CLASSROOM EXPERIENCES FOR THE VISUALLY CHALLENGED COMPUTER LITERACY STUDENT

James Wolfer [1]

Abstract — *Blind or severely visually impaired students face a variety of unique challenges in the course of pursuing their college education. While some of these challenges are intrinsic, often a modest adjustment to course content can assist in making material more accessible. This work describes a series of experiences designed to illustrate computing concepts and applications in a manner accessible to both blind and sighted students in a computer literacy class. Using a combination of custom and publicly available resources, these "hands-on" demonstrations include the tactile exploration of both 2D and 3D images and volumes, interaction with small, mobile, robots, and data sonification including the sonification of visual imagery.*

Index Terms — Assistive Technology, Computers in Society, Computer Literacy, General Education, Technology Education

INTRODUCTION

Blind or severely visually impaired students face a variety of unique challenges in the course of pursuing their college education. While some of these challenges are intrinsic, often a modest adjustment to course content can assist in making material more accessible. This work describes a series of experiences designed to illustrate computing concepts and applications in a manner accessible to both blind and sighted students in a computer literacy class. Earlier work [1] gave a general overview of a computer literacy course, in this work we expand the discussion to include specific adaptations for the visually challenged student.

From an instructor's perspective, it is critical that the approach to teaching computer literacy engage the students as well as develop skills. The use of assistive Technologies should not simply engage students, but also act as a bridge toward mutual understanding. As Burgstahler and Ladner [2] describe, society can benefit from the increasing participation of people with disabilities in the computing fields. Working together in the classroom can for a bridge to future collaboration, as described by Slowik, et al [3].

Finally, a computer literacy course must address the immediate needs of the stake-holders: students, instructors, and employers. Bartholomew [4], for example, had employers rank the relative importance of a variety of skills. The results ranked spreadsheet skills first, followed by word processing, database, and presentation skills.

COURSE OBJECTIVES

Recognizing that we must address both the skills and awareness components of computer literacy, we have designed a course that devotes approximately half of the instructional time to skills acquisition and half to developing a level of computer awareness. Over time, the skills component has been well defined, including hands on laboratory experience with each of the basic component skills: word processing, spreadsheets, database, and presentation.

Observing that we must develop a variety of topics from scratch, and that time is limited, we elected to create a class where topics were introduced through a sequence of targeted experiences and demonstrations drawing on internet resources, faculty research, and contemporary culture. To that end, our educational objectives include:

- Basic computer vocabulary
- Insight into algorithms
- A hint of theoretical computing
- Legal, ethical, and societal
- Computing as communication
- Applications of computing in disciplines ranging from medicine to remote sensing.

To reach these instructional goals, we deployed actual demonstrations and/or hands on classroom experience both to engage students and to make them aware of applications beyond those already familiar to them. In addition, we make the material accessible to students with a variety of visual challenges.

SKILLS INSTRUCTION

The skills component involves basic instruction in the use of the Microsoft Office suite for developing papers and presentations. In order to make this suite accessible for the

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visually challenged student the university provides access to Window-Eyes [5]. This software allows the student to navigate a typical screen using keyboard shortcuts coupled with a synthetic-voice screen reader. The software is application aware, and through this interface the student is able to complete most of the skills requirements. One downside to the commercial assistive software is the lack of a standard interface, such that skills acquired using Window-Eyes do not transfer transparently to competing systems such as the JAWS [6] system. An additional concern is the cost of this software for individual use. Hopefully we can adapt open-source solutions in the future.

BASIC VOCABULARY

A large part of the class is devoted to building basic vocabulary. Hardware concepts and components ranging from CPU's to the definition of bits and bytes are discussed. Memory, peripheral components, IO devices, and their interconnection are described and physically demonstrated. Following the mastery of the "language of computing" we move to develop insight as follows.

Systems, Theory, Algorithms, and Programming

We introduce Linux, and a discussion of the tradeoff between proprietary and open source solutions for both personal and business computing. We also discuss the role of open source for developing countries in the light of recent computer initiatives, and use this to start a discussion of computer security.

While computing theory and programming are not required in the computer literacy course, we would like for our students to have some insight into the foundations of computing. To this end we present the following demonstrations and discussions:

- Lindenmayer systems for plant morphology.
- Demonstration of a simple sort.
- Demonstration of Linear Search
- Demonstration of Binary search.

