

# Writing a software renderer in Javascript

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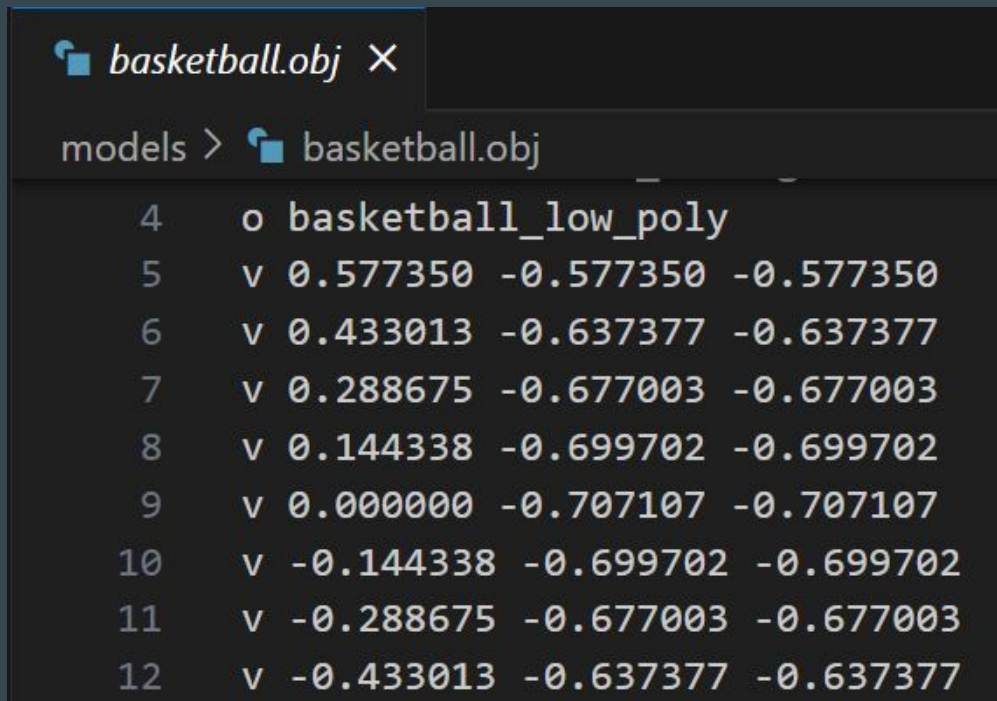




[https://pipding.github.io/3dage\\_renderer/renderer](https://pipding.github.io/3dage_renderer/renderer)

