



UNIVERZA
V LJUBLJANI

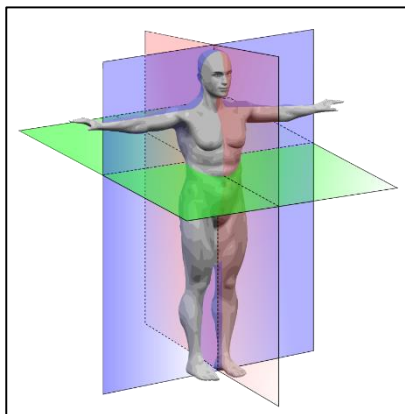
FE

Fakulteta
za elektrotehniko

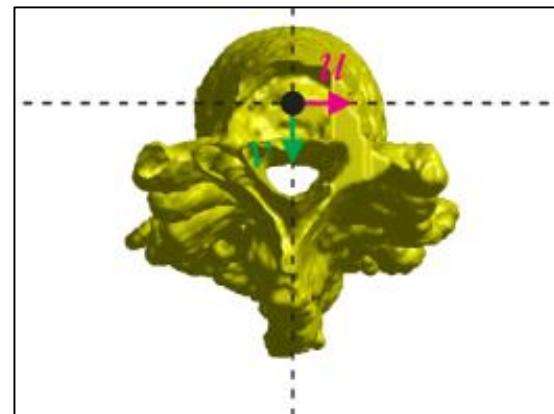
PRIPRAVA NA LABORATORIJSKE VAJE

Vaja 4: Prikazovanje 3D slik v 2D

Obdelava slik in videa
prof. dr. Tomaž Vrtovec



LABORATORIJ ZA SLIKOVNE TEHNOLOGIJE
LABORATORY OF IMAGING TECHNOLOGIES



PRIKAZOVANJE 3D SLIK v 2D

Pregled



3D slike: primer slike ukrivljene strukture

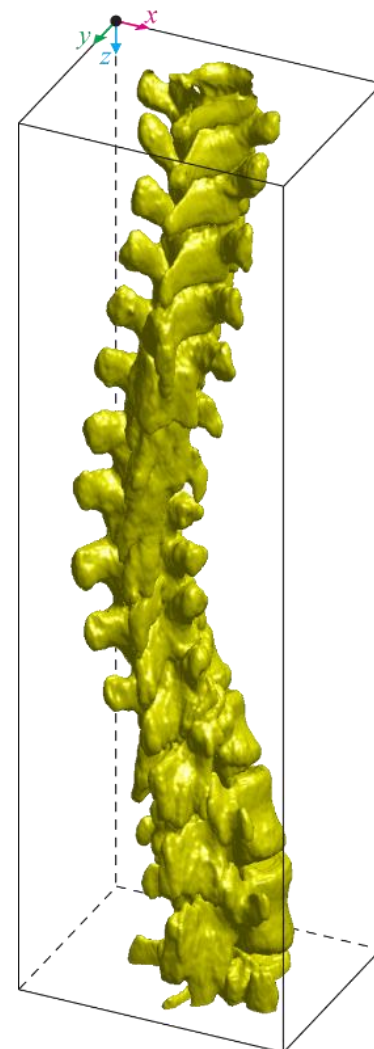
- koordinatni sistem slike
- koordinatni sistem opazovane ukrivljene strukture (žile, sapnik, črevo, kosti, čeljust, hrbtenica)
- preslikava koordinatnih sistemov

