

# A Course Recommender System Using Multiple Criteria Decision Making Method

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## Abstract

A recommender system is a specific type of information filtering technique that presents the user-relevant information, which is implemented by creating a user's profile and comparing it to the other existing reference characteristics stored in the database. This paper developed a course recommender system capable of helping prospective students to choose relevant post graduate courses by multiple criteria decision making method. First, the multiple criteria decision making method was given. Then, the system prototype, which aimed at amalgamating the multiple criteria decision making model and the collaborative filtering recommendation system, was described. Finally the system architecture was illustrated.

**Keywords:** Recommender system, Course recommender system, Multiple criteria decision making

## 1. Introduction

The decision making process to choose a post graduate course can be very tedious and complicated. Students, especially non-native ones, often find it difficult to find a course which is best suited for them. Students need to choose among varied courses based on a number of decisions and recommendations. The decisions will be influenced by the background of the student and personal or career interests.

A recommender system is a specific type of information filtering technique that presents the user-relevant information, which is thought of being relevant or interesting. Recommender systems are implemented by creating a user's profile and comparing it to the other existing reference characteristics stored in the database. A user's profile is created, then matched to the available references, based on which, valid recommendations are made to the user.

Most recommender systems may adopt either the content-based or the collaborative filtering approaches to offer recommendations to users [7]. The content-based approach uses information about an item to

make suggestions on this item. Other researchers [8], who use the content-based approach to compare contents with user profiles, recommended items which were similar to what a given user had preferred in the past. Often, some weighting schemes have been applied which gave high weights to discriminating words. Once an object is decided, it will be shown to the user, and the feedback will be elicited.

A collaborative recommender system makes use of a database to provide a user with a preference to suggest items which a different user could find useful. There are two types of collaborative filtering approaches or algorithms [3], i.e. a prediction algorithm, which predicts a numerical value advising the likeliness of an item for the user, and a recommendation algorithm, which provides a list of finite items that an active user will find most beneficial. Thus the collaborative filtering can be based on memory (users) or model (items) [3].

Recommender systems have been successfully applied in many different fields. Mei-Hua Hsu [9] has developed an online personalized English learning recommender system capable of providing students with reading lessons that suit their different interests and therefore increase the motivation to learn. Miller et al. [10] developed the recommender system of movie lens, which built and extended a movie recommendation research service to provide movie, DVD, and VHS video recommendations, along with a search capability. Again, more successful applications can be found in online food stores [11], online book stores, such as Amazon.com [12], and so on.

The cognitive process of making decisions which lead to choice of an alternative or course of action is referred to as decision making [5]. Druzdzel and Flynn [6] argued that there were two basic methods or approaches to supporting the process of decision making. The first is directed at building support procedures or systems which involve use of algorithms to imitate human experts. The second approach is based on an assumption that the most reliable method dealing with complex decisions is through a set of normative principles of how decisions should be made.

Criteria are defined as the benchmarks or standards used to judge rules or test acceptability [4].

Multiple Criterion Decision Making (MCDM) deals with problems with multiple and probably conflicting criteria. Its processes deal predominantly with problems with discrete decision spaces. A MCDM problem involves generating alternatives before structuring the criteria for evaluation followed by selection of relevant alternatives [4]. MCDM problems have been characterized [5] as: 1. MCDM Problems have multiple criteria which could be either attributes or objectives; 2. Certain criterion conflict with one another; and 3. Criterion may have different units of measurement; The solutions to a MCDM problem are selected by either the best alternative(s) or best alternative from previously specified finite alternatives.

This paper developed a system which aimed at helping students to choose relevant post graduate courses. The system described herein aimed at amalgamating the multiple criteria decision making model and a collaborative filtering recommendation system, in order to help a prospective student seeking to determine the most relevant post graduate course to pursue at their faculty. The recommendations made are based on the user-entered information and mathematical formulae to enable the system to recommend the best suitable courses from the available ones for the particular user. The paper was organized as: Following the introduction in Section 1, Section 2 described a multiple criteria decision making method. In Section 3, the system prototype, which aims at amalgamating the multiple criteria decision making model and the collaborative filtering recommendation system, is presented. The system architecture was illustrated in Section 4. And the future works were discussed in Section 5.

