

XXXIII CONGRESSO NAZIONALE AIRO

AIRO2023

BOLOGNA,
27-29 OTTOBRE 2023

PALAZZO DEI CONGRESSI

Radioterapia Oncologica: l'evoluzione al servizio dei pazienti

Gemelli



ART

Advanced Radiation
Therapy

Fondazione Policlinico Universitario Agostino Gemelli IRCCS
Università Cattolica del Sacro Cuore

Image Registration

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Radioterapia e Oncologia clinica

DICHIARAZIONE

Relatore: Nicola Dinapoli

Come da nuova regolamentazione della Commissione Nazionale per la Formazione Continua del Ministero della Salute, è richiesta la trasparenza delle fonti di finanziamento e dei rapporti con soggetti portatori di interessi commerciali in campo sanitario.

- Posizione di dipendente in aziende con interessi commerciali in campo sanitario **(NIENTE DA DICHIARARE)**
- Consulenza ad aziende con interessi commerciali in campo sanitario **(NIENTE DA DICHIARARE)**
- Fondi per la ricerca da aziende con interessi commerciali in campo sanitario **(Varian Medical System)**
- Partecipazione ad Advisory Board **(NIENTE DA DICHIARARE)**
- Titolarità di brevetti in compartecipazione ad aziende con interessi commerciali in campo sanitario **(NIENTE DA DICHIARARE)**
- Partecipazioni azionarie in aziende con interessi commerciali in campo sanitario **(NIENTE DA DICHIARARE)**
- Altro

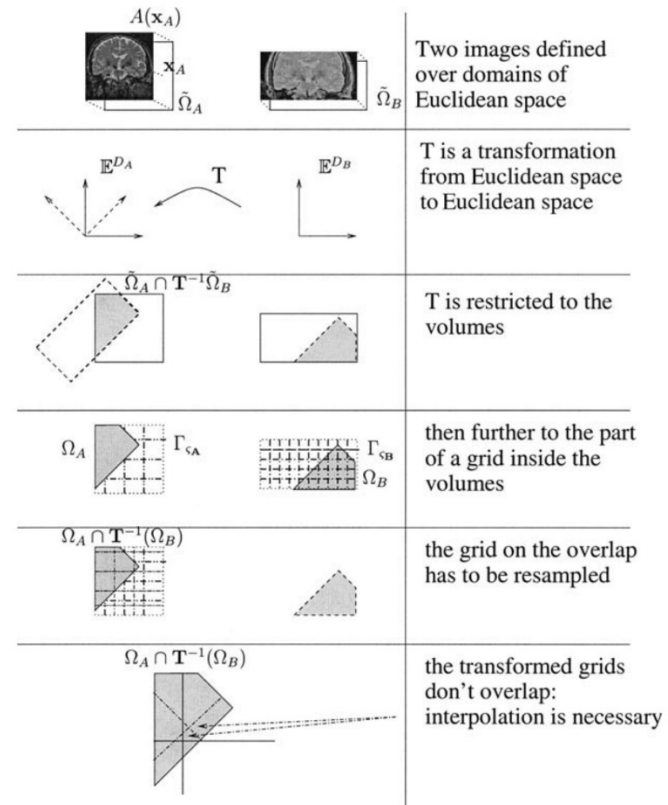
Definition: image registration is the process of transforming different sets of data into one coordinate system. Data may be multiple photographs, data from different sensors, times, depths, or viewpoints. Registration is necessary in order to be able to compare or integrate the data obtained from these different measurements.

Richard Szeliski, Image Alignment and Stitching: A Tutorial. Foundations and Trends in Computer Graphics and Computer Vision, 2:1-104, 2006.

Rigid registration:

1. scaling
2. 6 degree of freedom roto-translation
3. interpolation

Hajnal, J. V., Hill, D. L. G., & Hawkes, D. J. (2001).
Medical image registration. *Medical Image Registration*,
46, 1–383.

