

Računalniška grafika

projekcije

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KONCEPTI?

- kako imenujemo matriko, katere inverz je transponirana matrika sama?
- katere linearne transformacije poznamo?
  - katero transformacijo izkoristimo za prehod iz levosučnega v desnosučni koordinatni sistem?
- ali je zrcaljenje toga transformacija?
  - kako v homogenih koordinatah predstavimo vektor in kako točko?
- kako iz homogenih koordinat preidemo v nehomogene koordinate?
- kako pridobimo nasprotno operacijo za vrtenje?
- kako izvedemo vrtenje okrog poljubne točke?
- kakšen mora biti vrstni red matrik pri veriženju transformacij?

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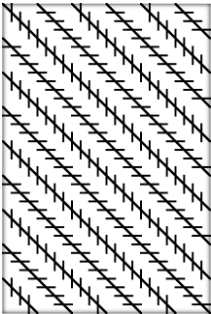
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OPTIČNE ILUZIJE



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optične iluzije

perspektiva



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3D street art

the crevasse



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PROJEKCIJE

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projekcije

vzporedne

pravokotne

od zgoraj

bočna

stranska

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projekcije

vzporedne

pravokotne

aksonometrične

trimetrične

dimetrične

isometrične

0,9:0,5:1

$\alpha:\beta:\gamma$

1:0,5:1

$\alpha:\beta:\gamma$

1:1:1

$\alpha:\beta:\gamma$

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projekcije

vzporedne

pravokotne

aksonometrične

poševne

kavalska

kabinetska

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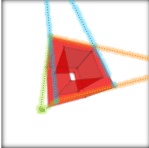
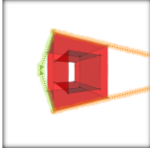

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**projekcije**  
perspektivne  
enobedna  
dvobedna  
tribežna



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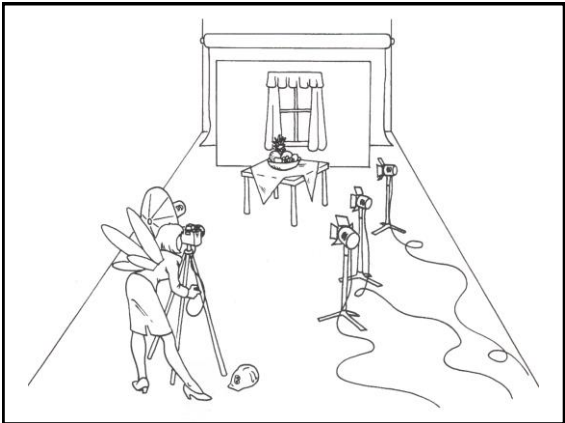
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**GRAFIČNI CEVOVOD**

