**Smart Computing Review**

# An Intelligent Course Recommendation System

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**Abstract:** Previous academic administration management systems had migrated from wired to wireless technology but were restricted to specific equipment, as such systems were not based on industry standards. The course recommendation system plays a significant role in managing the curriculum and counseling students on academic matters, with a view to fostering their academic progress. However, the system does not have the time to advise individual students on the details of which fields and courses they should pursue. The rapid progress of IT technologies has enabled users to access 'any service, anytime, anywhere', and wireless internet services have enabled users to access internet services even while traveling. Cellular phones have evolved to smart phones, which can provide visual telephone service, DMB service, and act as smartphones. Users can access service categories that offer new possibilities and are accessed and used in ways different from traditional services. Thus, cellular phones are a representative terminal for ubiquitous learning. This paper proposes a mobile course recommendation system to help students choose and access courses necessary for their major fields of study. When students apply to take courses, the proposed system recommends the most suitable ones, using an inference engine that considers not only course sequences but also students' information. The system is able to assist the course coordinator in counseling students. The students use their personal cellular phones to track their courses and receive course recommendations from the system. We searched for relationships between subjects, using association rules, by mining data about the courses already taken by students, and compared these to existing course trees. This information could be used for updating course trees.

**Keywords:** Intelligent Courseware Recommendation, Academic Administration System, Relevance Analysis

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# Introduction

Universities offer a wide course selection to students studying in different fields; however this has generated various unintended problem areas. Students may choose a specific course based on the reputation of the teacher, the course time, the course difficulty, or other factors not directly related to a specific field of study. Although they may achieve the required number of credits to graduate, the breadth of knowledge they acquire may not equip them well for the professional world they face after graduation [1, 2].

To address this problem, guidance counselors should check students' study majors and recommend suitable courses. However, getting this assistance to students is not an easy task. Academic administration systems were initially intranet-based; they then progressed to the wired Internet. For the sake of convenience, the system is now wireless.

The requirement for mobile data access is increasing as the amount of information available on the Internet grows. Today's web applications are designed for a wide range of target devices ranging from mobile phones to web browsers in PC environments. The availability of mobile services presents new possibilities and challenges for service users and service providers. Users can access services that offer new possibilities and methods that differ from traditional services. Service providers creating value-added mobile services face challenges during the development stage because they must adapt services to new devices and media.

In this paper we propose an intelligent course recommended system that focuses on the relation between course categories and students' preferences when it comes to subject recommendation. The proposed system has been developed to recommend suitable courses to individual students, taking into consideration courses already taken, with the aim of maximizing students' professional foundation. We analyzed a proportion of senior student participants in order to evaluate the performance of the proposed system. We examined the number of participants who took the recommended subjects. Thus, we could analyze the proportion of lectures accessed that were appropriate to individual subject fields.

Association rules have been used to discover patterns in other databases. For example, university course enrollment data were analyzed to identify combinations of courses taken by groups of students [3, 4]. After analyzing a considerable volume of course attendance data, we applied an association rule to understand the link between subjects chosen with those proposed by faculty guidance advisors. We applied a minimum support and minimum confidence variable, variously, and found an association rule. As the result of examining the validity of this rule, we wish to apply to a revision enactment, or reference data, to the attending lecture tree.

# Background

## ■ Course Coordinators

Course coordinators create and manage course curricula. They are appointed from the group of senior lecturers, associate professors, and professors belonging to the faculty. Coordination of a registered degree course is the responsibility of one particular course coordinator who is responsible to the head of the academic unit offering the course. The appointment of course coordinators enhances inter- and intra-faculty course coordination [5].

A course coordinator's role includes the following:

- developing and monitoring efforts for continuous course improvement, and reporting on course improvement projects to the faculty advisory committee through the department head;
- determining appropriate course plans (in consultation with department heads, study center directors, and other coordinators) for students transferring to the course from another course or institution, once exemptions and credits have been determined;
- maintaining a record of approved evolutionary course changes in the course development and approval process;
- counseling students on academic matters and encouraging their progress in the course;
- providing appropriate information on the course, and promoting the quality and range of students enrolled in the course;
- resolving operational matters, including timetable matters and adjustments to assessment requirements, to balance student workloads;
- ensuring that student enrollments conform with the course structure and prerequisites, and that students have met all course requirements before being certified eligible for graduation;
- negotiating teaching allocations for the course with relevant department heads and center directors;
- providing leadership in the course development and approval process.

## ■ Association Rules

The determination of association rules is an interesting subfield of database mining. It originated from the analysis of large amounts of supermarket shopping data, where association rules describe how often items are purchased together. For example, the association rule “beer ⇒ diaper (80%)” means that 80% of customers who purchased beer, bought diapers. Such rules can be useful for decisions concerning [3, 6].

