A Course on Digital Video Special Effects

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Abstract

We present a brief overview of our course "Digital Video Special Effects" taught in the College of Computing at Georgia Institute of Technology. This course is offered as an elective at the undergraduate level every year and is very popular with the undergraduate students. Here we present the goals that lead to this course and a discussion of the material that is covered. We also present what the students are expected to do and how they learn to "deal" with digital video as a medium. The merger of the technical aspects of video processing, with the entertainment aspects of generating special effects make this a very unique class. It aims to make analysis, processing, and synthesis of video ubiquitous to the students, while teaching them the technical aspects of what can be done with video.

1 Introduction

In this paper, we present a new course that we offer at the undergraduate level in the College of Computing at Georgia Institute of Technology. This course, entitled "Digital Video Special Effects," is designed to teach students video and audio manipulation, processing, analysis, and synthesis. Students undertake a deep technical study of how video special effects are generated and use the material taught in this class to generate a short video production to showcase their own special effect. This class is in its second year; the pilot offering was in spring 1999 as a quarter long class. In spring 2000, it is offered as a semester long (Georgia Tech moved to the semester system in academic year 1999-2000) and is now a part of our college's undergraduate graphics specialization.

This paper describes the design ideas that lead to this class, a brief description of what topics are covered, and what students are expected to learn and do during the course of the term. We also discuss some of the development environments that are being used in this class by the students and describe the equipment that is provided. In addition, we will describe the projects from the last year's class as that should provide ample understanding of why this class is well-liked by the undergraduates. Finally, we present a discussion of how we are planning to improve this offering in the upcoming years.

2 Goals

The main goal of this course is to teach undergraduate students concepts associated with digital media, specifically digital video. Students learn the basics of digital video/audio while studying special effects production. This course offers undergraduates the opportunity to apply and deepen their core computer science and engineering knowledge by extending that knowledge to manipulation of digital video. Creating a short segment with special effects teaches the students to apply their graphics, imaging, and software engineering expertise. In generating this segment, the students exercise their technical abilities to express their creative skills. The technical content covered in this class includes:

- Methods for digital video and audio manipulation and processing: This includes issues ranging from how digital video (imagery and sound) are encoded/represented in a computer and how these signals can be processed, analyzed, and resynthesized. This is where many of the computer vision aspects are covered.
- 2D and 3D graphics; camera placement and movement, lighting, and shadows: This includes a study of how synthetic scenes and objects are generated and relates to the issues of how virtual cameras are represented, moved, and the role lighting and shadows play in the generation of scenes.
- Merging of video, audio, and graphics streams: This is a study of how real imagery can be merged with graphics OR how audio streams are merged to generate synthetic scenes
- Narrative and story telling: This is an essential part of the class, as the students need to generate a short segment with a story, to showcase their technical effect. For this we study different existing literature on cinematography and storyboarding.
- Putting it all together to make a final production: Finally, we undertake a study of how to bring in all the pieces together into a final production. This includes a study of shot-selections and editing.

Students who take this course: Upper class undergraduate students at Georgia Tech take this class as a senior year elective. Graduate students are allowed with some additional work as requirement to get graduate credit. This class is designed with the interests of students from computing, engineering, and other fields in mind, serving as a very effective bridge between different areas.

This class introduces these students to technical concepts associated with digital video and audio. Students learn about video manipulation, processing, and editing, for the purpose of generating a short segment with their own special effects. Students develop "plug-ins" for commercial packages using their own code to generate the effects. Plug-in writing requires that students learn practical aspects of digital image processing, computer graphics, and production teamwork.

To date, in addition to computing students, engineering students who have been exposed to classes in signals and systems and have some programming experience also take this class. These students are interested in extending their technical skills in the area of digital media, while learning more about graphics and system development. Our Literature, Communication and Culture department at has several courses dealing with Video/Film. The students from these programs, though lacking in technical abilities, are also allowed to take this course with specific permission from the instructor, as we cover both the technical and non-technical issues of digital video. The insight of these artisticallyoriented students is valuable for in-class discussions and these students work to incorporate artistic expression in their group work. Additionally, the students lacking in technical background pick up valuable technical expertise in the course material of the class. The only pre-requisite for this class is programming experience. Coursework in computer vision, and graphics, and signals and systems is considered a bonus. Special enrollments are allowed on a case-by-case basis.

