Logic Programming PROLOG

• Motivation & Conceptualization:
  What is Logic?  What is Logic Programming?

• Foundations:
  Terms, Substitution, Unification, Horn Clauses
  Proof (Resolution)

• Examples:  List Processing; Integer

• Issues
  Search Strategies, Declarative/Procedural, . . .

• Operators — NOT, !

• Utilities
An **EXPERT SYSTEM** is

a **computer program** which exhibits Expert Level performance in solving complex problems.

Reasons with *Facts about the World*: Combines

- General Facts/Rules (about Diseases, ... ) with

- Specific Facts (about Patient)

to Produce *new Facts* (diagnosis).
MEDICAL Expert Systems

- MYCIN: Blood Infections  
  (Shortliffe @ Stanford)

- CADUCEUS: Internal Medicine  
  (Pople @ Pittsburg)

- CASNET: Glaucoma  
  (Weiss @ Rutgers)

- Present Illness Program: Kidney  
  (Pauker @ MIT)

- Digitalis Advisor: Erratic Heartbeat  
  (Silverman @ MIT)

- VM: Ventilator Management  
  (Fagan @ Stanford)

- ALVEN: Ventricle Movement  
  (Tsotsos @ Toronto)

- ONCOCIN: Cancer Treatment Protocols  
  (Shortliffe @ Stanford)

...
Domains

- Medicine
- Chemistry
- Instruction
- Job-Shop Management
- Financial Planning
- Computer Diagnosis, Configuration
- VLSI Design
- Molecular Genetics
- Signal Analysis
- Structural Mechanics
- Mathematics
Logic Programming Framework

Is $\sigma$ true?

Knowledge Base

Proof Procedure

Yes ... No
Advantages of Framework

• Simply store “truths”

• Information is
  – Modular
    * Easy to Build
    * Easy to Modify (Extend, Debug)
    * Capable of Explanation
  – Declarative
    – Re-use same info for different tasks
Computers Manipulate **SYMBOLS**

- Numbers
  - 3, 5, ...
  - Addition, ...

- Propositions
  - “D1 is an inverter”,
    “Fred has a fever”, ...
  - Deduction, ...

Motivation
SIMPLE DEDUCTION

• Socrates is a man.

• If Socrates is a man,
  Then Socrates is mortal.
SIMPLE DEDUCTION

- Socrates is a man.

- **If** Socrates is a man, **Then** Socrates is mortal.

- Socrates is mortal.

General:

\[ \alpha \Rightarrow \beta \]

\[ \alpha \]

\[ \beta \]
Example of Deduction

Goal: Socrates is Mortal

Socrates is Mortal
RULES  
R1: If Socrates is Man  
Then Socrates is Mortal  

FACTS  
ode  
ode  
ode  
Socrates is Man  
ode  
ode
Example of Deduction

**Plato is Mortal**

**Plato is Cat**

**Plato is Man**

**Plato Purrs**

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**RULES**

R1: If Plato is Man
    Then Plato is Mortal

R2: If Plato is Cat
    Then Plato is Mortal

R3: If Plato Purrs
    Then Plato is Cat

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**FACTS**

- Plato is Mortal
- Plato is Cat
- Plato is Man
- Plato Purrs
Prolog’s Proof Process

Knowledge Base

Rule Set
Fact Set

GOAL

Prolog’s Proof Process

Yes...No
Just Manipulating Symbols

• Consider
  • Today is Tuesday.
  • If Today is Tuesday, Then This is Belgium.

• This is Belgium.

• NOT Claiming
  Today is Tuesday
  ...

• GIGO
RULES:

R1: if 1) You have a Parking Permit &
    2) This space is Permit-Parkable,
then You can park at this space.

R2: if 1) This space is a Parking Space &
    2) Permit-Sign at this space &
    3) Current date is Acceptable,
then This space is Permit-Parkable.

R3: if 1) Current time is 7am-Midnight &
    2) This space is Permit-Parkable,
then You can park at this space.

R4: if 1) Current month is Dec-Mar,
then Current date is Acceptable.

R5: if 1) Current month is in Apr-Nov &
    2) Current day of month is \( \leq 15 \),
then Current date is Acceptable.
**Backward Chaining**

**GOAL:** You can park at this space.

**FACTS:** This space is a Parking Space.  
You live near this space.  
You have a Parking Permit.  
Current month is in Apr-Nov.  
Current day is Tuesday.  
Current day of month is $\leq 15$.  
Permit-Sign at this space.  
You own a car.  
Your car is $> 5$ years old.  
Current time is 3am.  
You have $18.00$.  
...
You can park at this space.

You have a Parking Permit.

This space is Permit-Park.

... parking space.

Permit-Sign...

... Dec-Mar.

...
R7: if 1) You live near this space &
    2) You own a car &
    3) You apply for a permit,
    then You have a Parking Permit.

R8: if 1) You can park at this space
    then You can take a car.
You can take a car.

You can park at this space.

You have a Parking Permit.

... live near...
... own car.

... apply for Permit.

This space is Permit-Park...

... parking space.

... Dec-Mar.

... <
Elaborations

- Certainty Factors

- User Interaction
  Focus of Attention, “Human Engineering”

- Variables

- Control of Search
  - Which (Sub)Goal?
  - Which Rule?
Research Issues

- Faster Computation
- “Deeper Knowledge”
  - First Principles
  - “Meta”
- Reasoning
  - Better Explanation
  - Theory of Decision Making
- Knowledge Acquisition
Other Types of Issues

- Technical
- Speed
- Reliability
- Social (Convincing)
- Legal/Political