The usefulness of this technique to address unique data mining problems is best illustrated in a simple example [7]. Suppose we are collecting data at the check-out cash registers at a large book store. Each customer transaction is logged in a database, and consists of the titles of the books purchased by the respective customer, perhaps additional magazine titles and other gift items that were purchased, and so on. Hence, each record in the database will represent one customer (transaction), and may consist of a single book purchased by that customer, or it may consist of many (perhaps hundreds of) different items that were purchased, arranged in an arbitrary order depending on the order in which the different items (books, magazines, and so on) came down the conveyor belt at the cash register. The purpose of the analysis is to find associations between the items that were purchased, i.e., to derive association rules that identify the items and co-occurrences of different items that appear with the greatest (co-)frequencies. For example, we want to learn which books are likely to be purchased by a customer who we know already purchased (or is about to purchase) a particular book. This type of information could then quickly be used to suggest to the customer those additional titles. You may already be "familiar" with the results of these types of analyses if you are a customer of various on-line (Web-based) retail businesses; many times when making a purchase on-line, the vendor will suggest similar items (to the ones purchased by you) at the time of "check-out", based on some rules such as "customers who buy book title A are also likely to purchase book title B," and so on [7].

First the program will scan all variables to determine the unique codes or text values (items) found in the variables selected for the analysis. In this initial pass, the relative frequencies with which the individual codes or text values occur in each transaction will also be computed. The probability that a transaction contains a particular code or text value is called Support; the Support value is also computed in consecutive passes through the data, as the joint probability (relative frequency of co-occurrence) of pairs, triplets, etc. of codes or text values (items), i.e., separately for the Body and Head of each association rule [7].

After the initial pass through the data, all items with a support value less than some predefined minimum support value will be "remembered" for subsequent passes through the data: Specifically, the conditional probabilities will be computed for all pairs of codes or text values that have support values greater than the minimum support value. This conditional probability - that an observation (transaction) that contains a code or text value X also contains a code or text value Y - is called the Confidence Value. In general (in later passes through the data) the confidence value denotes the conditional probability of the Head of the association rule, given the Body of the association rule. In addition, the support value will be computed for each pair of codes or text values, and a Correlation value based on the support values. The correlation value for a pair of codes or text values {X, Y} is computed as the support value for that pair, divided by the square root of the product of the support values for X and Y. After the second pass through the data those pairs of codes or text values that (1) have a confidence value that is greater than some user-defined minimum confidence value, (2) have a support value that is greater than some user-defined minimum support value, and (3) have a correlation value that is greater than some minimum correlation value will be retained [7].

Given a set of transactions D, the problem of mining association rules lies in finding all rules that have support and confidence greater than the user-specified thresholds. That is to say, given a database of transactions, a minimal confidence threshold, and a minimal support threshold, the problem consists of finding all association rules whose confidence and support are greater than the corresponding thresholds [8].

## ■ Related Works

The Intelligent Online Academic Management System (IOAMS) is an intelligent web-based system, which offers an effective tool for the higher education sector. It is designed to provide academic advice and monitor progress [9]. It provides functions such as automated enrollment, tracking of enrollment variations, providing academic advice based on students’ personal profiles and interests, creating study plans for students according to current stage of progress, calculating credits, and final sign off from the institution. The system contains a powerful inference engine based on Resolution with Partial Intersection and Truncation (PT resolution) [10]. It periodically updates its database from the university’s student administration system. There is a *course finder* that recommends suitable courses, based on the prospective student’s field of interest, military merit, and career history [11].

A course recommendation system is used to provide students with suggestions when they have trouble choosing courses. One such system has been designed [1]. That particular study presented a system based on the Prediction Methodology proposed [12]. To adapt teaching to individual abilities in the distance learning environment, it used a method to construct personalized courseware by building a personalized web tutor tree, and mining both the context and structure of the notion of similarity. It included five algorithms, including the Naïve Algorithm for tutor topic trees, and Level_generate Algorithms to generate web tutor topic of K+1 levels, as well as experimental results [12].

To improve upon the limitations of these systems, we propose an intelligent course recommendation system, which is based on a course tree, students' course enrollment data, the importance of the subjects, and relation of major/minor subjects. Thus, the proposed system facilitates individualized course selection assistance.

# System Design

## ■ System Architecture

This paper proposes a system consisting of a client section that presents the course to the student, a server section for course management and recommendations, and a database (DB). Figure 1 shows the system architecture.