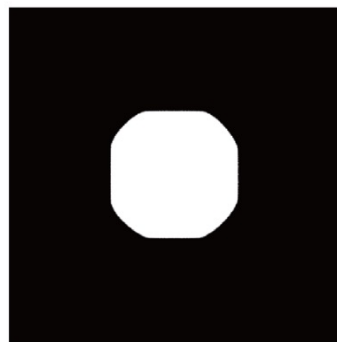


Deformable registration:

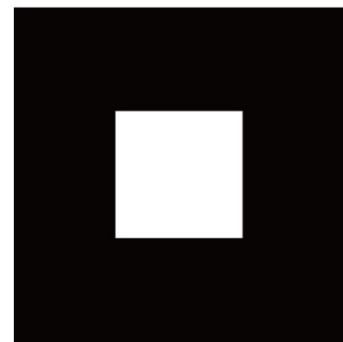
Identifies the spatial correspondence in order to minimize the differences between two or among multiple sets of images.

It introduces geometric *transformation*.

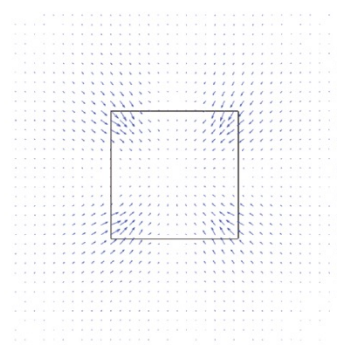
Dowling, J. A., & O'Connor, L. M. (2020). Deformable image registration in radiation therapy. *Journal of Medical Radiation Sciences*, 67(4), 257–259.



