Written Assignment

CS 148 Autumn 2014-2015

Due Date: in class on Tuesday, 4 November 2014

Answer the questions in the spaces provided or on separate sheets of paper. You are allowed to form groups of **three** for discussion, but note that you have to write your solutions **individually**.

Honor Code Statement

1. The Honor Code is an undertaking of the students, individually and collectively:

   1. that they will not give or receive aid in examinations; that they will not give or receive unpermitted aid in class work, in the preparation of reports, or in any other work that is to be used by the instructor as the basis of grading;

   2. that they will do their share and take an active part in seeing to it that others as well as themselves uphold the spirit and letter of the Honor Code.

2. The faculty on its part manifests its confidence in the honor of its students by refraining from proctoring examinations and from taking unusual and unreasonable precautions to prevent the forms of dishonesty mentioned above. The faculty will also avoid, as far as practicable, academic procedures that create temptations to violate the Honor Code.

3. While the faculty alone has the right and obligation to set academic requirements, the students and faculty will work together to establish optimal conditions for honorable academic work.

Honor Code Acknowledgement

I acknowledge and accept the Honor Code.

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Signature: 

True/False Questions

1. [10 points] The following statements are either true or false. Circle the correct answer to the left of the question. Explain your answer.

   (a) **True** **False** The BRDF of the surface of a Lambertian object for a single wavelength can be specified as a one-dimensional function.

   Solution:

   (b) **True** **False** The RGB and YUV color spaces are related by a linear transformation.

   Solution:

   (c) **True** **False** The ambient component of the Phong illumination model is equivalent to a constant BRDF.

   Solution:

   (d) **True** **False** For every visible wavelength, there exists a combination of RGB that can reproduce it.

   Solution:

   (e) **True** **False** A red flashlight appears red because it absorbs all colors other than red.

   Solution:

   (f) **True** **False** Any image that can be produced by an ideal CMYK printer can also be produced by an ideal CMY printer.

   Solution:

   (g) **True** **False** The Gauss Seidel method can diverge when solving the discretized rendering equation while the Gauss Jacobi method always converges.

   Solution:

   (h) **True** **False** In order to capture the refraction of light in water, one needs to compute the refraction of light over 3D space as opposed to only at the surface of the water.

   Solution:

   (i) **True** **False** Irradiance increases under a magnifying glass.

   Solution:

(j) **True** **False** The reflection of light in a room full of mirrors can be accurately modeled using the radiosity approach.

Solution:

(k) **True** **False** Color-blindness results from a lack of cones in the human eye.

Solution:

(l) **True** **False** Tone mapping is applied to the gamma encoded images to convert them back to the original scene luminance.

Solution:

(m) **True** **False** For frequencies below the flicker fusion rate, an intermittent light stimulus appears to be completely steady to the observer.

Solution:

Multiple Choice Questions (It is possible to have any number of true choices in each question including zero. Explain your answer.)

2. [2 points] What does the global illumination model approximate?
   A. Ambient reflection in Phong illumination model
   B. Diffuse reflection in Phong illumination model
   C. Phong illumination model
   D. None of the above

Solution:

3. [2 points] Radiant intensity is properly defined for
   A. A point light source
   B. A laser beam
   C. A light bulb
   D. A strictly uni-directional light source

Solution:

4. [2 points] An HDR image is suitable for
   A. A scene where all objects are brightly lit

B. A scene where all objects are in shadow

C. A scene where some objects are brightly lit and the other objects are in shadow

D. None of the above

Solution:

5. [2 points] When a light beam is transmitted through a material

A. Light energy is always lost

B. Light energy is never lost

C. Light energy is lost if there is absorption of light

D. Light energy is not lost if there is reflection of light

Solution:

6. [2 points] Which of the following statements are true?

A. Given a fixed amount of power emitted from a light source, the smaller the light's solid angle, the smaller the radiance.

B. The irradiance of light power on a surface is smaller when the surface area is larger.

C. Irradiance can be understood as light intensity per unit solid angle.

D. In the Phong reflection model, the diffuse coefficient dependent on the radiance of the incoming light.

Solution:

7. [2 points] OpenGL shading can model

A. Emission

B. Mirrors

C. Absorption of light in a media

D. Diffuse reflection of light from the light source

Solution:

8. [2 points] Which of the following statements is true regarding gamma encoding and human vision? Circle all correct answers.

