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Systems Science Ph.D. Program  
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Spring 2007  
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### 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). RA overlaps with and extends log-linear modeling in the social sciences, Bayesian networks and graphical models in machine learning, decomposition techniques in multi-valued logic design, Fourier methods for compression, and other modeling approaches. It can be used for confirmatory and exploratory statistical modeling as well as for non-statistical applications.

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

If possible projects will aim at a conference or journal publications. The advanced topics in the course will include:

- state-based RA and k-systems analysis
- Fourier-based RA techniques (& regression)
- set-theoretic RA & binary decision diagrams
- RA loopless models with *many* variables (“dependency analysis”)
- identification with inconsistent data
- intra-model analyses
- modeling with latent variables
- RA and genetic algorithms
- binning
- the OCCAM software package

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

**TEXT** (in addition to materials used in SySc 551/651): Materials not on web will be distributed in class (see bibliography in syllabus).

Outline (tentative)

Apr 3	Course introduction/organization; over 551 exam
Apr 5, 10 Apr 5	State-based RA Guest lecture: Dr. Michael Johnson, Kaiser Permanente <i>J, JZ, ZJ</i>
Apr 12, 17	Fourier RA (variable- & state-based); relation to regression <i>ZZ, Z</i>
Apr 19, 24 Apr 26, May 1	Set-theoretic RA; relations to information-theoretic RA; binary decision diagrams; modified SRA <i>ZSH, ZM, AZP, AZ, GZP</i>
May 3	Presentation of planned projects
May 8	RAGA: RA and genetic algorithms <i>SZ03a, ZSS, SZ05</i>
May 10	RANN: RA and neural networks <i>LZM, CS, CLZ, LSZ, SZ03b</i>
May 15	Searching the lattice of structures <i>KG, W</i>
May 17	EDA (loopless model searching) <i>STZ</i>
May 22	Time series: mask analysis, log-linear approaches <i>ZSH, KB47-63</i>
May 24	Intra-model analysis <i>KK62-67</i>
May 29	Binning; fuzzy inductive inference; ordinal variables <i>Shafe, KB67-70</i>
May 31	Modeling with latent variables <i>H</i>
June 5	Identification with inconsistent data <i>A</i>
June 7,12	Project presentations

References *Underlined: to be distributed; other papers are available on the DMM page:*

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.

*[Cellier – do I have his papers? For binning/fuzzy inductive inference]*

*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)

[check pages] KG: Klir, George J. *Architecture of Systems Problem Solving*. Plenum Press, New York, 1985, pp. 212-266, 281-284.

*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., and 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](http://www.nwcil.pdx.edu/pubs/prestructuring_nns.php)

[also Hari's reference, article I have] Shafe, *Kybernetes*, binning

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

[get better reference] *SZ03a*: Shervais, S. and Zwick, M. (2003). "Ordering Genetic Algorithm Genomes With Reconstructability Analysis." *International Journal of General Systems*: accepted, in press.

*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.

*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.

ZSS: Zwick, M., and Shervais, S. (2004). "Reconstructability Analysis Detection of Optimal Gene Order in Genetic Algorithms." *Kybernetes*, vol. 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.