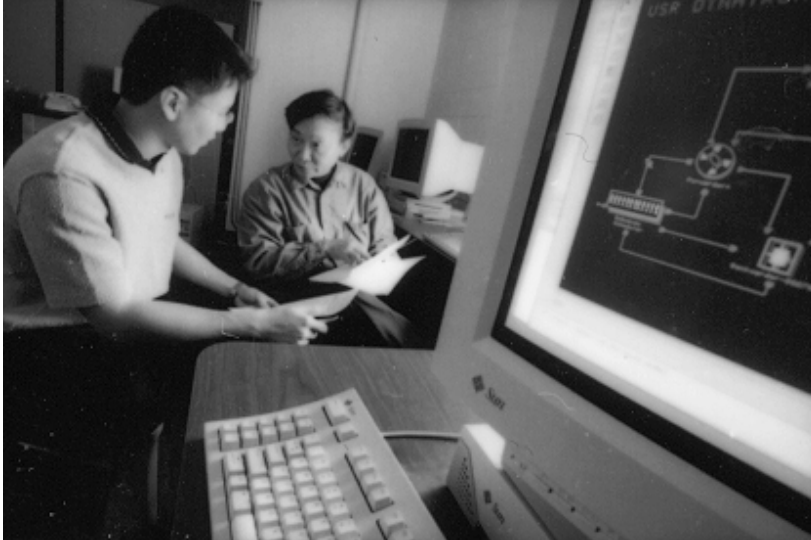


Networks, Communication, and Control 1999–2000



Externally Funded Research Projects

Nonlinearity and Uncertainty in Control System Design

R. Freeman*

Sponsor: National Science Foundation (CAREER Award)

A basic purpose of feedback is to reduce the effect of uncertainty on the behavior of a system. When applied inappropriately, however, feedback can also increase the risk of instability and other undesirable phenomena. An obstacle to the successful design of feedback controllers has long been the presence of nonlinearity in models and in real systems. The goal of this project is to develop innovative methods for designing feedback controllers for uncertain nonlinear systems and to educate future engineers and researchers in their application. During the course of this project, the PI will identify those flexibilities in new and existing nonlinear design methods which can be exploited to obtain good controllers for practical applications.

Adaptive Signal Processing Techniques for Spread Spectrum Multiple Access

M. Honig*

Sponsor: Army Research Office

This project is concerned with signal processing and coding techniques for Direct-Sequence (DS)-Code-Division Multiple Access (CDMA) in a peer-to-peer network. Topics to be investigated include the performance of adaptive interference suppression algorithms in the presence of wireless channel impairments, combined coding and adaptive interference suppression, and joint adaptation of transmitters and receivers.

*Denotes Networks, Communication, and Control Group faculty member(s), listed in alphabetical order.

Dynamic Resource Allocation for Code-Division Multiple Access

M. Honig* and S. Jordan

Sponsor: National Science Foundation

This project is concerned with techniques for supporting integrated services over a wireless cellular network. A fundamental problem is how to allocate radio resources to different users to optimize an overall network objective criterion while satisfying quality-of-service constraints. Wireless networks based on Direct-Sequence (DS) – Code-Division Multiple Access (CDMA) networks are considered, since DS-CDMA is a strong contender for next-generation cellular systems. Radio “resources” in a DS-CDMA network include the transmitted powers, processing gains, and number of assigned codes. The focus of this research is on dynamic resource allocation in the presence of time-varying user requests. The project’s goals are: (1) develop techniques for dynamic resource allocation given multiple traffic flows with different quality-of-service requirements; and (2) characterize performance / complexity tradeoffs associated with these techniques given simple traffic and propagation models.

Multi-Cell Dynamic Resource Allocation

M. Honig*

Sponsor: Motorola

This project studies utility-based resource allocation methods for wireless networks. Each user is assumed to have a utility function which indicates the utility derived from the service vs. the amount of resource (e.g., power, time slots, or codes) allocated to that user. A typical objective is to allocate resources to maximize total utility or revenue summed over all users. Pricing strategies are being investigated which may accomplish this objective. Both single-cell and multi-cell models with other-cell interference and mixed services (voice and data) are being considered.

Multuser Transmitter Optimization for Cellular Communications with Coordinating Base Stations

M. Honig*

Sponsor: National Science Foundation

Reliable communications within a mobile cellular network are hampered by detrimental phenomena such as: fading due to multipath; near-far effects causing power imbalance; multiuser interference; intersymbol interference; and additive thermal noise. Techniques such as multiuser detection and preprocessing at the transmitter can improve error performance and system capacity. This project studies the optimal design of multiuser-transmission schemes for a variety of cellular scenarios, and the adaptation of transmitter-spreading codes in the context of Direct-Sequence – Code-Division Multiple Access (DS-CDMA).