model

transformacija  
modela in pogleda

izračun osvetlitve

projekcija

rasterizacija in  
prekrivanje

slika

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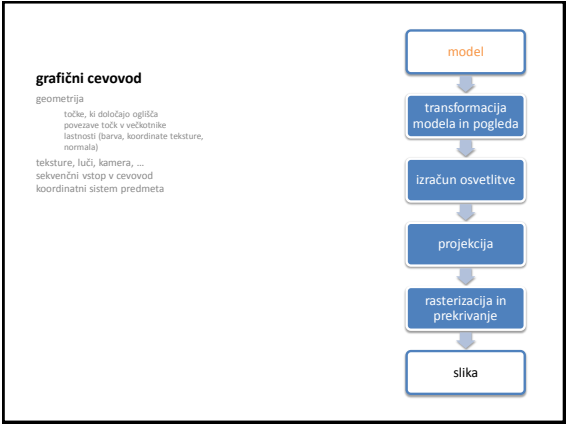
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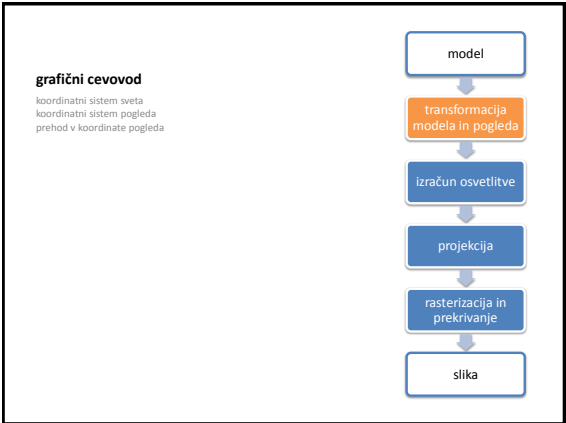
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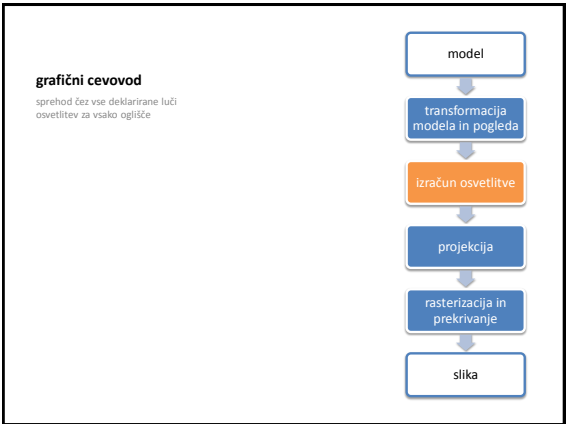
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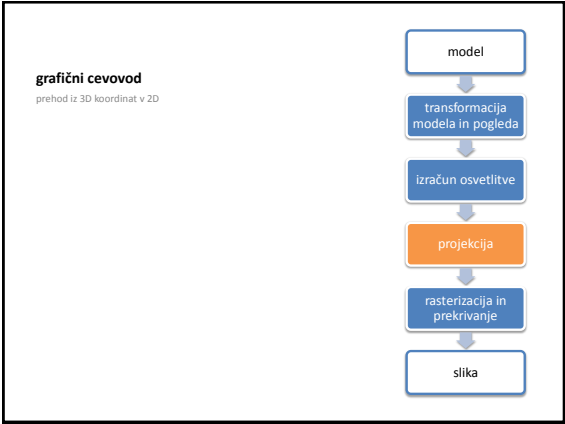
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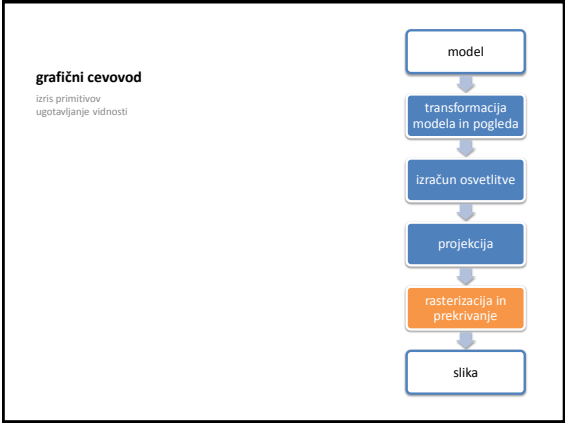
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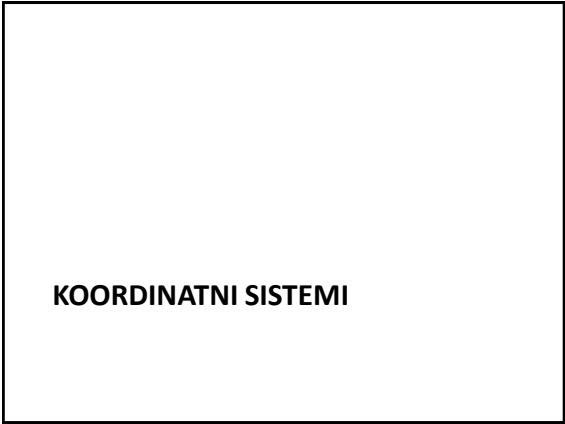
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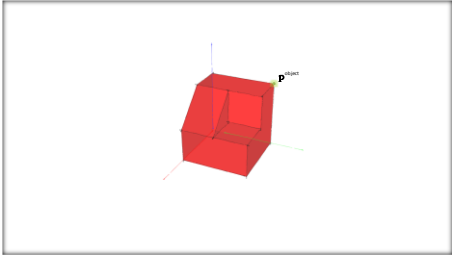
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koordinatni sistemi

