Indian J.Sci.Res. 17(2): 22-31, 2017

ISSN: 0976-2876 (Print)
ISSN: 2250-0138(Online)

FEATURE BASED SELECTION OF CELL PHONE: AN INTEGRATED APPROACH

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Abstract - In past three decades, the mobile phone has received a worldwide acceptance because of its rapid and extensive growth in the domain of communication and information technology. Thus, now a days, the cell phone has been become a ubiquitous communication device and it is need of the time. The total number of mobile phone subscriptions has crossed the world population. In order to attract maximum number of the consumers, the companies throw tremendous number of handsets every so often in the market and a huge competition among the companies to develop different and cheap products. In such a marketing environment, the selection of a mobile phone has been become a tardy and irritating task for the consumer who want to choose a most suitable mobile phone for her/himself within a defined price range and specification. The aim of this paper is to overcome such a tardy job and purpose a multi-criteria decision making (MCDM) approach for evaluating the cellphone options in respect to the users' preference order. The analysis approach comprises of KANO model for feature selection based on the consumer behavior and their satisfaction. The evaluation of attributes is done by using two MCDM techniques. In more precisely, Fuzzy Analytic Hierarchy Process (FAHP) is applied to determine the relative weights of the features and the rank of the various mobile phone alternatives is determined by an extension of Technique for Order Preference by Similarity to Ideal Solution (M-TOPSIS).

Keywords - Cell phone selection, Fuzzy-AHP, Kano Model, M-TOPSIS, MCDM techniques.

I. Introduction

The cell phone is a globally pervasive electronic gadget and communication device because of its need as well as helplessness by the time of development of communication systems and technology. By the late 1980s, with the launch of the first GSM phone, the mobile phones have shown a swift evolution as the generations develop. Its birth combined with its rapid and widespread acceptance can be considered as one of the most significant developments in the communication history context and in information technology over the past three decades. The number of mobile cellular subscriptions worldwide is approaching to the world population. Mobile cellular subscriptions reached near about 7 billion at the end of 2014, with a penetration rate of 96%. More than half of these (3.6 billion subscriptions) will be in the Asia-Pacific region. In developing countries, mobile-cellular penetration will reach 90% by the end 2014, as compared to 121% in developed countries. Mobile-cellular growth rates have reached their lowest-ever level (of 2.6% globally), indicating that the market is approaching to saturation level. The continuous increase in mobile-cellular subscriptions is mostly due to growth in the developing world: penetration in developing countries ongoing to grow twice as much as in developed countries (3.1% compared with 1.5%, respectively, in 2014), (ICT 2014).

In India total wireless subscriber base increased to 960.58 million at the end of February, 2015 from 952.34 million at the end of January, 2015; thereby registering a monthly growth rate of 0.86%.The shares of urban and rural wireless subscribers were 58.01% and 41.99% respectively at the end of February, 2015. The Wireless Tele-density in India increased from 76.02% of the total population at the end of January, 2015 to 76.60% at the end of February. The phones in the market will make an impact only with added features with the young and upwardly mobile generation.

In order to address to the maximum number of consumer in the society, companies throw different types of handsets every so often on the market. The large scale of the products on the market reflects the social and financial status of buyer, moreover their preferences and their attitudes towards usage of them. In such a market environment, a mobile phone selection becomes an important problem for a consumer who wants to choose the most appropriate handset for her/himself even though she/he is interested in telephones in a fixed range of price [20]. With such ideas in mind, the mobile phone selection can be considered as a complex multi-criteria decision problem. The main objective of this study is to propose a mechanism to decide on the most suitable mobile phone in the marketplace for consumer.

The proposed approach in our study incorporates, Kano model for criteria selection and categorization, fuzzy AHP for evaluation of the weight of each criteria and M-TOPSIS for rank prioritization of different models of cellphone.

The paper has been organized as follows: Section 2 briefly revises the literature related to cellphone studies,

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consumer behavior and customer satisfaction, and the main requirements of multi-criteria decision making methods used in this context. Section 3 presents some fundamental concepts regarding KANO model, fuzzy set theory, the methods Fuzzy AHP and M-TOPSIS. Section 4 presents the results and discussion of this research. Finally, conclusions about this research work and suggestions for further research are made in Section 5.

II. Literature review

It is imperative and significant for companies to understand how consumers go about choosing between products or alternatives [17]. According to [14] a product is anything that can be offered to a market to suffice a want or need, including services, experiences, events, information, physical goods and ideas etc. [20] declared that a product is any tangible and intangible thing that satisfies a need of customers or users. By definition, consumer behavior is "the decision process and physical activity individuals engage in when evaluating, acquiring, disposing or using of goods and services" [16]. According to [4] consumer behavior involves; how consumers buy, what they buy, why they buy, and when they buy. Various studies on consumer behavior regarding consumers as key determinants of organizational success and it have been found that the most successful organizations are those that are customer-centered.

Adding new features to the mobile phone has been common in the phone industry. Knowing the features that customers prefer ought to be of special interest for the mobile phone marketers and manufacturers. But according to [19], it is not always noticeable that adding new features will upgrade the product evaluation. Prior research has found out that adding new features might enhance product evaluations regarding low-complexity products, but the opposite might be the case for high-complexity products due to the negative learning cost inferences related to the new features, and also that this can in fact persist even if the consumers are given explicit information about the new features.

