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Knowledge-based systems that determine the appropriate students major: In the faculty of engineering and information technology

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Abstract
In this paper a Knowledge-Based System (KBS) for determining the appropriate students major according to his/her preferences for sophomore student enrolled in the Faculty of Engineering and Information Technology in Al-Azhar University of Gaza was developed and tested. A set of predefined criterions that is taken into consideration before a sophomore student can select a major is outlined. Such criterion as high school score, score of subject such as Math I, Math II, Electrical Circuit I, and Electronics I taken during the student freshman year, number of credits passed, student cumulative grade point average of freshman year, among others, were then used as input data to KBS. KBS was designed and developed using Simpler Level Five (SL5) Object expert system language. KBS was tested on three generation of sophomore students from the Faculty of Engineering and Information Technology of the Al-Azhar University, Gaza.
The results of the evaluation show that the KBS is able to correctly determine the appropriate students major without errors.

Keywords: Knowledge-based system, Students major, KBS, University, SL5 Object

Introduction

The staffs of the faculty of Engineering and Information technology in Al-Azhar University of Gaza spend two to three weeks collecting data from the registrar office and students major preferences. After the collection of data is completed, they all saved in an excel sheet. Then, the group of staff dedicated to determine student majors takes a number of hours trying to figure out the appropriate student major taking into consideration student's preferences and the faculty criterion for each major.

The main objective of the KBS is to determine the appropriate students major minimizing the time spent by the dedicated group while identifying the appropriate student major in the Faculty of Engineering and Information Technology in Al-Azhar University.

In Al-Azhar University, students get admitted to the different majors in the Faculty of Engineering and Information Technology after they successfully passed the scientific branch of the high school with at least 75%, students are required to study their freshman year without getting a major yet. Once the student finished the freshman year, he or she can major in Computer and Communication Engineering, Mechatronics Engineering, Software Engineering, Medical Devices Engineering, Renewable Energy Engineering, Computer Science, or Information Systems. A student can major in one of the 7 majors if he/she satisfies specific requirements such as High school score, number of credits finished, pass some subjects in the freshman year, such as Math, Electrical Circuits, and Electronics for Computer and Communication Engineering, Mechatronics Engineering, Medical Devices Engineering, Renewable Energy Engineering. Other courses such as Introduction to Computing and Computer Programming I are used for Software Engineering, Computer Science, and Information Systems.

Knowledge-Based System Definition

A computer application that performs tasks that would otherwise be performed by a human expert [1, 2]. For example, there are KBS that can diagnose human illnesses, diagnoses cars problems, make financial forecasts, and schedule routes for delivery vehicles [12]. Some KBS are designed to take the place of human experts, while others are designed to aid them.

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KBS are part of a general category of computer applications known as artificial intelligence [17]. To design a KBS, one needs a knowledge engineer, an individual who studies how human experts make decisions and translates the rules into terms that a computer can understand. Knowledge-based system is a synonym for Expert Systems and Rule Based Systems. However, knowledge is the sort of information that people use to solve problems.
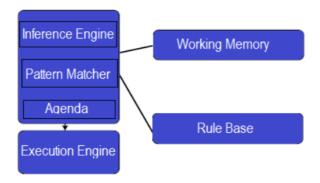
Advantages of KBS
KBS have the following advantages over human experts:
- The knowledge is permanent
- The knowledge is easily replicated
- The knowledge is represented explicitly, and can be evaluated
- The system is consistent - whereas human practitioners have bad days, computers don't.
- Once built, running costs are low

Knowledge-based system Architecture
A knowledge based system generally follows the architecture in fig. 1; this is the architecture of typical KBS. The working memory stores facts about the world; it is also sometimes called the "fact base". The knowledge base stores the system's rules. The rules, objects, and the initial facts form KBS "program". The inference engine is the "black box" that performs reasoning over the facts and rules; the left hand side of fig. 1 is called the "Rule Engine". Inside the rule engine, the pattern matcher selects rules that are applicable given the facts in the fact base, and activates these rules - that is, places them on the agenda. Then the execution engine fires the rules on the agenda in a particular order. The agenda can also be called the "conflict set", since all the rules on the agenda are applicable now, and are therefore in conflict; then the algorithm by which the execution engine decides on an order in which to fire the rules is called "conflict resolution".

