Applications of Uncertainty Techniques in Science and Engineering: Algebraic Approach

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Prediction is one of the main objectives of science and engineering. For example, in Newton's mechanics, we want to predict the positions and velocities of different objects (e.g., planets) at future moments of time.

In Physics we usually know the exact equations that describe the objects of interest, and we know how to solve these equations. This is the case for Newton's mechanics, for example. In this case, prediction is a purely mathematical problem - of solving the corresponding equations. In practice we have uncertainty.

The basis for prediction is that we observed similar situations in the past, and we expect similar outcomes. In mathematical terms similarity corresponds to symmetry, and similarity of outcomes to invariance. For example, if we drop a ball, it falls down regardless of whether we change location (shift) or rotate our bodies to face another direction. In this case shift and rotation represent symmetries.

In modern physics: theories are usually formulated in terms of symmetries (not differential equations). A natural idea follows: let us use symmetry to describe uncertainty as well.

In this presentation, we overview the following topics:

Prediction and symmetries in describing systems:
  • chemical and biochemical applications;
  • applications to geosciences;
  • applications to physics.

Prediction, symmetries in describing uncertainty (if time allows):
  • interval computations;
  • neural networks;
  • Dempster-Shafer approach;
  • complexity.

Design and control (if time allows):
  • types of intelligent control (Mamdani, etc.);
  • different operations in intelligent control;
  • best intelligent control in terms of tropical algebras.