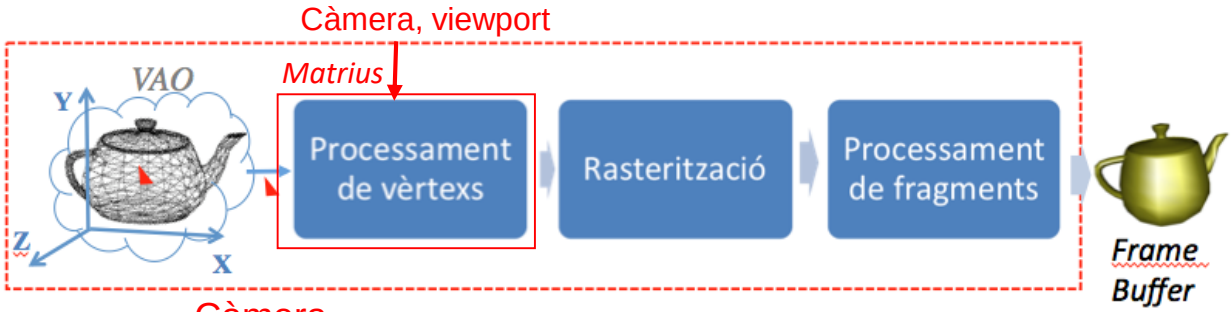
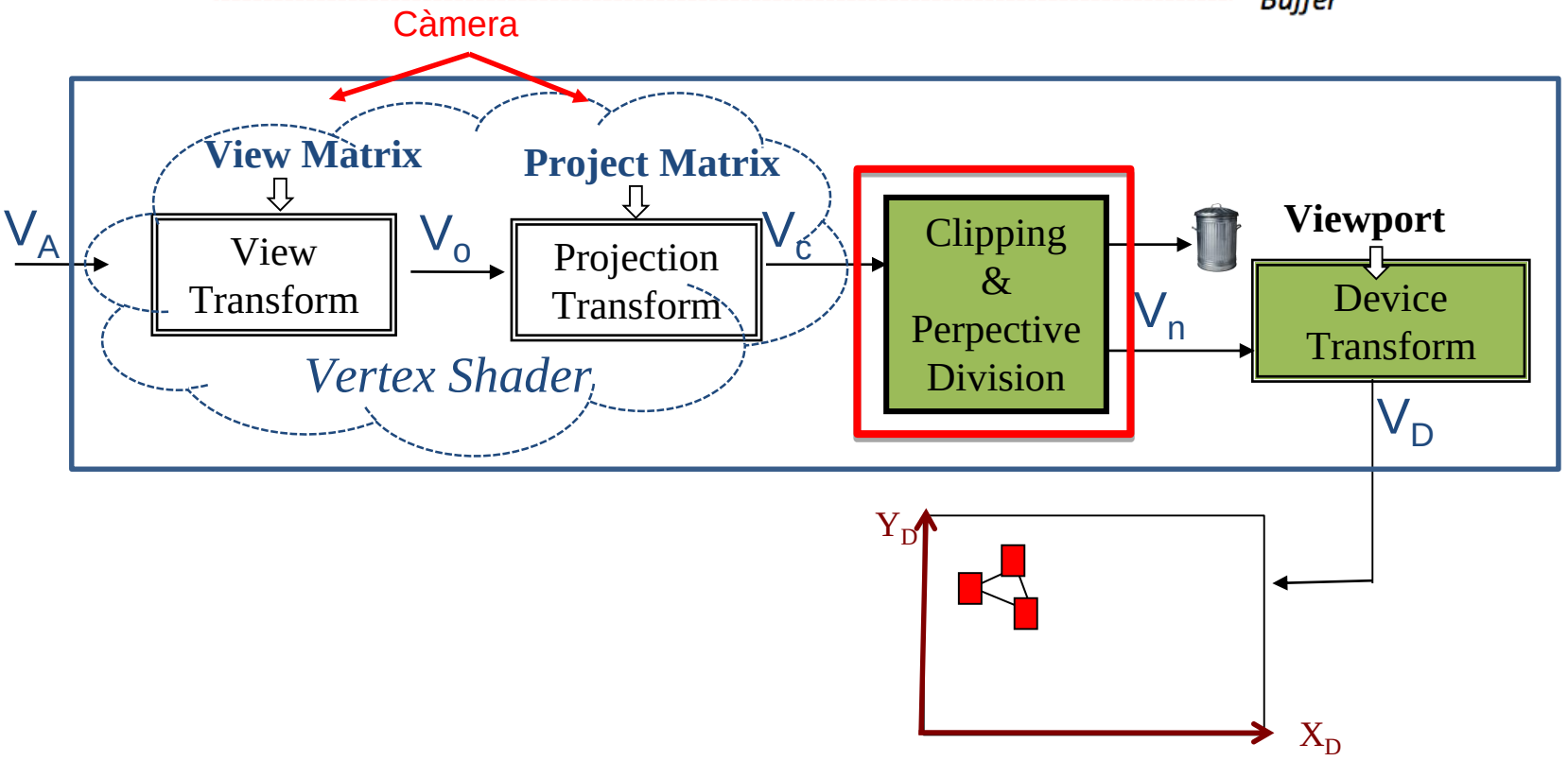
Classe 4: Procés de Visualització