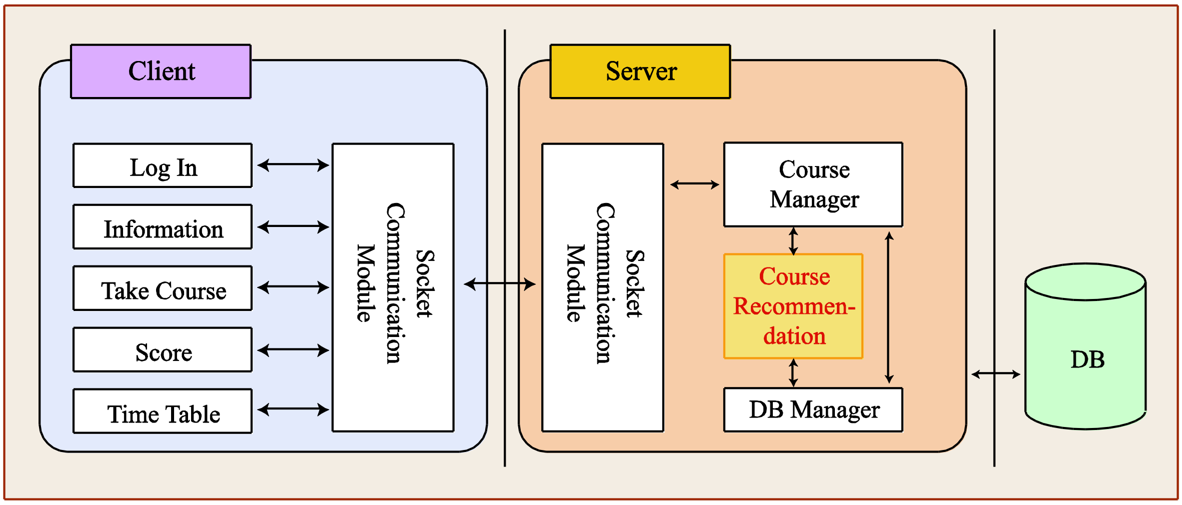


Figure 1. System Architecture

The client section consists of five menu modules and a socket communication module. Users communicate with the server using mobile devices through the socket communication module. The "Log In" module controls connection to the system. The "Information" module confirms and updates the user's basic information. Users can search for new courses and confirm course recommendations with the "Take Course" module. The "Score" module allows users to inquire about grades and term credits. The "time table" module confirms the current timetable.

When a user logs in, the server creates a thread into the Socket Communication Module. The server Socket Communication Module takes complete charge of the communication with the client's Socket Communication Module to exchange data. The "Course Manager" module performs data manipulations as required.

## ■ Course Recommendation Mechanism

The proposed method assesses a learner's weak subjects and analyzing individual abilities to be able to advise individual learners which fields of study would be suitable and which courses they should take [12]. Figure 2 shows the course recommendation mechanism.

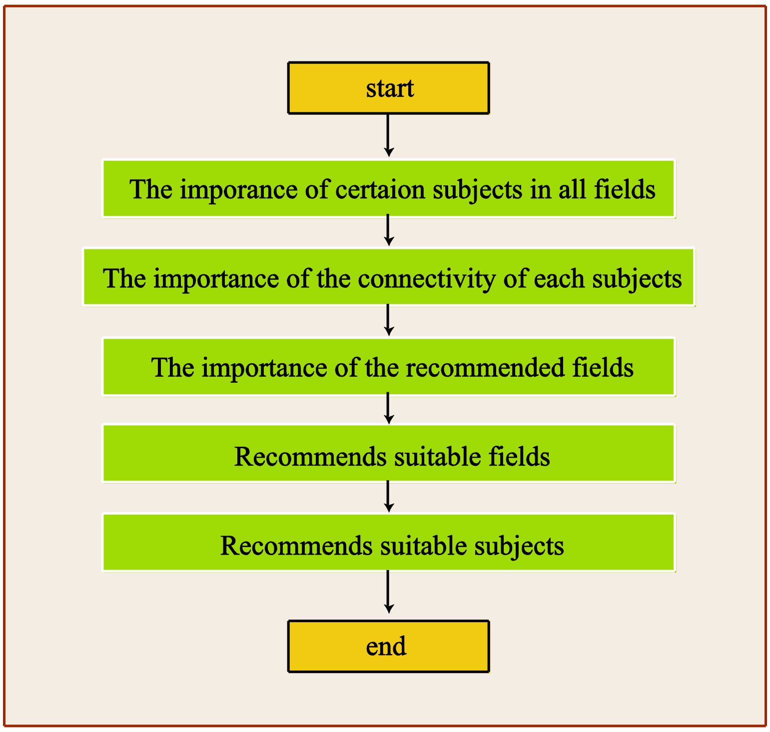


Figure 2. Recommendation Mechanism

**Step 1: The importance of certain subjects in all fields**

The recommendation algorithm displays the importance of a subject when considered in the context of all fields in the department. The relevant term is the one that applies to the courses taken.

$$wField_j = C(1,j) + C(2,j) + C(3,j) + \cdots + C(n,j) \qquad (1 \le j \le m) \tag{1}$$

i: Field index j: Index of optional subjects available in relevant term

n: The number of relevant fields in the faculty

m: The number of optional subjects

C(i, j): The importance of each subject in each field

Compulsory and core subjects: 4 points

Subjects that are to be encouraged: 2 points General subject: 1 point

If a subject's value is high, proposed system will determine that it is an important subject in its field. This classification is useful for making recommendations when information about which fields are the most suitable for a particular student is lacking. The algorithm is as follows:

```
Denote n is the number of the department's fields
Denote m is the count of optionalCourses
Calculate the optionalCourses and subjects of each field
Extract the availablePoints from the maximum possible points of each field
Calculate the sum of subject’s weight value
```

Table 1 shows the lectures that students in the third grade have taken and Table 2 shows an example of the first step of the recommendation algorithm for the second semester in the third grade.

