CRIS: A Rule-Based Approach for Customized Academic Advising

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ABSTRACT

This study presents a customized academic e-advising service by using rule-based technology to provide each individual learner for recommending courses for college students in Taiwan. Since academic advising for taking courses is mostly by advisors to assist students to achieve educational, career, and personal goals, which made it important in the higher education system. To enhance the counseling effectiveness for advisors to assist students in fitting their professional field and improve their learning experience, we proposed an application system, called CRIS (course recommendation intelligent system). The CRIS consists of six functions: academic profile review, academic interest analysis, career and curriculum matchmaking, recommend courses analysis, department recommend analysis and record assessment. This work provides the solution in three layers, data layer, processing layer and solution layer, via four steps: (1) database design and data transfer, (2) student profile analysis, (3) customized academic advising generation and (4) solution analysis. A comparison of academic score and the combination of individual students' interest in learning and academic achievement satisfaction survey are conducted to test the effectiveness. The experiment result shows that the participating college students considered that the CRIS helpful in their adjustment to the university and it increased their success at the university.

Keywords: Customized e-advising, Expert Systems, Rule-Based Systems, Recommendation Systems.

1. INTRODUCTION

Rapidly evolving computer technology, coupled with the exponential growth of the internet information services allows the universities more sufficient resources to train more outstanding industry professionals. As at January 2014, there are 161 universities, more than 800,000 college students in Taiwan. It is expected that the missions of colleges not only include delivery of knowledge, assist students discover their interest in learning and their strength aspects but also educate students capable of working toward professional skills to meet industry requirements. To cope with such condition, the emerging of e-advising intelligent customized systems in college which help students find their interesting learning major so that they can graduate on time becomes highly attractive. Academic advising, consisted of advising students their ongoing registered courses based on the profile of the students, and on the courses offered in the semester, is one of the core responsibilities for the academic faculty in the university education system. However, the huge work loading of academic advising and academic evaluation services becomes a burden on the human academic advisors because they could face a monotonous process by answering the same questions repeatedly and they might need to update the professional knowledge of changes on prerequisites, processes or curricula courses by the university to offer learners advice on their further education.

Expert systems (ESs), designed to support users in decision making process, have been widely utilized to solve complex problems by automated inference and reasoning knowledge to provide decision-making ability of a human expert [1,2]. Kamarthi *et al.* [3] proposed the concept to automate the process of academic e-advisor by describing the purpose, design, and development of the expert system ADVISOR for the selection of courses in 1992. Biletskiy *et al.* [4] proposed an e-Advising system for continued learning that is intended to automate the process of transferring course credits between institutions and to recommend courses for further study. Biletskiy *et al.* [5], described a technical solution for personalized search of learning objects on the Web, which proposes a comparison of a learner's profile and learning object descriptions. They develop ontological models of the learner and learning objects for determination and adjustment of the learner's preferences using corresponding ontologies. Castro-Schez *et al.* [6] proposed a system allowing students to build their own knowledge by providing feedback regarding their actions while performing a problem based learning activity or while making changes to problem statements, so that a higher order thinking skill can be achieved. This feedback is the consequence of an automatic assessment. The authors proposed a method using the language processor techniques for developing these kinds of systems. This method could be also applied in subjects in which problem statements and solutions can be formalized by mean of a formal language and the problems can be solved in an algorithmic way. As to the learning domain and content of educational systems, considering the learners' goals, their experiences, their existing knowledge, their insufficient flexibility to evaluate learners' learning efficiency, skill and knowledge are well discussed in e-learning and could be considered to be designed in the advisor system. For example, Baylari and Montazer [7] proposed a personalized multi-agent e-learning system based on item response theory and artificial neural network which presents adaptive tests and personalized recommendations. These agents add adaptability and interactivity to the learning environment and act as a human instructor which guides the learners in a friendly and personalized teaching environment.

This study aims to improve the academic advising performance for a local private university, Kao Yuan University (KYU), by proposing an e-advising system to automate the process of suggesting solutions for recommending courses for further study. We analyzed learner's academic history (based on transcripts and other records) which was retrieved between Year 2012 and 2014. This paper is organized as follows. The background of the empirical case is discussed in Section 2.

Methodology is given in Section 3. Section 4 illustrates the analyzing result. Conclusions are discussed in Section 5.

2. EMPIRICAL CASE – KAO YUAN UNIVERSITY

Profile of Empirical University

Kao Yuan University (KYU) found in 1986, is the first e-generation academy located in the Kaohsiung Science Park, Taiwan. At present, it contains four colleges (the College of Mechatronic Engineering, the College of Engineering, the College of Business and Management and the College of Informatics), eight graduate schools, 21 departments and diploma programs. Currently, the number of students enrolled at KYU is in the region of 9,000. The number of students in KYU grows steadily recently versus there is no academic advisor. Furthermore, the academic information system in KYU is a mixed system, where it does not provide the analysis function of studying courses based on individual student's learning ability and interest in learning tendencies. This made students basically comply with the provisions of the courses or ask instructors for recommendation of courses, which brought enormously managerial workload to faculty members at KYU. Students will also transfer to another department when they really prefer another major or they have learning difficulty in their study.

