Forum: Knowledge Base for the Emerging Discipline of Computer Graphics

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Abstract

Computer Graphics is evolving as a discipline characterized by the fusion of artistic and technical theories and skills. The goal of the SIGGRAPH Curriculum Working Group has been to create a knowledge base that defines this discipline. This knowledge base is presented as a palette of subject areas and skills that forms the necessary educational framework for creation of undergraduate curricula that specialize in computer graphics. It facilitates the development of attributes that will create paths toward professional work, graduate studies, and lifelong skills-development and learning. The knowledge base is offered for faculty members designing new computer graphics programs or those evolving existing ones, students crafting their own programs of study, and administrators and accreditors seeking guidance for framing and assessing computer graphics programs.

Keywords: Curriculum, education, knowledge base, discipline.

1 The Emerging Discipline of Computer Graphics

Three essential criteria must be met for a body of knowledge and set of practices to qualify as a discipline [Bertoline 1998; Rumble 1998; Sheth and Parvatiyar 2002]. First, theoretical and conceptual specialization must be demonstrated, often through a well-established and fairly unique research agenda. Next, it must be shown that the discipline can be characterized by a unique cultural identity. Finally, a discipline must demonstrate relative autonomy, in that a distinctive knowledge base can be articulated.

The computer graphics discipline's theoretical and conceptual autonomy and unique cultural identity are evident in many of SIGGRAPH's programs and activities. That such a "special interest" group exists lends validity to the claim that computer graphics is an emerging discipline. An annual conference serves to distinguish the interests of the computer graphics community from other communities. The annual conference provides a venue for presentation of research findings. Professional journals and periodicals help define the bounds of the discipline and specialized research interests. Certainly, this and other evidence substantiates claims that computer graphics constitutes an emerging discipline.

The task assigned to the SIGGRAPH Education Committee's Curriculum Working Group has been to define the knowledge base associated with the computer graphics discipline. Because this knowledge base is most closely associated with the broader discipline, and not any particular application or industry, it has great potential as a starting point for curriculum development and evaluation. It defines, in broad terms, those skills and concepts that every computer graphics student should have some exposure to and with which every instructor ought to have some familiarity.

2 Previous Work

The SIGGRAPH Education Committee has sponsored a number of projects and reports that recommend topics and curricula for computer graphics education. Perhaps the most significant of these was the "Computer Graphics Taxonomy Project" by Jacquelyn Ford Morie. The report aims to define a taxonomy of CG concepts that covers all topics relevant to computer graphics. "The taxonomy includes basic and advanced CG concepts that are pertinent across many disciplines, from art to engineering" [Morie 2001]. The SIGGRAPH Education Committee has sponsored other curriculum projects, but each was focused on a single sub-discipline of CG, e.g., art, scientific visualization, computer science, and engineering.

The SIGGRAPH Curriculum Working Group can trace its beginnings to the SIGGRAPH 2001 Conference Educators Program. One of that year's forums was titled "The Emerging Computer Graphics Discipline," led by Gary Bertoline of Purdue University [Bertoline 2001]. Bertoline challenged the audience to think of computer graphics as a renaissance discipline, on a continuum between art and computer science and electrical and computer engineering.

Discussions led to a second forum at the SIGGRAPH 2002 Conference, where the goal was to try to develop a knowledge base for the discipline of computer graphics. Bertoline and Laxer suggested that computer graphics had a multidisciplinary nature, involving components of cognitive psychology, geometry, imaging science, technology, art, design, and computer science. The audience was challenged to come up with core topics that were crucial to a computer graphics student's education and that addressed this multidisciplinary nature. Two long lists of topics were generated, one from the computer science perspective and one from the art perspective. From these lists, a knowledge base for the computer graphics discipline began to emerge.

3 History of the Curriculum Working Group

The next step was to devote significant effort to refining this knowledge base and the creation of a broad curricular framework for computer graphics. To that end, Bertoline and Laxer submitted a grant proposal to the SIGGRAPH Education Committee to bring ten computer graphics educators, representing computer science and art, together for a one day workshop immediately preceding the SIGGRAPH 2003 Conference. At that workshop, the participants agreed on a common core set of topics for all

computer graphics students. Further, tracks for the artistically inclined student and the technically inclined student were identified.

At the conclusion of the 2003 workshop, the participants realized that they had significant input from the computer graphics education community, but no input from the computer graphics industry, the very people who would employ graduates of computer graphics programs. Thus, the Working Group decided to hold another workshop the day before the SIGGRAPH 2004 Conference and invite industry representatives to meet with the group and express their thoughts on what skills and knowledge they would like to see in students graduating from computer graphics programs. Excellent input was received from several industry representatives which the Working Group used to refine the developing curriculum.

In 2005 the Working Group met once more on the day before the SIGGRAPH Conference to finalize the core set of topics and further refine the two tracks (artistic and technical). Excellent progress was made, and momentum was built, but the work could not be accomplished in the one day. The group met again that November to continue their work.

4 Proposed Curriculum/Knowledge Base

What follows is the knowledge base as defined during the Working Group's November 2005 meeting. Of interest, the two tracks defined during the earlier meetings were merged into a single knowledge base. The group's rationale was that this ought to reflect a united knowledge base defining the discipline of computer graphics, and not tracks specific to isolated applications. That is, it is suggested that every computer graphics student will invest some amount of time, whether small or large, with every listed concept.

There are sixteen broad headings, many with sub-headings and additional detail. Content isn't meant to be exhaustive but, instead, provide general guidance and examples of curricular experiences and concepts. A greatly-abbreviated outline follows:

Fundamentals – overview of the discipline; industry highlights; careers; chronology; terms, concepts, and theories; tools

Professional Issues – ACM/IEEE code of ethics; project management, support, and synergy; communications; access issues (ADA); copyright, property rights, and licensing

Physical Sciences – weight, mass, and inertia; physical properties of light

Math – manipulation of objects in coordinate space; geometry; transformations; numerical methods

Perception & Cognition – psycho-biological foundations of visual perception; spatiality; motion; human-computer interaction

Programming & Scripting – theory and technique; languages; algorithms; graphics APIs

Animation – principles of animation; kinematics; rigging; rigid body dynamics; procedural animation

Image Synthesis / Rendering – material properties/interaction with light; reflection and shading models; texture mapping; sampling and anti-aliasing techniques, ray tracing; shaders

Real-time Graphics – optimization; level of detail modeling; virtual reality

Modeling – polygonal modeling; deformations; parametric primitives; subdivision surfaces; modeling economy

Graphics Hardware – input/output devices; special purpose chip sets; programmable architectures; graphics card features

Image Processing & Manipulation – computer vision; image acquisition issues; graphics/image file formats

Writing – storytelling; character development; point of view; narrative support of CG experiences

Cultural Trends & Historical Perspectives – tastes; timelines; genres, schools of thought, and movements; the influence of art on politics, societies, cultures, economies, & vice versa

Design Studies – stylistic consideration; aestheticism; media as a social, cultural, political, and critical force; color theory; design principals

Advanced Topics – scientific visualization; artificial intelligence

5 Future Work

Having refined the knowledge base, the Working Group is now eager to solicit feedback from other academicians, industry professionals, and students; hence the presentation of complete details of the knowledge base in a forum at the 2006 SIGGRAPH Conference.

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