In his study of [8] constructs a performance evaluation process for airlines by use of TOPSIS method. The aim of the study is to propose two Fuzzy-MCDM methods are proposed for solving the MCDM problem: Fuzzy Analytic Hierarchy Process (FAHP) has been applied to determine the relative weights of the evaluation criteria and the extension of the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) is applied to rank the alternatives.

A number of articles have been reported in literature on the study of cellphone features, design attributes, and customer satisfaction for a product that includes the mathematical model and other solving techniques. As stated in various literature selection of cell phone has been considered as MCDM problem, in the present work also. A construct of seven criteria and 24 sub-criteria have been selected for evaluation. A Kano model, Fuzzy AHP and M-TOPSIS techniques have been used for evaluation of the problem.

III. Proposed methodology

In this process, first of all, seven criteria and 24 sub-criteria have been selected for evaluation. A Kano model based on questionnaire has been made for criteria classification and the responses of experts/consumers related to cell phone have been collected.

On the basis of these responses, finally we knew about the categories of features. After Kano classification, weights of each criterion have been calculated. For weight calculation, fuzzy responses have been taken from the experts and decision makers and then fuzzy AHP technique has been applied. After calculating the weight of each criterion, M-TOPSIS technique has been used for prioritizing the different models of cell phone in a fixed range of price, with the help of weights of criteria that have been calculated earlier by fuzzy AHP technique. Flowchart of the proposed technique has been given in Fig. 1.

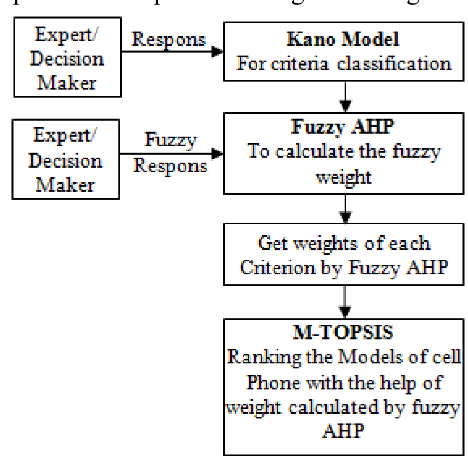

Figure 1. Proposed Technique

A. KANO Model

The customer is usually not able to accurately specify the desired product attributes in the real buying situation. With a simple questionnaire, only the tip of the iceberg and not the real needs of the customer are often identified [18]. Therefore a methodical support is important to identify which product criteria or attributes create more satisfaction than others [6]. A method that is capable to identify the core of the customer requirements is Kano method [5]. The Kano model was first developed in 1984 by Dr. Noriaki Kano and his colleagues [13] to categorize the attributes of a product or service, based on how well they are capable to satisfy customers' needs. Based on theoretical foundations a two-dimensional model of quality attributes has been presented.

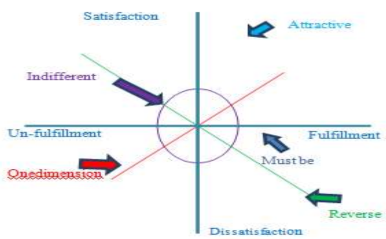

Figure 2. Kano Model

Fig. 2 shows, the extent to which a quality element is provided to indicate on the X-axis. If the arrow moves more towards the right, the extent of the quality element provided is greater, while the arrow moves more towards the left, the less the extent to which the quality element is provided. On the Y-axis the customer satisfaction is indicated. The higher the arrow, the higher the customer satisfaction, while the lower the arrow, the higher the customer dissatisfaction. Based on these axes, the Kano model classifies product criteria into distinct categories. Each quality category affects customers in a different way.

The different quality elements of the theory of attractive quality are as follows: [2], [8],[13].

1. Must-be requirements (M): must-be requirements are a decisive competitive factor, and the customer will be extremely dissatisfied if they are not fulfilled, and will not be interested in the product at all. On the other hand, as the customer takes these requirements for granted, their fulfillment will not increase satisfaction level significantly.

2. One-dimensional requirements (O): in this category of requirements, the customer satisfaction is proportional to the level of fulfillment of need, the higher the customer's satisfaction with the higher the level of fulfillment, and vice versa. One-dimensional requirements are generally clearly demanded by the customer.

3. Attractive requirements (A): these requirements are the product criteria having the greatest influence on how satisfied a customer with a given product or service. Attractive requirements are neither explicitly expressed nor expected by the customer. Fulfilling theserequirements may lead to more than proportional satisfaction. However, there is no feeling of dissatisfaction if they are not met.

4. Indifferent requirements (I): this category means that the customer is not much interested in this product or service, whether it is present or not.

5. Reverse requirements (R): this means that, the customers not desire that attribute of product, but they also expect the reverse of it.

6. Questionable requirements (Q): this rating indicates that either the customer misunderstood the question, or an illogical response was given, or the question was phrased incorrectly.