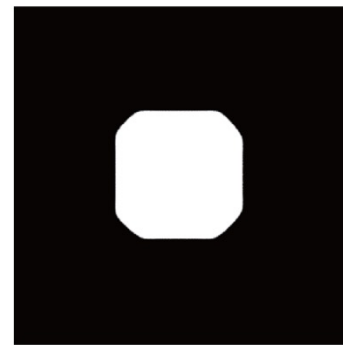
A



B

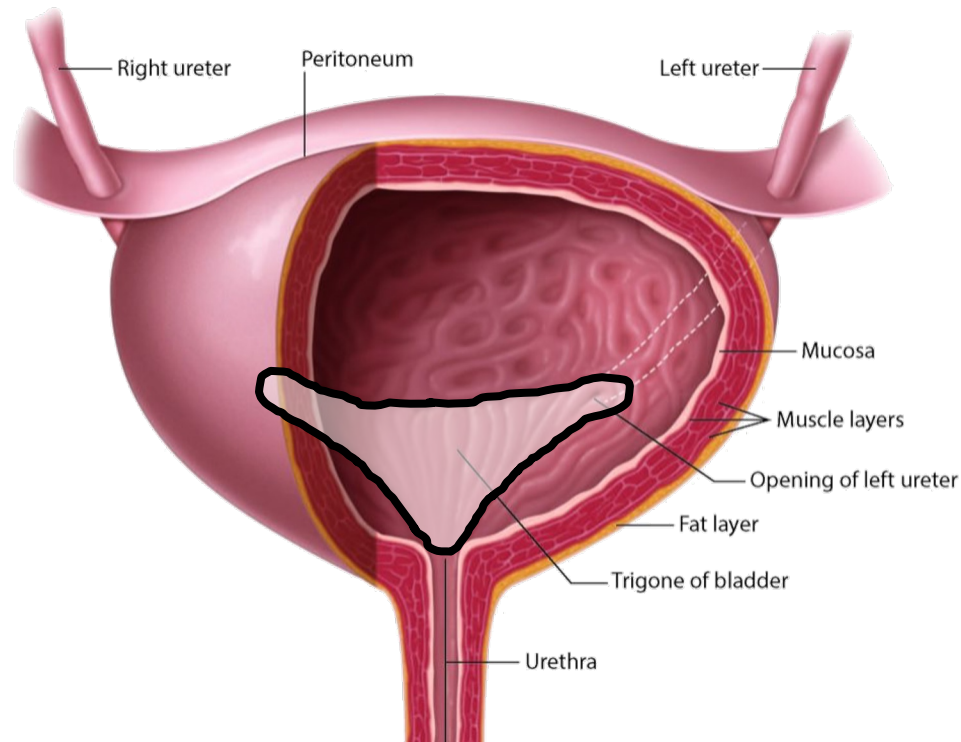


C

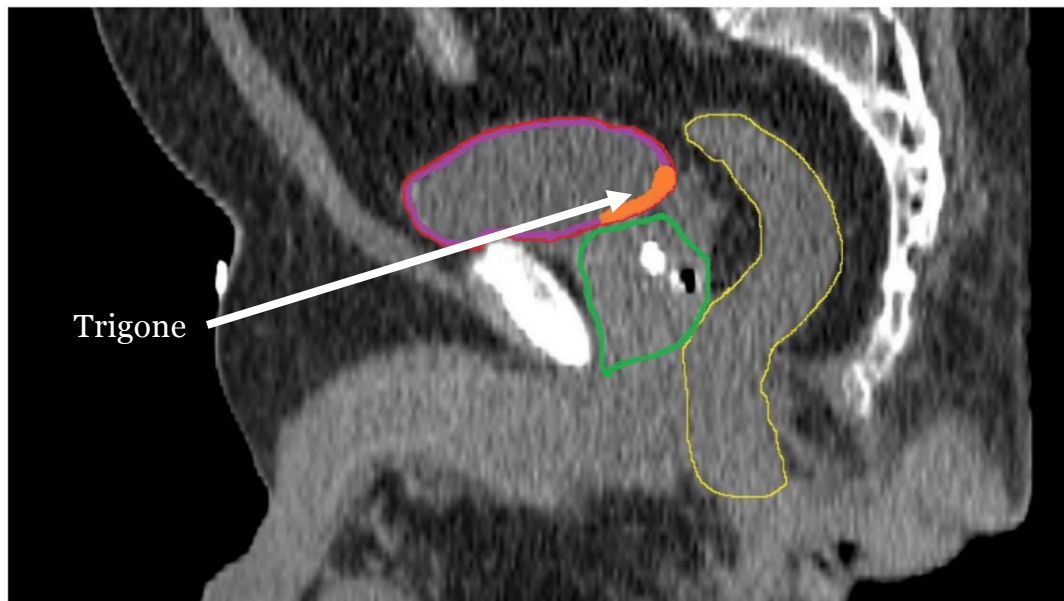


D

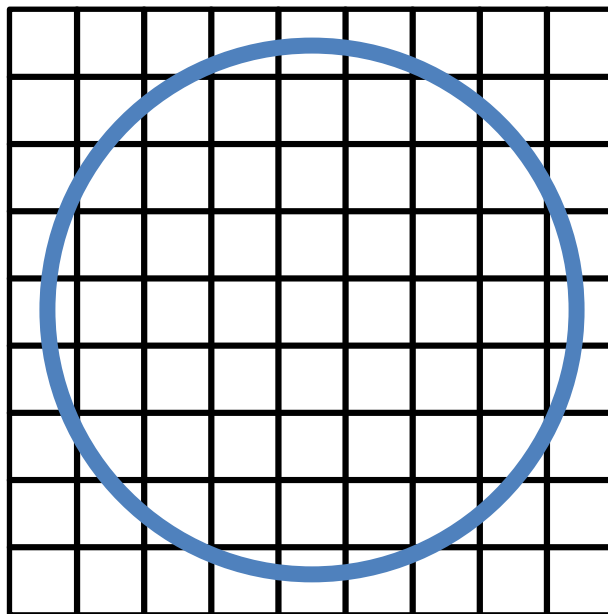
Deformable registration: The “bladder case”



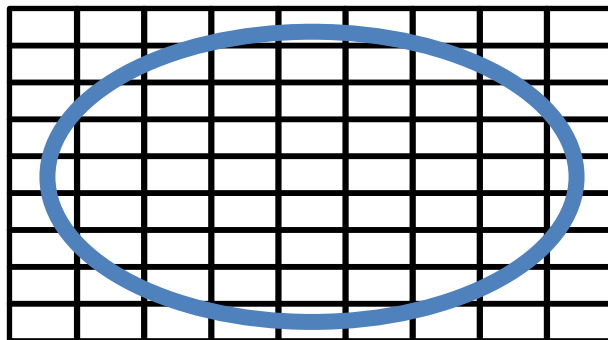
Deformable registration: The “bladder case”



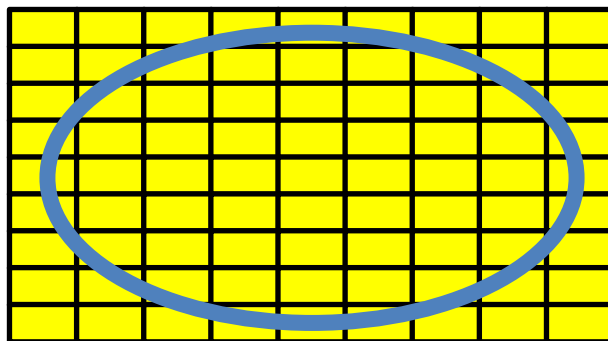
How does bladder deform itself?



