Chapter 2

Rule-Based Expert Systems

[Michael Negnevitsky. 2004. *Artificial Intelligence*: *A Guide to Intelligent Systems*. 2nd Ed. Addison-Wesley. ISBN: 0321204662.]

2.7 MEDIA ADVISOR: a Demonstration Rule-Based Expert System

• We next consider a simple RBES. The Leonardo ESS was selected as a tool to build a decision-support system called MEDIA ADVISOR. The system provides advice on selecting a medium for delivering a training program based on the trainee's job. For example, if a trainee is a mechanical technician responsible for maintaining hydraulic systems, an appropriate medium might be a workshop, where the trainee could learn how basic hydraulic components operate, how to troubleshoot hydraulics problems and how to make simple repairs to hydraulic systems. On the other hand, if a trainee is a clerk assessing insurance applications, a training program might include lectures on specific problems of the task, as well as tutorials where the trainee could evaluate real applications. For complex tasks, where trainees are likely to make mistakes, a training program should also include feedback on the trainee's performance.

Knowledge base

/* MEDIA ADVISOR: a demonstration rule-based expert system

Rule: 1
if   the environment is papers
or   the environment is manuals
or   the environment is documents
or   the environment is textbooks
then   the stimulus_situation is verbal

Rule: 2
if   the environment is pictures
or   the environment is illustrations
or   the environment is photographs
or   the environment is diagrams
then   the stimulus_situation is visual

Rule: 3
if   the environment is machines
or   the environment is buildings
or   the environment is tools
then   the stimulus_situation is 'physical object'

Rule: 4
if   the environment is numbers
or   the environment is formulas
or   the environment is 'computer programs'

then   the stimulus_situation is symbolic

Rule: 5
if   the job is lecturing
or   the job is advising
or   the job is counselling
then   the stimulus_response is oral

Rule: 6
if   the job is building
or   the job is repairing
or   the job is troubleshooting
then   the stimulus_response is 'hands-on'

Rule: 7
if   the job is writing
or   the job is typing
or   the job is drawing
then   the stimulus_response is documented

Rule: 8
if   the job is evaluating
or   the job is reasoning
or   the job is investigating
then   the stimulus_response is analytical

Rule: 9
if   the stimulus_situation is 'physical object'
and   the stimulus_response is 'hands-on'
and   feedback is required
then   medium is workshop

Rule: 10
if   the stimulus_situation is symbolic
and   the stimulus_response is analytical
and   feedback is required
then   medium is 'lecture - tutorial'

Rule: 11
if   the stimulus_situation is visual
and   the stimulus_response is documented
and   feedback is not required
then   medium is videocassette

Rule: 12
if   the stimulus_situation is visual

and   the stimulus_response is oral
and   feedback is required
then   medium is 'lecture – tutorial'

Rule: 13
if   the stimulus_situation is verbal
and   the stimulus_response is analytical
and   feedback is required
then   medium is 'lecture - tutorial'

Rule: 14
if   the stimulus_situation is verbal
and   the stimulus_response is oral
and   feedback is required
then   medium is 'role-play exercises'

/* The SEEK directive sets up the goal of the rule set

seek medium

Objects

MEDIA ADVISOR uses six linguistic objects: *environment*, *stimulus_situation*, *job*, *stimulus_response*, *feedback* and *medium*. Each object can take one of the allowed values (for example, object *environment* can take the value of *papers*, *manuals*, *documents*, *textbooks*, *pictures*, *illustrations*, *photographs*, *diagrams*, *machines*, *buildings*, *tools*, *numbers*, *formulas*, *computer programs*). An object and its value constitute a fact (for instance, the *environment* is *machines*, and the *job* is *repairing*). All facts are placed in the database.

Options

The final goal of the RBES is to produce a solution to the problem based on input data. In MEDIA ADVISOR, the solution is a medium selected from the list of four options:

    medium is workshop
    medium is 'lecture - tutorial'
    medium is videocassette
    medium is 'role-play exercises'

Dialogue

In the dialogue shown below, the ES asks the user to input the data needed to solve the problem (the **environment**, the **job**, and **feedback**). Based on the answers supplied by the user (answers are indicated by arrows), the ES applies rules from its **knowledge base** to infer that the *stimulus_situation* is *physical object*, and the *stimulus_response* is *hands-on*. Rule 9 then selects one of the allowed values of *medium*.

Object	Allowed value	Object	Allowed value
environment	*papers*	*job*	*lecturing*
	manuals		*advising*
	documents		*counselling*
	textbooks		*building*
	pictures		*repairing*
	illustrations		*troubleshooting*
	photographs		*writing*
	diagrams		*typing*
	machines		*drawing*
	buildings		*evaluating*
	tools		*reasoning*
	numbers		*investigating*
	formulas		
	computer programs	*stimulus_response*	*oral*
			hands-on
			documented
			analytical
stimulus_situation	*verbal*		
	visual		
	physical object	*feedback*	*required*
	symbolic		*not required*

What sort of environment is a trainee dealing with on the job?
⇒ **machines**

Rule: 3
if	the environment is machines
or	the environment is buildings
or	the environment is tools
then	the stimulus_situation is 'physical object'

In what way is a trainee expected to act or respond on the job?
⇒ **repairing**

Rule: 6
if	the job is building
or	the job is repairing
or	the job is troubleshooting
then	the stimulus_response is 'hands-on'

Is feedback on the trainee's progress required during training?
⇒ **required**

Rule: 9
if   the stimulus_situation is 'physical object'
and   the stimulus_response is 'hands-on'
and   feedback is required
then   medium is workshop

medium is workshop

Inference techniques

The standard inference technique in Leonardo is backward chaining with opportunistic forward chaining, which is the most efficient way to deal with the available information. However, Leonardo also enables the user to turn off either backward or forward chaining, and thus allows us to study each inference technique separately.

