

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

Martine Ceberio and Vladik Kreinovich
University of Texas at El Paso, El Paso, Texas 79968,
USA
`mceberio@utep.edu, vladik@utep.edu`

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 $\mathbf{x}(\alpha) \stackrel{\text{def}}{=} \{x : \mu(x) \geq \alpha\}$ 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 $x_1, \dots, x_n$, and we know the relation $y = f(x_1, \dots, x_n)$ 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

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

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 evolutionary 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 to many successes shows that many new successes are ahead!

References

- [1] A. Bhatia and H. Hagrass, “A Time Series Based Explainable Interval Type-2 Fuzzy Logic System”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [2] A. Blažič, V. Logar, and I. Skrjanc, “Fuzzy Interval Oxygen Estimation in an Electric Arc Furnace from Scarce Output Measurements”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [3] R. I. Bustos Marambio, A. D. Navas Fonseca, D. A. Saez, and G. A. Jimenez Estevez, “Demand Side Management for Microgrids based on Fuzzy Prediction Intervals”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [4] D. Chakraborty, P. K. Muhuri, A. K. Varshney, and D. Lohani Q. M., “Probabilistic Interval Type-2 Intuitionistic Fuzzy c Means clustering Algorithm”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [5] L. Decker, D. F. Leite, and D. Bonacorsi, “Explainable Log Parsing and Online Interval Granular Classification from Streams of Words”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [6] G. P. Dimuro, H. S. Santos, T. Asmus, J. C. Wieczynski, J. Pinheiro, B. Bedregal, and H. Bustince, “Constructing Interval-Valued Fuzzy Material Implication Functions derived from General Interval-Valued Grouping Functions”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [7] Z. Ellerby and C. Wagner, “Does Permitting Uncertain Estimates Help or Hinder the Wisdom of Crowds?”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [8] A. Endo, O. Cartagena, J. Ocaranza, D. A. Saez, and C. Muñoz, “Fuzzy and Neural Prediction Intervals for Robust Control of a Greenhouse” *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.
- [9] X.-J. Gan, J. Sun, D.-W. Gong, D.-B. Jia, H.-W. Dai, and Z.-M. Zhong, “An Interval Multi-Objective Evolutionary Algorithm Based on MOEA/D”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI’2022*, Padua, Italy, July 18–23, 2022.

- [10] S. Kabir and C. Wagner, “Visualization of IV Regression for Facilitating Data and Model Insight”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.
- [11] L. S. Maciel, “A trading strategy based on BitCoin high and low prices: the role of an evolving fuzzy model for interval-valued time series forecasting”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.
- [12] E. M. Monks, B. Moura, G. Bayer Schneider, A. Correa Yamin, R. H. Sander Reiser, and H. S. Santos, “Towards Interval-Valued Fuzzy Approach to Video Streaming Traffic Classification” *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.
- [13] H. T. Nguyen, O. Kosheleva, and V. Kreinovich, “Data Processing under Fuzzy Uncertainty: Towards More Efficient Algorithms”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.
- [14] W. Phusakulkajorn, A. Nunez, J. Hendriks, J. Moraal, R. Dollevoet, and Z.-L. Li, “A multiple spiking neural network architecture based on fuzzy intervals for anomaly detection: a case study of rail defects”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.
- [15] T. A. Runkler, “Pareto Interval Type-2 Fuzzy Decision Making for Labeled Objects”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.
- [16] R. Said, M. Elarbi, S. Bechikh, C. A. Coello Coello, and L. Ben Said, “Interval-based Cost-sensitive Classification Tree Induction as a Bi-level Optimization Problem”, *Proceedings of the 2022 IEEE World Congress on Computational Intelligence IEEE WCCI'2022*, Padua, Italy, July 18–23, 2022.