

Computer Systems

Database Systems

G. Ozsoyoglu, M. Ozsoyoglu

This research area focuses on performance issues in relational databases, database query processing and distributed database query processing, file allocation in distributed databases, database design, object-oriented databases, statistical database security problems, and relational interfaces for non-relational databases.

Software Engineering

Software Architecture and Design

Podgurski, White, Zhang

The objective of this research is to develop, specify, and analyze prototypical or reference architectures for important families of software applications, such as those used in Internet commerce, manufacturing, biomedical control, and avionics, and to derive general principles and methodologies such as formal verification for the design of complex software systems.

Software Testing Reliability and Security

Podgurski, White, Liberatore

This work focuses on techniques for improving the reliability and security of software systems and applications. It addresses techniques for software testing, reliability estimation, problem classification and prioritization, and security validation. A recent area of investigation is the reliability and security of distributed applications such as web services. Other research projects involve software OO-testing, including GUI testing and data coverage testing of embedded systems.

Networks

Ergun, Liberatore, Malakooti and Sahinalp

Research activities include data dissemination, background distributed computing, distributed middleware and services, overlay networks, quality of service, routing, random graphs for network modeling, and packet filtering and classification; development of intelligent networks using intelligent mobile agents.

Theory of Computation

Algorithms

Ergun, Liberatore, Sahinalp

Research activities include randomized algorithms, approximation methods, network algorithms, caching and prefetching, data compression, massive data sets, computational learning theory, program checking and correctness, combinatorial pattern matching, data structures and indexing, embeddings of metric spaces, sublinear algorithms.

Logic, programming, and verification

Zhang

Research activities include the semantics of programming languages and logic and models for reasoning about software, hardware, and security-critical systems.

Computer Architecture

Design Methodologies and Design Automation

Papachristou, Saab

This research area is concerned with the development of behavioral and structural level design methodologies and tools for the creation of VLSI-based systems and for multiple-processor architectures. Central to this work is the continued development of a third-generation design automation system for VLSI.

Artificial Intelligence

Applied Artificial Intelligence

Beer, Branicky, Ernst, Merat, Pao

The active on-going research in artificial intelligence is both basic and applied. The basic research develops large classes of problems, while the applied research produces high quality solutions to particular problems, e.g., an expert system for a particular industrial application. Much of the AI research is coordinated by the Center for Automation and Intelligent Systems Research (CAISR), an interdisciplinary research center at CWRU, which fosters links with related research efforts at the University, such as computer vision and robotics.

Intelligent Systems, Neural Nets And Fuzzy Logic

Barmish, Loparo, Pao, Branicky, Merat, Malakooti, Tabib-Azar

The use of methods of 'machine intelligence' to accomplish control of systems. Particular topics of interest include: (1) the use of feed forward artificial neural nets to detect tool wear in parts machining processes, and to model load demand of electric power systems; (2) the use of fuzzy logic methods to attain anti-lock braking for automobiles, to control manufacturing processes and chemical processes, to detect events of gait in neuro-prosthetic systems that provide walking for paraplegics using electrical stimulation; (3) the analysis of combined discrete and continuous state 'hybrid' dynamic systems; (4) novel computation techniques such as quantum computing and associated networks; (5) the development of Monte Carlo methods in the absence probability distributions

Expert Systems

Professors Ernst, Malakooti, Merat, Pao, Zhang

The research on expert systems is primarily concerned with using artificial intelligence techniques to represent and reason about knowledge. Current research includes (1) common-sense reasoning; (2) development of multiple criteria based expert systems for solving design and facility layout problems; and (3) applied research in a number of different challenging applications, such as fault diagnosis in discrete event systems. Most of these applications are based on knowledge which has been extracted from experts in the application domains.

Bioinformatics

Computational Genomics

M. Ozsoyoglu, Pao, Sahinalp, Nadeau

Algorithmic tools for molecular sequence analysis and discovery, computational studies of repeats and large scale genome rearrangements, comparative genomics, phylogenetics of the human genome, cellular pathway modeling and analysis, , database representation, querying and visualization of genomic pathways.

Systems & Control

Control Applications

Branicky, Buchner, Cavusoglu, Liberatore, Loparo, Phillips

Topics include: (1) The development of anti-lock braking systems using fuzzy logic control methods; (2) Development of methods of automotive control and computer assisted tools for engineering analysis and design (e.g., development of computer based tools for system level failure mode effect analysis) ; (3) Developing technology for advanced power train, energy management, sensing and control strategies for electric and hybrid vehicles; (4) the use of methods of control engineering to solve problems involving industrial and manufacturing processes; (5) developing advanced analysis and design tools for robotic assembly, agile manufacturing, (6) control over networks (QoS provisioning and multi-agent software).

Control And Filtering Theory

Barmish, Cavusoglu, Lin, Loparo

Topics include: (1) nonlinear control theory work addressing questions regarding the behavior, stability and control of dynamic systems that are inherently nonlinear in the relationships between their inputs, outputs, and internal states; (2) stochastic control theory work involving the study of the behavior, stability and control of dynamic systems that possess a element of randomness in their operation over time; (3) Stochastic filtering theory work, investigating the extraction of information about internal variables of a system from noise corrupted measurements of system outputs. (4) Robust control and analysis with emphasis on new Monte Carlo techniques and models for addressing system uncertainty.

