



Northeastern University

CenSSIS Annual Reports

Bernard M. Gordon Center for Subsurface Sensing
and Imaging Systems (CenSSIS)

January 01, 2008

Year Eight Annual Report : 2008

Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems (Gordon-CenSSIS)

Recommended Citation

Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems (Gordon-CenSSIS), "Year Eight Annual Report : 2008" (2008). *CenSSIS Annual Reports*. Paper 4. <http://hdl.handle.net/2047/d10015917>

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Section 7C Education and Precollege Outreach

Table 7C-1. Education Leadership Team

Name	Institution	Department [†]	Gordon-CenSSIS Title/ Functional Area
Stephen McKnight	Northeastern University	ECE	Education Leader
Michael Ruane	Boston University	ECE	Education Coordinator
Rafael Rodriguez	University of Puerto Rico at Mayaguez	ECE	Education Coordinator
Birsen Yazici	Rensselaer Polytechnic Institute	ECSE	Education Coordinator
Claire Duggan	Northeastern University	Center for STEM Education	K-12 Outreach Coordinator
Kristin Hicks	Northeastern University	Gordon-CenSSIS	Partnership and Education Services Coordinator
Paula Leventman	Northeastern University	Gordon-CenSSIS	Diversity Coordinator

1. Education Program Elements

The Education Program integrates advances from the research thrusts and exposes students to the unifying concepts of the Center’s vision. Students then take the insights they learn in class and apply them to their studies and thesis problems. In this way the advances from one area of subsurface imaging are spread to other areas, and the “diverse problems, similar solutions” mission becomes a reality. The leaders of the Education Program are listed in Table 7C-1.

The elements of the Gordon-CenSSIS Education Program are shown schematically in Figure 7C-1. Beginning at the freshman level with the High-Tech Tools and Toys Laboratory and Gordon-CenSSIS Scholars program, undergraduates are brought into the Center through research experiences and coursework. At the graduate level, courses on SSI topics are offered at all four partner universities and students from each university have access to selected courses offered at other institutions through distance education technology. This access to courses at other Gordon-CenSSIS universities as well as student and faculty inter-university collaboration, visits, and exchanges is referred to as the “Distributed Uni-

versity.” Outreach activities also include summer REU programs for undergraduates from other institutions, student collaborations with other NSF and NIH research centers, and programs for elementary school, middle-school, and high-school students and teachers. Each element of Figure 7C-1 is now described in more detail.

2. High-Tech Tools and Toys Laboratory

As a part of the Gordon-CenSSIS initiative, each university has brought industrial quality “tools and toys” (engineered imaging systems) to campus in new, discovery-based, educational laboratories. The Center promotes a philosophy of putting modern technology into the hands of students as early as possible in their education. We are enabling them to use this technology to solve real, open-ended problems in a series of hands-on High-Tech Tools and Toys Modules.

Since the spring semester of 2005, the NU High-Tech Tools and Toys Lab (HTT&TL) has been offered as a 4SH freshman course, GE U111 Engineering Problem Solving and Computation, featuring problem solving and programming in MATLAB and C/C++. Control programs for the National Instruments data acquisition cards and Agilent instrumen-

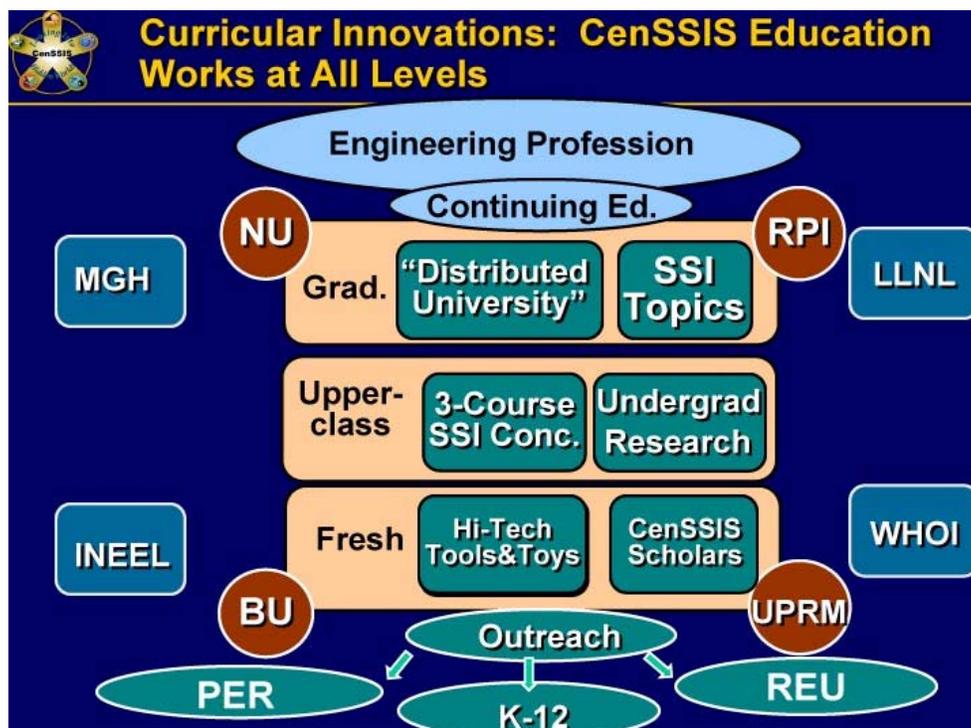


Figure 7C-1. Elements of the Gordon-Gordon-CenSSIS education program.

tation are written in C/C++ and MATLAB using the Data Acquisition and Instrument Control Toolboxes. This year, new impedance-matched ultrasound transducers and acoustic focusing lenses were purchased to replace the handmade transducers, giving the students much cleaner signals to work with. In addition, a second major project has been introduced in which the students write programs in C++ to sort a stack of ping-pong balls shown in a video image sequence by color. This provides a new project well-suited to the C++ programming environment that students can tackle when they move from MATLAB to C++. Moreover, it avoids just redoing the labs they have already done in a different language.

There have been two HTT&TL sections of the GE U111 course offered at NU since the spring of 2005. Professor Gilead Tadmor, the developer of the HTT&TL curriculum for the GE1102 course, and Center Education Director, Prof. Stephen McKnight, each taught one 24-student section of the course in both 2007 and 2008.