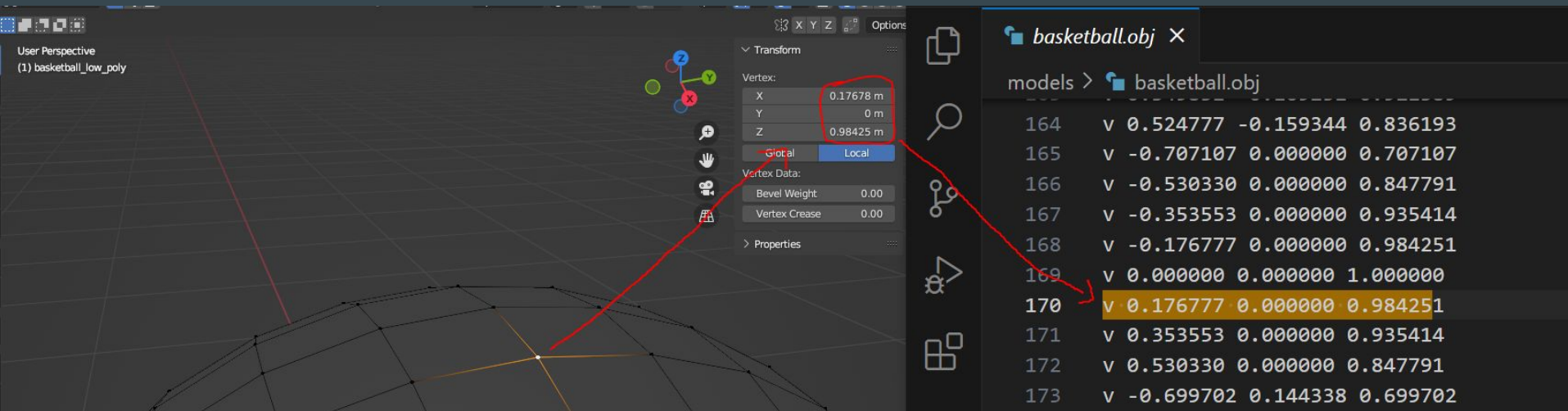


# Inside an .obj file

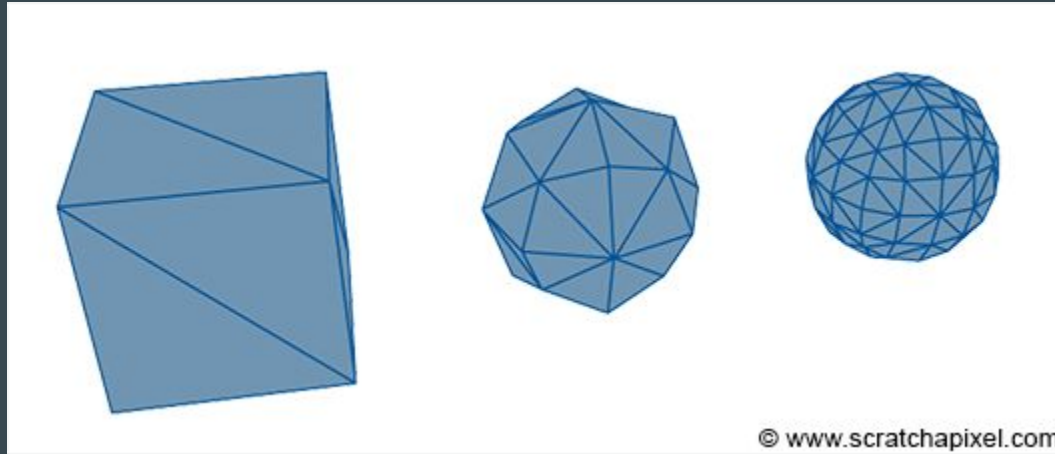


```
o basketball_low_poly
v 0.577350 -0.577350 -0.577350
v 0.433013 -0.637377 -0.637377
v 0.288675 -0.677003 -0.677003
v 0.144338 -0.699702 -0.699702
v 0.000000 -0.707107 -0.707107
v -0.144338 -0.699702 -0.699702
v -0.288675 -0.677003 -0.677003
v -0.433013 -0.637377 -0.637377
```

# Inside an .obj file



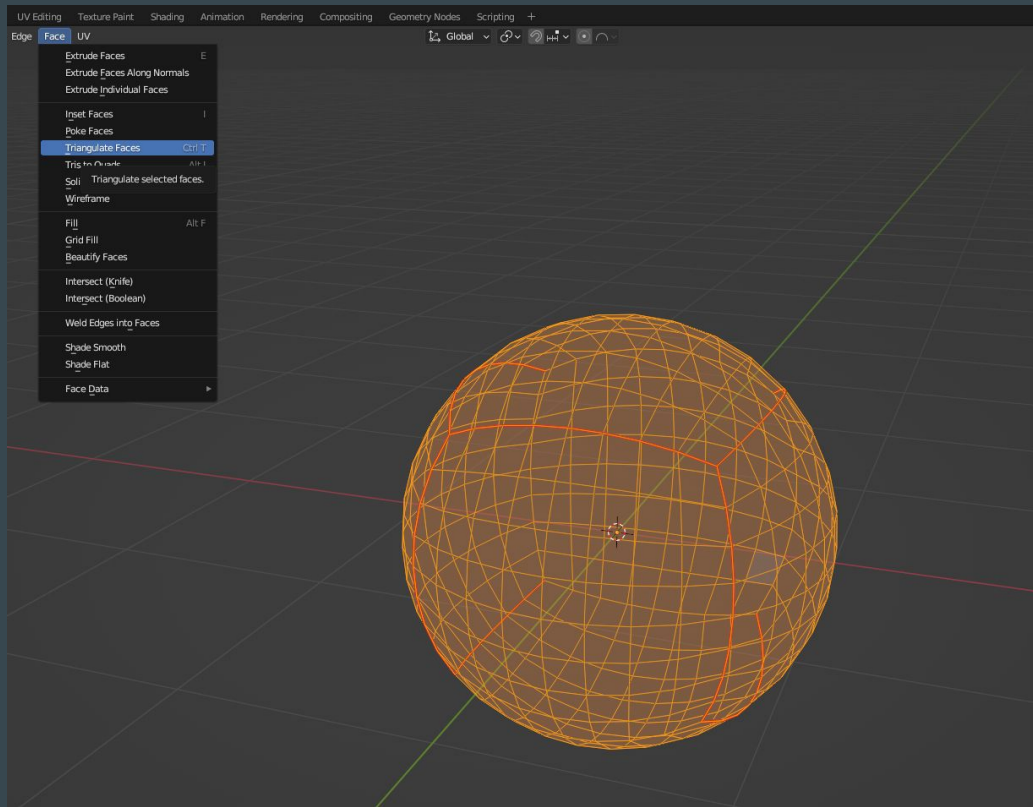
# Triangles all the way down



(Bean, 2020)

- Bean, N. (2020). It Starts with Triangles :: K-State CIS 580 Textbook. [online] K-State CIS 580 Textbook. Available at: <https://textbooks.cs.ksu.edu/cis580/13-basic-3d-rendering/02-it-starts-with-triangles/>

# Triangles all the way down





# Why triangles?

1. Triangles are always flat
2. Triangles are always convex
3. Triangles can be used to draw any other 2D shape

Ok, triangles. Now what?