A Control Theoretic Approach to Wireless Multimedia QoS Management

C. C. Lee* and A. H. Haddad*

Sponsor: Motorola

An analytical framework is very important for comprehensive network bandwidth management in a differentiated quality-of-service environment. Our approach includes an adaptive traffic source model that accounts for a wide variety of network traffic types. Based on this model, we designed a systematic means for managing throughput, delay, and loss on both a per-flow basis and an aggregated basis. These performance variables are readily translated to various quality-of-service attributes and / or utility functions of interest. Accordingly, we designed an analytical core for designing integrated call admission, bandwidth allocation, and rate-adaptation algorithms for provisioning differential quality of service.

Design and Evaluation of Self-Organizing Protocols for Wireless Networks

C. C. Lee*

Sponsor: Motorola

The project is concerned with design and analysis of a self-organizing algorithm and the associated routing protocols for a wireless network of low-cost nodes with varying transmitting powers. The heart of the design is a logical backbone architecture through which data communications between all the nodes in the network including mobile nodes are seamlessly supported. Our design features self-organizing, hierarchical-routing, optimal logical backbone topology (theoretically proved), minimal control and maintenance overhead, minimal communication complexity (theoretically proved), minimal computational complexity in terms of time and space (theoretically proved), full scalability, and self-healing.

Journals Edited

A. H. Haddad*, Assoc. Editor at Large, *IEEE Trans. Automatic Control*.

A. H. Haddad*, Assoc. Editor, *IFAC Journal on Control Engineering Practice*.

M. L. Honig*, Editor for Communications, *IEEE Trans. Information Theory*.

Journal Papers

M. L. Honig* and M. K. Tsatsanis, "Adaptive techniques for multiuser CDMA receivers," *IEEE Signal Processing Magazine*, vol. 17, no. 9, May 2000, pp. 49–61.

J.-B. Kim and M. L. Honig*, "Resource allocation for DS-CDMA with multiple traffic types," *IEEE Trans. Vehicular Technology*, vol. 49, no. 2, March 2000, pp. 506–519.

U. Madhow and M. L. Honig*, "Performance of MMSE interference suppression with random signature sequences," *IEEE Trans. Information Theory*, vol. 45, no. 6, Sept. 1999, pp. 2039–2045.

Symposium Sessions Organized / Chaired

R. A. Freeman*, Local Arrangements Chair, *2000 American Control Conference*, Chicago, IL, June 28-30, 2000.

M. L. Honig*, Member Program Committee, *IEEE Int. Symp. on Information Theory*, 2000.

Invited Talks and Seminars

R. A. Freeman*, P. Kokotovic, R. Sepulchre, M. Krstic, M. Jankovic, and A. Teel, "Constructive Nonlinear Control Design," *1999 Conf. on Decision and Control*, Phoenix, AZ, Dec. 1999.

A. H. Haddad*, "Analysis and Optimization of Wireless Networks with Voice and Data Traffic," *University of Newcastle*, Newcastle, New South Wales, Australia, Aug. 11, 1999.

A. H. Haddad*, "Analysis and Optimization of Wireless Networks with Voice and Data Traffic," *Australian National University*, Canberra, Australia, Sept. 6, 1999.

A. H. Haddad*, "Analysis and Optimization of Wireless Networks with Voice and Data Traffic," *University of Canterbury*, Christchurch, New Zealand, Nov. 5, 1999.

- M. L. Honig*, "Large System Performance of Reduced-Rank Interference Suppression for DS-CDMA," *Allerton Conf. on Communications, Computing and Control*, Oct. 1999.
- M. L. Honig*, "Forward-Link Performance of Satellite CDMA with Linear Interference Suppression and One-Step Power Control," *IEEE Globecom*, Rio De Janeiro, Brazil, Dec. 1999.
- M. L. Honig*, "Reduced-Rank Interference Suppression for DS-CDMA," *Ohio State University*, April 2000.
- M. L. Honig*, "Adaptive Signal Processing for Short-Code CDMA," *Communication Theory Workshop*, Haines, Florida, May 2000.
- M. L. Honig*, "Adaptive Multiuser Parallel Decision-Feedback with Iterative Decoding," *IEEE Int. Symp. on Information Theory*, Sorrento, Italy, June 2000.
- M. L. Honig*, "Large System Performance of Multiuser Decision-Feedback Detectors," *IEEE Int. Symp. on Information Theory*, Sorrento, Italy, June 2000.
- M. L. Honig*, "Adaptive Signal Processing for Short-Code CDMA," Motorola, Arlington Hts, IL, July, 2000.
- M. L. Honig*, "Adaptive Signal Processing for Short-Code CDMA," ArrayCom, San Jose, CA, Aug. 2000.

