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AGENT-BASED INTELLIGENT ACADEMIC ADVISOR SYSTEM

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Abstract

Academic advising is one of the most important activities of the faculty members for following up and guiding the students during their study. It includes many time consuming tasks, as the academic advisor needs to investigate the cases of all student individually to specify the available choices, and to apply his expertise in providing suitable advice for each student. Registration and timetabling systems greatly affect the length of the studying period of the students, as the timetable contradictions may reduce the chance of registering courses for students. Also there are practical cases that require changing timetables instead of reconstructing the whole timetable from scratch, like technical problems in lab, late arrival of new faculty members, and delaying decisions of student re-enrollment. This paper introduces an intelligent advising system that adopts multi-agents technology for suggesting courses for students, and modifying the faculty timetables automatically to satisfy as much registration requests as possible. This will reduce the cases where students are not able to be enrolled in courses due to contradictions in timetables.

Introduction

Academic advising is becoming very hard and time consuming especially with the increasing number of enrollment of students and the decreasing advisors/students ratio. There is a real need to the introduction of intelligent academic advising system to relax the burden of academic advisors, and assist both the student and the academic advisor to accomplish their goals.

There are many tasks that the academic advisor is required to perform, including clarification of career and life goals, interpretation of institutional requirements, enhancing the awareness of the student about available educational resources, and many other tasks, but the most important and obviously affecting the enrollment period of the student in the academic institution is the planning of courses during the enrollment time, as this is the main factor that can drive the student to accomplish his academic degree in the shortest possible time [10].

All the research efforts that have been conducted for timetabling automation have adopted the creation of timetables from scratch, although, modifying an existing timetable is frequently needed, especially for resolving conflicts that arise when suggesting a new course to a student, or when we need to join two sections for example. Regenerating a new timetable in this case is not possible because there are students who are already enrolled in the academic subjects according to the current timetable, so what is needed is just a partial adjustment that takes in consideration the timetables of students enrolled in the suggested subject.

Expert systems science is a branch of Artificial Intelligence (AI), that aims at developing intelligent software to simulate human experts behavior in a certain domain of expertise like education, industry, medicine, or any other domain of expertise, by acquiring knowledge from its different sources, and using this acquired knowledge in finding solutions for problems in that domain.

In the last few years, agent technology has proved its eligibility in the software industry because of the advantages that Multi-agent systems have in complex and distributed environments. Multi-agent systems (MAS) are commonly intended as computational systems where several autonomous entities called agents, interact or work together to perform some tasks. In MAS communication enables the agents to exchange information on the basis of which they coordinate their actions or cooperate with each other.

The paper is organized as follows: Section 2 provides background of academic advising in addition to the used technologies like (MAS), Expert systems, and the scheduling problem in general. In section 3, the design of the proposed system is presented, and the implementation is specified. Section 4 demonstrates a sample run of the implemented prototype and discusses the results, and finally, conclusions and ideas for future work are discussed.

Background

Advising and tracking the progress of a student throughout his entire study for the required degree plays an important role towards his success. The academic advisor is responsible for providing the student with the right information in the right time to let the student fulfill the requirements of his academic degree within the shortest possible time, and the highest level of achievement. Tasks of the academic advisor include choosing the major, minor and the required program that a student wishes, in addition to planning the schedule of the courses of the required program for the entire period of the student's enrollment in the academic institute.

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According to the National Academic Advising Association (NACADA), academic advising include the following tasks [1]:

- Development of suitable educational plans, Clarification of career and life goals,
- Selection of appropriate courses and other educational experiences,
- Interpretation of institutional requirements,
- Enhancement of student awareness about educational resources available such as internships and learning assistance programs,
- Evaluation of student progress toward established goals and development of decision making skills with reinforcement of student self-direction.

