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University of Ruse

INTELLIGENT COMPUTER SYSTEMS

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LECTURE 6

MECHANISMS FOR INFERENCE CONTROL

1. Introduction
2. Propositional rules
3. Types of inference mechanisms

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Inference specifics

- **Symbolic reasoning** - used in applied areas where mathematical methods are absent or computationally bulky;
- **A combination of deductive logic and plausible reasoning** – a large part of the world's expertise is heuristic, and programs that incorporate expert-level knowledge must combine the two methods.
- **Clear problem-solving strategy** - just as it is useful to separate domain-specific knowledge from inference methods, it is also useful to separate the problem-solving strategy. The same KB and inference method can lead to radically different behaviors for different strategies.

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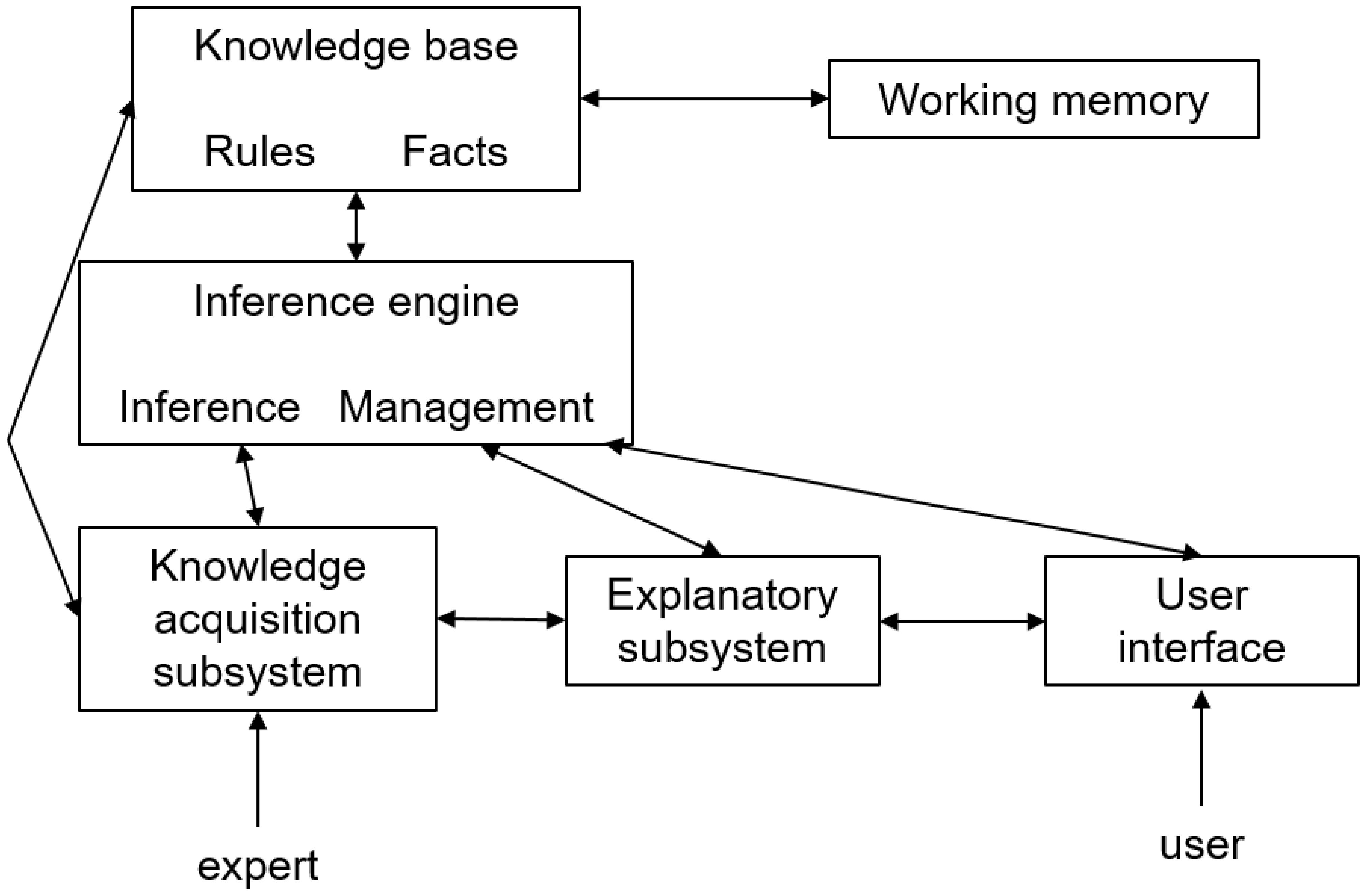
CONTENT 1

