Chapter 77
Fuzzy Linguistic Modelling in Multi Modal Human Computer Interaction:
Adaptation to Cognitive Styles using Multi Level Fuzzy Granulation Method

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ABSTRACT

The purpose of this chapter is to explore fuzzy logic based methodology for computing an adaptive interface in an environment of imperfect, vague, multimodal, complex nonlinear hyper information space. To this end, based on fuzzy linguistic modelling and fuzzy multi level granulation an adaptation strategy to cognitive/learning styles is presented. The granulated fuzzy if-then rules are utilized to adaptively map cognitive/learning styles of users to their information navigation and presentation preferences through natural language expressions. The important implications of this approach are that, first, uncertain and vague information is handled; second, a mechanism for approximate adaptation at a variety of granulation levels is provided; third, a qualitative linguistic model of adaptation is presented. The proposed approach is close to human reasoning and thereby lowers the cost of solution, and facilitates the design of human computer interaction systems with high level intelligence capability.

INTRODUCTION

The growing amount of information on the WEB and the heterogeneous characteristics of Web users have lead to a considerable attention to web-based adaptive hypermedia systems (WAHS) by the research community (Brusilovsky, 1996, 2001). The power of hypermedia of web technology is in its capability to support non-linear navigation in hyperspace and multimedia presentation of the web content. WAHS offers an alternative to the traditional "one-size-fits-all" hypermedia and Web systems by adapting to the goals, interests, and knowledge of individual users represented in

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the individual user models (Brusilovsky, 2001). WAHS aims to minimize cognitive overload faced by users, to alleviate the disorientation problem of users, to enhance the usability and the utility of the system by applying intelligent information adaptation (personalization) techniques for user/system interactions that take into account individual differences of users (Mobasher & Anand, 2010). Adaptation involves two key activities:

1. A user modelling activity to develop a user model and
2. An adaptation activity that leverages a 'rich' user-model to personalize the information content, the information presentation style and the navigation path of the system to the user (Brusilovsky, 1996).

One of the ways to enhance the efficiency of WAHS is to build accurate user models. It can be achieved by taking into account human factors (or individual differences) that have significant effects on human computer interaction and on the learning process (Nikos, Panagiotis, Zacharias, Constantinous, & George, 2009; Triantafillou, Pomportsis, & Demetriadis, 2003). Research into individual differences suggests cognitive/learning styles have significant effects on student learning in hypermedia systems (Triantafillou, Pomportsis, & Demetriadis, 2003; Chen, 2002; Mitchell, Chen, & Macredie, 2010; Nikos, Panagiotis, Zacharias, & Costas, 2009).

Information imperfection, that is, information used in one or more respects is imprecise, uncertain, incomplete, unreliable, vague or partially true, is an inherent characteristics of WAHS (Garcia, & Sicilia, 2010). Imprecision of WAHS is rooted in imprecision of its input information. Sources of input information to build a user model are either the explicit information provided by subjective judgments of users/experts or the implicit information inferred by monitoring and measurement of a user behaviour, or combination of both. This imprecision is passed on user model and then on adaptation strategy that is guided by heuristics, hypotheses, or approximate decisions.

The purpose of this chapter is to explore fuzzy logic based methodology of computing an adaptive interface in an environment of imperfect, vague, multimodal, complex nonlinear hyper information space. To this end, based on fuzzy linguistic modelling and fuzzy multi-level granulation an adaptation strategy to cognitive/learning styles is presented. The granulated fuzzy if-then rules are utilized to create a fuzzy inference system (FIS) to adaptively map cognitive/learning styles of users to their information navigation/presentation preferences through natural language expressions. The important implications of this approach are that, first, uncertain and vague information used is handled; second, a mechanism for approximate adaptation at a variety of granulation levels is provided; third, a qualitative linguistic model of adaptation is presented. The proposed approach is close to human reasoning and thereby lowers the cost of solution, and facilitates the design of human computer interaction systems with high level intelligence capability.

The chapter is organized as follows. First I present a brief description of WAHS and fuzzy logic theory in WAHS. The description of cognitive and learning styles is given. Navigation and presentation preferences of users are presented. The adaptation process, examples of fuzzy granulation of input and output linguistic variables, and an inference mechanism of adaptation are presented. The next section is devoted to description of a simulation example to illustrate the proposed approach. Finally, we present conclusions and future work.

WEB-BASED ADAPTIVE HYPERMEDIA SYSTEMS AND FUZZY LOGIC THEORY

WAHS can be defined as the technology that allows personalization for each individual user of hypermedia application. The process of personal-