Prerezi

- ravninski prerezi
- ukrivljeni prerezi

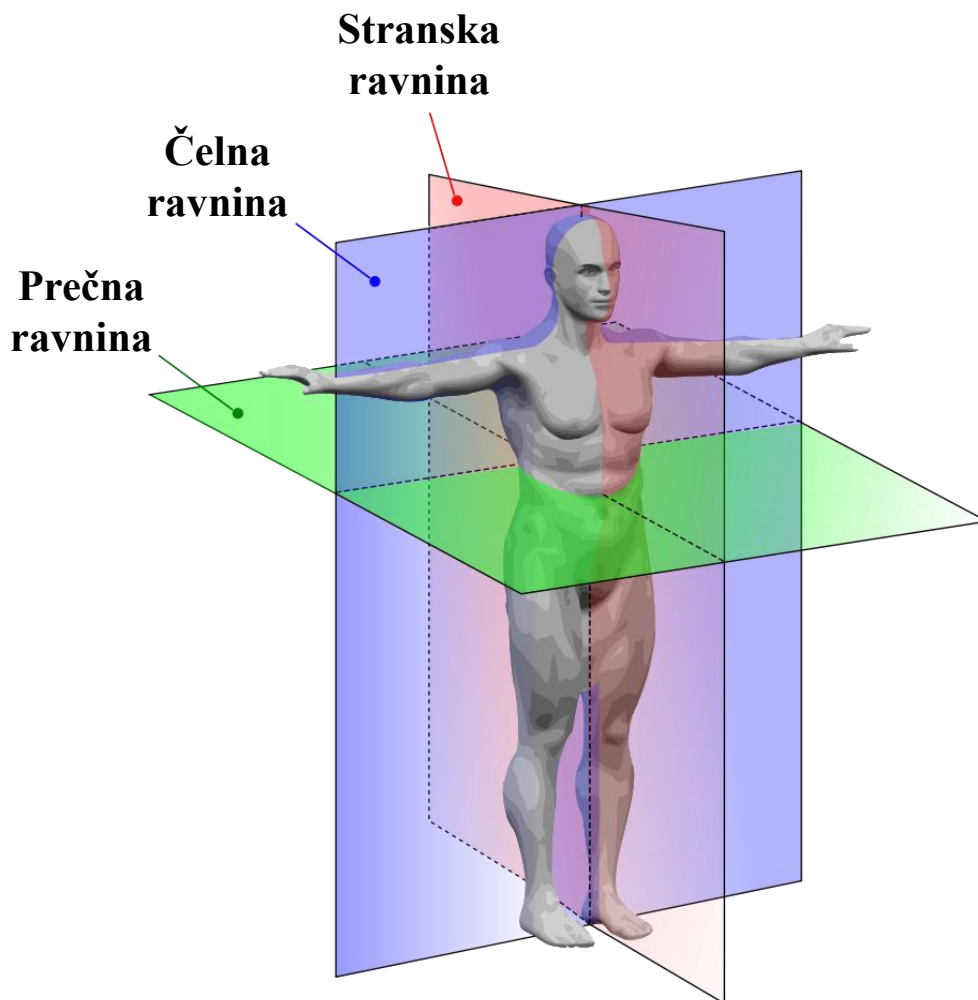
Projekcije

- osnovne projekcije



3D SLIKE

Anatomske ravnine in smeri

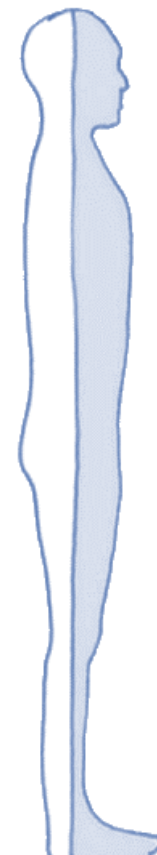


**Stranska
ravnina**



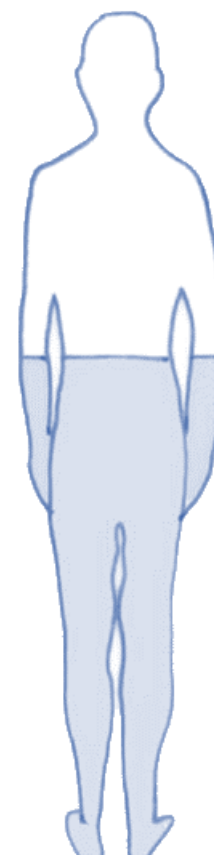
**lateralna,
sagitalna**

**Čelna
ravnina**



**frontalna,
koronalna**

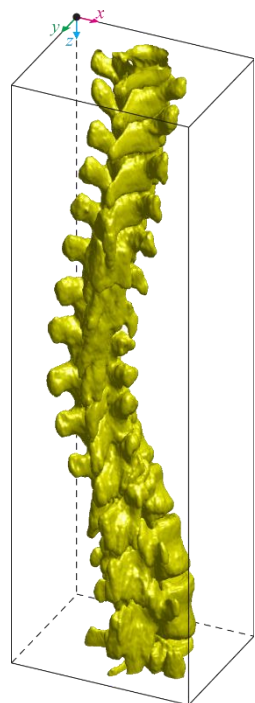
**Prečna
ravnina**



**tranzverzalna,
aksialna**

3D SLIKE

Koordinatni sistem slike



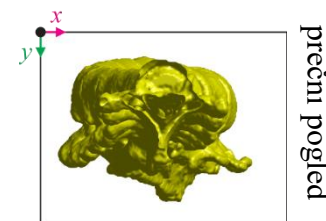
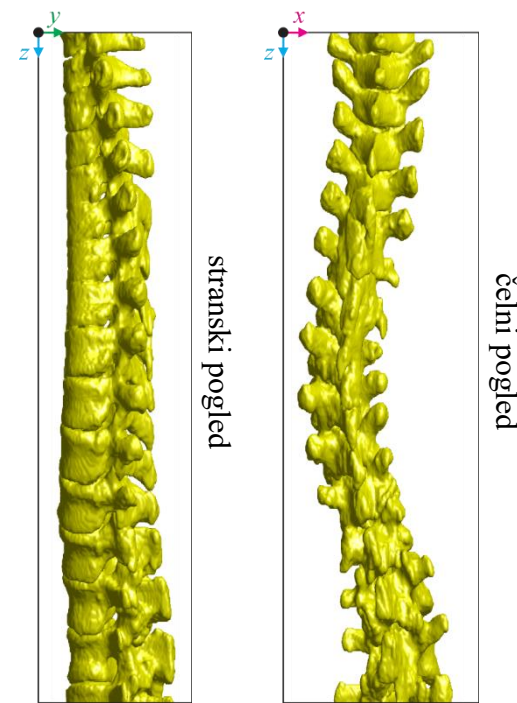
3D pogled

Koordinatni sistem slike:

$$\mathbb{R}_I^3 \rightarrow (x, y, z)$$

Anatomske smeri:

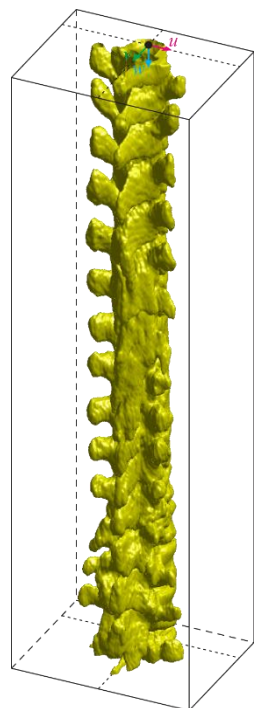
- levo-desno (*angl.* sinistro-dexter axis): x
- naprej-nazaj (*angl.* ventro-dorsal axis): y
- navzgor-navzdol (*angl.* cranio-caudal): z



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3D SLIKE

Koordinatni sistem strukture



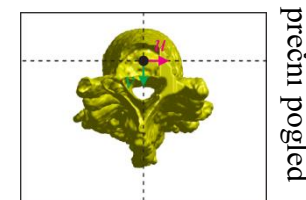
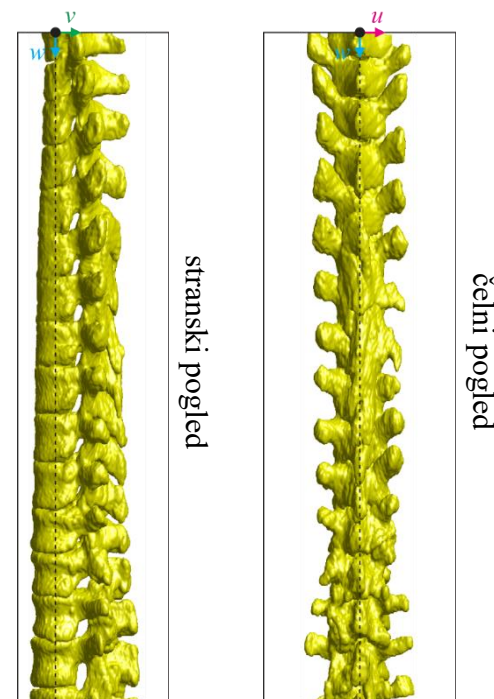
3D pogled

Koordinatni sistem strukture:

$$\mathbb{R}_S^3 \rightarrow (u, v, w)$$

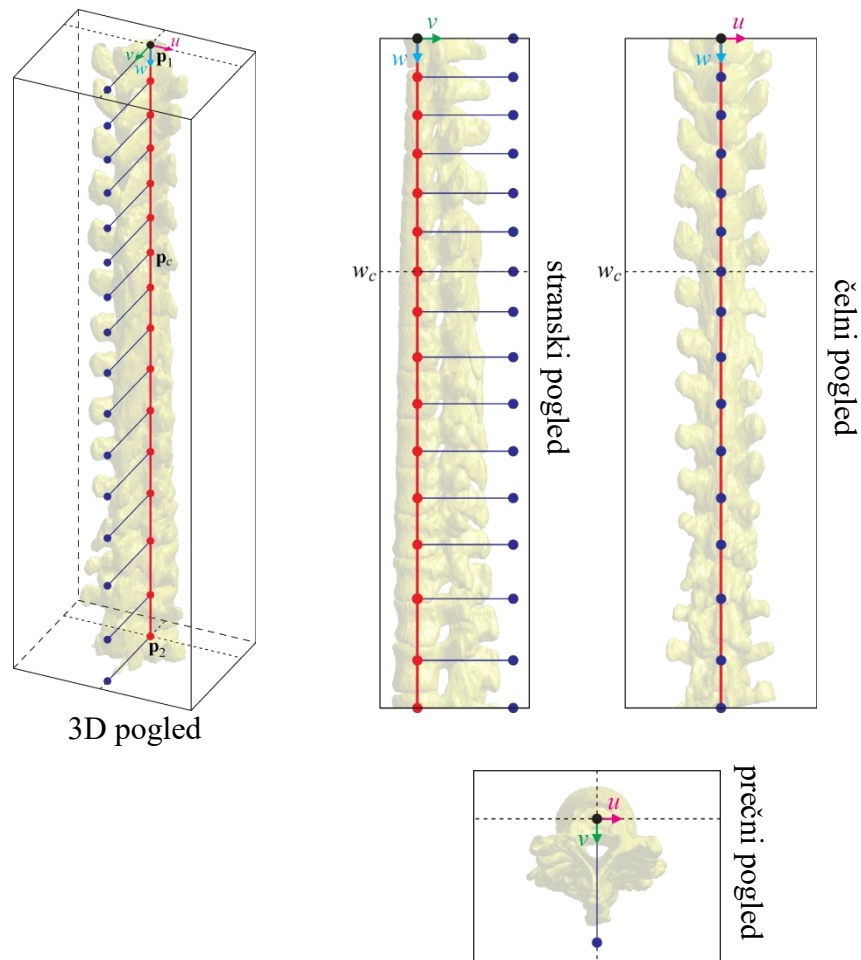
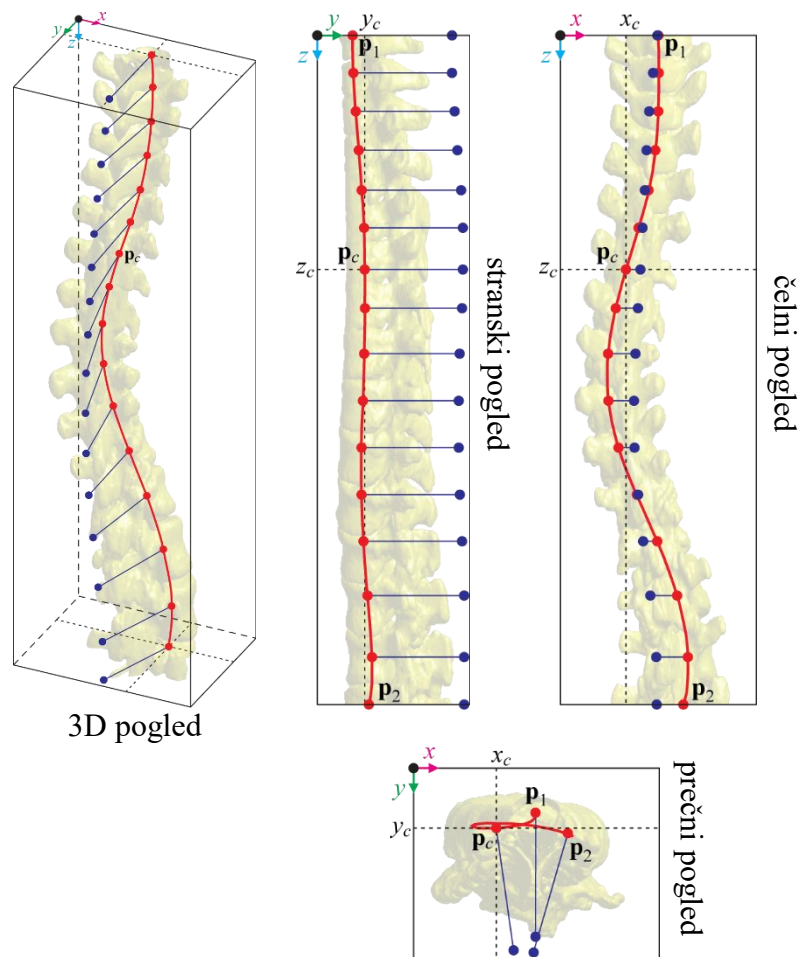
Anatomske smeri:

- levo-desno: u
- naprej-nazaj: v
- navzgor-navzdol: w



3D SLIKE

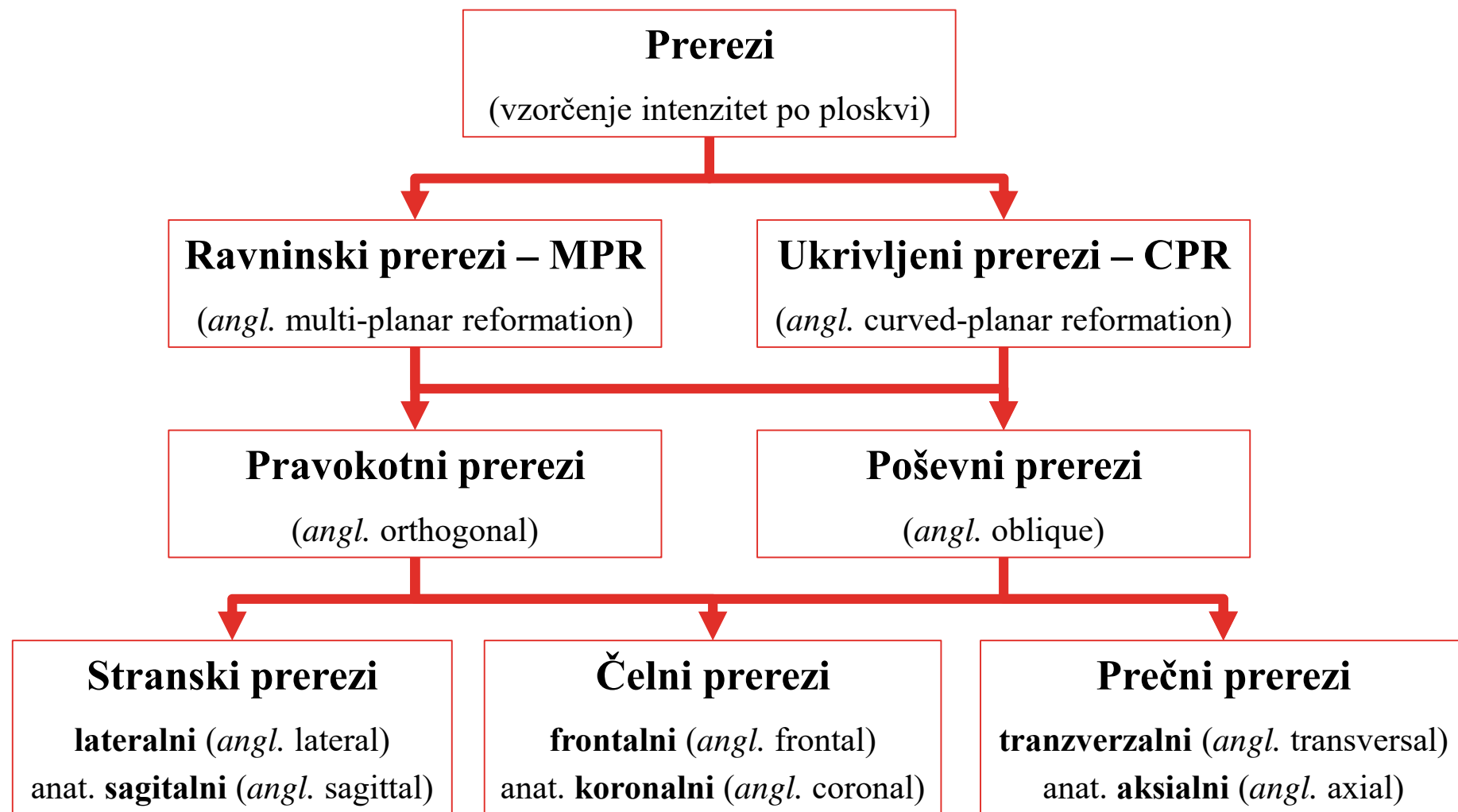
Preslikava koordinatnih sistemov



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PREREZI

Pregled



PREREZI

Ravninski prerezi

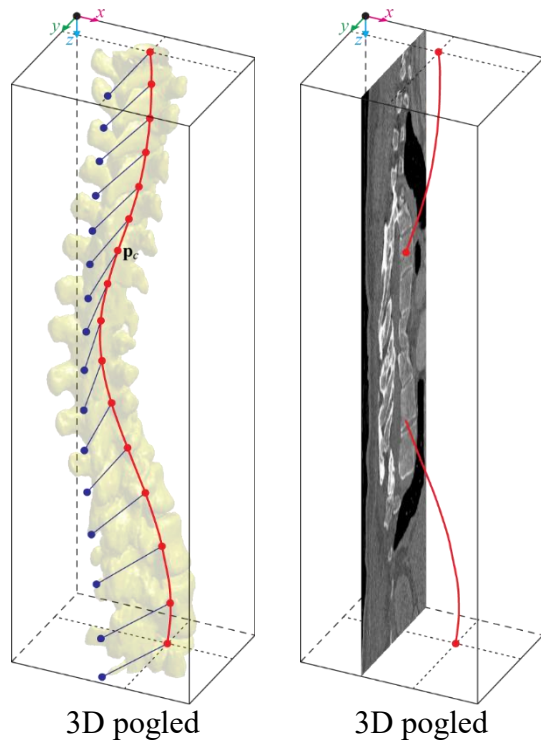


Ravninski prerezi – MPR (*angl.* multi-planar reformation)

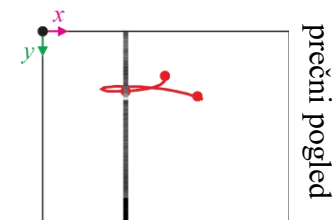
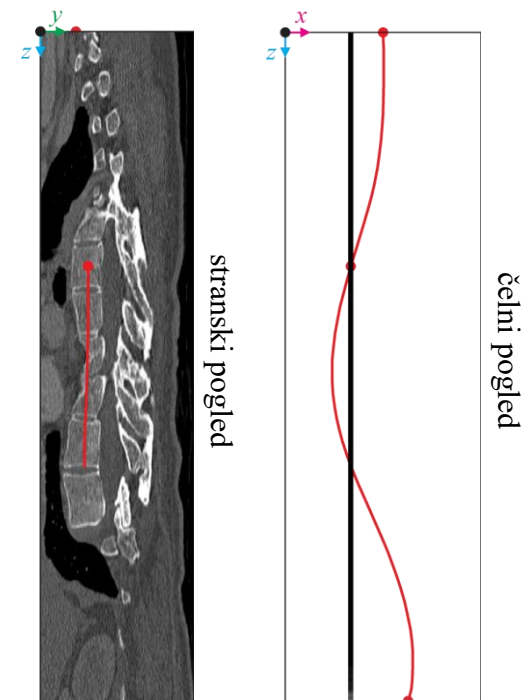
- temeljijo na koordinatnemu sistemu slike
- dve vrsti:
 - **pravokotni ravninski prerezi** (*angl.* **orthogonal MPR**): ravnina vzorčenja je pravokotna na eno od osi koordinatnega sistema slike
 - stranski pravokotni ravninski prerezi
 - čelni pravokotni ravninski prerezi
 - prečni pravokotni ravninski prerezi
 - **poševni ravninski prerezi** (*angl.* **oblique MPR**)
 - stranski poševni ravninski prerezi
 - čelni poševni ravninski prerezi
 - prečni poševni ravninski prerezi
 - (posplošeni poševni ravninski prerezi)

