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ORIGINAL PAPER

MULTI-CRITERIA GROUP DECISION MAKING MODEL USING SINGLE-VALUED NEUTROSOPHIC SET

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ABSTRACT. **Background:** In this article, we introduce some approaches for decision making in the neutrosophic set. The purpose of this study is to develop a neutrosophic multi-criteria group decision-making (MCGDM) model based on hybrid score-accuracy functions for approving a tender for construction under a simplified neutrosophic environment. Five criteria have been selected from experts' opinions to be considered for the distribution of tender. In this paper, we use the score functions, the accuracy functions, and the hybrid score-accuracy functions of single-valued neutrosophic numbers (SVNNs) and ranking method for SVNNs, those will help for making a decision.

Methods: Decision making under uncertain situation is an important aspect of those days. For this, we have developed the multi-criteria decision-making model using a single-valued neutrosophic set. The main aim is to select an appropriate tender for assigning the work to be done, so that the output will be the best one, under the available resources.

Results: We have developed an algorithm for taking proper decisions for the selection of a contractor for the construction of a public/government work.

Conclusions: We have verified our algorithm with the help of an example. We have considered five criteria. However, this algorithm can be applied for multi-criteria decision making. Also, it can be applied to other case studies too.

Key words: Neutrosophic set, Indeterminacy, Fuzzy set, Decision making.

INTRODUCTION

By using multiple criteria decision making (MCDM) methods, group decision-makers can choose the best alternative given multiple criteria. For that, a strategic method needs to be implemented to this decision made in uncertainty. In MCDM difficulties, a group decision matrix is built by aggregating the individual evaluation of each decision-maker to find a group adequate solution that is most preferred by the decision-makers.

Logistics management is a component of supply chain management. It plans, implements, and manages the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of creation and the point of consumption in order to meet customers' requirements. In this connection our model is expected to be useful for the logistic practices for decision making.

The main fields within logistics are Procurement logistics, production logistics, distribution logistics, disposal logistics. Our work can help in different fields of logistics [Swierczek 2019].

Horizontal logistics collaboration allows a great opportunity for companies to diminish their distribution charges. By forming a combination, companies have the potential to become more productive. However, the selection of a coalition structure is a difficult job for decision-makers. The decision-maker needs to distinguish and choose the best workable partner(s) to carry out a joint plan

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concerning many patterns. This paper aims to propose a unique combination of group decision making [Sun, 2019, Harish, 2020].

For the choice of any object to a bye, we have decided from the available object and other opportunities like home delivery and time management quality. Since logistics management is a component of supply chain management, decision-makers have to ensure the flow of work management quality.

The fuzzy sets theory proposed by Zadeh in 1965. It has been very successful in dealing with difficulties involving uncertainty. Fuzzy set theory can be used to model imprecision in MCDM problems. [Pramanik, Mukhopadhyay 2011] performed an intuitionistic fuzzy MCDM strategy for teachers selection based on the grey relational analysis.

Till now fuzzy and intuitionistic fuzzy MCDM difficulties are investigated by many researchers. Uncertainty performs a vital role in group decision-making problems. Presently multiple researchers use uncertainty in the model formulation of different MCDM problems. So neutrosophic sets should be utilized in the decision-making method. The idea of the neutrosophic set was acquainted by [Smarandache 2005].

Distribution of tender for some construction can be considered as multi-criteria group decision-making (MCGDM) problem that generally consists of selecting the most desirable alternative from all the given alternatives. Classical MCGDM approaches deal with crisp numbers i.e. the weights of criteria are measured by crisp numbers. However, it is not always possible to present the information by crisp numbers. In order to deal with such a situation, the notion of the fuzzy set was introduced by Zadeh and Atanassov extended the concept of fuzzy sets (FSs) to intuitionistic fuzzy sets (IFSs) in 1986. The distribution of tender generally involves subjective judgment of experts, which makes the accuracy of the results highly questionable. In order to tackle the problem, a new methodology is needed. Liang and Wang studied the fuzzy multi-criteria decision making (MCDM) algorithm for personnel selection. Gunor and others developed an analytical hierarchy process (AHP) for personnel selection.

