Artificial Intelligence

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Intelligence: Ability to understand and react.

Allows:

1. React dynamically and quickly.
2. Recognize the relative importance of different elements of the situation.
3. Handling ambiguity, contradictions, incomplete and uncertain information.

AI

Artificial Intelligence (AI) refers to the development of abilities of natural intelligence to an extent ia machine.

Definitions

John McCarthy

The term "AI" was coined by John McCarthy (MIT, 1956). AI being a branch of computer science, is concerned with making computers behave like humans.

Rich and Knight

"AI is the study of how to make computers do things which at the moment people are better at doing" – Rich and Knight

Akerkar and Sajia

"AI is the branch of computer science that attempts to solve problems by mimicking the human thought process using heuristics and a symbolic, non-algorithmic approach" - Akerkar and Sajia

John Durkin

"AI is the field of study in computer science that pursues the goal of making a computer reason in a manner similar to humans" - John Durkin

Approaches

Thinking Humanly:

- Cognitive modeling approach
- This approach tries to solve a problem by seeing how human brains work and tries to incorporate the human problem-solving process into a machine by one of three ways:
  - Introspection (Observing one's own thoughts)
  - Psychological experiments (Observing someone else in action)
  - Brain imaging (Observing the brain in action)

Thinking Rationally:

- Laws of thought approach
- This approach is based on logic and the process of reasoning.
- It uses syllogisms which when provided patterns for argument structures always yield conclusions given correct premises.

Acting Humanly:

- Turing test approach
- In this the interrogator asks questions to both a human and machine. If he is unable to discriminate who is who, the machine passes the Turing test.
- To pass the Turing test, a machine must be equipped with techniques for natural language processing (NLP), knowledge representation, automated reasoning and machine learning

Acting Rationally:

- Rational agent approach
- A rational agent is one, so as to achieve the best outcome or the best expected outcome when there is uncertainty
- It is more generalized than the Laws of thought approach

Task Domains

1. Mundane tasks:
    - Perception
    - Communication (NLP)
    - Common sense reasoning
2. Formal Tasks:
    - Game Playing
    - Mathematical reasoning
3. Expert tasks:
    - Engineering tasks
    - Medical tasks

AI Techniques

1. Search based Techniques

    1.1. Brute Force Search (Uninformed)

    1.2. Informed Search (Heuristic)

2. Knowledge
3. Abstraction

Search techniques:

1. Search provides a way of solving problems for which no more direct approach is available. It also provides a framework into which any direct techniques that are available, can be embedded.
2. A search program finds the solution of a problem by trying various sequences of actions until a solution is found.

Advantages:

- Search techniques might be the best way when all other options are exhausted.
- The search process itself finds the sequence of actions to achieve the goal.

Disadvantages:

- In real world problems, the search space is so large that it is impossible or impractical to explore the entire search space.

Knowledge based Techniques:

The use of knowledge provides a way of solving complicated problems by manipulating the structures of concerned objects. Knowledge is indispensable but also voluminous and constantly changing (dynamic), hard to characterize accurately. Also, the organization of knowledge greatly impacts its usage and efficiency of the technique using it.

An AI technique, is a method that exploits knowledge that should be represented in such a way that:

- The knowledge captures generalization so that a separate representation of individual situations is not required.
- Important properties of situations are grouped together else the knowledge reduces to simply a large amount of data.
- It is understandable by the people involved in the project.
- It is easily modifiable to reflect changing situations.
- It is usable, even when information is not accurate or complete.
- It should be able to narrow down the range of search possibilities.
- It finds a way of separating important features and notifications from the unimportant ones, that would confuse any process.

AI Solutions

Two categories:

1. Weak Solutions/Weak AI
    - General search methods.
    - Not motivated by achieveing human level performance.
    - Primary aim for these solutions is ***NOT*** to model how a human thinks.
    - They require more computations and less knowledge.
    - These methods aim to solve any problem.
    - Not very effective in specific tasks.
    - For e.g. A* search.
2. Strong solutions/Strong AI

    AKA Knowledge-based, or intensive solutions

    - Used for expert systems.
    - More knowledge, hence less computations.
    - Achieve better performance in specific tasks.
    - Can be guided by weak AI.

Phases of AI Solutions:

1. Search and Logic
2. Probability Based
3. Neural Networks

Problem Formulation

State - Information about environment. It is a general representation of a problem. Technically, the state should contain *all* information about its environment. While describing a problem, we generally only include all the information necessary to make a decision for the task at hand.

State Space - The set of all possible states. Each state represents a possible configuration of the problem. The problem can make a transition from one state to another by using one of the actions or operators available. An operator refers to some representation of an action. An operator usually includes information about what must be true in the world before the operator is applied, and how the world is changed after the operator is applied.

State Space Search

The state space search problem solving method is a way of defining a given problem as a problem of moving around in a state space, where each state corresponds to a legal position in the problem.

The problem solving progresses by starting at an initial state, using a set of rules to move from one state to another, and attempting to end up in a final state.