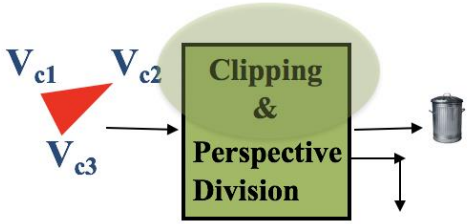
- **Processament dels vèrtexs**
  - **Retallat**
  - **Divisió perspectiva**
  - **Pas a coordenades de dispositiu**
- Rasterització
- Processament dels fragments: el fragment shader

Processament de vèrtexs





Clipping

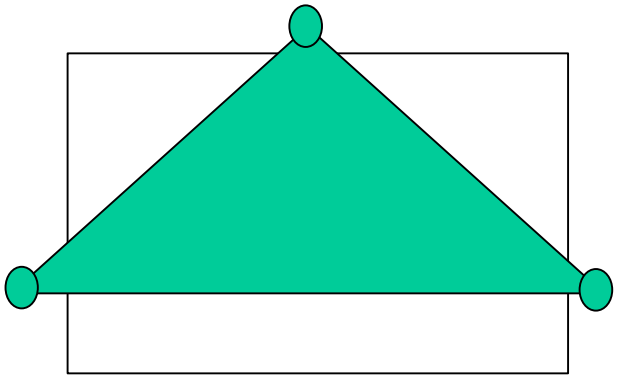


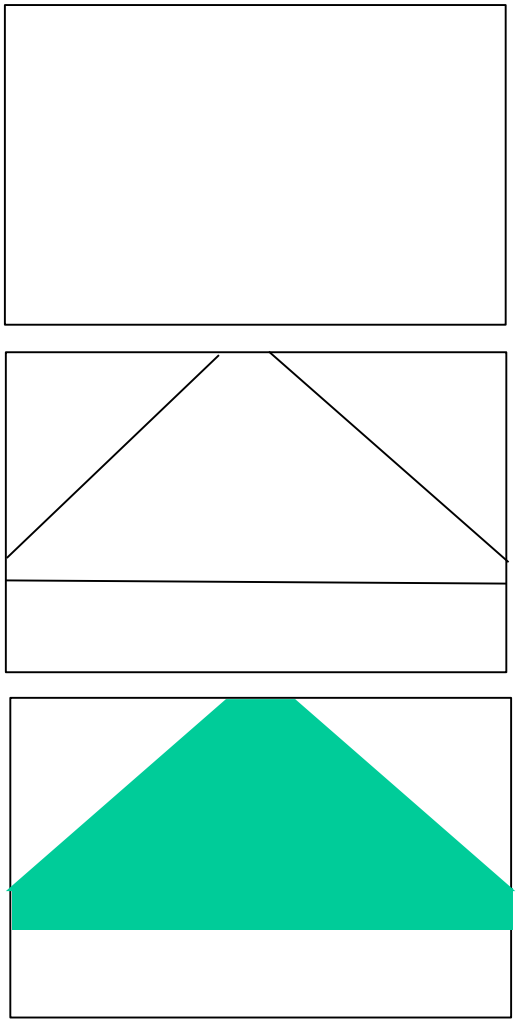
Condició per a que un Vèrtex sigui interior al volum de visió:

$$-w_c \leq x_c \leq w_c$$
$$-w_c \leq y_c \leq w_c$$
$$-w_c \leq z_c \leq w_c$$

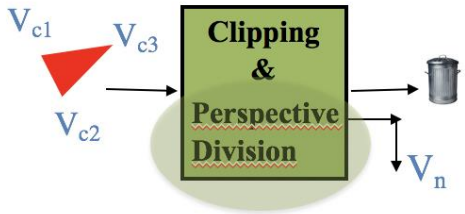
$V_c = (x_c, y_c, z_c, w_c)$ on $w_c = 1$ en ortogonal

$V_c = (x_c, y_c, z_c, w_c)$ on $w_c = -z_o$ en perspectiva





Projecció: Ortogonal



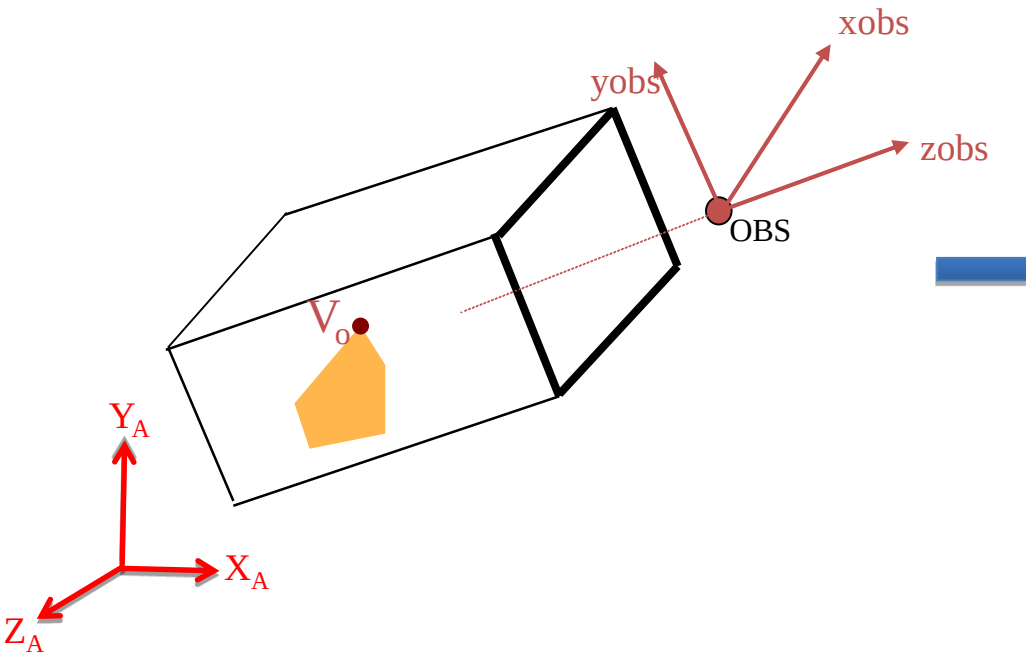
$$PM = \begin{pmatrix} a & 0 & 0 & e \\ 0 & b & 0 & f \\ 0 & 0 & c & d \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

