Propositional Logic

Introduction

- Propositional logic (PL) is a simple but powerful way to represent knowledge using symbols and logical connectives.
- It is the foundation of many AI systems, including expert systems, question-answering systems, and automated planners.

Syntax of Propositional Logic

- Atomic sentences: These consist of a single proposition symbol, which can be true or false.
- Complex sentences: These are constructed from simpler sentences using logical connectives:
    - not (¬): negates a sentence
    - and (∧): conjunction of two sentences
    - or (∨): disjunction of two sentences
    - implies (⇒): conditional statement
    - if and only if (⇔): biconditional statement

Semantics of Propositional Logic

- Models: These are possible worlds, each of which assigns true or false to every proposition symbol.
- Truth: The truth value of a sentence is determined by the truth values of its components and the connectives used to combine them.
- Truth tables: These tables specify the truth value of a complex sentence for each

possible combination of truth values for its components.

Inference in Propositional Logic

- Entailment: A sentence α entails another sentence β if β is true in all worlds where α is true.
- Inference rules: These rules allow new sentences to be derived from existing ones, such as Modus Ponens and And-Elimination.
- Resolution: A complete inference procedure that can determine if a sentence is entailed by a knowledge base.

Applications of Propositional Logic

- Automated reasoning: Used in theorem provers and other systems for formal logic.
- Expert systems: Used to represent knowledge in rule-based systems.
- Planning: Used to represent states, actions, and goals in automated planning systems.

Conclusion

- Propositional logic is a powerful tool for representing and reasoning about knowledge.
- It is the foundation of many AI applications and is an important topic for anyone interested in the field.

Predicate logic

Introduction

- Predicate logic is a more expressive language than propositional logic, allowing for the representation of objects, relations, and functions.
- It is used extensively in AI for knowledge representation, reasoning, and planning.

Syntax

- Constants: Symbols that represent objects (e.g., John, Mary, 1, 2).
- Variables: Symbols that stand for any object (e.g., x, y, z).
- Predicates: Symbols that represent relations or properties (e.g., Brother, >, Red).
- Functions: Symbols that represent functions (e.g., FatherOf, Plus).
- Terms: Expressions that refer to objects (e.g., John, FatherOf(John), x).
- Atoms: Simple sentences that state facts (e.g., Brother(John, Mary), > (2, 1)).
- Quantifiers:
    - Universal quantifier (∀): “For all” (e.g., ∀x Person(x)).
    - Existential quantifier (∃): “There exists” (e.g., ∃x King(x)).

Semantics

- Interpretation: Specifies which objects, relations, and functions are referred to by the symbols.
- Model: A possible world with objects, relations, and functions.
- Truth: A sentence is true in a model if it is satisfied by the interpretation in that model.

Examples

- “All men are mortal”: ∀x Man(x) ⇒ Mortal(x)
- “There is a king”: ∃x King(x)
- “John is the father of Mary”: FatherOf(John, Mary)

Applications

- Knowledge representation: Representing facts and rules about the world.
- Reasoning: Deriving new knowledge from existing knowledge.
- Planning: Describing states, actions, and goals for planning problems.

Conclusion

- Predicate logic is a powerful tool for representing and reasoning about complex knowledge.
- It is a fundamental part of AI and is used in many applications.

Comparison of Propositional and Predicate Logic

Feature	Propositional Logic	Predicate Logic
Syntax	Propositions, logical connectives (AND, OR, NOT, implies, if and only if)	Constants, variables, predicates, functions, quantifiers (for all, there exists)

Semantics	Truth tables, interpretations	Models, interpretations
Expressive Power	Limited, can only represent facts	More expressive, can represent objects, properties, relations
Examples	“The sky is blue”, “It is raining”	“All men are mortal”, “There exists a cat that is black”
Applications	Simple knowledge representation, rule-based systems	Complex knowledge representation, natural language processing, database systems

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