Characteristics of Ranking Problems with Multiple Attributes

An Online Continuing Education Course for Engineers

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Characteristics of Ranking Problems with Multiple Attributes

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1.0 Introduction

In this course, a basic introduction will be provided of different types of methods that can be used to solve problems where a number of alternatives with various characteristics or attributes need to be ranked or selected. There are many different methods and approaches to solve these types of problems. The intent of this course is to provide a high-level overview of types of decision methodologies and then to focus specifically on the ranking or selection type of problem. This type of problem is called a multiple attribute decision-making problem. These problems typically have a set of attributes that are used to measure the performance of an alternative and an approach is needed to help arrive at the best of the identified alternatives. The multiple attribute decision-making problem is one of a very practical nature and we see it in decisions made personally, in industry and in the public section.

In an organization, there are typically limited resources. We are unable to launch every new product that we'd like because we don't have the manpower, dollars or time available to do so. Additionally, when we consider how we may want to consider these decisions, the attributes associated with the decisions tend to conflict. For example, we may want to launch a product that improves our customer service but at the same time minimize our operating costs. These two attributes or decision criteria may be in conflict with each other.

Based on the data that is available and the circumstances around the decision, there are a number of methods that can be used to solve these problems. This course is intended to provide some background in ways to solve these types of problems. Other courses are under development that walks students through the specific computations associated with various methods. The following topics are discussed in this course:

- An introduction to multiple attribute decision-making methods, multiple objective decision-making methods and group decision-making methods
- A discussion of the main features of a multiple attribute decision-making problem
- A description of the decision matrix used in these problems
- A discussion of non-compensatory models (trade-offs between attributes are not permitted)
- A discussion of compensatory model (trade-offs between attributes are permitted)

Multiple attribute decision-making methods can be very relevant and practical to use in real-world decision making. The development of attributes to use in decisions is addressed in the

PDHEngineer.com course Developing the Right Decision Framework. This course leads students through a step-by-step process to develop effective decision models to solve corporate-wide problems. The course brings together tools and techniques along with a conceptual and analytical framework that can be applied across a breadth of decisions facing an organization. The Developing the Right Decision Framework course provides insights into the development of attributes for decisions, however, is not necessary for this course. If the student has further interest in this development process, taking that course is suggested.

Multiple attribute decision-making problems are part of a broader class of decision-making problems classified under Multiple Criteria Decision Making (MCDM). Multiple criteria decision making refers to decision making in the presence of a number of decision-making criteria or attributes that are usually conflicting. These types of problems are common in everyday life, business, academia and the public sector. For example, an individual may be looking to purchase a new home. This home needs to have adequate square footage for himself and his family, be stylish, have a large enough year, be in the proximity of schools or shops, be of a price point that is affordable to the homeowner and many other potential considerations. The potential homeowner may want to get the most square footage for the least costs but with the other preferences taken into consideration, which leads to a set of attributes or objectives that conflict. In this example, most likely, the cost of the home will increase as the square footage increases.

In business, an executive team may want to meet overall profitability objectives but want to improve their customer services. There may be costs with improving customer service such as hiring more call center representatives or opening a new call center, however, this improvement in the services may cost the company money and therefore reduce their profitability.

Similarly, you see the same type of consideration in the public sector. For example, a water utility may be mandated to reduce the number of water main breaks, however, it must accomplish this with the same resources that they had available last year. The activities that are sacrificed due to these budget limitations must be considered to meet the new mandate.

It is easy to see that these types of conflicting objectives are a common aspect of decisions that assess and rank a number of alternatives. There is a science behind the methods that can be used to assess these types of problems. This science falls into the classification of Multiple Criteria Decision Making (MCDM). Within this type of decision making, there are two primary groups of methods. These two groups are multiple attribute decision making (MADM) and multiple objective decision making (MODM). Multiple attribute decision making (MADM) methods involve solving a ranking problem that uses a set of decision criteria or attributes. Multiple objective decision making (MODM) involves solving problems where the solution is optimized by trading-off conflicting objectives subject to resource constraints. This classification of problems is typically more difficult to model and utilizes linear programming-based techniques to solve these problems.

