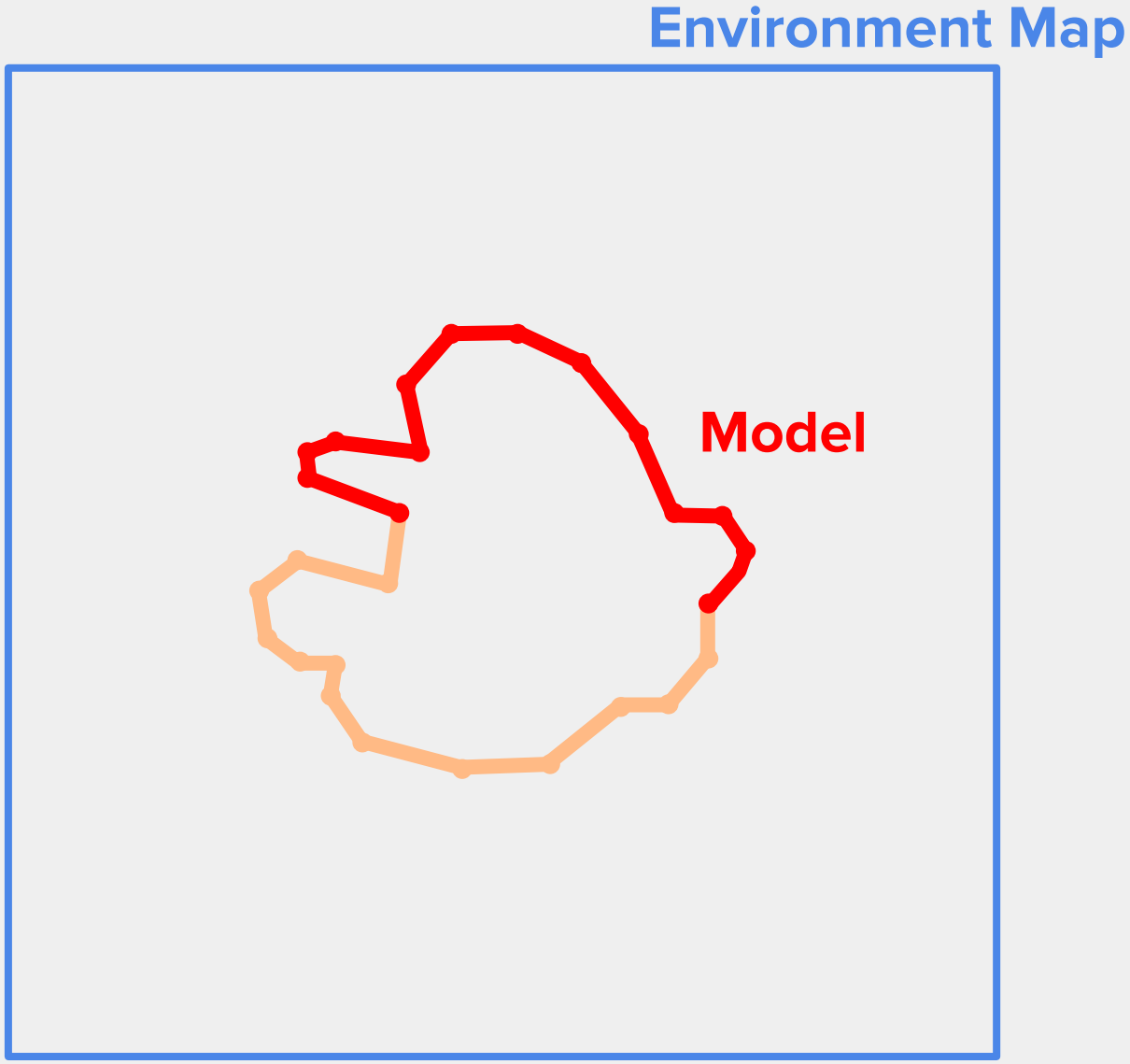
Fast Realistic Rendering

Physically-Based Rendering

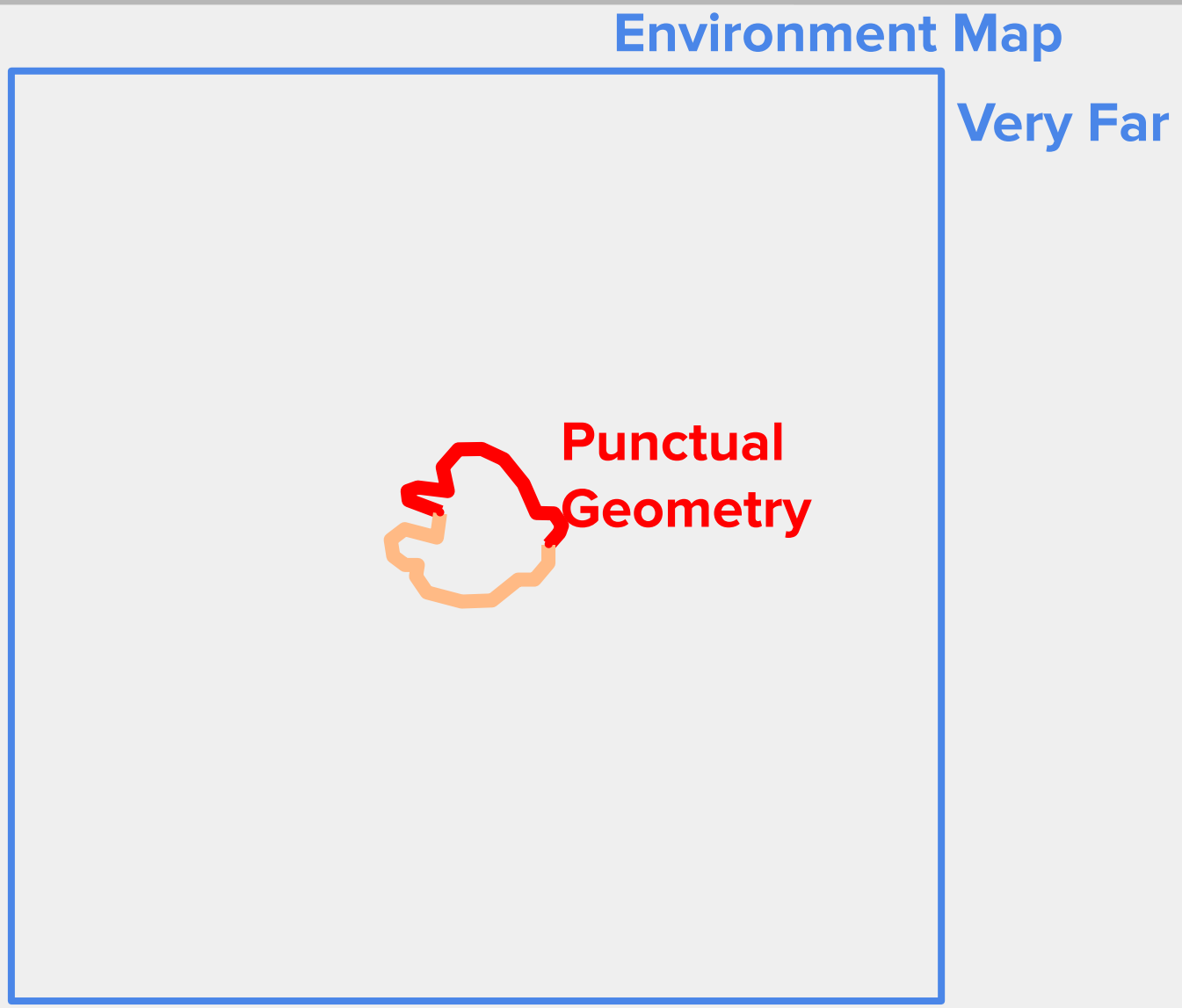
Image-Based Lighting

Marc **Comino**
mcomino@cs.upc.edu

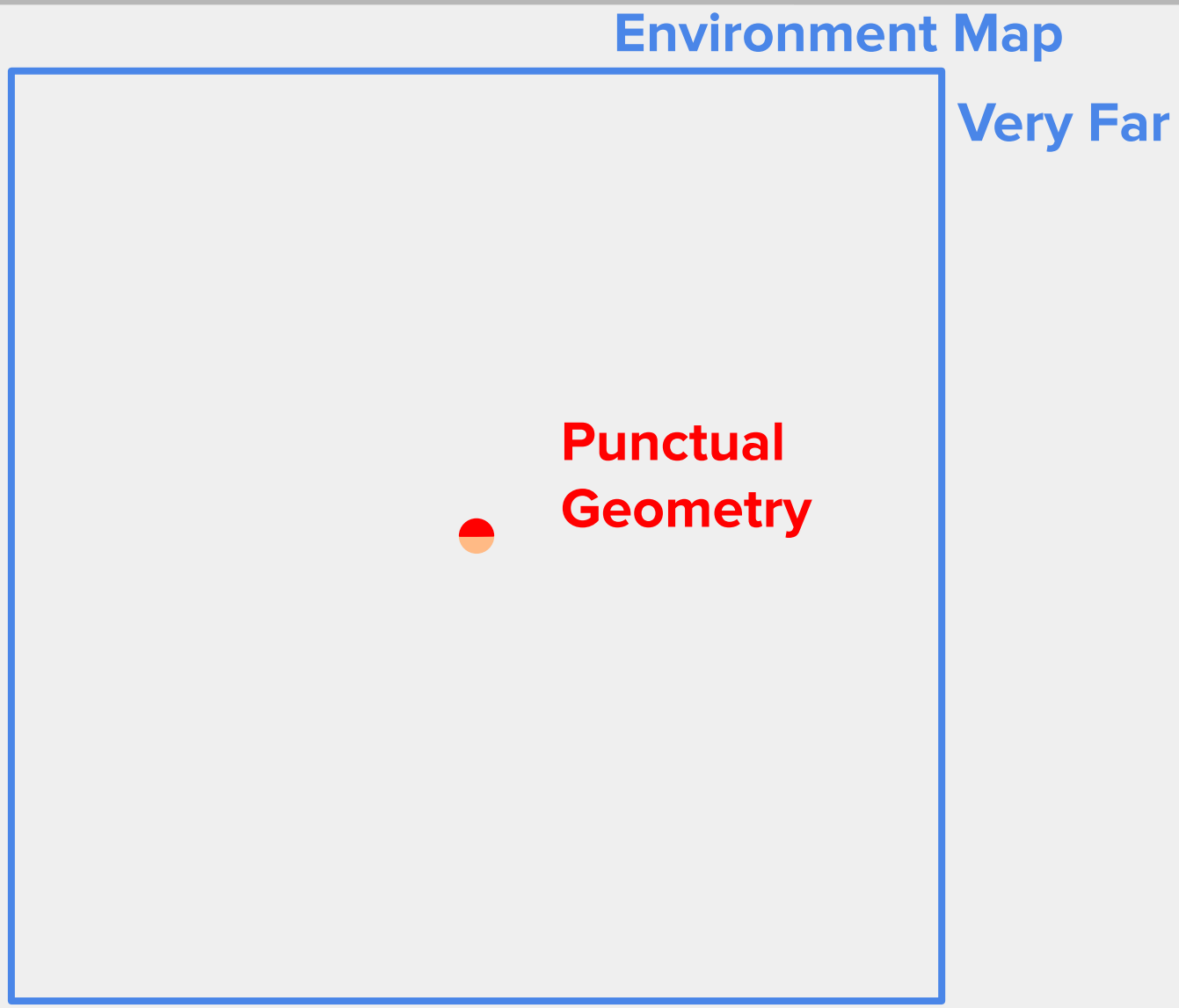
Reflection



Reflection



Reflection



Reflection

Environment Map

```
glGenTextures(1, &specular_map_);

...
glBindTexture(GL_TEXTURE_CUBE_MAP,
specular_map_);
LoadCubeMap(dir);
glBindTexture(GL_TEXTURE_CUBE_MAP, 0);
...
```

Very Far

Reflection

Environment Map

LoadCubeMap

```
...
LoadImage(path + "/right.png",
GL_TEXTURE_CUBE_MAP_POSITIVE_X);
LoadImage(path + "/left.png",
GL_TEXTURE_CUBE_MAP_NEGATIVE_X);
LoadImage(path + "/top.png",
GL_TEXTURE_CUBE_MAP_POSITIVE_Y);
...
glTexParameteri(GL_TEXTURE_CUBE_MAP,
GL_TEXTURE_MAG_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_CUBE_MAP,
GL_TEXTURE_MIN_FILTER, GL_LINEAR);
glTexParameteri(GL_TEXTURE_CUBE_MAP,
GL_TEXTURE_WRAP_S,
GL_CLAMP_TO_EDGE);
...
```

