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DESIGNING OF NETWORK FOR THE DISMANTLING CENTERS OF THE END-OF-LIFE VEHICLES BY FUZZY ABC METHOD

Abstract: *In this paper, the ABC classification of possible locations for ELV dismantling centers in the presence of uncertainties is considered. The proposed ABC classification algorithm is based on Pareto analysis. The uncertain criteria values are described by linguistic expressions specified by waste management. They are modelled using fuzzy sets.*
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1. INTRODUCTION

Determining dismantling order of ELV in dismantling center is one of ELV waste management problems. The considered problem is not a straight forward task. Many aspects, such as environmental features, social impact assessment, cost considerations, etc. must be accounted for, in order to point to an adequate management of recycling processes.

Designing of network of dismantling centers can be stated as multi-attribute decision making. In the other words, the set of possible locations described by numerical values is defined first. In the second, each possible location is evaluated according to all attributes. Finally locations will be ranked according to aggregated marks.

In practice, one of the most widely used techniques for classification of different items is the ABC method which is based on Pareto analysis. This method is very easy for understanding and use. In classical ABC method, items are divided into three categories A, B, and C, according to one crisp criterion. Selection of the classification criterion depends on the kind of the problem being considered and in the first place it is based on estimation of the management. Typically items of group A represent 5 to10 percent in terms of quantity and 90 to 95 percent in terms of the value. Items of group B reperent 10 to 15 percent in terms of quantity and 85 to 90 percent in terms of the value. These items have average important for management. All other considered items belong to group C and they relatively unimportant.

The traditional ABC method may not be able or appropriate to provide a good classification of items in practice [1]. However, if one wishes to make the classification more realistic, we need to use more criteria and imprecise data. The classification problem besomes a multi-citeria classification problem under uncertainties that has been studied by some researchers in the past.

Uncertainty of data or information that are used for definition of criteria values can be described by using the fuzzy set theory ([2],[3]). Fuzzy logic enables us to emulate the human reasoning process and make a decision based on vague or imprecise data [4].

The fuzzy set theory resembles human

reasoning in its use of approximate information and uncertainty to generate decisions. We can come to a conclusion that the fuzzy approach in treating uncertainties in real-world applications has numerous advantages when compared to other approaches.

In the literature, there are certain number of papers in which fuzzy multi-criteria ABC methods were developed for classification of different items under uncertain environments. A brief literary review of papers dealing with classification of inventory items by fuzzy ABC is given later in the paper. In [5] the new fuzzy ABC model was developed for classification of items according to their importance in terms of frequency and costs. Values of treated criteria are uncertain and they are described by triangular fuzzy numbers. Classification criterion is defined as product of both considered criteria. In [6] items are evaluated according to three criteria: unit price, demand and quality which are modeled with continuous fuzzy numbers that have different shapes of membership functions. Also, the relative criteria weights of are, and they are defined the pair wise comparison matrix according to conventional AHP method. The classification criterion is calculated as sum of these considered criteria with respect to their relative importance. Ramanathan, [7] developed the model which was based on weighted linear optimization. The proposed model is applied for the each considered item. The aim function is used to aggregate the performance of an item in terms of different criteria to a single score. Every constraint from the constraint set is defined as the product of weight and value of criterion, and must be less than or equal to one. Number of constraints are equal to number of criteria. The model uses a maximization objective function to get the optimal scores. These scores can then be used to classify the items. In [8] criteria for determination of elements and group of elements of considered systems are unit price, flexibility and demand. Values of considered criteria can be crisp or uncertain. It was assumed that weights of criteria are different and are defined by the matrix of pairs for comparison of relative relation of criteria importance. The matrix elements values are uncertain. The all uncertainties are described by fuzzy numbers. Criteria values are normalized according to criteria type by applying simple normalization. Weighted normalized criteria values are aggregated in unique criteria function according to which the classification of considered elements and group elements of equipment is performed. In [9] attributes for evaluation of considered items can be independent (with values being either nominal or non-nominal) and dependent which values are nominal. The authors generate in various ways the membership functions of independent nominal and independent non-nominal attributes. For the each item "grade of membership" is calculated, in the each class of dependent attributes. Authors defined the fuzzy classification rule for inventory items.

This paper is organized in the following way: in Section 2 the problem statement is given, in Section 3 modeling of uncertainties are presented, in Section 3 a new fuzzy ABC ABC model is developed and conclusions are presented in Section 4.

2. PROBLEM STATEMENT

2.1 Basic assumptions

ABC classification of possible locations for ELV dismantling centers is based on the following assumptions:

-Each possible location is characterized by ABC classification criteria: (1) age of vehicle, (2) the need for spare parts, (3) possession of special tools for dismantling of ELVs, (4) condition of cars, (5)

income/unit ELV, and (6) the level of pollution of water and soil by the ELV.
-Classification criteria values of possible location are given by linguistic expressions, specified by waste management.
-Linguistic expressions are modeled by triangular fuzzy numbers.
-Relative importance of considered criteria are given by a linguistic expressions.

3. MODELING OF UNCERTAINTIES

In this Section, the modeling procedure of uncertainties that exist in the developed model, is described.

3.1 Modeling of criteria values

In this paper, the developed procedure of modeling the uncertain criteria values of the each considered possible location is presented.