A. Advantages of Intelligent Academic Advisor

There are many advantages to the intelligent academic advisor that can be briefed as follows:

Availability: The Intelligent academic advising system is available all the time, while the human academic advisor has fixed and limited time, and needs prior appointment.
Initiative: The Intelligent academic advising system takes the initiative to contact the students, while the human academic advisor waits for students to come to contact him/her.
Comprehensiveness: The Intelligent academic advising system gives much knowledge and information about academic requirements in different levels: university, college, and department with rational explanation for these requirements, while human academic advisor has a limited memory capacity to memorize all details and reasons.
Knowledge-based advice: The Intelligent academic advising system can make short-term as well as long-term plans using the appropriate background knowledge while human academic advisor can only take the interests of the student in account, without applying previous cases similar to his/hers.
Continuous monitoring: The Intelligent academic advising system continuously monitors students' progress toward educational goals by up-to-date information while the human academic advisor needs to access different records to keep track of the student record.

B. Expert Systems and Multi-Agent Systems

Expert systems science is one of the branches of Artificial Intelligence (AI), that aims at developing intelligent software to simulate human experts behavior in a certain domain of expertise like education, industry, medicine, or any other domain of expertise, by acquiring knowledge from its different sources, and using this acquired knowledge in finding solutions for problems in that domain.
In the last few years, agent technology has come to the forefront in the software industry because of the advantages that Multi-agent systems have in complex and distributed environments. Multi-agent systems (MAS) are commonly intended as computational systems where several autonomous entities called agents, interact or work together to perform some tasks. In MAS communication enables the agents to exchange information on the basis of which they coordinate their actions or cooperate with each other and this is done through Agent Communication Languages (ACL).

C. Academic Timetabling

The most obvious service that the academic advisor provides to the student is the careful and rational planning of the course plan, as this directly affects the enrollment time of the student in the academic institution. This process is tightly coupled with the timetabling system used in generating the institute's timetable.
The timetabling problem is a specific type of scheduling problem which requires scheduling a sequence of lectures between teachers and students in a prefixed period of time satisfying a set of constraints of various types [2].
There are two types of constraints: hard and soft constraints, hard constraints are those that must be satisfied (i.e. they cannot be violated) and soft constraints are those that are preferably satisfied, but may be relaxed if necessary in order to create a complete timetable.
University Course Timetabling Problems is an NPhard problem, which is very difficult to solve by conventional methods and the amount of computation required to find optimal solution increases exponentially with problem size. [3].
The manual solution of the timetabling problem usually requires a lot of work. In addition, the solution obtained may be unsatisfactory in some respect; for example a student may not be able to take the courses he/she wants because they are scheduled at the same time.
For the above reasons, a considerable attention has been devoted to automated timetabling. A large number of diverse methods have been already proposed in the literature for solving timetabling problems. These methods come from a number of scientific disciplines like Operations Research, Artificial Intelligence, and Computational Intelligence and can be divided into four categories:
1. Sequential Methods, that deals with timetabling problems as graph problems. Generally, they order the events using domain-specific heuristics and then assign the events sequentially into valid time slots in such a way that no constraints are violated for each timeslot [4].
2. Constraint Based Methods, according to which a timetabling problem is modeled as a set of variables (events) to which values (resources such as teachers and rooms) have to

be assigned in order to satisfy a number of hard and soft constraints [5].

3. Cluster Methods, in which the problem is divided into a number of events sets. Each set is defined so that it satisfies all hard constraints. Then, the sets are assigned to real time slots to satisfy the soft constraints as well [6].

4. Meta-heuristic methods, such as genetic algorithms (GAs) [7], simulated annealing, Tabu search [8], and other heuristic approaches, that are mostly inspired from nature, and apply nature-like processes to solutions or populations of solutions, in order to evolve them towards optimality [9].

Architecture of the Proposed System

The proposed research project aims at developing an intelligent environment based on intelligent agents to act as an academic advisor that suggests courses to be registered for students, and modify the faculty timetables to satisfy as much registration requests as possible. This will reduce the cases where students are not able to register courses due to contradictions in timetables.

