AC 2009-838: INTRODUCING ADVANCED WIRELESS SENSOR NETWORKS INTO UNDERGRADUATE RESEARCH

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Introducing Advanced Wireless Sensor Network Undergraduate Research

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Abstract

Advances in sensor technology and the availability of affordable mass data storage devices are enabling a new security infrastructure. The infrastructure goes beyond traditional wired supercomputers, clusters, and workstations to include more ubiquitous observing and sensing systems, intelligent and remotely operable instrumentation, and handheld communication devices. Although timely and important, the introduction of these advances in undergraduate curriculum is limited. In this paper, we report our effort in linking advanced wireless sensor networks and undergraduate research.

Introduction

Within the last decade, we have seen tremendous technological advances in sensors, wireless networking, and processing that not only make the connection between the physical world and cyber-informatics world possible, but also make such connection affordable. Even though quality of service, security and privacy for wireless connection; and information integration are challenges, introducing wireless sensor network technology into undergraduate research can help attract and prepare future engineers. To achieve this goal, we started with individualized research experiences.

The multi-disciplinary program involves faculty from two colleges and three departments; the 10 projects ranges from smart material based transducer, to networking protocol development, information security of the wireless networking, and wireless sensor network in biomedical applications. The program is designed to provide opportunities for promising undergraduates in Engineering and Engineering Technology to engage in interdisciplinary research projects during a 10 week summer period. It is hosted by the Engineering Technology Department in the College of Technology and Mechanical Engineering Department in the College of Engineering of the University of Houston. It is a unique interdisciplinary opportunity that helps undergraduates explore the next generation of sensor network infrastructure. Our program is characterized by four broad goals, namely: recruit academically promising students from underrepresented populations; expand undergraduate research opportunities; increase the number of undergraduate students with research skills and experience; and improve long-term student outcomes.

Logistics We advertise the research opportunity through a designated website (http://tech.uh.edu/Research/NSF-REU/), email list such as ETD-list, and direct contacts with faculty members from campus serving under-represented student population. Within a month, we received a diverse set of applications from which eleven students were selected. Figure 1 shows the distribution of gender and demographics of the applicants (left column) and participants (right column).

