UC Berkeley Graphics Prelim Syllabus

or *what every graphics student should know*

There is no comprehensive, up to date graphics text. The resources offered here cover roughly the material that we intend. Often there is extraneous material. In general, we require a degree of comfort with the underlying principles — for example, we expect you to use sufficient good sense to realise that a knowledge of SPHIGS or PHIGS is not what we are driving at. We expect that you will be able to relate concepts and algorithms. We have tried to include as many resources as possible, and this means there are some redundancies; for example, Foley and Van Dam's book and Watt's book say pretty much the same things about transformations.

The physical world

Overall thrust: that without which graphics is impossible.

Radiometry

Radiance, irradiance, and radiosity; bidirectional reflectance distribution functions; directional hemispheric reflectance; albedo; spectral quantities and colour; Lambertian + specular models; basic familiarity with scattering. **Resources:** Sillion, chapter 2; Foley and Van Dam, chapter 16; Watt, chapter 14.

Geometry

Homogenous coordinates; rigid transformations; projection, orthographic and perspective; pinhole cameras; basic lenses. **Resources:** Foley and Van Dam, chapters 5, 6, 7; Watt, chapter 3.

Rendering

Overall thrust: the way physical effects of illumination drive the design of rendering algorithms.

The graphics pipeline

Digitization algorithms, including Bresenham's algorithm and polygon fill; transformation hierarchies; clipping, including parametric clipping; texture mapping, both projective and orthographic; models of specularities; shading interpolation methods, including Phong and Gouraud shading; basic notions of procedural shaders, including displacement mapping and bump mapping. **Resources:** Foley and Van Dam, chapters 3, 16; Watt, chapters 3, 4, 5; The Renderman Companion.

Ray tracing

Recursive formulation; intersection computations; refraction, specular reflection; sampling and aliasing; reflection and refraction caustics and reverse ray-tracing. Bidirectional ray-tracing. **Resources:** Foley and Van Dam, chapter 16; Watt, chapter 8.

Radiosity methods

Transfer modes (specular to diffuse, diffuse to diffuse, diffuse to specular, specular to specular); interreflection kernel; simple finite element methods; **Resources:** Sillion, chapters 3, 4, 7

Global illumination

Basic multi-pass rendering; basic ideas of scattering. Detailed knowledge of algorithms not required. **Resources:** Chen et al., 1991

Modelling and computational geometry

Overall thrust: choice of representation has profound effects on what can be modelled.

Boundary models

Piecewise (linear, quadratic, cubic, etc.) functions; meshes of triangles; basic B-spline curves and surfaces, including continuity and knots; basic Bezier curves and surfaces, including De Casteljau algorithm; implicit surfaces; computing intersections between curves and surfaces, and surfaces and surfaces. **Resources:** Foley and Van Dam, chapter 11; Bartels, Beatty and Barsky Chapters 1-4 and 9-10

Solid models

Different representations of solids (such as CSG, Breps, voxels, sweeps, instanciations ...) and conversions between them; issues affecting efficient and robust computation of bounding boxes, convex hulls, CSG operations between polyhedral Breps; hierarchical structuring of complex models and scenes, and auxiliary data structures to make use of these models efficiently for rendering, animation, or collision detection; **Resources:** Foley and Van Dam, chapter 12; Mortenson, chapters 9, 10;

Visibility

Painters alg, Z-buffer, Warnock's algorithm, BSP-trees; strengths and weaknesses of each case; level of detail. **Resources:** Foley and Van Dam, chapter 15; Funkhouser *et al.*.

Building models

Methods using range data and image data; distance between surfaces and points; fitting problems; mesh completeness and zippering algorithms; basic photogrammetry; fitting simple models to image data; recovering texture models from image data. **Resources:** Curless and Levoy; Debevec, Taylor and Malik; Hoppe *et al.*

Animation

Overall theme: functions of time make models move

Simple spring mass models; keyframing as interpolation; forward and inverse kinematics; Jacobians and singularities; advantages and disadvantages of kinematic animation systems; motion capture — tracking points on real objects to animate virtual ones. **Resources:** Gleicher; Tu and Terzopolous; Hodgins; Murray, Li and Sastry, chapter 2 Watt, chapter 13

Resources

- Watt, A. "3D Computer Graphics," Addison Wesley, 1993.
- Sillion, F. and Puech, C. "Radiosity and global illumination," Morgan Kauffman, 1994.
- Foley, J. and Van Dam, A. and others "Computer graphics : principles and practice," Addison Wesley, 1996
- Mortenson, "Geometric Modelling," Wiley, 1985.
- Bartels, R. and Beatty, J. and Barsky, B., "An introduction to splines for use in computer graphics and geometric modelling," Morgan Kauffman, 1987.
- Chen, S.E.; Rushmeier, H.E.; Miller, G.; Turner, D. A progressive multi-pass method for global illumination. (SIGGRAPH 91, Las Vegas, NV, USA, 28 July-2 Aug. 1991).
- Curless, B.; Levoy, M. A volumetric method for building complex models from range images. SIGGRAPH-96, 1996.

- Gleicher, M., , “Retargeting Motion to New Characters”, SIGGRAPH-98.
- Hodgins, JK. Animating human motion. SCIENTIFIC AMERICAN, 1998 MAR, V278 N3:64-69;
- Richard M. Murray, Zexiang Li, S. Shankar Sastry. A mathematical introduction to robotic manipulation, Boca Raton : CRC Press, c1994.
- Funkhouser, T.A. and Sequin, C.H. and Teller, S.J., "Management of large amounts of data in interactive building walkthroughs", ACM Symposium on Interactive 3D Graphics, 1992.
- Tu, X. and Terzopolous, D., "Artificial Fishes: Physics, Locomotion, Perception, Behavior", SIGGRAPH-94, 1994.
- Debevec, P.E. and Taylor, C.J. and Malik, J., "Modeling and Rendering Architecture from Photographs: A Hybrid Geometry- and Image-Based Approach", SIGGRAPH -96, 1996.
- Hoppe, H. *et al.*, "Piecewise Smooth Surface Reconstruction", SIGGRAPH-94, 1994.