How does bladder deform itself?



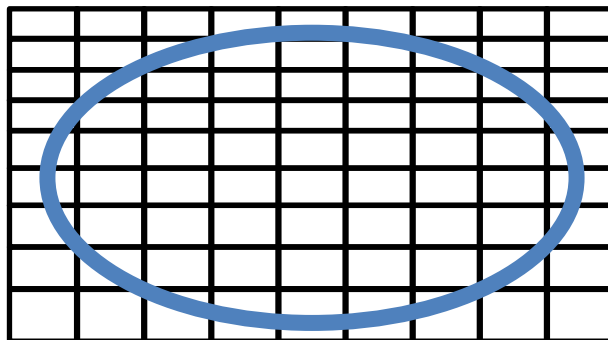
How does bladder deform itself?



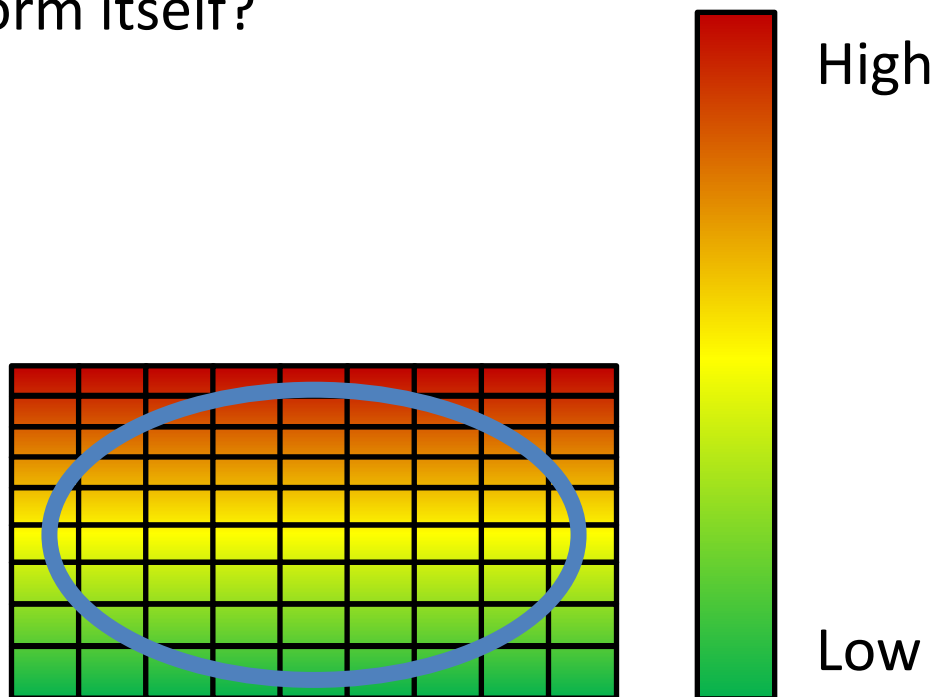
High

Low

How does bladder deform itself?



