Annual Report 2010

Industrial and Manufacturing Systems Engineering

KANSAS STATE UNIVERSITY

Contents

Message from the Department Head

Dear Colleagues and Friends,

I am pleased to provide you with the third annual report of the Kansas State University Department of Industrial and Manufacturing Systems. Our intention is to not only offer the hard data that indicates achievement and impact, but also to share the context in which we operate.

The IMSE department has been educating young engineers for more than a half century. In the early years of K-State's engineering college, our emphasis was on shop practice. In 1937, the industrial arts department was established, and by 1954 the department was renamed industrial engineering and industrial arts. Kansas State University has been granting industrial engineering degrees since that time. Over the years, we have maintained a hands-on, project-oriented research and education experience. While still stressing manufacturing process and systems, today we increasingly emphasize the application of industrial engineering to service industries, especially health care systems.

Our department employs 12 faculty members, 10 of whom have research assignments. In the fall, our programs enrolled 167 B.S., 96 M.S., and 16 Ph.D. students. We offer two distance education master's programs for working professionals. The first is the master of science in operations research provided under contract to the U.S. Army. The second is a master of engineering management provided to working professionals across the country. We have also created a concurrent B.S./M.S. degree program that attracts some of our top undergraduate students into our graduate program. These students have proven to become highly productive researchers.

During 2010, the K-State IMSE faculty authored 22 journal articles, five book chapters, and 41 articles in refereed transactions and conference proceedings. IMSE extramural grant expenditures exceeded $3.8M. Our faculty also served in editorial positions on 36 journals.

In this issue we highlight our work in health care operations. We are pleased to announce that we have formed the Health Care Operations Resource Center. This university center will facilitate our research efforts and provide projects that enhance the education of our students while simultaneously helping to improve health care operations across the state of Kansas. Of particular interest to our colleagues may be the research we are conducting jointly with faculty at the University of Kansas Medical Center to model the spread of sepsis throughout the human body.

Please feel free to contact me about anything you read in this annual report. You may also want to check us out on the Web at *www.imse.ksu.edu*.

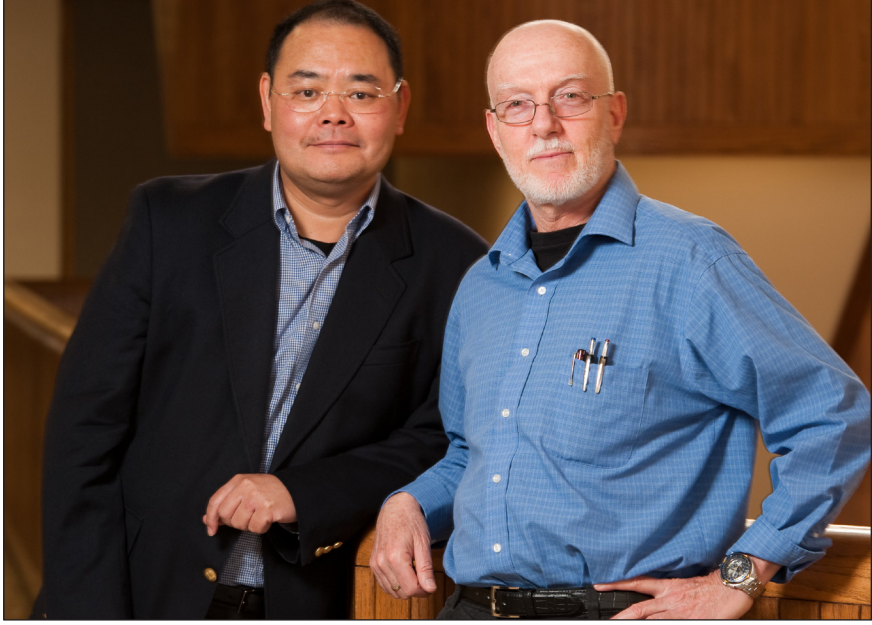
Regards,

Bradley A. Kramer

Bradley A. Kramer, Ph.D.
Professor and Head, IMSE
Ike and Letty Evans Engineering Chair
Director, Advanced Manufacturing Institute

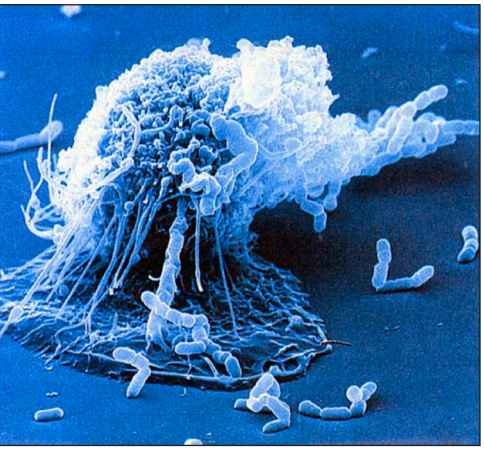
Feature

Engineering health care



The work of industrial engineers in health care settings has traditionally been limited to management of operations and workflow logistics, helping hospitals and clinics to operate more efficiently and effectively, and having an indirect influence on enhanced client treatment. Now, an innovative approach by two Kansas State University engineering faculty is pushing these boundaries and may lead to developments that have a more direct effect on patient care.

Using system dynamics, agent-based simulation and evolutionary games, David Ben-Arieh, industrial and manufacturing systems engineering professor, and Chih-Hang (John) Wu, associate professor, have developed a method to model the progression of different sepsis episodes through the human body at a cellular level. By modeling the human immune and inflammatory responses at an aggregate level using advanced parallel simulation mechanisms, the aim of this research is to develop an assessment tool that medical staff can use to predict outcomes or risk of a patient during an episode of care by comparing a series of simulated prognostic indicators with the actual patient's status.



Sepsis is a potentially serious medical condition in which the bloodstream is overwhelmed by bacteria. In the United States there are approximately 750,000 new sepsis cases each year with mortality rates between 20%–80% within 30 days, making it the second leading cause of death among non-coronary patients. In addition to its heavy toll on patients, sepsis is a burden on the nation's health care system. Annually, it accounts for as much as 25% of intensive care unit (ICU) bed utilization and $1.7 billion in treatment costs.

According to Wu, the team's method begins with modeling the initial bacterial infection or tissue damage, human immune responses and antibody effects, including resistances of antibody agents over time using sophisticated stochastic evolutionary dynamics games.

"Interestingly, our preliminary research results have shown that our agent-based simulators, based on purely human immune responses, can produce consistent yet more robust results compared to existing analytical models based on system dynamics approaches," he said. "Additionally, they are compatible with clinical trial results found in existing publications."

The current research is being conducted in collaboration with the University of Kansas Medical School Hospital, which has teams responsible for clinical trials and blood cell culturing to confirm the mathematical models at both laboratory and clinical levels.

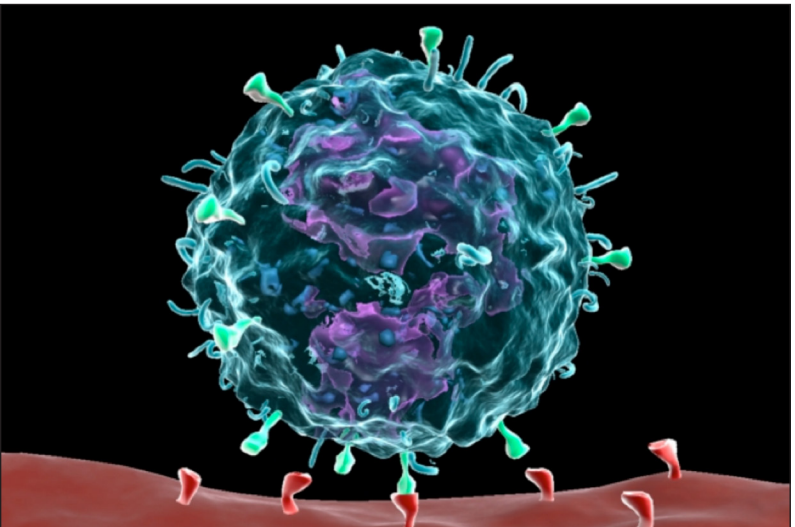
"We understand system dynamics. They know biology," said Ben-Arieh. "Together we have the opportunity to develop a support tool for physicians to use when making care decisions. We believe such a tool would

enable them to make more effective and efficient treatment decisions, producing better outcomes for both patients and the health care system."

