

PORTLAND STATE UNIVERSITY
Systems Science Ph.D. Program
Professor Martin Zwick
725-4987

Spring 2009
TuTh 4:40 - 6:30 PM
Harder House 104
zwick@pdx.edu

SySc 610: **DISCRETE MULTIVARIATE MODELING-II**

From description of SySc 651 (which is DMM-I): In this course, information theory is used as a framework for modeling and data mining: for analyzing static or dynamic relations among discrete variables, for detecting complex interaction effects, and for discovering nonlinearities in continuous variables made discrete by binning. In the systems literature, these information-theoretic and related set-theoretic methods, used together with graph theory techniques, are called “Reconstructability Analysis” (RA).

SySc 610 *continues* the presentation of discrete multivariate modeling (SySc 551/651), and will focus on (a) student projects and (b) lectures on advanced topics.

Projects will aim at conference or journal publications. Possible projects are:

- intensive analysis of some dataset
- software development that enhances the current set of RA tools
- performance study of an RA method (e.g., Fourier RA, BDD-SRA)
- theoretical study on RA methods

Lectures will include most if not all of the following advanced topics (& perhaps others):

- more on state-based RA & SB-RA software; SB-RA & decision analysis
- continuous functions (DVs): expected value, k-systems, & j-systems approaches
- set-theoretic RA: binary decision diagrams; ‘modified’ SRA; approximating IRA
- Fourier-based (regression-like) RA calculations
- more on loopless models: algebraic techniques & ‘dependency analysis’
- intra-model analyses (Krippendorff)
- modeling with latent variables
- RA used with genetic algorithms & neural networks
- RA analysis of cellular automata dynamics
- illustration of RA time-series analysis
- OCCAM software architecture
- identification with inconsistent data

Prerequisites: SySc 551/651 (or – with permission of the instructor –solid background in log-linear modeling, Bayesian networks, or related methods)

TEXT (aside from SySc 551/651 texts): Materials not on web will be distributed in class.

Tentative outline

Mar 30	Course introduction/organization; over 551 exam
Apr 2	RA time-series analysis <i>ZSK, STZ [KB47-63]</i>
Apr 7,9	Fourier-based (regression-like) RA <i>[Z], ZZ</i>
Apr 14	Continuous functions (DVs): expected value, k-systems, u-systems <i>J, JZ</i>
Apr 16	State-based modeling & decision analysis Guest lecture: Dr. Michael Johnson, Kaiser Permanente <i>ZJ</i>
Apr 21	Presentation of planned projects
Apr 23 Apr 28, 30	Set-theoretic RA: 'modified' SRA SRA (continued): binary decision diagrams; approximating IRA <i>ZSH, ZM, AZP, AZ, GZP</i>
May 5,7	Algebraic techniques, dependency analysis, intra-model analyses <i>STZ; KK62-67</i>
May 12	Modeling with latent variables <i>H</i>
May 14	Identification with inconsistent data <i>A</i>
May 19,21	Applications: genetic algorithms, neural nets preprocessing <i>SZ03a, ZSS, SZ05; LZM, CS, CLZ, LSZ, SZ03b</i>
May 26	Applications (continued): cellular automata
May 28	OCCAM software architecture <i>W, WZ</i>
June 2, 4, 9	Project presentations

References *Underlined: to be distributed; other papers are available on the DMM page:*
<http://www.pdx.edu/syssc/research-discrete-multivariate-modeling>

A: Doug Anderson (1996). *The Identification Problem of Reconstructability Analysis: A General Method for Estimation and Optimal Resolution of Local Inconsistency*. Ph.D. dissertation, Systems Science Ph.D. Program, Portland State University.

AZP: Al-Rabadi, A., Zwick, M., and Perkowski, M. (2004). "A Comparison of Modified Reconstructability Analysis and Ashenhurst-Curtis Decomposition of Boolean Functions." *Kybernetes*, vol. 33, No. 5/6, pp. 933-947.

AZ: Al-Rabadi, A., and Zwick, M. (2004). "Modified Reconstructability Analysis for Many-Valued Functions and Relations." *Kybernetes*, vol. 33, No. 5/6, pp. 906-920.

CLZ: Chambless, B., Lendaris, G., and Zwick, M. (2001). "An Information Theoretic Methodology for Prestructuring Neural Networks." International Joint Conference on Neural Networks (IJCNN), Washington DC.

CS: Chambless, B., and Scarborough, D. (2001). "Information-Theoretic Feature Selection for a Neural Behavioral Model." International Joint Conference on Neural Networks (IJCNN), Washington DC.

