# SIMULATING A PROFESSIONAL EMPLOYMENT ENVIRONMENT IN A SENIOR ELECTIVE ENGINEERING COURSE

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**Abstract**
Engineering faculty members face continuing challenges in their ever-expanding professional workload and the priorities and commitments of their ever-changing student values. This paper describes the course content and classroom delivery of a senior elective engineering course in which the words "classroom" and "course" are not used (at least, not intentionally). Since most of these "students" will be employed professionally within the next year, this experience (okay, engineering course) seeks to provide an environment that gives them some preparation for their first professional employment (while also learning about "image formation and processing" systems and applications, as required by the course description in the university catalog).

## 1. Introduction

The format for the course, called Image Formation and Processing, provides several features that seek to simulate an engineering graduate's early professional employment. A few days before this "special assignment" begins, a group of relatively new employees receives an email explanation of their selection as part of this special corporate project--to investigate a potential new corporate business initiative in the "imaging" industry. They will have about 20% of their corporate workload assigned to this four-month special initiative, in which, together, we will explore the possibilities of our company expanding into one or more of three areas of imaging and image processing:

1) a **commercial venture** in the "imaging hardware systems" manufacture and/or sales,
2) a **research venture** in developing new "image processing methods" with funding by corporate and/or government contracts and grants, and
3) a **service venture** in providing "contract image processing services" for public agencies and private companies.

This paper presents both the traditional description and scope of the course content as described in the course catalog (based on the textbook content) and also the innovative format and delivery of the professional experience (delivered through the context of the corporate team assignment).

**2. Our Corporate Environment**

On the Thursday before the first meeting on Monday, the corporate team (i.e., the enrolled students) receive a message from the project coordinator (i.e., professor), explaining the purpose and format of the special corporate project to which they have been assigned.  The message begins:

# BAYLOR IMAGING ENTERPRISES

**August 19, 2009**

**To:  Members of Company Project 4353**

**Greetings.  You may already have heard something about a new assignment I have undertaken, but let me start at the beginning so all of you will have a common background and perspective on this short-term corporate project.  Your role in this project will involve part of your time for about four months, starting Monday, August 24, and continuing through early December.  Here are the background and context of this project.**

**I have accepted our company's "invitation" to serve as the coordinator for a corporate initiative to explore the possibility of our company entering one or more aspects of the "imaging" industry.  With the approval of your regular supervisor, you have been selected to be part of this important company project.  Our regular meetings will be MWF at 9:05 am, in Rogers 314.**

**We will be exploring as a group the major areas of the imaging industry, including three broad and diverse areas that we have identified for our possible corporate commercial venture:**
>    **1)   imaging hardware systems (and components) and their areas of application,**
>    **2)   image processing research and development applications, and**
>    **3)   commercial image processing services and applications.**

**Welcome to the team,**
**Jim Farison**

The complete message with more explanation for this introduction to the project ("course") is shown in the Appendix.

**3. Team Schedule and Meeting Structure**

The regular team meetings were held three times per week, from 9:05 – 9:55 am on MWF, except for various public or corporate "holidays" For the project period (i.e., semester), there were 42 scheduled meeting dates from August 24 through Dec. 7. One regular session was used for an "interim assessment" of their learning progress (i.e., midterm test). The other 41 sessions were used in two ways: 27 sessions for traditional instructor presentations from the materials in the textbook and 14 sessions directly related to the special nature and format of this "course."

Fifteen sessions of the remaining 41 meeting times were converted to other special purposes in support of their three sets of presentations. In time sequence, the schedule comprising the 14 special sessions of the course were:
   a) one regular session during the second week was held in a laboratory where the author's collection of the past five years of issues for several magazines and journals is stored, to expose the team to the published imaging literature for their subsequent presentations,
   b) two regular sessions were replaced by individual meetings with the project coordinator (aka, instructor) to review and refine their proposed individual third projects,
   c) two sessions immediately preceding their third presentations were given as released time to help them develop and complete their final "actual image processing" project, and
   d) nine sessions (three sets of three consecutive sessions each) were committed to the topical presentations prepared by the students, to be described below.

**4. Textbook**

The instructor has used the book, "Digital Image Processing," by Rafael C. Gonzalez and Richard E. Woods, Prentice Hall, as the required textbook for his course for several years. Now in its third edition (© 2008), it is very well illustrated, an important factor for an image processing text. With the instructor's considerable commitment of time for the students' own investigations, only selected portions of the textbook can be covered. Following in Table 1 are the chapters in the text and the specific portions included (at least to some degree) in this course.

