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INTRODUCTION TO SHADING

PHONG VS GOURAUD SHADING MODELS IN BLENDER

WHAT IS SHADING?

Shading is a technique in 3D computer graphics that simulates the effects of on surfaces, enhancing the perception of depth and realism

IMPORTANCE

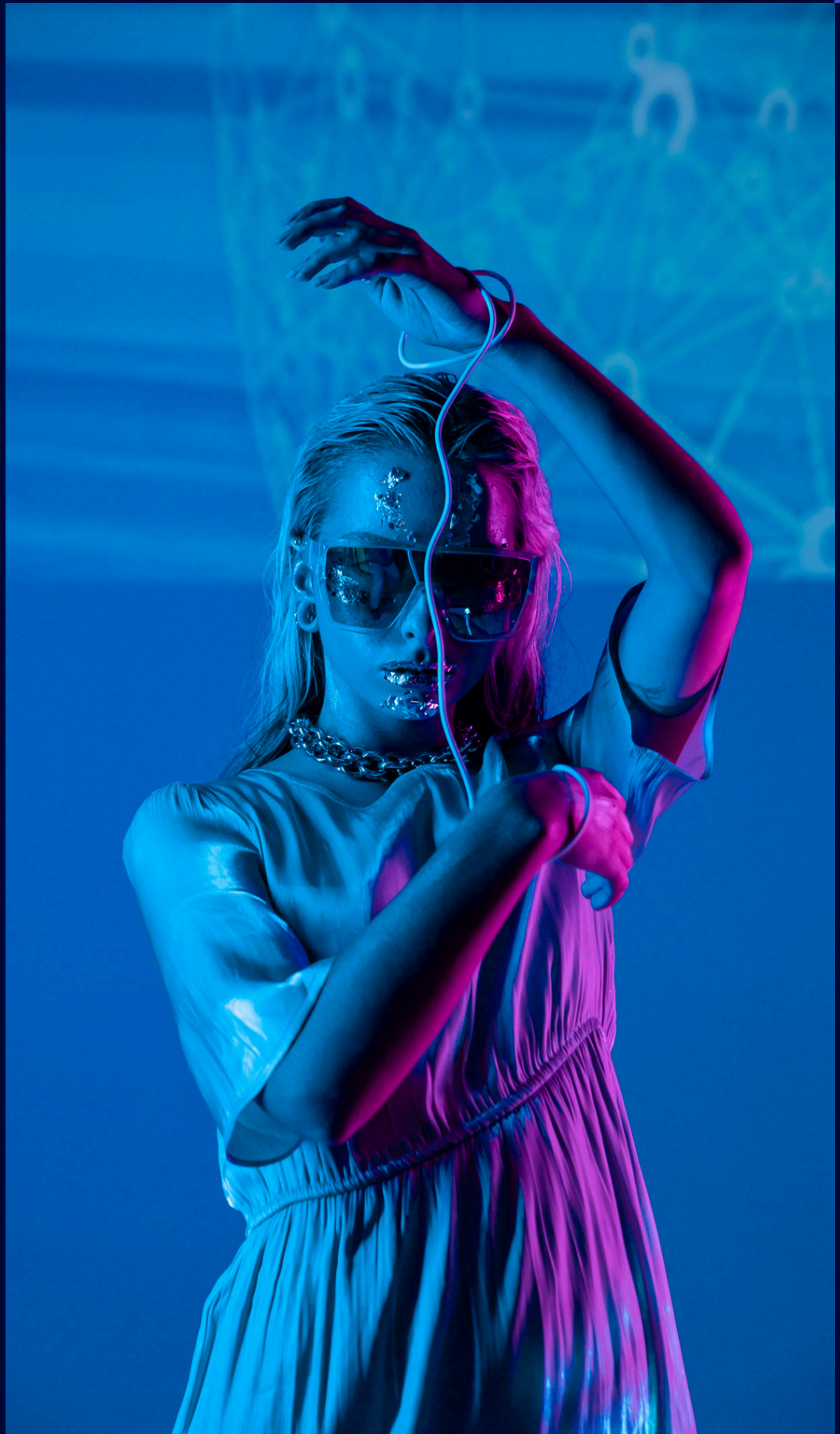
Proper shading is crucial for achieving realistic renders, as it affects how materials and textures appear under various lighting conditions

OVERVIEW OF SHADING TECHNIQUES

01 **Flat Shading**: Applies a single color to each polygon, resulting in a faceted look.

02 **Gouraud Shading**: Interpolates vertex colors across polygons for smoother transitions.

03 **Phong Shading**: Computes color at every pixel using normal interpolation and light reflection model.