Table 1. Subjects that students in third grade have taken

| Term | Subjects |
|---|---|
| Second grade: first semester | Circuit Theory, Electromagnetism, Electrical and Electronic Instrumentation |
| Second grade: second semester | Signals and Systems, Internet Programming |
| Third grade: first semester | Computer Architecture, Electronic Circuits |

Table 2. Example of the first step of the recommendation algorithm

| Subject | Fields | | | | | | wField | Rank |
|---|---|---|---|---|---|---|---|---|
| | Signal processing | Commu-nication | Energy & Controls | Com-puter | High-frequency | Semicon-ductor | | |
| Computer Networks | 2 | 4 | 2 | 4 | 1 | 1 | 14 | 3 |
| Antenna Engineering | 2 | 1 | 1 | 1 | 4 | 1 | 10 | 2 |
| Control Engineering | 2 | 1 | 4 | 1 | 1 | 1 | 10 | 2 |
| Algorithms | 1 | 1 | 1 | 4 | 1 | 1 | 9 | 1 |
| Quantum Optoelectronics | 1 | 1 | 1 | 1 | 4 | 1 | 9 | 1 |
| Energy Conversion Devices | 1 | 1 | 4 | 1 | 1 | 1 | 9 | 1 |
| Electric System Controls | 1 | 1 | 4 | 1 | 1 | 1 | 9 | 1 |

**Step 2: The importance of the connectivity of each subject**

The recommendation algorithm displays the importance of prerequisite subjects, considering the relevant fields in the department. Relevant fields are those that apply to the courses taken.

$$w\Pr erequisite_j = \frac{CCP_{1_{st}Field} + CCP_{2_{nd}Filed} + \cdots CCP_{n_{st}Field}}{PCP_{1_{st}Field} + PCP_{2_{nd}Filed} + \cdots PCP_{n_{st}Field}} \quad (1 \le j \le m) \tag{2}$$

i: Field: index　　j: Index of optional subjects available in relevant term

n: The number of relevant departments　　m: The number of optional subjects

$CCP_i$: Completed subject points　　$PCP_i$: Prerequisite subject points

Essential prerequisite subject: 1 point

Optional relevant prerequisite subject: 0.5 point

If a subject has a particularly high value, proposed system determines whether the student has accumulated a certain amount of knowledge about that subject. The proposed system then estimates whether a given subject is suitable for the student. The algorithm is as follows:

```
Denote m is the count of optionalCourses
Calculate the Prerequisite subject points from sum of each field's the
prelecpoint
Check whether the student completed prerequisite
IF the student completed prerequisite,
    then calculate the sum of weight value about completed subject point
Calculate Prerequisite weight value from relataionship value such as
completePoint
    over preReqPoint
```

**Step 3: The importance of the recommended fields**

The recommendation algorithm displays the importance of recommended fields in the department. In other words, the algorithm indicates which fields in the user's faculty are the most appropriate.

$$wSuitability_j = \frac{\sum_{i=1}^{n} \sum_{k=1}^{Ci} CP(i,k)}{\sum_{i=1}^{n} \sum_{k=1}^{Fi} FP(i,k)} \quad (1 \le j \le m)$$

$$= \frac{\{CP(1,C_1)+CP(1,C_2)+\cdots+CP(1,C_i)\}+\cdots+\{CP(n,C_1)+CP(n,C_2)+\cdots+CP(n,C_i)\}}{\{FP(1,C_1)+FP(1,C_2)+\cdots+FP(1,C_i)\}+\cdots+\{FP(n,C_1)+FP(n,C_2)+\cdots+FP(n,C_i)\}}(1 \le j \quad (3)$$

i: Field index j: Index of optional courses in the relevant term

n: The number of relevant departments m: The number of optional subjects

k: Subject index of specific fields

$F_i$: The number of subject fields until previous semester or grade

$C_i$: The number of subject fields completed by the previous semester or grade

FP: Fields point CP: Complete point

The core subject: 1 point Subjects to be encouraged: 0.5 points

This value indicates the fields in the department that are the most suitable for the student. Each course is organized by considering a subject tree; the tree of recommended subjects and which subjects have or have not been completed. Because each user has a user profile, the algorithm's recommendations are customized to individual users. The algorithm is as follows:

```
Denote n is the number of the department's fields
Denote m is the count of optionalCourses
Calculate the sum of FieldPoint and CompletePoint
Calculate Suitability weight value such as sum of FieldPoint over sum of
 CompletePoint
Find the suitable field
Calculate Suitability weight value
```

**Step 4: Recommends suitable Fields**

Fourth reasoning algorithm displays the fields of concerns in faculty.

$$wFavoriteFiled_j = PFP_1 + PFP_2 + \cdots + PFP_m \quad (4)$$

i : field index

j : index of optional course of relevant term

m : The number of optional subjects

$PFP_i$ : Personal field point

- $1^{st}$ interested subjects : 4 points

- $2^{nd}$ interested subjects : 2 points

- $3^{rd}$ interested subject : 1 points

Students can select a field to broaden their general knowledge or to extend it to a new subject area. The proposed system can consider the breadth of the major field of study a student is interested in, and recommend a course subject in the subject area or in related fields. The algorithm is as follows:

```
LET m be the count of optionalCourses
SELECT optionalCoursesPoints in Stduent's Personal Favorite Fields FROM
Student's Dept_Lecture
FOR j=1 TO m
   FOR i=1 TO 3
      IF j-th Course is in the i-th Favorite Field THEN
```

```
            w_FavoriteField[i] += Personal Field Point of i-th Favorite Field
    END FOR
END FOR

Denote m is the count of optionalCourses
Find the student's personal favorite fields
Calculate favorite field weight value such as sum of personal field point
```