Inference engine

A software module that implements the inference mechanisms and stands between the user and the KB.



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CONTENT 1

Inference engine – main functions

- Review existing facts and rules and add new facts when possible;
- Determining the order in which the inference will be drawn, thus guiding the consultation with the user.

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CONTENT 1

Inference mechanisms

Direct the ES when using the preserved in its KB:

- facts;
- rules.

The most commonly used inference mechanism is through a logical rule.

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Propositional rule

The most commonly used logical rule is of the propositional type:

IF A THEN G

A – premise/proposition;

G – conclusion, inference.

Proposition

Special type of statement, whose truth we define. It can be either *true* or *false*, but never both at one and the same time.

- *Elephants are mammals.*
- *Some birds can fly.*

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Propositions - types

- **Simple/literals** - do not contain other propositions;
- **Composite/clauses** - contain several statements that are related to each other with relationships of the type AND, OR, NO, IMPLIES (IMPLICATION) and EQUIVALENCE (DOUBLE IMPLICATION).

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Propositional rule - types

- **Definitive**

Example:

Has (x, feathers) OR (Can (x, fly) AND Can (x, lay-eggs)) ->class (x, birds)

Given the appropriate facts, it can be logically inferred whether an object is a bird or not.

- **Empirical**

Example:

Condition (machine, does-not-want-to-start) AND Condition (headlights, weak) ->

Condition (battery, dead)

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Propositional rule - conclusions

- it is simplified and reasoning with it is easy to understand;
- some conclusions that are true cannot be drawn;
- in traditional programming, all the necessary information is expected to be available to start work. In the ES, the inference engine must also be able to handle incomplete information.

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CONTENT 3

Inference mechanisms - types

- data driven;
- goal driven;
- hybrid.

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CONTENT 3

Inference mechanisms - types

- If A is known to be true and there is a rule that says "If A, then B", we can conclude that B is true.
- If B is known to not be true, and if there is a rule "If A, then B", we can conclude that A is not true.

Data driven inference mechanisms

IF A THEN G →

Each **IF A THEN G** rule is applicable when there are facts in the KB that satisfy condition **A**:

- **if there is an applicable rule** - we apply it and this will lead to the addition of new facts to the KB. Rules given this way may become applicable even if they were previously inapplicable;
- **if there are no applicable rules** - we contact the user for additional information.

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Facts - input

When working with the system, the user must start by entering facts:

- **textual** - this requires a language to transform the facts into an appropriate internal representation.
- **with a menu** - an acceptable solution, but there is often a need for greater flexibility.

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Data driven inference mechanisms - example

- Rule 1: If the size of a person's hands are different, then the type of his profession is manual work.
- Rule 2: If the man's collar is priestly, then his profession type is religious.

Ivan's attributes:

"hand size": "different";

"collar": "none".

Since the premise of rule 1 is true, we can conclude that Ivan's occupation type is manual labor.

If rule 2 is tested, it will fail because Ivan's collar is not priestly.