GOURAUD SHADING (VERTEX-BASED)

01 INTRODUCTION

- Developed by Henri Gouraud in 1971
- Interpolation technique for computer graphics
- Creates smooth shading across polygonal surfaces

02 Methodologies

- Vertex Normal Calculation
- Lighting Computation:al Calculation
- Color Interpolation

STEPS TO DRAW A CIRCLE USING GOURAUD SHADINGION

Since circles aren't natively supported in Gouraud (which works with polygons), you approximate the circle by creating a regular polygon:

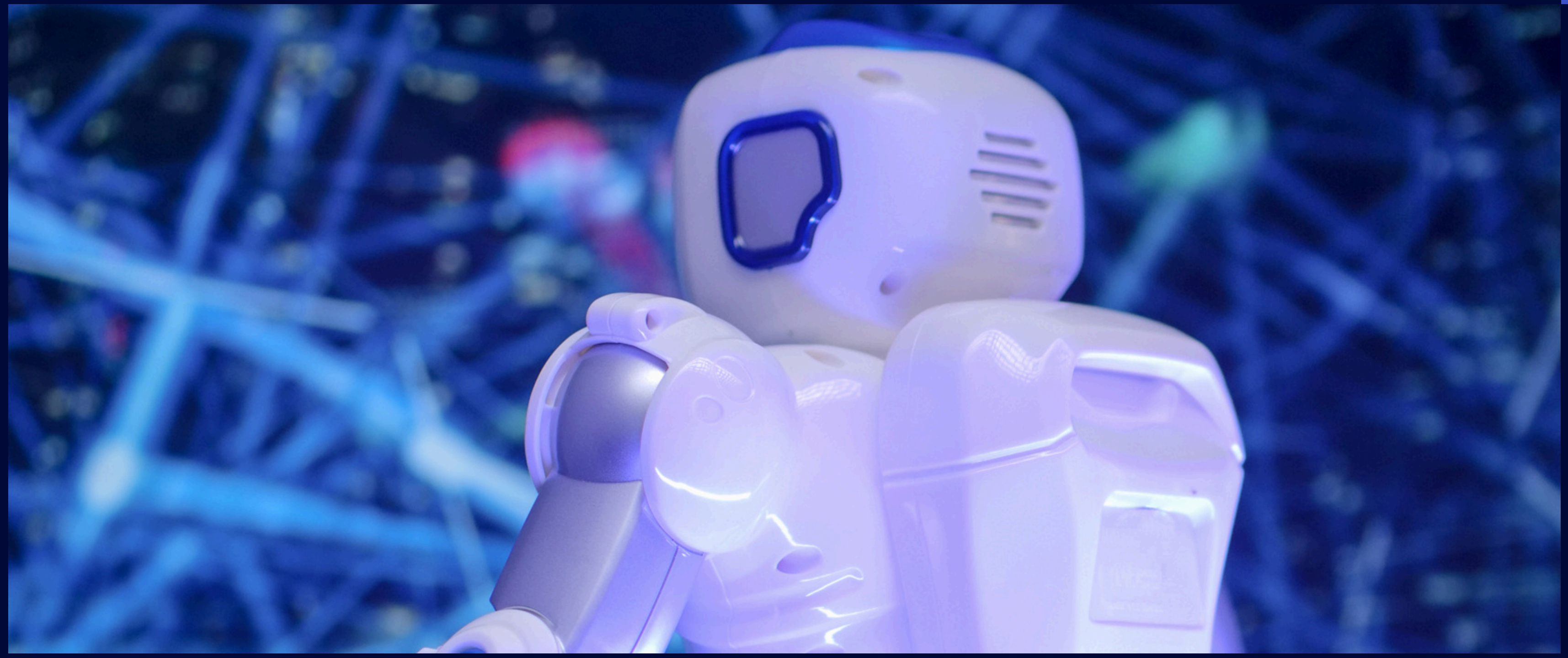
- Choose the number of sides, e.g., $n = 24$
- Compute the coordinates for each vertex around a center:

$$(xi,yi)=(r\cdot\cos(\theta i),r\cdot\sin(\theta i))$$

where:

$r = 3$ (radius), $\theta i = 2\pi i/n$

Connect each adjacent vertex to the center (0,0) to form triangular sectors.



