The University of Nebraska-Lincoln is one of five universities chosen to receive a Raven II robotic surgical system, in addition to the two schools heading the project, as part of an effort to spur collaborative innovation in surgical technology. The Raven was developed by researchers of the University of Washington and the University of California, Santa Cruz.

Kearney Lackas, mechanical engineering student at UNL, said the standard open-source platform the Raven provides gives each of these universities a starting point to improve upon with their own research.

Lackas plans to work on tool development for the system.

“If one university develops code or a tool, they can just hand it off to the next university and they can build it from there,” Lackas said. “Instead of one university trying to figure out the next best surgical robot, they’re trying to have seven universities work on the same one, so they can just build off of each other.”

Collaboration instead of competition is the key here; everyone is working towards a similar goal of improving surgical robotics and ultimately moving closer to better outcomes in patient care through telemedical technology.

“NASA really loves this robot because it is completely wireless,” Lackas said. “That’s one of the big pushes for this robot, that surgeons could log in from anywhere in the world and control the robot.”

The remote capabilities of the Raven have been tested in extreme environments, including the rangelands in California and in a submersible chamber off the coast of Florida (in the Florida experiment, the robot was being controlled by researchers in Seattle).

The seven identical Raven II robots were built with financial support from the National Science Foundation.

Left: Mechanical engineering student Kearney Lackas demonstrates the use of PHANTOM Omni controllers with the Raven surgical robot. Right: The robot is expected to perform tasks compatible with the Fundamentals of Laparoscopic Surgery skill set, such as peg transfer.
Dr. Lance Pérez, currently a professor of electrical engineering at the University of Nebraska-Lincoln, recently became an official investigator in the CAST collaboration, though he has been working with the researchers for a few years.

“My core research expertise is in the area of wireless communication, broadly speaking, but I’ve always done system design and signal processing,” Pérez said. “So when Shane [Farritor] started working on the surgical robots and needed somebody to do image processing, he contacted me; I’ve been fulfilling that role on the various surgical robot projects.”

His team is currently working on building a miniaturized stereoscopic imaging platform for the surgical robots developed by the mechanical engineering group.

“When we miniaturize that and get it fully developed, then the robots will be able to get very high quality stereoscopic video streams from in vivo robots,” Pérez said.

A well-known problem in image processing is stereo matching. The Pérez team took two webcams and put them together to create a stereo camera – one with a left and right view.

“You’re going to get a stereo pair, a pair of images,” said Jay Carlson, a research associate. “Andrew [Kowalczuk] and Eric [Psota] work on developing the sort of algorithms that allow computers to, in real time, match areas in the left and right images, calculate the distances between them, and then, using that information and some calibration, figure out where these points are in space, automatically.” In other words, it would recognize the depth of the scene, rather than just a 2-D image.

The human body does this easily. We look with both our left and right eyes to process an image and get depth perception.

“It’s difficult to design algorithms that can match the speed and accuracy of the human brain, but the researchers of Pérez’s Mobile Communications and Coding lab currently have the world’s best algorithm for stereo matching, as evaluated by the Middlebury Stereo Evaluation, in terms of its combination of real-time speed and accuracy.

“A year ago, we would be doing one stereo match every 10 seconds,” Carlson said. “Now we’re doing 20 of them every second. So it’s more like video-grade, 20 frames per second (fps), 30fps and that’s the goal: to do real-time stereo matching.”

“The classic example that I think of is a beating heart. If you do a surgery on a beating heart, the surgeon can freeze an image of that heart, say ‘I want to do an incision right here.’ Then while the heart’s beating, the robot can match that rhythm and do that very careful precision incision because it’s able to track it in real time,” Carlson said.

“In the long-term vision, we’d like to build a real-time, three-dimensional display system that doesn’t require the surgeons or anyone else to wear special eye gear to create the depth,” Pérez said. “So the surgeon could literally walk around [the image], see things from different angles, without having to be co-located with the robot” - A holographic image of sorts, though the term doesn’t adequately explain the precision of the desired image.

