Session T1D3

Planning a Multidisciplinary Imaging Course to Attract and Serve a Diverse Student Constituency

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Abstract

This paper presents the author's experience and sample answer to the question, "How do you develop a single course on 'imaging' (or any multidisciplinary/interdisciplinary subject) that will attract and serve engineering students with different backgrounds, interests, and needs, while also providing a useful exposure to both the diverse imaging systems (hardware) and image processing tools and applications (software) that are important today?"

Introduction

Courses that are required in a curriculum gain an automatic enrollment and obviously must be offered so students can meet degree requirements. Technical electives covering important and contemporary subjects within the major may also attract a sufficient enrollment to justify their being offered. On the other hand, there may well also be a set of additional subjects of interest to the faculty and attractive to some of the students in the major, but for which student demand is perhaps marginally adequate to justify their offering. This paper describes a situation and subject of this type and outlines the solution that the author has developed that proved successful in that specific situation. It is provided with the expectation that the solution may also be applicable to other instructors in other places with different subjects, but with similar circumstances.

Baylor University is a private university, located in Waco, Texas. Baylor offers accredited B.S. degree programs in Electrical and Computer Engineering, Mechanical Engineering, and Engineering, and is currently graduating about 45 students per year, primarily from and about equally divided between ECE and ME, plus a couple of Engineering majors each year. Last summer, Baylor also initiated a graduate program, with traditional research-oriented M.S. programs in Biomedical Engineering, Electrical and Computer Engineering and Mechanical Engineering and a more professionally oriented Master of Engineering. Thirteen students were enrolled in this first year of the program.

The author has had a strong interest in imaging system and image processing applications, and in the past at a larger state university had taught the following courses in this area:

Machine Vision Systems, an elective undergraduate/graduate EE course,
Medical Imaging Systems, a graduate course in BME
Advanced Imaging Techniques, a graduate course in EE initially, then in BME

Special Topics in Medical Imaging Research, a graduate course in BME

The challenge the author faced in his desire to make this area of study available to Baylor students was how to package an elective course that would appeal to a sufficient number of students to justify the course. After an initial offering in fall 2002 under the department's EGR 4396 Special Topics in Engineering label, the current course, EGR 4353 Imaging Formation and Processing, was approved and first offered in fall 2004. While definitely not overenrolled, it did attract six students, sufficient to proceed in an initial offering. It is that experience that is reviewed in this paper, in a format that is intended not only to report on this experience but also to illustrate the approach in a way that might be applied in similar circumstances but with different details.

Student Enrollment Eligibility

First, the new course was strategically placed to be available to the maximum number of students. EGR 4353 Image Formation and Processing is listed as an elective in ECE and is available, with advisor approval, as a senior elective in the other engineering majors. It also carries graduate credit for graduate students with approval of the instructor and student's advisor, but with the requirement of a supplementary component beyond those required for undergraduates. The prerequisite for EGR 4353 is EGR 3335 Signals and Systems, a junior course currently required for all of our engineering majors, and which has prerequisites of Linear Algebra and Ordinary Differential Equations. While EGR 3335 deals entirely with continuous-time signals and systems, it provides the important concepts of linear and nonlinear operations, convolution, Fourier transforms and frequency spectrum, transfer functions and filtering, convolution and sampling, and MATLAB experience.

Accordingly, and most importantly, for Baylor's specific circumstances, this course is (potentially) available to all of our engineering students. Its current catalog description reads:

> EGR 4353 Introduction to image formation systems that provide images for medical diagnostics, remote sensing, industrial inspection, nondestructive materials evaluation and optical copying. Image processing, including image enhancement, analysis and compression. Student specialization through assignments and project. (3-0)

Course Content Selection

Computer applications are characteristically of interest to engineering students, so an imaging course has a lot going for it right away. Associated with that, images are inherently visual and naturally compatible with computer manipulation and storage. They naturally have the potential for interest, even fun, for students.

