NEW YORK UNIVERSITY

COMPUTER SCIENCE DEPARTMENT
CSCI-GA.2270 – 001 COMPUTER GRAPHICS
FALL 2022

FINAL EXAM

DATE: 12/19/2022
TIME: 06:00 PM– 7:50 PM
TYPE: ONLINE

QUESTION	POINTS	
Q1		/20
Q2		/15
Q3		/15
Q4		/15
Q5		/15
Q6		/20

FULL NAME: Yuxiang Chai STUDENT ID: N19027974…….

Print your name and ID on this page (now), and write out and sign the Honor Code pledge before turning in this paper. Note: It is a violation of the Honor Code to discuss this midterm exam question with anyone until after everyone in the class has taken the exam. You have 110 minutes to complete the test.

"I pledge my honor that I have not violated the Honor Code during this examination."

Yuxiang Chai

Signature

Q1) True/False – Multiple Choice - Circle the correct option. (1pts x 20 = 20 pts)

Red is the answer

1. (True) (False) A TV has to have the same number of pixels of the image it displays.

2. (True) (False) Even vector images have to be rasterized before display.

3. (True) (False) In projective methods, at most one triangle can project onto the same pixel.

4. (True) (False)Shearing is a well-known transformation technique which pushes the object sideways.

5. (True) (False) If v = (ScaleRotate)x, rotation is applied to x first during transformation.

6. (True) (False) Any 2D matrix can be decomposed into a product of scale, scale, rotation in order.

7. (True) (False) DDA is an incremental method which describes the supersampling of noisy image data.

8. (True) (False) Per-vertex shading cannot produce any details in the shading that are smaller than the primitives used to draw the surf ace.

9. (True) (False) View volume culling is the removal of geometry that is obscured or occluded by other geometry closer to the camera.

10. (True) (False) Local illumination considers the interaction of light from all the surfaces in the scene.

11. (True) (False) Mass-spring implementation should actually *guarantee* conservation of momentum, due to the way we explicitly apply the equal and opposite forces. However, it is never possible to guarantee it or get close to it in a simulation.

12. (True) (False) Hermite smoothing handles mach bands coming from discontinuities in derivatives in intensity.

13. Process of reconstructing a full color image from the incomplete color samples output from an image sensor is called….
    A. Global illumination
    B. Perlin noise generation
    C. Demosaicing
    D. Raycasting

14. Which is false about raytracing?.
    A. Raytracing computes ray from viewpoint through pixel center
    B. Raytracing is computationally very efficient and a fast technique
    C. Raytracing produces very high degree of visual realism
    D. It finds the first object hit by the ray

15. ….. is a phenomena which describes the loss of degree of freedom in 3D.
    A. Euler angles
    B. Quaternions
    C. Gimbal Lock
    D. Subsampling

16. Which statement is false about Cohen-Sutherland clipping?
    A. It is a line-rectangle clipping algorithm;
    B. It extends the window's sides and breaks up the space into 9 regions
    C. It assigns 2-bit and 3-bit binary outcodes to each region in 2D and 3D respectively
    D. If a line is not accepted and its two endpoints are in the same half space of a clipping edge, it is directly rejected