A. Human eyes are more sensitive to changes in darker tones than brighter tones.

B. Human eyes are more sensitive to changes in brighter tones than darker tones.

C. Gamma encoding allocates more bits to the darker tones in the image.

D. Gamma encoding allocates more bits to the brighter tones in the image.

Solution:

9. [2 points] Which color space(s) is/are cylindrical?
   A. YUV
   B. CMY
   C. HSV
   D. RGB

Solution:

10. [2 points] Which statement is incorrect regarding light distribution functions?
    A. BTDFs and BSSRDFs can both be used to model transparency.
    B. BRDFs, BTDFs, and BSSRDFs are all used to decide how much light is reflected, transmitted and absorbed on the surface.
    C. BRDFs accurately account for the reflection, absorption, transmittance of light.
    D. BRDFs always depend on the wavelength of the light.

Solution:

11. [2 points] Which of these statements is incorrect?
    A. The Phong model can be approximated by a BRDF.
    B. The Continuous Lighting Equation depends on the visibility of the scene to the light source.
    C. Global Illumination can only model diffuse surfaces.
    D. Radiosity and the diffuse Phong model can be used together to get a better solution.

Solution:

Short Answer Questions

12. [5 points] Describe the YUV and and HSV color spaces. What is a common application for each of these color spaces? How do you convert a color in HSV space to YUV space?

Solution:

13. [5 points] Consider a spherical environment map stored as an image. Why can distortion arise when the viewpoint differs significantly from the viewpoint in which the environment map was acquired? How can you reduce this distortion?

Solution:

14. [5 points] Describe how you would combine the Phong model and radiosity to render a scene with ambient, diffuse, and specular illumination.

Solution:

15. [5 points] Explain Nusselt's analog and how it can be used to calculate form factors.

Solution:

16. [5 points] Where are cones most densely packed on the retina? Is the same true for rods?

Solution:

17. [5 points] Why is the RGB color model unsuitable for use in printing?

Solution:

18. [5 points] In subsurface scattering, light incident on a given location scatters internally and exits from another location on the surface. How would you extend the 4D BRDF to model subsurface scattering?

Solution:

19. [5 points] Many photo inkjet printers often have more than four cartridges required for the CMYK model. What is an advantage of the having more than four cartridges?

Solution:

Long Answer Questions

20. [8 points] Consider a cube $ABCDEFGH$ with edge length R. A point light source with radiant intensity I_l is located at point A, and seven tiny diffuse planar patches (with diffuse coefficient k_d) are located at B, C, D, E, F, G, and H, respectively, all with normals straightly pointing to A. Each patch has an area of a and we assume that $a << R^2$. Derive an expression for the radiosity of any one of the patches.

Solution:

21. [8 points] Explain how to approximate the form factor using a hemicube. Why is it advantageous to use a hemicube instead of a hemisphere?

Solution:

22. [8 points] Give a 2x2 example (different from the one given in class) where the Jacobi approach converges, diverges and goes in an infinite cycle. Show that the iterative solution to radiosity can diverge in the case of perfectly reflective surfaces.

Solution:

23. [8 points] Consider performing radiosity computations with moving point lights. Assume that the motion of the point lights are known. Do you need to recompute the entire matrix for computing the radiosity as the lights move? Why or why not? Is it possible to perform this computation in parallel?

Solution:

24. [8 points] Rendering Equation in presence of a participating media: Consider a emitting participating medium e.g. fire with spatially constant emission throught the space. When a ray is traced from point A to point B in this medium, light is accumulated along the ray based on the distance between A and B. How will the rendering equation change? What would change in the finite element method? Does anything change if the emission was spatially varying instead of constant?

Solution:

25. [8 points] For an 10-bit display, denote its maximum luminance intensity by $I_{\max}$ and denote its minimum luminance intensity by $I_{\min}$. Given that the just-noticeable relative difference of intensity is equal or larger than 2%, calculate the range of the 1023 steps where the difference in intensity values on one level are noticeable to the those two levels away. under the following conditions:

    1. $I_{\min} = 0$,, with decoding gamma $\gamma = 2$
    2. $I_{\min} = 0.03 I_{\max}$, with decoding gamma $\gamma = 2$
    3. $I_{\min} = 0$, with decoding gamma $\gamma = 1$
    4. $I_{\min} = 0.01 I_{\max}$, with decoding gamma $\gamma = 1$

Solution: