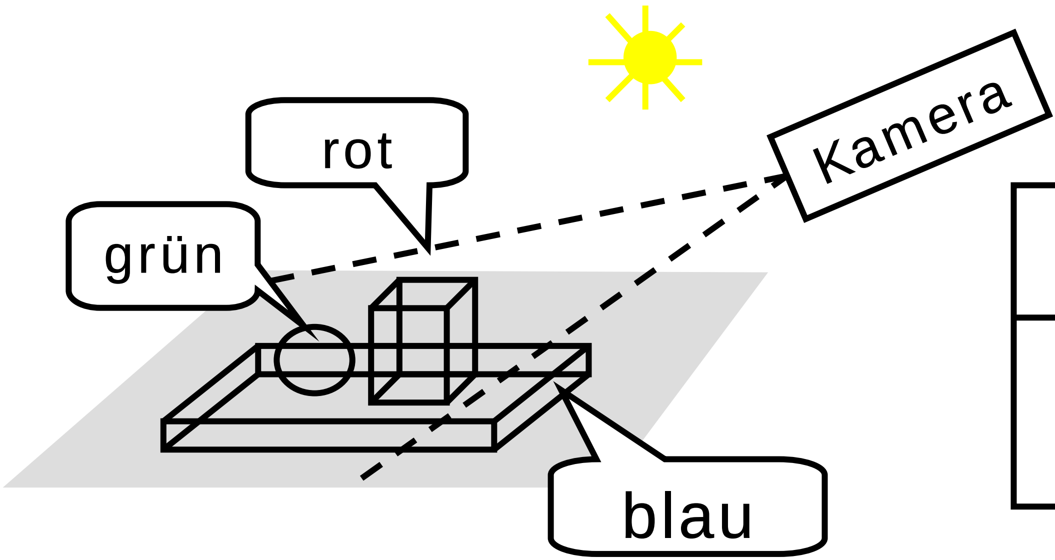
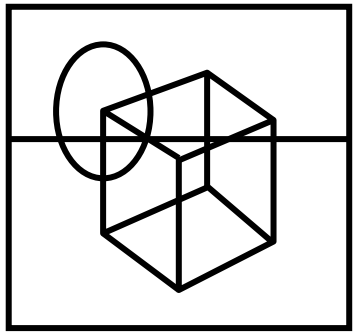
Computergrafik 2010