Fault Detection And Diagnosis

Loparo, Buchner

Research combining advanced theoretical topics with solutions to industrial problems of high relevance and economic importance. Topics include: (1) the detection specific identification of failure events in systems and, when possible, the detection of incipient failures, through the use of nonlinear filtering of measured system inputs and outputs; (2) The use of nonlinear dynamics and chaos theory for failure detection: the use of chaos concepts and other advanced model-based methods for vibration signature analysis, fault detection, diagnosis and prognosis (<http://www.eecs.cwru.edu/laboratory/bearing/>)

Identification And Adaptive Control

Lin, Lopao, Phillips

Research directed towards specific application problems and the development of new theory. Topics include: (1) adaptive control of nonlinear systems, adaptive control of multi-input, multi-output systems having unknown and time varying input-output delays; (2) predictive adaptive control of non-minimum phase systems and the development computationally efficient methods of predictive control; (3) development and application of methods for real-time identification of parameters for linear systems having unknown input-output delays, and for nonlinear systems.

Complex Systems Approach to Complexity

Mesarovic

A range of alternative concepts of complexity are under investigation by a widening circle of research. This approach is based on the concept of a complex system considered as a relation of subsystems with an identifiable existence (functioning) on their own. Problems of scaling/stratification, coordination, emergence and others are investigated mathematically, as well as in a number of disciplines.

Robust Control

Barmish, Chankong

Development of control strategies to robustify against parametric uncertainty and unmodelled dynamics, development of robust Monte Carlo methods for simulation, study of computational complexity in robust control and associated numerical methods, and recasting of robust control problems as tractable mathematical programming problems

Global Systems (<http://www.eecs.cwru.edu/research/>)

Global Systems Analysis and Sustainable Development

Mesarovic, Sreenath

This research addresses one of the most challenging tasks of systems science and systems engineering, i.e., to understand the world as a system and develop methods to assess the evolution of the system. In order to advance understanding of the global system, two principle obstacles are being addressed: complexity by using a multi-level, hierarchical architecture and uncertainty by interactive human/computer reasoning support process. The

focus of the research is on interaction between global issues which represents a distinguishing characteristic of the global future (referred to as the global problematique). A range of issues are considered-from demographic transition and aging to carrying capacity, prospects for global climate change, impact of financial markets on development, etc. Collaborative research with a global network of universities is underway through the UNESCO Global-problematique Education Network Initiative(Genie). The Network is made up of fifteen universities from countries around the world strategically select in order to provide a global coverage. Joint research with member institutions is conducted via the Internet. The research ranges from modeling and methods of complex systems analysis under true uncertainty analysis of specific issues such as global coordination of greenhouse gas emission reduction policies, water resources and health carrying capacity of Africa, etc.

Mathematical Modeling And Systems Analysis Of Global Change Phenomena

Mesarovic, Sreenath

The use of mathematical modeling of global economic and physical phenomena, in conjunction with computer simulation, to develop alternative scenarios of the future. This work involves a determination of what changes are possible within an environmental system, on the basis of the structure of mathematical models that represent its behavior (or hypotheses about its behavior).

Applied Physics

Electromagnetics, High Frequency Communications and Devices

Hazon, Ko, Merat, Tabib-Azar, Young

Research activities include electromagnetic propagation and scattering, high frequency acoustic circuits, generation and detection of extremely sharp pulses, in situ monitoring in aggressive environments, biotelemetry, wireless communications for in situ arrays of biosensors.

Ultrasonic Monitoring of Fatigue Specimens In-Situ

Hazon

The objective of this research is to monitor both the critical diameter and length of a fatigue specimen by beaming sharp ultrasonic signals through a specimen. This approach is preferred in aggressive environments and when mechanical measuring devices are not welcome.

Experiments have shown that the method can be used for the detection and tracking of cracks which may or may not be visible.

Electronics & MEMS

Circuits and Computer-Aided Design

Garverick, Merat, Young

Research activities include mixed-signal CMOS integrated circuit design, microelectromechanical and microfluidic system integration, low-noise sensor/actuator interfacing, data conversion, wireless communications, medical instrumentation, high-temperature electronics using SiC and SOI technologies, MEMS RF tuning components for mobile communication circuits, MEMS sensors for biomedical and inertial sensing applications, microfabrication and integrated circuits process development, high-temperature and low-power telemetry circuit design, low-phase-noise VCO design.

Semiconductor Materials and Devices

Tabib-Azar, Mehregany, Young, Ko

Research activities include design, modeling, fabrication, and testing of microsensors; microactuators; micro-opto-mechanical devices including optical scanners and optical switching fibers; microelectromechanical systems; silicon carbide materials, processing, and device research; electronic devices in mobile communication circuits; microfabrication and

integrated circuit process development; RF MEMS, physical sensors including pressure sensors and strain sensors using silicon and SiC materials; Single crystal MEMS fabrication technology including smart-cut-based silicon and SiC process.