According to Ben-Arieh, this would prove especially useful for small hospitals which are generally not well equipped to deal with septic patients, providing the time necessary to transport the patient to a larger facility for care. Or, it could help an ICU make best use of its resources to focus on patients who are at a higher risk of developing septic shock, a condition that can result in multiple organ dysfunction.

While Ben-Arieh and Wu's work on sepsis research is of itself remarkable, the real significance is the exciting opportunities for expanded industrial engineering applications on the health care industry, according to Bradley Kramer, IMSE department head and professor. "Interdisciplinary research is always challenging," he said. "Successful ventures such as the sepsis research could possibly open the door to additional partnerships for research on other diseases, leading potentially to breakthroughs that help hospitals and clinics operate more efficiently and effectively, as well as help save lives."

"Health care is a growing focus within the industrial engineering field," Kramer said. "Through their research, Drs. Ben-Arieh and Wu are charting a new and socially significant course for future researchers to pursue."



Achieving 'center' status

The industrial and manufacturing systems engineering's health care initiative has achieved Kansas State University Center status, providing the opportunity for better recognition and more successful cooperation with health care providers.

"Center designation status gives clients and potential research sponsors an indication of university commitment to this effort, and provides project stability and permanency for our efforts," said David Ben-Arieh, IMSE professor who along with associate professor John Wu is leading the effort. "With this status we hope to also engage faculty from across the university to expand the scope and reach of projects, creating advances in numerous areas of research and the opportunity for new funding sources." With time and sustainable funding levels, Ben-Arieh and Wu hope to seek Regents Center designation.

Since its focus on health care operations began in 2007, the IMSE department has completed 14 projects with clinics and hospitals across the state, engaging more than 40 undergraduate and graduate students in the work. The projects have ranged from facility planning and optimization of medical supply ordering for small rural hospitals to emergency room workflow improvements and information systems design for large urban medical centers. As part of this effort, the department has hosted four workshops on improving operations for hospital and clinic administrators and supervisors. An advisory council of health care industry leaders has been established to guide efforts and provide recommendations for future growth.

According to Wu, applying industrial engineering approaches to untraditional projects, such as sepsis and other similar efforts is a primary reason why the Health Care Operations Resource Center is needed. "Relating our efforts to an engineering department actually creates barriers when researchers, medical professionals, and administrators are first introduced to our services," he said. "We believe the center designation will allow us to overcome this difficulty and open doors to new collaborations."

The Center will continue to provide opportunities for students to gain valuable hands-on experience by conducting specific projects to improve health care operations in specific institutions. The Center will also be engaged in research that leads to advances in Health Care Operations industry-wide.

"Today, more than ever, there is a recognition among most Americans, regardless of their political leanings, that our health care industry needs to operate more efficiently to reduce costs, provide consistently high quality of care, and maximize patient satisfaction," Wu said. "The purpose of K-State's Health Care Operations Resource Center is to help do just that."

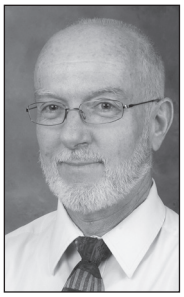
Faculty

Faculty

Bradley A. Kramer
Department Head and Professor

Dr. Kramer is professor and head of the industrial and manufacturing systems engineering department, director of the Advanced Manufacturing Institute (AMI), and holds the Ike and Letty Evans Engineering Chair at Kansas State University. His current effort is focused on building efficient means for accelerating collaborative university and industry innovation. Dr. Kramer joined the faculty in 1985.

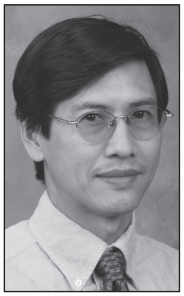
Education:
- B.S. Kansas State University
- M.S. Kansas State University
- Ph.D. Kansas State University



David Ben-Arieh
Professor

Dr. Ben-Arieh concentrates mainly on applications of decision theory and operations research in the area of health care delivery systems and product development. He teaches courses in the area of production and inventory control and health care systems and conducts research in these areas. His interests include DEA modeling, risk-mitigation techniques and information system modeling. His industrial experience includes working for AT&T Bell Laboratories, and consulting for the aerospace industry and health care organizations. Dr. Ben-Arieh joined the faculty in 1990.

Education:
- B.S. Ben-Gurion University, Israel
- M.S. Ben-Gurion University
- Ph.D. Purdue University



Shing I. Chang
Associate Professor

Dr. Chang teaches courses related to quality engineering at both undergraduate and graduate levels. His main research interests include multivariate statistical process control for manufacturing and health care, nonlinear profile monitoring, neural networks and fuzzy set applications in quality engineering, and multivariate experimental designs. In addition, he coordinates assessments of student learning outcomes for ABET accreditation. Dr. Chang joined the department in 1991.

Education:
- B.S. Tsing-Hua University, Taiwan
- M.S. Arizona State University
- Ph.D. Ohio State University

Timothy W. Deines
Instructor

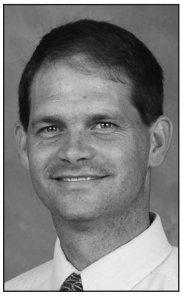
Mr. Deines teaches manufacturing courses. His areas of research include manufacturing processes, composite manufacturing and machining, and energy manufacturing. He is a member of the Institute of Industrial Engineers (IIE) and Society of Manufacturing Engineers (SME). He was awarded the 2007 Making a Difference Award by the Kansas State University Women in Engineering and Science Program. Mr. Deines joined the IMSE department as an instructor in 2000.

Education:
- B.S. Kansas State University

Kimberly Douglas-Mankin, P.E.
Associate Professor

Dr. Douglas-Mankin's research focuses on development and assessment of effective strategies for K-12 outreach, recruitment and retention of engineering and science students, particularly those who are under-served and under-represented in these fields. Dr. Douglas-Mankin is a licensed professional engineer. Her teaching and research focuses on management systems engineering, quality engineering, performance assessment, engineering economics and transportation engineering. She joined the faculty in 2003.

Education:
- B.S. Oklahoma State University
- M.S. Oklahoma State University
- Ph.D. Arizona State University



Todd Easton
Associate Professor

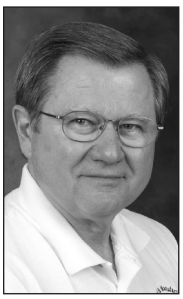
Dr. Easton performs research in discrete optimization with an emphasis in integer programming and graph theory. His current research in integer programming focuses on finding improved techniques to solve integer programs. In particular, he has developed fast techniques to perform exact simultaneous uplifting for sets of binary variables. His graph theory research develops algorithms and heuristics to solve computationally challenging problems. Lately, he has been modeling and optimizing the response to the spread of an epidemic in rural Kansas. Dr. Easton joined the faculty in 2001.

Education:
- B.S. Brigham Young University
- M.S. Stanford University
- Ph.D. Georgia Institute of Technology

John R. English
Dean

Dr. English is dean of the College of Engineering, professor of industrial and manufacturing systems engineering, and holds the LeRoy C. and Aileen H. Paslay Chair in Engineering at Kansas State University. His research interests include quality control, reliability engineering and applied statistics. He has numerous journal articles in these areas. He is a registered professional engineer in the state of Arkansas and a fellow IIE. Dr. English joined the faculty in 2007.

