

# Advancing Hydrological Management in the Mekong Delta through Technological Development and Educational Training

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*ABSTRACT: The NSF IREE grant was used to support collaborative research between the Networked Control Systems Laboratory and two universities in Vietnam: Danang University of Technology and Can Tho University. PI Linda Bushnell was the main coordinator of the research efforts. PI Bushnell spent two weeks at DUT teaching UW's Math308 course to a group of 34 students. In addition, she spent one week at CTU conducting research. Jon Chen, an undergraduate student at UW, spent six weeks at CTU conducting research. Tung Pham, a graduate student at UW, spent one week at CTU conducting research. The course and the research were successful. In addition, a new graduate student from CTU, Nghi Nguyen, has started at UW for his MS program and will be working on this research with PI Bushnell.*

## INTRODUCTION

- Name of awardee institution for current NSF award: University of Washington, Department of Electrical Engineering.
- NSF Grant No. ECS-0621605
- A brief summary of work being carried out under current NSF Award: Current work is to develop a low-cost, data-logging salinity sensor, to develop an interface software system using LabVIEW that will display the sensor readings in a way to facilitate analysis, and to apply control theory tools to models of the Mekong Delta river system to come up with an optimal schedule for opening and closing the sluice gates on the river to optimize the agriculture and aquaculture production.
- Reasons/Rationale for International Cooperation Carried out under IREE: PI Bushnell has built up a strong collaboration with researchers at CTU and this was a way to spend more time at CTU working one-on-one with the CTU researchers. In addition, the two students were able to spend more time in the labs at CTU and in field tests of the sensors.
- Provide an explanation of how the researcher was selected and why he/she was the best qualified candidate: PI Bushnell participated in the travel. In addition, she chose two students to travel to Vietnam to collaborate with the CTU researchers. Both Jon Chen and Tung Pham were currently working in the PI's laboratory on the project. Jon is lead on the LabVIEW Mapping Tool project and Tung is lead on the salinity sensor project.
- Anticipated research and education outcomes: PI Bushnell successfully taught Math 308, Linear Algebra, to a group of 34 students at Danang University of Technology. Jon Chen taught a course

on LabVIEW basics to a group of 5 students/instructors at Can Tho University. In addition, Jon had this group work on the LabVIEW Mapping Tool software, helping to develop the software into a second version. Tung Pham organized a field study to be conducted in the Mekong River, collecting data around one of the sluice gates.

- Information about host laboratory: Danang University of Technology and Can Tho University were both hosts to the PI and students. DUT is working closely with UW on an MOU to mimic the digital systems/embedded systems program. They invited five faculty from UW each year to visit and/or give lectures or courses at DUT. In addition, they send 4-5 students from DUT to UW each year to audit courses. They were awarded the Advanced Program in Digital Systems from the Vietnamese government, which means they are funded to excel in this area. CTU and the PI's laboratory have been collaborating for almost 3 years. Dean Dr. Cong is the main point of contact for PI Bushnell. During this trip, the PI and her students were in one of the laboratories in the Mechatronics Department.
- Name of travelers and the early-career category of each (assistant professor, associate professor, post-doc, graduate student, undergraduate student: Linda Bushnell (Research Assistant Professor), Jon Chen (undergraduate student), Tung Pham (graduate student).
- Dates of travel: Linda Bushnell (July 11 to Aug 2, 2008), Jon Chen (July 1 to Aug 16, 2008), Tung Pham (July 24 to Aug 6, 2008).

### **RESEARCH ACTIVITIES AND ACCOMPLISHMENTS OF THE INTERNATIONAL COOPERATION**

- Program of research carried out during international research experience: The PI and students worked on two of the NSF-funded projects while in Vietnam. The first task completed was to test the data-logging salinity sensor in the Mekong Delta around one of the sluice gates. Jon Chen, Tung Pham and Nghi Nguyen (from CTU) traveled to the Tra-Vinh Province in the Mekong Delta on July 29<sup>th</sup>. Unfortunately, the sensor that Tung had built for the trip was confiscated in the Taipei airport, so we were unable to test out that sensor. As a backup, we tested the YSI 6600 sensor and took readings on both sides of the sluice gate.

