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13. ABSTRACT (Maximum 200 words)

Each institution of the Center for Intelligent Control Systems, Brown University, Harvard University and M.I.T., administered its own pre-doctoral fellowship program which attracted outstanding American graduate students. However, Brown University's Center Fellows were supported under a separate grant, DAAL03-89-G-0010. The criteria for selection was academic excellence and interest in the research of the Center. Continuance of fellowship support was contingent upon superior performance in the graduate program.

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Center for the Study of Intelligent Control Systems

Fellowships

Professor Sanjoy K. Mitter

March 10, 1993

U.S. Army Research Office

DAAL03-86-G-0208

Massachusetts Institute of Technology
Center for Intelligent Control Systems
77 Massachusetts Avenue
Cambridge, MA 02139-4307

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6. AUTHORS OF REPORT: Sanjoy K. Mitter

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   All Manuscripts are listed in the final report of contract ARO DAAL03-86-K-0171.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

Graduate Students Supported by ARO Center Fellowships

Karen Adler
Christopher Barat
Richard Barry
Peter Belhumeur
Bonnie Berger
Kenneth Chou
Jonathan Eckstein
David Fry
Michael Fu
Saul Gelfand
Paul Glasserman
Stuart Golden
Gaile Gordan
Peter Hallinan
Clem Karl
Kenneth Keeler
Philip Klein
Morris Lee
Peter Li
Kevin Manbeck
Barbara Moore
Mark Nitzberg
William Nowlin
Abhay Parekh
Michael Parker
Michael Parzen
Asif Pothiawala
Christopher Raphael
Thomas Richardson
Todd Rovelli
Robert Schapire
Alex Solomonoff
John Spinelli
Yang Wang
Joel Wein
Julia Yang

Degrees Awarded

The following students supported under this contract completed their degrees under this grant:

Brown University

Christopher Barat completed his dissertation entitled ``A Quasi-Gaussian Model for Real Textures" in 1989 under the supervision of Ulf Grenander.

Kevin Manbeck completed his Ph.D. thesis in May 1990. Manbeck's thesis explored the use of the "Iterated conditional means" algorithm for computing approximate Bayes optimal reconstructions for single photon emission computed tomography. The tomography reconstruction problem is a prototype for other image reconstruction problems which entail solution of ill-posed inverse problems, e.g., deblurring, reconstruction of SAR imagery, etc. Experimentation with the algorithm used real data, in contract to the simulation experiments on which most of our and other researchers' earlier algorithm development relied. Both controlled physical phantom experiments and experiments with clinical patient data were done. The thesis also reports interesting theoretical results on rotation invariance, isotropy, of lattice-based Markov Random Field models.

Michael Parzen received CICS fellowship support early in his graduate program and received the Sc.M. degree in Applied Mathematics in 1989; he subsequently completed his Ph.D. at the Harvard School of Public Health.

Christopher Raphael completed research on his Ph.D. thesis in 1991. His thesis research was on algorithms for the "radiation dose therapy" problem. This problem can be regarded as a "dual" of the tomography reconstruction problem. Up to now, most research on dose therapy optimization has concentrated on understanding the behavior of ad hoc adaptations of tomography reconstruction algorithms. Raphael focused on the careful mathematical formulation of the problem in terms of optimization criteria together with necessary constraints--a constrained optimization problem. Then he developed computational algorithms as a consequence of the optimization criterion.

Todd Rovelli completed his dissertation on ``Simultaneous Estimation of Isotope Intensity and Attenuation Coefficients in Single Photon Emission Tomography" in 1991 under the direction of D.E. McClure.

Alex Solomonoff received CICS fellowship support early in his graduate program and completed his dissertation entitled ``Spectral Methods for Discontinuous Problems" in 1992 under the direction of David Gottlieb.

Harvard University

Michael Fu completed his Ph.D. thesis "Optimization of Queueing System Using Perturbation Analysis" under the direction of Professor Y.C. Ho.

Paul Glasserman completed his Ph.D. thesis "Equivalence Methods in the Perturbation Analysis of Queueing Networks" under the direction of Y.C. Ho.