Education:
- B.S. University of Arkansas
- M.S. University of Arkansas
- Ph.D. Oklahoma State University



R. Michael Harnett
Professor

Dr. Harnett's interests center on large-scale systems modeling and optimization. He teaches courses in operations research, nonlinear programming, theory of decisions and games, and reliability theory. He joined the faculty in 1988.

Education:
- B.S. Louisiana Polytechnic Institute
- M.S. University of Alabama
- Ph.D. University of Alabama

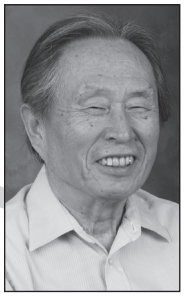
Jessica Heier Stamm
Assistant Professor

Dr. Heier Stamm's research is focused on application of operations research and industrial engineering techniques to humanitarian relief and public health. She is specifically interested in design and analysis of systems with decentralized decision makers and development of methods that lead to decentralized solutions that approximate the performance of centrally optimal decision making. Her work also involves characterizing existing practices and decision-making processes in humanitarian supply chains. Dr. Heier Stamm is a member of the undergraduate committee. She joined the faculty in 2010.

Education:
- B.S. Kansas State University
- Ph.D. Georgia Institute of Technology

Faculty

Faculty



E. Stanley Lee
Professor

Dr. Lee's research interest is primarily in the optimization and systems analysis area such as intelligent and soft computing, uncertainty reasoning, support vector machines and neural-fuzzy computing, fuzzy logic, probabilistic approaches and evidence theory. Another aspect is the applications of these techniques to solve various engineering and social problems such as water resource management, alternative energy developments, pollution and environmental systems, and the efficiency of nonprofit and profit organizations. Dr. Lee teaches courses in optimization theory, queuing, operations research and production, and inventory control. Dr. Lee joined the faculty in 1966.

Education:
- B.S. Chung-Cheng Institute of Technology, Taiwan
- M.S. North Carolina State University
- Ph.D. Princeton University

Shuting Lei
Associate Professor

Dr. Lei's research interests include machining of difficult-to-machine materials such as structural ceramics, titanium alloys, superalloys and composites; laser-assisted machining of ceramics; femtosecond laser micromachining; numerical modeling of manufacturing processes; and development of novel cutting tools. He teaches courses in manufacturing. Dr. Lei joined the faculty in 1999.

Education:
- B.S. Tsinghua University, China
- M.S. Tsinghua University, China
- Ph.D. Purdue University

Zhijian (ZJ) Pei
Professor

Dr. Pei's research interests include semiconductor wafer manufacturing processes, traditional and nontraditional machining processes, subsurface damage measurement in machined surfaces and energy manufacturing. He teaches manufacturing processes and systems, semiconductor manufacturing processes, product and process engineering, nontraditional machining processes, lean manufacturing and Six Sigma. Dr. Pei joined the faculty in 2000.

Education:
- B.S. Zhengzhou Institute of Technology, China
- M.S. Beijing Institute of Technology, China
- Ph.D. University of Illinois at Urbana-Champaign

Malgorzata J. Rys
Associate Professor

Dr. Rys' research interests include the human element in transportation systems, visibility and retro-reflectivity, rumble strips design and performance, roundabouts design and performance, modeling and simulation of natural disasters, transportation logistics, experimental design and benefit-cost analysis. She teaches courses in human factors engineering/ergonomics, design of experiments and engineering economy. Dr. Rys joined the faculty in 1989.

Education:
- B.S./M.S. Technical University of Wroclaw, Poland
- M.S. Kansas State University
- Ph.D. Kansas State University

Chih-Hang (John) Wu
Associate Professor

Dr. Wu's interests include mathematical programming, network optimization, applied operations research, transporation and air traffic systems, digital image processing, pattern recognition, material handling, robot control strategy, flexible manufacturing systems design, group technologies and machine loading. Dr. Wu joined the faculty in 1993.

Education:
- B.S. National Cheng Kung University, Taiwan
- M.S. Pennsylvania State University
- Ph.D. Pennsylvania State University

Adjunct Faculty

Kelly Easton

Dr. Easton's area of focus is in operations research with an emphasis in discrete optimization. She was employed as a research associate at Barclays Global Investors, 1994–1996, where she developed nonlinear optimization models and a GUI for financial research. She is currently employed by The Sports Scheduling Group where she develops sports schedules for various college conference and professional leagues.

Education:

B.A. Johns Hopkins University
M.S. Stanford University
Ph.D. Georgia Institute of Technology

Graham Fisher

Dr. Fisher is currently director of intellectual property at MEMC Electronic Materials Inc. He joined MEMC in 1985 and has held various positions including chief scientist, director of operations technology, technical operations manager, and applications engineering manager. His most recent research interests have centered on silicon materials and manufacturing science; developing robust, high-throughput manufacturing processes for silicon wafers for the semiconductor; and solar industries.

Education:

B.Sc. University of Salford, England
Ph.D. University of London, England

Young-Jou Lai

Dr. Lai is a senior forecast modeler of supply chain management at the Halliburton Company. He also serves as an associate editor of the International Journal of Revenue Management. His recent professional interests are in the area of forecasting, optimization, planning/scheduling, inventory control, and risk management with focus on modeling visualization, system development and automation in a global operational environment.

Education:

B.S. National Cheng Kung University, Taiwan
M.S. Kansas State University
Ph.D. Kansas State University

Jiangang Sun

Dr. Sun is a mechanical engineer in the nuclear engineering division at Argonne National Laboratory. His current research interests are in nondestructive evaluation (NDE) technologies including optical scanning, infrared thermal imaging, ultrasonic scanning and x-ray imaging for characterization of advanced materials and manufacturing processes. He has also conducted research in computational thermo-hydraulic analysis for nuclear reactor systems and in multiphase flow and heat transfer processes.

Education:

B.S. University of Science and Technology of China
M.S. University of Illinois at Urbana-Champaign
Ph.D. University of Illinois at Urbana-Champaign

RESEARCH

Research

Artificial life

An interdisciplinary research area, artificial life intends to combine various disciplines such as artificial intelligence, neural network, fuzzy sets, psychology, and humanistic aspects to study or to model the living systems or human-level artificial systems or machines that exhibit intelligent autonomous behavioral characteristics of human or living systems. At the same time, IGI-Global published a journal on artificial life research.

Applied soft computing

Fuzzy neural network, known as fuzzy adaptive network (FAN), and support vector machines are used to model not-well-defined, vague or humanistic systems such as thermal comfort, human fatigue, presidential elections, financial credit ratings, soft-pad grinding in manufacturing, and cell formation in cellular manufacturing.

Convex fuzzy systems and optimization

Definitions of convex and concave functions for crisp systems are too restrictive to apply to fuzzy or more general systems. Several new concepts in this area have been proposed. These new concepts can be used to promote more concise optimization theories, which can be applied to more general fuzzy systems, parallel to the Karush-Kuhn-Tucker theory for classical systems.

Decentralized decision making

Many problems arising in both public and private sectors involve numerous individual decision makers, each with their own objectives and levels of information, who utilize resources within a common system. In general, decentralized decision making can perform poorly in comparison to systems where a centralized planner makes choices. However, central control can be costly and unrealistic in many practical settings. Traditional optimization approaches that adopt a centralized perspective are therefore not sufficient for these scenarios. By combining tools from optimization and algorithmic game theory to analyze such systems, methods are sought that lead to decentralized solutions that approximate the performance of centrally optimal decision making but are practical to implement. This work will contribute to the fundamental understanding of decentralized systems in general and, in particular, systems arising in public-impact scenarios such as humanitarian response and public health.

