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A Three-Day Workshop on
Info-Gap Theory and Its Applications in Design and Strategic Planning
Los Alamos National Laboratory, Los Alamos, NM
22–24 August 2011

Course Rationale Decisions under uncertainty arise in many disciplines, including engineering, economics, public policy, medicine, biological conservation, homeland security and so on. In these disciplines one uses data and models to formulate and evaluate designs and plans.

Info-gap theory is a method for analysis, planning, decision and design under uncertainty. 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. Our scientific and technical understanding may be incomplete. 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, biological conservation, financial and monetary economics, project management, medicine and homeland security, and more.

This workshop is devoted to learning the methodology of info-gap analysis and its integration with other decision tools.

Course Structure This course has three components. *Lectures* present new material and *exercises* allow the participants to master this material. The first day and a half are devoted to lectures and exercises. The last day and a half are devoted to *mini-projects* which are formulated and implemented by the participants in small groups. This facilitates the thorough internalization of the concepts and methods learned, their integration with other methods familiar to the participants, and their application to problems of interest.

Sources

- Yakov Ben-Haim, 2006, *Info-gap Decision Theory: Decisions Under Severe Uncertainty*, 2nd edition, Academic Press, London.
- Yakov Ben-Haim, 2010, *Info-Gap Economics: An Operational Introduction*, Palgrave.
- Yakov Ben-Haim, 2005, Info-gap Decision Theory For Engineering Design. Or: Why ‘Good’ is Preferable to ‘Best’, appearing as chapter 11 in *Engineering Design Reliability Handbook*, Edited by Efstratios Nikolaidis, Dan M.Ghiocel and Surendra Singhal, CRC Press, Boca Raton.
- Yakov Ben-Haim, 2009, Info-gap forecasting and the advantage of sub-optimal models, *European Journal of Operational Research*, 197: 203–213.
- Yakov Ben-Haim, Interpreting null results from measurements with uncertain correlations: An info-gap approach, *Risk Analysis*, vol.31 (1), pp.78–85.
- Tania Mirer and Yakov Ben-Haim, 2010, Reliability Assessment of Explosive Material Based on Penalty Tests: An Info-Gap Approach, Proceedings of the Institution of Mechanical Engineers, Part O, *Journal of Risk and Reliability*, vol. 224(4), pp.346–355.
- Yakov Ben-Haim, Clifford C. Dacso, Jonathon Carrasco and Nithin Rajan, 2009, Heterogeneous Uncertainties in Cholesterol Management, *International Journal of Approximate Reasoning*, 50: 1046–1065.
- Lior Davidovitch and Yakov Ben-Haim, 2008, Is your profiling strategy robust? To appear in *Law, Probability and Risk*.
- Yoshihiro Kanno and Yakov Ben-Haim, 2011, Redundancy and Robustness, Or, When is Redundancy Redundant? *ASCE Journal of Structural Engineering*, to appear.
- <http://info-gap.com>

Brief Outline

Day 1 Monday 22 August 2011

MORNING

10:00–10:50 *Lecture 1. Info-Gap Theory: Overview and Examples.*

11:00–11:50 *Lecture 2. Probabilistic reliability with info-gap uncertainty.*

11:50–12:10 Coffee break.

12:10–13:00 *Lecture 3. Info-Gap Statistics.*

LUNCH 13:00–14:00

AFTERNOON

14:00–14:50 *Exercises:*

◦ Standard: *Trigger mechanism.*

◦ Challenge: *Static deflection of a cantilever.*

15:00–15:50 *Exercise. Choosing between two discrete lotteries.*

15:50–16:10 Coffee break.

16:10–17:00 *Exercise.*

◦ Standard: *Investment for bio-diversity.*

◦ Challenge: *Estimate spring stiffness with model uncertainty.*

Day 2 Tuesday 23 August 2011

MORNING

10:00–10:50 *Lecture 4. Optimizer's Curve: An Info-Gap Response.*

11:00–11:50 *Lecture 5. Vibration suppression with uncertain load.*

11:50–12:10 Coffee break.

12:10–13:00 *Exercise: Accelerated lifetime testing.*

LUNCH 13:00–14:00

AFTERNOON

14:00–17:00 *Brain-storm and initiate mini-projects.*

Day 3 Wednesday 24 August 2011

MORNING

10:00–12:00 *Guided independent work on mini-projects.*

12:00–13:00 *Preliminary reports on mini-projects.*

LUNCH 13:00–14:00

AFTERNOON

14:00–17:00 *Guided independent work on mini-projects.*

Detailed Outline

Day 1 Monday 22 August 2011

MORNING

10:00–10:50 *Lecture 1. Info-Gap Theory: Overview and Examples.*¹

- Examples of severe info-gaps.
- Principle of indifference.² Probability is powerful but not applicable in all situations. We illustrate this and discuss several paradoxes of probability.
- Expected utility with uncertain probabilities, or: Save the Sumatran rhinoceros.³
- Estimating an uncertain pdf.⁴

11:00–11:50 *Lecture 2. Probabilistic reliability with info-gap uncertainty.*⁵

- Discrete system with 2 sub-units: reliability, redundancy, uncertain correlations.⁶
- Origin of fat tails.
- Value at risk. Quantile uncertainty.⁷
- Quantile risk.⁸

11:50–12:10 Coffee break.

