Development of a Synchronous Distance Education Project Between UGA and Kagoshima University

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Abstract

An IT architecture was proposed herein to deliver synchronous distance education materials from UGA to Kagoshima University. This architecture was designed for extensive computer and Internet resources such as gigabits network, video conferencing and remote control software. But we found that it could be adapted to minimal IT resources such as cable modem at 1 Mbps and audio-only feedback between teacher and students. System performance and student feedback for the first 7-week class period are reported herein.

Introduction

One of the thrusts in the UGA/Biological & Agricultural Engineering Department curriculum is to enhance the experiential learning aspects for our engineering students during class lectures as well as during laboratory experiments needed for the course. Based on Student Technology fees and departmental funds, the Collaborative Distance Education (CDE) Laboratory was created in Summer 2003 to achieve the first goal (Thai1). This lab currently has 30 workstations for students and a teacher station connected to an isolated 1.0 Gbps LAN with direct connection to the UGA Gigabit backbone. These PCs are equipped with specialized software to allow synchronous collaborative interactions between teacher-students and student-student for in-class projects, as well as for receiving classroom instructions from experts located outside the Athens campus via videoconferencing technologies. The second goal can be met by improving and increasing access to our laboratories, along with more test equipment and lab stations, however, expanding laboratories requires sizable investments in equipment and lab-proctoring personnel. Our innovative approach capitalized on the facts that about 90-95% of BAE students have PCs and Internet access from their residence, and that our teaching test apparatuses are accessible and controlled through networked PCs. Thus in Spring 2002 and using the ENGR-4540/6540 course (Applied Machine Vision) as a starting point, we had designed a computer system, consisted of a Web/FTP server and 2 completely equipped test stations, that allows students to access the test stations from anywhere in the Web to perform their laboratory assignments in spectrometry and machine vision techniques without having to be physically present in the laboratory, but without loosing the touch and feel of actual hands-on experimentation (Thai2). This system is operational since January 2002 and has good performance even from modem connections at 56 Kbps and 60
Naturally, in the next phase of development, we seek to combine the 2 existing resources to create a state-of-the-art Collaborative Distance Engineering Education facility that can serve on-campus students as well as off-campus students who can be in industry for continual education purposes or are in other universities pursuing standard academic goals. Thus we propose to create a Distance Education program between The University of Georgia and Kagoshima University (UGA sister University in Japan) using the Applied Machine Vision course as a demonstration vehicle to "go on line" in January 2004. This project answers the call for internationalization at UGA and would be among the firsts of such facilities. Future expansions of this concept to other UGA strength areas would garner interests from industry for just-in-time training of its employees and also funds from public or private educational organizations overseas.

As the BAE computer network infrastructure had been built and ENGR-4540/6540 was already taught once, we do have most of the instructional materials on hands at the present time. Although some KU students are conversant in English, teaching from BAE-UGA to students in Kagoshima-Japan still has many challenges to overcome: KU Agricultural Engineering Department computing infrastructure is only adequate for a small student group; converting the existing instructional materials to be useful in a mixed synchronous-asynchronous mode of learning, especially into another language; issues of student motivation levels and learning retentions at the remote site; a 14-hour difference between Athens and Kagoshima; just to mention a few. To alleviate these problems and to respond effectively to issues as they arise during the progress of this project, each university has a team of faculty and staff dedicated to this project: on the UGA side, the teaching faculty of ENGR-4540 and staff from the Office of Instructional Support & Development (Dr. Chi Thai, Michele Estes from OISD and a Ph.D. student from the College of Education); on the KU side, faculty of KU College of Agriculture (Drs. Kazuo Morita and Koichi Iwasaki, Agricultural Engineering, and 2 graduate engineering students). The overall goal is to develop an effective Distance Education program between the University of Georgia and Kagoshima University using the Applied Machine Vision course (ENGR-4540/6540) as a demonstration vehicle. The specific objectives are:

1) Design and implement a computer network architecture suitable for teaching interactively local and remote students simultaneously.