Discrete optimization

We are currently performing research in discrete optimization with an emphasis in integer programming and graph theory. This integer programming research focuses on finding improved techniques to solve integer problems. Our graph theory research develops algorithms and heuristics to solve computationally challenging problems.

The bulk of our recent integer programming research uses feasible integer points to generate valid inequalities and facet-defining inequalities. This technique has led to numerous new results in integer programming, including development of the algorithm to simultaneously lift sets of general integer variables, a new way to perform sequential lifting, polynomial time methods to simultaneously lift numerous inequalities into a cover inequality and discovering a new class of facet-defining inequalities called three-set inequalities for the knapsack polytope.

The most recent research in graph theory primarily revolves around modeling the spread of infectious diseases. This research has received funding from the National Science Foundation. Another aspect we are proud to announce is the formation of EPICENTER at Kansas State, which seeks to model and describe the spread of epidemics. This research has developed a core simulation software package, which can be applied to specific instances of certain diseases. The ultimate goal of this research is to use integer programming and graph theory concepts to devise methods and policies to contain the spread of an infectious disease so that the impact of such an unfortunate event is as small as possible.

Fuzzy data envelope analysis

Data envelope analysis (DEA), based on linear programming, has proven to be a highly useful tool for comparing and improving the efficiencies of non-profit and very large organizations such as hospitals and educational institutions. But, basic systems of such nonprofit organizations are vague and not well defined. Thus, a fuzzy approach can help to overcome some of the problems in applying DEA. A book in this area will be published by IGI-Global, entitled *Fuzzy Data Envelopment Analysis: Technologies, Concepts and Applications*.

Fuzzy interactive, multilevel decision making

Multilevel optimization plays an important role in decentralized planning for organizations in which decision makers are arranged at hierarchical levels, and is a very useful tool for large organizations such as government policy, economic systems, and transportation networks. Since the problem is not well defined, fuzzy approach appears to be ideally suited to improve the basic multilevel approaches. A book has been published in this area: *Fuzzy*

and Multi-Level Decision Making: Interactive Computational Approach, Springer-Verlag, London (2001). Another book to solve the multi-level problem based on evolutionary concepts is in the development stage.

Guidelines for installations of centerline rumble strips

In the United States, roadway departure crashes correspond to approximately 40% of all traffic crashes, and their associated estimated annual cost is about $100 billion. According to the most recent crash statistics, in 2009 there were 11,185 fatal roadway departure crashes on rural highways, resulting in 23,169 fatalities. Thus, roadway departure crashes are a significant problem in the United States. Centerline rumble strips (CLRS) are raised or indented patterns installed mainly on two-lane undivided highways, utilized to alert drivers that they are crossing the center of the travel lane, by producing noise and vibration when crossed by vehicles' tires. CLRS primarily address the problem of drowsy or inattentive drivers on two-lane, two-way highways drifting left out of their lane and striking an oncoming vehicle. It is estimated that 50 – 70 million adults in the United States have chronic sleep and wakefulness disorders. In addition, it is estimated that CLRS can reduce approximately 25% of cross-over crashes. However, states' departments of transportation (DOTs) have reported some potential disadvantages in the usage of CLRS, such as levels of exterior noise created by the patterns, and the decrease in visibility of the pavement markings installed over CLRS and their influence on operational use of the travel lane. Understating how CLRS affect these factors is vital for improving current and future applications of CLRS, which will contribute to saving lives.

The primary goal of this research is to provide guidance on future installations of CLRS for policy makers, based on current good practices and on specific investigations of exterior noise, retroreflectivity and operational use of the travel lane. Therefore, objectives of this research were a) to obtain updated information on DOTs' policies and guidelines for installation of CLRS in the United States in order to identify current good practices; b) to verify before-and-after safety effectiveness of CLRS currently installed in Kansas; c) to determine if CLRS cause levels of exterior noise that can disturb nearby residents and to propose a guideline minimum distance from houses for installation of CLRS in Kansas; d) to compare retroreflectivity levels of pavement markings installed over CLRS and over flat pavement under dry and wet conditions, in addition, to compare retroreflectivity of pavement markings installed over rectangular versus football shaped CLRS; e) to determine retroreflectivity decay rates over time for pavement markings installed over CLRS (This result will provide guidance of when repainting is necessary.); f) to verify if there is a relationship between retroreflectivity levels and safety on sections of highway treated with CLRS; g) to estimate the effects of CLRS on vehicles' operational speed and lateral position and to verify if it is safe to install CLRS on sections of highways with narrow shoulders; and h) to establish an objective criterion of when it is economically beneficial to install CLRS, given known values of traffic volume, shoulder width, length of project and presence of other types of rumble strips.

Health care initiatives

Now in its fourth year, the health care focus continues to grow with numerous projects including the modeling of the progression of different sepsis episodes (e.g., systemic inflammatory response (SIR), sepsis, severe sepsis and then septic shock) in the human body at a cellular level using system dynamics, agent based simulation and evolutionary games. The aim is to model the human immune and inflammatory responses at an aggregate level using advanced parallel simulation mechanisms, thus allowing acute care providers or care managers to predict outcomes or risk of a patient during an episode of care by comparing a series of simulated prognostic indicators with actual patient's status. This could help an intensive care unit (ICU) to make best use of its resources to focus on patients who are at a higher risk of developing sepsis shocks. The current effort is conducted with a close collaboration with the University of Kansas Medical School Hospital.

Another project uses data envelopment analysis (DEA) methodology to assess the effectiveness of safety-net clinics in the state of Kansas. The Center of Engagement and Community Development funded the project. This research focuses on assessing the effectiveness, core competencies and weaknesses of individual clinics regardless of size, location or community served. In addition, the project studies the differences between clinics that are state funded vs. unfunded ones, and clinics in rural areas vs. urban clinics.

In addition to research-oriented projects, we have been continuously involved with more service-oriented projects that provide support to the local health care industry. Such projects include facility planning design and analysis, information systems support, improving patient flow, reducing patient waiting times and enhancing patient safety.

A health care advisory council consisting of state officials, hospital administrators, physicians,

insurance companies and non-profit health care organizations was formed in 2007 to oversee our diversified efforts in outreach, research and community engagements. In addition, the council has been providing valuable suggestions, recommendations and help to develop strategic plans for future directions.

Laser-based manufacturing processes

The objective in our research is to develop laser-based manufacturing processes for various applications. Recent research includes laser-assisted machining (LAM) for difficult-to-machine materials such as ceramics and laser micromachining of various materials. Building on several years of experience in LAM of silicon nitride, we are trying to apply LAM to a new bioceramic material, which is difficult to be shaped using conventional machining processes. We are also actively working on femtosecond laser micromachining research with collaborators in academia and industry. With high-intensity, ultra-short pulses from a femtosecond laser, we are trying to develop new laser machining techniques to create features at both micro and nanoscale. We have conducted micromachining for polyurea aerogel and demonstrated high-quality cuts for this highly porous polymer. A deep microhole drilling study has also been carried out. Currently we are working on femtosecond laser machining of solar cells. We are also pushing toward nanoscale machining in dielectrics. Besides the heavy experimental nature in our research, we also attempt to gain fundamental knowledge of the processes through numerical modeling and simulation.

Laser-scattering measurement of subsurface damage in machined surfaces

For semiconductor wafer manufacturing, subsurface damage induced by mechanical machining processes must be removed by subsequent processes. However, current subsurface damage characterization methods are mostly destructive, time consuming and expensive. There are no nondestructive evaluation methods that can provide subsurface damage information across the whole wafer. Lack of such tools has hindered further reduction in manufacturing costs of semiconductor wafers and integrated circuits. Collaborating with Dr. JG Sun at Argonne National Laboratory, we developed two laser-based techniques, an improved laser-scattering method and an innovative cross-polarization confocal-microscopy method to measure subsurface damage in silicon wafers nondestructively.