Oliver Vornberger

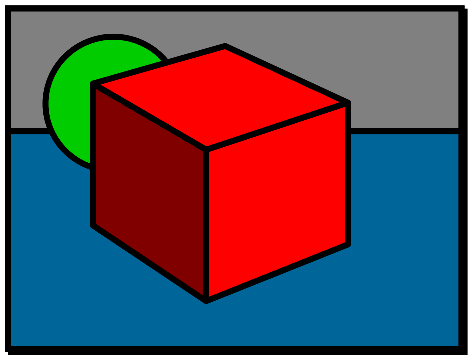
Kapitel 15:
Viewing Pipeline

Sequenz von Transformationen



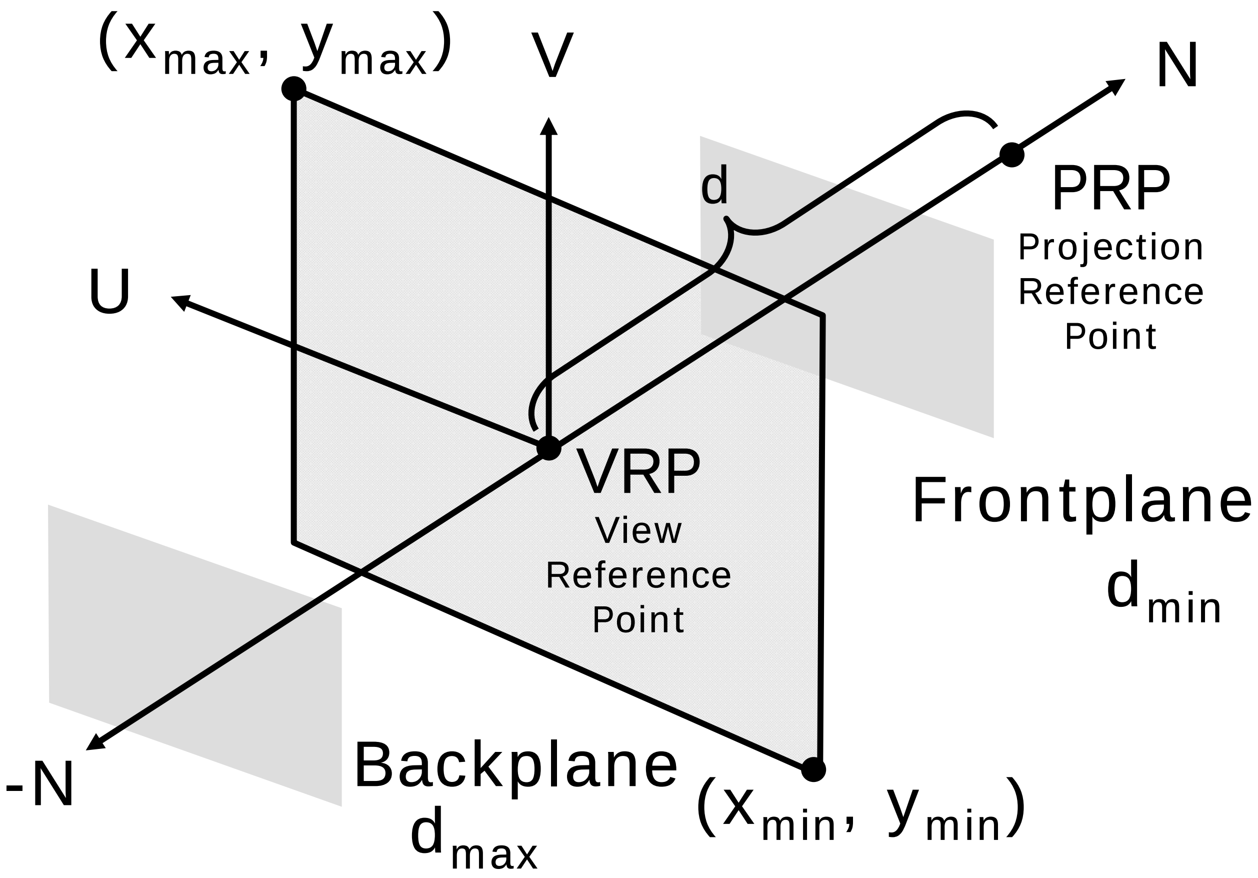


- Modeling
- View Orientation
- View Mapping
- Device Mapping

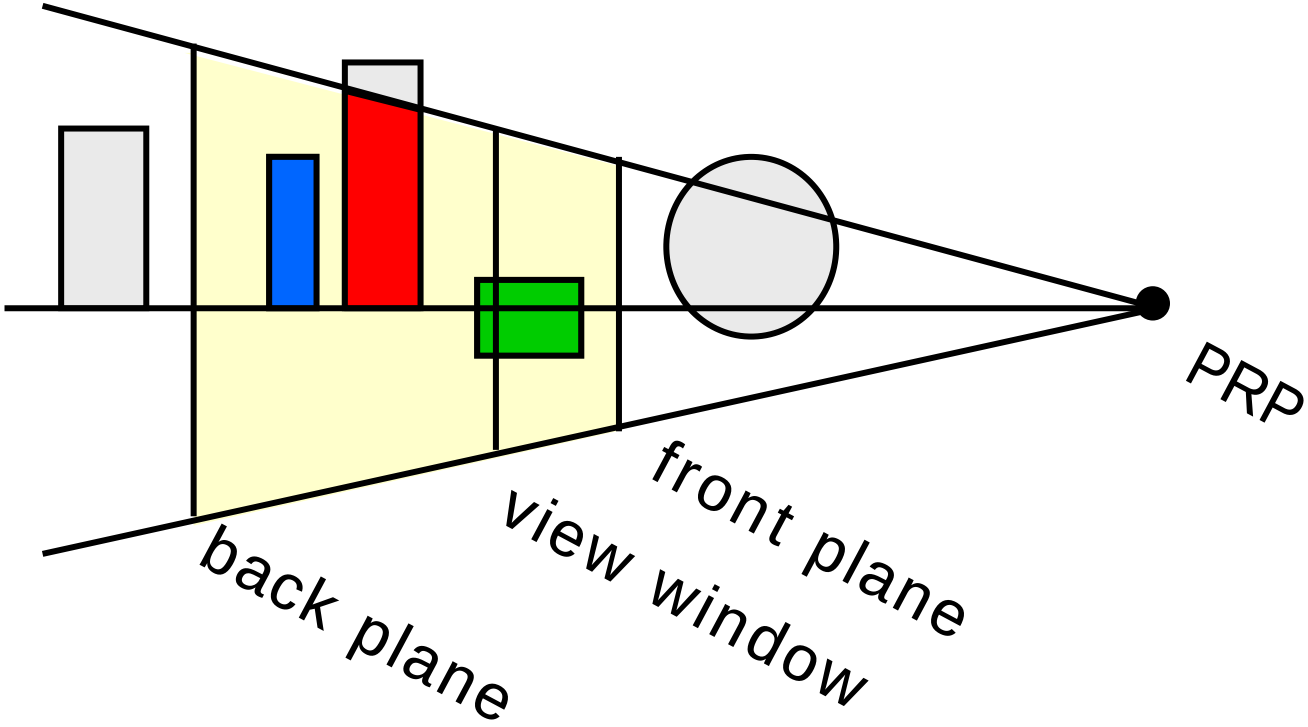


Die synthetische Kamera

View **R**eference **C**oordinate System



View Volume



erforderliche Informationen

- Objekte beschrieben in Modellkoordinaten, z.B. Mittelpunkt (0,0,0) und Kantenlänge 1
- Szene beschrieben durch Weltkoordinaten d.h. Objekte platziert durch Translation, Skalierung und Rotation
- Synthetische Kamera beschrieben durch U, V, N, VRP

$$\underbrace{d,}_{\text{PRP}}\ \underbrace{x_{max},\ y_{max},\ x_{min},\ y_{min}}_{\text{Bildfläche}},\ \underbrace{d_{min},\ d_{max}}_{\text{Front Back}}$$

Viewing Pipeline

1.) Modeling: MC$\rightarrow$ WC

beschreibe Szene in Weltkoordinaten

2.) View Orientation: WC$\rightarrow$ VRC

überführe Szene in Kameraperspektive

3.) View Mapping: VRC$\rightarrow$ NPC

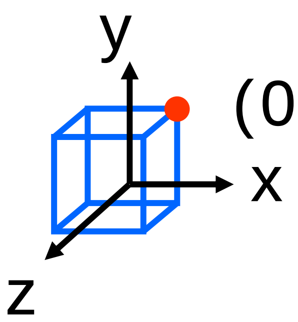
überführe Szene in Einheitswürfel

4.) Device Mapping: NPC$\rightarrow$ DC

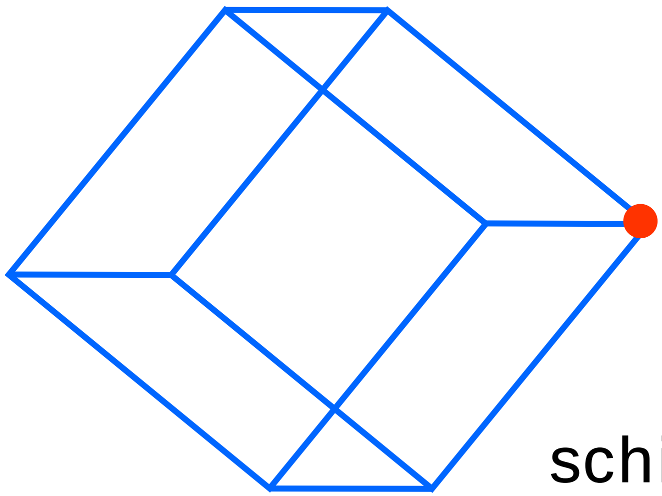
projiziere Szene auf Bildschirm

Modeling

Würfel mit Kantenlänge 1, Mittelpunkt (0,0,0)



(0.5, 0.5, -0.5, 1.0)



(0.71, 0.0, -0.5, 1.0)

(3.53, 0.0, -2.5, 1.0)

(3.53, 0.0, 17.5, 1.0)

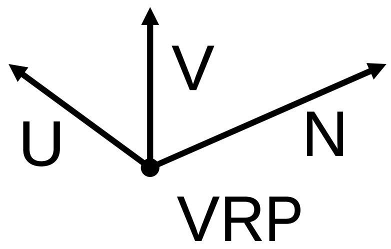
Drehe um 45°

Skaliere um Faktor 5

schiebe um 20 nach vorne

View Orientation

Gegeben sei die
synthetische Kamera:

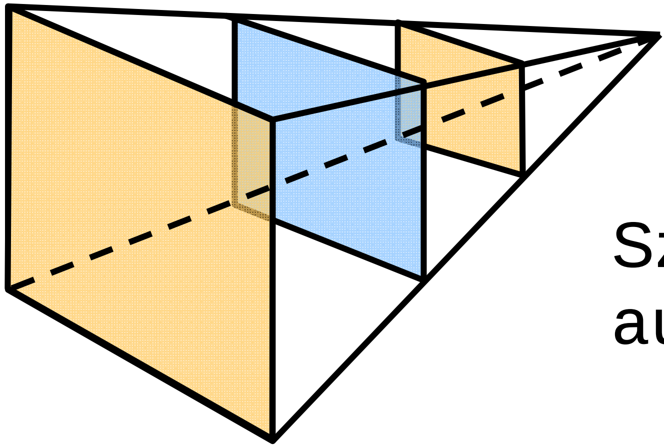


Bilde $M := \begin{pmatrix} U_x & V_x & N_x & VRP_x \\ U_y & V_y & N_y & VRP_y \\ U_z & V_z & N_z & VRP_z \\ 0 & 0 & 0 & 1 \end{pmatrix}$

