

# A CLASSIFIED REVIEW ON THE COMBINATION FUZZY LOGIC–GENETIC ALGORITHMS BIBLIOGRAPHY: 1989–1995

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In this paper, we present a classified review of the bibliography on the combination fuzzy logic—genetic algorithms. The classification is developed collecting the papers making reference to an specific fuzzy logic area.

## 1 Introduction

Recently, numerous papers and applications combining fuzzy logic (FL) and genetic algorithms (GAs) have become known, and there is an increasing interest in the integration of these two topics.

The present bibliography collects a big quantity of references in this growing area, although unfortunately they are not all the possible. Some of the references are incomplete because either we have earlier versions before to be published or we have got them incomplete. Comments, corrections, papers and references for maintaining the report are welcome.

The classification has been made following the table 1 that contains the keywords and the number of papers on each of them. We have tried to cover the application of FL based tools to GA (with the name of fuzzy genetic algorithms) and different areas of the fuzzy logic making useful the classification. When a paper belongs to more than one area then we have selected the area that can make easy its search or use.

Table 2 collects the classified data related to the number of works published in each one of the classification areas per years, these last belonging to the time interval considered in our paper. It can be observed the increasing interest existing in the last few years.

The next section presents a short introduction about FL and GAs for readers which are not familiarized with these topics. The third section shows the classified bibliography.

Table 1: Classification keywords

<b>1</b>	Fuzzy genetic algorithms	16
<b>2</b>	Fuzzy clustering	11
<b>3</b>	Fuzzy optimization	23
<b>4</b>	Fuzzy neural networks	23
<b>5</b>	Fuzzy relational equations	4
<b>6</b>	Fuzzy expert systems	5
<b>7</b>	Fuzzy classifier systems	20
<b>8</b>	Fuzzy information retrieval and database quering	5
<b>9</b>	Fuzzy decision making, financial, and economic models	7
<b>10</b>	Fuzzy regression analysis	3
<b>11</b>	Fuzzy pattern recognition and image processing	16
<b>12</b>	Fuzzy classification — Concept Learning	17
<b>13</b>	Fuzzy logic controllers (Design, Learning, Tuning, Applications)	171
<b>14</b>	Fuzzy logic miscellaneous	24
	<b>Fuzzy logic — Genetic algorithms: Total</b>	<b>345</b>

Table 2: Number of contributions per year

Year	Classification Area														Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1989	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2
1990	0	0	0	0	0	0	0	0	0	0	3	0	4	0	7
1991	0	0	0	0	0	0	2	0	0	0	0	0	7	0	9
1992	1	0	3	2	0	0	1	0	0	0	1	1	15	0	24
1993	4	2	3	5	0	0	4	2	3	1	2	5	36	2	69
1994	5	4	7	7	2	3	6	1	2	2	5	4	51	10	109
1995	6	5	10	9	2	2	7	2	2	0	4	7	57	12	125

## 2 Fuzzy Logic and Genetic Algorithms

### 2.1 Fuzzy logic

FL may be viewed with two different meanings as was expounded in by Prof. Zadeh, the pioneer of fuzzy logic and fuzzy set theory (in L.A. Zadeh, Foreword. In: P-Z. Wang, K.F. Loe (Eds.) *Between Mind and Computer: Fuzzy Science and Engineering*, World Scientific, London, 1993).

(a) a narrow interpretation, FLn, in which fuzzy logic is basically a logic of approximate reasoning; and (b) a wide interpretation, FLw, in terms of which fuzzy logic is coextensive with the theory of fuzzy sets, that is, classes of objects in which the transition from membership to nonmembership is gradual rather than abrupt.

In the narrow sense, fuzzy logic may be viewed as a generalization and extension of multivalued logic. But the applicability of fuzzy logic is far than that of multivalued logic because FLn provides many concepts and techniques which are not a part of multivalued logic. Among such concepts and techniques — which play a key role in the applications of fuzzy logic — are those of the linguistic variable; the concepts of possibility and necessity; concepts of truth and usability—qualification; fuzzy quantification and cardinality. Furthermore, the agenda of FLn is quite different from that of classical multivalued logical systems.

In its wide sense, FLw, fuzzy logic is a very broad theory with many branches, among them fuzzy sets, fuzzy arithmetic, fuzzy mathematical programming, fuzzy pattern recognition, fuzzy control, fuzzy probability theory, fuzzy topology, the calculi of fuzzy rules and fuzzy graphs, and fuzzy logic, FLn, in its narrow sense. It should be noted that there is a growing trend to interpret the fuzzy logic in its wide sense since the label fuzzy logic is more euphonious and more self—explanatory than *fuzzy set theory*. Regardless of its interpretation, the role model for fuzzy logic is the human mind.

### 2.2 Genetic algorithms

GAs are general purpose search algorithms which use principles inspired by natural genetic populations to evolve solutions to problems. The basic idea is to maintain a population of knowledge structures that evolves over time through a process of competition and controlled variation. Each structure in the population represents a candidate solution to the concrete problem and has an associated *fitness* to determine which structures are used to form new ones in the competition process. The new ones are created using genetic operators such as *crossover* and *mutation*. GAs have had a great measure of success in

search and optimization problems. The reason for a great part of their success is their ability to exploit the information accumulated about an initially unknown search space in order to bias subsequent searches into useful subspaces, i.e., *their robustness*. This is their key feature, particularly in large, complex, and poorly understood search spaces, where classical search tools (enumerative, heuristic, . . .) are inappropriate, offering a valid approach to problems requiring efficient and effective search techniques.

A GA starts off with a population of randomly generated solutions, *chromosomes*, and advances toward better solutions by applying genetic operators, modeled on the genetic processes occurring in nature. In these algorithms we maintain a population of solutions for a given problem and this population undergoes evolution in a form of *natural selection*. In each generation, relatively good solutions reproduce to give offspring that replace the relatively bad solutions, which die. An *evaluation* or *fitness function* plays the role of the environment to distinguish between good and bad solutions. The process of going from the current population to the next one constitutes a *generation* in the execution of a GA.

Although there are many possible variants of the basic GA, the fundamental underlying mechanism operates on a population of chromosomes or individuals (representing possible solutions to the problem) and consists of three operations: evaluation of individual fitness, formation of a gene pool (intermediate population), and recombination through crossover and mutation.

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