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Multicriteria Decision Technique on Product Prioritization

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Abstract: *Multi criteria decision making (MCDM) process involves evaluating alternative solutions against multiple criteria to select the best options. The decision making process is simple if the criteria are of same type, uncorrelated and deterministic. AHP (Analytic Hierarchy Process) is one of the decision making technique. AHP is an appropriate method to address the prioritization problem to make better decisions. It allows the use of qualitative, as well as quantitative criteria in evaluation. AHP helps decision-makers choose the best product from several options. The customer chooses a best car in the given alternatives through pair wise comparison method. This paper is to discuss and apply the principles and techniques of the AHP in the product prioritization.*

Keywords: *Multi Criteria Decision-Making, Analytic Hierarchy Process, Pair wise Comparisons.*

1. INTRODUCTION

MCDM is concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision makers facing such problems. Typically, there does not exist a unique optimal solution for such problems and it is necessary to use decision maker's preferences to differentiate between solutions."Solving" can be interpreted in different ways. It could correspond to choosing the "best" alternative from a set of available alternatives. Another interpretation of "solving" could be choosing a small set of good alternatives, or grouping alternatives into different preference sets. An extreme interpretation could be to find all "efficient" alternatives.

Multiple criteria decision making (MCDM) refers to making decisions in the presence of multiple, usually conflicting, criteria [6].MCDM problems are common in everyday life. The customer decided to purchase a new car. The criteria are comfort, safety, fuel, price etc. In this situation the Analytic Hierarchy Process is used. It is one of the MCDM methods [1].

The Analytic Hierarchy Process (AHP) is a popular and powerful tool used by decision makers to evaluate alternatives in problems that contain not only tangible and quantitative factors, but also intangible and qualitative factors as well. AHP provides a proven, effective means to deal with complex decision making and can assist with identifying and weighting selection criteria, analyzing the data collected for the criteria and expediting the decision-making process. In its simplest form, this structure comprises a goal, criteria and alternative levels.

Each set of alternatives would then be further divided into an appropriate level of detail, recognizing that the more criteria included, the less important each individual criterion may become. Assign a relative weight to each one. Each criterion has a local (immediate) and global priority. The sum of all the criteria beneath a given parent criterion in each tier of the model must equal one. Its global priority shows its relative importance within the overall model.

The number of pair wise comparisons grows quadratically with the number of criteria and options. For instance, when comparing 9 alternatives on 4 criteria and 81 pair wise comparisons are needed to build the score matrix. The rest of this study devoted to providing an introduction to AHP as well as this is an effective technique for product prioritization. In this work to demonstrate how it can be applied in product prioritization.

2. LITERATURE SURVEY

2.1 The Analytic Hierarchy Process

Decisions involve many intangibles that need to be traded off. To do that, they have to be measured alongside tangibles whose measurements must also be evaluated as to, how well they serve the objectives of the decision maker. The Analytic Hierarchy Process (AHP) [5] is a theory of measurement through pair wise comparisons and relies on the judgments of experts to derive priority scales. It is these scales that measure intangibles in relative terms. The comparisons are made using a scale of absolute judgments that represents how much more; one element dominates another with respect to a given attribute. The judgements may be inconsistent, and how to measure inconsistency and improve the judgments, when possible to obtain better consistency is a concern of the AHP. The derived priority scales are synthesized by multiplying them by the priority of their parent nodes and adding for all such nodes.

2.2 Brand Name Selection through AHP

For a tool that has such broad applicability, the analytical hierarchy process (AHP) is not as widely known as might be expected. AHP makes assessments, prioritization and selection among options more readily measurable. Thus it is a part of the toolkit for a growing number of practitioners. AHP, which grows out of work that was done in the field of operations research [9] by mathematician Thomas Saaty, has evolved into a rich set of methods with assessment and prioritization at their core. So the AHP is the decision making process by which decision can easily be taken by comparing alternatives according to criteria provided. Brand name influence the quality of the products purchased [2] [10], the effectiveness of the products and activities offered, and the profitability of the purchase processes. Identification of best brand name that will be contributes to the quality, effectiveness, and efficiency of the organization.

2.3 Multi Criteria Decision Support Using AHP

AHP is a multiple criteria decision support techniques in the decision making paradigm [4] and to examine practical implications and highlight some of the limitations inherent in AHP.A case study approach of a project site selection illustrates the key issues in the implementation of AHP in real life situation. In MCDM [1] to examine the aspects of theoretical constraints and their corresponding practical implications of the analytical hierarchy process (AHP) for application in the field of multi criteria decision support. Results of this case study of project site selection have demonstrated the robustness of AHP methodology [5]. In the synthesis process, the consistency ratio provides a means for consistency diagnosis and subsequent iteration also facilitates refinement of intuitive judgment by the decision makers. Rank reversal, which is conceived in many research literatures to be among the dominant demerits of multi criteria decision support methodologies [3], was found to have negligible effect in this case study using AHP.

