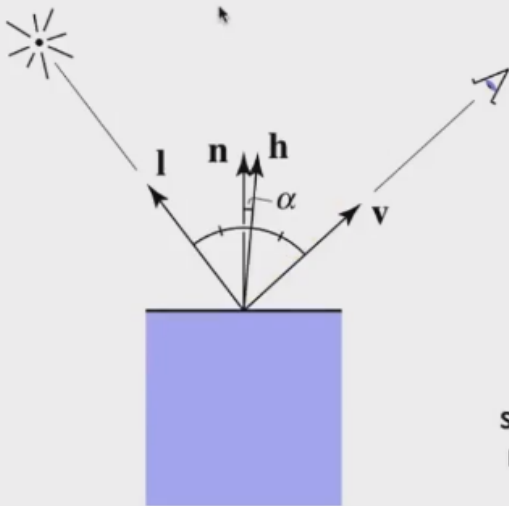


Shading 2

- BP reflectance model
 - (2) Specular Term 高光



$$\mathbf{h} = \text{bisector}(\mathbf{v}, \mathbf{l})$$
 (半程向量)

$$= \frac{\mathbf{v} + \mathbf{l}}{\|\mathbf{v} + \mathbf{l}\|}$$
 易于计算

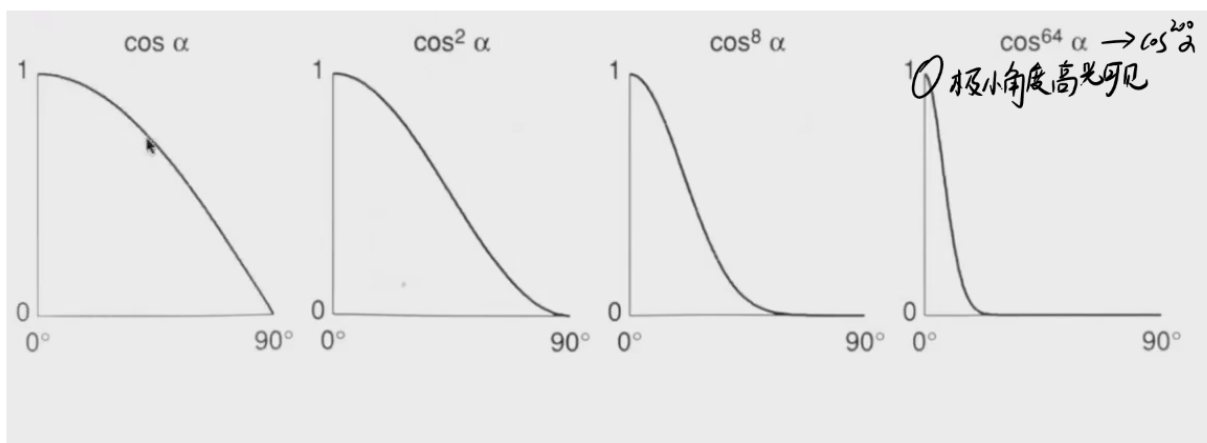
$$L_s = k_s (I/r^2) \max(0, \cos \alpha)^p$$

