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A New Topsis Method Based Mutual Information for Mobile Phone Selection

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Abstract
Information knowledge and telecommunication manufacture are going through most important changes newly with the access of mobile phones. The present learn propose a multi-criteria decision making (MCDM) setting to judge various mobile phone alternative based on customer desire Gülçin Büyüközkan. This study wishes for build up an approach based on entropy technique for order performance by similarity to ideal solution (TOPSIS) for ranking suitable mobile phone choice. The uniqueness of the document appears from its talent to offer an effectual evaluation of mobile phone selection with for the first time.
Used for indicating the capability of this method, an example is given to select the most suitable phone for clients.

Keywords: Entropy, Mobile Phone Selection, TOPSIS

1. Introduction
In the late 1980ies, the mobile phone technology has been built and commenced, and from the time when it has known a fast and extensive development. The increase of the technology has engendered a turn down of mobile phone prices, providing improved right to use for the masses. Tag on a wider buyer base, manufacturers have going ahead to well again react to buyer expectations [8] and appear among a variety of designs and features to deal with diverse desires in the market, associated to social and financial segmentation of the market. Customers are being obtainable with a variety of mobile phones in a particular price group and the selection of a mobile phone grow to be a key problem [6]. Below these conditions, selecting the mainly suitable telephone can be considered as a complex multi-criteria decision problem. This works aims to offer a decision method in favour of mobile phone selection.
Multi-criteria decision making (MCDM) support with providing the mainly appropriate alternative with a large set of alternatives, where many dissimilar decision criteria require to be respected simultaneously. In the present work, the recommended method employs the technique for order performance by similarity to ideal solution based on entropy for the told ambition. The basic philosophy of TOPSIS [2] is an attractive MCDM technique that deal with the positive and negative ideal solution for achieving decision problems [1-5]. In MCDM, different criteria must be evaluated in the goal to get an only alternative.
The present research is planned as succeeding plan; the next section describes briefly multiple criteria decision making. Section 3 administrate a full description of the methodology employed. Section 4 present the techniques used in our study which is Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Section 5 offer a numerical example to demonstrate the application of the recommended arrangement. Conclusions are accessible inside section 6.

2. Multiple Criteria Decision Making
Multiple-criteria decision-making (MCDM) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision-making. MCDM has been developed since 1970s. A decision-making problem is the process of finding the best option from all of the feasible alternatives. In almost all such problems the multiplicity of criteria for judging the alternatives is pervasive. That is, for many such problems, the decision maker wants to solve a multiple criteria decision making (MCDM) problem. A MCDM problem can be concisely expressed in matrix format as:

3. Methodology
In our study, we adopt a process based in two-step. In the first one concept of entropy was used to find out the criteria weight.

Entropy is a term in information theory, also known as the average amount of information [4]. The Entropy Method calculates the criteria weights. According to the degree of index dispersion, the weight of all indicators is calculated by information entropy. Entropy method is highly reliable and can be easily adopted in information measurement [10]. In the second step the Technique for order preference by similarity to ideal solution TOPSIS. This technique was initially developed by Hwang and Yoon (1981), subsequently discussed by many [9, 3]. TOPSIS finds the best alternatives by minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative-ideal solution (Jahanshahloo & *et al*., 2006) [7]. All alternative solutions can be ranked according to their closeness to the ideal solution. Because its first introduction, a number of extensions and variations of TOPSIS have been developed over the years.

The process can be presented as follow:

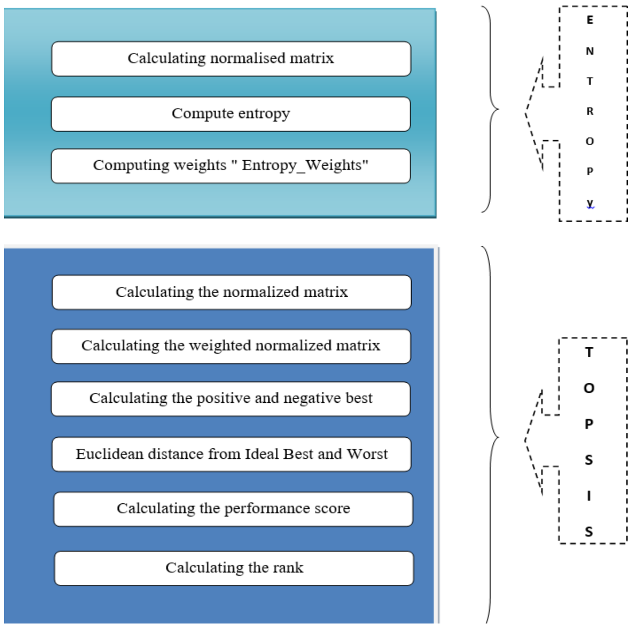

Fig 1: The processing methodology

4. The TOPSIS method

Technique for order preference by similarity to ideal solution TOPSIS was initially developed by Hwang and Yoon (1981), subsequently discussed by many [9, 3]. TOPSIS finds the best alternatives by minimizing the distance to the ideal solution and maximizing the distance to the nadir or negative-ideal solution [7]. All alternative solutions can be ranked according to their closeness to the ideal solution. Because its first introduction, a number of extensions and variations of TOPSIS have been developed over the years. General TOPSIS process with six steps is listed below:

