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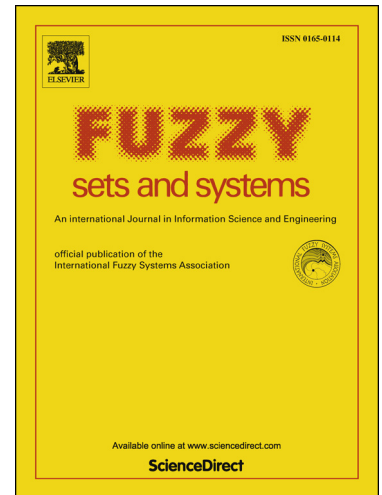
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# Intersections and unions of fuzzy sets of operands

S. Mashchenko

## Abstract

We investigate intersections and unions of sets with fuzzy sets of operands. These are natural generalizations of the corresponding operations which involve crisp sets of operands. It is shown that the resulting set is a fuzzy set of type-2 (T2FS). We prove several results which enable us to simplify constructing the type-2 membership functions for intersections and unions of fuzzy sets of operands. We check that de Morgan's laws hold for these two operations with fuzzy sets of operands. As far as the two operations on crisp sets are concerned, the resulting T2FS can be represented as two standard fuzzy sets of its sections. We provide some insight into how these sections are related.

**Keywords:** fuzzy set; set operations; type-2 fuzzy set

## 1 Introduction

Unions, intersections and complements of fuzzy sets play an important role in a large body of research carried out in the areas of decision theory, game theory, optimal control, pattern recognition, information retrieval, linguistics and other sciences (see references given in [1], [2]). Algebraic products and algebraic sums showed up in studies of fuzzy events [3], logic [4], fuzzy semantics [5] and fuzzy automata [6]. To investigate fuzzy reasoning new operations called bounded sum and bounded difference [7] were introduced.

Development of the theory of type-2 fuzzy sets (T2FS) and its application in the scientific research have led to investigation of operations on them. Mizumoto and Tanaka studied the operations on T2FS and the properties of their membership functions [8, 9]. Nieminen's article [10] was devoted to some features of the algebraic structure of T2FS. Kaufmann and Gupta [11] and Dubois and Prade [12] investigated the join and meet operations between fuzzy numbers according to the minimum of a  $t$ -norm. Dubois and Prade [12-14] suggested a formula for the composition of type-2 fuzzy relations as an extension of the type-1. Karnik and Mendel [15,16] obtained a general formula for the composition of type-2 fuzzy relations.

In the book [17] one can find theoretical foundations of T2FSs, various methodologies for generating membership functions of intervals and general T2FSs, and some new applications of T2FSs. The paper [18] introduces new operations on the algebra of fuzzy truth values. The authors of [18] use their findings to derive some information on the type-2 fuzzy relations and their compositions which particularly enables them to define interval-valued T2FSs and interval-valued type-2 fuzzy relations and investigate their properties. The article [19] discusses set-theoretic and algebraic operations on T2Fs, and properties

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