Preference Elicitation without Numbers

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Abstract

The development of autonomous multi-agent systems acting upon the interests of one or more users involves the elicitation of preferences of these users. In decision theory, models have been developed with which one is able to perform this elicitation. Some common anomalies have been identified to existing models for applying preference elicitation in electronic commerce settings. This paper presents a novel preference elicitation model based on cross modality matching.

1. Preference Elicitation

Preference elicitation is the process of extracting necessary preference or utility information from a user [1]. This process plays an essential part in the development of autonomous multi-agents systems that are to be deployed in electronic commerce applications. For such applications, agents typically act upon the interests of one or more users.

Utility functions describe the satisfaction that someone receives from consuming commodities. The relation between utilities and preferences is given by defining utility as the measurement of strength or intensity of a person’s preferences [2]. As mentioned, e-commerce agent software acts upon behalf of users and therefore should always include some notion of utility as to express what the preferences are of these users. Capturing this notion explicitly is imperative for systems that are delegated with, for example, making or supporting decisions, planning future actions, or advising users on the decision of choosing between products.

Utility functions can vary widely from user to user, as well as from situation to situation. As such, utility functions are considered difficult to extract from users. Additionally, people usually find it hard to attach utilities to commodities. For example, although one may easily prefer one car over the other, it is often hard to express exactly how much this car is preferred over the other. This paper presents a novel elicitation model to assess utilities from users. Our elicitation model is based on a cross-modality matching technique, removing the barrier for users to give absolute values for utilities, but allowing for alternative modalities to express utilities. This paper demonstrates theoretically how to convert the measured modality-based utilities into absolute values. The method is based on the psychophysical law stating that sensation is a power function of stimulus [6].

Utility Functions

We let utility describe the measurement of usefulness. A value function can be used to predict one’s preferences, hence it is called a utility function. Let this function be denoted by $u$. For every possible outcome $C$, there is a utility $u(C)$ associated with the outcome that denotes the preference for that outcome. A user can make a decision according to the expectations of utilities. The process of obtaining these utilities is called utility elicitation.

Utility Measurement

Essential to utility elicitation is measuring the utilities for specific goods for a user. Several well known utility measurement methods have been described [3] previously by Farquhar. The purpose of his survey was to provide an integration of existing methods of assessing single-attribute expected utility functions and to present some new assessment methods that may be appropriate for further applications and research. If a person were truly to maximise expected utility, the methods described in the survey would elicit utilities exactly. Wakker and Denef [7] describe the certainty equivalent and probability equivalent methods. McCord and de Neufville [4] extensively describe the lottery equivalent method, which would be called a paired-gamble method. Finally, Farquhar describes the gamble-tradeoff [3], which was designed to enable eliciting utilities when probabilities are distorted or unknown. A number of anomalies have been identified to these existing models, rendering them difficult for our intended usage of utility measurement. These anomalies are described in [5].
2. Cross Modality Matching

In our method, we use a technique called cross modality matching that comes from psychophysics and that is described extensively by Stevens [6]. The method is based on the psychophysical law: whatever a stimulus increases, the intensity of sensation grows in accordance with a common basic principle: in every sense modality, sensation is a power function of stimulus. The main motivation behind our method is to avoid that subjects have to use numerical values to directly represent utility. This is because: firstly, people tend to calculate expected values using existing methods for utility measurement (see Section about utility measurement methods) and this might not be a realistic reflection of reality. Secondly, the use of direct scaling to measure utilities lacks a theoretical justification [7].

The Magnitude Estimation Method We first have to let subjects make a magnitude estimation of the area of a circle. According to Stevens [6], sensation magnitude $\psi$ grows as a power function of the stimulus magnitude $\phi$, thus $\psi = k\phi^\beta$. The constant $k$ depends on the units of measurement; the value of exponent $\beta$ serves as a kind of signature that may differ from one sensory continuum to another. In the years between 1953 and 1975 more than three dozen continua have been examined and were found to fit the power function. We can thus describe the growth of the sensation magnitude of the area of a circle $\psi_0$ as a power function of the stimulus magnitude of the area of a circle $\phi_0$, as $\psi_0 = k\phi_0^m$.

Cross Modality Matching We want to make a cross modality matching between the utility of the amount of money and visual area (the subjective value of, for example, the area of a circle). Cross modality matching uses two different sense modalities. It assumes that in the first sense modality the sensation $\psi_1$ is related to its stimulus $\phi_1$ by a power function with the exponent $m$, i.e., $\psi_1 = k\phi_1^m$. Likewise, in the second sense modality, a similar equation is assumed, but with a different exponent $n$, i.e., $\psi_2 = k'\phi_2^n$. Now, if $\psi_1$, i.e. visual area, is matched to $\psi_2$, i.e. subjective value of monetary amounts, at several different values over a range of stimuli, for these stimuli we then can write $\psi_1 = \psi_2$. This implies that for the equated values $\psi_1$ and $\psi_2$ we can substitute the stimulus values, so that $k\phi_1^m = k'\phi_2^n$. It is possible to rewrite this equation to

$$\phi_1 = \sqrt[2]{{\frac{k'}{k}} \phi_2^n}. \tag{1}$$

Utility Measurement by Cross Modality Matching Ultimately, we are interested in the exponent of the power function describing the sensation of monetary values. In log terms, the power law equation is: $\log \psi = \beta \log \phi + \log k$. The exponent $\beta$ is the slope of this linear log line. When we know a number of outcomes for the values of $\psi$ and $\phi$, it is possible to estimate the values of $\beta$ and $k$, using the method of least squares. Now we can estimate a power function having obtained a number of outcomes for the values of $\psi$ and $\phi$. When we use the magnitude estimation method, it is now possible to estimate the power function that relates $\psi$ and $\phi$: $\psi = k\phi^m$. It is now also possible to estimate the power function that relates $\phi_1$ and $\phi_2$ as in equation 1. Combining the functions of magnitude estimation and cross modality matching, we can derive the value of $n$: the exponent of the power function that describes the sensation magnitude of the second sense modality.

3. Discussion

Preference elicitation is essential in multi-agent systems that are acting upon the interests of their users. Examples of such systems are widely known, ranging from user profiling agents to action-based agent-mediated marketplaces. To obtain preferences from users is a difficult and elaborate task, but rewards itself by the better alignment between buyer and seller.

We have presented a preference elicitation model that can be used for the design of multi-agent systems. The main idea of this model is that it enables users to state their preferences in some given kind of modality (for example, circle sizes), removing the need to quantify preferences. For future research, we foresee the application of our new model in agent-mediated e-commerce settings as to obtain preferences from clients autonomously.

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References