SIGGRAPH2006

Physically-Based Reflectance for Games

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The latest version of these course notes, together with other supplemental material, can be found on the course web site at http://www.cs.ucl.ac.uk/staff/J.Kautz/GameCourse/

Agenda

- 8:30 - 8:40: Introduction (Naty)
- 8:40 - 9:15: Reflectance (Naty)
- 9:15 - 10:15: Game Development (Dan, Naty)
- 10:15 - 10:30: Break
- 10:30 - 11:15: Rendering (Point Lights) (Naty, Dan)
- 11:15 - 12:00: Rendering (Environment Maps) (Jan)
- 12:00 - 12:15: Conclusions / Summary (All)

Physically-Based Reflectance for Games

8:30 - 8:40: Introduction

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Motivation for Game Developers

- Understand physical principles of reflectance
- Physically principled rendering methods
  - Not “physically correct” (no such thing)
- A means, not a goal
  - In games, like film, the goal is to “look right”
  - Under unpredictable conditions, without tweaks
  - Physically principled methods can assist

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As in film, the goal in games is not accurate simulation but verisimilitude. Film has one advantage over games – each shot is carefully framed, lit, shot and processed while in games the final rendered frame is only partially under the control of the developer. The player may change camera angles, object placement, in some cases even lighting conditions in unpredictable ways. In film rendering it is quite common to “fix it in post” as rendering artifacts are manually adjusted away in post-processing. Games do not have the benefit of such manual adjustments to the final render. For these reasons, game rendering can benefit from physically principled rendering methods even more than film rendering.

Also, understanding the physical principles involved is useful even when a conscious decision is taken to diverge from these principles for artistic reasons (as often happens in both film and game production).

Motivation for Academic Community

- Realistic real-time rendering techniques are a major area of research
- Often, this research is underutilized in the game development community
- Understanding the constraints on rendering techniques used in games can help develop more directly usable techniques

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Of the vast amount of published research on real-time rendering techniques, only a tiny percentage is actually utilized in game development. In some cases this might be due to game developers being unaware of the relevant research or lacking the time to implement or experiment with it, but in many cases the research results are simply not usable in game development. The reasons are various: sometimes the described techniques use too much computational resources or storage to be practical, sometimes they are not sufficiently amenable to artist control or do not otherwise fit in the game production pipeline. It is our hope that a better understanding of the constraints involved in game development will help researchers in the field of real-time rendering achieve greater adoption of their research results in the game development community.

Focus of this Course

- There are three main phenomena relevant to rendering a scene
  - Light is emitted
    - By sun, artificial lights, etc.
  - Light interacts with the rest of the scene
    - Surfaces, interior volumes, particles, etc.
  - Finally, light interacts with a sensor
    - Human eye or camera

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Due to time constraints, we have chosen to focus in this course on a specific aspect of the physical phenomena underlying the behavior of light in the scene.

Focus of this Course

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    - By sun, artificial lights, etc.
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  - Finally, light interacts with a sensor
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We focus on the interaction of light with the scene,

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Specifically with solid objects, not atmospheric particles or other participating media.

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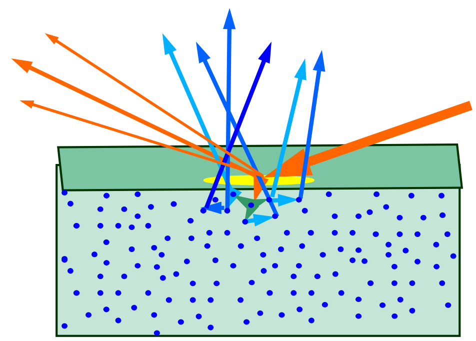
We will focus most on surface interactions.

Focus of this Course

- Reflectance - interaction of light with a single surface point
- Interior interactions, interreflections, etc. abstracted into a *reflectance model*



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If we observe what happens when light strikes a surface point on an object, we will see that some of the light is reflected directly from the surface, and the rest penetrates the surface. Of the light penetrating the surface, some is absorbed, and some undergoes scattering before being re-emitted. In this diagram, all the exitant light comes out of the small yellow circle, which we abstract as a single surface point. The fundamental assumption here is that light entering at other points does not affect the light exiting this one, which lets us abstract the relationship between light entering and exiting that point into a *reflectance model*.

Focus of this Course

- Reflectance abstraction tied to scale
  - Abstracted phenomena must occur below the scale of observation
- For example, in satellite imagery forests are often treated as reflectance models
  - Interreflection and occlusion of light by trees, branches and leaves are abstracted

