(1) object ordered render:

```
for obj in Objects:
    find all pixels influenced by obj
    update pixes
```

] OpenGL

(2) for each pixel

```
find all the objects influencing pixel
update pixel
```

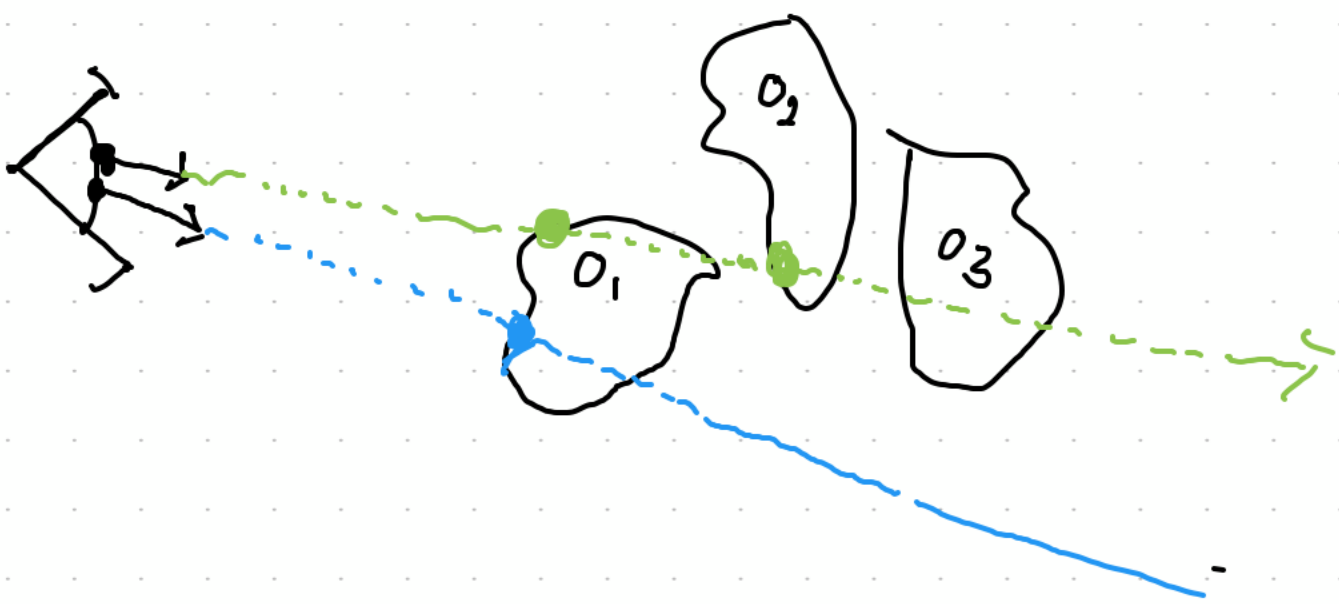
] Ray tracing

Basic Raytracing Algo

(1) ray generation:

(2) ray intersection: find closest object intersected by ray

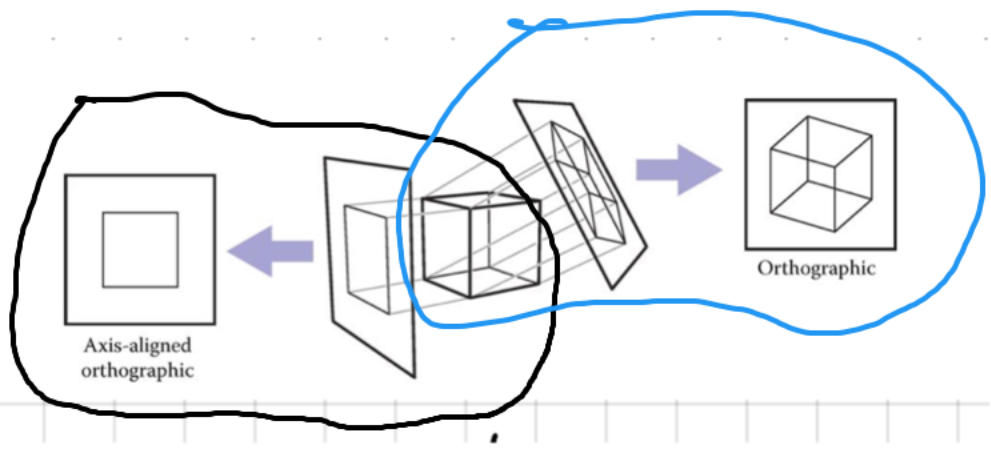
(3) shading: compute color based on ray intersection



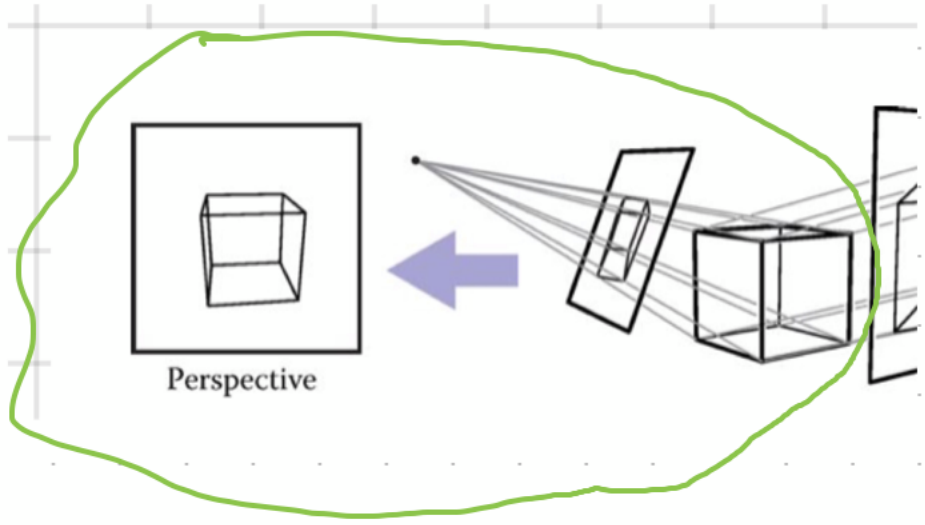
For each pixel
    compute view rays
    find "first" object hit by ray
        (find a surface normal)
    set pixel color to a value computed from
        hit point, light, normal

Projections

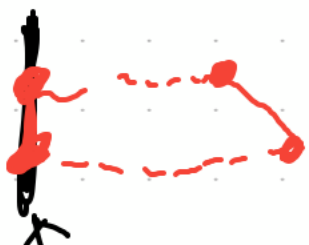
orthographic projections

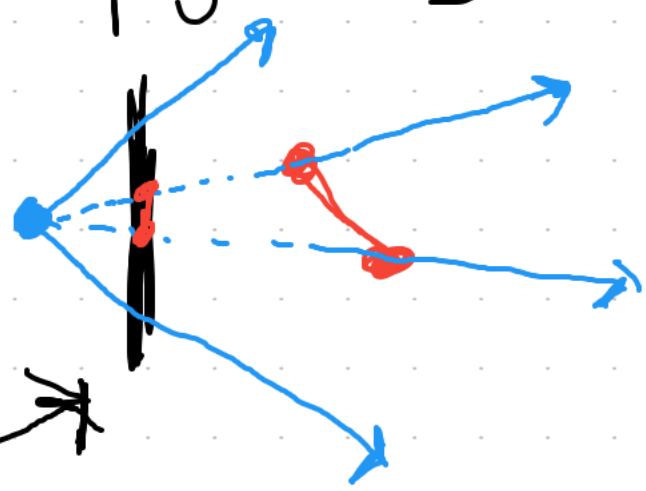


perspective projection



orthographic





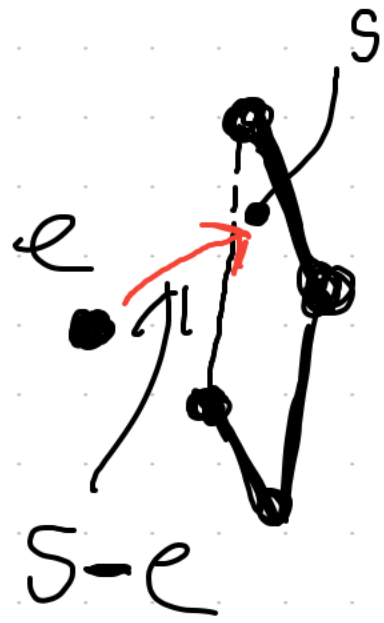
perspective projections

view plane

Computing View Rays

Ray representation

$$p(t) = e + t(s - e)$$

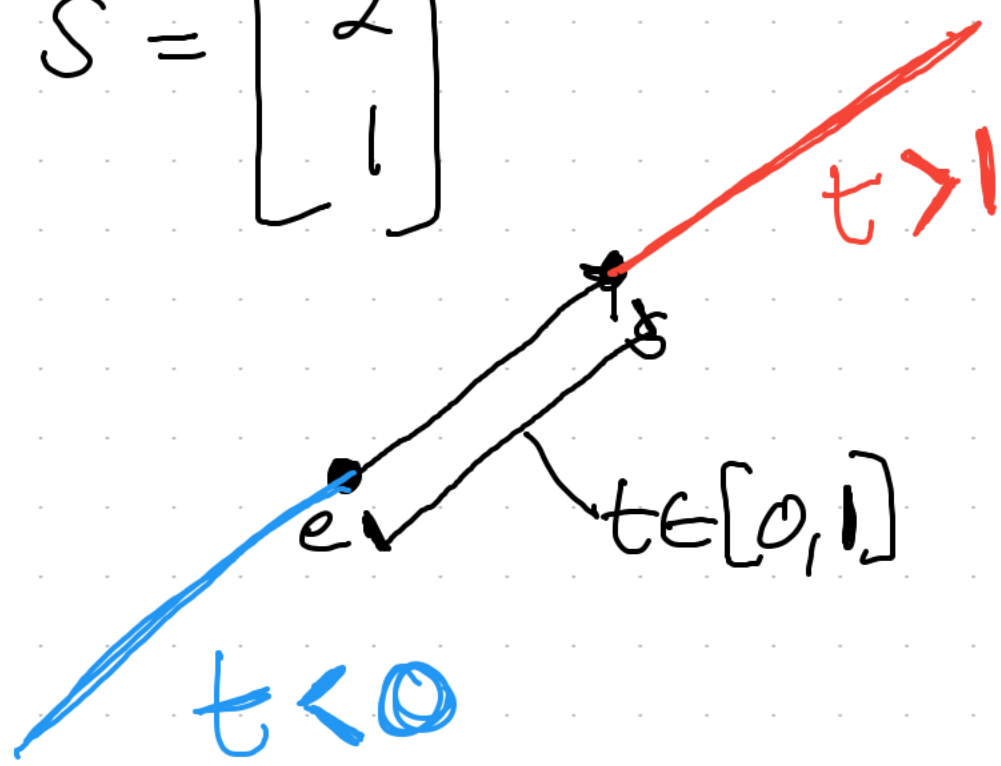