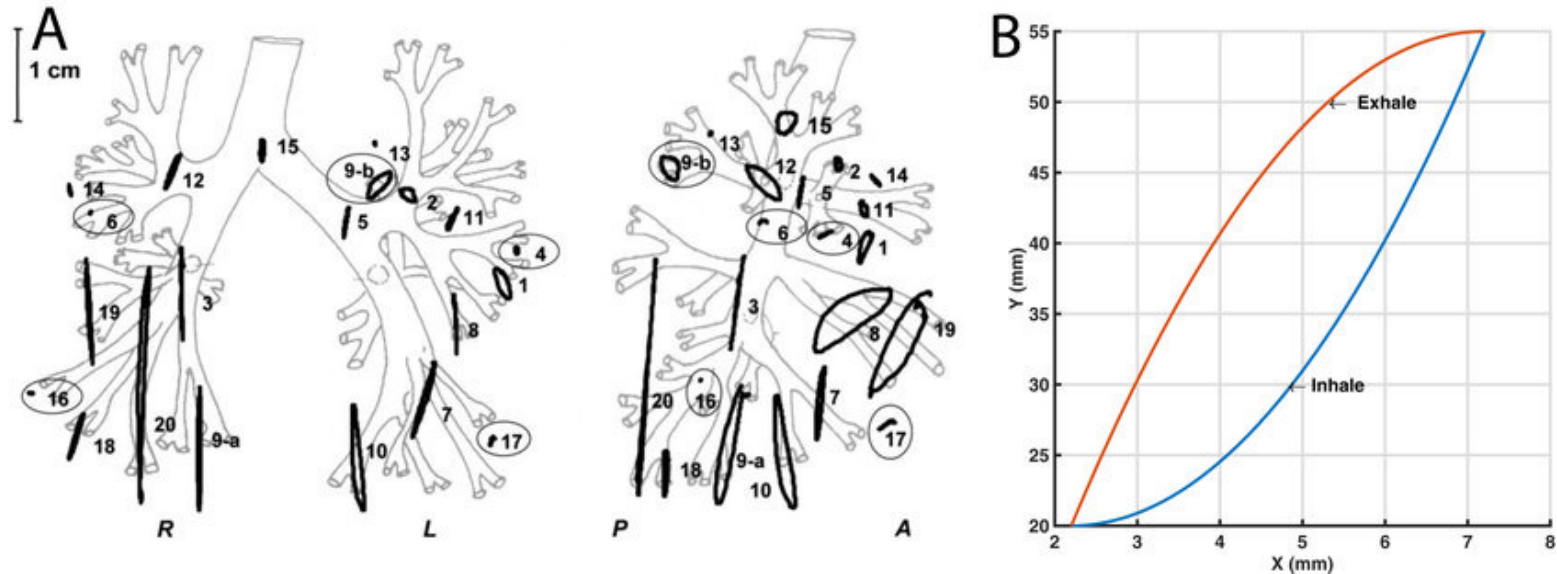
How does bladder deform itself?



These artifacts can affect different steps in radiotherapy planning and treatment:

- 1) Structure reconstruction (e.g. by CBCT)
- 2) Online and offline adaptation
- 3) Online and offline dose distribution adaptive summation
- 4) Hollow organs or lungs registrations

