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Intelligent Medicinal Prescription System for HIV/AIDS patients using Ayurveda Therapy: Working of inference engine of Oracle Policy Modeling and CORVID

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Abstract

Development of an accurate Medicinal Prescription System is itself a challenge, since it is very difficult to incorporate the human perceptions, responses, and their cognitive abilities along with medical expertise into it. The proposed Medical Prescription System is designed for treatment of HIV/AIDS patients using Ayurveda Therapy. The step by step procedure of developing the Rule based System starts from selection of appropriate system building tool, knowledge base formation, and rule generation. The selection of system building tools often becomes domain specific and is dominated by the type of rules to be generated and the accuracy with which the interfaces are drawn. In this paper researchers have presented the outcomes of the detailed study of Rule based system tools and the parameters required for selecting appropriate tools. The detailed study of working of inference engine and Rule formation is shown using two expert system building tools. The comparison between CORVID and Oracle Policy Modeling (OPM) will help the developers for making the appropriate building tool selection.

Keywords: Medicinal Prescription System, HIV/AIDS, Ayurveda, Building Tools, Inference Engine

1. INTRODUCTION

Medicinal Prescription System(MPS) is a rule based system, which simulates the thought process of a medical expert to take complex decisions for medicinal prescription. This system when built with care acts as an expert ready reckoner and helps to improve the accuracy of the medical advice given to the patients. In medicinal treatment, there are different types of patients: patients who need critical care, long term treatments, and short-term treatments. Critical Care and long-term treatments are usually given to patients suffering from fatal as well as non – fatal but seriously critical diseases. Among the fatal diseases which include Hemophilia, Cancer, HIV/AIDS…etc., HIV/AIDS is though fatal, there may not be any emergency for longer time in the life span of the patient. In such a case, there is a need to treat the patient using standard as well as alternate medicinal therapies. Often the alternate medicinal therapy is used to increase the immunity and latency period of the patient [13]. Ayurveda is being used as an alternate medicinal therapy for treating the HIV/AIDS patients. In this paper, researchers have addressed the issues related to the choice of rule based system building tools, and compared two example expert system building tools based on rule formation, handling complexity in designing rules and the uncertainty associated with it. The milestones in this process includes structure of MPS, significance of Ayurveda, study of system building tools and working of inference engine of two example expert system building tools Exsys CORVID and OPM.

1.1 General Rule Based System

Every computerized model of Rule Based System follows a working model: working memory that are variables, Knowledge Base that are Rule files, Inference Engine which is Program Logic and User interface.
Knowledge Base contains the domain knowledge. It is also called as long-term memory, Working Memory includes the set of facts that are known about the domain, and Inference engine is an algorithm which uses knowledge base and working memory to infer. User interface is an electronic interface, through which user can interact with ES.

1.2 Significance of Ayurveda Therapy in HIV/AIDS

Ayurveda is an ancient medicinal system of India, which proposed an alternative approach to the western medicine of diagnosis and treatment [14] [15]. The word Ayurveda is a Sanskrit word, "Ayur" means life and "Veda" means knowledge, so combinedly it means "Knowledge of Life". According to Ayurveda each individual has unique

combination of Tridoshas, called as "Prakriti". Prakriti comprises of Vata, Pitta and Kapha (Ayurvedic Biological Constituents [5] [6] [7]. If these Tridoshas are balanced in a person then we can say that, such a person is a healthy both physically and spiritually. Ayurveda is completely based on natural or herbal therapy, so, there is no side effects even.

The research work is done on developing techniques or expert systems for identifying HIV/AIDS ([1],[2],[3][4],[5]); but not much work is done on computer aided medicinal system that can be used as a supportive system where patients undergo a treatment for a long period using Ayurveda Therapy.

The external cause in AIDS is HIV infection but its internal cause is Ojokshaya (decreased immunity) which is mainly responsible for the disease. Therefore, AIDS should be prevented and managed with the help of Ayurveda's "Rasayana" Therapy. "Bala" is used for physical strength in Ayurveda. According, to Ayurveda, the loss of Ojas leads to degeneration and wasting of the body. Thus, to maintain immunity against the disease a variety of Rasayana drugs has been described in Ayurveda. When the immunity increases the latency period of the HIV +ve patient increases and their quality of life is improved. Hence there is a need to have a supportive Medicinal Prescription System using Ayurveda therapy.

