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Decision support system using Dhouib-Matrix-TP1 heuristic for pentagonal fuzzy transportation problem

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ABSTRACT

In this paper, a decision support system (DSS) is provided to assist the decision-maker in obtaining the best solution for the transportation problem under uncertainty. Fuzzy parameters of the transportation problem are presented by pentagonal fuzzy numbers. The centroid ranking function transforms these pentagonal fuzzy numbers into crisp ones. Then, a novel, improved greedy method named Dhouib-Matrix-TP1 (DM-TP1) is used in order to help the decision-maker promptly find a suitable solution. Specifically, this DSS is composed of three components: the data base component considers a pentagonal fuzzy number; the Model Base component thinks through the original heuristic DM-TP1; and the User Interface component deliberates the convivial graphical output of the generated transportation plan solution using the Python programming language. Experiments in the literature on fuzzy transportation problems show that the novel proposed heuristic, DM-TP1, is easy to understand and allows the decision-maker to handle transportation problems under pentagonal fuzzy numbers. Also, the DM-TP1 is robust and can be applied to find a feasible initial solution in less time.

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1. INTRODUCTION

The transportation problem (TP) is one of the most important types of optimization problems. The main objective of this problem is to determine the minimal total transportation cost where supply and demand limits are satisfied. Numerous real-world applications, including inventory control, plan location, scheduling, investment, and production, utilize the TP. In uncertain circumstances, the demand and supply quantities, as well as the cost coefficients, are represented using fuzzy numbers. In these cases, we encounter the fuzzy transportation problem (FTP), where we consider fuzzy parameters such as triangular, trapezoidal, pentagonal, and hexagonal numbers. Then, the FTP will be solved by several methods, such as Vogel's approximation method (VAM), the North-West corner method (NWCR), the modified distribution method (MODI), and the least cost method (LCM).

The Pentagonal fuzzy transportation problem (PFTP) is one of the best-known existing methods to deal with fuzzy parameters of TP. The transportation demands, supplies, and costs have been analyzed in this research using Pentagonal Fuzzy Numbers (PFNs). The centroid ranking function converts these PFNs into crisp ones. A new constructive heuristic, known as Dhouib-Matix-TP1 (DM-TP1). The decision-maker receives a graphic representation of the generated transportation plan. In particular, we developed a new decision support system (DSS) to assist the decision-maker.

In fact, to help and improve decision-making, a wide variety of DSS applications have been developed in many fields since the early 1970s. The DSS is generally referred to as an interactive tool that aids decision-makers in resolving both organized and unstructured problems. A study of DSS applications that were published from 1971 until April 1988 is conducted in [1]. A review of DSS published between May 1988 and December 1994 that was conducted later in 1998 by [2]. For the survey concerning the period from 1995 until 2001, a detailed description is depicted in [3]. According to these surveys, the application areas of DSS are multiple, such as:
- Accounting/auditing [4]–[7], finance [8]–[10],
- Marketing/transportation/logistics [11]–[13],
- Production and operations management [14]–[17],
- Agriculture [18]–[21], education [22]–[25],
- Hospital/healthcare [26]–[28],
- Government [29]–[32],
- Natural resources [33]–[36].

In this paper, a DSS using the Dhouib-Matrix-TP1 is proposed to help the decision-maker solve PFTP. Figure 1 presents the proposed DSS, which consists of three components:
- The information presented in data base component are presented as PFN,
- The Model Base is enhanced by the novel DM-TP1,
- The Python programming language is used to create the User Interface, which outputs a graphical depiction of the solution that has been generated.

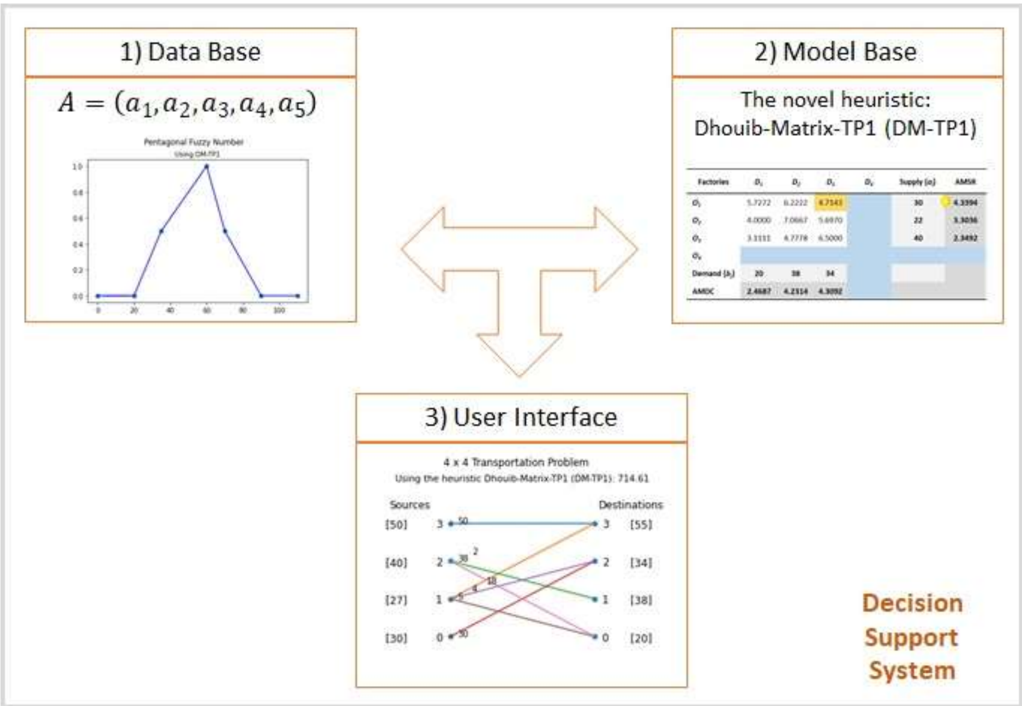


Figure 1. The three components of the proposed DSS for the PFTP

Moreover, the DM-TP1 heuristic is simple, and it ensures a high-quality solution in a few iterations for any real-life FTP. Furthermore, this research primarily contributes to the following areas:
- Design a new decision support system.
- Support managers in their decision-making activities.
- Consider the Decision-maker preferences as PFNs.
- Facilitate the decision processes in PFTP.
- Solve speedily any real-life FTP.

To illustrate the proposed DSS using the Dhouib-Matrix-TP1 method, three numerical examples are unraveled and compared to other techniques from the literature. Meanwhile, the proposed heuristic, DM-TP1, is very simple to apply to real-life FTP thanks to its graphical representation. The results prove clearly that the novel DM-TP1 heuristic is a promising approach to finding a feasible initial solution for PFTP. The rest of this manuscript is structured as follows: section 2 outlines certain preliminary concepts of fuzzy numbers and some basic notions of PFN. Section 3 explains the fuzzy transportation problem and reviews the background of FTP. The suggested heuristic (Dhouib-Matrix-TP1) is thoroughly explained in Section 4. Section 5 illustrates the proposed heuristic with three numerical examples. Section 6 concludes by discussing the findings and future work.

