EXPERT SYSTEMS

Fundamentals of Artificial Intelligence

Session 14

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Agenda

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Introduction

Expert Systems

Rules Engine

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Expectation vs. Reality

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Challenges

4

- ❑ A Lot of Hard work
  - ❖ Know The Details Of The Suit
  - ❖ Get Your Story Straight
  - ❖ Do Your Research
  - ❖ Understand The Law

- ❑ Constantly Updating Yourself With New Information

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Introducing Expert Systems for Lawyers

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Question-based Search
- Search less, answer more
- Save time by asking your legal question in language you would use with a colleague

Find Similar Language
- Leave no stone unturned
- Highlight text to find other cases with similar language to strengthen your position

Document Analyzer
- Ensure your arguments are bulletproof
- Check overturned and questioned treatments on a case documents

Question-focused Case Overviews
- Get straight to the point
- Automatically summarize a case in the context of your query

Case Treatments
- Avoid bad law
- Quickly spot cases that have been overturned or criticized

Ask your question in natural language.

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For Medical Practitioners

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MYCIN
- It was based on backward chaining and could identify various bacteria that could cause acute infections.
- It could also recommend drugs based on the patient's weight.
- It is one of the best Expert System example.

DENDRAL
- Expert system used for chemical analysis to predict molecular structure.

PXDES
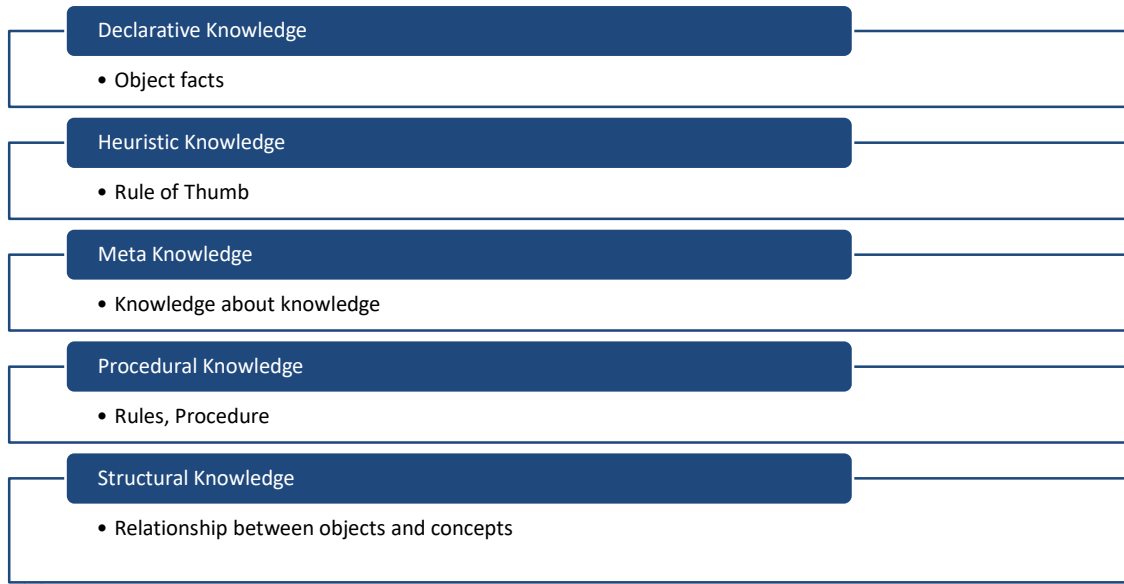- An Example of Expert System used to predict the degree and type of lung cancer

CaDet
- One of the best Expert System Example that can identify cancer at early stages