Fig. 1: The architecture of a typical knowledge based system

SL5 Object language
SL5 Object, Simpler Level 5 Object Expert System Language is a rule-based language for specifying expert systems. Architecturally, SL5 Object is a production system executing a rule based program; thus, the SL5 Object language is a declarative (rather than imperative) language. The SL5 Object engine is implemented in Delphi Embarcadero RAD Studio XE6 [17].

Literature Review
There are many knowledge based systems that were designed to diagnose diseases[7-27], and a few expert system that advise student in selecting appropriate major[3-6]. But there is no specialized expert system for determining the appropriate student major based on his/her freshman year and his/her requested majors.

Author in [3] used Artificial Neural Networks and expert systems to obtain knowledge for the learner model in the Linear Programming Intelligent Tutoring System to be able to determine the academic performance level of the learners.

The authors in [4] presented the design and development of an expert system that aimed to improve the method of selecting the best suitable faculty/major for student planning to be enrolled in Al-Azhar University. The basic idea of their approach was designing a model for testing and measuring the student capabilities like intelligence, understanding, comprehension, mathematical concepts and others, and applying the module results to a rule-based expert system to determine the compatibility of those capabilities with the available faculties/majors in Al-Azhar University. The result was shown as a list of suggested faculties/majors that are most suitable with the student capabilities and abilities.

The author in [5] described an Internet-based expert system which provides advice to high school students or college freshmen who are seeking assistance in selecting a potential major. It emulates a professional academic advisor. The on-demand, approximately 15-min consultation gathers information from the student on his or her grades, degree of enjoyment of traditional courses, standardized test scores, interests, and aptitudes. It assesses student qualifications for a variety of majors. The expert system recommends six majors from among 60 widely diverse majors for the students to consider and produces a report that fully describes the students' responses in such a way that the output can be used by a human advisor.

Authors in [6] proposed an expert system-SAES which aims to provide intelligent advice to the student as to which major he/she should opt. SAES acquires knowledge of academic performances as well as explicit and implicit interests of the candidate. Knowledge representation in SAES is done by the use of a combination of case based and rule based reasoning. SAES draws inferences on the basis of acquired knowledge and also takes into account the degree of dilemma faced by the candidate and the time he/she takes to decide the interest areas. SAES then recommends the most suitable majors for each candidate, which are further classified as strong, mild and weak on the basis of calculated relative probabilities of success.

Methodology
KBS requires the students' data and faculty criterion data to be stored in MS access data base.

Student data
The Student data is collected from student record in registration office and the student himself/herself (student major requests 1, 2, and 3). Then the student data is stored in MS access table to be ready for the KBS to read. The student data include:
1. High School score,
2. Results in Math I in the student freshman year,
3. Results in Math II in the student freshman year,
4. Results in Electrical Circuits in the student freshman year,
5. Results in Electronics I in the student freshman year,

6. Number of credits passed in the student freshman year,
7. CGPA of the freshman year,
8. Results in Introduction to Computing in the student freshman year,
9. Results in Computer Programming I in the student freshman year,
10. Student major request 1
11. Student major request 2
12. Student major request 3

Faculty criterion for each major

The criterion for each major as specified by the faculty of Engineering and Information technology are stored in another MS access table to be ready for the KBS to read. The Faculty criterions are:
1. Minimum High School score for each major,
2. Minimum Average of (Math I, Math II, Electrical Circuits, Electronics I)
3. Minimum of Number of credits passed in the student freshman year,
4. Minimum CGPA of the freshman year for each major,
5. Minimum Average of (Introduction to Computing, Computer Programming I)
6. Minimum Number of credits passed in the student freshman year,

Process to determine the appropriate major

KBS is designed and developed using SL5 Object which supports the use of MS access data base. KBS opens and read the faculty criterion from criterion table and the students' data from student table (See Fig. 1).