Step 1: Entropy Method for Weight Determination:

- In matrix B, feature weight p_{ij} is of the ith alternatives to the jth factor:

$$p_{ij} = X_{ij} / \sum_{i=1}^{m} X_{ij} \qquad (1 \le i \le m, i \le j \le n)$$

- The output entropy e_j of the jth factor becomes

$$e_j = -k / \sum_{i=1}^{m} p_{ij} \ln p_{ij} \qquad (k = 1/\ln m; 1 \le j \le n)$$

- Variation coefficient of the jth factor: g_j can be defined by the following equation:

$$d_j = 1 - e_j \qquad (1 \le j \le n)$$

Note that the larger gj is the higher the weight should be.

- Calculate the weight of entropy α_j :

$$w_j = g_j / \sum_{i=1}^{m} g_j \qquad (1 \le j \le n)$$

- Calculate the adjusted weight β_j

$$\beta_j = \lambda_j w_j / \sum_{i=1}^{n} \lambda_j w_j$$

Step 2: TOPSIS for ranking alternatives:

- Calculate the normalized decision matrix A. The normalized value a_{ij} is calculated as;

$$a_{ij} = x_{ij} / \sqrt{\sum_{i=1}^{m} (x_{ij})^2} \qquad (1 \le i \le m, 1 \le j \le n)$$

- Calculate the weighted normalized decision matrix

$$V = (a_{ij} * w_j) \qquad (1 \le i \le m, 1 \le j \le n)$$

- Calculate the positive ideal solution V + and the negative ideal solution V –

$$V^{+} = \{V_1^{+}, V_2^{+}, \ldots, V_n^{+}\} = \{(Max \; v_{ij} \setminus j \in J), (Min \; v_{ij} \setminus j \in J)\}$$

$$V^{-} = \{V_1^{-}, V_2^{-}, \ldots, V_n^{-}\} = \{(Min \; v_{ij} \setminus j \in J), (Max \; v_{ij} \setminus j \in J)\}$$

- Calculate the separation measures, using the m-dimensional Euclidean distance

$$S_i^{+} = \sqrt{\sum_{i=1}^{n} (v_{ij} - V^{+})^2} \qquad (1 \le i \le m, 1 \le j \le n)$$

$$S_i^{-} = \sqrt{\sum_{i=1}^{n} (v_{ij} - V^{-})^2} \qquad (1 \le i \le m, 1 \le j \le n)$$

- Calculate the relative closeness to the ideal solution

$$Y_i = \frac{S_i^{-}}{S_i^{+} + S_i^{-}} \qquad (1 \le i \le m)$$

Where $Y_i \in \{0,1\}$. The larger Y_i is, the closer the alternative is to the ideal solution.

- Rank the alternatives according Y_i

5. Numerical example

Mobile phone consumers order of ranking mobile phone specification are; price 13.4%, camera and operating system (OS) 11.97%, battery 8.97%, screen size 7.71%, RAM, speed, and CPU 7.07%, Bluetooth 6.59% and weight, memory, and dimensions 6.06% this was obtained through random selection of mobile phone consumers.

Table 1: Order of ranking mobile phone specification (%)

	Initial relative weights											
	Dimensions (mm)	Weight (g)	Screen Size (inc)	Memory (GB)	RAM (GB)	Speed (mbps)	Blue touth	Camera (MP)	OS (Honey comb)	CPU (GHz)	Battery (mAh)	Price (S)
W	6.06	6.06	7.71	6.06	7.07	7.07	6.59	11.97	11.97	7.07	8.97	13.4

Mobile phone consumer way of ranking mobile phone specification is subjective; entropy analysis can be applied to smooth this subjectivity. During the TOPSIS analysis these assumptions were made for mobile phone specification for dimension the bigger the better, for weight the lighter the better and price the cheaper the better whiles the rest of the mobile phone specifications the higher (speed, Bluetooth, CPU, operating System (OS), and camera), bigger (RAM, memory and screen size) and longer (battery) the better. TOPSIS analysis selected the best mobile phone with the best mobile phone specification.

