# A Multi-Study Program Recommender System Using ELECTRE Multicriteria Method

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# A Multi-Study Program Recommender System Using ELECTRE Multicriteria Method

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***Abstract* - Selection of study program plays an important role in the success of a person to determine his future. One of the risks associated with the selection of study is the incompatibility with the needs of the current job vacancies in companies that significantly affect the future of these students. Since there are many criteria that must be considered, then through this recommender system, students are able to know what fields are the most appropriate for them. This system is built based on Electre method. When a student fills out a questionnaire, he must be consistent with his/her answer to obtain the best output based on his/her will and characteristics. This research uses descriptive analytical method and presents a summary of the results of surveys and interviews of 310 colleges in accordance with the codification which connect with Job Career so it can be a reference to prospective students in finding employment in the future company.**

## I. Introduction

Recommender systems that have been made previously are based on content-based filtering method and AHP. This technique matched item to a user profile or query-based content and not the opinion of other users. The system has some information about each item, recommendation can be given even if the system only receive a rating in small quantities, or even none at all. Each item must be described in accordance with the features that appear on the user's profile, and the profile of each user should be collected and modeled, firstly, seek representation documents. Second, create a profile that allows for documents that are not seen to be recommended. The weakness of the Recommender system based on content-based filtering and AHP is that very large number of questions amounted to 2700 questions must be filled by respondent and takes a long time in charging to generate the desired output[1].

To eliminate the weaknesses in Recommender system based on content-based filtering and AHP, researchers attempt to combine the ELECTRE technique. One of them is the study carried out by lindal et al [2]. They use a combination of simple technique, which is generated from the prediction's ranking generated out of content-based prediction and prediction ELECTRE. The advantages of ELECTRE are used to reduce the impact of sparsity problem and early rater. ELECTRE technique is only useful when the system has received rating in a rather large amount, because few amount of the ratings data would complicate the system to make recommendations [3].

Recommendations from ELECTRE technique does not rely on user ratings. This technique does not need to gather information about a particular user because the assessment is not based on individual taste. Knowledge-based recommender system is a technique that uses the knowledge of the user and the product in building a knowledge-based approach to produce a recommendation. These characteristics make knowledge-based useful when implemented alone or as a complement of other types of recommender systems [4]. Si & Jin used a mixed model for filtering approach, which aims to group (clustering). The use of this method can evoke recommendation and make it easier in terms of selection decisions based on existing widely considerable variations [5]. Recommender systems are based on research with respondents who have difficulty in choosing varying courses opened by universities in the Kopertis III region, making it easier for users to choose the desired study program based on company needs at this time. Programs and academic studies in 300 universities in total located in the region Kopertis III Jakarta, with 200 varieties of courses that opened in the Kopertis III area out of the 500 courses opened throughout Indonesia[1].

## II. Theoretical Review

This section briefly explains about Recommender Systems, Electre, and MCDM, and also investigates some previous studies related to the implementation of the recommender systems. This section will also explains the methodology used in this study.

2.1. Recommender Systems

According to [3] a recommender system is a system which recommends a solution of explicit problems based on hierarchical structure. In the most general formulation, recommendation problems are reduced by rating to items which have not been recognized by a user.

A recommender system itself can be defined as a system which generates individual recommendation as an output, or it can also be defined as a system which helps user to find desired items by giving recommendation based on one of the recommended content items (content-based filtering) or similar user ratings on recommended items (collaborative filtering). In another area, for example, information filtering recommender system uses problems analysis techniques to help customers find products they want to buy by producing similarity of prediction score or a list of recommended products for specific customers [6].

The recommender system is also usually classified into the following categories:

a. Content based recommendation (Content based Filtering): The user will be recommended items similar to the user preferred in the past.
b. Collaborative recommendations (Collaborative Filtering): The user will be recommended items similar to the user preference and interest in the past.
c. Hybrid approach (hybrid collaboration): These methods combine collaborative and content-based methods.