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Data driven inference mechanisms - procedure

Procedure Answer;

Review the KB for the set **S** of applicable rules;

While S is nonempty and the problem is not solved **do**

begin

call **Select-rule** (**S**) to select rule **R** from **S**;

apply **R** and update KB;

review KB for new applicable rules and expand **S** if possible;

end;

end;

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CONTENT 3

Data driven inference mechanisms - problems

- **If there is more than one applicable rule, in what order should they be applied?** - Different strategies differ mostly in the effort devoted to solving the task for rule selection. Possible strategies:
  - a simple and "cheap" strategy - to select the first encountered rule when traversing S. If the rules are not well ordered, this can lead to many redundant steps. Any extensions designed to overcome this drawback can make management quite complicated.
  - introducing weights to the rules according to their importance.

- **The program "fires" the rules one after the other, and its behavior sometimes seems aimless to untrained users** - this undermines the user's confidence in the reliability of the system.

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Goal driven inference mechanisms

Only rules applicable to any specific G goal are considered.

Achieving G is equal to proving that the fact corresponding to G is truth-valued.

In some tasks, reaching a goal requires setting and reaching sub-goals. This can lead to a fruitless search if most of the subgoals are unreachable, but there is always a path from each subgoal to the original goal.

IF A THEN G

←

CONTENT 3

Goal driven inference mechanisms - example

Rule: If Ivan has a dragon tattoo, then Ivan has been in China.

Given fact: Ivan has not been in China.

New fact: Ivan does not have a dragon tattoo.

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Goal driven inference mechanisms - procedure

Procedure Reach (**G**);

Review KB for the set of rules **S** that define **G**;

If S is empty **then** ask the use for a new **G else**

  while G is unrecognized and **S** is a nonempty set **do**

    begin

      call **Select-rule** (**S**) to select the rule **R** from **S**;

      G ← condition (**R**);   *{A becomes new G}*

      If G is unrecognized **then** call **Reach** (**G**);

      If G is true **then** apply **R;**

    end;

end;

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Goal driven inference mechanisms - steps

- All rules whose right side can establish the truth of G are collected.
- If there is more than one suitable rule, a selection is made using the "Select-rule" procedure.
- After the rule R is selected, its left side A is examined to see if R is applicable. If there is no information about A in the KB, determining its truth becomes a new subgoal and the "Reach" procedure is recursively applied to A.
- The search proceeds systematically backwards from the set goal until we reach a subgoal for which there are no rules. The system then turns to the user and asks for relevant facts:
  - if the user cannot provide the required information - the rule that the system is currently working on cannot be used, but other paths of reasoning can be explored.
  - if the supplied information indicates that G is true, R is applied. The process continues until it is determined whether G is true or false or until the applicable rules are exhausted.

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CONTENT 3

Goal driven inference mechanisms - conclusions

- Since the left side A of the chosen rule R becomes the next subgoal G, choosing a rule is equivalent to choosing a subgoal.
- Strategies differ in effort in solving this task for subgoal selection:

➢ a simple and "cheap" strategy - to choose the 1st rule encountered while traversing S. If the rules are not well ordered, this may lead to exploration of unpromising subgoals. As in the case of data management, extensions designed to overcome these shortcomings can complicate the strategy.

Goal driven inference mechanisms

Advantages:

- they do not seek additional information and do not apply rules that are not related to the main goal;
- the system can explain its behavior simply by telling the user what goal it is working on and what rule it is using.

Main disadvantage: the user cannot guide the work by adding relevant information about the task. This may make the strategy unacceptable when a fast, real-time response is required.

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Hybrid strategy

The idea - to alternate between the two phases, by using the information given by the user to determine a goal, and then to ask him for additional information in the process of working on the chosen goal.

Procedure Alternate;

Repeat

User to input facts in the KB;

Call **Answer** to find the consequences;

Call **Select-goal** to choose a goal **G**;

Call **Reach** (**G**) to attempt to establish **G**;

until problem is solved;

end;

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