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GRADUATE SURVEY ARTICLE

Application of Simple Average Weighting Optimization Method in the Selection of Best Desktop Computer Model

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ABSTRACT

Multi-Criteria Decision Making (MCDM) is one of the most emerging concepts in today's world which enables a decision maker to select the best strategies among different available alternatives. MCDM technique helps to remove the biasness and confusion while selecting a product or process. In recent few years different MCDM methodologies finds wide area of applications in industries as well as in our daily life. In this paper, such one type of application is broadly described. One example is taken from our daily life, which is generally faced by most of the students while purchasing a desktop computer. The main objective of this paper is to select the best desktop computer models among five different models actual available in the market having different configurations. For this analysis, 100 computer users have been surveyed to know their relative preferences and choices, which of the computer specifications is most important to them. For this present analysis few numbers of criteria have been considered and also there are number of sub-criteria within each criterion (for example, the processor may be different for different models like I3, I5, I7 etc.). The MCDM methodology which is adopted for this selection process is known as Simple Average Weighting (SAW) method.

Keywords: Multi-Criteria Decision Making, Simple Average Weighting, Desktop Computers, Criteria, Sub-Criteria

1 Introduction

Computers now a days became an essential gadget in everyday life. In this ever-developing world, computers make our work faster and easier which makes it more demanding electronic devices [1]-[2]. There are lots of computer models available in the market from various brands with different configurations which makes the buyers more confusing which is the best model to buy according to their need. This paper aims to remove this type of confusion from the buyer's mind and provides a perfect solution to this type of problem through MCDM methodology [1]-[2]. There are different types of MCDM methods like AHP (Analytic Hierarchy Process) [3]-[4], TOPSIS [5-6], PROMETHEE [7], AHP-FUZZY [8] etc. which can also be applied to select the best alternatives.

The present investigation involves the selection of the best desktop computer model by simple average weighting method [2] from 5 available models in the market (shown in Table 1) based on the market survey of 100 people having 5 different criteria (i.e. Processor, Hard Disk Capacity, Screen Size, RAM, Brand) and each criteria have their own sub-criteria.

Table 1: *Five Desktop Models Available in the Market that are Considered for this Analysis*

Models	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Model 1	I3	Samsung	23.8 Inch	2TB	8GB
Model 2	I3	Dell	21.5 Inch	1TB	4GB
Model 3	I5	BenQ	18.5 Inch	512GB	4GB
Model 4	I7	HP	18.5 Inch	1TB	16GB
Model 5	I5	AOC	15.6 Inch	1TB	4GB

The above mentioned 5 most important criteria is considered for this analysis which the buyers actually noticed while purchasing a desktop computer. Obviously other criteria can also be considered e.g. graphics card, screen resolution etc. [1], [6]. for this analysis but it varies from researchers to researchers which criteria's is to be considered. The main aim of this paper is to select the best desktop model among 5 models actual available in the market. Previously different researchers adopted different MCDM methods [1]-[2] and applied in many fields such as water management, energy management, telecommunication industry, automobile industry etc. [6]. but very few research works have been reported of applying MCDM techniques in our daily life for the selection of best process and strategies, hence there is a scope of implementing multi-criteria decision making for the selection of household appliances and electronics devices associated with our daily life.

2 Literature Review

For the past few years several researchers [9]-[12] applied different MCDM methodology in various field of applications such as industrial sector, private sector, energy management [13]-[15] waste management, environmental management, supply chain management, supplier selection [16-17] etc. and also receives good outcome results which makes the MCDM methodology more popular among the researchers [14]. At present most of the researchers mainly focuses on the area of industrial applications. Afshari *et al.* [18] applied simple average weighting method for the selection of personnel in Iran. Most of the researchers generally adopted the hybrid MCDM process for their analysis since it provides more accurate results [1-2], [9-10]. AHP can be integrated with SAW, Mitra *et al.* [2] adopted AHP-SAW technique for the selection of the best laptop model, this paper introduces the calculation of the weightages of the main criteria by AHP methodology and further using these weightages in the SAW analysis and also Mitra *et al.* [1] adopted the integrated AHP-TOPSIS methodology in their paper for the selection of the best desktop computer model. Some researchers also implemented Fuzzy [19]-[22] concept along with AHP, TOPSIS and SAW for the decision-making process. Deni *et al.* [23] implemented Fuzzy -SAW (FSAW) [22] for selecting high achieving student in faculty level, in this research paper six criteria is being considered and based on this criteria's the whole analysis is carried out. Gupta and Gupta [24] compares SAW, FSAW, Fuzzy-TOPSIS [22] for vendors rating. From the analysis it is found that Fuzzy-TOPSIS is more effective in rating the vendors more accurately and more precisely. Kumar *et al.* [25] applied FSAW in Punj Lyord plant Gwalior (India) for the selection of an appropriate maintenance strategy for material handling purposes.

3 Theoretical Analysis

This paper aims to select the best desktop model by the application of the integrated AHP-SAW [2] methodology. At first Analytic Hierarchy Process (AHP) [3] is applied to find out the weightages of the main criteria [26] and then further using these weightages in the SAW thus making this process a hybrid

MCDM process. SAW [27]-[28] is one of the most widely used MCDM method since it is very easy to apply and due to its simplicity in operation. The step by step process of SAW is described in detail below [18].

Step 1: Based on the market survey of the people, create a pair-wise comparison matrix of n × n for the main criteria according to Saaty's pair-wise comparison scale [3]-[4] shown in Table 2. In this case n = 5, since 5 criteria is considered for this present analysis

$$A\ (n_i \times n_j) = \begin{bmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & a_{n3} & \cdots & a_{nn} \end{bmatrix}$$

Table 2: *Saaty's 9 Pair-Wise Comparison Scale [3]*

Saaty's pair wise comparison scale	Compare factor of i & j
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values when compromise is needed

Step 2: Normalized the pair-wise comparison matrix by using Equation 1

$$N_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \ \ldots\ldots\ (1)$$

Where, i = 1, 2, 3…. n

j = 1, 2, 3…. n

Step 3: Find all the row averages of the normalized matrix to find the weightages (priority vector) of all the criteria's i.e. w_j

Step 4: Find out the consistencies of all the main criteria

a) Multiply the pair-wise comparison matrix with the row average matrix to find out the weighted consistency matrix.

b) Divide each elements of the weighted consistency matrix by their respective priority vector (weightages) to find out the consistencies of each criteria.

c) Find out the averages of all the consistencies to calculate the λ_{max}.

Step 5: Checking of consistency [26]

a) Find out the Consistency Index (CI) value by using Equation 2

$$\mathrm{CI} = \frac{\lambda_{max} - n}{n - 1} \ \ldots\ldots\ (2)$$

b) Find out the Consistency Ratio (CR) by using Equation 3.

$$\mathrm{CR} = \frac{CI}{RI} \ \ldots\ldots\ (3)$$

Where, CI is the Consistency Index, and

RI is the Randomly Generated Index value which can be obtained from Table 3

Table 3: *RI Value (Randomly Generated Index) According to the no of Comparison n*

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.58

c) Now if the CR value is less than 0.1, then it can be concluded that the decision maker judgement for the pair-wise comparison matrix is true and consistent. If the CR value is greater than 0.1 then the pair-wise comparison matrix needs to be altered and then again consistency is checked until the CR value is restricted within 0.1. in this analysis up to 10% of inconsistency in the decision maker judgements can be allowed, so the CR value needs to be restricted within 0.1.

