Workshop Proposal for the 2007 American Control Conference
Proposed Title: Engineering Applications in Genomics
Proposed Duration: 2 Days

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Main Workshop Goal: To provide a tutorial introduction to the current engineering research in genomics.

Description

Genomics concerns the study of large sets of genes with the goal of understanding *collective* function, rather than that of individual genes. Such a study is important since cellular control and its failure in disease result from *multivariate* activity among cohorts of genes. Very recent research indicates that engineering approaches for prediction, signal processing and control are quite well suited for studying this kind of multivariate interaction. The aim of this workshop will be to provide the attendees with a state of the art account of the research that has been accomplished in this field thus far and to make them aware of some of the open research challenges.

The workshop will provide a tutorial introduction to the current engineering research in genomics. The necessary Molecular Biology background will be presented and techniques from signal processing and control will be used to (i) unearth intergene relationships (ii) carry out gene-based classification of disease (iii) model genetic regulatory networks and (iv) alter (i.e. control) their dynamic behaviour. The workshop will be divided into two parts. On the first day, we will focus on building up the necessary molecular biology background. NO PRIOR EXPOSURE TO MOLECULAR BIOLOGY WILL BE ASSUMED. On the second day, we will discuss the application of engineering approaches for attacking some of the challenging research problems that arise in genomics related research. A more detailed description of the material to be covered on each day follows.

Syllabus

Workshop Day 1

- 1. *Review of Organic Chemistry*: Sugars, Fatty Acids, Amino Acids and Nucleotides (1 hour 45 minutes)

- 2. *DNA, RNA and Proteins*: Transcription, Translation, the Genetic Code, Chromosomes and Gene Regulation (2 hours)

- 3. *Genetic Variation, Genetic Engineering: Recombinant DNA Technology and Microarrays* (1 hour 45 minutes)

- 4. *Procaryotes, Eucaryotes, Eucaryotic Cell Structure, Cell Cycle, Mitosis, Meiosis, Apoptosis, Cancer as the breakdown of Cell Cycle control* (2 hours)

Workshop Day 2

- 5. *Analysis of cDNA Microarray Images* (1 hour 45 minutes)

- 6. *Unearthing Genomic Relationships using the Coefficient of Determination* (2 hours)

- 7. *Models of Genetic Regulatory Networks* (1 hour 45 minutes)

- 8. *Intervention and Control in Genetic Regulatory Networks* (2 hours)

Workshop Materials

Detailed notes covering the material on the first day will be handed out at the workshop. The material for the second day will consist of the following journal articles, copies of which will be included in the workshop notes. Alternatively, the proposer may choose to use material from an introductory book entitled, "Genomic Signal Processing with Control," CRC Press, 2006 that he has just finished up with a co-worker this summer.

- 1. Chen, Y., Dougherty, E. R. & Bittner, M. L. (1997). Ratio-Based Decisions and the Quantitative Analysis of cDNA Microarray Images. *Journal of Biomedical Optics*, Vol. 2, No. 4, 364-374.

- 2. Kim, S., Dougherty, E. R., Bittner, M. L., Chen, Y., Sivakumar, K., Meltzer, P., & Trent, J. M. (2000). A General Framework for the Analysis of Multivariate Gene Interaction via Expression Arrays. *Biomedical Optics*, Vol. 4, No. 4, 411-424.

- 3. Shmulevich, I., Dougherty, E. R., Kim, S., & Zhang, W. (2002a). Probabilistic Boolean Networks: A Rule-based Uncertainty Model for Gene Regulatory Networks. *Bioinformatics*, 18, 261-274.

- 4. Shmulevich, I., Dougherty, E. R., & Zhang, W. (2002c). Gene Perturbation and Intervention in Probabilistic Boolean Networks. *Bioinformatics*, 18, 1319-1331.

- 5. Shmulevich, I., Dougherty, E. R., & Zhang, W. (2002d). Control of Stationary Behavior in Probabilistic Boolean Networks by Means of Structural Intervention. *Biological Systems*, Vol. 10., No. 4, 431-446.

- 6. Datta, A., Choudhary, A., Bittner, M. L., & Dougherty, E. R. (2003). External Control in Markovian Genetic Regulatory Networks. *Machine Learning*, Vol. 52, 169-191.

- 7. Datta, A., Choudhary, A., Bittner, M. L., & Dougherty, E. R. (2004). External Control in Markovian Genetic Regulatory Networks: The Imperfect Information Case. *Bioinformatics*, Vol. 20, No. 6, 924-930.

- 8. E. R. Dougherty and A. Datta, "Genomic Signal Processing: Diagnosis and Therapy," *IEEE Signal Processing Magazine*, 107-112, January 2005.

- 9. R. Pal, A. Datta, M. L. Bittner and E. R. Dougherty, "Intervention in Context-Sensitive Probabilistic Boolean Networks," *Bioinformatics*, Vol. 21, No. 7, 1211-1218, 2005.

- 10. R. Pal, A. Datta, A. J. Fornace, M. L. Bittner and E. R. Dougherty, "Boolean Relationships Between Genes Responsive to Ionizing Radiation in the NCI 60 ACDS," *Bioinformatics*, Vol. 21, No. 8, 1542-1549, 2005.

- 11. E. R. Dougherty, A. Datta and C. Sima, "Research Issues in Genomic Signal Processing," *IEEE Signal Processing Magazine*, Vol. 22, No. 6, 46-68, November 2005.

- 12. R. Pal, I. Ivanov, A. Datta, M. L. Bittner and E. R. Dougherty, "Generating Boolean Networks with a Prescribed Attractor Structure," *Bioinformatics*, Vol. 21, No. 21, 4021-4025, 2005.

- 13. A. Datta, R. Pal and E. R. Dougherty, "Intervention in Probabilistic Gene Regulatory Networks," *Current Bioinformatics*, Vol. 1, 167-184, 2006.

- 14. A. Choudhary, A. Datta, M. L. Bittner and E. R. Dougherty, "Intervention in a Family of Boolean Networks," *Bioinformatics*, Vol. 22, No. 2, 226-232, 2006.

- 15. R. Pal, A. Datta and E. R. Dougherty, "Optimal Infinite Horizon Control for Probabilistic Boolean Networks," *IEEE Trans. on Signal Processing*, Vol. 54, No. 6, part 2, 2375-2387, June 2006.

- 16. A. Datta, R. Pal, A. Choudhary and E. R. Dougherty, "Control Approaches for Probabilistic Gene Regulatory Networks," *IEEE Signal Processing Magazine* (to appear).

Aniruddha Datta

Aniruddha Datta is a Professor in the Department of Electrical and Computer Engineering at Texas A & M University, College Station, Texas. He holds a B. Tech degree in Electrical Engineering from the Indian Institute of Technology, Kharagpur, an M.S.E.E. degree from Southern Illinois University, Carbondale and an M.S. (Applied Mathematics) and Ph.D. degrees from the University of Southern California. He is the author of three books in the controls area and has authored more than eighty journal and conference papers. He is a Senior Member of IEEE, and has served as an Associate Editor of the *IEEE Transactions on Automatic Control* and the *IEEE Transactions on Systems, Man and Cybernetics-Part B*. His areas of interest include adaptive control, robust control, PID control and Genomic Signal Processing.
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