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Phase 1: Per-triangle operations

# Ok, triangles. Now what?

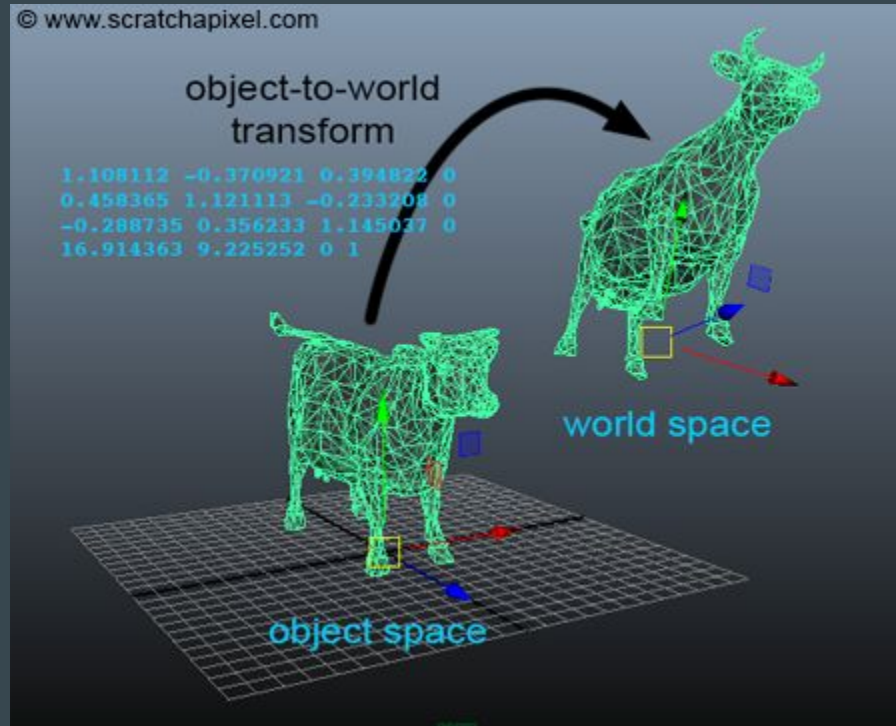
Phase 1: Per-triangle operations

Phase 2: Per-pixel operations

## Per-triangle operations - applying rotation matrix

$$\begin{pmatrix} 1, 2, 3, 4 \\ 5, 6, 7, 8 \\ 9, 8, 7, 6 \end{pmatrix}$$

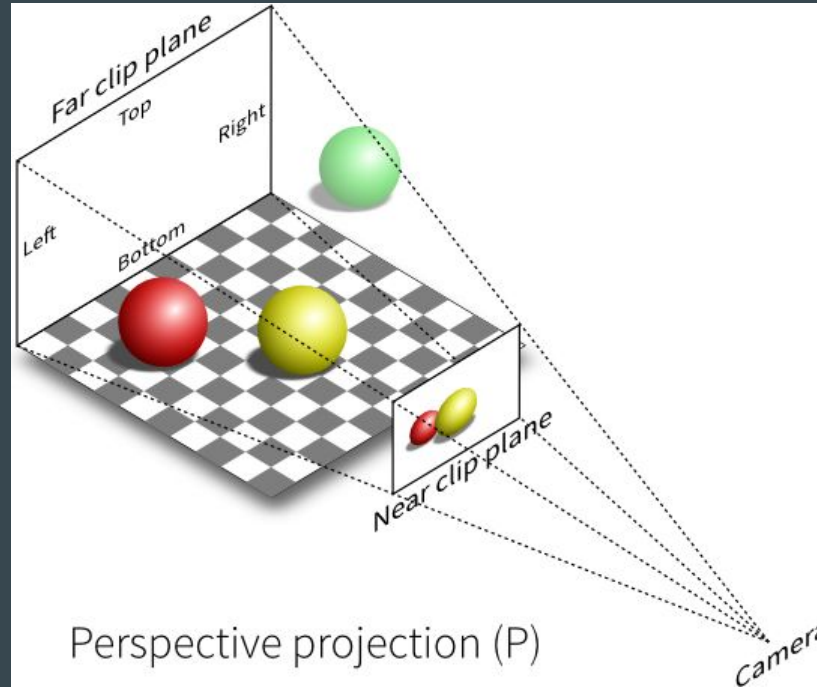
# Per-triangle operations - applying rotation matrix