1.3 Structure of Prescriptional Expert System

According to the diagram shown in Figure 1.1, the step by step process of designing the MPS is

Step 1. Knowledge engineer gathers the domain knowledge from domain expert,

Step 2. Develops Knowledge base and Working memory,

Step 3. Develops Prescription System by taking the help of different System building tools that are provided by inference engines to make appropriate decision.

Here, the emphasis is given on designing the MPS and the selection of building tools which further extends the medical practitioner's point of view.

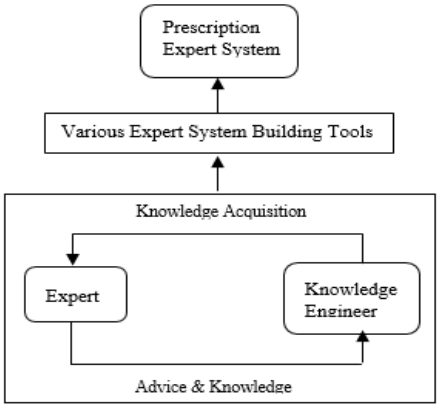


Figure 1.1 Structure of Expert System [Source adapted from [24]]

1.4 MPS Requirements and Specifications

The considerations for buidling MPS are that system should be

- simple enough to create the knowledge base.
- built using appropriate tools which are capable of simple and complex rule generation.
- as far as possible open source and free.
- written using simple widely used platform indpendent language.
- with easy input mehod.

The parameters used for assessment of rule based system tools must include: Knowledge Acquisition, Knowledge Representation Scheme, Interface, Knowledge Base Repository, Rules (Representation, Engine, and optimization), Programming Techniques, and support.

2. ANALYSIS OF SYSTEM BUILDING TOOLS

Before starting the development of Medicinal Prescription Expert System, a thorough analysis of different Rule based System building tools is being carried out. The exhaustive search for the tools which satisfy the MPS requirements revealed that there are 45 different tools available. Those tools were classified at three distinct levels: first; Type Level Classification, second; Rule Based System (RBS) & Business Rule Management System (BRMS) Level Classification, Third; Programming Level Classification.

2.1 Programming Level Classification

Table 2.1indicate that out of 45 different Rule Based System building tools more than 70% tools were written using JAVA.

Table 2.1: Programming Level Classification [Source adapted from [24]]

Language Classes	Source/Vendor	Tools	C	C++	.NET	JAVA	OWL	php	Python	Cyc	Java Script	AJAX
Free	ghg.net	CLIPS	√									
	jboss.org	Drools				√						
	agfa.com	Euler				√						
	eXpertise2Go.cor	eXpertise2Go				√						
	info-sapient	InfoSapient				√						
	cin.ufpe.br	JEOPS				√						
Commercial	Acquire Intelligence	Acquire	√	√	√	√						
	Corticon	Corticon Decision Mgmt Software				√						
	EXSYS	Corvid				√						
	Fair-Isaac	Blaze Advisor			√	√						
	Gensym	G2	√	√								
	Haley Enterprise	CIA	√	√		√						
	ILOG	Rules and Jrules	√	√	√	√						
	GAIA- Group	jColibri				√						
	corelogic.com	MindBox			√							
	Rule Core Systems	RuleCore							√			
	XpertRule	XpertRule			√						√	√
Free for non-commercial use	JBoss	Jboss				√						
	Sandia Labs	Jess				√						
	Oracle Policy Au	OPM				√						
	Production Systems Technologies	CLIPS/R2		√	√							
		OPS/R2	√	√								
		OPSJ			√							
Commercial & Open Source	OpenRules.com	OpenRules				√						
Free & Open Source	d3web.de	d3Web				√						
	kt.ijs.si	JDEXi				√						
	jlogic	JLog				√						
	jlisa	JLisa				√						
	ofbiz.apache.org	OFBiz				√						
	Cycorp	OpenCyc				√				√		
	OpenExpert.org	OpenExpert						√				
	openl-tablets.org	OpenL Tablets				√						
	SemWebCentral	Sweet Rules				√						
	tyruba	TyRuBa				√						
Earlier existing systems But currently withdrawn	Computer Associates	Aion	√		√							
	dtrules.com	DTRules				√						
	jena.apache.org	Jena2				√						
	Stanford Univ.	JTP				√						
	mandarax.source forge.net	Mandarax				√						
	Pega Systems	PegaRules				√						
	Link Removed	Pellet					√					
	pyke.sourceforge .net	PyKE							√			
	mcom.cs.cmu.edu	ROWL					√					
	CDAC.in	Vidwan				√						