The sort and the searches are designed to reveal the concept of an algorithm. We do not show programs for doing these operations; instead we show by example how simple steps can solve complicated problems. By observing a search or sort happens, and by describing how a programmer might implement them, students gain insight into the nature of programming. For all students, this is at a descriptive level and no special accommodation, other than a note-taker, is made for the visually impaired.

Computer Graphics

While describing computer graphics we reference contemporary motion pictures, particularly those composed of computer generated animation. To gain an appreciation of the nature of graphics primitives, such as the pixel, we provide the following demonstrations:

- Mona Lisa pixel brightness
- Stereographic display monitor
- Genetic-Program Computer Art

It is during our discussion of computer graphics where a concerted effort is made to engage the sight-challenged students. In addition to carefully describing what other students are seeing we explore a variety of approaches for making visual imagery accessible through other senses. Specifically, we use both touch and sound to communicate aspects of visual imagery. For example, Figure 1 shows a processed image displaying binary texture. This image was subsequently mapped to sound [7] as illustrated in the sonogram of Figure 2. Other sonification systems are also demonstrated, including the vOICe system [8] and the Soundmural [9] system.

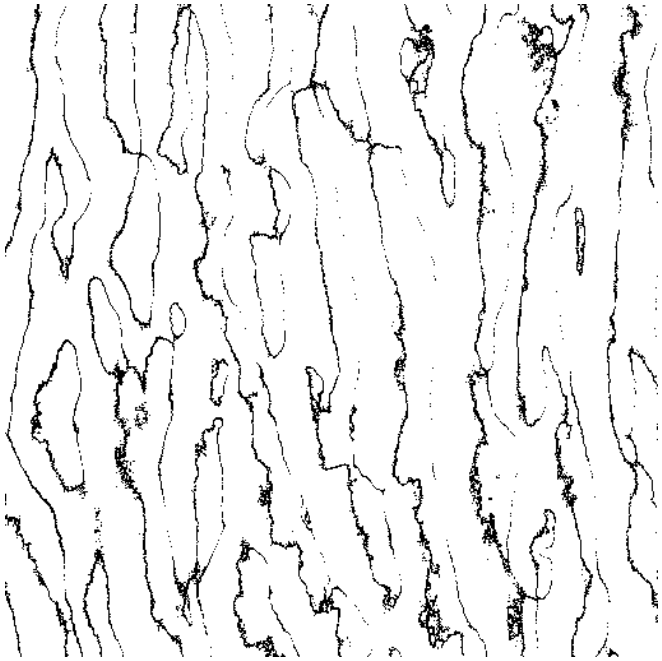

FIGURE 1
VISUAL TEXTURE

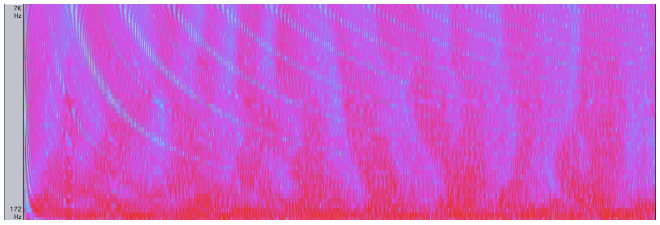

FIGURE 2
AUDIO SPECTROGRAM

Finally, we use computer graphics to make the transition from a discussion of images to artificial intelligence through genetically programmed art [10].

ARTIFICIAL INTELLIGENCE

In one sense Artificial Intelligence is the study of problems that are extremely difficult to solve and to for which we assume intelligence is required. On the other hand, it also provides a "mirror", a reflection surface against which to test our own presuppositions. It is in this sense we approach AI through a series of robot demonstrations. Specifically, we provide live demonstrations for the following:

- Khepera II
- BalBot robots
- Remote sensing

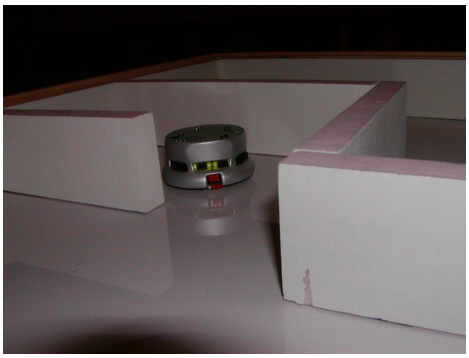

FIGURE 3
KHEPERA II ROBOT

The Khepera II robot shown in Figure 3 is a hockey-puck sized robot composed of a computer, two differentially driven wheels, and eight infrared proximity sensors. Driven in an obstacle avoidance mode, these robots traverse a maze. Students interact with the robot by placing barriers in front of them, forcing the robots to alter their behavior in real-time.

FIGURE 4
BALBOT ROBOT

The Balbot robots, shown in Figure 4, are dynamically-stable, inverted pendulums which balance through sensing their relationship to the surface on which they stand. Students interact with these robots by introducing minor perturbations to the robot's equilibrium, then observing the robot attempt to recover. The robot is also capable of exploring its surroundings while avoiding walls, people, and other impediments to its progress. Since visually impaired students can directly interact with the robots through senses such as touch and sound, they form a powerful illustration of the use of computers in a mobile platform. It also provides a transition into the use of these technologies in other domains, such as medicine, described next.

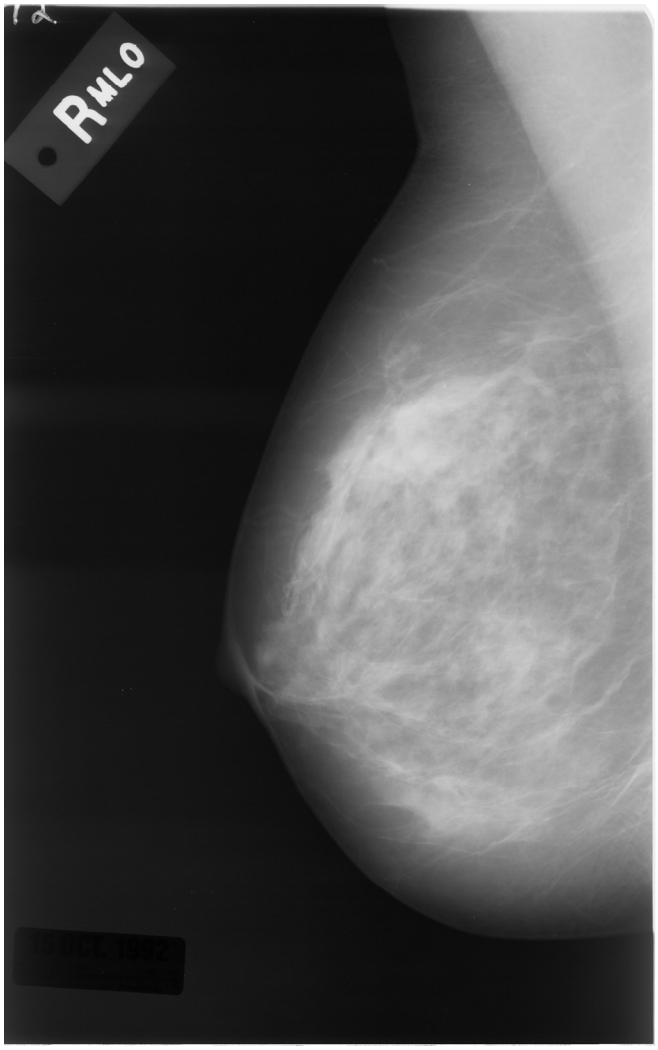

FIGURE 5
MAMMOGRAM

MEDICAL APPLICATIONS: CARDIOLOGY AND MAMMOGRAPHY

To further illustrate contemporary applications of computers, we demonstrate their use in medicine through illustrations of animated echocardiology, and the automated detection of ventricular borders. The students are exposed to the concepts of computer aided diagnosis, and we tie the discussion into the previous robot experiences by discussing robotic surgery.

We also show images of digital mammograms, describe the types of lesions that occur, and discuss the problems associated with the interpretation, storage, and retrieval of such large image databases. We also use this as a discussion point, exploring issues of privacy, law, and ethics. In order to engage the blind students we translate the medical imagery into sound, as described above, and into tactile explorations.