Table 2: Qualification of 10 dissimilar mobile phones offered in the mobile phone market

	Criterias											
	Dimensions (mm)	Weight (g)	Screen Size (Inc)	Memory (GB)	RAM (GB)	Speed (Mbps)	Blue Touth	Camera (MP)	OS (Honey comb)	CPU (GHz)	Battery (mAh)	Price (S)
Phone 1	86341.0625	135	3.9	128	4	5.7	2.1	8	1.2	1	2537	698
Phone 2	115758.15	170.1	4.3	64	4	3.1	3	8	2.4	1.5	2836	719
Phone 3	270216	390	8.2	64	4	5.76	2.1	5	3.2	1.2	6930	529.99
Phone 4	81884.005	135	4.65	64	4	5.76	3	5	4	1.2	3062	725
Phone 5	75031.25	110	3.8	64	2	2.9	3	5	2.4	1	2625	359.99
Phone 6	71940	90	2.44	64	2	3.1	2.1	5	7	0.8	1750	479.99
Phone 7	62781.696	140	3.5	128	2	5.8	4	8	5	1	2506	870
Phone 8	68512.5	117	4.2	64	2	5.8	2.1	8	2.4	1.4	2625	420
Phone 9	80638.65	141.8	4	64	2	5.76	2.1	8	2.2	1	2625	529
Phone 10	115584	130	4.3	64	2	7.2	2.1	5	2.2	1	2240	679.99

In this study, we give weight of 1 for the beneficial criteria and we give weight of 0 the disadvantageous criteria. We assume that both weight (g) and price are disadvantageous criteria and all other criteria are beneficial. The next table recapitulate this indication.

Table 3: Weighting of advantageous and disadvantageous criteria

	Weighting Criteria											
	Dimensions (mm)	Weight (g)	Screen Size (Inc)	Memory (GB)	RAM (GB)	Speed (mbps)	Blue Touth	Camera (MP)	OS (Honey comb)	CPU (GHz)	Battery (mAh)	Price (S)
Wcriteria	1	0	1	1	1	1	1	1	1	1	1	0

6. Computational Results

The hybrid entropy and TOPSIS methods made it more helpful for the decision maker to calculate the performances of several phones category. MATLAB was employed for the two parts of the proposed model. In the first part, MATLAB was used to calculate entropy weights that are presented in Table 4.

Table 4: Entropy weights

Entropy_Weights											
Dimensions (mm)	Weight (g)	Screen Size (Inc)	Memory (GB)	RAM (GB)	Speed (mbps)	Blue Touth	Camera (MP)	OS (Honey Comb)	CPU (GHz)	Battery (mAh)	Price (S)
0.169	0.141	0.064	0.067	0.082	0.057	0.038	0.037	0.159	0.022	0.113	0.045

And in the second part, MATLAB was used to calculate to calculate the score performance and rank various alternatives.

In Table 5, we show the normalized values that were calculated.

Table 5: The normalized decision matrix

	Normalized_Matrix											
	Dimensions (mm)	Weight (g)	Screen Size (inc)	Memory (GB)	RAM (GB)	Speed (Mbps)	Blue Touth	Camera (MP)	OS (Honey Comb)	CPU (GHz)	Battery (mAh)	Price (S)
Phone 1	0.230	0.243	0.270	0.500	0.426	0.341	0.251	0.379	0.105	0.280	0.245	0.355
Phone 2	0.309	0.306	0.298	0.250	0.426	0.185	0.359	0.379	0.211	0.420	0.274	0.366
Phone 3	0.722	0.702	0.569	0.250	0.426	0.344	0.251	0.237	0.282	0.336	0.670	0.270
Phone 4	0.218	0.243	0.322	0.250	0.426	0.344	0.359	0.237	0.352	0.336	0.296	0.369
Phone 5	0.200	0.198	0.263	0.250	0.213	0.173	0.359	0.237	0.211	0.280	0.253	0.183
Phone 6	0.192	0.162	0.169	0.250	0.213	0.185	0.251	0.237	0.617	0.224	0.169	0.244
Phone 7	0.167	0.252	0.243	0.500	0.213	0.347	0.479	0.379	0.440	0.280	0.242	0.443
Phone 8	0.183	0.210	0.291	0.250	0.213	0.347	0.251	0.379	0.211	0.392	0.253	0.214

Phone 9	0.215	0.255	0.277	0.250	0.213	0.344	0.251	0.379	0.193	0.280	0.253	0.269
Phone 10	0.309	0.234	0.298	0.250	0.213	0.431	0.251	0.237	0.193	0.280	0.216	0.346

Afterwards, the normalized values were included to find out the weighted normalized decision matrix. The results are exposed in Table 6.

