The NSF Engineering Research Center for Computer-Integrated Surgical Systems and Technology: A Director’s Retrospective

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Let me start out with a short personal history. After receiving my Ph.D. from Stanford University in 1976, I spent the first 19 years of my career as a Research Staff Member and research manager at IBM’s T.J. Watson Research Center. While there, I became interested in whether a three-way partnership between people, technology, and information could have the same transformative effect on surgery that it was having on industrial production. I started a research group within IBM that developed several prototype systems, including a system for hip surgery that was commercialized as “Robodoc” and other systems for minimally-invasive surgery and surgical navigation. I was collaborating with several leading medical institutions, including Johns Hopkins, Brigham and Women’s Hospital (BWH), and NYU Hospital. I moved to Johns Hopkins in September 1995 in order to be able to work more closely with surgeon end users.

Shortly before I moved to JHU, I mentioned my plans to the then-Director of the NSF Engineering and Education Centers Division, who brought my attention to an open call for ERC proposals. The deadline (within a few months) was too soon for us, but we were able to respond to the next call a year or so later. After many trials and tribulations, our proposal was accepted on the first attempt. Perhaps the keys to our success in the competition were the strength of our vision and the strength of our team. In addition to the Johns Hopkins Engineering and Medical Schools, out initial partner institutions included MIT, BWH, and Carnegie-Mellon University. Over time, the number of collaborating institutions grew to include Morgan State University, The University of Pennsylvania, Harvard University, and Columbia University.

Our goal from the beginning was to create a family of surgical systems that combine innovative algorithms, robotic devices, imaging systems, sensors, and human-machine interfaces to work cooperatively with surgeons in the planning and execution of surgical procedures. Looking back, I believe that we were successful in following this vision, both in terms of technical accomplishment and, more importantly, in training a new generation of engineers for an emerging field. At the time we started, the field of computer-integrated surgical (CIS) systems was quite new – especially in the area of medical robotics, where there was not yet a well-established industry with which to collaborate. We were able to pioneer technology and techniques that are now ubiquitous, and our graduates have provided significant leadership both in industry and academia. Much of this impact has continued after our formal “graduation” as an NSF-funded ERC. For example, an ERC-funded collaboration with Intuitive Surgical has led to open-source medical robotics hardware and software platforms currently deployed at over 30 leading academic institutions around the world.

Of course, the path from initial proposal to final graduation and beyond was not always smooth. Locally, although JHU already had a tradition of engineering-medicine collaboration, the creation of a multi-department, multi-divisional center was new for us. Developing effective administrative arrangements between JHU and our partner institutions also took some time. The cooperative agreement with NSF took a very long time to negotiate. Since the Center could not be announced publicly until the agreement was signed, we were not able to advertise for staff until the time we were supposed be a fully functioning ERC. This made our startup year rather stressful. I recall being somewhat discouraged after the first few site visits, but was reassured to learn that this was not unusual for new ERC Directors. Eventually, we were able to develop a smoothly functioning organization that could respond to NSF’s requirements (site visits, extensive annual reports, etc.) while supporting our research, education, and industry missions. I also truly came to value working with Lynn Preston, who became our immediate Program Director, in addition to her role managing the entire ERC program.

One significant challenge for us was finding the most effective way to organize our research program. Originally, we had organized our research thrusts, broadly, around the major technical components of a CIS system – “Modeling and Analysis”, “Interface Technology,” etc. Over time, we found it much more effective to organize our thrusts along the lines corresponding roughly to families of testbeds tied to aspects of our system vision. One was “Surgical CAD/CAM”, reflecting the integration of image-based planning with the use of appropriate technology to carry out the planned procedures. Another was “Surgical Assistants”, emphasizing highly interactive surgical procedures. Both thrusts drew upon common technology and components, and there was a great deal of cross-talk between thrusts. A third thrust focused on systems infrastructure common to Surgical CAD/CAM and Surgical Assistants. This structure worked very well, in part because of the really outstanding people who acted as Thrust Leaders. Weekly meetings with the thrust leaders helped ensure that the parts fit well together. I suppose that one lesson for other ERCs would be to be fairly flexible in how you organize yourselves and to be willing to try things until you find what works best.

Looking back, I think that the most gratifying thing to me about the entire experience has been the chance to work with a team of extremely talented individuals in pursuing a shared vision. As I mentioned earlier, we have had a substantial impact on our field, both through the technology and systems that we developed and through the diaspora of people who have gone through our program. Institutionally, I believe that we have also made a significant impact on my university, both through the faculty we hired and nurtured and through our role in the evolving culture of our engineering school. From the time it was formed, the ERC was unusual in the degree to which it involved multiple departments in our engineering school, multiple divisions within the university, and multiple academic institutions in a long-term partnership. Our success helped reassure both participating departments and faculty that there is much more to be gained from collaborating with such interdisciplinary centers than there is to be lost in terms of departmental control. Today, something over half the sponsored research in our engineering school is conducted in centers, many of which span departments and divisions.

Although the CISST ERC still has some formal existence as a “graduated” center, most of its program now resides in successor organizations at JHU. The Laboratory for Computational Sensing and Robotics (LCSR) took over the administrative functions of the CISST ERC, together with the robotics-related research components. Like the CISST ERC, LCSR is a trans-departmental research organization with something over 200 people. Although LCSR’s research spans multiple areas, it is widely regarded as one of the premier medical robotics laboratories in the world. More recently, the Malone Center for Engineering in Healthcare (MCEH) at Johns Hopkins was created with a generous gift from John Malone. The Director of MCEH was the Deputy Director of the CISST ERC, and many faculty members (including me) are affiliated with both MCEH and LCSR. These organizations and others within JHU are very well positioned to take our vision of computer-integrated medicine to the next level.