Computer-Integrated Surgical Systems and Technology Engineering Research Center

The Johns Hopkins University (lead institution)

A National Science Foundation Engineering Research Center since 1998

Partner Institutions:

- *The Brigham and Women's Hospital*
- *Carnegie Mellon University*
- *Johns Hopkins Medical Institutions*
- *The Johns Hopkins University*
- *Massachusetts Institute of Technology*
- *Shadyside Hospital*

Developing novel computing methods, interfacial technologies, and computer-integrated surgical systems to revolutionize surgical procedures in the 21st century

The impact of Computer-Integrated Surgical Systems and Technology (CISST) on medical care procedures within the next 20 years will be as significant as the impact of Computer-Integrated Manufacturing (CIM) Systems and Technology has been on manufacturing over the past 20 years. A novel partnership between human surgeons and machines, made possible by advances in computing and engineering technology, will overcome many of the limitations of traditional surgery. By extending human surgeons' ability to plan and carry out surgical interventions more accurately and less invasively, Computer Integrated Surgery (CIS) systems will address a vital national need to greatly reduce costs, improve clinical outcomes, and improve the efficiency of health care delivery. Further, the combination of consistent execution, patient and task models, and logging of intraoperative and outcome data made possible by CIS systems will produce the same sort of *process learning* advantages for surgery that have been realized in semiconductor CIM systems.

Research

The research approach of the CISST Engineering Research Center (CISST ERC) will speed CISST research and eventual deployment by reducing the very substantial implementation barriers required to assemble the critical mass of support infrastructure needed for experimental work in this field. Further, by promoting interoperability of components between testbeds, it will promote more rapid dissemination of results between clinical areas.

The ERC's research activities are organized into three thrusts:

Thrust 1: Modeling and Analysis — The goal of this thrust is to study fundamental advances in algorithms and methods for modeling patient and surgical procedures, using such models in the planning and execution of surgical procedures, and realizing these advances in robust, supported software libraries suitable for research and application prototyping.

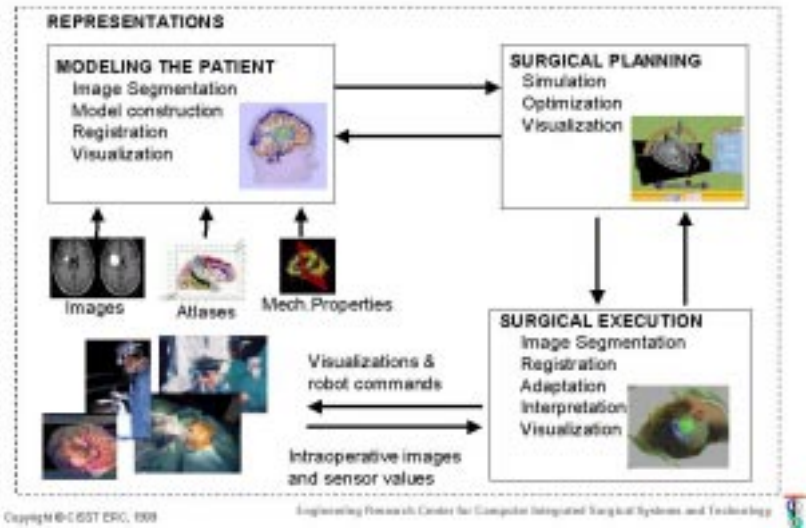
Thrust 2: Interfacial Technologies — The goal of this thrust is development of novel sensing, robotics, and human-machine interface subsystems transcending human sensing and manipulation limitations in performing surgical tasks.

Thrust 3: Systems — The goal of this thrust is integration of subsystems into an evolving family of surgical systems and testbeds addressing realistic and important surgical needs. It involves three closely interrelated activities: 1) integration of core research into modular subsystems and libraries; 2) integration of these subsystems into testbeds; and 3) pre-clinical and clinical validation of these testbeds in specific surgical applications.

Education

The goal of our Education and Outreach Program is to create new, interdisciplinary undergraduate and graduate engineering programs that foster teamwork and focus on realistic challenges in computer-integrated

CIS Systems: Coupling Information to Action



surgical systems and technology. We are developing new courses for both engineering and medical students, as well as for practitioners in industry and surgeons; and we are establishing effective links among the ERC's partner institutions to support collaborative education and research programs through the creation of the "CIS Channel." We are developing new programs of outreach to K-16 institutions, creating an internship/mentoring program with industrial sponsors of the ERC, and developing an assessment and tracking process for the education program.