B. Ressult of KANO

The customer satisfaction coefficients are plotted in Fig 4.

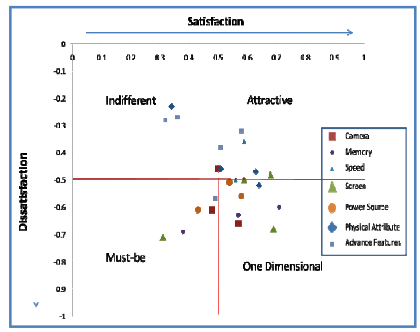

Figure 4. Customre Satisfaction Coefficient (Graphical Representation)

The diagram can be approximately divided into four quadrants according to the four types of requirements. Each criterion is represented through a particular geometric notation. A sub-criteria represented by a particular notation can be identified in the Fig. 4 through its corresponding

numeric value in Table.1. According to Fig. 4, the corresponding sub-criteria of a particular criterion are fairly distributed in different quadrants, hence in our framework the chosen features/attribute are perfectly unbiased. According to the Fig. 5, in study it has been observed that some attribute in Indifferent category at their initial time but later it change the

position, and overall it makes a cycle after passing time. Some attribute always in the category of must be e.g. Making Call. If we see the example of NFC or HDMI, are in Indifferent category and it may be come in attractive or must be in future time, it all depend on costumer requirement and their satisfaction.

Table.1. Summary of KANO Model questionnaire results

Features / Attribute	A	M	O	R	Q	I	Total	Grade	SI	DI
CA1 - Front Camera (MP)	28	**41**	18	0	0	9	96	**M**	0.48	-0.61
CA2 - Main Camera Resolution (MP)	19	27	**36**	0	0	14	96	**O**	0.57	-0.66
CA3 - Supports HD Video Recording (px)	**27**	23	20	1	1	24	96	**A**	0.50	-0.46
SC1 - Touch screen	16	**54**	14	0	0	12	96	**M**	0.31	-0.71
SC2 – Screen Size (inches)	**37**	19	26	3	0	11	96	**A**	0.68	-0.48
SC3 - Screen Resolution (px)	24	23	**42**	0	0	7	96	**O**	0.69	-0.68
SC4 - Gorilla Glass	**34**	25	23	0	0	14	96	**A**	0.59	-0.50
ME1 - Internal Memory (GB)	27	17	**41**	0	0	11	96	**O**	0.71	-0.60
ME2 - Expandable memory	19	**49**	17	0	1	10	96	**M**	0.38	-0.69
ME3 - RAM Size (GB)	21	26	**34**	0	0	15	96	**O**	0.57	-0.63
SP1 - Advance CPU (GHz)	**29**	23	25	0	0	19	96	**A**	0.56	-0.50
SP2 - Download Speed	**36**	15	19	2	0	24	96	**A**	0.59	-0.36
PS1 -Battery Talk Time (minutes)	**29**	26	22	0	1	18	96	**A**	0.54	-0.51
PS2 - Removable Battery	14	**30**	25	6	0	21	96	**M**	0.43	-0.61
PS3 - Battery Capacity (mAH)	24	22	**32**	0	0	18	96	**O**	0.58	-0.56
AF1 - OS updates (Version)	**38**	13	17	1	0	27	96	**A**	0.58	-0.32
AF2 - NFC (Near Field Communication)	22	14	11	1	3	**45**	96	**I**	0.36	-0.27
AF3 - DLNA	**32**	20	16	0	1	27	96	**A**	0.51	-0.38
AF4 - Dual SIM	28	**36**	19	0	0	13	96	**M**	0.49	-0.57
AF5 - HDMI Support	19	16	10	1	3	**47**	96	**I**	0.32	-0.28
MD1 - Light Weight (grams)	29	18	**31**	2	0	16	96	**O**	0.64	-0.52
MD2 - Slim Size (mm)	**34**	19	24	3	1	15	96	**A**	0.63	-0.47
MD3 - Sleek Design	25	15	6	2	2	**46**	96	**I**	0.34	-0.23
MD4 - Water Proof (meters & time)	**33**	28	16	0	0	19	96	**A**	0.51	-0.46

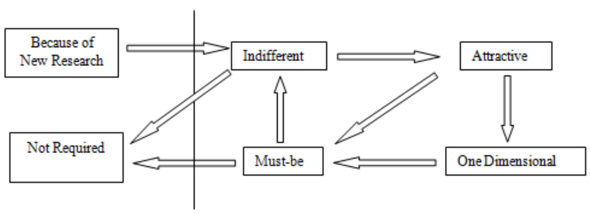

Fig. 5 category change cycle of Kano

C. Fuzzy AHP

The analytic hierarchy process (AHP) pioneered in 1971is one of the extensively used Multi Criteria Decision Making methods to determine the priorities among different criteria and comparing alternatives for each criterion. It is also used for modeling unstructured problems in the areas such as political, management sciences, social, and economic. Based on the pair-by-pair comparison values for a set of objects, AHP is applied to extracta corresponding priority vector that represents preferences in criteria's. The AHP method creates and deals with a very unbalanced scale of judgment,. A fuzzy AHP problem was first presented in 1980 by [7]. The fuzzy AHP approach allows a more accurate description of the decision-making process [3]. The fuzzy AHP method can be applied in many different areas in decision-making process because of its accuracy. This was oriented to the rationality of uncertainty due to vagueness or imprecision.