Machining of semiconductor wafers

Semiconductor devices are found almost everywhere-in computers, cell phones, televisions, automobiles, and airplanes. More than 90 percent of the semiconductor devices in use today are built on silicon wafers. We are using finite-element analysis and theoretical modeling to develop grinding parameters for cost-effective silicon-wafer manufacturing. Progress in this research area will mean decreased cost of silicon wafers and semiconductor devices.

Manufacturing of biofuels

Growing concern over limited petroleum resources, environmental impacts and national security has stimulated broad interest in producing and utilizing biofuels (e.g., biodiesel and ethanol) from domestic biomass resources. Collaborating with faculty in the department of biological and agricultural engineering, we are working on manufacturing-related issues in producing biofuels from algae and cellulosic biomass.

Profile analysis for multivariate statistical process control

Traditional statistical process control (SPC) focuses on monitoring one quality characteristic at a time. Recent research on SPC has expanded its role to monitor multiple quality characteristics simultaneously. A special case in multivariate SPC is the profile analysis in which a quality characteristic is measured over time or space. Most current research tackles this problem by forming a quality characteristic vector containing all measured points in a profile. We have been working on dimension-reduction techniques to further simply the difficulty of SPC implementation. Specifically, wavelet filtering is applied to separate a profile into two distinct channels. The approximate channel contains the information on profile shape changes while the detail channel bears the information of amplitudes of a profile. We then apply a cubic B-Spline function to fit the signals from the approximate channel. Dimension reduction is then achieved by considering only a handful of control points in the B-Spline function. We have been working on applying this framework on composite manufacturing. For example, measures from various temperature sensors mounted inside an autoclave provide several similar temperature profiles over time. The proposed method would be able to provide a way to monitor production changes from batch to batch. We have also been applying profile analysis on bioinformatics applications. For example, the profile analysis approach is proposed to a cancer research that groups lipids' outputs on skin layers of

experimental white mice according to the lipids' chemical properties such as LysoPC, PC, ePC, LysoPE and PE. Instead of treating each test result under a group as one independent entity, the proposed method treats all tests under one group as one profile. Variations from experimental white mice under the same treatment can be clustered together, while inter-treatment profiles can be compared according to their B-Spline functions.

Public-impact supply chains

While many of the earliest applications of operations research and industrial engineering were in the public sector, many opportunities remain to improve supply chains that deliver goods and services to those impacted by disasters and ongoing public health challenges. Problems arising in these areas often require new modeling ideas, because constraints and objectives of such problems differ from seemingly similar private sector counterparts. As a result, solving these problems advances our understanding of theory as well as practice. Recent and ongoing efforts in this area focus on empirical studies of supply chain practices of private companies, government agencies and non-governmental organizations involved in disaster response. Investigation of both successful and unsuccessful public-impact supply chains will advance understanding of gaps between the theory of supply chain management and actual practice, and develop a deeper knowledge of how decisions are made in these contexts. This research will contribute to supply chain systems for humanitarian response and public health that are more efficient, effective and equitable in addressing critical needs.

A review of overhead guide sign lighting policy

It has been almost 10 years since Drs. Russell, Rys and Rys conducted a study, sponsored by the FHWA, to determine minimum luminance requirements for overhead guide signs. The luminance value of 3.2 cd/m^2 was found to be the absolute minimum acceptable sign legend luminance for proper legibility of overhead guide signs. Based on these minimum and retro-reflectance characteristics of sheeting materials commonly used at that time, it was concluded that several cars did not provide sufficient illumination toward overhead mounted signs for proper sign legibility unless higher retro-reflective sheeting was used. Since that time, three major developments have taken place:

1. There are a number of new retro-reflective sign sheeting types on the market.
2. The classification of retro-reflective sign sheeting types has significantly changed.
3. There is now a federal mandate for maintaining minimum retro-reflectivity.

In addition, states have until 2012 to implement and continue using an assessment or management method to maintain traffic sign retro-reflectivity at or above the minimum levels that the FHWA has adopted and included in revision 2 of the 2003 MUTCD. Also, if overhead signs need to be illuminated, it should be done in the most cost-effective manner, taking advantage of newer lighting systems that use less energy and are more cost-effective than most of the older systems and bulbs.

The main objective of this project is to determine the most cost-effective method to maintain the minimum retro-reflectivity levels for overhead guide signs that will satisfy FHWA requirements and be consistent with minimizing life-cycle costs. It will include a study of cost and safety benefits of using different retro-reflective sheeting versus external lighting for overhead guide signs, and the most cost-effective means of external illumination considering life-cycle costs of newer, lower energy systems.

Rotary ultrasonic machining of hard-to-machine materials

Using rotary ultrasonic machining, we develop new drilling methods for hard-to-machine materials such as advanced ceramics, titanium, stainless steel and composites. Many components made from these materials require drilling operations. However, these materials are notorious for their poor machinability, resulting in high cost and low efficiency with current drilling methods. Therefore, there is a critical need to develop more cost-effective drilling processes for these materials. Research in this area has been supported by NSF, Boeing, Sonic Mill and NBR Diamond Tool.

Ultra-precision, non-contact surface strain measurements

The main objective of this multi-department (civil, mechanical and industrial engineering) research effort is development of ultra-precision, non-contact measurement techniques to measure dynamic changes on surface strains in a variety of real-world applications, including bridge inspection, pre-stress concrete elements manufacturing, semiconductor water surface strains measuring and metallic structure dynamic stress. Previous research efforts have shown that by recognizing tiny shifts of the fringes or speckle patterns reflected by the measured surfaces, precise surface strain changes can be calculated mathematically using sophisticated digital-imaging processing algorithms and their corresponding domain transformations.

RESEARCH

Our objective is to dynamically measure pre-stressed concrete element distension processes using low-cost, high-precision but rugged optical devices that can be used by field engineers. Various innovative image-processing algorithms and optic design processes based on nonlinear optimization and matrix factorization are used for calculating image correlations and peak-findings processes. We were able to use fundamental operations research techniques to enhance the speckle resolution tenfold. Therefore, it was possible to use low-cost hardware (camera and optical components) to achieve a high measure of precision.

In recent work, we revamped this development to work with general surfaces, including rough (concrete, papers, textured) and smooth (metal, semi-conductor wafers and polished) surfaces, using a single unified device, while maintaining +/-15 m-strains of accuracies (i.e., 1.5x10-5 of the effective measuring spans). Robust optimization design models were used to efficiently identify sensor repositioning processes and determine speckle images' capture on the fly. Second-generation prototype devices are currently being extended to perform two-dimensional strain measurement and surface-stress structure studies.

PUBLICATIONS

Publications

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GRANTS

Grants

- "A Review of KDOT Overhead Guide Sign Lighting Policy," Kansas Department of Transportation, $89,000, **Malgorzata Rys** with A. Rys and E. Russell, Nov. 2010 – June 2012.

- "Attosecond Optical Technology Based on Recollision and Gating," U.S. Department of Defense, $1,250,000, Co-PI **Shuting Lei**, Z. Chang and C.L. Cocke, May 2010 – April 2011.

- "CAREER: Fundamental research on silicon wafer fine grinding to foster a quantum leap in manufacturing of silicon wafers," National Science Foundation, $514,855 (including two workshop supplements, two RET supplements, four REU supplements, one IREE Supplement, and one book-writing supplement), **ZJ Pei**, Feb. 2004 – Jan. 2012.