2.4 Software Requirements Prioritizing

The importance of candidate software requirements can vary by orders of magnitude, yet most software providers do not have accurate and efficient means for selecting among them. Software requirements prioritization [9] describes a case study at Ericsson Radio Systems AB of two techniques for software requirements prioritizing as a means for determining the importance of candidate requirements, a pair-wise comparison technique [10] and a numeral assignment technique. The results from the case study indicate that the pair-wise comparison technique is an efficient, informative and accurate means for finding the candidate requirements importance. So mostly recommend the pair-wise comparison technique for software requirements prioritizing.

3. METHODOLOGY

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions. Based on mathematics and psychology In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. It has particular application in group decision making, and is used around the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, and education.

3.1 Primary Functions of AHP

Structuring Complexity

The objective and the criteria should be identified. If there are any other sub criteria, those must be enlisted under criteria. In this way, a model has to be structured.

Measurement on A Ratio Scale

The sub criteria and criteria must be compared with each other and weights must be put on every criterion. A ratio scale has been invented by which priorities or criteria can be compared and can be given weights.

Synthesis

AHP synthesizes (combine the parts into whole) the individual results and complete the matrix. That is how appropriate weight of each criterion can be obtained from the matrix. Then selected alternatives are compared with each other in accordance with the matrix. Then the best alternative is achieved.

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight [7] or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques [8]. The numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives relative ability to achieve the decision goal.

3.2 Pair wise Comparison Method

In the pair wise comparison method, criteria and alternatives are presented in pairs of one or more refers. It is necessary to evaluate individual alternatives, deriving weights for the criteria, constructing the overall rating of the alternatives [11] and identifying the best one.

The alternatives by { A_1, A_2,…., A_n}(n is the number of alternatives),their current weights by {w_1,w_2,.....,w_n}, and the matrix of the ratios of all weights by

$$W = [w_i / w_j] = \begin{pmatrix} w_1/w_1 & w_1/w_2 \ldots\ldots & w_1/w_n \\ w_2/w_1 & w_2/w_2 \ldots\ldots & w_2/w_n \\ . & . & . \\ w_n/w_1 & w_n/w_2 \ldots\ldots & w_n/w_n \end{pmatrix}$$

The matrix of pair wise comparisons A= [a_{ij}] represents the preference between individual pairs of alternatives (A_i versus A_j, for all I, j = 1, 2,…,n). They are usually chosen from a given scale (1/9,1/8,……8,9).Given n alternatives {A_1,A_2,….,A_n}, a decision maker compare pairs of alternatives for all the possible pairs, and comparison matrix A is obtained, where the element a_{ij} shows the preference weight of A_i obtained by comparison with A_j.

$$A= [a_{ij}] = \begin{pmatrix} 1 & a_{12} & \ldots & a_{1j} & \ldots & a_{1n} \\ 1/a_{12} & 1 & \ldots & a_{2j} & \ldots & a_{2n} \\ - & & & & & \\ 1/a_{1j} & 1/a_{2j} & \ldots & a_{ij} & \ldots & a_{in} \\ - & & & & & \\ 1/a_{1n} & 1/a_{2n} & \ldots & a_{in} & \ldots & 1 \end{pmatrix}$$

The a_{ij} elements estimate the ratios w_i/w_j *where w* is the vector of current weights of the alternative. If a matrix A is absolutely consistent, so that A=W and in the ideal case of total consistency, the principal Eigen value (λ_{max}) is equal to n, i.e. "λ_{max} = n", the relations between the weights and the judgements will be given by $w_i / w_j = a_{ij}$ for i, j = 1, 2,…n. The weights w_i, i=1, 2... n, were obtained using the eigenvector method, they are positive and normalized, and satisfy the reciprocity property.

Let A = [a_{ij}] for all i,j=1,2,…,n denote a square pair wise comparison matrix, where a_{ij} gives the relative importance of the elements i and j. Each entry in the matrix A is positive ($a_{ij} > 0$) and reciprocal ($a_{ij} = 1/a_{ji}$ for i, j=1, 2,.., n)

In the Eigen vector method, w is the weight vector. The traditional Eigen vector method for estimating weights in the analytic hierarchy process yields a way of measuring the consistency of the referee's preferences arranged in the comparison matrix. If a square pair wise comparison matrix is absolutely Consistent.