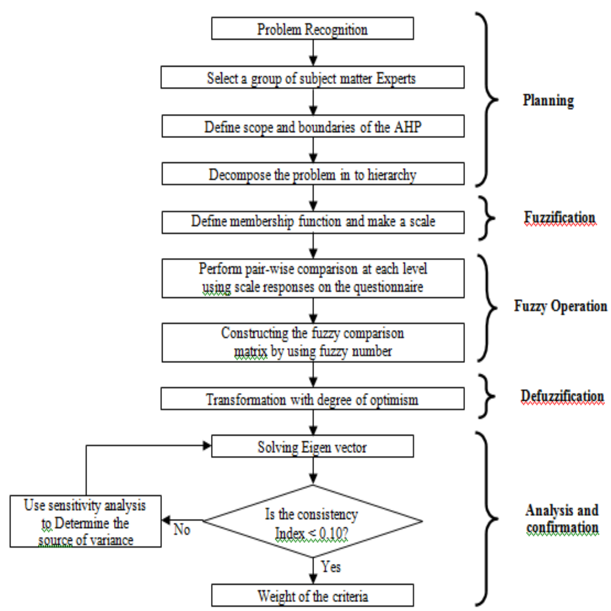

Fig. 6 Flowchart of Fuzzy AHP Procedure

A major contribution of fuzzy set theory is its capacity of representing vague data. Fuzzy set theory implements classes or groupings of data with boundaries that are not sharply defined (i.e. fuzzy). Accordingly, linguistic variables are a critical aspect of some fuzzy logic applications, where general terms such a "large," "medium," and "small" are eachused to capture a range ofnumerical values. A fuzzy set is defined by a membership function and all the information about a fuzzy set is described by its membership function. In the fuzzy AHP triangular fuzzy numbers are utilized to improve the scaling scheme in the judgment or procedure of this the approach is shown in Fig. 6:

D. Fuzzy AHP Methodology

Step 1: Constructing the fuzzy comparison matrix: By using triangular fuzzy numbers, with pair wise comparison, the fuzzy judgment matrix $\tilde{A}$ (a_{ij}) is constructed as equation;

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \tilde{a}_{13} & \cdots & \tilde{a}_{1(n-1)} & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \tilde{a}_{23} & \cdots & \tilde{a}_{2(n-1)} & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \cdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ \tilde{a}_{(n-1)1} & \tilde{a}_{(n-1)2} & \tilde{a}_{(n-1)3} & \cdots & 1 & \tilde{a}_{(n-1)n} \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \tilde{a}_{n3} & \cdots & \tilde{a}_{n(n-1)} & 1 \end{bmatrix}$$

$$\tilde{a}_{ij} = \begin{cases} 1 & i = j \\ \tilde{1},\tilde{2},\tilde{3},\tilde{4},\tilde{5},\tilde{6},\tilde{7},\tilde{8},\tilde{9} \text{ etc.} & i \neq j \end{cases}$$

Where

Step 2: Estimating the degree of optimism for $\tilde{A}$

Degree of satisfaction for the judgment matrix $\tilde{A}$ is estimated by the α-cut value and index of optimism μ.

$$\hat{a}_{ij}^{\alpha} = \mu a_{iju}^{\alpha} + (1-\mu)\mu a_{ijl}^{\alpha} \ \forall \mu \in [0,\ 1]$$

$$\tilde{A} = \begin{bmatrix} 1 & \hat{a}_{12}^{\alpha} & \cdots & \hat{a}_{1n}^{\alpha} \\ \hat{a}_{21}^{\alpha} & 1 & \cdots & \hat{a}_{2n}^{\alpha} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{a}_{n1}^{\alpha} & \hat{a}_{n2}^{\alpha} & \cdots & 1 \end{bmatrix}$$

Step 3: Solving fuzzy Eigen value.

A fuzzy Eigen value, λ is a fuzzy number solution to

$$\tilde{A}\tilde{x} = \tilde{\lambda}\tilde{x}$$

Where is $\tilde{A}$ n × n fuzzy matrix containing fuzzy numbers $\tilde{a}_{ij}$ and $\tilde{x}$ is a non-zero n×1, fuzzy vector containing fuzzy number $\tilde{x}_i$ .To perform fuzzy multiplications and additions by using the interval arithmetic and α−cut, the equation becomes equivalent to

$$\left[a_{i1l}^{\alpha}\ x_{1l}^{\alpha},\ a_{i1u}^{\alpha}\ x_{1u}^{\alpha}\right] \oplus \ldots \oplus \left[a_{inl}^{\alpha}\ x_{nl}^{\alpha},\ a_{inu}^{\alpha}\ x_{nu}^{\alpha}\right] = \left[\lambda x_{il}^{\alpha},\ \lambda x_{iu}^{\alpha}\right]$$

Where

$$\tilde{A} = \left[\tilde{a}_{ij}\right],\quad \tilde{x}^{t} = \left(\tilde{x}_1,\ \ldots\ldots\ldots\ldots,\ \tilde{x}_n\right)$$

$$\tilde{a}_{ij}^{\alpha} = \left[a_{ijl}^{\alpha},\ a_{iju}^{\alpha}\right],\quad \tilde{x}_{i}^{\alpha} = \left[x_{il}^{\alpha},\ x_{iu}^{\alpha}\right],\quad \lambda^{\alpha} = \left[\lambda_{l}^{\alpha},\ \lambda_{u}^{\alpha}\right]$$

For $0 < \alpha \leq 1$ and all i, j, where i=1, 2,…..,n and j=1,2,…..,n.

