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Determined by Tolerances with Rough Set Based MCDM

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Keywords: rough set (RS), multi criteria decision making, entropy, process planning

Abstract: **Problem definition:** Rough set based MCDM method has been developed for rule extraction and classification from inconsistent and incomplete data structures. During the analysis, lower and upper approaches use the incomplete and uncertain data. Incomplete information analysis and knowledge base reduction methods can able to use the minimization of uncertainty also the structure does not contain strict constraints like fuzzy sets. **Academic / Practical relevance:** The rough set, first proposed by Pawlak [1] in 1982, that enables the discovery of the necessary information using large databases, as well as it can be used in the analysis of missing data structures and uncertain data. Also developed algorithm can be used as a tool in multi-criteria decision making techniques. **Methodology:** The rough set concept was developed to analyze of imprecise structures in multi-criteria decision making problems, and it was derived from fuzzy logic approach by evaluating the data which covers the lower and upper limits. **Results:** The results were solved with the developed algorithm, entropy-based approach, fuzzy MCDM, fuzzy AHP, and compared with the rough set-based approach that gave the same results with the fuzzy logic based MCDM, fuzzy logic based AHP, while the entropy-based result gave 75% similar results. It shows that the proposed method is reliable and suitable as other MCDM methods. **Managerial implications:** In view of the fact that the data are uncertain or incomplete, the existing multi-criteria decision making methods will be insufficient, seeing as the rough set-based multi-criteria decision making algorithm can able to overcome this deficiency.

1. Introduction

This study develops the rough set based MCDM algorithm in which uncertainty and incomplete data that can be evaluated and to apply in large data systems. Suggested algorithm is examined with lower and upper limit values of the data which includes the ambiguous data as fuzzy logic.
Briefly, in this study;
- Rough Set(RS) based MCDM algorithm is developed,
- mathematical model is represented for the proposed algorithm.

RS can be applied to a many areas like artificial intelligence techniques, conflict analysis, pattern detection, and image analysis. Pawlak et al. (1994) evaluates rough sets and their mathematical properties in detail. The RS theory takes into account the relation of inseparability and equivalence in the solution of the problem [1,2]. However, RS theory able to use uncertainity multi-criteria problems Qian et al. (2010) carried out the evaluation process of the problem by using the similarity relations with the group approach in the evaluation of more than one alternative situation [3]. In many applications, different categories can be addressed, not only with different combinations of management, but also property values selected evaluation features to decision making, in which define objects or alternatives of problem space. Wu and Leung, 2011, defined a new model and the generalization model with the theoretical approach to the uncertainty that would suggest the generalization of the problem, and then proposed the development of an approach characterized by uncertainty [4]. The relationship of equivalence is a powerful tool for approaching the wrong and uncertain goal in decision information systems. At the same time, the relationship of closeness may apply to restrictive for many applications, and various situational structures. The RS models have been explored to eliminate such negative situations. In general, the relation between correspondence and restriction was examined such as Sun et al. (2017) [5].

A new uncertainty measure was introduced in the decision-based theoretical RS model for attribute reduction. The proposed model analyzed the uncertain and incomplete data structures. This paper is organized as follows. Section 2 provides the literature survey about RS structure. Section 3 describes RS theory. Section 4 introduces the proposed RS based MCDM problem. Section 5 discuses the experiments for performance evaluation and results. Finally, Section 6 covers the conclusions and future works.

2. Lıterature Survey

RS based MCDM algorithm has been developed by taking a clear and flexible situation with a certain and uncertain information structure. Analyzing of the missing and uncertain data with the RS based MCDM discussed and developed as an algorithm for evaluation of the connections between the data, obtaining the relevant rules and classification with the similarity and difference factors. This study makes more effective, accurate and fast decisions by using the rough set based MCDM algorithm.

Roy and Maji, 2007, developed the center-based restricted algorithm using the comparison table for MCDM based fuzzy soft set [6]. Since the first study of Pawlak (1982, 1991) [1,7], RS theory has developed theoretically rapidly respect of machine learning, pattern recognition and artificial intelligence [8]. The low approach can able to analyze the theoretical definitions, each of which contains a complete concept in RS model. However, this theoretical description is not very rigid and flexible for real world applications. Ziarko (2008) [9] presented a RS model of variables with a lower approach to specific error levels [10,11,15]. Pawlak proposed a general framework and the probabilistic RS. The data reduction structure and string of conditions and attributes with the same level of performance can be dealth with a separate subset of a sufficient structure.