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Type of Knowledge

Declarative Knowledge
- Object facts

Heuristic Knowledge
- Rule of Thumb

Meta Knowledge
- Knowledge about knowledge

Procedural Knowledge
- Rules, Procedure

Structural Knowledge
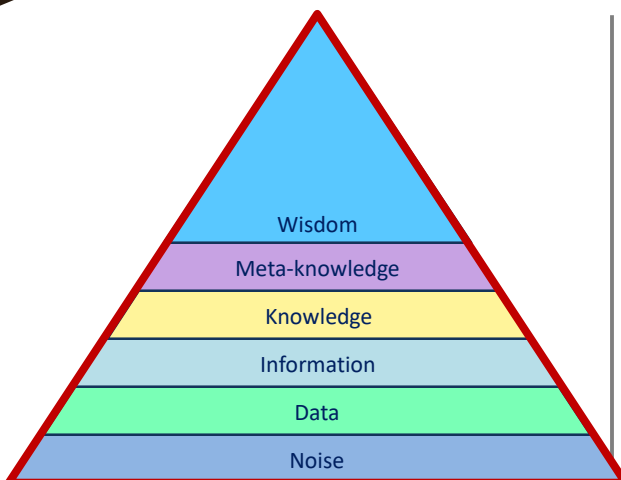- Relationship between objects and concepts

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Knowledge Pyramid

- **Wisdom:** Using Knowledge in a fruitful way

- **Meta-knowledge**: Rules about knowledge

- **Knowledge**: Rules about using information

- **Information**: Useful data, potentially knowledge

- **Data:** useful noise, potentially information

- **Noise:** just about everything in the domain

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Expert Systems

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Rule Based Expert System

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Expert System is an interactive and reliable computer-based decision-making system which uses both facts and heuristics to solve complex decision-making problems.

❑ In mid 80s AI community felt:
  ❖ Should put AI to commercial use
  ❖ Solving them as a search problem is an answer
  ❖ Get all rules of the game from domain experts

❑ Take knowledge from Lawyers, Doctors, Industry experts, put them in a system, add all the rules of the industry and you got a solution

❑ To make it work,
  ❖ Look for a condition in the domain
  ❖ Create a "condition – action" response

❑ It is a pattern directed inference system

❑ For example:
  ❖ Sitting in your house and you realize that wall looks dirty
  ❖ You know that if wall is dirty call maintenance team and get them them to paint

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A rule looks up a pattern in a part of state and modifies it to result in a new state!

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Declarative Programming

- ❑ Most of our programming comes under imperative programming
  - ❖ Imperative programming is a programming paradigm that uses statements that change a program's state

- ❑ In Expert Systems, we use declarative programming
  - ❖ Declarative programming is a programming that expresses the logic of a computation without describing its control flow

- ❑ Helpful for experts who do not have programming experience
  - ❖ Declarative programming is also called "Production"
  - ❖ Unifying format for heuristic knowledge, business rules and action
  - ❖ Still in use in Banking, Law and Medicine
  - ❖ Turing complete

- ❑ No pre-decided action sequence

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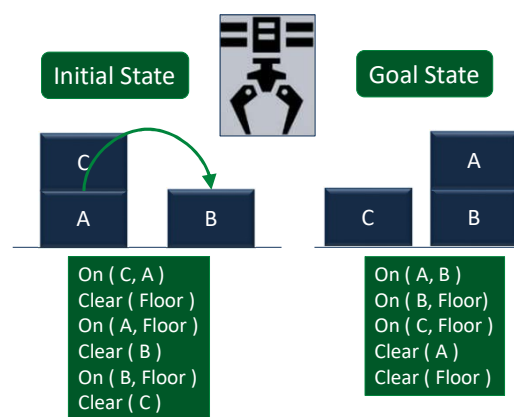
Production Rules Example

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- ❑ IF (at bus stop AND bus arrives) THEN action(get on the bus)

- ❑ IF (on bus AND not paid) THEN action(pay) AND add(paid)

- ❑ IF (on bus AND paid AND empty seat) THEN sit down

- ❑ Conditions and actions must be clearly defined
  - ❖ Can easily be expressed in first order logic!
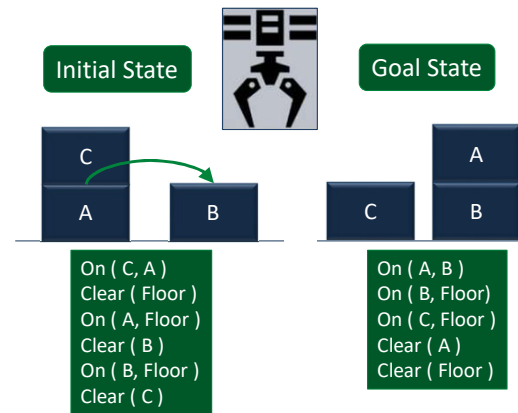
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Example - Blocks World