PREREZI

Stranski pravokotni ravninski prerezi



prerez

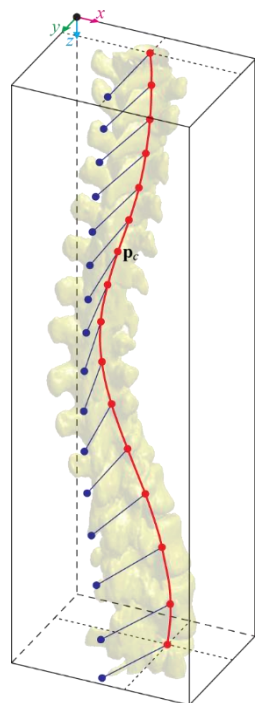


$$M_{x=x_c}(y, z) = I(x_c, y, z)$$

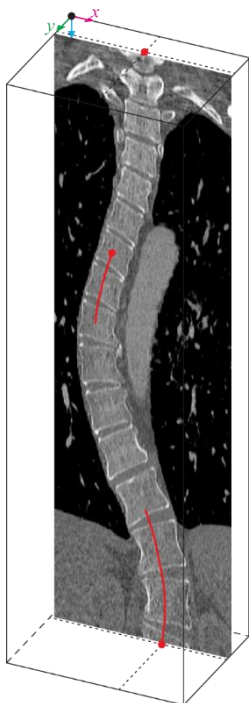
Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images.* Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.

PREREZI

Čelni pravokotni ravninski prerezi



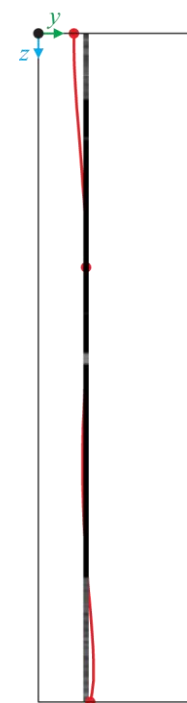
3D pogled



3D pogled



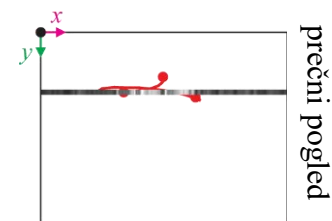
prerez



stranski pogled



čelni pogled



prečni pogled

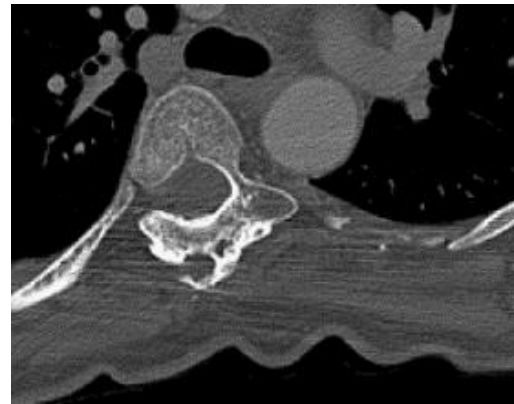
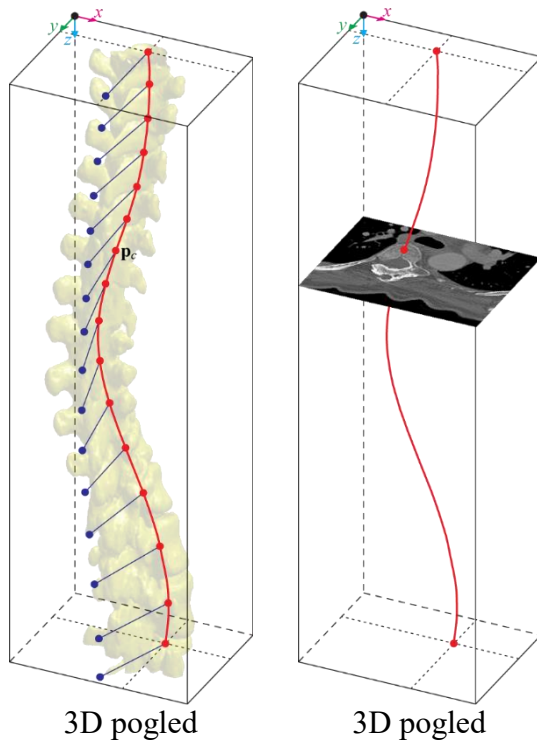
$$M_{y=y_c}(x, z) = I(x, y_c, z)$$

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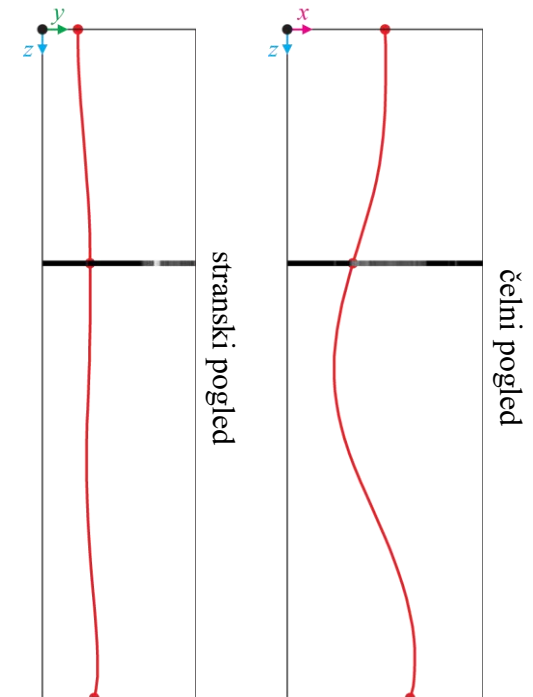


PREREZI

Prečni pravokotni ravninski prerezi



prerez



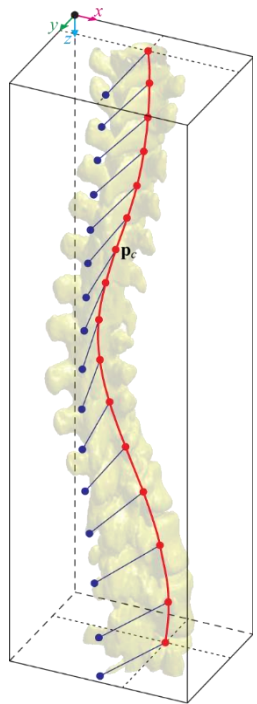
$$M_{z=z_c}(x, y) = I(x, y, z_c)$$

Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images.* Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.



