It takes Chinese characters as input and, by following the instructions of a computer program
 - It produces other Chinese characters, which it presents as output
- Does the machine literally “understand” Chinese? – Strong AI
- Is it merely simulating the ability to understand Chinese? – Weak AI

AI based Problem Solving

- What is AI?
 - An attempt to *replicate* human intelligence
 - AI is that activity devoted to making machines intelligent, and intelligence is that quality that enables an entity to *function* appropriately and with *foresight* in its environment. (Nilsson)
- In general,
 - AI is an attempt to *automate* intelligent behaviour
 - The branch of Computer Science dealing with *intelligent behaviour automation*

AI based Problem Solving

- What is AI?
 - An attempt to *automate intelligent behaviour*
- The capability of reasoning, planning, learning, understanding etc. by
 - perceiving the world,
 - acquiring knowledge through this experience and
 - subsequently acting in the world with this additional knowledge

AI based Problem Solving

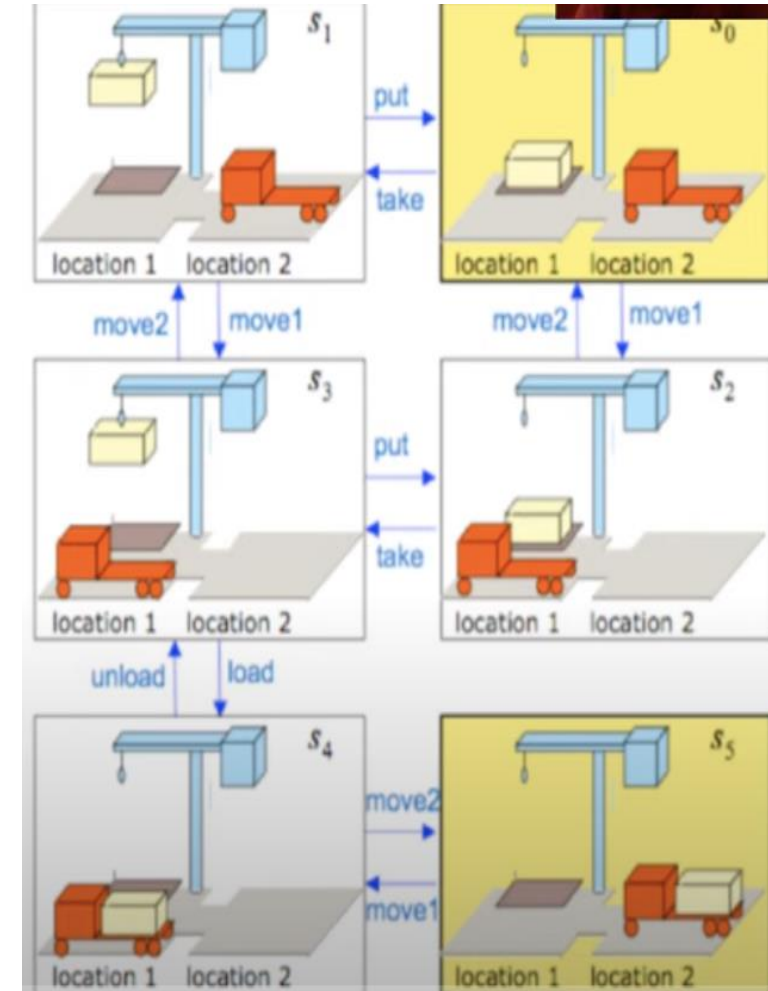
- Reasoning
 - Logically Inferring conclusions from available knowledge
 - Diagnosing an ailment from symptoms
 - Proving theorems in mathematics
- Automated ways to use what is known to reason about something which is not explicitly known.
- Automated Reasoning:
 - **Deduction**

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*

AI based Problem Solving

- Planning
 - Deciding on a sequence of actions that may help achieve a specific goal with high probability
 - Actions have preconditions to be satisfied and positive/negative aftereffects
 - Planning the best path for a robot