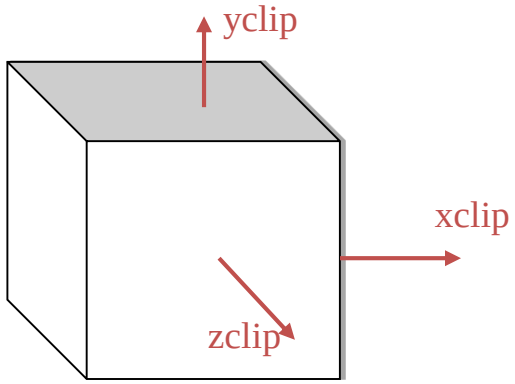
$a = 2/(r-l)$ $\quad e = (r+l)/(r-l)$

$b = 2/(t-b)$ $\quad f = (t+b)/(t-b)$

$c = 2/(zf-zn)$ $\quad d = (zn+zf)/(zf-zn)$

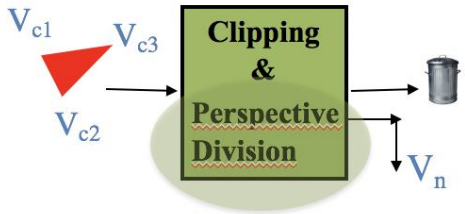
$$V_c = (x_c, y_c, z_c, w_c) \text{ on } w_c = 1$$

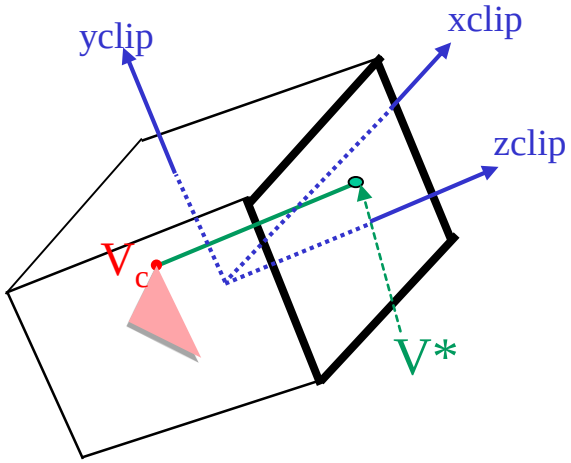




$$-1 \le x_c \le 1$$
$$-1 \le y_c \le 1$$
$$-1 \le z_c \le 1$$

Projecció: Ortogonal





$V_c = (x_c, y_c, z_c, w_c)$ on $w_c = 1$

$$-1 \leq x_c \leq 1$$
$$-1 \leq y_c \leq 1$$
$$-1 \leq z_c \leq 1$$

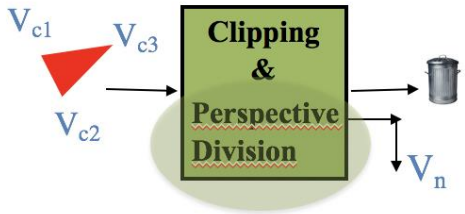
Vèrtex projectat:
$V_x^* = V_{cx}$ $V_y^* = V_{cy}$

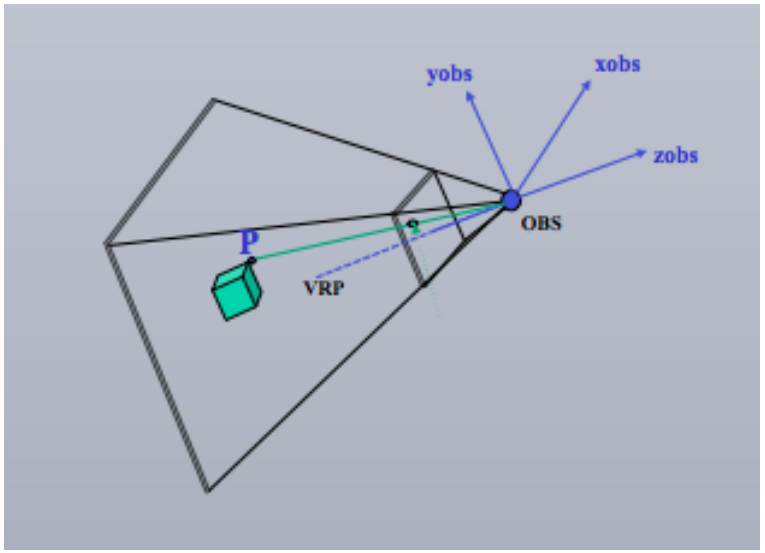
$$\mathbf{V^* = V_c / w_c = V_n}$$

$$\mathbf{-1 \leq x_n \leq 1}$$
$$\mathbf{-1 \leq y_n \leq 1}$$
$$\mathbf{-1 \leq z_n \leq 1}$$