Step 4: Determining the weights of features

The Eigen value method is used for calculating the eigenvector or weighting vector for each pair-wise matrix. λ_{max} Has been calculated, then Normalization of both the matrix of pair wise comparisons and evolution of priority weights (approximate features weights).

Step 5:Check Consistency Ratio (CR)

In order to control the results of this method, the consistency ratio are calculated for each of the matrices and overall inconsistency for the hierarchy. The deviations from consistency are expressed by the following equation:

$CI = \dfrac{\lambda_{\max} - n}{n-1}$ Where, CI is consistency index and n order of matrix.

The consistency ratio (CR) has been used to estimate directly the consistency of pair wise comparisons

$CR = \dfrac{CI}{RI}$ Where RI (Random Index) is according to the rank of the matrix, and selected from Table 2.

Table 2. Value of RI according to the rank of Matrix

Matrix Rank	2	3	4	5	6	`7
RI	0.00	0.58	0.90	1.12	1.24	1.35

The comparisons are acceptable if CR< 0.1. The original values in the pair wise comparison matrix must be revised by the decision maker, if the consistency test is not passed. Fuzzy comparison matrices and there consistency ratio for criteria and sub-criteria has been calculated similarly and all values are shown in *Table 3.*

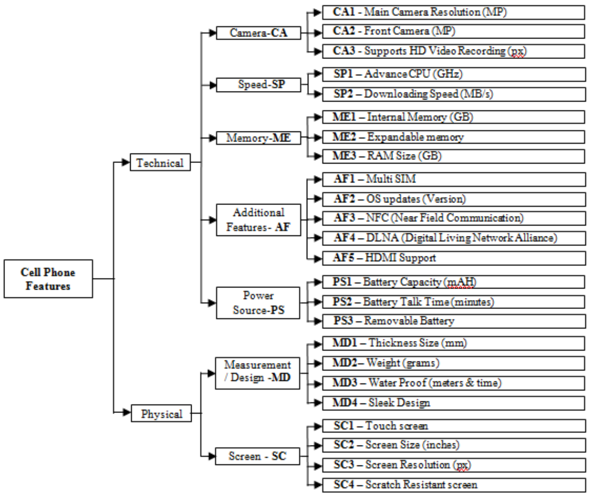

Fig.7 Hierarchy of Cell phone features/attribute

Table 3. The final weight from FAHP

	Features/Attribute	Weight	Weight Ranking
CA-1	Main Camera Resolution	0.105103	1
CA-2	Front Camera	0.054519	9
CA-3	HD Video Recording	0.050460	10
SP-1	Advance CPU	0.097915	2
SP-2	Download Speed	0.021496	18
ME-1	Internal Memory	0.068666	4
ME-2	Expandable Memory	0.022341	17
ME-3	RAM	0.058291	7
AF-1	Multi SIM	0.044485	11
AF-2	OS Updates	0.031125	13
AF-3	NFC	0.009966	23
AF-4	DLNA	0.016623	21
AF-5	HDMI	0.008482	24
PS-1	Battery Capacity	0.031005	14
PS-2	Battry Talk Time	0.058683	6
PS-3	Removable Battery	0.020992	19
MD-1	Slim Size	0.031544	12
MD-2	Weight	0.022719	16
MD-3	Water Proof	0.011252	22
MD-4	Sleek Design	0.018460	20
SC-1	Touch Screen	0.071269	3
SC-2	Screen Size	0.062573	5
SC-3	Screen Resolution	0.056094	8
SC-4	Gorrila Glass	0.025939	15

E. M-TOPSIS

M-TOPSIS method has been reported a novel, modified TOPSIS (M-TOPSIS) method to solve the problems of TOPSIS such as rank reversals and evaluation failure when alternativesare symmetrical. It has been applied to a large number of application cases in advanced manufacturing [1], purchasing and outsourcing [12], and financial performance measurement [9].

Its basic principle is that the chosen alternatives should have the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS) [15]. In this context, the domain set of alternatives have been defined as n-dimensional Euclidean space. Therefore, each alternative has been represented as a point in this space. In order to be able to define the zenith and the nadir points, a basic assumption is that each attribute is characterized by either monotonically increasing or decreasing utility. In this report, a novel, modified TOPSIS (M-TOPSIS) method has been described as a process of calculating the distance between the alternatives and the reference points.