Symposium Papers

- B. E. Miller, J. E. Colgate, and R. A. Freeman*, "Environment delay in haptic systems," *Proc. IEEE Int. Conf. on Robotics and Automation*, San Francisco, CA, 2000, pp. 2434–2439.
- B. E. Miller, J. E. Colgate, and R. A. Freeman*, "Framework for the design of stable haptic systems," *Proc. World Automation Conf. ISORA*, Maui, Hawaii, 2000 (Best Student Paper Award).
- V. L. Rawls and R. A. Freeman*, "An adaptive approach to cost reduction in nonlinear uncertain systems using Lyapunov design," *Proc. 38th IEEE Conf. on Decision and Control*, Phoenix, AZ, Dec. 1999, pp. 4730–4735.
- V. L. Rawls and R. A. Freeman*, "Comparison of receding horizon control and an adaptive approach to cost reduction using Lyapunov design in nonlinear systems," *Proc. 2000 American Control Conf.*, Chicago, IL, June 28–30, 2000, pp. 265–269.
- V. L. Rawls and R. A. Freeman*, "Adaptive minimum-cost Lyapunov-descent control of nonlinear systems," in *Proc. 2000 American Control Conf.*, Chicago, IL, June 28–30, 2000, pp. 1649–1653.
- P. Komolkiti, X.-H. Liu, C. C. Lee*, A. H. Haddad*, M. Needham, and S. Gilbert, "Feedback control for channel allocation in multimedia wireless systems," *Proc. 2000 American Control Conf.*, Chicago, IL, June 28–30, 2000, pp 2799–2803.
- K.-S. Lee, C. C. Lee*, and A. H. Haddad*, "Quantum level for stochastic discrete-time sliding modes," *Proc. 2000 American Control Conf.*, Chicago, IL, June 28–30, 2000, pp 3817–3821.
- M. L. Honig*, G. Woodward, and P. D. Alexander, "Adaptive multiuser parallel decision-feedback with iterative decoding," *Proc. IEEE Int. Symp. on Information Theory*, Sorrento, Italy, June 2000, p. 995.
- R. Ratasuk and M. L. Honig*, "Large system performance of multiuser decision-feedback detectors," *Proc. IEEE Int. Symp. on Information Theory*, Sorrento, Italy, June 2000, p. 985.
- W. Xiao and M. L. Honig*, "Large system performance of reduced-rank adaptive algorithms," *Proc. 1999 Allerton Conf. on Communications, Control, and Computing*, Oct 1999.

- W. Xiao and M. L. Honig*, "Forward-link performance of satellite CDMA with linear interference suppression and one-step power control," *Proc. 1999 Globecom Conf.*, Rio de Janeiro, Brazil, Dec. 1999, pp. 2461–66.
- W. Xiao and M. L. Honig*, "Convergence analysis of adaptive reduced-rank linear filters for DS-CDMA," *Proc. Conf. On Information Sciences and Systems*, Princeton, NJ, March 2000.

Ph.D. Dissertations

- Vincent L. Rawls, *Adaptive Methods for Performance Improvement in Nonlinear Lyapunov Design* (2000, advisor: R. Freeman*)
- Brian E. Miller, *Stability of Haptic Systems Exhibiting Non-Passive Behavior* (2000, advisors: J. E. Colgate and R. Freeman*)
- Joon Bae Kim, *Resource Allocation for DS-CDMA with Multiple Traffic Types* (2000, advisor: M. L. Honig*)
- Rapeepat Ratasuk, *Adaptive Multiuser Demodulation for Wireless Multiple Access Communications* (2000, advisor: M. L. Honig*)
- Wayne Phoel, *Adaptive Interference Suppression for DS-CDMA* (2000, advisor: M. L. Honig*)
- Theresa A. Fry, *Performance Analysis of TDMA Networks with Mixed Voice and Data Traffic* (2000, advisors: C. C. Lee* and A. H. Haddad*)