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Move Block A on top of B

Initial State

On (C, A)
Clear (Floor)
On (A, Floor)
Clear (B)
On (B, Floor)
Clear (C)

Goal State

On (A, B)
On (B, Floor)
On (C, Floor)
Clear (A)
Clear (Floor)

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Example - Blocks World

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Initial State

C
A   B

On (C, A)
Clear (Floor)
On (A, Floor)
Clear (B)
On (B, Floor)
Clear (C)

Goal State

A
C   B

On (A, B)
On (B, Floor)
On (C, Floor)
Clear (A)
Clear (Floor)

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Example - Blocks World

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Stack_Block

Find_Space_on_Target

Grasp

Clear_Top

Get_Rid_of_Stuff

Move

Ungrasp

Initial State

C
A   B

On (C, A)
Clear (Floor)
On (A, Floor)
Clear (B)
On (B, Floor)
Clear (C)

Goal State

A
C   B

On (A, B)
On (B, Floor)
On (C, Floor)
Clear (A)
Clear (Floor)

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Example - Blocks World – Four Blocks

17

Stack_Block

Find_Space_on_Target

Grasp

Clear_Top

Get_Rid_of_Stuff

Move

Ungrasp

Initial State

Goal State

C		D
A		B

		A
D	C	B

On (C, A)
On (D, B)
Clear (Floor)
On (A, Floor)
On (B, Floor)
Clear (C)
Clear (D)

On (A, B)
On (B, Floor)
On (C, Floor)
On (D, Floor)
Clear (A)
Clear (C)
Clear (D)
Clear (Floor)

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Example - Blocks World – Four Blocks

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Initial State

Goal State

C		D
A		B

		A
D	C	B

On (C, A)
On (D, B)
Clear (Floor)
On (A, Floor)
On (B, Floor)
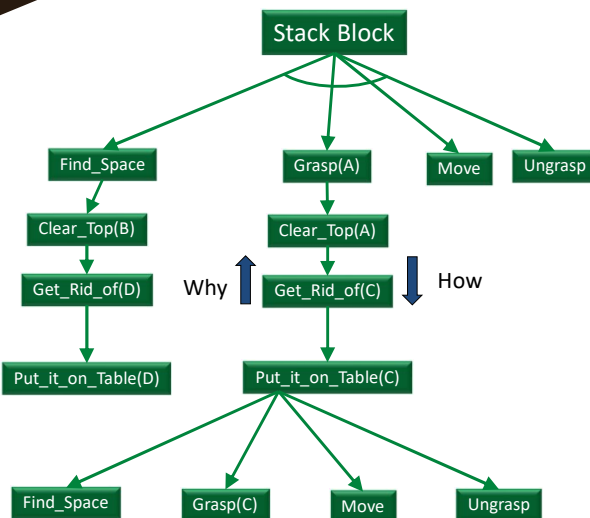Clear (C)
Clear (D)

On (A, B)
On (B, Floor)
On (C, Floor)
On (D, Floor)
Clear (A)
Clear (C)
Clear (D)
Clear (Floor)

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Goal Tree or And Tree

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```
                    Stack Block

Find_Space        Grasp(A)      Move    Ungrasp

Clear_Top(B)      Clear_Top(A)

Get_Rid_of(D)     Get_Rid_of(C)
          Why                How

Put_it_on_Table(D)  Put_it_on_Table(C)