(Scratchapixel.com, 2024)

- Scratchapixel.com. (2024). Transforming Objects using Matrices. [online] Available at: <https://www.scratchapixel.com/lessons/3d-basic-rendering/transforming-objects-using-matrices/using-4x4-matrices-transform-objects-3D.html> [Accessed 30 Nov. 2024]

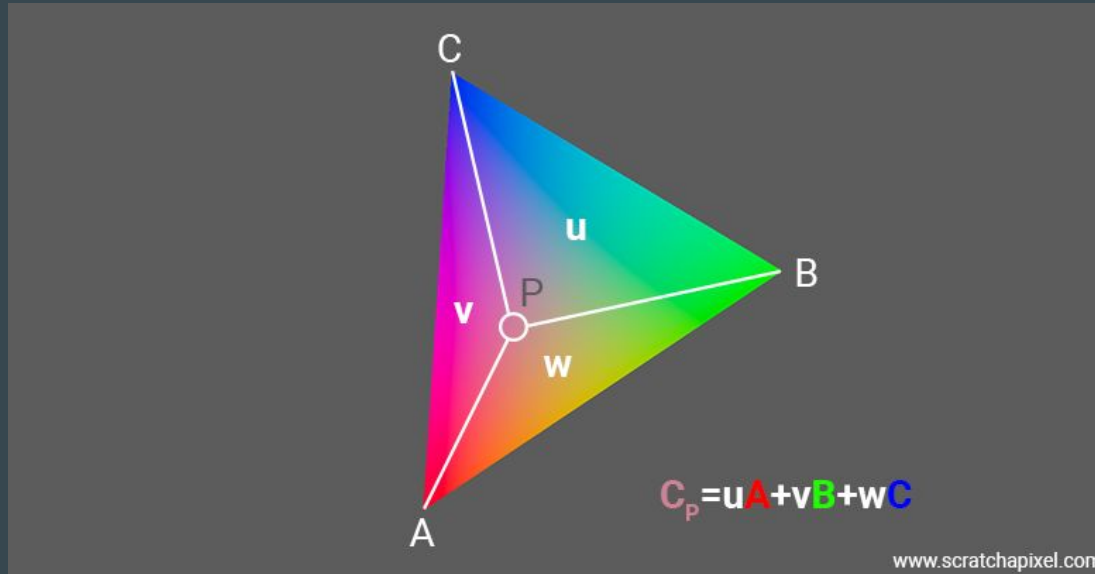
# Per-triangle operations - Screen-space projection



(Szauer.com, 2016)

- Szauer, G. (2016). Understanding Coordinate Transformations · LegacyOpenGL. [online] Gitbooks.io. Available at: <https://gdbooks.gitbooks.io/legacyopengl/content/Chapter4/CoordinateTransforms.html> [Accessed 30 Nov. 2024]