2.2 Multi Criteria Decision Making (MCDM)

Multi Criteria Decision Making (MCDM) is a decision-making technique based on several existing alternatives or a theory which explains about decision making process by considering many criteria. In order to model recommendation problems as MCDM, one must follow four general steps of modeling methodology to make a decision for the problem [4]:

a. Decision object. It defines the object on which decisions must be made and the reasons of the decision recommendation.
b. Family of criteria. Namely, it defines identification and modeling of a set of criteria that influence decision, and a complete and non-redundant recommendation.
c. Global preference model. It defines aggregator function for marginal preference on each criterion to global preference from decision maker for every item.
d. Decision support process. Namely, it defines study of various categories and types of recommender systems that can be used to support decision makers' recommendations, in accordance to the results of previous steps.

Implementation of the MCDM method in a recommender system has yet to be explored systematically. Recommender System is capable to explain some system contributions which involve several MCDM methods. This system has many domain applications. On the other hand, a comprehensive analysis will facilitate understanding and system development that can identify dimension which distinguish, explain, and categorize multi-criteria system recommender, based on existing taxonomy and categorization that is used in the analysis and classification of online user decision sample[7].

MCDM is a theory of decision making that considers a limited set of alternative options against many criteria. The problem in MCDM can be formulated as follows:

Suppose there are M criteria and N alternatives. We must choose some or a set of alternatives which fulfill criteria as maximum as possible [9]. MCDM problem can be modeled in decision matrix.

TABLE 1:
Decision Matrix [7]

| | Criteria | | | | |
|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | $C_3$ | ... | $C_N$ |
| **Alternative** | $W_1$ | $W_2$ | $W_3$ | ... | $W_N$ |
| $A_1$ | $a_{11}$ | $a_{12}$ | $a_{13}$ | ... | $a_{1N}$ |
| $A_2$ | $a_{21}$ | $a_{22}$ | $a_{23}$ | ... | $a_{2N}$ |
| $A_3$ | $a_{31}$ | $a_{32}$ | $a_{33}$ | ... | $a_{3N}$ |
| . | . | . | . | ... | . |
| . | . | . | . | ... | . |
| . | . | . | . | ... | . |
| $A_M$ | $A_{M1}$ | $A_{M2}$ | $A_{M3}$ | ... | $a_{MN}$ |

Decision matrix is a matrix of size M x N where the element aij indicates the performance of alternative Ai when evaluated against the criteria Cj (for i = 1,2,3, ..., M and j = 1,2,3, ..., N).[4]

MCDM methods using the Analytic Hierarchy Process (AHP), can convert ordinal scale to ratio scale and even check the consistency[12].

2.3 ELECTRE (Elimination Et Choix Traduisant La Réalité) Method

ELECTRE (Elimination Et Choix Traduisant La Réalité) is a system that uses ELECTRE method which is a method of multicriteria decision-making based on the concept of outranking using pairwise comparison of alternatives based on any criteria appropriate [8].

The steps are as follows:

a. Normalized decision matrix. Each attribute is changed to a comparable value.
b. Weighted normalized matrix. Once normalized, each column of the matrix R multiplied by the weight of the weight (w) determined by the decision maker.
c. Determine the set of concordance and discordance index. For each pair of alternatives k and l (k, l = 1,2,3, ..., m and $k \neq l$) a set of criteria is divided into two subsets, namely concordance and discordance.
d. Calculate the matrix of concordance and discordance. Calculate the concordance matrix to determine the value of the elements in the concordance matrix by adding weights included in the mathematical concordance set. Determine the value of the elements in the discordance matrix by

dividing the maximum difference of criteria included into discordance subsets with a maximum difference of the value of all the existing criteria.

e. Determine the dominant matrix of concordance and discordance. Matrix F as dominant concordance matrix can be constructed with the aid of a threshold value, by comparing the value of each concordance matrix element with the threshold value. Calculate the dominant discordance matrix. The matrix G as the dominant discordance matrix can be built with the help of the threshold value.
f. Determine the aggregate dominance matrix. The matrix E as aggregate dominance matrix is a matrix in which each element is the multiplication between the elements of F matrix to the corresponding elements of matrix G.
g. Elimination of the less favorable alternative. The matrix E gives the preferred order of each alternative, that is, if the alternative is a better alternative than Al. Thus, the line in the matrix E which has the least number can be eliminated. Thus, the best alternative is an alternative that dominates other alternatives.