Bilde $T := M^{-1}$

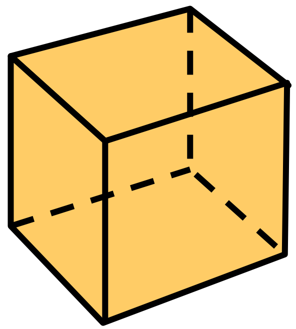
Transformiere jedes Objekt mit T

View Mapping

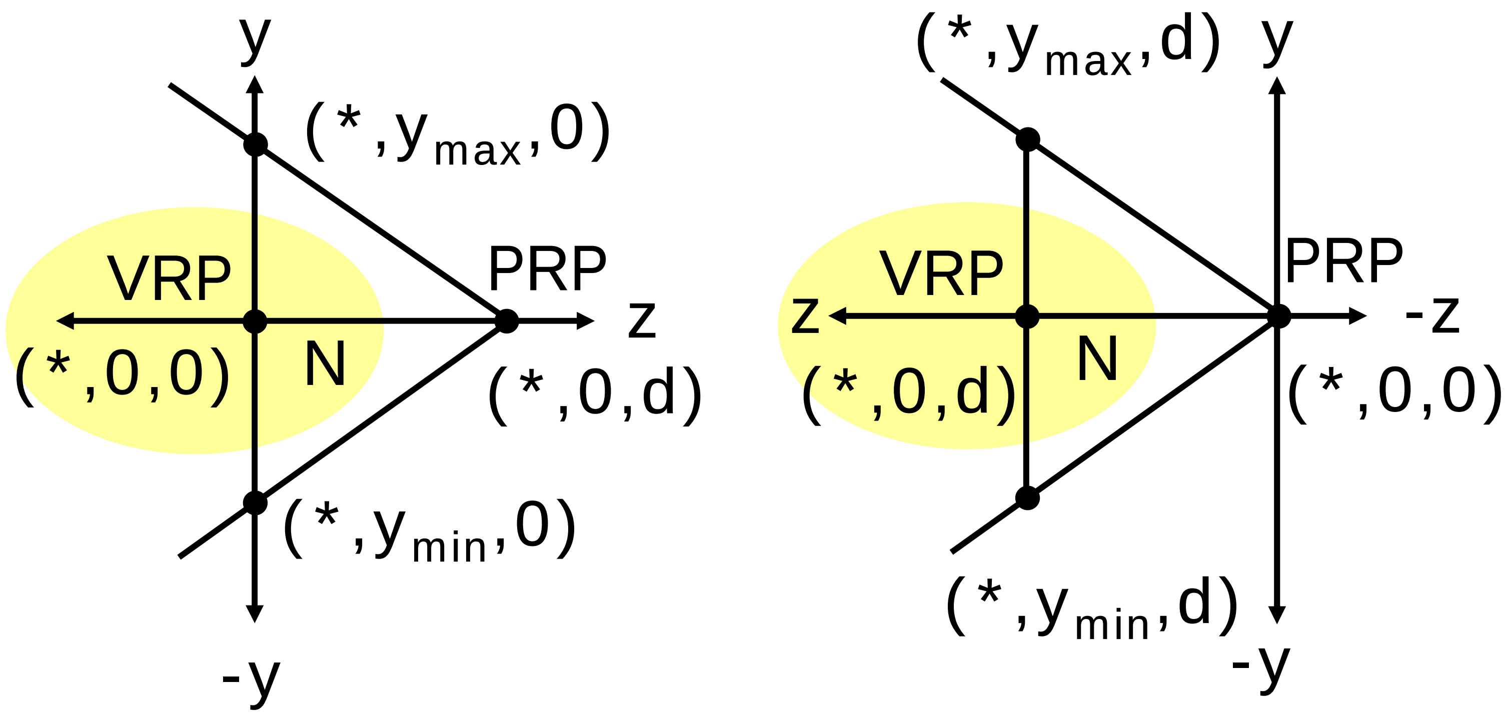


Szene ist beschrieben
aus Sicht der Kamera

Ziel:
Transformation in
den Einheitswürfel



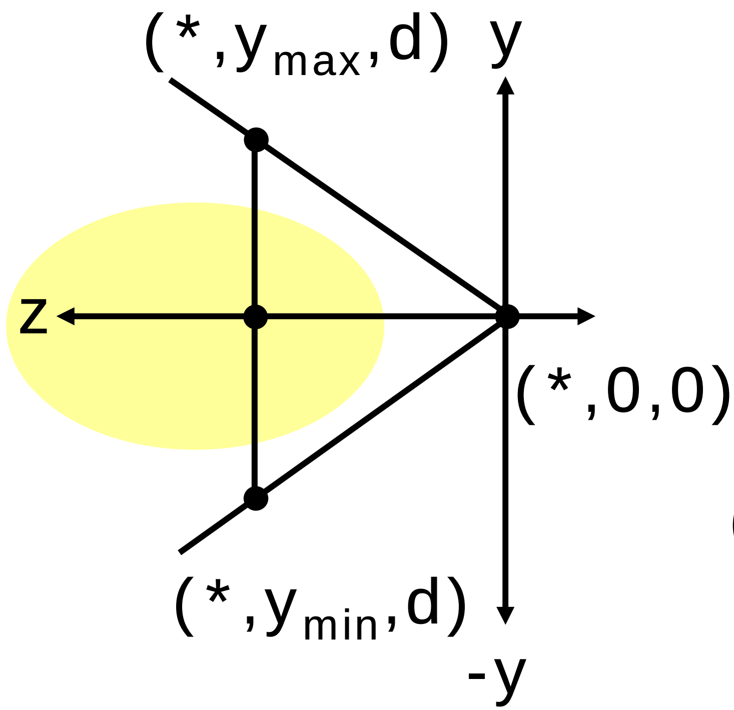
Auge in den Ursprung

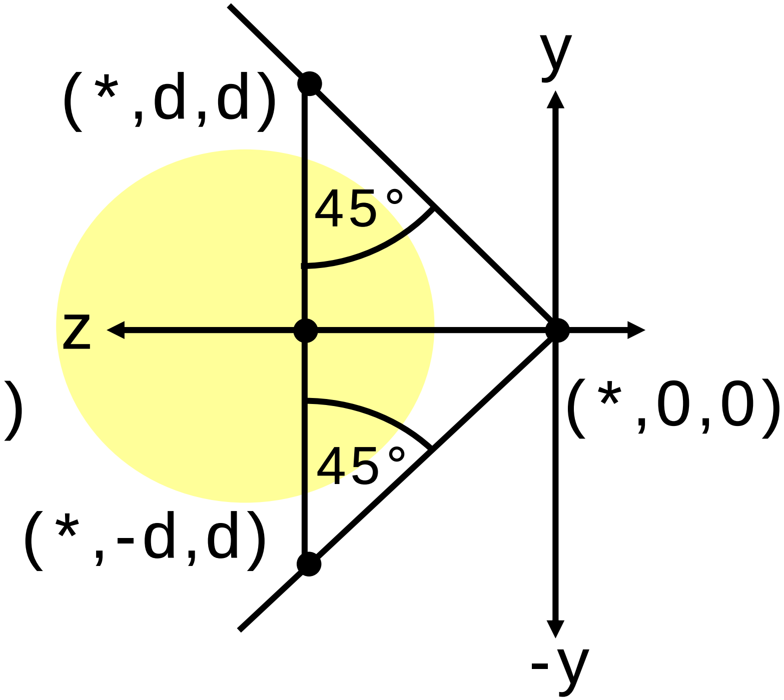


schiebe PRP in Ursprung $\quad z := z-d$

spiegel an x/y-Ebene $\quad z := -z$

Symmetrischer Pyramidenstumpf





$$y' := k_1 \cdot y + k_2 \cdot z$$

$$z' := z$$

$$d := k_1 \cdot y_{max} + k_2 \cdot d$$

$$-d := k_1 \cdot y_{min} + k_2 \cdot d$$

Skalierungskoeffizienten

Lösung des Gleichungssystems liefert für y:

$$k_1 = \frac{2d}{y_{max} - y_{min}} \quad k_2 = -\frac{y_{max} + y_{min}}{y_{max} - y_{min}}$$

Analog für x-Werte:

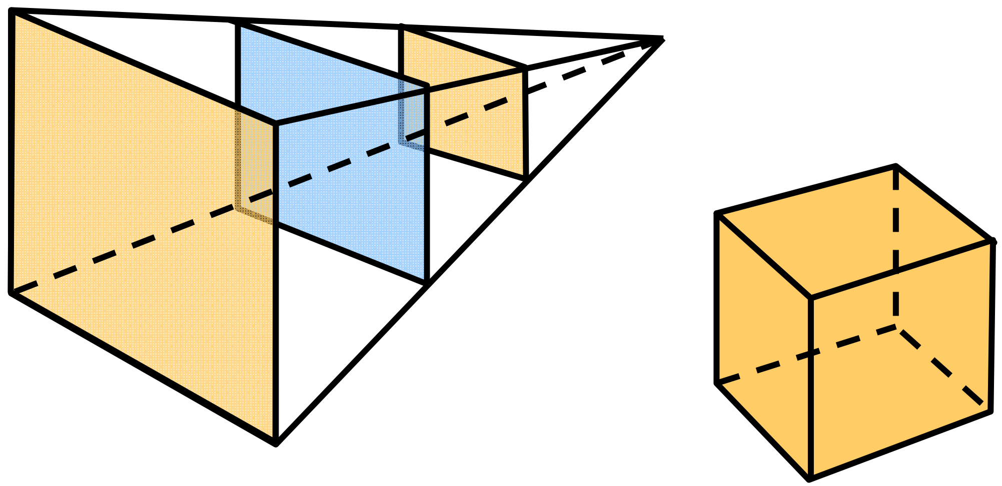
$$k_3 = \frac{2d}{x_{max} - x_{min}} \quad k_4 = -\frac{x_{max} + x_{min}}{x_{max} - x_{min}}$$

Transformationsmatrix

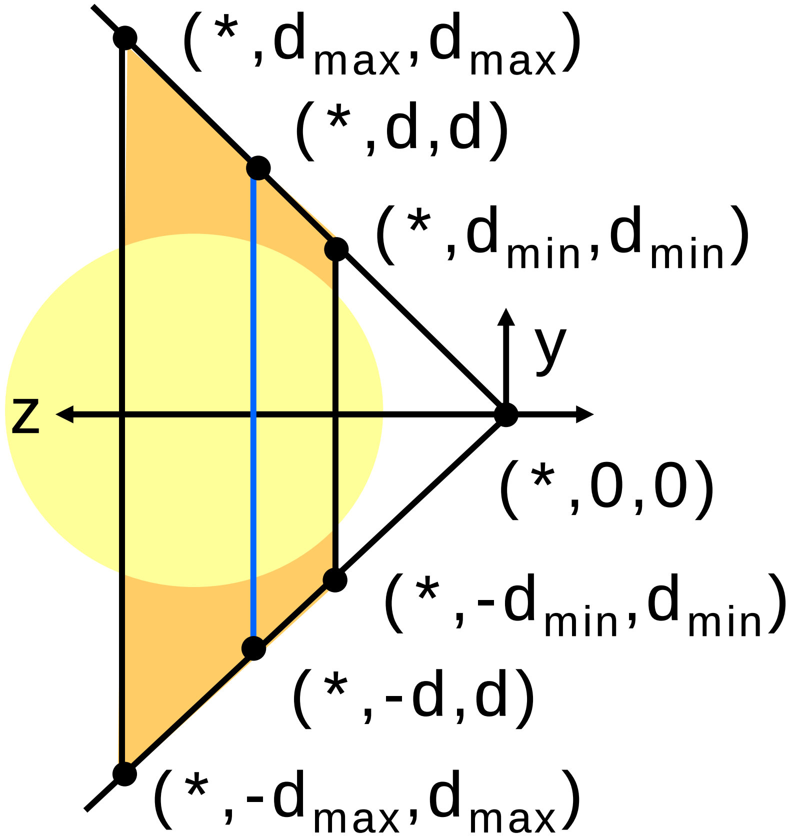
$x' := k_3 \cdot x + k_4 \cdot z$ $y' := k_1 \cdot y + k_2 \cdot z$ $z' := z$

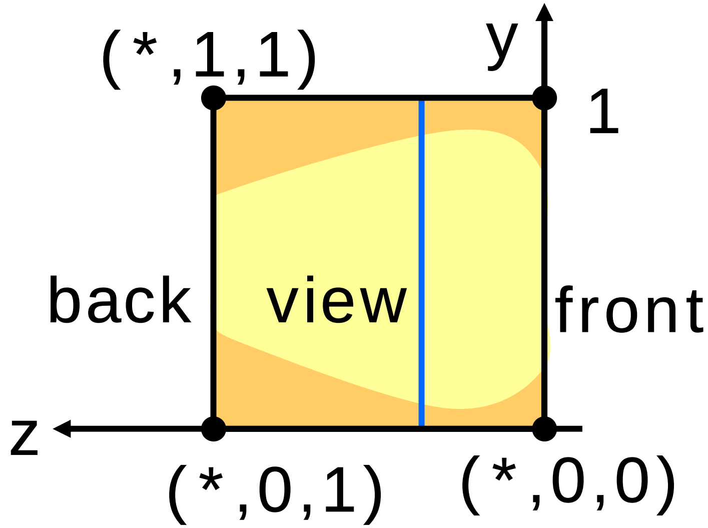
$$\begin{pmatrix} \frac{2d}{x_{max}-x_{min}} & 0 & -\frac{x_{max}+x_{min}}{x_{max}-x_{min}} & 0 \\ 0 & \frac{2d}{y_{max}-y_{min}} & -\frac{y_{max}+y_{min}}{y_{max}-y_{min}} & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