The consistency index (CI) as follows:

$$CI = \frac{\lambda_{max} - n}{n-1}$$

It is well known that small changes in a_{ij} imply small changes in λ_{max}, with the difference between this and n being a good measure of consistency.

The Consistency ratio (CR) as

$$CR = \frac{CI}{RI}$$

where RI is the average value of CI value for random matrices using the Saaty scale [6].

The nine point rating scale enables the comparison of importance between qualitative and quantitative criteria. In order to express the differences in importance between criteria, the scale begins with the value "1" for a pair of criteria which are equally important and usually continues in steps of two with odd numbers until "9" if the first criterion is overwhelmingly more important than the second. In order to express the opposite relation, i.e. that criterion A is overwhelmingly less important than criterion B, the reciprocal rating values, in this case 1/9, are assigned.

4. EXPERIMENTAL RESULT

In this work the AHP technique is used to make a decision to purchase the best car according to the criterion. Pair wise comparison method is used to product prioritization.

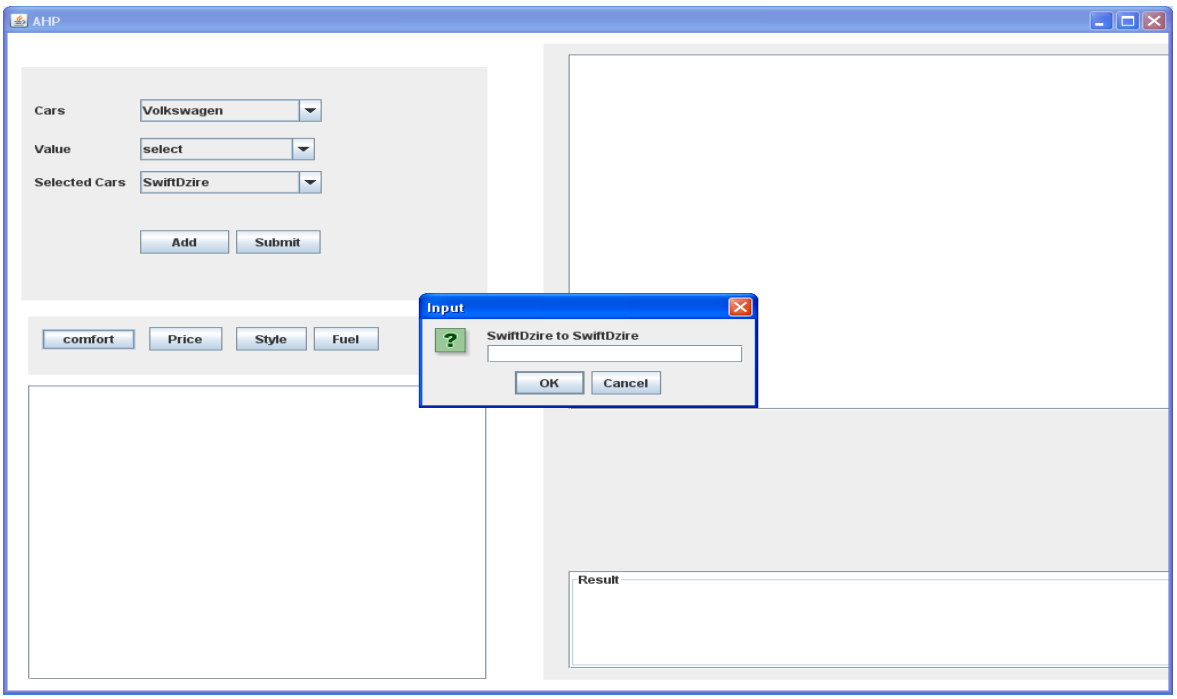

Fig 4.1. *Get input Values for alternatives*

In this figure the AHP utilizes pair wise comparisons to establish priority measures for both criteria and the decision alternatives. The priorities of the nine cars in terms of the cost criterion, comfort

criterion, fuel criterion, and style criterion. Pair wise comparisons are fundamental building blocks of AHP. In establishing the

Priorities for the nine cars in terms of comfort criterion. The cars are considered two at a time (pair wise). That is Swift dzire to Honda amaze, Swift dzire to Alto, Swift dzire to Indica vista and so on. The AHP employs an underlying scale with values from 1 to 9 to rate the relative preferences for two items.