Application of MCDA in the Election of Study Program

The study began with the observation and implementation of the selection study program recommender system to minimize errors that would result from the failure of electing study program in this study prior to its numbering of 2700 questions to prospective new students. The data was processed using a descriptive analytic method to present a summary of the results of the questionnaire survey and interviews done manually and online. Survey of private colleges in the Kopertis III region was done to find which courses are open in every university. There were 310 universities in accordance with codifying universities in Kopertis III, with 200 courses opened. The author also came to Career Job-seeking courses to find any information needed by companies today [1].

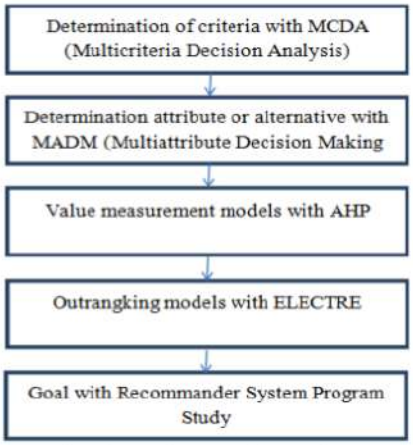


Fig. 2 Steps Conducted in the Study

## III. Implementation And Results

Analysis of the application of multi-criteria recommender system study selection program using ELECTRE generates a result of execution that can be expected to make a recommendation for prospective new students by classifying criteria, sub-criteria and alternatives to the existing questionnaires. The process of filling out the questionnaire by the respondents should be consistent in order to produce the expected output.

ERD (Entity Relationship Diagram)

ERD is a model of a relational database based on the perception in the real world; the world is always composed of a set of objects that interact with each other. An object is called entity and relationships of its so-called relationship. An entity is unique and has the attribute as a differentiator with other entities. [10]

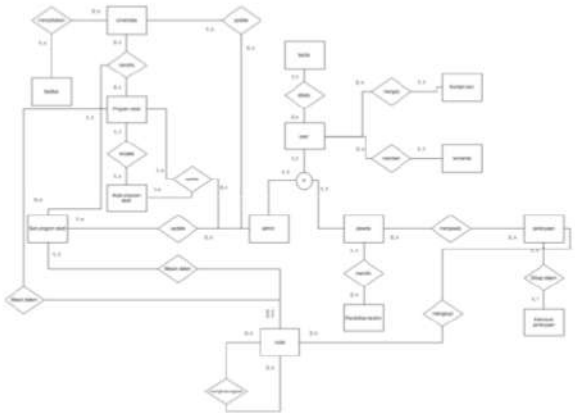

Fig. 3 ERD of Study Program Recommender System[1]

Calculations using ELECTRE methods as follows:

| Alternative | Criteria | | | | |
|---|---|---|---|---|---|
| | Expense | Career | Reputation | Study programs | Sub-programs Study |
| Health | 5 | 5 | 3 | 3 | 3 |
| Technique | 3 | 3 | 4 | 2 | 3 |
| Computer | 4 | 5 | 1 | 3 | 2 |

Decision-making giving preference weights as:
W = (5, 4, 3, 3, 1)

The decision matrix formed from the following table:

$$\begin{bmatrix} 5 & 5 & 3 & 3 & 3 \\ 3 & 3 & 4 & 2 & 3 \\ 4 & 5 & 1 & 3 & 2 \end{bmatrix}$$

To solve the above problem with the method ELECTRE will be done with the steps described earlier:

1. Normalized decision matrix:

$$\begin{bmatrix} 0{,}707 & 0{,}650 & 0{,}696 & 0{,}639 & 0{,}639 \\ 0{,}424 & 0{,}390 & 0{,}696 & 0{,}426 & 0{,}639 \\ 0{,}565 & 0{,}650 & 0{,}174 & 0{,}639 & 0{,}426 \end{bmatrix}$$

2. Weighted normalized matrix

$$\begin{bmatrix} 3{,}536 & 2{,}604 & 2{,}089 & 1{,}919 & 0{,}640 \\ 2{,}121 & 1{,}562 & 2{,}089 & 1{,}279 & 0{,}640 \\ 2{,}828 & 2{,}604 & 0{,}522 & 1{,}919 & 0{,}426 \end{bmatrix}$$

3. Determine the set of concordance index.
   a. Concordance. A criteria in an alternative if:
   $c_{ki} = \{j, v_{kj} \geq v_{ij}\}, untuk\ j = 1,2,3, \dots, n$

   The result:

| Concordance | Health | Technique | Computer |
|---|---|---|---|
| Health | - | 2, 4 | 1, 2, 3, 4, 5 |
| - | 1,2, 4 | | 4, 5 |
| Computer | 1,2 | 1, 2, 3 | - |

   b. Discordance. A criteria in an alternative if:
   $D_{ki} = \{j, v_{kj} \geq v_{ij}\}, untuk\ j = 1,2,3, \dots, n$

   The result:

| Discordance | Health | Technique | Computer |
|---|---|---|---|
| Health | - | 1, 5 | - |
| Technique | 1, 3, 5 | - | 1, 2 |
| Computer | 3, 4, 5 | 4, 5 | - |

4. Calculate the matrix of concordance and discordance

$$c_{ki} = \sum_{j \in c_{ki}} Wj$$

$c_{12} = w_2 + w_4 = 4 + 3 = 7$
$c_{13} = w_1 + w_2 + w_3 + w_4 + w_5 = 5 + 4 + 3 + 3 + 1 = 16$
$c_{21} = w_1 + w_2 + w_4 = 5 + 4 + 3 = 12$
$c_{23} = w_4 + w_5 = 3 + 1 = 4$
$c_{31} = w_1 + w_2 = 5 + 4 = 9$
$c_{32} = w_1 + w_2 + w_3 = 5 + 4 + 3 = 12$

The result:

$$\begin{bmatrix} - & 7 & 16 \\ 12 & - & 4 \\ 9 & 12 & - \end{bmatrix}$$

Calculate the matrix of concordance

$$d_{kl} = \frac{\max\{|v_{kj} - v_{ij}|\} j \in D_{kl}}{\max\{|v_{kj} - v_{ij}|\} \forall_j}$$

Calculations:

$$d_{12} = \frac{\max\{|v_{1j} - v_{2j}|\}_{j \in D_{12}}}{\max\{|v_{1j} - v_{2j}|\}_{\forall j}}$$

$$= \frac{\max\{|3{,}535 - 2{,}121|\ ;\ |0{,}639 - 0{,}639|\}}{\max\{|3{,}535 - 2{,}121|\ ;\ |2{,}603 - 1{,}562|\ ;|2{,}785 - 2{,}785|\ ;|1{,}918 - 1{,}279|;|0{,}639 - 0{,}639|\}}$$

$=1$

$$d_{13} = \frac{\max\{|v_{1j} - v_{3j}|\} j \in D_{13}}{\max\{|v_{1j} - v_{3j}|\} \forall_j}$$

$$= \frac{max\ (0)}{max\ \{|3{,}535 - 2{,}121|;|2{,}603 - 1{,}562|;|2{,}785 - 2{,}785|;|1{,}918 - 1{,}279|;|0{,}639 - 0{,}639|\}}$$

$=0$

$$d_{21} = \frac{max\ \{|v_{2j} - v_{1j}|\}_{j \in D_{21}}}{max\ \{|v_{2j} - v_{1j}|\}_{\forall j}}$$

$$= \frac{max\ \{|2{,}121 - 3{,}535|;|1{,}562 - 2{,}603|;|2{,}785 - 2{,}785|\}}{max\ \{|3{,}535 - 2{,}121|;|2{,}603 - 1{,}562|;|2{,}785 - 2{,}785|;|1{,}918 - 1{,}279|;|0{,}639 - 0{,}639|\}}$$

