Decision Filed Theory

Lan Shao
University of Oulu, Finland

Jouni Markkula
University of Oulu, Finland

INTRODUCTION

Development advanced ICT based systems, applications and services for improving our daily life require understanding and modeling of how people make decisions. The human decision making has been of interest, and theories been developed, in different fields of science, including economics, psychology, sociology and computer science. There exist a number of well-known and widely applied decision making theories, such as causal decision theory, evidential decision theory and game theory. In ICT field, formal decision making models are used, for example, in developing decision support systems, artificial intelligence solutions and intelligent services. Growing number of application of these systems can be found in such areas as electronic commerce, intelligent traffic and health.

Decision Filed Theory (DFT) is one of the younger human decision making theories that has significant potential for practical applications in real-world decision making situations. It employs a dynamic decision making model, compared to static models that most of the traditional decision theories are relying on, and builds on psychology, whereas the earlier models are commonly based on economics and rational utility theories. These characteristics make it potentially useful for present day application needs. Along with development of technology, the DFT has been studied for solving various kinds of decision making problems in different contexts. Several successful empirical studied have shown that DFT theory is able to explain human's dynamic behavior in many areas and it can be applied as a basis for ICT system design.

By a glance to the existing research, we can see that the DFT has been adapted to different application contexts. However, for having stronger evidence for its validity to practical empirical cases and understanding its trends and current state, the existing scientific literature needs to be reviewed and analyzed more systematically and in a structured way. This article presents the results of our study, where we analyze and synthesized the existing research knowledge on DFT with the means of Systematic Literature Review (SLR). The purpose is to give and evidence based view to the development of Decision Field Theory and its applications, which offers an understanding of its validity for practical applications and future potential.

BACKGROUND

Decision Field Theory, initially proposed by Busemeyer and Townsend (1993), is a dynamic cognitive approach to describe and explain human decision making under risk and uncertainty. It provides a formal theory and a mathematical model of human decision behavior, which takes into account two of the basic phenomena of human decision making that are not covered by most of the other theories: variability of preference of choices

DOI: 10.4018/978-1-5225-2255-3.ch183

and systematic relation between preferences and deliberation time (Busemeyer & Townsend, 1993). Before the theory has been applied to solve multiple options problems of decision making, it has experienced several stages that are the foundation for present theory. The early deterministic subject expected utility (SEU) theory is restricted to the choices between two options (Savage, 1954). This theory can be applied to predict the trend of preferences on options, but it can't explain the dynamic change of preference. It was followed by the Sequential SEU Theory (DeGroot, 1970), which take into account the sequential order of consecutive decisions. The main problem of the Sequential SEU theory is that the knowledge and experience in the past has no influence on current decision making, which goes against with real human deliberative process. The Random Walk SEU Theory (Busemeyer, 1985) solves this problem by setting an initial preference state. The deterministic decision making theories originate from the basic proposal that the action is either true or false between two conflict actions, which is referred to binary preference relation (Fishburn, 1988). In subsequent, it was used for two or more attributes decision making under dynamic environment (Diederich, 1997). After that, DFT was gradually mature and widely used.

DFT is a method that provides insights into relationship between preference evolution and dynamic decision making. The following original and classic mathematical equation is used to explain the dynamic evolution of preferences during the deliberation time.

$$P(t+h) = SP(t) + V(t+h)$$

In this equation, *P* is the Preference vector, *S* is the Growth-decay matrix and *V* the Valence vector, which are explained below. The equation can be decomposed further as

$$p_i(t+h) = s_{ii} \cdot p_i(t) + \sum_{k \neq i} s_{ik} \cdot p_k(t) + v_i(t+h)$$

In general, DFT consider time as a dynamic factor which lead to frequent change in human's preference among various options. So for the time series $\{t_0, t_1, t_2 \ldots t_i, t_j \ldots t_n\}$, the preferences on options fluctuate upon specific time point and forms preferences series $\{p_0, p_1, p_2 \ldots p_i, p_j \ldots p_n\}$. In the equation, the time points *t* and *t+h* are two adjacent time moments, and parameter *h*, referred as time unit, denotes the distance between two moments of decision making. From microscopic side, decision making is a continuous process when the moment is sequential. So, the length of *h* approaches to zero in the limit (Abad, 2014). While from the macroscopic side, decision making is intervallic. Thus, time unit *h* is equal to an arbitrary value.

Preference Vector *P*

The row vector $P(t)' = [P_1(t), P_2(t), \ldots\ldots, P_n(t)]$ represents the preference state at time *t* for the *n* options.

Growth-Decay Matrix *S*

The decision makers' perception of decision case is not only determined by current information, but it also would be affect by their previous knowledge or similar experience (Van Horne, 1967). Consequently, the preferences value in current moment is influenced positively or negatively by the decision makers' memory. The matrix *S*, referred as feedback vector, is formed as $S = (I - h\Gamma)$ that is assumed to be symmetric ($r_{ij} = r_{ji}$, for all *i, j*). The diagonal elements of s_{ii} provide memory for previous states of the system. The off-diagonal values of s_{ik} allow for competitive interactions among competing alternatives. The researchers (Busemeyer et al., 2008; Qin et al., 2013) explain the implication of s_{ii} value in four following conditions.

- $0 < s_{ii} < 1$ indicates that memory of decision maker has positive feedback on current decision problem.