# Per-pixel operations - Barycentric coordinates

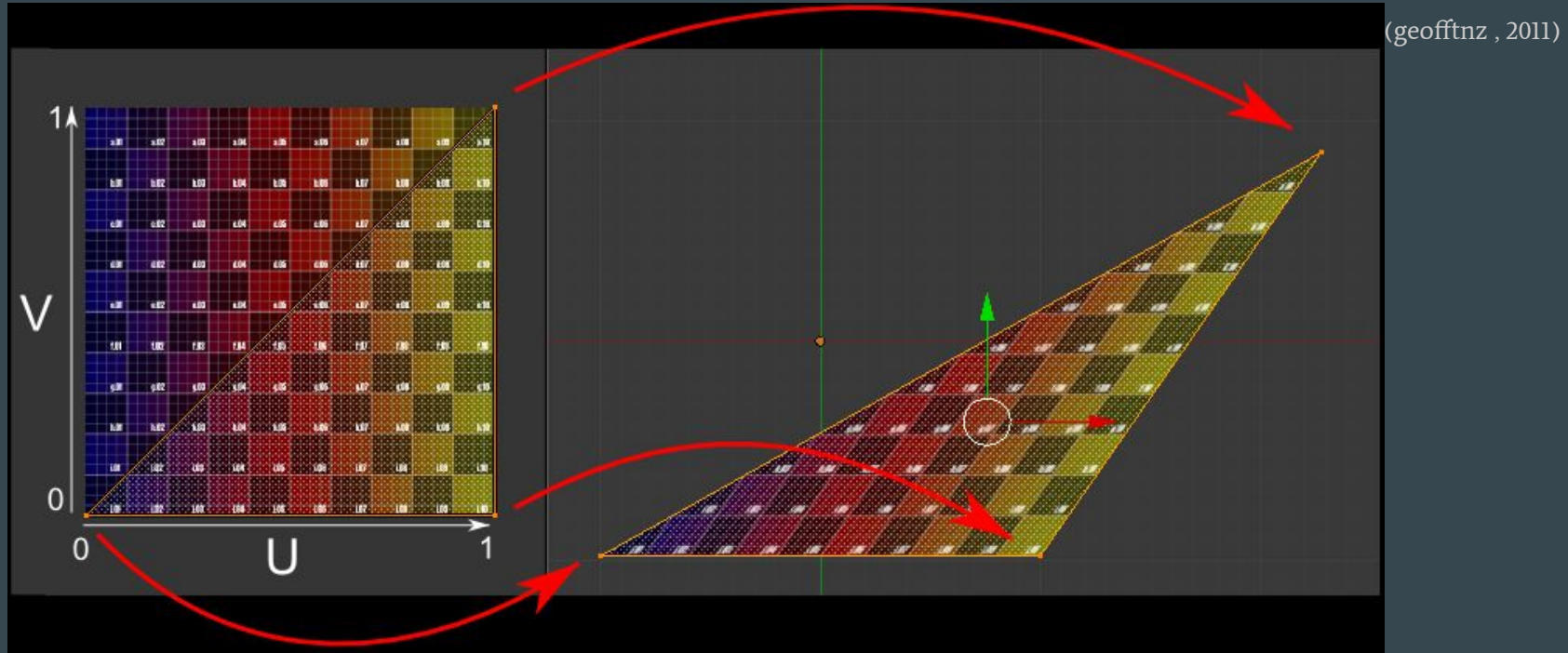


(Scratchapixel.com, 2024)

- www.scratchapixel.com. (2024). Ray-Tracing: Rendering a Triangle. [online] Available at: <https://www.scratchapixel.com/lessons/3d-basic-rendering/ray-tracing-rendering-a-triangle/barycentric-coordinates.html> [Accessed 30 Nov. 2024]