Solutions to MCDM problems are either to design the best alternative or to select the best one among previously specified finite alternatives. The MCDM process involves designing/searching for an alternative that is the most attractive overall criteria.

There are two alternative sets of solutions with MADM and MODM problems due to the different problem setting. MADM problems contain a finite number of alternatives. MODM problems have an infinite number of alternatives. MADM problems are used for the selection from a number of defined alternatives. MODM problems design the solution based on the objectives and constraints.

Multiple objective decision making (MODM) is not associated with the problem where the alternatives are predetermined. The goal of these methods is to design the 'best' alternatives by considering the interactions within the design constraints which best satisfy the decision-maker by way of attaining some acceptable levels of a set of some quantifiable objectives. The common characteristics of MODM methods are that they possess a set of quantifiable objectives, a set of well-defined constraints, a process of obtaining trade-off information between stated objectives.

A distinguishing feature of the MADM problem is that there is usually a limited number of predetermined alternatives. The alternatives have associated with them a level of achievement of the attributes based on the final decision to be made. The final selection of the alternative is made with the help of inter-and intra-attribute comparisons. The comparisons may involve explicit or implicit trade-off.

The below table compares some of the features and differences between MADM problems and MODM problems. These problems differ in their definition of criteria, objectives, attributes, constraints, alternatives and usage. The common aspect of these problems is that they have multiple objectives or attributes that most likely are conflicting that need to be accounted for in the development of a solution to the decision.

	MADM	**MODM**
Criteria (defined by)	Attributes	Objectives
Objective	Implicit	Explicit
Attribute	Explicit	Implicit
Constraints	Inactive (incorporated into attributes)	Active
Alternative	Finite number, discrete (prescribed)	Infinite number, continuous (emerging as a process goes)
Usage	Selection/Evaluation	Design

Another classification of decision problem that can assist in the development of multiple attribute decision-making models are Group Decision Making (GDM) techniques. Sometimes it

is necessary to get the consensus of a group of individuals and extract their ideas and expert opinion for making decisions. Group decision-making techniques are methods that we can use to accomplish this. Depending on the group expertise, dominance, and political nature of the various decision-makers involved in the process, you may choose to apply different group decision-making techniques based on the group's composition. These techniques are also helpful to use when only subjective data is available. Because it is hard to look into the future, sometimes the only resource you may have to get a forecast of future events is to poll experts in the field and use their expert opinion in the process. Group decision-making techniques can be used in combination with the development of multiple criteria decision-making models. MCDM models involve decisions and the decision should be representative of the key decision-makers. Understanding the fundamentals of group decision making can be helpful in developing analytical models such as these. Group decision-making techniques are not covered in this course, however, are addressed in another PDHengineer course.

1.1 Examples of MADM, MODM and GDM Methods

A myriad of methods exists in each of these fields. Individuals have spent their careers researching and developing new methods in the areas of MADM, MODM and GDM. Below are some of the more common methods used in each of the three categories along. Understanding that there is a breadth of methods that can be used is important. Even more important is knowing which methods are best for your decision-making environment. As a note, there are many variations and extensions of these methods. Those listed below are the most fundamental version of the method.

1.1.1 Multiple Attribute Decision Making (MADM) Methods

Below is a list of some multiple attribute decision-making methods.

- Dominance Method
- Maximin
- Maximax
- Disjunctive Method
- Conjunctive Method
- Lexicographic Method
- Elimination by Aspect
- Permutation Method
- Linear Assignment method
- Simple Additive Weighting
- Hierarchical Additive Weighting Method
- ELECTRE
- TOPSIS
- Multiple Attribute Utility Theory

- Hierarchical Tradeoffs Method
- LINMSP Interactive Simple Additive Weighting Method
- Multidimensional Scaling with Ideal Point

An interesting aspect of the application of these methods is that different methods may produce different selection results. Each of these methods has a set of procedures that are used to arrive at the final solution. Some of these methods are biased towards one type of solution set. It is important to understand the biases and methodological processes to understand the nature of the solution that is generated. From experience, there are a number of methods that arrive at robust solutions that are easily explained to the decision-maker. Being able to explain to the decision-maker what the method or process does, how the information is used and the nature of the result generated is important for decision-makers to use and be comfortable with the final solution.