Due to space and resource limitation, we have restricted the enrollment in this class to 21 in spring 1999, and 30 in the spring 2000 term. In both terms, the class was fully subscribed within the first day of advance registration. We have had waiting lists of up to 20 students both

years. The students who have taken this class love it, as is evident by their participation and enthusiasm.

3 Syllabus

The syllabus of this course includes:

Description	Lectures
Introduction to new paradigms Introduce the class to digital video and discuss what it means to work with digital video and film.	1
Representations of Digital MediaHow is digital video represented in a computer and how can it be manipulated/processed. Discussion includes both video and audio.	2
Computing Methodologies How to process, manipulate, and analyze video. Present toolkits that will be used. Tutorials.	2
Introduction to Signal Processing (and Computer Vision) A short introduction to the basic principles of Signal Processing.	1
Introduction to Audio, Image, and Video Processing. Introduce filtering, convolving, and smoothing, with examples for both video and audio.	2
Compositing, Rotoscoping, and Chroma-keying	1
Cameras Perspective and Orthographic Projections, Camera parameters, motion, calibration, etc.	2
Introduction to Computer Graphics	2
Lighting, Shadows, Texture	1
Blending, Crossfading	1
Audio Effects / Mixing	1
Morphing (2D and 3D)	1
Merging Graphics with Video	1
Matched Moves	1
Tracking and Pose-Estimation	1
Editing/Storyboarding, Putting it together	1

Guest Speakers In spring 2000, from Sportvision, Rhythm & Hues, Adobe, etc.	3
Critiques In-class evaluation and critique of well-known effects from feature films.	2
Case Studies In spring 2000, “Pyramids”, [Burt & Adelson 1983a, 1983b] “Tour into the Picture” [Horry *et al.* 1997], “View Morphing & Interpolation” [Seitz & Dyer 1996; Chen & Williams 1993].	4
Class Presentations and Discussions of Projects	4

The syllabus is designed to ensure that students pick up the basics of signal processing, computer vision, and computer graphics, as these are the important ingredients in the study of special effects generation. In addition to lectures on various topics listed above, guest lectures from various experts in the fields of special effects are also presented. In addition, some portion of the class is dedicated to presentations of case studies of some of the recent work that may be appropriate. Finally, several lecture sessions are reserved for group discussion of ongoing projects, and to help the students work on their specific project ideas one-on-one with the Instructor and the TA.

At the end of each semester, students present their productions to the general community to highlight their technical and artistic skills. Each student creates a CD-ROM and Digital Video (DV) tape containing all the work accomplished during the term. This will be an artifact for their portfolios, which they can share with their prospective employers and prospective graduate schools.

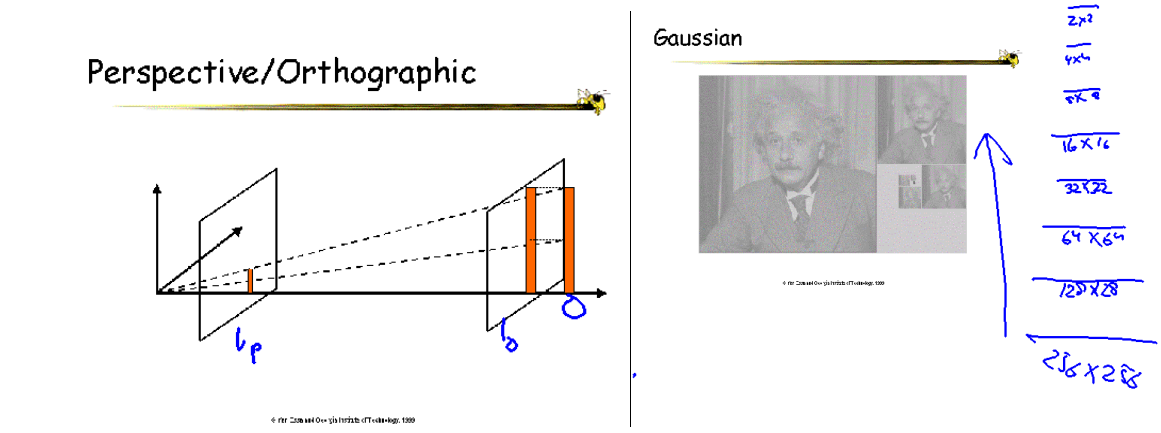

Figure 1: Snapshots of the lectures from the Classroom 2000 system. On the left is an image from the lecture on Perspective transformation, and on the right is an image from the lecture on Gaussian Pyramids (http://eclass.cc.gatech.edu/zenpad/db/listLecture.php3?Course=cs4480_00_Spring).

