Chapter 1
Computational Intelligence Using Type-2 Fuzzy Logic Framework

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ABSTRACT

In this chapter, the authors expand the notion of type-2 fuzzy sets. An introduction to standard and interval (type-2) fuzzy sets and systems is explained in the early part of the discussion. The chapter also covers the ideas of hybrid type-2 fuzzy system. Next, the authors study the applicability of type-2 fuzzy logic (FL) system in student's performance in oral presentation as it is clearly new field of research topic and have an excellent opportunity to combine several fuzzy set method developed in the recent years. The proposed application shows the linkage of type-2 fuzzy system with TOPSIS. The present chapter also highlights the possible future directions for type-2 FL system research. By the end of the chapter, the authors hope that even those with little previous experience of fuzzy logic should be enabled to apply these methods in their own application areas and/or begin research in this fascinating and exciting area.

1. INTRODUCTION

The concept was first proposed by (Zadeh, 1975). Subsequently Mizumoto and Tanaka (1976) developed and discussed some properties of type-2 fuzzy sets but no work was done to further develop it into a useful and practical tool. Karnik et al. (1999) introduced the concept of "*Footprint of Uncertainty*" and the upper and lower membership functions to describe type-2 fuzzy sets. Using interval type-2 fuzzy sets they developed the singleton and non-singleton type-2 fuzzy architectures for practical applications in engineering. A simple and straightforward treatment of s was given by Mendel and John (2002). The three dimensional nature of type-2 fuzzy sets suggest that uncertain-

ties could be better accommodated compared to the two dimensional type-1 fuzzy sets.

The overall work plan of the proposed chapter is as follows:

A.   An introduction to standard and interval (type-2) fuzzy sets.
B.   Basic operations of type-2 fuzzy sets.
C.   Introduction to type-2 fuzzy system.
D.   Introduction to various hybrid type-2 FL system:
E.   A case study on the applicability of Students' Performance in Oral Presentation Using Interval Type-2 Fuzzy Approach.
F.   Future directions for type-2 FL system research and applications.

The objectives of this chapter is to: (i) review the literature; (ii) perspective on the issues and problems related to computational intelligence using interval type-2 fuzzy logic based on the application to Students' Performance in Oral Presentation research; and, (iii) identify future research directions. This chapter is organized as follows. Section 2 introduces detail definitions and discussions of type-2 fuzzy sets and incorporate views of others. In section 3, concepts of type-2 fuzzy system are introduced. A brief introduction and logic of various hybrid type-2 fuzzy systems is stated in section 4. A case study on the applicability of Students' Performance in Oral Presentation using Interval Type-2 Fuzzy Approach will be framed in Section 5. Section 6 puts emphasis on the issues of future directions for type-2 FL system. The conclusions to this chapter are given in Section 7.

2. BACKGROUND

A type-2 fuzzy set is characterized by a fuzzy membership function, i.e., the membership grade for each element of this set is a fuzzy set in [0,1], unlike a type-1 set where the membership grade is a crisp number in [0,1]. Such sets can be used in situations where there is uncertainty about the membership grades themselves, e.g., an uncertainty in the shape of the membership function or in some of its parameters. Consider the transition from ordinary sets to fuzzy sets. When we cannot determine the membership of an element in a set as 0 or 1, we use fuzzy sets of type-1. Similarly, when the situation is so fuzzy that we have trouble determining the membership grade even as a crisp number in [0,1], we use fuzzy sets of type-2. This does not mean that we need to have extremely fuzzy situations to use type-2 fuzzy sets. There are many real-world problems where we cannot determine the exact form of the membership functions, e.g., in time series prediction because of noise in the data. Another way of viewing this is to consider type-1 fuzzy sets as a first order approximation to the uncertainty in the real world. Then type-2 fuzzy sets can be considered as a second order approximation. Of course, it is possible to consider fuzzy sets of higher types but the complexity of the fuzzy system increases very rapidly. For this reason, we will only consider very briefly type-2 fuzzy sets.

Type-1 fuzzy sets, which represent uncertainties by numbers in the range [0,1], have been widely adopted in neuro-fuzzy systems by Lucas et al. in 2007. However, the membership functions of type-1 fuzzy sets are often overly precise, requiring each element of the universal set to be assigned a particular real number (Greenfield et al. 2007). Type-2 fuzzy sets were proposed for dealing with this difficulty. A type-2 fuzzy set allows its associated membership degrees to be uncertain and expressed as type-1 fuzzy sets (Wagner et al., 2008;, Karnik et al., 2001; Greenfield et al., 2005). Most of type-2 fuzzy logic systems adopted interval type-2 fuzzy sets that are a special kind of type-2 fuzzy sets. This may be partly due to that the inference involving type-2 fuzzy sets is much more complex and time-consuming than that involving interval type-2 fuzzy sets. Liang and Mendel 2000a developed

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