Journal of Intelligent & Fuzzy Systems 40 (2021) 3815–3817
DOI:10.3233/JIFS-189474
IOS Press

Book Review

Jozo Dujmović, *Soft Computing Evaluation Logic: The LSP Decision Method, and Its Applications*, IEEE Press and Wiley, Hoboken, New Jersey, 2018

Vladik Kreinovich*
Department of Computer Science, University of Texas at El Paso, TX, USA

We need to make decisions. Whatever decisions we make,

- whether it is an individual decision – what house to buy, what car to buy,
- or it is a group decision – e.g., where to build a school,

we need to take into account many different criteria.

For example, when we buy a house, we take into account:

- its price,
- its size,
- how far is its location from our workplaces and from stores,
- how noisy is this location,
- how close is this location to the nearest park,
- how safe is this location, etc.

Traditional decision-theory approach is not always adequate. In the traditional decision theory approach, we describe our preference for each criterion by a numerical value – known as *utility*. The utilities corresponding to several criteria are then combined into a single utility value describing the alternative as a whole.

There are many possible functions that combine several utility values into a single value. It has been proven that if we assume that criteria are, in some reasonable sense, independent from each other, then the overall utility is equal:

- either to a weighted linear combination of the individual utilities
- or to the product of these utilities raised to some powers.

In some situations, these combination functions work well. However, in many other situations, the criteria are not independent and, as a result, the traditionally used combination rules do not describe well how we make decisions.

The general idea of graded logics. Instead of gauging each criterion by a *utility value*, a natural idea is to describe our satisfaction with each criterion by a *degree of satisfaction*.

Whatever scale we use to describe these degrees, we can always re-scale this degree to the interval [0, 1]. For example, if we ask the use to describe his/her degree of satisfaction on a scale form 0 to 10, then we can divide this degree by 10 and get the values from the interval [0, 1].

*Corresponding author. Vladik Kreinovich, Department of Computer Science, University of Texas at El Paso, 500 W. University, El Paso, TX 79968, USA. E-mail: vladik@utep.edu.

Such [0, 1]-valued degrees are a starting point for *fuzzy logic* analysis. However, as we will explain shortly, the author goes beyond the traditional fuzzy logic formulas. So, to avoid possible misunderstandings, he uses a more general term "graded logic" to describe Zadeh's idea that everything is a matter of degree – without necessarily following the usual fuzzy ways of describing "and"- and "or"-operations.

Why do we need to go beyond fuzzy logic. The user's goal is to satisfy the first criterion as much as possible *and* to satisfy the second criterion, etc. So, a seemingly natural idea is to use the fuzzy "and"-operation (t-norm) to combine the degrees to which each criterion is satisfied into a degree to which the whole and-combination is satisfied. In some cases, this idea works, but in many practical situations, it does not work well, and there are several reasons for this.

The first reason is that in fuzzy logic, we usually select *one* single *"and"-operation* and use it every time we need to estimate our degree of certainty in a statement of the type "*A* and *B*". In contrast, in decision making, how we combine the degrees of two criteria depends on how related they are:

- for some pairs of criteria, there is almost no relation between them, while
- for other pairs of criteria, we may have a strong dependence.

This fact necessitates the use of *several different "and"-operations* in different situations. (By the way, this need for different "and"- and "or"-operations is in perfect agreement with the use of logical connectives like "and" and "or" in natural language: e.g., when we say "or", we sometimes mean the usual inclusive "or" and sometimes an exclusive "or".)

Another reason for going beyond the traditional fuzzy logic reasons is that the usual fuzzy "and"-operations are commutative. So, if we use these operations to combine the degrees to which different criteria are satisfied, this would mean that we consider all criteria to be *equally important*. In reality, different criteria may have *different importance*. For example:

- some criteria are absolutely necessary, so a solution in which this criterion is not satisfied is not acceptable, while
- other criteria are more like wishes, so it is OK if one or more of these criteria are not satisfied.

Yes another reason why we need to go beyond the usual fuzzy theory is that for fuzzy "and"-operations – just like for the 2-valued "and" – if one of the statements is false, i.e., has degree of confidence 0, then the whole "and"-combination is false. In decision making, if one of the ten criteria for, e.g., buying a house is not satisfied, it may still be a good decision – especially since sometimes, this is inevitable: there is simply no alternative in which all the criteria from our wish list are satisfied.

Also, the current "and"-operations are based – via the associativity property – on using only *binary* relations. In reality, there may be dependence between three criteria – e.g., that the value of the third criterion is close to e.g., the sum of the first two. In this case, we *do not* have any dependence between any two criteria, but we *do* have a strong dependence between the three of them. To reflect this, it is desirable to have "and"-operations estimating the truth values of statements of the type $A_1 \,\&\, A_2 \,\&\, \ldots \,\&\, A_n$ for $n > 2$.

Similarly arguments explain why we need to go beyond the traditional fuzzy logic approach when describing statements including "or".

What the book proposes. The author analyzed how people actually make decisions, and he concluded that people use:

- four different "and"-operations,
- four different "and"-operations, and
- several "neutral" (averaging) operations.

It is worth mentioning that, in effect, most of these operations are not pure "and"- and "or"-operations: they *combine* the usual "and"- and "or"-ideas:

- some of these combinations are closer to "and",
- some operations are closer to "or", and
- some operations are equally distant from both and are, in this sense, neutral.

All these operations can be described in terms of linear combinations, products, and raising to a given power.

The author conjectures – the book calls it *Graded Logic (GL) Conjecture* – that we can reasonably well describe all human decision making by using only a few such *n*-ary operations.

As a result, to describe how people make decisions, we do not need – as the current fuzzy methodology seems to imply – to find the most appropriate *functions* that would describe "and", "or", and "not": it is now sufficient to just estimate the values of *a few* corresponding real-valued *parameters*.

This leads to the general methodology that the author proposes under the name of Logic Scoring of Preferences (this is the mysterious LSP from the book's title):

- we elicit the expert degrees,
- we find the parameters describing the appropriate combination operations, etc.

This methodology is illustrated, in detail, on several practical examples ranging from buying a house to making a serious medical decision.

There is also a lot of related interesting theory – with many open problems. While there is a lot of research results about fuzzy "and"- and "or"-operations, the new operations are *not* covered by these results. They have to be studied, in effect, from scratch.

The book contains many new interesting results about the new operations – and many challenging open questions. The main open question is, of course, to explain *why* these few specific "and"- and "or"-operations are used. There are also many other open questions.

This is not all. And, of course, the book contain much more material that what can be discussed in a few-page review.

Who should read (and study) this book. This book describes a new innovative approach to decision making, an approach that has already led to several successful applications. So, of course, it can be recommended to practitioners who are looking for more adequate solutions to decision making problems.

It can also be recommended to theoreticians who are eager to encounter new challenging tasks – this books provides many such tasks, and the good news is that they are not just tasks of mostly mathematical interest, these are tasks motivated by applications – so theoretical breakthroughs have a good chance of leading to practical successes.

And, of course, last but not the least, this book, with its numerous examples and clear explanations, will be very good for students who want to learn state-of-the-art decision making techniques.