In this class, we use various educational technology innovations to enhance the classroom lectures and the out-of-class the classroom interactions between students. The class meets in a state-of-the-art classroom, equipped with video facilities to show videos (VHS, DVD, QuickTime, AVI, etc.). Additionally, the class lectures are captured using the Classroom 2000 system [Abowd 1999]. A student can then review these lecture by seeing all the slides (shown in Figure 1) and the video of the lecture at a later date. To facilitate out-of-the-classroom interactions and to provide a simple way for students to work on collaborative documents, a Co-Web (called SWIKI) is used. This Co-Web is the primary repository of all the documentation that is generated by the students for projects they undertake during the semester.

Books: A significant problem with this course is the absence of a suitable textbook. No book is available that covers the technical aspects of the concepts we are interested in teaching the students. For this reason, we just assign one text and then recommend various other books that are guides for using commercially available software. During the term various readings are handed out from different computer vision and graphics books and proceedings as appropriate. Here is the list of recommended books:

- T. Wittenburg, *Visual Special Effects Toolkit in C++*, 1997.
- *Adobe After Effects 4.0: Classroom in a Book*, 1999
- *Adobe Premiere 5.0: Classroom in a Book*, MacMillan Computer Pub, 1998
- B. de Leeuw, *Digital Cinematography*, AP Professional, 1997
- R. Shamms Mortier, *After Effects 4 In Depth*, The Coriolis Group, 1999.

4 Resources provided to the class

4.1 Software

Students are introduced to various existing commercial tools like Adobe After Effects, Adobe Premiere, MAYA, and Sound Forge. Development toolkits for most of these products are available allowing students to develop plug-ins. Based on their level of expertise and interest, students choose a development environment appropriate for their project. Licenses for all these commercial packages are purchased to support this class. In the first year of teaching this class, we encouraged everyone to develop plug-ins for Premiere; however, students complained about the difficulty in using the toolkit SDK for complicated processing. .

Figure 2: View of our “studio.”

For this reason, we are now making available to the students a homegrown software system in C/C++ on Windows NT that uses the Intel Image Processing Library, Intel Computer Vision Library, and the Microsoft Vision SDK for more advanced video processing and analysis tasks. The students use this system to do development of their effects and then import the processed/synthesized video into Premiere for editing. We have seen very positive results when students are given at-least some skeleton code to deal with some of the low-level details of file formats, compression, and UI on a given platform.

Figure 3: Examples of the compositing assignment from spring 2000 class. Floating Guitar, Vanishing person, and Super Dude. Projects by Chow, Furdell, and Wong respectively.

4.2 Hardware

This class has a very heavy equipment demand. This demand is not just limited to the computing platforms and includes cameras, lights, and audio equipment. For this class we have established a complete new PC cluster with high-end 600MhZ Pentium III PCs. Each PC has 256 MB Ram and 30 Gigabytes of local diskspace. The reason for the large diskspace is to allow students local temporary space for manipulating video. An additional 50 Gigabytes of diskspace is provided on the server for students to store data after processing.

Each workstation is equipped with a DVRaptor card, which captures video in Digital Video (DV) format from a digital camera. We have also purchased 10 Canon Elura Mini-DV cameras exclusively for this class. These cameras are given to each group for the duration of the term. In addition to this equipment, students are provided tripods, special lights, rooms with green screens, microphones, and almost any other reasonable item to help them with their productions.

5 Projects undertaken by students

Students in the class are expected to do one initial project and then choose a final project. The initial project is undertaken individually, while the final project is worked on in teams of 3-4 students. In addition to the project, each student group works on a critique of a segment from a feature film and leads a short class discussion. We describe some of these projects here briefly.

5.1 Compositing from 2000

To provide with hands-on experience of dealing with digital video and all the equipment that is available to the class, their first assignment is to undertake simple chromakeying. We have built two separate locations in our research area dedicated to help students with this project (and the final projects as needed). Each of these locations is equipped with a either a large blue or green screen. In addition, we provide the students with appropriate diffuse lighting so that they can light the scene uniformly without harsh shadows.