   Find_Space   Grasp(C)   Move   Ungrasp
```

Initial State

C   D
A   B

On (C, A)
On (D, B)
Clear (Floor)
On (A, Floor)
On (B, Floor)
Clear (C)
Clear (D)

Goal State

A
D   C   B

On (A, B)
On (B, Floor)
On (C, Floor)
On (D, Floor)
Clear (A)
Clear (C)
Clear (D)
Clear (Floor)

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How Expert System Works!

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❑ Let go to a very small zoo with a few animal

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How Expert System Works!

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❑ Let go to a very small zoo with a few animal

Has hair → R1 → Mammal

Has Claws, Has Sharp Teeth, Forward Pointing Eyes → R2

R2, Eats Meat → R3 → Carnivore

Mammal, Carnivore, Has Spots, Very Fast → R4 → Cheetah

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Production Rules

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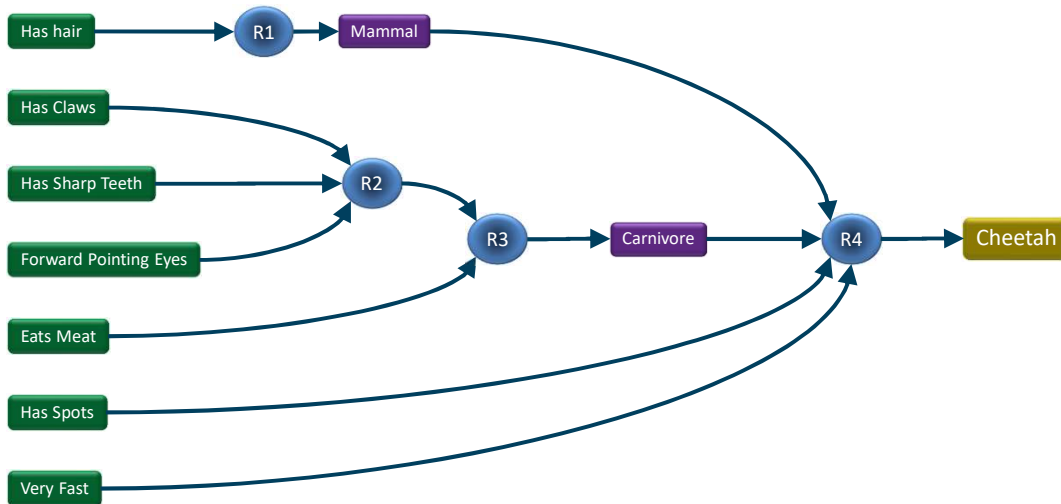
❑ Rule set of < condition, action > pairs
  ❖ "if condition then action"

❑ Mainly three parts
  ❖ The set of production rules
  ❖ Working Memory
  ❖ The recognize-act-cycle

❑ Match-resolve-act cycle
  ❖ Match: Agent checks if each rule's condition holds
  ❖ Resolve:
    ➢ Multiple production rules may fire at once (conflict set)
    ➢ Agent must choose rule from set (conflict resolution)
  ❖ Act: If so, rule "fires" and the action is carried out

❑ Working memory:
  ❖ Rule can write knowledge to working memory
  ❖ Knowledge may match and fire other rules

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Production Rules

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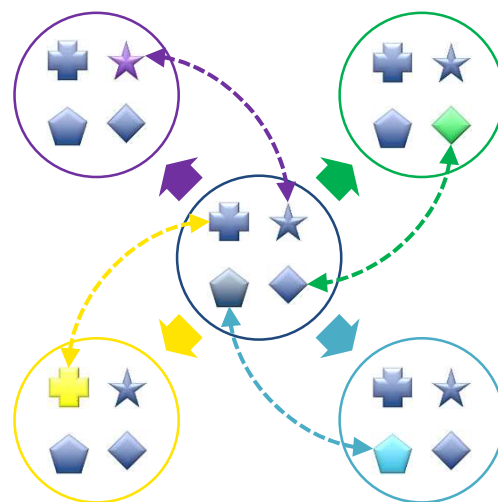
Advantages	Disadvantages
❑ Expressed in natural language ❑ Highly modular, so we can easily remove, add or modify an individual rule	❑ Does not exhibit any learning capabilities, as it does not store the result of the problem for the future uses ❑ During the execution of the program, many rules may be active hence rule-based production systems are inefficient

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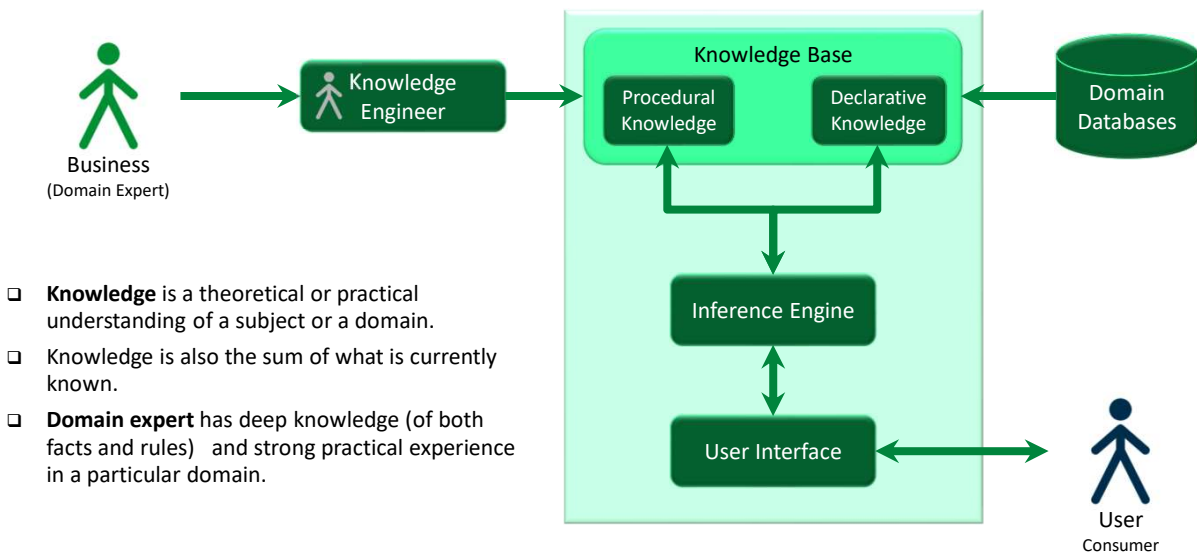24

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Characteristics of Expert System

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- ❑ High Performance

- ❑ Understandable

- ❑ Reliable

- ❑ Highly Responsive

- ❑ Flexible

- ❑ Secure

- ❑ Should be kept current

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Components of Expert Systems

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- ❑ **Knowledge** is a theoretical or practical understanding of a subject or a domain.
- ❑ Knowledge is also the sum of what is currently known.
- ❑ **Domain expert** has deep knowledge (of both facts and rules)   and strong practical experience in a particular domain.

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Components of Expert Systems

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- ❑ Knowledge Base
  - ❖ A repository of facts