The pedagogical philosophy of this course is “romance before rigor.” Programming con-

cepts are taught using MATLAB to control the instrumentation to do ultrasound imaging of shapes concealed in opaque gelatin. After the students have learned control and imaging in the relatively friendly programming environment of MATLAB, they will do digital imaging and sorting experiments in the more demanding C/C++ environment.

The HTT&TL is an effective tool to address the diversity of student backgrounds so that beginning programming concepts can be taught to students who have little programming background without turning off those students who have more computer experience. Besides experiencing the excitement of real-time computer control and measurement, students gain *systems-level* experience in subsurface imaging that they can relate to medical ultrasonic imaging and computer vision applications.

At NU, the HTT&TL is also used as an outreach vehicle as it provides an engaging method by which to capture the interest of students with varying degrees of programming skills.

In the summer of 2007 the HTT&TL was used by Prof. McKnight and two public-

school-teacher co-instructors in a two-week intensive summer course for 15 Boston-area middle-school and high-school teachers. The course was offered under the auspices of the Contextualized Content Course (CCC) program, funded through the Boston Science Partnership (BSP). The BSP is an NSF Math Science Partnership of investigators from NU, U-Mass Boston, and the Boston Public Schools. Participants in the program, public school teachers who are enhancing their understanding of physics concepts in waves and electricity and magnetism, used the HTT&TL facility to study propagation and interference of 40 kHz ultrasonic waves in air. This involved an extension of the “Speed of Sound in Air” experiment that is the first lab that GEU111 freshman do in the HTT&TL.

At BU, the HTT&TL continues to enhance and develop experiments using Gordon-CenSSIS undergraduate students. The students work on undergraduate research programs and with visiting middle- and high-school teachers in a summer Research Experience for Teachers (RET) program.

The BU HTT&TL and Professor Michael Ruane offered two freshmen classes, EK131 and EK132, in fall 2007 with a total enrollment of 43 students. The students used imaging equipment with MATLAB and LabVIEW IMAQ software to accomplish tasks such as coin recognition and identification, liquid-level measurement, object tracking, image-guided control, and computer-integrated microscopy. They also used a FLIR IR camera for thermal characterization of objects around campus and built a LabVIEW acoustic processing module with a visiting National Instruments engineer. In spring 2008, Prof. Anna Swan is teaching another EK131 and EK132 module on optical sensing in which students assemble a series of circuits with optical sources and detectors and integrate them with National Instruments DAQ hardware.

The BU HTT&TL also supports summer programs including UROP, REU, RET, and high school research interns. Our NSF GK-12

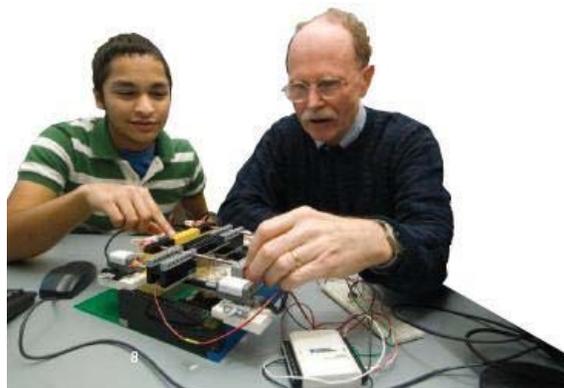


Figure 7C-2. High school student Neel Hajare and Gordon-CenSSIS BU Education Coordinator Michael Ruane work on Neel’s robot.

teachers and fellows had a training workshop in the HTT&TL during August 2007, to reinforce discovery learning and to inform the GK-12 fellows of available resources. The GK-12 fellows also helped with middle school outreach in the HTT&TL during their summer program. Summer REU students were given a tour of the HTT&TL as an example of hands-on learning, and used the HTT&TL for project prototyping and as an area for meetings and computer work outside their regular labs.

During the spring open house for prospective freshmen, about 100 students visited the BU HTT&TL. High school outreach efforts also brought visiting classes to the lab, serving about 60 high school and middle school students. The lab also participated in a successful proposal to the Massachusetts STEM Collaborative, which will support teacher workshops in summer 2008. Finally, the lab was shown to teachers and researchers in Photonic Problem-Based Learning (PBL), a project by Three Rivers Community College and the New England Board of Higher Education to develop PBL modules in sensing and photonics.

Members of the BU summer UDesign Program and Project STEP-UP also toured the lab. Two summer research students worked on Gordon-CenSSIS HTT&TL stations, bringing LabVIEW software updates to the systems. Generally, Gordon-CenSSIS Scholars are given card access to the HTT&TL to

build a sense of community and to provide a study area and computer network access.

The BU HTT&TL also supported a summer high school honors program student, Neel Hajare during July and August. Neel built an apparatus to demonstrate an early Computer Aided Tomography design. Using LEGO NXT components, Neel built a mechanical system to control 96 scans of a target phantom. In place of x-rays, he used an optical phantom with varying index and a laser/photodiode sensor. MATLAB algorithms were used to invert the scans. This project was highlighted in the 30th anniversary article for the Summer Term high school honors program.

Two new Gordon-CenSSIS Scholars, Anna Evans and Ian Leatherman, were given book awards and funding for laboratory research experiences. Anna is working in the HTTTL to characterize the near-IR sensitivity of inexpensive web cams. Ian is currently a MATLAB tutor and will work in a lab in the fall. John Gancarz, a BU engineering Scholar, also has begun working on a small thermal controller system to allow students to fabricate small circuit boards for their projects.