Peter Hallinan completed his Ph.D. thesis "Deformable Templates for the Recognition and Interpretation of Human Faces" under the direction of Professor David Mumford. Hallinan has been working on thye problems of finding the optimal match between an intensity

template for a face, in which various degrees of freedom are allowed, with an unknown image.

Kenneth Keeler completed his Ph.D. thesis "Map Representations and Optimal Encoding for Image Segmentation"in October 1990.

M.I.T

Bonnie Berger completed her Ph.D. thesis "Using Randomness to Design Efficient Deterministic Algorithms" under the direction of Professor Silvio Micali in May 1990. She is currently Assistant Professor of Mathematics, MIT, Cambridge, Massachusetts.

Kenneth Chou completed his Ph.D. thesis "A Stochastic Modeling Approach to Multiscale Signal Processing" under the direction of Professor Alan Willsky in May 1991. Chou's work comprises the continuing study of multiscale processes and their application to signal processing. The part of the work involving state-space models on dyadic trees includes theoretical results on system theory, stability, and steady-state properties as well as experimental results on approximating signals using these state models. The part involving stochastic models based on the wavelet transform includes results on estimating noisy processes using a fast transform approach based on these models. Finally, there are results on interpolating sparse fine-scale data using full coarse-scale data. He is currently at SRI International, Menlo Park, California.

Jonathan Eckstein completed his Ph.D. thesis "Splitting Methods for Monotone Operators with Applications to Parallel Optimization" under the direction of Professor Dimitri P. Bertsekas. He is currently at Thinking Machines, Cambridge, Massachusetts.

Saul Gelfand completed his Ph.D. thesis "Analysis of Simulated Annealing Type Algorithms" under the direction of Professor Sanjoy K. Mitter. He is currently at the Electrical Engineering Department, Purdue University, West Lafayette, Indiana.

Stuart Golden completed his S.M. thesis "Identifying Multiscale Statistical Models Using the Wavelet Transform" under the direction of Professor Alan Willsky in April 1991. He is currently at Sparta Inc., Laguna Hills, California.

W. Clem Karl who has been a Center Fellow for part of his doctoral program completed his Ph.D. thesis "Reconstructing Objects From Projections" in February 1991. The research, under the direction of Professor George Verghese (with Professors Alan Willsky and B.K.P. Horn on the committee), treated the reconstruction of smooth convex surfaces from noisy silhouette projections, using curvature information from the boundaries of the projections. It also addressed the mathematically related problem of reconstructing (static or dynamic) ellipsoids from projections. A key task in both the contexts is the solution of a linear system of equations for an unknown symmetric matrix X, subject to the constraint that it be positive-semi-definite (PSD). Karl has developed innovative algorithms for this task, the most interesting of which is based on a clever scheme for recursive polyhedral approximations of the convex positive cone of PSD matrices. His algorithms also handle more general constraints that require X-X1 and X2-X to be PSD, for specified X1, X2. The second part of Karl's thesis studies the use of discrete support-hyperplane measurements to construct convex objects. He characterizes the consistency of support measurements via a local, linear condition, and shows how to use this condition in reconstruction. He also develops and uses various notions of discrete curvature, as well as global measurements of object smoothness (based on the isoperimetric inequality). He is currently at the Laboratory for Information and Decision Systems, M.I.T., Cambridge, Massachusetts.

Philip Klein completed his S.M. thesis "Efficient Parallel Algorithms for Planar, Chordal, and Interval Graphs" in October 1988.

Sanjeev Kulkarni completed his Ph.D. thesis "Problems of Computational and Information Complexity in Machine Vision and Learning" under the direction of Professor Sanjoy K. Mitter in July 1991. He is currently at the Department of Electrical Engineering, Princeton University, Princeton, New Jersey.

Abhay Parekh completed his Ph.D. thesis "A Generalized Processor Sharing Approach to Flow Control in Integrated Services Networks" under the direction of Professor Robert Gallager in August 1992. He is currently at IBM TJ Watson Research Center, Yorktown Heights, New Jersey.