1.1.2 Multiple Objective Decision Making (MODM) Methods

Below is a list of a number of multiple objective decision making (MODM) methods.

- Global Criterion Method
- TOPSIS for MODM
- Utility Function
- Bounded Objective Method
- Lexicographic Method
- Goal Programming
- Goal Attainment Method
- Method of Geoffrion and Interactive Goal Programming
- Surrogate Worth Trade-off Method
- Method of Satisfactory Goals
- Method of Zionts-Wallenius
- STEM and Related Methods
- SEMOOS and SIGMOP Methods
- Method of Displaced Ideal
- GPSTEM Method
- Method of Steuer (Interactive MOLP Method
- ISGP (Interactive Sequential Goal Programming)
- MOST (Multiple Objective Superior Technique)
- Parametric Method
- Constraint Method
- MOLP Methods
- Adaptive Search Methods

Again, this only represents a partial list of these methods with new developments on an ongoing basis. Multiple objective decision-making problems typically are more sophisticated to construct and use. When you have multiple conflicting objectives subject to resource constraints, these problems can provide sophisticated and detailed solutions to your decision problem.

1.1.3 Group Decision Making (GDM) Methods

Below is a partial list of group decision making methods.

- Brainstorming
- Trigger method
- SIL method
- Gordon's Approach
- Brainwriting
- Method 6-3-5
- Pin-card method
- BBB method
- Collective notebook
- Nominal Group Technique (NGT)
- Synectics
- Surveys
- Delphi Method
- Conferences
- SPA
- Mor
- ISM
- DEM
- Simul
- Game

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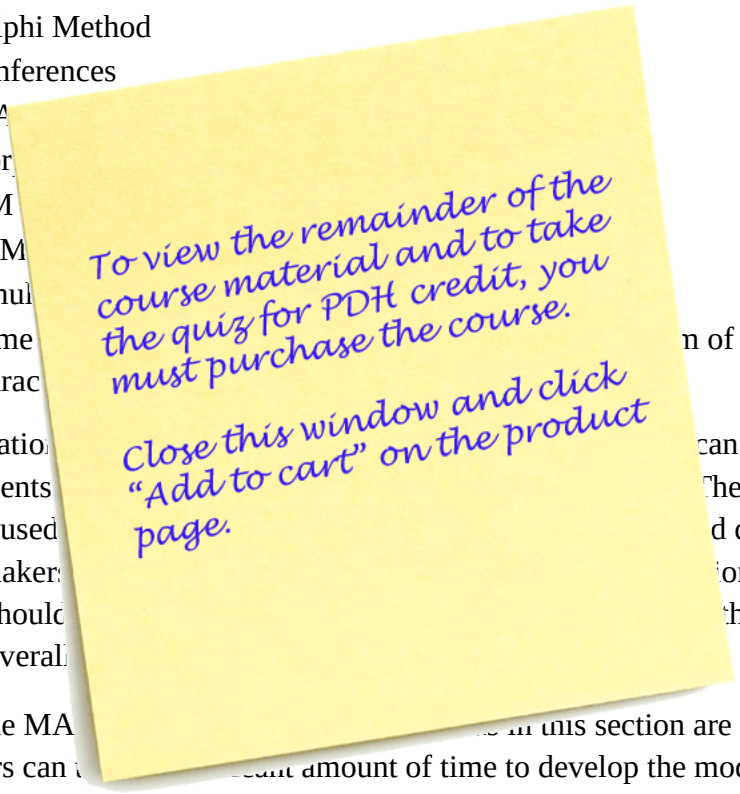

The applicatio can be helpful to mitigate environments These types of techniques can be used d develop a consensus among decision-maker ions or even the components that should hods can benefit the decision process overal

Some of the MA in this section are straightforward and easy to use. Others can amount of time to develop the models and use and lead