Rule Systems

Rule-based knowledge representation is useful for specifying inference steps in a declarative way.

Example:

If	**(region.color = green) and (region.location = picture-bottom)**
then	**(region.type = grass)**

Rules may express different types of reasoning:

premise	→	**conclusion**	***logical implication***
antecedence	→	**consequence**	***inference from given preconditions***
evidence	→	**hypothesis**	***interpretation of facts***
situation	→	**action**	***situated behaviour***
IF	→	**THEN**	***informal paraphrase***
left-side	→	**right-side**	***can mean anything***

Rules typically refer to a frame-based knowledge base.

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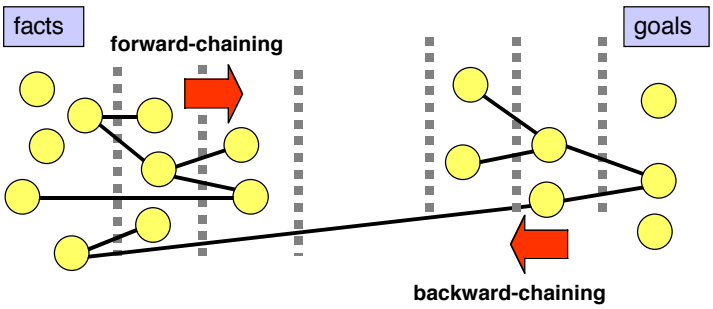
Forward and Backward Inferences

Rule systems may support forward and/or backward inferencing



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The Rule System OPS5

OPS5 ("Official Production System, Version 5")
- developed at CMU 1980 ...
- implementation language for successful expert systems (XCON, XSEL a.o.)

CLIPS
- reimplementation of OPS5 in C for NASA
- freeware

JESS
- reimplementation of OPS5 in Java
- freeware

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Rules in OPS5

Syntax of a rule in OPS5:

<rule>::=	[P <rule-name> <antecedent> --> <consequent>]
<antecedent>::=	{<condition>}
<condition> ::=	<pattern> | - <pattern>
<pattern> ::=	[<object> {^<attribute> <value>}]
<consequent> ::=	{<action>}
<action> ::=	[MAKE <object> {^<attribute> <value>}] | [MODIFY <pattern-number> {^<attribute> <value>}] [REMOVE <pattern-number>] | [WRITE {<value>}]

Example: "If there are 2 disks close to each other and with equal size, make them a wheel pair"

```
[P  find-wheel-pair [disk   ^location   <x1>                ^size   <y>]
                    [disk   ^location   |<x2> - <x1>| < 10  ^size   <y>]   --> ... ]
```

Variable

- depth-first search
- limited expressiveness for constraints

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Rule Selection

The order of execution cannot be completely controlled in a rule system. It is expected that the user abstracts from individual inference steps.

Rules are selected in a recognize-and-act cycle. If more than one rule can be applied, a" conflict resolution" process decides.

Conflict resolution strategies available in a typical rule system:

• prefer old facts (goals)	*breadth-first search*
• prefer new facts (goals)	*depth-first search*
• prefer more special rule	*more special = more conditions*
• prioritize rules	*e.g. by memory order (PROLOG)*
• use meta-rules	*rules about rule selection*

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When Is Rule-based Interpretation Feasible?

- **Successful applications for restricted domains**
  - recognising airports (McKeown et al. 85)
  - classification of forestry in aerial images (Pinz 85)
  - 2D image analysis
- **Problems with degraded images**
- **Domain knowledge and control not separated**
  - free choice of interpretation strategy dependent on task and context
  - separation of control and knowledge representation may be required for complexity management
- **Does not scale beyond - say - 1000 rules**

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