**Step 5: Recommends suitable subjects**

Finally, the recommendation algorithm recommends suitable subjects.

$$w_{sum\,j} = Rank(wField_j) + Rank(w\Pr erequisite_j) + Rank(wSuitabukuty_j) + Rank(wFavoriteField_j) \tag{5}$$

The proposed system assigns the rank in each part of the algorithm based on a weighting, such as a first-order subject is k rank points, a second-order subject is k-1 rank points, a third-order subject is k-2 rank points, and the remainder are converted to 0 points. The final values are summed and the choices are presented to the user in descending order. The algorithm is as follows:

```
Denote m is the count of optionalCourses
Calculate rank weight value such as rank of Field, Prerequisite, Suitability and
   FavoriteField
Sort rank weight value
```

## System Evaluation

To evaluate the effectiveness of the system presented in this paper, we conducted a survey of 214 senior students and 18 graduate students in the Electrical Engineering Department of Hanyang University [13, 14]. Two professors with experience as course coordinators were selected as curriculum experts. The proposed system recommended options for majors on the basis of the tree of courses already taken. In the case of students in the first semester of the fourth grade, they were able to select the subjects that they wanted to take in the following term.

First, among the weak point of faculty, because it is difficult to do systematic subject selection about a major field, Table 3 shows the result of correspondence analysis between the recommendation result of the system and course taken.

Table 3. The number of course taken within a system recommendation subject order

| Term \ The order of priority | 1st | 2nd | 3rd | 4th | 5th | 6th |
|---|---|---|---|---|---|---|
| Second grade: first semester | 199 | 93 | 32 | 201 | - | - |
| Second grade: second semester | 179 | 172 | - | - | - | - |
| Third grade: first semester | 153 | 49 | 68 | 108 | - | - |
| Third grade: second semester | 90 | 95 | 41 | 41 | - | - |
| Fourth grade: first semester | 47 | 58 | 117 | 34 | 36 | 20 |
| Fourth grade: second semester | 100 | 79 | 28 | 27 | 19 | - |

According to the result of an attending lecture requisition of a second term of three year, students could select 4 subjects. About subject that system presents, 90 students who take a course 1st order recommendation subject, 2nd orders 95 students, 3rd orders 41 students, it was not more in 4th orders 41 people. If there was course recommendation system that recommend course and inform student's major field, then they will be able to learn about a major field.

Table 4. The percentage courses taken that were actually recommended by the curriculum expert

| Term | Student of No.1 | … | Student of No.18 | average |
|---|---|---|---|---|
| 2-2 | 100.0% | … | 50.0% | 72.2% |
| 3-1 | 66.7% | … | 33.3% | 72.7% |
| 3-2 | 66.7% | … | 33.3% | 38.9% |
| 4-1 | 0.0% | … | 0.0% | 42.6% |
| 4-2 | 100.0% | … | 50.0% | 39.5% |
| total | 61.5% | … | 30.8% | 52.7% |

Second, for the 18 graduate students, Table 4 shows the percentage of courses taken that were actually recommended by the curriculum expert in each term. For the 18 graduate students, Table 5 shows the relationship between the subjects recommended by the curriculum experts and those recommended by the system.

Table 5. The relationship between subjects recommended by the curriculum expert and those recommended by the proposed system

| Term | Student No.1 | … | Student No.18 | Average |
|---|---|---|---|---|
| Second grade: second semester | 100.0% | … | 100.0% | 94.4% |
| Third grade: first semester | 66.7% | … | 66.7% | 78.2% |
| Third grade: second semester | 100.0% | … | 66.7% | 87.0% |
| Fourth grade: first semester | 100.0% | … | 100.0% | 94.4% |
| Fourth grade: second semester | 100.0% | … | 50.0% | 97.4% |
| Total | 92.3% | … | 76.9% | 89.5% |

Regarding subjects recommended by a curriculum expert, the ratio of taken courses fails as the school year goes up. The degree of conformity between subjects recommended by curriculum experts and those recommended by the proposed system averaged 89.5%. Therefore, the proposed system functions well as a course coordinator; it not only helps with course-selection choices but also improves the proportion of courses taken that are relevant to each student's major field, thus helping students to accumulate knowledge in their major field.

To analyze the performance of the proposed system, it was compared with the Intelligent Online Academic Management System (IOAMS) [8]. Students deciding their courses for the second semester of the fourth grade completed a survey, and a course coordinator recommended subjects. After the proposed system and IOAMS had also recommended subjects, the accuracy of selection relative to that of the course coordinator was examined. A comparison of the performance of the proposed system and that of IOAMS is shown in Table 6.

The average accuracy of the proposed system was 91.4%, whereas that of IOAMS was 67.1%. In most cases, the proposed system matched students with subjects better that IOAMS. However, in the case of student No. 6, the performance of IOAMS was better than that of the proposed system. Student No. 6 was simultaneously attending lectures in subjects that were and were not in the subject tree. The proposed system recommended subjects adaptively, but IOAMS recommended subjects based on the first configured field. The proposed system can diagnose and recommend appropriate subjects for students, which is usually the role of a course coordinator.