The second task was to work on the development of the LabVIEW software for the mapping tool that will display the sensors' data back in the laboratory. Jon Chen organized 4 other researchers at CTU to work on the project and they came up with a new version of the software program. In addition, documentation was completed.

- How the work on-site is related to the work of the current NSF award: It was essential that we test our sensors in the Mekong Delta to get an idea about what the salinity readings were in that area. Figure 1 shows the test data that we took with the YSI 6600 sensor. This data was taken around a large sluice gate in the Tra-Vinh Province of Vietnam. The picture shows how the salinity varies around the gate (in salinity units). Note that this was the "wet" season in Vietnam, so the salinity was not as high as in the "dry" season.

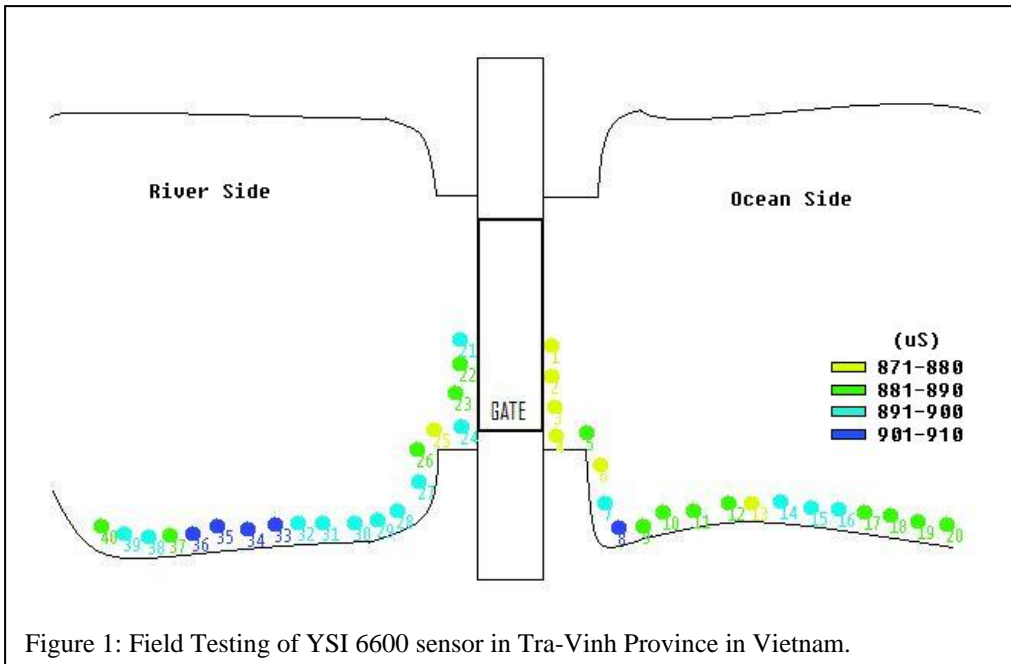


Figure 1: Field Testing of YSI 6600 sensor in Tra-Vinh Province in Vietnam.

**TABLE 1**

Conductivity readings for the YSI sensor and our sensor (DL = our data-logging sensor), including the average of our salinity sensor.