  - ❖ Stores all the knowledge about the problem domain specific high quality knowledge
  - ❖ This knowledge should be adequate to exhibit intelligence
  - ❖ Build in consultation with Domain expert with extensive research

- ❑ Components of Knowledge Base
  - ❖ Factual Knowledge: The knowledge which is based on facts and accepted by knowledge engineers comes under factual knowledge.
  - ❖ Heuristic Knowledge: This knowledge is based on practice, the ability to guess, evaluation, and experiences.
  - ❖ Knowledge Representation: It is used to formalize the knowledge stored in the knowledge base using the If-else rules.

- ❑ Working Memory
  - ❖ Represents current state
  - ❖ Contains a set of records or statements called "working memory elements"
  - ❖ Model of the problem is stored as a short term memory

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Components of Expert Systems

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- ❑ Inference Engine
  - ❖ Brain of the system
  - ❖ Rules to resolve the query
  - ❖ Selects rules and facts as per the query
  - ❖ Provides reasoning
  - ❖ Helps in formulating the Conclusion
  - ❖ User has to choose strategy of implementation
  - ❖ Commonly proceeds in two modes, which are:
    - ➢ Forward chaining
    - ➢ Backward chaining

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Components of Expert Systems

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- ❑ User interface
  - ❖ Input and output frontend for the end-users
  - ❖ A language for the expression of knowledge;

- ❑ Rule or Production
  - ❖ Represents a move (action or change in state)
  - ❖ Has a unique name or ID
  - ❖ It has one or more conditions on LHS
  - ❖ Has one or more conditions on RHS

- ❑ Facts and Rules
  - ❖ A fact is a small portion of important information
  - ❖ Facts on their own are of very limited use
  - ❖ The rules are essential to select and apply facts to a user problem

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Grocery Store - Program to Bag Grocery

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- ❑ What should be business rules?
  - ❖ Self Service, Paper bags

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Grocery Store - Program to Bag Grocery

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❑ In what order??

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Grocery Store - Program to Bag Grocery

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❑ Deal with specific cases
  ❖ Rice bag in the bottom

❑ Get details of apparently similar looking items
  ❖ Frozen peas vs. fresh cut peas

❑ Look for missing rules
  ❖ Build a system, run it
  ❖ Wait for exceptions to occur

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Expert System

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Capabilities	Incapable
❑ Advising	❑ Substituting decision making
❑ Instructing and assisting in decision making	❖ Humans will always be needed
❑ Demonstrating	❑ Possessing human capabilities
❑ Deriving a solution	❑ Generate knowledge base