## Relevance Analysis

Table 6. Comparison of accuracies of the proposed system and IOAMS (%)

| Student \ System | The Proposed System | IOAMS |
|---|---|---|
| No. 1 | 88.1 | 88.1 |
| No. 2 | 83.3 | 45.8 |
| No. 3 | 95.2 | 80.9 |
| No. 4 | 78.6 | 59.5 |
| No. 5 | 95.2 | 80.9 |
| No. 6 | 83.3 | 91.7 |
| No. 7 | 94.4 | 63.9 |
| No. 8 | 100.0 | 42.9 |
| No. 9 | 93.3 | 86.6 |
| No. 10 | 94.4 | 36.1 |
| No. 11 | 94.4 | 66.7 |
| No. 12 | 88.1 | 78.6 |
| No. 13 | 95.2 | 80.9 |
| No. 14 | 100.0 | 80.9 |
| No. 15 | 86.1 | 58.3 |
| No. 16 | 95.2 | 42.8 |
| No. 17 | 100.0 | 94.4 |
| No. 18 | 72.2 | 44.4 |
| Average | 91.4 | 67.1 |

## ■ Inquiry into the Association Rule in Relation to Lectures

This paper investigates the association rule for 214 senior students registered in the Hanyang University's Department of Electrical and Computer Engineering in 2008 [13, 14]. The proposed system recommended major options from a course tree. The target of the association rule is 40 major optional subjects. Enterprise Miner Release 4.1 within SAS System ver.8 was used for data mining.

| studentNum | lecNum |
|---|---|
| 1994111101 | COM307 |
| 1994111101 | ELE201 |
| 1994111101 | PHY213 |
| 1994111101 | ELE207 |
| 1994111101 | PHY208 |
| 1994111101 | COE351 |

...

| | |
|---|---|
| 1994111101 | ECE458 |
| 1994111101 | ENE439 |
| 1994111101 | ELE417 |
| 1994111101 | GEN358 |
| 1994111102 | COM307 |
| 1994111102 | ELE201 |

Figure 3. Taking a Lecture Record – Relation DB

The data required to find the association rule are the student number (studentNum) and the course number (lecNum) as shown in Figure 3. The relational database form was changed to a transactional form, as shown in Table 7, so that all courses that a student has taken can be found in one transaction.

Table 7. Taking a Lecture Record – Transactions DB

| Transaction-id | Courses |
|---|---|
| 1994111101 | COM307, ELE201, … |
| 1994111102 | … |
| … | … |
| 1994111214 | … |

## Data Visualization

This is the analysis of course enrollment data before we obtain the association rule [15, 16]. Table 8 shows the number of subjects students took for each term. Support means the percentage of student enrollment for each subject. The set up subject shows the number of courses that are basic level courses, which can branch out into more specific majors.

Table 8. The Number of Subjects students took for each term

| Term | Minimum Support Subject | | | Set up Subject |
|---|---|---|---|---|
| | Over 50% | Over 40% | Over 30% | |
| 2-1 | 3 | 4 | 5 | 6 |
| 2-2 | 2 | 2 | 2 | 3 |
| 3-1 | 2 | 2 | 5 | 7 |
| 3-2 | 0 | 2 | 2 | 7 |
| 4-1 | 1 | 1 | 1 | 10 |
| 4-2 | 1 | 2 | 2 | 7 |
| Total | 9 | 13 | 17 | 40 |

Table 9. Subject Numbers of courses taken in each field

| Suppor / Fields | Core Subjects | | | Recommended Subjects | | |
|---|---|---|---|---|---|---|
| | Over 50% | Over 40% | Set up Subject | Over 50% | Over 40% | Set up Subject |
| Communication | 5 | 7 | 8 | 2 | 2 | 4 |
| Semiconductor & VLSI | 1 | 2 | 6 | 3 | 4 | 6 |
| Digital Signal Processing | 4 | 4 | 7 | 5 | 8 | 17 |
| Energy & Control | 2 | 3 | 11 | 3 | 3 | 3 |
| High Frequency | 1 | 2 | 7 | 2 | 2 | 4 |
| Computer | 0 | 1 | 8 | 0 | 0 | 1 |

Table 9 shows the number of subjects that satisfy the minimum support of 50% and 40% of core subjects and recommended subjects in each field. The courses Communication and Digital Signal Processing had the highest enrollment of students.

Figure 4 shows the ratio of courses taken in a Signal processing field and Figure 5 shows the ratio of courses taken in a computer field. The computer field is different from other fields because it has high ratio of enrollment of courses throughout all terms. Electronic circuit has a very high ratio of course taken at 91%, in spite of subject importance being 3 points. Computer network is low by the ratio of courses taken at 42%, but subject importance is 10 points. Such courses could become target for change at the next course tree revision.