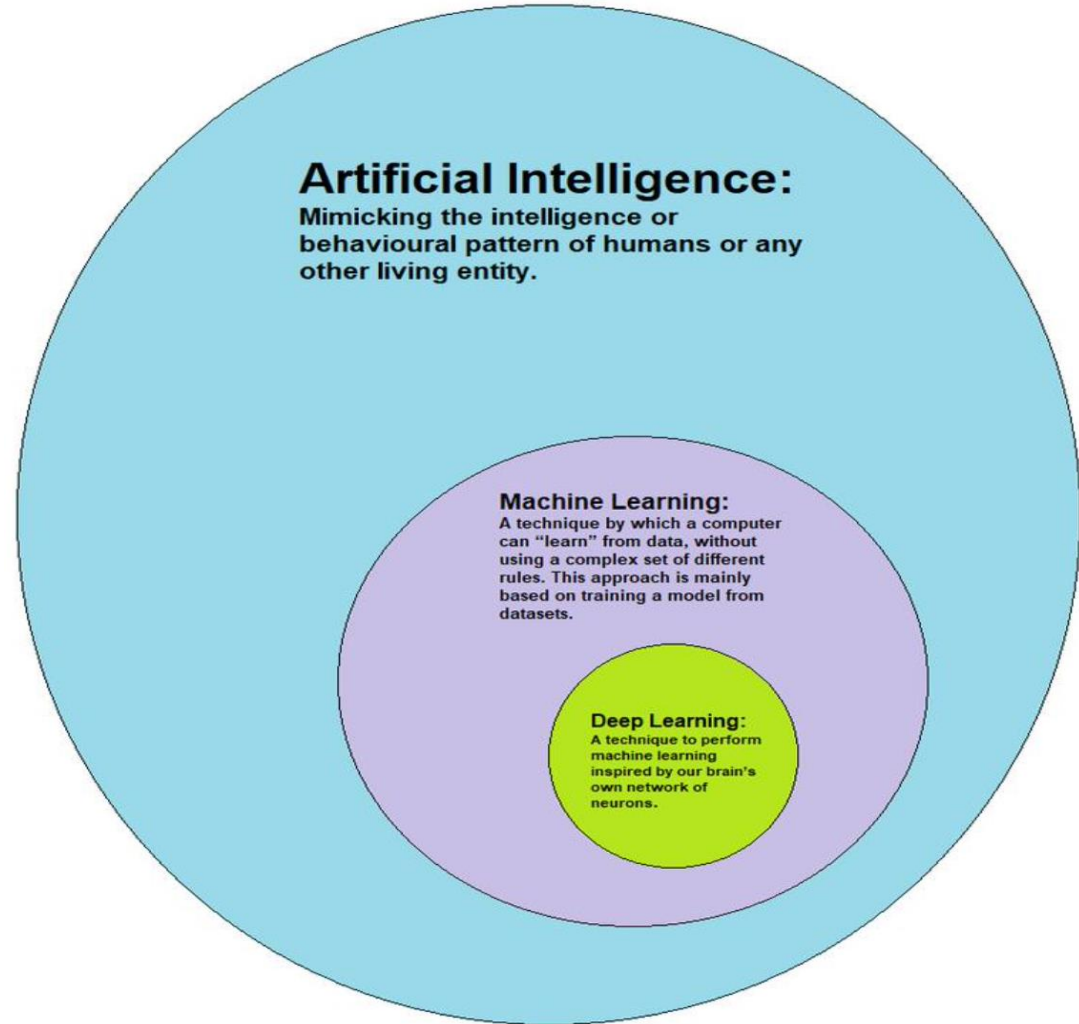


AI based Problem Solving

- Learning:
 - Building mathematical models and making predictions using past information (data)
 - Supervised, unsupervised, reinforcement
 - Learning traffic patterns, recommending movies

AI based Problem Solving

- Broad Techniques
 - Search
 - Logic
 - Constraint satisfaction
 - Planning
 - Probabilistic reasoning
- Machine learning
- Deep learning



