Abstract

Multiple criteria decision making (MCDM) is a fundamental part of our daily lives. Therefore, several analysis methods for MCDM called multiple criteria decision analysis (MCDA) are herein proposed. The analytic hierarchy process (AHP) is a basic approach to assist with users' MCDM. The choice of evaluation criteria is a key to successful decision-making support, including interactive assistance systems based on the AHP. With appropriate evaluation criteria, decision-support systems can help users find an importance weight on each of the criteria and organize their selection interests. This process of preference structuring is helpful for users who want to select a target from alternatives, particularly when they have uncertain preferences and have not yet described their needs enough to search targets using appropriate keywords. Here, the question is how to prepare such evaluation criteria beforehand.

This thesis introduces *aspects* that are possible viewpoints of items and that represent "why the users look at items," and it proposes a framework for obtaining aspects from users' gaze behavior while browsing multi-attribute content. In addition, this study proposes aspect-based interactive decision assistance.

First, this thesis proposes a framework of an aspect-oriented probabilistic generative model of gaze behavior that is based on topic models. This framework enables us to learn aspects in a data-driven fashion as a form of the degree of relationships between aspects and each attribute value. Also, this framework can estimate users' selection interests by using learned aspects. As such, by estimating users' selection interests together with constructing state space of selection interests from users' gaze behavior, this model can apply proactive item recommendation.

The following two characteristics in this situation make the design of the gaze behavior model difficult: 1) users do not always compare items in the content, and users do not always focus on all attributes of items; and 2) users' gaze behavior is affected by the spatial layout of the content. This thesis proposes two kinds of

models to overcome these difficulties.

For the first difficulty, this thesis introduces a multiscale detection method of users' comparison behavior named the *Multiscale Exact Test (MSET)*. The idea of MSET is that users' significant gaze behavior can be detected using the deviations in the distributions of observations by modeling users' neutral gaze behavior. Users' comparison behavior can be detected together with its scale by comparing the p-value calculated from observed gaze behavior to the significance level. The proposed model learns aspects taking into account users' comparison behavior by regarding the attribute-of-focus detected by the MSET as the gaze behavior model of the observations. We evaluated the validity of this two-step framework of aspect learning using the correlations between learned aspects and task-related attribute values.

For the second difficulty, this thesis specifically focuses on the spatial effect of users' gaze behavior called center bias. The basic idea of this approach is to unify both external factors (i.e., center bias) and internal factors (i.e., preference) in a single generative model. The validity of this proposed framework is supported by the prediction accuracy of the region of interests or item of interests through selection interests.

Once aspects are learned, an interactive system supports the users' MCDM such that the system assists users to recognize the problem structure by directly mentioning aspects. This thesis finally introduces aspect-based interactive assistance based on the AHP. By estimating user preferences from gaze behavior, the system assists users' decision making instead of the AHP. Through interaction during decision making, we show the validity of the effectiveness of using aspects.