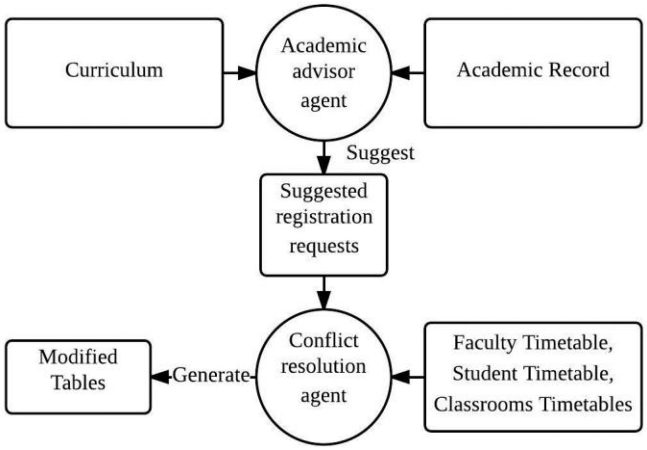

Figure 1. Architecture of the proposed system

As explained in Figure 1, the proposed system has two agents, the first is the academic advisor agent that suggests courses to be registered for a student according to information derived from his academic record (transcript), his current timetable, and the curriculum of the academic program. The generated requests for registration messages are to be processed by the second agent is the conflict resolution agent that takes registration requests and try to satisfy as much of them as possible, by altering the current timetables without contradicting with the current students timetables.

A. Academic Advisor Agent

The academic advisor agent emulates the course planning task of the human academic advisor, where he looks for the best timetable for the student to make him achieve the academic degree in the shortest possible time.

The input to the academic advisor agent is the case data of a specific student. This case data consists of the **transcript of the student** that contains his academic record including his current academic level, passed subjects, and grades; and the **curriculum of the academic program** that contains the subjects to be studied in each level of the curriculum, credit hours, attendance hours of each subject, and prerequisites.

The output of the academic advisor is the suggested subjects to be added to the student's timetable.

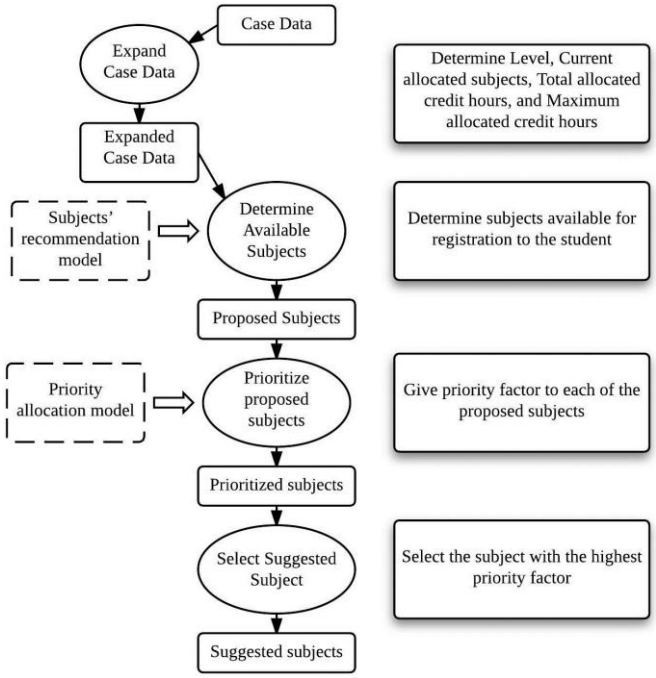

Figure 2. . Inference structure of the Academic Advisor Agent

The inference structure of the Academic advisor agent is described in Figure 2. The following is a description of the inference steps and static roles of the inference structure.

1. Inference Steps The academic advisor agent has four inference steps, the following is a brief description of each of these steps:

a. Expand case data The "Expand case data" inference step gets the data of the current student including his transcript which specifies the courses that he had passed, the curriculum of his academic program that specifies the courses of each level in the program with the credit hours, attendance hours, and prerequisites of each course, and the current timetable of the student.