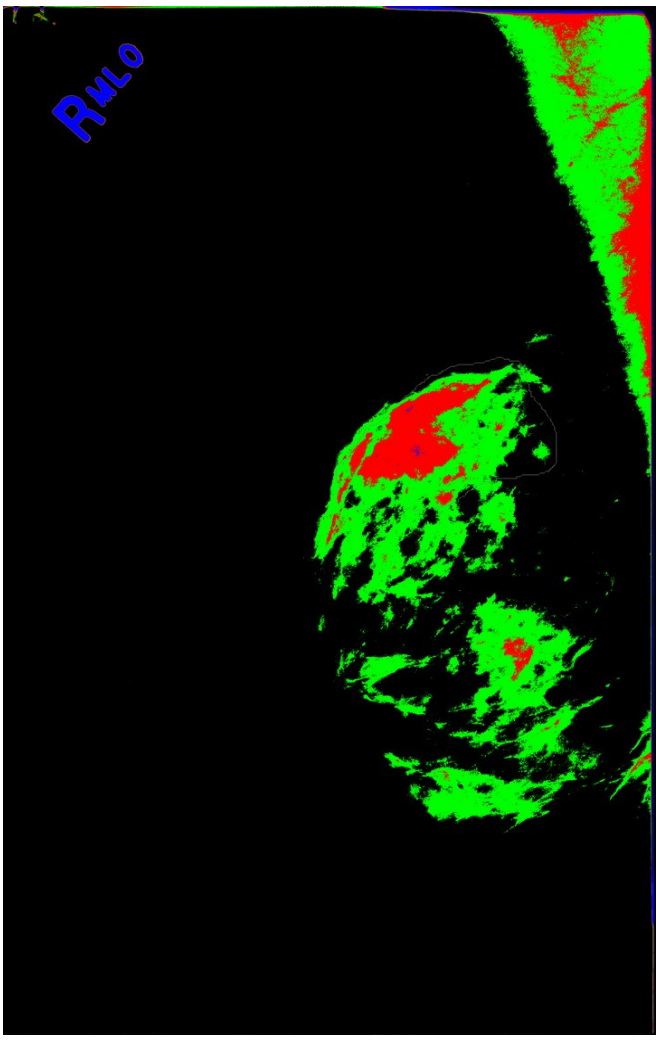

FIGURE 6
MAMMOGRAM

Specifically we expose them to:

- Haptic Mouse
- Phantom Omni
- Speech recognition

The Logitech IFeel mouse, along with custom software [11], is used to explore the texture of an image of the Mona Lisa. Using this interface the students receive tactile feedback coupled to the brightness of the underlying image.

We then use this as an additional information channel from the computer to help them to find a lesion in a mammogram such as those shown in Figure 5 and Figure 6.

In a similar vein, we introduce the Sensable Phantom Omni. This six degree-of-freedom, force feedback robot allows a realistic sensation of "touching" objects embedded in visual scenes. Again, this is a novel experience for most students, and substantially expands their experience base. It also begins a discussion of practical uses ranging from virtual clay sculpting to medical training.

Finally, we provide a demonstration of a commercial off-the-shelf speech dictation system. This gives the students insight into both the strengths and limitations of current technology in the context of something they do easily, by virtue of being human, but which is difficult for computers. It also gives the visually challenged student direct experience with an alternative interface which may afford immediate advantage for their academic pursuits such as report generation.

OBSERVATIONS AND FUTURE WORK

While the demonstrations described seem to create genuine interest among the students, they do not cover the gamut of possibilities for the visually handicapped student. In the future we would like to further examine the potential of open-source software such as the Adrianne [12] project for making technology more available to these students. We would also like to explore the role of aesthetics in making the interfaces more effective, by providing, for example, pleasant sound mappings for our images. Finally, we would like to explore the use of these technologies coupled with computer games to enhance their experience.

SUMMARY

We believe that we have crafted a series of experiences to augment the traditional lecture and serve to introduce the essence of computing ranging from programming and theory to artificial intelligence. By introducing a series of experiences that emphasize senses other than strictly visual and embedding them in experience-based lectures, we believe that we make the material both more accessible and more enjoyable to our visually challenged students.

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