iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** III **Month of publication:** March 2020

DOI:

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue III Mar 2020- Available at www.ijraset.com

Fuzzy Analytic Hierarchy Process for Evaluating Customer's Choice

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Abstract: ***The wide application of laptop and usability in the everyday work is the important factor that made laptops to be used widely. Every customer prefers laptops which have all the desired features at an affordable price. The study of customer's choice is also very important before manufacturing and marketing a product. Thus, this paper is based on the preferences of customers while selecting a laptop and also comparing some of the alternatives and selecting the best one out from them. In this paper, Fuzzy Analytic Hierarchy Process (AHP) is applied to obtain the relative weight of different criteria on the basis of which a customer selects a laptop. The weight of a criterion defines its importance over other criteria and this helps in deciding which feature is more important to the customer. Further for selecting one among various alternatives, two methods i.e. TOPSIS and SAW are compared.***

Keywords: Analytic hierarchy process, Fuzzy AHP, TOPSIS and SAW, laptop selection

I. INTRODUCTION

Laptops are considered as one of the most important electronic gadget which serves various purposes in everyday life. In this era of technology, it is the utmost requirement of every human. Therefore, there is a need for the study of desirability of customers which will help in launching a desired, productive and useful product in the market. Satisfying a customer is the biggest deal of the present companies and also the success of companies depends upon the factor that how well they have satisfied the customer or how well they have understood the need of customers. The gathering of the exact information about the customer's choice without any mathematical modeling is not possible. So a method for evaluating the responses of the customer, multi-criteria decision making MCDM methods are adopted among which fuzzy AHP is one of the MCDM methods. MCDM means selecting the best alternative among the set of alternatives [8-11]. The evaluation and selection of laptop based on the weight of different criteria which gives a quantitative result, where both are beneficial for both the sellers and buyers while launching and selecting the best laptops.

This paper includes fuzzy AHP to handle the fuzziness of data. Analytic Hierarchy Process AHP is proposed by Saaty [1, 2] to obtain priorities of criteria on the basis of which different alternatives are compared and the best one is selected. A ranking is given to each of the alternative. This paper describes the fuzzy AHP for giving the weight to each criteria while selecting a laptop i.e. storage, processor, graphics, RAM, battery, cost, optical drives, connectivity and display. Further, the latest laptops were selected and the result of first step i.e. Fuzzy AHP is used in comparing of the products. For comparison between alternatives also requires a pair wise decision matrix and two MCDM methods are applied for getting the best one out.

II. CONCEPT OF FUZZY ANALYTIC HIERARCHY PROCESS (AHP)

The AHP is not accurately deals with the vague nature of the data but fuzzy AHP can handle the imprecise nature of the random decision data. The steps in fuzzy AHP are as follows:

A. The aim for the decision problem is set and then the various criteria are determined.
B. Based on the criteria, a fuzzy pair-wise matrix is generated using triangular fuzzy conversion scale.
C. Decisions are made and the data related to the problem is collected. A feedback is collected from different users for ranking the most important criteria for them.
D. The data obtained from the customers are evaluated and a decision matrix is made using geometric mean method of Buckley [3, 4].
E. Fuzzy Synthetic Extent is calculated from the matrix. Then, the weights to different criteria are given based on Chang's method.
F. Consistency of the matrix is checked.
G. Various alternatives are chosen and then compared after making one more matrix for alternatives-criteria.

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III. FUZZY ANALYTIC HIERARCHY PROCESS (AHP)

The steps described above are explained below in sequence:

1) *Aim:* The aim for the decision problem is evaluating customer's preference while buying a laptop. The parameters chosen are:

Storage	RAM
Processor	Display
Cost	Connectivity
Graphics	Optical Drive
Battery	

2) *Fuzzy pair wise Triangular Fuzzy Number (TFN) Conversion Scale:* The TFN is used in the matrix formation. Various tables for making the fuzzy matrix are described in literature. One such is shown below in TABLE I.