2.2 Type Level Classification

The six different classes were formed these are: Free, Commercial, Free for non-commercial use, Commercial - Open Source, Free - Open Source and Earlier existing systems but currently withdrawn, mentioned in table 2.2.

Table 2.2: Type Level Classification

Type	Free	Commercial	Free for non-commercial use	Commercial & Open Source	Free & Open Source	Existing systems But currently withdrawn
Count	6	11	6	1	10	10

2.3 RBS and BRMS Level Classification

45 different Expert System building tools were again classified in table 2.3 based on two different rule formation methods: Rule Base System (RBS) and Business Rule Management System (BRMS). Twelve were RBS and five were BRMS.

Table 2.3: RBS & BRMS Level Classification

Tools	RBS	BRMS
Acquire Software	√	
CLIPS	√	
Corticon	√	
drools	√	
Fair-Isaac Blaze Advisor		√
ILOG Rules and Jrules		√
Infosapient	√	
Jboss		√
JEOPS	√	
Jess	√	
JLisa	√	
MindBox		√
OFBiz	√	
OpenRules		√
OPSJ	√	
Rule Core	√	
TyRuBa	√	
XpertRule	√	

After the mapping of MPS requirements and specifications with the classification of different tools the two tools identified are: OPM and Corvid.

To compare the two tools the following steps are used:

- Create the knowledge base with the parameters found by performing the clinical study of HIV/AIDS patients' case papers (This is confidential part of our study and is protected.)
- Create simple and complex rules using the two tools.
- Compare the two tools using the above – mentioned parameters in section *1.4*

On Comparison, the following observations are made:

Table 2.4: Comparison Table for Rule Based System Tools

Sr.no	Criteria	OPM	Corvid
1.	Classification Group	Free for non- commercial use	Commercial, provides evolutionary version free
2.	Language Support	JAVA	JAVA Applets
3.	Interface	Easy but requires little knowledge of specialized way of formulating the rules.	Easy but a layman cannot build their ES.
4.	Generation of rules	Easy to write	Easy to write
5.	Simple Rules writing & handling	Easy to write	Easy to write
6.	Complex Rules writing & handling	Easy to write	Easy to write if only if user has the knowledge of rule formation

7.	Facilities provided	Controls (text fields & buttons) can be drawn using drag & drop facility	Controls (text fields & buttons) can be drawn by using menu driven panels.

After the exhaustive analysis, the following observations are made:

1. For generating simple rules both the tools use different methods.
2. For generating complex rules and handling uncertainty OPM and Corvid has a strong mechanism.

The section 3 demonstrates the mechanism followed by OPM and Corvid tool to handle uncertainty.

3. STRATEGY USED IN INFERENCE ENGINE OF EXAMPLE TOOLS

Peter Szolovits has drawn the attention towards handling uncertainty and decision- making in medical reasoning systems, he discussed various probabilistic models of uncertainty like "Idiot Bayes" formulation, Bipartite Graph Model, Noisy Or, Polytrees, Bayes Networks etc. also discussed the methods used for decision making under uncertainty, those are decision trees, Influence diagram and utilities and time [9]. Out of above mentioned two ES building tools, Corvid has used decision tree and OPM used Patented Linear Inferencing Algorithm to minimize uncertainty in decision making.

3.1 Working of Corvid Inference engine

Inference engine of Corvid uses Decision Tree in another way we can say that Corvid has used tree logic diagram along with confidence factor to handle the uncertainty [12].