$$= k_s (I/r^2) \max(0, \mathbf{n} \cdot \mathbf{h})^p$$

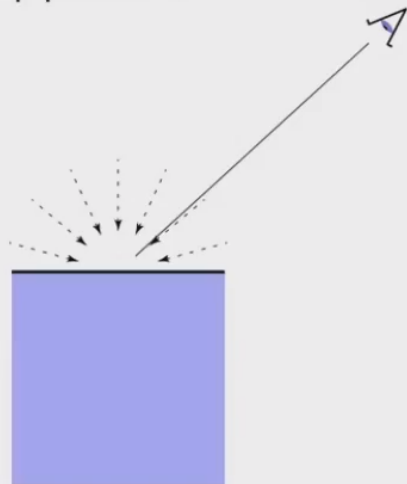
specularly reflected light

specular coefficient 色

指数



- (3) Ambient Term 简化环境光,保证不黑



$$L_a = k_a I_a$$

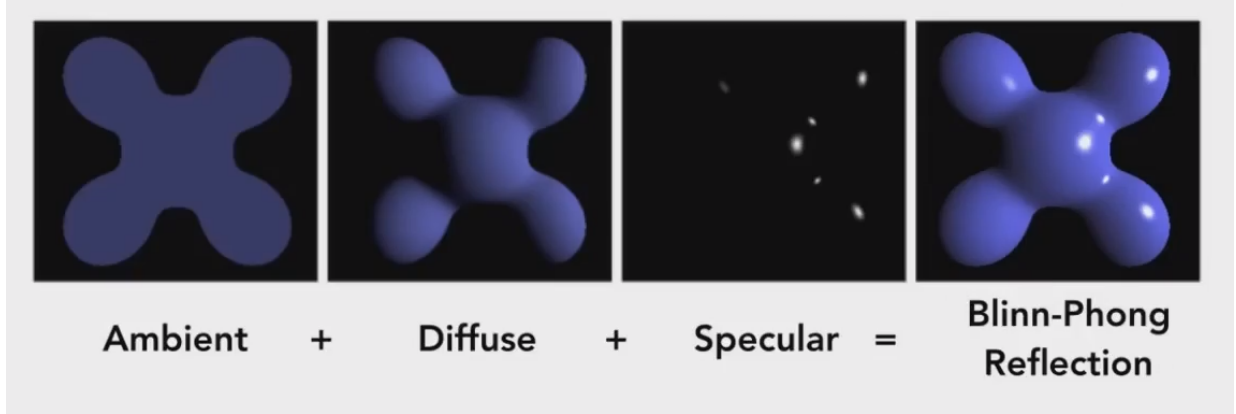
ambient coefficient

reflected ambient light

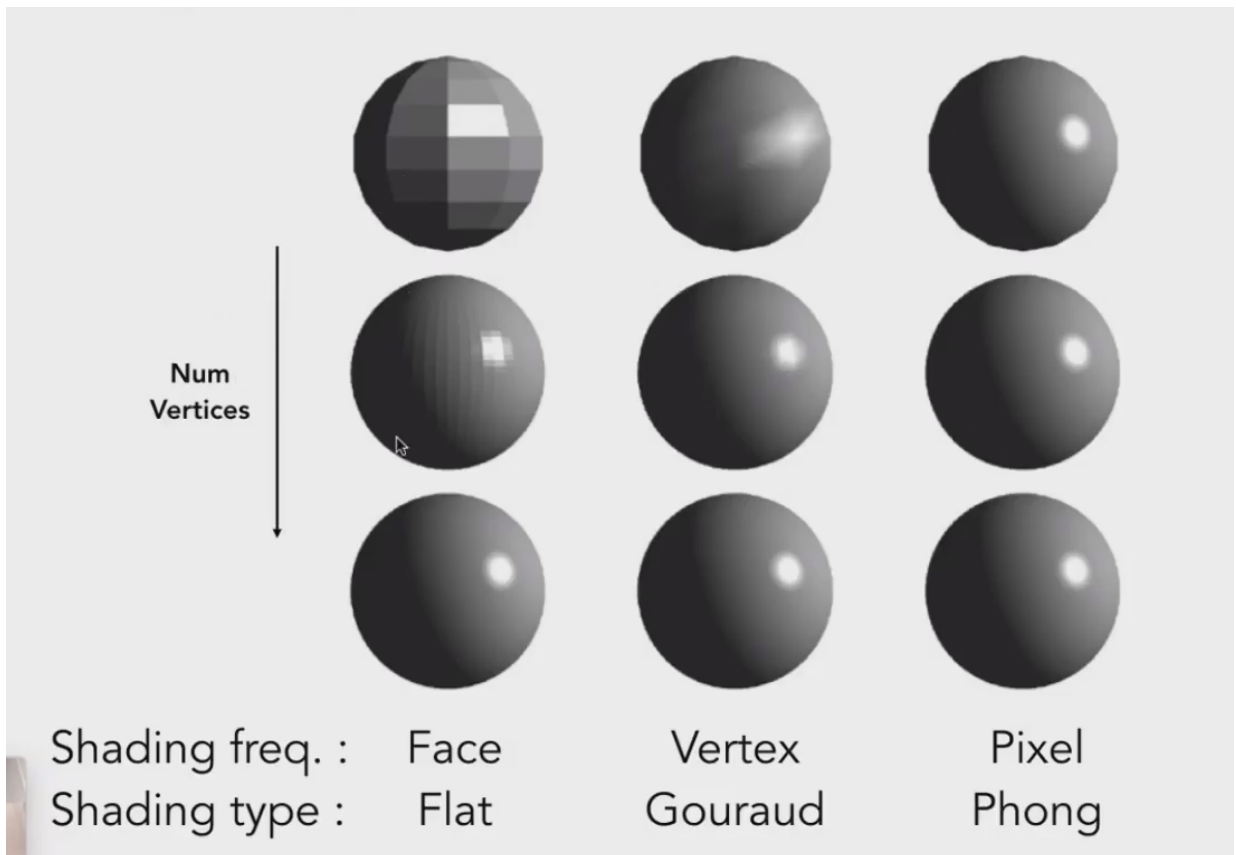
极度简化

常量 无方向性

- 步骤



- shading frequencies 着色频率
 - flat shading 对三角着色
 - gouraud shading 对顶点着色 中间线性插值
 - phong shading 用每个插值出的点的法线对像素着色
 - 对比