“In principle we can do it,” Pérez said. “We’ve been working on all the image processing necessary to support that vision, and the next step would be to build it.”
Mentor and student explore new endeavors

Bernadette McCrory, a CAST student researcher since 2006, graduated this May with a Ph.D. in Biomedical Engineering. During her time at CAST, McCrory primarily worked with Drs. Hallbeck, LaGrange, Stergiou and Oleynikov. McCrory’s primary projects involved the development of new robotic surgical tools for minimal access surgery and advanced tools for natural orifice surgery.

McCrory will begin teaching at UNL part-time for the Mechanical and Materials Engineering Department this fall, as well as starting full-time at Madonna Rehabilitation Hospital as a Research Scientist in the Movement and Neurosciences Center within the Institute for Rehabilitation Science and Engineering.

“I can’t express my gratitude enough for all of the CAST faculty and staff who have assisted me over the years,” McCrory said. “It has been an absolute pleasure and my hope is to continue my relationship with CAST and UNMC as I move into the next phase of my career.”

Dr. Susan Hallbeck will be taking a year-long leave of absence from UNL to participate in healthcare engineering research at the Mayo Clinic in Rochester, MN, in conjunction with the Center for the Science of Health Care Delivery.

“This center’s mission is to transform the way that patients receive and experience health care,” Hallbeck said. “Research projects within the center will allow me to integrate my industrial engineering skill set to participate in all three focus areas of the center.”

These areas include value analysis, systems engineering and research.

Past research associates reflect on their time at CAST

Jeff Midday, M.S.
Project Engineer
Friction Stir Link
“Working with CAST really opened my eyes to the medical approval process. Careful attention to patient and physician needs is critical to making any good medical device.”

Nate Otten, B.S.M.E.
Ph.D. student in Robotics
Carnegie Mellon University
“During my time working with CAST, I’ve learned the value of hard work and perseverance. Nothing worth having comes easily, but when a group of dedicated and determined individuals commits to accomplishing something, great things are possible.”

Tyler Wortman, M.S.
Ph.D. student in Mechanical Engineering
Massachusetts Institute of Technology (MIT)
“I remember spending many late nights at CAST the night before a demonstration or surgery to make sure the surgical robot worked correctly. This hard work paid off when I was able to watch the robot successfully accomplish tasks that had never been done before in robotic surgery.”

Amy Lehman, Ph.D.
University of Nebraska-Lincoln
“I have really benefited from the CAST collaboration. Working with Dr. Farritor and Dr. Oleynikov, I have learned to better determine the needs from a medical perspective and how to implement these needs through engineering.”

Bernadette McCrory (left) pictured with Dr. Susan Hallbeck (right).
CAST hosts NU Board of Regents

The Center for Advanced Surgical Technology hosted the University of Nebraska Board of Regents on May 18, as part of a visit that occurs every two years.

CAST was selected as a stop because it has collaborations across three NU campuses.

“This cross-campus integration is of great interest to the Regents,” said Marsha Morien, Executive Director of CAST. “The goal of the visit was to show that we have even more new technology under development with expanding membership of the faculty in the Center.

Dr. Dmitry Oleynikov delivered the agenda, “From Analog Records to Digital Surgery.”

National Science Foundation Fellowship recipients Tyler Wortman, Amy Lehman, Tom Frederick, Eric Markvicka and Nate Otten were recognized with their mentor, Dr. Shane Farritor.

The Regents participated in a hands-on demonstration of latest mini-surgical robot prototype, received an overview of surgical skills training and comparison of ergonomics in minimally invasive surgery and learned about a new NASA prototype for robotic pleural catheter insertion.

Letter from the Director

CAST’s focus on collaboration with various disciplines has fostered partnerships with investigators from universities known for surgical robotic research nationwide, like the University of Washington and the University of California, Santa Cruz.

CAST also has the opportunity to collaborate across our own University of Nebraska campuses, and we were fortunate to be chosen to showcase our expanding research in a visit from the NU Board of Regents.

The revolutionary imaging technology in development by UNL electrical engineers breaks ground on a new standard of visualization in medicine. High quality imaging is a key component to improving upon our own surgical robots.

We are always excited to see the students and researchers associated with CAST maximize their experiences with us to succeed in future educational and professional endeavors, and we wish all of them the best of luck.

Sincerely,

Dmitry Oleynikov, M.D., F.A.C.S.
Professor of Surgery
Director, Center for Advanced Surgical Technology