- "Collaborative Research: Fundamental Research on Titanium Drilling with Rotary Ultrasonic Machining," National Science Foundation, $311,363 (including one RET supplement and four REU supplements), Co-PI **ZJ Pei** and J.G. Sun, July 2009 – Jun 2012.

- "Collaborative Research: Mathematical Modeling and Experiemental Study of Femotosecond Laser Machining of High Aspect Ratio Microstructures (HARMs)," National Science Foundation, $117,999, Co-PI **Shuting Lei** and Z. Chang, $117,999, Feb. 2009 – Aug. 2011.

- "Data Collection to Support NBAF Risk Assessment," Gryphon Scientific, $33,841, **Malgorzata Rys** with M. Vanier, L. Zurek and J. Harrington, March 2010 – Dec. 2010.

- "Data Collection to Support NBAF Risk Assessment," Signature Science, LLC, $36,837.48, **Malgorzata Rys** with M. Vanier and J. Harrington, March 2010 – Dec. 2010.

- "Develop and Implement Early-State Technology Development Assistance Center," Kansas Department of Commerce, $45,000, PI **Bradley Kramer**, Aug. 2007 – July 2010.

- "Developing a Scheduling Software Package for Westside High School," Westside High School, $18,000, **Todd Easton**, March 2010 – June 2011.

- "Early-Stage Technology Development Assistance Center: Bridging the Gap Between New Technologies and Commercialization," U.S. Department of Commerce, $170,000, PI **Bradley Kramer**, Aug. 2007 – July 2010.

- "Early-Stage Technology Development Assistance Center: Phase Two Accelerating Innovation through Collaborative Partnerships and Networks," U.S. EDA and partners, $780,000, PI **Bradley Kramer**, Aug. 2007 – July 2010.

- "EDA Early-Stage Technology Development Assistance Center: Phase II," Kansas Technology Enterprise Corporation, $50,000, PI **Bradley Kramer**, July 2007 – June 2010.

- "Improved Deployment of the Tele-Tracking Bedboard Monitoring System," Children's Mercy Hospital (Kansas City), $23,680, Co-PI **David Ben-Arieh** and **Chih-Hang (John) Wu**, May 2010 – Feb. 2011.

- "Graduate Student Support," University Transportation Center, Kansas State University, $10,000, **Malgorzata Rys**, Jan. 2010 – May 2011.

- "Implementation of Non-Contact Strain Measurement Devise for Bridges and Piers," Kansas Department of Transportation, $7,022, **Chih-Hang (John) Wu** with B. T. Beck and R. Peterman, May 2009 – Dec. 2010.

- "Innovative Laser–Based Techniques for Characterization of Subsurface Cracks in Semiconductor Wafers," National Science Foundation, $171,863 (including one RET supplement and two REU supplements), Co-PI **ZJ Pei** and with J.G. Sun, Sept. 2005 – Aug. 2010.

- "K-State STEP: Increasing the Number and Diversity of Students Graduating in STEM Fields at Kansas State University," National Science Foundation, DUE-0525556, $1,662,943, **Kimberly Douglas-Mankin**, 2005 – Present.

- "Kansas Bioprocessing Science and Engineering Center," National Science Foundation PFI Grant IIP 0917984 and partners, $702,339, PI **Bradley Kramer**, March 2010 – Feb. 2013.

- "Kansas Opportunity Innovation Network," U.S. EDA and partners, $1,440,000, PI **Bradley Kramer**, Aug. 2010 – Sept. 2013.

- "Kansas Technology Enterprise Corporation Center of Excellence Grant Agreement," Kansas Technology Enterprise Corporation, $468,566, PI **Bradley Kramer**, July 2010 – June 2011.

- "Keeping Vehicles on the Roadway in Rural Areas: Analysis of Run-Off-the-Road Crashes," University Transportation Center, Kansas State University, $119,972, **Malgorzata Rys** with S. Dissanayake, E. Russell, and R. Stokes, Nov. 2009 – May 2011.

- "Operational Process for EPA Radiation and Indoor Environments: Laboratory Environmental Professional Student Intern Program," U.S. Environmental Protection Agency, $222,500, **Kimberly Douglas-Mankin** with Brian R. Hanson and Bruce C. Snead, 2006 – Present.

- "Part-Time M.S. Program in Industrial Engineering – Spring 2010," U.S. Department of Defense, $47,231, **Todd Easton**, Jan. – May 2010.

- "Part-Time M.S. Program in Industrial Engineering – Summer 2010," U.S. Army, $25,182, **Todd Easton**, June – Aug. 2010.

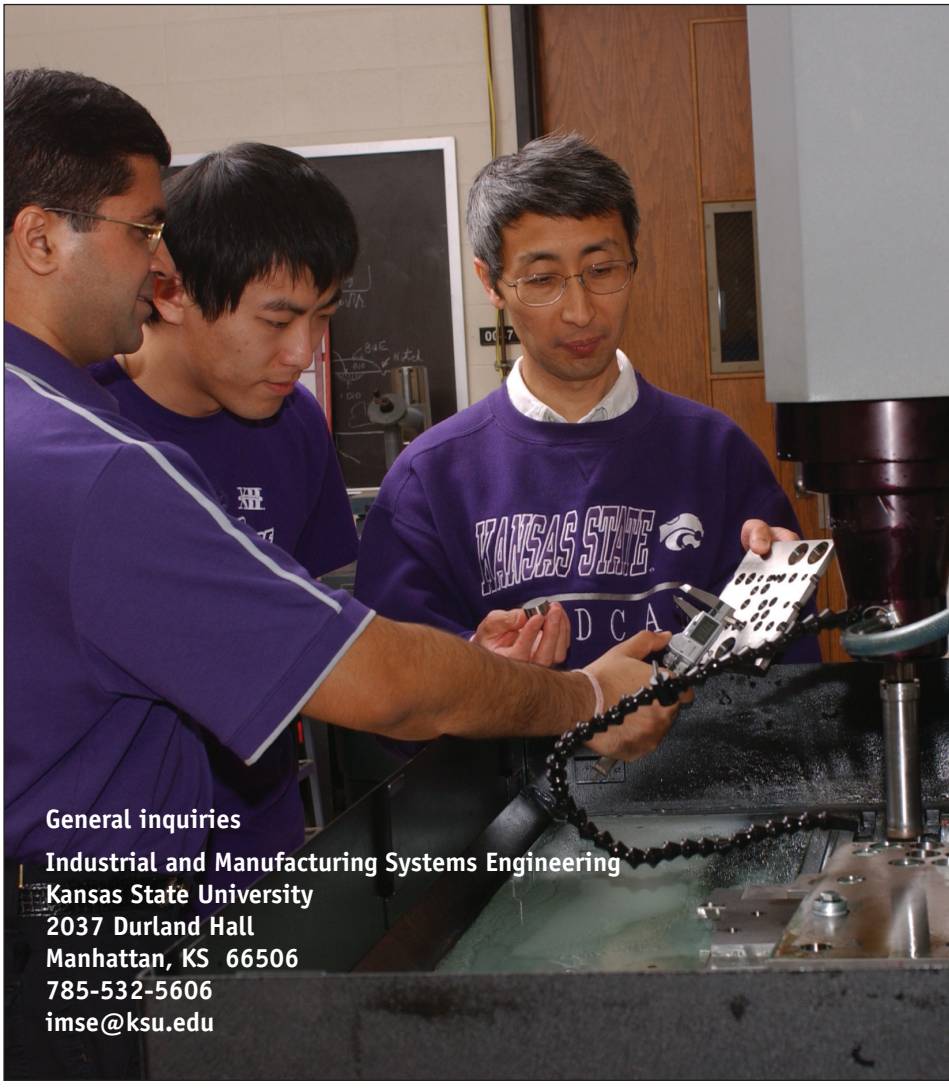
- "Part-Time M.S. Program in Industrial Engineering – Fall 2010," U.S. Army, $59,989, **Todd Easton**, Aug. – Dec. 2010.

