Building an Expert System in Visual Prolog for Weekly Time Table

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Abstract

One of the major things that cannot be dispensed with in every educational institution is the schedule of lessons. The aim of this research is to develop *an Expert System in Visual Prolog for Weekly Time Table (ESWTT)*. The suggested ESWTT mainly consists of two phases. The first phase is responsible for automatic acquiring of human expert knowledge. The second phase is concerned with the construction of time table from the entered knowledge by using forward chaining method (data driven interface). When ESWTT tested by experts and end users, it was found that ESWTT performance in constructing KB and building the table was exact (the building ability of ESWTT is 100 %.). The same technique could be used to build Expert System Shell based on any other educational departments, mathematics, physics, etc.,). The only difference is to acquire knowledge suitable to the desired department.

المستخلص

من الأمور الرئيسية التي لا يمكن الاستغناء عنها في كل مؤسسة تعليمية الجدول الزمني للدروس. الهدف من هذا البحث هو تطوير نظام خبير بلغة برمجة فيجيوال برولوك للجدول الأسبوعي. النظام المقترح (ESWTT) يتكون أساسا من مرحلتين. المرحلة الأولى هي المسؤولة عن الاكتساب التلقائي لمعرفة الخبراء. المرحلة الثانية تعنى ببناء الجدول الزمني من المعرفة التي أدخلت باستخدام طريقة التسلسل إلى الإمام (forward chaining) أو ما تسمى بواجهة البيانات المدفوعة (data driven interface). عند اختبار منظومة (ESWTT) من قبل الخبراء والمستخدمين النهائيين تبين إن كفاءة (ESWTT) في بناء قاعدة المعرفة وفي بناء الجدول الزمني للدروس الأسبوعية هو 100%. نفس التقنية يمكن أن تستخدم في بناء واجهات خبيرة لبقية الأقسام التعليمية ألأخرى (الرياضيات، الفيزياء،...الخ.) والفرق الوحيد هو باكتساب المعرفة الخاصة بكل قسم.

Keywords: Expert system, knowledge acquisition, and knowledge engineering.

1. Introduction

Expert systems (ES) are computer applications which embody some non-algorithmic expertise for solving certain types of problems. For example, expert systems are used in diagnostic applications servicing both people and machinery. They also play chess, make financial planning decisions, configure computers, monitor real time systems, underwrite insurance policies, and perform many other services which previously required human expertise [1]. Expert system mainly consists of four components: Knowledge-Based (KB), inference engine, user interface, and knowledge acquisition [2, 3]. The KB consists of rules and facts that are acquired from knowledge, opinion, and experiences of experts. It defines the knowledge presentation schemes which specify the relationship between rules and facts representing related experiences [3]. The process of building knowledge-base is part of knowledge engineering [4]. The inference engine is a processor that matches the facts contained in the working memory with the domain knowledge contained in the knowledge base to draw conclusions about the problem [5]. Knowledge acquisition facility allows adding, editing and deletion of rules in the knowledge base [6]. These components are illustrated in figure 1 below:-

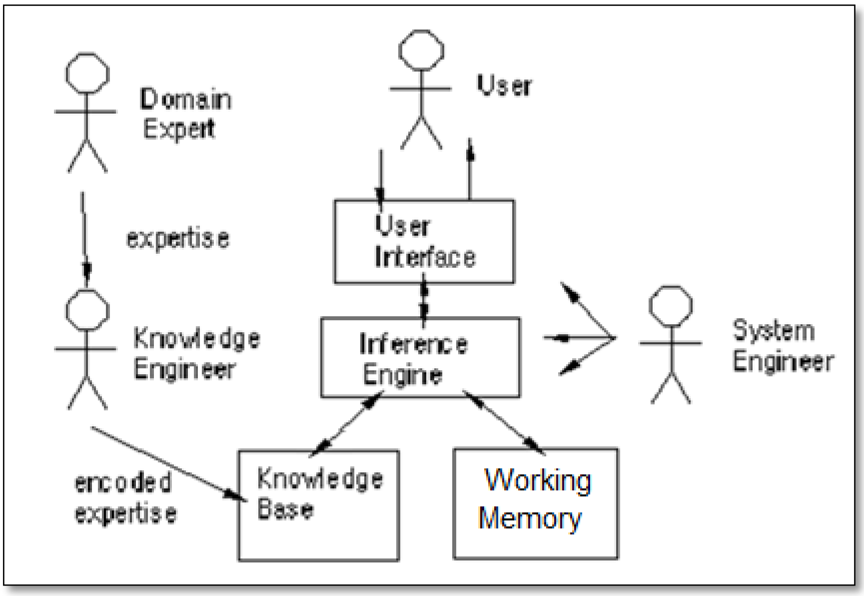

Figure 1 Expert system components and human interfaces

Most expert systems are developed using specialized software tools called *shells*. These shells come equipped with an inference mechanism (backward chaining, forward chaining, or both), and require knowledge to be entered according to a specified format [7].

