Digital Imaging Experiences for Undergraduate Engineering Students

Kauser Jahan, John Chen, Shreekanth Mandayam, Robert Krchnavek, Beena Sukumaran, Yusuf Mehta, Jennifer Kadlowec, Paris von Lockette and Robi Polikar

Rowan University, College of Engineering
Glassboro, NJ 08028

ABSTRACT

Our project is an effort by a multidisciplinary team of engineering faculty members at Rowan University to integrate digital imaging technology (DIT) into the undergraduate engineering curriculum. It builds upon the experience and interest of faculty to promote new topics and innovative methods of teaching. The work is an effort to provide students with the skills directly relevant to the evolving needs of the industry and the marketplace. Projects involve the development of digital imaging curriculum and focus on the creation of a leading edge digital imaging laboratory/studio to facilitate the use of nontraditional learning approaches that encourage interactive learning, team building, and creative problem solving among students and instructors. A number of visual experiemtns will be developed and used to introduce students to the multidisciplinary engineering principles and use of DIT. Some of these activities will be used for K-12 outreach activities. Though our dissemination efforts we will encourage other schools to adopt our curriculum and modules to enhance their undergraduate curriculum and to promote engineering education outreach opportunities.

INTRODUCTION

Digital imaging is a burgeoning field that represents one of the major research and development focus areas of the electrical industry today, with sales exceeding 10 billion dollars per year. Digital Image Technology (DIT) is a highly successful technology that helps engineers and scientists characterize materials both at the micro and macro level. A digital image can be an enormous source of information for engineers and scientists. The topographic features of the earth, the severity of air, land and water pollution and the microstructure of materials are just some common examples where DIT is of tremendous significance. DIT technologies such as X-ray tomography, optical or infrared imaging provides extensively detailed information that is invisible to the human eye thereby enhancing the understanding of the material or the process. Engineers play an important and expanding role in this exciting field, yet undergraduate engineering students in civil and environmental, chemical and mechanical are rarely exposed to digital imaging through their coursework. This educational project is a bold effort by a multidisciplinary team of engineering faculty at Rowan University to integrate *digital imaging technology* (DIT) in their undergraduate engineering curriculum.

Traditionally courses related to digital image processing reside in the Physics and Electrical Engineering curriculum. Digital image processing is a rapidly evolving field with growing applications in science and engineering. All engineers play an important and expanding role in this exciting field, yet undergraduate engineering students in civil and environmental, chemical and mechanical are rarely exposed to digital imaging through their required traditional engineering coursework.

It is important to note that DIT is becoming more and more appealing and popular in consumer products such as digital cameras, scanners, and high-definition television (HDTV). The new generation of students is also familiar with imaging techniques common in biotechnology such as X-rays, CT scans, MRI, mamograms and ultrasound etc. Educators are being challenged to develop teaching tools that engage students' imaginations and provide a platform for integrating state-of-the-art modern technology into the undergraduate curricula. Therefore it is expected that the activities proposed would generate enthusiasm and enhance student understanding and learning. In recent years NSF has funded a number of educational efforts in digital imaging [DUE #9553741, DUE#9650842, DUE#0126637, DMR #9820336, REU#0097593]. Most of these efforts have typically resided at a specific program at the lead institution. However there is a dire need to address the integration of DIT at all levels and field of the engineering curriculum to facilitate student learning and student preparation in cutting edge technology. This project is a bold effort by a multidisciplinary team of engineering faculty at Rowan University to integrate digital imaging technology in their undergraduate engineering curriculum that will eventually serve as a national model.

OBJECTIVES

The specific goals of this project are to:

- *Provide* specialized skills and training to students in the emerging field of digital imaging technology ,
- *Demonstrate* the application of various imaging techniques in the characterization and visualization of the microstructure of different engineering materials,
- *Expose* students to the state of the art technologies in image acquisition, processing and analyses,
- *Develop* novel hands-on experiments using various imaging techniques that can be readily used by different engineering disciplines ,
- *Ensure* the highest quality SMET education by improvingg existing undergraduate courses, curricula and laboratories byy developing hands-on innovative experiments,
- *Dissemination* of information through web pages, CD-ROMs and seminars for targeted audiences such as K-12 outreach, new faculty preparation and teacher/technician training.

To accomplish these goals, this collaborative project maximizes the curricular impact by vertically integrating proposed DIT modules beginning with the Freshman year, followed by the fundamental engineering courses, the Junior-Senior research

projects course, and finally, advanced level elective courses on DIT topics.

The proposed project comprises of eight modules that introduce students to fundamentals of DIT and its applications. Some of the experiments are being proposed from experiments already developed by Rowan faculty or from NSF funded research or educational grants at other institutions. Experiments based on image processing will be an integral part of the mentioned courses and the establishment of an organized image-processing laboratory will enable students to carry out experiments that supplement lecture materials. The proposed modules are indicated in Table 1.