Automated Problem Solving: Requirement

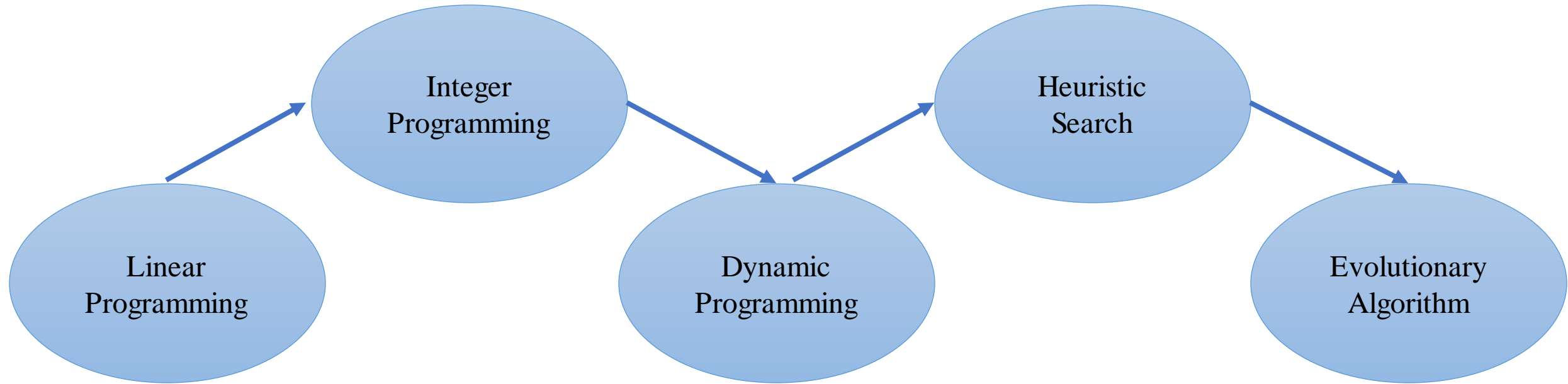
- Typically assumes an entity called '*AI enabled Agent*'
 - Being AI-enabled, this agent do not need to be individually programmed for each problem instance



How much can computer aid us in our ability to solve problems?

The Ability to Solve Problems

- Search: Efficient trial and error
 - Enormous computational complexity
 - Space-time trade-off
 - Use of domain knowledge - heuristics



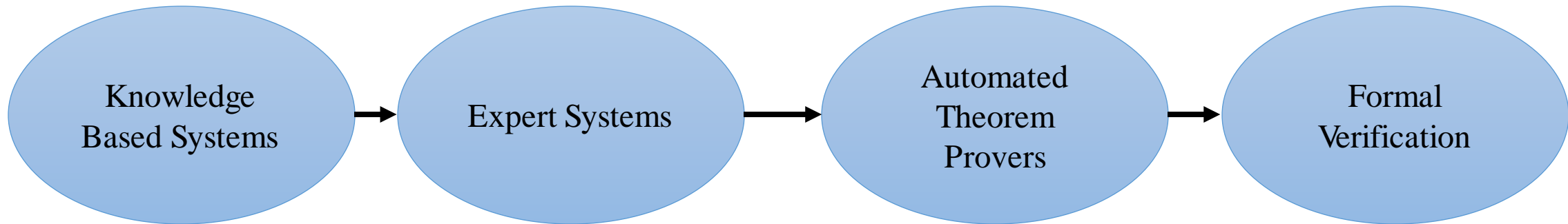
During 1985-1995 computation becomes free

Knowledge and Deduction

- Storing data does not signify anything
- We have to learn how to deduct knowledge from it
- Understanding the rules, able to interpret and use the rules to deduce new data
- What kind of logic enable us to do so?
 - Propositional Logic
 - First Order Predicate Logic
- Important
 - What do I know?
 - What do other one know?
 - What do I know about the other?

Knowledge and Deduction

- How to store and retrieve knowledge?
- How to interpret facts and rules, and be able to deduce?
- The gap between knowledge and realization
- Logics of knowledge



- The knowledgebase may be huge
- Between 1990-2000 the storage becomes free

Next Generation Issue: Smart Communication

The Ability to Learn

- Can we learn to solve a problem better?
 - Learning the answers
 - Learning the rules of the game
 - Learning to plan

What is AI?

- Automated Problem Solving
- Logic and Deduction
- Machine Learning
- Deep Learning