In order to eliminate the negative conditions of uncertainty and incomplete information, we proposed RS based MCDM method. It is more sensitive and accurate analysis of unclear data other than fuzzy logic. We used the ANP, Entropy, Fuzzy MCDM techniques for compare of the RS based MCDM approach.

The RS theory takes into account only the clarity of the data and the improvement of the data quality, as well as it deals with the data required for them. Furthermore, RS theory can be used in the evaluation of data for cases where statistical methods [2]. The heuristic algorithms with criterion protection have a quick decline, while situations after redundancy can still contain unnecessary attributes.

3. ROUGH SET THEORY

3.1 Introduction

The RS theory also allows the practical application of rules reduction and classification. As can be seen in the applications, it is possible to obtain very realistic results as a result of data and database applications.

3.2 Rough Set(RS)

The representation of data and characteristics with the lower and the upper value approaches are so important for the cluster characteristics of the RS theory in the information system. Representation of the information system and decision features of RS theory is given in detail. Basic rough set structure is given in Figure 1.

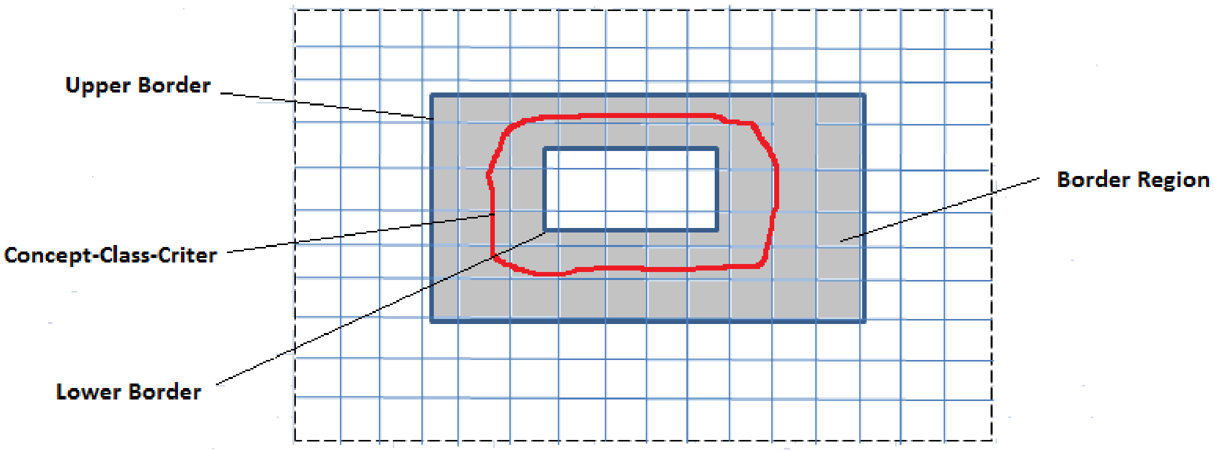

Figure 1. Basic Rough Set Structure

The bottom approach is the combination of all the X set is $\underline{R}(X)$, and the combination of all X sets with an unclear intersection of $\overline{R}(X)$ X represents the upper approach.

3.3 Rough Numbers and Rough Set (RS)'s Boundary Range

The parameters are determined by using subjective assumptions in RS. Membership function values are inevitable in fuzzy logic. The most important feature of the fuzzy set theory is the evaluation of the data by taking into account the lower and upper limits determined by using the direct data without the need for any auxiliary data [12]. RS theory fulfills the necessary classification and evaluation process by taking into consideration that its own assumption parameters instead of the probability theory in fuzzy logic [13].

$a : U \rightarrow V_a$

$DS : T = (U, A \cup \{d\})$ the decision value is taken into consideration rather than the decision feature.

3.4 Characteristics of Rough Set (RS) Theory

The most basic features of the RST are the coverage of the X value in the U space; blank set; universal set; the intersection characteristics of the upper bound and the lower bound which are given in Table 1 and Figure 2 in detail.

