Selection of the Desktop Computer Model by AHP-TOPSIS Hybrid MCDM Methodology.

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ABSTRACT: *Many a times in selecting a suitable product, strategy, process or service option to accomplish a job one may encounter with a variety of choices, preferences or criteria and each criterion may have a number of sub-choices or, sub-criteria which make the proper selection process a most challenging task. In the present investigation to select the best possible model of Desktop computer among 5different available models,a hybrid Multi-Criteria Decision Making (MCDM) methodology,combining AHP and TOPSIS system tool, have been adopted. The alternative available options in selecting the best model include different criteria like RAM, Hard Disk Capacity, Processor type, Brand or make and Screen size. Again, each criterion has a number of sub-criteria like RAM size may be of 4GB, 8GB, 16 GB.*

Key Words: *MCDM, AHP, TOPSIS, DESKTOP COMPUTER*

I. Introduction

Now-a-days computer have become a quite essential electronic gadgets in our daily lives. Computers skills and knowledge added values to our everyday lives. To meet the customers' requirements and specifications there are also lots of computer models, having different combination of RAM, hard disk capacity, processor type, screen size etc., are available from different brands. It's very confusing for the common people and students to select the best Desktop model among different available brands having a variety of specifications.

In this present investigation, 5 different models of Desktop computer have been chosen which are actually available in the market through a market survey and the best model is selected by applying hybrid MCDM [1,7] methodology namely AHP and TOPSIS. AHP (Analytic Hierarchy Process) and TOPSIS (Technique for Order of Preferences by Similarity to Ideal Solution) are two different MCDM tool that can be applied in any decision-making circumstances. For better results two or more MCDM tools can be combined together that give rise to a new hybrid MCDM methodology. Hybrid combination of AHP and TOPSIS [2-3] isapplied here for the selection process. Apart from AHP and TOPSIS there are some others MCDM tools like MAXMIN, SAW, ELECTRE, VIKOR [4-6] etc.

For the present analysis a market survey of 100 people has been done to know their views about the Desktop computer specifications which matters them most and what is their configuration requirements.Also, their subjective or, qualitative preferences over one particular criteria like RAM with respect to another say, hard disk capacity are surveyed. Similarly, how they subjectively prefer among different sub-criteria like 4GB, 8GB, 16GB within a criterion i.e., RAM is noted. All the weightages of the criteria and sub-criteria is found out by applying AHP and these weightage values are used while performing TOPSIS, also the decision matrix is formed according to the weightages found by AHP. While performing AHP all the judgements is validated by checkingthe consistency analysis at the end of each and every step.

II. Theoretical Analysis

The Analytic Hierarchy Process (AHP) is a Multi Criteria Decision Making technique for analyzing complex decisions. AHP finds out the weightages of each criteria and sub-criteria and basically deals with the conversion of qualitative nature of a product into quantitative value based on the Saaty's [2] 9 pair comparison scale as shown below in Table 1.

Analytic Hierarchy Process (AHP) consists of following steps as follows [1]: -

Step 1: Identification of the problem and constructing the hierarchy tree as shown below in Fig 1.

Step 2: Construct a pair-wise comparison matrix according to the Saaty's 9 pair scale by collecting the customer reviews through a market survey.

Step 3: Normalization and weightage calculation of the pair-wise comparison matrix.
Step 4: Calculation of consistency for each of the elements and finding the average.
Step 5: Checking of consistency. The judgements are acceptable if the Consistency Ratio (CR) is less than 0.1.

Technique for Order of Preferences by Similarity to Ideal Solution (TOPSIS) is based on the concept that the best-chosen model should have the shortest geometric distance from the Positive Ideal Solution (PIS) and the longest geometric distance from the Negative Ideal Solution (NIS).

TOPSIS consists of following steps as follows [7]:-
Step 1: Create a Decision matrix consisting 'n'criteria's and'm' alternatives according to the weightages found by AHP based on Hwang and Yoon's pair wise comparison scale [3] as shown below in Table 2.
Step 2: Normalization of the Decision Matrix.
Step 3: Calculate the weighted Normalized Decision matrix.
Step 4: Determining Positive Ideal Solution (PIS) as well as Negative Ideal Solution (NIS).
Step 5: Calculate the Relative Closeness Co-efficient values.

Abbreviations and Acronyms

MCDM (Multi Criteria Decision Making), AHP (Analytic Hierarchy Process), TOPSIS (Technique for Order of Preferences by Similarity to Ideal Solution), Positive Ideal Solution (PIS), Negative Ideal Solution (NIS), RAM (Random Access Memory).