Industrial Collaboration and Technology Transfer

The CISST ERC's strategic plan calls for collaboration with industry to "create an infrastructure of systems and devices that will permit rapid prototyping and validation of application concepts." To accomplish this goal the ERC has gained the participation of large and small companies in a collaboration that provides opportunities in the areas of research (discovery), product development, education, and commercialization. The industry sectors and companies that are potential collaborators are varied and diversified and include technical areas such as medical imaging, robotics, medical simulation, surgical instrumentation, computing, telecommunications, instrumentation, interventional guidance and innovative therapies, human machine interaction, and ergonomics. We recognize that the industrial sectors include large, medium, and small companies that have different needs, resources, marketing strategies, and strategic goals of their own. Therefore, the collaboration and outreach strategy is to provide for various levels of membership, maximum flexibility, and continuous review and refinement as the Center grows.

Facilities

The CISST ERC is situated on the Homewood Campus of the Johns Hopkins University in Baltimore, MD. The administrative offices of the ERC house the Center Director and Administrative staff. There is 4,450 sq. ft. of ERC laboratory space in the New Engineering Building Basement assigned to the ERC's Director, Dr. Taylor, that houses 3 robotics laboratories as well as space for 25 students, engineers, ERC faculty, and visiting engineers and students from our industrial exchange programs. Our collaboration with the School of Medicine provides 1,275 sq. ft. of lab and office space under the direction of the ERC's Deputy Director, Dr. Anderson.

Other CISST ERC faculty bring additional important facility resources. The Center for Medical Robotics and Computer Assisted Surgery (MRCAS) at Carnegie Mellon University was formed to foster the application of robotic technologies; Dr. Kanade is co-director of the MRCAS. Dr. DiGioia is an orthopaedic surgeon and serves as the director of Shadyside Hospital's Center for Orthopaedic Research (COR). There are 1,200 sq. ft. of MRCAS lab and 1,300 sq. ft. of Computer Vision lab space available for ERC research.

The Massachusetts Institute of Technology's Artificial Intelligence Laboratory conducts research that is two-fold. Researchers there work to understand human intelligence at all levels—including reasoning, perception, language, development, learning, and social levels—and to build useful artifacts based on intelligence. A new 1,500 sq. ft. area is dedicated for work on medical image analysis; it includes dedicated workstations, tracking equipment, and other devices for use in developing segmentation, registration, and tracking algorithms. The Surgical Planning Lab at the Brigham and Women's Hospital is a multidisciplinary, high-tech research institution combining the fields of Computer Science and MRI Radiology towards a goal of real-time 3D imaging of patients during surgery.

The Johns Hopkins Microsurgery Advanced Design Laboratory (MADLAB) is dedicated to the design and development of innovative microsurgical tools and techniques. The MADLAB is located within the Wilmer Eye Institute on the East Baltimore medical campus under the direction of Dr. de Juan. A staff of five engineers, scientists, and artists work closely with clinical personnel to identify potential areas of innovation, generate unique solutions to clinical obstacles, and rapidly develop ideas into near-market-ready products. MADLAB resources include a full machine shop, engineering/CAD workstations, video editing/animation equipment, a surgical wet lab, and animal OR facilities.

Center Organization and Leadership

The ERC has been established as a special program within the Whiting School of Engineering and is administered in a manner similar to that of a separate department. As the ERC Director, Dr. Russell Taylor reports directly to the Dean of the School of Engineering on all matters related to ERC research and administration.

The Center's organizational structure has been specifically designed to have advisory input from both industry (through the Industrial Policy Advisory Committee) and the ERC Strategy Board comprised of physicians, scientists, and engineers from all three of the ERC collaborative institutions as well as from outside institutions. Dr. Taylor's primary faculty appointment in the School of Engineering and Deputy Director Dr. James Anderson's in the School of Medicine provide additional assurance of multidisciplinary involvement in decisions regarding ERC administrative and research activities. All three main research thrust areas have leaders representing at least two of the three collaborative institutions, and each has major clinician involvement in research program development.

Dr. Taylor is Director of the ERC and is primarily responsible for the scientific conduct of the research program and the overall operation of the ERC. He chairs the leadership committee and co-chairs the Strategy Board. He is responsible for setting the ERC directions and allocates resources with input from the Leadership Committee, Strategy Board, and Industrial Advisory Policy Committee.

Dr. Anderson is the ERC's Deputy Director and acts as the ERC focal point for Medical School Programs. He assists Dr. Taylor in the overall direction and management of the ERC. He has primary responsibility for executive oversight of the Outreach, Medical Affairs, and Diversity programs.

Mr. Peter Bouxsein, Director of Outreach Programs, has primary responsibility for the Industrial Affiliates program.

Mr. Jeffrey Jarosz is Director of the Education Program. He is responsible for the implementation and coordination of educational initiatives and develops mentoring and educational outreach programs.

The ERC is managed by an Executive Director, Dr. Leigh Abts, who has overall administrative and financial responsibility for the function of the center. He reports directly to the Center Director and is supported by an Administrative Assistant.

Center Headquarters

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