Human Computer Interaction

- IR
- NLP
- Computer Vision
- Robotics

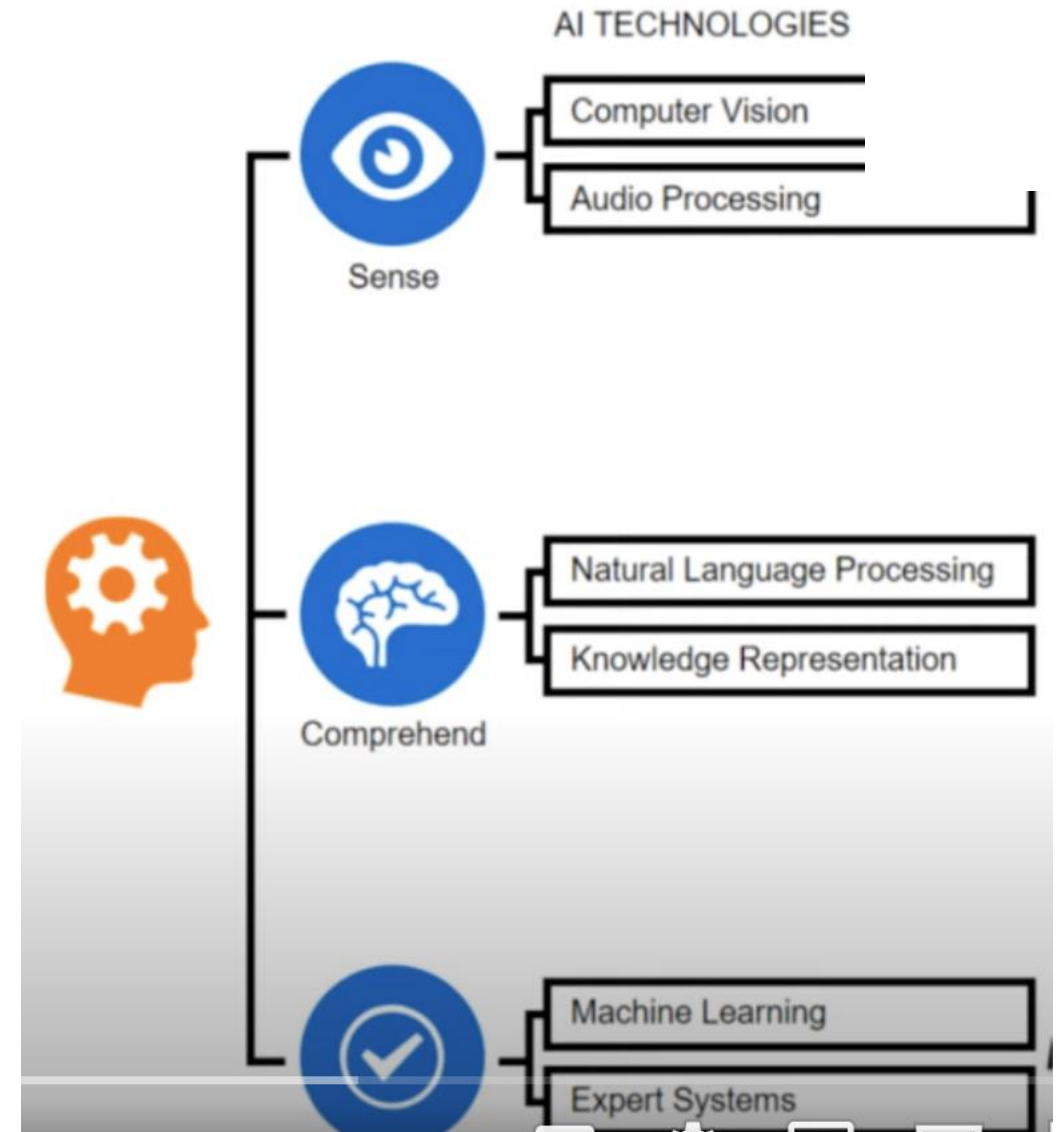
AI: Areas

04/01/2024

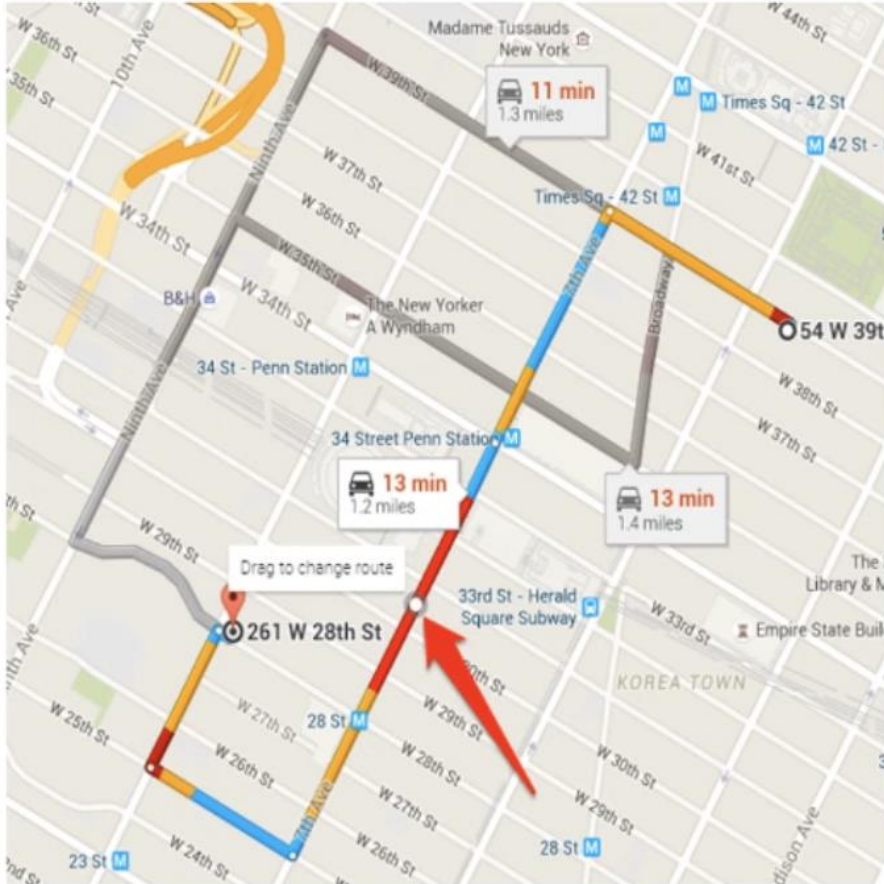
Koustav Rudra

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



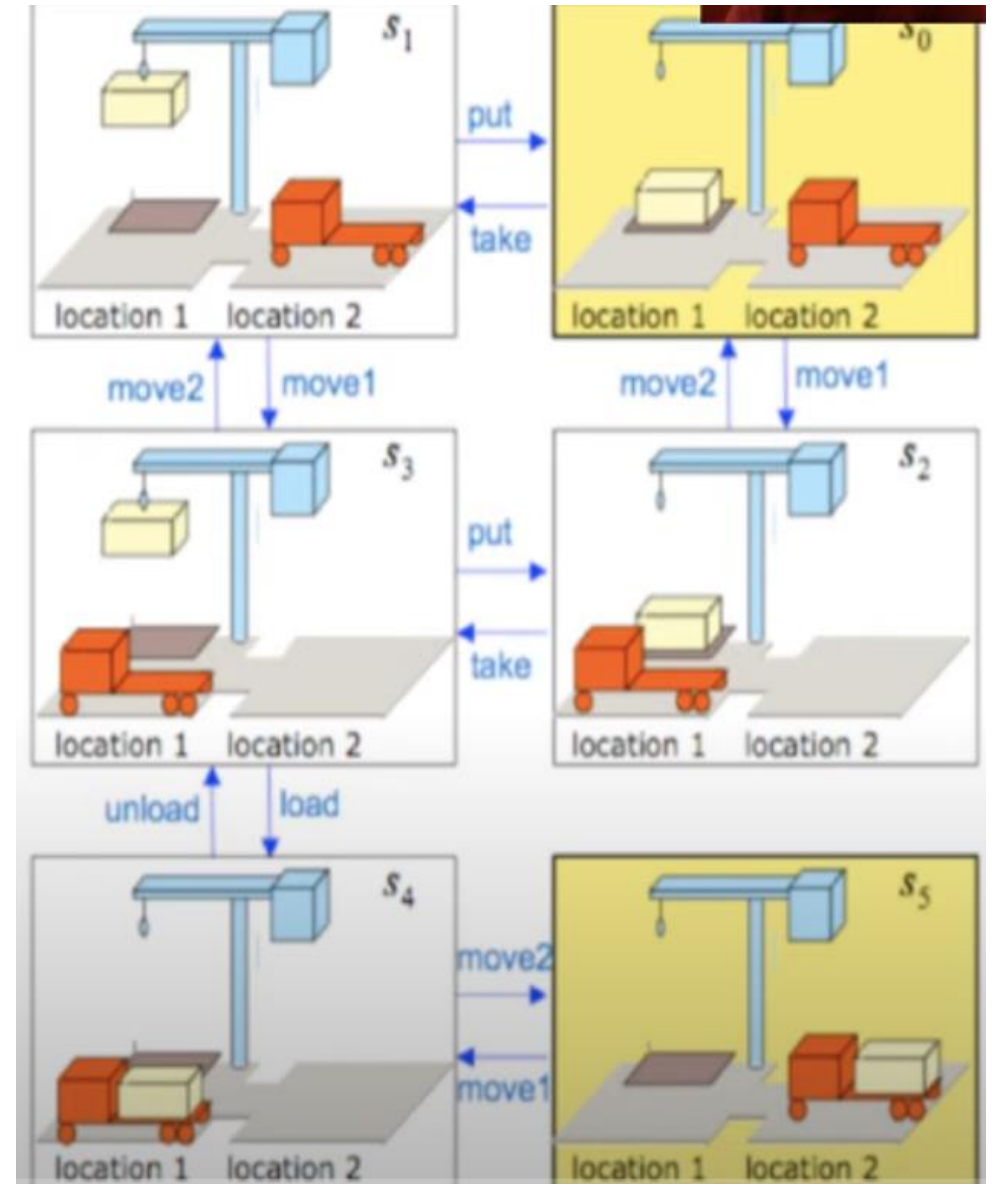
Constraints and Optimization



- **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*
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 - Case: *These marbles are from this bag*
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 - 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