**5. Instructor Presentations**

As noted earlier, the instructor had 27 sessions (of the total 42 sessions) for textbook content presentation; hence, the partial coverage of several chapters. Selection of textbook materials for classroom presentation after the fundamentals were introduced was based on the trade-offs between: 1) "important" material and concepts in imaging and image processing, and 2) the originality of the class members in selecting and completing their three presentation. Since the instructor's presentations were for both "teaching traditional material" and "preparing the students for their three projects," the balance came out to 27 sessions for textbook-related

material and the balance for application experience.  The regular classroom sessions were presented with PP-visuals.  Adoption of the textbook provides access for the instructor to the publisher's 570 power-point slides for all of the figures in the text.

Table 1. Outline of Classroom Coverage of the Course's Textbook

| Ch. | Chapter Title | Text pages | Pages used in course |
|---|---|---|---|
| 1 | Introduction | 1-31 | 1-31 |
| 2 | Digital Image Fundamentals | 35-99 | 35-99 |
| 3 | Intensity Transformations and Spatial Filters | 104-192 | 104-176 |
| 4 | Filtering in the Frequency Domain | 199-304 | 199-304 |
| 5 | Image Restoration and Reconstruction | 311-385 | 311-370 |
| 6 | Color Image Processing | 394-456 | 394-424 |
| 7 | Wavelets and Multiresolution Processing | 461-521 | - - - |
| 8 | Image Compression | 525-623 | 525-544 |
| 9 | Morphological Image Processing | 627-680 | 627-647 |
| 10 | Image Segmentation | 689-787 | 689-701 |
| 11 | Representation and Description | 795-857 | - - - |
| 12 | Object Recognition | 861-907 | - - - |
| A | Coding Tables | 910-914 | - - - |
| -- | Bibliography & Index | 915-942, 943-954 | - - - |

Table 2. Publisher PP Provided/Used by Instructor; Additional PP Created/Used by Instructor.

| Ch. | Chapter Title | Textbook Figures/PP | Textbook PP Used in Course | Instructor PP Used in Course |
|---|---|---|---|---|
| 1 | Introduction | 24 | 24 | 44 |
| 2 | Digital Image Fundamentals | 41 | 41 | 50 |
| 3 | IntensityTransforms, Spatial Filters | 59 | 45 | 51 |
| 4 | Filtering in the Frequency Domain | 67 | 67 | 83 |
| 5 | Image Restoration & Reconstruction | 49 | 38 | 19 |
| 6 | Color Image Processing | 51 | 28 | 2 |
| 7 | Wavelets, MultiresolutionProcessing | 39 | -- | -- |
| 8 | Image Compression | 54 | 9 | 17 |
| 9 | Morphological Image Processing | 44 | 37 | 6 |
| 10 | Image Segmentation | 63 | 7 | -- |
| 11 | Representation and Description | 49 | -- | -- |
| 12 | Object Recognition | 25 | -- | -- |
| A | Coding Tables | 5 | -- | -- |
| -- | Bibliography & Index | -- | -- | -- |

This is a substantial benefit in a very visually-oriented course; the alternative (not having those PP slides) would be quite a challenge in presenting the material effectively. For this course, the instructor supplements the textbook visuals by creating his own PP slides of words and/or equations representing his outline and notes for the lectures. These are interleaved with the textbook figures, to integrate the material as it is presented in the textbook itself. The current number of these supplemental textual PP slides used in the instructor's classroom presentations now totals 272 original slides.

## 6. Team Member Presentations

There were 13 active team members: 7 male and 6 female (plus one non-participating "auditing" male student). This number made the presentation time allocation a bit awkward numerically. Each of the three sets of presentations was scheduled for three successive meeting days, requiring two days with 4 presentations and one day with 5. To bring the practical issue of fairness (equal presentation time allocation), presentations (including question, moving from seats to podium, etc.) were scheduled to start at 14-minute intervals. To meet this presentation time schedule, on the "5-presentation" days, the meeting time was extended by 5 minutes (meaning the presentation schedule started at 9:00 am rather than 9:05 am), giving approximately 55 minutes (4 x 14 = 56 minutes). On the five-presentation days, the overall time was extended by an additional 15 minutes, starting at 8:45 am (5 x 14 = 70). This worked, as there was no scheduled use of this room before this class, nor did any participants have a scheduled responsibility.

