Points on Operational Semantics

Vladik Kreinovich

Department of Computer Science
University of Texas at El Paso
El Paso, TX 79968, USA
vladik@utep.edu
http://www.cs.utep.edu/vladik

1. Traditional and Operational Approaches

- *Traditional approach to science:*
  - we develop deep theoretical notions, models, and theories;
  - we also try re-describe the abstract notions in observable terms.
- *Problem with traditional approach:* sometimes, we do not know how to check our abstract theories.
- *Example:* superstring theory.
- *Alternative approach:* reformulate all the notions and theories in directly observable (operational) terms.
- *Examples:*
  - special relativity (Einstein);
  - quantum physics (Heisenberg).

2. An Example from Fuzzy Techniques

- *Problem:* there are many different fuzzy analogs of logical operations (t-norms, t-conorms, etc.)
- *Why it is a problem:*
  - fuzzy logic is usually not formulated as an operational theory,
  - so it is not always clear how to relate membership degrees $\mu(x)$ to something directly observable.
- *Alternative approach:*
  - start with an operational definition, and
  - select the most adequate t-norms and t-conorms based on these definitions
- A *frequency* interpretation leads to $a \cdot b$ (independence), $\min(a, b)$ and $\max(1 + b - 1, 0)$ (Frechet inequalities).
- An expert marking degrees on a *scale* leads to scale-invariance hence $\min(a, b)$ (maximally scale-invariant) and fractionally linear t-norms.
- *Empirical analysis:* we cannot get exact values of $\mu(x)$ hence interval-valued fuzzy sets.

3. An Example from Computations

- *Fact:* in modern physics, we need operators, functionals, etc., objects of higher order.
- *Related problem:* in computations, we produce approximate (close) values;
  - for *real numbers*, closeness is easy to describe;
  - for *operators*, there are many different norms, and it is difficult to agree on the most adequate one.
- *Solution:* analyze the problem operationally:
  - which quantities we will be able to observe?
  - these are the quantities that we want to be computed as accurately as possible
- *Resulting approach:* domain theory.
- *Additional advantage:* faster computations – no need to waste time on computing non-observable features.

4. Conclusion

- *Fact:* operational semantic is known and successfully used in physics.
- *Fact:* operational semantics is under-used in knowledge representation and processing.
- *Conclusion:*
  - we should learn more about operational semantics, and
  - we should use operational semantics more.