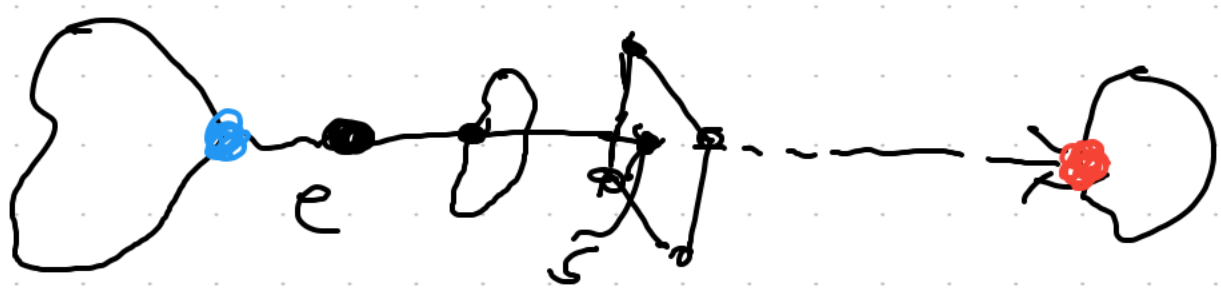
Q: $e = \begin{bmatrix} 3 \\ 2 \end{bmatrix}$ $s = \begin{bmatrix} 2 \\ 1 \end{bmatrix}$

$t \in [0, 1]$

$t < 0$

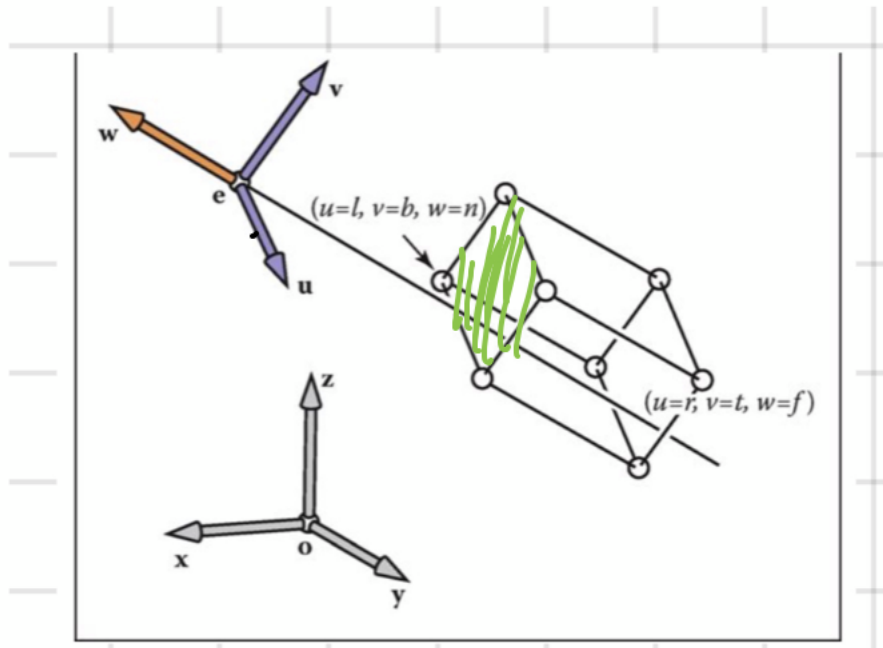
$t > 1$





How do we find s

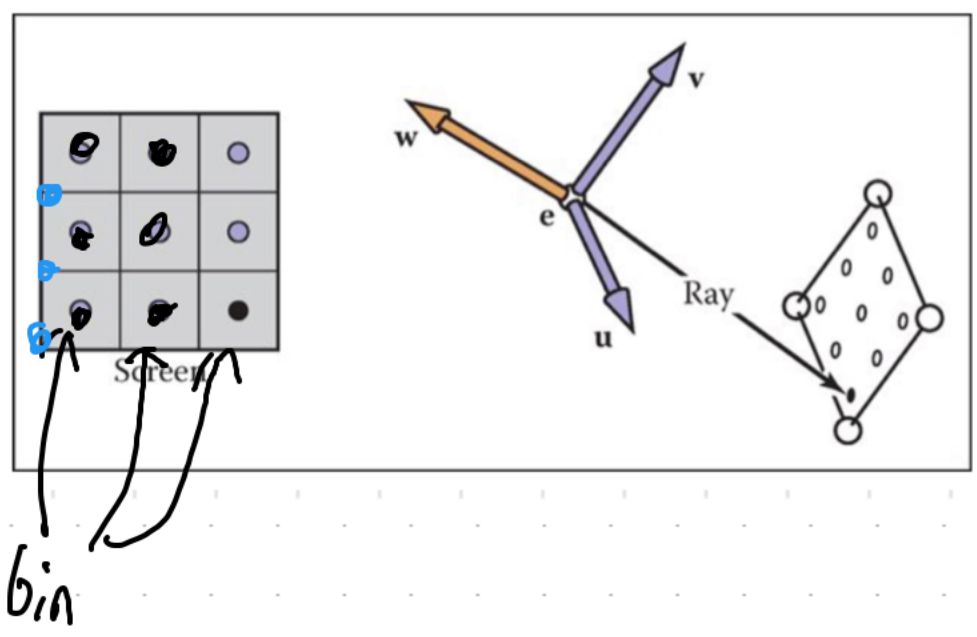
define
- e: eye position
- g: gaze direction
- t: up direction