Very Far

Reflection

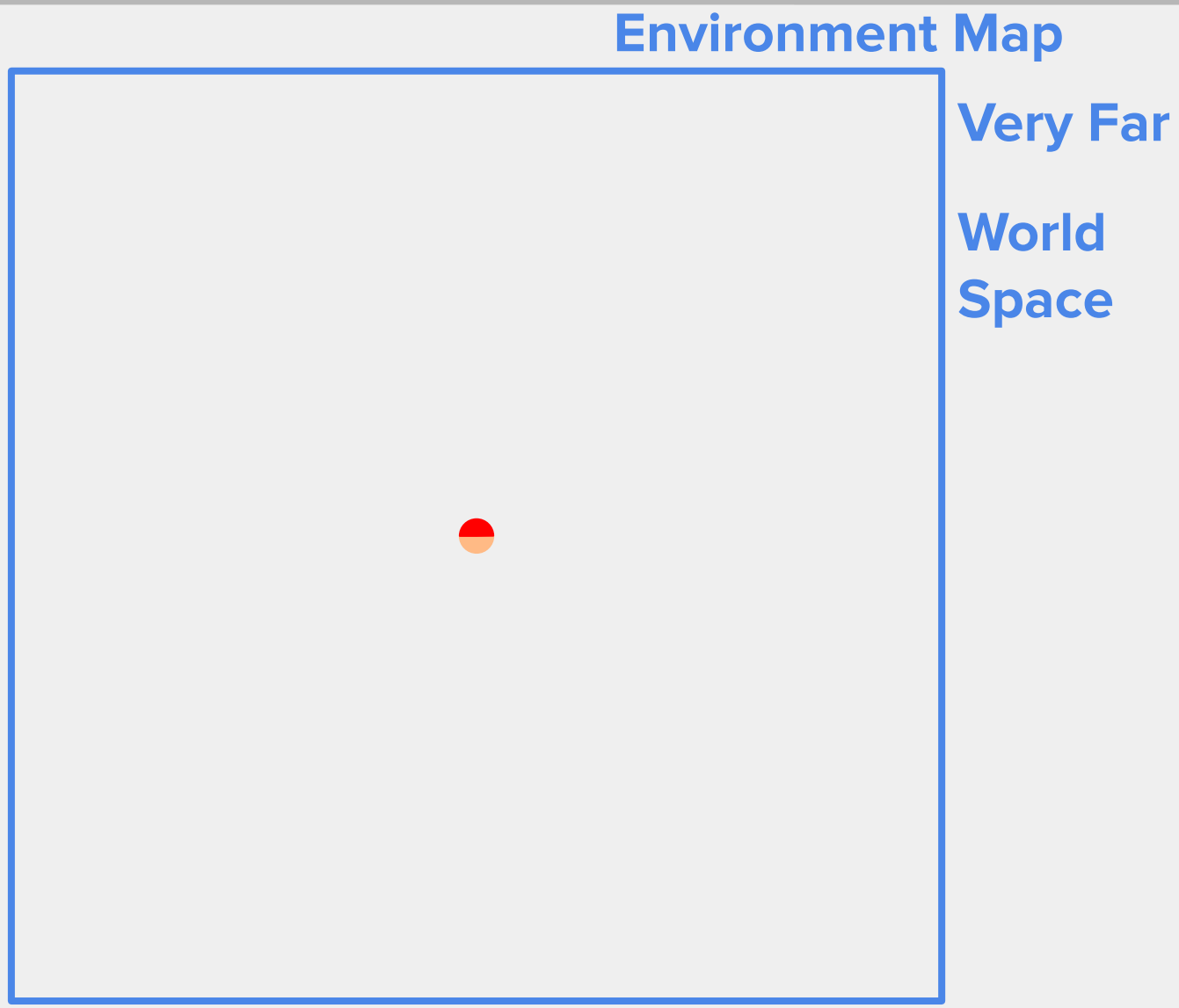
Environment Map

LoadImage

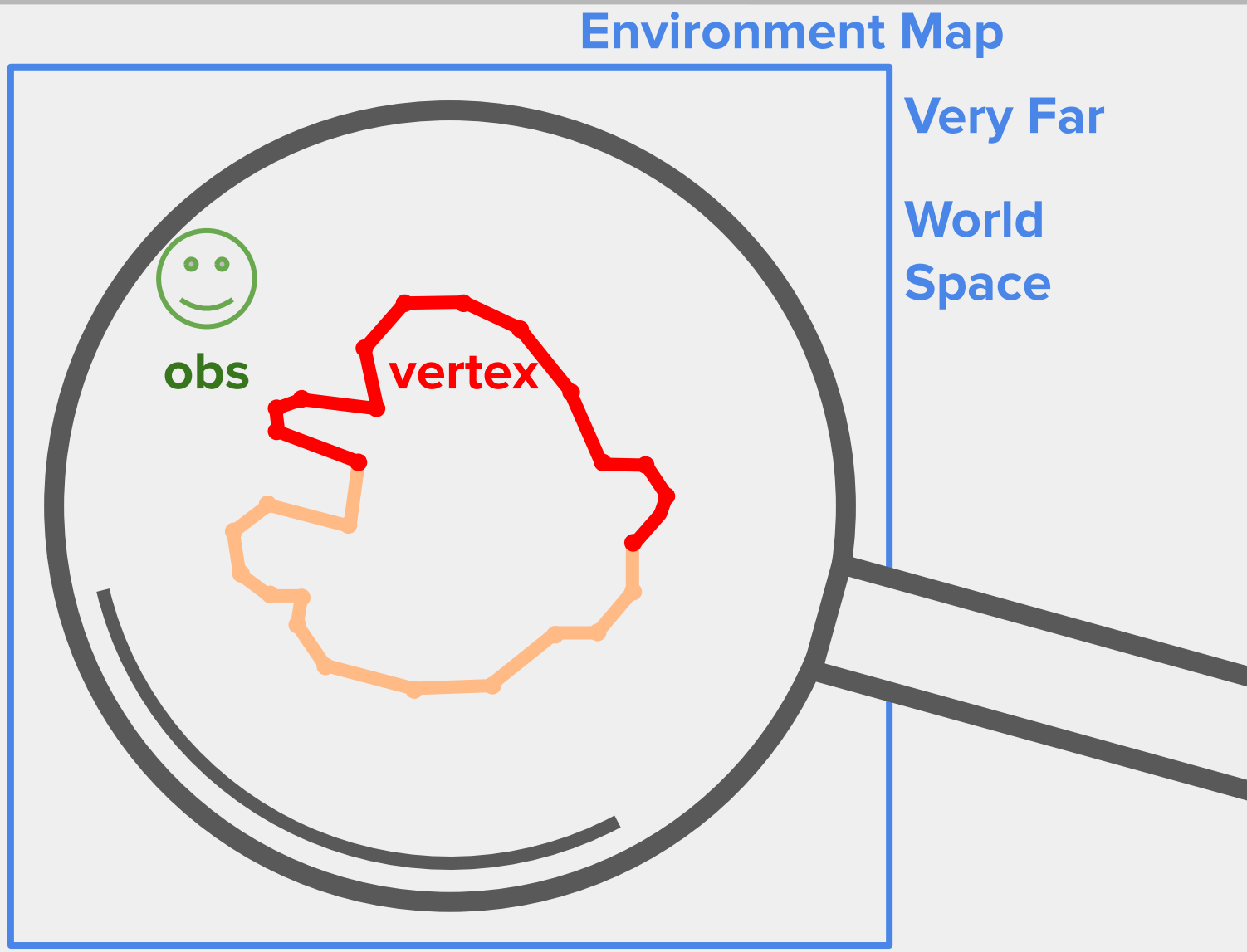
```
QImage image;
image.load(path.c_str());

QImage gl_image = image.mirrored();
glTexImage2D(cube_map_pos, 0, GL_RGBA,
image.width(), image.height(), 0, GL_BGRA,
GL_UNSIGNED_BYTE, image.bits());
```

