THE OHIO STATE UNIVERSITY

Graduate Studies in Industrial and Systems Engineering

Human Systems Integration

Introduction

Human Systems Integration (HIS), or Human Factors Engineering, can be briefly defined as the discipline concerned with positively influencing relationships between people (designers, engineers, users, customers, etc.), organizations (that design, manufacture, use, or regulate technology), and methods and processes (for designing, producing, or operating systems or equipment). It is an interdisciplinary field with roots in engineering, psychology, and physiology. HSI has become an important element in the design of many products (as diverse as automobiles, computers, handheld mobile communication devices, and sporting goods) and the design and operation of complex systems (including aviation, surface transportation, and health care delivery systems). This has created a strong job market for individuals with appropriate knowledge and skills.

At OSU, Human Systems Integration is composed of two broad areas: Cognitive Engineering and Physical Ergonomics & Biomechanics. Students benefit from incorporating both areas of HSI in their graduate programs, though most will structure a concentration in one of the two areas.

Research in HSI takes place in laboratories on campus and in application settings away from campus. Our faculty, research staff, and students engage in interdisciplinary research with faculty and students from a variety of departments and programs, including Psychology, Computer Science, Aviation, Physical Medicine, Orthopedic Surgery, Pathology, Sociology, Physical Therapy, Occupational Therapy, Mechanical Engineering, and Design.

Focus Areas

Cognitive Engineering

Cognitive engineering knowledge, methods, and tools guide the design of systems to support human performance in complex settings. Cognitive engineering is concerned with cognitive functions such as problem solving, decision making, attention, perception, and memory. Cognitive engineering is a highly interdisciplinary field, drawing upon research in artificial intelligence, cognitive psychology, linguistics and more traditional human factors research. Consequently, our research and educational program at Ohio State involves many cooperative efforts among the Departments of Computer Science, Psychology, Aviation and Medicine.

Research activities focus on the application of the cognitive sciences and human factors engineering to the study and design of complex person-machine systems. In many cases, the machine is a computer system with reasoning capabilities that it uses to assist (consulting or critiquing systems) or teach (intelligent tutoring systems) the human.

Current research includes work in aviation, medicine, nuclear power plant design and the development of advanced information retrieval systems. Examples of ongoing research projects include:

- The design of systems to support distributed work in air traffic management systems;
- Design of a knowledge-based system for aiding searchers of large bibliographic databases;
- Cognitive modeling of human problem-solving in nuclear power plant emergencies;
- Exploration of interface design issues associated with the introduction of artificial intelligence systems into aircraft and the space station.

As noted above, our research centers around the design of real, complex systems. Within such applied contexts, our research seeks to identify general design principles and to develop models of human performance.

Affiliated Faculty: Smith, Woods, Rayo, Morison

Biomechanics and Physical Ergonomics

Biomechanics is the application of physics and engineering principles and methods to the quantitative assessment of forces and moments that act on the human body during work or other activities. Physical ergonomics is concerned with reducing injury risk and enhancing the safety and productivity of the humans in systems of interest through the design of work environments and products that take into consideration human anthropometry, strength, dexterity, and other physical capabilities and limitations. Physical ergonomics incorporates

a range of approaches and methods, including biomechanical measurements and modeling, industrial engineering techniques, and task analysis, to provide a complete picture of the stresses an activity may pose on the human actors in a system of interest.

Physical ergonomics researchers develop methods of measuring, analyzing, and controlling the physical forces that act upon the human body as a function of various occupational requirements.
Areas of primary focus for occupational biomechanics and physical ergonomics researchers include back disorder studies, shoulder and upper extremity studies, and intervention research. Examples of recent research projects include:

- Investigation of physical demands associated with low back injuries in distribution centers and development of interventions to reduce physical demands experienced by distribution center workers.
- Ongoing development and refinement of biomechanical models to assess the mechanical loading of the spine during lifting, lowering, pushing, & pulling;
- Development of ergonomic interventions that address needs of imaging technologists and other health care professionals.
- Designing hospital patient rooms to address ergonomic needs of hospital staff as well as patients and their families.
- Assessment of musculoskeletal injury risk during physically challenging automotive assembly tasks and evaluation of potential work redesign initiatives.
- Development and evaluation of ergonomic solutions for emergency medical services workers.
- Identifying opportunities for ergonomic solutions to reduce physical demands experienced by family caregivers.
- Ergonomics assessment of high school students' and teachers' use of computers.
- Evaluation and modeling of right angle torque tool use by workers in automobile assembly operations.