PREREZI

Stranski poševni ravninski prerezi



3D pogled



3D pogled

$$\beta = \beta_p = 0^\circ$$

$$\gamma = \gamma_p = 25^\circ$$



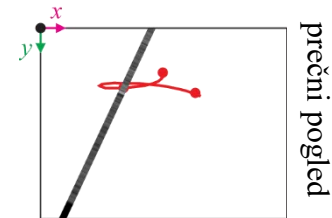
prerez



stranski pogled



čelni pogled



prečni pogled

$$M_{x=x_c, \beta=\beta_p, \gamma=\gamma_p}(y, z) = I(R(0, \beta_p, \gamma_p)[x_c, y, z])$$

$$M_{x=x_c, \beta=\beta_p}(y, z) = I(R(0, \beta_p, 0)[x_c, y, z]) = I(R_y(\beta_p)[x_c, y, z])$$

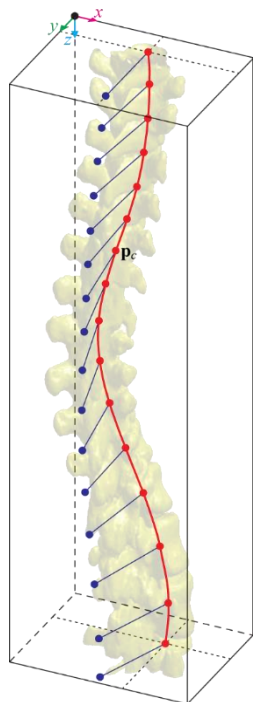
$$M_{x=x_c, \gamma=\gamma_p}(y, z) = I(R(0, 0, \gamma_p)[x_c, y, z]) = I(R_z(\gamma_p)[x_c, y, z])$$

Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*

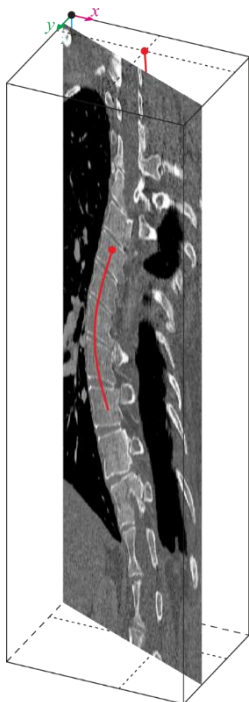


PREREZI

Čelni poševni ravninski prerezi



3D pogled



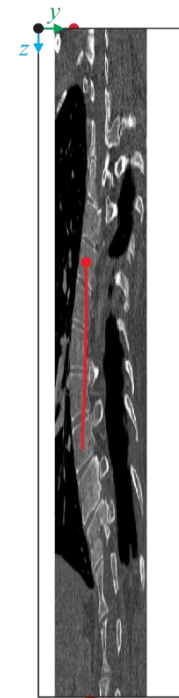
3D pogled

$$\alpha = \alpha_p = 0^\circ$$

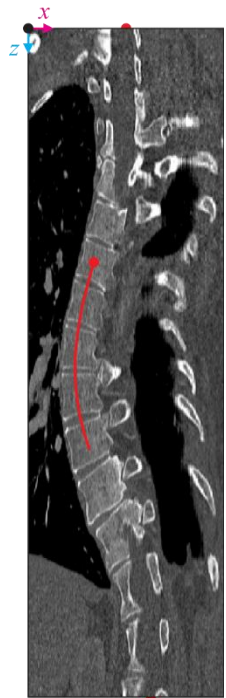
$$\gamma = \gamma_p = 25^\circ$$



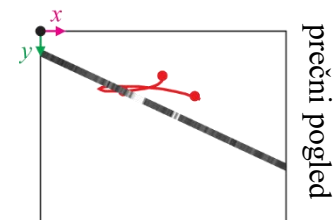
prerez



stranski pogled



čelni pogled



prečni pogled

$$M_{y=y_c, \alpha=\alpha_p, \gamma=\gamma_p}(x, z) = I(R(\alpha_p, 0, \gamma_p)[x, y_c, z])$$

$$M_{y=y_c, \alpha=\alpha_p}(x, z) = I(R(\alpha_p, 0, 0)[x, y_c, z]) = I(R_x(\alpha_p)[x, y_c, z])$$

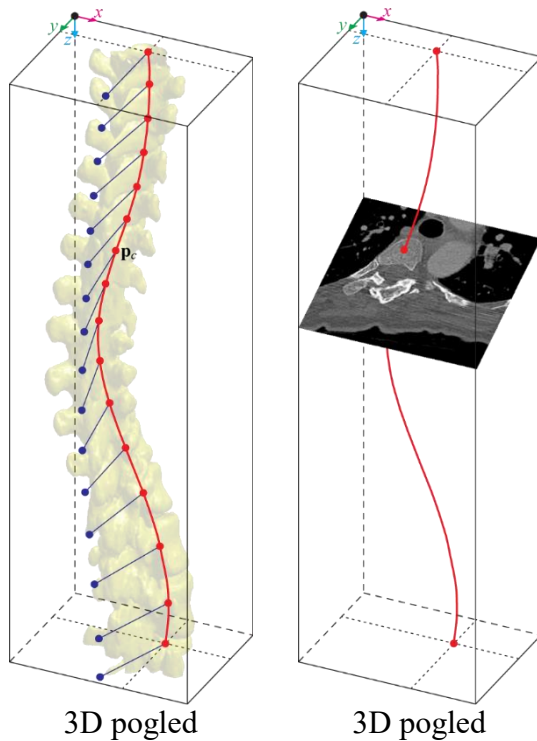
$$M_{y=y_c, \gamma=\gamma_p}(x, z) = I(R(0, 0, \gamma_p)[x, y_c, z]) = I(R_z(\gamma_p)[x, y_c, z])$$

Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*



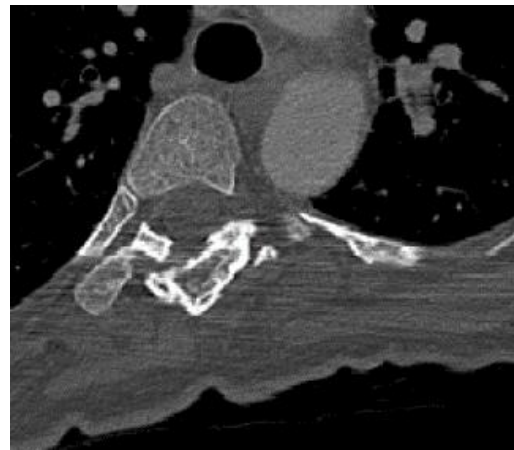
PREREZI

Prečni poševni ravninski prerezi

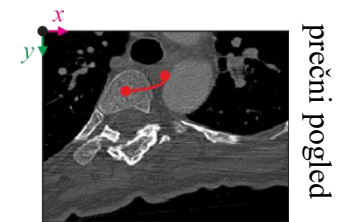
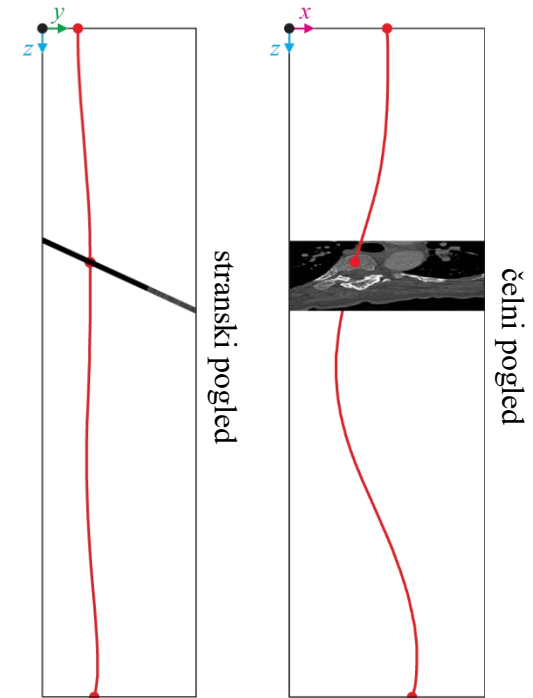


$$\alpha = \alpha_p = 25^\circ$$

$$\beta = \beta_p = 0^\circ$$



prerez



$$M_{z=z_c, \alpha=\alpha_p, \beta=\beta_p}(x, y) = I(R(\alpha_p, \beta_p, 0)[x, y, z_c])$$

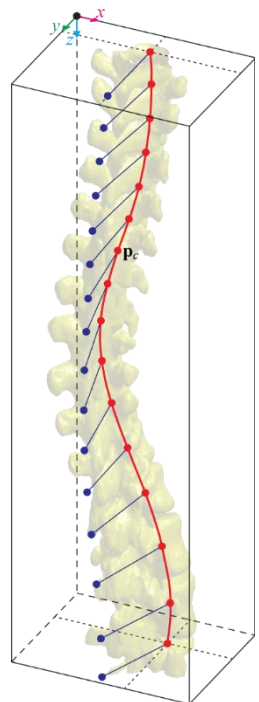
$$M_{z=z_c, \alpha=\alpha_p}(x, y) = I(R(\alpha_p, 0, 0)[x, y, z_c]) = I(R_x(\alpha_p)[x, y, z_c])$$

$$M_{z=z_c, \beta=\beta_p}(x, y) = I(R(0, \beta_p, 0)[x, y, z_c]) = I(R_y(\beta_p)[x, y, z_c])$$