Table 1: Proposed Digital Imaging Experiments

#	Experiment Title
1	Visualizing Pollutant Diffusion and Determining Pollutant Diffusion Speed from Analyzing Sequential Images
2	Imaging of Pore Spaces in Attached-Growth Biological Systems
3	Analysis of Internal Structure of Composite Materials and Prediction of Performance
4	Digital Imaging in Biomechanics
5	Biomedical Image Processing Applications
6	Ultrasonic Imaging System for Detecting Cracks in Metal and Concrete Pipes
7	Image Compression using Multi-resolution Wavelet
8	Applications of Thermal Imaging for Analysis

PROJECT IMPLEMENTATION

The College of Engineering at Rowan University has an innovative non traditional engineering program that is highly ranked nationwide[1-6]. A well-qualified diverse multidisciplinary team with the requisite expertise are participating in this project. All faculty are well established as both exceptional teachers and scholars. Furthermore, they have experience relevant to successfully develop and implement the proposed DIT experiences for the undergraduates. Each experiment is being developed by offering a Junior/Senior Engineering Clinic on Digital Imaging.

Rowan University has pioneered an innovative progressive engineering program that uses multidisciplinary team oriented Designed to be strongly multidisciplinary and project-focused, *Engineering Clinics* foster the structured development of engineering problem solvers. In the junior and senior year, clinics involve students in research/design or laboratory/product development activities. Many of these projects require various DIT techniques[7-10]. The Rowan Engineering programs are include a 20-credit hour, 8-semester Engineering Clinic sequence. These Clinic classes are the Program's hallmark.

The Rowan University College of Engineering has a brand new engineering building, including state-of-the-art equipment and computer resources, and a dedicated and extremely competent faculty. DIT relevant topics and research typically reside in the Electrical Engineering core curriculum. However at Rowan University, faculty have already teamed up from various disciplines to promote DIT in the curriculum. Upper level courses and multidisciplinary clinic projects have already been successfully implemented. Equipment holding for integrating DIT technology is also significant. The College has obtained microscopes, digital cameras, X-ray Scanners and various software for the project. Equipment acquisition and experiment development is complete. A digital imaging laboratory has been set up in the electrical and computer engineering department. A dynamic website has been setup with the following url:

http://users.rowan.edu/~jahan/imaging/Webpage/index.htm

The main page of the website is shown below in Figure 1.

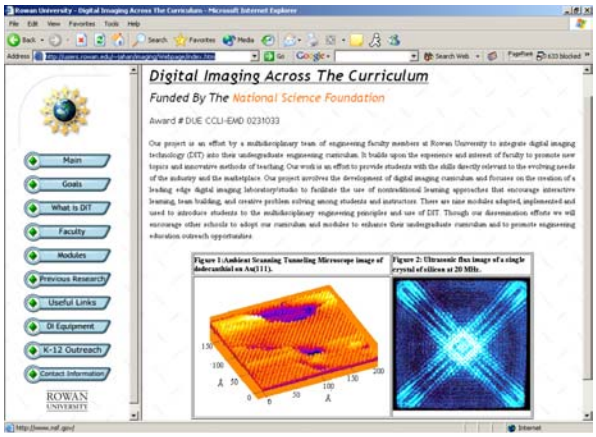

Figure 1: Main web page for the DIT project

The web page has links to the experiments developed (Modules) and also pictures of the equipment at hand (DI Equipment). Details of the experiments have been provided such that other institutions can adopt them readily. Details include an introduction to the module, experimental setup, method, results, discussion and references. Contact information for each module is also provided. Useful links such as tutorials on digital imaging are also available.

A module on digital imaging was offered for our middle school workshop for girls titled "Attracting Women into Engineering". Participants were introduced to basic concepts of digital imaging (colors and numbers) and were allowed to take digital images of a particular object and analyze the images. Digitizing of mamaograms and the identification of radiodense tissue through imaging was also introduced to the participants as a mechanism for detecting breast cancer.

CONCLUSIONS

This project allows Rowan engineering faculty and students to promote the integration of new technology into the engineering courses. It builds up on the experience and interest of faculty to promote new topics and innovative methods of teaching. The project also allows the development of digital imaging curriculum and focuses on the creation of a leading edge digital imaging laboratory/studio to facilitate the use of nontraditional learning approaches that encourage interactive learning, team building, and creative problem solving among students and instructors. K-12 outreach has also been an exciting component of the DIT project. The colors and numbers

module is very well received by middle school girls. It is anticipated that the developed modules will be adopted by other institutions easily.

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