Knowledge Representation Techniques

Reasoning

- Monotonic Reasoning:
  - Once the conclusion is taken, then it will remain the same even if we add some other information to existing information in our knowledge base.
- Non-Monotonic Reasoning
  - Some conclusions may be invalidated if we add some more information to our knowledge base.
  - It says that if a statement *w* follows from a set of premises *M* and $M \subseteq M'$, *w* does not necessarily follow from M'

Monotonic Logic

- Adding knowledge does not decrease the set of prepositions that can be derived.
- To solve monotonic problems, we can derive the valid conclusion from the available facts only, and it will not be affected by new facts.
- Monotonic reasoning is used in conventional reasoning systems.
- Any theorem proving is an example of monotonic reasoning.
- Example: Earth revolves around the Sun.
  - It is a true fact, and it cannot be changed even if we add another sentence in knowledge base like, "The moon revolves around the earth" Or "Earth is not round," etc.

Monotonic Logic

Advantages of Monotonic Reasoning:

- In monotonic reasoning, each old proof will always remain valid.
- If we deduce some facts from available facts, then it will remain valid for always.

Disadvantages of Monotonic Reasoning:

- We cannot represent the real world scenarios using Monotonic reasoning.
- Hypothesis knowledge cannot be expressed with monotonic reasoning, which means facts should be true.
- Since we can only derive conclusions from the old proofs, so new knowledge from the real world cannot be added.

Non-Monotonic Logic

- Logic will be said as non-monotonic if some conclusions can be invalidated by adding more knowledge into our knowledge base.
- Non-monotonic reasoning deals with incomplete and uncertain models.
- "Human perceptions for various things in daily life,“ is a general example of non-monotonic reasoning.
- Example: Suppose the KB contains following knowledge:
  - Birds can fly; Penguins cannot fly; Pitty is a bird
  - So from the above sentences, we can conclude that Pitty can fly.
- However, if we add one another sentence into knowledge base "Pitty is a penguin", which concludes "Pitty cannot fly", so it invalidates the above conclusion.

Non-Monotonic Logic

Advantages of Non-monotonic reasoning:

- For real-world systems such as Robot navigation, we can use non-monotonic reasoning.
- In Non-monotonic reasoning, we can choose probabilistic facts or can make assumptions.
- Since that Non-monotonic Reasoning depends on assumptions, It will change itself with improving knowledge or facts.

Disadvantages of Non-monotonic Reasoning:

- In non-monotonic reasoning, the old facts may be invalidated by adding new sentences.
- It cannot be used for theorem proving.

Default Logic

- The default logic is a reasoning method that allows for the drawing of conclusions from a set of given premises that are incomplete or uncertain.
- It is based on the principle of assuming the truth of something unless there is evidence to the contrary.
- Example: A rule used by football organizers might be:
  - "A football game shall take place, unless there is snow in the stadium." This rule is represented by $\frac{football : \neg\, snow}{takesPlace}$
  - The interpretation of the default is: If there is no information that there will be snow in the stadium, it is reasonable to assume ¬snow and conclude that the game will take place.
  - But if there is a heavy snowfall during the night before the game is scheduled, then this assumption can no longer be made.

Default Logic

- The main features of default logic are:
  - **Default assumptions:** these are assumptions that are made in the absence of contrary evidence.
  - **Exceptions:** these are statements that override default assumptions in the presence of specific evidence.
  - **Non-monotonicity:** this means that the truth value of a statement can change when new information is introduced.
- Default logic is often used in conjunction with other AI techniques, such as first-order logic or probabilistic reasoning.

Applications of Default Logic

- **Diagnostic reasoning:** Default logic can be used to diagnose problems when information is incomplete or uncertain. For example, a medical expert might use default logic to diagnose a patient based on symptoms and test results.
- **Planning and decision-making:** Default logic can be used to plan and make decisions when information is incomplete or uncertain. For example, a robot might use default logic to plan its actions in an uncertain environment.
- **Natural language processing:** Default logic can be used to interpret and generate natural language utterances. For example, a chatbot might use default logic to interpret a user's input and generate a response.
- **Robotics:** Default logic can be used to control robots in uncertain environments. For example, a robot might use default logic to avoid obstacles or find its way to a goal.
- **Predictive modeling:** Default logic can be used to build predictive models when information is incomplete or uncertain. For example, a machine learning algorithm might use default logic to predict outcome of a decision.

Circumscription logic

- Circumscription was introduced by John McCarthy in the 1980s.
- The key idea in circumscription is to define a minimal or simplest possible model that satisfies some initial set of assumptions, while allowing for the possibility of adding exceptions or special cases.
- In other words, it represents the "normal" state of affairs unless specific information contradicts it. It focuses on specifying which predicates should be minimized or "circumscribed" to ensure consistency while explaining away exceptions.
- Circumscription and Default Logic differ in the way they approach default assumptions and exceptions.
- Circumscription focuses on finding a minimal model that captures normal behavior while explaining exceptions, while Default Logic employs default rules to handle defaults and exceptions explicitly.
- The choice between these formalisms depends on the specific problem domain and the requirements of reasoning.