Step 6: Prepare an (m × n) evaluation matrix according to the Hwang and Yoon comparison scale [5] shown in Table 4. Where, 'm' is the number of alternatives and 'n' is the number of criteria.

$$R\ (m_i \times n_j) = \begin{bmatrix} r_{11} & r_{12} & r_{13} & \cdots & r_{1n} \\ r_{21} & r_{22} & r_{23} & \cdots & r_{2n} \\ r_{31} & r_{32} & r_{33} & \cdots & r_{3n} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & r_{m3} & \cdots & r_{mn} \end{bmatrix}$$

Table 4: *Hwang and Yoon Comparison Scale [5]*

Qualitative estimation	Bad	Good	Average	Very Good	Excellent	Type of Criteria
Quantitative estimation	1	3	5	7	9	MAX
	9	7	5	3	1	MIN

Step 7: Normalized the evaluation matrix according to the Equations given in 4 and 5.

a) For beneficial criteria, i.e. if the criteria is positive (whose larger values is desired)

$$n_{ij} = \frac{r_{ij}}{r_j^{max}} \ \ldots\ldots\ (4)$$

Where, i = 1, 2, 3…. m

j = 1, 2, 3…. n

b) For non-beneficial criteria or cost criteria, i.e. if the criteria is negative (whose smaller values is desired)

$$n_{ij} = \frac{r_j^{min}}{r_{ij}} \ \ldots\ldots\ (5)$$

Where, i = 1, 2, 3…. m

j = 1, 2, 3…. n

r_j^{max} = Largest number in the column of j

r_j^{min} = Smallest number in the column of j

Step 8: Calculate the Additive Weighted Sum for each of the alternatives by using Equation 6

$$W_i = \sum_{j=1}^{n} w_j n_{ij} \ \ldots\ldots\ (6)$$

Where, w_j = Weightages of the criteria

n_{ij} = Normalized values

Now, the alternatives with the highest weighted sum (W_i) is termed as the best alternatives and the alternatives is ranked according to the weighted sum values in the decreasing order.

4 Methodology

At first AHP is applied to find out the weightages [29] of the criteria and the consistency is also checked to ensure that the decision maker judgements are consistent. After finding the weightages SAW is applied and the weightages found through AHP is used [30]. All the calculations are shown step by step in details in the next section of this paper.

Table 5 shows a pair-wise comparison matrix which is created according to the Saaty's 9 pair comparison scale shown in Table 2 based on the market survey of 100 computer users. In this matrix each and every criterion is compared [31] with the other criteria to find out the relative importance's among each other. For example, when processor is compared to processor itself, value 1 is allotted in the cell a_{11} according to Satty's scale [3] which states that 1 stands for the equal importance. Now if processor is compared to brand, 3 is allotted in the cell a_{12} which states that moderate importance according to Saaty's scale, which means

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processor seems to be moderately important when compared to brand according to the customer views [1]-[2]. While purchasing a desktop computer the processor quality is somehow matters more to the customers than brand. In this way this pair-wise comparison matrix is formed based on the relative choices and preferences of the buyers.

Table 5: *Pair-Wise Comparison Matrix*

Comparisons	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Processor	1	3	5	7	5
Brand	1/3	1	6	3	2
Screen Size	1/5	1/6	1	1/3	1/3
Hard Disk Capacity	1/7	1/3	3	1	1/3
RAM	1/5	1/2	3	3	1
Total	1.87619048	5	18	14.33333333	8.66666667

The pair-wise comparison matrix is normalized by dividing each elements of Table 5 by their respective column sum as given by Equation 1 thus obtaining the normalized matrix as shown in Table 6. Then calculating all the row averages of the normalized matrix to find out the weightages of the criteria's as shown in the Table 6.

Table 6: *Normalization of the Pair-Wise Comparison Matrix*

Comparisons	Processor	Brand	Screen Size	Hard Disk Capacity	RAM	Row Average	Weight %
Processor	0.53299492	0.6	0.27777778	0.48837209	0.57692308	0.49521357	49.52135743
Brand	0.17766497	0.2	0.33333333	0.20930233	0.23076923	0.23021397	23.02139729
Screen Size	0.10659898	0.03333333	0.05555556	0.02325581	0.03846154	0.05144105	5.14410452
Hard Disk Capacity	0.07614213	0.06666667	0.16666667	0.06976744	0.03846154	0.08354089	8.35408891
RAM	0.10659898	0.1	0.16666667	0.20930233	0.11538462	0.13959052	13.95905185
Total	1	1	1	1	1	1	100

