Teaching Computer Graphics in Context
Computer Graphics Education 09 Workshop
Munich, Germany, March 31-April 1, 2009

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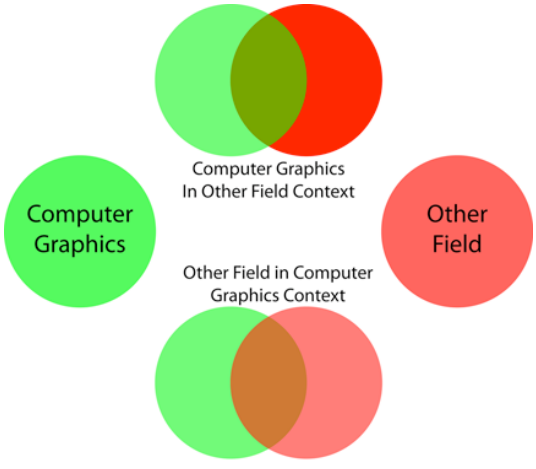
This workshop was organized to explore ideas in computer graphics education with a focus on teaching computer graphics in context. While previous workshops have focused on designing the computer graphics curriculum, this workshop recognized the importance of designing the students' learning experience within the curriculum. The workshop was held immediately before the Eurographics 2009 conference in Munich, Germany and was co-sponsored by Eurographics and ACM SIGGRAPH. Participation was by invitation based on submitted position papers.

The workshop began with an exploration of what "context" means for teaching computer graphics. The wide variety of kinds of computer graphics education among the participants led to some interesting discussion of the relationship between the computer graphics and the context in different fields. This led us to uncover a very interesting distinction in teaching computer graphics that had not fully emerged in other workshops: the difference between

- teaching computer graphics using a context from a different field, and
- teaching a subject in a computer graphics context.

This distinction was sometimes difficult to keep clear, but let's consider the case of computer graphics and the sciences. If you teach a computer graphics course (for example in a computer science program) you might choose to use a context of the sciences for course examples and projects; this is teaching computer graphics using a context. Or you might teach computer graphics in a course on visualization within a science program (for example, physics or chemistry); this is teaching the science in a context of computer graphics.

Another way to think of this is shown by the figure to the right. Let's consider the two areas of computer graphics and the context field as disks having RGBA color and with the alpha of 0.6. The overlap area then represents the teaching where the computer graphics and the context field overlap. You see that the two overlap areas have quite different colors: in the top area, the overlap is primarily computer graphics, but with some content from the other field; in the bottom are, the overlap is primarily the other field, but with some content from computer graphics.



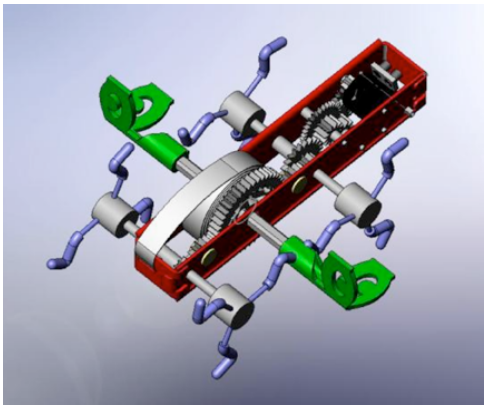
Whichever way you think about it, this distinction affects the way computer graphics is taught by faculty and learned by students. With this distinction in mind, the workshop focused on how we can think of each of these two approaches and how the approach changes the nature of the computer science instruction. It is important to note that these approaches are not separated by a bright, clean line; several of the workshop participants teach courses with both approaches, and some courses can easily be viewed as falling into both camps. This distinction should be approached with some caution.

Teaching a Subject in a Computer Graphics Context

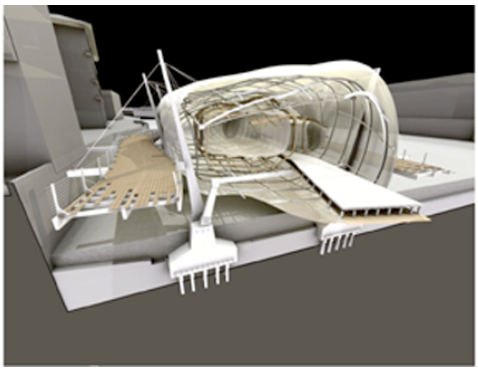
Some examples of this approach help to illustrate its breadth. At the workshop we saw

- Engineering design, using modeling tools taught by tutorials for student design project work.
- Architectural design, where students use many graphics applications to learn the attributes of the tools. Learning reflects the students' need to achieve particular results and is supported by consulting with faculty.
- Scientific visualization, where students learn principles, approaches, and methods for visualizing scientific data and principles. As the tools have evolved, this field needs less programming and tool development.
- Program design, where computer science students use graphical tools such as Alice to learn programming and computational thinking.
- Animation, where the emphasis is on principles of effective visual communication and tools are used but not emphasized.