predmet



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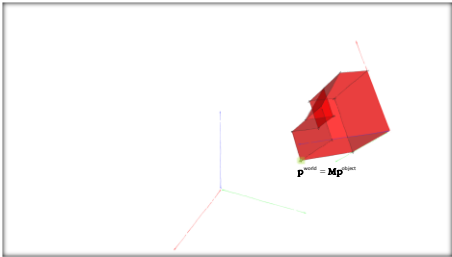
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koordinatni sistemi

svet



predmet → svet  $M$

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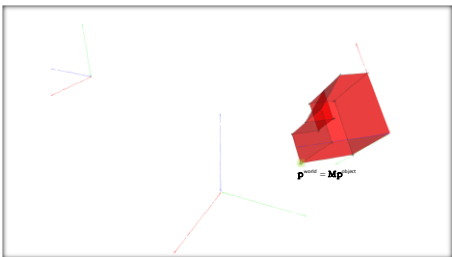
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koordinatni sistemi

pogled



pogled → svet  $C$  svet → pogled  $C^{-1}$  predmet → pogled  $p^{camera} = C^{-1}Mp^{object}$

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koordinatni sistemi

pogled

$$w = \frac{c-f}{|c-f|}$$
$$u = \frac{up \times w}{|up \times w|}$$
$$v = w \times u$$

$$C = [u \ v \ w \ e]$$

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projekcija

perspektivna

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projekcija

vzporedna

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Projekcije

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PROJEKCIJSKA TRANSFORMACIJA

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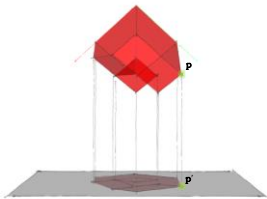
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projekcijska transformacija  
vzporedna pravokotna projekcija



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projekcijska transformacija  
perspektivna projekcija  
poenostavljen primer



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projekcijska transformacija

perspektivna projekcija

poenostavljen primer

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projekcijska transformacija

perspektivna projekcija

poenostavljen primer

$$\frac{p'_y}{d} = \frac{p_y}{p_z}, \quad \frac{p'_x}{d} = \frac{p_x}{p_z}$$

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projekcijska transformacija

perspektivna projekcija

poenostavljen primer

$$p'_x = \frac{p_x d}{p_z}, \quad p'_y = \frac{p_y d}{p_z}, \quad p'_z = d$$

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projekcijska transformacija

perspektivna projekcija  
poenostavljen primer

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1/d & 0 \end{bmatrix} \begin{bmatrix} p_x \\ p_y \\ p_z \\ 1 \end{bmatrix} = \begin{bmatrix} p_x \\ p_y \\ p_z \\ p_z/d \end{bmatrix} \Rightarrow \begin{bmatrix} p_x d / p_z \\ p_y d / p_z \\ d \\ 1 \end{bmatrix}$$

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projekcijska transformacija

perspektivna projekcija  
poenostavljen primer

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & -1/d & 0 \end{bmatrix} \begin{bmatrix} p_x \\ p_y \\ p_z \\ 1 \end{bmatrix} = \begin{bmatrix} p_x \\ p_y \\ p_z \\ -p_z/d \end{bmatrix} \Rightarrow \begin{bmatrix} -p_x d / p_z \\ -p_y d / p_z \\ -d \\ 1 \end{bmatrix}$$

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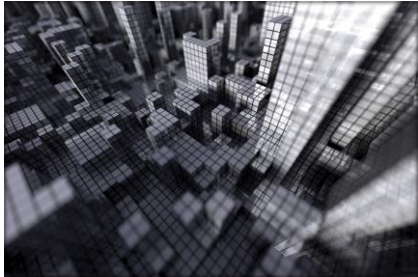
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realizem

fokus in globinska ostrina



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**realizem**  
nitje oko



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**realizem**  
kromatska aberacija



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**realizem**  
zaslonka



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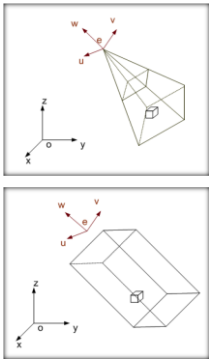
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VIDNO POLJE



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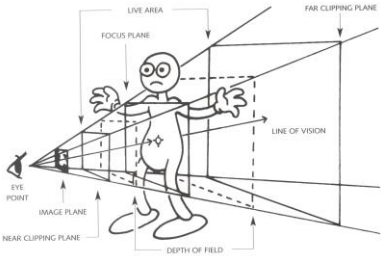
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vidno polje  
terminologija