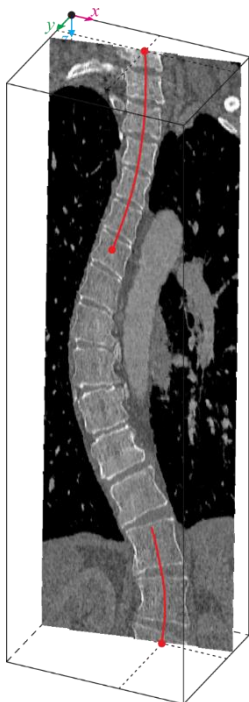
Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*

PREREZI

Posplošeni poševni ravninski prerezi



3D pogled

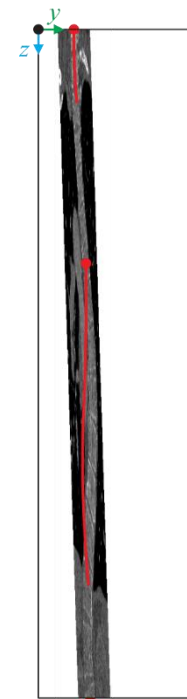


3D pogled

$$M_{\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3}^s$$



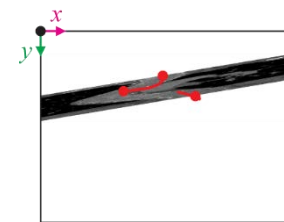
prerez



stranski pogled



čelni pogled



prečni pogled

$$M_{\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3}^n(y, z) = I(R^n[x_j, y, z])$$

$$M_{\mathbf{p}_1, \mathbf{p}_2, \mathbf{p}_3}^s(x, z) = I(R^s[x, y_j, z])$$

Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*



PREREZI

Ukrivljeni prerezi

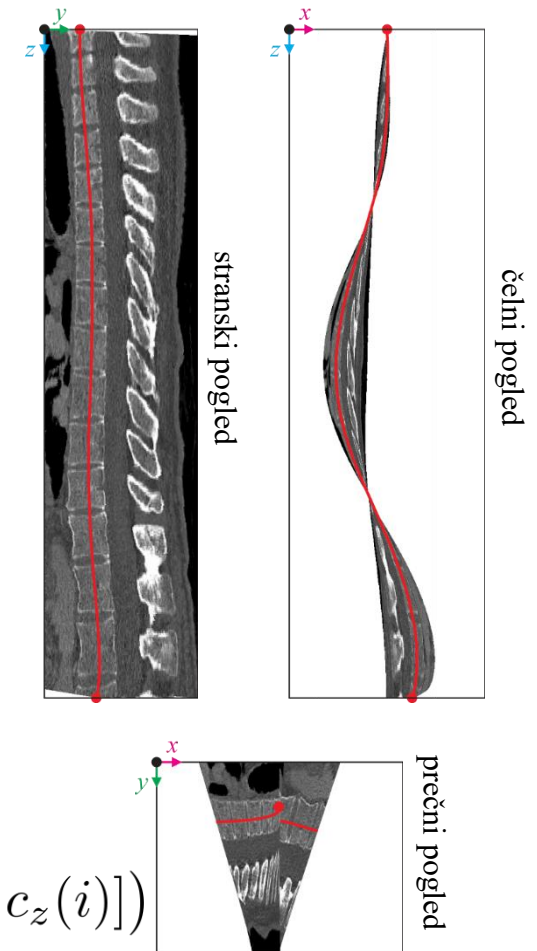
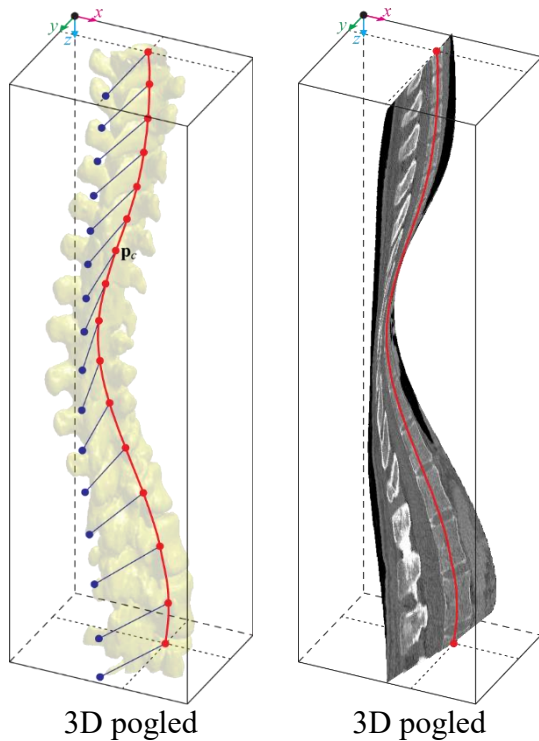
Ukrivljeni prerezi – CPR (*angl.* curved-planar reformation)

- temeljijo na koordinatnemu sistemu opazovane strukture
- dve vrsti:
 - **pravokotni ukrivljeni prerezi** (*angl.* orthogonal CPR)
 - stranski pravokotni ukrivljeni prerezi
 - čelni pravokotni ukrivljeni prerezi
 - prečni pravokotni ukrivljeni prerezi
 - **poševni ukrivljeni prerezi** (*angl.* oblique CPR)
 - stranski poševni ukrivljeni prerezi
 - čelni poševni ukrivljeni prerezi
 - prečni poševni ukrivljeni prerezi



PREREZI

Stranski pravokotni ukrivljeni prerezi



$$C_{u=u_c}(v, w) = I(u_c, v, w)$$

$$C_{u=u_c}(y, c_z(i)) = I(R_{\hat{t}(i)}(\varphi(i)) R_x(\alpha(i)) [c_x(i) + \Delta x, y, c_z(i)])$$

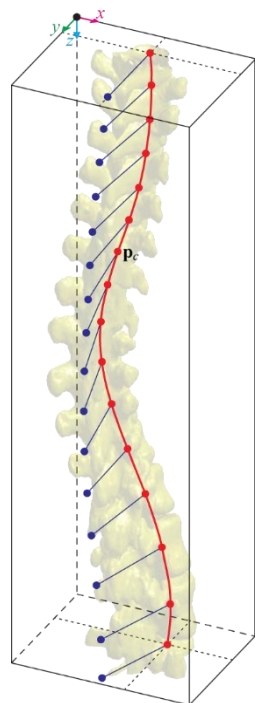
$$C_{u=u_c}(y, c_z(i)) = I(R_z(\varphi(i)) [c_x(i) + \Delta x, y, c_z(i)])$$

Vrtovec T: Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.