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

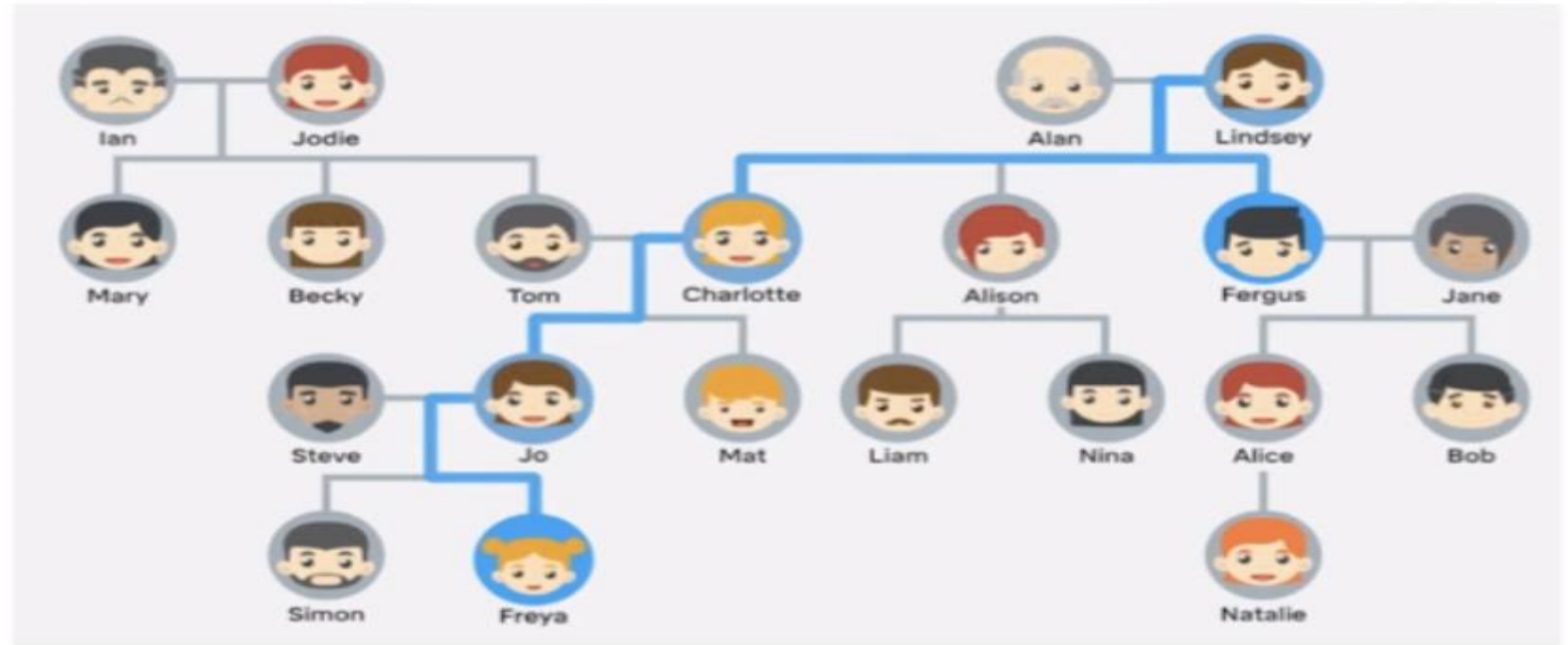
$\text{mother}(x, z), \text{father}(z, y)$
 $\Rightarrow \text{maternalgrandfather}(x, y)$