Shells contain facilities that can simplify knowledge acquisition. It provides a step-by-step methodology and a user-friendly interface for a knowledge engineer The friendly interface allows the domain experts themselves to be directly involved in structuring and encoding the knowledge [4]. Non-programmer expert can understand shells without understanding the lengthy learning process.

A Boltzmann machine neural network based system is developed for finding optimal faculty schedule by Hisham Al-Rawi and Nahla Mohi Al-Din [8]. The system first formulate the problem of time tabling in a graph form and the optimal scheduling problem is considered as a graph coloring problem[8]. A rule based expert system to automatically select cutting parameters in milling operators is designed by Luis Rubio, Manuel De la Sen, Andrew P. Longstaff and Simon Fletcher[9]. The knowledge base of the system presents considerations of stability, machine drives efficiency and restrictions while adaptively controlling milling forces in suitable working points. A cost function has been conceived and constructed to Pareto-optimise cutting parameters subjected to muti-objective purposes, namely: tool-life, surface roughness, material remove rate and stability rate parameter. Shibly Rahman, Faisal Khan, Brian Veitch and Paul Amyotte [10] developed A knowledge-based expert system, ExpHAZOP+,HAZOP (Hazard and Operability) to automate the manual HAZOP analysis and accelerate the process. ExpHAZOP+ comprises a graphical **user interface** (GUI), a knowledge-base and an inference engine. One of the unique features of ExpHAZOP+ is the fault propagation algorithm, an aspect of the inference engine, which defines the propagation of deviations to all downstream equipment. The dynamic knowledge-base of ExpHAZOP+ allows a user to update knowledge while performing the HAZOP analysis and to use that knowledge in the result. ExpHAZOP+ is easy to use and provides results in a standard report format. Pamela N.Gray and Xenogene G. [11] designed eGanges which is a map-based, expert-friendly expert system shell that allows construction of nested rule or procedure maps using glosses of nodes in the maps. Gloss options include links between nodes in the same map and between parallel maps. eGanges is an expert system shell, mainly for the domains of law, quality control management, and education. Shikhar Kr. Sarma, Kh. Robindro Singh and Abhijeet Singh [12] developed an architectural framework of an Expert System in the area of agriculture and describe the design and development of the rule based expert system, using the shell ESTA (Expert System for Text Animation). The designed system is intended for the diagnosis of common diseases occurring in the rice plant. Hussein H. Owaied proposed framework model for expert system shell which is based on the integration of Rule-base and the case-based forms using Blackboard [4] which facilitate applying more than one problem solving methods and search techniques in inference engine of the expert system shell. The Rule-base and Case-base formats have been converted into tables.

Motivated by the need for an expert system that allows domain expertise to construct a suitable KB without any Rule-duplication, an expert system for building Weekly Time Table is suggested. The suggested system helps experts to construct the KB without the need for the expert system designer. Multiple KB systems could be constructed by different experts through providing suitable knowledge acquiring. The aim of this work is to:

1- construct Table of weekly lessons,
2- generate report on classrooms, laboratories and hours booked by academic levels,
3- generate report on the lectures and leisure hours of faculty members and finally,
4- since some of the faculty members teaches more than one stage and more than one subject so the program must take into account that conflicts do not occur on the dates of lectures for the same lecturer.

ESWTT was implemented using Visual Prolog.

2. Expert System

An expert system program may be either domain specific or general-purpose. Domain specific program is used for developing specific application domains i.e. A program that is designed for the purpose of calculating graduation rates for students cannot be based, for example, the diagnosis of faults in vehicles. Similarly the program which is handling databases and information retrieval of data cannot be used, for example, translating or summarizing texts. The programs operate within domain-specific knowledge, which is designed to work with it. General-purpose program offers flexibility and generality to solve different types and areas of problems. It provides the following benefits [13]:

1- Can be used for different applications.
2- Allows fast expert system construction.
3- No need for high programming skill.
4- Cost reduction.