12:10–13:00 *Lecture 3. Info-Gap Statistics.*⁹

- Embedding a statistical test in an info-gap robustness analysis.
- Distributional uncertainty.
- Statistical test of the mean with distributional uncertainty.¹⁰
- Test of false nulls with uncertain sampling distribution.¹¹

LUNCH 13:00–14:00

AFTERNOON

14:00–14:50 *Exercises:*

- Standard: *Trigger mechanism.*¹²
- Challenge: *Static deflection of a cantilever.*¹³

15:00–15:50 *Exercise. Choosing between two discrete lotteries.*¹⁴

15:50–16:10 Coffee break.

16:10–17:00 *Exercise.*

- Standard: *Investment for bio-diversity.*¹⁵
- Challenge: *Estimate spring stiffness with model uncertainty.*¹⁶

¹[lanl2011ws-Lec01.pdf](#)

²(1) Lecture Notes on Info-Gap Uncertainty (igunc.tex), sections 1 and 2. (2) Yakov Ben-Haim, *Info-Gap Decision Theory*, 2nd ed., 2006, (henceforth “IGDT”), sections 2.2 and 2.3.

³Lecture Notes on Conservation Management, or: Robustness, Expected Utility and the Sumatran Rhinoceros (rhino.tex).

⁴(1) Lecture Notes on Info-Gap Estimation and Forecasting (estim.tex), section 4, (2) IGDT, section 3.2.13.

⁵[lanl2011ws-Lec02.pdf](#)

⁶Yakov Ben-Haim, 2010, *Info-Gap Economics: An Operational Introduction*, (henceforth “IGE”), Palgrave-MacMillan, section 4.1.

⁷(1) IGE, sec. 4.2. (2) Lecture Notes on Probabilistic Failure Models (pfm.tex), sec. 13. (3) IGDT, section 10.2.

⁸Lecture Notes on Probabilistic Failure Models (pfm.tex), section 13.

⁹[lanl2011ws-Lec03.pdf](#)

¹⁰Tanya Mirer and Yakov Ben-Haim, 2010, Reliability Assessment of Explosive Material Based on Penalty Tests: An Info-Gap Approach, working paper.

¹¹(1) Yakov Ben-Haim, 2010, Interpreting Null Results from Measurements with Uncertain Correlations: An Info-Gap Approach, working paper. (2) L.J. Moffitt and Yakov Ben-Haim, 2010, Robustness Analysis of Expert Dispute About Incubation Time, working paper.

¹²Problem Set on Robustness and Opportuneness (ps2_rk-h01.tex), #41.

¹³Problem Set on Robustness and Opportuneness (ps2_rk-h01.tex), #4.

¹⁴Problem Set on Hybrid Uncertainties (pshybunc01.tex) #10.

¹⁵Problem Set on Robustness and Opportuneness (ps2_rk-h01.tex) #35.

¹⁶Problem Set on Robustness and Opportuneness (ps2_rk-h01.tex) #38.

Day 2 Tuesday 23 August 2011

MORNING

10:00–10:50 *Lecture 4. Optimizer's Curve: An Info-Gap Response.*¹⁷

- Why best-model optimization is not a good bet if the best model is highly uncertain.¹⁸

11:00–11:50 *Lecture 5. Vibration suppression with uncertain load.*¹⁹

- We consider the choice between stiffness and damping in designing a vibrating cantilever subject to uncertain impact loads.

11:50–12:10 Coffee break.

12:10–13:00 *Exercise: Accelerated lifetime testing.*

- Background.²⁰
- Exercise.²¹

LUNCH 13:00–14:00

AFTERNOON

14:00–14:30 *Brainstorming on mini-projects.*

14:30–17:00 *Guided independent work on mini-projects.*

Day 3 Wednesday 24 August 2011

MORNING

10:00–12:00 *Guided independent work on mini-projects.*

12:00–13:00 *Preliminary reports on mini-projects.*

LUNCH 13:00–14:00

14:00–17:00 *Guided independent work on mini-projects.*

¹⁷[lanl2011ws-Lec04.pdf](#)

¹⁸(1) Lecture Notes on the Optimizer's Curse (optimizers-curse03.tex). (2) *IGDT*, section 11.4.

¹⁹[lanl2011ws-Lec05.pdf](#)

Supporting material:

(1) *IGDT*, section 3.2.1.

(2) Lecture Notes on Robustness and Opportuneness (\risk\lectures\ro.tex), section 6.

²⁰Lecture Notes on Acceptance Testing (acctes.tex), section 10.

²¹Problem Set on Acceptance Tests (hwacc.tex), #11.