Very Far

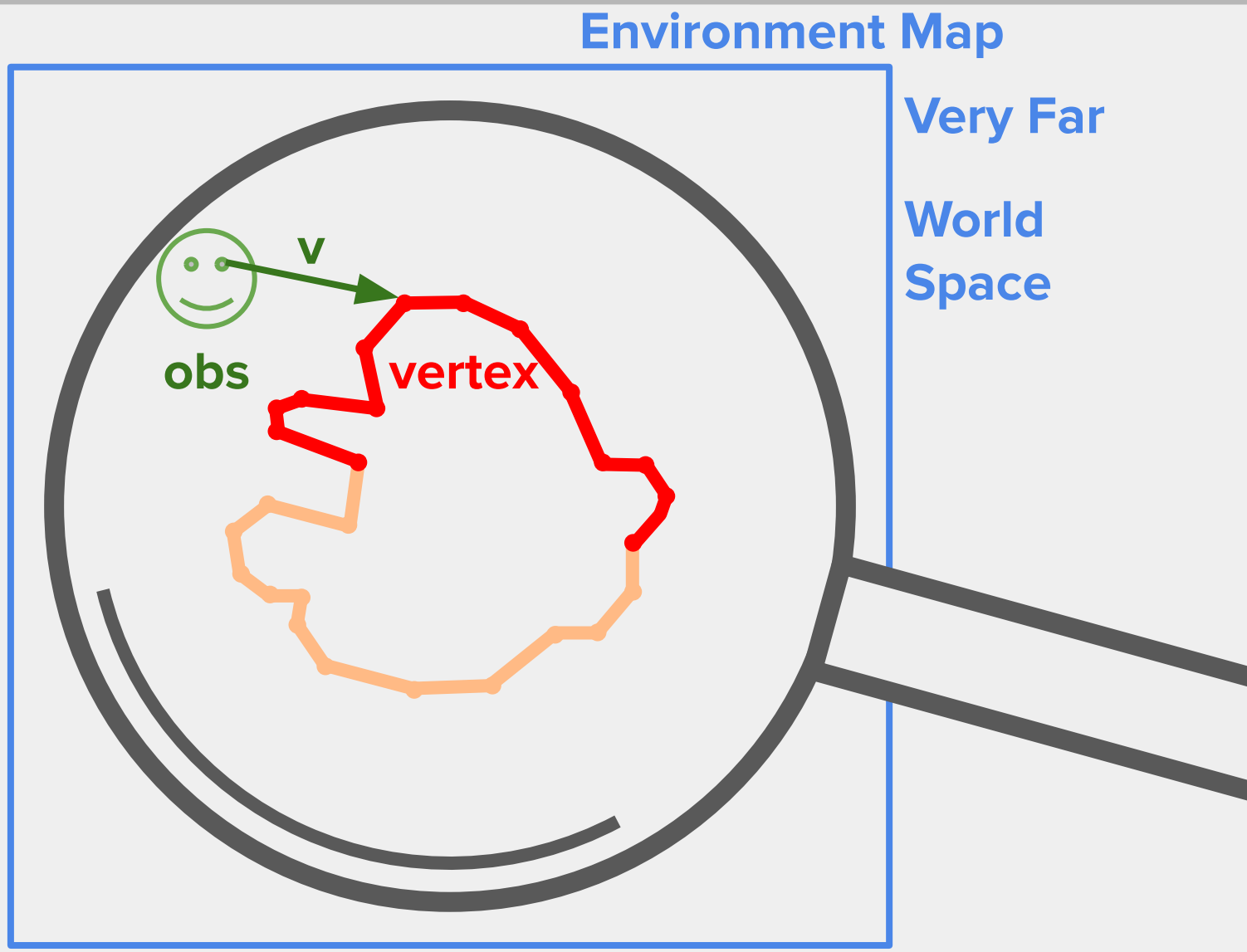
Reflection



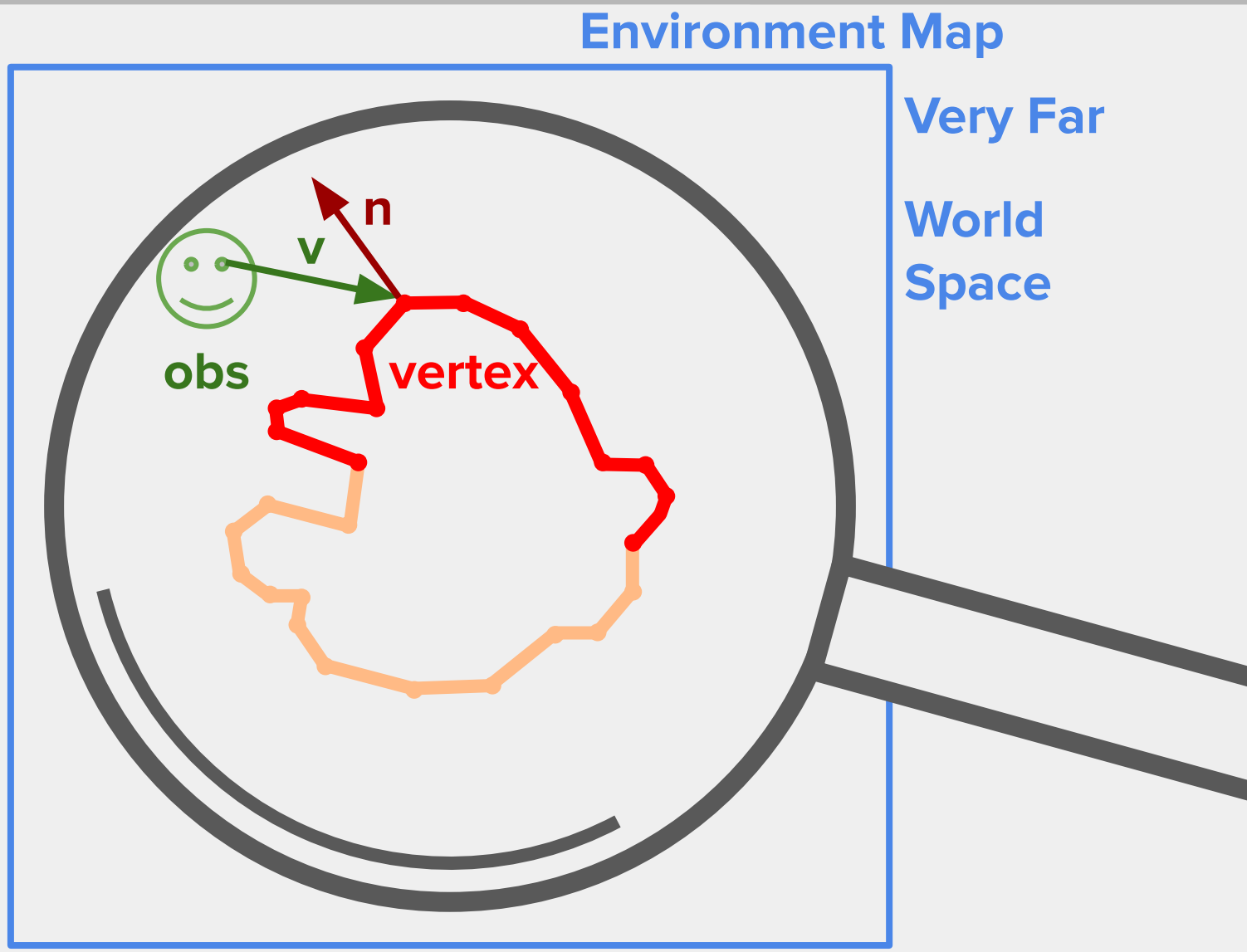
Reflection



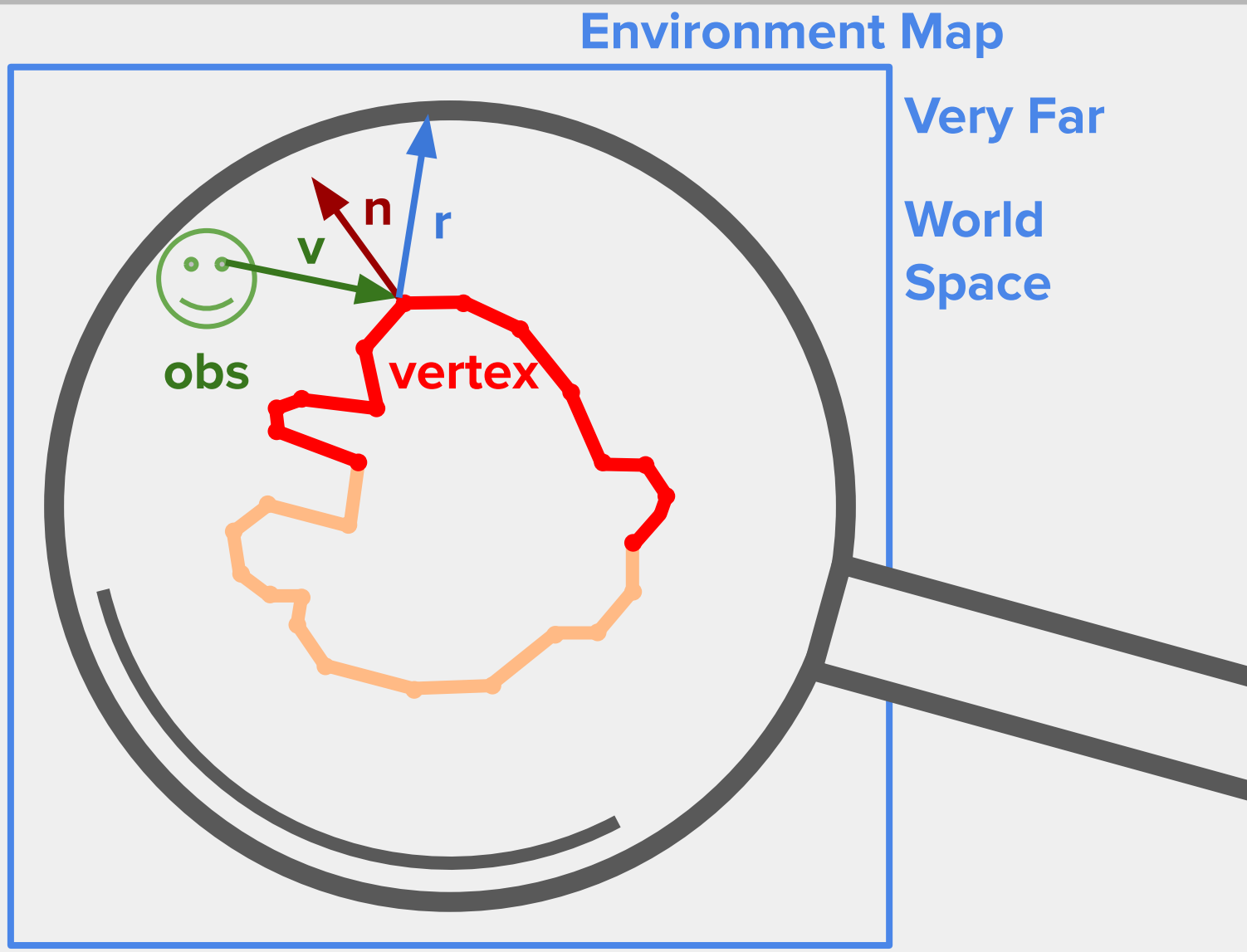
Reflection



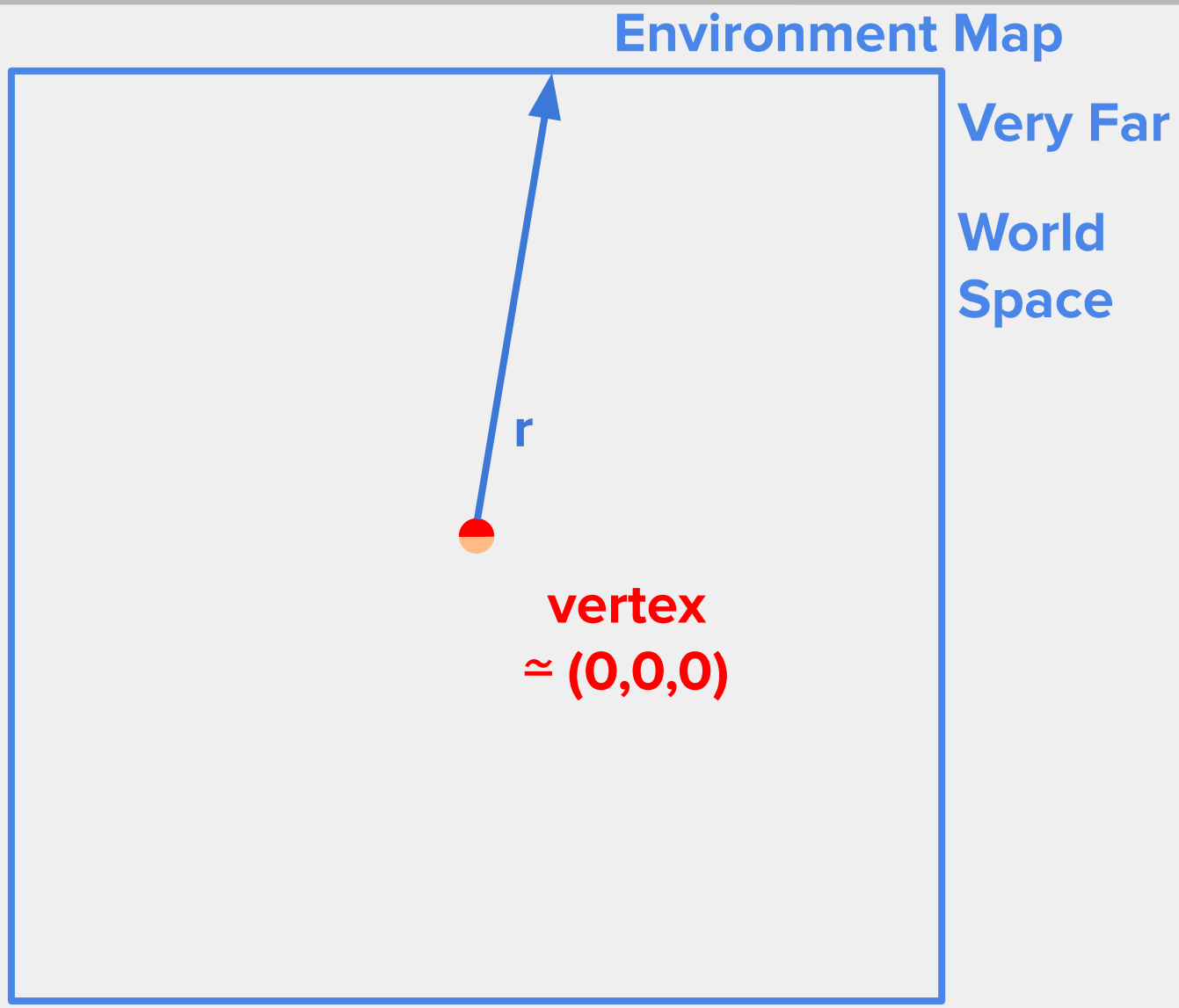
Reflection



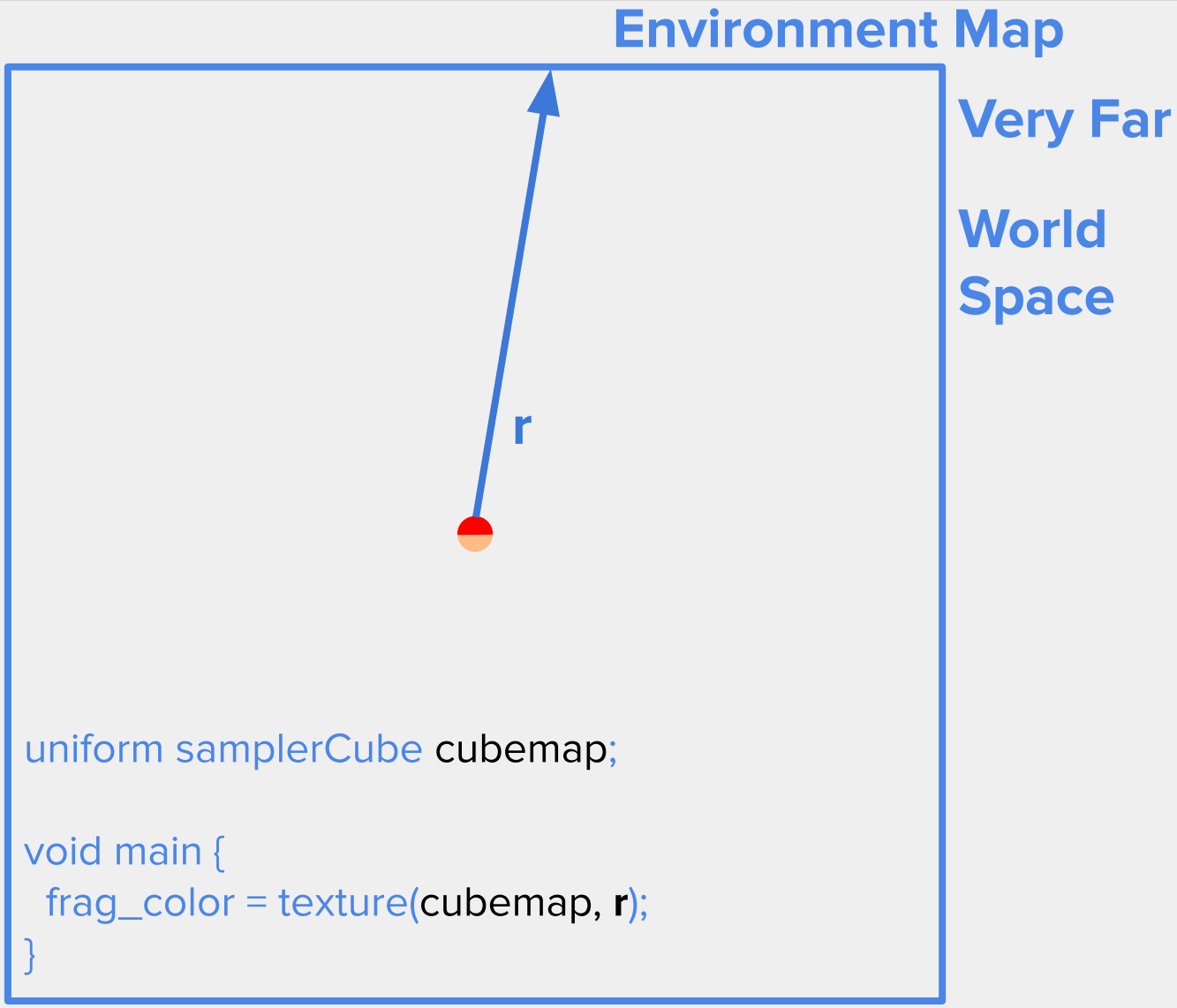