## 2. A Multiple Criteria Decision Making Method

In this system, the multiple criteria decision making method used is detailed as below:

Step 1: Construct the decision matrix  $D^k$ ,  $k=1, \dots, K$ , for each DM.  $K$  is the number of DMs.

The structure of the decision matrix can be expressed as follows:

$$D^k = \begin{matrix} & X_1 & X_2 & \dots & X_j & \dots & X_n \\ \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_i \\ \vdots \\ A_m \end{matrix} & \left\{ \begin{matrix} x_{11}^k & x_{12}^k & \dots & x_{1j}^k & \dots & x_{1n}^k \\ x_{21}^k & x_{22}^k & \dots & x_{2j}^k & \dots & x_{2n}^k \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{i1}^k & x_{i2}^k & \dots & x_{ij}^k & \dots & x_{in}^k \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{m1}^k & x_{m2}^k & \dots & x_{mj}^k & \dots & x_{mn}^k \end{matrix} \right\} \end{matrix}$$

where  $A_i$  ( $i = 1, \dots, m$ ) denotes the  $i$ -th alternative,  $X_j$  ( $j = 1, \dots, n$ ) represents the  $j$ -th attribute,  $x_{ij}^k$  ( $k = 1, \dots, K$ ) indicates the performance rating of alternative  $A_i$  with respect to attribute  $X_j$  by  $k$ -th decision maker.

Step 2: Construct the normalized decision matrix  $R^k$  for each decision maker. For the  $k$ -th DM, the normalized value of the decision matrix can be any linear-scale transformation to keep  $0 \leq x_{ij}^k \leq 1$ . Using the three operators “ $\odot$ ”, “ $\circ$ ”, and “ $\otimes$ ” [1], the normalized value is represented as

$$r_{ij}^k = x_{ij}^k \odot \{ x_{i1}^k \circ x_{i2}^k \circ \dots \circ x_{in}^k \} \otimes x_j^{k*}$$

where  $x_j^{k*} = \max_i \{ x_{ij}^k \}$ ,  $i = 1, \dots, m$ .

The elements will be further normalized as:

$$r_{ij}^k = \frac{r_{ij}^k}{\sqrt{\sum_{j=1}^n (r_{ij}^k)^2}}$$

Step 3: Determine the positive and negative ideal solutions  $V^{k+}$  and  $V^{k-}$  for each DM:

$$V^{K+} = \{ r_1^{k+}, \dots, r_n^{k+} \} \\ = \{ ( \max_i r_{ij}^k / j \in J ), ( \min_i r_{ij}^k / j \in J' ) \}$$

$$V^{K-} = \{ r_1^{k-}, \dots, r_n^{k-} \} \\ = \{ ( \min_i r_{ij}^k / j \in J ), ( \max_i r_{ij}^k / j \in J' ) \}$$

where  $J$  is associated with the benefit criteria and  $J'$  is associated with the cost criteria.

Step 4: Assign a weight vector to the attribute set for the group. Each DM will elicit weights for attributes as  $w_j^k$ . Each element of the weight vector  $W$  will be the operation result of the corresponding elements of the attributes' weights per DM.

Step 5: Calculate the separation measure from the positive and the negative ideal solutions  $\overline{s_i^+}$  and  $\overline{s_i^-}$  respectively for the group.

There are two sub-steps to be considered in Step 5. The first one concerns the distance measure for individuals; the second one aggregates the measures for the group.

Step 5a: Calculate the measures from positive ideal solutions and negative ideal solutions individually:

$$S_i^{K+} = \left[ \sum_{j=1}^n w_j^k (v_{ij}^k - v_j^{k+})^p \right]^{1/p}, \text{ for alternative } i,$$

$i=1, \dots, m$

$$S_i^{K-} = \left[ \sum_{j=1}^n w_j^k (v_{ij}^k - v_j^{k-})^p \right]^{1/p}, \text{ for alternative } i, \\ i=1, \dots, m$$

where  $p \geq 1$  is a integer,  $w_j^k$  is the weight for the attribute  $j$  of DM  $k$ , and  $\sum_{j=1}^n w_j^k = 1$

Step 5b: Calculate the measures of the positive and the negative ideal solutions for the group.