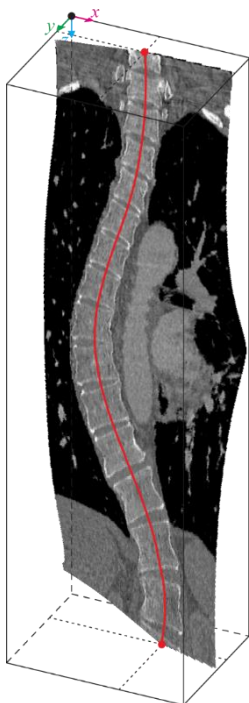


PREREZI

Čelni pravokotni ukrivljeni prerezi



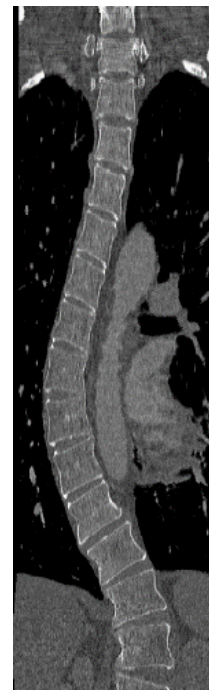
3D pogled



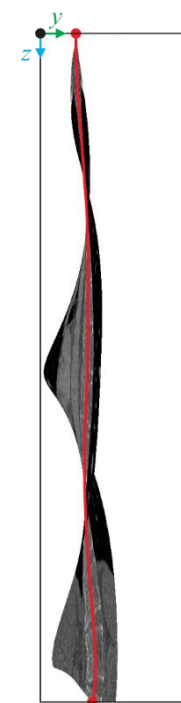
3D pogled



prerez



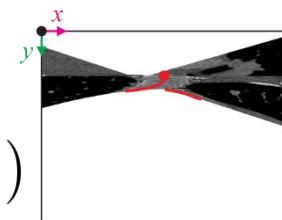
prerez



stranski pogled



čelni pogled



prečni pogled

$$C_{v=v_c}(u, w) = I(u, v_c, w)$$

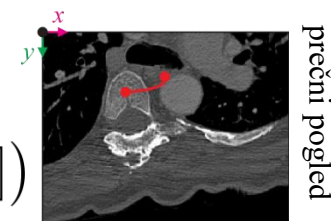
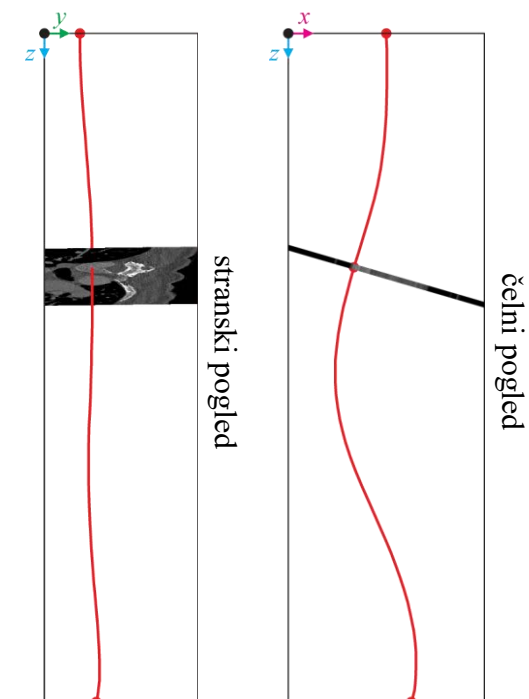
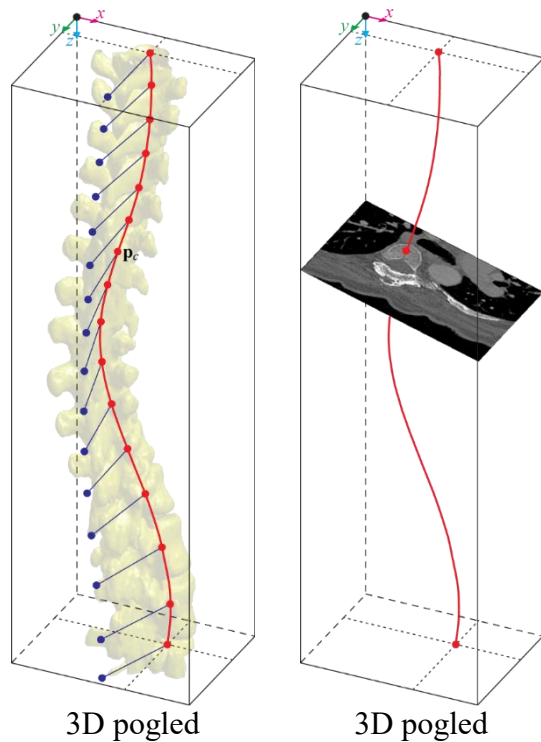
$$C_{v=v_c}(x, c_z(i)) = I(R_{\hat{t}_{(i)}}(\varphi(i)) R_y(\beta(i)) [x, c_y(i) + \Delta y, c_z(i)])$$

$$C_{v=v_c}(x, c_z(i)) = I(R_z(\varphi(i)) [x, c_y(i) + \Delta y, c_z(i)])$$

Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*

PREEREZI

Prečni pravokotni ukrivljeni prerezi



$$C_{w=w_c}(u, v) = I(u, v, w_c)$$

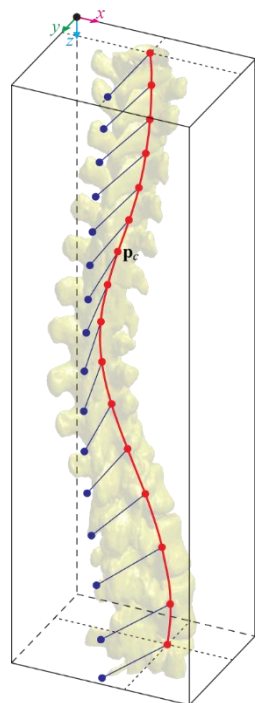
$$C_{w=w_c}(x, y) = I(R_{\hat{t}(i)}(\varphi(i_p)) R_y(\beta(i_p)) R_x(\alpha(i_p)) [x, y, c_z(i_p)])$$

$$C_{w=w_c}(x, y) = I(R(\alpha(i_p), \beta(i_p), \varphi(i_p)) [x, y, c_z(i_p)])$$

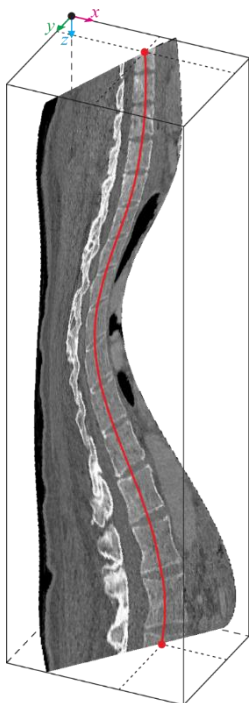
Vrtovec T: Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.

PREREZI

Stranski poševni ukrivljeni prerezi



3D pogled



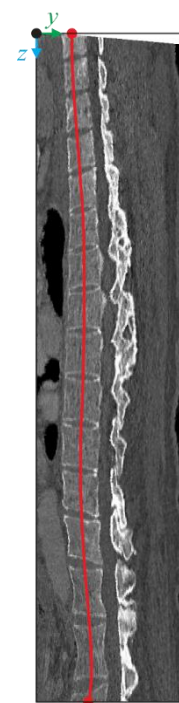
3D pogled



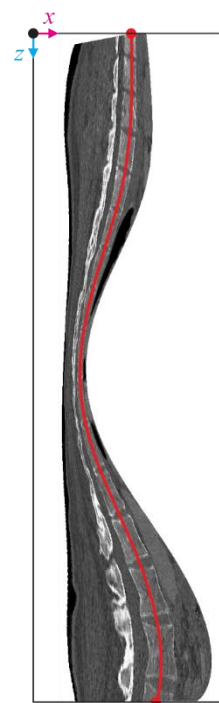
prerez



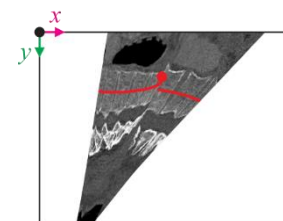
prerez



stranski pogled



čelni pogled



prečni pogled

$$C_{u=u_c, \phi=\phi_p}(v, w) = I(R_w(\phi_p)[u_c, v, w])$$

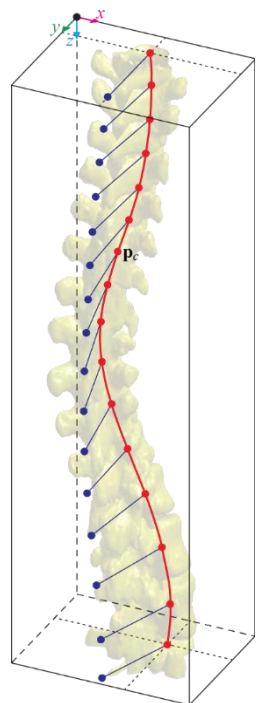
$$C_{u=u_c, \phi=\phi_p}(y, c_z(i)) = I(R_{\hat{t}(i)}(\varphi(i) + \phi_p) R_x(\alpha(i)) [c_x(i) + \Delta x, y, c_z(i)])$$

$$C_{u=u_c, \phi=\phi_p}(y, c_z(i)) = I(R_z(\varphi(i) + \phi_p) [c_x(i) + \Delta x, y, c_z(i)])$$

