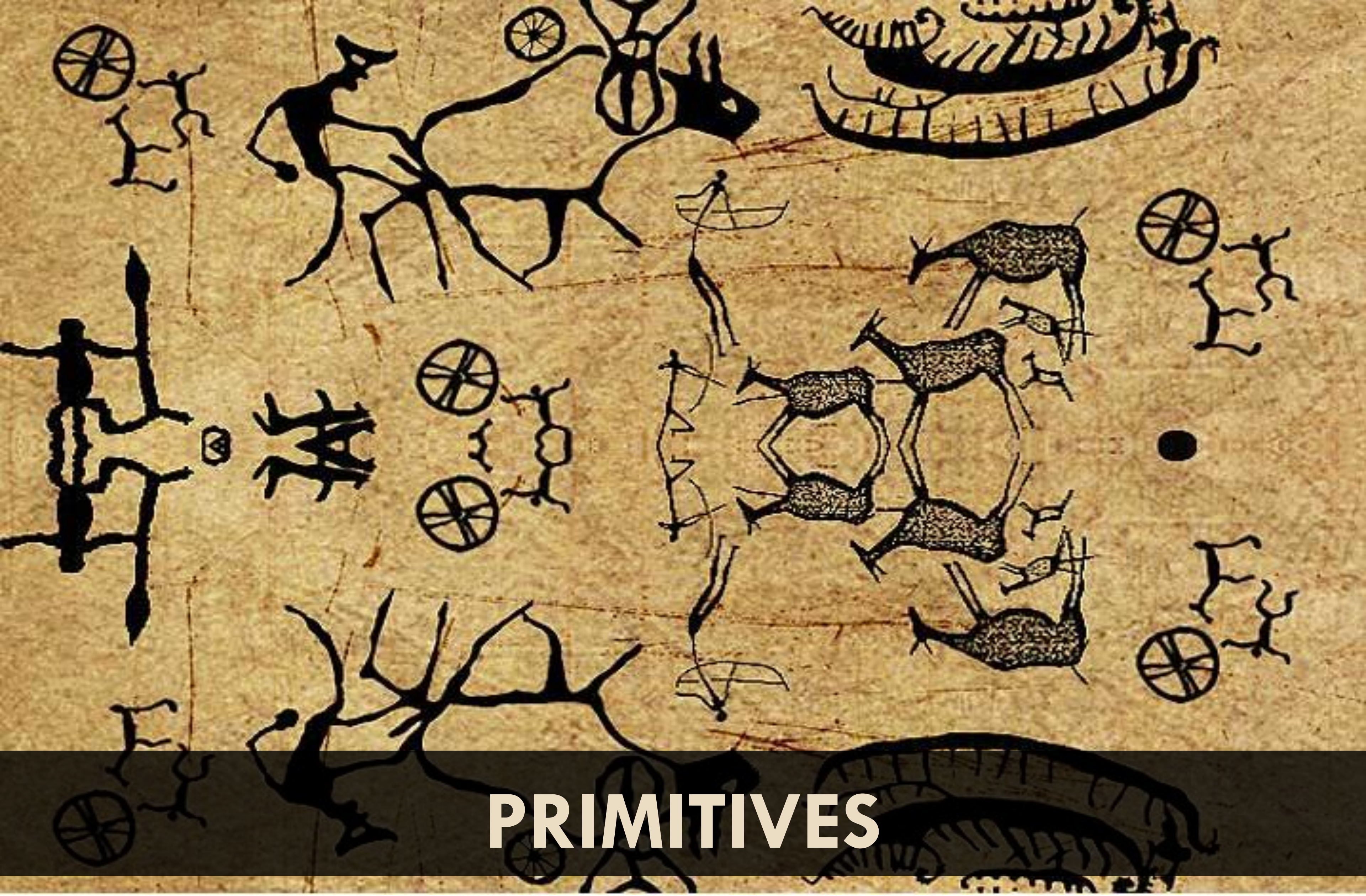


PRIMITIVES

SEMINAR 2

Computer Graphics 2

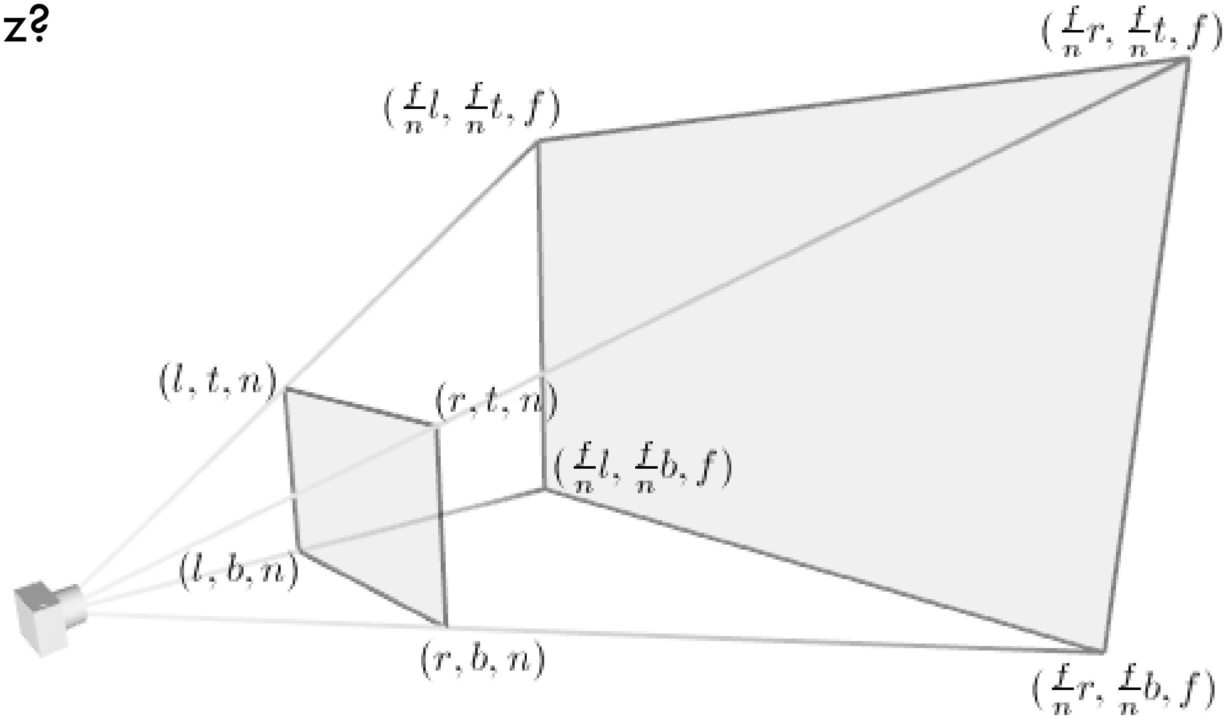
Primitive Shading

- Light source located at camera position
- Lower light intensity of distant objects
- Creates illusion of depth

```
Double intensity = MaxIntensity / ray.HitParam;
return ray.HitModel.Color * intensity;
```