2. THE FUZZY CONCEPTS

This section describes many definitions of fuzzy numbers. Also, some concepts related to pentagonal fuzzy numbers are illustrated. In general, a fuzzy set is introduced by [37] as follows: A fuzzy set A in X is characterized by a membership function or grade of membership $\mu_A(x)$. $A = \{(x, \mu_A(x) | x \epsilon X)\}$ with $\mu_A(x): X \rightarrow [0,1]$.

2.1. Fuzzy set

A fuzzy set A is defined on universal set of real number R, is said to be fuzzy number if its membership function has the following properties [38], [39]:
- A must be normal and convex fuzzy set.
- The support of A, must be bounded.
- There exist at least one $x \epsilon R$ with $\mu_A(x) = 1$.
- $\mu_A(x)$ is piecewise continuous.

2.2. Pentagonal Fuzzy number

A fuzzy number $A = (a_1, a_2, a_3, a_4, a_5)$ is called PFN [40], [41] if its membership function is as follows Figure 2.

$$\mu_A(x) = \begin{cases} 0, & for\ x < a_1 \\ \left(\frac{x-a_1}{a_2-a_1}\right), & for\ a_1 \leq x \leq a_2 \\ \left(\frac{x-a_2}{a_3-a_2}\right), & for\ a_2 \leq x \leq a_3 \\ 1, & for\ x = a_3 \\ \left(\frac{a_4-x}{a_4-a_3}\right), & for\ a_3 \leq x \leq a_4 \\ \left(\frac{a_5-x}{a_5-a_4}\right), & for\ a_4 \leq x \leq a_5 \\ 0, & for\ x > a_5 \end{cases} \quad (1)$$

Here, a_3 is the middle point and $(a_1,\ a_2)$ and $(a_4,\ a_5)$ are the left and right-side point of a_3 respectively. The middle point a_3 has the grade of membership 1.

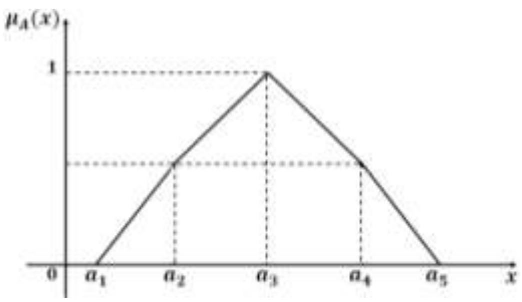


Figure 2. Graphical representation of linear pentagonal fuzzy number with symmetry

A generalized PFN $A = (a_1, a_2, a_3, a_4, a_5)$ has the following membership function:

$$\mu_A(x;w_1;w_2) = \begin{cases} 0, & for\ x < a_1 \\ w_1\left(\frac{x-a_1}{a_2-a_1}\right), & for\ a_1 \le x \le a_2 \\ 1-(1-w_1)\left(\frac{x-a_2}{a_3-a_2}\right), & for\ a_2 \le x \le a_3 \\ 1, & for\ x = a_3 \\ 1-(1-w_2)\left(\frac{a_4-x}{a_4-a_3}\right), & for\ a_3 \le x \le a_4 \\ w_2\left(\frac{a_5-x}{a_5-a_4}\right), & for\ a_4 \le x \le a_5 \\ 0, & for\ x > a_5 \end{cases} \quad (2)$$

Here w_1 and w_2 are the grades of points a_2 and a_4.
The ranking function proposed by [39] is used to convert the PFNs to crisp numbers which is presented by 3:

$$R(\tilde{a}) = \left(\frac{a_5^2+a_4^2+a_5a_4-a_1^2-a_2^2-a_1a_2}{3\times(a_5+a_4-a_1-a_2)}\right) \quad (3)$$

3. THE FUZZY TRANSPORTATION PROBLEMS

The main objective of the transportation problem is to reduce the total cost of moving objects from sources to destinations. In general, the transportation demand, supply and cost quantities are assumed be known exactly. But, in real problems, the decision-makers have no crisp information about theses parameters. Then, the problem can be formulated using FTP. The formulation of this problem is presented in the following way:

$$minimize\ \tilde{Z} = \sum_{i=1}^{m}\sum_{j=1}^{n}\tilde{c}_{ij}\tilde{x}_{ij} \quad (4)$$

$$s.t. \sum_{j=1}^{n}\tilde{x}_{ij} \approx \tilde{a}_i, i = 1,2,\cdots,m,$$

$$\sum_{i=1}^{m}\tilde{x}_{ij} \approx \tilde{b}_j,\ \ j = 1,2,\cdots,n,$$

$$\sum_{i=1}^{m}\tilde{a}_i \approx \sum_{j=1}^{n}\tilde{b}_j$$

$$\tilde{x}_{ij} \ge \tilde{0}, \qquad i = 1,2,\cdots,m, j = 1,2,\cdots,n.$$

where:
$\tilde{a}_i$: the total fuzzy supply of the commodity at the ith source
$\tilde{b}_j$: the total fuzzy demand for the commodity at the jth destination.
$\tilde{c}_{ij}$: the fuzzy transportation cost for a unit quantity of the commodity from the ith source to the jth destination.
$\tilde{x}_{ij}$: the quantity that should be transported form the ith source to the jth destination of fuzzy decision variables.
If $\sum_{i=1}^{m}\tilde{a}_i = \sum_{j=1}^{n}\tilde{b}_j$, then the FTP is known as balanced FTP, otherwise it is unbalanced FTP.

The basic TP was first advanced in [42], a fuzzy linear programming is devised in [43] and the TP with fuzzy constraints is solved in [44]. After that, several authors have revealed an investigation about FTP such as [45]–[61]. In these research, fuzzy parameters of TP (the demands, the supplies, and the costs) are embodied as triangular, trapezoidal, pentagonal, and hexagonal fuzzy numbers. In this paper we focus on FTP with PFN where little researchers are carried out investigations on this field: The first application is proposed in 2016 by [62] using the Accuracy function to convert demand, supply and cost to crisp values and the optimal solution is obtained by the VAM Method. The fully FTP is solved without any conversion in [63]. In 2019, the allocation table method (ATM) is applied to solve the PFTP in [64]. The optimal solution is found using the new proposed method and the extended MODI method. Next, the crisp TP is converted into the FTP by the means of different types of fuzzy numbers in [65].

Recently, a new ranking technique to transform a PFTP into a crisp one was introduced in [39]. Then, the proposed algorithm is used to uncover the fuzzy, realistic solution. In the same year, a new ranking algorithm to solve FTP with generalized PFNs and generalized HFNs was proposed in [66]. The proposed algorithm is based on the Centroid ranking technique. Moreover, an algorithm to optimize the full FTP in the pentagonal and hexagonal fuzzy domains is proposed in [67]. In 2022, this work will be extended to solve triangular, trapezoidal, decagonal, hendecagonal, and dodecagonal fuzzy numbers in the same way as in [68], [69] used the IQR to rank PFN. Also, they presented a new algorithm to obtain the least value for the optimum solution. Martin [70], Mari's algorithm is proposed to find the best solution for FTP. The author used only the Hungarian algorithm and, on rare occasions, Vogel's algorithm with MODI algorithms. Also, Vidhya and Ganesan [71] solved the PFTP without requiring an initial feasible solution. The extended MODI method and the core and spread method are serve as the foundation for the proposed method. More recently, a new ranking technique based on the centroid concept was proposed in [72]. In this paper, a new method to find an initial, basic, and feasible solution is also introduced.