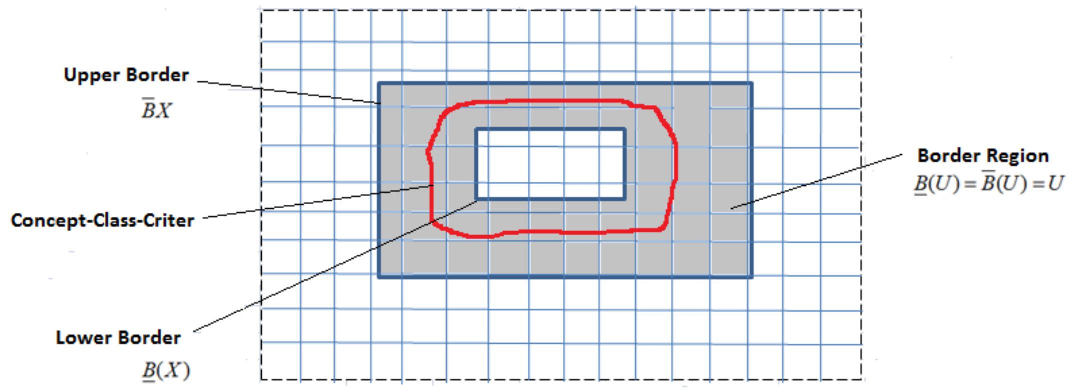

Figure 2. Rough Set Boundary Range

3.5 Recognition Matrix (Based on Positive Region)

T distinctive matrix indicates by M (T), the matrix which defined as:

$$m_{ij} = \begin{cases} \{c \in C:\ c(u_i) \neq c(u_j)\} & \text{if } \exists\ d \in D\ [d(u_i) \neq d(u_j)] \\ \lambda & \text{if } \forall\ d \in D\ [d(u_i) = d(u_j)] \end{cases}$$

i, j = 1,2, ..., n . (6)

The complementary feature u_i ,u_j and
symbols represents set of objects, covering all condition attributes that classify with different classes. When denoted by M (T), which is the distinctive matrix of T, the structure of the equation of the M (T) that is corresponding to the indices in the matrix i, j or u_i represents C-positive values in the region. $m_{ij}. = \lambda d$ is the logical system. It can be defined the null set of values. In the case of minimal divisibility, the T reduction states of this function is defined according to the positive region.

3.6 Determinability Function by Objects

For any $U = \{u_1, u_2, ..., u_n\}$ each logical structure can be described in the minimum separator normal form can be described in case of reduction. The properties of the determinability function according to the objects are;

(1) u_i , u_j is a combination of m_{ij} all variables with the condition.

(2) $\vee m_{ij} = \perp\ (false)$ is $m_{ij} = \varphi$ with the condition.

(3) $\vee m_{ij} = t(true)$ is $m_{ij} = \lambda$ with the condition.

4. ROUGH SET BASED MCDM ALGORITHM

4.1 Introduction

The rough set based MCDM algorithm has been developed in particular analyzing of problems that can include inaccuracy and uncertainty information. The information stored in information systems can be able to solve rough set theory with upper and lower approaches.

This study involves the development of a rough set based decision making algorithm and its implementation with a decision support model. MCDM provides decision making opportunities to managers for making effective and correct decisions in short time.
MCDM has taken into account the open and flexible structure of the structure, which has a holistic approach, taking into account all the factors affecting the system. In this study, the definition and methodological rough set theory framework of MCDM algorithm is given in below:

The system space is expressed with $U = \{x_1, x_2, ..., x_n\}$, the criteria or attributes are symbolized by $C = \{c_1, c_2, ..., c_m\}$ and the weight values belonging to the criteria $\omega=(\omega_1,\omega_2,...,\omega_m)$ vector. The changes in the system must satisfy the condition that the total value of the weight value is equal to $\Sigma\omega_h=1$with the condition $\omega_h \geqslant 0$ [15, 25]. Rough set based decision model λ similarity status taking into account the process steps in the following algorithm has been developed. In this algorithm, the decision matrix is defined as $T=(t_{ij})_{nxm}$ dimension considering the n alternative and m criterion structure in rough set based MCDM.

The distance measurement is calculated by aking into account the formulas (10) and (11). The distance between ξ_{ij}^{kh} and $\xi_{ij}^{kC}(1\leqslant i\ j, \leqslant n)$ alternatives are taken into consideration according to the x_i and x_j the attributes in U space. C (ξ_{ij}^{kC}) in U space refers to measure of the distance between the x_i and x_j alternatives' distance weight. The distance measure, $0\leqslant\xi_{ij}^{kh}\leq 1$ ve $0\leqslant\xi_{ij}^{kC}\leq 1$ limitations and the distance measurement values ξ_{ij}^{kh} and ξ_{ij}^{kC} evaluated with λ similarity degree in nxn U space.

$$\xi_{ij}^{kh} = \sqrt{f_k\big(c_h(x_i)\big)^2 - f_k\Big(c_h\big(x_j\big)\Big)^2} \text{ [14]} \qquad (10)$$

$$\xi_{ij}^{kC}=\sum_{k=1}^{m} w_k \xi_{ij}^{Kh} \qquad (11)$$

λ examines the distance values between the alternatives and determines the conjunction with $x_i \in U$ [14].