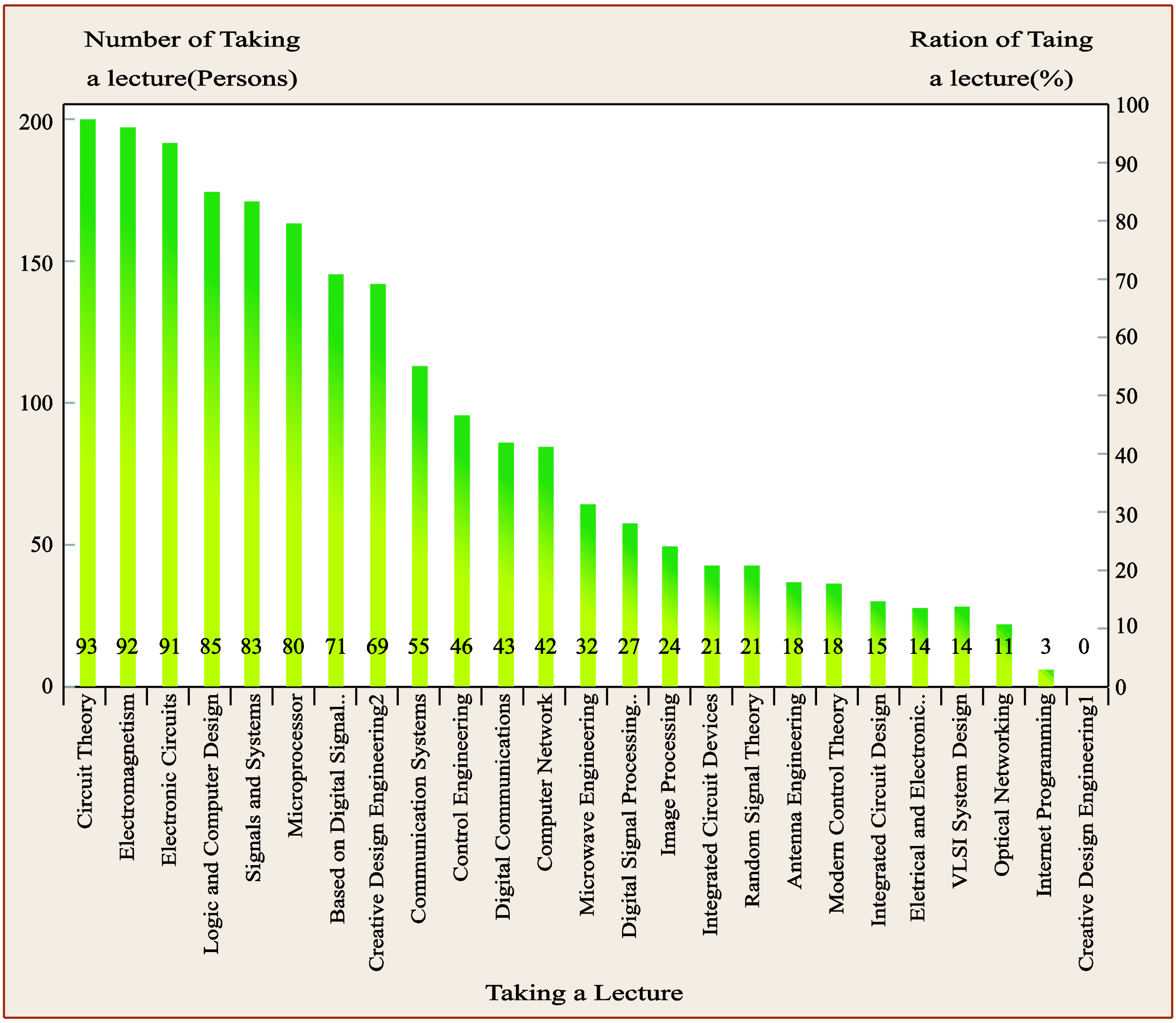


Figure 4. Ratios of Taking Lectures in the Signal Processing Field

## ■ Analysis Results of the Association Rule in Relation to Taking Lectures

This paper sets a minimum confidence level of 80%, and uses minimum support levels of 50%, 40%, and 35% to search for other types of pattern by Table 10. This constitutes a very high numerical value, and is unlike the general association rules for pattern analysis.

Table 11 shows number of searching association rule that do not belong in same field in taking a course tree. For a support level of 40%, we found 1652 association rules that 'Solid State Electronics Physics' is included as following of association rule 13 between subjects that do not belong in same field in taking a course tree. But according to analysis result, the 13th association rule were identified as 'Solid State Electronics Physics' has relationship 'Electronic circuit' in another filed. Therefore, 'Solid State Electronics Physics', 'Electromagnetism', 'Electronic circuit' are included mainly to these rule, these subject may include 'Circuit Theory" subject in new good handle field.