4. THE NEW GREEDY METHOD FOR THE PENTAGONAL FUZZY TRANSPORTATION PROBLEM: DHOUIB-MATRIX-TP1

In this section, we will describe the novel greedy method Dhouib-Matrix-TP1 (DM-TP1) exploited to generate rapidly a suitable feasible solution for the PFTP. DM-TP1 was first invented in order to unravel the TP in the neutrosophic domain [73] and in the trapezoidal fuzzy area [74]. Actually, the DM-TP1 heuristic is one component of the Dhouib-Matrix (DM) concept, in which different heuristics and metaheuristics are invented. For the traveling salesman problem (TSP), the greedy heuristic Dhouib-Matrix-TSP1 is introduced in [75]–[80]. Concerning the assignment problem, the constructive heuristics Dhouib-Matrix-AP1 and Dhouib-Matrix-AP2 are introduced in [81]–[84]. Moreover, two novel approximation methods (the Dhouib-Matrix-3 and the Dhouib-Matrix-4) were invented in [85]–[93]. Furthermore, a new optimal method, Dhouib-Matrix-SPP, is designed for the shortest path problem in [94] and confirmed as the fastest artificial method for the autonomous mobile robot path planning problem in [95]. Besides, an original method, Dhouib-Matrix-MSTP, is conceived for the Minimum Spanning Tree Problem in [96].

DM-TP1 is a column-row method based on statistical metric functions, and in this paper, we will enhance DM-TP1 with a novel metric ratio: $(Max - 3 \times Standard\ Deviation)$. The first step starts with the defuzzification of the PFN, as in [39] and presented by (1). Then, the DM-TSP1 method is used to unravel the TP. This new greedy method, Dhouib-Matrix-TP1, is composed of nine steps, as depicted in Figure 3. Obviously, the DM-TP1 will execute step 1, step 2, step 3, step 4, and step 9 only once and will iterate step 5, step 6, step 7, and step 8 (iterations) 8 $(n + m)$ iterations. Thus, DM-TP1 is a very rapid method, and we will test its performance in the next section with a stepwise application.

Figure 3. The nine steps of the DM-TP1

5. NUMERICAL EXAMPLES

5.1. Example 1

Through this first numerical example [39], the proposed approach is explained in detail. Figure 4 depicts the original pentagonal fuzzy matrix of TP. (1) of the Ranking Technique is used to transform PFNs into crisp ones. (matrix presented in Figure 5). Next, compute each element of the advanced microwave scanning radiometer (AMSR) column and the average min demand column (AMDC) row using ($Max - 3 \times Standard\ Deviation$) as explained in step 3 and 4. After that, select the highest value (4.8678 which corresponds to column 4). Thus, at column four, select the smallest element equal to 5.1667 as explained in step 5 as shown in Figure 6. Hence, allocate the smallest value between supply and demand (50) and discard row 4 step 6 or 7 as shown in Figure 7. Next, calculate the elements of AMSR and the elements of AMDC, choose the maximal value (5.5650) and select its corresponding smallest element (6.4286).

Factories	D_1	D_2	D_3	D_4	Supply (a_i)
O_1	(2,4,6,8,9)	(3,5,7,8,9)	(2,4,5,6,7)	(3,4,6,7,12)	30
O_2	(0,2,5,6,8)	(4,5,6,8,11)	(2,3,5,7,11)	(1,5,6,9,11)	27
O_3	(1,2,3,4,5)	(2,3,4,6,8)	(4,5,6,8,9)	(6,7,8,9,13)	40
O_4	(3,5,6,7,8)	(1,5,6,7,8)	(2,7,8,9,10)	(3,3,4,5,9)	50
Demand (b_j)	20	38	34	55	

Figure 4. The pentagonal FTP matrix

Factories	D_1	D_2	D_3	D_4	Supply (a_i)
O_1	5.7272	6.2222	4.7143	6.6667	30
O_2	4.0000	7.0667	5.6970	6.4286	27
O_3	3.1111	4.7778	6.5000	8.8889	40
O_4	5.7143	5.1111	6.8000	5.1667	50
Demand (b_j)	20	38	34	55	

Figure 5. The crisp TP matrix

Factories	D_1	D_2	D_3	D_4	Supply (a_i)	AMSR
O_1	5.7272	6.2222	4.7143	6.6667	30	4.4882
O_2	4.0000	7.0667	5.6970	6.4286	27	3.6296
O_3	3.1111	4.7778	6.5000	8.8889	40	2.4712
O_4	5.7143	5.1111	6.8000	5.1667	50	4.7645
Demand (b_j)	20	38	34	55		
AMDC	2.3452	4.3409	4.3748	4.8678		

Figure 6. Select the element d_{44}

Factories	D_1	D_2	D_3	D_4	Supply (a_i)	AMSR
O_1	5.7272	6.2222	4.7143	6.6667	30	4.4882
O_2	4.0000	7.0667	5.6970	6.4286	27	3.6296
O_3	3.1111	4.7778	6.5000	8.8889	40	2.4712
O_4						
Demand (b_j)	20	38	34	5		
AMDC	2.4687	4.2314	4.3092	5.5650		

Figure 7. Select the element d_{24}

Now, assign the smallest value (5) and discard column 4 as shown in Figure 8. Next, calculate the elements of AMSR and the elements of AMDC, choose the maximal value (4.3394) and select its corresponding smallest element (4.7143). Next, affect the smallest value (30) and discard row 1 as shown in Figure 9. Next, calculate the elements of AMSR and the elements of AMDC, choose the maximal value (5.2955) and select its corresponding smallest element (5.6970). The process is repeated, all columns are discarded, and DM-TP1 computes the total cost as shown in Figure 10. Figure 11 illustrates the graphical representation of the transportation plan obtained by DM-TP1.