At RPI, the HTT&TL has been integrated into the award-winning RPI “studio” teaching model that features a tight integration of short lectures and interactive laboratory experiences. The Electrical Computer and Systems Engineering department has dedicated one of the studio classroom/laboratory spaces for a sensing and imaging studio. Gordon-CenSSIS Scholars at RPI start with summer internships in Center-related labs, and are encouraged to take this course as a follow-up. Professor Birsen Yazici used the HTT&TL studio in a sophomore course, ENGR-2961, Introduction to Sensing and Imaging, in spring 2005, 2006 and 2007 and she will be teaching the course again in fall 2008. The course emphasizes physical principles of imaging and spectroscopy and includes hands-on experiments in optical sensing and imaging, and simulation-

based experiments for the x-ray and visible range. The course content also includes experiments with a virtual chest x-ray imager and hands-on experiments with ultrasonic transducers. This course also produces a steady flow of motivated students to the second-tier Gordon-CenSSIS courses at RPI: ECSE-4962 (Introduction to Subsurface Sensing and Imaging Systems) and ECSE-6963/BMED-6961 (Cell and Tissue Image Analysis). Students who perform well in these classes are encouraged to enter graduate study.

The HTT&TL program is also a central education component at UPRM. The freshman Introduction to Electrical Engineering course created by Prof. Jose Colom-Ustariz is taught annually in the HTT&TL and was offered in Fall 2007 and Spring 2008, each time to 28 students. Instructor Miguel Figueroa taught the course.

The purpose of this course is to introduce students to different areas of electrical engineering. The course consists of a one-hour lecture followed by a two-hour lab experience every week. This course is also used as a source for selecting Gordon-CenSSIS Scholars as the very best students in the course are offered the opportunity to participate in the Scholars Program by reviewing course modules in the HTT&TL at UPRM and participating in student leadership council activities and undergraduate research.

The laboratory is also being regularly used at UPRM to teach a Computer Vision course, since it has an image acquisition setup that uses MATLAB. This course has been offered yearly at the HTT&TL since August 2003.

UPRM Gordon-CenSSIS Scholars Natalia Gerena and Sonny Samot have been working in the UPRM HTT&TL on the development of a JAVA interface to control the LEGO Mindstorm robots. The goal of this project is to develop a more flexible interface to program the robots that can make the robots do more complicated functions than the ones available in the LEGO interface.

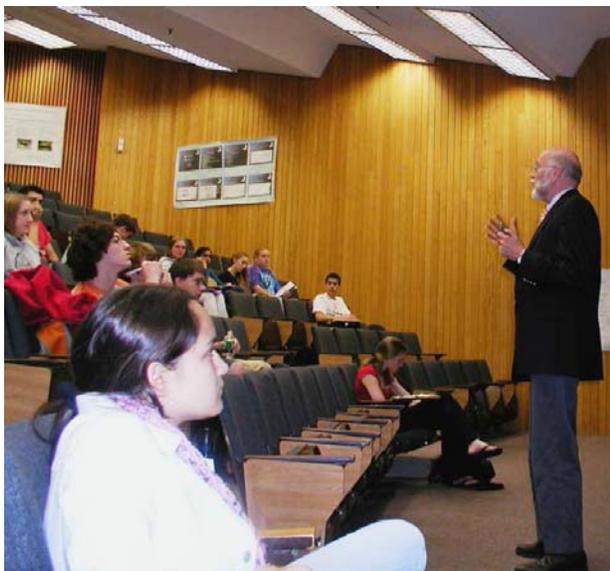


Figure 7C-3. Education Leader Prof. Stephen McKnight talks to potential Gordon-CenSSIS Scholars at Freshman Forum.

In the spring of 2007 and 2008, UPRM has held and is holding a monthly “Gordon-CenSSIS Day at Tools and Toys.” The HTT&TL is open to all students during the day. Under the supervision of the lab assistant, Gordon-CenSSIS Scholars and SLC members, students try different laboratory modules. The goal is to motivate more students to participate in graduate and undergraduate Gordon-CenSSIS research.

3. Undergraduate Research Programs

The Center has made a concerted effort to engage undergraduate students in sensing and imaging research, course development, and K-12 outreach. This is articulated via the “pipeline” discussed in Section 7C-8. The Gordon-CenSSIS Scholars and REU programs discussed below have been a source for identifying and mentoring highly-motivated undergraduates, even as freshmen. The following subsections illustrate the major elements of our undergraduate research programs.

3A. Gordon-CenSSIS Scholars

In 2002, the four Gordon-CenSSIS academic partners initiated a program to engage incoming students in the activities of the Center. During the past six years, approximately 195

Gordon-CenSSIS Scholars have been appointed. An active recruitment program aimed at admitted students (Figure 7C-3) enabled the program to achieve the goal that the Scholars be broadly representative of the population as a whole (approximately 50% female and 30% minority). This diverse group of students has become actively engaged in a variety of Center efforts such as K-12 outreach, seminars and the HTT&TL experiences. (See Section 7C-7.) The Gordon-CenSSIS Scholars receive book vouchers in recognition of their participation. Further details on the student demographics of this program are given in Section 7E-4.

In the spring of 2007, a group of 16 freshmen students were selected as Gordon Engineering Leadership Scholars at NU to begin participation at the commencement of their freshman year in fall of 2007. Like the NU Gordon-CenSSIS Scholars, these students received a \$1000 book voucher; they are also expected to attend the same workshops and meetings and participate in research and/or K-12 in their freshman year. In addition to these benefits, the Gordon Engineering Leadership Scholars will have the opportunity to obtain funding to support research work that they would choose to do in their sophomore year as long as they maintain a GPA of at least 3.4.

In the spring of 2007, NU Gordon-CenSSIS Scholars Amanda Angell, Matthew Bouchard, Sarah Brown, Eilish Corey, David Diaz, Morgan Galaznik, Caitlin Kenney and Sean Sullivan were working on Center research projects. Amanda continued to work with Professor Carey Rappaport on computational modeling of wave propagation in layered realistic media such as human flesh, soil, and paint and varnish layers. Matt and Sean continued to work in the Optical Science Laboratory under the direction of Professor Charles DiMarzio. Sarah Brown, Eilish Corey, David Diaz and Morgan Galaznik began working with Professor Carey Rappaport and a graduate student in the SoilBED laboratory (see Figure 7C-4). Caitlin Kenney began working with Rick Moore on the automation of a radiology



Figure 7C-4. NU Graduate student Clay Kurison works with Gordon-CenSSIS Scholars Jonathan Sarafinas and Tim Dyer in SoilBED.

chair that would retain position-specific information for each radiologist who would use the chair.