2) Implement a software approach that supports interaction and collaboration features in the lecture delivery task, between teacher and students, as well as between students (local and remote sites).

3) Develop an Instructional Design framework so as to provide an effective environment for learning and assessment in the area of machine vision technology suitable for distance education delivery.
Description of Instructional Facilities

Following a computer system engineering approach, there were 2 major aspects that need to be addressed (Shi et al.):  
1) Development of a supporting platform (i.e. communication protocols) for real-time interactive distance learning between UGA and KU campuses.  
2) Appropriate software development, showing the same view of the contents being delivered by teacher to local and remote students, capable of many interaction channels, along with facilities for event capturing and activities recording. These recorded documents can be edited and published as courseware at a later time.

A) Communication Protocols & System Architecture

To be compatible with KU campus, we will be using TCP/IP protocols for all computer communications including technical content delivery and videoconferencing for "people" contact. This method is most flexible as it uses the existing GigaBits Ethernet in Athens campus, however there exists a Quality of Service (QoS) problem as the existing network routers are not programmed to give priority to videoconferencing packets within the World Wide Web. Our approach is to offer this class MWF from 8 to 9 AM (GA time), which translates into 10 to 11 PM (Kagoshima time) (which is asking a lot of dedication from the KU students). Teaching was planned to be done from the CDE Lab of Driftmier Center (UGA) to local Athens students, while the KU students will be joining in from Kagoshima via the Internet, consequently we need to coordinate the information flow between 3 physical facilities:

- The UGA Collaborative Distance Education (CDE) Laboratory, equipped with 30 PCs for students and a teacher station connected to an isolated 1.0 Gbps LAN.
- The UGA web-enabled Spectral Imaging (WSI) Laboratory, consisted of a Web/FTP server and 2 completely equipped test stations.
- The KU Food Safety Education (FSE) Laboratory with a total of 10 Notebook PCs connected via a 100 Mbps Ethernet network.

Other design criteria for the IT system architecture between UGA and KU were:

- Symmetry, so that either UGA or KU can be the originating instruction site for local as well as remote students in the future.
- Bandwidth minimization of all overseas Internet communication lines.

After some iterations, the final system architecture chosen for our project is described in Figure 1 where one can recognize readily the 3 physical labs.

In Figure 1, let's start with the CDE Lab, wherein the Athens Teacher Station is in full interaction with the local UGA student PCs, and other tools needed for instruction such as a screen projector to let local students view its desktop, a Tablet PC for hand-written notes, and a FireWire camera for props or equipment demonstration. The Athens Teacher Station can also remotely control the Machine Vision Stations of the WSI Lab (which is located in a different part of the BAE building) to demonstrate the use of spectrometry and machine vision equipment to students residing in the CDE Lab. Thus lecture, demonstration and laboratory activities are merged seamlessly into the Athens Teacher Station which data screens can also be sent to the...
**Figure 1:** Information Flow between Athens and Kagoshima
Kagoshima Teacher Station, which in turn relays these data screens to the local KU student Notebooks or via its own screen projector for the KU students to watch. This daisy-chain scheme is used to satisfy the "symmetry" and "bandwidth minimization" criteria mentioned above. The human presence and interaction aspects between both sites are fulfilled using video conferencing equipment such as the Tandberg 880 system on the UGA side and the ViaVideo II for the Kagoshima side (H.263 (video) and G.722 (audio) protocols). In other words, we use only 2 long distance Internet lines during a typical class period. Furthermore, the class instructor can remotely administer the Machine Vision PCs from home during off-business hours, while the students can log in from home into the Web/FTP Server (http://weblabs.engr.uga.edu) to perform their lab assignments and transfer lab data to their home computers for further analysis. Lastly, arrangement for remote access from KU into a UGA PC named QuantIm is also necessary, because our departmental software site license does not allow us to install a copy of the image processing software called QuantIm on a PC outside of the BAE department.