Linguistic Scale	TFNs	Reciprocal TFNs
Equally important	(1,1,1)	(1,1,1)
Weakly important	(2/3,1,3/2)	(2/3,1,3/2)
Strong more important	(3/2,2,5/2)	(2/5,1/2,2/3)
Very strong more important	(5/2,3,7/2)	(2/7,1/3,2/5)
Absolutely more important	(7/2,4,9/2)	(2/9,1/4,2/7)

3) *Constructing Fuzzy pair-wise Criteria Matrix:* The matrix representation is given below:

$$A=\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} \quad (1)$$

Where aij is the fuzzy triangular number, aij = (*lij*, *mij*, *uij)*, and aji = 1/aij.

For every triangular fuzzy number, aij describes the membership function, μ(x) which is a continuous real number mapping from minus infinity to positive infinity to the closed interval [0,1] and is defined as the equation (2).

$$u(x)=\begin{cases} \frac{x-l}{m-l}, l \le x \le m \\ \frac{u-x}{u-m}, m \le x \le u \\ 0, \ otherwise \end{cases} \quad (2)$$

4) Decision matrix from different users using Buckley geometric mean method: The Buckley's geometric mean method is used for estimating the decision matrix made after collecting preferences from different users. The matrix is obtained by multiplying each decision maker's view over each criteria and then taking the nth root of the product, where n is the number of decision maker as in equation (3).

$$uij = \left(\prod_{i=1}^{n} a_{ijk}\right)^{1/n} \quad (3)$$

Where a_{ijk} is the TFNs of k^{th} decision maker.

5) Finding the Fuzzy Synthetic Extent: The above matrix is then used for finding the value of fuzzy synthetic extent, S for each criteria and that is depicted in equation (4).

$$S_i = \sum_{j=1}^{m} uij \otimes \left[\sum_{i=0}^{n}\sum_{j=1}^{m} uij\right]^{1}$$

Where $\sum_{j=1}^{m} uij = \left(\sum_{j=1}^{m} lj, \sum_{j=1}^{m} mj, \sum_{j=1}^{m} uj\right)$ and

$$\sum_{i=0}^{n}\sum_{j=1}^{m} uij = \left(\sum_{i=1}^{n} ij, \sum_{i=1}^{n} mj, \sum_{i=1}^{n} uj\right) \quad (4)$$

This step is followed by finding the appropriate weight of the criteria by using Chang's method as follows (5):

$$V(S_b \geq S_a) = \begin{cases} 1, & if\ (m_b \geq m_a) \\ 0, & if\ (l_a \geq u_b) \\ \dfrac{l_a - u_b}{((m_b - u_b) - (m_a - l_a))}, & otherwise \end{cases} \quad (5)$$

Chang's method is based on the extent or degree of the possibility of one criteria preferred over another.
All possible terms (S_i, i=1 to k, where k=1, 2,3…,n but k≠i) are noted and weight are evaluated as shown by equation (6).

$$V(S_t \geq S_1, S_2, \ldots, S_k) = \min V(S_t \geq S_k) = w'(S_t) \quad (6)$$

6) Consistency Check of the Matrix: In order to evaluate the designed matrix, the consistency check is necessary. The consistency rate (CR) is the ratio of the consistency index (CI) and the random generated consistency index (RI). The value of CR should be less than 0.1 for the matrix to be consistent.

RI is obtained from the fixed values as described in the Saaty's AHP approach. For nine criteria, n=1.45 as in TABLE II.

TABLE II: RI for different number of criteria available.

n	RI	n	RI
3	0.58	8	1.41
4	0.90	9	1.45
5	1.12	10	1.49
6	1.24	11	1.51
7	1.32	12	1.48

CI is the consistency index evaluated from the Eigen value, λ_{max}. This gives the rate of inconsistency in the measurement of the criteria importance as in equation (7).

$$CI = \frac{\lambda_{max} - n}{n - 1}$$
$$\lambda_{max} = \sum_{j=1}^{n}{}' \alpha_{ij} \frac{W_j}{W_i} = n \quad ,i,j = 1,2,\ldots,n \quad (7)$$

IV. CALCULATION AND ANALYSIS

The calculation and evaluation is done as described in above steps. The pair-wise matrix is obtained and the synthetic extents are calculated. The following table shows each and every step involved while selecting a laptop.