GZP: Grygiel, S., Zwick, M., and Perkowski, M. (2004). "Multi-Level Decomposition of Probabilistic Relations." *Kybernetes*, vol. 33, No. 5/6, pp. 948-961.

H: Hagenaars, Jacques A. *Loglinear Models with Latent Variables*. Series: Quantitative Applications in the Social Sciences, Paper # 94, Sage Publications, Beverly Hills, California, 1993. (ISBN 0-8039-4310-5, paperback), pp. 20-52.

J: Jones, Bush. "Reconstructability Analysis for General Functions." *Int. J. General Systems*, 1985, Vol. 11, pp. 133-142.

JZ: Johnson, M.S., and Zwick, M. (2000). "State-Based Reconstructability Modeling for Decision Analysis." *Proceedings of The World Congress of the Systems Sciences and ISSS 2000*, Allen, J.K. and Wilby, J.M. eds., Toronto, Canada: International Society for the Systems Sciences.

KB: Knoke, David and Burke, Peter J. (K & B). *Log-Linear Models*. Series: Quantitative Applications in the Social Sciences, paper # 20. Sage Publications, Beverly Hills, California, 1980. (ISBN 0-8039-1492-X, paperback)

KK: Krippendorff, Klaus (K). *Information Theory: Structural Models for Qualitative Data*. Series: Quantitative Applications in the Social Sciences, Paper # 62, Sage Publications, Beverly Hills, California, 1986. (ISBN 0-8039-2132-2, paperback)

LSZ: Lendaris, G., Shannon, M., & Zwick, M. (1999). "Prestructuring Neural Networks for Pattern Recognition Using Extended Dependency Analysis." Invited paper, *Applications and Science of Computational Intelligence II AeroSense '99*, Orlando FL, SPIE.

LZM: Lendaris, G., Zwick M., and Mathia, K. (1993). "On Matching ANN Structure to Problem Domain Structure." *Proceedings of World Congress on Neural Networks '93* (WCNN-93, Portland), Earlbaum/INNS. See also other Lendaris papers on NN prestructuring: http://www.nwcil.pdx.edu/pubs/prestructuring_nns.php

STZ: Shannon, T., and Zwick, M. (2004). "Directed Extended Dependency Analysis for Data Mining." *Kybernetes*, vol. 33, No. 5/6, pp. 973-983.

SZ03a: Shervais, S. and Zwick, M. (2003). "Ordering Genetic Algorithm Genomes With Reconstructability Analysis." *International Journal of General Systems*, Vol. 32(5), pp. 491-502.

SZ03b: Shervais, S. and Zwick, M. (2003). "Using Reconstructability Analysis to Select Input Variables for Artificial Neural Networks." *International Joint Conference on Neural Nets*, Portland OR, July 20-24.

SZ05: Shervais, S., and Zwick, M. (2005). "Ordering Genetic Algorithm Genomes With Reconstructability Analysis: Discrete Models." *IEEE conference on Systems, Man, and Cybernetics*, Hawaii, Oct. 10-12.

WZ: Willett, K., and Zwick, M. (2004). "A Software Architecture for Reconstructability Analysis." *Kybernetes*, vol. 33, No. 5/6, pp. 997-1008.

W: Willett, K. and Zwick, M. (2007). *OCCAM: A Reconstructability Analysis Program* (OCCAM manual).

Z: Zwick, M. (2004). "Reconstructability Analysis with Fourier Transforms." *Kybernetes*, vol. 33, No. 5/6, pp. 1026-1040.

ZJ: Zwick, M., and Johnson, M. S. (2004). "State-Based Reconstructability Analysis." *Kybernetes*, vol. 33, No. 5/6, pp. 1041-1052.

ZM: Zwick, M. & Mishchenko, A. (2006). "Binary Decision Diagrams and Crisp Possibilistic Reconstructability Analysis." Presented *International Conference on Complex Systems*, Boston.

ZSH: Zwick, M., and Shu, H. (1995). "Set-Theoretic Reconstructability of Elementary Cellular Automata." *Advances in Systems Science and Applications*, 1, pp. 31-36.

ZSK: Zwick, M., Shu, H., and Koch, R. (1995). "Information-Theoretic Mask Analysis of Rainfall Time-Series Data." *Advances in Systems Science and Applications*, 1, pp.154-159.

ZSS: Zwick, M., and Shervais, S. (2004). "Reconstructability Analysis Detection of Optimal Gene Order in Genetic Algorithms." *Kybernetes*, 33, No. 5/6, pp. 1052-1062.

ZZ: Zwick, M., and Zeitler, E. (1973). "Image Reconstruction from Projections." *Optik*, Vol. 38, No. 5, pp.550-565.