Interval-Related Papers at the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022

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The biannual IEEE World Congress of Computational Intelligence WCCI – which in 2022 was held in Padua, Italy, on July 18–23 – includes the IEEE International Conference on Fuzzy Systems FUZZ-IEEE as one of its three component conferences. Due to multiple relations between interval and fuzzy techniques, usually, fuzzy conferences include many interval-related talks, and this year's conference was no exception. Talks presented at WCCI'2022 cover all three major aspects of fuzzy-interval relation.

Historically the first aspect of this relation is that many fuzzy data processing algorithms use interval computation techniques. This use is related to the fact that fuzzy information about a real-valued quantity – which is usually described by assigning, to each real number x, a degree $\mu(x) \in [0, 1]$ to which this is a possible value of the quantity of interest – can be equivalently described as a nested family of intervals $\mathbf{x}(\alpha) \overset{\text{def}}{=} \{x : \mu(x) \geq \alpha\}$ corresponding to different certainty degrees:

- from the widest interval $\mathbf{x}(0)$ about which we are absolutely confident that it contains the actual value of the quantity

- all the way to the narrowest interval $\mathbf{x}(1)$ for which we have the lowest certainty.

It turns out that if we have fuzzy information about quantities $x_1, \ldots, x_n$, and we know the relation $y = f(x_1, \ldots, x_n)$ between x_i and another quantity y, then the fuzzy information about y can be computed by applying, for each α, interval computations techniques to find the range

$$\mathbf{y}(\alpha) = f(\mathbf{x}_1(\alpha), \ldots, \mathbf{x}_n(\alpha)) = \{f(x_1, \ldots, x_n) : x_1 \in \mathbf{x}_1(\alpha) \,\&\, \ldots \,\&\, x_n \in \mathbf{x}_n(\alpha)\}.$$

At this conference, a new faster way of using interval computations when processing fuzzy data is described in [13].

A related aspect of fuzzy-interval relation is that:

- while in the traditional probabilistic prediction schemes, the prediction results come with intervals (called *prediction intervals*) corresponding to different probability-based confidence,

- in the prediction schemes based on expert knowledge (i.e., on fuzzy information), it is reasonable to produce intervals corresponding to different fuzzy-related degrees of confidence.

Applications of this idea presented at the conference include applications to bitcoin trading [11], to classification [16], to detecting rail defects [14], to electric arc furnaces [2], to electric grids [3], to greenhouse control [8], to log parsing [5], and to video streaming [12].

The third aspect of fuzzy-interval relation comes from the fact that experts cannot pinpoint their degree of confidence by providing a single number, it is much more natural for them to come up with an interval of possible degrees. The resulting *interval-valued fuzzy* techniques more adequately describe expert knowledge and thus, not surprisingly, lead to more effective applications. Example presented at the conference include:

- *clustering and classification* [4] (this paper, by the way, combines both fuzzy and probabilistic knowledge – a useful but still rare feature in fuzzy systems),

- more reliable *crowdsourcing* results [7],

- more adequate *multi-objective optimization* [9, 15],

- more adequate description of human *reasoning*, in particular, of common-sense understanding of if-then statements – which is, as is well known, different from logical if-then with its counter-intuitive statements like "if $2 + 2 = 5$ then Mars rotates around the Earth" [6], and

- more adequate and more helpful *visualization* [10].

Not only are such applications more effective: since the underlying interval-valued fuzzy degrees better reflect expert knowledge, the resulting systems are much more explainable [1, 5] – an important feature which is lacking in many deep-learning-based AI applications.

As one can see from the paper titles, several of these papers also use neural and evolutionary techniques – a usual feature for WCCI congresses that include neural and evolutional conferences as the other two components. Such productive collaboration of various techniques – interval, probabilistic, fuzzy, neural, evolutionary – is, in our opinion, the direction that needs to be pursued more: the fact that it has led toi many successes shows that many new successes are ahead!

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