This inference step determines the current level of the student according to the curriculum of his program, the total allocated hours and the maximum credit hours that can be registered for him according to the rules of the institute and his performance indicated in the transcript.

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b. Determine available subjects The "Determine available subjects" inference step locates for the subjects that can be added to the timetable of the case student according to the curriculum, student's level, current timetable of the case student, total allocated credit hours, and maximum allowed hours for the student according to his current accumulated GPA.

c. Prioritize proposed subjects The "Prioritize proposed subjects" calculates a priority factor to each of the suggested subjects. For example, subjects that are prerequisites to other subjects have higher priority, also subjects in lower levels have higher priority according to the rules of the institute.

d. Select suggested subjects The "Select suggested subjects" inference step selects the subjects with the highest priority factor in the sequence of the suggested subjects. In case of having multiple subjects with equal priority, the student will be offered the option of choosing among them.

2. Domain models The academic advisor agent uses two domain models: subject recommendation model, and priority allocation model. The following is a description of each of these models and the knowledge that it encapsulates.

a. Subject recommendation model The knowledge included in this model is used to determine the subjects that can be suggested to be included in the timetable of the student, the rules displayed hereafter are extracted from the regulations of the higher education system in Saudi Arabia, and the regulations applied in the University of Tabuk.

Rule1: The maximum credit hours that can be registered to a student is 18 hours, with exception of 2 extra hours for graduates.

Rule2: The student has to pass the prerequisites of the subject before registration in that subject.

Rule3: If the student has failed in a subject, this subject has the priority to be registered for that student in the next semester.

Rule4: Only subjects that are not passes by the student are suggested for registration.

b. Priority allocation model The knowledge included in this model is used to determine the priority of suggested subjects according to the current student case.

Rule1: Subjects in lower levels in the curriculum, have higher priority to other subjects in higher levels.

Rule2: Subjects that are prerequisite to other subjects in higher levels of the curriculum have the highest priority for registration.

Rule3: Subjects that are prerequisite to more number of subjects have higher priority to other subjects with less number.

Rule4: Failed subjects have higher priority to other subjects in the same or next level.

B. Conflict Resolution Agent

In case of having contradiction between a suggested subject and other subjects in the timetable of the case student, the conflict resolution agent tries to modify the allocated time slots of the contradicting subject, without affecting the timetables of students already registered in that subject.
The input to the conflict resolution agent is:

1. The suggested subject(s) to be added to the timetable of the case student.
2. Current timetable of the student that includes the subjects enrolled in the timetable of the case student.
3. Current timetable of the program that includes allocation of instructors, rooms and time for each subject in the program.
4. Current timetables of all students enrolled in the program.

The output of the conflict resolution agent is the resource allocation to the suggested and contradicting subjects of a modified timetable of the case student that maximizes his opportunity to achieve his academic degree in the shortest possible time.

$Sub = \{s1, s2, s3, \ldots, sn\}$ //Sub is the set of all subjects in a curriculum

$St = \{st1, st2, st3, \ldots, stm\}$ //St is the set of students

$\exists ss : ss \in Sub$ //ss=suggested subject

$Timeslots = \{t1, t2, t3, \ldots, tx\}$ //Timeslots= available time slots

$$S_{coexist} = \bigcup_{i=1}^{m} \{s : s \in Sub, st_i \in St, registered(st_i, s), registered(st_i, ss), s \neq ss\}$$

//$S_{coexist}$ is the set of subjects that are registered with suggested subject in any student's timetable

$$S_{contradict} = \{s : s \in Sub, s \in S_{coexist}, (timeslots(s) \cap timeslots(ss) \neq \phi)\}$$

//$S_{contradict}$ is the set of subjects that contradict with suggested subject timetable

$if\ (S_{contradict} \neq \phi)\{$ //if there is a subject contradiction

$$CoexistTimeSlots = \bigcup_{i=1}^{n} \{t : t \in timeslots(s_i), s_i \in S_{coexist}\}$$

//CoexistTimeSlots is the set of all time slots allocated to subjects in $S_{coexist}$