YSI (mS)	DL 1 <sup>st</sup> (mV)	DL 2 <sup>nd</sup> (mV)	DL 3 <sup>rd</sup> (mV)	DL 4 <sup>th</sup> (mV)	Avg DL (mV)
63.5	472	473	473	473	472.75
61.3	483	485	485	482	483.75
56.4	502	504	502	503	502.75
54.4	525	528	526	528	526.75
51.9	536	537	538	539	537.5
49.1	556	557	557	557	556.75
46	575	578	576	578	576.75
42.8	632	635	634	636	634.25
38.3	658	654	655	656	655.75
35.7	680	684	684	681	682.25
31.8	723	724	723	722	723
28	760	762	762	764	762

- A substantive description of the general interaction between researcher and host laboratory during the international research experience: Jon Chen stayed at the host laboratory in Can Tho University for 6 weeks. Linda Bushnell and Tung Pham stayed there for 1 week each. In addition, PI Bushnell was at a host lab in Danang University of Technology for 2 weeks before her trip to CTU.

At DUT, PI Bushnell taught a course, Math 308 – Linear Algebra, for 34 students. She interacted with a group of 20 researchers who were working on a project for Intel. The students received credit and grades for the UW-based course. The students had homework, a midterm and a final.

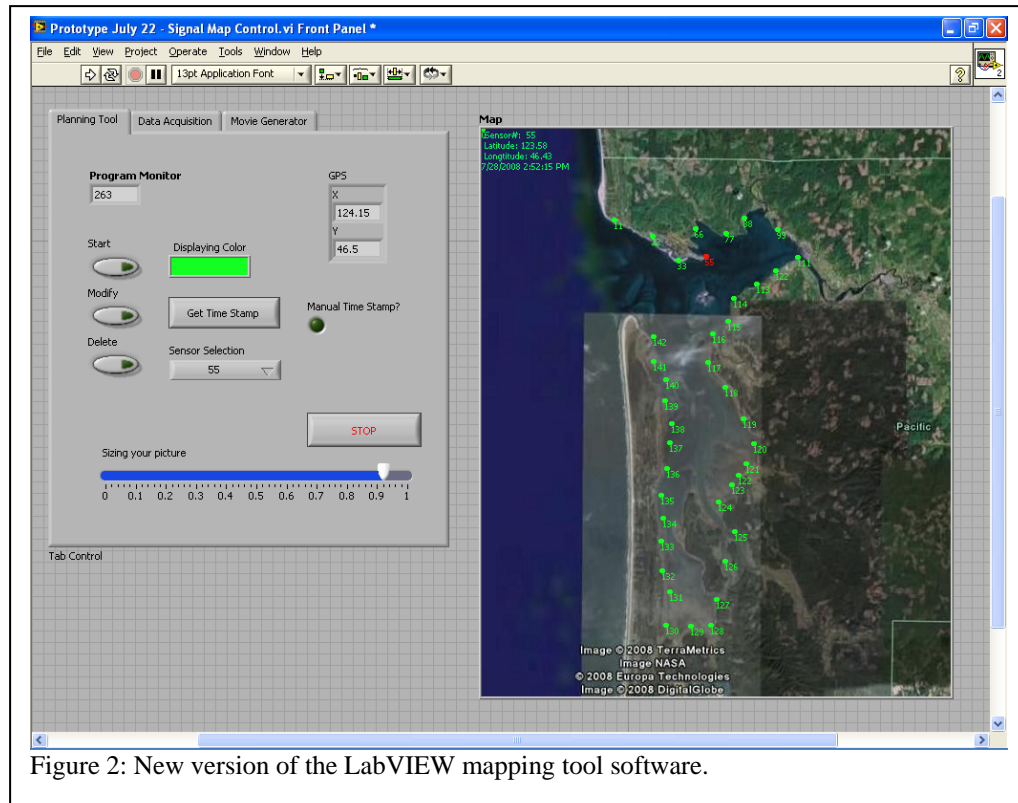


Figure 2: New version of the LabVIEW mapping tool software.

In addition, they paired up into two-person teams to present a project (how linear algebra is used in various fields such as game theory, cryptology, biology, structural design, etc.).