Table 6: The weighted normalized decision matrix

	Weighted_Normalized_Matrix											
	Dimensions (mm)	Weight (g)	Screen Size (inc)	Memory (GB)	Ram (GB)	Speed (mbps)	Blue Touth	Camera (MP)	OS (Honey Comb)	CPU (GHz)	Battery (mAh)	Price (S)
Phone 1	0.039	0.034	0.017	0.033	0.035	0.019	0.009	0.014	0.016	0.006	0.027	0.016
Phone 2	0.052	0.043	0.019	0.016	0.035	0.010	0.013	0.014	0.033	0.009	0.031	0.016
Phone 3	0.012	0.122	0.099	0.036	0.016	0.035	0.019	0.009	0.008	0.045	0.007	0.076
Phone 4	0.037	0.034	0.020	0.016	0.035	0.019	0.013	0.008	0.056	0.007	0.033	0.016
Phone 5	0.034	0.028	0.017	0.016	0.017	0.009	0.013	0.008	0.033	0.006	0.028	0.008
Phone 6	0.032	0.023	0.010	0.016	0.017	0.010	0.009	0.008	0.098	0.005	0.019	0.011
Phone 7	0.028	0.035	0.015	0.033	0.017	0.019	0.018	0.014	0.070	0.006	0.027	0.020
Phone 8	0.031	0.029	0.018	0.016	0.017	0.019	0.009	0.014	0.033	0.008	0.028	0.009
Phone 9	0.036	0.036	0.017	0.016	0.017	0.019	0.009	0.014	0.0310	0.006	0.028	0.012
Phone 10	0.052	0.033	0.019	0.016	0.017	0.024	0.009	0.008	0.0310	0.006	0.024	0.015

Subsequent to calculate the weighted normalized decision matrix, the positive and negative ideal solutions were calculated**,** results are accessible in Tables 7 and 8 correspondingly.

Table 7: The positive ideal solution

Positive_best											
Dimensions (mm)	Weight (g)	Screen Size (inc)	Memory (GB)	RAM (GB)	Speed (mbps)	Blue touth	Camera (MP)	OS (Honey comb)	CPU (GHz)	Battery (mAh)	Price (S)
0.122	0.023	0.036	0.033	0.035	0.024	0.018	0.014	0.098	0.009	0.076	0.008

Table 8: The negative ideal solution

Negative_best											
Dimensions (mm)	Weight (g)	Screen Size (inc)	Memory (GB)	RAM (GB)	Speed (mbps)	Blue Touth	Camera (MP)	OS (Honey comb)	CPU (GHz)	Battery (mAh)	Price (S)
0.028	0.099	0.010	0.016	0.017	0.009	0.009	0.008	0.016	0.005	0.019	0.020

The global performance of each phone type is identified by the closeness coefficient shown in Table 9.

Table 9: The closeness coefficient

Performance_Score	
Phone	SC
Phone 1	0.358
Phone 2	0.378
Phone 3	0.552
Phone 4	0.429
Phone 5	0.377
Phone 6	0.497
Phone 7	0.431
Phone 8	0.371
Phone 9	0.353
Phone 10	0.391

According to these results, ranks of diverse phone category are accessible in Table 10.

Table 10: Ranks of diverse phone category

Rank	
Phone	Rank
Phone 1	9
Phone 2	6
Phone 3	1
Phone 4	4
Phone 5	7
Phone 6	2
Phone 7	3
Phone 8	8
Phone 9	10
Phone 10	5

These outcomes mean that mobile phone 3 is the best alternative followed by phone 6, phone 7, phone 4, phone 10, phone 2, phone 5, phone 8, phone1 and phone 9 in this order. We notice that the best mobile phone has the biggest screen size.

Mobile phone consumer way of ranking mobile phone specification is subjective; entropy analysis can be applied to smooth this subjectivity so random weight make price the most important criteria but in reality screen size it's the most important one.

TOPSIS examination choose the best mobile phone through all the best mobile phone specifications.

7. Conclusion

The key aim of this work is to recognize the most appropriate mobile phone alternative by considering different decision criteria and customer preferences into account. Assessment of mobile phone options contain subjective and qualitative judgments and necessitate diverse difficult factors. For this reason, the assessment problem needs MCDM methods to perfectly choose the most appropriate mobile phone alternative.

Entropy and TOPSIS investigation can support purchaser in building the correct decision. Results from Entropy and

TOPSIS study are objective and precise, eliminating subjective weighting of specification. With this tool, a client is able to buy the most excellent mobile phone whiles construct of mobiles phones can make mobile with exclusive technological characteristics designed at particular customer.

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