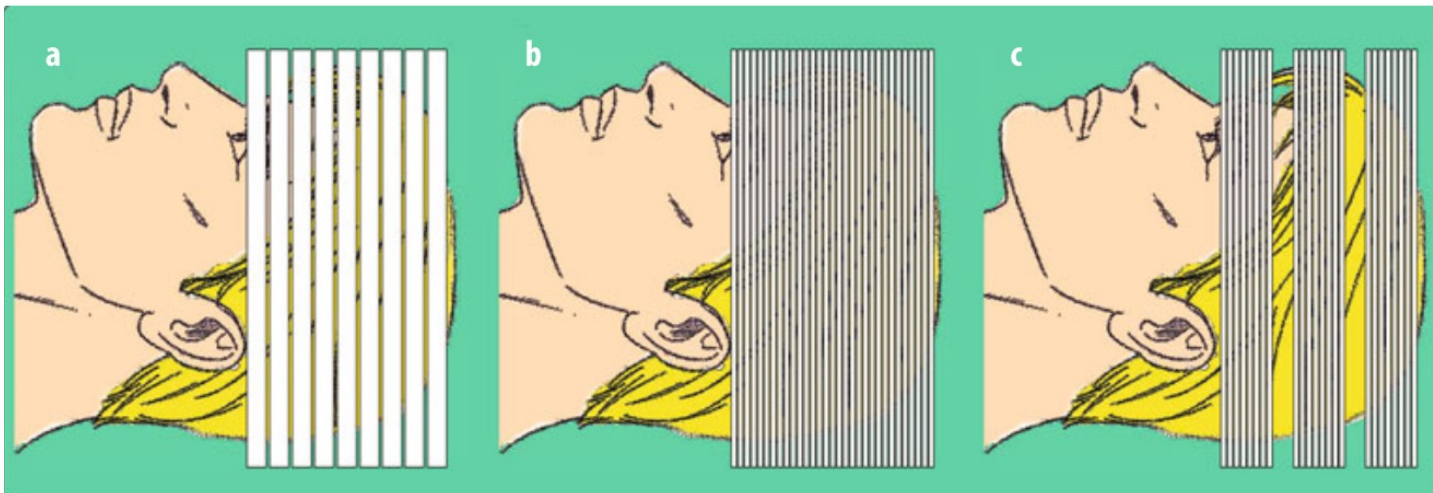
Lung hysteresis



Escolar, J. D. D., & Escolar, A. (2004). Lung hysteresis: A morphological view. *Histology and Histopathology*, 19(1), 159–166.

Image registration problems: what kind of imaging?