For each student in the student table, the KBS follow these steps:
1. Read one student record
2. Calculate the average score of the four subjects (Math I *4 + Math II *4 + Electrical Circuits *3+ Electronics I*3)/14
3. Calculate the average score of the two subjects (Introduction to Computing + Computer Programming I)/2
4. Check if student data satisfy the requirement of the first major that was requested: if yes, store the major in the data base directly; otherwise check if the student data satisfy the requirement of the third major that was requested: if yes, store the major in the data base directly; otherwise store in the data base "None of the majors requested is fulfilled".
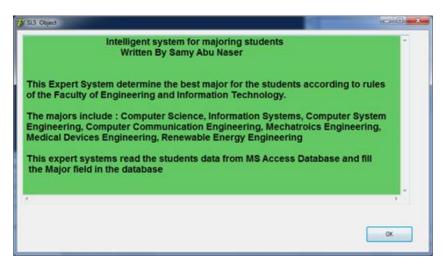5. Read next student record

Fig. 2: Opening Session of KBS system

At the end of KBS session, KBS display a summary of how many students in each major and closes the MS access data base as in Figure 3.
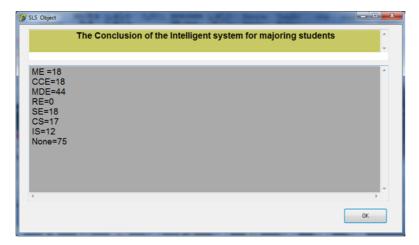

Fig. 3: Summery of KBS system

Evaluation of the KBS

The KBS system was tested using the student data and faculty requirements of the previous three years (2013, 2014, and 2015). The faculty requirement is different for every year depending on the number of new enrolled student every year. The results of testing of batch of students in each year were excellent when compared with the manual method used in all three years.

Conclusion

A Knowledge-Based System was designed and developed for determining the appropriate sophomore students major. KBS determine the major to students enrolled in the Faculty of Engineering and Information Technology in Al-Azhar University of Gaza.

A set of predefined criterions by the Faculty of Engineering and Information Technology is taken into consideration before a sophomore student can select a major. These criterions include high school score, score of subject such as Math I, Math II, Electrical Circuit I, and Electronics I taken during the student freshman year, number of credits passed, student cumulative grade point average of freshman year. KBS was implemented using SL5 Object expert system language. KBS was tested on three generation of sophomore students from the Faculty of Engineering and Information Technology of the Al-Azhar University. The evaluation shows that the KBS is able to correctly determine the appropriate students major without problems.

Source code of KBS written in SL5 Object Expert System Language

```
CLASS db1 INHERIT msaccess
WITH sn NUMERIC
WITH r1 STRING
WITH r2 STRING
WITH r3 STRING
WITH sno STRING
WITH sname STRING
WITH calc1 NUMERIC
WITH calc2 NUMERIC
WITH electricity NUMERIC
WITH electronic NUMERIC
WITH icomp NUMERIC
WITH prog NUMERIC
WITH twajihi NUMERIC
WITH pcredit NUMERIC
WITH gpa NUMERIC
WITH major STRING
WITH subj4 NUMERIC
WITH subj2 NUMERIC

CLASS db2 INHERIT msaccess
WITH sn NUMERIC
WITH me1 NUMERIC
WITH me2 NUMERIC
WITH cce1 NUMERIC
WITH cce2 NUMERIC
WITH mde1 NUMERIC
WITH mde1 NUMERIC
WITH re1 NUMERIC
WITH re2 NUMERIC
WITH se1 NUMERIC
WITH se2 NUMERIC
```

```
WITH cs1 NUMERIC
WITH cs2 NUMERIC
WITH is1 NUMERIC
WITH is2 NUMERIC

INSTANCE mstable1  ISA db1
  WITH access IS  write
  WITH action IS open
  WITH eof  := FALSE
  WITH index file  := " "
  WITH file name := "majoring.mdb"
  WITH table name := "table1"
  WITH active := TRUE

INSTANCE mstable2  ISA db2
  WITH access IS  read
  WITH action IS open
  WITH eof  := FALSE
  WITH file name := "majoring.mdb"
  WITH table name := "table2"
  WITH active := TRUE

ATTRIBUTE start SIMPLE
ATTRIBUTE X   NUMERIC
ATTRIBUTE r1  NUMERIC
ATTRIBUTE r2  NUMERIC
ATTRIBUTE r3  NUMERIC
ATTRIBUTE me  NUMERIC
ATTRIBUTE cce NUMERIC
ATTRIBUTE re  NUMERIC
ATTRIBUTE mde NUMERIC
ATTRIBUTE se  NUMERIC
ATTRIBUTE cs  NUMERIC
ATTRIBUTE is  NUMERIC
ATTRIBUTE subj4  NUMERIC
ATTRIBUTE subj2  NUMERIC
ATTRIBUTE num of me  NUMERIC  INIT 0
ATTRIBUTE num of cce NUMERIC  INIT 0
ATTRIBUTE num of re  NUMERIC  INIT 0
ATTRIBUTE num of mde NUMERIC INIT 0
ATTRIBUTE num of se  NUMERIC INIT 0
ATTRIBUTE num of cs  NUMERIC INIT 0
ATTRIBUTE num of is  NUMERIC  INIT 0
ATTRIBUTE num of none NUMERIC INIT 0
ATTRIBUTE calc stats NUMERIC INIT 0

INSTANCE the domain ISA domain
 WITH start := TRUE
WITH X  := 0
WITH r1  := 0
WITH r2  := 0
WITH r3  := 0
WITH me  := 0
WITH cce := 0
WITH re  := 0
WITH mde := 0
WITH se  := 0
WITH cs  := 0
WITH is  := 0
WITH subj4 := 0
WITH subj2 := 0

INSTANCE the application ISA application
 WITH title display := introduction
```