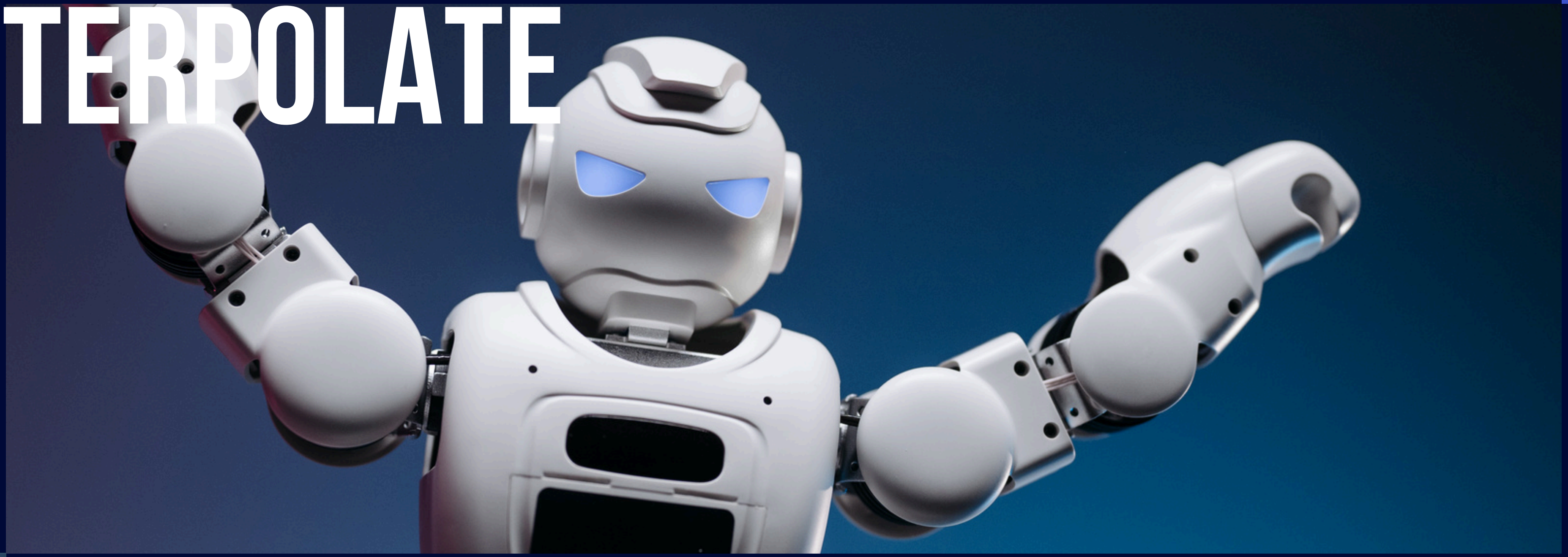
STEP 2: ASSIGN NORMALS TO VERTICES

At each vertex compute a normal vector pointing outward from the center:

$$\vec{N}_i = \frac{(x_i, y_i)}{|\vec{P}_i|}$$

These normals are used for lighting calculations.

STEP 4: TRIANGULATE AND INTERPOLATE COLORS



- Each triangle has 3 vertices with intensities I1, I2, I3
- To shade any point P within the triangle, compute barycentric coordinates (w1,w2,w3) for that point and apply the interpolation:

$$I_P = w_1 I_1 + w_2 I_2 + w_3 I_3$$

- This gives the final pixel color at P.
- This interpolation creates a smooth gradient effect across the triangle.

STEP 5: RENDER THE CIRCLE

Now render each triangle of the polygon:

- Use the interpolated values across each triangle
- The result is a smooth-shaded circle where light smoothly transitions across the surface

DRAWING A CIRCLE IN BLENDER WITH GOURAUD SHADING

Working Example:

Click here

01

ADVANTAGES

- Computationally efficient compared to more complex shading techniques.
- Produces smoother shading than flat shading by reducing the faceted appearance of polygonal models.

02

LIMITATIONS

- Cannot capture specular highlights within polygons
- Produces visual artifacts like Mach bands at shading transitions

APPLICATIONS

- Early computer graphics and video games for smooth shading with limited resources

- Still used when computational efficiency matters more than detailed specular effects

PHONG SHADING (PIXEL-BASED)

01 INTRODUCTION

- Developed by Bui Tuong Phong in 1973.
- Presented in his Ph.D. thesis at the University of Utah.
- Major advancement in computer graphics rendering techniques.

02 DEFINITION:

- Phong Shading is an interpolation method used in 3D computer graphics.
- It performs per-pixel lighting calculations, resulting in realistic shading across curved surfaces.