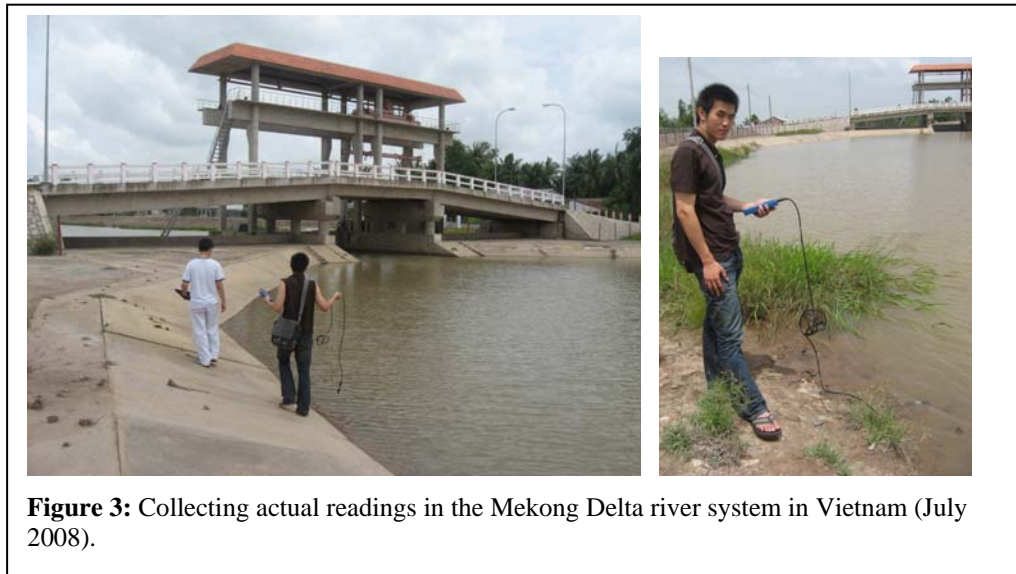
At CTU, PI Bushnell worked in a laboratory with other researchers. She directed the design and collection of the experimental data around one of the sluice gates in the Mekong Delta.

At CTU, Jon Chen worked with 4 other researchers on the LabVIEW mapping tool project. Jon stayed at CTU long enough to teach a LabVIEW Basics course to the 4 researchers. He also directed the project and supervised the 4 researchers. They were able to come up with a new version of the interactive software for displaying the sensor data on a jpeg map. When Nghi Nguyen (from CTU; our new graduate student at UW) came to UW, he was already up to speed on the LabVIEW project, having worked with Jon over the summer. Jon came back to UW for 2 weeks to hand off the project to Nghi and one other student, Phuong Truong. At this time, Phuong and Nghi are finishing up this software for the testing phase.

At CTU, Tung Pham organized a trip to collect data in the Mekong Delta, collected the data and analyzed the results. Tung brought two of the sensors he made in the UW lab and one commercial sensor. One of the sensors (the new, phase II sensor) was confiscated in the Taipei, Taiwan airport, and hence, could not be tested in Vietnam. Tung was able to test with the other sensors to collect the data shown above.

- Discuss the research accomplishments of student(s) during the trip: Jon Chen developed a Phase II version of the LabVIEW software for planning, analyzing and displaying sensor data on a jpeg map. See Fig. 2 above. The specific example of this project was to display sensor readings taken in Willapa Bay (WA State) and the Mekong Delta on jpeg maps. Jon had a group of 4 researchers at CTU who learned LabVIEW and then helped to update the software. They were successful in creating a new version of the software, which is in the final stages of tweaking and will be ready for testing soon.

Tung Pham stayed at CTU only one week, but was able to gather data in the field around one of the sluice gates in the Mekong Delta. He took two sensors to gather data during a one-day trip. Advance permits were not obtained, so the testing could only be done in one day.