3.1.1 Decision Tree / Tree Logic Diagram

Several systems require multiple trees and rules together to provide appropriate decision, for all possible combinations of inputs provided by user [12].

To write complex rules, researcher prepared a table of tautology, so that no condition could be missed as well as to support appropriate decision making. For example- Let there are three different symptoms S1, S2 and S3. On their different combination, different dosages of medicine must be given, then in such situation table 3.1 is considered.

Table 3.1: Table for Decision Making

S2	S1	S3
T	T	T
T	T	F
T	F	T
T	F	F
F	T	T
F	T	F
F	F	T
F	F	F

Based on table 3.1 the complex rules are written in Logic Block, shown in figure 3.1, in this way, there will be less redundancy and more accuracy can be achieved.

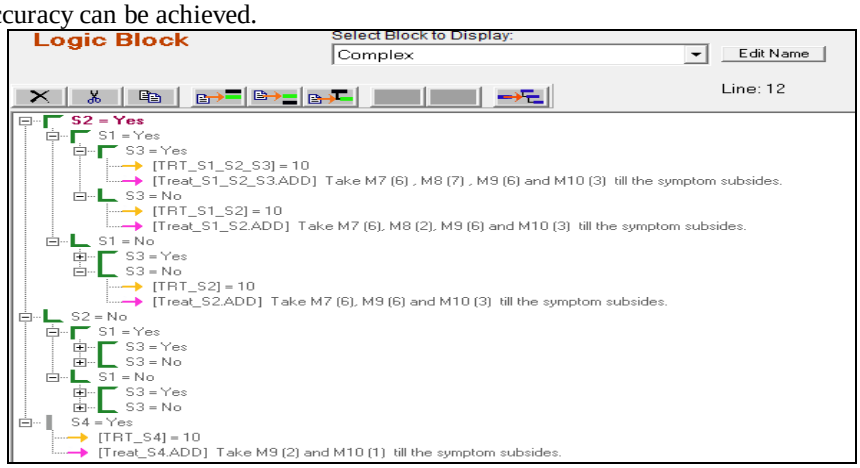


Figure 3.1 Tree Structure for Complex Rules

Now, if we consider the part of tree logic diagram shown in figure 3.2, is the more illustrative, showing that if patient is suffering from symptom S2 and not from S1 and S3, then he/she has to take medicine, M7, M9 and M10.

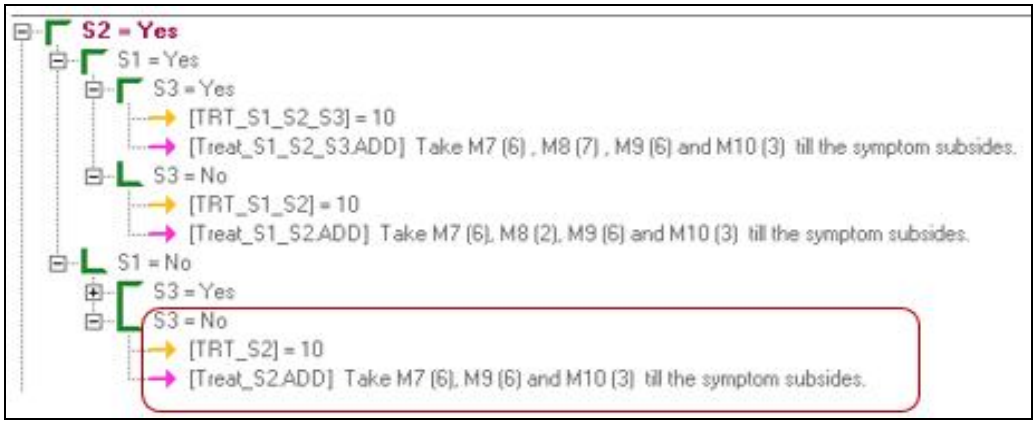


Figure 3.2 Tree Structure for prescribing medicine against symptom S2

Along with this Corvid generated rules in RuleView, that is equivalent to the rule

IF
Patient is suffering from S2 AND not suffering from S1 AND not suffering from S3
THEN take medicine M7, M9 and M10.