The first step in building any time table is Knowledge acquisition. It is the process of transforming the extracted knowledge (domain experts' knowledge) to forms suitable to be saved in the Knowledge-Based System (KBS). Many researchers and practitioners have identified this process as a bottleneck that restricts the development of expert system. The knowledge should be validated and verified to improve its quality. Then the acquired knowledge is organized and encoded in the KB [13].

In this work, Acquiring knowledge from domain experts is via friendly user interface using natural language. The user interface allows the expert to enter in Arabic or in English. The acquired knowledge is saved in the KB.

3. The ESWTT Identification

The first step in designing and developing ESWTT, is to define the following: What are the goal(s) of the program and where it will be used and by whom?
The goal is to design and build a program using Visual Prolog as programming language, and the outputs are: -

a - Table of weekly lessons.
b - Report on classrooms, laboratories and hours booked by academic levels.
c - Report on the lectures and leisure hours of faculty members.

The program will be used by the Department of Computer Science at a college of science, thus it is important to specify information concerning the following queries:

1 - Is the department contains preliminary and graduate studies?
2 - What is the number of grades?
3 - What is the number of subjects, the number of students for each stage?
To how many students groups the single-stage is divided?
4 - What are the names of the subjects taught at each stage?
What are the theoretical and practical hours for each subject? Teaches each material?
5 - What is the number of classrooms and laboratories? What is the name of each classrooms and lab? What is the capacity for each?
6 - Are there hours where the classrooms are reserved for other purposes related to the department or college?

The specified information will be used as inputs for the program.

4. The ESWTT Architecture

ESWTT is mainly consists of three subsystems (as illustrated in Figure 2), each of which is used to perform specific task.

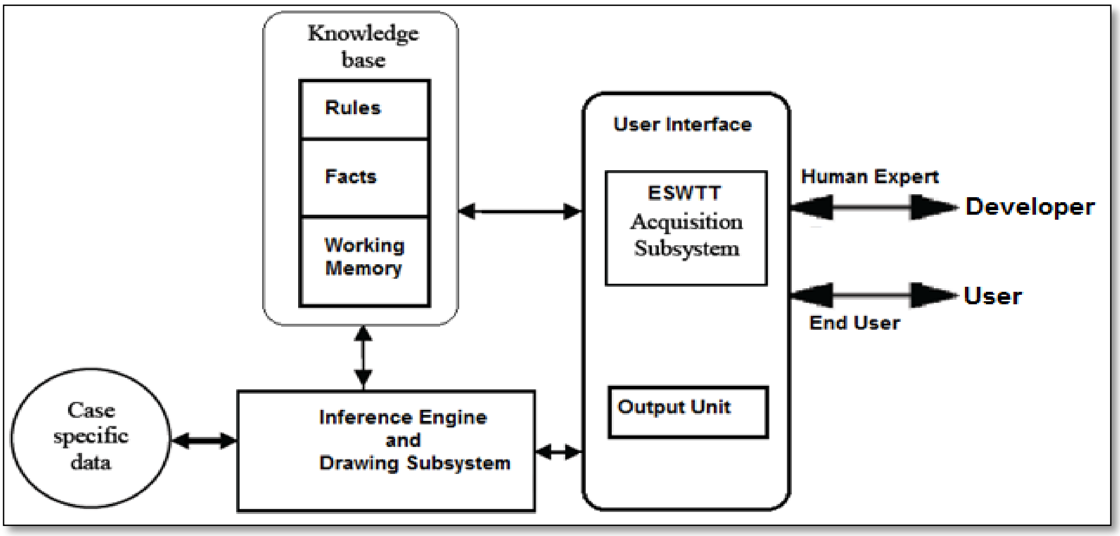

Figure 2: ESWTT architecture.

4.1. ESWTT Acquisition Subsystem

ESWTT acquisition subsystem is shown in Figure 3.The developed acquisition subsystem obtains knowledge from human expert by "automatic knowledge acquisition and knowledge engineer". Input is stored in the KB to be used later by the inference engine. The following subsections are the detailed explanation of each module.