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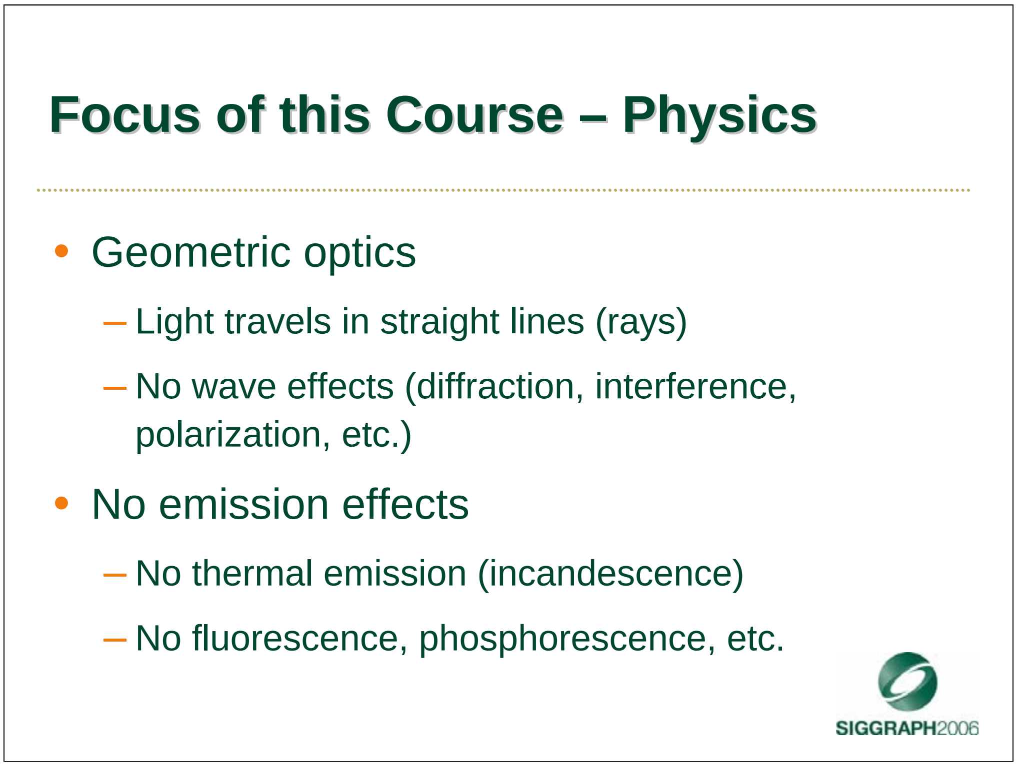
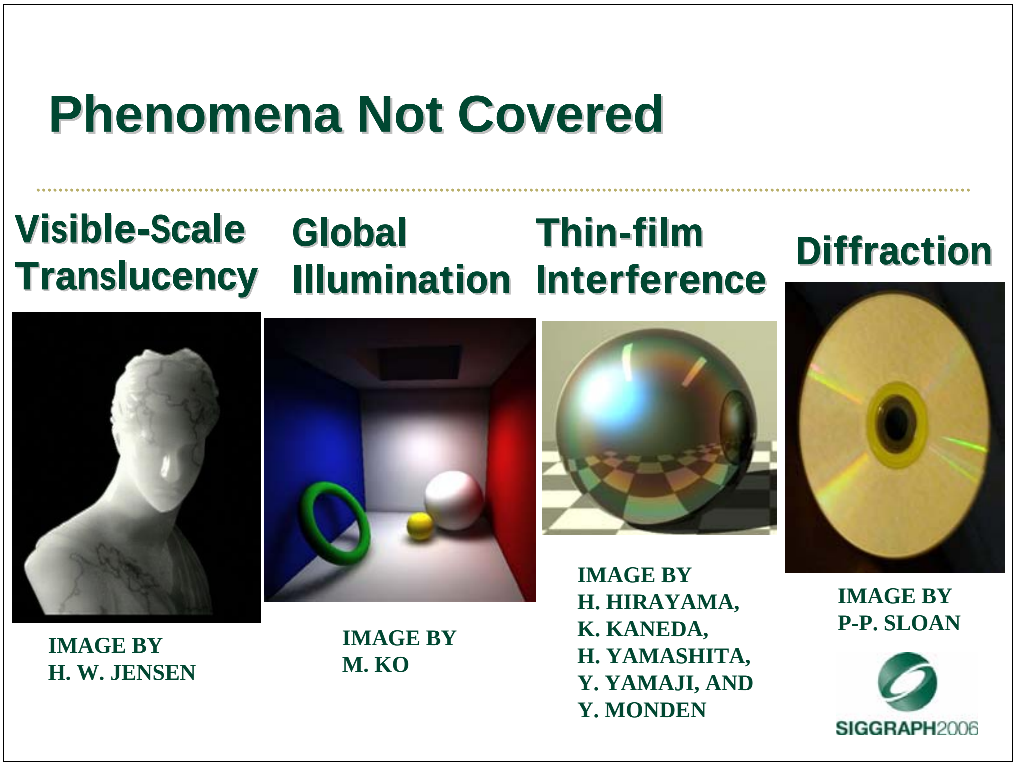
The validity of the reflectance model is based on the assumption that the area from which the exitant light was emitted can be approximated by a point. Obviously the validity of this approximation will vary with the scale of phenomena under observation.



Again due to time constraints, we choose to focus on geometric optics exclusively and ignore effects resulting from the wave nature of light. We do not discuss the physics of light emission either.



These are all outside the domain of our course. There are real-time techniques for rendering these phenomena, which can be researched by developers interested in incorporating them into their games.