- "Patient Flow Analysis and Improvement," Kansas City VA Medical Center, $120,000, Co-PI **David Ben-Arieh** and **Chih-Hang (John) Wu**, Jan. 2010 to Dec. 2011.

- "Phase IV & V: Farm-Scale, Phosphorus-Recovery Master Agreement Construction, Start-Up and Monitoring (P08-0102)," Kansas Environmental Management Associates, LLC, $120,984, PI **Bradley Kramer**, Jan. 2007 – Jan. 2011.

- "SGER: Exploratory Research on Solid Carriers for Manufacturing Algae Biofuels in the Ocean," National Science Foundation, $120,560 (including one RET supplement, and two REU supplements), Co-PI, **ZJ Pei** and W.Q. Yuan, Sept. 2008 – Feb. 2010.

- "Student participation in the 2009 NSF Civil, Mechanical and Manufacturing Innovation Grantees and Research Conference; June 22–25, 2009; Honolulu, Hawaii," National Science Foundation, $225,782, **ZJ Pei**, Nov. 2008 – April 2011.



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GRANTS

Grants

- "Study of KDOT Policy on Lane and Shoulder Minimum Width for Application of CLRS," Kansas Department of Transportation, $59,000, **Malgorzata Rys** with E. Russell, July 2009 – June 2011.
- "Ultrasonic Vibration-Assisted Pelleting of Cellulosic Biomass for Biofuel Manufacturing," National Science Foundation, $371,033 (including two REU supplements), Co-PI **ZJ Pei** and D.H. Wang, Sept. 2010 – Aug. 2013.
- "Workshop/Collaborative Research: 2011 NSF CAREER Proposal Writing Workshop; University of Connecticut; Storrs, Connecticut; April 4-5, 2011," National Science Foundation, $24,998, **ZJ Pei**, Feb. 2011 – Jan. 2012.
- "Workshop/Collaborative Research: 2010 NSF Proposal Writing Workshop; September 1-2, 2010; University of Nebraska-Lincoln," National Science Foundation, $24,827, **ZJ Pei**, May 2010 – April 2011.
- "Workshop/Collaborative Research: 2010 NSF CAREER Proposal Writing Workshop; Georgia Institute of Technology; Atlanta, Georgia; March 25-26, 2010," National Science Foundation, $20,411, **ZJ Pei**, Oct. 2009 – Sept. 2010.
- "Workshop/Collaborative Research: 2009 NSF CAREER Proposal Writing Workshop; George Mason University; Arlington, Virginia; March 12–13, 2009," National Science Foundation, $22,958, **ZJ Pei**, Aug. 2008 – July 2011.
- "Workshop/Collaborative Research: 2008 NSF CAREER Proposal Writing Workshop; March 27 and 28, 2008; Northwestern University; Evanston, Illinois," National Science Foundation, $23,758, **ZJ Pei**, Feb. 2008 – Jan. 2010.
- "Workshop: NSF Proposal Writing Workshop, August 22 and 23, 2007, University of Alaska," National Science Foundation, $48,535, Co-PI **ZJ Pei** and J. Twomey, June 2007 – May 2011.

Professional Leadership

David Ben-Arieh
- Editorial board member, International Journal of Information and Operations Management Education
- American Association of Telemedicine, Human Factors special interest group
- Society of Health Systems, body of knowledge group
- Member, IFIP work group 5.1, Information Technology in the Product Realization Process
- Member, IFIP work group 5.3, CAD/CAM and Information Systems

Shing Chang
- Editorial board member, International Journal of Information and Decision Sciences (IJIDS)
- Editorial board member, International Journal of Experimental Design and Process Optimisation (IJEDPO)

Kimberly Douglas-Mankin
- Editor, The Journal of Women and Minorities in Science and Engineering
- Advisory committee member, National Science Foundation STEP PI meeting, 2009-2011
- External advisory board, Louisiana Tech NSF ADVANCE
- External advisory board, Iowa State STEM Student Enrollment and Engagement Through Connections (SEEC)
- WEPAN Awards Committee

Todd Easton
- Guest editor, International Journal of Artificial Life Research

John English
- Juror, National Council for Engineering Examinations and Surveyors
- Member, board of directors, Reliability and Maintainability Symposium
- Member, board of directors, NISTAC
- Member, IIE Honors and Awards Committee
- Member, board of directors, Kansas Foundation for Engineers

Bradley Kramer
- Vice-chair, board of directors, IDEA Center

E. Stanley Lee
- Editor, associate editor, or editorial board member of the following journals:
  - International Journal of Artificial Life Research
  - International Journal of Operations Research
  - International Journal of Modeling and Simulation
  - Fuzzy Optimization and Decision Making
  - Mathematical Sciences Research Hot-line
  - Computer and Mathematics with Applica¬tions
  - Indian Journal of Management and Systems
  - Journal of Engineering Chemistry and Metallur¬gy
  - The Journal of Fuzzy Systems Association, Taiwan
  - Journal of Nonlinear Differential Equations: Theory, Methods, and Applications
  - Journal of the Chinese Institute of Industrial Engineers
  - International Journal of Fuzzy Systems
  - The Chinese Journal of Process Engineering
  - Journal of Uncertain Systems (JUS)
  - Optimization and Engineering
  - Journal of Intelligent Information Management
  - Annals of Fuzzy Sets, Fuzzy Logic and Fuzzy Systems
  - Applied Computational Intelligence and Soft Computing
  - Advances in Computational Research
  - International Journal of Mechatronics and Manufacturing Systems
  - International Journal of Manufacturing, Materials and Mechanical Engineering
- Honorary professor, Chinese Academy of Sciences, People's Republic of China

