CS-208: Artificial Intelligence
Lectures-03
AI Problem Characteristics

Seven AI Problem Characteristics

CHARACTERISTIC-I: Is the problem decomposable or not?

Decomposable means that breaking the given problem into smaller(Independent) sub-problems, each of which can be solved by using small collection of specific rules.

Advantage: Large problem can be solved easily using this problem decomposition technique

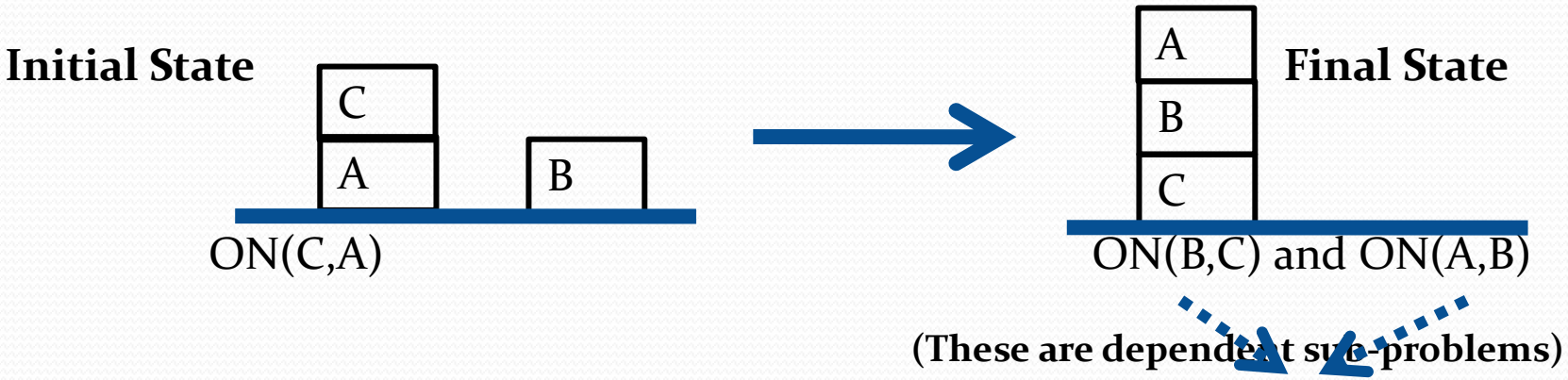
Problem-1: Integration (Example of Decomposable Problem)

$$\int (x^2 + 3x)dx = \int x^2 dx + \int 3x dx + c = \frac{x^3}{3} + \frac{3x^2}{2} + c$$

(These are independent sub-problems)

Conclusion: ***Here the sub-problem are independent and can be solved separately in parallel. So this problem is decomposable***

- **Problem-2 : Block World (Example of Non-decomposable Problem)**



Rules of the Game:

1. CLEAR(*x*) → ON (*x*, Table) *Pick the Block X and place it on the table*

   if block x has nothing on it

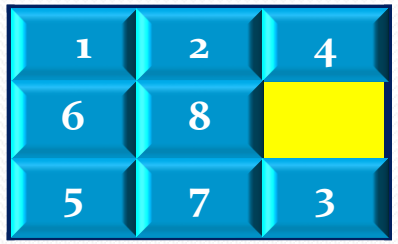
2. CLEAR(*x*) and CLEAR(*y*) → ON(*x*, *y*) *Place Block X on Block Y*

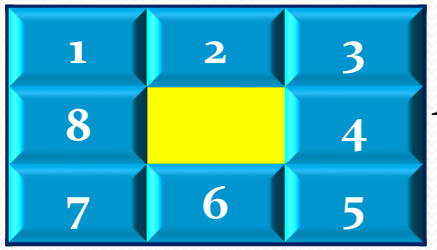
Conclusion: ***Here the sub-problem are dependent and can be solved in sequence. So this problem is not decomposable***

CHARACTERISTIC-II: Can Solution Steps be Ignored or Undone?

Consider the following three types of problems:

1. Mathematical Theorem Proving.
2. The 8-Puzzle Problem: There is square tray in which eight small square tiles are placed. Each tile has distinct number (1 to 8) on it. The ninth small square tile space is uncovered creating a blank space. A tile that is adjacent to the blank space can be slide into the place. A game consist of a starting position and a specified goal position. The Goal is to transform the starting position into goal position by sliding the tiles around'

Initial State 

→ 

Final State

3. Playing Chess .

These problems are belong to three different classes, namely:

1. ***Ignorable Class***: in which solution steps can be ignored. Theorem proving is an example of ignorable class problem. This class of problems can be using a simple control structure that never backtrack(easy to implement).
2. ***Recoverable Class***: in which solution steps can be undone. The 8-puzzle is an example of recoverable class problem. This class of problems can be solved by a slightly more complicated control strategy that does sometimes make mistakes and backtracking will be necessary to recover from the mistakes using stack.
3. ***Irrecoverable Class***: in which solution steps can be neither ignored nor undone. Playing Chess is an example of irrecoverable class problem. This class of problems can be solved by a system that expends a great deal of effort in making each decision (since every decision must be final) and planning process

CHARACTERISTIC-III: Is the Problem Universe Predictable?