WITH conclusion display := Conc
WITH exit := FALSE
WITH refraction := FALSE

INSTANCE introduction ISA display
 WITH wait := TRUE
 WITH delay changes := FALSE
 WITH items [1] := textbox 1

INSTANCE textbox 1 ISA textbox
 WITH location := 10,10,800,350
 WITH pen color := 0,0,0
 WITH fill color := 100,200,100
 WITH justify IS left
 WITH font := "Arial"
 WITH font style IS bold
 WITH font size := 14
 WITH text :="

 Intelligent system for majoring students
        Written By Samy Abu Naser

This Expert System determine the best major for the students according to rules
of the Faculty of Engineering and Information Technology.

The majors include: Computer Science, Information Systems, Computer System
Engineering, Computer Communication Engineering, Mechatroics Engineering,
Medical Devices Engineering, Renewable Energy Engineering

This expert systems read the students data from MS Access Database and fill
 the Major field in the database"

INSTANCE Conc ISA display
 WITH wait := TRUE
 WITH delay changes := FALSE
 WITH items [1] := title textbox
 WITH items [2] := result textbox

INSTANCE title textbox ISA textbox
 WITH location := 20,10,800,70
 WITH pen color := 0,0,0
 WITH fill color := 200,200,100
 WITH justify IS center
 WITH font := "Arial"
 WITH font style IS bold
 WITH font size := 14
 WITH text := " The Conclusion of the Intelligent system for majoring students"

INSTANCE result textbox ISA textbox
 WITH location := 20,90,800,300
 WITH pen color := 0,0,0
 WITH fill color := 170,170,170
 WITH justify IS left
 WITH font := "Arial"
 WITH font size := 14
 WITH text :=" --===--"

RULE r1
IF start
THEN action OF mstable1 IS top
AND action OF mstable2 IS top
AND start := FALSE
AND subj4 := ((mstable1.calc1 * 4) + (mstable1.calc2 * 4) + (mstable1.electricity * 3) + (mstable1.electronic * 3)) / 14
AND subj2 := (mstable1.icomp + mstable1.prog) / 2

RULE r2
IF me = 0
AND mstable1.gpa >= mstable2.me1
AND mstable1.pcredit >= 24
AND subj4 >= mstable2.me2
THEN me := 3

RULE r3
IF cce = 0
AND mstable1.gpa >= mstable2.cce1
AND mstable1.pcredit >= 24
AND subj4 >= mstable2.cce2
THEN cce := 3