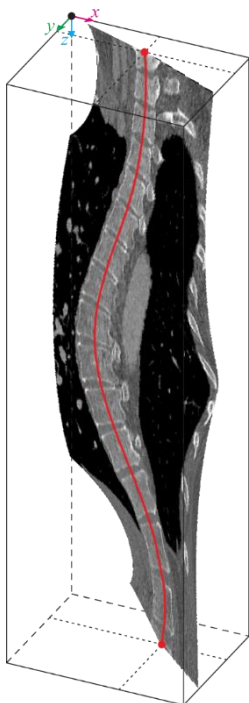
Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*

PREREZI

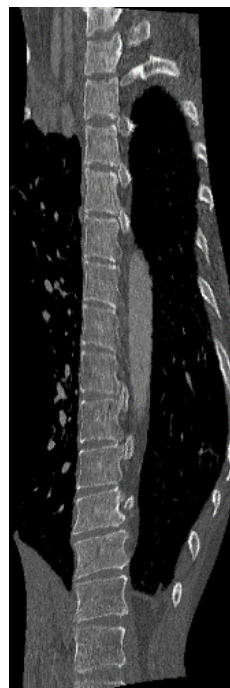
Čelni poševni ukrivljeni prerezi



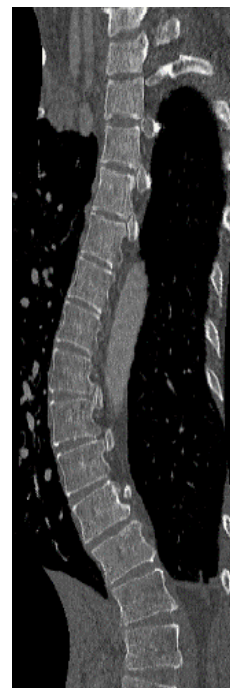
3D pogled



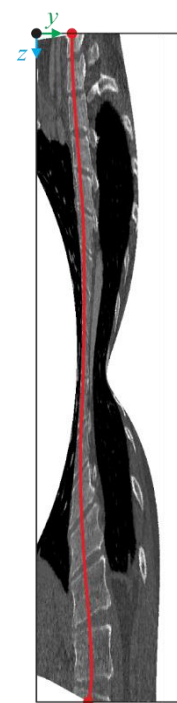
3D pogled



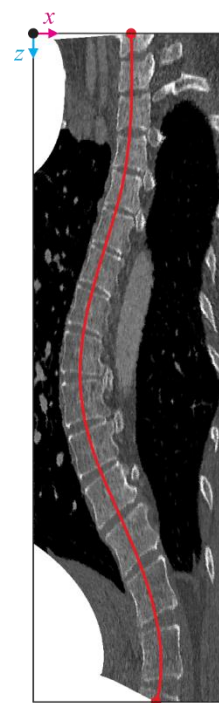
prerez



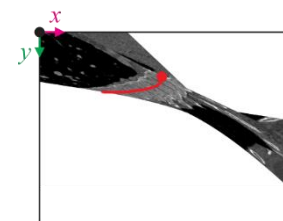
prerez



stranski pogled



čelni pogled



prečni pogled

$$C_{v=v_c, \phi=\phi_p}(u, w) = I(R_w(\phi_p)[u, v_c, w])$$

$$C_{v=v_c, \phi=\phi_p}(x, c_z(i)) = I(R_{\hat{t}(i)}(\varphi(i) + \phi_p) R_y(\beta(i)) [x, c_y(i) + \Delta y, c_z(i)])$$

$$C_{v=v_c, \phi=\phi_p}(x, c_z(i)) = I(R_z(\varphi(i) + \phi_p) [x, c_y(i) + \Delta y, c_z(i)])$$

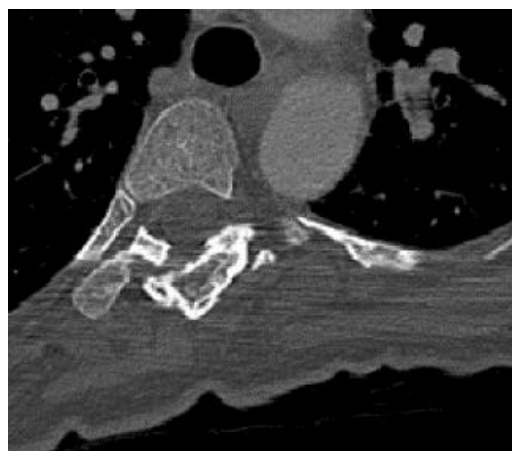
Vrtovec T: Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.

PREREZI

Prečni poševni ukrivljeni prerezi



Enaki prečnim poševnim ravninskim prerezom, pri čemer so centrirani v izbrani točki $\mathbf{p}_c = (u_c, v_c, w_c)$ na krivulji.



prerez

Vrtovec T: *Automated Determination of the Spine-Based Coordinate System for an Efficient Cross-Sectional Visualization of 3D Spine Images. Spinal Imaging and Image Analysis. Li S, Yao J (ur.), Springer, 2015.*

PROJEKCIJE

Vrste projekcij



Ravninske projekcije

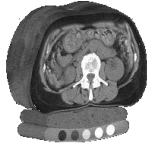
- temeljijo na koordinatnemu sistemu slike
- dve vrsti:
 - **pravokotne ravninske projekcije** (stranska, čelna, prečna)
 - **poševne ravninske projekcije** (stranske, čelne, prečne)

Ukrivljene projekcije

- temeljijo na koordinatnemu sistemu opazovane strukture
- dve vrsti:
 - **pravokotne ukrivljene projekcije** (stranska, čelna, prečna)
 - **poševne ukrivljene projekcije** (stranske, čelne, prečne)

LABORATORIJSKE VAJE

Prikazovanje 3D slik v 2D

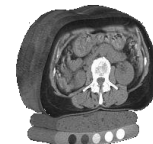


3D slike človeškega telesa, pridobljene s slikovno tehniko računalniške tomografije (CT):

- Nalaganje 3D slik v 3D matriko.
- Pridobivanje in prikazovanje 2D pravokotnih ravninskih prerezov (stranski, čelni, prečni).
- Pridobivanje in prikazovanje 2D pravokotnih ravninskih projekcij (stranske, čelne, prečne) na osnovi poljubne funkcije točk (npr. maksimalna vrednost, povprečna vrednost, ...).

LABORATORIJSKE VAJE

Primer

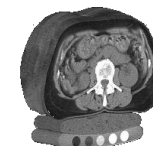


Pravokotni
ravninski prerezi

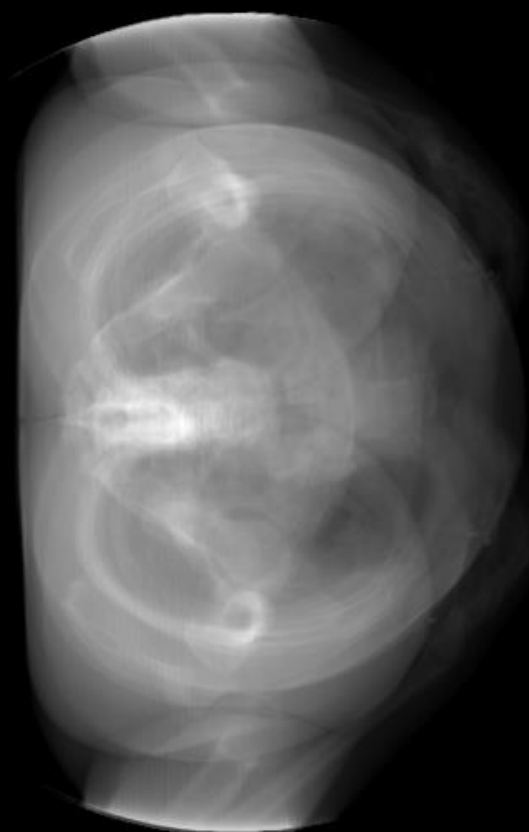


LABORATORIJSKE VAJE

Primer

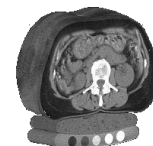


Pravokotne projekcije
povprečnih vrednosti



LABORATORIJSKE VAJE

Primer



Pravokotne projekcije
maksimalnih vrednosti