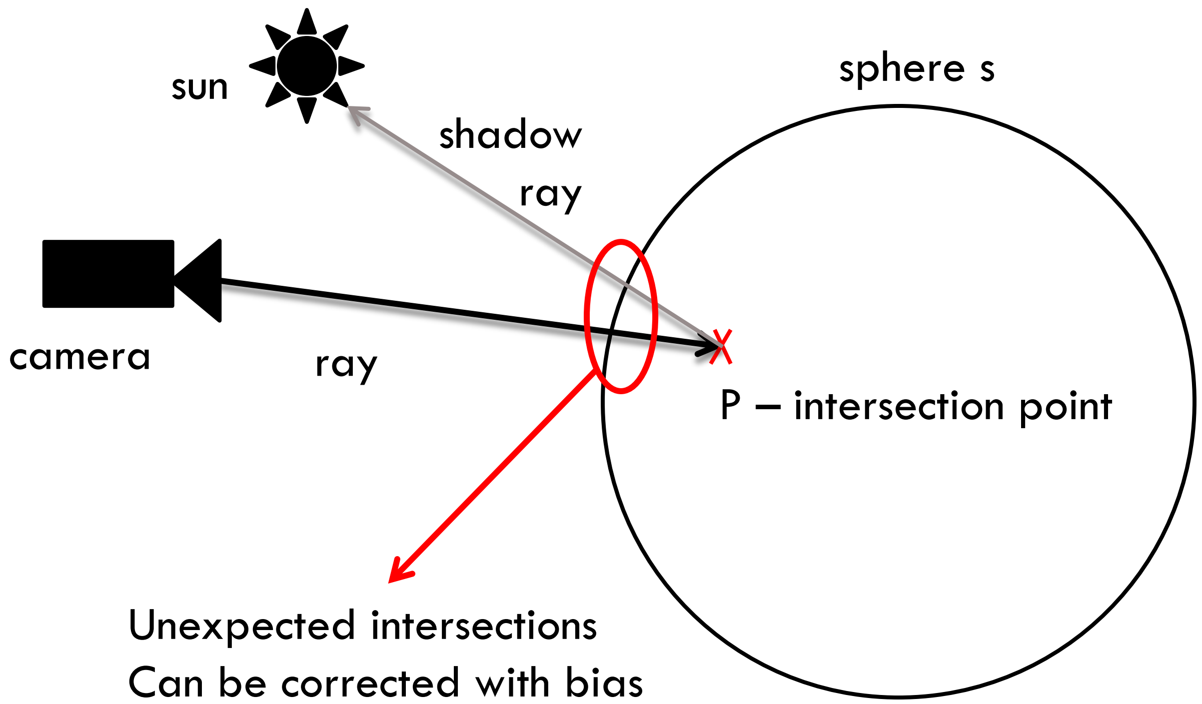
zNear & zFar

- Objects too close to camera would block all visible space
  - zNear clips objects too close
- Objects too far from camera are negligibly small
  - zFar clips invisible objects
- Why z?



Bias

- In computers: $Double \subset \mathbb{Q}$
- We use bias to correct for missing numbers
- Bias value depends on scene



AABB (Axis Aligned Bounding Box)

- Defined by two points representing minimum and maximum extend of the box B_0 and B_1
- Intersection parameter can be calculated for each axis aligned plane defining the AABB ($t_{0,x}$, $t_{1,x}$, $t_{0,y}$, $t_{1,y}$, $t_{0,z}$, $t_{1,z}$)