The group separation measure of each alternative will be combined through an operation “ $\otimes$ ” for all DMs. Thus, the two group measures of the positive and the negative ideal solutions are:

$$S_i^+ = S_i^{I+} \otimes \dots \otimes S_i^{K+}, \text{ for alternative } i.$$

$$S_i^- = S_i^{I-} \otimes \dots \otimes S_i^{K-}, \text{ for alternative } i.$$

The geometric mean of all the distance measures will result into:

$$\overline{S_i^+} = \left( \prod_{k=1}^K S_i^{k+} \right)^{\frac{1}{K}}, \text{ for alternative } i$$

$$\overline{S_i^-} = \left( \prod_{k=1}^K S_i^{k-} \right)^{\frac{1}{K}}, \text{ for alternative } i$$

Step 6: Calculate the relative closeness  $\overline{C_i^*}$  to the ideal solution and rank the alternatives in descending order. The relative closeness of the  $i$ -th alternative  $A_i$  with respect to the positive and negative ideal solutions can be expressed as:

$$\overline{C_i^*} = \frac{\overline{S_i^-}}{\overline{S_i^+} + \overline{S_i^-}}, i = 1, \dots, m$$

The larger the index value, the better the performance of the alternative.

Step 7: Rank the preference order.

A set of preference alternatives can now be ranked according to the descending order of the value of  $\overline{C_i^*}$ .

### 3. System Prototype

The user for the prototype would be a prospective student, who need help to make decisions regarding choosing a course which is best suitable for him or her.

The decision making would be supported by the prototype, which aims at generating most relevant courses to a user. The recommendations made are only to guide the user and help the decision making process.

The prototype makes use of the multiple criteria decision making model and a recommender system to generate the most relevant post graduate courses to a user, based on the criteria set by the user and values assigned in the database. It also provides additional information of a course, which aims at helping the staff to update new courses when the faculty makes some changes.

The recommender system uses simplistic calculations to find out the least distance between the course preferences set by the user and the course values defined in the database. It will work in the following way:

For a prospective student:

A prospective student accesses the faculty's website to gain information about the available post graduate courses. The student is prompted to initiate the recommender system to help him or her make the decision. First, the user will have to fill out the questionnaire by simply choosing the most relevant description for each of the questions. For instance: “Are you a Full time / Part time student”?

In order to expedite the process of filling up the questionnaire, certain presets have been incorporated in the design to aide the user. For instance, if a user is very interested in programming, other questions will be answered automatically, keeping the user's preference for programming. However the user will still have the option to change the attributes.

The user then submits the finished questionnaire. This shall trigger the calculations and a least distance will be computed from the entered profile and the database entry for every course. This loop shall be executed thrice and thus the user will have three most relevant courses recommended, which match his or her preferences. A graphical representation would also be displayed to depict the degree to which a course matches a user's preference. This is done by converting the least distance into a percentage and displaying it.

For a staff member configuring a new course recently offered by the faculty:

The staff member would have to first activate the “add a course” function to enter the name of the new course. He or she would then assign the values in the database. Once done, the new course would appear as an option.

Certain key issues of the multiple criteria model used in the prototype include:

Quantification of qualitative ratings is to judge the importance of criteria to evaluate an alternative, which will be assigned by the user.

The profiling of courses requires significant analysis on the various permutations when selecting the criteria for the available courses. The course selection and scope is limited to the faculty related post graduate degrees only and considers various conditions and business rules. These conditions or criteria include student type, course type, type of study, fields that the user is interested in, previous qualifications, and work experience.

An average of three profiles was created for each of the respective courses. The values entered for the profiles were based on research done on the curriculum for each course. This process identified some limitations with regards to exclusions of weightings and business rules. For example, a selection of a research study could be improved to filter only the courses that are relevant and therefore to eliminate redundant selection choices. This would also minimize some of the duplicate results from the recommender system calculation.

## 4. System Architecture

The layered architecture for this course recommender system is shown in Fig.1. It includes several layers. The client layer interfaces with a presentation layer via a web browser. The web browser interfaces with a business layer typically encapsulated in an application server. The business objects includes the algorithms for the recommender systems by applying the profiling data stored on an access database.

## 5. Future works

Future studies on this recommender system include the addition of weightings to each selection criteria. Whilst the current rating mechanism is a good starting point to apply in the linear algorithm, the recommendation will also consider weightings when calculating the recommendation. In addition, a condition matrix will be devised to include conditions, business rules and actions. The business rules should drive a selection filter mechanism which will narrow the selection criteria while the user navigates through the user interface. Future work will also incorporate

techniques for ordering preferences by similarity to ideal solution and a collaborative filtering recommendation system.

