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

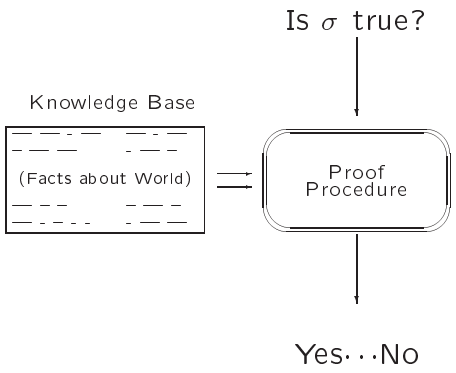
- MYCIN: Blood Infections
  (Shortliffe @ Stanford)
- CADUCEUS: Internal Medicine
  (Pople @ Pittsburg)
- CASNET: Glaucoma
  (Weiss @ Rutgers)
- Present Illness Program: Kidney
  (Pauker @ MIT)
- Digitalis Advisor: Erratic Heartbeat
  (Silverman @ MIT)
- VM: Ventilator Management
  (Fagan @ Stanford)
- 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



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, . . .

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:

$$\frac{\alpha \qquad \alpha \Rightarrow \beta}{\beta}$$

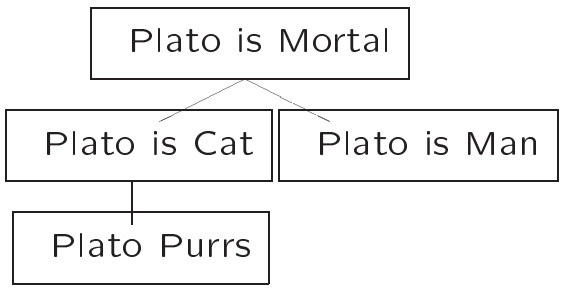
Example of Deduction

Goal: Socrates is Mortal

Socrates is Ma

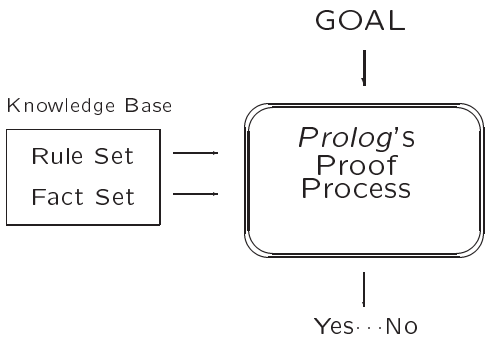
RULES	FACTS
	o
R1: If Socrates is Man	o
Then Socrates is Mortal	o
	o
	Socrates is Man
	o
	o

Example of Deduction



RULES	FACTS
	o
R1: If Plato is Man	o
Then Plato is Mortal	o
R2: If Plato is Cat	o
Then Plato is Mortal	o
	Plato Purrs
R3: If Plato Purrs	o
Then Plato is Cat	o
	o

Prolog's Proof Process



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.

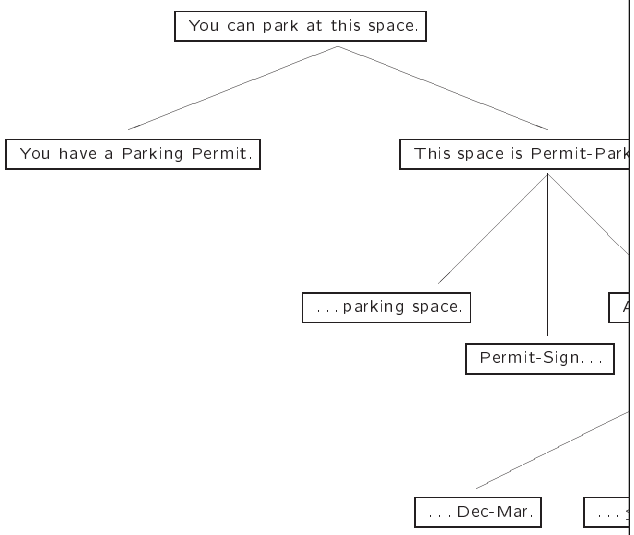
R4: if 1) Current month is Dec-Mar,
then Current date is Acceptable.

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

Backward Chaining

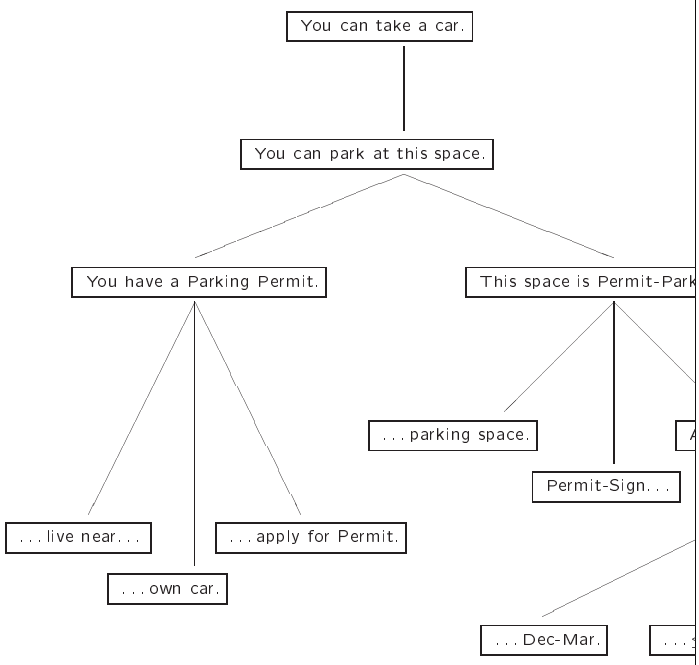
GOAL: You can park at this space.

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.
. . .



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.



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