AABB – intersection parameters

$$r(t) = O + t\boldsymbol{r}$$

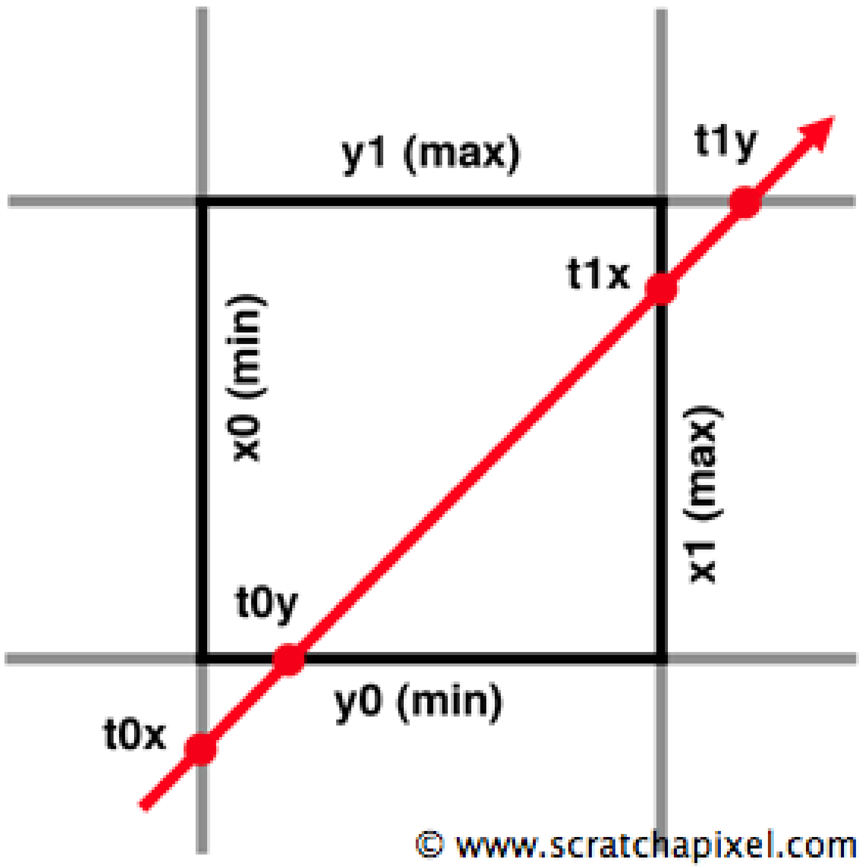
$$y = B_{0,x}$$

$$O_x + tr_x = B_{0,x}$$

$$t_{0,x} = \frac{B_{0,x} - O_x}{r_x}$$

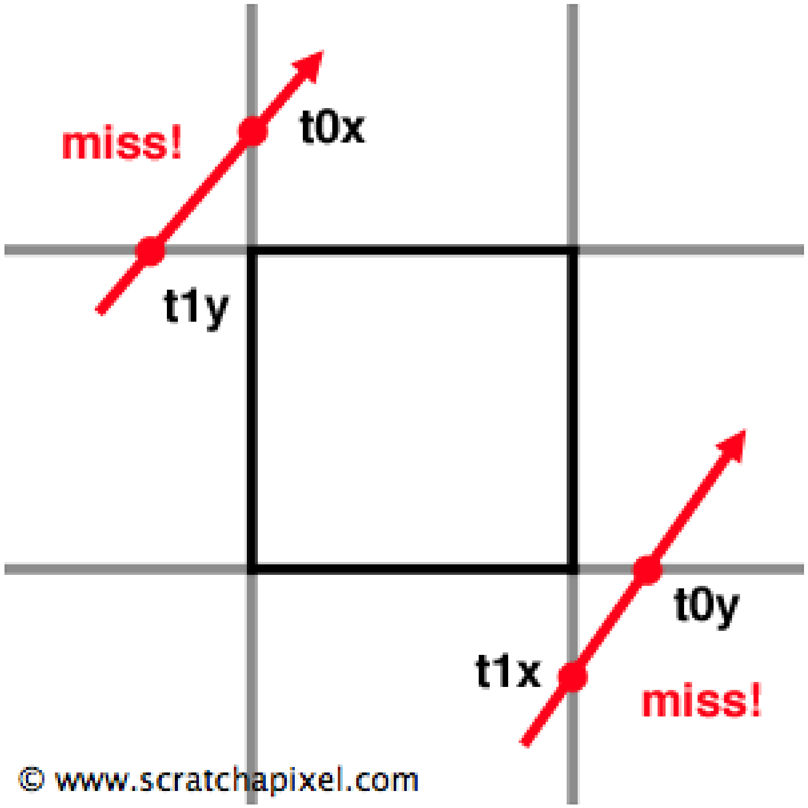
$$t_{min} = max\{t_{i,j} \mid \forall j \exists i : \forall k \; t_{i,j} \leq t_{k,j}\},$$
$$i \in \{0,1\}, k \in \{0,1\}, j \in \{x,y,z\}$$

$$t_{max} = min\{t_{i,j} \mid \forall j \exists i : \forall k \; t_{i,j} \geq t_{k,j}\},$$
$$i \in \{0,1\}, k \in \{0,1\}, j \in \{x,y,z\}$$



AABB checking for intersection

- Intersection actually occurs iff. $t_{min} \leq t_{max}$
- Resulting hit parameter is t_{min}



Sphere

$$\|X - C\|^2 - R^2 = 0$$

- Defined by center point C and radius R
- Intersection point can be solved analytically or geometrically

