Dealing with Uncertainties in Computing:
from Probabilistic and Interval Uncertainty
to Combination of Different Approaches,
with Application to Geoinformatics,
Bioinformatics, and Engineering

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Most data processing techniques traditionally used in scientific and engineering practice are statistical. These techniques are based on the assumption that we know the probability distributions of measurement errors etc.

In practice, often, we do not know the distributions, we only know the bound $\Delta$ on the measurement accuracy – hence, after the get the measurement result $\tilde{x}$, the only information that we have about the actual (unknown) value $x$ of the measured quantity is that $x$ belongs to the interval $[\tilde{x} - \Delta, \tilde{x} + \Delta]$. Techniques for data processing under such interval uncertainty are called interval computations; these techniques have been developed since 1950s; see, e.g., [1].

In many practical problems, we have a combination of different types of uncertainty, where we know the probability distribution for some quantities, intervals for other quantities, and expert information for yet other quantities.

There exist a lot of theoretical research and practical applications in dealing with these types of uncertainty: interval, fuzzy, and combined. However, even for the simplest basic data processing techniques, it is often still necessary to undertake a lot of research to transit from probabilistic to interval and fuzzy uncertainty; see, e.g., [2].

The purpose of this talk is to describe the theoretical background for interval and combined techniques, to describe the existing practical applications, and ideally, to come up with a roadmap for such techniques.

We start with the problem of chip design in computer engineering. In this problem, traditional interval methods lead to estimates with excess width. The reason for this width is that often, in addition to the intervals of possible values of inputs, we also have partial information about the probabilities of different values within these intervals – and standard interval techniques ignore this information.

It is therefore desirable to extend interval techniques to the situations when, in addition to intervals, we also have a partial probabilistic information. In the talk, we give a brief overview of these techniques, and we emphasize the following three application areas: computer engineering, bioinformatics, and geoinformatics.

References