On the other hand, many engineering students are more interested in hardware and laboratories than they are in mathematics (even computer-based math) and computational manipulation. Therefore, it seemed important that the course had a significant consideration of imaging systems and their hardware (not only to attract certain students but also because knowledge of the imaging system is often essential to the understanding of the resulting images). However, neither the campus nor the community currently provided the desirable access to many of the types of equipment necessary for a physical laboratory component or any realistic industrial or clinical exposure. Consequently, the course could have only the traditional "lecture" format (with 43 fifty-minute sessions per semester). Nonetheless, it seemed best for the course, both for appeal and pedagogy, to have a non-trivial "imaging systems" component as well as the "image processing" component.

The textbook selected for the course was Digital Image Processing (Second Edition), 2002, by Rafael C. Gonzalez and Richard E. Woods, published by Prentice Hall. It has a number of desirable features, with good on-line help. While it has less directly on imaging systems than desired for this course, it does have quite a strong first chapter that reflects actual imaging applications by their spectral range of operation. The course was formed around the following textbook chapter outline and order:

1. Introduction (with a section on Examples of Fields that Use Digital Image Processing)
2. Digital Image Fundamentals
3. Image Enhancement in the Spatial Domain
4. Image Enhancement in the Frequency Domain
5. Image Restoration
6. Color Image Processing
8. Image Compression (selected sections)
9. Morphological Image Processing
10. Image Segmentation

Chapter 1 was supplemented significantly by the instructor with additional material on the physics, hardware, and image generation characteristics of the various image formation systems and applications.

The text material with the indicated supplement represents the core of the course. Textbook readings and homework assignments were the same for all enrolled students, as were the midterm tests and final exam.

However, the additional emphasis and time devoted to supplementing the imaging systems material in the textbook is considered an important feature of the course. This material not only offered an emphasis of particular interest for some engineering students, but it also increased attention to the fundamental importance of the hardware and sensing issues in appreciating the merits and limitations of the various image generation systems and the resulting images included in the course.

Methods of Individualization

So far, two "student recruiting" features of the course have been reviewed: 1) maximizing the student accessibility to the course, and 2) rebalancing the content of the course for wider student appeal. These features are the same for all students. Perhaps the most significant feature of the course is its individualization.

Three papers were required of each student during the course. Each such assignment featured some instructor guidance, with student self-selection subject to instructor approval. Each approved topic became a written paper distributed to the other students and an oral presentation delivered in regular class sessions. Papers were to be prepared and delivered with professional quality, and were graded accordingly. Written papers and oral presentations were evaluated by the instructor and written commentary was provided by the instructor to each student for each of the three papers. Students receiving graduate credit had a bit higher standards for the first two papers, and distinctly higher standards for the content and delivery of the third paper.

The three papers were the primary means by which the different interests and needs of the individual students were accommodated within a single structured course. The first paper was assigned upon completion of Chapter 1 on image formation, and was to be an expanded coverage of some specific type of imaging system or component. After covering some of the fundamental image properties and image processing techniques, the second paper was to be selected from an appropriate portion of some peer-reviewed and published research paper. The third paper, near the end of the course, was to be a modest original project by the student involving image processing "research" for some actual image(s). The subject and material for each paper was the student's choice, subject to instructor's approval for appropriateness of content, level and length. These assignments required student exposure to a variety of sources and types of literature in the field of imaging systems and applications and image processing techniques, ranging from commercial products to research literature. The titles of the three papers presented by each student are shown in Table 1.

Depending upon the students' specific interests, the papers ranged from three independent topics (e.g., students 1 and 2) to a specific and purposeful focus (student 4). Student 3 tried his own hand on image processing for the same type of image as covered in his published literature report. Student 6 used the first and third papers to provide support for his area of thesis research.

Evaluation and Grading of Student Work

Student learning and performance were evaluated with two midterm tests and a final exam, with rather limited traditional homework assignments (because of the time devoted to paper preparation), and the written and oral presentation quality of the three individualized papers. Specifically, the final score was determined by the following weightings:

Class attendance and participation (-1% for absences > 3)	10%
Homework assignments	10%
In-class midterm tests (two midterms at 10% each)	20%
Comprehensive final exam	20%
Project and paper 1 (imaging component or system)	10%
Project and paper 2 (research literature report)	10%
Project and paper 3 (student's original image processing project)	20%

Significantly, a full 40% of the course grade was based on the students' three individualized written papers and classroom presentations.

