

UCS1524 – Logic Programming

Introduction to Logic Programming



Outline

- Introduction to logic programming
- Course overview
- Course objectives
- Course outcomes

Introduction

- **Artificial Intelligence (AI)** is the ability for an artificial machine to act intelligently.
- **Knowledge representation and reasoning** is the field of **AI** dedicated to representing information about the world in a form that a computer system can utilize to solve complex tasks such as
 - diagnosing a medical condition
 - having a dialog in a natural language.
- **Logic Programming** is a method that computer scientists are using to try to allow machines to reason.
- In logic programming, **logic** is used to represent knowledge and manipulate knowledge using **inferences**.

What is logic?

- The philosophical definition is that logic is a description of how **one should think**.
- In the context of AI, logic is "**formal**," which means it resembles math in its clarity and lack of ambiguity.
- E.g.
 - Logic for an even number
 - Logic to be a grandparent
 - Logic to be a sibling
- Types of logic (w.r.t AI)
 - Propositional
 - Predicate or first order

Propositional logic

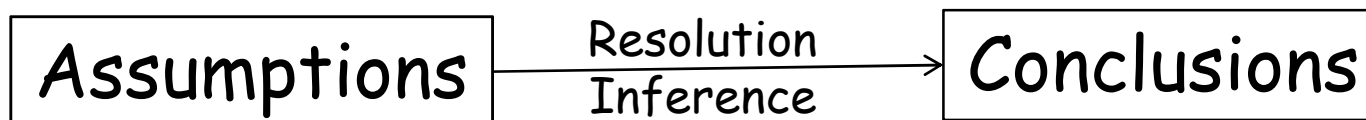
- It is concerned with propositions and their interrelationships.
- “Apple is a fruit” - **single sentence: express facts**
- “If a person is cool or funny, then he is popular” :
compound sentence: express logical relations
 - $C \vee F \Rightarrow P$
- Assumes the world contains facts
- Less expressive power
 - Some humans are intelligent
 - I like AI

First order logic

- It is an extension of propositional logic.
- Assumes the world contains
 - Objects : apple, bird, man
 - Predicates : maps to either true or false
 - $\text{Brother}(X,Y)$
 - Functions : maps to one element
 - $\text{FatherOf}(X)$
 - Quantifiers
 - All dolphins are mammals
 - $(\forall x) \text{dolphin}(x) \rightarrow \text{mammal}(x)$
 - Some mammals lay eggs
 - $(\exists x) \text{mammal}(x) \wedge \text{lays-eggs}(x)$

How to describe logic?

- Knowledge Representation
 - **Syntax**: rules used to express facts and concepts.
 - **Semantics**: determine the truth value of the logic formula.
- Knowledge Manipulation
 - **Reasoning** : specification of how an answer can be produced.
 - **Resolution inference system** : required for proving theorems



Why Prolog?

- **Prolog**, PROgramming in LOGic, is a declarative programming language which is based on the ideas of logic programming.
- Prolog was to make logic look like a programming language and allow it to be controlled by a programmer to advance the research for theorem-proving.
- Many non-logical primitives have been added to the language which are beneficial to programmers.

Example for Reasoning in Prolog

- **Example:** Given information about fatherhood and motherhood, determine grand parent relationship.
- **Facts**
 - father(Ram,Anu)
 - Mother(Nithya,Anu)
 - Mother(Selvi,Nithya)
 - Father(Shankar, Nithya)
 - In logic, words like father, mother are called *predicates*.
 - A statement like father(Ram,Anu) is called an atomic formula called an *atom*, stating a true fact
- **Express the grand parent relationship:**
 - grandparent(X,Z) : parent(X,Y), parent(Y,Z).
 - parent(X,Y) : father(X,Y).
 - parent(X,Y) : mother(X,Y).
 - *These are called conditional statements*
- **?- grandparent(Q,Anu)**

Course Overview

- Logics
 - Propositional logic
 - Syntax, semantics and resolution principles
 - Predicate logic or First order logic
 - Syntax, semantics and resolution principles
- Logic Programming
 - Answer generation
 - Horn Clause Programs
 - Semantics of logic program
 - Procedural semantics
 - Model-theoretic semantics
 - Evaluation Strategies

Course Overview

- **Programming in Prolog**
 - Syntax and semantics
 - Facts, questions and variables
 - Rules and structures
 - I/O and Exception handling
- **Prolog and AI**
 - Data structures
 - Problem solving strategies in AI
- **Prolog and Expert Systems**
 - Features, functions, structure
 - Knowledge representation and shell implementations

Course Objective

- To understand the foundations of Logic programming
- To learn programming in PROLOG
- To implement informed and uninformed search algorithms in PROLOG
- To implement Expert system shell in PROLOG

Course Outcome

- Understand the foundations of logic (K2)
- Understand the foundations of logic programming (K2)
- Write programs in PROLOG (K3)
- Implement AI search algorithms in PROLOG (K3)
- Implement a simple Expert system shell in PROLOG (K3)

Books

- **TEXTBOOKS**

1. Uwe Schoning, “Logic for Computer Scientists”, Birkhauser, 1999 (Units I, II).
2. Ivan Bratko, “PROLOG: Programming for Artificial Intelligence”, 4th Edition, Pearson, 2011 (Units III, IV, V).

- **REFERENCE BOOKS**

1. Kees Doets, “From Logic to Logic Programming”, MIT Press 1994.
2. Patrick Blackburn, Johan Bos, Kristina Streignitz, “Learn PROLOG Now”, College Publications, 2006.
3. Dennis Merritt, “Building Expert Systems in PROLOG”, Amzi! Inc. 2000
4. Helder Coelho, Jose C Cotta, “PROLOG by Example: How to Learn, Teach and Use It”, Springer–Verlag, 2011.
5. W F Clocksin, C S Mellish, “Programming in PROLOG”, Springer-Verlag, 2016.