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# An Innovative Multi-Criterial Decision Method for Complex Systems

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**Abstract:** This article proposes on methodological and algorithmically level an information system to support group expert decision making using Analytical Network Process (ANP). Optimization of decision making complex process is currently a significant issue in many real-life industrial, service or public sector processes. Multi-criterial decisions are at present usually made by experts individually or in committees by voting. The methodology for synthesis of decisions from multiple decision makers is universal and can be applied to a wide range of practical applications including not only industrial or business applications, but also public sector or political applications. The main contribution of this paper is the novel approach to group decision synthesis and its implementation as a web application that allows large and decentralized teams to cooperate on the same task. Individual members of teams are ranked and their weight in the synthetized decision is based on other team member`s opinion on their proficiency in a particular matter. Pairwise comparisons provided by the decision support system are easy to grasp, because they are using fuzzy linguistic (Zadeh, 1965) variables instead of sharp values.



Keywords**:** Decision making, Group decision making, ANP, Group Decision synthesis, Multi-criterial decision analysis, Python

## 1. INTRODUCTION

Multi Criteria Decision Making (MCDM) provides strong decision making in domains where selection of best alternative is highly complex. The main purpose of his paper is to identify various applications and the approaches, and to suggest approaches which are most robustly and effectively useable to identify best alternative. Multi criteria decision making have been applied in many domains. MCDM method helps to choose the best alternatives where many criteria have come into existence, the best one can be obtained by analysing the different scope for the criteria, weights for the criteria and the choose the optimum ones using any multi criteria decision making techniques. This survey provides the comprehensive developments of various methods of FMCDM and its applications. There are different classifications of MCDM problems and methods. A major distinction between MCDM problems is based on whether the solutions are realised explicitly or implicitly defined. Multiple-criteria evaluation problems: These problems consist of a finite number of alternatives, explicitly known in the beginning of the solution process. Each alternative is represented by its performance in multiple criteria (Aruldoss *et al.*, 2013). The problem may be defined as finding the best alternative for a decision-maker, or finding a set of good alternatives. One may also be interested in "sorting" or "classifying" alternatives. Sorting refers to placing alternatives in a set of preference-ordered classes (such as assigning credit-ratings to countries), and classifying refers to assigning alternatives to non-ordered sets (such as diagnosing patients based on their symptoms). Multiple-criteria design problems (multiple objective mathematical programming problems): In these problems, the alternatives are not explicitly known. An alternative (solution) can be found by solving a mathematical model.

The number of alternatives is either infinite or not countable (when some variables are continuous) or typically very large (Bellman and Zadeh, 1970) if countable (when all variables are discrete). Multi-Criterial decision making is part of everyday life without people realizing it. Though we can make decisions on everyday topics easily, in business the decisions need to be driven by a clear and deterministic approach to be widely accepted. There are multiple algorithms that provide good mathematical frameworks to support a single person decision. Group decisions are more difficult, because there is no final theorem on how to organize factors of Multi-Criterial decisions and how the group decision is different from synthetized single person decisions. In this paper a novel approach to group decision making is proposed. ANP is used as a mathematical framework for the solution because pairwise comparisons are easier to grasp for decision makers as (Blumenthal, 1997) suggests. Synthesis of people's decisions is made using weighted median and results in a single group decision.

This methodology is universal and can be applied in many fields of practical applications. Implementation of the solution is done using Python, but the methodology does not require Python and can be implemented in any other programming language. This paper consists of three logical parts, algorithm of the solution, implementation and outlining


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possible applications. General knowledge of Analytical Network Process is assumed.

## 2. PROBLEM GROUP DECISION FOMULATION

Group decision making has two main issues. The first is how to aggregate individual judgements, and the second is how to construct a group choice from individual choices. (Saaty, 1996; 2004; 2013) proposed geometric mean for synthesis of multiple decisions for its reciprocal property. Main property of the synthetizing function is to be as resistant to deviations as possible. One person's opinion shouldn't shift whole group decision a bit sideways. For this purpose, weighted mean is chosen, as it is statistically more resistant to deviation than the geometric mean. Standard single person ANP uses this process to come to the best alternative.