In 8-puzzle problem, we know exactly what will happen every time we will make a move. Here, it is possible for us to plan an entire sequence of moves to get into goal state and confident about the resulting state.

Advantage: We can use planning to avoid having to undo an unwanted move during actual moves. Still it be necessary to use backtrack wrong moves during the planning process.

In card games like bridge, this type of planning is not be possible. Because it is not possible to know where are all the cards or what other player will do them during their turns.

Types of Problems

1. Certain Outcome: Example 8-puzzle problem, where the problem universe is predictable. This type of problems can be solved by planning *without feedback from the environment*.

2. Uncertain Outcome: Example card games, where problem universe is not predictable. This type of problems may be solved by using probability and plan revision according to *the feedback from the environment* during the game is required.

CHARACTERISTIC-IV: Is good solution Absolute or Relative?

Problem-1 (Here *Good Solution is Absolute*)

Consider the following facts on a database:

1. Marcus was a man.
2. Marcus was a Pompeian.
3. Marcus was born in 40 A.D.
4. All men are mortal.
5. All Pompeian died when the volcano erupted in 79 A.D.
6. No mortal lives longer than 150 years (*in the context of human*).
7. It is now 2020 A.D.

Find an asnswer to the question: *Is Marcus alive now?*

8. Marcus is mortal ← from 1 and 4
9. Marcus age is 1980 ←from 3 and 7
10. Marcus is dead now ← from 6, 8 and 9

One way reasoning to get the answer

11. All Pompeian are dead now ←from 7 and 5.
12. Marcus is dead now ←from 11 and 2

Alternative way of reasoning to get the answer

Here there are two reasoning paths that will lead to the answer and we are interested in any one of the answer to question irrespective of which path was being followed.

If we followed one path that successfully lead to the answer then there is no reason to go back and explore other paths that might also lead to the solution

Problem-2: The travelling Salesperson (*Here Good solution is Relative*)

Problem Statement: To find shortest route in visiting each city exactly once from the given list of cities with starting and ending with one of the given city.

Solution: Find distances for all possible routes (*finding the all possible candidate solution*) and select the route with shortest distance (*selecting the best candidate solution*).

Any Path Problem (good solution is absolute)	Best Path Problem (good solution is relative)
Easier to solve	Harder to solve
It can be solved in a reasonable amount of time using heuristics that suggest good path to explore	Much more exhaustive search will be needed.

CHARACTERISTIC-V: Is the Solution a State or Path?

Problem-1: Consider the interpretation for the sentence: "*The bank president ate a dish of pasta salad with the fork*".

Consider following components of this sentence (these components have more than one interpretaions and one of them is appropriate):

- ***Bank*** → *one meaning is Financial Institution and the other is a side(bank) of a river.*
- **Dish** → *one meaning is* a *food (prepared in a particular way) and the other is concave pot.*
- **Pasta salad** → *one meaning is salad containing pasta and the other can be like* ***dog-food*** *does not contain dog.*
- **With the fork** → *one meaning modifies the verb eat and other modification structures like with vegetable and with his/her friends.*

Because of interaction among the interpretations of the constituents of this sentence, some search may be required to find the final interpretation for the sentence. So solution to the problem is the sequence of operations that produce the final state.

Problem-2: Water Jug Problem.

Here it is sufficient to report that the problem is solved and the final state is (2,0).

CHARACTERISTIC-VI: What is the Role of Knowledge?

Knowledge Required for playing Chess(confined to chess game):

1. Rules for making the legal moves
2. Control strategy mechanism
3. Good strategy and tactics to constrain the search and speedup execution.

Knowledge Required for Understanding News Story / matter (very vast) :

Requires lot of previous knowledge about persons, events, situations, etc. to understand /follow the news.

CHARACTERISTIC-VII: Does the Task Requires Interaction with a Person?

Based on this characteristic the AI problems can be divided into two categories namely: *Solitary* and *Conversational*.

Solitary: in which the computer is given a problem description and produces an answer with no intermediate communication and/or no demand for an explanation of the reasoning process.

***Conversational*:** in which there is intermediate communications between a person and the computer, "**either** *to provide addition assistance to the computer* **or** *to provide additional information to the user* **or** *both*".