Abstract

Multi-attribute decision analysis (MADA) problems involve the task of ranking a finite number of decision alternatives, each of which is explicitly described in terms of different characteristics (also, often called attributes, decision criteria, or objectives), which have to be taken into account simultaneously. Among various MADA methods, multi-attribute utility theory (MAUT) is one widely used method to solve MADA problems. However, substantial empirical evidence and recent research have shown that it is usually difficult to build mathematically rigorous utility functions based on attributes and the conventional attribute utility function often does not provide a good description of individual behavioral/psychological preferences.

As a substitute for utility theory, in 1979 Kahneman and Tversky proposed the S-shaped value function in the Prospect Theory to better represent decision makers'(DMs) behavioral/psychological preferences, and in 1999 Heath et al. suggested that the inflection point in the S-shaped value function can be interpreted as a target. To develop this concept further, target-oriented decision analysis involves interpreting an increasing, bounded function, properly scaled, as a cumulative distribution function (cdf) and relating it to the probability of meeting or exceeding a target value, i.e. it argues that target serves as reference point and alters outcomes in a manner consistent with the value function of *Prospect Theory*. As an emerging area considering the behavioral aspects of decision analysis, target-oriented decision analysis lies in the philosophical root of Simon's *bounded rationality* as well as represents the *S-shaped value function of Prospect Theory*.

In fact, decision analysis with targets/goals has a long history in the literature. Distance-based approach is one widely used method in decision analysis problems. However, different distances should have different impacts on DMs' preferences, which is missed in the distance-based approach. In this sense, revisiting the targets/goals in decision analysis problems is essential to many decision problems.

This research builds upon past research work and makes an intensive/in-depth study on target-oriented decision analysis from the following three aspects:

1. *Target-oriented decision analysis with different types of target preferences and hybrid uncertain targets: We propose two methods to target-oriented decision model with different target preferences and extend those two methods to target-oriented decision analysis with fuzzy targets*

   (a) Target-oriented decision analysis with different types of target preferences
   Original target-oriented decision model presumes that the DM has a monotonically increasing target preference, e.g., the attribute/criterion wealth. However, there are three types of target preferences: "the more the better" (corresponding to benefit target preference), "the less the better" (corresponding to cost target preference), and range targets (too much or too little is not acceptable).
   The key ideas of our methods are to use the cdf and level set of the probability distribution function (pdf) in the target-oriented decision model. Compared

with previous work, our methods can model different types of target preferences and induce four shaped value functions: S-shaped, inverse S-shaped, convex, and concave.

(b) Target-oriented decision analysis with fuzzy targets
In addition, target-oriented decision model assumes that target has a random pdf. It is well known that all facets of uncertainty cannot be captured by a single probability distribution. Fuzzy uncertainty is considered by DMs to linguistically specify their uncertain targets. In our research, we extend those two methods to decision analysis with fuzzy targets. Compared with the pioneering work on fuzzy decision analysis by Bellman and Zadeh, our research outperforms in terms of three aspects.

2. *Multi-attribute target-oriented decision analysis: We develop a non-additive multi-attribute target-oriented decision model based on fuzzy measure and fuzzy integral, and develop a prioritized aggregation operator to model the prioritization between targets/attributes.*

(a) Non-additive multi-attribute target-oriented decision analysis
In many situations, multiple attributes are of interest. Several researches have extended the target-oriented decision model into multi-attribute case. In their model, multi-additive value function is used to aggregate partial target achievements while assuming the mutual independence between different targets. However, it is recognized that in many decision problems attributes are interdependent. On the other hand, even if, in an objective sense the targets are mutually independent (probabilistically mutually independent), they are not necessary considered to be independent from the DM's subjective viewpoint. Thus traditional approaches are not adequate for such complex situations.

The key idea of our work to model the interdependence between different targets is to use the fuzzy measure and fuzzy integral. In our research, several similarities between multi-attribute target-oriented decision model and non-additive fuzzy integral have been discovered. Hence, the λ-fuzzy measure is used as a technique to induce the possible combinations of indices of meeting targets and fuzzy integral is used to model the non-additive multi-attribute model. Compared with previous research, our method can model the interdependence from DM's subjective viewpoint as well as be of simple use in real applications.

(b) Prioritized multi-attribute target-oriented decision analysis
Furthermore, the importance information associated with different targets plays a fundamental role in the comparison between alternatives by overseeing tradeoffs between respective satisfactions of different targets. A concept closely related to the importance information is the priority, which does not allow the tradeoffs between different targets. In some cases, the DM may have a prioritization between different targets.

In our research, a prioritized OWA aggregation operator has been proposed to model the prioritization between different targets based on the Ordered Weighted Averaging (OWA) operator and Hamacher t-norms.

3. *Application to Kansei evaluation problems: We extend the proposed decision models into Kansei evaluation context and propose a Kansei evaluation model based on prioritized multi-attribute fuzzy target-oriented decision analysis. A case study for Kansei evaluation of Japanese traditional crafts is also conducted to illustrate the proposed Kansei evaluation model.*

   Differed from existing work on Kansei evaluation, our proposed Kansei evaluation model can

   (a) solve the inconsistent preference order relations on Kansei attributes,

   (b) integrate the psychological preferences in satisfaction degree of Kansei attributes,

   (c) and consider the prioritization between different Kansei attributes.

   By using our model, consumers can choose their preferred products according to their Kansei preferences. The consumer-oriented Kansei evaluations for traditional crafts in Japan provides possible solutions for both consumer-oriented product design and recommendation strategy for traditional crafts in Japan. Thus we believe that the proposed Kansei evaluation model would be of great help for marketing or recommendation purposes.

In conclusion, our efforts in studying the target-oriented decision model are to solve decision analysis with hybrid uncertain targets and different target preferences, non-additive and prioritized multi-attribute target-oriented decision analysis, and then apply the decision models in Kansei evaluation problems.

Key word: S-shaped function; Bounded rationality; Target-Oriented decision model; Different target preferences; Possibilistic/Probabilistic uncertainty; Fuzzy measure and fuzzy integral; Prioritized aggregation; Kansei evaluation; Japanese traditional crafts.