To get the ranking result for all alternatives and then choose the best alternative to help the most appropriate decision making.

Therefore, in the proposed model, the λ similarity factor is the most basic function. This basic function evaluates all the alternatives with $(0\leqslant f_k(c_h(x_i))\leq 1)$ condition that is so quite difficult when the existing criteria are incomplete or uncertain. The rough set approach performs an approximate value assignment for these uncertain and incomplete data cases and evaluates the data by assigning it according to the behavior status of the other data in the system.

In case of uncertainty or incomplete data in the decision-making process, the transaction is performed by taking A_k^+ ve A_k^- parameters into account. These parameters are shown in equations (12) and (13) [14].

$$\underline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^-)(x_i) = min\left\{A_k^-(x_i)\,\middle|\,\frac{1}{l}\sum_{k=1}^{l}\chi_{Y^-}^{[x_i]_k^{\lambda}} \geq \alpha, \quad x_i \in U\right\} \quad (12)$$

$$\overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^-)(x_i) = mak\left\{A_k^-(x_i)\,\middle|\,\frac{1}{l}\sum_{k=1}^{l}\chi_{A^-}^{[x_i]_k^{\lambda}} \geq \alpha, \quad x_i \in U\right\} \quad (13)$$

and

$$\underline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^+)(x_i) = min\left\{A_k^+(x_i)\,\middle|\,\frac{1}{l}\sum_{k=1}^{l}\chi_{A^+}^{[x_i]_k^{\lambda}} \geq \alpha, \quad x_i \in U\right\} \quad (14)$$

$$\overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^+)(x_i) = mak\left\{A_k^+(x_i)\,\middle|\,\frac{1}{l}\sum_{k=1}^{l}\chi_{A^+}^{[x_i]_k^{\lambda}} \geq \alpha, \quad x_i \in U\right\} \quad (15)$$

Any α (0 <α ve1) and x_i∈U,

$$\underline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^-)(x_i) \leq \overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^+)(x_i) \quad (16)$$

veya $\underline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^+)(x_i) \leq \overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^+)(x_i)$ (17)

or

$$\overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^-)(x_i) \leq \overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^+)(x_i) \quad (18)$$

are expressed.

Table 1. Rough Set Based MCDM Algorithm

Algorithm 1

Input

(U, C, K, ω) to enter the data of the rough cluster information system in the state space

Output

Sequencing of the alternatives;

[Step1.] Defining the data input space (U, K) and Boundary = (Lower, Upper) values, taking into account the Pawlak approach.

[Step2.] Defining and calculating the upper approach function, Üst¯K(S).

[Step3.] Finding the core regions of all criteria functions

[Step5.] The distance measure is calculated by considering the following formulas and ξ_{ij}^{kh} and ξ_{ij}^{kC}(1⩽i j, ⩽n)

$$\xi_{ij}^{kh} = \sqrt{f_k\left(c_h(x_i)\right)^2 - f_k\left(c_h(x_j)\right)^2}$$

$$\xi_{ij}^{kC} = \sum_{h=1}^{m} w_h \xi_{ij}^{kh}$$

[Step6.] The threshold value determined and the λ-likeness classes are applied for all data.

$$[x_i]_k^{\lambda} = \left\{y \in U \,\middle|\, \xi_{ij}^{kC} \leq \lambda, \quad \lambda \in [0,1], \quad k = 1, 2, \ldots, l\right\}, \qquad x_i \in U$$

[Step 7] For each data assigned the upper and lower approach parameters with A_{k+} and A_{k-} values.

[Step8.] Setting of the α precision parameter under the condition (0<α≤1)

[Step9.] When calculating the upper and lower approximations with α parameters are evaluated by taking into consideration their status.

[Step10.] Comparison of the threshold values of inputs λ: A ⟶ [0, 1], according to the rough set (U, V, K, w) according to the threshold value is given in the t ∈ [0, 1] range in the rough set.

[Step11.] Optimal decision ej if | S…K (ej) | = =i) {1,2, ¯, m} | SimalK (ei) | rule selection.

[Step12.] if j has more than one value, to select an appropriate value

[Step13.] Defining and calculating of the lower approximation function, AltK (S).