Reflection



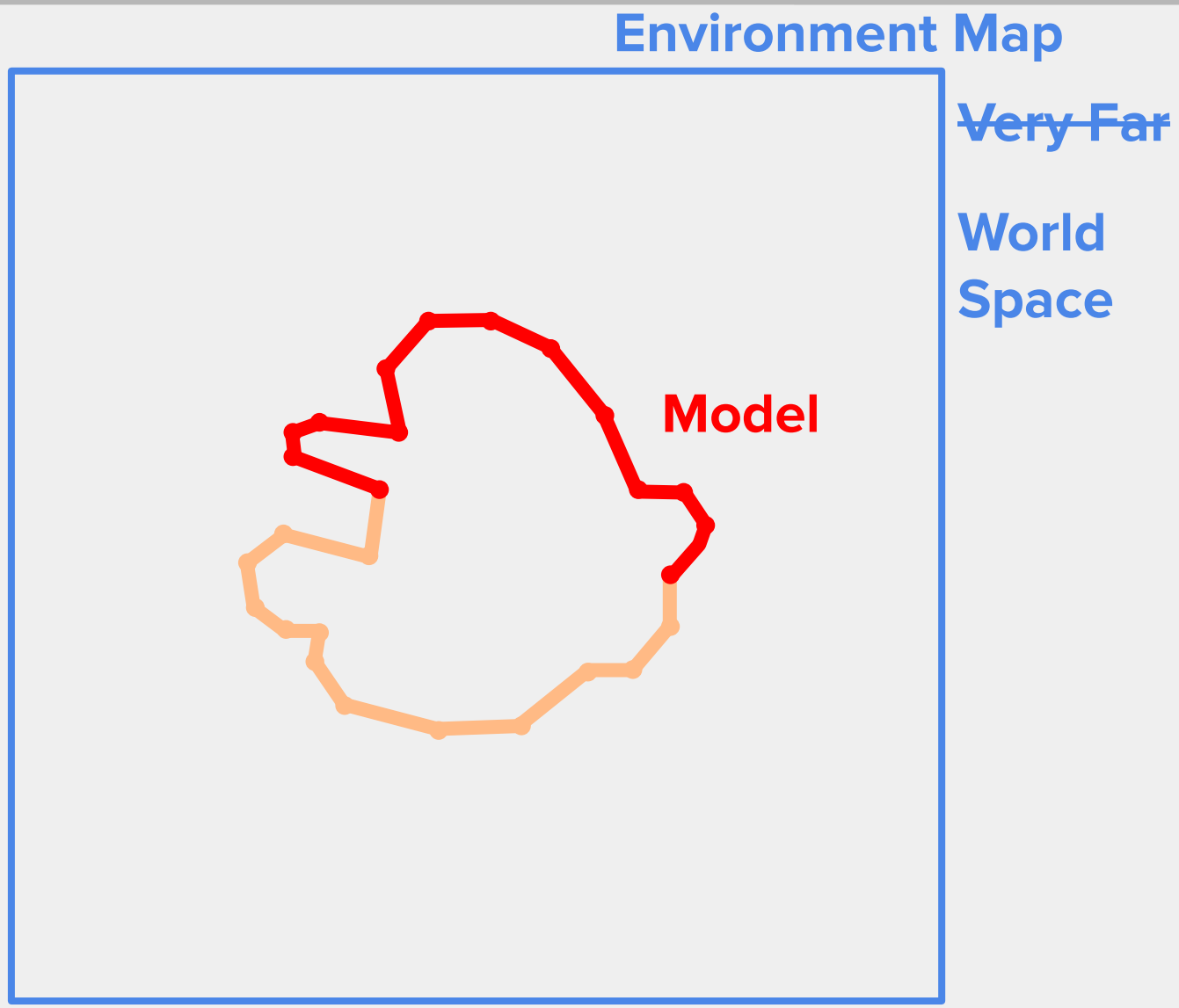
Reflection



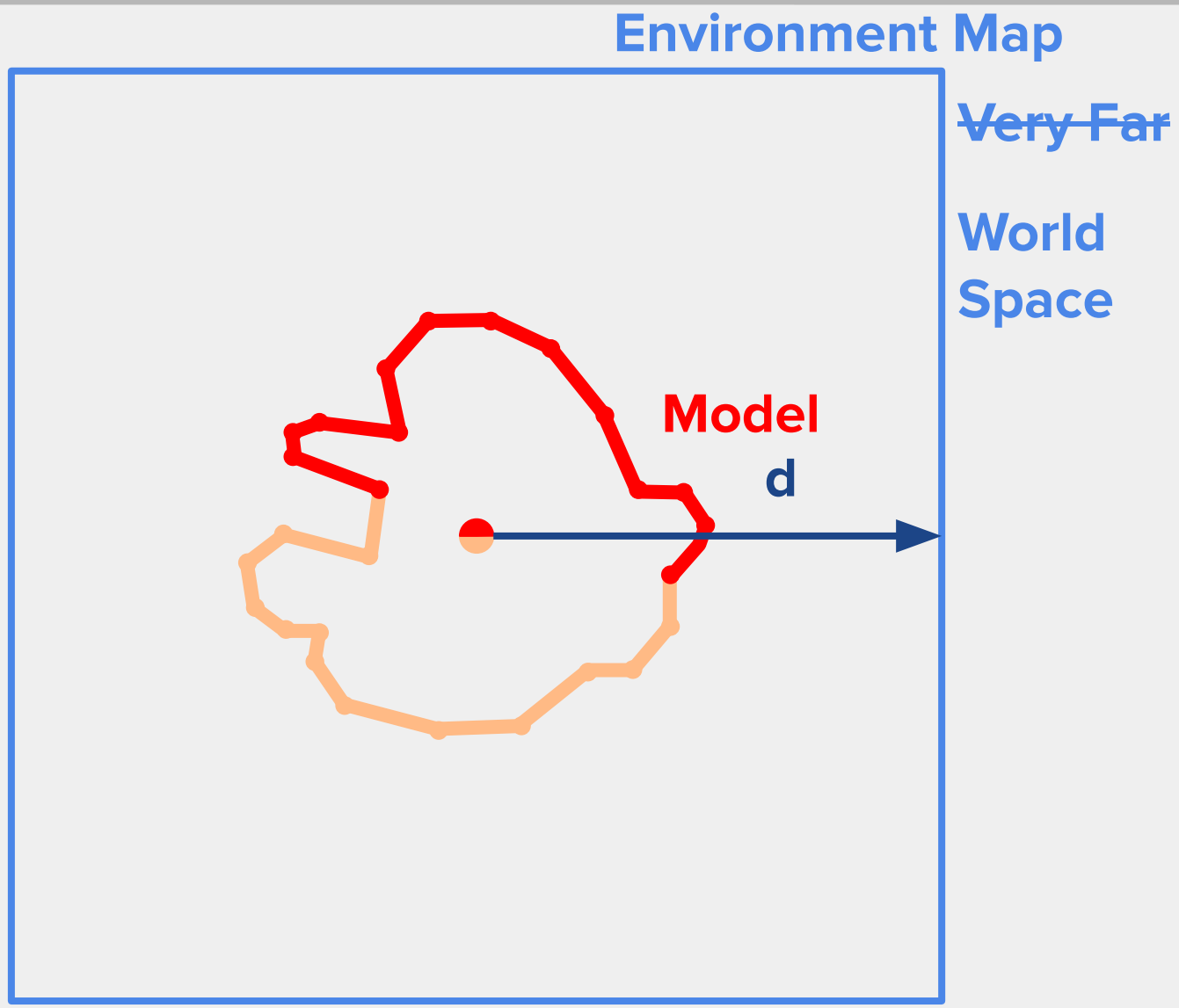
Reflection


Environment Map
Very Far
World Space
r
uniform samplerCube cubemap;
void main {
frag_color = texture(cubemap, r);
}