RULE r4
IF mde = 0
AND mstable1.gpa >= mstable2.mde1
AND mstable1.pcredit >= 24
AND subj4 >= mstable2.mde2
THEN mde:=3

RULE r5
IF re = 0
AND mstable1.gpa >= mstable2.re1
AND mstable1.pcredit >= 24
AND subj4 >= mstable2.re2
THEN re:=3

RULE r6
IF se = 0
AND mstable1.gpa >= mstable2.se1
AND mstable1.pcredit >= 24
AND subj2 >= mstable2.se2
THEN se := 3

RULE r7
IF cs = 0
AND mstable1.gpa >= mstable2.cs1
AND mstable1.pcredit >= 24
AND subj2 >= mstable2.cs2
THEN cs := 3

RULE r8
IF is = 0
AND mstable1.gpa >= mstable2.is1
AND mstable1.pcredit >= 24
AND subj2 >= mstable2.is2
THEN is := 3

RULE r9
IF mstable1.r1 = "ME"
AND me = 3
THEN r1 := 1
AND me := 2

RULE r10
IF mstable1.r1 = "CCE"
AND cce = 3
THEN r1 := 1
AND cce := 2

RULE r11
IF mstable1.r1 = "MDE"
AND mde = 3
THEN r1 := 1
AND mde := 2

RULE r12
IF mstable1.r1 = "RE"
AND re = 3
THEN r1 := 1
AND re := 2

RULE r13
IF mstable1.r1 = "SE"
AND se = 3
THEN r1 := 1
AND se := 2

RULE r14
IF mstable1.r1 = "CS"
AND cs = 3
THEN r1 := 1
AND cs := 2

RULE r15
IF mstable1.r1 = "IS"
AND is = 3
THEN r1 := 1
AND is := 2

RULE r16
IF mstable1.r2 = "ME"
AND me >= 2
THEN r2 := 1
AND me := 1

RULE r17
IF mstable1.r2 = "CCE"
AND cce >= 2
THEN r2 := 1
AND cce := 1

RULE r18
IF mstable1.r2 = "MDE"
AND mde >= 2
THEN r2 := 1
AND mde := 1

RULE r19
IF mstable1.r2 = "RE"
AND re >= 2
THEN r2 := 1
AND re := 1

RULE r20
IF mstable1.r2 = "SE"
AND se >= 2
THEN r2 := 1
AND se := 1

RULE r21
IF mstable1.r2 = "CS"
AND cs >= 2
THEN r2 := 1
AND cs := 1

RULE r22
IF mstable1.r2 = "IS"
AND is >= 2
THEN r2 := 1
AND is := 1

RULE r23
IF mstable1.r3 = "ME"
AND me >= 1
THEN r3 := 1
AND me := -1

RULE r24
IF mstable1.r3 = "CCE"
AND cce >= 1
THEN r3 := 1
AND cce := -1

RULE r25
IF mstable1.r3 = "MDE"
AND mde >= 1
THEN r3 := 1
AND mde := -1

RULE r26
IF mstable1.r3 = "RE"
AND re >= 1
THEN r3 := 1
AND re := -1

RULE r27
IF mstable1.r3 = "SE"
AND se >= 1
THEN r3 := 1
AND se := -1

RULE r28
IF mstable1.r3 = "CS"
AND cs >= 1
THEN r3 := 1
AND cs := -1

RULE r29
IF mstable1.r3 = "IS"
AND is >= 1
THEN r3 := 1
AND is := -1

RULE r30
IF r1 =1
AND calc stats = 0
THEN mstable1.major := mstable1.r1
AND mstable1.subj4 := subj4
AND mstable1.subj2 := subj2
AND action OF mstable1 IS update record
AND action OF mstable1 IS advance
AND subj4 := ((mstable1.calc1 * 4) + (mstable1.calc2 * 4)
+ (mstable1.electricity * 3) + (mstable1.electronic * 3)) / 14

AND subj2 := (mstable1.icomp + mstable1.prog) / 2
AND r1 := 0
AND r2 := 0
AND r3 := 0
AND me := 0
AND cce := 0
AND mde := 0
AND re := 0
AND se := 0
AND cs := 0
AND is := 0
AND X := 0