Figures and Tables

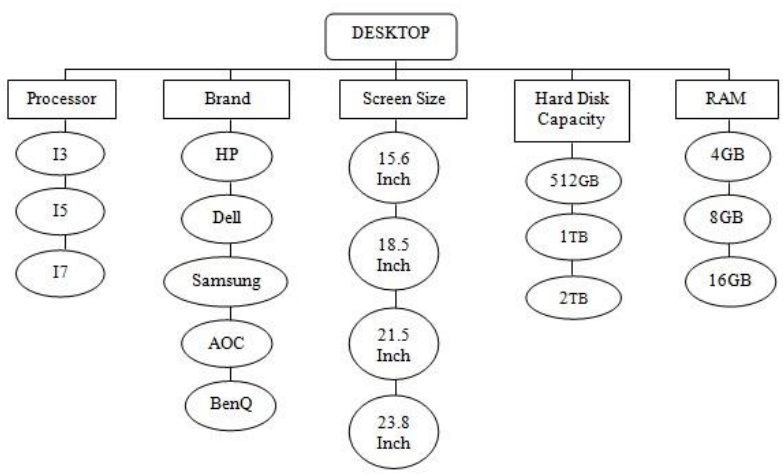

Fig 1. Hierarchy tree for desktop computer

Table 1: Saaty's pair wise comparison scale [2]

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

Table 2: Hwang and Yoon's pair wise comparison scale [3]

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

Table 3: 5 Desktop computer models available in the market

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

Table 4: Randomly Generated Consistency Index (RI) value according to the order of the matrix n [2]

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

III. Research Methodology

This section covers each and every calculation in detail. Each and every step of AHP and TOPSIS are shown below. For the present investigation 100 people have been surveyed to know their views about the relative preferences among the criteria (likeProcessor, Screen size, Hard disk capacity etc.) and also, among the sub-criteria (like 512GB, 1TB, 2TB hard disk capacity) within a criterion (i.e., hard disk capacity).

3.1. Table 5: Pair-wise comparison matrix of the main criteria

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	1.8762	5	18	14.3333	8.6667

According to the market survey a pair-wise comparison matrix is prepared and the summation of each columns is done as shown in Table 5.

3.2. Table 6: Weightage calculation of the pair-wise comparison matrix

Comparisons	Processor	Brand	Screen Size	Hard Disk Capacity	RAM	Row Average	Weight %
Processor	0.5330	0.6	0.2778	0.4884	0.5769	0.4952	49.52
Brand	0.1777	0.2	0.3333	0.2093	0.2308	0.2302	23.02
Screen Size	0.1066	0.0333	0.0556	0.0232	0.0385	0.0514	5.14
Hard Disk Capacity	0.0761	0.0667	0.1667	0.0698	0.0385	0.0835	8.35
Ram	0.1066	0.1	0.1667	0.2093	0.1154	0.1396	13.96
Total	1	1	1	1	1	1	100

Each of the elements in Table 5 is divided by their respective column sum such as (1/1.8762)=0.5330 to obtain all the elements in Table6.Now finding the average of each row in table 6 such as{(0.5330+0.6+0.2778+0.4884+0.5769)/5}=0.4952 and finding the weightage of each main criteria respectively. Graphical representation is shown in Fig 2.

3.3. Calculation of consistency for the main criteria

$$\begin{bmatrix} 1 & 3 & 5 & 7 & 5 \\ 1/3 & 1 & 6 & 3 & 2 \\ 1/5 & 1/6 & 1 & 1/3 & 1/3 \\ 1/7 & 1/3 & 3 & 1 & 1/3 \\ 1/5 & 1/2 & 3 & 3 & 1 \end{bmatrix} * \begin{bmatrix} 0.4952 \\ 0.2302 \\ 0.0514 \\ 0.0835 \\ 0.1396 \end{bmatrix} = \begin{bmatrix} 2.7258 \\ 1.2337 \\ 0.2632 \\ 0.4319 \\ 0.7587 \end{bmatrix} \Rightarrow \begin{Bmatrix} 2.7258/0.4952 \\ 1.2337/0.2302 \\ 0.2632/0.0514 \\ 0.4319/0.0835 \\ 0.7587/0.1396 \end{Bmatrix} = \begin{bmatrix} 5.5043 \\ 5.3591 \\ 5.1171 \\ 5.1696 \\ 5.4351 \end{bmatrix} \begin{matrix} \text{Processor} \\ \text{Brand} \\ \text{Screen size} \\ \text{Hard disk capacity} \\ \text{RAM} \end{matrix}$$

The pair-wise comparison matrix is multiplied with the row average matrix (priority vector matrix) and all the elements of the resultant matrix is further divided by their respective row average values to find out the consistencies of each and every elements of the main criteria. The resultant matrix found by multiplying the pair-wise decision matrix with the priority vector matrix is known as the weighted sum matrix. After finding all the consistency of each of the elements, average consistency (λ_{max}) is calculated by taking the averages of all the consistencies which is shown in the next section.