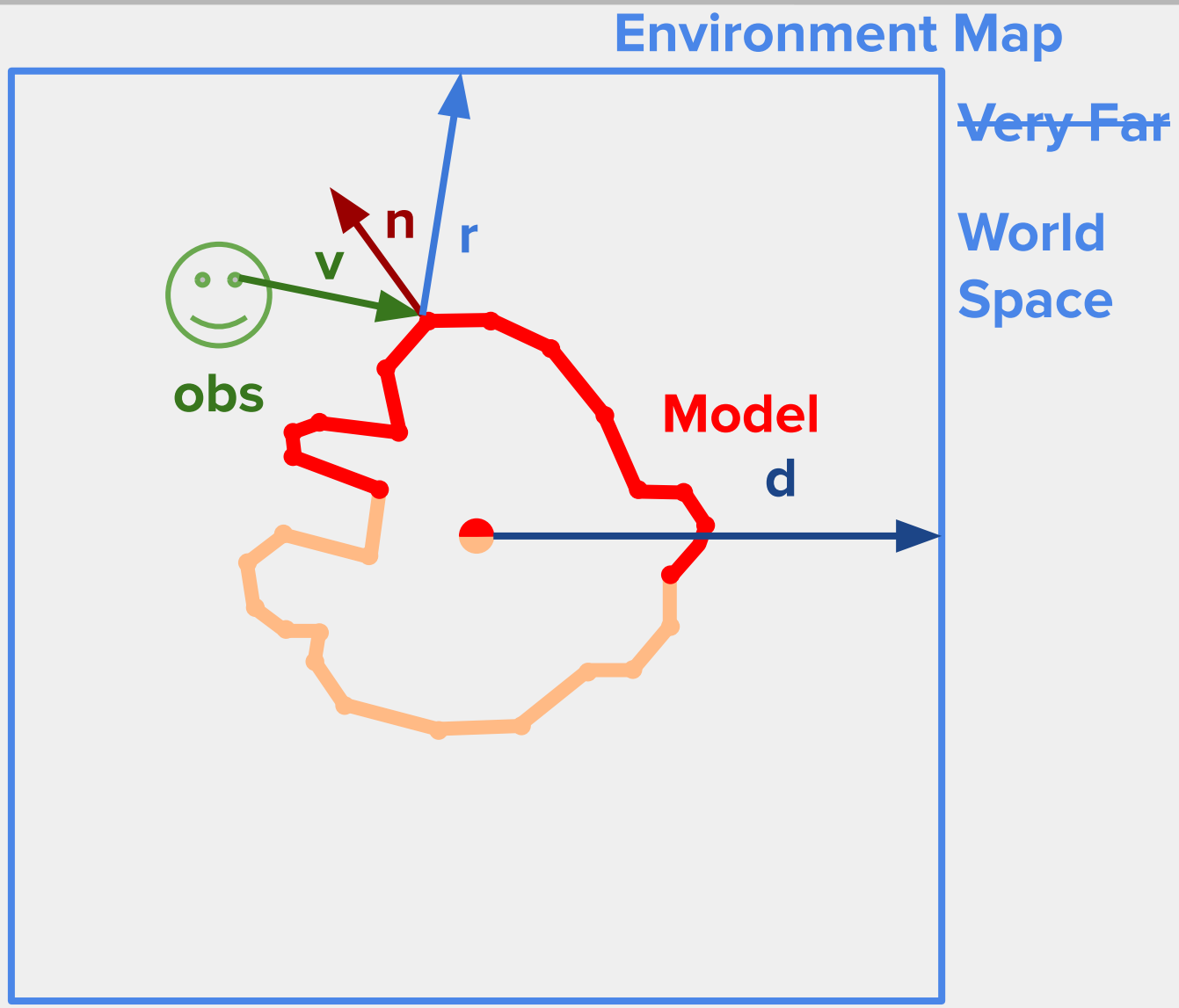
Reflection Advanced



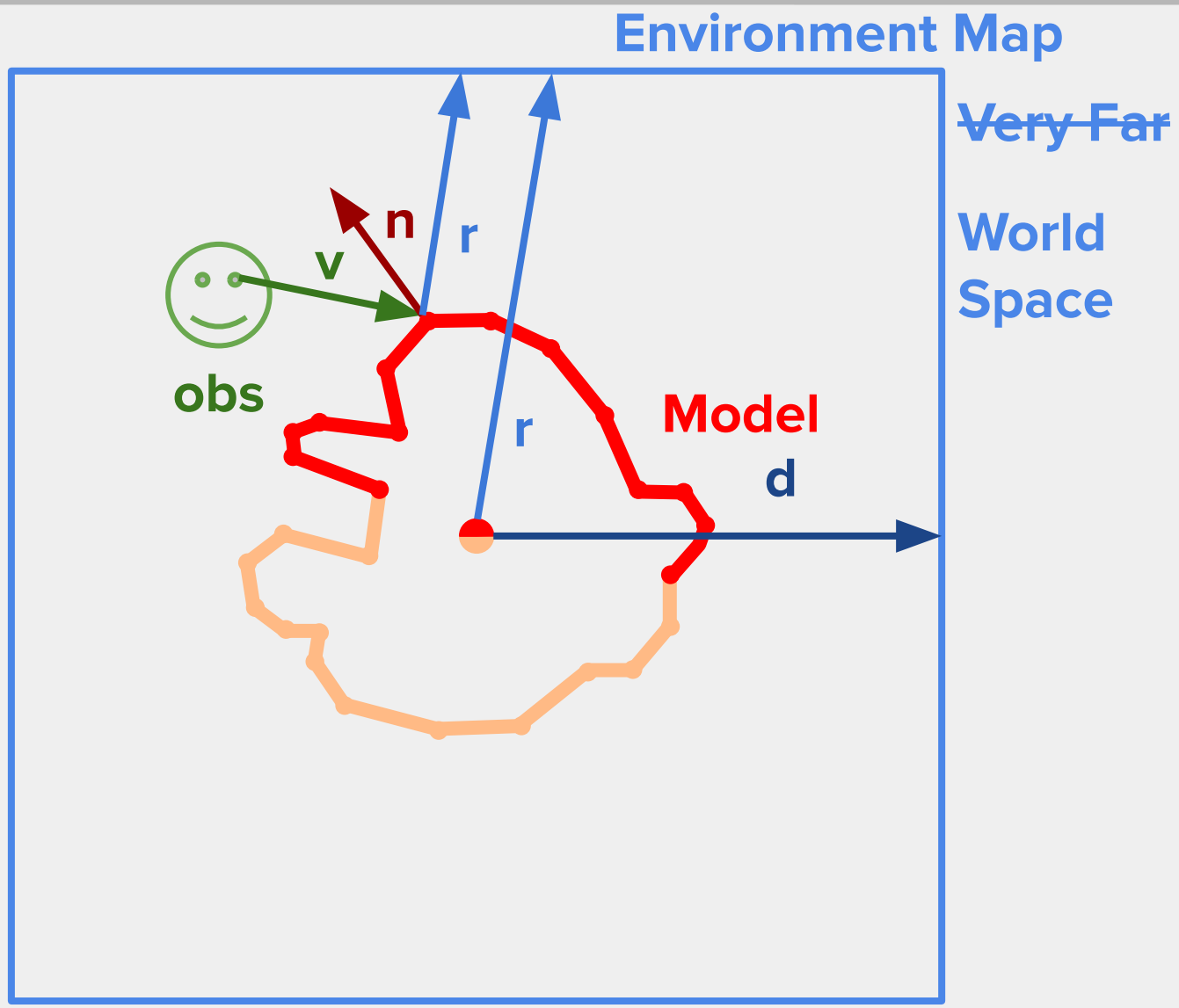
Reflection Advanced



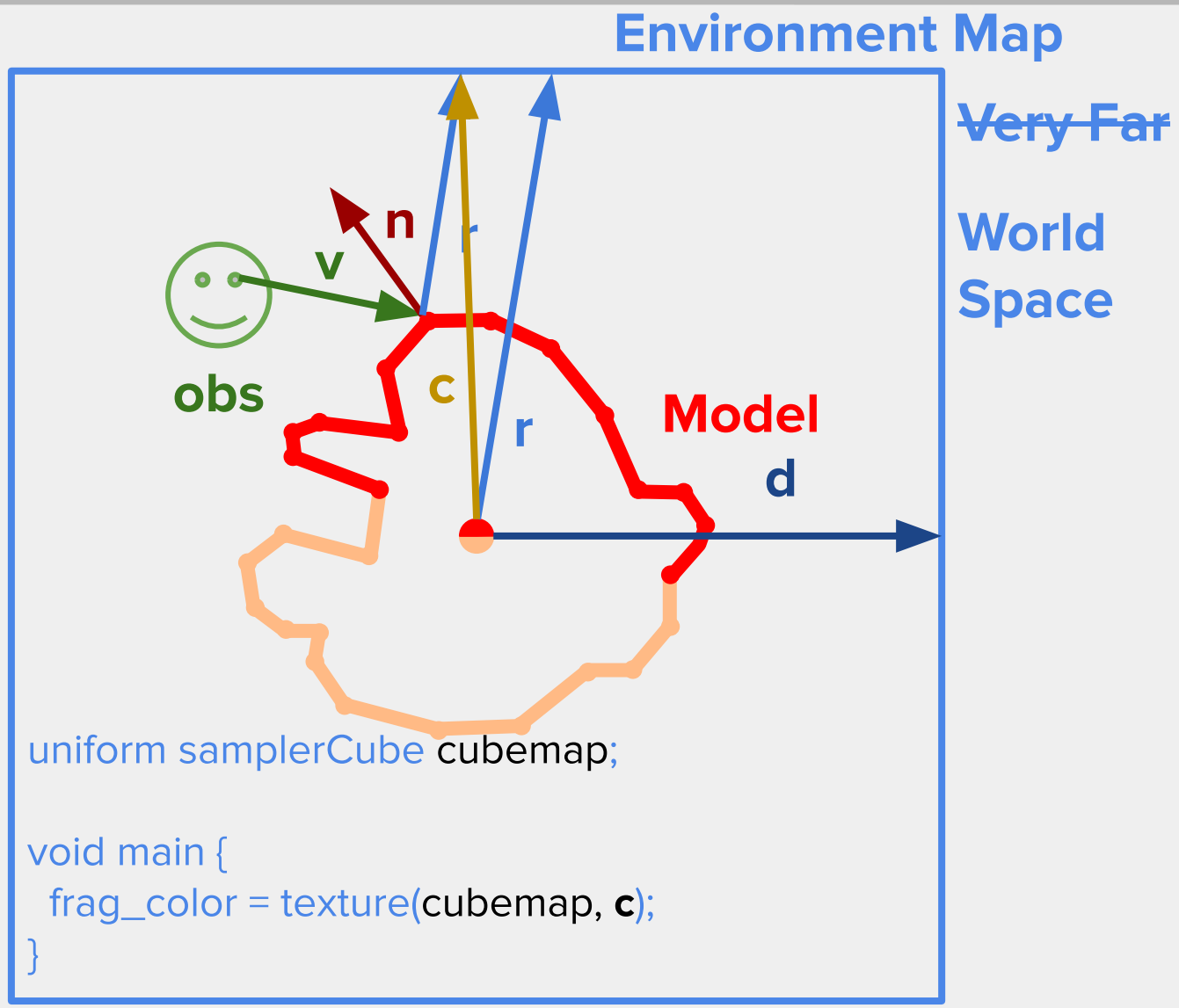
Reflection Advanced



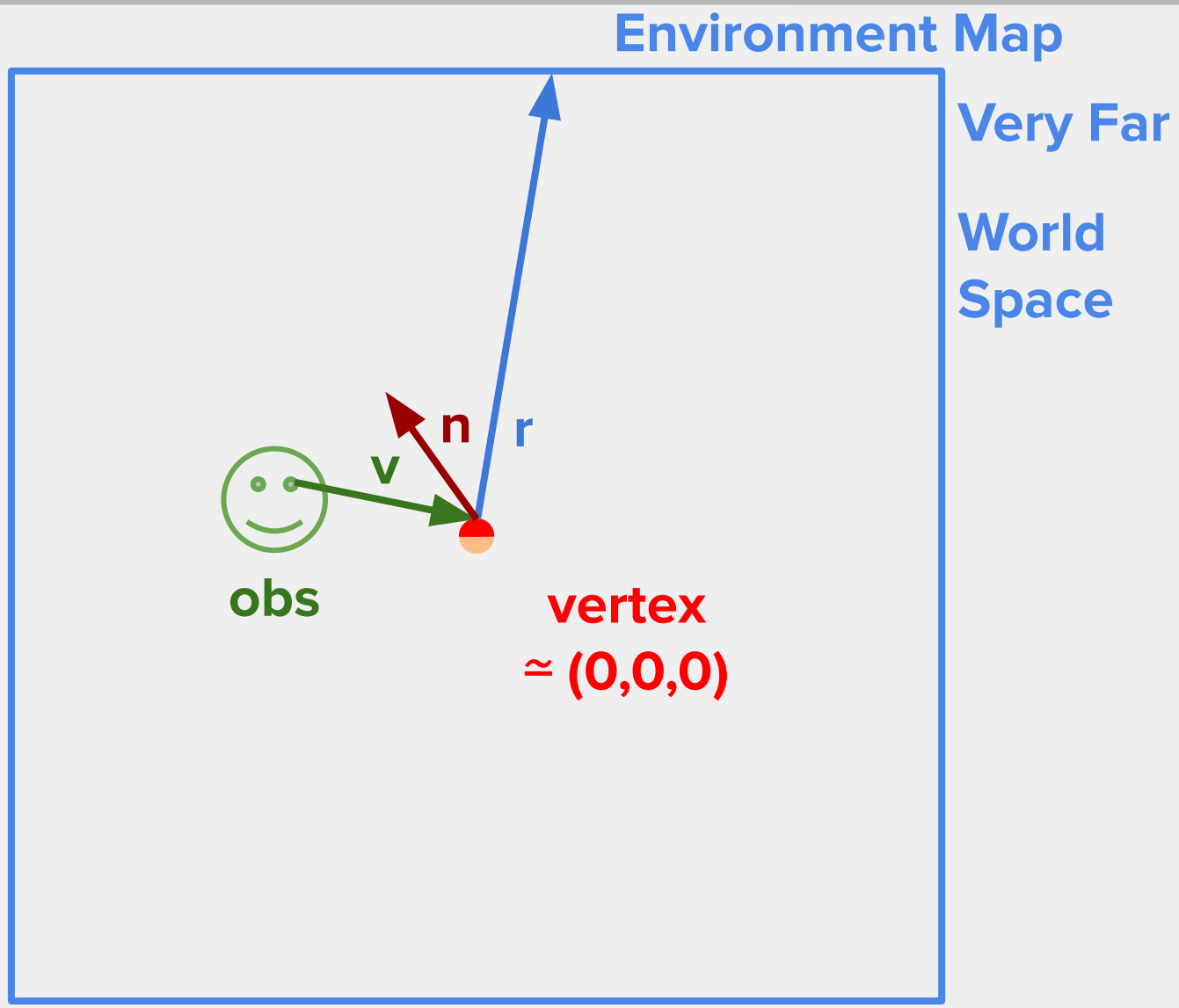
Reflection Advanced



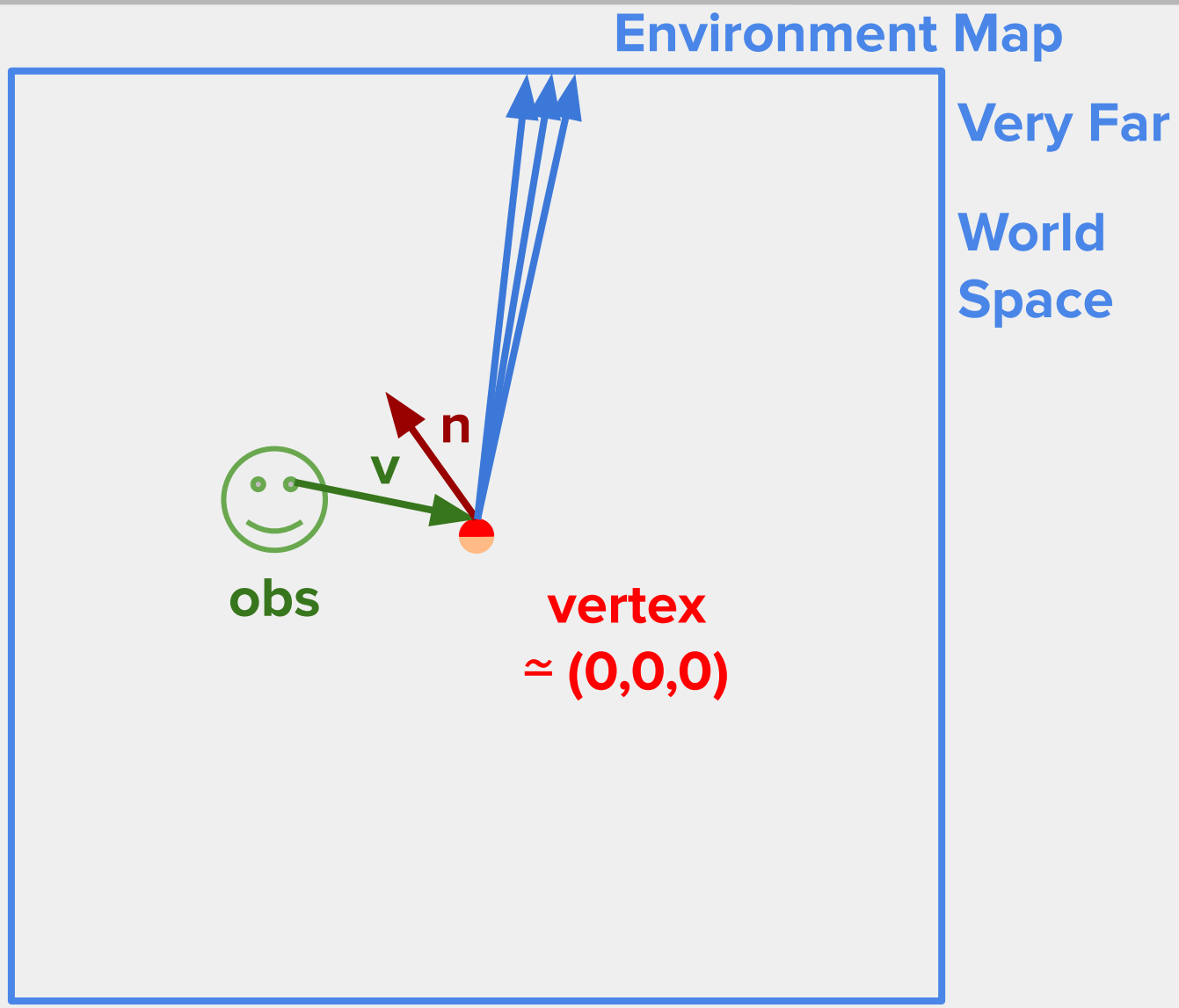
Reflection Advanced