Above rule can also be presented in graphical way, shown in figure 3.3:

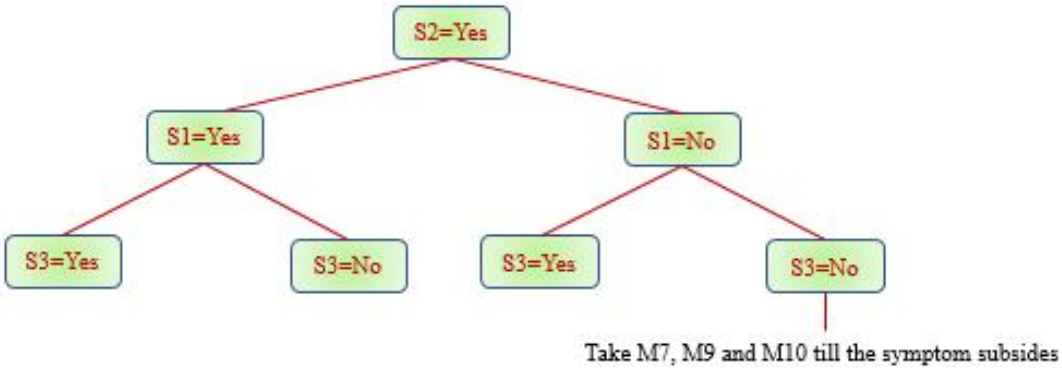


Figure 3.3 Graphical representation of Tree Structure for prescribing medicine against symptom S2

3.1.2 Confidence Factor

Another aspect for reducing the uncertainty is to use Exsys Corvid Confidence factor that enable the system to reach to the "best fit" for concluding [12].

To implement the concept of confidence factor, Corvid enables the developers to define confidence variables that are only applied in the THEN part of the rule. A confidence value is assigned to the confidence variable and every confidence value shows the degree of certainty. Confidence value is also known as probability or certainty score [12].

The value that is assigned to the confidence variable Indicates that how likely the action/item applies in a specific end user's situation based on the answers they provide. Generally, there are multiple confidence variable that covers various possible actions and the system will select the most likely [11, 12].

If we consider the red marked part of figure 3.2, it has included the confidence factor as $[TRT\_S2] = 10$, which shows that if patient is suffering from symptom S2 and not from S1 and S3, then it is the 100% guarantee that system will display the prescription: "Take medicine, M7, M9 and M10" [12].

3.1.3 Final Medicinal Prescription

Corvid incorporate all simple as well as complex rules and infers appropriate prescription shown in figure 3.4

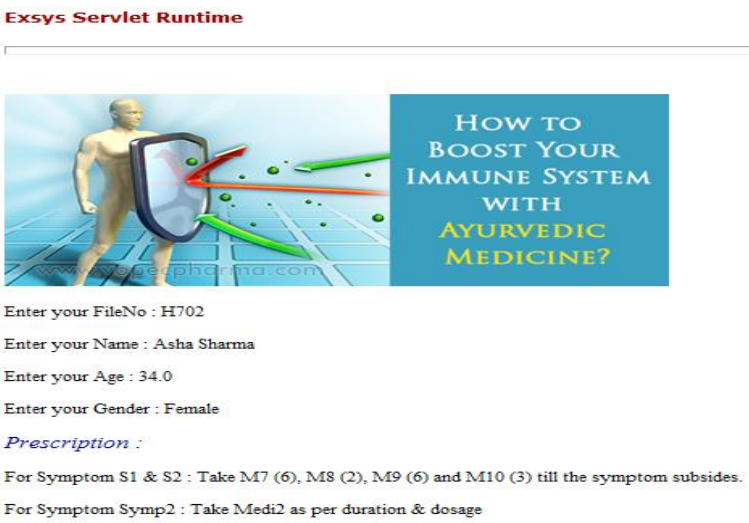


Figure 3.4 Final medicional prescription

3.2 Working of OPM Inference engine

To handle the uncertainty while prescribing the medicine in OPM, researcher wrote some complex rules. As OPM used Patented Linear Inferencing Algorithm that is faster than Rete algorithm.