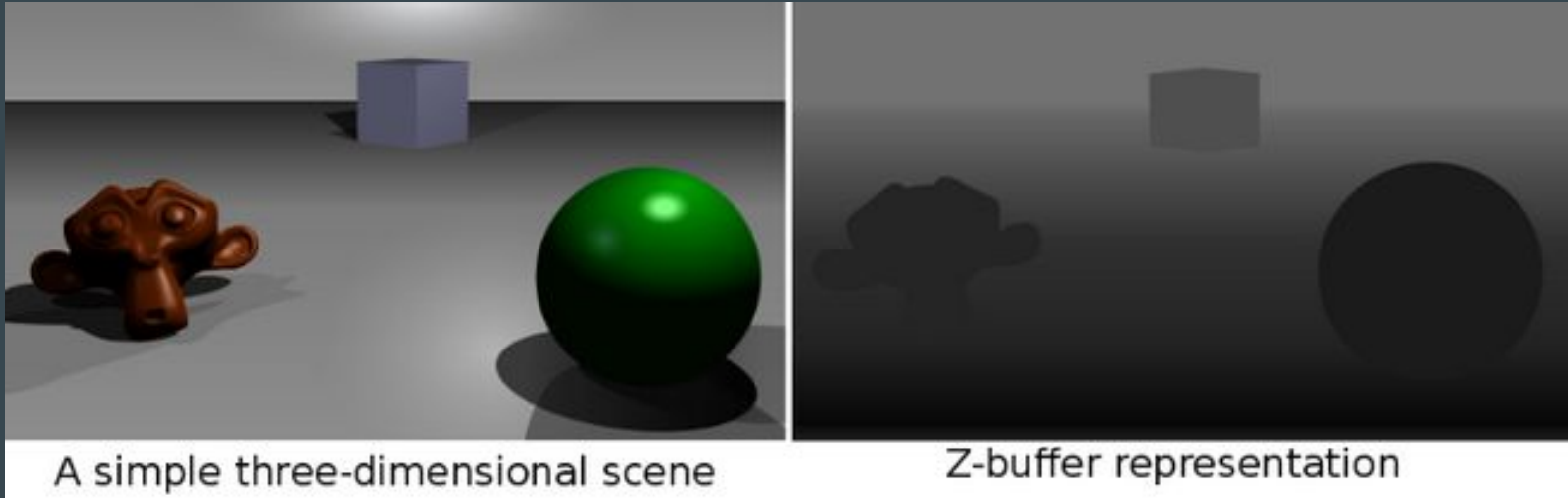


# Per-pixel operations - Texture lookup



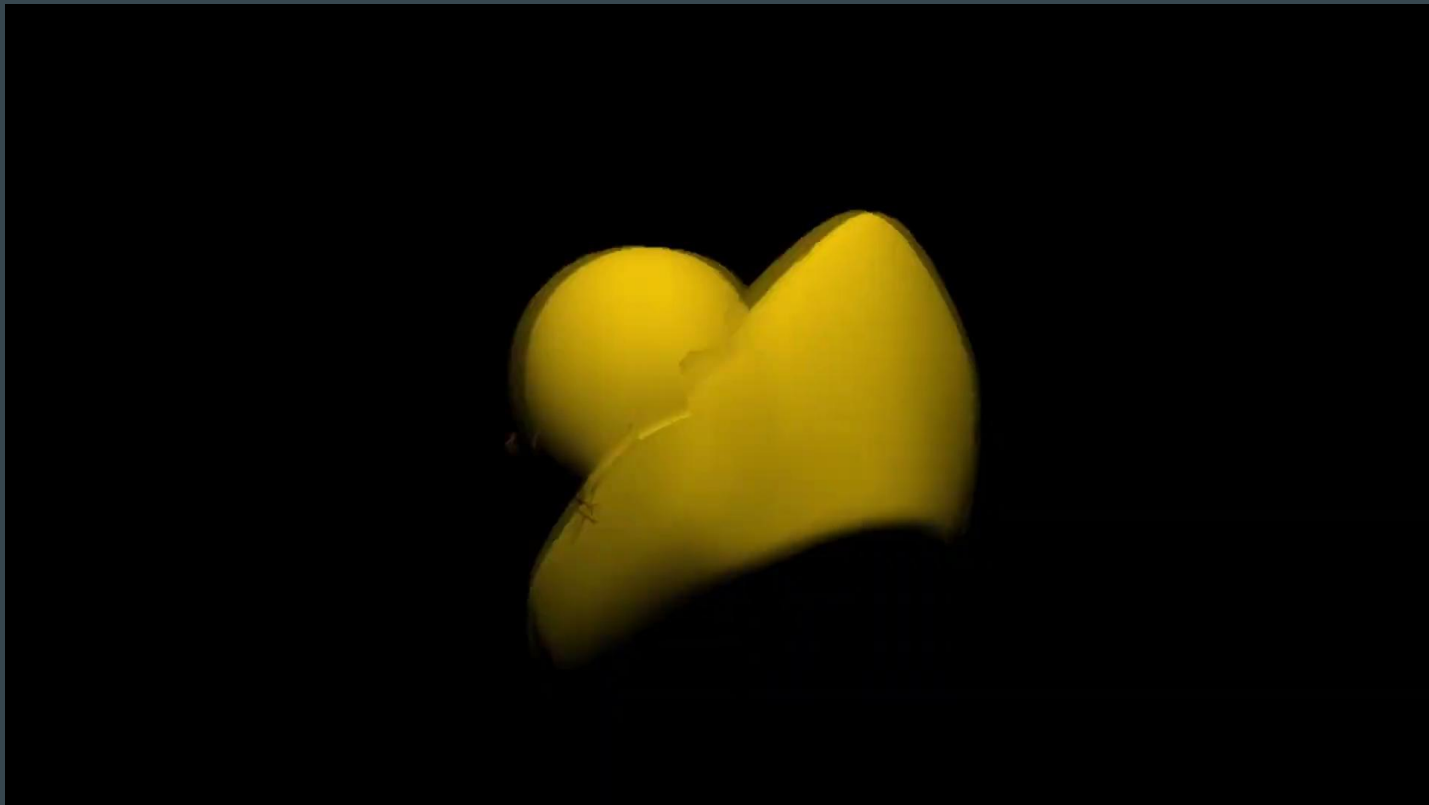
- geofftnz (2011). About OpenGL texture coordinates. [online] Stack Overflow. Available at: <https://stackoverflow.com/questions/5532595/about-opengl-texture-coordinates> [Accessed 30 Nov. 2024]