Table 4 Alternatives and their features value { $X = [x_{ij}]_{m\times n}$}

	CA1	CA2	CA3	SP1	SP2	ME1	ME2	ME3
A1	13	5	1080	1.3	21	8	32	1
A2	8	1.9	1080	1.2	42	8	64	1.5
A3	6.7	5	1080	1.2	21.1	8	128	1
A4	13.1	.3	1080	1.5	42	8	32	2
A5	5	1.3	1080	1.2	21.1	16	0	1
A6	8	2	1080	1.5	21.1	16	64	2
A7	13	2	1080	2.3	21	16	32	2
A8	13	2	1080	1.2	21	16	32	2
A9	13	2	1080	1.6	42.2	16	64	2
A10	13.1	2	1080	2.0	21	16	0	2
A11	13	5	1080	1.7	21.1	16	64	2
A12	8	1.3	1080	1.0	7.2	8	32	1
A13	13	5	1080	1.5	21	16	32	2

	AF1	AF2	AF3	AF4	AF5	PS1	PS2	PS3
A1	1	0	0	0	0	2600	10	0
A2	1	0	0	1	0	2600	17	1
A3	1	0	1	1	0	2200	17	1
A4	0	1	1	1	1	2300	13	1
A5	1	1	0	0	0	2070	24	0
A6	0	1	1	1	1	1800	10	1
A7	0	0	1	1	0	3100	7	0
A8	1	0	0	0	0	2500	6	1
A9	1	1	0	0	0	3300	28	0
A10	1	0	0	1	0	2500	27	0
A11	1	0	0	0	0	3000	24	1
A12	1	0	0	1	0	3140	14.5	1
A13	1	0	0	0	0	2500	8	1

	MD 1	MD 2	MD 3	MD 4	SC 1	SC 2	SC 3	SC 4
A1	8	158	0	1	1	5.5	921600	0
A2	8.9	163	0	1	1	5.25	921600	0
A3	8.9	134	0	1	1	4.7	921600	1

A4	10.5	138	1	1	1	4.55	921600	1
A5	11.6	143	0	1	1	4.5	921600	1
A6	9	137	0	1	1	4.2	983040	0
A7	9.1	150	0	1	1	5.5	2073600	0
A8	7.95	141	0	1	1	5.0	921600	1
A9	9.9	196	0	1	1	6.0	921600	1
A10	8.1	125	0	1	1	5.0	2073600	0
A11	8.9	162	0	1	1	5.5	921600	0
A12	9.4	161	0	1	1	5.5	518400	0
A13	8.8	177	0	1	1	5.5	921600	1

Table 5. Normalized Decision Matrix (ND)

	CA1	CA2	CA3	SP1	SP2	ME1	ME2	ME3
A1	0.98	1.00	0.00	0.23	0.39	0.00	0.25	0.00
A2	0.37	0.34	0.00	0.15	0.99	0.00	0.50	0.50
A3	0.20	1.00	0.00	0.15	0.39	0.00	1.00	0.00
A4	1.00	0.00	0.00	0.38	0.99	0.00	0.25	1.00
A5	0.00	0.21	0.00	0.15	0.39	1.00	0.00	0.00
A6	0.37	0.36	0.00	0.38	0.39	1.00	0.50	1.00
A7	0.98	0.36	0.00	1.00	0.39	1.00	0.25	1.00
A8	0.98	0.36	0.00	0.15	0.39	1.00	0.25	1.00
A9	0.98	0.36	0.00	0.46	1.00	1.00	0.50	1.00
A10	1.00	0.36	0.00	0.76	0.39	1.00	0.00	1.00
A11	0.98	1.00	0.00	0.53	0.39	1.00	0.50	1.00
A12	0.37	0.21	0.00	0.00	0.00	0.00	0.25	0.00
A13	0.98	1.00	0.00	0.38	0.39	1.00	0.25	1.00

	AF1	AF2	AF3	AF4	AF5	PS1	PS2	PS3
A1	1.00	0.00	0.00	0.00	0.00	0.53	0.18	0.00
A2	1.00	0.00	0.00	1.00	0.00	0.53	0.50	1.00
A3	1.00	0.00	1.00	1.00	0.00	0.27	0.50	1.00
A4	0.00	1.00	1.00	1.00	1.00	0.33	0.32	1.00
A5	1.00	1.00	0.00	0.00	0.00	0.18	0.82	0.00
A6	0.00	1.00	1.00	1.00	1.00	0.00	0.18	1.00
A7	0.00	0.00	1.00	1.00	0.00	0.87	0.05	0.00
A8	1.00	0.00	0.00	0.00	0.00	0.47	0.00	1.00
A9	1.00	1.00	0.00	0.00	0.00	1.00	1.00	0.00
A10	1.00	0.00	0.00	1.00	0.00	0.47	0.95	0.00
A11	1.00	0.00	0.00	0.00	0.00	0.80	0.82	1.00
A12	1.00	0.00	0.00	1.00	0.00	0.89	0.39	1.00
A13	1.00	0.00	0.00	0.00	0.00	0.47	0.09	1.00

