

Bayesian Belief Network Modelling: workshop on theory and practice with application to fisheries and environmental assessment

Overview

Objectives: The aims of the workshop are to familiarize participants with Bayesian decision network modelling concepts, methods and software, to facilitate the development of new applications of Bayesian network modelling in Japanese fisheries and environmental research and management.

Dates: November 21-22, 2016

Location: Seikai National Fisheries Research Institute, Nagasaki

Instructors: Dr. Murdoch McAllister, Associate Professor in Fisheries Assessment and Statistics, UBC Institute of the Oceans and Fisheries.

Requirements: 1) Your own computer
2) Pre-install Hugin lite freeware (www.hugin.com)
3) Pre-install Genie freeware (installation software to be provided) (genie.sis.pitt.edu)
4) Pre-install Excel with Data Analysis Toolpack and Solver added in.

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Workshop outline: Bayesian decision networks for fisheries and environmental assessment

Day 1, Monday November 21st

1. Introduction to workshop (1pm-115pm)

- Hiroyuki Kurota
- Murdoch McAllister
- Participants

- Aims of workshop
- Review of what's to be covered

2. Seminar: Foundations of decision analysis and implementation of Bayesian decision networks (115pm-2pm)

- What is decision analysis and where did it come from?
- Common implementations of decision analysis in fisheries and environmental analysis
- What is a Bayesian belief network and how can it be useful (Charniak 1991)?
- What's Bayesian about Bayesian belief networks?
- Illustrating key concepts of Bayesian inference and modeling in a Bayesian belief network.

3. Exercise in Excel: Atlantic Mackerel example with the observation being pelagic egg density and the hypotheses to be different spawning stock sizes of mackerel (2-3pm)

4. Introduction to Hugin Bayesian network software (Seminar and Exercises). (315-5pm)

- The same Mackerel exercise developed in Excel but in Hugin.
- Developing Bayesian networks to represent fisheries systems
- Learning the key features of Hugin BBN software

Day 2, Tuesday November 22nd

1. Recap on Day 1 session and brief discussion of what's been covered so far. (830-845am)

2. Exercises on learning about the structure of a decision network and how to evaluate the influence of different sources of uncertainty in a decision analysis. (845am-10am).

- Developing a decision network to evaluate stock rebuilding policies for Atlantic redfish
- For Atlantic redfish, trawl survey stock abundance index data drive the assessment. The largest uncertainty is in the forecasted strength of a cohort that is to recruit to the fishery in two years. A BBN will be built to explore the potential consequences of different fishery management options under different scenarios for cohort strength.
- Formulation of utility functions and evaluation of the Expected Value of Perfect Information (i.e., potential value of information that could be obtained from different research approaches)

2. Seminar: Introduction to developing networks using Genie and comparison of Genie vs. Hugin Researcher. (1015-1045am).

3. Exercise: Setting up a Bayesian belief network using Genie software (1045-12noon).

Lunch break 12-1pm.

4. Seminar: Using network software to analyse datasets on complex systems (1-130pm)

5. Exercise: Using network software to analyze datasets on fisheries systems (130-230pm)
 - Reading in and discretizing continuous data from computer simulation evaluation of different catch limit setting methods for the formulation of conditional probability tables in a decision network.
6. Exercise: Development of a decision network using outputs from a simulation evaluation of different management methods. (230-4pm)
7. Exercise: Participants either work on developing BBNs of interest to them or work on additional provided exercises (a number to choose from (e.g., on accounting for non-biological considerations in fisheries decision analysis) with detailed instructions) (4-445pm)
8. Seminar: Participants report on results of their own BBNs (445-5pm).
9. Conclusion of workshop (5pm)

General Comments on Running of Workshop

There will be a strong emphasis on learning about the different types of uses of influence diagrams and Bayesian networks, careful attention to different ways to analyze how Bayesian networks work, how to run the Hugin and also Genie software, setting up influence diagram model structures (what nodes to include and how they should be linked), populating the conditional probability tables, using the equation and probability distribution features in Hugin, careful attention to setting up utility functions, instructions on different ways to analyze, view and communicate about influence diagram results. Attention will also be given on how to use influence diagram models to set up Bayesian networks from the analysis of datasets. Some attention will be given to developing networks dealing with human dimensions issues in fisheries management policy evaluations.

Recommended reading

- Barton, D.N., Kuikka, S., Varis, O., Uusitalo, L., Henriksen, H., J., Borsuk, M., de la Hera, A., Farmani, R., Johnson, S., and Linnell, J.D.C. 2012. Bayesian Networks in Environmental and Resource Management. *Integrated Environmental Assessment and Management*. 8:418-429.
- Charniak, E., 1991. Bayesian Networks without Tears. *Artificial Intelligence Magazine*. pages 50-63.
- Haapasaari, P., Michielsens, C. G. J., Karjalainen, T. P., Reinikainen, K., and Kuikka, S. 2007. Management measures and fishers' commitment to sustainable exploitation: a case study of Atlantic salmon fisheries in the Baltic Sea. *ICES Journal of Marine Science*, 64: 825–833.
- Haapasaari, P., Kulmala, S., and Kuikka, S. 2012. Growing into Interdisciplinarity: How to Converge Biology, Economics, and Social Science in Fisheries Research? *Ecology and Society* 17(1): 6-18.

- Hilborn, R. and C. J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York. p. 493-502.
- Kuikka, S., Hildén, M., Gislason, H., Hansson, S., Sparholt, H., and Varis, O. 1999. Modeling environmentally driven uncertainties in Baltic cod (*Gadus morhua*) management by Bayesian influence diagrams. ICES J. Marine. Science 56: 629–641.
- Levontin, P. Kulmala, S., Haapasari, P., and Kuikka, S. 2011. Integration of biological, economic, and sociological knowledge by Bayesian belief networks: the interdisciplinary evaluation of potential management plans for Baltic salmon. ICES J. Mar. Sci. 68(3) 632-638.
- Mantyniemi, S., Kuikka, S., Rahikainen, M., Kell, L. T., and Kaitala, V. 2009. The value of information in fisheries management: North Sea herring as an example. – ICES Journal of Marine Science, 66: 2278-2283.
- Prairie, Y. T. 1996. Evaluating the predictive power of regression models. Can. J. Fish. Aquat. Sci. 53: 490–492.
- Uusitalo, L., 2007. Advantages and challenges of Bayesian networks in environmental modeling. Ecological modelling 203: 312–318.
- Uusitalo, L., Vehkalahti, K, Kuikka, S., Soderkultalahti, P. 2005. Studying species associations from commercial catch data: a Baltic Sea application. Fisheries Research 72: 301–310.
- Uusitalo, L., Kuikka, S., and Romakkaniemi, A. 2005. Estimation of Atlantic salmon smolt carrying capacity of rivers using expert knowledge. ICES Journal of Marine Science, 62: 708-722.
- Uusitalo, L., Kuikka, S., Kauppila, P., Soderkultalahti, P., and Back, S., 2012. Assessing the Roles of Environmental Factors in Coastal Fish Production in the Northern Baltic Sea: A Bayesian Network Application. Integrated Environmental Assessment and Management. 8, (3) 445–455 .