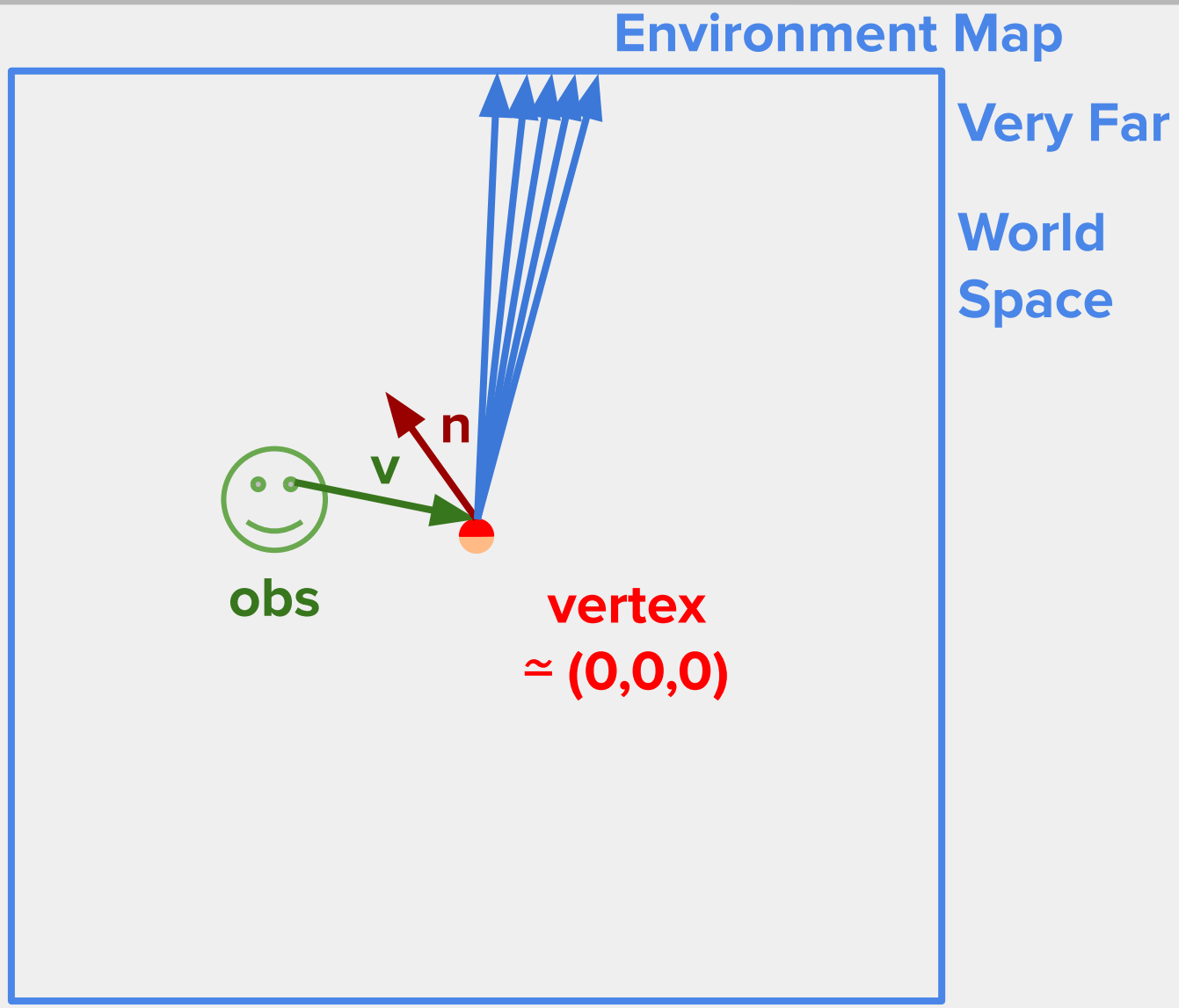
Reflection



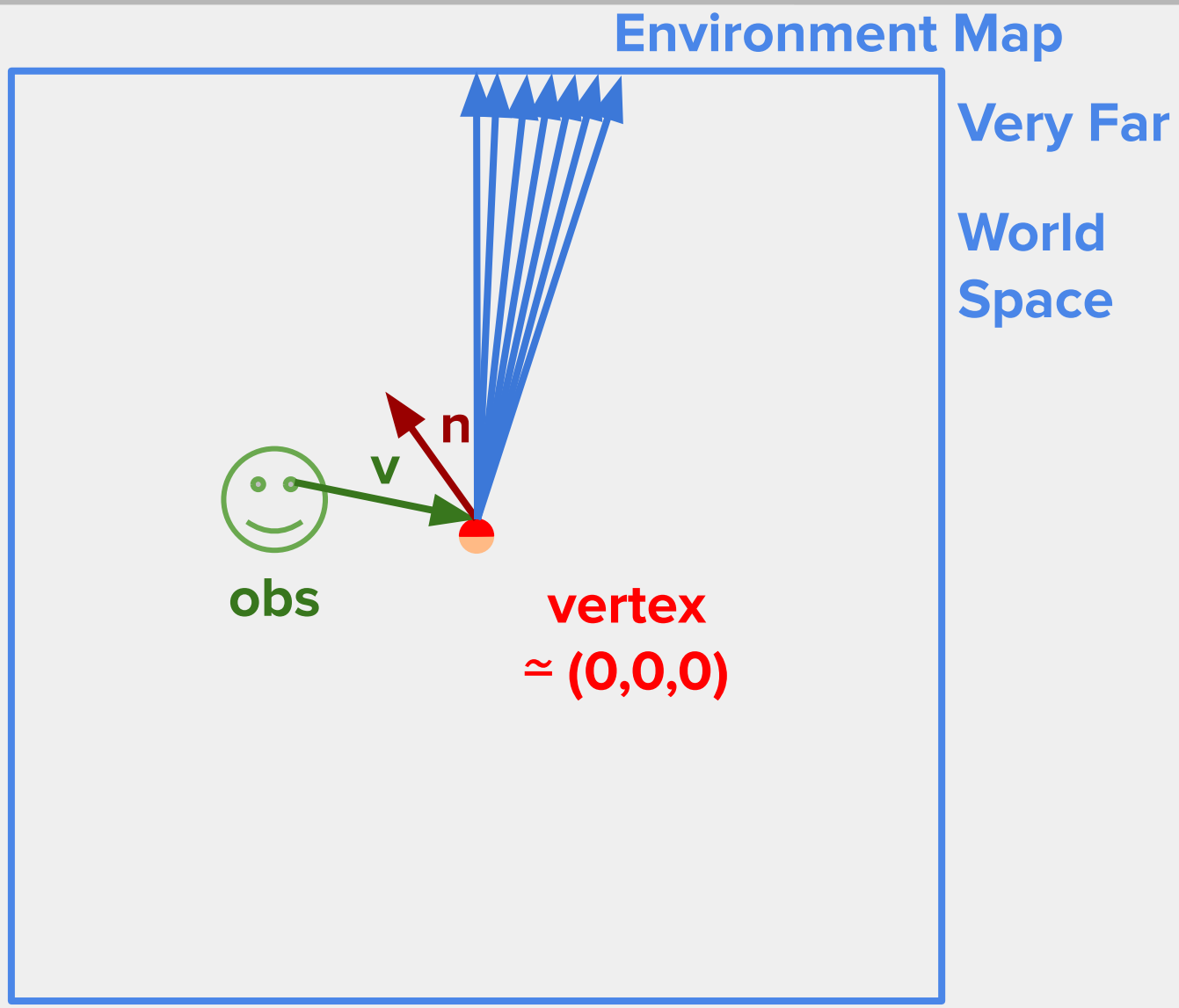
Diffuse Irradiance



Diffuse Irradiance



Diffuse Irradiance



Diffuse Irradiance

$$L_o(\mathbf{v}) = \int_\Omega f(\mathbf{l}, \mathbf{v}) \otimes L_i(\mathbf{l})(\mathbf{n} \cdot \mathbf{l})\, d\omega_i$$