V_z^* per càlculs posteriors i indica distància a window

Projecció: Perspectiva





$$PM = \begin{pmatrix} 1/ra*a & 0 & 0 & 0 \\ 0 & 1/a & 0 & 0 \\ 0 & 0 & c & d \\ 0 & 0 & -1 & 0 \end{pmatrix}$$

$a = tg\ (FOV/2)$

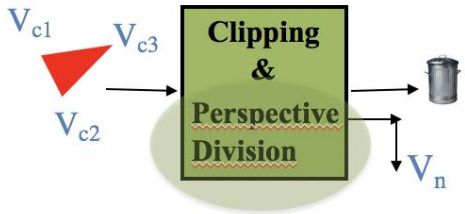
$c = (zf+zn)/(zn-zf)$

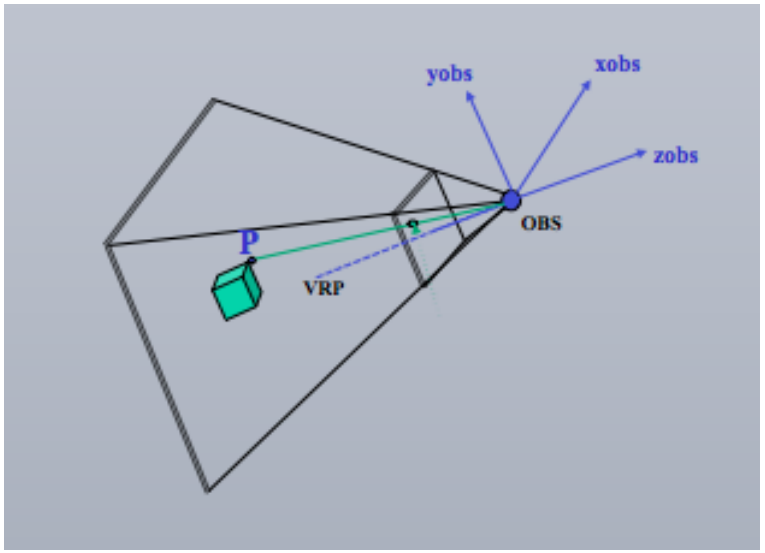
$d = 2*zn*zf/(zn-zf)$

$V_c = (x_c, y_c, z_c, w_c)$ on $w_c = -z_o$

$$-w_c \leq x_c \leq w_c$$
$$-w_c \leq y_c \leq w_c$$
$$-w_c \leq z_c \leq w_c$$

Projecció: Perspectiva



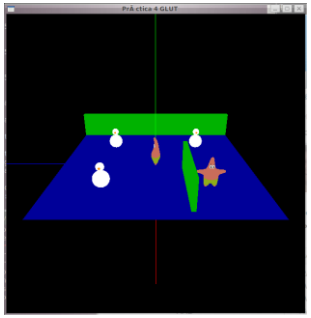


Vèrtex projectat:

$V^*=V_c/w_c = -V_c/z_o$

$x^* = -x_c/z_o \quad y^*=-y_c/z_o \quad z^*=-z_c/z_o$

Inversament proporcional a distància a observador ☺

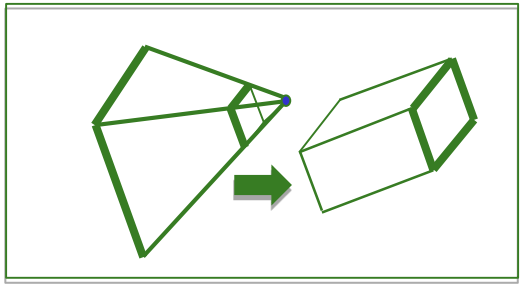


$V_c = (x_c,y_c,z_c,w_c)$ on $w_c=-z_o$

$-w_c \leq x_c \leq w_c$

$-w_c \leq y_c \leq w_c$

$-w_c \leq z_c \leq w_c$



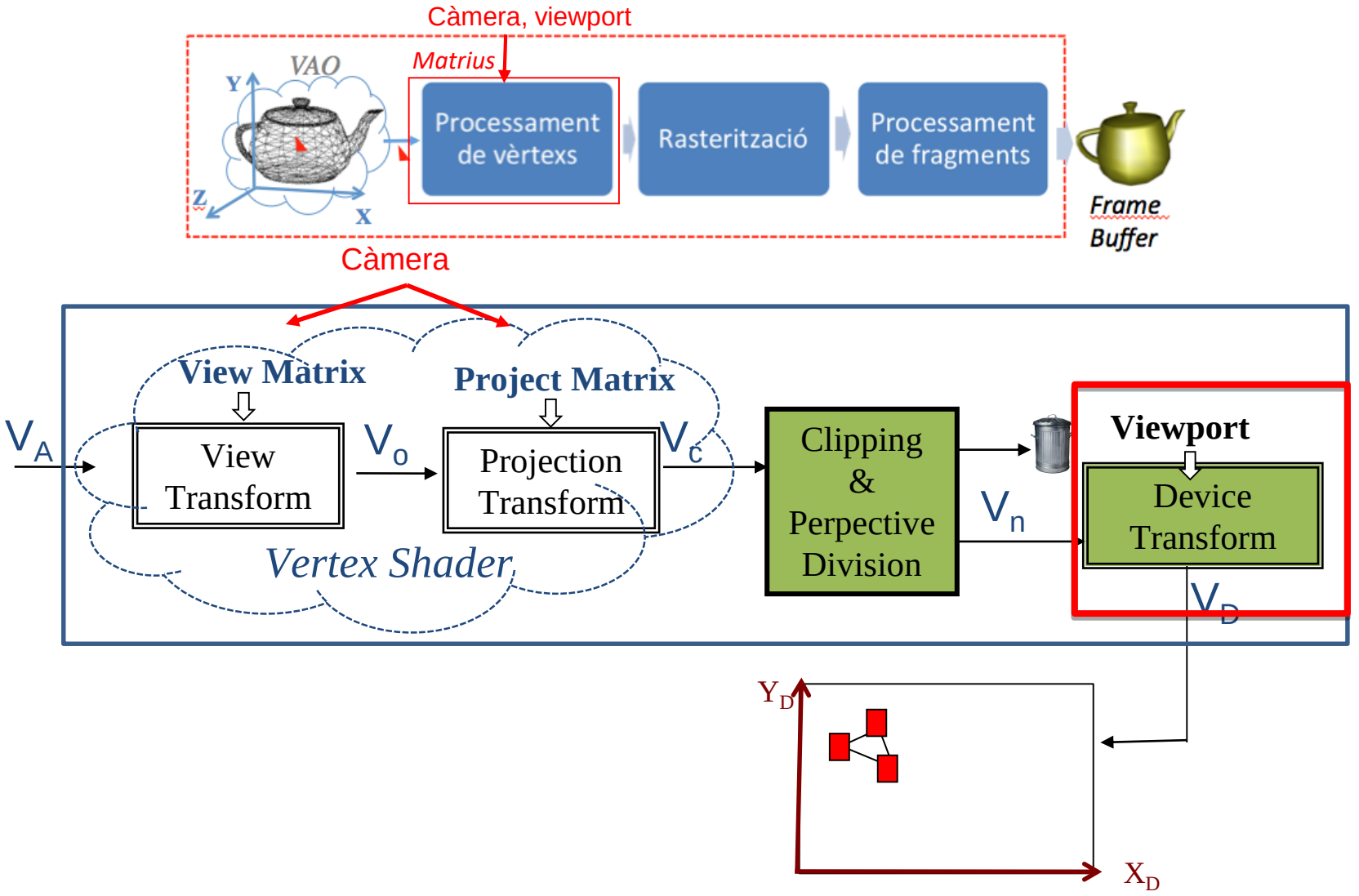
$-1 \leq x_n \leq 1$

$-1 \leq y_n \leq 1$