Pyramide und Einheitswürfel



Überführung in Einheitswürfel

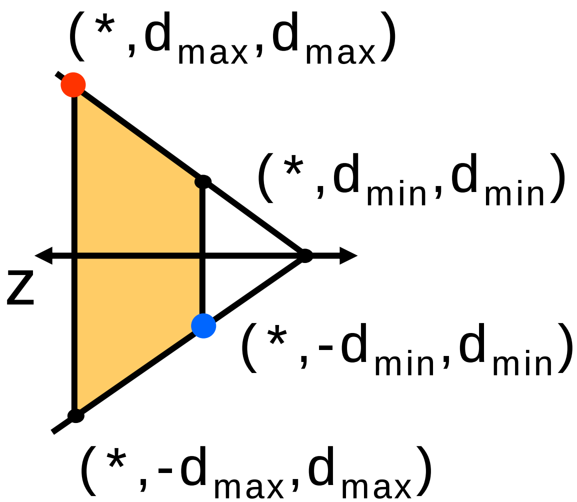


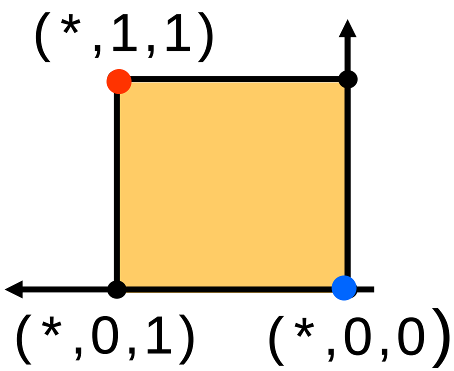


$$y' = k_1 + k_2 \cdot \frac{y}{z}$$

$$z' = k_3 + k_4 \cdot \frac{1}{z}$$

Gleichungssystem





$$y' = k_1 + k_2 \cdot \frac{y}{z}$$

$$z' = k_3 + k_4 \cdot \frac{1}{z}$$

$$1 = k_1 + k_2 \cdot \frac{d_{\max}}{d_{\max}}$$

$$0 = k_1 + k_2 \cdot \frac{-d_{\min}}{d_{\min}}$$

$$1 = k_3 + k_4 \cdot \frac{1}{d_{\max}}$$

$$0 = k_3 + k_4 \cdot \frac{1}{d_{\min}}$$

Skalierungskoeffizienten

Lösung des Gleichungssystems liefert

für y:

$$k_1 = \frac{1}{2} \qquad k_2 = \frac{1}{2}$$

für z:

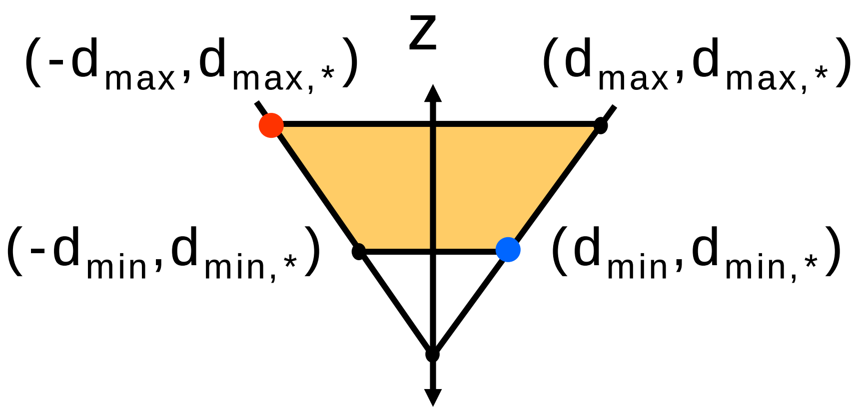
$$k_3 = \frac{d_{max}}{d_{max} - d_{min}} \qquad k_4 = \frac{-d_{min} \cdot d_{max}}{d_{max} - d_{min}}$$

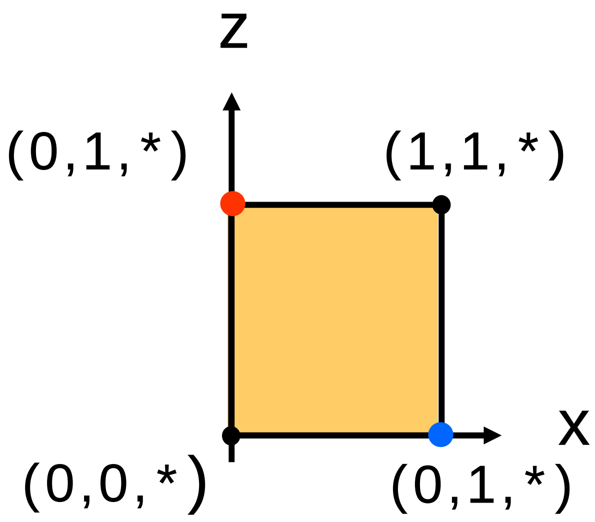
Skalierungskoeffizienten

Lösung des Gleichungssystems liefert

für x:

$$k_5 = \frac{1}{2} \qquad k_6 = \frac{1}{2}$$





Vorbereitung der Matrix

geeignet für spätere Division durch z:

$$x' = \tfrac{1}{2} + \tfrac{1}{2} \cdot x/z \qquad = (\tfrac{1}{2} \cdot x + \tfrac{1}{2} \cdot z)/z$$

$$y' = \tfrac{1}{2} + \tfrac{1}{2} \cdot y/z \qquad = (\tfrac{1}{2} \cdot y + \tfrac{1}{2} \cdot z)/z$$

$$z' = \frac{d_{max}}{d_{max} - d_{min}} + \frac{-d_{min} \cdot d_{max}}{d_{max} - d_{min}} \cdot \frac{1}{z}$$

$$= \left(\frac{d_{max}}{d_{max} - d_{min}} \cdot z + \frac{-d_{min} \cdot d_{max}}{d_{max} - d_{min}}\right)/z$$

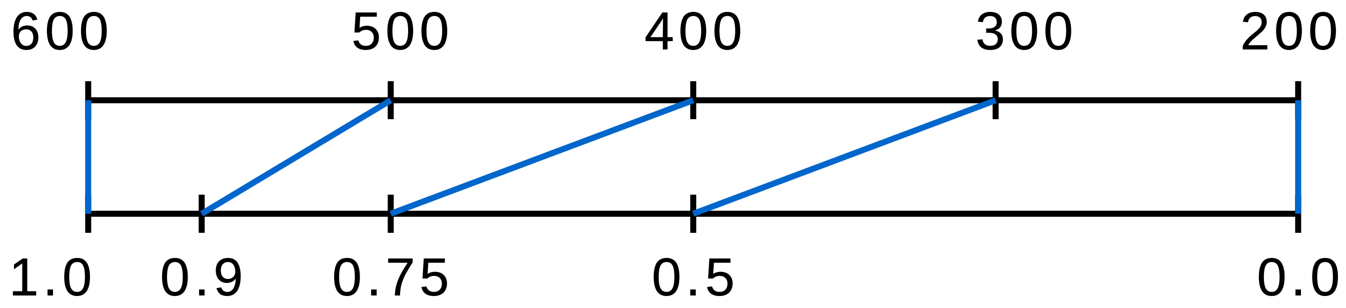
Transformationsmatrix

$$x' := (\underbrace{k_6}_{\frac{1}{2}} \cdot x + \underbrace{k_5}_{\frac{1}{2}} \cdot z)/z \qquad y' := (\underbrace{k_2}_{\frac{1}{2}} \cdot y + \underbrace{k_1}_{\frac{1}{2}} \cdot z)/z \qquad z' := (\underbrace{k_3}_{\frac{d_{max}}{d_{max}-d_{min}}} \cdot z + \underbrace{k_4}_{\frac{-d_{min} \cdot d_{max}}{d_{max}-d_{min}}} \cdot 1)/z$$

$$\begin{pmatrix} \frac{1}{2} & 0 & \frac{1}{2} & 0 \\ 0 & \frac{1}{2} & \frac{1}{2} & 0 \\ 0 & 0 & \frac{d_{max}}{d_{max}-d_{min}} & \frac{-d_{min} \cdot d_{max}}{d_{max}-d_{min}} \\ 0 & 0 & 1 & 0 \end{pmatrix}$$