[Step14.] Optimal decision e_j if $|S\_K(e_j)|=\vee_{i}\in\{1,2,\ldots,m\}|S\_K(e_i)|$ rule selection.
[Step15.] Selecting an appropriate value if j has more than one value
[Step16.] Calculation of $\delta_k(x_i)$function.
The alternative in (U, C, K, ω) on $x_i \in U$. parameter consideres the sorting format of the alternatives is $\delta(x_i)$ which is the optimal index function.
The evaluation of all alternatives consider the weight values of the C criteria, and the proposed algorithm classify all characteristics.
Minkowsky distance considered in especially,

$$\delta_k(x_i) = \left(\left|\underline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^{+})(x_i) - \underline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^{-})(x_i)\right| + \left|\overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^{+})(x_i) - \overline{Ap}_{\sum_{k=1}^{l}(x_i)_k^{\lambda}}^{\alpha}(A_k^{-})(x_i)\right|\right)/2 \quad (19)$$

It shows the similarity relationship of any object. Any α ($0 < \alpha \leq 1$) range;

$$\delta(x_i) = \sum_{k=1}^{l} \lambda_k \delta_k(x_i), \qquad x_i \in U \qquad (20)$$

5. APPLICATION

This study aims to present the rough set based MCDM algorithm with a general purpose structure in an integrated structure. It is aimed to define and apply the problem together with the algorithm developed for the solution of the problems consisting of many criteria. A unique algorithm has been developed in accordance with the rough set based MCDM structure.

5.1 Description of the problem

Shipbuilding construction is part of the project-based production model. According to the ship project structure includes the flexible production plans that can be implemented with product type. Suggested algorithm developed and applied to shipbuilding model data for analyze and evaluate of the whole criteria and alternatives in this study. Since shipbuilding is a project-based production model that is important to determine the delivery time and to make the right decision among the planned production plan strategies. Therefore, information flow, design development, production planning, testing and acceptance planning process are so criticial for project based manufacturing. Briefly, shipbuilding includes the main part of the assembly of the raw, semi-finished and processed materials together with machinery and equipment.
The ship building process includes a hybrid structure that includes the fixed position and process. The body block is the main process in shipbuilding, including intermediates. Various parts are combined to form body blocks. Different production plans can be used for this process. In this context, rough set based MCDM algorithm has been developed in the process of evaluating and analyzing alternative production plans according to various criteria. We used the Mei et al. paper's data set. It was applied to proposed algorithm and compared the results with Mei et al. study. With the planning model used, the resources such as labor force, material and production strategies.
The semi products and materials, the project type production planning model evaluates the production plans of the intermediates.
Trostman et al. [16] suggested the production plans for the order type production process which have the following characteristics:
(1) The product is redesigned in each new order;
(2) Customer orders only consist of a product order [16];
(3) The product is produced only once and is rarely reproduced from the same product; if the product is reproduced, there is no fixed production time;

(4) The level of production automation is relatively low. Examples of order type productions can be given in heavy industries.
These include shipbuilding, comprehensive, functional machine construction, steel structure construction, special equipment.

5.2 Characteristics of Alternative and Critical Criteria

The project type production should be select the appropriate plan from the plan design and alternative plans for production houlds. It includes the body parts, body components, equipment units, equipment palette and boat blocks. These parameters are taken into consideration while creating alternative production plans such as production capacity for shipbuilding. The reinforcement work shop; the lifting and carrying capacity of the shipbuilding dock; the workshop of the production area; the assembly welding workshop were taken into consideration. In addition, the distance between the process, molding, welding zone and the storage area considered together with the settlement factors. It was assumed that the work assignments were carried out in a balanced and coordinated manner, taking into account the workload balance [17].

5.2.2 Body Block Division and Assembly Principles

Structural features are considered as follows:
(1) During the assembly and welding process, the region of the structural process density must be taken into account when installing the housing block connection.
(2) Divided boat blocks must have sufficient rigidity.
We prefer to use Kong et al. (2006) [18] paper's decision matrix data in this study. Also, they described the assembly operations as A, B, C, D as follows:
Structure Diagram A (Alternative A): N-articulated plates are welded to the inner section and then the inner base frame is mounted. After assembly, the ribbed plates are suspended and then welded to frame and the inner base, ribbed parts. After welding, the welding frame is inverted and placed on the outer bottom plate. The outer sole and the skeletal structure are combined with the final welding process.
Structure Diagram B (Alternative B): N jointed sheets are welded automatically and then the inner base is joined to the longitudinal frame by welding. After assembly, the ribbed plates are suspended and then the ribs are joined to the longitudinal frame with the inner base. The inner base and ribbed plates are joined to the longitudinal frame by welding process. After welding, the bottom is suspended and joined to the frame. Then the outer bottom plate is placed. Finally, the outer soleplate is welded to the ribbed sheets together with the outer base longitudinal frame.