Table 1. Titles of Students' Three Papers

Student ID	Student Program	Paper 1 - Report on a specific imaging system or component	Paper 2 - Report from published image processing research	Paper 3 - Report on original image processing research project
1	BS ECE	NEXRAD Doppler Radar System	Adaptive Regularized Constrained Least Squares Image Restoration	Regaining Images: Investigating the Effect of Thresholding on Histogram Equalized Image by Using Difference Images
2	BS ECE	Molecular Imaging Systems	On Piecewise-Quadratic Filter for Gaussian Noisy Image Filtering	The Blind Deconvolution Algorithm
3	BS ECE	Imaging using the Enhanced Thematic Mapper Plus (ETM+)	Application of Image Processing for the Conservation of the Medieval Mosaic	Restoring a Corrupted Image by an Intuitive Method
4	Joint BS ECE/MS BME	Hearing Images - An Overview of Ultrasound Imaging Technology	A Filter Design Method for Minimizing Ringing in a Region of Interest in MR Spectroscopic Images	Morphological Reconstruction of X-Ray Images
5	MS BME	Infrared Imaging Systems and Their Safety Applications	Face Recognition under Varying Illumination Based on a 2D Face Shape Model	Various Test Results of Image Registration via Normalized Cross-Correlation
6	MS ME	The CCD Camera and Its Involvement in Heat Transfer/Thermal Imaging	Simulating Poor Visibility Conditions Using Image Processing	Image Processing of Liquid Crystal Images for Modeling Cooling Temperatures of Gas Turbine Engines

Student Evaluation of Course

All six of the students participated in the University-wide course evaluation process, completed at the end of the course, but before the final exam or course grades. Following are some responses of particular interest, given the unique characteristics of this course. The first two items give student information, while the next four course evaluation items were considered most pertinent to this specific course (StA denotes strongly agree, A denotes agree, SlA denotes slightly agree, SlD denotes slightly disagree, D denotes disagree, and StD denotes strongly disagree).

Did your academic background prepare you for this course?	Yes - 5, No - 1
What grade do you expect to receive in this course?	A - 2, B - 4

The course was well organized.	StA - 3, A - 2, SlD - 1
Assignments contributed to my understanding of course content.	StA - 2, A - 4
I learned a great deal from this course.	StA - 1, A - 5
The instructor used procedures and methods conducive to learning.	StA - 1, A - 5

Instructor's Observations

The instructor was quite gratified with the diverse student enrollment, which provided a good basis for evaluating the successfulness of the purposeful flexibility in the course content and methods. Also, the level of student interest was generally good, as is often evident for an elective course, especially when it is compared to required courses. The modest size also facilitated an important degree of individual attention and interaction in the course, especially for the students' project selection, development and presentation, and for the instructor's feedback. The students seemed to accept the papers and projects relatively well. The final grades for the six students were: four A's, one B and one C.

The instructor concludes that this individualized course content and format are worth the extra effort, both for the students and the instructor, and quite likely was a factor that gained the level of enrollment that provided the opportunity to give the course. Further, the diversity of students likely enriched the course. On the other hand, it appears that it is unlikely the course with this content and format could be extended beyond engineering students due to its prerequisites.

Conclusion

This paper has described three features of an elective course structure to maximize student enrollment, especially in a situation where enrollment might otherwise be inadequate to support the offering of the course:

- maximizing the student accessibility to the course by judicious choice of prerequisite(s),
- rebalancing the content of the course for wider student appeal within the available audience,
- individualization of course content through significant student selection in assignments.

The author/instructor considers its individualized content a successful format for this course and subject, and expects to continue its availability. It is hoped that this example will be of help to other faculty members who teach somewhat interdisciplinary courses, and/or elective courses that might struggle for sufficient enrollment to be offered. Further, in the conference presentation of this paper, it is hoped that it will stimulate an active interaction among faculty colleagues for further exploration and improvement of the format and that it will prompt applications of some of the ideas to other situations and subjects.

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Dr. Farison is professor and chair of the Department of Engineering at Baylor University. He holds his MS and PhD in EE from Stanford University, and served for 34 years at the University of Toledo, including 10 years as Dean of Engr. Research interests have ranged from discrete-time control to image processing. He is Baylor's ASEE campus rep and vice chair/program chair of ASEE's Multidisciplinary Engineering Constituent Committee. He has PE in OH and TX.