Jerry Prince completed his Ph.D. thesis "Geometric Model-Based Estimation from Projections" under the direction of Professor Alan Willsky in January 1988. He is currently at Department of Electrical and Computer Engineering, The Johns Hopkins University, Baltimore, Maryland.

Thomas Richardson completed his Ph.D. thesis "Scale Independent Piecewise Smooth Segmentation of Images Via Variational Methods" under the direction of Professor Sanjoy K. Mitter in February 1990. He is currently at AT&T Bell Laboratories, Murray Hill, New Jersey.

Irvin Schick completed his Ph.D. thesis "Robust Recursive Estimation of the State of a Discrete-Time Stochastic Linear Dynamic System in the Presence of Heavy-Tailed Observation Noise" under the direction of Professor Sanjoy K. Mitter in May 1989. He is currently at the Laboratory for Information and Decision Systems, M.I.T., Cambridge, Massachusetts.

John Spinelli completed his Ph.D. thesis "Reliable Date Communication in Faulty Computer Networks" under the supervision of Professor Robert Gallager in 1990.

Robert Schapire completed his Ph.D. thesis "The Design and Analysis of Efficient Learning Algorithms" under the direction of Professor Ronald Rivest in February 1991. His dissertation considers various theoretical aspects of machine learning with special emphasis on the design and analysis of efficient learning algorithms. Schapire has worked as a post-doctoral fellow at Harvard University.

9.0 BRIEF OUTLINE OF RESEARCH FINDINGS

Center for Intelligent Control Systems
Graduate Fellowship Program

Each institution of the Center for Intelligent Control Systems, Brown University, Harvard University, and M.I.T., administered its own pre-doctoral fellowship program which attracted outstanding American graduate students. However, Brown University's Center Fellows were supported under a separate grant, DAAL03-89-G-0010. The criteria for selection was academic excellence and interest in the research of the Center. Continuance of fellowship support was contingent upon superior performance in the graduate program.

Harvard University

David Fry has taken leaves rather than faces as a test bed, and has developed an algorithm of species recognition based on matching which allows reshuffling of parts, but penalizes the amount of translation and rotation of each part before reassembling.

Gaile Gordan worked on recognition of individuals from laser range data of their face. She analyzed the use of the principal curvatures and other differential-geometric invariants for recognition.

Morris Lee focused on performing object recognition and recovering the velocities of moving objects by using moments to recover the affine transformations of images and objects.

Mark Nitzberg studied a nonlinear edge-enhancing filter and investigating an image segmentation model that accounts for occlusions by allowing regions to overlap.

William Nowlin studied the recovery of a deformation of a fluid-supported membrane fingertip with attached magnetic sources through remote sensing of one component of the magnetic field.

M.I.T

Richard Barry under the direction of Professor Pierre Humblet continued his research on optical networks. His research considers optical networks using wavelength division multiplexing where the path a signal takes is determined by the network switches, the wavelength of the signal, and location the signal originated. Therefore, a signal is routed through a combination of circuit switching and wavelength routing (assigning it a wavelength). He presents lower bounds on the minimum number of wavelengths needed based on the connectivity requirements of the users and the number of switching states. The bounds hold for all networks with switches, wavelength routing, and wavelength changing devices. Both nonblocking and blocking networks are considered. Networks with near optimal wavelength re-use are presented. He shows that these networks can be implemented in a distributed fashion using existing devices. In addition, he presents a lower bound on the number of switching states of a network using a combination of circuit switching, λ-routing, and frequency changing.

Peter Li continued his research which focuses on cancelling intersymbol interference in direct detection optical systems. In this research, the interest is in direct detection systems where the received signal passes through a photodetector, that squares the signal, and a low-pass electrical filter. This channel model departs from the linear channel case. He seeks filtering structures to compensate for intersymbol interference.

The sources of intersymbol interference that are of interest come from optical filtering in a multi-wavelength network and from dispersion in long distance transmission. These intersymbol interference can limit the number of signaling levels, data rates and transmission distances in direct detection systems. By designing zero-forcing electrical filters and evaluating their performance, improvements have been observed in these areas. He has succeeded in modeling and solving the problem and are preparing a paper on this subject.