# Per-pixel operations - Depth buffer

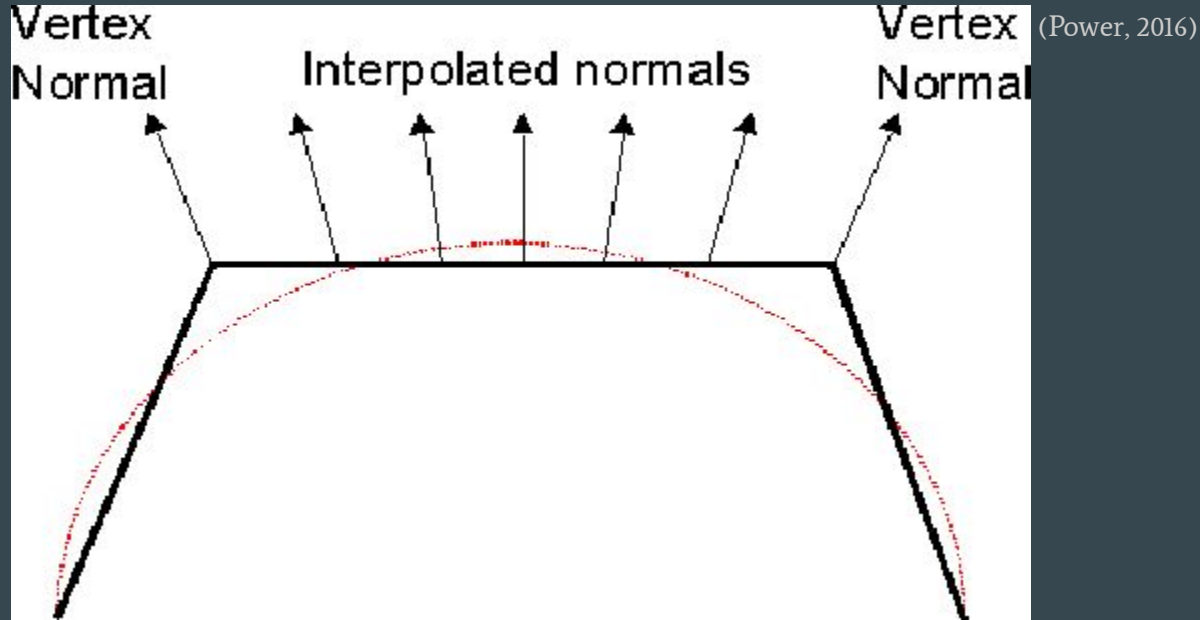


- -Zeus- (2009). Graphical representation of what a Z buffer looks like. [online] Wikimedia Commons. Available at: [https://commons.wikimedia.org/wiki/File:Z\\_buffer.svg](https://commons.wikimedia.org/wiki/File:Z_buffer.svg) [Accessed 30 Nov. 2024]