3.4. Table 7: Checking of Consistency

No of Comparisons (n)	5
Average Consistency (λ Max)	5.3170
Consistency Index (CI)	0.0793
Randomly Generated Consistency Index (RI)	1.12
Consistency Ratio (CR)	0.0708
Consistent	Yes

Average consistency (λ_{max}) = {(5.5043+5.3591+5.1171+5.1696+5.4351) / 5}
= 26.5852/5
= 5.3170

Consistency Index (CI) = (λ_{max} - n)/(n - 1)
= (5.3170 - 5)/(5 - 1)
= 0.0793

Since the number of comparisons is 5, so from Table 4, RI value corresponding to the number 5 is 1.12.

Consistency Ratio (CR) = CI/RI
= 0.0793/1.12
= 0.0708< 0.1

Since the consistency ratio (CR) value is less than 0.1,then the pair-wise comparison matrix is consistent and the judgements is true.

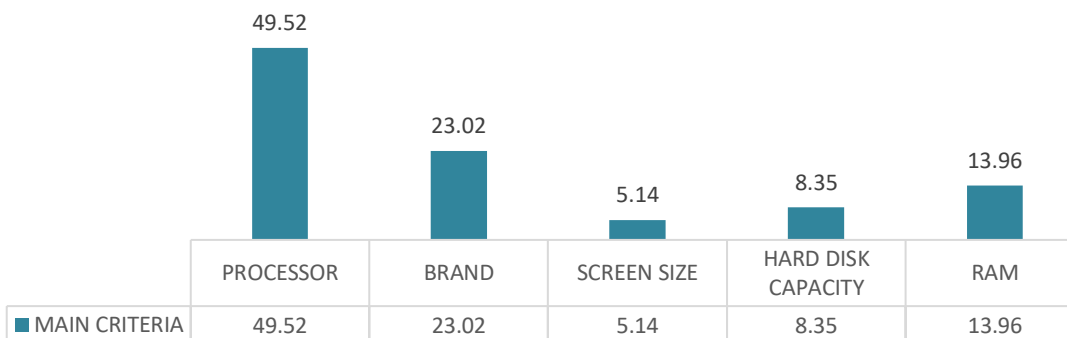

Fig 2. Graphical representation of the main criteria of desktop computer

Similarly, the weightages of all the sub-criteria are found out by following the same process like the main criteria and checking of consistency are also done for each of the sub-criteria. Summary of all the main-criteria and sub-criteria of the Desktop model are given below in Table 8.

3.5. Table 8: Summary of all the weightages of main criteria and sub-criteria

		Weight %		Weight %		Weight %		Weight %		Weight %
Main criteria	Processor	49.52	Brand	23.02	Screen Size	5.14	Hard Disk Capacity	8.35	RAM	13.96
Sub-criteria	I3	19.32	HP	48.96	15.6 Inch	26.33	512 GB	63.33	4GB	72.35
	I5	72.35	Dell	15.50	18.5 Inch	55.79	1TB	26.05	8GB	19.32
	I7	8.33	Samsung	27.49	21.5 Inch	12.19	2TB	10.62	16GB	8.33
			AOC	3.22	23.8 Inch	5.69				
			BenQ	4.82						

In the previous section all the weightages of the criteria and the alternatives are calculated by using AHP now applying TOPSIS to the above method.

3.6. Table 9: Elements of the decision matrix

Models	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Model1	4	7	1	1	3
Model2	4	5	3	5	7
Model3	7	4	9	9	7
Model4	3	9	9	5	2
Model5	7	1	5	5	7
Summation of The Square of Entire Column	139	172	197	157	160
Square Root of The Sum	11.7898	13.1149	14.0357	12.530	12.6491

Each elements of the Decision matrix are placed according to the weightages found by AHP (in the previous section) such as, in the processor column we can see that I5 is acquiring the highest priority (weightage) i.e.72.35% followed by I3 (19.32%) and I7 (8.33%). So I5 is allotted as 7 followed by I3 as 5 and I7 as 3. In this way all the elements are placed and the Decision matrix is created as shown in Table 9.
Squaring and adding all the elements of the entire column and finding the square root of each column.