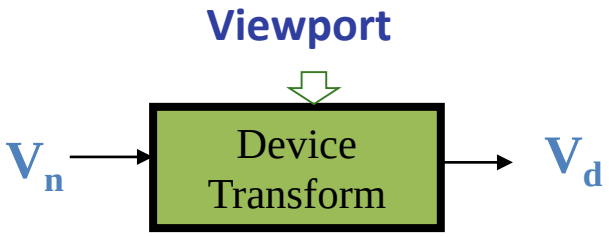
$-1 \leq z_n \leq 1$

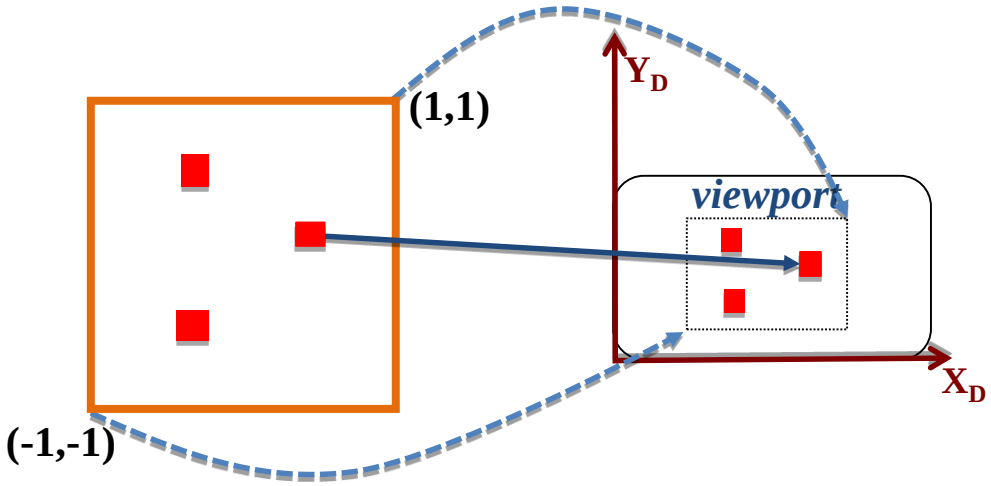
$V^*=V_c/w_c \rightarrow V_n$

Transformació a coordenades de dispositiu



Transformació a coordenades de dispositiu

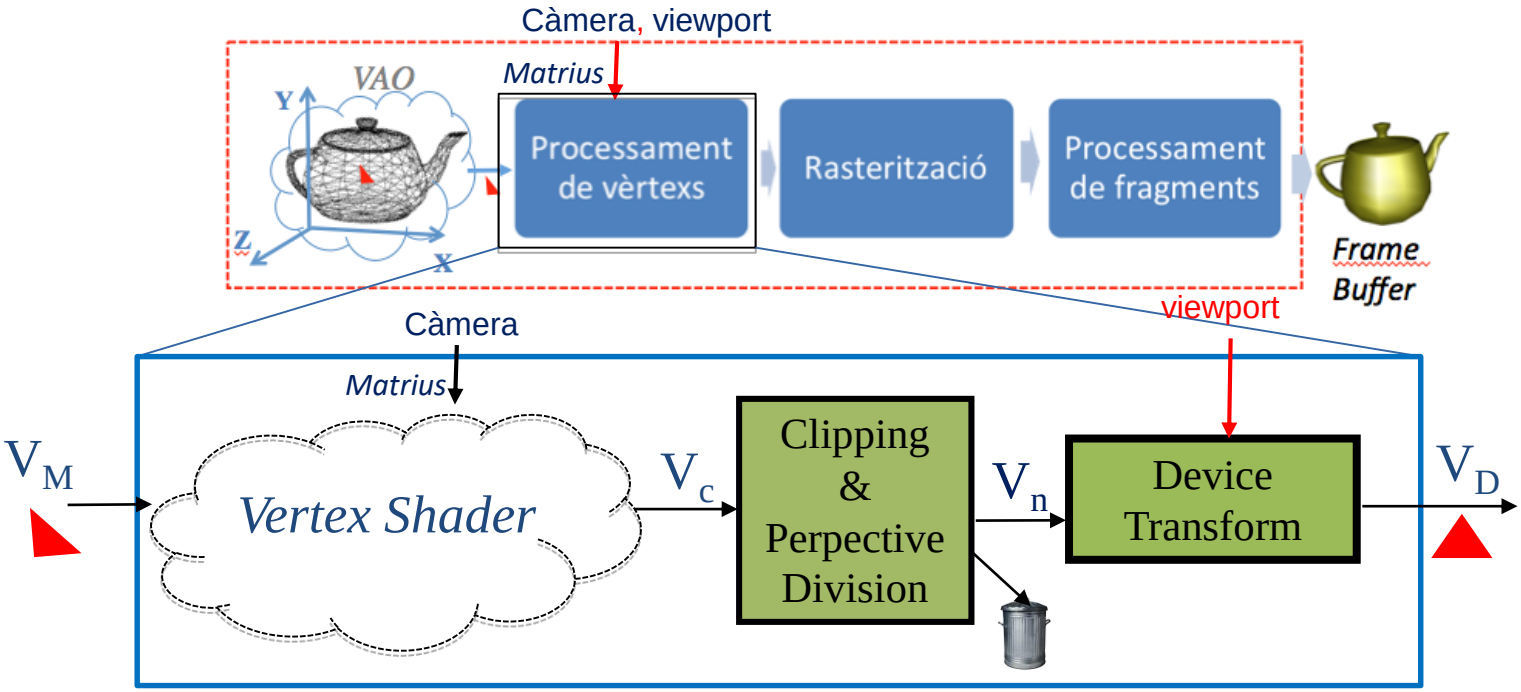




Depth range transformation

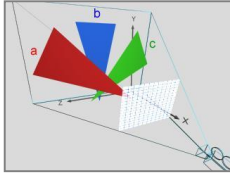
- Vn.z [-1,1] → [0,1], per defecte.