### **BROADER IMPACTS OF THE INTERNATIONAL COOPERATION**

- How the supplement award promoted diversity: PI Bushnell and two students went to Vietnam to work with researchers and students at Danang University of Technology and Can Tho University. During Prof. Bushnell's course at DUT, the makeup of the class was about 25% women. Jon Chen is from Taiwan and Tung Pham is from Vietnam.
- How the supplement award helps expand the original scope of the current award: The supplemental award allowed PI Bushnell and two students to travel to Vietnam to collect data on the Mekong Delta river system. This could not have been done without the grant.

PI Bushnell was also able to teach UW's Math 308 course at Danang University of Technology on this supplemental grant. This had huge benefit to the 34 students at DUT and also for Prof. Bushnell.

Prof. Bushnell also gave seminars at CTU on her research in sensor systems for the Mekong Delta.

- How the travel fosters closer future interaction between awardee institution and host institution: After traveling to Vietnam the first time in April 2007, PI Bushnell invited one student from CTU to apply to UW for an MS degree. The student, Nghi Ngyuen, is now at UW and is working in Prof. Bushnell's laboratory. Nghi is responsible for overseeing the whole project on sensors in Vietnam.

Furthermore, Prof. Bushnell is in contact with researchers at DUT and CTU for the current project and for future collaborations.

- How the visit has helped to enhance international perspective for the U.S. researchers. Include information on activities that increased the researcher's familiarity with foreign languages, culture, and applicable technological trends and business practices: This was the second trip to Vietnam for Prof. Bushnell. The first trip was for 2 weeks in April 2007. That trip was only to CTU to meet

the researchers and to give seminars. For this second trip, Prof. Bushnell stayed for 3 weeks and taught a 2-week course at DUT. She gave seminars at CTU and also did research at CTU. Prof. Bushnell learned some Vietnamese and was immersed in the Vietnamese culture for 3 weeks.

Jon Chen stayed in Vietnam for 6 weeks and learned more of the Vietnamese language. He interacted with more students and researchers during this time. He learned a lot about the culture and food and was able to travel after his work was done to other parts of the country.

Tung Pham is from Vietnam, so he was comfortable in the culture and with the language.

## DISCUSSION AND SUMMARY

- Summary of the most significant accomplishments of the international research experience: We were able to take real sensor readings in the Mekong Delta river system near one of the larger sluice gates. In addition, we were able to design and implement a Phase II version of our LabVIEW mapping tool software.
- Recommendation for “Best Practices” in future operation of the IREE Program: My only recommendation is to mail the equipment vs. taking it with you in your luggage.

## ACKNOWLEDGEMENTS

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## BRIEF BIOGRAPHIES OF RESEARCHERS

**Linda Bushnell** received the B.S. degree and the M.S. degree in electrical engineering from the University of Connecticut in 1985 and 1987, respectively. She received the M.A. degree in mathematics and the Ph.D. degree in electrical engineering from the University of California at Berkeley in 1989 and 1994, respectively. She was the Program Manager of the Systems & Control Program at the U.S. Army Research Office and an Adjunct Assistant Professor of Electrical and Computer Engineering at Duke University from 1994 to 2000. In September 2000, she joined the Electrical Engineering Department at the University of Washington, where she is now a Research Assistant Professor. Dr. Bushnell's research interests include networked control systems and control and sensors for hydrology applications.

**Tung Pham** received his BS degree and MS degree in Electrical Engineering at the University of Washington in 2006 and 2008, respectively. He specialized in the area of embedded systems. For his graduate work, he designed and constructed a data-logging salinity sensor. He is now employed at B.E. Meyers in WA State.

**Jon Chen** received his BS degree in Electrical Engineering at the University of Washington in June 2008. He specialized in the area of embedded systems and control systems. He is now employed at National Instruments in Taipei, Taiwan.

## PHOTOS



**Figure 4:** Various Photos from the trip to Danang University of Technology in Vietnam.



**Figure 4:** Various Photos from the trip to Can Tho University in Vietnam.