Types of State Views

1. Atomic View States are numbered to be differentiated, but we cannot view the details of each state, or the values of the variables in the state.
2. Propositional/Factored View We can view inside the state.
3. Relational View State objects are represented in how they relate to each other.
4. First Order View (Relational + Functions)

Question **- Consider a problem where we have 2 rooms and 1 vacuum cleaner. Each room may or may not have dirt in it. The vacuum cleaner can only be in one room at a time.How will this problem be represented in all the 4 views?**

R1 - Room1

R2 - Room2

D - Dirt

ND - No Dirt

V - has vacuum cleaner

Atomic View

1. (R1DV, R2D)
2. (R1D, R2DV)
3. (R1DV, R2ND)
4. (R1D, R2NDV)
5. (R2NDV,R1D)
6. (R2ND,R1DV)
7. (R1NDV,R2ND)
8. (R1ND,R2NDV)

Do rest later

Problem Solving

1. Define/Formulate the Problem.
2. Analyze
3. Task Knowledge
    - Isolation
    - Knowledge Representation
4. Choose an appropriate technique and apply it.

Steps to Define/Formulate a Problem

1. States
2. Inital State
3. Actions
4. Transition Model
5. Goal Test
6. Path Cost

Question Travel from City A to City B (formulate the problem using above 6 steps)

1. **States**

    Each state is a location between A and B.

2. **Initial State** - A
3. **Actions**
    - Choosing a mode of transport from A to some intermediate location, say C.
4. **Transition Model**
    - The state resulting from travelling from a previous location to the current location will have the current location as source, for the next segment of the journey.
5. **Goal Test**
    - Is current location same as specified destination location.
6. **Path Cost**
    - Path cost can be either the amount of fare expended, time taken, or distance travelled.

Chess Board

1. States 32 pieces, each of which can have 64 position. Each state will be defined by a 32-tuple containing the X and Y co-ordinate of each piece, and which player's turn it is (B/W). If a piece has been moved off the board, it's coordinates will be (-1,-1).
2. Initial State Each piece will be at the starting position defined in chess. Starting player is white.
3. Actions Each piece has certain rules for movement. Each player takes turns in moving, and can only move one piece at a time, following the legal rules for that piece. Pieces off the board cannot be moved.
4. Transition Model Each movement will result in a new state defined by the new positions of the pieces, and the turn will change. Movement for each piece will be according to the rules for that piece.
5. Goal Test
    - Checkmate from either side. (Win/Lose)
    - No possible moves from either side. (Draw)
6. Path cost can be either the time taken, the number of pieces lost, or the number of moves taken until the game ends.

Vacuum Cleaner

1. **States**
    - Each room can be dirty/not dirty.
    - Vacuum cleaner can be in Room 1 or Room 2
2. **Initial State**
    - The rooms can be in any configuration. We can choose which room to put the vacuum cleaner in .
3.

***Question* 8 Puzzle Problem**

Consists of a 3x3 board with 8 numbered tiles and a blank space. A tile adjacent to the blank space can slide into the space. The objective is to reach a specified goal state.

For example:

7	4	3
1		2
5	9	8

7	8	9
1	3	2
5	4	

(Initial State on the left, Desired Final State on the Right)

1. **States**

   A state description specifies the location of each of the 8 tiles and the blank space in one of the nine squares.

2. **Initial State**

   Any possible configuration can be designated as initial state.

3. **Actions**

   Actions can be defined as *movements of the **blank*** space left,right,up or down. Different subsets of these are possible depending on where the blank spsace is.

4. **Transition Model**

   Given a state and action, this returns the resulting state. For example, if we apply the action *left* to the start state, the resulting state will have 1 and the blank space switched.

5. **Goal Test**

   In this we compare whether the current configuration matches the goal configuration.

6. **Path Cost**

   Let us assume each move costs 1. Path cost will be number of steps.

Production System

A production system provides a structure for the search process in AI system It is a program or system that facilitates in descirbing the search process and performing the search process

Prodcution syntax

$$if \rightarrow then$$

$$antecedent \rightarrow consequence$$

Control Strategies

Control Strategies decide which rule to apply next during the search process It needs to deal with certain situations like:

- absence of any rules exactly matching the given fact
- more than one rule matching the given fact

  In this case a conflict resolution strategy must be used to decide on a single matcing rule

A good control strategy saves time.

Characteristics of a Good Control Strategy

1. It should cause movement which takes us nearer to our goal. Each appliaction of an if-else rule should take us closer to our goal.
2. It should be systematic.

Water Jug Problem

You are given 2 jugs 4L and 3L wihtout any marking and a tap to fill the 2 containers with water.

The Goal is to get exactly 2L of water in the 4L water jug.

