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Basic Techniques in Computer Graphics

Assignment 6

Date Published: November 19th 2019, Date Due: November 26th 2019

- All assignments (programming and text) have to be completed in teams of 3–4 students. Teams with fewer than 3 or more than 4 students will receive no points.
- Hand in **one solution per team per assignment**.
- Every team must work independently. Teams with identical solutions will receive no points.
- Solutions are due 14:30 on November 26th 2019. Late submissions will receive zero points. No exceptions!
- Instructions for **programming assignments**:
  - Download the solution template (a zip archive) through the Moodle course room.
  - Complete the solution.
  - Prepare a new zip archive containing your solution. It must contain exactly those files that you changed. **Only change those files you are explicitly asked to change in the task description.** The directory layout must be the same as in the archive you downloaded.
  - Upload your zip archive through Moodle before the deadline. Use the Moodle group submission feature. Only in the first week (when Moodle groups have not been created yet), list all members of your group in the file `assignmentXX/MEMBERS.txt`. Remember, only one submission per group.
  - Your solution must compile and run correctly **on our lab computers** using the exact same `Makefile` provided to you. Do not include additional libraries and do not change code outside of the specified sections. If it does not compile on our machines, you will receive no points.
- Instructions for **text assignments**:
  - Prepare your solution as a single pdf file per group. Submissions on paper will not be accepted.
  - If you write your solution by hand, write neatly! Anything we cannot decipher will receive zero points. No exceptions!
  - Add the names and student ID numbers of all team members to every pdf.
  - Unless explicitly asked otherwise, always justify your answer.
  - Be concise!
  - Submit your solution via Moodle, together with your coding submission.

Exercise 1 Barycentric Coordinates **[12 Points]**

In the lecture we encountered barycentric coordinates multiple times already: In rasterization they can be used to check whether a point lies within a triangle, in our shading algorithms they provide a way to interpolate colors or normals and they are an important part of texture mapping. The definition of barycentric coordinates directly gives a way to compute them for a given point by solving a linear equation system. However this is not the most efficient way when barycentric coordinates have to be computed for multiple points in a row. Here we will use an alternative approach.

(a) **[4 Point]**

Give a parametric representation $l(\lambda)$ of a line in 2D defined by points $\mathbf{p}_1, \mathbf{p}_2 \in \mathbb{R}^2$ such that $l(0) = \mathbf{p}_1$ and $l(1) = \mathbf{p}_2$. Compute the intersection parameter as well as the intersection point of such a line with a scanline(line parallel to the x-axis) implicitly defined by $y = y_0$ where y_0 is the offset from the x-axis.

(b) **[2 Points]**

The points $A = (1,1)^T, B = (5,2.5)^T, C = (4,5)^T$ form a triangle on the screen. Now consider the scanline given by $y = 4.0$. Compute the intersection parameter λ_0 and intersection point E of line $\overline{BC}$ with the scanline. Do the same for line $\overline{CA}$ to get λ_1 and point D.

(c) **[2 Points]**

For point $Q = (3.5, 4.0)^T$ on the scanline compute the parameter λ_2 on the line $\overline{DE}$.

(d) **[4 Point]**

Finally give the formula to compute the barycentric coordinates using $\lambda_0, \lambda_1, \lambda_2$ and compute the barycentric coordinates of Q. Hint: the definition of barycentric coordinates gives you an easy way to check if your solution is correct.

Exercise 2 Color Models **[12 Points]**

(a) **[4 Points]**

Explain in one sentence what metamerism is. Why does it make sense to only represent color with three base colors during rendering.

(b) **[4 Points]**

Give three color models (one hardware oriented, one user oriented and one scientifically founded) and their main usage (or advantage).

(c) **[4 Points]**

Explain the differences between an *additive* and a *substractive color model*. Name one example for both categories.

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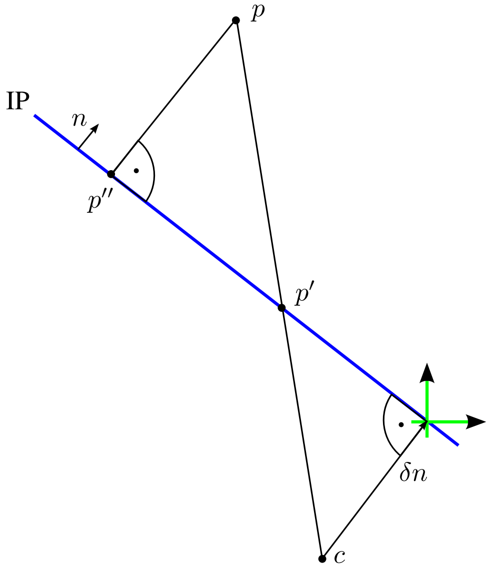
Exercise 3 Projections **[16 Points]**

Consider the following setup, which is a 2D sketch of a 3D scene. c is the camera center with the image plane IP (blue line) and the focal length δ. n is the unit-length normal of IP. p' is the projection of p on to IP. Note that the the origin of the coordinate system (green arrows) lies in the image plane.



(a) **[4 Points]**

p, c, $n \in \mathbb{R}^3$ and $\delta \in \mathbb{R}$ are given. Compute the point p'' on IP that can be used to compute p'.

(b) **[4 Points]**

Show how p' can be computed as a scaling of p''.

(c) **[4 Points]**

Consider a line l in the scene above that goes through the origin of the coordinate system and has a direction vector $p - p'$. What is the vanishing point of l?

(d) **[4 Points]**

Briefly explain the steps that are necessary to transform the general projection setting shown above to the setting of the standard projection. You do not need to give the detailed transformation matrices. However, describe what each transformation step achieves!