Professional Leadership

Shuting Lei

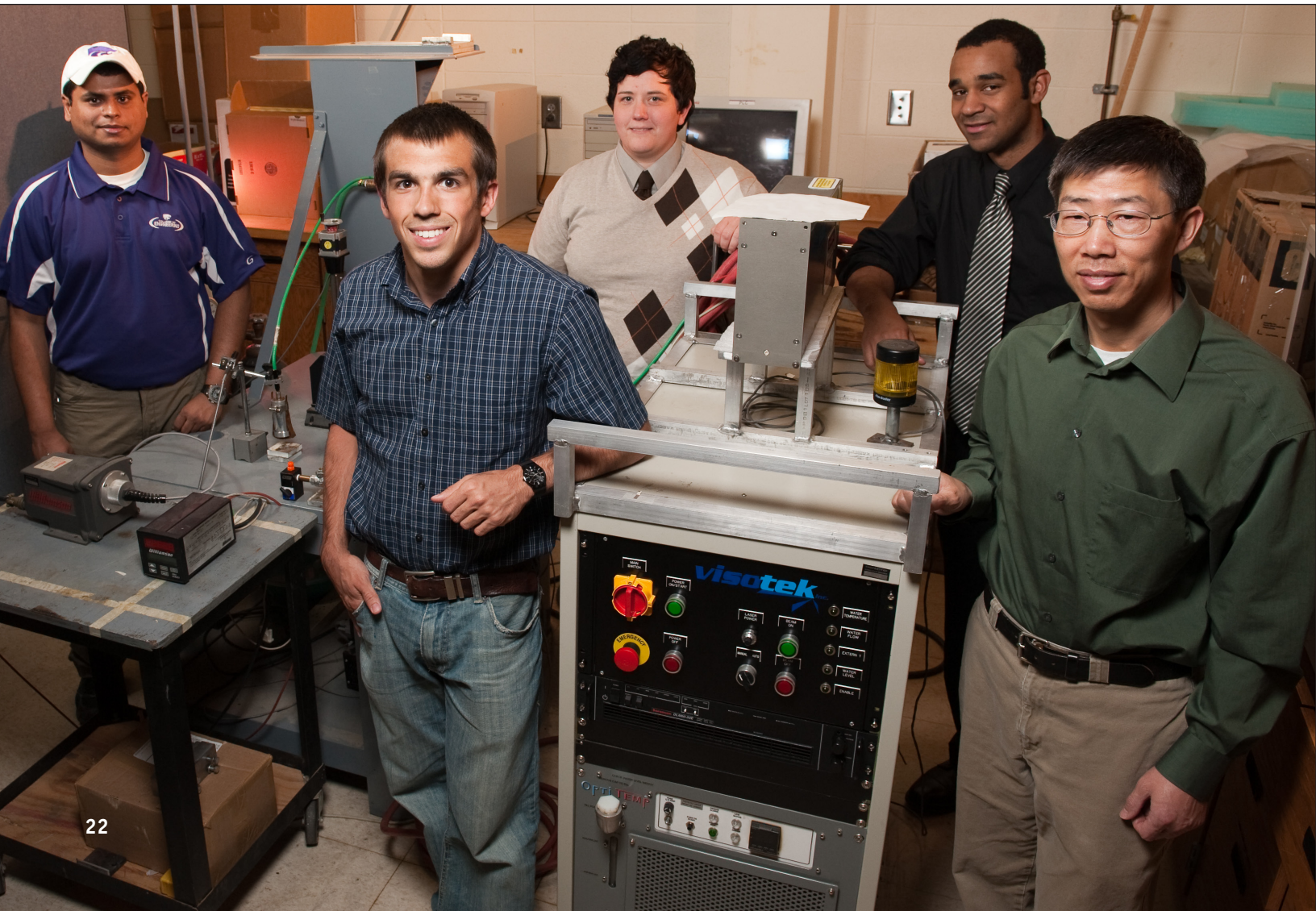
- Editorial board member, International Journal of Mechatronics and Manufacturing Systems
- International editorial review board, International Journal of Manufacturing, Materials and Mechanical Engineering

Zhijian Pei

- Associate editor, Journal of Manufacturing Processes
- Associate technical editor, Machining Science and Technology
- Editorial board member, International Journal of Engineering Business Management
- Editorial board member, International Journal of Machine Tools and Manufacture
- Editorial board member, International Journal of Machining and Machinability of Materials
- Editorial board member, Journal of Machining and Forming Technologies
- Editorial board member, Open Mechanical Engineering Journal
- Editorial advisory board member, Recent Patents on Mechanical Engineering
- Organizer, 2010 NSF CAREER Proposal Writing Workshop
- Chair, ASME MED Manufacturing Processes Technical Committee

Malgorzata Rys

- Editorial board member, International Journal of Industrial Engineering – Theory, Applications, and Practice



Undergraduate Studies

Undergraduate

Undergraduate

Undergraduate enrollment in the industrial and manufacturing systems engineering department continues to grow. In 2010, we had a total enrollment of nearly 170 undergraduate students, with women making up approximately 30 percent of those students. Most IMSE students complete two engineering intern positions prior to graduation. During spring and fall 2010 commencement ceremonies, 24 BSIE degrees were granted. Graduates of our program are in strong demand in Kansas, the Midwest region and across the nation. Companies that recruited our graduates last year include Accenture, Altec Industries, Inc., Burlington Northern-Santa Fe Railway, Exxon Mobile, Halliburton, Honeywell, Hormel Food and J.B. Hunt. Average annual starting salary for our graduates is nearly $63,000.

The IMSE department's concurrent B.S./M.S. degree program allows top students to start work on a master of science degree while they are still undergraduate students. Starting salaries for graduates of this program has been approximately 20% more than that of B.S. graduates. Students accepted in this program earn a broader and deeper appreciation for industrial engineering through advanced-level coursework. They also significantly enhance their technical skill set through active engagement in research.

IMSE students and faculty are working together to improve health care systems. Our goal is to increase the quality of health care while simultaneously reducing costs. To do so, students work with IMSE faculty on projects sponsored by hospitals, clinics and other health organizations. Last year, 11 IMSE undergraduate students worked on projects emphasizing process improvement, facility layout and safety with multiple hospitals in Kansas City and Wichita. To accomplish these projects, students used IMSE tools such as process modeling, simulation, quality engineering, and design and implementation of modern information systems.

Awards

In 2010, one of our students received the Material Handling Education Foundation Scholarship. Since its inception in 1976, 30 K-State IMSE students out of the approximately 675 total recipients have been awarded this scholarship. That means some 4.4 percent of all awards given nationally were received by students from our department.

IIE student chapter

The department has an active student chapter of the Institute of Industrial Engineers; advisor is Dr. Malgorzata J. Rys. IIE officers organized a number of activities promoting academic and social interaction among the members. The chapter hosted student/faculty picnics, mentor day, a financial workshop, and a tailgate party with the Oklahoma State University IIE student chapter and the Kansas City IIE senior chapter; sponsored displays at K-State Open House; and participated in the Technical Paper Conference. For the third consecutive year, the chapter received the Gold Award in the IIE national chapter recognition competition.

Graduate Studies

graduate

Graduate program

The industrial and manufacturing systems engineering department is committed to excellence in scholarly research and graduate teaching. Our graduate classes typically enroll 20 or fewer students each. Graduate students are individually known by the IMSE faculty and will work directly with our faculty members to conduct their research projects.

We have an active graduate student council that advocates on behalf of our graduate students and arranges for social gatherings such as picnics and celebrating the Chinese New year and Diwali.

We offer four graduate degrees: the master of science in industrial engineering (MSIE), the master of science in operations research (MSOR), the master of engineering management (MEM) and a doctor of philosophy in industrial engineering. The master's degrees in operations research and in engineering management are available via distance learning to better serve our students.

The MSIE program teaches students mathematical, scientific and analysis skills to solve complex business problems in manufacturing, health care, transportation, financial organizations, communications, government, military and many other organizations. The MSOR program focuses on application of mathematical models to analyze complex problems and develop optimum solutions. The MEM program is geared toward management of engineering or highly technical organizations as well as money, people and equipment.

Admission requirements

Applicants for our graduate degrees must possess a bachelor's degree in engineering with at least a 3.0 grade point average or equivalent from accredited institutions. Students not possessing a degree in engineering must have a background that includes the equivalent of core undergraduate engineering and mathematics courses. International students must have an Internet-based TOEFL of 79 or higher. GRE scores are required for all of our graduate degree applicants, except distance learning (online) applicants whose working addresses are located within the USA.

Areas of concentration

The IMSE department offers a rich variety of projects in the areas of operations research, human factors, manufacturing processes, production, health systems, uncertainty representation and intelligent reasoning, as well as quality engineering. In addition to basic research, our curriculum emphasizes collaborative and interdisciplinary research, collaboration with industrial partners, and development and modeling of various industrial processes. Please refer to the research section to get a feel for our current research.

Where to apply

Graduate Studies
Department of Industrial and
Manufacturing Systems Engineering
2037 Durland Hall
Kansas State University
Manhattan, KS 66506 USA

Phone: 785.532.5606
Fax: 785.532.3738
Email: imse@ksu.edu

Application materials

- Online application: *www.k-state.edu/grad/application*
- Confirmation sheet
- Application fee
- Official transcripts
- TOEFL* and GRE scores
- Affidavit of financial support*
- Statement of objectives
- Three letters of recommendation

* *required for international students only*

Contact Information

Contact

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Rys, Malgorzata	Associate Professor	Durland 2015	785-532-3733	malrys@ksu.edu
Wu, Chih-Hang (John)	Associate Professor	Durland 2018	785-532-3734	chw@ksu.edu

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