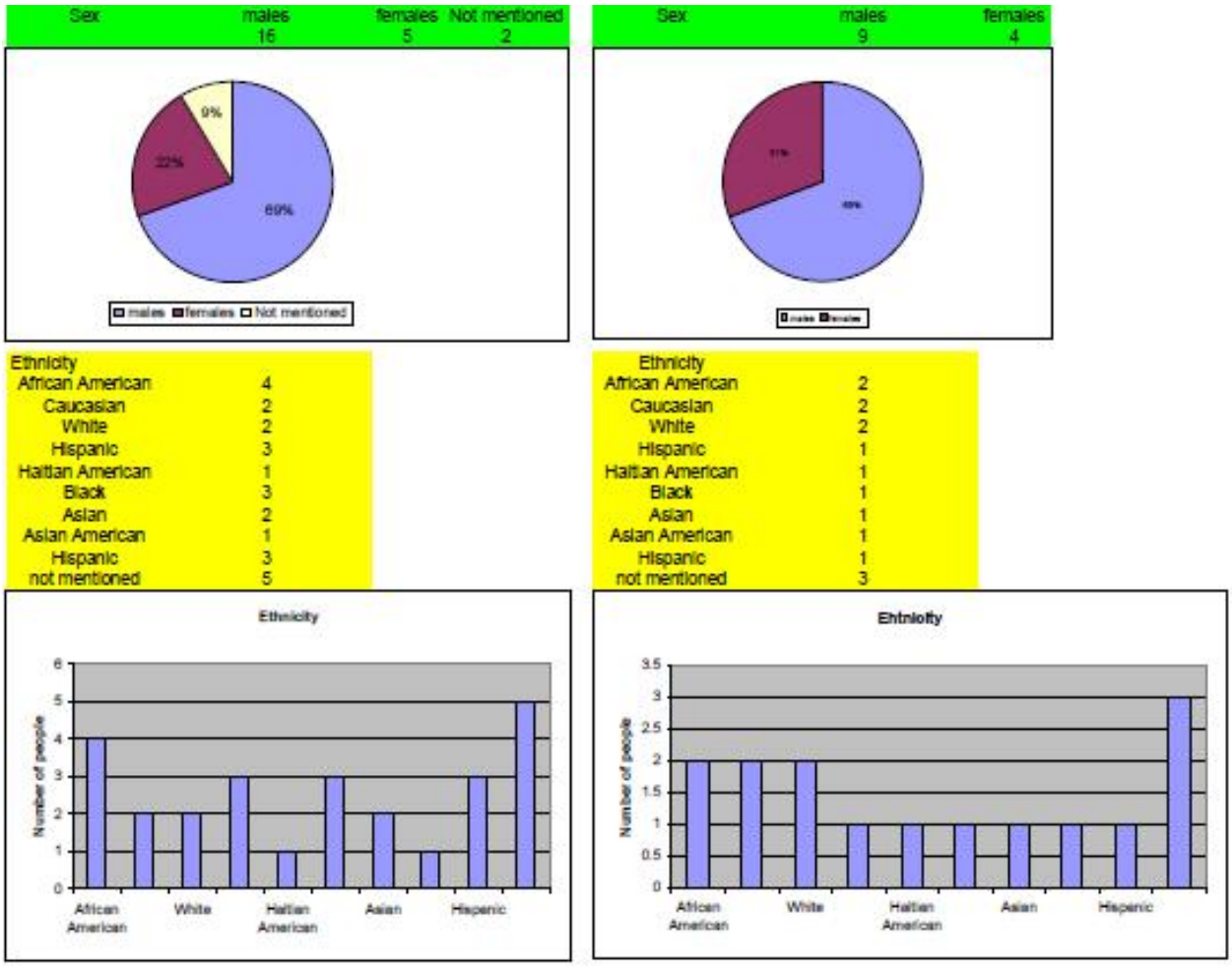

Figure 1 Demographic Distribution of Students Applicants and Participants.

In order to accommodate eight students from outside of the Houston area, we contacted the housing program at the University of Houston (UH) and arranged a 10-week stay for students in the residential halls. All participants were issued temporary UH ID cards which gave them access to computers and networks as well as dining options on campus.

A lot of effort was devoted to a diversified enrichment program for REU participants, as shown in Figure 2. In specific, UH Quality Enhancement Program (QEP) put together an academic and professional writing workshop to prepare students with research skills such as using library resources; writing research proposals, reports, and scientific articles; and preparing power point presentation.. Participants also get one-on-one writing and presentation consultations. Field trips were organized to visit Greater Houston TranStar, Port of Houston, and Johnson Space Center, to get participants experiences with current security infrastructure in real world.

Faculty mentors and their graduate students also helped students develop their writing and presentation skills. Examples of the projects are listed below:

- **Continuous Monitoring and Tracking Based on Smart Sensor Networks** - Students learn about the wireless sensor networks, feature extraction, object identification and

tracking. In addition, they independently complete a small project using the existing sensor network test bed and software platforms in the ISGRIN lab.

1) Group writing Sessions
2) Weekly Individual Writing Session
3) Discovery Seminar Series
4) Weekly Group Meetings on every Fridays
5) Field Trip to TranStar: Transportation Surveillance with networked camera
6) Trip to Port of Houston, security infrastructure
7) Professional development seminars: include topics such as Patent and intellectual properties; research methods and ethics; project management and Microsoft Project training; graduate study opportunities and graduate exam preparation,
8) Group Meeting and final project presentation
9) Trip to Johnson Space Center

Figure 2 Enrichment Program and Activities for REU Participants

- **Programmable System on Chip (PSoC) Based Wireless Smart Sensor Nodes** – in this project, students: (1) Become familiar with the principles and technology of PSoC and other similar state-of-the art technology products: (2) Build and demonstrate a prototype software defined or smart sensor system that acquires data, then using a communication system to send data to a host at high speed based on "intelligent" decisions; and (3) Have the opportunity to get real world experience as they develop new and novel ways to utilize the PSoC device in sensor applications.
- **Health Management System Using Wireless Sensor Networks** - Students were involved in the research in digital interface design between the sensor and equipment being monitored; developed and implemented software for data security and higher level applications that analyze and model the data.
- **Biosensors and Biosecurity** - Students studied and get to understand a logical progression of a life cycle of a typical biotechnology product, starting with isolation and characterization of microorganisms, use of a microorganism to produce a product, and an application of the product involving nanobiotechnolgy, and applications in environmental biotechnology, bioenergy and biosecurity.
- **Next Generation Sensor Networking with Interoperability** - Students worked on the development of sensor nodes that will monitor a rocket engine test stand with control sensors and actuators. Each sensor node will be loaded with historical sensor/actuator readings. The playback circuit will be a good experience for the undergraduate students.

Assessment Instruments and Results

Various assessment instruments were designed to evaluate the outcome of REU participants, including pre- and post- surveys, interviews, and presentation evaluation. Figure 3 shows the designed pre- and post- survey.

You can choose from (1) excellent; (2) good; (3) poor; (4) no experience

1) My experience in conducting research project is:
2) I can formulate a research question.
3) I can formulate a research problem.
4) I can identify basic principles and knowledge related to the research question or problem.
5) I can develop a research plan to address or resolve a specific question or problem.
6) I can find refereed research papers (articles) via the library databases.
7) I can collect and interpret data and information in an attempt to resolve the question or problem.
8) I understand the role of data management (ownership, collection, storage and sharing) in conducting research.
9) I understand responsible authorship (accurate representation of results, and open and honest assessment of the findings)
10) I can demonstrate awareness of the responsible conduct of research.
11) I can articulate research findings through written form.
12) I can create a research poster.
13) I can articulate research findings through oral presentations.
14) I can demonstrate the role that research plays in Science, Technology, Engineering and Mathematics careers.
15) I can demonstrate awareness of career options within the Science, Technology, Engineering and Mathematics fields.
16) I know all the preparatory steps necessary for applying a graduate school.
17) I plan to attend graduate school: yes or no question

Figure 3 Pre- and Post- program survey questions

Figure 4 shows the distribution of participants' response to the first sixteen questions in the survey (denoted as Qx in the figure). For each question, the first bar shows the number of students choosing answer (1) excellent in the pre-program survey and the second bar shows the similar information in the post-program survey. Similar interpretation can be said about the other bars. Each question corresponds to eight bars (since we have 4 options for each of the 16 questions), some of which are not shown because the number of students choosing the answer is zero.