Factories	D_1	D_2	D_3	D_4	Supply (a_i)	AMSR
O_1	5.7272	6.2222	4.7143		30	4.3394
O_2	4.0000	7.0667	5.6970		22	3.3036
O_3	3.1111	4.7778	6.5000		40	2.3492
O_4						
Demand (b_j)	20	38	34			
AMDC	2.4687	4.2314	4.3092			

Figure 8. Select the element d_{13}

Factories	D_1	D_2	D_3	D_4	Supply (a_i)	AMSR
O_1						
O_2	4.0000	7.0667	5.6970		22	3.3036
O_3	3.1111	4.7778	6.5000		40	2.3492
O_4						
Demand (b_j)	20	38	4			
AMDC	2.6666	3.6333	5.2955			

Figure 9. Select the element d_{23}

```
Console 1/A
Balanced TP: 147

Best Assignment:  Cij  Nbre Items  Total
     3 -> 3        5.17   *   50        =   258.5
     1 -> 3        6.43   *   5         =  32.15
     2 -> 1        4.78   *   38        =   181.64
     0 -> 2        4.71   *   30        =   141.3
     1 -> 2        5.7   *   4         =  22.8
     1 -> 0        4.0   *   18        =  72.0
     2 -> 0        3.11   *   2         =  6.22

Total Transportation Cost: 714.61
```

Figure 10. The generated solution by DM-TP1

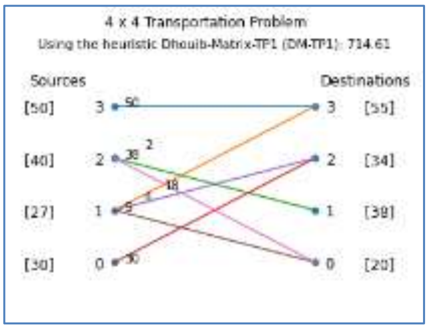


Figure 11. The graphical representation of the transportation plan

Table 1 compares the result generated by DM-TP1 to several results created by several methods depicted in [39]. Figure 12 depicts the computed deviation of each method from the literature to the result generated by DM-TP1. The best solutions are generated by DM-TP1 and Srinivasan's methods. However, DM-TP1 is distinguished by its speed: DM-TP1 needs only 8 iterations to generate the result. Moreover, other transportation problems under pentagonal fuzzy environment (from the literature) are used in order to approve the created DSS's effectiveness.

Table 1. The numerical results for DM-TP1 and other heuristics

Methods	Optimal solutions	Deviation to DM-TP1
NWCM	896.12	0.254
LCM	727.19	0.018
Russell's approximation method	727.19	0.018
Row minima method	721.17	0.009
Column minima method	727.19	0.018
VAM method	717.86	0.005
Srinivasan'd method	714.47	0.000
DM-TP1	714.4736	0.000

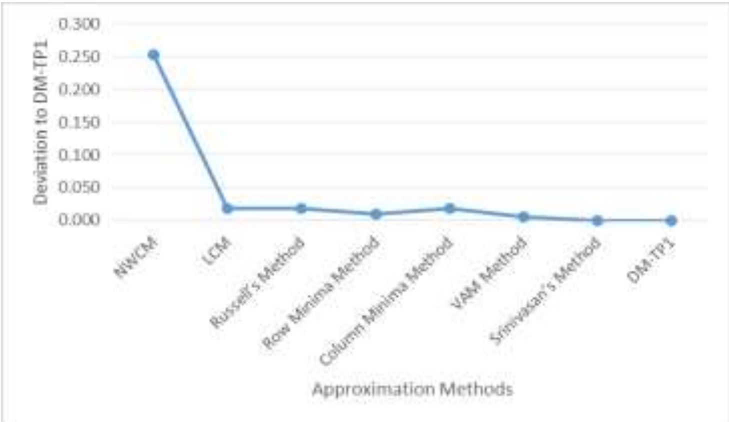
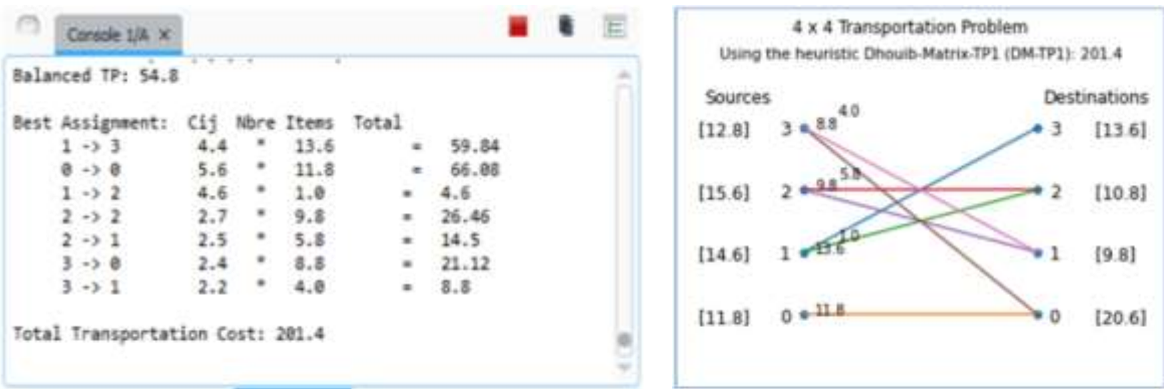


Figure 12. Comparing DM-TP1 to other methods

5.2. Example 2

Let us consider the example presented by [97]. Figure 13 illustrates the initial basic feasible solution generated bt DM-TP1 as shown in Figure 13(a) with the total cost of (201.4) and its graphical network transportation plan is represented in Figure 13(b). The DM-TP1 solution represents an improvement of the quality of the solution by (8.35%) where the method proposed in [97] found (218.22).

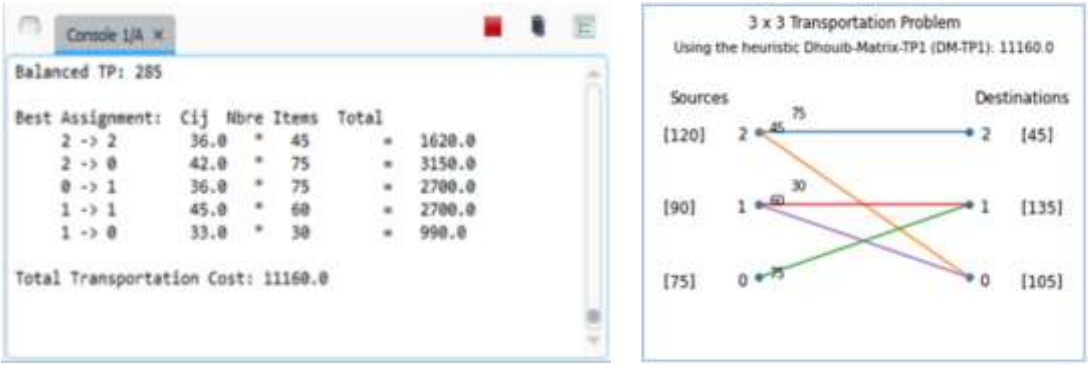


(a) (b)

Figure 13. The obtained solution by DM-TP1 (a) the best assignment and (b) the graphical of network transportation plan

5.3. Example 3

Furthermore, another example is taken from [98]. DM-TP1 found the same result as Vogel's approximation method and the generated result are represented in Figure 14. The proposed method provides a new improved heuristic Dhouib-Matrix-TP1 that helps to find promptly a suitable initial solution as shown in Figure 14(a). Therefore, in the real problems, the decision-makers have no crisp information about transportation cost, supply, and demand quantities. Furthermore, the decision maker was able to view the resulting solution due to the user interface as shown in Figure 14(b), which was developed in Python programming language. The DM-TP1 heuristic can also assist the decision maker to have high-quality solution in real-time. With few iterations, the proposed methodology can be used to solve complex real-world problems and is therefore straightforward to understand.