e.g. $4^2+4^2+7^2+3^2+7^2 = 139$

$\sqrt{139} = 11.7898$

3.7. Table 10: Normalized values of the decision matrix

Model	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Weights	0.4952	0.2302	0.0514	0.0835	0.1396
Model1	0.3393	0.5337	0.0712	0.0798	0.2372
Model2	0.3393	0.3812	0.2137	0.3990	0.5534
Model3	0.5937	0.3050	0.6412	0.7183	0.5534
Model4	0.2544	0.6862	0.6412	0.3990	0.1581
Model5	0.5937	0.0762	0.3562	0.3990	0.5534

All the elements in Table 9 is divided by the square root of the sum of their respective column to obtain the Normalized values of the Decision matrix (Table 10).e.g. 4/11.7898 = 0.3393

3.8. Table 11: Weighted values of the decision matrix

Model	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Model1	0.1680	0.1229	**0.0037**	**0.0067**	0.0331
Model2	0.1680	0.0878	0.0110	0.0333	***0.0772***
Model3	***0.2940***	0.0702	***0.0330***	***0.0600***	***0.0772***
Model4	**0.1260**	***0.1580***	***0.0330***	0.0333	**0.0221**
Model5	***0.2940***	**0.0176**	0.0183	0.0333	***0.0772***

The weights are multiplied with each of the elements of the Normalized Decision matrix (Table 10) of their respective column to obtain the weighted values (Table 11). e.g. 0.4952*0.3393 =0.1680
Bold and itallics represents the largest number of each and every column.
Bold and underlined represents the smallest number of each and every column.

3.9. Table 12: Determining positive ideal solution

Model	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Model1	-0.1260	-0.0351	-0.0293	-0.0533	-0.0441
Model2	-0.1260	-0.0702	-0.0220	-0.0267	0
Model3	0	-0.0878	0	0	0
Model4	-0.1680	0	0	-0.0267	-0.0552
Model5	0	-0.1404	-0.0147	-0.0267	0

3.9.1. Table 13: Squaring the above elements

Model	Processor	Brand	Screen Size	Hard Disk Capacity	RAM	Summation of Row	Square Root (S^+)
Model1	0.0159	0.0012	0.0008	0.0028	0.0019	0.0228	0.1509
Model2	0.0159	0.0049	0.0005	0.0007	0	0.0220	0.1483

Model3	0	0.0077	0	0	0	0.0077	0.0878
Model4	0.0282	0	0	0.0007	0.0030	0.0320	0.1788
Model5	0	0.0197	0.0002	0.0007	0	0.0206	0.1437

The largest number of each column is subtracted from each and every elements of their respective column in Table 11 and thus obtaining all the values in Table 12. e.g. 0.1680 - ***0.2940 =***-0.1260
Squaring each and every elements of Table 12 and thus obtaining all the values inTable 13. All the rows of Table 13 are summed up and finding the square root of the sum for each and every row thus obtaining the Positive Ideal Solution (PIS).

e.g. $\sqrt{(0.0159 + 0.0012 + 0.0008 + 0.0028 + 0.0019)} = \sqrt{0.0228} = 0.1509$

3.10. Table 14: Determining negative ideal solution

Model	Processor	Brand	Screen Size	Hard Disk Capacity	RAM
Model1	0.0420	0.1053	0	0	0.0110
Model2	0.0420	0.0702	0.0073	0.0267	0.0552
Model3	0.1680	0.0527	0.0293	0.0533	0.0552
Model4	0	0.1404	0.0293	0.0267	0
Model5	0.1680	0	0.0147	0.0267	0.0552

3.10.1. Table 15: Squaring the above elements

Model	Processor	Brand	Screen Size	Hard Disk Capacity	RAM	Summation of Row	Square Root (S^-)
Model1	0.0018	0.0111	0	0	0.0001	0.0130	0.1139
Model2	0.0018	0.0049	0.00005	0.0007	0.0030	0.0105	0.1025
Model3	0.0282	0.0028	0.0008	0.0028	0.0030	0.0378	0.1943
Model4	0	0.0197	0.0008	0.0007	0	0.0213	0.1459
Model5	0.0282	0	0.0002	0.0007	0.0030	0.0322	0.1794

The smallest number of each column is subtracted from each and every elements of their respective column in Table 11 and thus obtaining all the values inTable 14. e.g. 0.1680 - **0.1260 =** 0.0420
Squaring each and every elements of Table 14 and thus obtaining all the values in Table 15. All the rows of Table 15 are summed up and finding the square root of the sum for each and every row thus obtaining the Negative Ideal Solution (NIS).