❑ Explanation	❖ Accurate results from inaccurate knowledge base
❑ Interpreting an input	❑ Refining knowledge on its own
❑ Predicting result	
❑ Alternative options	

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Application of Expert System

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❑ Information management

❑ Hospitals and medical facilities

❑ Helpdesk management

❑ Employee performance evaluation

❑ Loan approval

❑ Virus detection

❑ Warehouse optimization (brick-mortar warehouse)

❑ Planning and scheduling

❑ Stock market trading

❑ Airline scheduling

❑ Cargo and logistics

❑ Process monitoring and control

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Reflect

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- ❑ An expert system differs from a database program in that only an expert system:
  - ❖ Contains declarative knowledge
  - ❖ Contains procedural knowledge
  - ❖ Features the retrieval of stored information
  - ❖ Expects users to draw their own conclusions

- ❑ Treatment chosen by doctor for a patient for a disease is based on _____
  - ❖ Only current symptoms
  - ❖ Current symptoms plus some knowledge from the textbooks
  - ❖ Current symptoms plus some knowledge from the textbooks plus experience
  - ❖ All of the mentioned

- ❑ A knowledge-based agent can combine general knowledge with current percepts to infer hidden aspects of the current state prior to selecting actions.
  - ❖ True
  - ❖ False

- ❑ Choose the correct option:
  A - Knowledge base (KB) is consists of set of statements
  B - Inference is deriving a new sentence from the KB.
  - ❖ A is true, B is true
  - ❖ A is false, B is false
  - ❖ A is true, B is false
  - ❖ A is false, B is true

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Next Session…

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- Introduction to Data Analytics
- Type of Data
- Introduction to Big Data
- Hadoop Eco System
- Tasks of AI Using Big Data

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ADDITIONAL MATERIAL

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Another forward and backward chaining example

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"*As per the law, it is a crime for an American to sell weapons to hostile nations.*"

"*Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an American citizen.*"

Prove that "Robert is criminal."

Robert is criminal

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Facts Conversion into FOL

"As per the law, it is a crime for an American to sell weapons to hostile nations. Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an American citizen."

❑ It is a crime for an American to sell weapons to hostile nations
  ❖ Let's say 'p', 'q' and 'r' are variables
    American (p) ∧ weapon(q) ∧ sells (p, q, r) ∧ hostile(r) → Criminal(p)   ...❶

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Facts Conversion into FOL

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"As per the law, it is a crime for an American to sell weapons to hostile nations. Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an American citizen."