Since fuzzy and intuitionistic fuzzy MCDM problems are widely studied, but indeterminacy should be incorporated in the model formulation of the problems. Indeterminacy plays an important role in the decision-making process. So neutrosophic set, the generalization of intuitionistic fuzzy sets should be incorporated in the decision making process. Neutrosophic set [Smarandache 2005] was introduced to represent the mathematical model of uncertainty, imprecision, and decision making. [Biswas et al. 2014] presented the entropy-based grey relational analysis method for multi-criteria decision making under single-valued neutrosophic assessment. [Biswas et al. 2014] also studied a new methodology to deal with neutrosophic multi-criteria decision-making problems. [Ye 2013] proposed the correlation coefficient of SVNSs for single-valued neutrosophic multi-criteria decision-making problems [Cyplik, 2011, Karaaslan, 2020].

The ranking order of alternatives plays an important role in the decision-making process. In this study, we present a multi-criteria group decision-making approach for giving a tender for the construction with known weights based on the score functions, the accuracy functions, and the hybrid score-accuracy functions proposed by [Ye 2013] under a simplified neutrosophic environment.

The rest of the paper has been divided into different sections. Section 2, is the preliminaries and the definitions. In this section, we procure the definitions and the preliminary results used in this article. Section 3 is on multi-criteria group decision-making methods based on hybrid score-accuracy function. In this section, we discuss the multi-criteria decision-making method in the single-valued neutrosophic environment. Also, we have formulated the algorithm for this. Section 4 deals with the validation of the developed model. In this section we consider an example to verify our model. In section 5 we have talked about the difference and advantage of our model. In section 6 is the conclusion on the work done in this article.

PRELIMINARIES AND DEFINITIONS

Definition 2.1: Let X be a non-empty set. A *neutrosophic set* A in X is characterized by truth-membership function T_A, indeterminacy-membership function I_A and falsity-membership function F_A. $T_A(x)$, $I_A(x)$, $F_A(x)$ are real standard or non-standard subsets of $]^{-}0,1^{+}[$. That is

$T_A: X \to]^{-}0,1^{+}[$

$I_A: X \to]^{-}0,1^{+}[$

$F_A: X \to]^{-}0,1^{+}[$

There is no restriction on the sum of $T_A(x)$, $I_A(x)$ and $F_A(x)$, so

$^{-}0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3^{+}$

Definition 2.2: Let X be a non-empty set. A single valued neutrosophic set (*SVNS*) A in X is characterized by truth-membership function T_A, falsity-membership function F_A and indeterminacy-membership function I_A. For each point x in X, $T_A(x), F_A(x), I_A(x) \in [0,1]$.

A SVNS A can be written as $A=\{(x, T_A(x), I_A(x), F_A(x)): x \in X, T_A(x), I_A(x), F_A(x) \in [0,1]\}$.

Definition 2.3: For a single valued neutrosophic set(*SVNS*) $A=\{(x, T_A(x), I_A(x), F_A(x)): x\in X, T_A(x), I_A(x), F_A(x)\in[0,1]\}$ in X, the triplets $(T_A(x), I_A(x), F_A(x))$ is called single valued neutrosophic number (*SVNN*),which is the fundamental element of a *SVNS A*.

Definition 2.4: The complement of a *SVNS* A is denoted by A^C and defined by

$A^C = \{(x, 1-T_A(x), 1-I_A(x), 1-F_A(x)): x \in X\}$.

Relations between two SVNSs:

1) A *SVNS* A is contained in the other *SVNS* B ($A \subseteq B$) if and only if $T_A(x) \leq T_B(x)$, $I_A(x) \geq I_B(x)$ and $F_A(x) \geq F_B(x)$, for all $x \in X$.
2) Two *SVNS*s A and B are equal ($A=B$) if and only if $A \subseteq B$ and $B \supseteq A$.

