Dr. Yakov Ben-Haim
Professor Emeritus
Former (2001–2021) Yitzhak Moda'i
Chair in Technology and Economics

Technion
Israel Institute of Technology
Faculty of Mechanical Engineering
Haifa 32000 Israel

http://info-gap.com http://yakovbh.net.technion.ac.il
Tel: +972-(0)73-378-3262, +972-50-750-1402 Fax: +972-(0)73-378-5711
yakov@technion.ac.il

Supervised Study Program for

Info-Gap Analysis of Risk and Reliability

036057

Website of the course:

https://yakovbh.net.technion.ac.il/courses/info-gap-analysis-of-risk-and-reliability

Guidelines: This document contains references to lecture notes, reading material, and exercises for 13 weeks of supervised study. Usually the student and professor will meet once a week; sometimes once in two weeks. The exercises are essential for mastering the material. The exercise files contain many additional exercises, and the student is encouraged to work out additional exercises that look interesting in light of the student's research interests.

Projects: A midterm project (40%) and a final project (60%) are both required. The requirements for these projects are presented at the end of this file.

Week 1:

Lecture notes:[1]

- Info-Gap Uncertainty, pp.3–12.
- Conservation management . . . , pp.2–9.

Reading material:

- *Info-Gap Decision Theory,* 2nd ed. (*IGDT*), chapter 2.
- Helen M. Regan, Yakov Ben-Haim, Bill Landford, Will G. Wilson, Per Lundberg, Sandy J. Andelman and Mark A. Burgman, 2005, Robust decision making under severe uncertainty for conservation management, *Ecological Applications,* vol.15(4): 1471–1477.

Exercises:[2]

- Homework problems on Info-Gap Uncertainty #10 a, b.

Week 2:

Lecture notes:

- Info-gap estimation and forecasting, pp.3–10.

Reading material:

- Yakov Ben-Haim, 2008, Info-gap forecasting and the advantage of sub-optimal models, *European Journal of Operational Research,* 197: 203–213.
- 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.
- *IGDT*, section 3.2.13.

Exercises:

- Homework problems on Robustness and Opportuneness (HWRO), #32 a–d.

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[1] Lecture note files are on the course website.
[2] Exercise files are on the course website.

Weeks 3–4:

Lecture notes:

- Info-gap estimation and forecasting, pp.11–35.

Reading material:

- Same as week 2.

Exercises:

- HWRO, #31, 38.

Week 5:

Lecture notes:

- Info-gap estimation and forecasting, pp.36–41.
- Robustness and opportuneness, pp.50–53 (portfolio investment).

Reading material:

- *IGDT*, section 3.2.7 (portfolio investment).

Exercises:

- HWRO, #43.

Week 6:

Lecture notes:

- Robustness and opportuneness, pp.54–56 (portfolio investment).
- Robustness and opportuneness, pp.58–60. (Search and evasion).
- Info-Gap Uncertainty, pp.26–27 (convexity and uncertainty).

Reading material:

- *IGDT*, sections 2.4 (uncertainty and convexity), 3.2.9 (search and evasion).

Exercises:

- HWRO #88a, 70 a–e.

Week 7:

Lecture notes:

- Info-Gap Uncertainty, p.28 (convexity and uncertainty).
- Robustness and opportuneness, pp.76–80 (WEI-WUV).

Reading material:

- *IGDT*, section 2.4 (uncertainty and convexity).
- Yakov Ben-Haim, 2018, WEI-WUV for assessing force effectiveness: Managing uncertainty with info-gap theory, *Military Operations Research,* 23(4): 37–49.

Exercises:

- HWRO, #66 a–e.

Week 8:

Lecture notes:

- Robustness and opportuneness, pp.81–92. (WEI-WUV).
- Robustness and opportuneness, pp.93–101 (Behavioral feedback).

Reading material:

- Yakov Ben-Haim, 2018, WEI-WUV for assessing force effectiveness: Managing uncertainty with info-gap theory, *Military Operations Research,* 23(4): 37–49.