3.2.1 Patented Linear Inferencing Algorithm

According to the Patented Linear Inferencing Algorithm, rulebased system has rulebase and set of input facts. The new facts are inferred as the various rules and facts are included in rulebase [10]. It represents the knowledge in the form of fact dependency tree that indicates which facts are used to produce other facts. In this dependency tree nodes represents facts whereas arc is a one-way arrow that joins two facts [10].
The above mentioned complex rules are numbered as r1, r2….and facts are labelled as f1, f2….

Case1: For some symptoms medicines are common

r3: Treatment is M1 if
The symptom is S2 or
The symptom is S3 or
The symptom is S4

r14: Dosage 2t3 if
The symptom is S4 and
Treatment is M1

Now, for dosages, system must show the specific advice, so, rules were written for symptoms S2, S3 and S4 separately, rule r14 is specified for symptom S4.

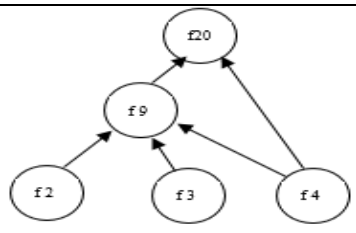
The OPM rulebase consist of several rules, out of two, that are fulfilling this particular case1 – r3: $f2 + f3 + f4 \rightarrow f9$ r14: $f9 + f4 \rightarrow f20$	

Figure 3.5 Fact dependency tree

Case2: For one symptom, there can be multiple medicines

r3: Treatment is M1 if
The symptom is S2 or
The symptom is S3 or
The symptom is S4

r4: Treatment is M3 if
The symptom is S4 or
The symptom is S2 or
The symptom is S3 or
The symptom is S5

r10: Dosage 5g3 if
The symptom is S4 and
Treatment is M3

r14: Dosage 2t3 if
The symptom is S4 and
Treatment is M1

For symptom S3 two different medicines can be prescribed, one is M1 and another is M3 that can be achieved by writing above four rules r3, r4, r10 and r14.

Above mentioned four rules fulfils case2 –

r3: $f2 + f3 + f4 \rightarrow f9$
r4: $f1 + f4 + f5 + f6 \rightarrow f10$

r10: $f4 + f10 \rightarrow f16$
r14: $f4 + f9 \rightarrow f19$

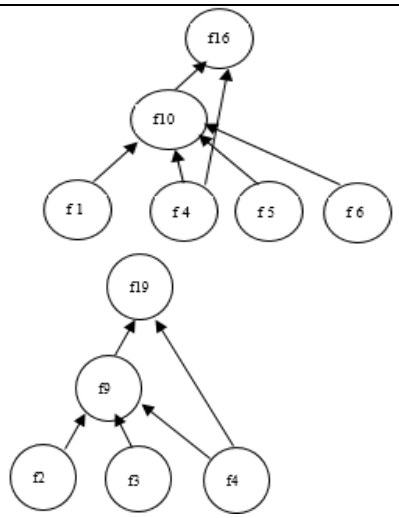


Figure 3.6 Fact dependency tree

3.2.2 Final Medicinal Prescription in OPM

Like CORVID, OPM also, incorporate all simple as well as complex rules and infers appropriate prescription shown in figure 3.5

Figure 3.5 Prescription according to the symptom1 & 2

4. CONCLUSION

As per the analysis of Rule Based System Tools and study of working of inference engine in medicinal prescription ES, based on two tools: OPM and Exsys Corvid, researcher conclude that both the tools are using different strategies that are mentioned in table 4.1, are successfully able to prescribe proper medicines.

Table 4.1: Strategies used by ES building tools

ES Building Tools	**Inference Engine Strategy**
OPM	Patented Linear Inferencing Algorithm
Exsys Corvid	Tree Structure with Confidence Factor

Though OPM and Exsys Corvid are using different strategies to handle uncertainty still both the Rule Based System building tools are equally helpful in prescribing the appropriate medicines, thus providing the supportive Medicinal Prescription System.

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