For each presentation day, presenters were to have their PP slides loaded onto the projector-connected computer before the starting time. To manage the presentation time and to equalize the time allocation, the instructor allocated time as follows:

$$12 \ < \ \text{ideal presentation time} < 12$$
$$11 \ < \ \text{presentation time plus time for questions} < \ 13$$
$$10 \ < \ \text{absolute minimum and maximum acceptable time} \ < \ 14$$

In order to stay on a fifteen-minute allocation, the primary variable to maintain the schedule was the time allocated for questions. With 3 x 13 = 39 presentations during the course, only once did the coordinator cut a presentation off due to the time limit. This gave 11-12 minutes for the respective presentations, 1-2 minutes for questions and discussion, and transition from one speaker to the next. This schedule, while fairly tight, seemed to work quite smoothly. The speakers were exceptionally responsible with the schedule expectations, with only one case in the 39 presentations where the speaker passed the 14 minute limit and was asked to stop just before completing the presentation "since we needed to give the other presenters their fair amount of time."

While some may reasonably consider this a bit unnecessarily structured (with legitimate reason), others will likely say, "How refreshing, compared to professional conferences where some presenters seem not to care about the fairness doctrine for presentation-time allocation.

## 7. Students' Response to the Course

Several factors contribute to making this annual elective course the success it has been:
1. the highly visual nature of the course content,
2. for the majority of the students, it was an elective so they had "chosen" the course,
3. simulation of the corporate environment was obviously a stretch (e.g., they were not being paid), but the content and format was far more like a corporate environment than a typical lecture course -
    * the "classroom" was re-arranged each day to be more like a conference room
    * they recognized the future professional benefit of the writing and presenting
    * students could choose the specific subject of each paper within the topic area
4. the relevance of the three major components (the three presentations) was "believable" for a corporate environment –
    * practical engineering system information about operation/application of imaging systems or components – a "hardware" manufacturing or service company,
    * contemporary imaging research – "corporate" or "sponsored" research in an imaging and image processing research company, and/or
    * contract image processing – an image processing services company for hospitals, government, and others with image analysis needs
5. the variety of presentations and information provided by the instructor AND the team members, as well as the varied format (professor, students, professor, students, etc.)

## 8. Assessment

The instructor's assessment of the "team members" was very favorable. Half of the evaluation of performance was based on two traditional assessments (tests), at the middle (20%) and the conclusion (30%) of the experience. Based on this traditional academic-style evaluation, the mid-point score was 97.0% and the end-point score was 87.5%, for a weighted average of 91.3%. The other half was based on their three presentations (weighted at 20%, 15%, and 15%). The three average scores were 93.0%, 92.8%, and 95.4%, an overall presentation average of 93.7%. Combined, the overall assessment score was 92.5%, with overall range from 87.5% to 95.4%.

## 9. Summary

This paper has described a senior elective engineering course that seeks to present a realistic simulation of a corporate environment through the students' investigation of three different potential corporate "new ventures" related to:  a potential new area of corporate manufacturing, of government- and/or corporate-sponsored imaging processing research, and/or contract image processing services.

APPENDIX
# BAYLOR IMAGING ENTERPRISES

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We will be exploring as a group the major areas of the imaging industry, including three broad and diverse areas that we have identified for our possible corporate commercial venture:

1) imaging hardware systems (and components) and their areas of application,
2) image processing research and development applications, and
3) commercial image processing services and applications.

I will plan the schedule and lead our regular group sessions so we can develop a common background that will provide the breadth and depth of information you will need to be prepared to select, research, develop and deliver your individual written reports and oral presentations for each of the three areas of our investigation noted above. That is, over the course of this project, each of you will have the opportunity:

1) to select for my approval a specific topic appropriate to our potential corporate enterprise from each of the three numbered areas listed above for your individual exploration, and
2) to prepare a written report and deliver an oral presentation to our group on your specific topic for each of the three areas.

The three primary resources we will use during this project are:

a) the outstanding book by Gonzalez and Woods, Digital Image Processing (third edition, ©2008), published by Pearson/Prentice-Hall, which each of you must have,
b) the published professional and corporate literature, some of which I can provide, and
c) the vast on-line resources of the imaging field.

Finally, we will also have two in-session evaluations of your individual effort and learning from all of the various components of our project, both from the collective DIP material that I will lead and from the topical presentations that each of you will provide. The first will occur a bit before half way of this four-month project, and the second will occur at the end. These, together with the extent and effectiveness of your individual contributions outlined above, will be the basis of the assessment of your performance that will be used to generate the evaluation at the end of the project.