RULE r31
IF r1 = 0
AND r2 = 1
AND calc stats = 0
THEN mstable1.major := mstable1.r2
AND mstable1.subj4 := subj4
AND mstable1.subj2 := subj2
AND action OF mstable1 IS update record
AND action OF mstable1 IS advance
AND subj4 := ((mstable1.calc1 * 4) + (mstable1.calc2 * 4)
+ (mstable1.electricity * 3) + (mstable1.electronic * 3)) / 14
AND subj2 := (mstable1.icomp + mstable1.prog) / 2
AND r1 := 0
AND r2 := 0
AND r3 := 0
AND me := 0
AND cce := 0
AND mde := 0
AND re := 0
AND se := 0
AND cs := 0
AND is := 0
AND X := 0

RULE r32
IF r1 = 0
AND r2 = 0
AND r3 = 1
AND calc stats = 0
THEN mstable1.major := mstable1.r3
AND mstable1.subj4 := subj4
AND mstable1.subj2 := subj2
AND action OF mstable1 IS update record
AND action OF mstable1 IS advance
AND subj4 := ((mstable1.calc1 * 4) + (mstable1.calc2 * 4)
+ (mstable1.electricity * 3) + (mstable1.electronic * 3)) / 14
AND subj2 := (mstable1.icomp + mstable1.prog) / 2
AND r1 := 0
AND r2 := 0
AND r3 := 0
AND me := 0
AND cce := 0
AND mde := 0
AND re := 0
AND se := 0
AND cs := 0
AND is := 0
AND X := 0

RULE r33
IF eof OF mstable1

AND calc stats = 0
THEN calc stats := 1
AND action OF mstable1 IS top

RULE r34
IF calc stats = 1
AND mstable1.major = "ME"
THEN num of me := num of me + 1
AND action OF mstable1 IS advance

RULE r35
IF calc stats = 1
AND mstable1.major = "MDE"
THEN num of mde := num of mde + 1
AND action OF mstable1 IS advance

RULE r36
IF calc stats = 1
AND mstable1.major = "CCE"
THEN num of cce := num of cce + 1
AND action OF mstable1 IS advance

RULE r37
IF calc stats = 1
AND mstable1.major = "RE"
THEN num of re := num of re + 1
AND action OF mstable1 IS advance

RULE r38
IF calc stats = 1
AND mstable1.major = "SE"
THEN num of se := num of se + 1
AND action OF mstable1 IS advance

RULE r39
IF calc stats = 1
AND mstable1.major = "CS"
THEN num of cs := num of cs + 1
AND action OF mstable1 IS advance

RULE r40
IF calc stats = 1
AND mstable1.major = "IS"
THEN num of is := num of is + 1
AND action OF mstable1 IS advance

RULE r41
IF calc stats = 1
AND mstable1.major = "none"
THEN num of none := num of none + 1
AND action OF mstable1 IS advance

RULE r42
IF calc stats = 1
AND eof OF mstable1
THEN text OF result textbox := "ME =" + num of me +
"\n"+ "CCE=" + num of cce +"\n"+ "MDE=" + num of mde
+ "\n"+"RE=" +
num of re + "\n"+"SE=" + num of se +"\n"+"CS="+ num of
cs +"\n" +"IS=" + num of is +"\n"+"None="+ num of none
AND exit OF the application := TRUE
RULE r43
IF r1 = 0
AND r2 = 0
AND r3 = 0

```
AND calc stats = 0
AND NOT eof  OF mstable1
THEN mstable1.major := "none"
AND  mstable1.subj4 := subj4
AND  mstable1.subj2 := subj2
AND action OF mstable1 IS update record
AND action OF mstable1 IS advance
AND subj4 := ((mstable1.calc1 * 4) + (mstable1.calc2 * 4)
+ (mstable1.electricity * 3) + (mstable1.electronic * 3)) / 14
AND subj2 := (mstable1.icomp + mstable1.prog ) / 2
AND me := 0
AND cce := 0
AND mde := 0
AND re := 0
AND se := 0
AND cs := 0
AND is := 0
END
```

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