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A decision support system for multiple criteria decision making problems

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Abstract

Configuration of a system for decision making problem which facilitates decision process and enables users to get higher quality advantages is a deal always in academic communities. This paper deals with proposing and constructing decision making system performing online software. The system implements the algorithm of MOORA and COPRAS techniques with an example of robot selection to test the applicability and validate multi criteria decision problem results. Results shows COPRAS and MOORA ranking of robots are very close to each other especially the 1st and second top alternatives. The software can be extended to the other decision making problems as well.

Keywords: decision support system (DSS), multiple criteria decision making (MCDM), complex proportional assessment (COPRAS), multi objective optimization based on ratio analysis (MOORA), STROMa (SysTem of RecOmmendation Multi-criteria)

1. *Short introduction*

Operation research is a discipline with wide range of concepts and logics from mathematical modelling and programming to efficiency and productivity measurement in order to aid us in complex and parametric decision problems. Multiple criteria decision making (Thery and Zarate, 2009; Yazdani et al. 2017) family as a major category of operation research has been discussed in order to facilitate evaluation and selection problems. Adopted algorithms, integrated formulas along to mathematical and logical approaches lead to the development of decision making methods. Multiple criteria decision making (MCDM) forms a perspective in decision theory which facilitates business processes in practice (Ghorabaee et al. 2017; Mardani et al. 2016) Zavadskas and Turskis (2011) believe developing economics, changing environment, sustainability of decisions are the reasons to develop new operation research techniques and specifically decision making approaches. A decision support system is defined a database, algorithm and user interface within a computer or operating system which can handle the whole decision making process in a visualized form. It can enhance quality and reliability of decision system.

In the real world issues, to overcome the complexity of the decision problem, we need to utilize the methods that are user-friendly and consider less computation to achieve the reliable solution. Mostly some decision support system comes up with simple methods like weighted product or simple additive tools. Rather than this the literature is saturated of using TOPSIS, VIKOR and other classical tools, so it is the moment to propose and validate to the more recent developed tools. This paper aims at finding solution for a typical decision making problem using two well-developed methods as complex proportional assessment (COPRAS) (Zavadskas et al. 1994) and multi objective optimization based on ratio analysis (MOORA) (Brauers and Zavadskas, 2006; Zavadskas et al. 2014). To get information and review of these methods, it is accessible (Brauers et al. 2008). The two methods have been employed in different decision making problems. Yazdani et al. (2017) studied on the affection of several normalization tools on COPRAS method. Moreover, in a supply chain, COPRAS has been applied with other methods to compare and release the performance of suppliers (Tavana et al. 2017). The application of the both MOORA and COPARS has been demonstrated in the evaluation of suppliers in a dairy company (Yazdani et al. 2017). The COPRAS method is a tool which originates from ratio and partial proportion of ideal parameters, while MOORA comes from a multi objective assessment which is able to distinguish negative and positive impact of criteria. As these two methods have been developed by same research group and are almost well-designed by MCDM configuration, they are chosen to be compared in a decision support framework. In addition, the difference of both methods algorithm can be realized in a common platform. Therefore, it is shown that the selected methods are validated and approved in a higher quality research. The application of integrated MCDM tool in a decision support framework is observed in advanced studies (Fallahpour et al. 2017; Ignatius et al. 206). The contribution of this article is the implementation of aforementioned methods in a decision support system in order to build a dashboard for easier data gathering and effective outcomes. This system is interpreted in the implementation part.

The paper is organized as this; section 2 presents main decision making tools as MOORA and COPRAS. Thereafter, implementation of DSS and a numerical example about robot selection problem is presented. Finally, a conclusion ends this paper and suggests short tips in section 4.

2. *Methodologies*

The paper intents to provide a group decision making system to show the performance of MCDM tools. The algorithms for two methods can be presented here;

2.1. Multi-objective optimization based on ratio analysis (MOORA)

MOORA, developed by, is a MCDM method consisting of two phases, namely, the reference point approach and the ratio system approach, and allows measuring both beneficial and non-beneficial criteria in a process of selecting an alternative from a set of alternatives.

