World Transactions on Engineering and Technology Education
Vol.3, No.2, 2004

Digital imaging experiences for undergraduate engineering students

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ABSTRACT: The authors' project is an effort by a multidisciplinary team of engineering faculty members at Rowan University, Glassboro, USA, 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 industry and the marketplace. Projects involve the development of a digital imaging curriculum and focus on the creation of a leading edge digital imaging laboratory/studio to facilitate the use of non-traditional learning approaches that encourage interactive learning, team building and creative problem-solving among students and instructors. A number of visual experiments are being developed and utilised to introduce students to multidisciplinary engineering principles and the use of DIT. Some of these activities will be used for K-12 outreach activities. Through these dissemination efforts, the College of Engineering at Rowan University will encourage other schools to adopt this curriculum and modules in order 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 US$10 billion per year. Digital image technology (DIT) is a highly successful technology that helps engineers and scientists characterise materials at both the micro and macro levels.

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 micro-structure 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.

Digital image processing is a rapidly evolving field with growing applications in science and engineering. Engineers play an important and expanding role in this exciting field, yet undergraduate engineering students from the civil, environmental, chemical and mechanical engineering disciplines are rarely exposed to digital imaging through their required traditional engineering coursework.

Traditionally, courses related to digital image processing reside in the physics and electrical engineering curriculum. This educational project is an enterprising endeavour by a multidisciplinary team of engineering academic staff at Rowan University, Glassboro, USA, to incorporate DIT in the engineering curriculum at the undergraduate level.

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 becoming increasingly familiar with imaging techniques common in biotechnology such as X-rays, computed tomography (CT) scans, magnetic resonance imaging (MRI), mammograms 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, the National Science Foundation (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 programme at the lead institution. However, there is a dire need to address the integration of DIT at all levels and fields of the engineering curriculum in order 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* specialised skills and training to students in the emerging field of digital imaging technology;
- *Demonstrate* the application of various imaging techniques in the characterisation and visualisation of the microstructure of different engineering materials;
- *Expose* students to state-of-the-art technologies in image acquisition, processing and analyses;

- *Develop* novel hands-on experiments employing various imaging techniques that can be readily used by different engineering disciplines;
- *Ensure* the highest quality science, mathematics, engineering, and technology (SMET) education by improving existing undergraduate courses, curricula and laboratories through the development of hands-on innovative experiments;
- *Disseminate* information through Web pages, CD-ROMs and seminars for targeted audiences, such as K-12 outreach, new faculty preparation and teacher/technician training.

In order to accomplish these goals, this collaborative project maximises the curricular impact by vertically integrating the 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 eight modules that introduce students to the fundamentals of DIT and its applications. Some of the experiments are being proposed from experiments already developed by Rowan University 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 organised image-processing laboratory will enable students to carry out experiments that supplement lecture materials. The proposed modules are listed in Table 1.

Table 1: Proposed digital imaging experiments.

No.	Experiment Title
1	Visualising Pollutant Diffusion and Determining Pollutant Diffusion Speed from Analysing 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 Wavelets
8	Applications of Thermal Imaging for Analysis

PROJECT IMPLEMENTATION

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

Rowan University has pioneered an innovative progressive engineering programme that utilises a multidisciplinary team orientation. It has also been designed to be strongly multidisciplinary and project-focused.

Engineering Clinics foster the structured development of engineering problem solvers. In the junior and senior years, clinics involve students in research/design or laboratory/ product development activities. Many of these projects require various DIT techniques [7-10]. The Rowan Engineering programmes include a 20-credit hour, 8-semester Engineering Clinic sequence. These Clinic classes are the Programme's hallmark.

The College of Engineering at Rowan University 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 reside typically 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 implemented successfully.

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 Department of Electrical and Computer Engineering. A dynamic Web site has been set up with the following url: http://users.rowan.edu/~jahan/imaging/Webpage/index.htm

The main page of the Web site is shown in Figure 1. 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 so that other institutions can adopt them readily. Details include an introduction to the module, experimental set-up, 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 a middle school workshop for girls titled *Attracting Women into Engineering*. Participants were introduced to the basic concepts of digital imaging (colours and numbers) and were allowed to take digital images of a particular object and analyse the images. The digitising of mammograms 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 engineering courses. It builds upon the experience and interest of faculty to promote new topics and innovative methods of teaching.

The project also permits the development of digital imaging curriculum and focuses on the creation of a leading edge digital imaging laboratory/studio to facilitate the use of non-traditional 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 colours and numbers module has been very well received by middle school girls. It is anticipated that other institutions will adopt the developed modules easily.