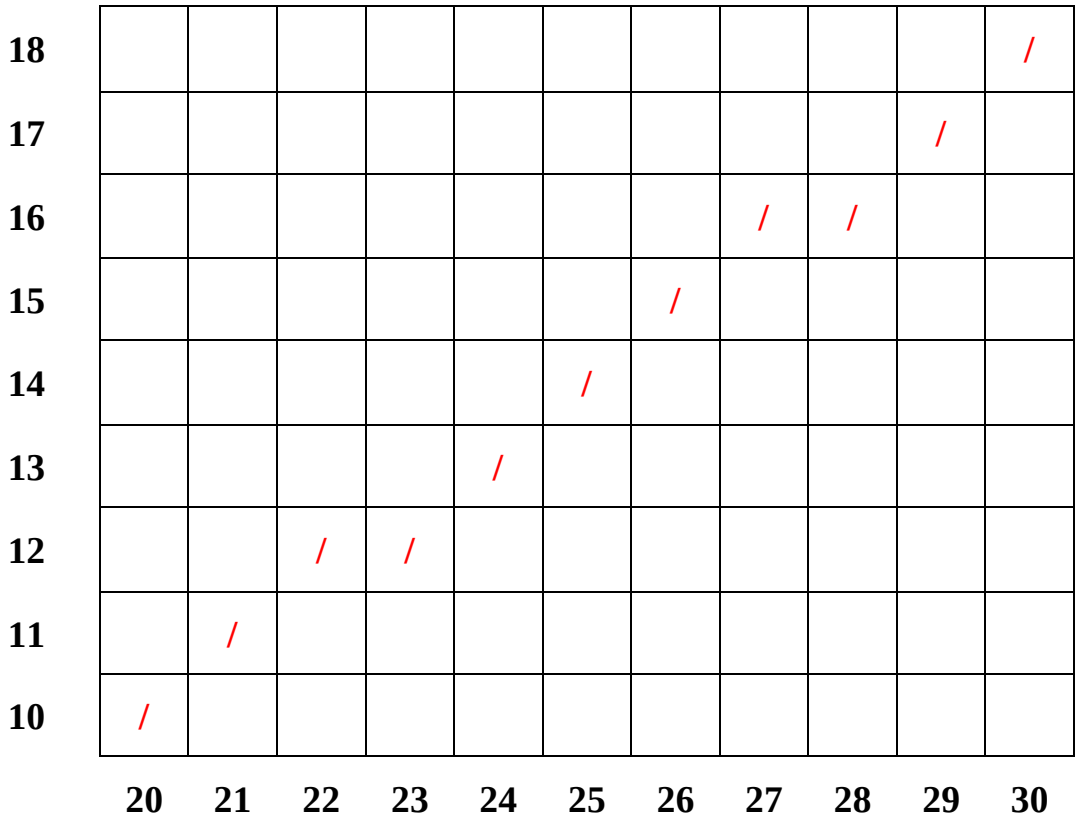
17. By using supersampling, setting each pixel value to the average color of the square area belonging to the pixel is called…
    A. Box filtering
    B. Box jagging
    C. Box culling
    D. Box clipping

18. $I'_L = I_L * fatt(d)$. In this formula, light source attenuation is computed and d is the…
    A. distance between the light source and the surface
    B. distance between the light source and viewer
    C. distance between the light source and the average surfaces in the given area

19. Which is correct about bump textures?
    A. It is the change in vector positions.
    B. It is an illusion of displacement.
    C. It does not use or affect surface normals
    D. It is also known as displacement mapping

20. Which step does not belong to smooth noise generation?
    A. Create a grid of random gradient vectors
    B. Compute points within grid using nearest nodes
    C. Interpolate between node values
    D. Never combine different smooth noise functions since they produce jaggy lines

Q2) Draw a line in between points (20,10) and (30,18) using Bresenham's method. Clearly show the intermediate computation steps.



HELPER CODE FOR BASIC BRESENHAM

```
dx=x1-x0
dy=y1-y0
D = 2*dy - dx
plot(x0,y0)
y=y0

for x from x0+1 to x1
        if D >= 0
            y = y+1
            D = D - (2*dx)
        D = D + (2*dy)
        plot(x,y)
```

X = 20, y = 10, D = 6

X = 21, y = 11, D = 2

X = 22, y = 12, D = -2

X = 23, y = 12, D = 14

X = 24, y = 13, D = 10

X = 25, y = 14, D = 6

X = 26, y = 15, D = 2

X = 27, y = 16, D = -2

X = 28, y = 16, D = 14

X = 29, y = 17, D = 10

X = 30, y = 18, D = 6

Q3) Thoroughly explain what raytracing is. What are the differences in between projective methods and raytracing? Why is it hard to achieve real-time raytracing?

ANSWER:

Ray tracing is a technique for generating an image by tracing the path of light through pixels in an image plane and simulating the effects of its encounters with virtual objects.