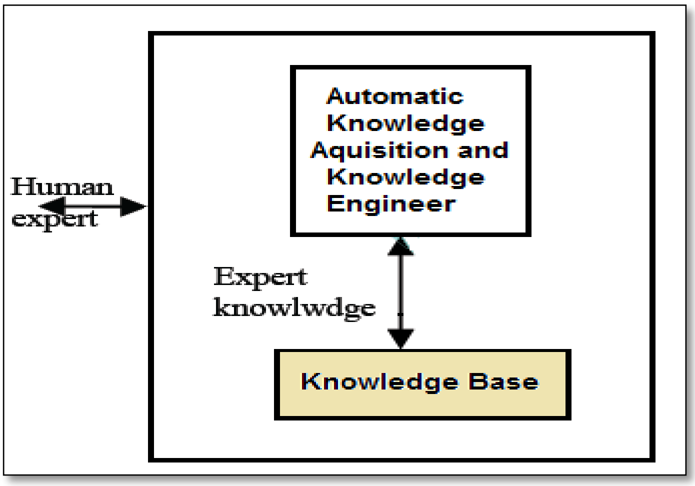

Figure 3: ESWTT acquisition subsystem

4.1.1. Automatic Knowledge Acquisition and Knowledge Engineer Module

The automatic knowledge acquisition and knowledge engineer module is the interface between human expert and ESWTT. It enables human expert to create his KB, and input information about it. The input KB is composed of set of facts and rules (IF <conditions> THEN <action list> ELSE <action list>).

4.2. ESWTT Knowledge Base

There is no graduate studies in the Department of Computer Science, an example of the input data is shown in table 1 bellow: -

Table 1: first and second stages' input data

stage	Subject	lecturer	Theoretical hours	Practical hours
First	Mathematics	Oras Khalid	2	0
	human rights	Wassan Muhsin	2	0
	Arabic	Ban Dawood	2	0
	logic design	Ahmad Saheb	2	2
	structured programming	Haider Natiq	2	2
	discrete mathematics	Ahmad Jmeel	2	2
	Organization	Ali Shameel	2	2
	English	Amna Firas	2	0
Second	Object oriented programming	Ammar Husain	2	2
	Graphics	Amer Jaafar	2	2
	woman & law	Wassan Muhsin	2	0
	Architecture	Reem Baqir	2	2
	English	Amna Firas	2	0
	data base	Ali Kadim	2	2
	system analysis	Ahmad Jmeel	2	2

From the above table, some of the faculty members teaches more than one stage and more than one subject so the program must take into account that conflicts do not occur on the dates of lectures for the same lecturer. Table 2 shows the number of subjects for each stage and the number of students. Table 3 shows the names of classrooms and their capacity. Finally Table 4 shows the names of labs and their capacity.

Table 2: Stage Information

Stage	Number of Groups for each Stage	Number of Students for each Stage	Number of Subjects for each Stage
First	2	80	8
Second	1	63	7
Third	1	33	7
Fourth	1	28	7

Table 3: Classroom Information

Classroom Name(Symbol)	Classroom Capacity
Zahraa(k1)	60
Hakeem(k2)	20
Classroom3(K3)	30

Table 4: Labs Information

Lab Name(Symbol)	Lab Capacity
Lab 1 (1)	15
Lab 2 (2)	15
Lab 3 (3)	15
Lab 4 (4)	15

As well as two hours were identified to be reserved for other purposes related to the department or college, from 10.30 to 12.30 on Tuesday. Also the official working days are from Sunday to Thursday and the official working hours starting from 8.30 am to 2.30 pm.

The program will be used by the employee responsible for the preparation of the weekly lessons in the Department of Computer Science, so the program should be uncomplicated and easy to understand and use, and the software interface must be user friendly.

At this stage, the input and output format of the information must be specified, i.e. how to enter the information required to define the specific domain within which the program will work. This information will be stored in the knowledge base. The output is preferred to be clear and understandable by the user.