1) Fuzzy pair-wise Criteria Matrix

TABLE. III Fuzzy Pair-Wise Comparison Martix Using Triangular Fuzzy Numbers

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1,1,1	0.28,0.33,0.4	0.4,0.5,0.66	0.11,0.5,0.66	0.4,0.5,0.66	0.4,1,1.5	0.66,1,1.5	0.66,1,1	1,1,1.5
C2	2.5,3,3.5	1,1,1	0.66,1,1.5	1,1,1.5	0.66,1,1.5	0.66,2,2.5	1.5,2,2.5	1.5,3,3.5	2.5,4,4.5
C3	1.5,2,2.5	0.66,1,1.5	1,1,1	1,1,1	1,1,1	1,1,1.5	0.66,2,2.5	0.66,2,2.5	1.5,3,3.5
C4	1.5,2,2.5	0.66,1,1.5	1,1,1	1,1,1	1,1,1	1,1,1.5	0.66,1,1.5	0.66,2,2.5	1.5,3,3.5
C5	1.5,2,2.5	0.66,1,1.5	1,1,1	0.33,1,1	1,1,1	1,1,1.5	0.66,1,1.5	0.66,2,2.5	1.5,3,2.5
C6	0.66,1,1.5	0.4,0.5,0.66	0.66,1,1.5	0.2,1,1.5	0.66,1,1.5	0.66,1	1,1,1	1,1,1.5	0.66,2,2.5
C7	0.66,1,1.5	0.4,0.5,0.66	0.66,1,1.5	0.2,1,1.5	0.66,1,1.5	0.66,1	1,1,1	1,1,1.5	0.66,2,2.5
C8	1,1,1	0.28,0.33,0.4	0.4,0.5,0.66	0.14,0.5,0.66	0.4,0.5,0.66	0.4,1,1.5,0.66	0.66,1,0.66	0.66,1	1,1,1,1.5
C9	0.66,1,1.5	0.22,0.25,0.28	0.28,0.33,0.4	0.11,0.33,0.4	0.28,0.33,0.4	0.28,0.2,0.66	0.4,0.2,0.66	0.4,1,1.5	0.66,1,1

After calculating the weights of the each criterion, five alternatives are chosen and then again a matrix of preference is made.

2) *Step.5:* The value of fuzzy synthetic extent

Table IV: Fuzzy Synthetic Extent

SYNTHETIC EXTENT OF EACH CRITERIA			
C1	0.041092	0.072449	0.14035453
C2	0.100029	0.19085	0.347021765
C3	0.075017	0.137836	0.252379465
C4	0.075017	0.137836	0.252379465
C5	0.069456	0.137836	0.252379465
C6	0.049439	0.100726	0.199789894
C7	0.049439	0.100726	0.199789894
C8	0.041357	0.072449	0.14035453
C9	0.027698	0.049292	0.107540467

The appropriate weight of the criteria by using Chang's method:

CRITERIA COMPARISON FOR WEIGHT CALCULATION BY CHANG'S METHOD								
C1	C2	C3	C4	C5	C6	C7	C8	C9
NO	0.254058	0.499809	0.499809	0.520218	0.762758	0.762758	1	1.25873
1	NO	1	1	1	1	1	1	1
1	0.741855	NO	1	1	1	1	1	1
1	0.741855	1	NO	1	1	1	1	1
1	0.741855	1	1	NO	1	1	1	1
1	0.525378	0.770761	0.770761	0.778374	NO	1	1	1
1	0.525378	0.770761	0.770761	0.778374	1	NO	1	1
1	0.254058	0.499809	0.499809	0.520218	0.762758	0.762758	NO	1
1	0.050392	0.268638	0.268638	0.300756	0.530435	0.530435	1	NO

Thus, with fuzzy AHP approach the desired product is recognized and the customer's choice is evaluated. This approach also helps the customer to choose the best product according to their specified limitations and also helps the manufactures to design and develop new product with the customer choice keeping in mind.

Out of five products one product matches with the prescribed specification at affordable price. Cost parameter is also one of the important parameter while deciding the price for a product to produced in the market. So, this study really gives a good balance of the benefit and cost aspects. In this paper, two methods are compared i.e. TOPSIS and SAW. The results by both the methods are near about with a small difference in selecting two alternatives whose weights are lower than other alternatives. weights. The matrix is found to be consistent and CR is less than 0.1.

