

## Foreword

When Javier Montero approached me with a request to write a foreword to the Special Issue on Soft Computing of the International Journal of Computational Intelligence Systems, I responded affirmatively and with no hesitation even though I knew that it would be a difficult task to say something that is meaningful in relation to the articles in this issue—articles authored by some of the leading contributors to soft computing and its applications. My anticipation proved to be correct.

To put my views in a proper perspective, a bit of history is in order. In 1990, David Hodges, then the Dean of Engineering at UC Berkeley, suggested to me to launch a Center for Research in Fuzzy Logic and its Applications. I was pleased by his suggestion but being a generalist at heart I felt that a better move would be to establish a center with a much broader scope. Dean Hodges accepted my counter suggestion. This was the genesis of BISC (Berkeley Initiative in Soft Computing). BISC made its debut in 1991.

The rationale for BISC was the following. Not just in politics but in many realms of human activity, including science, there is a tendency to be nationalistic—a tendency to form communities centered on methodologies—communities which believe that their methodologies are superior to all others. Such communities employ the well-known Hammer principle. When the only tool you have is a hammer everything looks like a nail. A similar principle is what I call the Vodka principle: No matter what the problem is, vodka will solve it.

The eighties of last century were the years of intense interest in the conception and design of intelligent systems. In the forefront were the methodology of AI and methodologies which were not in AI, principally neurocomputing, probabilistic computing, evolutionary computing and fuzzy logic. My idea was to form a coalition of fuzzy logic, neurocomputing, evolutionary computing, probabilistic computing, and call it soft computing. BISC was an implementation of this idea.

I gave quite a bit of thought to how to call the coalition. The word "soft" was intended to suggest that what the members of the coalition had in common was a tolerance for imprecision, uncertainty, approximation and partiality of truth. Another possibility was "computational intelligence." I did not choose this label for the following reason. In 1980, Nick Cercone decided to start a new journal on artificial intelligence. At that time, AI was losing its glamour. For this reason, Nick Cercone chose the label "Computational Intelligence," for his journal. The journal has been in existence since then. What is important to note, however, is that Cercone used the term "computational intelligence" in more or less the same sense as "artificial intelligence."

Given the existence of the journal "Computational Intelligence," I settled on the name "Soft Computing." Furthermore, the name "Soft Computing" underscored that soft computing is

not wedded to intelligent systems. The concepts and techniques of soft computing are applicable to the conception and design of any kind of system, and not just intelligent systems. The principal thesis of soft computing was and remains that, in general, superior performance can be achieved through the use of the constituent methodologies of soft computing in combination rather than in a stand-alone mode. Today, hybrid systems, such as neurofuzzy systems, are in wide use.

Several years after the debut of BISC, Jim Bezdek, as I recall, suggested that IEEE take the initiative of promoting computational intelligence as a combination of neurocomputing, evolutionary computing and fuzzy logic. With the power of IEEE behind the initiative, computational intelligence began to grow in popularity and importance. Today, the Computational Intelligence Society is one of the fastest growing societies in the IEEE. I believe that in the best interest of soft computing it is important to view computational intelligence as a partner rather than as a competitor.

In large measure, my perceptions of what soft computing is and what it has to offer are close to those expressed in this Issue. A point which I should like to make is that, in the United States, the use of fuzzy logic in various application areas has been hampered by the fact that in engineering curriculum courses on fuzzy logic are few in number. In coming years, what is likely to happen is that courses on computational intelligence or computational intelligence/soft computing will be included in most engineering curricula. Should this happen, fuzzy logic will be a beneficiary. An encouraging development is that the Computational Intelligence Society has taken a first step in this direction by setting up a subcommittee chaired by Luis Magdalena to design a course on computational intelligence.

The synergy of fuzzy logic, neurocomputing and evolutionary computing derives from the complementarity of what they have to offer. But what is not widely recognized is that there exists a very basic, asymmetric relationship between fuzzy logic, on one side, and neurocomputing and evolutionary computing on the other. More specifically, the concept of a fuzzy set has a position of centrality in fuzzy logic. The concept of a fuzzy set is a generalization of the concept of a set—a concept which has a position of centrality not only in mathematics but, more generally, in all scientific theories. What this implies is that any scientific theory,  $T$ , may be generalized by replacing the concept of a set in  $T$  with that of a fuzzy set, leading to what may be called fuzzy  $T$ . Examples: fuzzy topology, fuzzy measure theory, fuzzy mathematical programming, fuzzy control, etc. Such generalization may be called FL-generalization or, much less euphoniously, fuzzyfication. FL-generalization is one of the most important contributions of fuzzy logic.

In large measure, but not entirely, neurofuzzy systems and products are the result of application of FL-generalization to neurocomputing. As a case in point, FL-generalizations of the back-propagation algorithm are described in the literature. In coming years we are likely to see

many more examples of application of FL-generalization to algorithms and procedures within neurocomputing and evolutionary computing.

A final point. An important issue which is addressed in the article by Enric Trillas, Claudio Moraga and Sergio Guadarrama concerns the relationship between Computing with Words (CW) and Computational Intelligence/Soft Computing. Basically, CW is a system of computation which adds to traditional systems of computation a capability which they do not have—a capability to compute with information described in a natural language. CW opens the door to a wide-ranging enlargement of the role of natural languages in soft computing and computational intelligence. The importance of CW derives from the fact that much of human knowledge is expressed in a natural language.

The Special Issue is an important compendium of authoritative articles on what soft computing is and what it has to offer. Its publication is a significant event. The authors and the editors deserve our thanks and congratulations.

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