Application of Fuzzy Numbers to Assessment of Human Skills

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ABSTRACT

Fuzzy logic, due to its nature of characterizing the ambiguous cases with multiple values, offers rich resources for dealing with assessment situations, a fact that gave us several times in past the impulse to apply its principles for such kind of situations. Fuzzy Numbers (FNs) play a fundamental role in fuzzy mathematics, analogous to the role played by the ordinary numbers in classical mathematics. In the present paper, the author utilizes a combination of the Triangular and Trapezoidal FNs with the Center of Gravity Defuzzification technique for assessing human skills. The results are illustrated by suitable examples (student and basketball players’ assessment), while the author’s method is compared with assessment methods of the bivalent and fuzzy logic that has been already used in earlier works.

KEYWORDS

Center of Gravity (COG) Defuzzification Technique, Fuzzy Logic, Fuzzy Numbers (FNs), Human Assessment, Triangular (TFNs) and Trapezoidal (TpFNs) Fuzzy Numbers

1. INTRODUCTION

Fuzzy logic, the development of which is based on fuzzy sets theory (Zadeh, 1965; Zadeh, 1975), provides a rich and meaningful addition to standard Boolean logic. Unlike Boolean logic, which has only two states, true or false, fuzzy logic deals with truth values which range continuously from 0 to 1. Thus, something could be half true 0.5 or very likely true 0.9 or probably not true 0.1, etc. In this way, fuzzy logic allows one to express knowledge in a rule format that is close to a natural language expression and therefore it opens the door to construction of mathematical solutions of computational problems which are imprecisely defined.

The assessment of a system’s effectiveness (i.e. of the degree of attainment of its targets) with respect to an action performed within the system (e.g. problem-solving, decision making, learning process, etc.) is a very important task that enables the correction of the system’s weaknesses resulting to the improvement of its general performance. The assessment methods that are commonly used in practice are based on the principles of the bivalent logic (yes-no). However, in our day to day life uncertain situations are frequently appear, in which a crisp characterization is not the more appropriate for an assessment. For example, a teacher is frequently not sure about a particular numerical grade characterizing a student’s performance.

Fuzzy logic, due to its nature of characterizing the ambiguous cases with multiple values, offers wider and richer resources covering such kind of situations. This gave as several times in the past the

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impulse to apply principles of fuzzy logic for the assessment of human or machine (in case of CBR systems) skills using as tools the corresponding system’s total uncertainty (e.g. see Voskoglou (2011) and its relevant references, (Voskoglou, 2015), etc.), the Center of Gravity (COG) defuzzification technique (e.g. see Subbotin, Ya, Badkoobeh, and Bilotskii (2004), Voskoglou (2014), and Voskoglou (2015), etc.) as well as the recently developed variations of this technique of the Triangular (e.g. see [8, 9], etc.) and of the Trapezoidal (e.g. see Subbotin and Ya (n. d.) and Voskoglou (2015), etc.) Fuzzy Assessment Models or, for brevity, TFAM and TpFAM respectively. The above fuzzy methods, although they can be used for individual assessment as well (Voskoglou, 2013), they are more appropriate for accessing the overall performance of a group of individuals (or objects) sharing common characteristics (e.g. students, players of a game, CBR systems, etc.).

In the present paper we shall use the Fuzzy Numbers (FNs) as a tool for assessing human skills and in particular two of the most commonly used forms of them, i.e. the Triangular (TFNs) and Trapezoidal Fuzzy Numbers (TpFNs). In contrast to the above mentioned fuzzy assessment methods, this approach is more appropriate for individual assessment. However, we shall adapt it for use as a tool for group assessment too.

The rest of the paper is organized as follows: In Section 2 we present the notion of a Fuzzy Number (FN), while in Section 3 we present the TFNs, the TpFNs and the basic arithmetic operations between them. In Section 4 we present suitable examples to describe the use of TFNs and TpFNs for assessing human skills. Finally, Section 5 is devoted to our conclusion and a brief discussion of the perspectives of future research on the subject.

2. FUZZY NUMBERS

2.1. Definitions

Let U denote the universal set of the discourse. We recall that a fuzzy set A in U (Zadeh, 1965) can be written as a set of ordered pairs in the form $A = \{(x, m_\Lambda(x)): x \in U\}$, where $m_\Lambda: U \rightarrow [0,1]$ is its membership function.

A Fuzzy Number (FN) is a special form of fuzzy set on the set $R$ of real numbers. FNs play a fundamental role in fuzzy mathematics, analogous to the role played by the ordinary numbers in classical mathematics.

Before giving the definition of a FN we recall the following related concepts:

**Definition 1:** A fuzzy set $A$ on $U$ with membership function $y = m(x)$ is said to be normal, if there exists $x$ in $U$, such that $m(x) = 1$.

**Definition 2:** Let $A$ be as in Definition 2, and let $x$ be a real number of the interval $[0, 1]$. Then the $x$-cut of $A$, denoted by $A^x$, is defined to be the crisp set:

$$A^x = \{ y \in U: m(y) \geq x \}$$  \hspace{1cm} (1)

Assume now that $U$ is a vector space over the field $R$ real numbers. We recall then that a crisp subset $A$ of $U$ is said to be convex, if, for all $y_1, y_2$ in $A$ and all $t$ in $[0, 1]$, $y = (1-t)y_1 + ty_2$ is also in $A$; in other words if every point of the line segment connecting $y_1$ and $y_2$ belongs also to $A$. Therefore, all the convex subsets of $R$ are ordinary closed real intervals.

One can define now the concept of a convex fuzzy set on $U$ as follows:

**Definition 3:** A fuzzy set $A$ on a vector space $U$ over $R$ is said to be convex, if its $x$-cuts $A^x$ are convex sets, for all $x$ in $[0, 1]$.  

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