From Interval-Valued Probabilities to Interval-Valued Possibilities: Case Studies of Interval Computation under Constraints

L. Gutierrez[1], **S. Benferhat**[2], **M. Ceberio**[1], **V. Kreinovich**[1],
R. L. Gruver[1], **M. Peña**[1], **M. J. Rister**[1], **A. Saldaña**[1],
J. Vasquez[1], and **J. Ybarra**[1]

[1]Department of Computer Science, University of Texas at El Paso,
El Paso, TX 79968, USA, lcgutierrez@miners.utep.edu, vladik@utep.edu

[2]Centre de Recherche en Informatique de Lens CRIL, Université d'Artois,
F62307 Lens Cedex, France, benferhat@cril.univ-artois.fr

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Abstract

In many engineering situations, we need to make decisions under uncertainty. In some cases, we know the probabilities p_i of different situations i; these probabilities should add up to 1. In other cases, we only have expert estimates of the degree of possibility μ_i of different situations; in accordance with the possibility theories, the largest of these degrees should be equal to 1.

In practice, we often only know these degrees p_i and μ_i with uncertainty. Usually, we know the upper bound and the lower bound on each of these values. In other words, instead of the exact value of each degree, we only know the *interval* of its possible values, so we need to process such interval-valued degrees.

Before we start processing, it is important to find out which values from these interval are actually possible. For example, if only have two alternatives, and the probability of the first one is 0.5, then – even if the original interval for the second probability is wide – the only possible value of the second probability is 0.5.

Once the intervals are narrowed down to possible values, we need to compute the range of possible values of the corresponding characteristics (mean, variance, conditional probabilities and possibilities, etc.). For each such characteristic, first, we need to come up with an algorithm for computing its range.

In many engineering applications, we have a large amount of data to process, and many relevant decisions need to be made in real time. Because of this, it is important to make sure that the algorithms for computing the desired ranges are as fast as possible.

We present expressions for narrowing interval-valued probabilities and possibilities and for computing characteristics such as mean, conditional probabilities, and conditional possibilities. A straightforward computation of these expressions would take time which is quadratic in the number of inputs n. We show that in many cases, linear-time algorithms are possible – and that no algorithm for computing these expressions can be faster than linear-time.