B) Teaching Modalities and Software Operations

The previous section showed that a daisy-chain remote control scheme, via the teacher stations, was required to achieve the data sharing and remote control features needed in this project. This is achieved using a software suite called NetSupport Manager (NSM- V.8.1) which has 2 components: NetSupport Control (NSC) and NetSupport School (NSS). NSC is deployed on the teacher stations of both sites. NSS is deployed on local student PCs for each site such that the Control Agent is on the local teacher station, while the Clients are deployed on the local student PCs (resulting in NSS-UGA and NSS-KU). Some of the main features of the NSS component are as follows:

1) The teacher can "Share-Watch-Control" each student PC on a one-on-one basis. This is used for quick response to student difficulties.
2) The teacher can “Show” his or her PC application to all or selected student PCs.
3) The teacher can “Exhibit” a selected student work to the rest of the class, or organize the class into sub-groups with assigned group leaders.
4) The teacher can send out instant surveys to check on the class understanding of concepts being presented (Yes/No answers).
5) Facilities for File Transfer, Distribution and Retrieval, and Video Playing are also available.

During a typical class session, the UGA teacher station interacts with the UGA students using NSS-UGA, it also connects to the KU teacher using NSC, and via the KU teacher station interacts with the KU students using NSS-KU. This is the architecture currently used to teach UGA students between the Tifton and Athens campuses, so it does work but it does take some time for the typical instructor to get used to know when and how to interact with whom. Typically, a PowerPoint slide can be shared to all students via the screen projectors on both sites, and the UGA teacher can interact with any student PC whether located in Athens or Kagoshima and, most importantly, change that student PC desktop content via the teacher own mouse and keyboard.

If the UGA teacher needs to show props, a FireWire document camera is available to send
images to all students via the communication channels established previously. Occasionally, when free-hand notes or graphics may be needed, a Tablet PC is also available for this purpose (it essentially becomes another "student PC" that gets chosen to be "exhibited" to other students).

As a backup, all pertinent screen interactions and speech clips occurring on the UGA teacher station will be recorded into a multimedia MP3 file using a software called Silicon Chalk\textsuperscript{4} for later publication on the web for all students to access for review. For local BAE students, we do plan to use Silicon-Chalk at the beginning of the project, essentially to allow them to have their own electronic copy of the class activities for later review (please see Thai\textsuperscript{5} for more details).

All course experimentation work will be done via the Web requiring only the software "Internet Explorer" and "NetMeeting" from any student PC regardless of location. The experimental procedures and tutorials will be available via the Web as well. The example at Thai\textsuperscript{6} has narrated tutorials showing how to log on the web server as well as how to use the spectrometry software.

**Instructional Design**

Education in the USA really means to provide a job skill upon graduation from high school or university, while in Japan education and learning is a lifelong process going through distinct phases (Rohlen and LeTendre\textsuperscript{7}): children up to 10 years old are left to follow their inclinations; incremental socialization processes start from elementary to middle school, shifting from family attachments to peer groups and teacher-centered learning. In the "intense years" of high school (Fukuzawa and LeTendre\textsuperscript{8}), learning techniques shift to small-group discussions, cooperative projects and self-reflective criticism preparing students for the university and for work in the adult world. At Kagoshima University, most subjects has only one 90 minute lecture per week with the professor (with minimal inquiries originating from students during class), afterwards students are pretty much on their own if they need further help, so it was assumed that Japanese students would be better prepared to learn on their own via Distance Education than students from USA. Ironically, distance education courses are not currently recognized for official credit by Japanese education ministries and university infrastructures, thus our project would be breaking new ground for Kagoshima University regarding issues such as information technology and network security to course administration.