Projective methods are projecting 3D triangles to 2D triangles on screen. It projects vertices and shade 2D triangles. Two or more triangles can be projected to the same pixel. And it is object-order rendering. But for raytracing, it computes the ray from the viewpoint through the pixel center and find the first object hit by the ray as well as the intersection point. Then it calculates the pixel shading. Shadow and reflection are better and it's more realistic and it's image-order rendering.

Because raytracing requires high computation resources, and it has great computational cost. With ordinary CPU and poor GPU, it's hard to achieve read time raytracing.

Q4) What is noise? How do we decide about a good noise function and what do we seek in a good noise generation? What is Perlin noise offering for this area? How can you relate using Perlin noise to use different octaves in noise combinations?

ANSWER:

Noise is random fluctuations in an expected signal. For noise function, we usually use smooth function plus white noise. We seek a controllable appearance, non-periodic, compact continuous and fast, easily mapped to surfaces and functions in a good noise generation.

Perlin noise offers an algorithm that produces natural appearing textures on surfaces. A single noise function is unstructured, but a combination of several noise functions has structure. We can

combine multiple noise octaves to get a better-looking result by using Perlin noise. After combining the multiple noise octaves, we can get a structured texture and then apply the colormap to the texture.

Q5) Describe mesh data structures and clearly explain the purpose of indexed mesh data structure?

ANSWER:

mesh data structures are for storing the mesh data and include polygon soup, indexed structure, indexed structure with adjacencies, winged edge, and half edge.

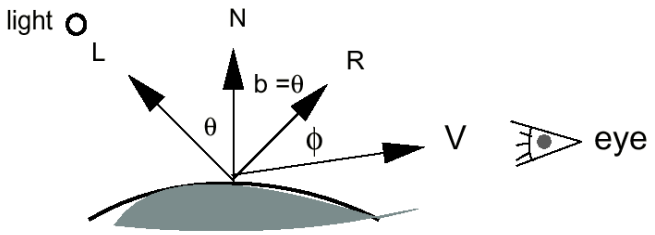
Indexed mesh data structure contains a vector of vertices and a vector of faces, which avoids replication of vertices in polygon soup. Each vertex stores the position and each face stores the references to positions of its vertices in the vector. It also stores the number of vertices of each face. It is simple but efficient and reduces the replication of vertices and edges.

Q6) Compute the intensity at the centroid of a white triangle with vertices P1, P2 and P3 using the Phong Illumination model considering the following equation:

$$I = I_a k_a + I_i(k_{diff}(N \cdot L) + k_{spec}(R \cdot V)^n)$$

where:
P1 = (1,1,1)
P2 = (0,2,1)
P3 = (0,0,1)
viewer position at (1,2,5)
$k_a = 0.7, k_{diff} = 0.9, k_{spec} = 0.6, n = 10$ with
ambient intensity = 0.1
point light intensity = 0.5 and position = (1,1,5) where both ambient and point light are white.

- Hint 1: Compute N first using the cross product of point subtractions
- Hint 2: Compute R using the method we studied in class (R=2N(NL)-L)



N = (0, 0, 1) by calculating the norm direction and make it unit vector

C = (1/3, 1, 1) of the triangle.

L = (1, 1, 5) – C = (2/3, 0, 4) and make it unit we get

L = (sqrt(37), 0, 6/sqrt(37)), then

R = 2*((0, 0, 1) dot (sqrt(37), 0, 6/sqrt(37))) * (0, 0, 1) - (sqrt(37), 0, 6/sqrt(37)) = (-sqrt(37), 0, 6/sqrt(37))

V = (1, 2, 5) – (1/3, 1, 1) = (2/3, 1, 4) normalize to (2/sqrt(157), 9/sqrt(157), 36/sqrt(157))

I = 0.1*0.7 + 0.5(0.9*(NL)+0.6*(RV)^10)

= 0.07 + 0.5*(0.9*6/sqrt(37) + 0.6*(70/(3*sqrt(37))^10)

= 0.85