A common theme in these is the use of computer graphics as a design tool, and the courses where computer graphics is taught or used often emphasize the design process. One approach is for students to produce a product and learn to work collaboratively, to develop communication skills, and to develop work iteratively through testing, debugging, and error checking as they build insight into the design. Another approach is for students to use computer graphics to explore a subject through simulation or animation, and to learn how to communicate with colleagues and clients graphically.



There are some common graphical themes in all these areas. Students need to learn an appropriate level of computer graphics concepts and skills, often involving visual language skills through some level of scripting or programming. These levels should adapt to the students' projects and should grow as the students' skills and concepts develop. However, the computer graphics is always learned as a means to an end, and the end lies in developing the ability to work in the subject field. We discovered context



as a way to become experimenters in designing experiences that will enhance students' ability to function in the world and deal with complex problem solving and innovation.

Teaching Computer Graphics Using a Context

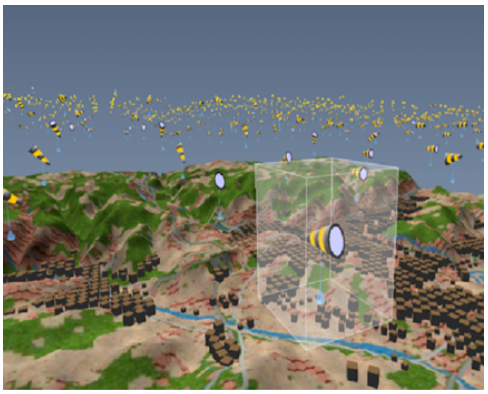
Courses in this group focus on computer graphics concepts and principles, and develop projects using programming or scripting. They may vary in the emphasis placed on different topics in computer graphics and on the depth of the discussion on these topics. They need not be in a technical field such as computer science or engineering; examples were given of such courses in several other fields. Two themes that ran through all these courses, however, were that the context motivates and reinforces the learning about computer graphics, and that the context should help students learn about visual communication using computer graphics.

Computer graphics courses find their homes in many different programs or departments. In many of these, there is a natural way that computer graphics contributes to the field, and that can provide a natural set of topics for examples and student projects. If the course is organized to take advantage of these topics, we say that the course uses an *intrinsic* context. On the other hand, if a course is in a field where there is no natural way that computer graphics contributes to the field, or if the course uses topics outside the area of the field, we say that the course uses an *extrinsic* context. Some computer graphics courses in animation, in the living and performance arts, and in games programs use an intrinsic context; some other computer graphics courses in these fields along with computer graphics courses in computer science or engineering use an extrinsic context.

Courses with Intrinsic Context

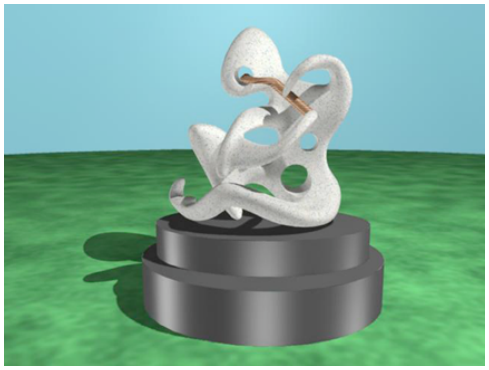
Courses in this group use the natural topics from the field hosting the graphics course to provide examples and student projects. The fact that there is a set of topics that can be drawn upon for a context makes it straightforward to select examples and student projects. Such courses include

- A computer graphics course in an animation program that focuses on animation algorithms and that develops animations for the theater and for physics simulations.
- A computer graphics course that focuses on modeling with specific work in theatre, sculpture, interior design, fine arts, games, and illustrations.
- A computer graphics course in a fine arts program that focuses on computer graphics principles and on developing visual language through programming and scripting.
- A course on scientific visualization that focuses on computer graphics principles but emphasizes techniques for creating scientific communications.



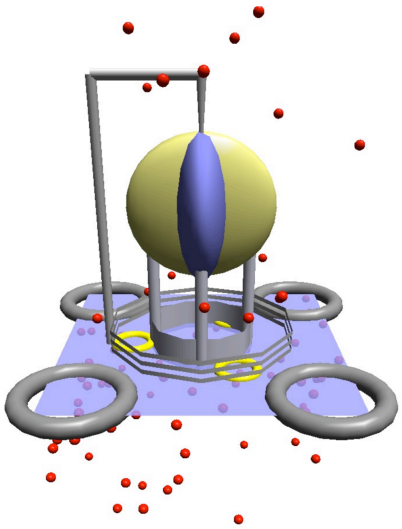
This group of courses may come from fields where there are other courses taught in a computer graphics context. For example, you may find a computer graphics course in an architecture program, and you are likely to find a computer graphics course in engineering.

