Managing Deep Uncertainty
in
Theoretical Biology and Biomedical Research
– Info-Gap Perspectives –

Yakov Ben-Haim
Yitzhak Moda'i Chair in Technology and Economics
Technion – Israel Institute of Technology
yakov@technion.ac.il, info-gap.com

Molecular and Cell Biology Department
Baylor College of Medicine
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Abstract

Researchers push the boundaries of the unknown. However, as John Wheeler noted, "As our island of knowledge grows, so does the shore of our ignorance." We deepen our knowledge, but this broadens the range of new and uncertain possibilities. New knowledge uncovers new unknowns. But more than that, the human response to new possibilities opens new domains for surprise and for research. This talk applies info-gap decision theory to the management of deep uncertainty in biology and biomedicine.

We begin by discussing three concepts. First, we introduce non-probabilistic *Knightian uncertainty*. Second, we discuss the evolutionary imperative **not** to optimize. Doing good enough – *satisficing* – is the key to successful management of deep uncertainty. Third, we explain that *indeterminism* is inherent in all innovative systems and societies.

These ideas generate the concept of an *innovation dilemma.* Science-based progress is founded on the belief in innovation. New and creative ideas underlie the advance of knowledge and of the human condition. However, what is new and innovative is also less familiar and more uncertain. This creates a dilemma: whether to use the new but uncertain innovation, or to remain with the state of the art? Info-gap theory provides a clear characterization of the dilemma, and a method for its resolution.

We illustrate these ideas with two applications of the info-gap concept of robustness to uncertainty.

How general is my model? The model seems to match the available data. How general or widely applicable is the model? Suppose I want to apply the model to a different population (different source of data). Would it still match? How much could the data differ, and the model would still be valid?

How good is my estimate or prediction? Given data, I estimate the value of a biologically meaningful parameter in a model, or predict a future value of this quantity. This depends on the data, but also on the structure of the model. For instance, if the model ignores second-order interactions, does this impugn the estimate? By how much can the structure of the model err, and the prediction is still reliable?

We approach these problems from two perspectives, one quantitative and the other qualitative.

Selected References (see also info-gap.com)

Books:

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- Barry Schwartz, Yakov Ben-Haim, and Cliff Dacso, 2011, What Makes a Good Decision? Robust Satisficing as a Normative Standard of Rational Behaviour, *The Journal for the Theory of Social Behaviour,* 41(2): 209-227. Link to pre-print: https://info-gap.technion.ac.il/files/2016/11/aaa-schwartz-ybh-dacso2011.pdf