Sphere – Geometric Solution

$t_0 = t_{ca} - t_{hc}$ $\quad t_1 = t_{ca} + t_{hc}$

$P = O + t_0\boldsymbol{r}$ $\quad P' = O + t_1\boldsymbol{r}$

$\mathbf{L} = C - O$ $\quad t_{ca} = \boldsymbol{L} \cdot \boldsymbol{r}$

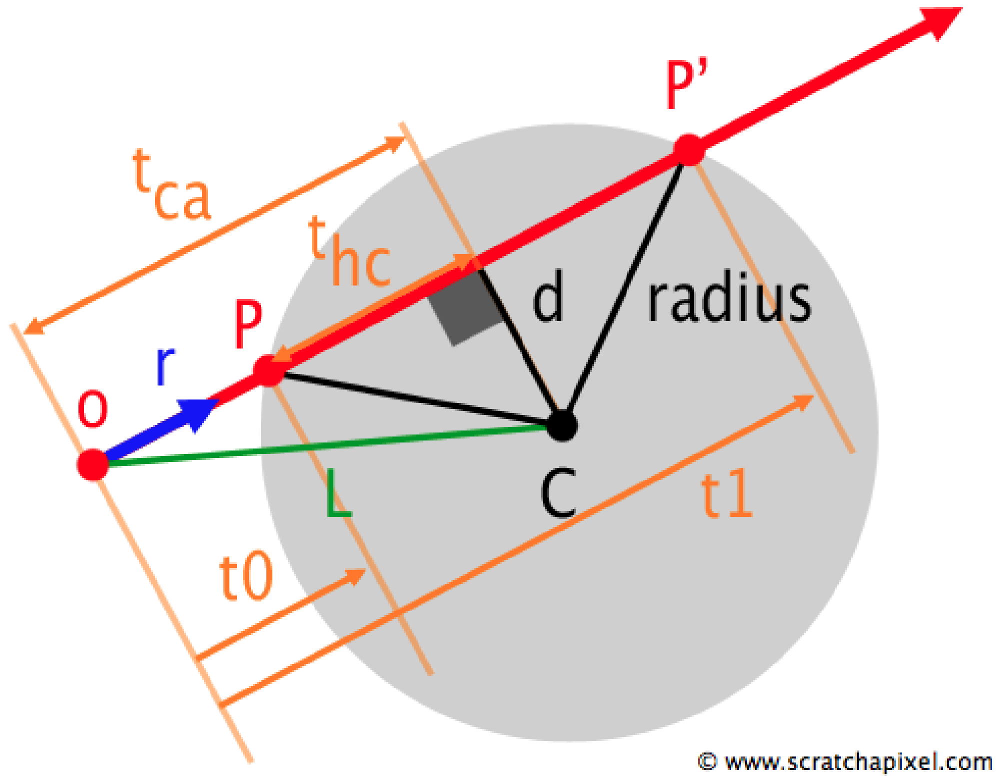
t_{ca} should be greater than zero.
What does $\boldsymbol{L} \cdot \boldsymbol{r}$ represent?
Using Pythagorean theorem:

$$d^2 + t_{ca}^2 = \boldsymbol{L}^2$$

$$d = \sqrt{\boldsymbol{L}^2 - t_{ca}^2}, 0 \leq d \leq R$$

$$d^2 + t_{hc}^2 = R^2$$

$$t_{hc}^2 = \sqrt{\boldsymbol{R}^2 - d^2}$$



Sphere – Analytical Solution

$$\|X - C\|^2 - R^2 = 0$$

$$\|O + t\boldsymbol{r} - C\|^2 - R^2 = 0$$

$$t^2(\boldsymbol{r} \cdot \boldsymbol{r}) + 2t\big(\boldsymbol{r} \cdot (O - C)\big) + (O - C)^2 - R^2 = 0$$

$$t^2 + 2t\big(\boldsymbol{r} \cdot (O - C)\big) + (O - C)^2 - R^2 = 0$$

$$at^2 + bt + c = 0$$

where:

$$a = 1$$

$$b = 2t\big(\boldsymbol{r} \cdot (O - C)\big)$$

$$c = (O - C)^2 - R^2$$

Ring

- Defined with origin C, normal **n** and radius R
- Same computation as ray-plane intersection
- After computing intersection parameter t we should check if $\|(O + t\boldsymbol{r}) - C\| \leq R$

Triangle

- Defined by three points A, B, C
- Intersection can be found using barycentric coordinates

$$\mathrm{P}(u, v) = (1 - u - v) * A + u * B + v * C$$

where: $\mathrm{u} > 0$

$\mathrm{v} > 0$

$\mathrm{u} + \mathrm{v} \leq 1$

If ray intersects triangle they have a common point:

$$O + t\boldsymbol{r} = (1 - u - v) * A + u * B + v * C$$

Questions?