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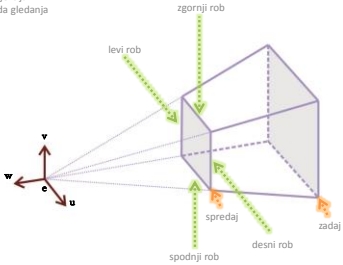
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vidno polje  
perspektivna projekcija  
prirežana piramida gledanja



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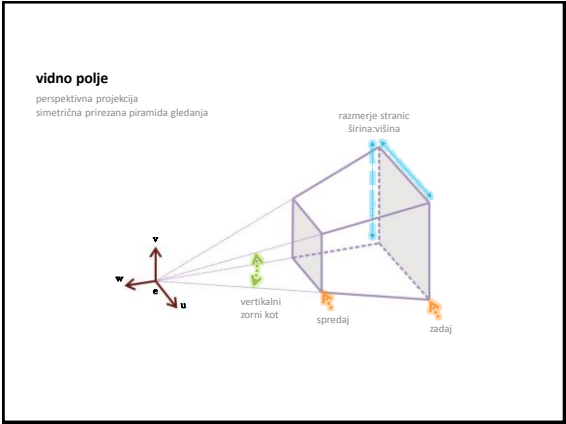
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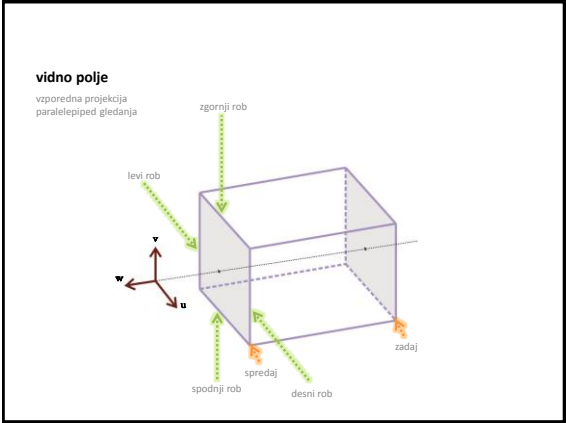
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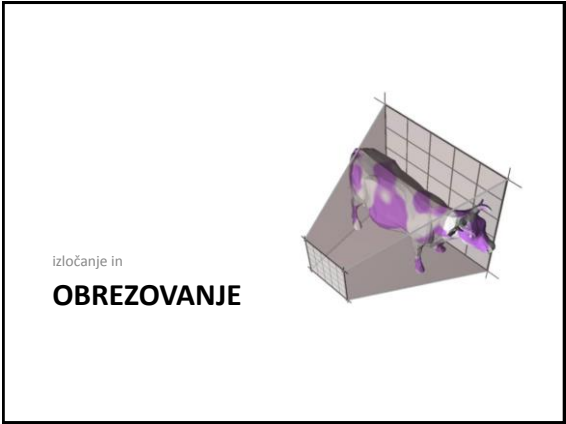
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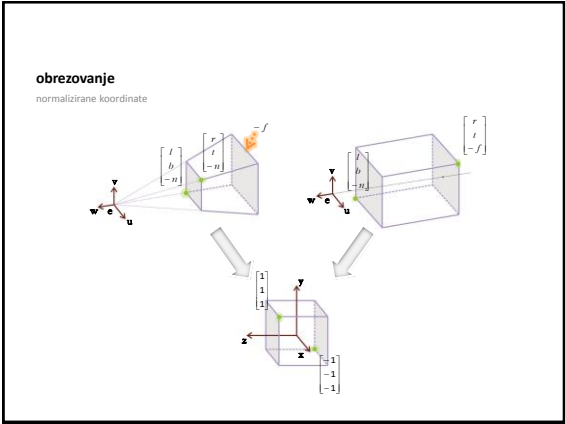
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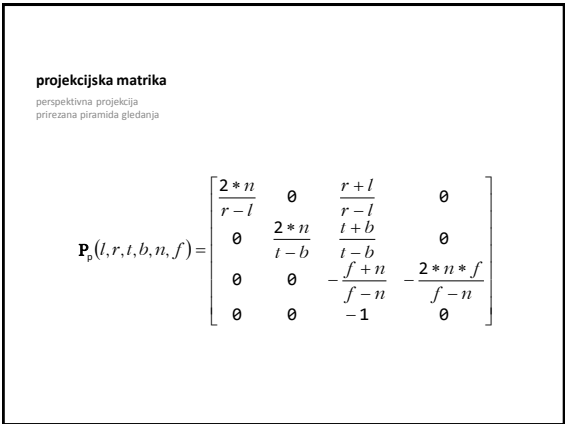
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**projekcijska matrika**  
perspektivna projekcija  
simetrična prizvana piramida gledanja