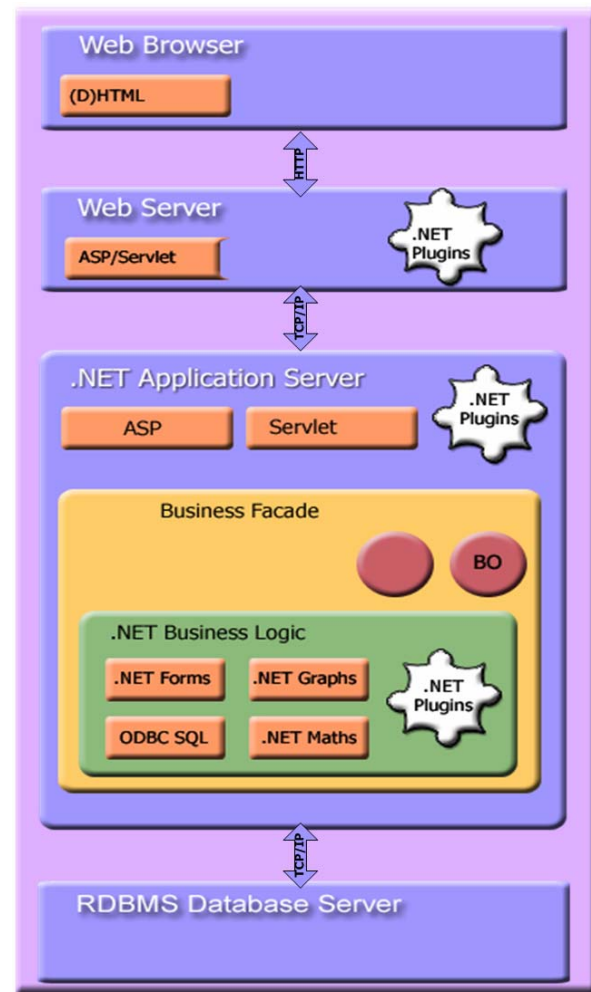


Fig. 1: System Architecture.

## 6. References

- [1] C. L.Hwang and Yoon, K., “Multiple Attribute Decision Making”, Springer-Verlag, Berlin. 1981.
- [2] K. Karta, “An investigation on personalized collaborative filtering for web service selection”, Post graduate thesis, University of Western Australia, Brisbane, 2005.
- [3] U. Shardanand and Maes, “Social information filtering: Algorithms for automating word of mouth”, *Proc. of CHI'95 -- Human Factors in Computing Systems*, pp. 210-217, 1995.
- [4] M. Balabanovic and Y. Shoham, “Combining content based and collaborative recommendation”, *Communications of the ACM*, 40, 3, 1997.

- [5] J. Lu, G. Zhang, D. Ruan and F. Wu, "Multi-objective group decision making", Imperial college press, Sydney, 2007.
- [6] M. J. Druzel and R. R. Flynn, "Decision support systems", *Encyclopedia of library and information science*, P. 7, 2007.
- [7] P. Resnick and H. R. Varian, "Recommender systems", *Communications of the ACM*, PP. 56–60, 1997.
- [8] Y. F. Wang, Y. L. Chuang, M. H. Hsu and H. C. Keh, "A personalized recommender system for the cosmetic business". *Expert Systems with Applications*, pp. 427–434, 2004.
- [9] M. H. Hsu, "A personalized English learning recommender system for ESL students", *Expert Systems Applications*, pp. 683–688, 2008
- [10] B. N. Miller, I. Albert, S. K. Lam, J. A. Konstan and J. Riedl, "Movie Lens unplugged: experiences with an occasionally connected recommender system", *Proceedings of IUI'03* pp. 263–266, 2003.
- [11] M. Svensson, J. Laaksolahti, k. K. Ho, and A. Waern, "A recipe based on-line food store", *Proceedings of IUI 2000*, pp. 260–263, 2000.
- [12] G. Linden, B. Smith and J. York, "Amazon.com recommendations: item-to-item collaborative filtering", *IEEE Internet Computing: Industry Report*, 2003.