The reason for this assignment is to get the students to think about both the subject matter and also how to control the environment for appropriate effect generation. In doing this assignment, the students learn to use Adobe After Effects and Premiere to do the compositing and final editing. They also learn to use the cameras and the digitizing system. Figure 3 shows some examples of the composites done by students in the spring 2000 class.

5.2 Critiques

To provide a stronger sense of the effort that the special effects industry undertakes and to understand the fine nuances of special effects generation, students are required to do a critical evaluation of a segment from a movie or some other video footage. Students study an effect of their choice and then present to the class their understanding of how the effect was generated. This is a very useful exercise for presenters and stimulates good class discussions. These critiques are available at http://minnow.cc.gatech.edu/dvfx/173.

5.3 Projects from 1999

A main aspect of this class is the production of one to five minute video segments to showcase the special effects that students develop for this class. This production is perhaps the high-point of theterm, as the students work countless hours shooting raw footage, implementing their effect, and then editing a final production. During the course of the term, we spend much time on trying to define a project that (1) is doable in the time available and (2) has enough technical merit. The students are then required to present an update every two weeks on their progress (bi-weeklies). An initial screening is scheduled three weeks before the finals week, which is just for the classmates, instructor, and TA. The final screening is in the last week of classes and is open to the public. The spring 1999 projects presentation was very well received and there was no standing room in the presentation room. We also received several requests for additional screenings after the final show.

In order to show the technical and artistic talents of the students doing these projects, here we briefly discuss some of the projects from the spring 1999 class. Figure 4 shows stills from three of these projects.

The left still is from a piece entitled “Tech Warz” by Haliburton, Johnson, and Peon. These students attempted to track colored sticks and replace them with renderings that appear like light sabers from a famous science fiction movie. In order to generate this effect, the students wrote code to track the brightly colored sticks. This code worked reliably in well-lit rooms without complex backgrounds. However, it failed to track in complex scenes. The students therefore had to develop a system to manually correct the tracking when and where it failed. This “failed” automatic vision-based tracking system should be perceived as a practical and very usable tool for doing an otherwise painstaking artistic task.

The middle still is from a piece entitled “The Beast” by Gdalevich, Moore, and Shleyfman. Here the students wrote an Adobe After Effects plug-in to take a green-screened silhouette of a person and composite it onto a real scene to show a “cloaked” alien. This was a similar effect to the one that appeared in the “Predator” (Twentieth Century Fox, 1987) movies.

The right image is from the “Flux Capacitor Pro” by Hedlund, Jones, and Laws. Here the students developed an Adobe Premiere plug-in to track a car and replace it with lightening. This was an effect motivated by the “Back to the Future” (Universal Pictures, 1985) movies.

In addition to the above-mentioned three projects, there are four more projects from the spring 1999 class which are available from the web pages for the class at http://www.cc.gatech.edu/classes/cs4803d_99_spring/projects.html.

The spring 2000 class is at present working on their final projects that are scheduled for final screening on April 28, 2000. We will be happy to show these at the workshop. The web page for this class is http://www.cc.gatech.edu/classes/AY2000/cs4480_spring/.

Figure 4: Three example projects from spring 1999 class. (left) Fighting with lightsabers, (center) a cloaked alien, and (right), a car vanishing into time.

6 Future

This is a very exciting class, very popular with students and also quite appreciated by the administration. However, we feel that there are still some ways we can improve. During the spring 2000 class, we found that the students are really interested in calibrating the cameras and the scene and tracking 3D objects. We intend to increase the amount of time spent on this aspect of the course next year. In fact, we are planning to add a 2nd assignment that will be on camera calibration. The students will use the existing code to do this and will develop additional code as needed.

The students of the spring 1999 class provided us with much feedback that helped improve our spring 2000 offering. We hope to again get some positive feedback from this year's offering to improve on the course for spring 2001.

7 Summary

We have designed a new and innovative class to teach students processing, analysis, synthesis, and manipulation of digital video. As a part of this class students develop a short video segment that showcases a special effect that they have generated. During this class they learn some basic principles of computer vision and graphics, and learn how to undertake a system building exercise in teams to produce an entertaining video piece. The students love this experience and seem to be in demand by the special effects production houses. We feel that we are succeeding in providing our students with a valuable learning experience.

8 References

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