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

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

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

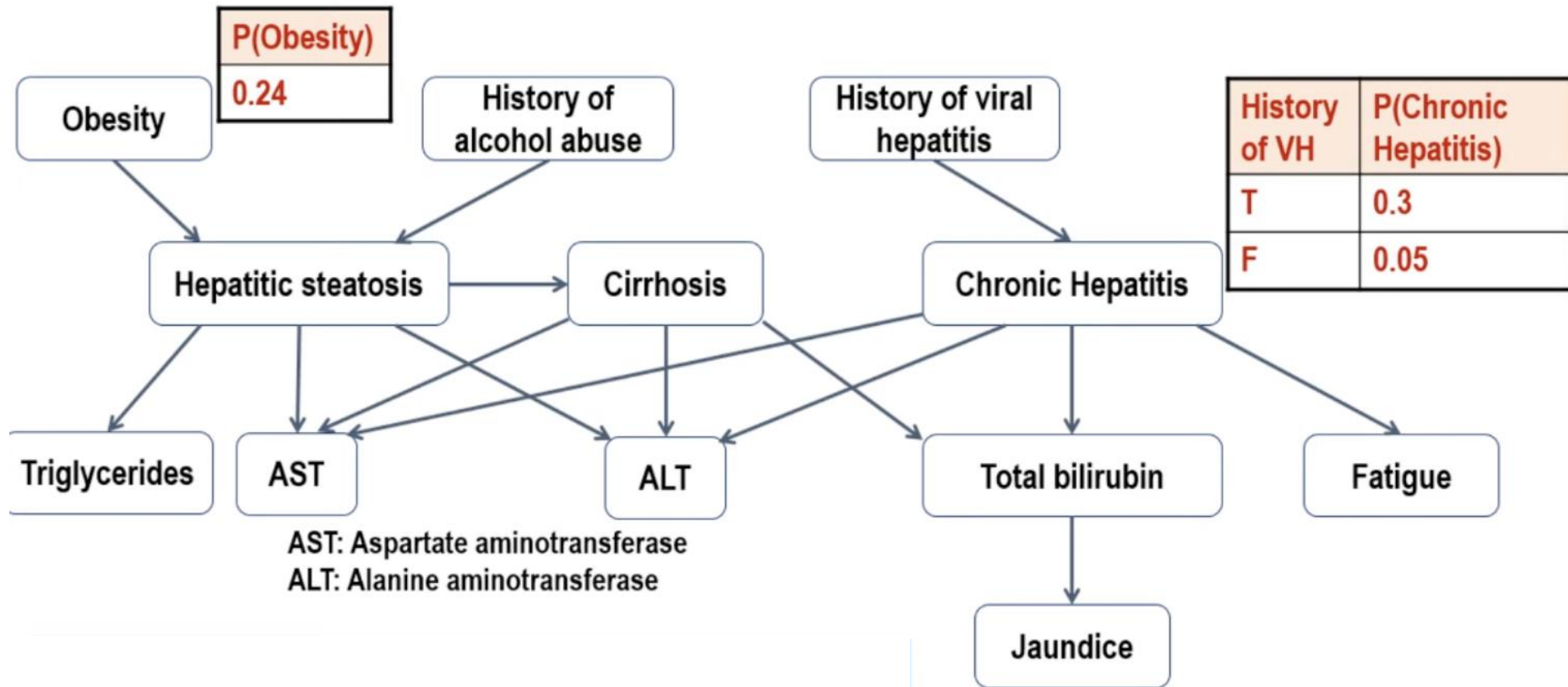
Who is the maternal great uncle of Freya?



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

How to use this?