e.g. $\sqrt{(0.0018 + 0.0111 + 0 + 0 + 0.0001)} = \sqrt{0.0130} = 0.1139$

3.11. Table 16: Separation from Positive and Negative Ideal Solution

Positive Ideal Solution (PIS)		Negative Ideal Solution (NIS)	
S1+	0.1509	**S1-**	0.1139
S2+	0.1483	**S2-**	0.1025
S3+	0.0878	**S3-**	0.1943
S4+	0.1788	**S4-**	0.1459
S5+	0.1437	**S5-**	0.1794

From theoretical analysis under section II it is already known that the best choices should have the shortest geometric distances from PIS (Positive Ideal Solution) and longest geometric distances from NIS (Negative Ideal Solution). From Table 16 it can be seen that the Model 3 has the shortest distances i.e. 0.0878 from PIS and has the longest distances i.e. 0.1943 from NIS among the other models, So this model can be termed as the best model among these 5 alternatives but it is very difficult to predict the best choices from this two values and arrage them in sequence so this two values are combined together to a single value which is known as Relative Closeness Co-Efficient value which is shown in Table 17.

3.12. Table 17: Relative Closeness values

C*	Closeness Co-Efficient	Weightage %
C1* (Model-1 computer)	0.4302	43.02
C2*(Model-2 computer)	0.4086	40.86

C3*(Model-3 computer)	0.6888	68.88
C4*(Model-4 computer)	0.4493	44.93
C5* (Model-5 computer)	0.5553	55.53

Closeness Co-efficient is calculated by $C^* = S^-/(S^+ + S^-)$

$C1^* = S1^-/(S1^+ + S1^-)$ e.g. $C1^* = 0.1139/(0.1509+0.1139) = 0.4302$

IV. Results and Discussion

From Table 17 Relative Closeness Co-efficient value for each Desktop model is found out. Now arranging the models in decreasing order according to their Relative Closeness Co-efficient.

4.1. Table 18: Ranking of Desktop computer Models

C*	Closeness Co-Efficient	Weightage %	Ranking
C3* (Model-3 computer)	0.6888	68.88	Rank 1
C5* (Model-5 computer)	0.5553	55.53	Rank 2
C4* (Model-4 computer)	0.4493	44.93	Rank 3
C1* (Model-1 computer)	0.4302	43.02	Rank 4
C2* (Model-2 computer)	0.4086	40.86	Rank 5

Here we can see in Table 17 that the highest Relative Closeness Co-efficient value is for the MODEL 3 i.e. 68.88%. Hence Model 3 Desktop Computer comes out to be the best acceptable model by the integrated AHP-TOPSIS hybrid MCDM analysis based on actual market survey. The final ranking is shown in Table 18 and also in Fig 3.

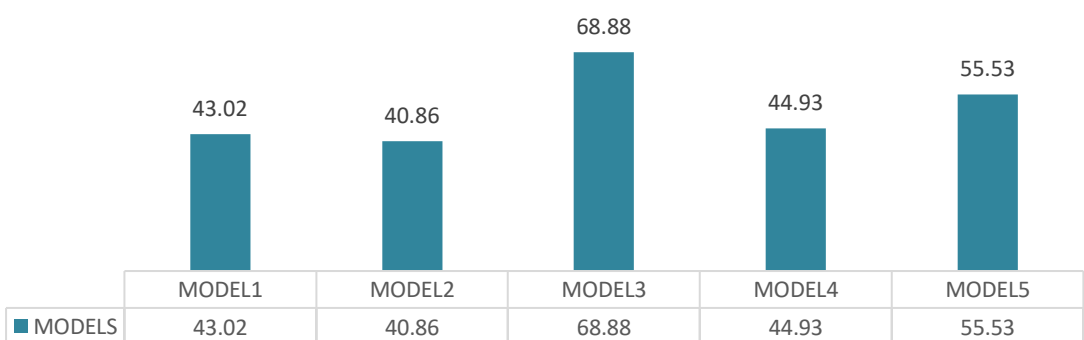

Fig 3. Graphical representation of the Relative Closeness Co-efficient values of Desktop Models

The present analysis to find out the acceptable ranking of available Desktop computers by using AHP-TOPSIS hybrid methodology based on market survey helps prospective customers to take proper decision in selecting Desktop model and also survey as a guide to the Desktop manufacturing companies to frame their future market strategy.

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