$for\ \_each\ \_(t) \in timeslots(ss)\{$

//alter suggested subject time slots so that it does not contradict with coexisting subjects timeslots

$if(t \in CoexistTimeSlots)\{$ //if there is contradiction

$for\ \_each\ \_(newt) \in Timeslots\{$

$if(t \in CoexistTimeSlots)\{$

$for\ \_each\ \_(newt) \in TimeSlots\{$

$if\ \_not(newt \in CoexistTimeSlots)\ \&\ \&$

$not(newt \in TimeSlots(ss))\{$

$t = newt$

}}}}}

Figure 3. Conflict Resolution Agent algorithm

As specified in Figure 3, the input to the conflict resolution agent is the subject suggested by the academic advisor agent

in addition to the current timetable of the student at hand and timetables of other students having courses with the same student.

The conflict resolution agent will intervene in case of having contradiction between the suggested subject timetable and one or more of the timetables of other subjects registered for some student having the same suggested subject.

It starts with looking for subjects registered for any student having the same suggested subject, if there is a contradiction between the suggested subject and any of these subject, the conflict resolution agent locates for alternative time slots for the suggested subject that do not contradict with any of the other subjects.

Conclusion

Academic advising is a critical activity for students, and time consuming activity for faculty members, as the academic advisor needs to investigate the individual cases of students to determine the available opportunities for each student to fulfill his academic degree in the shortest possible time. Registration and timetabling systems are the most important factors that affect the length of the studying period of the students, as the timetable contradictions may reduce the chance of registering courses for students.

In this paper, a design for an intelligent advising system was introduced, the proposed system focused on the task of altering the current timetable of a student trying to optimize his achievement to gain the academic degree.

The proposed system consisted of two major components, the academic advisor agent, and the conflict resolution agent. The academic advisor agent used the academic advising knowledge in evaluating the case of the current student, and suggesting subjects to be added to the timetable of the current case according to their priority. The conflict resolution agent used the scheduling knowledge for altering the timetable of the suggested subject in a way that does not affect the consistency of the timetables of students who are enrolled in the suggested subject.

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Biographies

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He worked as a research assistant at the Central Lab for Agricultural Expert Systems (CLAES) during the period from 1994 to 1998, and as a researcher at (CLAES) during the period from 1998 to 1999. During the period from 1999 to 2002 he worked as an assistant professor at (ISSR), Cairo University, Egypt, then as an assistant professor at the Community College, Computer Science department King Abdualaziz University, Tabuk, Saudi Arabia during the period from 2002 to 2006, currently he is working as an associate professor at (ISSR), Department of Computer Science, Cairo University, and the Community College, Department of computer science, University of Tabuk, Tabuk, Saudi

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MOHAMMED M. ALHAWITI was born in Tabuk, Saudi Arabia in 1983. Alhawiti earned his Bachelor degree in mathematics education in 2004 from Tabuk Teachers' College (currently Education & Arts College), Tabuk, Saudi Arabia. He earned his Master of Science degree and Ph.D. in educational technology from Indiana State University, Terre Haute, Indiana, USA in 2009 and 2011 respectively.
He worked as a math teacher between 2004 and 2005. Between 2005 and 2006, he worked as an instructor at the Educational Technology Department in Tabuk Teachers' College. Currently, he works as an assistant professor at the Education & Arts College and the Dean of Tabuk Community College, University of Tabuk, Tabuk, Saudi Arabia.
Dr. Alhawiti is a member of several honor societies including Phi Lambda Theta (International Honor Society and Professional Association in Education), the Golden Key International Honor Society, and the Honor Society of Phi Kappa Phi. He is also a member of the Association for Advancement of Computing in Education (AACE). Dr. Alhawiti is the chairman of the Permanent Committee of Distance Education in the University of Tabuk. He is also a member of several committees at the university level including Tabuk University Advisory Committee, the Permanent Committee for Developing University of Tabuk's Portal, and Tabuk University Council.