Welcome to the team,

Jim Farison

# BAYLOR IMAGING ENTERPRISES

## Series 1 - Contemporary Imaging Systems, Components, and Applications

### Monday, September 21, 2009 (9:00-9:55 am)
"Magnetic Resonance Imaging" – Ryan Richards
"Astronomy in the Ultraviolet Band" – Daniel Jepson
"Ultrasound Imaging in Obstetrics" – Diana Joseph
"Mobile Camera Phones" – Renée Michaud

### Wednesday, September 23, 2009 (9:00-9:55 am)
"Positron Emission Tomography Scanning" – Melissa Hayes
"Scanning Electron Microscope" – Kelsey Ehlers
"Microwave Imaging Systems as the Better Alternative
for Breast Cancer Detection" – Elyssa Palivan
"X-Ray Imaging Systems and Their Industrial Applications"
– Nnamdi Nwabudike

### Friday, September 25, 2009 (8:45-9:55 am)
"Medical X-Rays" – Richard Landicho
"Sonar Imaging Systems and Hardware" – Devery Johnson
"Night Vision" – Matt Griffey
"Synthetic Aperture Radar" – Michele DuVall
"IRIS Recognition Technology" – Anthony Lefear

# BAYLOR IMAGING ENTERPRISES

## Series 2 - Contemporary Imaging Processing Research Applications

### Monday, September 21, 2009 (9:00-9:55 am)

Vehicle Detection by Means of Stereo Vision-Based Obstacles Features Extraction
and Monocular  Pattern Analysis" – Michelle Duval
"Rhesus Monkey Brain Imaging Through Intact Skull
with Thermoacoustic Tomography" – Kelsey Ehlers
"STL Mesh Reconstruction for Bio-Medical Rapid Prototyping Model"
– Matt Griffey
"Semi-Automatically Labeling Objects in Images" – Melissa Hayes

### Wednesday, September 23, 2009 (8:45-9:55 am)

"Energy-Efficient Image Compression for Resource-Constrained Platforms" –
Daniel Jepson
"Learning Color Names for Real-World Applications" – Devery Johnson
"High Resolution Quantitative Imaging of Cornea Elasticity
using Supersonic Shear Imaging" – Diana Joseph
"Dynamic 2D Ultrasound and 3D CT Image Registration of the Beating Heart" –
Richard Landicho
"Detection and Segmentation of Concealed Objects in Terahertz Images"
– Anthony Lefear

### Friday, September 25, 2009 (9:00-9:55 am)

"Segmentation of the Optic Disc, Macula and Vascular Arch
in Fundus Photographs" – Renee Michaud
"Myocardial Motion Analysis from B-Mode Echocardiograms" –
Nnamadi Nwabudike
"Rhesus Monkey Brain Imaging Through Intact Skull
with Thermoelastic Tomography" – Elyssa Palivan
"Personal Authentication Using Hand Vein Triangulation
and Knuckle Shape" – Ryan Richards

# BAYLOR IMAGING ENTERPRISES

Series 3 – Image Processing Research Project Presentations

## Monday, November 30, 2009 (8:45-9:55 am)

"Effectiveness of Median Filters for Varying Degrees of Salt & Pepper Noise" – Diana Joseph

"RGB Image Breakdown and Restacking" – Matt Griffey

"Using Matlab Filtering to Remove Image Degradation and Noise Added by Scanning Images into a Computer" – Renée Michaud

"Deblurring Image Using Blind Deconvolution Algorithm Matlab" – Nnamdi Nwabudike

"Elimination of Noise Using Mean Filtering" – Michele Duvall

## Wednesday, December 2, 2009 (9:00-9:55 am)

"Weiner Filter" – Richard Landicho

"Removing Periodic Noise in Images" – Daniel Jepson

"Multi-Spectral Image Analysis Using LANDSAT Images" – Anthony Lefear

"Magic Eye Images" – Kelsey Ehlers

## Friday, December 4, 2009 (9:00-9:55 am)

"High Boost and Homomorphic Filtering for Image Enhancement" – Ryan Richards

"Shading Correction" – Elyssa Palivan

"Image Processing Techniques: Unsharp Masking and High Boost Filtering" – Devery Johnson

"The Crosses of 'The Chapel in the Woods' – Canny Edge Detection" – Melissa Hayes