$$\mathbf{P}_p(\alpha, a, n, f) = \begin{bmatrix} \frac{1}{a - \tan \frac{\alpha}{2}} & 0 & 0 & 0 \\ 0 & \frac{1}{\tan \frac{\alpha}{2}} & 0 & 0 \\ 0 & 0 & -\frac{f+n}{f-n} & -\frac{2*n*f}{f-n} \\ 0 & 0 & -1 & 0 \end{bmatrix}$$

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**projekcijska matrika**  
pravokotna projekcija

$$\mathbf{P}_o(l, r, t, b, n, f) = \begin{bmatrix} \frac{2}{r-l} & 0 & 0 & -\frac{r+l}{r-l} \\ 0 & \frac{2}{t-b} & 0 & -\frac{t+b}{t-b} \\ 0 & 0 & -\frac{2}{f-n} & -\frac{f+n}{f-n} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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**projekcijska matrika**  
pravokotna projekcija  
simetrična

$$\mathbf{P}_o(w, h, n, f) = \begin{bmatrix} \frac{2}{w} & 0 & 0 & 0 \\ 0 & \frac{2}{h} & 0 & 0 \\ 0 & 0 & -\frac{2}{f-n} & -\frac{f+n}{f-n} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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projekcijska matrika

posebna projekcija  
zanik sveta z uporabo striženja  
pravokotna projekcija

$$\mathbf{P} = \mathbf{P}_o \mathbf{H}(\theta, \varphi) = \mathbf{P}_o \begin{bmatrix} 1 & 0 & \cot \theta & 0 \\ 0 & 1 & \cot \varphi & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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matrika naprave

transformacija v koordinate naprave

$$\mathbf{D}(x_0, x_1, y_0, y_1) = \begin{bmatrix} \frac{x_1 - x_0}{2} & 0 & 0 & \frac{x_0 + x_1}{2} \\ 0 & -\frac{y_1 - y_0}{2} & 0 & \frac{y_0 + y_1}{2} \\ 0 & 0 & \frac{1}{2} & \frac{1}{2} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

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transformacijska veriga

matrika modela  
matrika kamere  
projekcijska matrika  
matrika naprave



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transformacijska veriga

matrika modela  
matrika kamere  
projekcijska matrika  
matrika naprave

$$\mathbf{p}' = \begin{bmatrix} p'_x \\ p'_y \\ p'_z \\ w' \end{bmatrix}$$

transformirana točka

$p'_x/w', p'_y/w'$   
slikovni element

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projekcija

projekcije  
vzporedne, perspektivne, taksonomija

grafični cevovod  
transformacija modela in pogleda, izračun osvetlitve, projekcija,  
rasterizacija in prekrivanje

koordinatni sistemi  
predmeta, sveta, pogleda, naprave

parametri kamere  
očišče, koordinatni sistem pogleda, projekcijska ravnina

vidno polje  
perspektivna projekcija, vzporedna projekcija

projekcijska matrika  
perspektivna projekcija, vzporedna projekcija,  
normalizirane koordinate, transformacijska veriga

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<http://www.cs.mtsu.edu/~jhankins/pages/planeview3D.html>  
[http://metal.brightcookie.com/2\\_draw/draw\\_t3/htm/draw3\\_2.htm](http://metal.brightcookie.com/2_draw/draw_t3/htm/draw3_2.htm)  
Baker, *Computer Graphics with OpenGL*, 3rd ed., ch 6,7  
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Akenine-Möller, Haines, Hoffman, *Real-Time Rendering*, 3rd Ed., ch 2,4,6  
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Eberly, *3D Game Engine Design*, ch 3.1-4  
Guid, *Računalniška grafika*, ch 5,6

dodatna literatura

DO PRIHODNJIČ

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