An initial decision matrix whose *kj*-th element displays the performance rating of the *k*-th alternative ($k = 1, \ldots, t$) upon the *j*-th decision criterion ($j = 1, \ldots, n$) is formed. See the matrix of Eq. (3). Hence:

Step 1. Normalizing the decision matrix. To obtain dimensionless and comparable elements in the evaluation process, the *kj*-th element of the initial matrix are normalized using the following equations:

$$r_{kj} = \frac{x_{kj}}{\sqrt{\sum_{k=1}^{t} x_{kj}^2}} \tag{1}$$

Step 2. Determining the weighted normalized matrix. The *kj*-th element of the normalized matrix is replaced by the one calculated using the following:

$$v_{kj} = r_{kj} \cdot w_j \tag{2}$$

Step 3. Computing the overall rating of benefit and cost criteria for each alternative. The overall rating of the *k*-th alternative considering the beneficial and non-beneficial criteria are calculated implementing Eqs. (12) and (13), respectively:

$$S_k^+ = \sum_{j \in J^{Max}} v_{kj} \tag{3}$$

where J^{Max} is the index set of the set of beneficial criteria for which higher values are desirable;

$$S_k^- = \sum_{j \in J^{Min}} v_{kj} \tag{4}$$

where J^{Min} is the index set of the set of non-beneficial criteria for which lower values are preferable.

Step 4. Evaluating the overall performance of each alternative. The overall performance of the k -th alternative is calculated as the difference between the overall ratings for beneficial and cost criteria:

$$S_k = S_k^+ - S_k^- \quad (5)$$

Step 5. Ranking the alternatives. The S_k values form a cardinal scale that can be used to compare and rank the alternatives: the higher the value of S_k, the more preferred is the *k*-th alternative.

2.2. COPRAS

COPRAS is another MCDM method which selects the best alternative among a lot of feasible alternatives by determining a solution with direct and proportional ratio to the best solution to the ratio with the ideal-worst solution (Zavadskas et al., 2007).

To solve MCDM problem by COPRAS, after determining the alternatives and the related criteria, follow steps below;

Step 1 – Normalize the decision matrix: suppose x_{ij} is the decision matrix of alternative j under the evaluation criterion i, and then normalized decision matrix is here;

$$r_{ij} = \frac{x_{ij}}{\sum_{j=1}^{m} x_{ij}}, \ j = 1,2,.....,m, \ i = 1,2,...,n \quad (6)$$

Step 2 – Calculate the weighted normalized decision matrix where w_i includes the weights of criteria and given by $\sum_{i=1}^{n} w_i = 1$;

$$v_{ij} = w_i \times r_{ij} \ , j = 1,2,.....,m, \ i = 1,2,...,n \quad (7)$$

Step 3 - Identify the sums of weighted normalized criteria values (P_j) for each alternative whose higher values are more preferable using the following equation;

$$P_j = \sum_{i=1}^{k} v_{ij} \quad (8)$$

Where k is the number of criteria value, which must to be maximized

Step 4 - Obtain the sums of weighted normalized criteria values (R_j) for each alternative whose smaller values are more preferable using the following equation;

$$R_j = \sum_{i=1}^{n-k} v_{ij} \quad (9)$$

Where $(n-k)$ is the number of criteria values, which should be minimized

Step 5 – Identify the relative weight of each alternative Q_j

$$Q_j = P_j + \frac{\sum_{j=1}^{m} R_j}{R_j \sum_{j=1}^{m} \frac{1}{R_j}}, \quad (10)$$

Step 7 – Determine the priority of the alternatives based on the values of Q_j. The greater amount of Q_j declares the higher preference (ranking) of each alternative.

3. *Implementation and a DSS*

3.1. *Implementation*

We developed software to implement a decision support system which efficiently illustrates decision making process and it has the ability to be extended. The software is designed to receive information about decision problem including performance rating of the alternatives, weights of each criteria and optimization direction of the proposed criteria. As Figure 1 declares, firstly a detail of the decision problem must be defined as in "Description" section. The user is asked to specify the type of problem choosing whether it is a quantitative or qualitative problem. It is easy to label decision problem, define number of decision factors etc. The next step is to compose decision matrix which is appeared in "Performance" headline. This task is done entering information of the alternatives with respect to each criterion. The whole information is thus stored in a database while the algorithm of the proposed MCDM method is written by Java computer language. Implementation of these methods is carried out in the STROMa (SysTem Of RecOmmendation Multi-criteria) application (Fomba et al. 2017). STROMa is an integrated web application developed in JSF2 (JavaServer Faces). The objective is to find the best multi-criteria aggregation operator for a given decision problem.

Figure 1 – A decision support dashboard for multi criteria decision problem

3.2. *A numerical example*

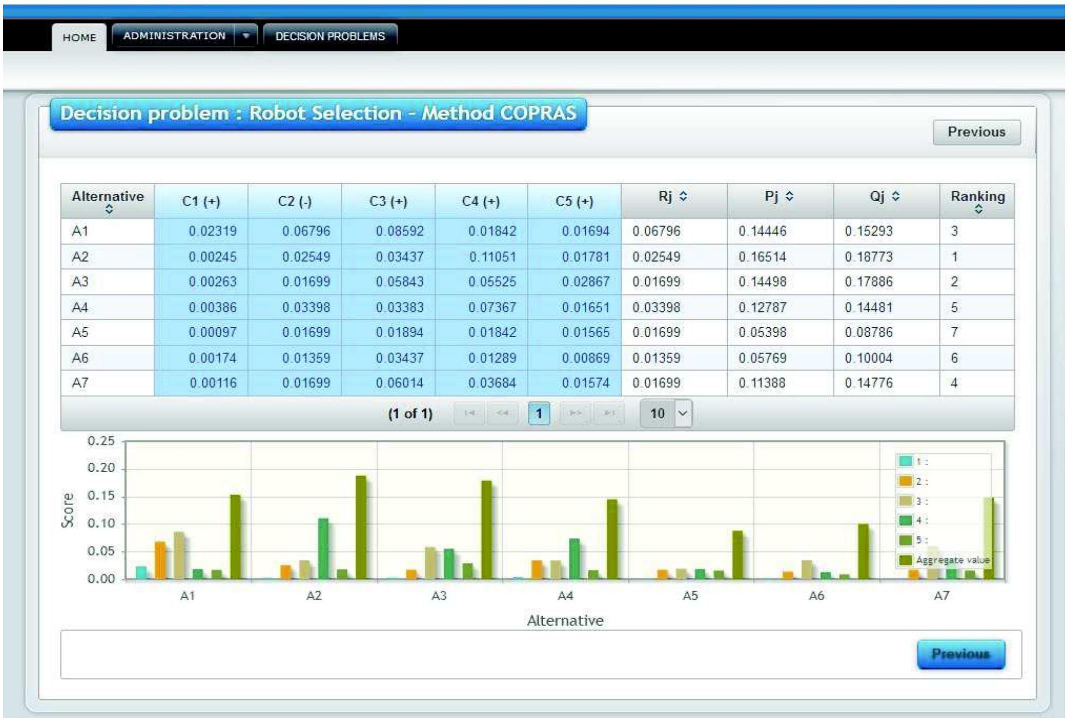
The paper examines a case example which is related to the selection of the most appropriate industrial robot (For more information see Chakraborty and Zavadskas, 2014). The weights of decision criteria are based on 0.036, 0.192, 0.326, 0.326 and 0.12, respectively for five criteria. Among five criteria, just C_2 is a cost criteria and rest of four factors are as benefit indicators. Table 1 shows the data and details for a robot selection decision problem including alternative information. The weights of decision criteria are shown in Figure 1. We object to solve the decision problem using COPRAS and MOORA methods which have been explained in the previous section.

Table 1 - Example of robot selection problem by Chakraborty and Zavadskas (2014)

Alternative robots	C_1	C_2	C_3	C_4	C_5
A_1	60	0.4	2540	500	990
A_2	6.35	0.15	1016	3000	1041

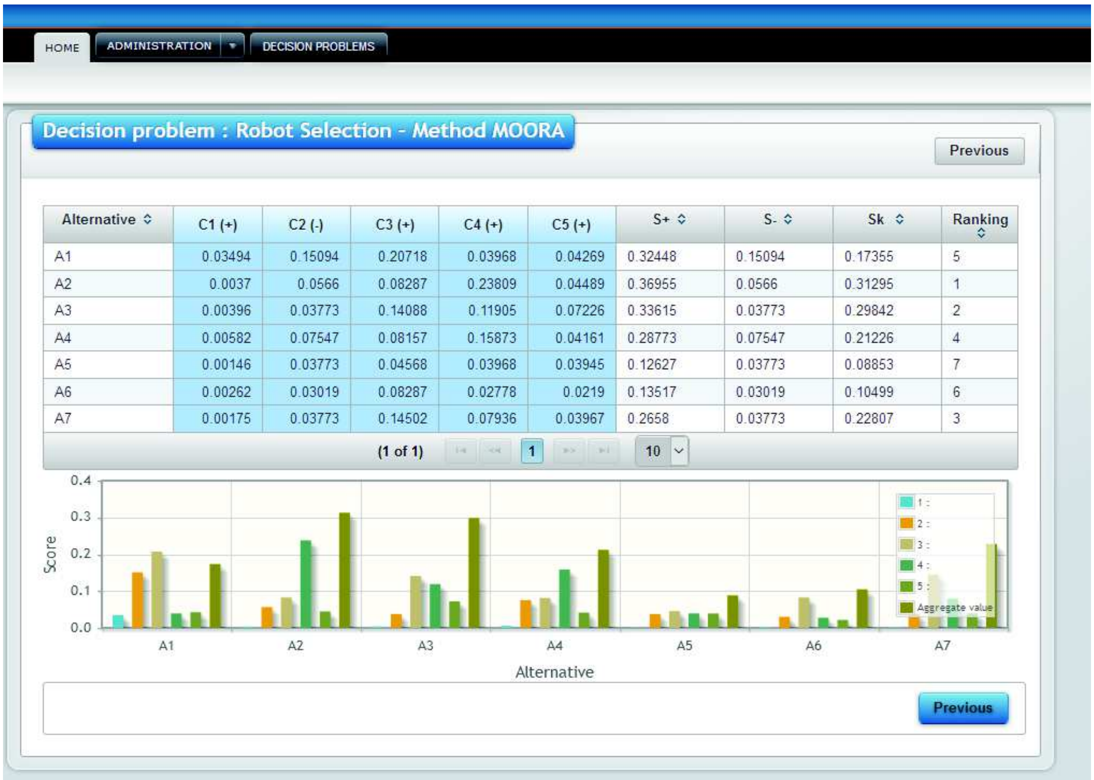
A_3	6.8	0.1	1727.2	1500	1676
A_4	10	0.2	1000	2000	965
A_5	2.5	0.1	560	500	915
A_6	4.5	0.08	1016	350	508
A_7	3	0.1	1778	1000	920