In addition to these research projects, several interdisciplinary projects with the College of Medicine involving the medical and surgical aspects of occupational biomechanics are currently underway.

Funding for these and past projects has been provided through grants from the National Institute for Occupational Safety & Health, National Institutes of Health, National Science Foundation, Department of the Interior, the Industrial Commission of Ohio, the Association of American Railroads, the National Institute for Disability and Rehabilitation Research, The Ohio Bureau of Workers Compensation, and from private industry.

Affiliated Faculty: Marras, Lavender, Sommerich

Research Facilities

Cognitive Systems Engineering Laboratory

The Cognitive Systems Engineering Laboratory houses computers and software for system development and experimentation. It includes video and audio recording and editing tools for usability studies. As part of joint research activities, students have access to facilities in the Human Performance Center, Laboratory for Artificial Intelligence Research, the Laboratory for Knowledge-Based Medical Systems, and the Aviation Psychology Laboratory.

Biomechanics and Physical Ergonomics Laboratories

Excellent facilities for biomechanics research and study exist at the Ohio State University. They include the Spine Research Institute's Biodynamics Laboratory, the Orthopaedics Ergonomics Laboratory, the Engineering Laboratory for Human Factors/ Ergonomics/ Safety, and the Center for Occupational Health in Automotive Manufacturing (COHAM). These laboratories are state-of-the-art facilities. Equipment that is available for laboratory-based and field research includes Grass and Delsys electromyographic systems, camera- and ultrasound sensor-based motion analysis systems, commercial and custom data acquisition systems, anthropometers, sonic digitizers, intra-abdominal pressure measurement devices, upper and lower extremity dynamometers, commercial and custom electrogoniometer systems, Lumbar Motion Monitors, and whole body and localized vibration measurement equipment. Data are acquired and processed using commercial and custom data acquisition and analysis software. Laboratory spaces are configurable to meet requirements of specific projects. COHAM is a high bay facility with an overhead lift system that houses research studies related to vehicle assembly.

Degree Programs

The ISE Department offers two degree programs for students who are interested in HSI; both are accredited by the Human Factors and Ergonomics Society:

The Master of Science (MS) program prepares students for applying HSI skills and knowledge in industry, consulting, health care, transportation, design, research, and other application areas, or further graduate study. A specialization in Occupational Safety and Ergonomics is made possible, in part, through a Training Project Grant from the National Institute for Occupational Safety and Health.

The Doctor of Philosophy (PhD) program is academically rigorous and emphasizes scholarly research and achievement. Students are prepared for careers in academia and research-oriented positions in government and private industry.

ISE Courses *(these lists are not exhaustive)*

- Human Factors Engineering Fundamentals:

ISE 5600 Principles of Occupational Biomechanics
ISE 5700 Introduction to Cognitive Systems Engineering

- Human Factors Engineering Methods:

ISE 5620 Risk Assessment Tools for Occupational Musculoskeletal Disorders
ISE 5770 Cognitive Systems Engineering: Design and Evaluation

- Cognitive Engineering Depth Courses:

ISE 5705 Distributed and Cooperative Work
ISE 5710 Safety and Complex Systems
ISE 5730 Information Analysis and Synthesis
ISE 5740 Human Centered Automation
ISE 5760 Visualization and HCI
ISE 5770 Cognitive Systems Engineering: Design and Evaluation
ISE 7700 Cognitive Systems Engineering: Advanced Topics
ISE 7710 Cognitive Systems Engineering: Research Practicum
ISE 7720 Cognitive Systems Engineering: Models and Methods