Courses with Extrinsic Context

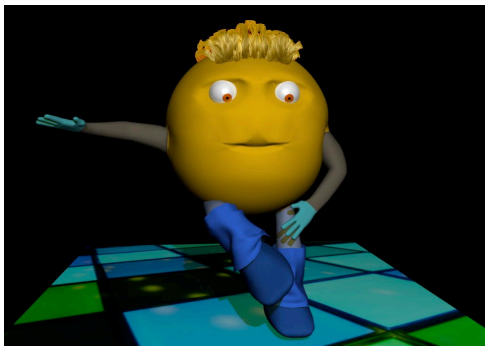


Although in principle this kind of course could come from many fields, those discussed at the workshop came from computer science. The contexts that were mentioned for such courses included

- The sciences and mathematics, including displaying surfaces and models of various scientific concepts and principles.
- Data display, where examples included environmental data, election data, and medical data. Some specific areas of interest include CT and MRI data.
- Games of various kinds, with an emphasis on so-called "serious games" that can include teaching games.
- Architecture and the modeling of architectural features with careful lighting and surface treatment.



Many of these courses involved API-based programming, with the more advanced courses also including shader programming with Renderman, GLSL, or HLSL. There was general agreement that the context for such a course should be from a real subject, and it was noted that the context might well present an application area where the student might specialize and develop a career path.



A number of issues were raised about these courses, because they involve work outside the technical topics of computer graphics. They include:

- How do you develop a graphics course around an extrinsic context?
- Who chooses the context for the course?
- How do you integrate the context material into the computer graphics content?
- How do you build the resources needed to support this kind of course?
  - These resources include examples and datasets that are not always easy to find.
  - Can we share these among our group and find ways for others to contribute?
- Do some contexts work better than others for this kind of course?
  - How much depth in the context area do students need?
  - How much detail in the context area should the graphics course provide?
  - Are there local experts who can come in to introduce the context?

  - Can the instructor collaborate with other disciplines in the context area?
  - Is there an institutional focus on an area that can serve as a context?
- How do you assess whether including a context improves the student's learning in the course?

There was broad agreement that for these courses, the context must not overtake the basic goals of teaching computer graphics but rather should augment the goals and generate interest from students and from the instructor.

Follow-up Activities

We realize that our workshop group is much smaller than the international computer graphics education world, and we believe that the issues the workshop raised need to be addressed by a larger group than ourselves. So we agreed that we would develop an online discussion group or wiki, and publicize it in a way that would encourage others to join the group and contribute ideas and resources such as examples and datasets. A specific goal of this outreach is to enable new people to expand their computer graphics courses to include external contexts.

We do not view this outreach as conflicting with other online resources, such as CGEMS or cgSource, that have been developed by SIGGRAPH and Eurographics, because it is never a complete product, but is a live, evolving, and growing entity that may link educators and resources in a new way. We hope that some formal resources can come from it, however.

We also agreed that workshop participants would develop, and would encourage others to develop, articles and papers that could be presented at SIGGRAPH or Eurographics education events. For SIGGRAPH 09, we plan to develop a BOF from this workshop and will schedule it to conflict with as few major conference activities as possible.

Looking Forward

The discovery of the distinction between these two types of teaching computer graphics was enlightening to the group and led to a lively interchange among the participants. We believe that there are several benefits to the computer graphics community in exploring the nature of teaching different subjects in a computer graphics context. We might learn better what kinds of tools work best for teaching graphics as a means to an end, for example, as well as learning about the particular application needs of various fields. We could also explore the question of developing computer graphics courses that would be service courses for various fields.

The discussion of teaching computer graphics using a context from another field yielded several questions of how the context is used that will need more work. The discussions among people who taught computer graphics in different contexts led to a need to see more examples, and we look forward to seeing the details of different kinds of courses. The overall goal is to create a richer learning environment by providing experience along with the computer graphics concepts. But perhaps the most intriguing point was the suggestion that computer graphics courses using contexts that touch on real-world problems that affect real people could be an important part of making a computer science program more effective in attracting and retaining women and students from

underrepresented groups in the field. We hope to see future work in this direction.

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Page 4, middle, a biological cell-level pump mechanism, Jacob Cram, Grinnell College, courtesy of Steve Cunningham.
Page 4, bottom, a frame from an animation by Pablo Quesada Barriuso, Rey Juan Carlos University, courtesy of Caroline Larboulette.

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