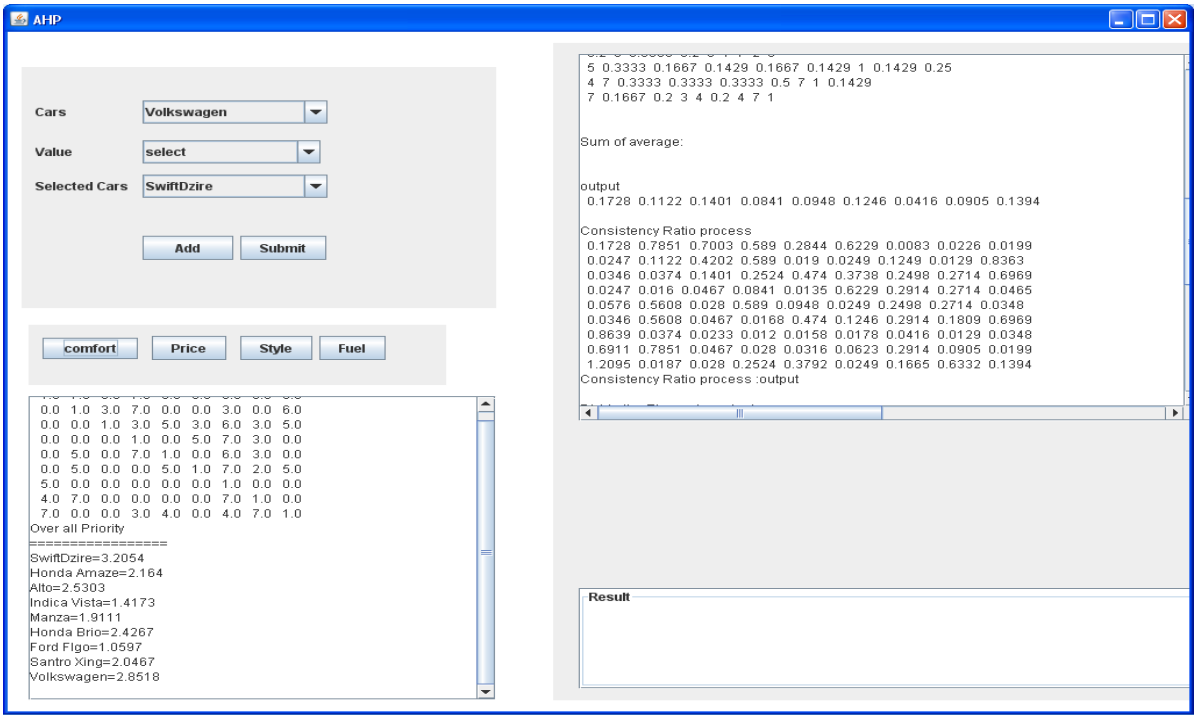

Fig 4.2. *Comfort criterion values for alternatives*

The preference of a comfort criterion will be stored in a matrix format. The nine cars are being considered the pair wise comparison matrix will consist of nine rows and nine columns. In the pair wise comparison matrix, the value in row i and column j is the measure of preference of the car in row i when compared to the car in column j. The value in the matrix that corresponds to comparing Swift dzire with Honda amaze is 7, the value that corresponds to comparing Swift dzire to Alto is 5 and so on. The preference rating for Honda amaze to Swift dzire is 1/7 i.e. reciprocal of the preference.

The exact mathematical procedure required to perform this synthesization involves the computation of eigen values and eigen vectors. Sum the values in each column of the pair wise comparison matrix. Divide each element in the pair wise matrix by its column total, the resulting matrix is referred to as the normalized pair wise column. Compute the average of the elements in each row of the normalized matrix, these averages provide an estimate of the relative priorities of the elements being compared. The synthesis provides the relative priorities for the nine cars with respect to the comfort criterion. Thus the average of Swift dzire (0.1728), honda amaze(0.1122), Alto(0.1401) and so on.

The AHP provides a measure of the consistency of pair wise comparison judgments by computing a consistency ratio. The values of consistency ratio of considered to indicate a reasonable level of consistency in the pairwise comparison. Multiply each value in the first column of the matrix by the relative priority of the first item considered, Multiply each value in the second column of the matrix by the relative priority of the second item considered and so on.Sum the values across the rows to obtain a vector of values labeled weighted sum. Divided the elements of the vector of weighted sums obtained in 1 by the corresponding priority value. Compute the average of these values is denoted by $\lambda_{max.}$ The same pair wise comparison procedure to set priorities for all four criterion in terms of the importance of each in contributing toward the overall goal of selecting best car. Eighty one pair wise judgment have to be made.