Optimization

Industrial, Production, Operational, Management Systems

Malakooti, Chankong

Optimization, multiple criteria decision making, and artificial intelligence techniques are used to improve quality, productivity, and cost efficiency of real-world problems including development of computer aided and integrated manufacturing/production planning and control; facility layout design, assembly line balancing; pattern recognition and clustering applied to group technology family formation; scheduling, machine set-up, tool life, and machinability. Research activities include applying optimization, decision making, multiple objectives (criteria), AI, artificial neural networks, pattern recognition/clustering to facility layout design, group technology, and assembly systems as well as developing multiple objective optimization and analysis for machine set-up, supervision, tool life, machinability, and sensing devices.

Optimization And Decision Theory And Methods

Chankong, Malakooti, Barmish

Basic theoretical work and specific applications. Topics include: (1) multi-objective optimization, large-scale optimization, and logic-based methods for optimization; (2) algorithms for machine part formation problems; (3) clustering algorithms for data compression; (4) algorithms and tools for VLSI design; (5) algorithms and methods for facility location and layout in manufacturing systems; (6) the use of systems analysis and decision theory methods to solve problems of the electric utility industry, such as quantification of the implications of transmission constraints for generation costs and resource planning.; (7) Optimal design of magnetic resonance imaging (MRI) pulse sequences, for clinical MR images to allow for the removal of motion artifacts (e.g., in images of the liver) and enhancements of images specific tissue types; (8) the application of systems analysis and decision theory methods to problems of information flow and control in health care; (9) robustness issues in optimization; (10) convex programs in systems and control; (11) application of optimization to radiation theory and gamma knife radiosurgery

Mechatronics

Automation, Sensing, Actuation and Machine Intelligence

Beer, Branicky, Cavusoglu, Merat, Newman, Pao, Phillips

Research activities include neural network applications; pattern recognition; artificial intelligence; hybrid systems, process automation; intelligent machine tool control; in-process gauging and control; adaptive learning methods applicable to robotics; system identification and adaptive control; intelligent control; the application of artificial intelligence to robotics systems and manufacturing; compliant control of robotics systems; non-contact inspection of production quality; machine vision for robotics applications; agile manufacturing systems; machine vision and image processing; rapid prototyping of computer-generated 3-D objects in engineering materials; computational intelligence, principles and applications; distributed computational intelligence in network client/server mode; distributed computational intelligence in network client/server mode; computational intelligence and associative memories; robustness considerations and related statistical techniques.

Computational Neuroscience and Autonomous Robotics

Beer(<http://vorlon.cwru.edu/~beer/group.html>)

Using computer simulation and theoretical analyses of models of complete neural/body/environment systems, this research pursues two objectives. First, it seeks to better understand the neural mechanisms of behavior in animals. Second, it seeks to apply biological control principles to the design of autonomous robots with the flexibility and robustness of animals. The tools employed in this work include continuous-time recurrent neural networks, evolutionary algorithms, and dynamical systems theory. This research is highly interdisciplinary, and includes collaborators from the Dept. of Biology and the Dept. of Mechanical and Aerospace Engineering.

Medical Robotics, Simulation, and Computer Assisted Surgical Systems

Cavusoglu

Research in this area focuses on applying robotics technology in the broadest sense to medical applications. Research activities include: design of teleoperated robotic tools for cardiac surgery and minimally invasive surgery; design of teleoperation controllers for high-fidelity telemanipulation of soft environments; haptic interfacing to real and virtual environments; design of surgical simulation systems for planning and training of surgical procedures; modeling and simulation of biological phenomena relevant to surgical applications.

Communications & Signal Processing

Signal processing

Buchner, Loparo, Merat, Pao

Research activities include neural network signal and information processing, image processing, time-frequency signal analysis, processing of genomic information, detection of tornados in radar images using wavelets, two-dimensional periodicity transforms, time domain and frequency domain analysis of engineering and physiological signals.

Space Communications and Networks

Ergun, Kinman, Ko, Malakooti, Merat, G. Ozsoyoglu, M. Ozsoyoglu, Papachrostou, Phillips, Sahinalp, Young

This research is primarily concerned with developing communications and networking solutions for near and deep-space applications. Current research includes: (1) MEMS tunable antennas for power efficient wireless communications; (2) miniature silicon optical reflectors which can be electrostatically deformed and steered; (3) tiled arrays of processors which can be reconfigured for a variety of communications and signal processing applications; (4) semantic-based database inquiry and data warehousing for space assets; (5) protocols and control architectures for remote teleoperation of robots; (6) protocols and systems for the intelligent routing of data in space networks; (7) wireless networks of biosensors for monitoring of astronauts; (8) efficient utilization of radio spectrum for space communications, performance modeling of radio communications using advanced coding schemes, Doppler and range measurements to space vehicles.

Hybrid Vehicle Powertrain Laboratory (Glennan 108)

This laboratory has state-of-the-art test and measurement equipment for transient and steady-state testing, analysis and control of hybrid vehicle powertrain systems. Various configurations including AC and DC motors, internal combustion engines (gasoline and diesel), batteries and fuel cells can be tested.