An initial trial class was performed in May-June 2003 with a small number of KU students. This trial run involved a PowerPoint slide set for class lecture narrated in English, and an actual web-enabled spectrometry experiment, both accessible via the web from Kagoshima (Thai\textsuperscript{9} and Thai\textsuperscript{6}). The lesson learned was that we need to provide KU students in advance with the same set of core instructional materials but narrated in Japanese. Fortunately, a member of the KU faculty team, Dr. Koichi Iwasaki, happened to be on sabbatical leave with the UGA BAE department from July 2003 until mid March 2004 and had agreed to perform this task.

Another complication arose from the differences between the academic calendars between the 2 universities. The normal Spring Semester for UGA starts around January 9 and ends at the beginning of May, while the KU calendar needs a 1-week in early February for final exams, and
has Spring vacations from February 20 to April 5. Our plan was to let the UGA classes to continue as normal and to record these lectures during these "time gaps" for later use by the KU students when they get back in class, then in May we would teach directly to the KU students only, as the UGA students had finished their term.

All assignments and tests from the Athens students will be handled in the traditional manner. The same assignments will be distributed to KU students using e-mail and collected from them the same way. However these e-assignments will be corrected using a Tablet PC system whereas the instructor can manually mark up corrections, comments and grades in the normal manner. The tests at the KU site will be performed under the supervision of the KU faculty, and e-mailed to the Athens teacher for grading and return.

KU student contact times will be scheduled via video-conferencing meetings, while the Athens students can use the video-conferencing route or the traditional face-to-face meeting. For the ultimate interactive and collaborative needs, we can use a connection between Tablet PCs on both sites (UGA and KU), and using the existing audio capabilities of NetSupport Control to conduct an instructional session similar in functionality to an "old-fashioned" chalkboard session, but extended into cyberspace.

All students will also have access to the UGA WebCT facilities to complete pre-course and regularly scheduled course evaluation surveys throughout the term. WebCT will also be used as the focal point for students-teacher off-line discussion sessions and for class materials archiving.

**Project Implementation**

By September 03, the IT architecture as described in Figure 1 was checked within the University of Georgia network and we ascertained that the proposed system was operational. In October 03, Dr. Morita bought 10 networked laptops for KU students, and the project had received the blessing from the KU International Committee. The next step was to request the KU network administration to open up several IP ports needed for the video conferencing and NetSupport software to work properly. The KU response was that they needed to hire consultants to study the security risk of opening the KU firewall for the requested ports, and that we could expect their final response by mid-January 04 (actually, we had not received any response by the end of February 04). However, the first day of class was already scheduled for January 9, 2004. At that point, the entire project was in jeopardy, but the KU students were still very much enthusiastic about the project. Consequently, the goal of the project drastically changed from the extensive system described in Figure 1 to finding a way to do synchronous distance education from UGA to KU with minimal IT resources. By the end of October 04, we had come up with a possible solution that was to teach into a desktop PC at one student apartment that has commercial cable modem services at a rate about 1 Mbps. But in early November 04, author Thai had health problems and could not go to work until January 2, 04, so we could not verify the feasibility of this solution until a few days just before classes started on January 9. With a cable modem rate of 1 Mbps, we found out that we could not maintain video conferencing and NetSupport Manager software to be active at the same time. Fortunately, the NetSupport Manager suite had
audio support, thus the final solution was for author Thai to don an audio headset and to use NetSupport Control (NSC) software to transmit PowerPoint slides to the student PC in Kagoshima, and to deliver lectures as normal, except that students and teacher can only hear each other, with no video feedback as planned in Figure 1. We also used the 2nd software component NetSupport School (NSS) to exhibit to Kagoshima the desktop of a Tablet PC for those occasions that needed ad-hoc hand-written notes or the desktop of another remote networked computer when we needed to do demonstrations of our spectrometer or video camera equipment (being controlled by said computer). The following photographs should give the reader an idea of a typical class session. Figure 2 depicts the instructor station showing the Tablet PC being used, with the main desktop in the back displaying the remote spectrometer in operation, while Figure 3 depicts the student PC in Kagoshima displaying live hand-written notes from the instructor at UGA.