	MD1	MD2	MD3	MD4	SC1	SC2	SC3	SC4
A1	0.99	0.54	0.00	0.00	0.00	0.72	0.26	0.00
A2	0.74	0.46	0.00	0.00	0.00	0.58	0.26	0.00
A3	0.74	0.87	0.00	0.00	0.00	0.28	0.26	1.00
A4	0.30	0.82	1.00	0.00	0.00	0.19	0.26	1.00
A5	0.00	0.75	0.00	0.00	0.00	0.17	0.26	1.00
A6	0.71	0.83	0.00	0.00	0.00	0.00	0.30	0.00
A7	0.68	0.65	0.00	0.00	0.00	0.72	1.00	0.00
A8	1.00	0.77	0.00	0.00	0.00	0.44	0.26	1.00
A9	0.47	0.00	0.00	0.00	0.00	1.00	0.26	1.00
A10	0.96	1.00	0.00	0.00	0.00	0.44	1.00	0.00
A11	0.74	0.48	0.00	0.00	0.00	0.72	0.26	0.00
A12	0.60	0.49	0.00	0.00	0.00	0.72	0.00	0.00
A13	0.77	0.27	0.00	0.00	0.00	0.72	0.26	1.00

Table 6. Weighted Normalized Decision Matrix (WD)

	CA1	CA2	CA3	SP1	SP2	ME1	ME2	ME3
A1	0.10	0.05	0.00	0.02	0.01	0.00	0.01	0.00
A2	0.04	0.02	0.00	0.02	0.02	0.00	0.01	0.03
A3	0.02	0.05	0.00	0.02	0.01	0.00	0.02	0.00
A4	0.11	0.00	0.00	0.04	0.02	0.00	0.01	0.06
A5	0.00	0.01	0.00	0.02	0.01	0.07	0.00	0.00
A6	0.04	0.02	0.00	0.04	0.01	0.07	0.01	0.06
A7	0.10	0.02	0.00	0.10	0.01	0.07	0.01	0.06
A8	0.10	0.02	0.00	0.02	0.01	0.07	0.01	0.06
A9	0.10	0.02	0.00	0.05	0.02	0.07	0.01	0.06
A10	0.11	0.02	0.00	0.08	0.01	0.07	0.00	0.06
A11	0.10	0.05	0.00	0.05	0.01	0.07	0.01	0.06
A12	0.04	0.01	0.00	0.00	0.00	0.00	0.01	0.00
A13	0.10	0.05	0.00	0.04	0.01	0.07	0.01	0.06

	AF1	AF2	AF3	AF4	AF5	PS1	PS2	PS3
A1	0.04	0.00	0.00	0.00	0.00	0.02	0.01	0.00
A2	0.04	0.00	0.00	0.02	0.00	0.02	0.03	0.02
A3	0.04	0.00	0.01	0.02	0.00	0.01	0.03	0.02
A4	0.00	0.03	0.01	0.02	0.01	0.01	0.02	0.02
A5	0.04	0.03	0.00	0.00	0.00	0.01	0.05	0.00
A6	0.00	0.03	0.01	0.02	0.01	0.00	0.01	0.02
A7	0.00	0.00	0.01	0.02	0.00	0.03	0.00	0.00
A8	0.04	0.00	0.00	0.00	0.00	0.01	0.00	0.02

	AF1	AF2	AF3	AF4	AF5	PS1	PS2	PS3
A9	0.04	0.03	0.00	0.00	0.00	0.03	0.06	0.00
A10	0.04	0.00	0.00	0.02	0.00	0.01	0.06	0.00
A11	0.04	0.00	0.00	0.00	0.00	0.02	0.05	0.02
A12	0.04	0.00	0.00	0.02	0.00	0.03	0.02	0.02
A13	0.04	0.00	0.00	0.00	0.00	0.01	0.01	0.02

	MD1	MD2	MD3	MD4	SC1	SC2	SC3	SC4
A1	0.03	0.01	0.00	0.00	0.00	0.05	0.01	0.00
A2	0.02	0.01	0.00	0.00	0.00	0.04	0.01	0.00
A3	0.02	0.02	0.00	0.00	0.00	0.04	0.01	0.03
A4	0.01	0.02	0.01	0.00	0.00	0.01	0.01	0.03
A5	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03
A6	0.02	0.02	0.00	0.00	0.00	0.00	0.02	0.00
A7	0.02	0.01	0.00	0.00	0.00	0.05	0.06	0.00
A8	0.03	0.06	0.00	0.00	0.00	0.03	0.01	0.03
A9	0.01	0.00	0.00	0.00	0.00	0.06	0.01	0.03
A10	0.03	0.02	0.00	0.00	0.00	0.03	0.06	0.00
A11	0.02	0.01	0.00	0.00	0.00	0.05	0.01	0.00
A12	0.02	0.01	0.00	0.00	0.00	0.05	0.00	0.00
A13	0.02	0.01	0.00	0.00	0.00	0.05	0.01	0.03

Table 7. Separation distance from PI and NI

	k_r^+	k_r^-
A1	0.15006	0.146
A2	0.15599	0.09771
A3	0.002	0.10053
A4	0.14135	0.14233
A5	0.341	0.10823
A6	0.14677	0.12143
A7	0.09955	0.18959
A8	0.13320	0.15874
A9	0.08712	0.18513
A10	0.08470	0.19039
A11	0.08613	0.18192
A12	0.848	0.09048
A13	0.10787	0.201
	Min (k_r^+) = 0.08470	**Max** (k_r^-) = 0.19039

F. Result of M-TOPSIS

After step by step calculation the final ranking has been done for all the alternative on the basis of relative closeness and it has been shown in Table XII. Limitation of this study is that the ranking has been done in a price range without any value to brand name.