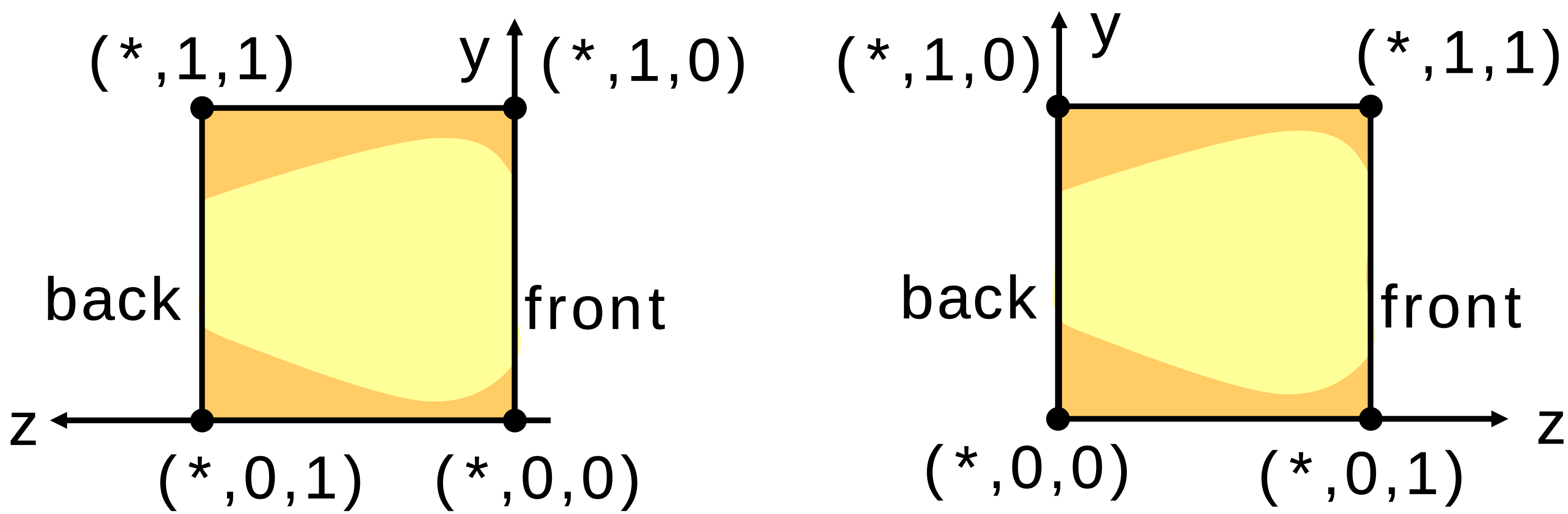
Obacht: Stauchung

$$z' := \frac{600}{600-200} + \frac{-200\cdot 600}{600-200} \cdot \frac{1}{z} \quad = 1.5 - \frac{300}{z}$$



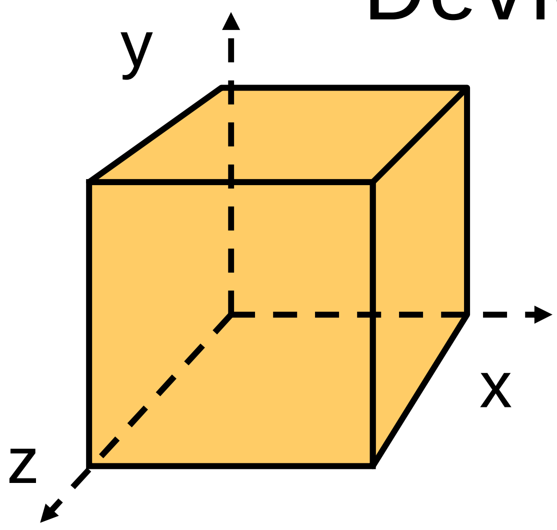
- Szene wird nichtlinear gestaucht
- Objekte drängeln sich an der back plane
- reicht für Sichtbarkeitsbestimmung aus.

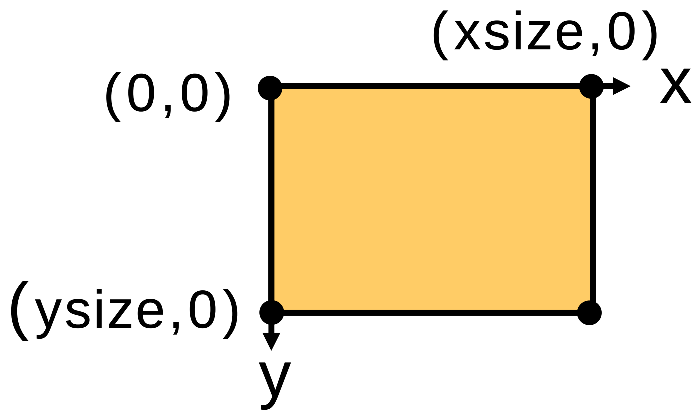
linkshändig - rechtshändig

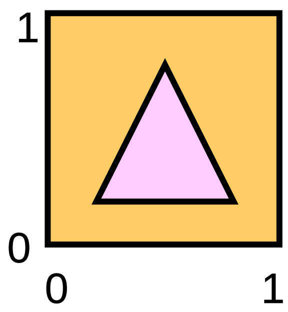


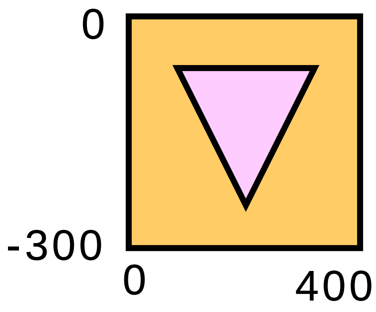
- spiegel an x/y-Ebene
- verschiebe back plane in x/y-Ebene