Definition 2.5: Let $\alpha = (T(\alpha), I(\alpha), F(\alpha))$ be a *SVNN*. Then the score function and the accuracy function of the *SVNN* α can be represented respectively, as follows:

$$s(\alpha)=(1+T(\alpha)-I(\alpha))/2, \text{ and } s(\alpha) \in [0,1] \quad (1)$$

$$h(\alpha)=(2+T(\alpha)-I(\alpha)-F(\alpha))/3, \text{ and } h(\alpha) \in [0,1] \quad (2)$$

For the score function of a *SVNN* α, if the truth-membership $T(\alpha)$ is bigger and the indeterminacy-membership $I(\alpha)$ are smaller, then the score value of a *SVNN* α is greater. For the accuracy function of a *SVNN* α, if the sum of $T(\alpha)$,$1-F(\alpha)$,$1-I(\alpha)$ is bigger, compared to the other SVNN, then the statement is more affirmative, i.e. the accuracy of the *SVNN* α is higher.

Proposition 2.1: Let a_1, a_2 be two *SVNNs*. Then the ranking method can be defined as follows:

1) If $s(a_1) > s(a_2)$, then $a_1 > a_2$;
2) If $s(a_1) = s(a_2)$, and $h(a_1) \geq h(a_2)$, then $a_1 \geq a_2$.

Operational definitions of the terms stated in the problem:

1. Technical approach: Technical Approach is the method of energy-saving tools that have large significance for a tender worker as well as industrial work. It gives the maximum advantage of the facility of the energy savings potential.
2. Management approach: Management or managerial system of any program is highly important because the quality of the supply and performance of work is handle by the technique of management system which is also beneficial for criteria of quick performance, technical and cost-effectiveness.

3. Quick performance: Quick performance is the main key of any work and the development of the society as well as personal. The good performance of a tender shows the degree of sincerity of the tenderer.
4. Price selection: The Price selection is the most important issue to select tender. The theory of evolution and natural selection of Price equation in such a way that the desire of the tender committee and host will have the optimum solution.
5. Credentials: This is a qualification, achievement, personal quality, or aspect of a person's background, typically when used to indicate that they are suitable for the tender or not.

MULTI-CRITERIA GROUP DECISION-MAKING METHODS BASED ON HYBRID SCORE-ACCURACY FUNCTION

In a multi-criteria group decision-making problem, let $\{A_1,A_2,A_3,\ldots\ldots.A_m\}$ be the set of alternatives and let $\{C_1,C_2,\ldots\ldots C_n\}$ be the set of all criteria. Let the committee of decision-makers assigned the weights of all criteria previously. In such a case, we develop two methods based on the hybrid score-accuracy functions for multiple-criteria group decision-making problems with known weights under single-valued neutrosophic environment and interval neutrosophic environment.

Multi-criteria group decision-making method in single valued neutrosophic environment:

In the group decision process under single valued neutrosophic environment, if a group of t decision makers is required in the evaluation process, then the k^{th} decision maker can provide the evaluation information of the alternatives A_i (i=1,2,….,m) on the criteria C_j (j=1,2,……,n), which is represented by the form of a *SVNS*

$$A_i^k = \{(C_j, T_{A_i}^k(C_j),\ I_{A_i}^k(C_j),\ F_{A_i}^k(C_j)) : C_j \in C\}.$$

Here

$0 \le T_{A_i}^k(Cj) + F_{A_i}^k(Cj) + I_{A_i}^k(Cj) \le 3$, $T_{A_i}^k(C_j)$, $I_{A_i}^k(C_j)$, $F_{A_i}^k(C_j) \in [0,1]$,

for k =1,2,…,t, j=1,2,…..,n, i =1,2,….,m.

For convenience, $(T_{ij}^k, I_{ij}^k, F_{ij}^k)$ is denoted as a *SVNN* in the *SVNS* A_i^k (k=1,2,….,t; i=1,2,…,m; j=1,2,…n). Therefore, we get the k^{th} single valued neutrosophic decision matrix $D^k=\left(A_{ij}^k\right)_{m\times n}$ (k=1,2,…,t).

