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A 4 Day Course on

Info-Gap Theory and Its Applications

27 February – 1 March 2012
Josef Ressel Centre for Optimisation under Uncertainty
University of Applied Sciences, Dornbirn, Austria

Course Rationale

Scientists, engineers, policy planners and analysts use measurements and science-based models to design systems, evaluate reliability, and make plans and policies. However, models may be simpler than reality, causal factors may be unknown, measurements may err or be incomplete, and systems may change over time in unknown ways. Probability is useful for modeling and managing some of these uncertainties. However some uncertainties are *info-gaps:* disparities between what *is known* and what *needs to be known* in order to make good decisions. For instance, we sometimes do not know the correct probability distribution or all of the relevant physical mechanisms such as non-linearities or time dependencies. This course studies info-gap theory for modeling and managing uncertainties in planning, design and decision problems. The course emphasizes the added value of an info-gap analysis as well as its limitations, and the integration of info-gap theory with probabilistic analysis.

Course Structure

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

The Instructor

Yakov Ben-Haim initiated and developed info-gap decision theory for modeling and managing severe uncertainty. Info-gap theory is applied in engineering, biological conservation, economics, project management, climate change management, homeland security, medicine, and other areas. He has been a visiting scholar in Australia, Canada, England, France, Germany, Italy, Japan, Korea, Netherlands, Norway, and the US. He has lectured at universities, medical and technological research institutions and central banks around the world. He has published more than 80 articles and 5 books. He is a professor of mechanical engineering and holds the Yitzhak Moda'i Chair in Technology and Economics at the Technion—Israel Institute of Technology.

The Participants

Students, researchers and analysts involved in risk analysis, reliability assessment and policy selection.

Registration

Please contact Ms Julia Schneider, T +43 5572 792 7113, julia.schneider@fhv.at There is no registration fee. Participants are free to attend part or all of the course.

Brief Outline

Day 1 Monday 27 February 2012
   09:00–10:00 *Lecture 1. Info-Gap Theory: Overview and Examples.*
   10:00–11:00 *Lecture 2. Probabilistic reliability with info-gap uncertainty.*
   11:00–11:30 Coffee break.
   11:30–12:30 *Lecture 3. Info-Gap Statistics.*
   12:30–13:30 *Exercise 1: Trigger mechanism.*
   19:00–20:00 *Public lecture: Model-Based Planning for an Uncertain Future:*
                     An Info-Gap Approach

Day 2 Tuesday 28 February 2012
   09:00–10:00 *Lecture 4. Optimizer's Curse: An Info-Gap Response.*
   10:00–11:00 *Lecture 5. Strategic interactions.*
   11:00–11:30 Coffee break.
   11:30–12:30 *Lecture 6. Forecasting.*
   12:30–13:30 *Exercise 2: Accelerated lifetime testing.*

Day 3 Wednesday 29 February 2012
   09:00–13:00 *Workshop—Bring your own problem. Group 1.*
   13:00–14:00 Lunch
   14:00–18:00 *Workshop—Bring your own problem. Group 2.*

Day 4 Thursday 1 March 2012
   09:00–13:00 *Workshop—Bring your own problem. Group 3.*
   13:00–14:00 Lunch
   14:00–18:00 *Workshop—Bring your own problem. Group 4.*

Detailed Outline

Day 1 Monday 27 February 2012

    09:00–10:00 *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]

    10:00–11:00 *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]

    11:00–11:30 Coffee break.

    11:30–12:30 *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]

    12:30–13:30 *Exercise 1: Trigger mechanism.*[12]

    19:00–20:00 *Public lecture: Model-Based Planning for an Uncertain Future: An Info-Gap Approach*

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[1] **dornbirn2012ws-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.

[3] Lecture 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] **dornbirn2012ws-Lec02.pdf**

[6] Yakov 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.

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

[9] **dornbirn2012ws-Lec03.pdf**

[10] Tanya 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.

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

Day 2 Tuesday 28 February 2012

09:00–10:00 *Lecture 4. Optimizer's Curse: An Info-Gap Response.*[13]
  ○ Why best-model optimization is not a good bet if the best model is highly uncertain.[14]

10:00–11:00 *Lecture 5. Strategic interactions.*[15]
  ○ We study planning and response in strategic interactions with an uncertain opponent.

11:00–11:30 Coffee break.

11:30–12:30 *Lecture 6. Estimation and Forecasting.*[16]
  ○ Use regression to predict with preliminary data from an unstable process.[17]

12:30–13:30 *Exercise 2: Accelerated lifetime testing.*
  ○ Background.[18]
  ○ Exercise.[19]

Day 3 Wednesday 29 February 2012

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13:00–14:00 Lunch

14:00–18:00 *Workshop—Bring your own problem. Group 2.*

Day 4 Thursday 1 March 2012

09:00–13:00 *Workshop—Bring your own problem. Group 3.*

13:00–14:00 Lunch

14:00–18:00 *Workshop—Bring your own problem. Group 4.*

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[13]**dornbirn2012ws-Lec04.pdf**

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

[15]**dornbirn2012ws-Lec05.pdf**
    Supporting material:
(1) *IGDT*, section 3.2.9.
(2) *IGE,* section 3.4.
(3) Lecture Notes on Robustness and Opportuneness (\risk\lectures\ro.tex), section 13.
(4) Strategic Interactions: Games with Uncertain Preferences (\lectures \risk\lectures\game02.tex).

[16]**dornbirn2012ws-Lec06.pdf**.

[17]*IGE,* sections 6.1, 6.2.

[18]Lecture Notes on Acceptance Testing (acctes.tex), section 10.

[19]Problem Set on Acceptance Tests (hwacc.tex), #11.