1. MR for brain – choose the sequence according delineation needs
(T1c – T2 – FLAIR – FSPGR)
2. MR for brain – 3D or 2D?



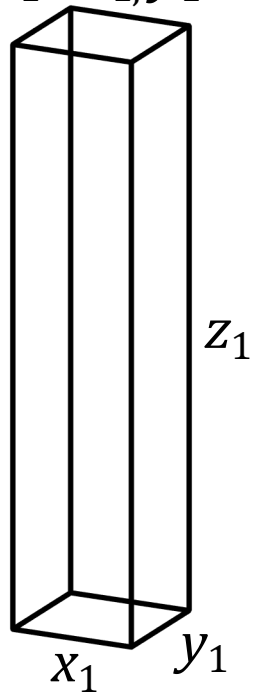
2D

3D

3D - multislab

Coriasco M, et al., Elementi di Risonanza Magnetica, Springer, 2014

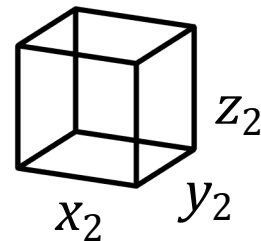
$$z_1 > x_1, y_1$$



z_1

$$x_1 < x_2$$

$$z_2 = x_2, y_2$$

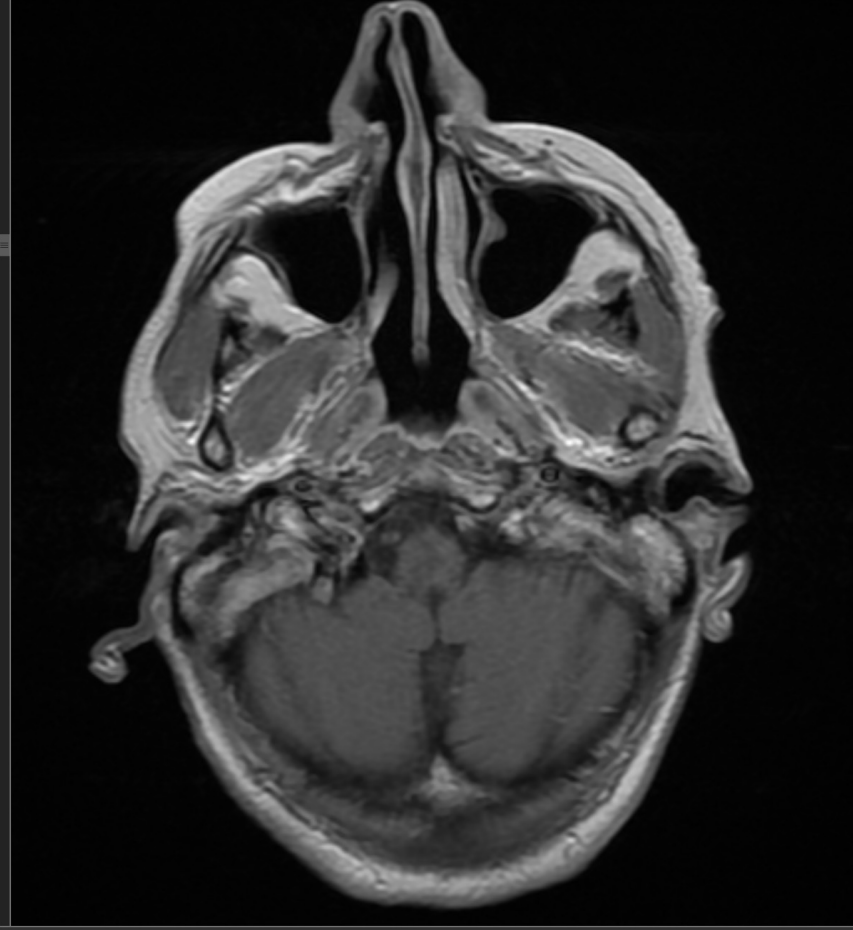
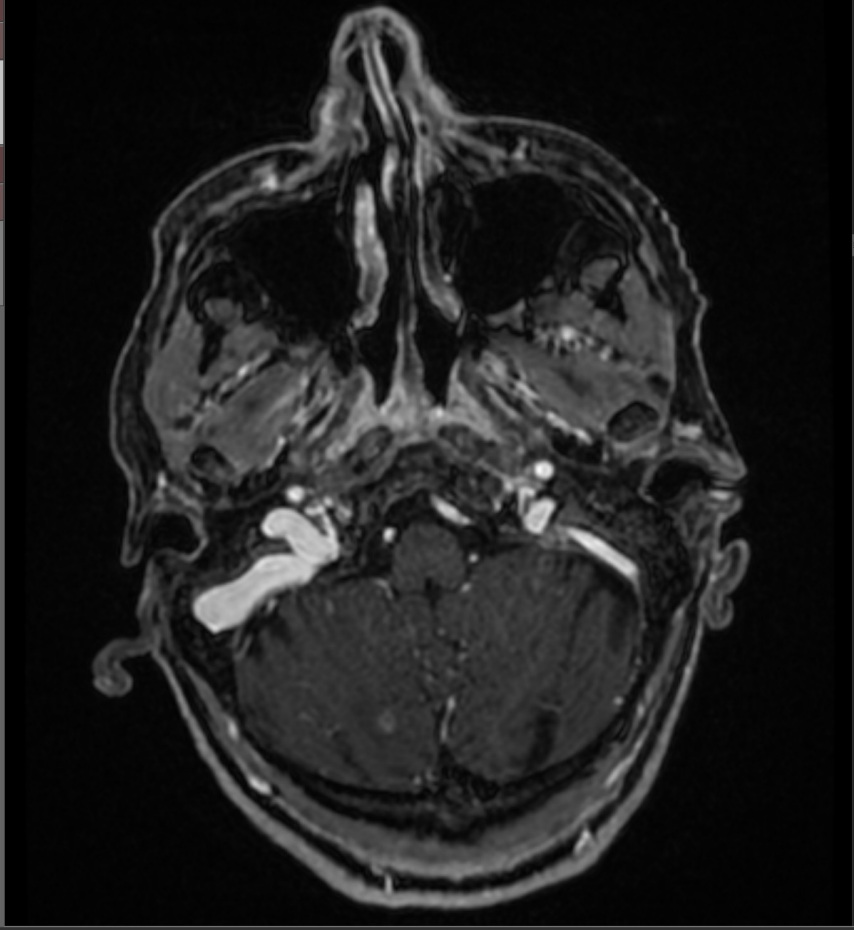