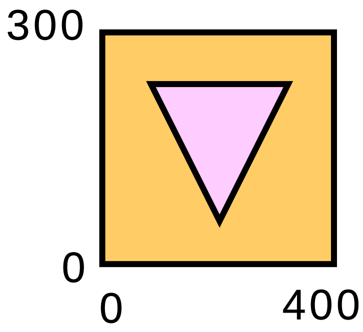
Device Mapping

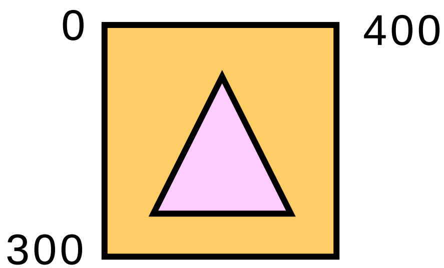




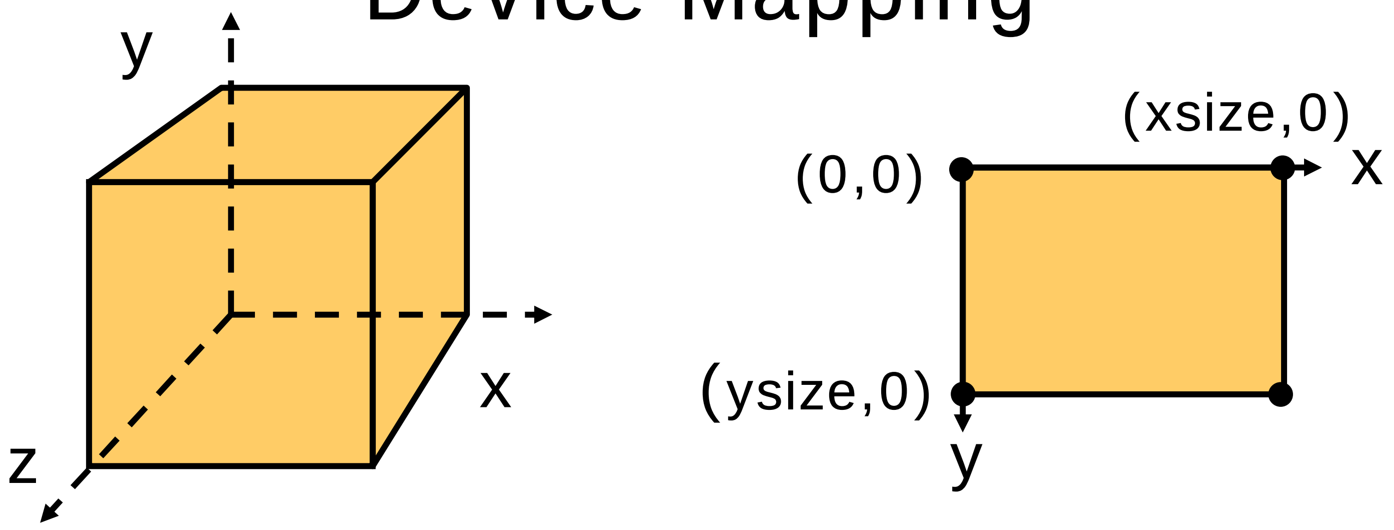








Device Mapping

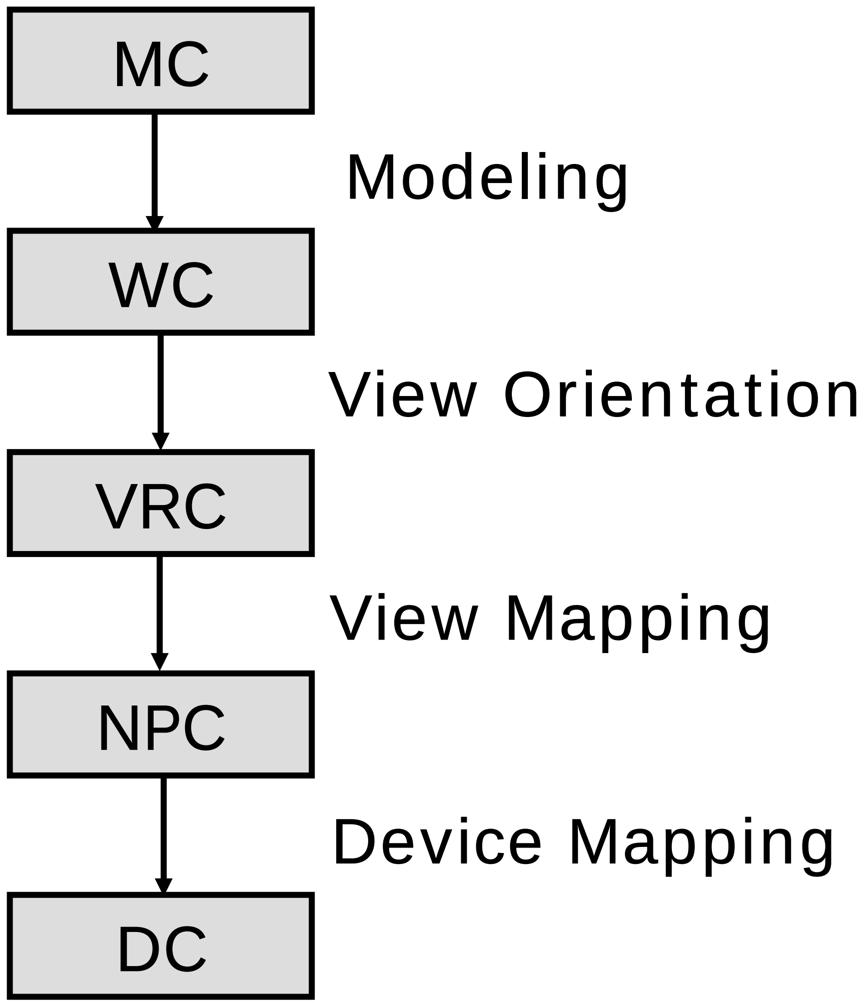


skaliere mit (xsize,-ysize) und verschiebe um +ysize

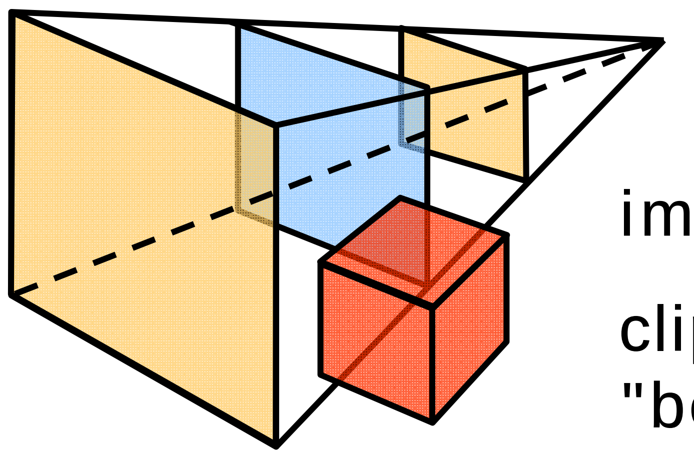
$$\begin{bmatrix} xsize & 0 & 0 & 0 \\ 0 & -ysize & 0 & ysize \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

z-Werte merken !