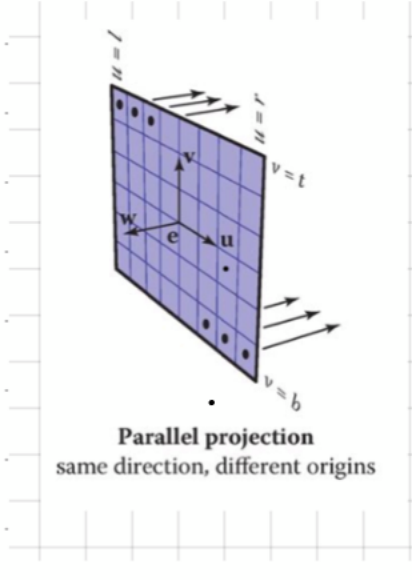
$$\vec{w} = -\frac{g}{\|g\|}$$

$$\vec{u} = \frac{t \times w}{\|t \times w\|}$$

$$\vec{v} = w \times u$$



Orthographic
wont the ray to be ⊥ the view plane
⇒ $-w$
and I get the "origin" of the ray by taking the center point in each bin



Parallel projection
same direction, different origins

Given

l: left $\quad l < 0 < r$

r: right $\quad b < 0 < t$

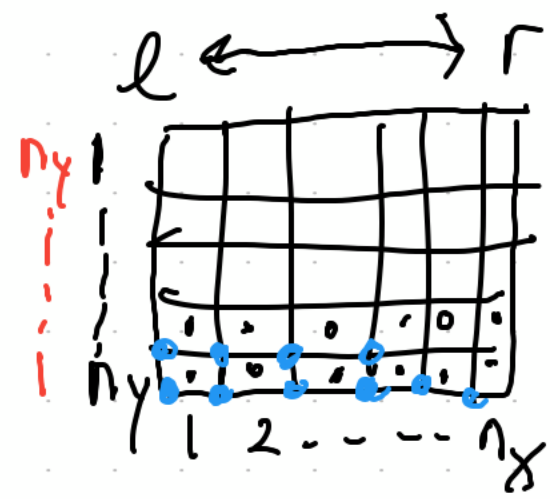
t: top

b: bottom

n_x: number of pixels in x

n_y: number of pixels in y

fit an $n_x \times n_y$ image into a rect $(r-l) \times (t-b)$



horizonal spacing: $\frac{r-l}{n_x}$

vertical spacing: $\frac{t-b}{n_y}$

w/ $\frac{1}{2}$ pixel space to Sample in the center

@ pixel (i, j) of the image we have point (u, v) on the inge plane

$$\ast \begin{cases} u = l + (r-l)(i+.5)/n_x \\ v = b + (t-b)(j+.5)/n_y \end{cases}$$

to generate ortographic view rays

Compute u, v (with $*$) — from previous page

$$ray.direction = -\vec{w}$$

$$ray.origin = e + u\vec{u} + v\vec{v}$$