To help our students find a major where they can succeed and graduate on time, the proposed CRIS e-advisor system is a conceptual expert system intended to automatically analyze the process of recommend courses based on the learner's academic history and learning interest.

Design Strategy

The proposed system aims to create a rule-based system for generating a customized courses and registered major recommendation for students. CRIS is a developing system, independent from the school academic system, which contains six functions: academic profile review, academic interest analysis, career and curriculum matchmaking, recommend courses analysis, department recommend analysis and record assessment. These functions are explained as follows. (1) Academic profile review: All the enrolled and academic data of the login user are listed to verify his/her study history. (2) Academic interest analysis: There are specified 65~85 questions for learners to answer to build the learner's learning interest profile. The questions are designed by interviewing all 21 department programs in KYU to determine the specific required learning attributes for each of the 21. These questions and answers for each learner are all stored in database to perform analysis by interest analysis module. (3) Career and curriculum matchmaking: Base on the career description of four colleges and 21 departments, we design career and curriculum rules, such as R1: $(DB01 \cap SA01 \cap PM01) \rightarrow PM$, and store them to rule base. The rule R1 means to become a project manager, you need to at least take courses of database management (course_id: DB01), system analysis and design (course_id: SA01) and project management (course_id: PM01). (4) Recommend courses analysis: According to the occupational classification, learner's learning interest score, there are rules defined what course are the choices for the learner and customized course module is designed to generate the courses (discussed in Section 3). (5) Department recommend analysis: Every department has defined standard interest score for their students. Based on the score value, program is designed to suggest the chosen department for learner. (6) Record assessment: The system provides the learner of four times to run the assessment. The output comes from the learner's satisfactory evaluation and the final grade of the learning subject. The short-term learn objective of CRIS is to focus on recommending the learners finding their interest and best fit career while studying in KYU. In the long term, on the other hand, KYU consider to cooperate with industry to train the best-fit students for the industry to turn into a win-win situation.

3. METHODOLOGY

This study analyzed student learning interest and academic data for proposing customized recommended courses. The CRIS is based on a three-layer architecture, shown as Fig. 1. The methodological framework for this research could be divided into four essential steps: (1) database design and data transfer, (2) student profile analysis, (3) customized academic advising generation and (4) solution analysis. Figure 1 depicts the framework of our approach. We redesigned the database structure, generate program to execute inference engine and generate the customized courses for each learner. The executing steps are listed as follow.

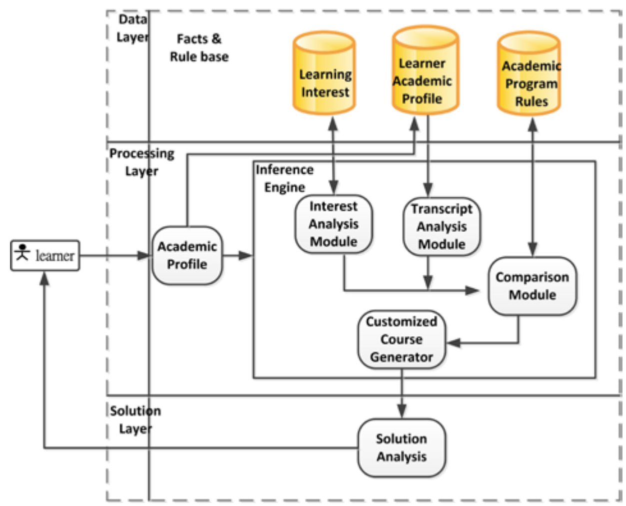

Fig. 1 System frame

Data Layer: It stores all relevant information, which is needed for further processing. The learning interest data gathered from web page and the relevant data of the student enrollment and academic profile transferred from academic system are imported into MySQL database. The academic program rules are generated based on the required and relevant course defined by each department in KYU. The database design and data transfer is processed in Data Layer.

Processing Layer: Academic profile procedure (AP) refers the learner's profile table to lists all the registered courses and scores of the login learner. The execution of interest analysis module (IAM) stores data to learning interest database. If transcript analysis module (TAM) is executed, it analyzes the learner's score of course base on rules within the academic program rules by using logical expressions and terms. Furthermore, it has been optimized to do the rule matching in a more efficient way. The comparison module (CM) on the basis of compares the average score of this course and then makes prediction. The step of student profile analysis is processed in Processing Layer.