In the fall of 2007, Sarah Brown continued her research activities. In addition, Eddie Vaisman and Daniel Dumanis began working with Prof. Akram Alshawabkeh and a graduate student on soil characterization projects. Kyle Nadeau also began working with Prof. David Kaeli on a GPU project.

At BU, past Gordon-CenSSIS Scholars have received book awards and, more recently, a stipend to encourage work on projects in the HTT&TL or in faculty research labs. Student response to the lab research program, which must be completed before junior year, has been limited (only one of six participants this year). Students feel pressure to work on classes or find employment or internships before doing undergraduate research. In 2007-2008, BU is providing an award to selected students in two parts: a \$500 book award and a \$500 salary stipend, to be used to pay the student while they work in a lab on research or K-12 outreach.

Anna Evans and Ian Leatherman were accepted as 2007 Scholars during the fall, and currently Prof. Ruane is recruiting additional

students, with a goal of five CenSSIS Scholars in this year's class. Anna is already working in the HTT&TL at BU on camera characterization, and Ian Leatherman is working as a MATLAB tutor, with plans to do lab work in summer or fall. On a day-to-day basis, these students work with Jeff DiMaria, a Gordon-CenSSIS graduate student who leads the HTT&TL lab work.

At RPI, the Gordon-CenSSIS Scholars program is structured as a summer program for five students. This format allows the program to capture the undivided attention of the undergraduate students for an extended period of time. Scholars are assigned to graduate students so that they can participate in cutting-edge research with daily guidance. This is also an opportunity for the graduate students to learn mentoring skills even as they get assistance in their doctoral projects. For example, RPI Scholars Kwame Kutten and Marion Albert were teamed with graduate student Nicolas Roussel. Kwame worked on deformable registration algorithms and Marion worked on tracking algorithms using the *C. Elegans* worm. Kwame has continued his work through the fall of 2007 and the spring of 2008. Kwame and another RPI Scholar, Jonathan Luisi, are now learning confocal microscopy techniques working with zebrafish.

The Gordon-CenSSIS Scholars program is also leveraged and co-run with RPI's Summer Undergraduate Fellowships program, and the Center's REU program. REU students LaToria Jones and Katrina Stewart of Spelman College spent the summer or 2007 developing novel methods to query the cytovascular map using natural language, to permit wider adoption by biologists. They used the GATE open-source language processing software tools to translate English sentences to extensible markup language (XML) queries. Although much remains to be done to actually realize usable natural language query systems, their work demonstrated the imagination and skill of Spelman undergraduate students.

At UPRM, the Scholars helped in the review of the modules for the Introduction to Electrical Engineering course and in the development of modules using the LEGO Mindstorm robots. As mentioned above in the HTT&TL section, Scholars Natalia Gerena and Sonny Samot have been working at the UPRM HTT&TL in the development of a JAVA interface to control the LEGO Mindstorm robots.

Also at UPRM, Christian Sanchez and David Gonzalez worked under the supervision of Dr. Nayda Santiago and graduate student Javier Morales in the implementation of algorithms in FPGA platforms and GPU architectures, and Carlos Solis started to work with Dr. Ingrid Padilla and graduate student María Serrano in the development of the SoilBED setup in civil engineering.

In January 2007, Scholar Natalia Figueroa began working with graduate student Lillian Certuche on the electromagnetic modeling of the UPRM SoilBED under the supervision of Dr. Rafael Rodríguez.

In general, the Scholars have sought stronger involvement with Gordon-CenSSIS through pursuing other opportunities that become available. NU students Sarah Brown, David Diaz, Morgan Galaznik and Christopher Wiley, applied and were accepted to the Gordon-CenSSIS 2007 REU Program and the Gordon-CenSSIS/NE-LSAMP 2007 REU Program. Scholars Hadi Esiely and Natalia

Gerena of UPRM, Howard Simpson of BU, and Anthony Serino and Carolyn Andrews of NU are now members of the Executive Committee of the Gordon-CenSSIS Student Leadership Council (see Section 7C-6).

3B. Research Experiences for Undergraduates (REU) Program

Gordon-CenSSIS received funding for three new summer undergraduate programs beginning in the summer of 2005. One was a continuation of our successful REU Program and the other two are programs intended to increase diversity, the NE-LSAMP REU Program and the partnership with Alabama A&M University (AAMU). These programs are described further in the Diversity Section (7E-4) of this report.

In the summer of 2007, we conducted similar group activities between all three programs to allow the 19 student participants to benefit from significant interaction with one another and we also coordinated some of the activities for our three summer programs with similar summer programs being run by the Northeast Louis Stokes Alliance for Minority Participation (NE-LSAMP) Program and the Center for High-rate Nanomanufacturing.

The Center selected eight undergraduate students to participate in the REU Program, six undergraduate students to participate in the NE-LSAMP REU Program, and five undergraduate students to participate in the AAMU Summer Program.



Figure 7C-5. Professor Badri Roysam of RPI with Spelman REU students Katrina Stewart (left) and LaTorria Jones (right).

As a result of our successful collaboration with Spelman College, we selected four Spelman students to participate in the Gordon-CenSSIS REU Program and the Gordon-CenSSIS/NE-LSAMP REU Program this summer. LaTorria Jones and Katrina Stewart of Spelman College worked with Prof. Badri Roysam at RPI (Figure 7C-5) on a project entitled “XML Representation and Querying of Automated Multi-Dimensional Image Analysis Results.” To further



Figure 7C-6. NE-LSAMP REU Student Lauren Taylor of NU working in SoilBED.

an existing collaboration between Professors David Kaeli and James Hale of Spelman College, Chanelle Green and Chawandia Mack of Spelman College each worked with Prof. Kaeli on projects respectively entitled, “GPU Implementation of Scientific Computing Applications” and “1-D Signal between 2 Points”.

For the summer of 2007, we also selected two REU participants from the partner universities: Karen Cui from BU and Morgan Galaznik from NU. Karen worked with Prof. Carey Rappaport on “Detecting Moving Objects in Tunnels Using Cross-Well Radar”, and Morgan worked with Professor Rappaport on “Concealed Weapon Detection.”