(a) (b)

Figure 14. The generated solution by DM-TP1 (a) the best assignment and (b) the graphical of network transportation plan

6. CONCLUSION

In this study, we have proposed a new greedy approach, called Dhouib-Matrix-TP1, to solve the entire FTP in where the cost, supply, and demand quantities are represented by pentagonal fuzzy numbers.Using the ranking function based on the centroid method, fuzzy parameters are converted to crisp values, and the best solution is obtained by the novel DM-TP1 heuristic. The proposed approach provides the decision-maker with a convivial DSS that helps him handle several kinds of real-life problems with a graphical representation of the generated transportation plan solution. The performance of the proposed method, DM-TP1, is demonstrated by unraveling three examples collected from the literature. The generated results prove that the novel method DM-TP1 is efficient and simply organized to find a good initial feasible solution in a short time. As an important extension of fuzzy sets, the concept of intuitionistic fuzzy numbers. This concept expresses vagueness and uncertainty about membership and non-membership functions. To characterize this uncertainty, imprecision, and vagueness in TP, future research will deal with enhancing this DSS to solve intuitionistic FTP. After that, as a generalization of intuitionistic fuzzy numbers, the neutrosophic FTP will also be added to this DSS. Because of the proposed DM-TP1 heuristic's strong performance, promising additional study will be conducted to evaluate its effectiveness on multi-objective TP.

REFERENCES

[1] H. B. Eom and S. M. Lee, "A survey of decision support system applications (1971–April 1988)," *Interfaces*, vol. 20, no. 3, pp. 65–79, Jun. 1990, doi: 10.1287/inte.20.3.65.
[2] E. B. Kim and C. Somarajan, "A survey of decision support system applications (1988-1994)," *Journal of the Operational Research Society*, vol. 49, no. 2, pp. 109–120, Feb. 1998, doi: 10.1057/palgrave.jors.2600507.
[3] S. Eom and E. Kim, "A survey of decision support system applications (1995-2001)," *Journal of the Operational Research Society*, vol. 57, no. 11, pp. 1264–1278, Nov. 2006, doi: 10.1057/palgrave.jors.2602140.
[4] W. C. Austin and H. B. Eom, "Decision support that anticipates the effects of variable prices," *Financial & Accounting Systems*, vol. 6, pp. 30–36, 1991.
[5] F. Pasiouras, C. Gaganis, and C. Zopounidis, "Multicriteria decision support methodologies for auditing decisions: The case of qualified audit reports in the UK," *European Journal of Operational Research*, vol. 180, no. 3, pp. 1317–1330, Aug. 2007, doi: 10.1016/j.ejor.2006.04.039.
[6] T. Chesney, S. Gold, and A. Trautrims, "Agent based modelling as a decision support system for shadow accounting," *Decision Support Systems*, vol. 95, pp. 110–116, Mar. 2017, doi: 10.1016/j.dss.2017.01.004.