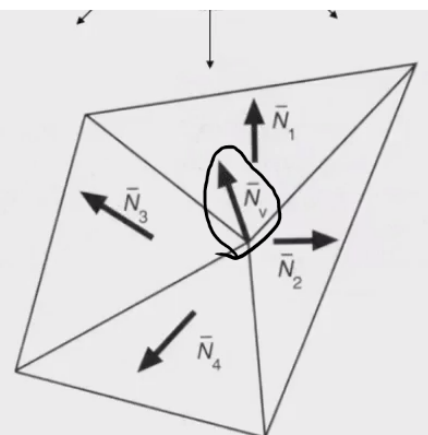
- defining per-vertex normal vectors 逐顶点法线

Otherwise have to infer vertex normals from triangle faces

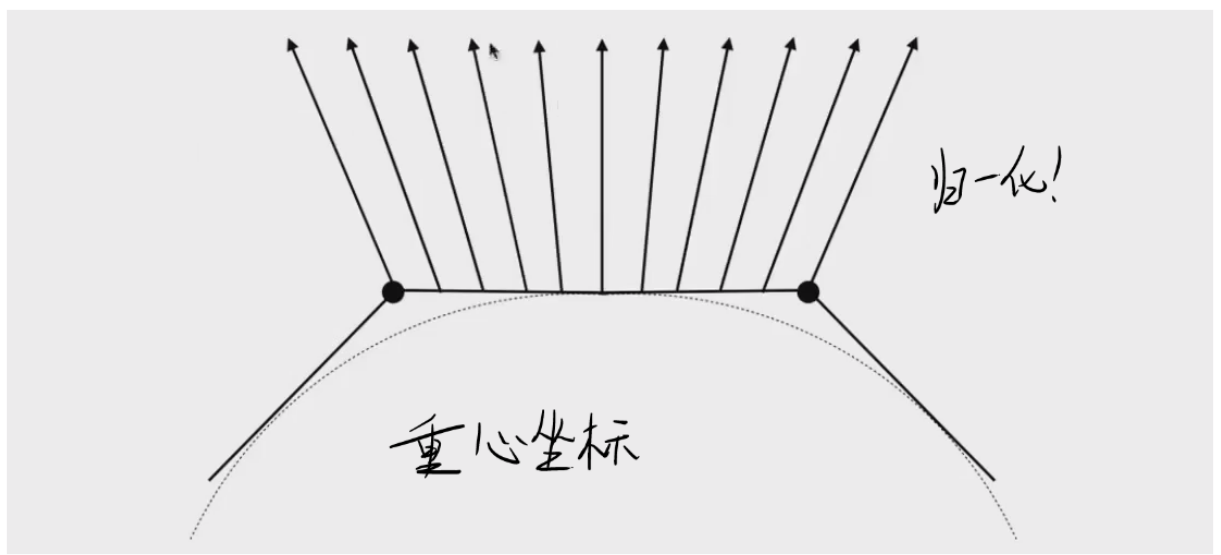
- Simple scheme: **average surrounding face normals**