Our other four REU participants, Jonathan Brand of the University of Rochester, Yemima Rose Citron of the University of Massachusetts at Amherst, Sarah Morrisey of Sacred Heart University and Lisa Storey of Carnegie Mellon University were selected from the pool of approximately 60 students who submitted applications, largely in response to our listing on the NSF REU web page.

For the Gordon-CenSSIS/NE-LSAMP REU program, we selected six students – four from NU and two from Spelman College. The original intent of this program was to select student participants from one of the NE-LSAMP Program participating universities

(NU, the University of Rhode Island, the University of Connecticut, the University of Massachusetts-Amherst, and Worcester Polytechnic Institute). However to broaden the pool of applicants, we also considered LSAMP-eligible students from other institutions.

For the AAMU summer program, we selected five undergraduate students from AAMU with the assistance of Profs. Tatiana and Nickolai Kukhtarev of AAMU. Profs. Kukhtarev were working with Professor Todd Murray of BU on collaborative research that the AAMU students became involved with during the summer. Two of the students returned for their second summer working at NU along with another new AAMU student, one AAMU student worked at BU and another worked at UPRM.

We were pleased to be able to select a diverse group of students in all three of our summer programs including eleven African-American students, thirteen female students and one Hispanic student.

The 19 Gordon-CenSSIS Summer Program participants and one LSAMP student were asked to attend seminars on presentation skills and graduate school preparation, a field trip to Woods Hole Oceanographic Institute, and the final research project presentations for each group (Figure 7C-7). There were also luncheon meetings for the students to discuss their research experiences and to become familiar with one another.



Figure 7C-7. Summer program students on the final day of research project presentations at BU.

BU also runs its own Photonics REU program. In summer 2007, 18 students participated. Several worked directly with Center researchers Malvin Teich, Anna Swan and Michael Ruane on photonics projects that cross over to Gordon-CenSSIS technologies. Prof. Mike Ruane, Gordon-CenSSIS Education Leader at BU, is the principal investigator for BU Photonics REU Program, which provides REU students with the opportunity to conduct research with top scholars in state-of-the-art labs, while also being exposed to the real-world ethics involved in the research through weekly seminars on ethics and best practices. This program will again support 18 students in summer 2008, and had over 180 applicants.

3C. Capstone Design Projects

Another area where undergraduates are involved in SSI projects is in Capstone Design projects. Several Capstone Design projects with SSI themes have been initiated.

Capstone Design students at BU continue to work on a set of Center-related questions. One team is building an autonomous vehicle guided by GPS sensors and an electronic compass. Another group is working on an intelligent image processing program to record and interpret the moves in the game of Go. An entirely undergraduate team of students is participating in a design project for the US Air Force in the Nanosat V competition. The BU entry includes an imaging sensor, and the students have worked with the HTT&TL to understand and develop their instruments. Another team is using sonar sensing technology to connect parking sensors to the Boston Wireless network and Google maps, to provide automated sensing of vacant parking in town. This technology is also

adaptable to homeland security in its basic detect-report-display on GIS capabilities.

Richard Moore, Center Program Director, worked with an NU Capstone Design group in 2007 to assist them with the development of their project. The group of students worked on the computerized automation of a radiology seat designed for a high-performance Digital Breast Tomosynthesis workstation, to be used by radiologists who spend many hours per day reviewing patient datasets for screening and diagnostic purposes. The capstone group took on the challenge of making an ergonomic workstation that

consists of an automated chair surrounded by viewing screens that remembers and maintains a set of specific settings for each radiologist who would use the system.

4. Introduction to SSI Course

Gordon-CenSSIS has affected the undergraduate curriculum at each of the universities by introducing an upper-class technical elective in ‘Subsurface Sensing and Imaging’ (SSI).

At NU, the Introduction to SSI course has been offered as a technical elective every other year since it was introduced in winter 2002 in team-taught format by Professors Dana Brooks and Charles DiMarzio.

In the spring semester of 2004, Profs. Brooks and DiMarzio adapted this course to the new NU semester system as ECE U692 (Subsurface Sensing and Imaging). With the extra time in the 14-week semester, we were able to have students take diffuse optical tomography data in the lab and analyze the data using code from the DOT toolbox. The students were able to analyze the data using truncated singu-

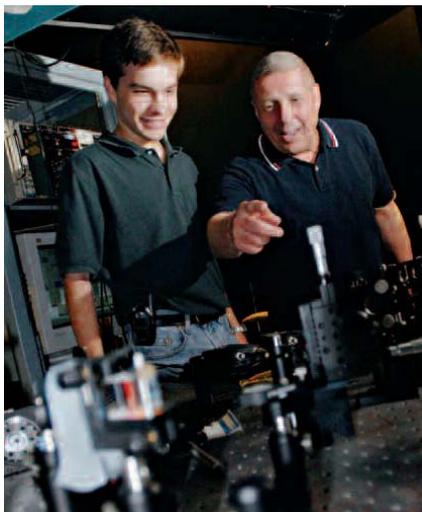


Figure 7C-8. BU REU participant David Whitney working on his summer research with Prof. Malvin Teich.

lar value decomposition and compare the results to those obtained using Tikhonov regularization.

In 2006, Professor Eric Miller taught the course with Prof. DiMarzio. In conjunction with their theoretical studies in scattering physics, signal processing, and inverse scattering, students worked in teams to acquire and process hyperspectral imaging data from one of the Gordon-CenSSIS laboratories.

In spring of 2008, Professor Edwin Marengo is teaching the course and the next scheduled offering of the course will be in 2010 with the newly developed textbook mentioned at the end of this section.

The Intro to SSI course at RPI continues to be updated and taught annually by Dr. Badri Roysam, and Dr. Kai Thomenius, who is currently the Chief technologist for Bio-imaging at the GE Global Research Center (see Figure 7C-9). This course not only benefits from the Gordon-CenSSIS unifying framework, but also has significant content related to bio-imaging systems at GE.

In this course, students were introduced to molecular sensing and imaging methods for each of the major imaging modalities using the common notion of contrast agents. The course also includes a field trip to the GE Global Research Center during which the students are shown each of the major imaging modalities and another trip to RPI's Advanced Microbiology core at the newly constructed Biotechnology Center.

Recent enrollment trends indicate a growing interest among biomedical engineering stu-

dents and employees of GE who are also students at RPI. The course is crosslisted as an Intro to Biomedical imaging course in the Biology Department.

The Introduction to SSI course at BU, SC569, is now a permanent listing on the course inventory at BU. It is offered every other year as a cross-listed graduate/undergraduate course with EM Fields and in Systems/Signal Processing prerequisites. The course presents the Center's model of physics-based signal processing for the detection and classification of subsurface objects and conditions. The course notes from SC569 are being used to develop the introductory chapters of the subsurface sensing and imaging textbook described below. This year, with Prof. Saleh on sabbatical, the course was not presented.



Figure 7C-9. Dr. Kai Thomenius demonstrates GE ultrasound imaging equipment in the RPI Intro to SSI course.

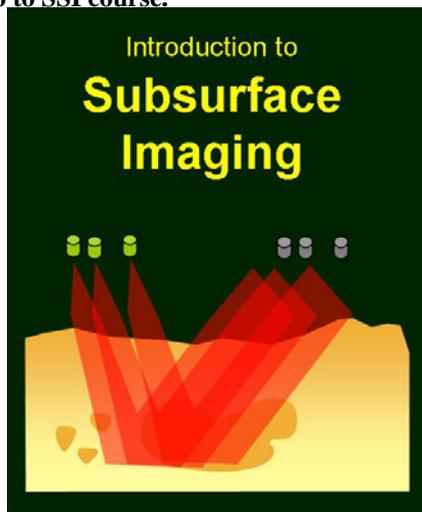


Figure 7C-10. Proposed cover for the SSI textbook.

Professor Bahaa Saleh and other Center collaborators are in the process of writing the textbook, Introduction to Subsurface Sensing and Imaging, (Figure 7C-10) that will collect and organize the results of the Gordon-CenSSIS unifying approach for graduate students and upper-level undergraduates.

This is a major element of the SSI course sustainment and dissemination strategy. We are already seeing the effect of students applying insight from one area of subsurface sensing to problems in other areas. Judy Newmark, a biology student at NU, applied a k-means statistical method that she learned from Professor Roysam's distance education course to a problem in embryo imaging, and a UPRM student ap-

plied the registration techniques from retinal imaging to a problem in remote sensing.

5. Graduate Programs: The “Distributed University”

A major educational goal of Gordon-CenSSIS is to pool the resources of the four academic institutions and the strategic affiliates into a “Distributed University” in which students from each university will have access to courses, laboratories, and faculty from the consortium.

5A. Cross-Registration and Distance Learning Courses

The Center’s Board of Directors has instituted a policy to allow students from each university to cross-register and receive credit for courses at the other partners while paying tuition at their home institution. A memorandum of agreement on this policy is in place at each university and allows students to earn credit for courses at other institutions by students from each of the universities.

Boston-area students can attend Gordon-CenSSIS courses in person at BU and NU. In the fall of 2007 and spring of 2008, Michael King, a Gordon Fellow enrolled at BU, took Prof. Stephen McKnight’s Scientific Foundations of Engineering course and Prof. Michael Silevitch’s Engineering Leadership course, both at NU. These courses are required within the Gordon Engineering Leadership Program at NU.

The center is also currently working with the manufacturing program at BU to expand the Distributed University format to the green manufacturing course available at BU.

To make Gordon-CenSSIS courses available for cross-registration beyond the Boston area, Gordon-CenSSIS offers certain courses by distance-education methods to all four universities. In the fall semester of 2007, Prof. Badri Roysam of RPI taught an updated version of the Biological Image Analysis course that he has offered in the distance format in past years. Bill Warger of NU took the course via teleconference call meetings.

5B. Distance Seminars

Beginning in 2003, Gordon-CenSSIS broadcast seminars to the partner institutions via WebEx (a web presentation, voice, and image transmittal package). These seminars were also recorded and uploaded to the Gordon-CenSSIS website for future viewing.

In the fall of 2007, the Gordon Engineering Leadership Program began semi-monthly seminar presentations made by engineering leaders (most of whom are representatives of the Center’s industrial partners) to the Gordon Fellows and the Gordon-CenSSIS community in the Boston area. We have recently begun to record these presentations so that they can be viewed by the larger Gordon-CenSSIS community.

Presentations to date include the following:

- Bernard M. Gordon, Founder, Analogic
- Joseph Callerame, Vice President of Science and Technology, American Science & Engineering
- Sorin Marcovici, Corporate Senior Technical Vice President, Analogic
- Mark Russell, Vice President of Engineering, Raytheon Integrated Defense Systems
- Emel Bulat, Director of Technology and Business Strategy, Textron Systems
- Michael Bunis, Principal, Fish & Richardson
- David Schafer, Technical Vice President, Analogic
- Colin Sanford, Vice President of Engineering, American Science and Engineering
- Eric Bailey, President & CEO, NeuroLogica
- Tim Nustad, General Manager, Global Components Engineering, GE Healthcare

In the summer of 2007, we also offered a series of presentations to the participants in the Gordon-CenSSIS Summer REU Programs which we made available to all partner universities. These presentations included a “Presentation Skills” seminar by Terry Beadle

of NU's Academic Technology Services Dept., an "Incorporating Ethics into Professional Decisions" seminar by Prof. Bob Tillman of NU's Cooperative Education Department, and the final research presentations made by the REU students at the conclusion of the summer.

5C. Conferences, Short Courses, and Workshops

The eighth Gordon-CenSSIS Research and Industrial Collaboration Conference (RICC) was held on October 3-4, 2007. It included student-led posters and oral sessions on research and education efforts. This year's RICC focused on imaging applications for Graphics Processing Units (GPUs) and developments in multimodal breast cancer detection. Day Two of the RICC was a focused conference on General Purpose Processing on GPUs. There were over 200 attendees at this event including many students.

5D. Cross-University Collaborations and Graduate Activities

Gordon-CenSSIS students become involved in many collaborative efforts among the Gordon-CenSSIS university partners and strategic affiliates.

In the fall of 2007, Gordon-CenSSIS Scholar Rosa Capó of UPRM began pursuing her graduate degree in electrical engineering at RPI.

During the summer of 2007, two UPRM graduate students, Sol Cruz and Luis Quintero spent a month at NU working with Prof. Max Diem testing algorithms to remove various types of spurious signals or noise from Raman imaging of biological materials.

5E. The Gordon Engineering Leadership Program

In August 2006, Northeastern University received a \$20 million gift from the Gordon Foundation. This gift helps to both sustain the R&D infrastructure of the Center and to launch programs to foster the development of engineering leaders (See Section **7E-3A** for

more information). The Gordon gift enabled Northeastern University to establish the Gordon Engineering Leadership Program. Gordon-CenSSIS Personnel, including Director Michael Silevitch and Education Leader Stephen McKnight, created this educational program to accelerate the development of engineering leaders who can direct multidisciplinary teams to bring innovative technical ideas to the market in a short period of time, meeting all cost goals. The curriculum of the program features a thesis-scale "Challenge Project" based on the academic advisor/dissertation model, but directed toward commercialization or deployment of a new technology. The Challenge Project is supported by newly developed courses in GSE121/122 "Engineering Leadership" and GSE131/132 "Scientific Foundations of Engineering" to give the graduate a broad scientific framework to support rapid "back-of-the-envelope" quantitative assessment of technology problems, an understanding of the non-technical issues of commercialization, and a successful experience of leading the development of a product in a time-critical environment.

In the fall of 2007, the first class of "Gordon Fellows" began their participation in the program. The first class is made up of nine students whose employers include the US Army Night Vision and Electronic Sensors Directorate, US Air Force Research Laboratory Sensors Directorate, Analogic Corporation, Neurologica Corporation, Raytheon Company, and Textron Defense Systems. The website for this program can be found at www.cenassis.neu.edu/gordonfellows.

Profs. Silevitch and McKnight gave presentations on the Gordon Engineering Leadership Program at the International Conference on Engineering Education in Coimbra, Portugal in the summer of 2007.

6. Student Leadership Council

The Gordon-CenSSIS-wide Student Leadership Council (SLC) is made up of approximately 150 students. The SLC is led by its

Executive Committee (EC) which is made up of one or more representatives from each of the university partners. Anthony Serino, a NU representative and Hadi Esiely-Barrera, a UPRM representative, have been co-Presidents of the SLC since April 2005. The other members of the EC are Howard Simpson of BU, Carolyn Andrews of NU, and Natalia Gerena of UPRM.

The EC met as needed in 2007 to discuss upcoming events such as the NSF Site Visit, the Research and Industrial Collaboration Conference (RICC) and the planned student meetings and seminars.

In November of 2007, the EC attended the NSF Annual Meeting in Washington DC and hosted the NSF Student Retreat focusing on engineering leadership and the design of the ideal PhD program. (Figure 7C-11). In December, the EC worked together to design the SWOT questionnaires which will be distributed to the Gordon-CenSSIS Students via email in March 2008. Ms. Kristin Hicks, the Partnership and Education Services Coordinator, acts as a facilitator, enabling the multi-university SLC to function smoothly.

7. K-12 Education Outreach

From its inception, Gordon-CenSSIS has partnered with the Center for Science, Technology, Engineering and Mathematics (STEM) Education, (formerly known as

CESAME) at Northeastern University to design, develop and implement the pre-college outreach program. Claire Duggan, Associate Director of the Center for STEM Education, is the Gordon-CenSSIS K-12 coordinator. This program involves activities in informal as well as formal science education and spans all K-12 grade levels.

The formal science program involves teachers and their students in a variety of activities. One of the main goals of the formal science program is to design and implement models that develop teacher expertise by strengthening their understanding of STEM content and pedagogy through Gordon-CenSSIS-related materials. This also involves working with K-12 students to increase their content knowledge and interest in STEM through real-world problems related to subsurface sensing and imaging. This also provides opportunities for affiliated undergraduate and graduate students to strengthen their presentation and leadership skills through participation in educational outreach offerings.

The components of the K-12 efforts are described below.

7A. Gordon-CenSSIS Scholars

As mentioned previously in Section 7C-2, upper-class NU Scholars began working with Boston-area teachers in the fall of 2003 and we expanded this effort to include freshman



Figure 7C-11. NSF ERC Student Leadership Council Representatives at the 2007 student retreat at the NSF ERC Annual Meeting.

Scholars in the spring of 2004. The Scholar volunteers work with teachers and programs affiliated with our partner university's K-12 outreach efforts.

Gordon-CenSSIS Scholars have assisted with a newly funded residential summer science program, the Exxon Mobil Bernard Harris Summer Science Program. They have also participated in school-based 'Science Days' (Boston Latin's Science Day and Science Fair), citywide events, the Boston Public School's Annual Science Fair (held at NU), the Future City and Building Bridges Competitions, sponsored by the American Society of Civil Engineers (also held at NU). The Scholars are also providing mentoring assistance to Boston Public School students preparing for AP exams in STEM areas, and serving as tutors at local middle schools.

At UPRM, the Center sponsored part of the Pre-College Engineering Program. The HTT&TL was also used to offer two workshops for visiting students to learn about communications, signal processing, and wave propagation applications. Graduate student Luis Quintero led this effort.

RPI Gordon-CenSSIS faculty and Scholars participate each semester in the Questar III program coordinated by teacher Meredith Borland. Her program buses top-ranking students from across the New York Capital District to RPI. Gordon-CenSSIS faculty members make presentations to these students on their respective areas of expertise. Many of the students go on to select engineering colleges, including RPI. In 2007, in recognition of his participation in this outreach, Prof. Badri Roysam received the Questar III Excellence in Service Award, New Visions METS high school classes 2002-2007 for outreach to high-school students.

7B. Research Experiences for Teachers Program

Summer research internships are an opportunity for teachers to participate in active research projects in professional laboratory set-

tings. The Research Experience for Teachers (RET) program is a six-week summer research experience for middle and high school mathematics and science teachers and Community College Faculty funded by the NSF. Since the summer of 2001 participants have worked in research laboratories at NU and BU in cooperation with Gordon-CenSSIS-affiliated faculty members. RET program goals include:

- Providing participants with an intensive summer research experience
- Making real connections between the research experience and the teacher's classroom curriculum.