Solution Layer: According to the content of rules, the customized course generator (CCG) then guide the learner by generating individual learner's course recommendations. Furthermore, the solution analysis (SA) provides the learner to evaluate the recommend courses to identify the efficiency of the CRIS. The steps of customized academic advising generation and satisfaction survey analysis are processed in Solution Layer.

The four steps are discussed in the following sections.

Database Design and Data Transfer

The collected data shows 103,235 academic and learning interest records which belongs to 1,423 students within the academic semester period between 8/1/2012 and 1/31/2014. Data collection was based on Relational database structure applied in the system. The original academic records data of students were stored in SQL server. Eight main tables (Student, Course, Score, Interest, St_Interest, Dept, Occupation, Category) were redesigned to be executed in the reference engine to apply rules in rule base to generate customized courses for students. This logical design was physically mapped into tables with relationship shown in Fig. 2. We transferred relational database into MySQL with php programming design to implement analysis service. The functions and attributes of tables are explained as follows.

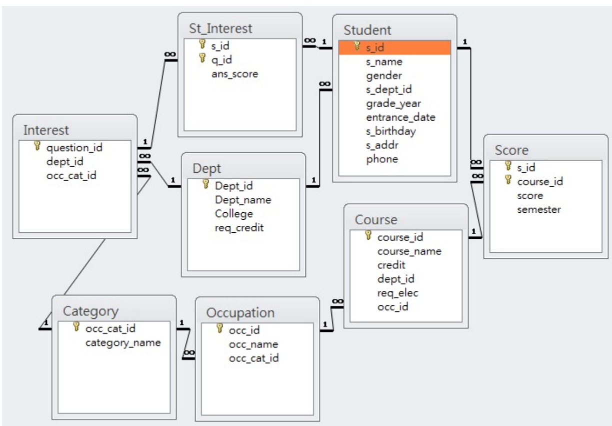

Fig. 2 Database design

1) Student: It maintains student's basic data and includes s_id, s_name, gender, s_dept_id, grade_year, entrance_date, birthday, address, phone number for each student.
2) Course: It maintains course's data and includes course_id, course_name, credit, dept_id, req_elec (required or elective of the course) and occ_id.
3) Score: It records each registered semester score details of the student and includes_id, course_id, score and semester.
4) Interest: It shows the learning interest mapping of question id and every department and diploma programs. It contains question_id, dept_id and occ_cat_id. The existing questionnaire design twenty questions associated with each department.
5) St_Interest: It records the learner's interest score details to calculate the association degree for student to the department. It includes s_id, q_id and ans_score.
6) Dept: It records the department details and includes Dept_id, Dept_name, College and req_credit, while req_credit is the sum of credits for completing the degree associated with each department.
7) Occupation: It records the occupation details and includes occ_id, occ_name and occ_cat_id.
8) Category: It records the occupation category and includes occ_cat_id and category_name.

Student Profile Analysis

As shown in Fig.1, a series of programs are designed to analyze the student profile. Some modules are as follows.

AP: It lists all the registered courses and scores of the login learner.

IAM: It performs academic interest analysis by calculating the points of their answered questions. Basically, there are specified 65~85 questions for learners to answer to build the learner's learning interest profile. There are 135 competency designed in the database. Questions 1 to 4 are designed to direct students to answer questions in four colleges in KYU. Normally each college contains 4 to 6 department programs and each program normally designed to provide four kinds of jobs and each job contain 5 questions. The output is the score of a section. The learners determine their interest point from 1 to 5. System then determines the top 3 highest score in his/her college to be considered as their learning interest. Exception handling process the equal scores of each section or learner choose the wrong college because of low score (less than average). Part of the academic interest analysis is shown in Fig.3.

Fig. 3 Business Administration Department interest analysis

These programs consider attributes in database tables as key attributes, such as q_id and score to calculate points. The following IAM algorithm is the program to output the suggest student associated interest and major program to the S_C_score table. Notations of qn, dn, bn represent the total numbers of question for a department, number of department and question number for a job, separately. ErrHandling (1) process the learning areas direction mismatch with interest and ErrHandling (2) process the detail career and interest mismatch for learners. Figure 4 shows the career and curriculum matchmaking for information technology.

Algorithm IAM

```
For i = 1 to c1
    Select s(rec.i) > 3
    If empty then call ErrHandling(1)
Next i
Switch (i)
```

```
For k = 1 to dn
  For j = 1 to bn
    s.rec.j = s.rec.j + s(rec.i*qn+j)
  Next j
  If sum(s(rec.(i*j)) > 4*bn
    Then call gen_out(i,j)→ output table S_C_score
      Exit
    Else call ErrHandling(2)
Next k
```

Fig.4 Career and curriculum matchmaking

Customized Academic Advising Generation

This step contains program CCG to generate the customized academic advising and is described as follows.