- Biomechanics & Physical Ergonomics Depth Courses:

ISE 5640 Occupational Safety: Analysis and Design of Work Environments
ISE 5610 Ergonomics in the Product Design Process
ISE 5620 Risk Assessment Tools for Occupational Musculoskeletal Disorders

All of the following, and which may be repeated:
ISE 7610 Advanced Topics in Biomechanics and Musculoskeletal Disorders: Spine biomechanics
ISE 7620 Advanced Topics in Biomechanics and Musculoskeletal Disorders: Upper Extremity biomechanics
ISE 7630 Advanced Topics in Biomechanics and Musculoskeletal Disorders: Contemporary Issues
ISE 7615 Biomechanics Research Practicum: Spine biomechanics
ISE 7625 Biomechanics Research Practicum: Upper Extremity biomechanics

Students in both the MS and PhD programs and in both focus areas gain a solid foundation in statistical analysis methods, experience in collecting and analyzing data, and in modeling methods appropriate to their area(s) of focus.

Complementary Areas of Study Outside of ISE Graduate students studying HSI may also find courses of interest in Mechanical Engineering (5700, 6700, 8702), Design (Design Research), Anatomy (6220), Biostatistics (6210, 6211, 6212, 6270, 7220, 7225, etc.), Epidemiology (6410, 6430, 6432, 7410, 7411), Environmental Health Sciences (5325, 7330), Psychology (5612, 5620, 6810, 6811), and elsewhere.

Student Backgrounds

Students entering the HSI graduate programs come from various academic areas, including engineering, computer science, mathematics, statistics, psychology, design, physiology, and kinesiology.

HSI Faculty Profiles

William S. Marras, **Ph.D, CPE**

Professor
Director of the Spine Research Institute, Biodynamics Laboratory, and Center for Occupational Health in Automotive Manufacturing (COHAM), Executive Director of the Institute for Ergonomics

PhD Wayne State University
National Academy of Engineers (2009)

Interests: Low back biomechanics, hand/wrist biomechanics, biomechanical modeling, industrial and rehabilitation biomechanics.

Phillip J. Smith, Ph.D.

Emeritus Professor, former Chair of ISE
Executive Director of the Institute for Ergonomics

PhD University of Michigan

Interests: Cognitive Systems Engineering, computersupported cooperative work, human-computer interaction, artificial intelligence, air traffic management, airline operations control, intelligent tutoring systems, information retrieval systems.

David D. Woods, **Ph.D**.

Professor
Director of the Cognitive Systems Engineering Laboratory

PhD Purdue University

Interests: Human-intelligent computer cooperation, human error, cognitive modeling, visualization, resilience engineering, complex adaptive systems.

Steve A. Lavender, Ph.D., CPE

Associate Professor
Director of the Orthopaedic Ergonomics Laboratory

PhD The Ohio State University

Interests: Occupational biomechanics, development and evaluation of workplace ergonomic interventions, developing risk models predictive of work-related musculoskeletal disorders, ergonomics in product design.

Carolyn M. Sommerich, Ph.D., CPE

Associate Professor
Director of OSU's NIOSH-sponsored Training Project Grant and the Engineering Laboratory for Human Factors/Ergonomics/Safety

PhD The Ohio State University

Interests: Workplace and school ergonomics, occupational biomechanics, work-related musculoskeletal disorders, electromyography, biomechanical modeling, universal design.

Michael Rayo, Ph.D.

Assistant Professor

PhD The Ohio State University

Interests: Medical Informatics, Cognitive Systems Engineering, design of threshold alarms, decision-support technologies, and human-machine teams in healthcare, military, transportation, and power generation settings

Alexander M. Morison, Ph.D.

Research Assistant Professor

PhD The Ohio State University

Interests: researching how new human-sensor perceptual systems provide opportunities to extend human perceptual and attentional fluency to new scenes at a distance over multiple temporal ranges.

Affiliated Faculty

Richard Jagacinski, Ph.D.
OSU Department of Psychology
Interests: Perpetual motor coordination, control theory, decision theory.

For More Information…

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