1. Formulate it as a space search Problem
2. Enlist all the possible rules
3. Find a possible solution
4. Apply BFS and DFS

X - water in 4L jug

Y - water in 3L jug

Inital State $(x, y) \rightarrow (0, 0)$

ANSWER

(0,0)

(4,0)

(1,3)

(1,0)

(0,1)

(4,1)

(2,3)

Rules

$(x, y) \rightarrow (0, 3)$

$(x, y) \rightarrow (4, 0)$

$(x, y) \rightarrow (x, 0)$

$(x, y) \rightarrow (0, y)$

if (x+y>=4 and y>0) :

$(x, y) \rightarrow (4, y - (4 - x))$

if (x+y>=3 and x>0):

$(x, y) \rightarrow (x - (3 - y), 3)$

if(x+y<=4 and y>0):

$(x, y) \rightarrow (x, y, 0)$

if(x+y<=3 and x>0):

$(x, y) \rightarrow (0, x + y)$

Formulating with 6 steps

States

Both jug can be empty or may have certain amount of water in them. Represented as:

$(0...4, 0...3)$

Inital States

Both jugs are empty

$(0, 0)$

Actions

- Fill up either container.
- Empty either container.
- Pour contents of one container into another.

Transitions (same as rules mentioned above.)

Goal Test

We will have reached our goal if 4L jug has 2L water.

I.e, if $state == (2, x)$, where $x \in [0, 3]$

Path Cost

Path cost can be:

- Number of moves.
- Amount of Water taken from tap.

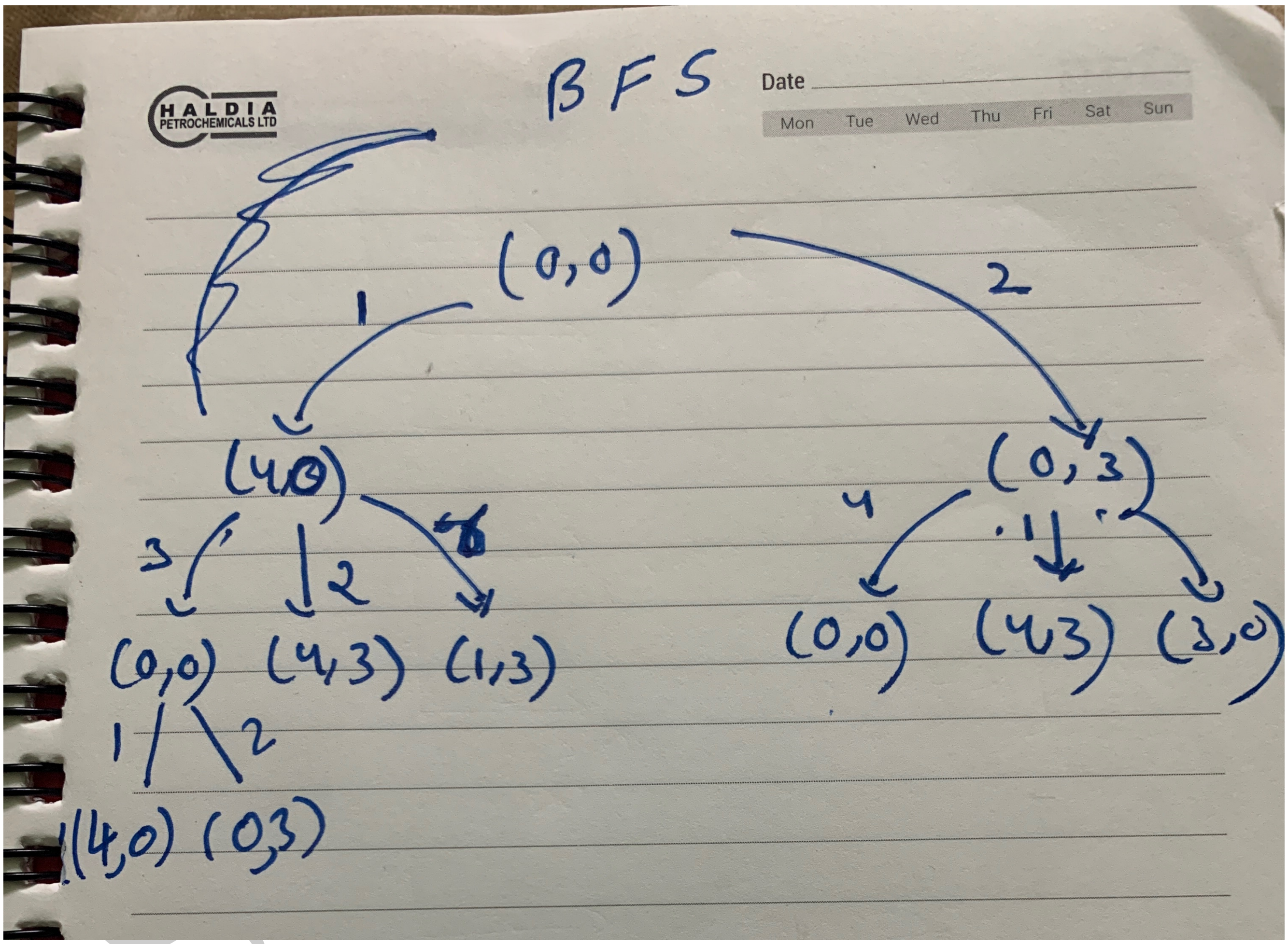

Figure 1: State Transition Tree for Water Jug Problem