Processament de vèrtexs: resum

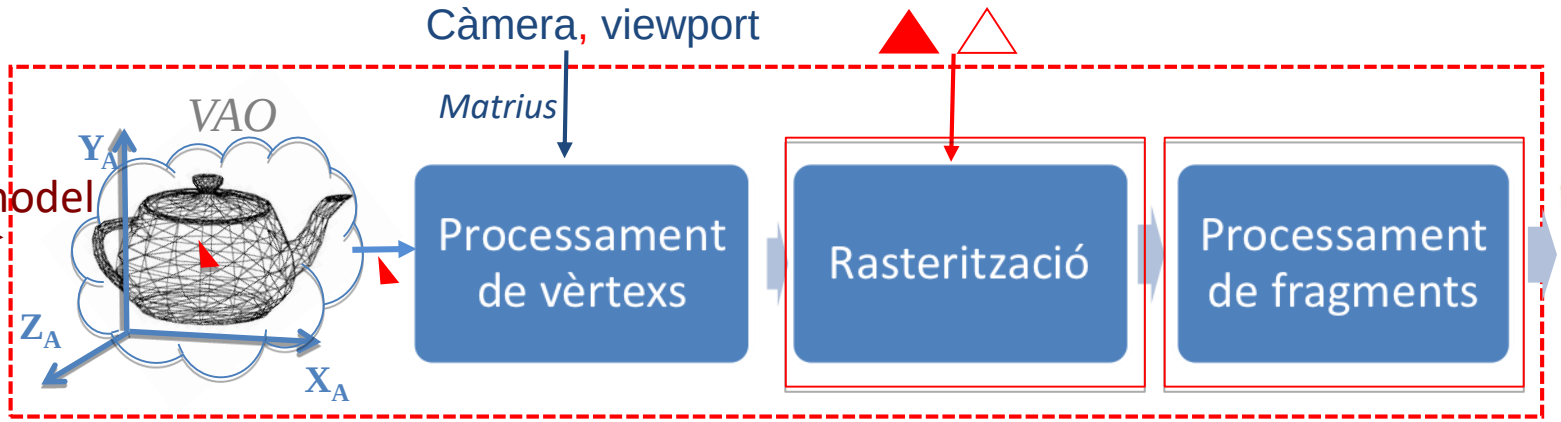


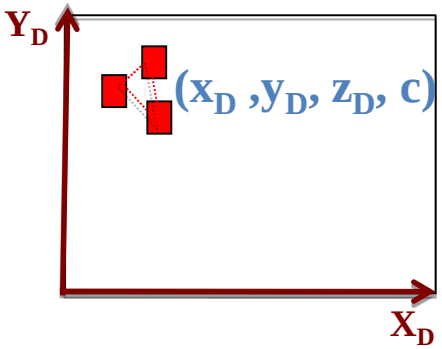
Classe 4: Procés de Visualització

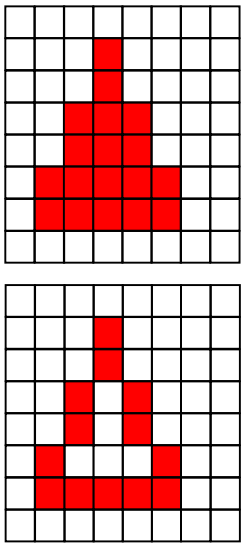
- Processament dels vèrtexs
  - Retallat
  - Divisió perspectiva
  - Pas a coordenades de dispositiu
- **Rasterització**
- **Processament dels fragments: el fragment shader**



Procés de visualització

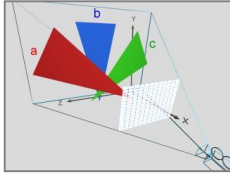




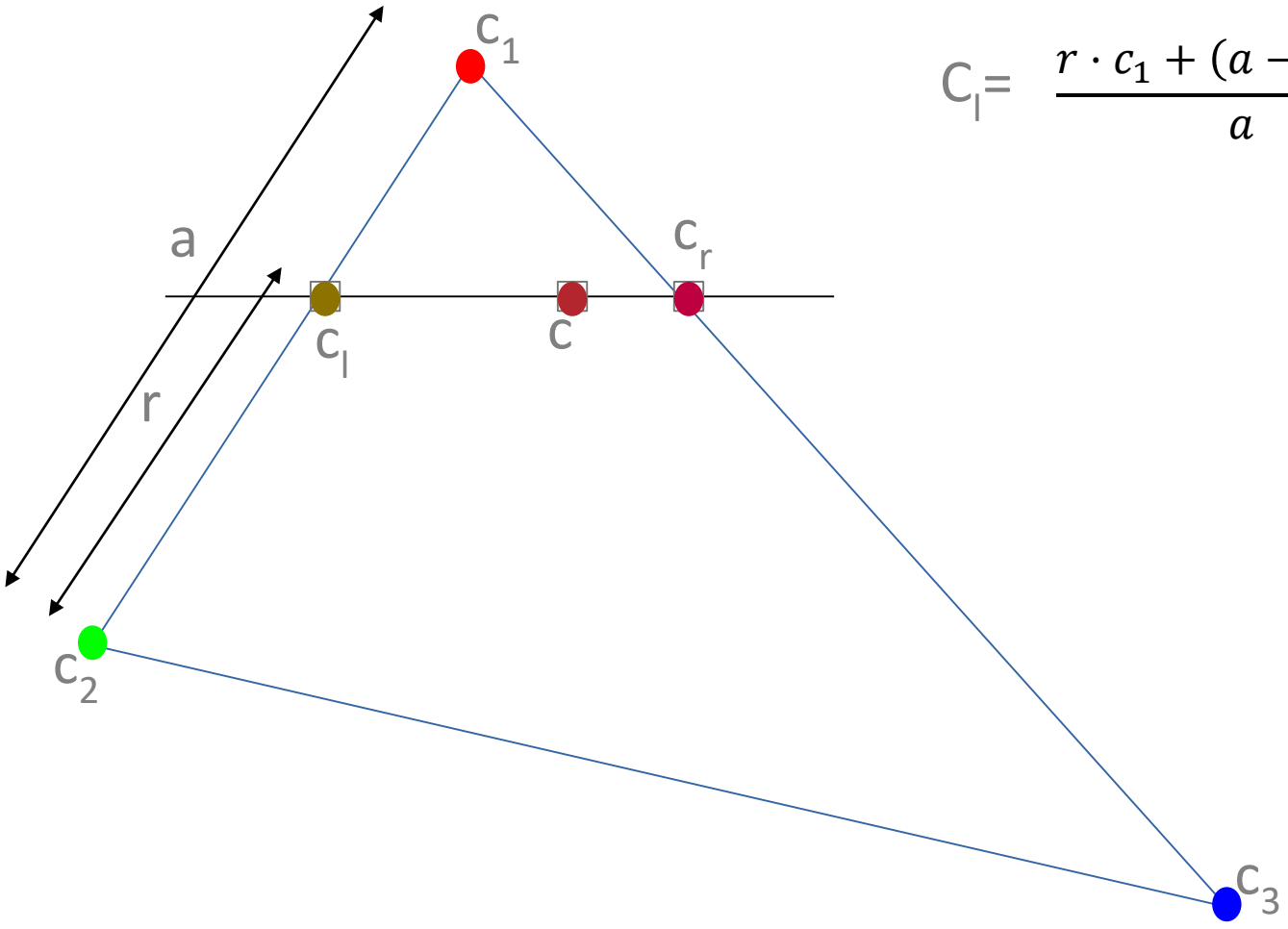


píxel(x,y,c)