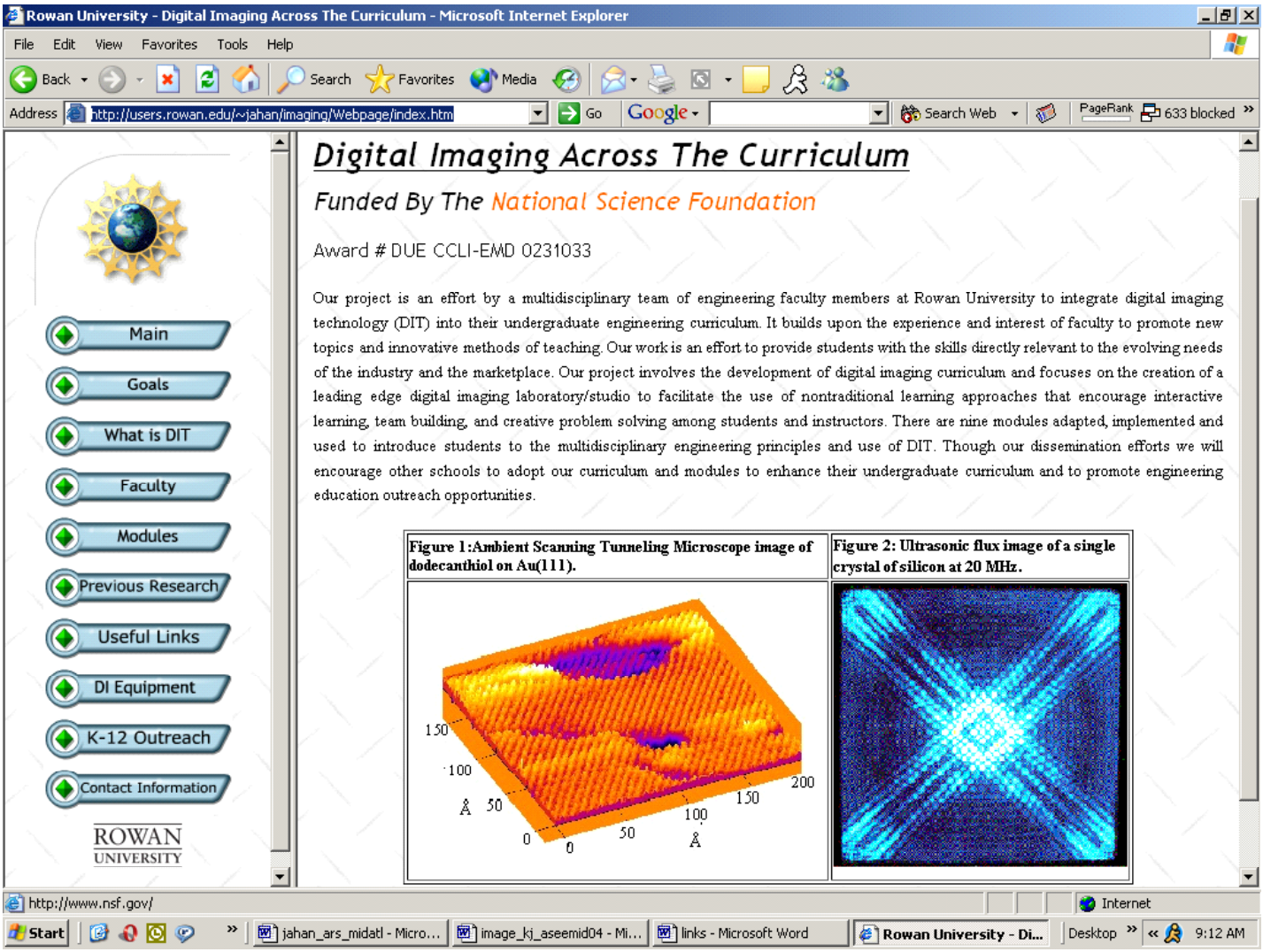

Figure 1: Main Web page for the DIT project.

ACKNOWLEDGEMENT

This project is being funded by a grant from the National Science Foundation (NSF DUE #0231033) and Rowan University.

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Conference Proceedings of the *7th UICEE Annual Conference on Engineering Education* under the theme: *Educating for the Global Community*

edited by Zenon J. Pudlowski

The *7th UICEE Annual Conference on Engineering Education*, held under the theme of *Educating for the Global Community*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was staged in Mumbai, Maharashtra State, India, between 9 and 13 February 2004.

This volume of Proceedings includes papers submitted to this Conference and offers a diverse compendium of articles that detail various international approaches to engineering education research and development related to the Conference theme, as well as other specific activities.

The 47 published papers, representing 21 countries, offer an excellent collection of works that tackle fundamental issues, concepts and achievements of individual researchers, as well as the concerns and challenges regarding engineering and technology education in different cultures.

The papers have been organised into the following groups:

- Opening and Keynote addresses
- Multimedia and the Internet in engineering education
- Quality issues and improvements in engineering education
- Innovation and alternatives in engineering education
- International examples of engineering education and training
- New trends and approaches to engineering education
- Important issues and challenges in engineering education
- Specific engineering education programmes

The variation of subjects, concepts, ideas and international backgrounds in this volume of Proceedings demonstrate the global nature of UICEE-run Conferences, as well as its relevance within the worldwide affairs related to engineering and technology education.

In order to ensure the high quality and value of the Proceedings into the future, all of the papers have undergone assessment by independent international peer referees and have been professionally edited. As such, it is envisaged that this volume will become a useful source of information on research and development activities in engineering and technology education, seen within the context of educating future engineers for the global community.

In order to purchase a copy of the Proceedings, a cheque for $A100 (+ $A10 for postage within Australia, and $A20 for overseas postage) should be made payable to Monash University - UICEE, and sent to: Administrative Officer, UICEE, Faculty of Engineering, Monash University, Clayton, Victoria 3800, Australia. Tel: +61 3 990-54977 Fax: +61 3 990-51547