![Figure 2: Instructor Station at UGA.](image1)

![Figure 3: PC at student apartment in Kagoshima.](image2)

Figures 4 and 5 showed how students typically gathered around the student PC for lectures, please note the positions of the keyboard in Figures 3 and 4 (bottom right) as they would give the reader an estimate of the size of the room. And as usual, some students were "engaged" in the lecture, while others were "just there" to enjoy the TV show.
Fortunately or unfortunately, depending on one's viewpoint, no local UGA students were enrolled for this class, thus there were only the 7 graduate students from KU in this project as it was implemented. The biggest issue was the language problem as the live lecture was delivered in English, fortunately there were among the Kagoshima group 2 Tanzanian students who were
fluent in English and they could explain back in Japanese difficult sections to their Japanese colleagues. By February 20, 2004, we had 7 weeks of classes and had finished the Spectrometry part and the KU students began their Spring vacations. When they get back in April, we will continue with the spectrometry web lab and get further along into the machine vision part of the course throughout the months of April and May (so we should be able to report more results at the ASEE meeting in June).

The WebCT pre-course survey showed both expected and unexpected results, and some results are reported here:

1) Most Japanese students were more comfortable with written English than with spoken English, consequently more hand-written notes were generated to explain more complex sections like the one on the "Grating Equation" and "Overlapping Diffraction Orders".
2) Most students were agreeing that they had good understanding of chemical concepts like atoms, electrons and molecules, and this turned out to be true as the class progressed.
3) Regarding their understanding of multivariate integral and differential calculus, half agreed that they had a good understanding, while the other half disagreed, and it turned out that all of them had problems knowing when to apply properly the differential or integral approaches in solving a homework problem about Beer-Lambert Law (light absorption in optical materials).
4) Most claimed that they don't have a good understanding of matrix algebra but this will be important in the future when we get into the Image Processing part, so the students were told to review linear algebra during their Spring vacations.
5) The majority claimed poor understanding of trigonometry and geometry, but only 1 struggled through the homework about reflection and refraction laws. This also warns us to go through the Lens Theory section much more carefully in the future.

When asked about the usefulness and usage pattern of the provided PowerPoint modules narrated in Japanese, so far only 1 student answered that survey, so we are not sure if this extra feature was not useful to them, or that they were leery of passing judgment on the work of Dr. Iwasaki who will come back to KU in March. A formative course survey was given at the end of the first 7 week-period, and so far only 2 students completed the survey, making us wondering about how many of them will come back for class in April. However the responses from these 2 students were encouraging:

1) Class lengths were just right or a little short.
2) The difficulty level and pace were just right.
3) One "strongly agreed" or the other "agreed" that what they are learning in this class is relevant to their future careers as engineers.
4) During group work and doing homework with a partner were found to be useful.
5) The activities that help them learn best were the lectures and homework assignments.

**Conclusions**

We have shown that the instruction model described in Figure 1, which required extensive computer and Internet resources, could be adapted to an unplanned situation with minimal IT resources (e.g. minimum network rate of 1 Mbps) and still delivered the instructional contents...
needed.

We have found that synchronous and asynchronous facilities complemented each other in this distance education project.

Overall and so far, the KU students seemed to go through the materials at a slower rate as compared to their US counterparts (from the Spring 2002 class), thus we don't think that we can maintain a parallel pace between the UGA and KU classes in the future, unless only KU students fluent in English are allowed to take this class.

BIBLIOGRAPHY

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BIOGRAPHICAL INFORMATION

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Associate Professor, Biological & Agricultural Engineering Department, University of Georgia. Research interests are in the development of optical sensing systems for stress and disease detection in peanut and cotton plants and for evaluation of quality of agricultural products using standard UV-VIS-NIR spectroscopy and Multi-spectral Imaging, and in the development of distance learning technologies and methodologies.

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