On the basis of evidence data of the considered possible locations can be calculated for the each quarter separately. Calculated values belong to the set of real numbers, and can be significantly different. Authors developed the new approach in modeling of the uncertain values of considered criteria which is based on data obtained over a period in the past.

Criteria values described with real number values are transformed into the set of linguistic expressions according to experience of the waste management. Number of the linguistic expressions is determined by the waste management. After that, all calculated values are normalized through the simple normalization procedure [10], on the (0,1] real number interval.

In this paper we use the ten linguistic expression: *very low value, low value, medium value, high value,* and *very high value.* The meaning of these expressions is specified by triangular fuzzy numbers in the interval (0,1] [2]; 0 denoting the lowest value and 1 denoting the highest value.

Triangular fuzzy numbers describing the achieved values of considered criteria are defined in the following way:

very low value	$(x; 0, 0, 0.2)$
low value	$(x; 0, 0.2, 0.4)$
medium value	$(x; 0.3, 0.5, 0.7)$
high value	$(x; 0.6, 0.8, 1)$
very high value	$(x; 0.8, 1, 1)$

3.2 Modeling of criteria importance

In this paper, it is assumed that the relative importance of each optimization criteria (k, $k' \in K$) is defined by three linguistic descriptors: *less important*, *important*, and *very important* which is modeled by triangular fuzzy numbers. The domain of each triangular fuzzy numbers is an integer which belongs to the interval [1,9]. The scale $\{1,\ldots,9\}$ is defined in the prototype Saaty scale measurement [9]. Value 1 defines that relative importance of criteria k is the lowest and 9 the highest. The memberships of these triangular fuzzy numbers are given by the subjective judgment of waste management.

In this paper, each triangular fuzzy number is given:

less important	$(x; 1, 1, 9)$
important	$(x; 1, 5, 9)$
very important	$(x; 1, 9, 9)$

Calculation of the optimization criteria weight vector is based on the method of comparison of fuzzy numbers ([11], [12]).

4. A NEW FUZZY ABC MODEL

In considered research domain, designing of network of ELV dismantling centers has both environmental and economical significance. From classification results the ways for determination of network of ELV dismantling centers.

Possible locations are indexed here by i=1,..,I. Waste management claim it to be clear that defined six criteria have the most important for designing of network.

Criteria values will be described by triangular fuzzy number $\tilde{v}_{ik} = (x; l_{ik}, m_i k, u_{ik})$, with the lower and upper bounds $l_i k, u_i k$ and a modal value $m_i k$, respectively. These values belong to the interval (0-1], with the value of 0 means that the value is very low value of 1 means that the value is very high. $l_{ik}, m_{ik}, \text{and} \, u_i k$ values are determined by the waste management. Values in the domain of the each fuzzy number which describes the criteria values i, i=1,..,I are obtained from the evidence data and estimation of the waste management. From the evidence data maximum value of each criterion value $i', i' = 1,..,I$ which is designated as v^{max} is determined. Criterion value of possible location i, $v_{ik}, i = 1,..,I; k = 1,..,K$ is divided by the v_k^{max} and mapped into interval from 0 to 1. According to defined triangular fuzzy numbers $\tilde{v}_{ik} = (x; l_i k, m_{ik}, u_{ik})$ and calculated values $\frac{v_{ik}}{v_k^{max}}$, the waste management joins the appropriate linguistic statement to the each possible location. In practice, oftenly possible location i, i=1,..,I could be accompanied with two, or thee linguistic expressions. In these cases, possible location i, i=1,.,I is accompanied with linguistic expression, e.g. triangle fuzzy number with the highest value of membership function for calculated normalized criterion value.

The algorithm of the proposed method is realized in the following steps.

Step 1. Calculation of weight vector of considered criteria by applying procedure which is presented in Section 3.2

Step 2. Calculation of criterion values by using procedure which is defined in Section 3.1.

Step 3. Normalization of cost-type criterion values:

$$\tilde{r}_{ik} = \left(\frac{l^{min}}{u_{ik}}, \frac{l^{min}}{m_{ik}}, \frac{l^{min}}{l_{ik}} \right)$$

Where:

$$l^{min} = \min_{i=1,\dots,k} l_{ik}$$

Step 4. Calculating of aggregated account of each possible location i, i=1,..,I:

$$\tilde{F}_i = \sum_{k=1}^{K} w_k \cdot \left(\tilde{v}_{ik} + \tilde{r}_{ik} \right)$$

Step 5. Calculating of scalar values of $\tilde{F}_i$:

$$F_i = \text{defuzz}\, \tilde{F}_i$$

Step 6. Ranking of possible locations according to $F_i, i = 1,..,I$. On the first place is location with highest value $F_i, i = 1,..,I$. On the last place is location with the lowest value $F_i, i = 1,..,I$.

Step 7. Calculating the relative and cumulative value of account of each location.

Step 8. On 80% of cumulative value of aggregated account are location for ELV dismantling centers.

5. CONCLUSION

In this paper, a new fuzzy multi-criteria ABC classification of possible locations is proposed. This is considered to be an important step in determining optimal network for ELV dismantling centers. Based on the consultation with the waste management, six criteria are identified to be the most relevant for location classification. These criteria values are described by linguistic terms which are modelled using fuzzy sets. The corresponding membership functions are determined based on the experience of the waste management. The developed ABC classification algorithm can handle criteria of different importance. The algorithm is flexible in the sense that it can be easily modified to include more than six criteria on which the criteria classification is to be based.

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