[7] W. A. Mater and H. Kanasro, “Advanced managerial accounting techniques and decision support system: an empirical analysis of small and medium enterprises in Jordan,” *European Scientific Journal, ESJ*, vol. 14, no. 22, p. 233, Aug. 2018, doi: 10.19044/esj.2018.v14n22p233.
[8] D. E. Stout, M. J. Liberatore, and T. F. Monahan, “Decision support software for capital budgeting,” *Management Accounting*, vol. 73, no. 1, p. 50, 1991, [Online]. Available: http://www.ezproxy.dsu.edu:2048/login?url=http://search.proquest.com/docview/229732767?accountid=27073
[9] M. Tavana, Q. Chung, and D. T. Kennedy, “Rho: a decision support system for pricing in law firms,” *Information & Management*, vol. 33, no. 3, pp. 155–165, Jan. 1998, doi: 10.1016/S0378-7206(97)00042-6.
[10] A. Palma-dos-Reis and F. M. Zahedi, “Designing personalized intelligent financial decision support systems,” *Decision Support Systems*, vol. 26, no. 1, pp. 31–47, Jul. 1999, doi: 10.1016/S0167-9236(99)00027-5.
[11] A. Vasquez-Marquez, “American airlines arrival slot allocation system (ASAS),” *Interfaces*, vol. 21, no. 1, pp. 42–61, Feb. 1991, doi: 10.1287/inte.21.1.42.
[12] P. Borne, B. Fayech, S. Hammadi, and S. Maouche, “Decision support system for urban transportation networks,” *IEEE Transactions on Systems, Man and Cybernetics Part C: Applications and Reviews*, vol. 33, no. 1, pp. 67–77, Feb. 2003, doi: 10.1109/TSMCC.2003.809355.
[13] F. Ülengin, Ş. Önsel, Y. İlker Topçu, E. Aktaş, and Ö. Kabak, “An integrated transportation decision support system for transportation policy decisions: The case of Turkey,” *Transportation Research Part A: Policy and Practice*, vol. 41, no. 1, pp. 80–97, Jan. 2007, doi: 10.1016/j.tra.2006.05.010.
[14] N. A. Moreira and R. C. Oliveira, “A decision support system for production planning in an industrial unit,” *European Journal of Operational Research*, vol. 55, no. 3, pp. 319–328, 1991, doi: 10.1016/0377-2217(91)90202-7.
[15] J. P. C. Kleijnen, “Simulation and optimization in production planning. A case study,” *Decision Support Systems*, vol. 9, no. 3, pp. 269–280, 1993, doi: 10.1016/0167-9236(93)90058-B.
[16] J. J. Jiang, G. Klein, and R. A. Pick, “A marketing category management system: a decision support system using scanner data,” *Decision Support Systems*, vol. 23, no. 3, pp. 259–271, Jul. 1998, doi: 10.1016/S0167-9236(98)00053-0.
[17] P. K. Dey, “Decision support system for risk management: a case study,” *Management Decision*, vol. 39, no. 8, pp. 634–649, Oct. 2001, doi: 10.1108/00251740110399558.
[18] G. A. Mendoza, W. Sprouse, W. G. Luppold, P. Araman, and R. J. Meimban, “An integrated management support and production control system for hardwood forest products,” *Computers in Industry*, vol. 16, no. 4, pp. 343–351, Aug. 1991, doi: 10.1016/0166-3615(91)90074-J.
[19] H. Navarro-Hellín, J. Martínez-del-Rincon, R. Domingo-Miguel, F. Soto-Valles, and R. Torres-Sánchez, “A decision support system for managing irrigation in agriculture,” *Computers and Electronics in Agriculture*, vol. 124, pp. 121–131, Jun. 2016, doi: 10.1016/j.compag.2016.04.003.
[20] R. Rupnik, M. Kukar, P. Vračar, D. Košir, D. Pevec, and Z. Bosnić, “AgroDSS: A decision support system for agriculture and farming,” *Computers and Electronics in Agriculture*, vol. 161, pp. 260–271, Jun. 2019, doi: 10.1016/j.compag.2018.04.001.
[21] Z. Zhai, J. F. Martínez, V. Beltran, and N. L. Martínez, “Decision support systems for agriculture 4.0: survey and challenges,” *Computers and Electronics in Agriculture*, vol. 170, p. 105256, Mar. 2020, doi: 10.1016/j.compag.2020.105256.
[22] M. P. Armstrong, P. Lolonis, and R. Honey, “A spatial decision support system for school redistricting,” *URISA Journal*, vol. 5, no. 1, pp. 40–52, 1993.
[23] F. J. Jüngen and W. Kowalczyk, “An intelligent interactive project management support system,” *European Journal of Operational Research*, vol. 84, no. 1, pp. 60–81, Jul. 1995, doi: 10.1016/0377-2217(94)00318-7.
[24] R. G. Taylor, M. L. Vasu, and J. F. Causby, “Integrated planning for school and community: the case of johnston county, North Carolina,” *Interfaces*, vol. 29, no. 1, pp. 67–89, Feb. 1999, doi: 10.1287/inte.29.1.67.
[25] M. Dimopoulou and P. Miliotis, “Implementation of a university course and examination timetabling system,” *European Journal of Operational Research*, vol. 130, no. 1, pp. 202–213, Apr. 2001, doi: 10.1016/S0377-2217(00)00052-7.
[26] G. A. Forgionne and R. Kohli, “HMSS: a management support system for concurrent hospital decision making,” *Decision Support Systems*, vol. 16, no. 3, pp. 209–229, Mar. 1996, doi: 10.1016/0167-9236(95)00011-9.
[27] L. Mohan, L. Muse, and C. McInerney, “Managing smarter: A decision support system for mental health providers,” *Journal of Behavioral Health Services and Research*, vol. 25, no. 4, pp. 446–455, Nov. 1998, doi: 10.1007/BF02287514.
[28] K. V. Ramani, “DSS-enabled materials management process at MP Trust Hospital,” *Production and Inventory Management Journal*, vol. 42, no. 1, pp. 1-11+v, 2001.
[29] J. Wilkenfeld, S. Kraus, K. M. Holley, and M. A. Harris, “GENIE: A decision support system for crisis negotiations,” *Decision Support Systems*, vol. 14, no. 4, pp. 369–391, Aug. 1995, doi: 10.1016/0167-9236(94)00027-P.
[30] W. Shaohui, “Application of decision support system in E-government,” in *Proceedings - International Conference on Management and Service Science, MASS 2009*, IEEE, Sep. 2009, pp. 1–4. doi: 10.1109/ICMSS.2009.5302532.
[31] S. Shan, L. Wang, L. Li, and Y. Chen, “An emergency response decision support system framework for application in e-government,” *Information Technology and Management*, vol. 13, no. 4, pp. 411–427, 2012, doi: 10.1007/s10799-012-0130-0.
[32] C. H. Ku and G. Leroy, “A decision support system: Automated crime report analysis and classification for e-government,” *Government Information Quarterly*, vol. 31, no. 4, pp. 534–544, Oct. 2014, doi: 10.1016/j.giq.2014.08.003.
[33] J. G. Borges, A. O. Falcao, C. Miragaia, P. Marques, and M. Marques, “A Decision support system for forest ecosystem management in Portugal,” 2003, pp. 155–163. doi: 10.1007/978-94-017-0307-9_17.
[34] M. Matthies, C. Giupponi, and B. Ostendorf, “Environmental decision support systems: current issues, methods and tools,” *Environmental Modelling and Software*, vol. 22, no. 2, pp. 123–127, Feb. 2007, doi: 10.1016/j.envsoft.2005.09.005.
[35] T. Myllyviita, “Decision support in assessing the sustainable use of forests and other natural resources - a comparative review,” *The Open Forest Science Journal*, vol. 4, no. 1, pp. 24–41, Feb. 2011, doi: 10.2174/1874398601104010024.
[36] S. Vinodh, K. Jayakrishna, V. Kumar, and R. Dutta, “Development of decision support system for sustainability evaluation: a case study,” *Clean Technologies and Environmental Policy*, vol. 16, no. 1, Jan. 2014, doi: 10.1007/s10098-013-0613-7.
[37] L. A. Zadeh, “Information and control,” *Fuzzy sets*, vol. 8, no. 3, pp. 338–353, 1965.
[38] K. P. Ghadle and P. A. Pathade, “Solving transportation problem with generalized hexagonal and generalized octagonal fuzzy numbers by ranking method,” *Global Journal of Pure and Applied Mathematics*, vol. 13, no. 9, pp. 6367–6376, 2017, [Online]. Available: http://www.ripublication.com
[39] R. Srinivasan, N. Karthikeyan, and A. Jayaraja, “A proposed ranking method to solve transportation problem by pentagonal fuzzy numbers,” *Turkish Online Journal of Qualitative Inquiry (TOJQI)*, vol. 12, no. 3, pp. 277–286, 2021.
[40] A. J. Kamble, “Some notes on pentagonal fuzzy numbers,” *International Journal of Fuzzy Mathematical Archive*, vol. 13, no. 02, pp. 113–121, 2017, doi: 10.22457/ijfma.v13n2a2.