Zusammenfassung Viewing Pipeline



Clipping



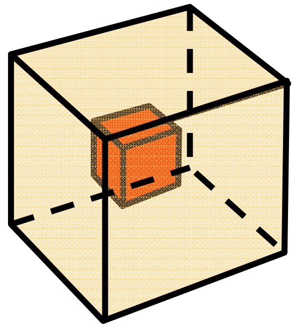
im WC:

clippen an sechs "beliebigen" Flächen

im NPC:

clippen an sechs "einfachen" Flächen

(6-Bit-Bereichscode)



Vergleich

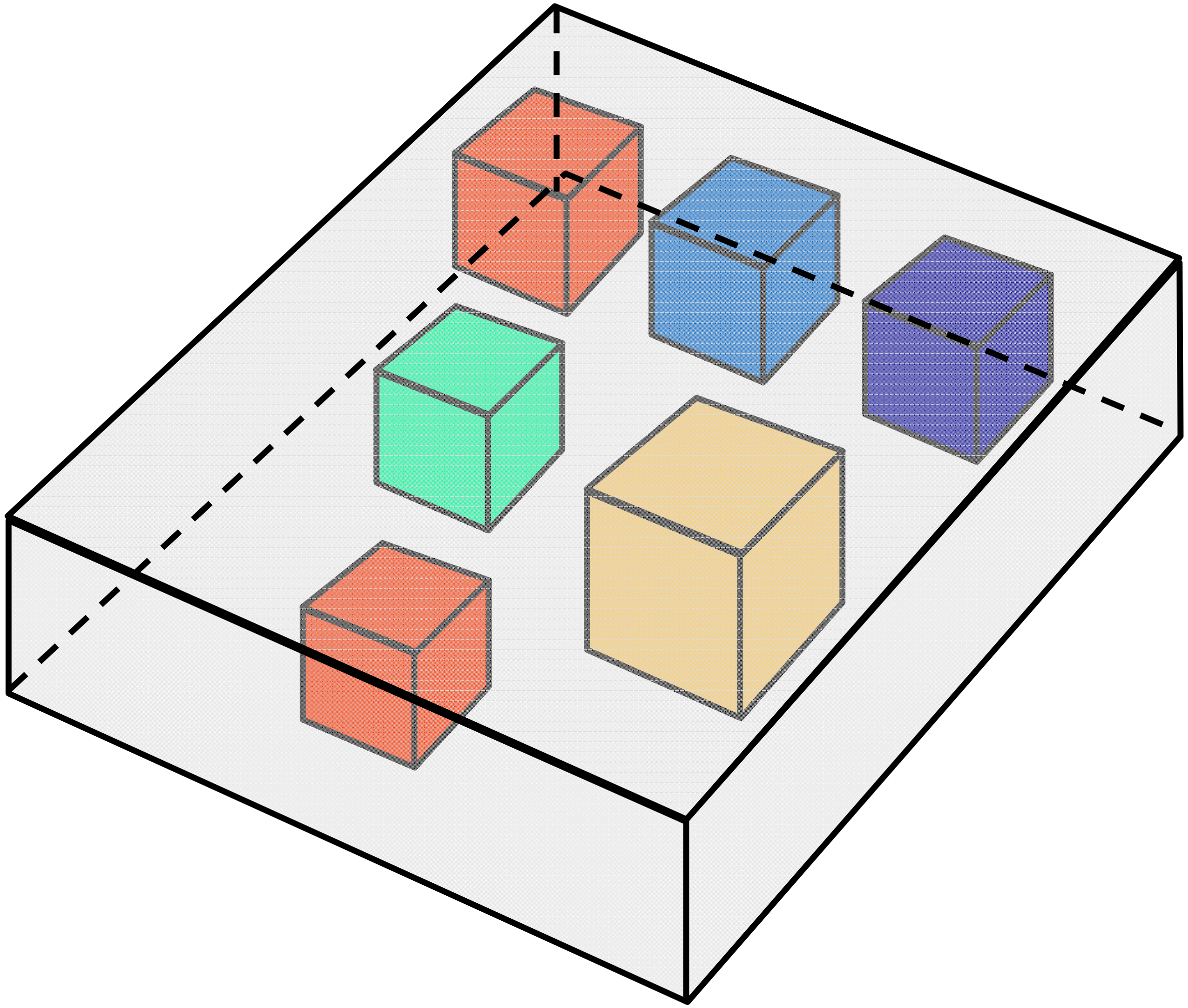
frühes Clipping:

- \- Clipping im WC schwierig
- \+ Transformation ins VPC und NPC mit reduzierter Szene

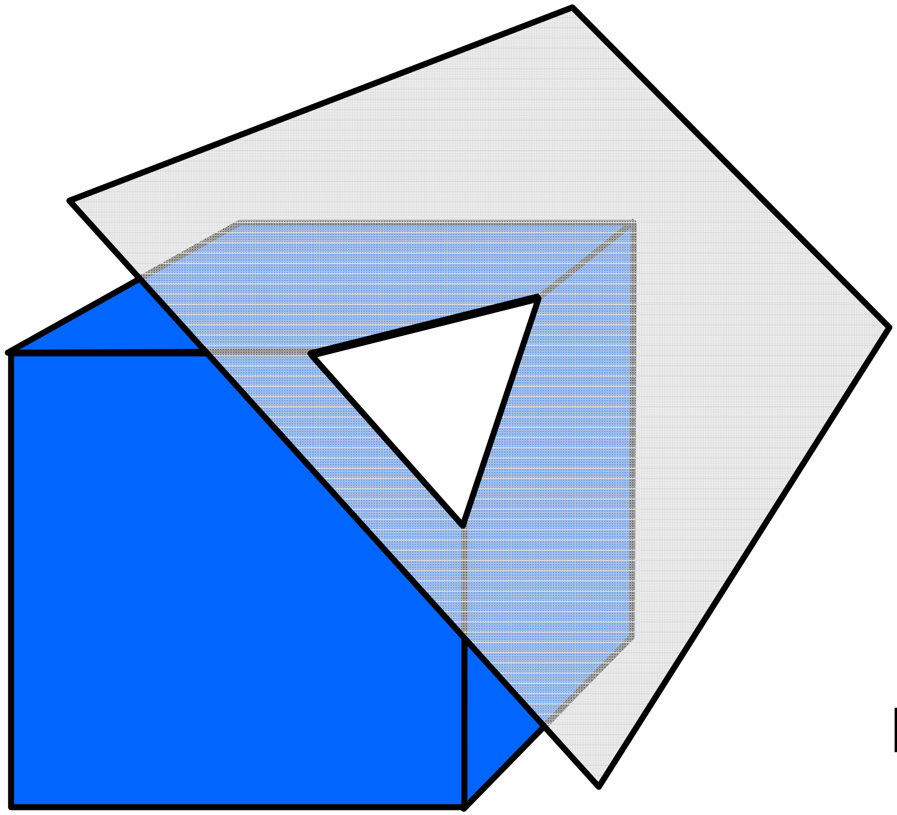
spätes Clipping:

- \- Transformation der kompletten Szene ins VPC und NPC
- \+ Clipping im NPC einfach

Umgebungsclipping



Probleme beim Clipping



Obacht:
Polyeder
zerfällt in
Polygone !