# Chapter 44
# Some Recent Defuzzification Methods

**Harendra Kumar**
*Gurukula Kangari University, India*

## ABSTRACT

*Defuzzification is a process that converts a fuzzy set or fuzzy number into a crisp value or number. Defuzzification is used in fuzzy modeling and in fuzzy control system to convert the fuzzy outputs from the systems to crisp values. This process is necessary because all fuzzy sets inferred by fuzzy inference in the fuzzy rules must be aggregated to produce one single number as the output of the fuzzy model. There are numerous techniques for defuzzifying a fuzzy set; some of the more popular techniques are included in fuzzy logic system. In the present chapter some recent defuzzification methods used in the literature are discussed with examples.*

## INTRODUCTION

Fuzzy set theory was introduced by Zadeh (1965). Fuzzy set is the extension of crisp set. In fuzzy, each and every element has the degrees of membership value which lies in [0,1]. Fuzzy set theory extends the classical set theory with memberships of its elements described by the classical characteristic function, to allow for partial membership described by a membership function. Thus, fuzzy set theory has great capabilities and flexibilities in solving many real-world problems which classical set theory does not intend or fails to handle. Fuzzy set theory was applied to control systems theory and engineering almost immediately after its birth. In many practical applications such as in fuzzy inference systems, the fuzzy results generated cannot be used as such to the applications, hence it is necessary to convert the fuzzy quantities into crisp quantities for further processing.

DOI: 10.4018/978-1-5225-1908-9.ch044

## Defuzzification

Defuzzification is a process that converts a fuzzy set or fuzzy number into a crisp value or number. Defuzzification is used in fuzzy modeling and in fuzzy logic control to convert the fuzzy inputs or outputs (or both) from the systems to crisp values. In another word, defuzzification interprets the membership degrees of the fuzzy sets into a specific decision or real value. This process is necessary because all fuzzy sets inferred by fuzzy inference in the fuzzy rules must be aggregated to produce one single number as the output of the fuzzy model. There are numerous methods are available for defuzzifying crisp value or number in the literature. Unfortunately, we have no systematic procedure for choosing a good defuzzification method, and thus we have to select one in considering the properties of application case. Hellendoorn and Thomas (1995) describe some defuzzification method with their respective merits and shortcomings dependent on the rule and domain. Yager and D. P. Filev (1995) address the problem of defuzzification in situations where in addition to the usual fuzzy output of the controller there exists some ancillary restriction on the allowable defuzzified value. Yager and Filev (2006) discussed a problem of selecting a crisp element based on information provided by a fuzzy set, a problem which manifests itself in the defuzzification step in fuzzy logic controllers. The matrix games with fuzzy payoffs have been extensively discussed by Deng-Feng Li (2013). Two major kinds of solution methods have been devised. One is the defuzzification approach based on ranking functions. Another is the two-level linear programming method which can obtain membership functions of players' fuzzy values (or gain floor and loss ceiling). An effective methodology for solving constrained matrix games with payoffs of trapezoidal fuzzy numbers (TrFNs), which are a type of two-person non-cooperative games with payoffs expressed by TrFNs and players' strategies being constrained has been developed by Li and Hong (2013). Recently, a new approach for defuzzification of generalized fuzzy numbers is established by Rouhparvar and Panahi (2015). This method uses in centre point of a triangle where the three bisector lines of its angles meet. There are various methods available for defuzzification; some of them are defined in the following section.

In the following sections, the most often used defuzzification methods are defined.

- **Center of Area (COA) Method:** In the Center of Area (COA) defuzzification method, we first calculate the area under the scaled membership functions and within the range of the output variable, then we uses the following equation to calculate the geometric center of this area.

$$z^* = \frac{\int z.\mu_{\tilde{A}}\left(z^*\right)dz}{\int \mu_{\tilde{A}}\left(z^*\right)dz} \tag{1}$$

where COA is the center of area, $x$ is the value of the linguistic variable, and $x_{\min}$ and $x_{\max}$ represent the range of the linguistic variable. The following figure illustrates the COA defuzzification method:

In figure 1, μ is the degree of membership, and the shaded portion of the graph represents the area under the scaled membership functions. This method is also known as center of gravity and centroid method. Center of area defuzzification is the most commonly used method, as it is very accurate method. It provides center of area under the curve of membership function. For complex membership functions, it puts high demands on computations. It is the most common used method for defuzzification.