[41] T. Pathinathan and K. Ponnivalavan, "Pentagonal fuzzy number," *International Journal of Computing Algorithm Integrated Intelligent Research*, pp. 1003–1005, 2014, [Online]. Available: www.mathsisfun.com/definitions/Pentagonal
[42] F. L. Hitchcock, "The distribution of a product from several sources to numerous localities," *Studies in Applied Mathematics*, vol. 20, no. 1–4, pp. 224–230, Apr. 1941, doi: 10.1002/sapm1941201224.
[43] H.-J. Zimmermann, "Fuzzy programming and linear programming with several objective functions," *Fuzzy Sets and Systems*, vol. 1, no. 1, pp. 45–55, Jan. 1978, doi: 10.1016/0165-0114(78)90031-3.
[44] M. ÓhÉigeartaigh, "A fuzzy transportation algorithm," *Fuzzy Sets and Systems*, vol. 8, no. 3, pp. 235–243, Sep. 1982, doi: 10.1016/S0165-0114(82)80002-X.
[45] L. Li, Z. Huang, Q. Da, and J. Hu, "A new method based on goal programming for solving transportation problem with fuzzy cost," in *2008 International Symposiums on Information Processing*, IEEE, May 2008, pp. 3–8. doi: 10.1109/ISIP.2008.9.
[46] F. T. Lin, "Solving the transportation problem with fuzzy coefficients using genetic algorithms," in *IEEE International Conference on Fuzzy Systems*, IEEE, Aug. 2009, pp. 1468–1473. doi: 10.1109/FUZZY.2009.5277202.
[47] P. Pandian and G. Natarajan, "A new algorithm for finding a fuzzy optimal solution for fuzzy transportation problems," *Applied Mathematical Sciences*, vol. 4, no. 1–4, pp. 79–90, 2010.
[48] H. Basirzadeh, "An Approach for solving fuzzy transportation problem," *Applied Mathematical Sciences*, vol. 5, no. 29–32, pp. 1549–1566, 2011.
[49] S. Chandran and G. Kandaswamy, "A fuzzy approach to transport optimization problem," *Optimization and Engineering*, vol. 17, no. 4, pp. 965–980, 2016, doi: 10.1007/s11081-012-9202-6.
[50] A. Ebrahimnejad, "On solving transportation problems with triangular fuzzy numbers: review with some extensions," in *2013 13th Iranian Conference on Fuzzy Systems (IFSC)*, IEEE, Aug. 2013, pp. 1–4. doi: 10.1109/IFSC.2013.6675629.
[51] A. Ebrahimnejad, "A simplified new approach for solving fuzzy transportation problems with generalized trapezoidal fuzzy numbers," *Applied Soft Computing Journal*, vol. 19, pp. 171–176, 2014, doi: 10.1016/j.asoc.2014.01.041.
[52] A. Ebrahimnejad, "An improved approach for solving fuzzy transportation problem with triangular fuzzy numbers," *Journal of Intelligent & Fuzzy Systems*, vol. 29, no. 2, pp. 963–974, Oct. 2015, doi: 10.3233/IFS-151625.
[53] A. Ebrahimnejad, "A fuzzy approach to transport optimization problem," *Optimization and engineering*, vol. 17, no. 4, pp. 981–985, 2016.
[54] A. Ebrahimnejad, "Fuzzy linear programming approach for solving transportation problems with interval-valued trapezoidal fuzzy numbers," *Sadhana - Academy Proceedings in Engineering Sciences*, vol. 41, no. 3, pp. 299–316, Mar. 2016, doi: 10.1007/s12046-016-0464-0.
[55] A. Ebrahimnejad, "New method for solving fuzzy transportation problems with LR flat fuzzy numbers," *Information Sciences*, vol. 357, pp. 108–124, Aug. 2016, doi: 10.1016/j.ins.2016.04.008.
[56] A. Ebrahimnejad, "A lexicographic ordering-based approach for solving fuzzy transportation problems with triangular fuzzy numbers," *International Journal of Management and Decision Making*, vol. 16, no. 4, p. 346, 2017, doi: 10.1504/IJMDM.2017.086997.
[57] S. K. Prabha, S. Devi, and S. Deepa, "An efficient algorithm to obtain the optimal solution for fuzzy transportation problems," *International Journal of Computer & Organization Trends*, vol. 4, pp. 32–39, Jan. 2014, doi: 10.14445/22492593/IJCOT-V4P309.
[58] M. Venkatachalapathy, A. Jayaraja, and A. E. Samuel, "A study on solving octagonal fuzzy numbers using modified vogel ' s approximation method," *International Journal of Pure and Applied Mathematics*, vol. 118, no. 6, pp. 201–207, 2018.
[59] R. Pavithra and G. Rosario, "A study on fuzzy transportation problem using hexagonal fuzzy number," *Advances and Applications in Mathematical Sciences*, vol. 18, no. 10, pp. 1173–1184, 2019.
[60] S. Thota and P. Raja, "New method for finding an optimal solution of generalized fuzzy transportation problems," *Asian Journal of Mathematical Sciences*, vol. 4, no. 2, pp. 19–24, 2020, [Online]. Available: https://ssrn.com/abstract=3813697
[61] S. Kalyani and S. Nagarani, "A fully fuzzy transportation problem with hexagonal fuzzy number," in *AIP Conference Proceedings*, 2020, p. 030078. doi: 10.1063/5.0016903.
[62] R. A. D. Ramesh and K. S. Deva, "An optimum solution for solving fuzzy pentagonal transportation problem," vol. 3, no. 11, pp. 292–293, 2016.
[63] P. U. Maheswari and K. Ganesan, "Solving fully fuzzy transportation problem using pentagonal fuzzy numbers," *Journal of Physics: Conference Series*, vol. 1000, no. 1, p. 012014, Apr. 2018, doi: 10.1088/1742-6596/1000/1/012014.
[64] G. C. Rabinson and R.Chandrasekaran, "A method for solving a pentagonal fuzzy transportation problem via ranking technique and ATM," *International Journal of Research in Engineering*, vol. 09, no. 04, pp. 71–75, 2019.
[65] A. S. Mhaske and K. L. Bondar, "Fuzzy transportation problem by using triangular, pentagonal and heptagonal fuzzy numbers with lagrange's polynomial to approximate fuzzy cost for nonagon and hendecagon," *International Journal of Fuzzy System Applications*, vol. 9, no. 1, pp. 112–129, Jan. 2020, doi: 10.4018/IJFSA.2020010105.
[66] R. Srinivasan and N. Karthikeyan, "A proposed method to solve transportation problem by generalized pentagonal and hexagonal fuzzy numbers," *International Journal of Aquatic Science*, vol. 12, no. 2, pp. 1499–1509, 2021.
[67] L. Kané, M. Diakite, S. Kane, H. Bado, and D. Diawara, "Fully fuzzy transportation problems with pentagonal and hexagonal fuzzy numbers," *Journal of applied research on industrial engineering*, vol. 8, no. 3, pp. 251–269, 2021.
[68] L. Kané, M. Diakité, H. Bado, and M. Konaté, "Solving fully fuzzy transportation problems," *Universal Journal of Mathematics and Mathematical Sciences*, vol. 15, pp. 63–96, Jan. 2022, doi: 10.17654/2277141722005.
[69] S. Gorhe and K. Ghadle, "A new algorithm to solve pentagonal fuzzy transportation problem," *Journal of Algebraic Statistics*, vol. 13, pp. 4847–4855, 2022.
[70] A. Martin, "Mari's algorithm is used to solve a fuzzy transportation problem using Pentagonal Fuzzy numbers," *YMER Digital*, vol. 21, no. 06, pp. 222–229, Jun. 2022, doi: 10.37896/YMER21.06/20.
[71] V. Vidhya and K. Ganesan, "A new ranking approach for solving fuzzy transportation problem with Pentagonal Fuzzy number," *Mathematics and Statistics*, vol. 10, no. 4, pp. 816–824, 2022, doi: 10.13189/ms.2022.100412.
[72] M. Bisht, I. Beg, and R. Dangwal, "Optimal solution of pentagonal fuzzy transportation problem using a new ranking technique," *Yugoslav Journal of Operations Research*, vol. 33, no. 4, pp. 509–529, 2023, doi: 10.2298/YJOR221120002B.
[73] S. Dhouib, "Solving the single-valued trapezoidal neutrosophic transportation problems through the novel dhouib-matrix-TP1 heuristic," *Mathematical Problems in Engineering*, vol. 2021, pp. 1–11, Nov. 2021, doi: 10.1155/2021/3945808.
[74] S. Dhouib, "Solving the trapezoidal fuzzy transportation problems via new heuristic: the dhouib-matrix-TP1," *International Journal of Operations Research and Information Systems*, vol. 12, no. 4, pp. 1–16, Feb. 2021, doi: 10.4018/IJORIS.294119.
[75] S. Dhouib, "Novel heuristic for intuitionistic triangular fuzzy travelling salesman problem," *International Journal of Applied Evolutionary Computation*, vol. 12, no. 4, pp. 39–55, Oct. 2021, doi: 10.4018/ijaec.2021100104.