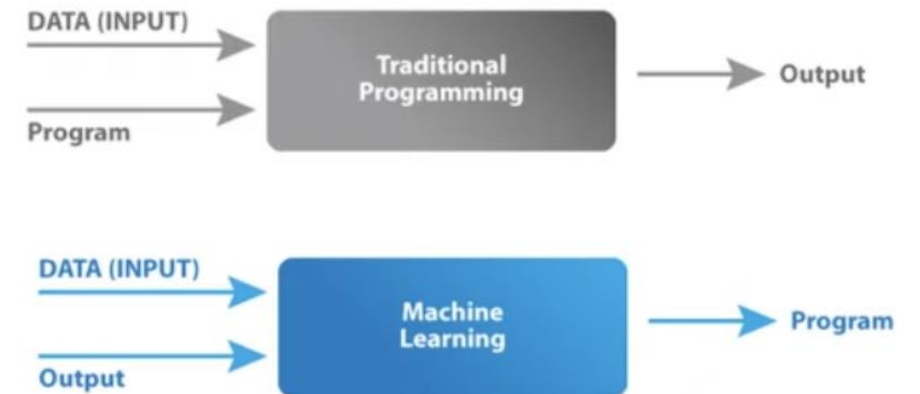
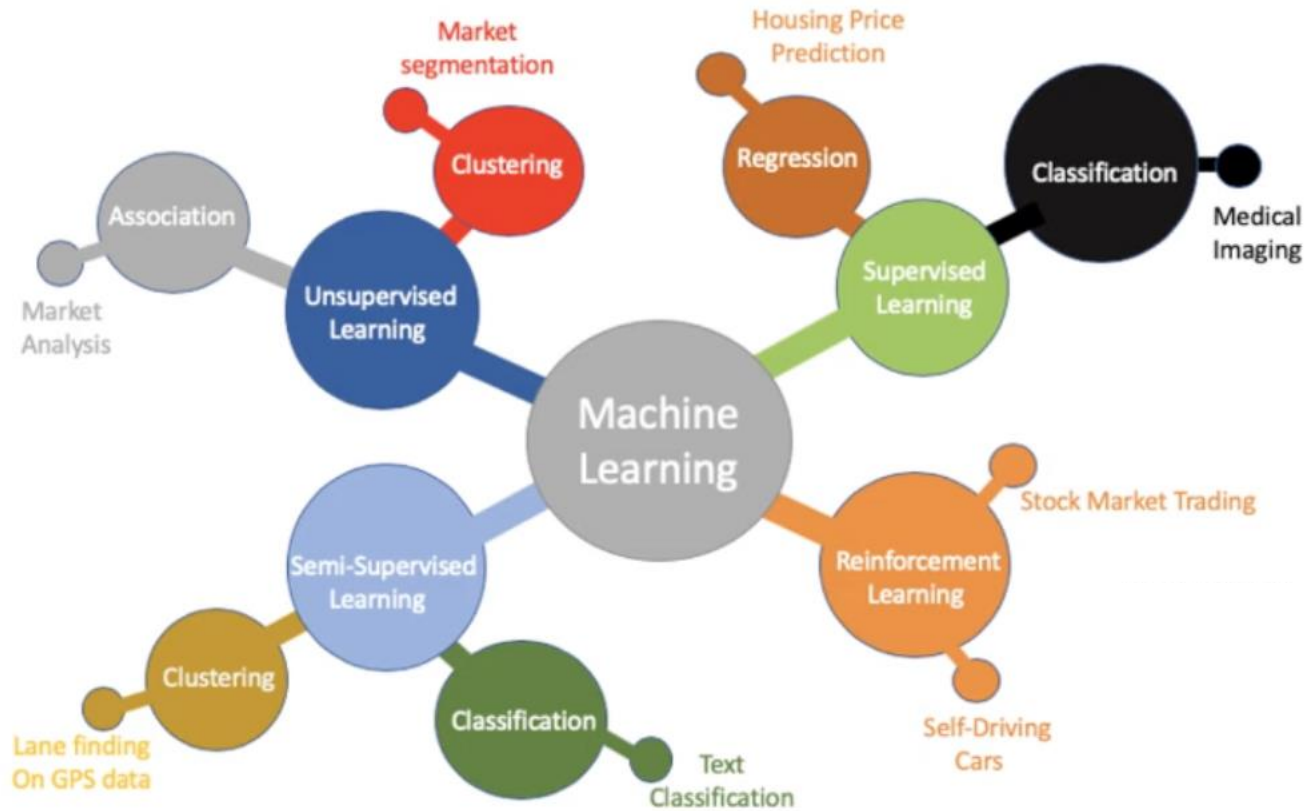
Reasoning under Uncertainty



- 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



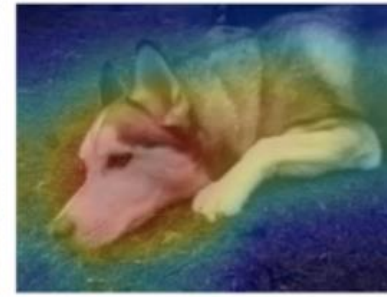
Husky Classified
as Wolf



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

Fundamentals

- The notion of expressing computation as an algorithm
- Godel's Incompleteness Theorem (1931)
 - In any language expressive enough to describe the properties of natural numbers there are true statements that are undecidable i.e., their truth can't be established by any algorithm
- Church Turing Thesis (1936)
 - The Turing Machine is capable of computing any computable function
 - This is the accepted definition of computability
 - NP-Completeness and Intractability affect the aspects of AI

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
- Introduction to IR/NLP

Thank You