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Exercise Sheet 5

Assignment 5.1 Transformations [3 Points]

Matrices are used for various transformations, including rotation and shear.

a) Describe in detail the following transformations:

$$A = \begin{pmatrix} -1 & 0 \\ 0 & 0.5 \end{pmatrix} \qquad B = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \qquad C = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{pmatrix}_h$$

[*1.5 Points*]

b) Rotate the rectangle with vertices $V_1 = (2, 2), V_2 = (3, 1), V_3 = (4, 2)$, and $V_4 = (3, 4)$ by 45° counter-clockwise. The position of V_1 should be the same after the rotation. Give the matrix (or matrices) to perform this transformation. Also answer the following questions:

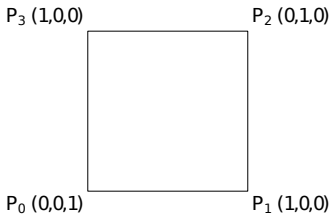
- What happens if you perform the same rotation...
  - without translating the object
  - after translating the center of the rectangle to $(0, 0)$
  - after translating the position of V_1 to $(0, 0)$ (and $V_2 = (1, -1), ...$)?
- Is it possible to perform the second operation with a single transformation matrix? If yes, provide the rotation matrices.

[*1.5 Points*]

Assignment 5.2 Barycentric Coordinates [3 Points]

a) How many barycentric coordinates does one need for a n-simplex? [*0.5 Points*]

b) Given the following square with (R,G,B) color values defined at the vertices:



Imagine splitting the square into two triangles along the diagonal between P_1 and P_3, and interpolate the color values using barycentric interpolation. Briefly (!) describe the color variation along $\overrightarrow{P_0P_2}$ (see also the next problem below). [*1 Point*]

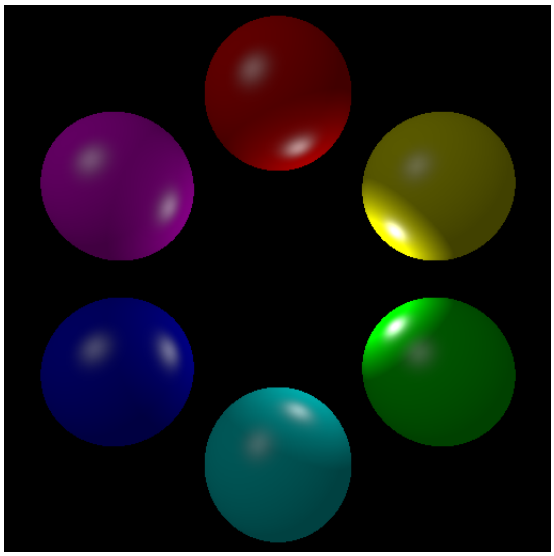
c) How does the color variation along $\overrightarrow{P_0P_2}$ change if you split along the other diagonal instead? [*0.5 Points*]

d) Come up with a way to directly calculate barycentric coordinates for a rectangle without prior subdivision into triangles. How many barycentric coordinates do you need and how are they defined for the vertices? Is it possible to apply this method to arbitrary quadrangles? [*1 Point*]

Assignment 5.3 Ray Tracing II [4 Points]

On the last exercise sheet, you already implemented the intersection calculation for the ray tracer, which only employed ambient lighting so far. In this exercise, the Phong lighting model should be completed (extended by the diffuse and specular components). Implement the method `PointLight::ComputeDirectContribution()` in the file `src/Raytracer/Scenes/PointLight.cpp` to calculate the diffuse and specular contribution. You can use your own solution from the last exercise sheet to complete this task. If you were not able to complete this task, you may download the newly uploaded skeleton from the elearning platform.

Hint: Make sure that the normals calculated correctly in `Sphere::GetIntersection`.



Submission: November 26, 2019, 14:15 CEST, via Moodle