From the comparison of the students' survey responses before and after the program, we can conclude that REU participants gained quite a bit knowledge and experience about research on various aspects of wireless sensor network based security infrastructure through the 10 week program.

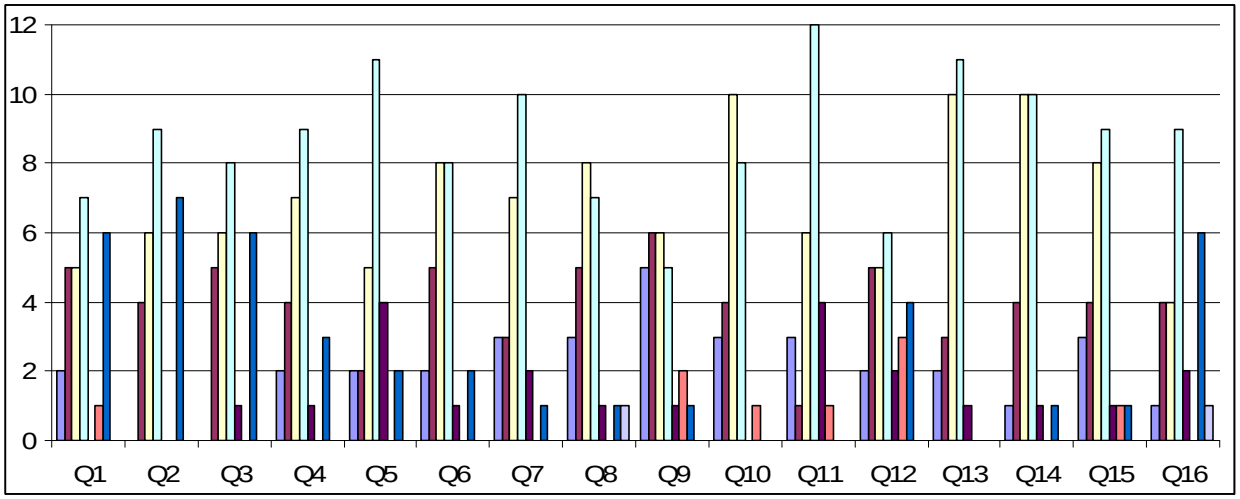

Figure 4 Pre- and Post- program survey results distribution

At the end of the 10-week program, we held a poster and presentation competition for the students to present their project result to fellow students and judges (including the senior personnel, graduate graduates, invited external judges). Figure 5 shows the presentation evaluation form.

Success Stories and Lessons Learned

The first year of the UH COT NSF REU Site program was very successful because we recruited academically promising students from under-represented population; expanded undergraduate research opportunities; and increased the number of under-graduate students with research skills and experience.

Because the fellow students participated in the program, the students in the ET (Engineering Technology) program are more attracted to various research opportunities on and off campus. In addition, participants from UH and UH-Downtown get award presenting their project on the UH Undergraduate Research Day in Oct. 2008. Conference papers have been submitted and accepted in the ASEE 09.

On the other hand, we also learned some lessons for the NSF REU Site program. For example, there were confusions among participants for the first week of the program because there were several seminars. They have to wait until the 2nd week before they get access to the network. In addition, participants feel the writing sessions should be more oriented towards technical writing, instead of things like grammar checking.

UH COT NSF REU Site – Sensor Networks and Security Infrastructure

Instruction to evaluators: Use these criteria to rate the oral & poster presentations on a scale of 1–5: (1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree).

Evaluation Categories	Sequence of presentation				
Oral Presentation	**1**	**2**	**3**	**4**	**5**
1. Research idea is clearly stated; steps well articulated.					
2. The presentation is well prepared, organized, and supports research idea.					
3. Research results are stated clearly and future work well addressed.					
4. The presenter answers questions and used the time effectively.					
Total score- Oral Presentation (max is 20 pts)	**/20**	**/20**	**/20**	**/20**	**/20**
Poster Presentation					
1. Display attracts viewer's attention, well organized, and easy to follow with good graphics and visual enhancement.					
2. Content is clear and easy to understand and enough detail is given to understand the results.					
3. The approach taken is appropriate for the problem and technically sound and free of unnecessary details.					
4. Conclusions are stated clearly and supported by the results.					
Total score- poster presentation (max is 20 pts).	**/20**	**/20**	**/20**	**/20**	**/20**
Total Points (Oral and Poster Presentations)	**/40**	**/40**	**/40**	**/40**	**/40**

Figure 5 Presentation Assessment Rubric