Bibliography

References

[1] Botsch, M., Kobbelt, L., Pauly, M., Alliez, P., and Lévy, B. *Polygon Mesh Processing*. A K Peters, 2010.

[2] Hughes, J. F., van Dam, A., McGuire, M., Sklar, D. F., Foley, J. D., Feiner, S., and Akeley, K. *Computer Graphics: Principles and Practice*, 3 ed. Addison-Wesley, Upper Saddle River, NJ, 2013.

[3] Velho, L., Frery, A. C., and Gomes, J. *Image Processing for Computer Graphics and Vision*, 2nd ed. Springer Publishing Company, Incorporated, 2008.

Specifically

- [3, Chapters 4-5].

Filters, contrast

1. Explain the difference between a low-pass filter and a high-pass filter. Provide examples of when each might be used.
2. Describe the Gaussian filter. How is it implemented, and what effect does it have on an image?
3. Define the concept of a convolution kernel. How is it used in image processing to apply filters? Illustrate with an example kernel and explain its effect on an image.
4. What is, in the frequency domain, the convolution in the spatial domain?
5. What is an edge detection filter? Name and describe one common edge detection filter.
6. Explain the process and purpose of histogram equalization. How does it improve the contrast of an image?

Color Theory

1. What is an *additive* color model?
2. Describe the RGB color model. How is it used to represent colors in computer graphics?
3. Describe the HSV color model. How does it differ from the RGB model? In which situations it might it be preferrable?
4. Explain the concept of color spaces and why different color spaces are used in computer graphics. Provide examples of at least three different color spaces and their applications.

5. Given the RGB values (34, 139, 34), convert this color to its equivalent in the HSV color space. Show all steps of your conversion.

Computational Geometry

1. Define the convex hull of a set of points in the plane. Describe an algorithm to find the convex hull and explain its time complexity.

2. Explain the concept of Delaunay triangulation. How is it related to the Voronoi diagram?

3. Describe the concept of a *line sweep* algorithm. Provide an example of a problem where this technique is useful.

4. Describe the sweep line algorithm for deciding if there are intersections in a set of line segments. What is the time complexity of this algorithm?

5. Prove that if we have 2 vectors $v_1 = (x_1, y_1)$ and $v_2 = (x_2, y_2)$, then

$$\left|\det \begin{pmatrix} x_1 & y_1 \\ x_2 & y_2 \end{pmatrix}\right| = |x_1 y_2 - y_1 x_2|$$

   is equal to area of the parallelogram with sides parallel to v_1 and v_2.

6. Prove that the area of a convex polygon of vertices $v_1 = (x_1, y_1)$, $v_2 = (x_2, y_2)$, ..., $v_n = (x_n, y_n)$ is equal to

$$\frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 & \dots & x_n \\ y_1 & y_2 & y_3 & \dots & y_n \end{vmatrix} = (x_1y_2 + x_2y_3 + \cdots + x_ny_1) - (y_1x_2 + y_2x_3 + \cdots + y_nx_1)$$

   NOTICE THAT this formula applies also to triangles. We can compute the area of a triangle also in this way. The expression

$$\frac{1}{2}\left|\det \begin{pmatrix} x_2 - x_1 & y_2 - y_1 \\ x_3 - x_1 & y_3 - y_1 \end{pmatrix}\right|$$

   Is equivalent to:

$$\frac{1}{2}\begin{vmatrix} x_1 & x_2 & x_3 \\ y_1 & y_2 & y_3 \end{vmatrix} = (x_1y_2 + x_2y_3 + x_3y_1) - (y_1x_2 + y_2x_3 + y_3x_1)$$

7. Given 3 points $a, b, p \in \mathcal{R}^3$, propose a mathod to determine if the point p is in the segment $\overline{ab}$.

8. Consider a parametrization of the sides of a convex quadrilateral $ABCD$ as follows:

$$\begin{gathered} A + t(B - A) \\ D + t(C - D) \\ A + s(D - A) \\ B + s(C - B) \end{gathered}$$

with $P = (s, t)$ in $[0, 1] \times [0, 1]$.

Design a map function that maps an image whose shape is any quadrilateral into other image whose shape is another quadrilateral, given the coordinates of both quadrilaterals. Describe how would you use it in order to enable the following transformations:

9. What is the point-in-polygon problem? Describe an algorithm to determine if a point lies inside a polygon and explain its complexity.

10. Describe one algorithm for computing the intersection of two convex polygons. Analyze the complexity of the proposed approach.

11. Discuss the importance of computational geometry in the field of computer graphics. Provide at least three specific examples where computational geometry is applied.

12. Define the term *polygon triangulation*. Describe an algorithm for triangulating a simple polygon and explain its time complexity.