Figure 4 shows how the program will generate the schedule of the hours of theoretical lessons as shown below:-

four 1	three 1	two 1	first 2	first 1		
operating system - k3	research bases - hakeem		mathmatics - zahraa		1	
operating system - k3			mathmatics - zahraa		2	احد
security - hakeem	advanced mathematics - k3		human rights - zahraa		3	
security - hakeem	advanced mathematics - k3		human rights - zahraa		4	
windows programming - hakeem	advanced programming - k3		arabic - zahraa		5	
windows programming - hakeem	advanced programming - k3		arabic - zahraa		6	
networks - hakeem		system analysis - k3	logic design - zahraa		1	
networks - hakeem		system analysis - k3	logic design - zahraa		2	اثنين
applications - hakeem		english - k3	structured prog. - zahraa		3	
applications - hakeem		english - k3	structured prog. - zahraa		4	
image processing - hakeem		woman & law - k3	discrete math - zahraa		5	
image processing - hakeem		woman & law - k3	discrete math - zahraa		6	
project		oop – hakeem	organization - zahraa	english - k3	1	
project		oop – hakeem	organization - zahraa	english - k3	2	ثلاثاء
					3	
					4	
			english - zahraa	organization - k3	5	
			english - zahraa	organization - k3	6	
		architecture - zahraa		discrete math - k3	1	
		architecture - zahraa		discrete math - k3	2	
		data base - zahraa		structured prog. - k3	3	اربعاء
		data base - zahraa		structured prog. - k3	4	
	artificial intelligence - zahraa			logic design - k3	5	
	artificial intelligence - zahraa			logic design - k3	6	
	algorithm design - zahraa	graphics - hakeem		arabic - k3	1	خميس
	algorithm design - zahraa	graphics - hakeem		arabic - k3	2	
	architecture - zahraa			human rights - k3	3	
	architecture - zahraa			human rights - k3	4	
	architecture - zahraa			mathmatics - k3	5	
	research bases - zahraa			mathmatics - k3	6	

Figure 4: Lessons' Time Table for the Theoretical Hours

Figure 5 shows how the program will generate the time table of the hours of practical lessons in the Department of Computer Science.

Official working hours is encoded so to shorten the place in the interface and each cell in the table in Figure 4 contains the name of the subject and the classroom in which the lecture will be received, and that each cell in the table in Figure 5 contains the name of the subject and the laboratory.

table1

four 1	three 1	two 1	first 2	first 1		
			logic design - 1		1	أحد
			logic design - 1		2	
			discrete math - 1		3	
			discrete math - 1		4	
			organization - 1		5	
			organization - 1		6	
		graphics - 1			1	اثنين
applications - 4		graphics - 1			2	
applications - 4		architecture - 1			3	
windows programming - 4		architecture - 1			4	
windows programming - 4		system analysis - 1			5	
	algorithm design - 4	system analysis - 1			6	
operating system - 4	advanced programming - 1				1	ثلاثاء
operating system - 4	advanced programming - 1				2	
security - 1	algorithm design - 4				3	
security - 1	artificial intelligence - 4				4	
networks - 1	artificial intelligence - 4				5	
networks - 1		data base - 4			6	
image processing - 1		data base - 4			1	أربعاء
image processing - 1		english - 4			2	
		oop - 4			3	
		oop - 4			4	
			english - 4		5	
				english - 4	6	
				organization - 4	1	خميس
				organization - 4	2	
				discrete math - 4	3	
				discrete math - 4	4	
				logic design - 4	5	
				logic design - 4	6	

Figure 5: Lessons' Time Table for the Practical Hours

4.2.1 The ESWTT Conceptualization

The second step of the process of developing the program includes identify concepts and key elements, determine the relationships and the connections among them, determine the general formulation of processes, which will be done on relationships and concepts, also control mechanisms are shaped, determine how to acquire knowledge and data by the program interface and where and how it will be stored.

4.2.1.1 Concepts and key elements

These are the official working days, the official working hours, stages, subjects, the number of theoretical hours, the number of practical hours, members of the Commission teaching, Classrooms, laboratories and students.

4.2.1.2 Relations and connections that bind concepts and key elements

The predicate logic is used to describe these relations as follows:

A - a relation that connects the Day, Official working hours, and Classrooms (information relating to the Classrooms as Classroom symbol,, its name, capacity whether the Classroom is empty or not), Stage, Subject Name, Number of theoretical and practical hours of that subject and finally the Lecturer whom teaches that subject, as shown below:-

place_name_capacity(DayNo,HourNo,PlaceNo,PlaceName,

PlaceCapacity,EmptyorNot,StageNo,
SubjectName,TheoreticalHours,
PracticalHours,LecturerName).

B - a relation that connects the Day, Official working hours, Labs (information relating to the Labs as Labs symbol,, its name, capacity whether the Labs is empty or not), Stage, Subject Name, Number of theoretical and practical hours of that subject and finally the Lecturer whom teaches that subject, as shown below:-

lab_name_capacity_empty_or_not(DayNo,HourNo,LabNo,
LabName,LabCapacity,
EmptyorNot,StageNo,
SubjectName,TheoreticalHours,
PracticalHours,LecturerName).

C- a relation that connects Subject Name with Number of theoretical and practical hours of that subject as shown below:-

subject(SubjectName,TheoreticalHours,PracticalHours).

D- a relation that connects Stage, Subject Name with the Lecturer whom teaches that subject as shown below:-

stage_subject_lecturer(StageNo,

subject(SubjectName, TheoreticalHours,PracticalHours),

LecturerName).

E- a relation that connects Stage with Number of students as shown below:-

stage_students_no(StageNo,NofStudents).

F- a relation that connects Stage with Number of Groups for that stage as shown below:-

stage_group(StageNo,NofGroups).

4.2.2 The ESWTT Processes Formulation

The third step in developing the ESWTT system is the general formulation of processes that will be done on the relations defined previously. From Figure 4 and Figure 5 above, the table cells are divided into: cells special for days, cells special for hours of each day, and stage-specific cells (and Groups for each stage) filled by the subject and the Lecturer whom teaches that subject. As the number of official working days is 5, and at each day the number of official working hours is 6 then the maximum number of cells for each stage (group of stage) is (5 * 6 = 30 cell).

The easiest way to build the table is by dividing it into several sub-tables. Since the availability of Classrooms and Labs is the main factor for the possibility of distributing theoretical and practical subjects' hours, therefore; a sub-table will be created for each Classroom and Laboratory. Each sub-table has 30 cell. This is known as the initialization process. Figure 6 shows Classrooms initialization as shown below:-

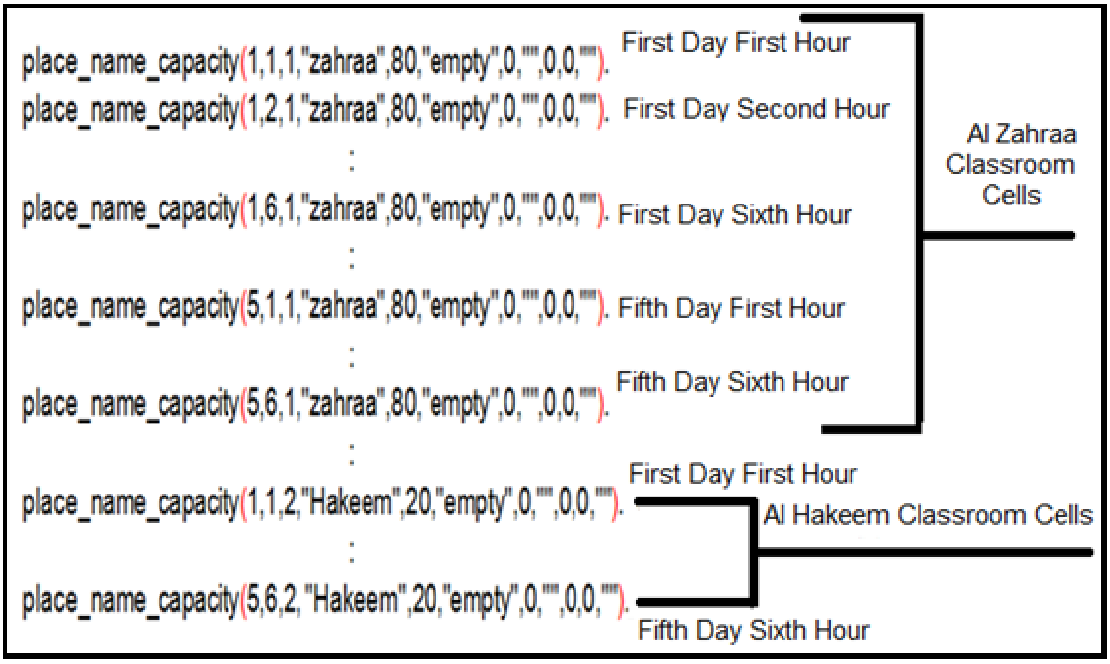

Figure 6: Classrooms initialization

By the same way, cells for each Lab and for every official working hour in every working day will be initialized as shown in figure 7 below:-

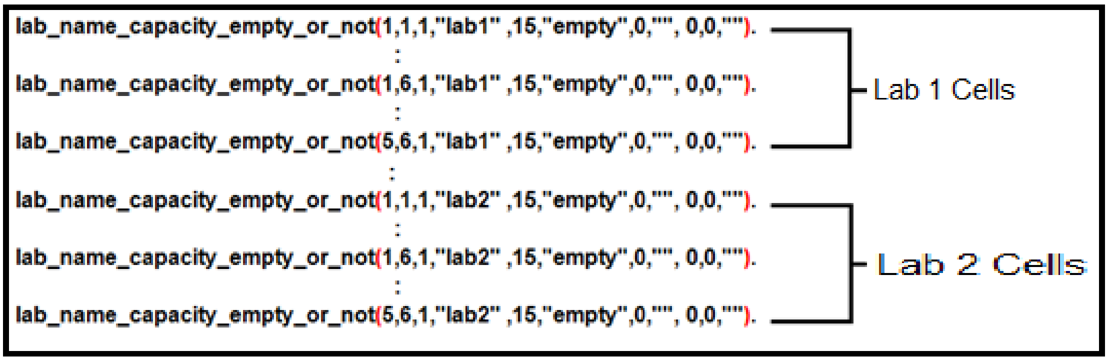

Figure 7: Labs initialization

All Classrooms and laboratories are empty and the value of 0 is placed for each of the stage, the number of theoretical and practical hours for each subject. "" value is placed for each subject name, the name of teaching lecturer (i.e. the table is empty for all official working hours).

4.3. ESWTT Inference Engine and User Interface Subsystem

The inference engine performs the task of communicating with the end-user (inexpert user) by executing rules which reside in the rule base with forward chaining capability where a dialog of (question/answer) begins between ESWTT and end-user. The Menu gives the end user the ability to answer with ("yes", "no") and to enter the required information to construct the time table of the lessons. ESWTT uses Data driven reasoning or forward chaining technique, which uses IF THEN rules to deduce a problem solution from initial data. ESWTT stores the produced solution in the KB to be used later by the drawing subsystem to draw the final result (table)to the end user. Example on the rules used in the inference engine is shown in Figure 8 below:-

Rule1: IF the student of a stage is taking two different lectures at the same date
THEN change the date of taking one of the lectures

Rule2: IF a lecturer is giving a lecture for two different stages and at the same date
THEN change the date of giving one of the lectures

Figure 8: Example on the rules used in the inference engine

4.4 Drawing Subsystem and Output Unit

The drawing subsystem takes the output knowledge; it deduced by the inference engine and which is stored in the knowledge base and draws the output time table as shown in figures 4 and 5 above.

5. Experimental Results

ESWTT provides user-friendly interface (consists of menus and windows). It provides many facilities to help both human experts and end-users with writing, and updating the knowledge they enter.

To test the ESWTT behavior and results, ESWTT was used to construct the time table of lessons for the computer science department in the college of science for women in Baghdad University. The ES knowledge-base was constructed by domain human experts. The feedback was positive. The system was tested by end-users. When ESWTT tested by experts and end users, it was found that ESWTT performance in constructing KB and diagnosing problems was exact.

6. Conclusions

One of the major things that cannot be dispensed with in every educational institution is the schedule of lessons. This can be accomplished with the use of Expert System. The developed system (ESWTT) acquire the necessary knowledge to build and construct the desired time table of the computer science department lessons. Visual Prolog is used to program the system. It is important to point out that the suggested system can construct the time table of lessons for any educational department by entering the knowledge of that department (Mathematics or Physics knowledge departments for examples).

ESWTT is considered as general expert system used for solving deduction problems. The generality issue allows users to use ESWTT to construct and draw different time tables, and in turns they could be used to deduce and draw different problems. The deduction and drawing accuracy of ESWTT reaches 100% which is acceptable.

ESWTT used fast inference engine strategy (forward chaining) Finally, ESWTT is provided with user-friendly interface to simplify the system usage for both human expert and the end user. As future work, develop the ability of the system to construct and draw time table for the department contains preliminary and graduate studies. Also natural language understanding with syntax and semantic analyzer might improve the system performance. Also using speech recognition system to allow end users use voice instead of writing.

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