Exercises:

- HWRO #92 a–d.

Week 9:

Lecture notes:

- Optimizer's Curse, pp.2–12.

Background material:

- Smith, James E. and Robert L. Winkler, 2006, The optimizer's curse: Skepticism and postdecision surprise in decision analysis, *Management Science,* Vol. 52, No. 3, pp.311–322.
- Thaler, Richard H., 1992, *The Winner's Curse: Paradoxes and Anomalies of Economic Life,* Princeton University Press.

Exercises:

- HWRO, #53 a–f, #59 a–f.

Week 10:

Lecture notes:

- Optimizer's Curse, pp.13–15.
- Robust-Satisficing Behavior, pp.2–10.

Reading material:

- *IGDT*, chapter 11 (Robust satisficing behavior).

Exercises:

- HWRO, #100, 101.

Week 11:

Lecture notes:

- Robust-Satisficing Behavior, pp.11–21.

Reading material:

- *IGDT*, chapter 11 (Robust satisficing behavior).

Exercises:

- HWRO, #90.

Week 12:

Lecture notes:

- Robust-Satisficing Behavior, pp.21–23, 41–46.

Reading material:

- *IGDT*, chapter 10 (Hybrid Uncertainties).

Exercises:

- HWRO, #47 b, 61 a–f.

Week 13:

Lecture notes:

- Robust-Satisficing Behavior, pp.46–47.
- Robustness and opportuneness, pp.102–108 (Monitoring for health and safety).

Reading material:

- *IGDT*, chapter 10 (Hybrid Uncertainties).

Exercises:

- HWRO, #94 a–g.

Midterm mini-project, required, 40%. There is no written exam. Rather, each student will formulate and solve an exam question whose solution is based on methods and concepts developed in the course. This question will involve info-gap robustness or opportuneness functions, and will be presented in 3 different versions, based on 3 different info-gap models of uncertainty: fractional-error for multiple uncertain parameters, energy-bound for an uncertain function, and Fourier ellipsoid-bound for an uncertain function. The exam question and its solution will be submitted to the professor as a pdf file. The submission will be no more than 4 pages long. Grading: 100 for thorough and correct formulation and solution. 85 for no more than minor errors. 70 for minor errors and no more than one substantial error. 0 for anything else. Students are welcome to consult with the professor before submission (but not "Is this correct?").

Final Project Guidelines

1. The project is devoted to the **risk assessment** or **reliability analysis** of a **complex system** based on info-gap decision theory. It will contain the following elements:
   (a) **Statement of the problem:** safety analysis, mission-dependability assessment, design optimization, project management and risk assessment, etc.
   (b) Mathematical **model of the system.** The system may be technological or economic, social, environmental, medical, etc.
   (c) Mathematical formulation of **failure criteria.**
   (d) Mathematical **uncertainty model** with info-gap (and possibly probabilistic) components.
   (e) Mathematical derivation of the **risk** or **reliability** of the system as expressed by info-gap robustness and possibly opportuneness functions. The presentation may be supported by numerical analysis where needed. This step explicitly combines the previous three steps.
   (f) Application of the results derived in step 1e to **resolution of the problem** identified in step 1a.
2. The project will be submitted in two stages.
   (a) Stage 1: Project **definition and outline** of items 1a–1d above. Students are welcome to submit an outline of about 1 page length by about the 10th week of the semester.
   (b) Stage 2: **Final report.** Electronic only, as pdf file, with text (including tables and graphs) not exceeding 10 pages.
3. Each student must submit his own project. **No team submissions.**
4. **Expected depth and complexity:** much more than the typical homework problem; much less than a realistic full scale analysis.
5. **Advice and suggestions** can be obtained by consulting with the instructor.
6. **Grading.** The final project makes up 60% of the final grade. The project grade will be one of four:
   - 100 (excellent): innovative, thorough and entirely correct analysis.
   - 85 (good): Solid, thorough and correct variation on an example developed in class.
   - 70 (pass): Basically correct but simple variation on an example developed in class.
   - 0 (fail): Everything else.