Forward chaining is data-driven reasoning, so we need first to provide some data. Assume that

the environment is **machines**
             '**environment**' instantiated by user input to '**machines**'

the job is **repairing**
             '**job**' instantiated by user input to '**repairing**'

feedback is **required**
             '**feedback**' instantiated by user input to '**required**'

The following process will then happen:

Rule: 3 fires   '**stimulus_situation**' instantiated by Rule: 3 to '**physical object**'
Rule: 6 fires   '**stimulus_response**' instantiated by Rule: 6 to '**hands-on**'
Rule: 9 fires   '**medium**' instantiated by Rule: 9 to '**workshop**'
No rules fire   stop

Backward chaining is goal-driven reasoning, so we need first to establish a **hypothetical solution** (**the goal**). Let us, for example, set up the following goal:

'medium' is 'workshop'

Pass 1
Trying Rule: 9   Need to find object '**stimulus_situation**'
Rule: 9 stacked   Object '**stimulus_situation**' sought as '**physical object**'

Pass 2
Trying Rule: 3   Need to find object '**environment**'
Rule: 3 stacked   Object '**environment**' sought as '**machines**'

ask environment

⇒ machines	'**environment**' instantiated by user input to '**machines**'
Trying Rule: 3	'**stimulus_situation**' instantiated by Rule: 3 to '**physical object**'
Pass 3	
Trying Rule: 9	Need to find object '**stimulus_response**'
Rule: 9 stacked	Object '**stimulus_response**' sought as '**hands-on**'
Pass 4	
Trying Rule: 6	Need to find object '**job**'
Rule: 6 stacked	Object 'job' sought as '**building**'
ask job	
⇒ **repairing**	'**job**' instantiated by user input to '**repairing**'
Trying Rule: 6	'**stimulus_response**' instantiated by Rule: 6 to '**hands-on**'
Pass 5	
Trying Rule: 9	Need to find object '**feedback**'
Rule: 9 stacked	Object '**feedback**' sought as '**required**'
ask feedback	
⇒ **required**	'**feedback**' instantiated by user input to '**required**'
Trying Rule: 9	'**medium**' instantiated by Rule: 9 to '**workshop**'

medium is workshop

It is useful to have a tree diagram that maps a consultation session with an ES. A diagram for MEDIA ADVISOR is shown in Figure 2.8. The root node is the goal; when the system is started, the inference engine seeks to determine the goal's value.

Does MEDIA ADVISOR handle all possible situations?

When we start to use our ES more often, we might find that the provided options do not cover all possible situations. For instance, the following dialogue might occur:

*What sort of environment is a trainee dealing with on the job*?
⇒ **illustrations**

In what way is a trainee expected to act or respond on the job?
⇒ **drawing**

Is feedback on the trainee's progress required during training?
⇒ **required**

I am unable to draw any conclusions on the basis of the data.

Thus, MEDIA ADVISOR in its present state cannot handle this particular situation. Fortunately, the ES can easily be expanded to accommodate more rules until it finally does what the user wants it to do.
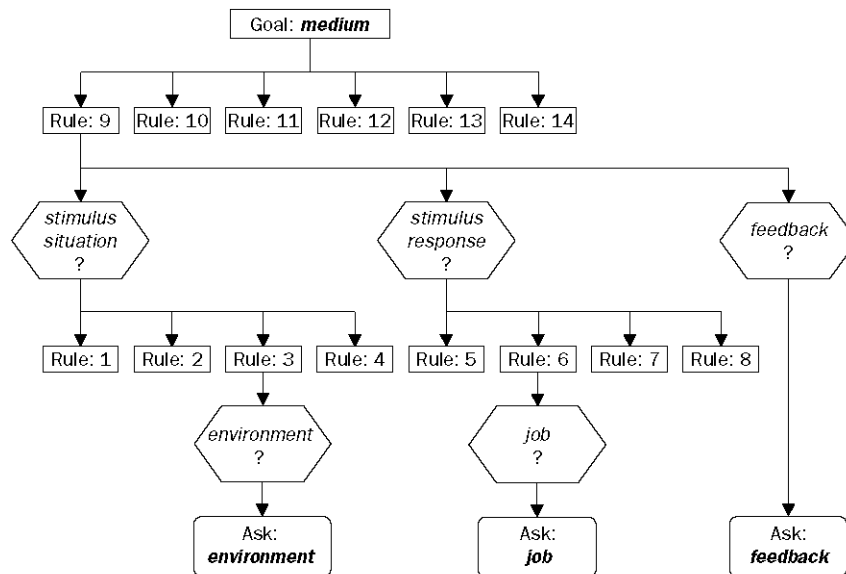
Figure 2.8 Tree diagram for the rule-based expert system MEDIA ADVISOR