## Per-pixel operations - Depth buffer

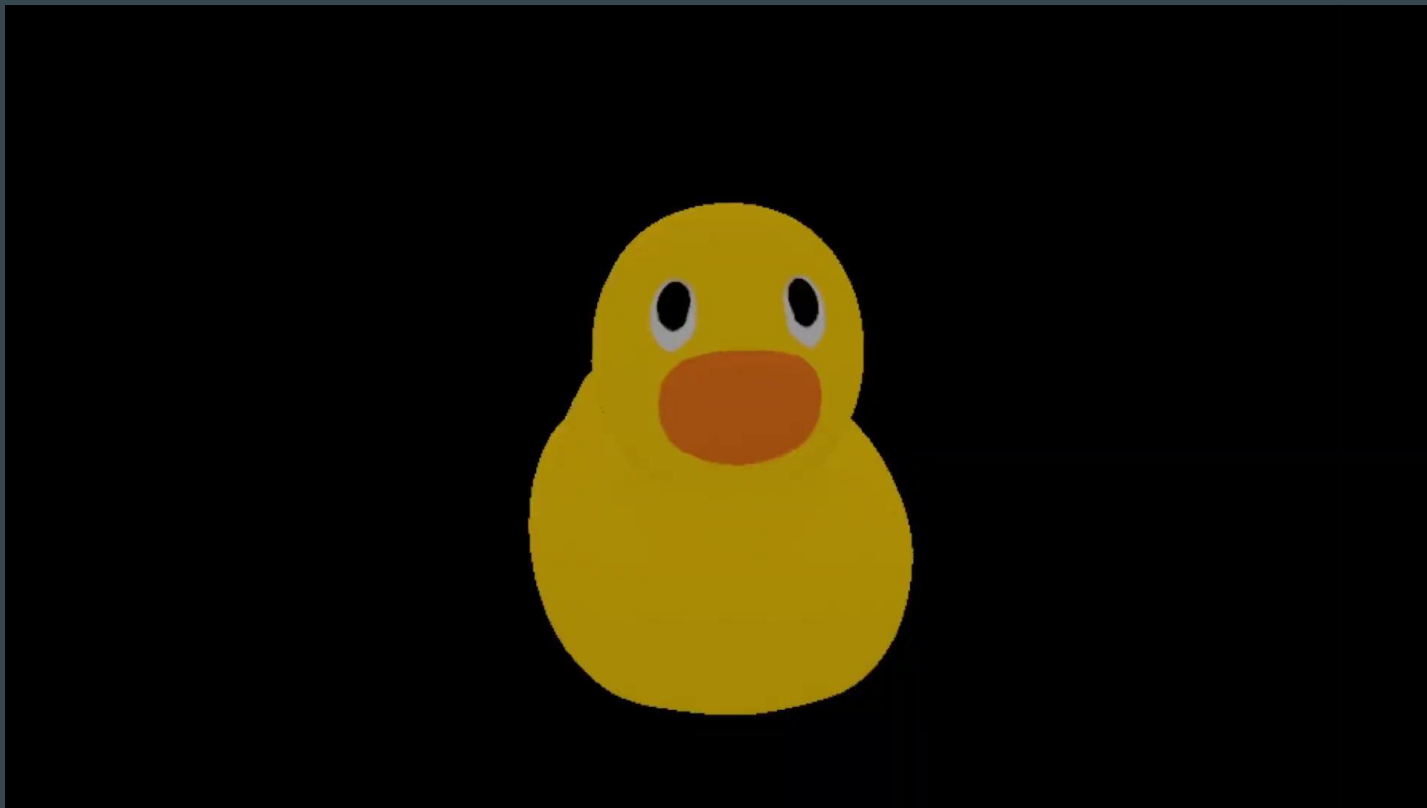


# Per-pixel operations - Normal interpolation



- Power, K. (2016). Shading Models. [online] itcarlow.ie. Available at: <https://glasnost.itcarlow.ie/~powerk/GeneralGraphicsNotes/LightingShadingandColour/shading.html> [Accessed 30 Nov. 2024]

# Per-pixel operations - Normal interpolation





# Limitations & improvements

- Only supports a single light source
- Does not support normal mapping
- Has room for performance optimisation
- Only supports triangulated meshes

# References

- Bean, N. (2020). It Starts with Triangles :: K-State CIS 580 Textbook. [online] K-State CIS 580 Textbook. Available at: <https://textbooks.cs.ksu.edu/cis580/13-basic-3d-rendering/02-it-starts-with-triangles/>
- Scratchapixel.com. (2024). Transforming Objects using Matrices. [online] Available at: <https://www.scratchapixel.com/lessons/3d-basic-rendering/transforming-objects-using-matrices/using-4x4-matrices-transform-objects-3D.html> [Accessed 30 Nov. 2024]
- Szauer, G. (2016). Understanding Coordinate Transformations · LegacyOpenGL. [online] Gitbooks.io. Available at: <https://gdbooks.gitbooks.io/legacyopengl/content/Chapter4/CoordinateTransforms.html> [Accessed 30 Nov. 2024]
- www.scratchapixel.com. (2024). Ray-Tracing: Rendering a Triangle. [online] Available at: <https://www.scratchapixel.com/lessons/3d-basic-rendering/ray-tracing-rendering-a-triangle/barycentric-coordinates.html> [Accessed 30 Nov. 2024]
- geofftnz (2011). About OpenGL texture coordinates. [online] Stack Overflow. Available at: <https://stackoverflow.com/questions/5532595/about-opengl-texture-coordinates> [Accessed 30 Nov. 2024]
- -Zeus- (2009). Graphical representation of what a Z buffer looks like. [online] Wikimedia Commons. Available at: [https://commons.wikimedia.org/wiki/File:Z\\_buffer.svg](https://commons.wikimedia.org/wiki/File:Z_buffer.svg) [Accessed 30 Nov. 2024]



# Further reading

- My research blog: [https://pipding.github.io/3dage\\_renderer/](https://pipding.github.io/3dage_renderer/)
- My renderer: [https://pipding.github.io/3dage\\_renderer/renderer/](https://pipding.github.io/3dage_renderer/renderer/)
- Scratchapixel.com (good for beginners):  
<https://www.scratchapixel.com/lessons/3d-basic-rendering/introduction-to-shading/what-is-shading-light-matter-interaction.html>
- How we trick our eyes into perceiving depth:  
<https://www.youtube.com/watch?v=D3IhkRulkFE>
- thebennybox (Youtube channel with a good guide to software rendering):  
[https://www.youtube.com/watch?v=Y\\_vvC2G7vRo&list=PLEETnX-uPtBUbVOok816vTl1K9vV1GgH5](https://www.youtube.com/watch?v=Y_vvC2G7vRo&list=PLEETnX-uPtBUbVOok816vTl1K9vV1GgH5)