Table 2. Application results for (Step1-Step5)

Weight	0,125	0,125	0,0625	0,125	0,0625	0,0825	0,0825	0,0425	0,0425	0,085	0,0825	0,0825
Criteria	Cr 1	Cr 2	Cr 3	Cr 4	Cr 5	Cr 6	Cr 7	Cr 8	Cr 9	Cr 10	Cr 11	Cr 12
Cr1		0,146291	0,223917	0	0	0,223917	0,591458	0,341271	0,591458	0,679265	0,472854	0,146291
Cr 2	0,146291		0,130514	0,146291	0,146291	0,130514	0,492611	0,267972	0,492611	0	0,441088	0,25
Cr 3	0,223917	0,130514		0,223917	0,223917	0	0,453491	0,182102	0,453491	0,130514	0,348325	0,282018
Cr 4	0	0,146291	0,223917		0	0,223917	0,591458	0,341271	0,591458	0,146291	0,472854	0,146291

Cr 5	0	0,146291	0,223917	0		0,223917	0,591458	0,420079	0,533688	0,146291	0,472854	0,146291
Cr 6	0,223917	0,130514	0	0,223917	0,223917		0,453491	0,182102	0,453491	0,130514	0,348325	0,282018
Cr 7	0,591458	0,492611	0,453491	0,591458	0,591458	0,453491		0,326523	0,5	0,492611	0,12381	0,65587
Cr 8	0,341271	0,267972	0,182102	0,341271	0,420079	0,182102	0,326523		0,326523	0,267972	0,209177	0,366482
Cr 9	0,591458	0,492611	0,453491	0,591458	0,533688	0,453491	0,5	0,326523		0,492611	0,144755	0,65587
Cr 10	0,679265	0	0,130514	0,146291	0,146291	0,130514	0,492611	0,267972	0,492611		0,384297	0,25
Cr 11	0,472854	0,441088	0,348325	0,472854	0,472854	0,348325	0,12381	0,209177	0,144755	0,384297		0,522192
Cr 12	0,146291	0,25	0,282018	0,146291	0,146291	0,282018	0,65587	0,366482	0,65587	0,25	0,522192	

Structure Diagram C (Alternative C): N jointed sheets are welded automatically and then the inner base is connected to the longitudinal frame and welded. The outer base plate B is assembled and then welded. In the

next process, the outer lower neck is joined to the frame and welded to the frame in the longitudinal direction. In addition, the ribbed plates in the inner bottom plate are combined and welded. After welding, the source frame is reversed; placed on the outer bottom plate and welded.

Structure Diagram D (Alternative D): The splice plates are welded to the outer bottom plate B. Subsequently, N jointed panels are welded internally. In addition, the inner base longitudinal frame is assembled and welded. The ribbed plates in the inner bottom plate are combined and welded. Then, the structure of the bottom plate and the frame is placed and joined to the formed frame. Finally, the body block is inverted and then welded to the external base plate-related components. Therefore, order type production, temporary product group section and production plan selection, production status, building technology, product structure characteristics etc. Parameters are considered in suggested algorithm.

5.3 Alternative and Criteria Values of the Problem

The criteria taken into consideration in this study were collected under 4 main groups. These are quality; degree of automation; welding process efficiency; and cost-effectiveness (Fig.3). The first one is the quality comprises of the processing of the accuracy and classification. The second main criteria is automation degree that consists of the setting ability; use of automation devices and degree of automation.

The third main criteria is welding process efficiency which covers the downward welding process ratio, the number of turning operations, the auxiliary measures, the difficulty of assembly. In terms of cost efficiency main criteria includes the time management, the number of employees, the use of existing equipment. Therefore, these identified criteria were also evaluated together with four alternative production plans. The list of these criteria is shown in Table 3 and the relation between the criteria and alternatives is shown in Figure 3.

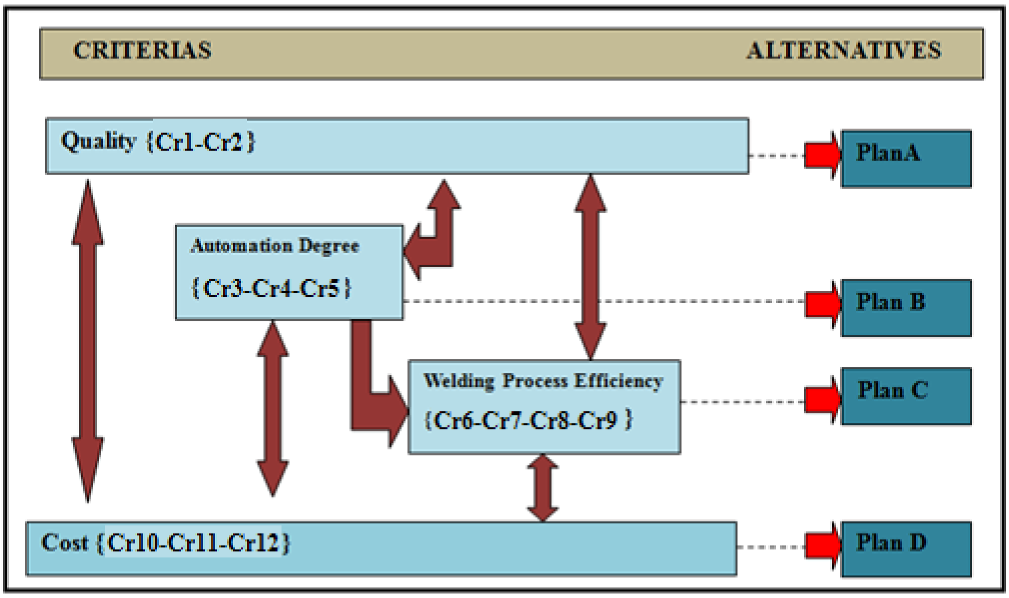

Figure 3 –Application's criteria and alternatives

Table 3. Index data of the block structure scheme.

		Alternatives			
Criteria Components	Weight	A	B	C	D
Quality					
Cr1. Processing accuracy	0.50	1.0	0.8	0.4	0.2
Cr2. Classification	0.50	1.0	0.8	0.6	0.4
Automation Degree					
Cr3. Setting ability	0.25	0.8	1.0	0.8	0.4
Cr4. Use of automation devices	0.50	1.0	0.8	0.4	0.2
Cr5. Degree of automation	0.25	1.0	0.8	0.4	0.2
Welding Process Efficiency					
Cr6. Downward welding process ratio	0.33	0.8	1.0	0.8	0.4
Cr7. Number of turning operations	0,33	0	0,4	1	0,8
Cr8. Auxiliary measures	0.17	0.4	0.8	1.0	0.4
Cr9. Difficulty of assembly	0.17	0.0	0.4	1.0	0.8
Cost efficiency					
Cr10. Time Management	0.34	1.0	0.8	0.6	0.4
Cr11. Number of employees	0.33	0.2	0.4	1.0	0.6
Cr 12. Current equipment utilization rate	0.33	1.0	0.8	0.6	0.0

5.4 Implementation of Rough Set Based MCDM Technique

In this section, suggested algorithm steps applied. Algorithm 1 steps are discussed in previsous section and shown that discussed rough set based MCDM process of evaluating the criteria and alternatives. Step 5 and Step 6 application process results are given in Table 2. Table 4 shows the results for λ= 0.25 and λ=0.65 (step 6 to step 15) in Algorithm 1.

Table 4. Results for λ= 0.25 (step 6to step 15) in Algorithm 1.

	Rough Set Based MCDM Index Results for λ= 0.25 **threshold value**	**Rough Set Based MCDM Index Results for threshold value**
Cr1	0,062823365	0,19027
Cr 2	0,08526546	0,19462
Cr3	0,105121522	0,213811
Cr4	0,075258083	0,202705
Cr5	0,075258083	0,203599
Cr6	0,105121522	0,213811
Cr7	0,010214353	0,399377
Cr 8	0,043661834	0,282559
Cr9	0,011942285	0,417494
Cr10	0,066979109	0,171649
Cr11	0,02525646	0,324859
Cr12	0,098215877	0,197765

5.5. Selection of Evaluation Indices and Reasonable Alternatives

In this study, each criterion was evaluated independently with the four main group level evaluation index which are quality satisfaction, degree of automation, resource efficiency and cost ratio for evaluation with each group's own level. Two-level evaluation index system is given in Table 3 [18]. The data were decided by experts and the basis of a single factor membership degree of each installation plan. Table 5 shows the average index operation results for rough set based MCDM algorithm (Step 1 to Step 13). According to these data, the relative importance rankings of the evaluation indices examined under 4 groups are given in Table 6.

This means that it increases the rationality index; the effect of working time and the number of workers in the body block building. B> A> C> D sequence was obtained by the rough set based MCDM. Thus Plan B is most proper for ship construction. (Step 6 to Step 15) results are given in Table 6. Traditional fuzzy comprehensive evaluation method and rough set based MCDM evaluation results are listed in Table 7.