❑ Country A has some missiles s.
- ∃ s Owns(A, s) ∧ Missile(s)

❑ It can be written in two definite clauses by using Existential Instantiation, introducing new Constant T1.
- Owns(A, T1)   … ❷
- Missile(T1)   … ❸

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Facts Conversion into FOL

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"As per the law, it is a crime for an American to sell weapons to hostile nations. Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an American citizen."

❑ All of the missiles were sold to Country A by Robert
- ∃ s Missiles(s) ∧ Owns (A, s) → Sells (Robert, s, A)   … ❹

❑ Missiles are weapons
- Missile(s) → Weapons (p)   … ❺

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Facts Conversion into FOL

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"As per the law, it is a crime for an American to sell weapons to hostile nations. Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an American citizen."

- ❑ Enemy of America is known as hostile.
  - ❖ Enemy(t, America) →Hostile(t)   … ❻

- ❑ Country A is an enemy of America.
  - ❖ Enemy (A, America)   … ❼

- ❑ Robert is American
  - ❖ American(Robert).   … ❽

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Forward Chaining Example

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- ❑ Step 1: choose the sentences which do not have implications
- ❑ Step-2:
  - ❖ Rule ❹ satisfy with the substitution {p/T1}, so Sells (Robert, T1, A) is added, which infers from the conjunction of Rule ❷and ❸.
  - ❖ Rule ❻ is satisfied with the substitution(p/A), so Hostile(A) is added and which infers from Rule ❼

- ❑ Step-3:
  - ❖ Rule ❶ is satisfied with the substitution {p/Robert, q/T1, r/A}, so we can add Criminal(Robert) which infers all the available facts
- ❑ And hence we reached our goal statement.

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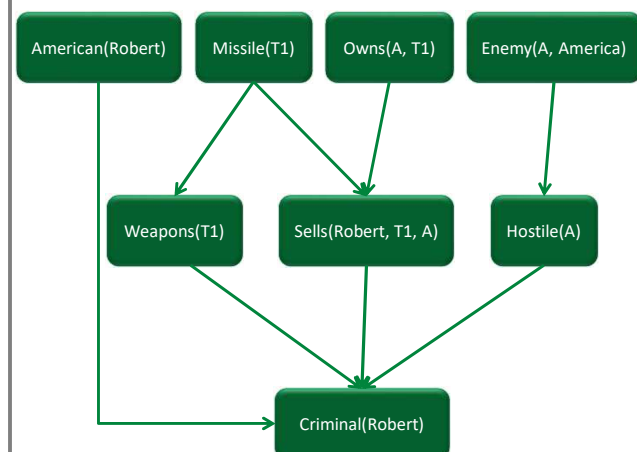
Facts Conversion into FOL

- American (p) ∧ weapon(q) ∧ sells (p, q, r) ∧ hostile(r) → Criminal(p) ... **1**
- Owns(A, T1) ... **2**
- Missile(T1) ... **3**
- ∃ p Missiles(p) ∧ Owns (A, p) → Sells (Robert, p, A) ... **4**
- Missile(p) → Weapons (p) ... **5**
- Enemy(p, America) →Hostile(p) ... **6**
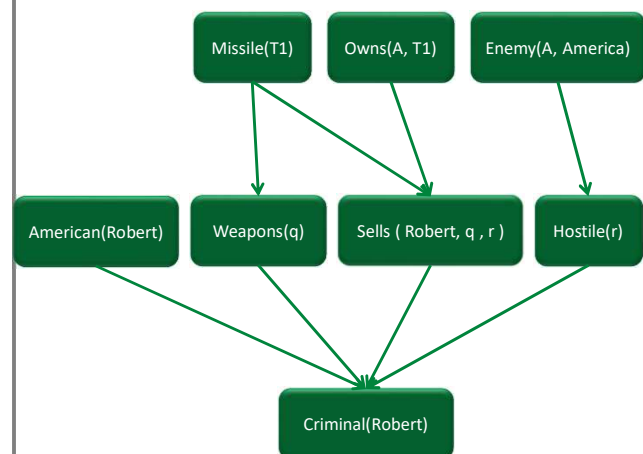- Enemy (A, America) **7**
- American(Robert) ... **8**

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Backward Chaining Example

- Step-1:
  - ❖ Take the goal fact "Robert is Criminal,"
- Step-2:
  - ❖ Infer other facts form goal fact which satisfies the rules.
- Step-3:
  - ❖ Extract further fact Missile(q) which infer from Weapon(q), as it satisfies Rule **5**
- Step-4:
  - ❖ Infer facts Missile(T1) and Owns(A, T1) form Sells(Robert, T1, r) which satisfies the Rule **4**, with the substitution of A in place of r.
- Step-5:
  - ❖ Infer the fact Enemy(A, America) from Hostile(A) which satisfies Rule **6**
- All the statements are proved true using backward chaining

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