Table 8. M-TOPSIS Calculation

	A = $[k_r^+ - \min(k_r^+)]^2$	B =$[k_r^- - \min(k_r^-)]^2$	$RS_r = \sqrt{A+B}$	Ranking
A1	0.00427	0.0024	0.08146	8
A2	0.00508	0.0086	0.11692	10
A3	0.00728	0.0081	0.12391	12
A4	0.00321	0.0023	0.07429	7
A5	0.00787	0.0067	0.12091	11
A6	0.00385	0.0048	0.09277	9
A7	0.00022	0.0000	0.01487	4
A8	0.00235	0.0010	0.05791	6
A9	0.00001	0.0000	0.00578	2
A10	0.00000	0.0000	0.00000	1
A11	0.00000	0.0001	0.00858	3
A12	0.00879	0.0100	0.13702	13
A13	0.00054	0.0003	0.02957	5

IV. Result and Discussion

From the literature review, it can be seen that numerous individual and integrated approaches have been proposed to solve the decision problem or Multi Criteria Decision Making (MCDM) problem. We have been used three method KANO model, Fuzzy-AHP and M-TOPSIS, to accommodate the uncertainty. First of all the criteria and features for selection of cell phone have been identified from literature and with the help of experts and users. These criteria have been classified into different categories by using Kano Model. The result of Kano Model has been shown in Table 2. Five features have been assessed in must-be category because these are the basic needs of consumer's. Six features have been assessed in the category of One-Dimensional because almost from these features give more satisfaction with extra fulfillment to the user's. Ten criteria have been assessed in the Attractive category. These features attract to consumers, because mobile phone is an attractive device and these features gives satisfaction to customer in the form of safety, luxuriousness, advanced technology and if these are not available in device that time consumer never dissatisfied. Only three features has been come under Indifferent category, the reason may be almost of the customer do not buy cell phone based on these features because these are less in use and second these are latest features in mobile phone and it is noticed that in future these features may be come under must-be or attractive or throw out from cell phone features list or anything can happened because the technology changes very fast day by day. None of the features comes under reversal or questionable category, but 2-3 response were showing some features into these categories, but that is less as compare to other responses so they neglected. In this research one thing is observed that in Kano model, the features or attribute continuously changes their category according to the advancement of time, technology and requirements or needs of consumer. For further analysis, a FAHP method (as in *Fig.8*) has been used to prioritize the criteria and to calculate their relative importance or weight. The hierarchy models (*Fig. 9*) have been developed for the all criteria and sub-criteria. Pair wise comparisons matrices have been developed for each criteria and sub-criteria by using fuzzy numbers (*Table 3*, and *Fig. 6*) with the help of decision maker, and relative importance weights have been calculated by converting the fuzzy value in crisp value with the help of α-cut value and optimism value (μ) as in *Fig. 7*. It was found 'main camera resolution' to be of highest importance with 10.12% followed by 'Advance CPU' 9.16% and then 'Touch Screen' with 7.36% (*Table 6*). And in the same table from the least side of importance was found for 'HDMI' with 0.83%, 'water proof' with 1.07% and then 'NFC' with 1.07%.

After identification, categorization, prioritization, and assessment of relative weights of features, rank the selected 13 models of cell phone by using M-TOPSIS methods. The tables obtained from calculation of this method are shown, step by step in *Table 5* to *Table 7*. The result has been shown in *Table 8.*

V. Conclusion

Mobile phone is a worldwide used communication device and it is now need of the time. The total number of mobile cellular subscriptions worldwide is approaching almost to the population of the world so it is a big market for companies. A methodology has been developed in this research work and Kano Model, Fuzzy AHP and M-TOPSIS has been used for analysis. First of all classification of 24 features in different category has been done by using Kano model. After classification of features in different categories, Fuzzy Analytical Hierarchy Process (F-AHP) method has been used to find out the relative weights of features. In this approach triangular fuzzy numbers have been introduced into the conventional AHP in order to improve the judgments of decision makers and experts. In final score 'Main Camera' and 'Advanced CPU' is at the top in weight ranking in result whereas 'Water proof' and 'HDMI' is at the bottom in ranking according to their respective weight or relative importance.

Another MCDM approach M-TOPSIS has been used to evaluate and ranking of selected different models of cell phone available in the market. For applicability of the approach 13 mobile phones of different brands has been selected and find out the ranking of these. In result mobile phone of latest brand has been found at top in ranking because these are giving same features in lesser price or more features in same price and it also fulfills the market point of view because in India, inspite of brand name, cell phones posing lesser price are more in demand.

Finally, it can be concluded that the proposed methodology will be an efficient and robust approach to solve the mobile phone selection problem for the present market scenario.

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