4.1 Calculation of Consistency

$$\begin{bmatrix} 1 & 3 & 5 & 7 & 5 \\ 1/3 & 1 & 6 & 3 & 2 \\ 1/5 & 1/6 & 1 & 1/3 & 1/3 \\ 1/7 & 1/3 & 3 & 1 & 1/3 \\ 1/5 & 1/2 & 3 & 3 & 1 \end{bmatrix} \times \begin{bmatrix} 0.49521357 \\ 0.23021397 \\ 0.05144105 \\ 0.08354089 \\ 0.13959052 \end{bmatrix} = \begin{bmatrix} 2.72579954 \\ 1.23373514 \\ 0.26322989 \\ 0.43187698 \\ 0.75868602 \end{bmatrix}$$

$$\begin{Bmatrix} 2.72579954/0.49521357 \\ 1.23373514/0.23021397 \\ 0.26322989/0.05144105 \\ 0.43187698/0.08354089 \\ 0.75868602/0.13959052 \end{Bmatrix} = \begin{Bmatrix} 5.50429083 \\ 5.35908018 \\ 5.11711786 \\ 5.16964793 \\ 5.43508278 \end{Bmatrix} \Rightarrow \begin{Vmatrix} Processor \\ Brand \\ Screen\ Size \\ Hard\ Disk\ Capacity \\ RAM \end{Vmatrix}$$

The consistency is calculated for every criterion as shown above. Now finding the average consistency λ_{max}.

$$\frac{5.50429083+5.35908018+5.11711786+5.16964793+5.43508278}{5} = \frac{26.58521959}{5} = 5.31704392$$

Average Consistency (λ_{max}) = 5.31704392

The pair-wise comparison matrix is multiplied with the row average matrix to find out the weighted consistency of the alternatives, then all the elements of the weighted consistency matrix [32] is divided by their respective priority vector to find out the consistency of each alternatives. Then finding the averages of all the consistency to find out the average consistency λ_{max}.

Consistency Index (CI) value is calculated by using Equation 2 as follows:

$$CI = \frac{(5.31704392-5)}{(5-1)} = \frac{0.31704392}{4} = 0.07926098$$

$$CR = CI / RI \Rightarrow \frac{0.07926098}{1.12} = 0.07076873$$

Here RI value is 1.12 taken from the Table 3. In this case there are 5 comparisons so, n = 5
Since, the CR value is less than 0.1, i.e. 0.07076873 ≤ 0.1 thus it can be concluded that the decision maker judgements for the pair-wise comparison matrix is consistent and well within the limit (i.e. 7%). Now SAW can be applied to the above method because all the weightages of the criteria have been calculated and the consistency is also checked which is well within the limit (Table 7).

Table 7: *Consistency Check*

No of Comparisons (n)	**5**
Average Consistency (λ_{max})	5.31704392
Consistency Index (CI)	0.07926098
Randomly Generated Consistency Index (RI)	1.12
Consistency Ratio (CR)	0.07076873
Consistent	**YES**

Table 8: *Evaluation Matrix*

Models	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Model 1	4	7	1	1	3
Model 2	4	5	3	5	7
Model 3	7	4	9	9	7
Model 4	3	9	9	5	2
Model 5	7	1	5	5	7

Table 8 shows the evaluation matrix which is created according to the Hwang and Yoon comparison scale based on the choices and preferences of the customers [33]. From Table 1 it can be seen that there are 3 types of processor that are taken into consideration (i.e. I3, I5, I7), so from the market survey of the buyers it is found that the demand of I5 processor is more followed by I3 and I7. So, the models with I5 processor (i.e. Model 3 and Model 5) is allotted with the maximum value i.e. 7 under the processor column followed by I7 (i.e. 4) and I3 (i.e. 3). Similarly, the most preferable brand among the computer users is found to be HP followed by Samsung and Dell, so HP is allotted the maximum value i.e. 9 followed by Samsung (i.e. 7) and Dell (i.e. 5) under the brand column. Likewise, all the values are placed in all the cells thus creating the evaluation matrix as shown in Table 8 based on the choices of the customers and buyers [34]. Although the magnitude of the values allotted in all the cells depends on the decision maker. This evaluation matrix is also known as the decision matrix [1].

