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Info-Gap Theory and Applications

Four Lectures

Department of Mathematical Informatics
Graduate School of Information Science and Technology
The University of Tokyo
4 August 2009

Brief Outline

Introductory Overview Seminar (including 15 minutes for discussion):
10:00–11:45: Decisions, decisions, decisions . . . . Info-gap theory and severe uncertainty.
3 Advanced Lectures:
13:00–14:30: Economics and public policy.
15:00–16:30: Statistical inference, estimation, forecasting and learning.
17:00–18:00: Robustness and behavior: proxy theorems, economics, quantum uncertainty.

Detailed Outline

Introductory Overview Seminar (including 15 minutes for discussion):
10:00–11:45:
DECISIONS, DECISIONS, DECISIONS . . . . INFO-GAP THEORY AND SEVERE UNCERTAINTY.
◦ Principle of Indifference
◦ Ellsberg's Paradox
◦ Info-Gap Robust-Satisficing Foraging
◦ Conservation Management, Or: Save the Sumatran Rhinoceros
◦ Design Analysis with Info-Gaps
◦ Summary

3 Advanced Lectures:
13:00–14:30: ECONOMICS AND PUBLIC POLICY.
◦ Principle of Indifference
◦ Taylor Rule for Inflation Targeting
◦ Expectations, Communication and Credibility
◦ Value at Risk with Info-Gaps
◦ Climate Change
◦ Enforcing Pollution Limits
◦ Max-Min and Robust-Satisficing
◦ Summary

15:00–16:30: STATISTICAL INFERENCE, ESTIMATION, FORECASTING AND LEARNING.
◦ Modelling the Phillips Curve
◦ Estimating an Uncertain PDF
◦ Info-Gap Forecasting

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◦ Statistical Tests with Distributional Uncertainty
◦ Learning and Deciding: Strategies and Structures

17:00–18:00:
Robustness and behavior: proxy theorems, economics, quantum uncertainty.
◦ Robust-Satisficing is a Proxy for Probability of Survival
◦ Info-Gap Indeterminism in Quantum Mechanics
◦ Equity Premium Puzzle: A Solution

Abstracts

Decisions, decisions, decisions . . . . Info-gap theory and severe uncertainty.
Info-gap theory is a method for analysis, planning, decision and design under uncertainty. Processes and systems are complex and our understanding is sometimes fragmentary. The future may differ from the past, so our models may err in ways we cannot know. Our data may lack evidence about surprises: catastrophes or windfalls. These are info-gaps: incomplete understanding of the system being managed. Info-gap theory provides decision-support tools for modelling and managing severe uncertainty. Info-gap theory has been applied by scholars around the world to engineering analysis and design, biological conservation, financial and monetary economics, project management, medicine and homeland security. This lecture introduces the basic concepts and illustrates applications to several disciplines, including an info-gap explanation of the Ellsberg paradox, foraging by animals, biological conservation, and neural nets for technological fault diagnosis.

Decisions in economics and public policy.
Planning and policy decisions in economics and public policy are based on our limited understanding of the complex processes involved, and on data which are often incomplete or inaccurate. Furthermore, experience from the past may not reliably reflect the future. In this talk we discuss policy analysis and selection in monetary economics, in financial investments, and in public policy for managing long-range climate change and for enforcing pollution limits. We introduce and explain the info-gap robust-satisficing and opportune-windfalling decision strategies, and we illustrate the difference from best-model optimization and from min-max strategies. We emphasize decision strategies which exploit existing data and models while recognizing their epistemic limitations.

Statistical inference, estimation, forecasting and learning.
Statistical tools for inference, estimation, forecasting and learning employ various assumptions, such as independence, homoscedacticity, large samples, statistical stationarity, etc. In some situations such assumptions may be violated to an unknown degree. Info-gap theory can then be combined with statistical tools to design algorithms which are robust to such violations. Furthermore, statistical tools are typically designed to optimize the outcome. We show that an outcome-optimizing strategy minimizes the robustness to unknown violations of underlying assumptions. As a consequence, the info-gap robust-satisficing strategy is to *satisfice* (rather than to optimize) the outcome and to *maximize* the robustness to the unknown violations. We present several examples of model estimation, statistical tests, and learning.

Robustness and behavior: proxy theorems, economics, quantum uncertainty.
The concept of robustness motivates much work on decisions under uncertainty, including info-gap theory. A decision which is more robust to uncertainty is preferred to a decision which is less robust. However, it is *not true* that a more robust decision is *necessarily* more likely to succeed. Robustness is not the same as probability. However, a class of theorems—called proxy theorems—establish conditions in which greater robustness entails greater probability of success. When robustness is a proxy for probability, then a robust strategy can be used to maximize the probability of success, without requiring any probabilistic information. Robust strategies are then especially attractive for decisions under severe uncertainty. In addition, the proxy property may explain why robust-satisficing seems

common in competition under uncertainty, e.g. in economic markets and in biological evolution. Finally, we will suggest a possible derivation of quantum mechanics in which quantum probability is derived from underlying indeterminism by virtue of a natural law of robust-satisficing.

Source material

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