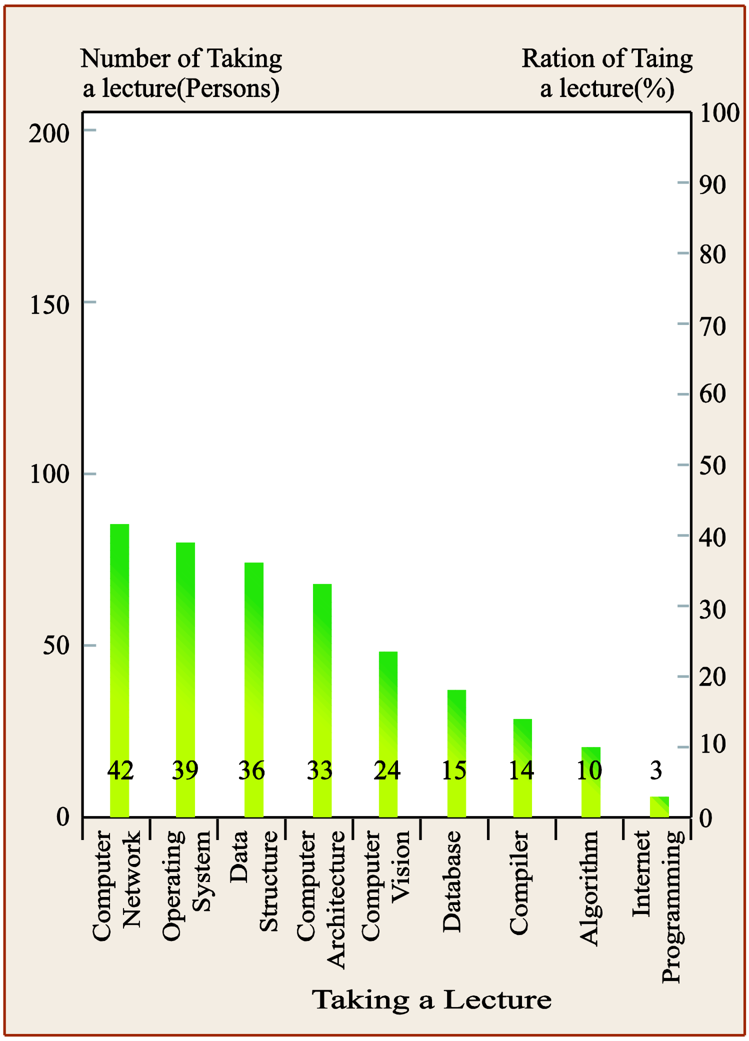


Figure 5. Ratios of Taking Lectures in the Computer Field

Table 10. Association Rules about Optional Subjects

| | Number of Searching Association Rules | Number of Searching Association Rules get out course tree |
|---|---|---|
| min_sup : 50%<br>min_conf : 80% | 1004 | 0 |
| min_sup : 40%<br>min_conf : 80% | 1652 | 13 |
| min_sup : 35%<br>min_conf : 80% | 1787 | 78 |

Table 11. Association rule that do not belong in same field in taking a course tree

| Subject Relationship | min_sup | min_conf |
|---|---|---|
| Solid State Electronics Physics -> Circuit Theory | 41.59% | 95.7% |
| Solid State Electronics Physics -> Circuit Theory & Electromagnetism | 41.12% | 94.62% |
| Circuit Theory & Solid State Electronics Physics -> Electromagnetism | 41.12% | 98.88% |
| Electromagnetism & Solid State Electronics Physics -> Circuit Theory | 41.12% | 98.88% |
| Operating System -> Circuit Theory | 38.79% | 97.65% |
| Operating System -> Circuit Theory & Electromagnetism | 37.85% | 95.29% |
| Operating System & Electromagnetism -> Electronic circuit | 36.45% | 95.12% |
| Operating System & Electronic circuit -> Electromagnetism & Circuit Theory | 35.98% | 97.47% |

For a support level of 35%, we found 1787 association rules and confirmed in the 20 association rules that 'Operating System' is included as following of association rule 78 between subjects that do not belong in same field in taking a course tree. Because 'Circuit theory', 'Electromagnetism', 'Electronic circuit' are included mainly to these rule, these subject may include 'Operating System' subject in new good handle field.

## Conclusions

Faculty systems provide opportunities for students to make informed selections of academic courses from a broad range of fields. This has meant that students, generally, did not acquire expert knowledge in any particular field of the kind that is expected of a graduate student. The course coordinator plays a significant role in building and managing curricula, and counseling students about these items. However, the course coordinator does not have the time to advise individual students on which fields of study are suitable and which courses they should take. A number of academic administration management systems set up previously have offered the function of tailoring personal curricula for individual students. These systems have a very large knowledge base and infer courses using students' subjective data.

This paper has proposed an intelligent course recommendation system to help students select course majors. The system has an inference engine that considers not only course trees, which hold information about courses in every field, but also personal courses that students have already taken. The system has an inference engine that considers not only course trees that hold information about available courses in all fields but also personal histories of the courses that students have already taken. The system acts as a substitute for a course coordinator in the role of counseling students. Students are able to keep track of their courses by using their cell phones, anytime and anywhere, and to improve their overall knowledge by taking the courses that the system's inference engine has recommended.

We searched for relationships between subjects, using association rules, by mining data about the courses already taken by students, and compared these to existing course trees. After analyzing a considerable volume of course attendance data, we applied an association rule to understand the link between subjects chosen with those proposed by faculty guidance advisors. As the result of examining the validity of this rule, we wish to apply to a revision enactment, or reference data, to the attending lecture tree.

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