As Figure 2 shows the detailed solution of COPRAS methodology is presented. The highlighted blue columns are weighted normalized matrix which is according formula 7. Then P_j and R_j values are measured using formulas 8 and 9, respectively. Finally Q_j values must be produced to release the ranking of robots. The last column shows the ranking of the robots as well. Outcomes validate the results with the study already done by Chakraborty and Zavadskas, 2014. The same rules are tracked for MOORA method as well. It is observed the ranking of MOORA and COPRAS is very close while the Spearman correlation coefficient between them is achieved the agreement of 0.89. The range is completely acceptable. The software is able to present a bar chart to compare alternatives ranking score schematically. This leads effective understanding for engineers and experts who desire deeper analysis.



Alternative	C1 (+)	C2 (-)	C3 (+)	C4 (+)	C5 (+)	Rj	Pj	Qj	Ranking
A1	0.02319	0.06796	0.08592	0.01842	0.01694	0.06796	0.14446	0.15293	3
A2	0.00245	0.02549	0.03437	0.11051	0.01781	0.02549	0.16514	0.18773	1
A3	0.00263	0.01699	0.05843	0.05525	0.02867	0.01699	0.14498	0.17886	2
A4	0.00386	0.03398	0.03383	0.07367	0.01651	0.03398	0.12787	0.14481	5
A5	0.00097	0.01699	0.01894	0.01842	0.01565	0.01699	0.05398	0.08786	7
A6	0.00174	0.01359	0.03437	0.01289	0.00869	0.01359	0.05769	0.10004	6
A7	0.00116	0.01699	0.06014	0.03684	0.01574	0.01699	0.11388	0.14776	4

Figure 2 – Illustration of COPRAS method



Alternative	C1 (+)	C2 (-)	C3 (+)	C4 (+)	C5 (+)	S+	S-	Sk	Ranking
A1	0.03494	0.15094	0.20718	0.03968	0.04269	0.32448	0.15094	0.17355	5
A2	0.0037	0.0566	0.08287	0.23809	0.04489	0.36955	0.0566	0.31295	1
A3	0.00396	0.03773	0.14088	0.11905	0.07226	0.33615	0.03773	0.29842	2
A4	0.00582	0.07547	0.08157	0.15873	0.04161	0.28773	0.07547	0.21226	4
A5	0.00146	0.03773	0.04568	0.03968	0.03945	0.12627	0.03773	0.08853	7
A6	0.00262	0.03019	0.08287	0.02778	0.0219	0.13517	0.03019	0.10499	6
A7	0.00175	0.03773	0.14502	0.07936	0.03967	0.2658	0.03773	0.22807	3

Figure 3 – Illustration of MOORA method

4. *Conclusion*

Employing technologies and innovative systems aids development a body of knowledge. In area of decision making theories and applications, evolution of decision support system allows experts and decision makers to get the chance of interfacing to a database and facilitating decision process. This short communication tries to present application of MCDM methods and their implementation in a decision support system. For this, a decision making problem is composed and the solution then is validated and visualized by a system called STORMa. Decision problem is basically tends to assess robots for a specific usage with respect to some criteria. We have solved decision problem with utilization of MOORA and COPRAS techniques and tried to enhance the accuracy of the results with implementation of the problem by decision-making software. This study suggests the development of other MCDM tools like TOPSIS or WASPAS in order to get such improvement in MCDM class.

In terms of group decision making approach, the decision making can be carried out by a team of decision makers to reflect different and integrated opinion of the participants. The proposed software and decision support system are enough flexible which enable a group of experts to decide efficiently. Therefore, it is possible to implement a group decision making structure in order to bring an optimized perspective for future research direction.

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