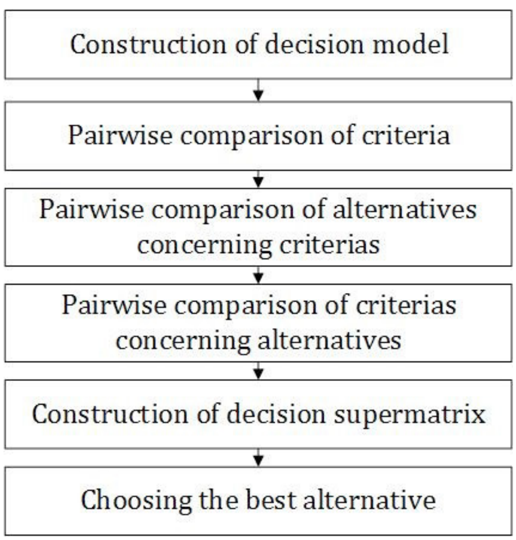


Fig.1. ANP process diagram

The synthesis of group decision is applied in the step of "construction of decision supermatrix". Here when inputting values of pairwise comparison these are synthetized from all decision makers that participated on the decision and weighted by their level of proficiency. Let us have a decision problem in which the personalist is choosing the right candidate for the job. There are three criteria: "Technical skills", "Experience", "Marketing skills", and two candidates (alternatives). The decision schema then looks this way:

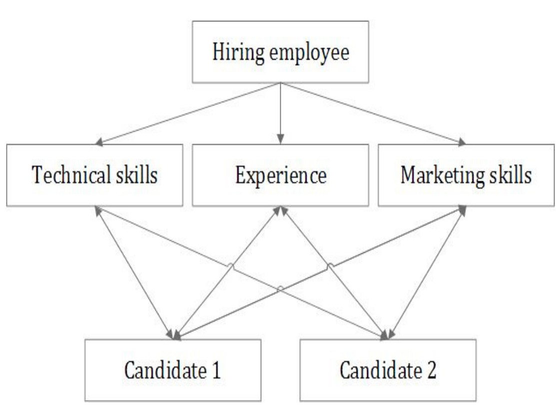


Fig.2. – Group decision scheme

The pairwise comparison scale has 5 fuzzy linguistic variables that represent values from 1 to 9, also middle values are applicable: The pairwise comparison scale has 5 fuzzy linguistic variables that represent values from 1 to 9, also middle values are applicable:

- 1 is absolutely more important than 2
- 1 is significantly more important than 2
- 1 is slightly more important than 2
- 1 might be more important than 2
- 1 is equally important than 2

Now let us assume that we have two decision makers. Decision maker A that is a veteran HR recruiter and decision maker B that is working in this area just for the first year. Decision maker A is assigned weight of 10/10 and decision maker B is assigned with weight 2/10. Concerning pairwise comparison of Experience vs. Marketing skills they voted this way: A – "Experience is slightly more important than Marketing skills" B – "Marketing skills are significantly more important than Experience". This corresponds to values A – 5, B – 7. The order of the comparison is important.

When comparing Experience to Marketing skills and using given votes we get comparison values A – 5 and B – 1/7 (inverted value for inverted question). To accompany the weights are propagated in this step and the result is a set of comparison values corresponding to A, B votes and weights:

[1/7,1/7,5,5,5,5,5,5,5,5,5,5]

Now with median defined as a middle value in a set, the resulting comparison value is 5 or "Experience is slightly more important than Marketing skills".

The voting of the decision maker B seems not to be considered in this case. However, the cote is considered and if multiple people would vote the same way it would shift the result. But alone it does not overrule or shift more experienced decision maker's decision. Using weighted geometrical mean would result in a value 2.75 which is significantly off the "better decision" of the more experienced decision maker. When the main goal is to suppress the irregularities and extreme values, the weighted mean scores better than standard approach using geometrical mean.

## 3. ALGORITMIZATION AND IMPLEMENTATION

Implementation is done in Python framework Django. For mathematical calculations the NumPy library for Python is used. In this part the most important implementation details are outlined to showcase possibility of implementing group ANP decision making using latest technologies.

Base application use-case diagram shows the most important and necessary parts of the application.