[76] S. Dhouib, "Neutrosophic triangular fuzzy travelling salesman problem based on dhouib-matrix-TSP1 heuristic," *International Journal of Computer and Information Technology(2279-0764)*, vol. 10, no. 5, Oct. 2021, doi: 10.24203/ijcit.v10i5.154.
[77] S. Dhouib, "Optimization of travelling salesman problem on single valued triangular neutrosophic number using dhouib-matrix-TSP1 heuristic," *International Journal of Engineering Transactions C: Aspects*, vol. 34, no. 12, Dec. 2021, doi: 10.5829/ije.2021.34.12C.09.
[78] S. Dhouib, S. Broumi, and M. Lathamaheswari, "Single valued trapezoidal neutrosophic travelling salesman problem with novel greedy method: the dhouib-matrix-TSP1 (DM-TSP1)," *International Journal of Neutrosophic Science*, vol. 17, no. 2, pp. 144–157, 2021, doi: 10.54216/IJNS.170205.
[79] S. Dhouib, "Novel heuristic for new pentagonal neutrosophic travelling salesman problem," *Neutrosophic Sets and Systems*, vol. 51, pp. 344–359, 2022, doi: 10.5281/zenodo.7135315.
[80] S. Dhouib, A. Zouari, S. Dhouib, and H. Chabchoub, "Integrating the artificial bee colony metaheuristic with Dhouib-Matrix-TSP1 heuristic for holes drilling problems," *Journal of Industrial and Production Engineering*, vol. 40, no. 3, pp. 177–187, Apr. 2023, doi: 10.1080/21681015.2022.2158499.
[81] S. Dhouib, "SettingsAn intelligent assignment problem using novel heuristic: The Dhouib-Matrix-AP1 (DM-AP1)," *International Journal of Intelligent Systems and Applications in Engineering*, vol. 10, no. 1, pp. 135–141, Mar. 2022, doi: 10.18201/ijisae.2022.277.
[82] S. Dhouib, "Novel optimization method for unbalanced assignment problems with multiple jobs: The Dhouib-Matrix-AP2," *Intelligent Systems with Applications*, vol. 17, p. 200179, Feb. 2023, doi: 10.1016/j.iswa.2023.200179.
[83] S. Dhouib, "Unravelling the assignment problem under intuitionistic triangular fuzzy environment by the novel heuristic Dhouib-Matrix-Ap1," *Yugoslav Journal of Operations Research*, vol. 33, no. 3, pp. 467–480, 2023, doi: 10.2298/YJOR220915005D.
[84] S. Dhouib and T. Sutikno, "Solving the trapezoidal fuzzy assignment problem using the novel Dhouib-Matrix-AP1 heuristic," *Bulletin of Electrical Engineering and Informatics*, vol. 12, no. 2, pp. 950–957, Apr. 2023, doi: 10.11591/eei.v12i2.4855.
[85] S. Dhouib, "Novel metaheuristic based on iterated constructive stochastic heuristic: Dhouib-Matrix-3 (DM3)," *Applied Computational Intelligence and Soft Computing*, vol. 2021, pp. 1–10, Dec. 2021, doi: 10.1155/2021/7761993.
[86] S. Dhouib and A. Zouari, "Adaptive iterated stochastic metaheuristic to optimize holes drilling path in manufacturing industry: The Adaptive-Dhouib-Matrix-3 (A-DM3)," *Engineering Applications of Artificial Intelligence*, vol. 120, p. 105898, Apr. 2023, doi: 10.1016/j.engappai.2023.105898.
[87] A. Zouari and S. Dhouib, "Optimizing the non-productive time of robotic arm for drilling circular holes network patterns via the Dhouib-Matrix-3 Metaheuristic," *International Journal of Mechatronics and Manufacturing Systems*, vol. 16, no. 1, p. 1, 2023, doi: 10.1504/ijmms.2023.10054319.
[88] A. Zouari, D. Souhail, F. Lehyani, and J. C. Sá, "Tool path length optimization in drilling operations: a comparative study," in *Lecture Notes in Mechanical Engineering*, 2024, pp. 293–301. doi: 10.1007/978-3-031-38241-3_33.
[89] S. Dhouib, "Multi-start constructive heuristic through descriptive statistical metrics: the Dhouib-Matrix-4 (DM4) metaheuristic," *International Journal of Operational Research*, vol. 1, no. 1, p. 1, 2021, doi: 10.1504/ijor.2021.10045069.
[90] S. Dhouib, "Finding the shortest holes drilling path in printed circuit board via the Dhouib-Matrix-4 technique," in *Advances in Transdisciplinary Engineering*, vol. 33, 2022, pp. 396–401. doi: 10.3233/ATDE221192.
[91] S. Dhouib, "Hierarchical coverage repair policies optimization by Dhouib-Matrix-4 metaheuristic for wireless sensor networks using mobile robot," *International Journal of Engineering, Transactions A: Basics*, vol. 36, no. 12, pp. 2153–2160, 2023, doi: 10.5829/ije.2023.36.12c.03.
[92] S. Dhouib and D. Pezer, "A novel metaheuristic approach for drilling process planning optimization: Dhouib-Matrix-4 (DM4)," *International Journal of Artificial Intelligence*, vol. 20, no. 2, pp. 80–92, 2022.
[93] S. Dhouib and D. Pezer, "Increasing the performance of computer numerical control machine via the Dhouib-Matrix-4 Metaheuristic," *Inteligencia Artificial*, vol. 26, no. 71, pp. 142–152, May 2023, doi: 10.4114/intartif.vol26iss71pp142-152.
[94] S. Dhouib, "An optimal method for the shortest path problem: the Dhouib-Matrix-SPP (DM-SPP)," *Results in Control and Optimization*, vol. 12, p. 100269, Sep. 2023, doi: 10.1016/j.rico.2023.100269.
[95] S. Dhouib, "Shortest path planning via the rapid Dhouib-Matrix-SPP (DM-SPP) method for the autonomous mobile robot," *Results in Control and Optimization*, vol. 13, p. 100299, Dec. 2023, doi: 10.1016/j.rico.2023.100299.
[96] S. Dhouib, "Innovative method to solve the minimum spanning tree problem: The Dhouib-Matrix-MSTP (DM-MSTP)," *Results in Control and Optimization*, vol. 14, p. 100359, Mar. 2024, doi: 10.1016/j.rico.2023.100359.
[97] A. Karpagam and V. Vijayalakshmi, "Membership and non-membership function of pentagonal fuzzy number," *American International Journal of Research in Science, Technology, Engineering & Mathematics*, vol. 25, no. 1, pp. 146–149, 2019.
[98] R. J. Mitlif, M. Rasheed, and S. Shihab, "An optimal algorithm for a fuzzy transportation problem," *Journal of Southwest Jiaotong University*, vol. 55, no. 3, 2020, doi: 10.35741/issn.0258-2724.55.3.7.

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