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HOW IT WORKS — KEY STEPS

Vertex Normal Calculation:

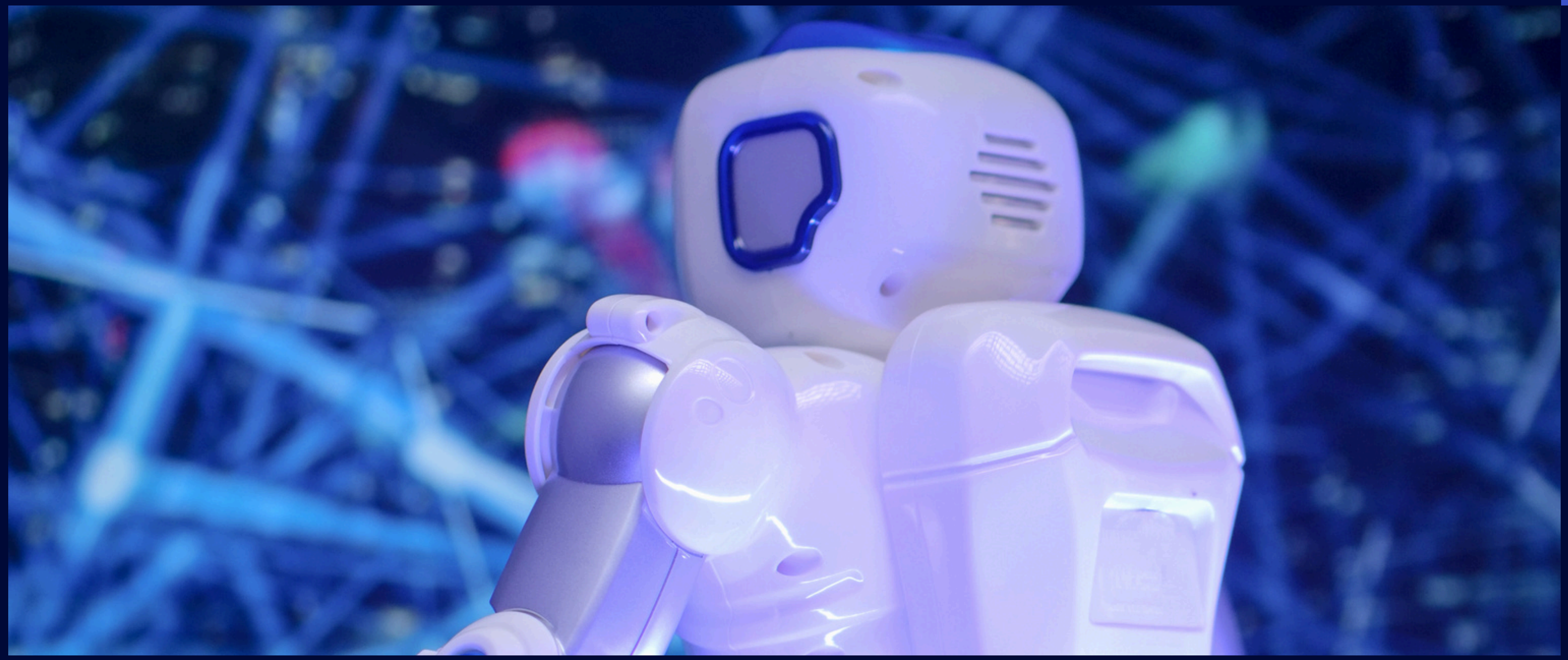
- Like Gouraud shading, it starts with normals at each vertex, typically averaged from adjacent faces.

Interpolation of Normals (Not Colors):

- The normals are linearly interpolated across each pixel in the triangle, not the colors.

Lighting Computation per Pixel:

- At every pixel, the Phong illumination model is applied using the interpolated normal vector.



PHONG ILLUMINATION MODEL FORMULA

$$I = I_{\text{ambient}} + I_{\text{diffuse}} + I_{\text{specular}}$$

With ach component defined as:

- Ambient:

$$I_{\text{ambient}} = k_a I_a$$

- Diffuse:

$$I_{\text{diffuse}} = k_d I_l (\vec{N} \cdot \vec{L})$$

- Specular:

$$I_{\text{specular}} = k_s I_l (\vec{R} \cdot \vec{V})^n$$

Where:

- k_a, k_d, k_s: reflection coefficients
- I_a: ambient light intensity
- I_l: light source intensity
- $\vec{N}$: interpolated surface normal
- $\vec{L}$: direction to light
- $\vec{R}$: reflection direction
- $\vec{V}$: view direction
- n: shininess exponent

MODELING AND RENDERING A CIRCLE IN BLENDER USING PHONG SHADING

Working Example:

Click here

01 **ADVANTAGES**

- Produces realistic and smooth highlights
- Specular reflections are accurately represented
- Ideal for curved surfaces like spheres or complex models

02 **LIMITATIONS**

- More computationally expensive than Gouraud shading
- Slower rendering in real-time applications due to per-pixel calculations
- Not physically accurate (compared to more modern PBR)

comparison table

Feature	Phong Shading	Gouraud Shading
Lighting Calc.	Per-pixel	Per-vertex
Interpolation	Normal vectors	Color values
Quality	High (smooth specular)	Medium (blurry highlig
Speed	Slower	Faster
Specular Accuracy	High	Low (missing highlight

THANK YOU FOR LISTENING