Then, the group decision making algorithm is as follows

Step 1: Hybrid score-accuracy matrix

The hybrid score-accuracy matrix $Y^k=\left(Y_{ij}^k\right)_{m\times n}$ (k=1,2,….,t; i=1,2,…,m; j=1,2,….,n) is obtained from the decision matrix $D^k = \left(A_{ij}^k\right)_{m\times n}$ by the following formula:

$$Y_{ij}^k = \tfrac{1}{2}(1+T_{ij}^k - I_{ij}^k) + \tfrac{1}{3}(T_{ij}^k + 1 - F_{ij}^k + 1 - I_{ij}^k) \quad (3)$$

Step 2: The average matrix

From the hybrid score-accuracy matrix, the average matrix $Y^A = \left(Y_{ij}^A\right)_{m\times n}$ (k=1,2,….,t; i=1,2,….,m; j=1,2,…n) is calculated by

$$Y_{ij}^A = \frac{1}{t}\sum_{k=1}^{t} Y_{ij}^k \quad (4)$$

The collective correlation coefficient between Y^k (k=1,2,….,t) and Y^A is given as follows:

$$C_k = \sum_{i=1}^{m} \frac{\sum_{j=1}^{n} Y_{ij}^k Y_{ij}^A}{\sqrt{\sum_{j=1}^{n}\left(Y_{ij}^k\right)^2}\sqrt{\sum_{j=1}^{n}\left(Y_{ij}^A\right)^2}} \quad (5)$$

Step3: Decision maker's weights

In decision making problems, the decision makers may have personal biases and some individuals may give unduly high or low preference values with respect to their preferred or repugnant objects. In this case we will assign very low weights to these false or biased opinions. Since the “mean value” is the “distributing centre” of all elements in a set, the average matrix Y^A is the maximum compromise among all individual decisions of the group. It mean sense, a hybrid score-accuracy matrix Y^k is closer to the average matrix Y^A. Then, the preference value (hybrid score-accuracy value) of the k^{th} decision maker is closer to the average value and evaluation is more reasonable and more important, thus the weight of the k^{th} decision maker is bigger. Hence a weight model for decision makers can be defined as:

$$\delta_k = \frac{C_k}{\sum_{k=1}^{t} C_k} \qquad (6)$$

where $0 \le \delta_k \le 1$, $\sum_{k=1}^{t} \delta_k = 1$ for $k=1,2,\ldots,t$.

Step4: Collective hybrid score accuracy matrix

For the weight vector $\delta=(\delta_1, \delta_2, \ldots \delta_k)^T$ of decision makers obtained from equation(6), we accumulate all individual hybrid score-accuracy matrices of $Y^k=\left(Y_{ij}^k\right)_{m\times n}$ $(k=1,2,\ldots,t;$ $i=1,2,\ldots.m;$ $j=1,2,\ldots,n)$ into a collective hybrid score-accuracy matrix $Y=\left(Y_{ij}\right)_{m\times n}$ by the following formula:

$$Y_{ij}=\sum_{k=1}^{t} \delta_k Y_{ij}^k \qquad (7)$$

Step5: Weights for criteria

The Weight of criteria for this model has to be decided by the experts or committee of decision makers according to their requirements which is denoted by w_j (j=number of criteria). The weight of criteria is based on the significance of the importance of the criteria and the total weight is always one.