V. CONCLUSION

This paper work is fully based on fuzzy AHP which is studied successfully. The problem is taken and evaluated. It has the capability to convert the random fuzzy data into a quantity and helped in the proper assessment and analysis without leaving any of the criteria untouched. Means fuzzy AHP takes every necessary part into account and gives the exact output of the complex decision making problem. The selected criteria preferences can be used in many areas. Similar problems can be solved easily with this method.

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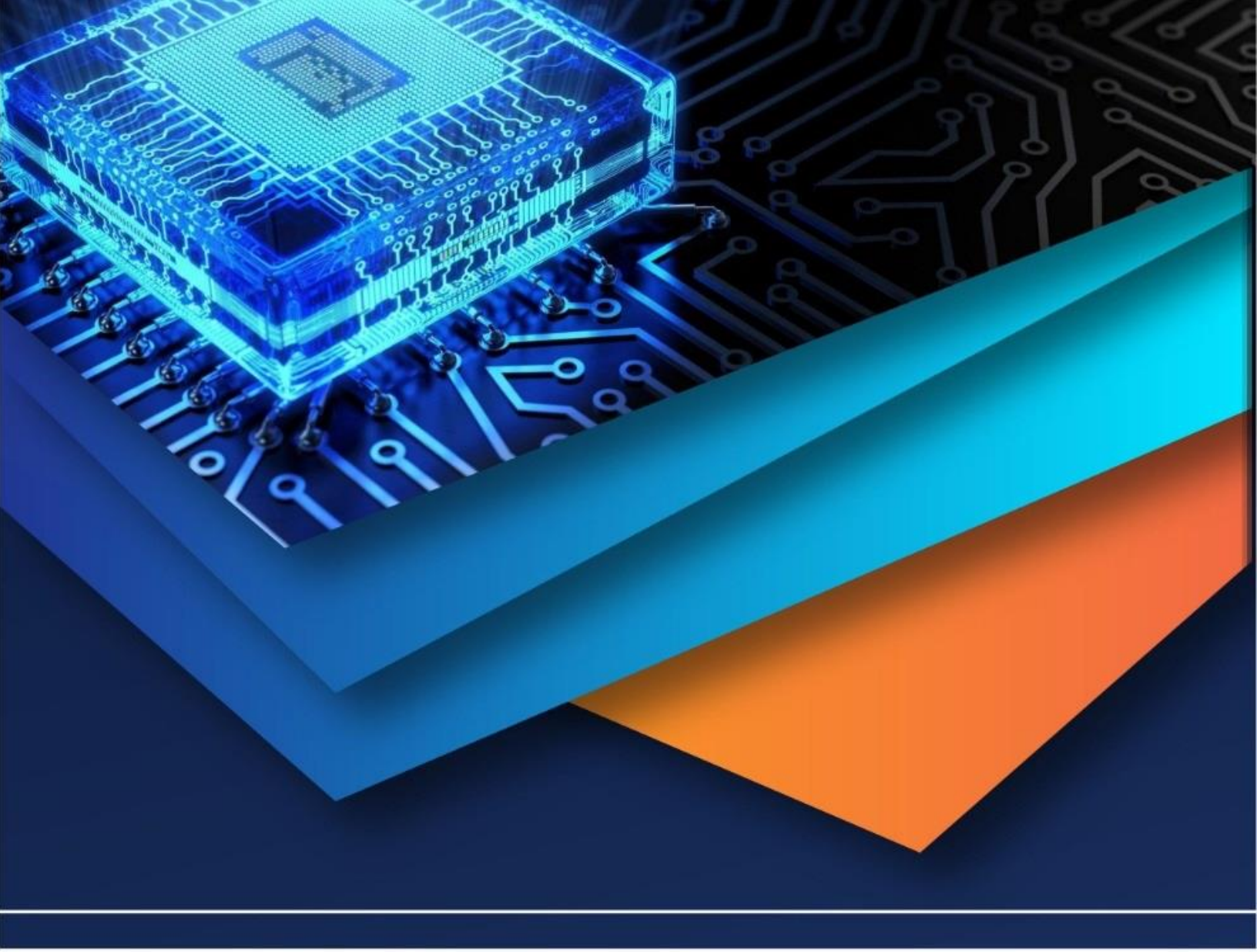

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