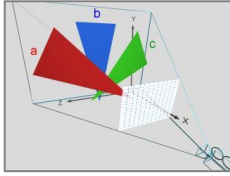
Fragments: $\{(x_D, y_D, z_D, c)_f\}$



Rasterització: interpolació



$$C_l = \frac{r \cdot c_1 + (a - r) \cdot c_2}{a}$$



Processament de fragments

Càmera, viewport

Matrius

VAO

Processament de vèrtexs

Rasterització

Processament de fragments

Frame Buffer

Càmera

Matrius

viewport

V_A

Vertex Shader

V_C

Clipping & Perpective Division

Device Transform

V_D

Rasterització

Frame Buffer

píxel(x,y,c)

EPA: Z_buffer

$\{(x_D, y_D, z_D, c)_f\}$

Fragment Shader

$\{(x_D, y_D, z_D)_f + \ldots\}$

Processament de fragments: El fragment Shader

Fragment Shader

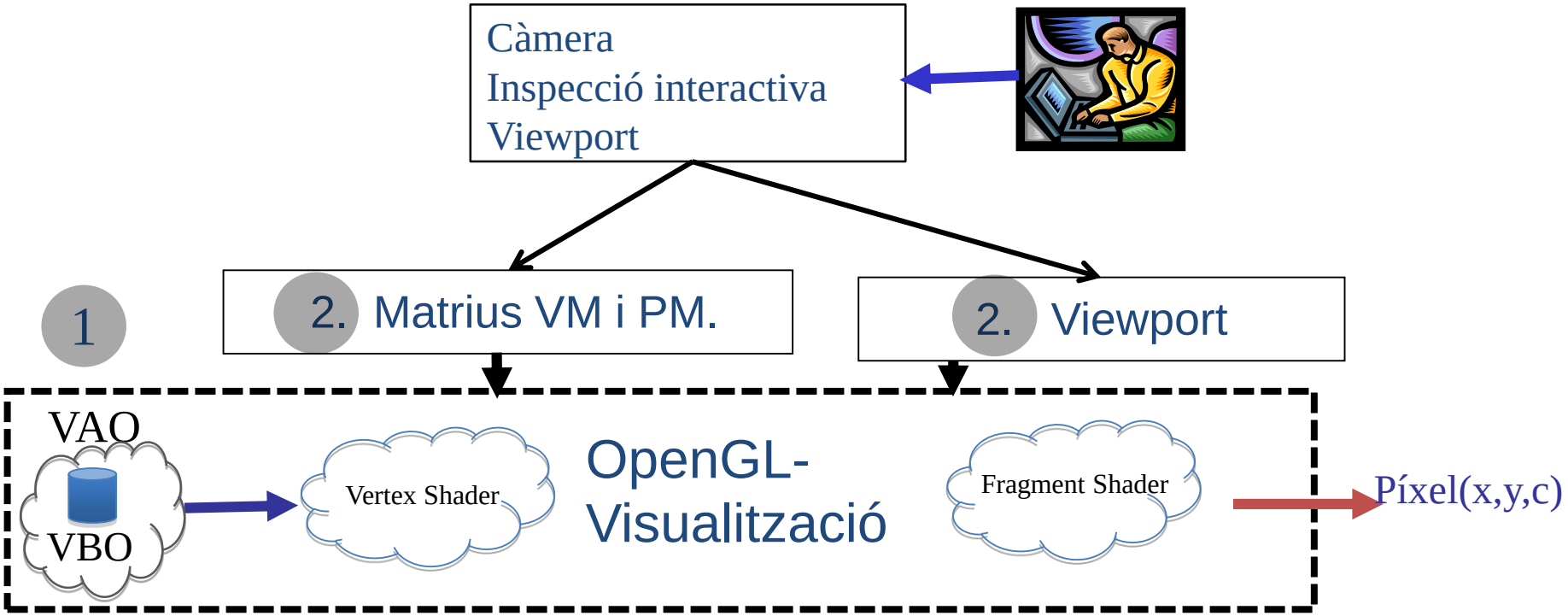
```
#version 330 core

in ...

out vec4 FragColor;

void main() {
    FragColor = vec4(0, 0, 0, 1);
}
```

Pintar/visualitzar en OpenGL 3.3 (resum)



3. Pinta_Model()

// Activa VAO i crida a glDrawArrays(…)

Classe 4: Conceptes i preguntes

- El procés de visualització projectiu: blocs funcionals que l'integren, ordre dels processos, sistemes de coordenades.
- Diferència entre vèrtex i fragment.
- Què cal fer, com a mínim, en el fagment shader?
- Què son les coordenades normalitzades?
- Què és i com funciona el retallat? Per què cal?
- Com i quan es passa a coordenades de dispositiu? Què són aquestes coordenades exactament?
- Què passa amb els `out` addicionals que puguem afegir al vertex shader? Com arriba aquesta informació al fragment shader?