$$N_v = \frac{\sum_i N_i}{\|\sum_i N_i\|}$$

对面积加权 平均

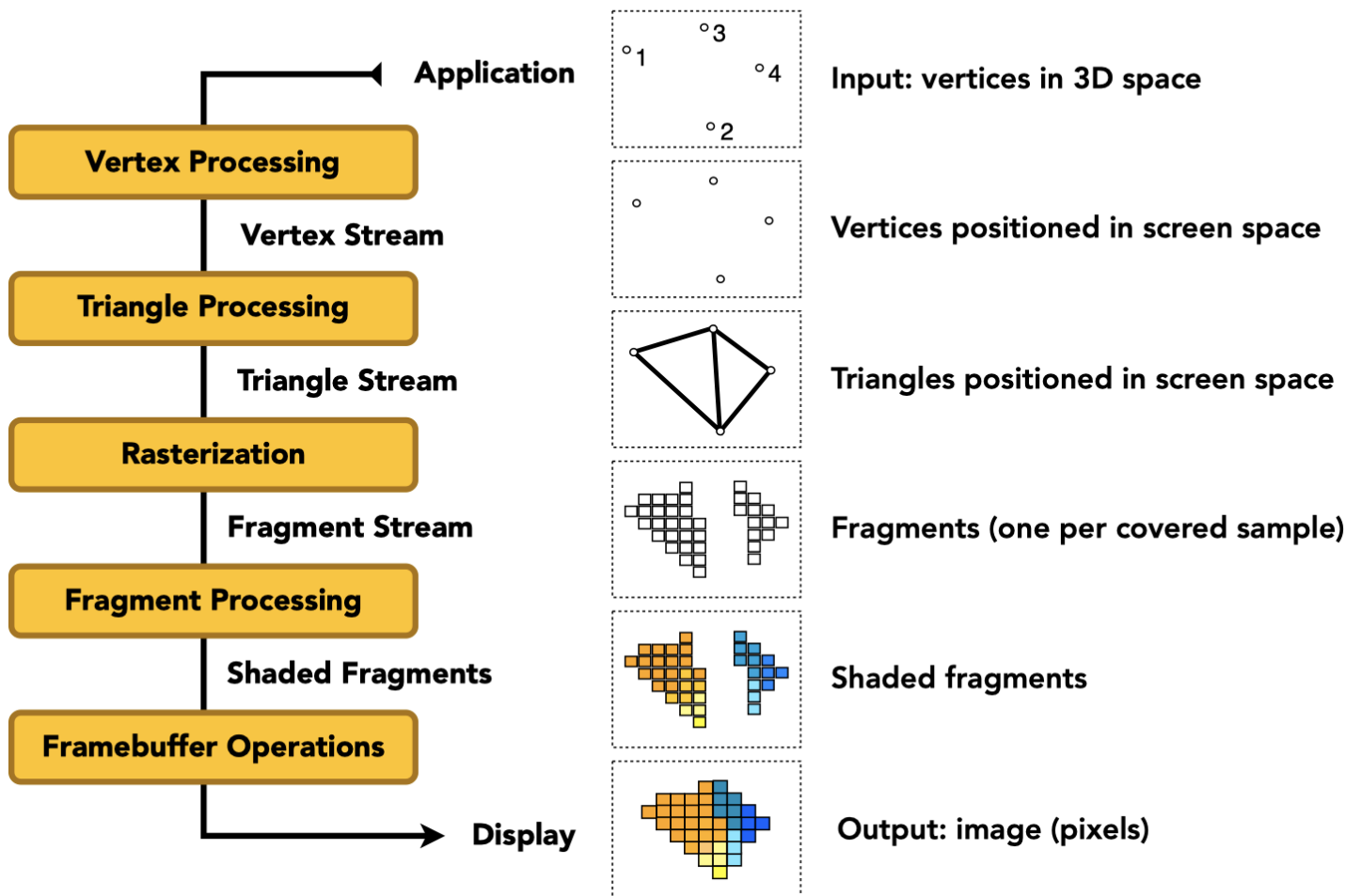


- defining per-pixel normal vectors 逐像素法线



Graphics (Real-time Rendering) Pipeline

Graphics Pipeline



- Vertex Processing
 - Model, View, Projection transforms
 - Shading, Texture mapping
 - Output: Vertex Stream
- Triangle Processing
 - Output: Triangle Stream
- Rasterization
 - Sampling

- Output: Fragment Stream
- Fragment Processing
 - Z-Buffer Visibility Tests
 - Shading, Texture mapping
 - Output: Shaded Fragments
- Framebuffer Operations
 - Output: image (pixels)

Shader Programs

- Program vertex and fragment processing stages
- 自己编程顶点和像素的着色流程
- Describe operation on **a single vertex (or fragment)**
- 每个元素都执行一次
- vertex / fragment shader
- More:
 - Geometry Shader
 - Compute Shader

学习API (OpenGL, DirectX, vulkan)

推荐: ShaderToy, 只需要关注着色

当下的实时渲染:

- 100's of thousands to millions of triangles in a scene
- Complex vertex and fragment shader computations
- High resolution (2-4 megapixel + supersampling)
- 30-60 frames per second (even higher for VR)

Graphics Pipeline Implementation: GPUs

- Specialized processors for executing graphics pipeline computations
- Heterogeneous, Multi-Core Processor
- 可并行的