All the criteria considered for this analysis is beneficial in nature that means whose larger values is desired. For example, higher the processor value it would be more preferable and same for the other criteria also, higher the RAM or hard disk capacity then it will be more preferable by the customers. So, by using Equation 4 normalization is done and shown in Table 9. The additive weightage is calculated for all the alternatives by using the Equation 6 and similarly all the weightages % is also calculated as shown in Table 10. The calculation for Model 1 is shown in detail below.

For Model 1, the calculation of simple additive weightage is as follows:

$$W_1 = (\mathit{0.49521357} \times 0.57142857) + (\mathit{0.23021397} \times 0.77777778) + (\mathit{0.05144104} \times 0.11111111) + (\mathit{0.08354089} \times 0.11111111) + (\mathit{0.13959052} \times 0.42857143) = 0.53685700 \text{ or } 53.685700\ \%$$

Similarly, all the additive weightages for all the models is found out in the same way as shown above for Model 1. All the calculated weightages and their percentages is shown in Table 10.

Table 9: *Normalization of the Evaluation Matrix*

Weights (w_i)	*0.49521357*	*0.23021397*	*0.05144104*	*0.08354089*	*0.13959052*
Models	**Processor**	**Brand**	**Screen Size**	**Hard Disk Capacity**	**RAM**
Model 1	0.57142857	0.77777778	0.11111111	0.11111111	0.42857143
Model 2	0.57142857	0.55555556	0.33333333	0.55555556	1
Model 3	1	0.44444444	1	1	1
Model 4	0.42857143	1	1	0.55555556	0.28571429
Model 5	1	0.11111111	0.55555556	0.55555556	1

Table 10: *Additive Weightage Summation*

Models	Simple Additive Weightage	Weightage %
Model 1	0.53685700	53.685700
Model 2	0.61402498	61.402498
Model 3	0.87210335	87.210335
Model 4	0.58018402	58.018402
Model 5	0.73537339	73.537339

5 Results and Discussion

Table 10 shows the weightages % of all the alternatives. After calculating the Simple Additive Weightages of all the alternatives, Model 3 is found to obtain the highest weightages % i.e. 87.210335% followed by Model 5, Model 2, Model 4 and Model 1. The ranking order of the computer models is shown in Table 11 according to the decreasing order of the weightage %.

Table 11: *Ranking of the Desktop Computer Models*

Models	Weightage %	Ranking
Model 1	53.68	Rank 5
Model 2	61.40	Rank 3
Model 3	87.21	Rank 1
Model 4	58.01	Rank 4
Model 5	73.54	Rank 2

The ranking of the models would be Model 3 > Model 5 > Model 2 > Model 4 > Model 1 respectively.

6 Conclusion

From this analysis it can be concluded that the Model 3 is the best preferable model based on the market views of the customers. This methodology provides a guideline to the students while purchasing a computer. The electronic stores and as well as the online shopping websites who sold computers can also be benefitted by this methodology. Since this paper provides a guideline about which of the desktop computer model is in demand right now in the market so that they can keep that model in adequate quantity to meet the needs of the customers. The same problems can also be solved by applying other MCDM methodology such as AHP, TOPSIS, FUZZY-AHP, FUZZY-SAW etc. This MCDM methodologies also helps the desktop manufacturing companies to shape their future business strategies based on the present market demand of the customers.

7 Declarations

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7.3 Competing Interests

The corresponding author confirms on behalf of all authors that there has been no conflict of interest in this publication. The objectives of this research article neither have any intention to promote any kind of computer brand mentioned in this article nor to degrade any computer manufacturing companies. This whole analysis is completely based on the market survey and the reviews of the desktop users.

7.4 Informed Consent

Consent from all respondent were taken by informing them purpose of this survey.

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