Table 5. Average index operation results of steps 1 through Step 15

Criteriar	Rough Set Based Index Value	Criteria	□
Cr1	0,105305626	Cr1	0,144694
Cr2	0,125513408	Cr2	0,124487
Cr3	0,177581257	Cr3	0,072419
Cr4	0,122575019	Cr4	0,127425
Cr5	0,123989484	Cr5	0,126011
Cr6	0,177581257	Cr6	0,072419
Cr7	0,181111311	Cr7	0,068889
Cr8	0,202926436	Cr8	0,047074
Cr9	0,17367071	Cr9	0,076329
Cr10	0,116233447	Cr10	0,133767

Cr11	0,163970033	Cr11	0,08603
Cr12	0,150221513	Cr12	0,099778

The PlanB is most suitable production plan to build a ship block. This result show that the shipbuilding firms during the production considers some of the criteria to optimşze the using resources such as materials, labor, leadtime etc.(Table 7). According to the calculated result, the object control reflects the effect of total block generation time on the construction of the body block (Table 8).

Tablo 6 Evaluation results of multi-featured index data of ship hull block schemes.

Evaluation Index	Entropt Value	Entropy Weight	AnP Based Weight	Fuzzy MCDM Weight	Rough Set Based Weight
Processing accuracy (Cr1)	0.5338	0.0885	0. 0682	0.0718	0.1053
Classification (Cr2)	0.6161	0.0729	0.0687	0.0598	0.1255
Setting ability (Cr3)	0.6412	0.0681	0.0682	0.0550	0.1775
Use of automation devices (Cr4)	0.5338	0.0885	0.0771	0.0813	0.1225
Degree of automation (Cr5)	0.6412	0.0681	0.0653	0.0526	0.1239
Downward welding process ratio (Cr6)	0.4868	0.0975	0.0771	0.0897	0.1775
Number of turning operations (Cr7)	0.5838	0.0790	0.0653	0.0622	0.1811
Auxiliary measures (Cr8)	0.4868	0.0975	0.0796	0.0933	0.2029
Difficulty of assembly (Cr9)	0.5838	0.0790	0.0964	0.0909	0.1736
Time Management (Cr10)	0.4868	0.0975	0.0796	0.0933	0.1162
Number of employees (Cr11)	0.6161	0.0729	0.1282	0.1112	0.1639
Current equipment utilization rate (Cr12)	0.5242	0.0904	0.1282	0.1388	0.1502

Table 7 Application results for alternatives

λ=0.25	[Plan A]-0.25,1	[Plan B]-0.25,1	[Plan C]-0.25,1	[Plan D]-0.25,1
	0,7545	0,746	0,6665	0,371
λ=0.35	[Plan A]-0.35,1	[Plan B]-0.35,1	[Plan C]-0.35,1	[Plan D]-0.35,1
	0,746	0,7105	0,371	0,6665
λ=0.45	[Plan A]-0.45,1	[Plan B]-0.45,1	[Plan C]-0.45,1	[Plan D]-0.45,1
	0,2761425	0,2826875	0,254665	0,231875

Table 8 Evaluation results of the alternative plans

	Entropi based MCDM	Soritng	Fuzzy Logic based MCDM	Sorting	Fuzzy Logic based AHP	Sorting	Rough Set Based MCDM	Soritng
Plan A	0,2463	3	0,7343	2	0,2756	2	0,7343	2
Plan B	0,2741	2	0,7459	1	0,2757	1	0,7459	1
Plan C	0,2791	1	0,6766	3	0,2312	3	0,6766	3
PlanD	0,2419	4	0,3843	4	0,2174	4	0,3843	4

6. CONCLUSION

Rough set approach is so important for information discovery and data mining. In particular, big data analysis, most of time includes the unclear and vogue data, this approach provides the analysis of the these kinds of data as deterministic value. Then it can be used to build the relational rules from creating decision making processes. Partial or complete dependencies in the data can be defined with the coarse cluster approach, and null values can be determined by eliminating unnecessary data. Missing data, dynamic data structures can be specified.

The following outputs were obtained with this study;
1. Describe the rough set theory for the MCDM problem
4. Development of rough set based MCDM algorithm
5. Comparison of the results of the developed algorithm with other MCDM techniques i.e. entropy, ANP, Fuzzy MCDM.
6. Using the developed algorithm analyzes the project type production parameters.

The concluded study as follows:
(1) As well as the fuzzy logic approach, an algorithm will be developed for the rough set approach.
(2) Detailed theoretical research is provided for the different definitions of uncertainty and classic risk decision-making, and proposed multi-stage models.
(3) A new approach has been introduced the fuzzy rough set based MCDM problem, which consists of two universes in upper and lower level.

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