CCG: The contents of career and curriculum rule are generated based on the IF-THEN rule format. The IF-THEN rule in a rule-based system is typically formed as $X \rightarrow Y$ (Fig.5a), in which X is an antecedent fact clause (node) and Y is a conclusion node. Two nodes, atomic and compound, exist in rule bases. One study [8] found that compound antecedents in rules are only presented in the conjunction format, such as「If (X_1 and X_2… and X_n) then Y」, and that only the atomic node is allowed to be a conclusion (Fig. 5b).

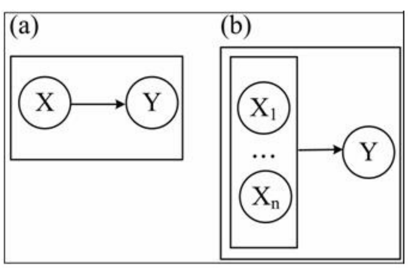

Fig. 5 (a) Basic rule; (b) Compound antecedent rule

Based on the score value in Score table, program first searches the courses with the score value greater than 90, then analyzes the rules within the academic rules by searching these course_id in rule base and prerequisite table. For any founded course_id, program checks every antecedent in rules. If the course_id exists in a basic rule, then the conclusion career attribute value is defined as the output of matched career. Program will call procedure RelCourse to list any course related to the dedicated course_id as suggested course. If the course_id exists in a compound antecedent rule, then the course_id of every other antecedent nodes (abbreviated as ant_cid) will be verified whether they exist in the Score table. If true, then the conclusion career attribute value is defined as the output of matched career, otherwise, the absent ant_id are processed as the suggested course. We then apply procedure RelCourse to list other suggested courses.

Solution Analysis

Solution layer contains procedure SA to perform solution analysis.

SA: The satisfaction analysis consists of two procedures. One is acting as a feedback survey to allow the learners four times of chance to evaluate after the learners had taken the system recommend courses, the learners key in score point with the range of 1 to 5 for each taken course. The other evaluates the score of each taken course to identify the efficiency of the CRIS. Part of the result is shown in Fig.6.

Fig. 6 Partial output

4. RESEARCH RESULTS

By following the proposed four steps, we constructed eight relational tables on data layer and execute the profile analysis in processing layer. The data of two colleges, the College of Business and Management and the College of Informatics, are applied into the CRIS. The average of 25 courses is generated for each student based on the execution of programs in processing layer. Based on the relationship of career, learning interest and prerequisities, there are 1421 rules generated and store in rule base. Figure 7 shows the satisfaction of students in 9 departments of two colleges, where the score ranking is from 0 to 5, where 0 indicates very disagree the system recommended courses and 5 indicated 100% satisfaction.

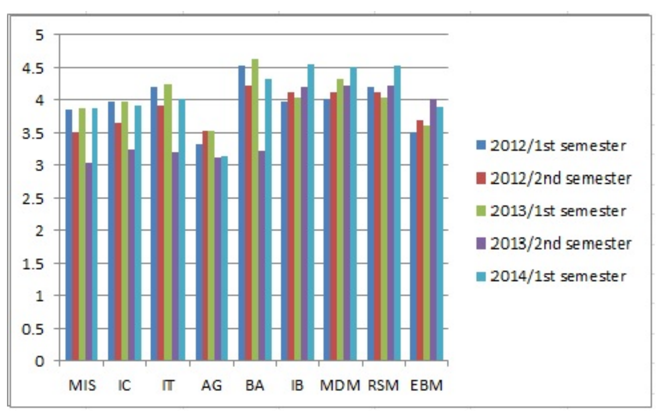

Fig. 7 Learner evaluation distribution bar chart

The result of experiment shows the performance of the proposed system. In comparison with the average semester data over years between 2012 and 2014, the proposed approach achieves about 80% ranking recommendation courses satisfaction, 3% satisfaction increase rate over years 2012 to 2014.

5. CONCLUSIONS

Analysis of learners' academic profile and course advising potentially benefit the students in KYU for better achievement on their study goals. The main contribution of the experimental results shows that the proposed approach achieves 80% of satisfaction on ranking recommendation courses for the past two years. In this study, rule-base design was used to construct course recommendation based on data between March, 2012 and May, 2014. Programs in processing layer were analyzed learners' preference, referred domain rule and then generated recommended courses. The approach is currently implemented as a prototype of advising scheme in KYU. Further research will focus on two directions. (1). Integrate the CRIS with the existing academic systems in KYU to facilitate academic intelligence; (2). Apply the CRIS in another two colleges, the College of Mechatronic Engineering and the College of Engineering, by adopting the domain knowledge of the above mentioned colleges to generate rules into CRIS.

6. ACKNOWLEDGEMENTS

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