Parul® University

ARTIFICIAL INTELLIGENCE II

UNIT-6

Symbolic Reasoning Under Uncertainty

Objectives of unit 6

6.1 Introduction To Nonmonotonic Reasoning
6.2 Logics For Non-monotonic Reasoning

6.1 Introduction To Nonmonotonic Reasoning

- **Symbolic reasoning under uncertainty** deals with situations where knowledge is incomplete, inconsistent, or subject to change.
  - Traditional logic assumes that knowledge is static and complete, but real-world scenarios often involve uncertainty.
- **Nonmonotonic reasoning** provides a framework to reason in dynamic and uncertain environments where conclusions can be revised.

6.1 Introduction To Nonmonotonic Reasoning

Nonmonotonic Reasoning

Definition: Nonmonotonic reasoning is a type of reasoning where adding new knowledge can invalidate previous conclusions.

•It models real-world reasoning, handling incomplete or evolving knowledge.

Key Characteristics:

1. **Revisable Conclusions**:
   - Conclusions may be withdrawn if new evidence contradicts them.
   - Example: "Birds fly" is revised when we learn about penguins.
2. **Default Reasoning**:
   - Assumes defaults unless proven otherwise.
   - Example: Assume someone is alive unless there's evidence they are not.
3. **Handles Incomplete Knowledge**:
   - Works with limited or uncertain information to infer conclusions.

6.1 Introduction To Nonmonotonic Reasoning

Applications of Nonmonotonic Reasoning

- **Expert Systems**: Revising medical diagnoses as new symptoms are observed.
- **Autonomous Agents**: Adjusting plans in dynamic environments.
- **Knowledge Representation**: Modeling laws, ethics, or any domain with evolving rules.

6.2 Logics for Nonmonotonic Reasoning

1. Default Logic

- **Introduced by**: Raymond Reiter (1980).
- Uses **default rules** to infer conclusions unless contradicted.
- A default rule has the form: **A : B / C**
- If A (precondition) is true and B (justification) is consistent, conclude C.
- **Example:** Rule: "If an animal is a bird and it's consistent that it can fly, assume it can fly."
- **Default:** Bird(x) : CanFly(x) / CanFly(x)
- If Bird(Tweety) and no evidence against CanFly(Tweety), conclude CanFly(Tweety).

6.2 Logics for Nonmonotonic Reasoning

2. Autoepistemic Logic

- Focuses on reasoning about an agent's knowledge of itself.

Introduces the modal operator L to represent "known" facts.

Example: ¬L(A) means "I do not know A."

Example: If an agent knows L(Bird(Tweety)) but does not know L(CanFly(Tweety)), it reasons about the lack of knowledge to infer.

6.2 Logics for Nonmonotonic Reasoning

3. Circumscription

Minimizes abnormalities by assuming normality unless specified otherwise.

If Abnormal(x) represents "x is abnormal," circumscription minimizes Abnormal(x).

Example: Knowledge Base:

- Bird(x) → CanFly(x)
- Abnormal(x) → ¬CanFly(x)

Circumscription assumes Abnormal(x) is false unless explicitly stated (e.g., penguins are abnormal birds).

6.2 Logics for Nonmonotonic Reasoning

4. Logic Programming with Negation as Failure

Assumes a statement is false if it cannot be proven true.

Commonly used in Prolog.

Example: Rule: CanFly(X) :- Bird(X), not Abnormal(X).

If Bird(Sparrow) and no evidence of Abnormal(Sparrow), conclude CanFly(Sparrow).

5. Modal Nonmonotonic Logics

Uses modal operators like □ (necessarily) and ◇ (possibly) to reason about uncertainty.

Example:

$\Box P \rightarrow Q$ means "If P is necessarily true, then Q."

6.2 Logics for Nonmonotonic Reasoning

Symbolic Reasoning Under Uncertainty

1. Bayesian Logic

Combines probabilistic reasoning with symbolic representation.

Example: "Given symptoms S, what is the probability of disease D?"

2. Fuzzy Logic

Handles vague and imprecise information.

Example: "The room is warm" might have a truth value of 0.8.

3. Dempster-Shafer Theory

Represents degrees of belief instead of strict probabilities.

4. Markov Logic Networks

Combines first-order logic with probabilistic graphical models.

Conclusion

•Nonmonotonic reasoning provides a foundation for reasoning under uncertainty, enabling systems to adapt to new information.

•It is widely used in AI applications like expert systems, autonomous agents, and knowledge representation.

•The choice of nonmonotonic logic depends on the application and computational constraints.