Step6: Calculate weighted hybrid score-accuracy matrix

From the collective hybrid score-accuracy matrix the weighted score-accuracy matrix

$$Y^W = \left(Y_{ij}^w\right)_{m\times n} (w=1,2,\ldots.,t;\ i=1,2,\ldots.m;\ j=1,2,\ldots,n)$$

is calculated by

$$Y_{ij}^w = w_j Y_{ij} \qquad (8)$$

Step7: Ranking the alternatives

To rank the alternatives, we can sum all values in each row of weighted hybrid score-accuracy matrix and find the overall weighted score-accuracy value of each alternative A_i $(i=1,2,\ldots.,m)$:

$$M(A_i)=\sum_{j=1}^{n} Y_{ij}^w \qquad (10)$$

According to the overall weighted score-accuracy values $M(A_i)$ of each alternatives A_i $(i=1,2,\ldots,m)$ we can rank the alternatives A_i $(i=1,2,\ldots,m)$ in descending order and choose the best alternative.

Step8: End.

VALIDATION OF THE DEVELOPED MODEL

In this section we present an example to validate our developed model.

Example of tender distribution for construction

Suppose that the central government or any state government of our country is going to construct a national highway or any building, then they need to choose the best construction company to build that highway or building for the use of the public. Then the government gives an advertisement in some well-circulated newspaper or the particular website of the government. Some interested construction companies may submit for the tender. After initial screening, four construction companies A_1, A_2, A_3, A_4 remain for further evaluation. A committee of four decision-makers D_1, D_2, D_3, D_4 has been formed to conduct the interview and choose the better construction company. Decision-makers consider five criteria to evaluate the better alternative. The five criteria are namely, technical approach (C_1), management approach (C_2), credentials (C_3), past performance (C_4), price (C_5). If four decision-makers D_q (q=1,2,3,4) are required in the evaluation process, then the five possible alternatives A_i (i=1,2,3,4) are evaluated by the form of SVNNs under the five criteria on fuzzy concept "excellence". Thus the four single-valued neutrosophic decision matrix can be obtained from the four experts and expressed respectively as follows.

Single valued neutrosophic decision matrix for D_1:

D_1	C_1	C_2	C_3	C_4	C_5
A_1	(.8,.2,.2)	(.8,.1,.2)	(.7,.2,.1)	(.8,.3,.1)	(.7,.2,.2)
A_2	(.7,.1,.1)	(.8,.2,.1)	(.6,.3,.2)	(.7,.2,.1)	(.8,.3,.2)
A_3	(.7,.1,.2)	(.8,.3,.2)	(.6,.3,.1)	(.7,.2,.3)	(.8,.2,.2)
A_4	(.7,.2,.3)	(.8,.2,.2)	(.7,.3,.1)	(.7,.1,.2)	(.8,.3,.1)

Single valued neutrosophic decision matrix for D_2:

D_2	C_1	C_2	C_3	C_4	C_5
A_1	(.7,.2,.2)	(.8,.2,.1)	(.8,.3,.2)	(.7,.2,.2)	(.8,.2,.3)
A_2	(.7,.1,.2)	(.8,.2,.2)	(.8,.1,.2)	(.8,.2,.1)	(.8,.3,.2)
A_3	(.8,.2,.1)	(.7,.3,.1)	(.8,.3,.2)	(.7,.2,.1)	(.7,.3,.2)
A_4	(.8,.1,.1)	(.7,.2,.2)	(.7,.2,.2)	(.7,.1,.2)	(.7,.2,.1)

Single valued neutrosophic decision matrix for D_3:

D_3	C_1	C_2	C_3	C_4	C_5
A_1	(.8,.2,.2)	(.7,.2,.1)	(.8,.3,.2)	(.7,.3,.2)	(.8,.2,.2)
A_2	(.7,.2,.2)	(.7,.1,.2)	(.7,.2,.2)	(.8,.2,.3)	(.8,.2,.1)
A_3	(.8,.3,.2)	(.8,.3,.2)	(.7,.1,.2)	(.8,.3,.4)	(.7,.3,.1)
A_4	(.7,.3,.2)	(.7,.2,.3)	(.7,.2,.2)	(.7,.2,.1)	(.8,.2,.2)

Single valued neutrosophic decision matrix for D_4:

D_4	C_1	C_2	C_3	C_4	C_5
A_1	(.7,.3,.2)	(.7,.2,.1)	(.8,.1,.2)	(.8,.3,.1)	(.7,.3,.2)
A_2	(.6,.3,.2)	(.8,.2,.1)	(.8,.3,.2)	(.8,.2,.3)	(.7,.3,.2)
A_3	(.7,.2,.1)	(.8,.3,.2)	(.7,.2,.1)	(.8,.2,.1)	(.8,.2,.1)
A_4	(.7,.2,.2)	(.8,.3,.3)	(.8,.1,.1)	(.7,.4,.3)	(.8,.1,.1)

From the above four single valued neutrosophic decision matrix, the following hybrid score- accuracy matrix are obtained by using eq (3).

Hybrid score-accuracy matrix for D_1:

Y_1	C_1	C_2	C_3	C_4	C_5
A_1	1.6	1.6833	1.55	1.55	1.5167
A_2	1.6333	1.6333	1.35	1.55	1.5167
A_3	1.6	1.5167	1.3833	1.4833	1.6
A_4	1.4833	1.6	1.4667	1.6	1.55

Hybrid score-accuracy matrix for D_2:

Y_2	C_1	C_2	C_3	C_4	C_5
A_1	1.5167	1.6333	1.5167	1.5167	1.5667
A_2	1.6	1.6	1.6834	1.6333	1.5167
A_3	1.6333	1.4667	1.5167	1.55	1.4333
A_4	1.7167	1.5167	1.5167	1.6	1.55

Hybrid score-accuracy matrix for D_3:

Y_3	C_1	C_2	C_3	C_4	C_5
A_1	1.6	1.55	1.5167	1.4333	1.6
A_2	1.5167	1.6	1.5167	1.5667	1.6333
A_3	1.5167	1.5167	1.6	1.45	1.55
A_4	1.4333	1.4833	1.5167	1.55	1.6

Hybrid score-accuracy matrix for D_4:

Y_4	C_1	C_2	C_3	C_4	C_5
A_1	1.4333	1.55	1.6833	1.55	1.4333
A_2	1.35	1.6333	1.5167	1.5667	1.4333
A_3	1.55	1.5167	1.55	1.6333	1.6333
A_4	1.5167	1.4833	1.7167	1.3167	1.7167

Now we find the average matrix Y^A, from the above four hybrid score-accuracy matrix Y_1, Y_2, Y_3, Y_4 by using the equation (4).

The average matrix Y^A:

Y^A	C_1	C_2	C_3	C_4	C_5
A_1	1.5375	1.6042	1.5667	1.5125	1.5292
A_2	1.525	1.6166	1.5167	1.5791	1.5250
A_3	1.575	1.5042	1.5125	1.5292	1.5541
A_4	1.5375	1.5208	1.5542	1.5167	1.6042

Now we determine the weights of the four decision makers, by using the eq (5) and eq (6) as follows:

$\delta_1 = 0.2498$, $\delta_2 = 0.2508$,
$\delta_3 = 0.2497$, $\delta_4 = 0.2497$

Therefore, by using the eq (7) the hybrid score-accuracy values of the four decision makers' evaluations are aggregated and the following collective hybrid score-accuracy matrix can be obtained as follows:

Y	C_1	C_2	C_3	C_4	C_5
A_1	1.5375	1.6042	1.5666	1.5125	1.5292
A_2	1.5251	1.6166	1.5169	1.5792	1.5250
A_3	1.5751	1.5045	1.5125	1.5292	1.5540
A_4	1.5377	1.5208	1.5542	1.5168	1.6041

Now for this multi-criteria decision making problem we assume the weights for the given criteria. We take the weight vector of the attributes as:

$W=[0.30, 0.25, 0.05, 0.15, 0.25]^T$

By using equation (8) we find the weighted hybrid score-accuracy matrix Y^W as follows

Y^W	C_1	C_2	C_3	C_4	C_5
A_1	0.46125	0.40105	0.07833	0.226875	0.3823
A_2	0.45753	0.40415	0.075845	0.23688	0.38125
A_3	0.47253	0.376125	0.075625	0.22938	0.3885
A_4	0.46131	0.3802	0.07771	0.22752	0.401025