$=1$

$$d_{31} = \frac{\max\{|v_{3j} - v_{1j}|\} j \in D_{31}}{\max\{|v_{3j} - v_{1j}|\} \forall_j}$$

$$= \frac{max\ \{|0{,}696 - 2{,}785|;|1{,}918 - 1{,}918|;|0{,}426 - 0{,}639|\}}{max\ \{|3{,}535 - 2{,}121|;|2{,}603 - 1{,}562|;|2{,}785 - 2{,}785|;|1{,}918 - 1{,}279|;|0{,}639 - 0{,}639|\}}$$

$=1$

$$d_{32} = \frac{\max\{|v_{3j} - v_{2j}|\} j \in D_{32}}{\max\{|v_{3j} - v_{2j}|\} \forall_j}$$

$$= \frac{max\ \{|1{,}918 - 1{,}918|;|0{,}426 - 0{,}639|\}}{max\ \{|3{,}535 - 2{,}121|;|2{,}603 - 1{,}562|;|2{,}088 - 2{,}088|;|1{,}918 - 1{,}279|;|0{,}639 - 0{,}639|\}}$$

$=0{,}408$

$$d_{23} = \frac{max\ \{|v_{2j} - v_{3j}|\}_{j \in D_{23}}}{max\ \{|v_{2j} - v_{3j}|\}_{\forall j}}$$

$$= \frac{max\ \{|2{,}121 - 2{,}828|;|1{,}562 - 2{,}603|\}}{max\ \{|3{,}535 - 2{,}121|;|2{,}603 - 1{,}562|;|2{,}088 - 2{,}088|;|1{,}918 - 1{,}279|;|0{,}639 - 0{,}639|\}}$$

$=0{,}665$

The result:

$$\begin{bmatrix} - & 1 & 0 \\ 1 & - & 0{,}665 \\ 0 & 0{,}408 & - \end{bmatrix}$$

5. Determine the dominant matrix of concordance and discordance

a. Calculating the dominant matrix concordance

$$c = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} C_{kl}}{m(m-1)}$$

$$= \frac{7+16+12+4+9+12}{3(3-1)} = 10$$

The Matrix:

$$\begin{bmatrix} - & 0 & 1 \\ 1 & - & 0 \\ 0 & 1 & - \end{bmatrix}$$

b. Calculating matrix of discordance:

$$d = \frac{\sum_{k=1}^{m} \sum_{l=1}^{m} C_{kl}}{m(m-1)}$$

$$= \frac{1+1+0{,}665+1+0{,}408}{3(3-1)} = 0{,}679$$

The Matrix:

$$\begin{bmatrix} - & 1 & 0 \\ 1 & - & 0 \\ 1 & 0 & - \end{bmatrix}$$

6. Determine the aggregate dominance matrix:
$e_{ki} = f_{ki} \, x \, g_{ki}$

The Matrix:

$$\begin{bmatrix} - & 0 & 0 \\ 1 & - & 0 \\ 0 & 0 & - \end{bmatrix}$$

## IV. Conclusion

A multi-criteria recommendation system with AHP and Electre has been developed to support prospective students or secondary school graduates in choosing courses. Multi-criteria decision-making applied in the system solves complex problems, and is able to handle the interdependence of elements in the system and not impose linear thinking. This electre method can intelligently generate decisions quickly once the respondents fill in the field of study, which is not possible by using a manual application (ie expert choice) where respondents can not get the results in real time. The results of the calculation can be used as a recommendation for prospective students to determine the choice of courses that will be the future goal. Excess Electre method can provide the best alternative decision solution in decision making with many criteria. Based on the calculation, the choice of technology has a threshold value of concordance dominant matrix of 10 and the threshold value of dominant matrix diconcordance 0.679.

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