Diffuse Irradiance

$$L_o(\mathbf{v}) = \int_\Omega f(\mathbf{l}, \mathbf{v}) \otimes L_i(\mathbf{l})(\mathbf{n} \cdot \mathbf{l})\, d\omega_i$$

$$f(l, v) = k_d * f_d + k_s * f_s$$

$$f_s = \frac{FGD}{4 * (n \cdot l)(n \cdot v)}$$

Diffuse Irradiance

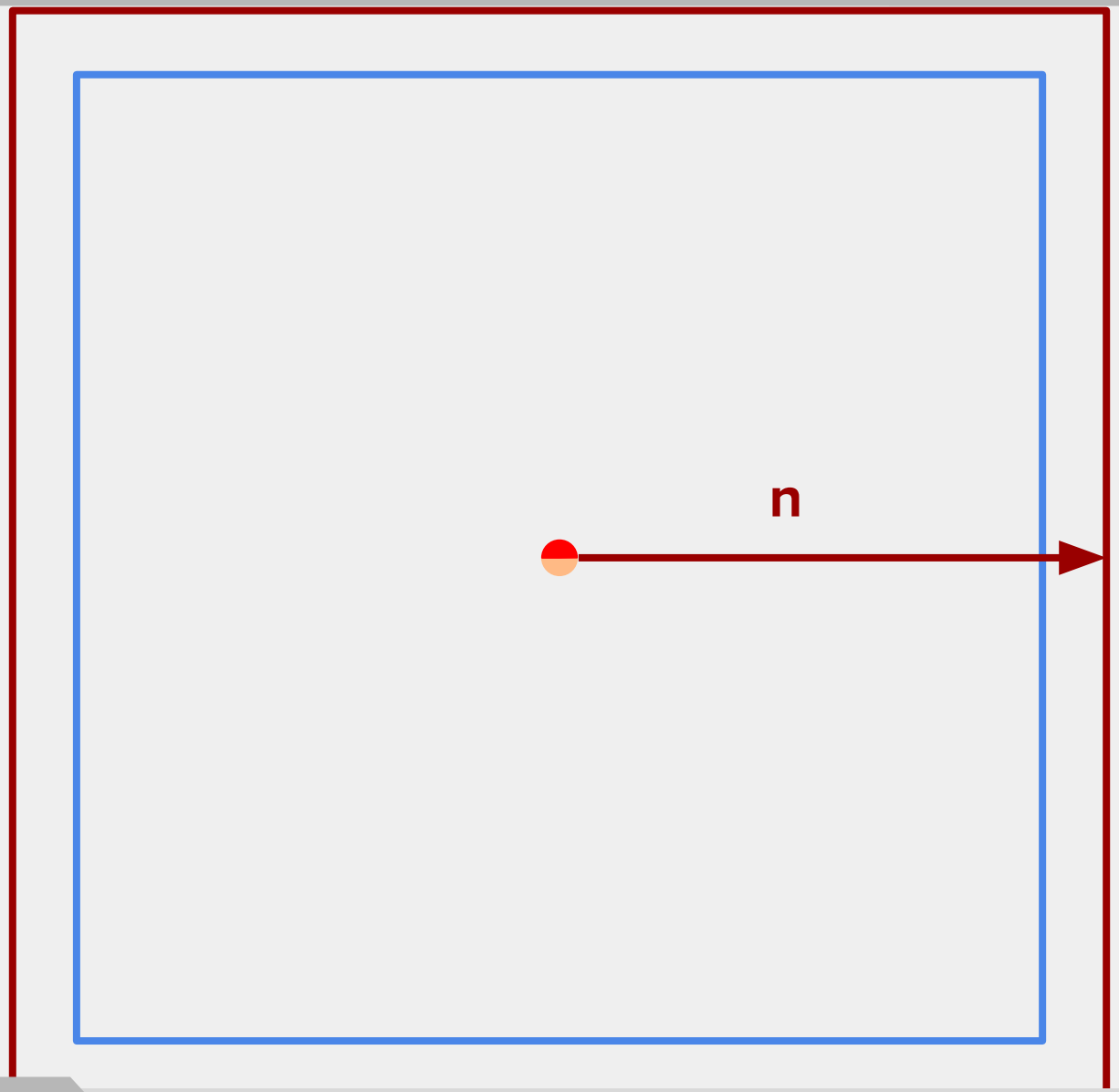
$$L_o(v) = k_d f_d \int_\Omega L_i(l) * (n \cdot l) d\omega_i$$
$$+ k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i$$

Diffuse Irradiance

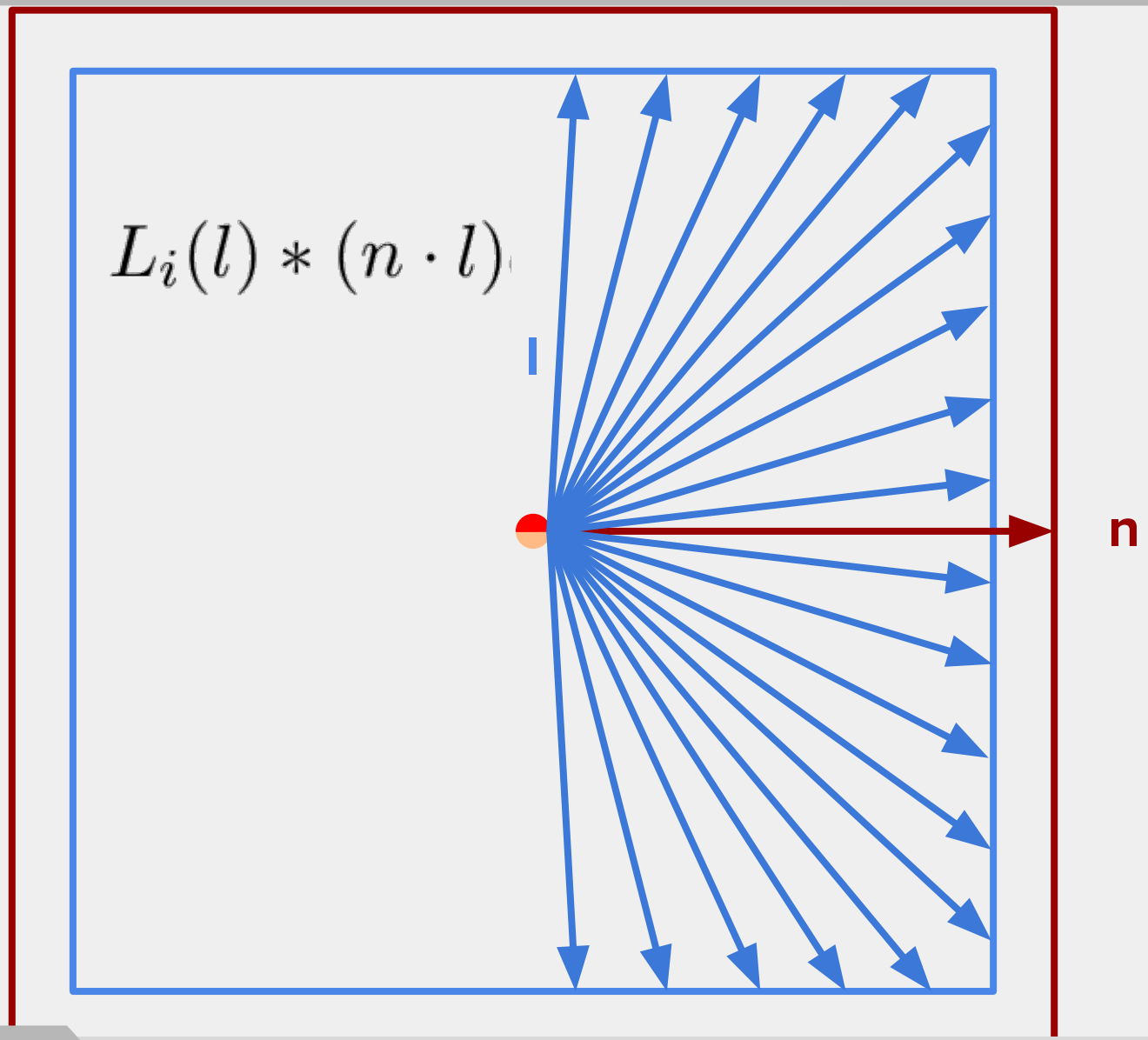
$$L_o(v) = k_d f_d \int_\Omega L_i(l) * (n \cdot l) d\omega_i$$

$$+ k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i$$

Diffuse Irradiance



Diffuse Irradiance



Diffuse Irradiance

$$L_o(v) = k_d f_d \int_\Omega L_i(l) * (n \cdot l) d\omega_i$$
$$+ k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i$$

Diffuse Irradiance

$$L_o(v) = k_d f_d \int_\Omega L_i(l) * (n \cdot l) d\omega_i$$

$$+ k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i$$

Specular IBL

$$k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i \approx$$

Specular IBL

$$k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i \approx$$

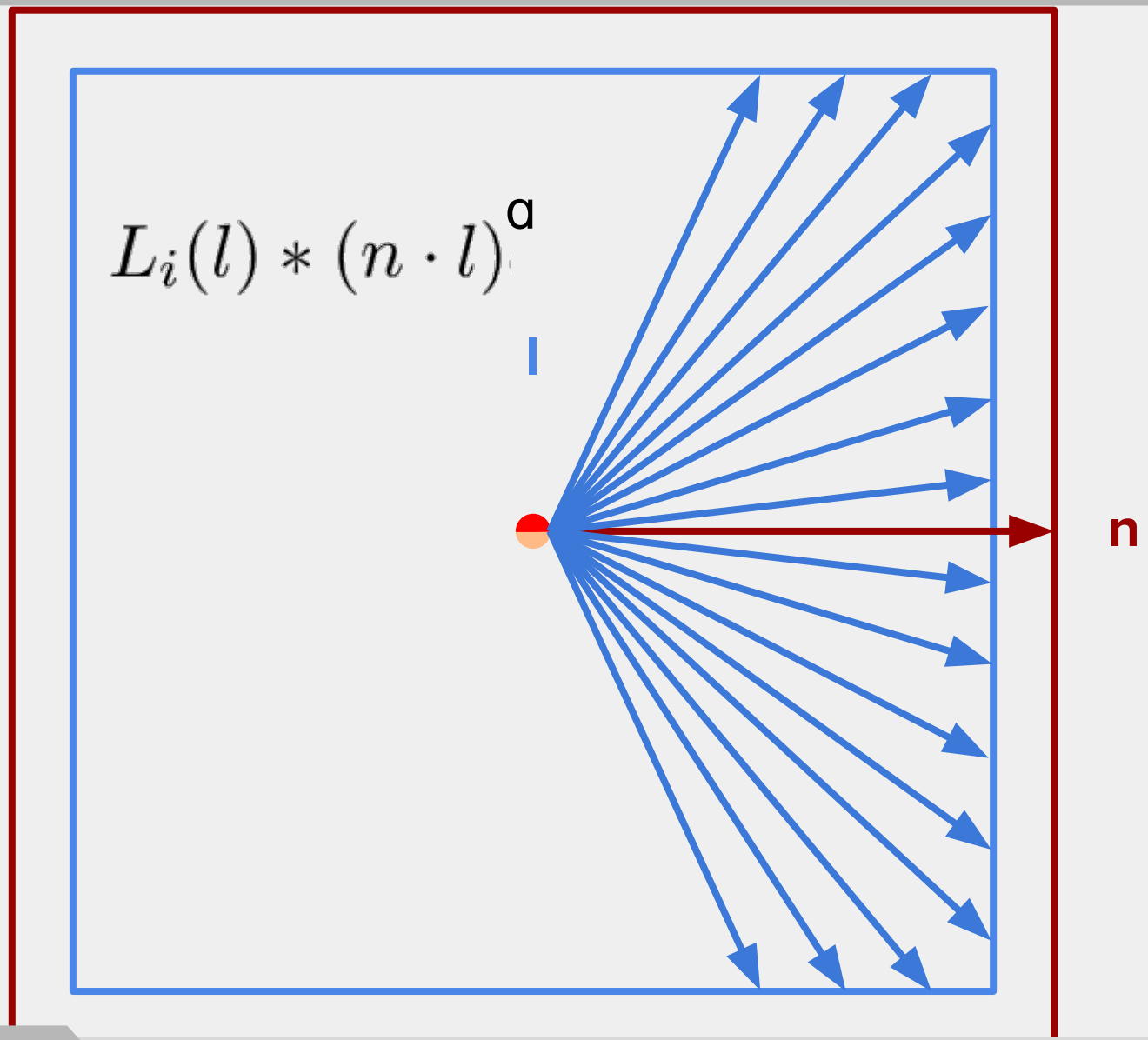
$$k_s * \frac{FG}{4(n \cdot v)(n \cdot v)} \int_\Omega D * (n \cdot l) d\omega_i$$