Now we can calculate the overall weighted hybrid score-accuracy values $M(A_i)$ for each alternatives A_i, i=1, 2, 3, 4 by using the equation (10):

$M(A_1)= 1.549805$, $M(A_2)= 1.555655$, $M(A_3)= 1.54216$, $M(A_4)= 1.547765$

According to the values of $M(A_i)$, i=1, 2, 3, 4, the ranking order of the alternatives A_i , i=1, 2, 3, 4, is $A_2 > A_1 > A_4 > A_3$. Hence the alternative A_2 is the best choice to give the tender for construction.

DIFFERENCE AND ADVANTAGES OF THE DEVELOPED MODEL

In 2014, Mondal and Pramanik introduced a multi-criteria group decision-making algorithm for teacher recruitment in higher education under a simplified neutrosophic environment. In that algorithm, they used hybrid score-accuracy function, where the score function depends on the truth-membership and falsity-membership values. Again they used completely unknown weights for each criterion in the algorithm. However, for our model, we use a new score function which depends on truth and indeterminacy membership values. By using the proposed score function we get a more accurate score value for a single-valued neutrosophic number. Again we have used the completely known weights for each criterion, which is important for any decision-making problem.

In our paper, we have taken neutrosophic indeterminacy function which is very unique and interesting for the decision if the value of indeterminacy membership in score function is very less then the truth membership value then the decision will more accurate.

CONCLUSIONS

In this paper, we used some suitable criteria for decision making to a better choice of a tender among the available tenders and we use function namely score function, accuracy function and hybrid score-accuracy function of SVNNs to select the better construction company to give the tender for construction under the neutrosophic environment, where the weights of the decision-makers are completely unknown and the weights of the criteria are completely known. This method can be used for group decision making with single-valued neutrosophic information is provide simple calculations and good flexibility but also handled with the group decision-making problems with known weights by comparisons with other relative decision-making methods under single-valued neutrosophic environments.

We have established a formula for making a decision. The data used in this paper has not taken from any source. We have considered these numbers for the verification of our algorithm. However, this algorithm can apply for any real source data.

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MODEL WIELOKRYTERIALNEGO GRUPOWANEGO PODEJMOWANIA DECYZJI PRZY ZASTOSOWANIU JEDNOWARTOŚCIOWYM UKŁADZIE NEUTROSOFICZNYM

STRESZCZENIE. **Wstęp:** W pracy przybliżono kilka rodzajów podejmowania decyzji w układzie neutrosoficznym. Celem pracy jest opracowanie modelu neutrosoficznego wielokryterialnego podejmowania decyzji (MCGDM) w oparciu o funkcje hybrydowej akuratności dla akceptacji ofert w uproszczonym neutrosoficznym środowisku. Wybrano pięć kryteriów na podstawie opinii ekspertów, które były użyte w trakcie budowania oferty. W trakcie badań zostały użyte funkcje oceny, akuratności, hybrydowe dla pojedynczych wartości neutrosoficznych (SVNNs) oraz metoda rankingu dla SVNNs. Służyły one jako wspomaganie do podejmowania decyzji.
Metody: Podejmowanie decyzji w niepewnym środowisku jest istotnym czynnikiem współcześnie. W tym celu opracowano wielokryterialny model podejmowania decyzji przy zastosowaniu jednowartościowego układu neutrosoficznego.
Wyniki: Opracowano algorytm podejmowania decyzji wyboru kontrahenta budowlanego dla zleceń rządowych.
Wnioski: Opracowany algorytm został przetestowany na przykładzie. W analizie uwzględniono pięć kryteriów, niemniej jednak opracowany algorytm może być użyty do wielokryterialnego podejmowania decyzji.

Słowa kluczowe: układ neutrosoficzny, nieokreśloność, układ rozmyty, podejmowanie decyzji

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