Based on their summer research experience, RET fellows develop classroom curriculum extensions tied to research-based instructional materials. The teachers implement these extensions in their classroom during the following academic year. Selected RET fellows participated in the annual Gordon-CenSSIS Site Visit. BU RET participants have worked primarily in the HTT&TL laboratory under the direction of Professor Michael Ruane. Participants have prepared a magnetic field sensor system for their high school physics class; implemented a MATLAB tool that takes video frames of an experiment (such as a ball on a parabolic trajectory), analyses the images for the target, and generates a plot of the motion. The most recent team developed a lesson focused on how a digital camera captures an image and on the challenges engineers face in designing a system to capture such an image. The lesson's goals and objectives are to help students understand how a digital image is captured. They learn why pixelation occurs by constructing and testing first one pixel and then an array of pixels. Ultimately, they engage in a design and evaluation process of an electronic circuit. This lesson was piloted in the Framingham (MA) Public Schools during the 2005-2006 academic year and has now been integrated into current course offerings.

BU also hosted one summer high school research intern, who used a color video camera

and MATLAB Image Processing Toolbox to develop a camera guidance sensor for a remote-controlled car. The sensor can identify colored regions and “forbidden” areas (hazards) and pass their coordinates to the RC car system.

Teams of RET participants have also worked at NU with Prof. Akram Alshwabkeh. Projects have included “Cleanup of Contaminated Soil with Electrokinetic Techniques” and “Electrochemical Analyses of Chloride Ions”.

With the ever-increasing focus on the environment, the addition of investigations into the remediation of contaminated soils and wastewater brings a “real-life” component to the middle and high school science curriculum.

While not all of the techniques used in this work can transfer to the classroom, various aspects can be used. Middle and high school students can investigate the conversion of an oil spill by oil-degrading microbes into masses of food and non-toxic living cells. Students can also investigate the effect of rain on a contaminated soil sample by tracking the level of iron contamination through spectroscopic means. Students in middle school science classrooms will be introduced to a lesson on “Oil-Hungry Microbes”, challenging students to consider why bioremediation is important.

An additional goal of the RET program is to build a dynamic STEM community for teachers across the country. Starting in 2004, the NU RET program received conference supplements from NSF to coordinate a pre-conference for RET participants in conjunction with the National Science Teachers Association (NSTA) national meeting and regional meetings. These pre-conferences have provided an opportunity for participants to share best practices, refine their presentation skills and strengthen cross-institution collaboration. These collaborative efforts have led to support for annual RET meetings at NSTA conferences through 2010. The NU RET

program spearheaded efforts to encourage more RET-led sessions at the March 2008 NSTA national meeting that will take place in Boston. This national leadership in the RET program is part of the Gordon-CenSSIS and the Center for STEM Education’s strategy to disseminate best practices to the K-12 community at large.

7C. Young Scholars

The Young Scholars program is a summer opportunity for Boston-area high school students interested in careers in Science and Engineering. During the six-week program, participants take field trips, where they learn about a particular branch of engineering. They see first-hand the jobs that engineers and scientists do, what degrees are necessary, and what the real world outside the classroom is like.

Directed by Claire Duggan, the Young Scholars Program at NU is currently funded by EMC Corporation with the intent to give future scientists and engineers an opportunity for hands-on experiences while still in high school. The program is open to Boston-area applicants who have completed either the sophomore or junior year in high school. It is a highly selective program, to which hundreds of students apply each year.

Since 2004, participants have worked in research laboratories within the Colleges of Arts and Science and Engineering at Northeastern. In many assignments students worked with faculty affiliated with Gordon-CenSSIS. Projects have included clean-up of contaminated soils by electrokinetic techniques, Finite Difference Time Domain antenna simulation, and tissue phantoms for biomedical imaging. Fifty-eight rising juniors and seniors have participated in the program to date.

Young Scholar alumni, those moving on to Gordon-CenSSIS partners and other institutions, are invited to continue to be part of our science support network. They are sent information on REU experiences, seminars, and future opportunities.

8. The Gordon-CenSSIS Pipeline

As documented by the National Academies of Science and Engineering, there is an impending national crisis arising due to the low number of students choosing to major in STEM subjects at the university level. (See report “Rising above the Gathering Storm”, available at www.nap.edu.) Gordon-CenSSIS recognizes the critical role that ERCs can play in addressing this crisis. Beyond the sharing of best practices in REU and RET programs and institutionalizing outreach efforts to the K-12 community, ERCs are in a unique position to

become a driver for reform in undergraduate education and in the expansion of cross-institutional collaboration to share effective strategies. As an example, Gordon-CenSSIS has developed a “Research and Education Pipeline for Student Enrichment”, shown in Figure 7C-12. The pipeline is a graphical way of illustrating the overarching coherence of the various Gordon-CenSSIS programs presented in this Education Section of the annual report. It is also a driver for the Gordon-CenSSIS Diversity Strategic Plan.

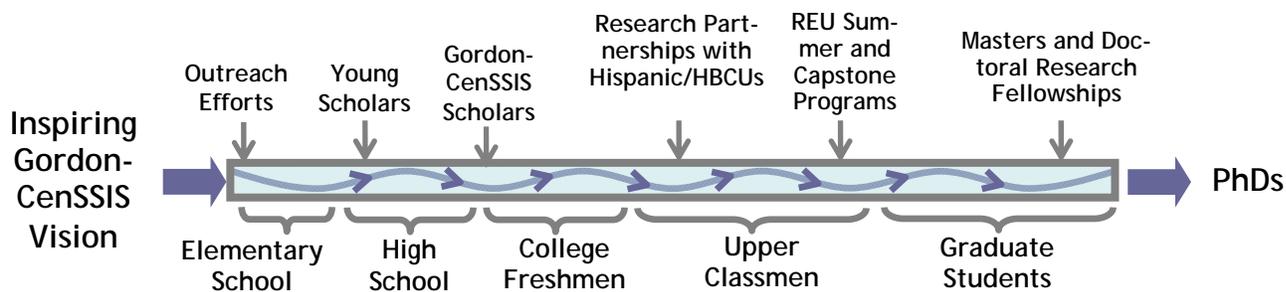


Figure 7C-12. Research and Education Pipeline for Student Enrichment.