Specular IBL

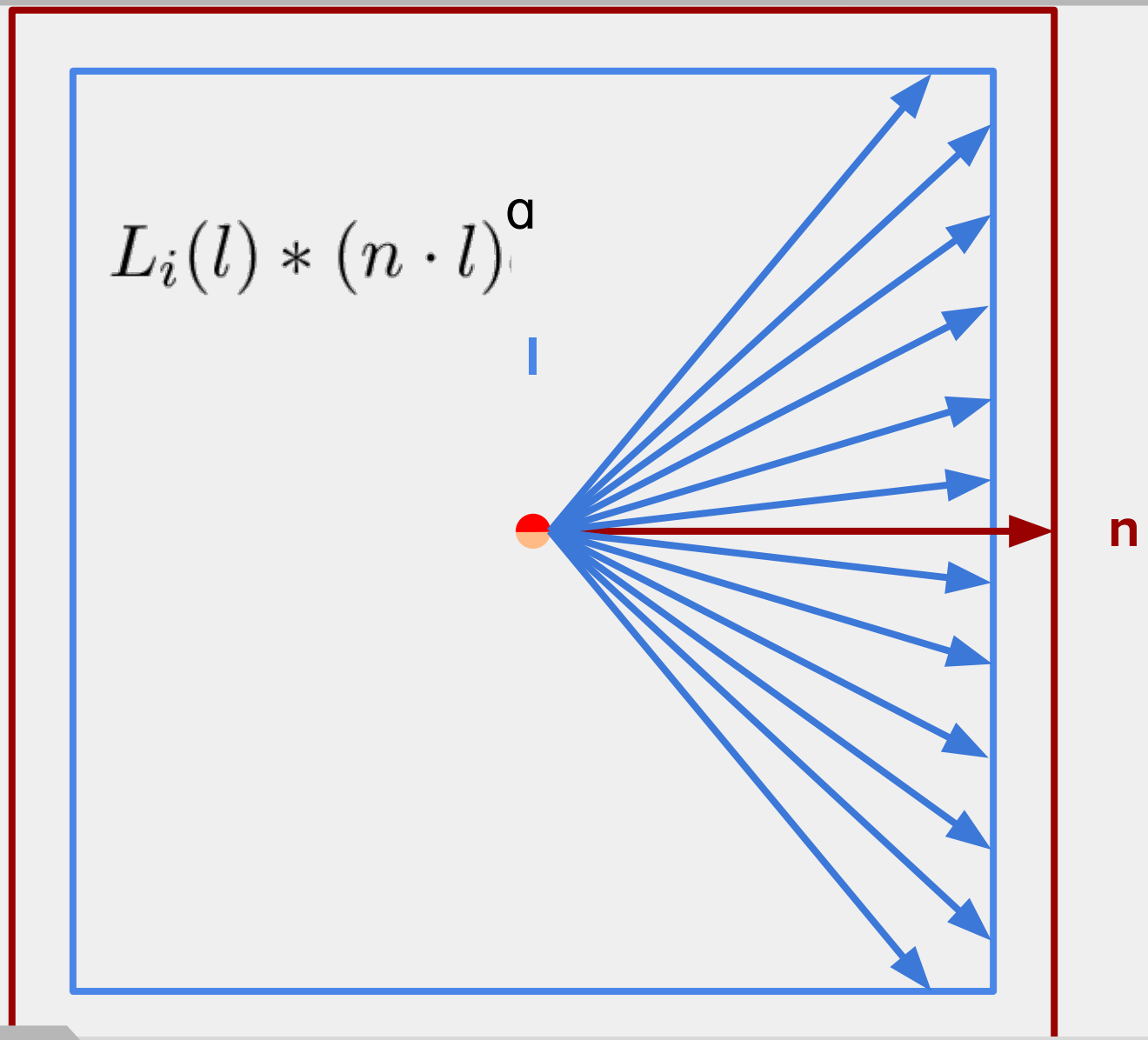
$$k_s \int_\Omega \frac{FGD}{4(n \cdot l)(n \cdot v)} L_i(l) * (n \cdot l) d\omega_i \approx$$

$$k_s * \frac{FG}{4(n \cdot v)(n \cdot v)} \int_\Omega D * (n \cdot l) d\omega_i$$

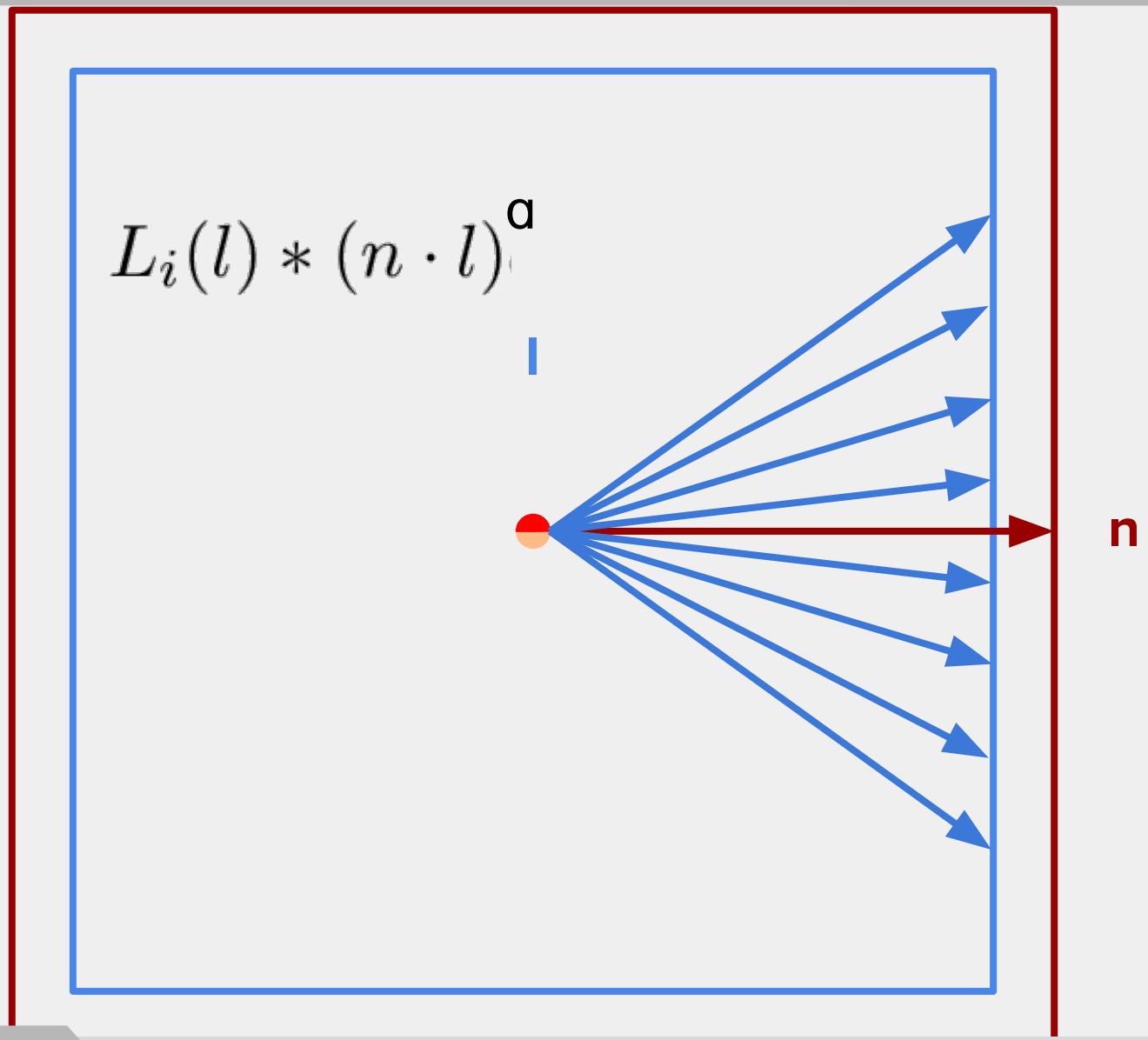
Specular IBL



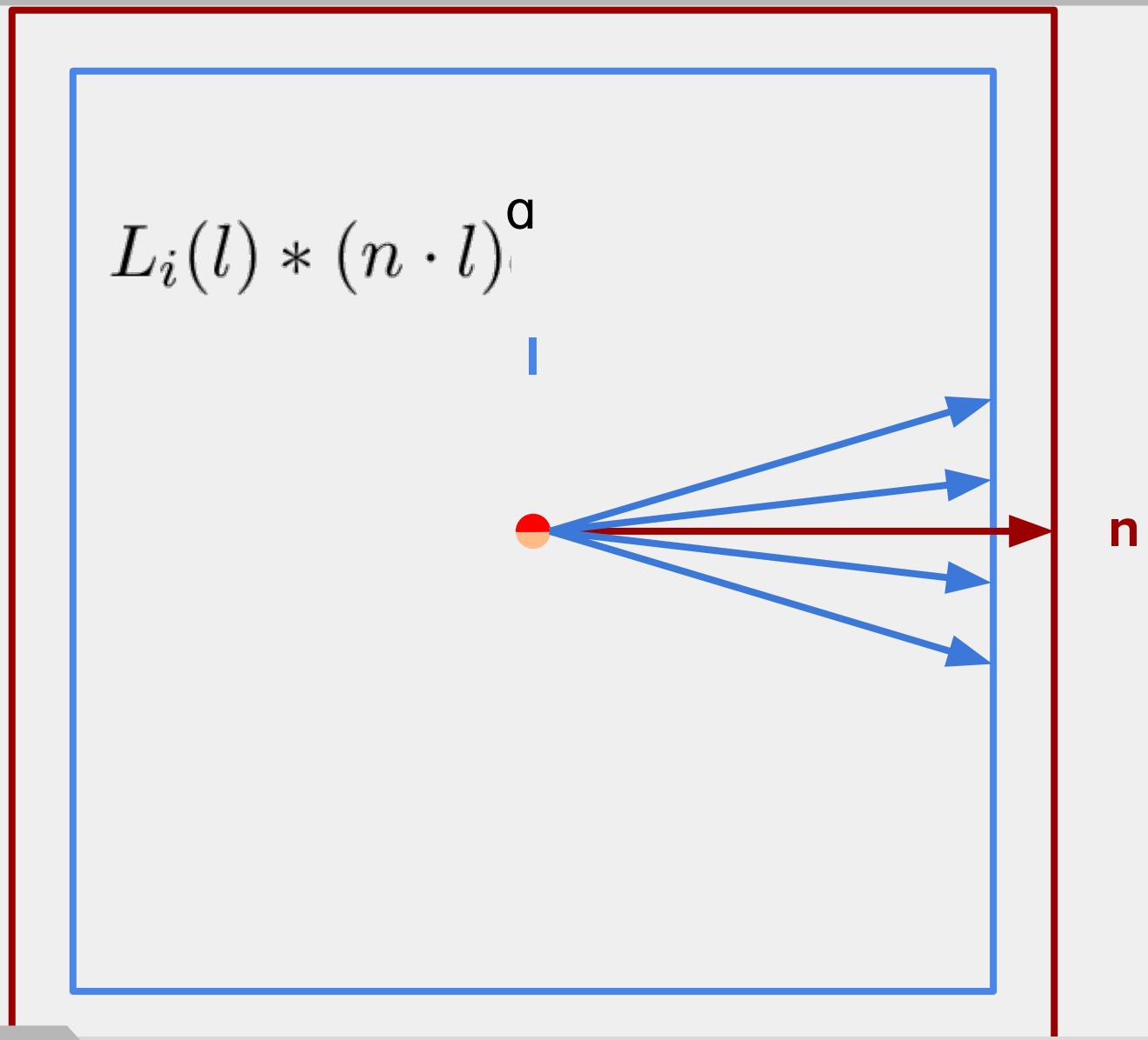
Specular IBL



Specular IBL



Specular IBL



Specular IBL

$$k_s * \frac{FG}{4(n \cdot v)(n \cdot v)} \int_{\Omega} D * (n \cdot l) d\omega_i \approx$$

Specular IBL

$$k_s * \frac{FG}{4(n \cdot v)(n \cdot v)} \int_{\Omega} D * (n \cdot l) d\omega_i \approx$$

Specular IBL

$$k_s * \frac{FG}{4(n \cdot v)(n \cdot v)} \int_\Omega D * (n \cdot l) d\omega_i \approx$$

$$k_s * FG' \int_\Omega D * (n \cdot l) d\omega_i$$

Specular IBL

$$k_s * FG' \int_{\Omega} D * (n \cdot l) d\omega_i$$

Specular IBL

$$k_s * FG' \int_{\Omega} D * (n \cdot l) d\omega_i$$

$$(F_0 + (1 - F_0)(1 - n \cdot v)^5)$$