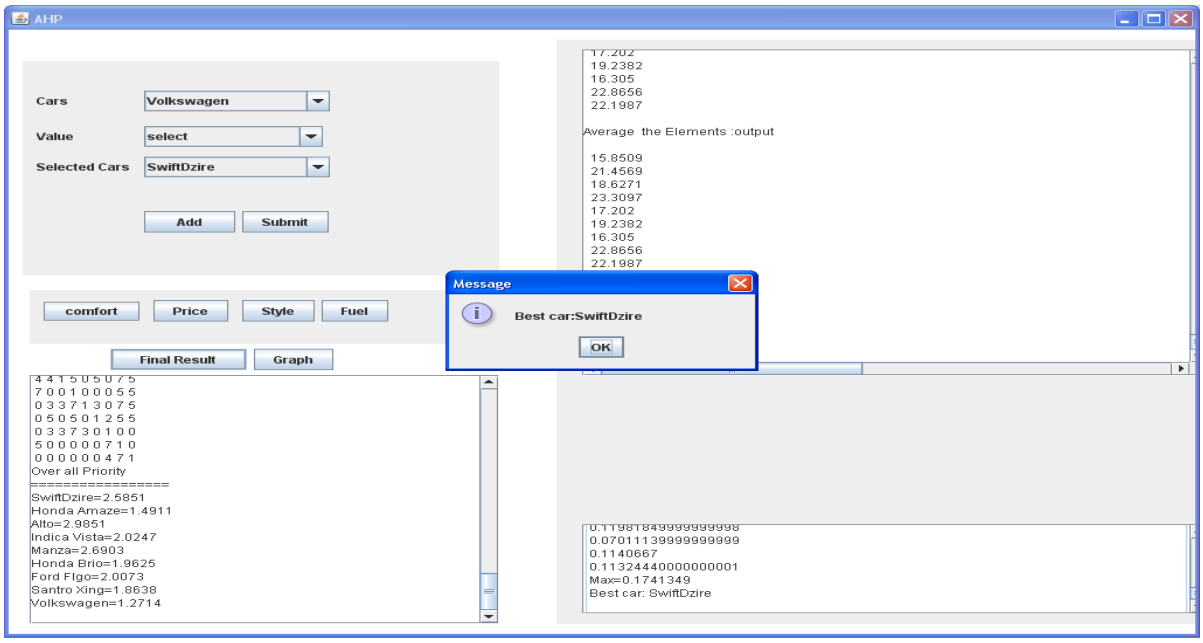

Fig 4.3. *AHP Process*

The overall priority for each decision alternatives is obtained by summing the product of the criterion priority of the decision alternatives with respect to that criterion. The criterion priorities were found to be 0.398 for price, 0.085 for fuel, 0.218 for comfort and 0.299 for style. The customer to make a decision regarding the purchase of a car based on the AHP priorities. So the Swift dzire is the referred car.

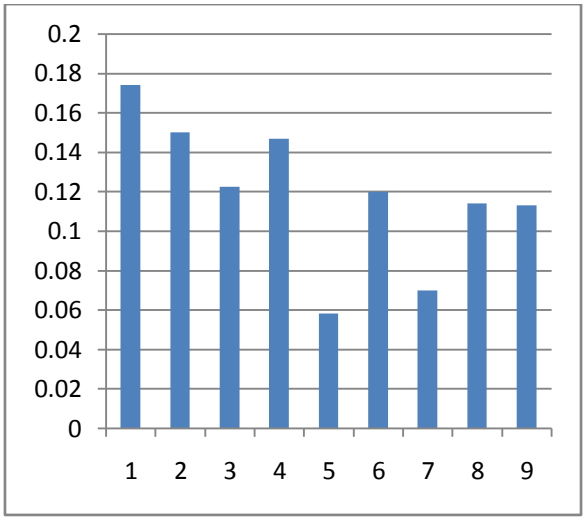

Fig 4.4. *Result graph for Product Prioritization*

In this graph, X axis is the alternatives of cars. And the Y axis is the overall priority values of the each car. So that the swift dzire is a preferred car for all type of customers.

5. CONCLUSION

The AHP method was a straightforward method for product prioritizing. Today most of the decisions are to be taken in increasingly complex environments. Most of them require different value systems and the use of experts from different fields. They succeed by using knowledge that is imprecise rather than precise. AHP which is a transparent technique is very useful to handle this type of situations where qualitative data is involved in the decision-making. AHP involves the principles of decomposition, pair wise comparisons and priority vector generation.

This paper has presented the AHP as a decision making tool in product prioritization.To select best car in AHP method that satisfied by the customer. The AHP develops a hierarchial relationship among decision levels. Four criteria, nine alternatives and eighty one pair wise comparisons have been used

in the product prioritization. The correctness of the decision is checked through consistency ratio.The main advantage of AHP is that it can be applied both qualitative and quantitative data. The result of this product prioritization gives the preferred car.

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