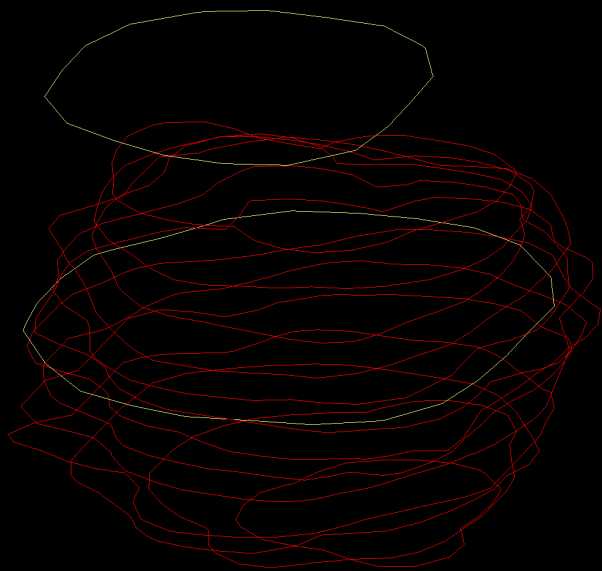
3D FSPGR

Morphological
T1 – T2*

2D

3D





Wires



3D model

Partial volume artifact

Signal
Intensity

Z coordinates FSPGR

FSPGR z	FSPGR val	T1c val	T1c z
0	10	68	0
0,5	12	68	0
1	15	68	0
1,5	27	68	0
2	28	68	0
2,5	26	68	0
3	168	68	0
3,5	258	68	0
4	285	160,375	4
4,5	284	160,375	4
5	274	160,375	4
5,5	223	160,375	4
6	78	160,375	4
6,5	64	160,375	4
7	52	160,375	4
7,5	23	160,375	4
8	10	22,5	8
8,5	7	22,5	8
9	12	22,5	8
9,5	78	22,5	8
10	15	22,5	8
10,5	33	22,5	8
11	15	22,5	8
11,5	10	22,5	8

Z coordinates T1c

Consider a voxel that contains fractional amounts f_A and f_B of two materials, A and B. The MR signal from the entire voxel (SV) will then reflect the **weighted average** of signals S_A and S_B from the two components

$$SV = f_A S_A + f_B S_B$$

Imperfect RF-pulse profiles may also cause to partial volume effects by exciting tissues outside the desired slice. When multiple slices are placed side by side, this interference is known as **cross-talk**.

Image registration problems: geometry inconsistencies

1. Movements among different series in the same study (MR)

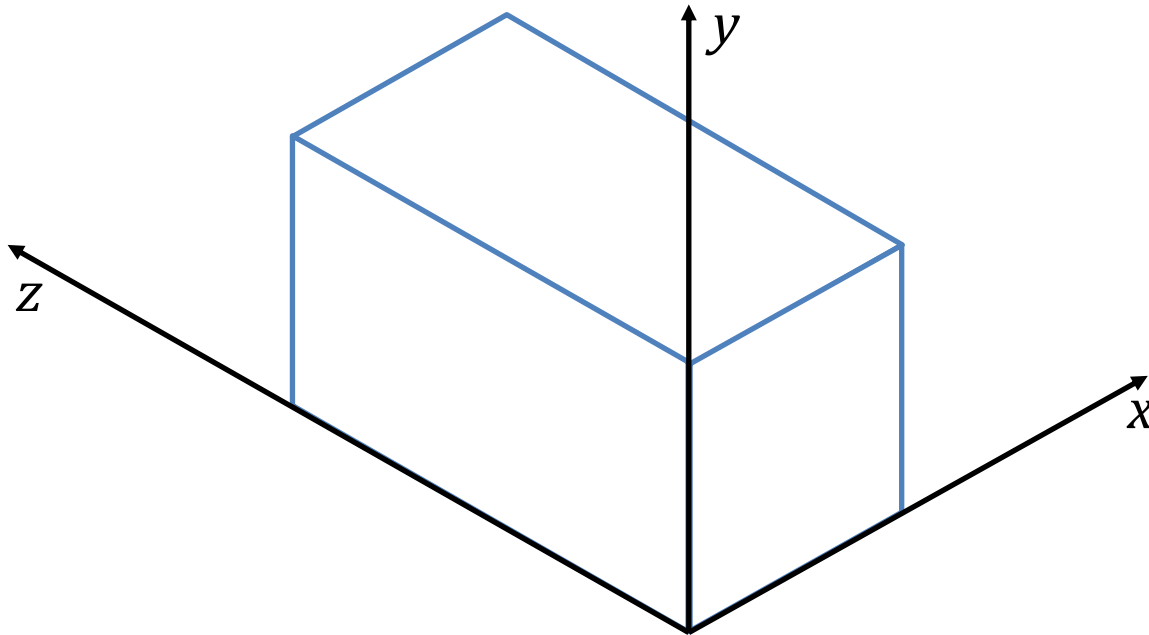


Image registration problems: geometry inconsistencies

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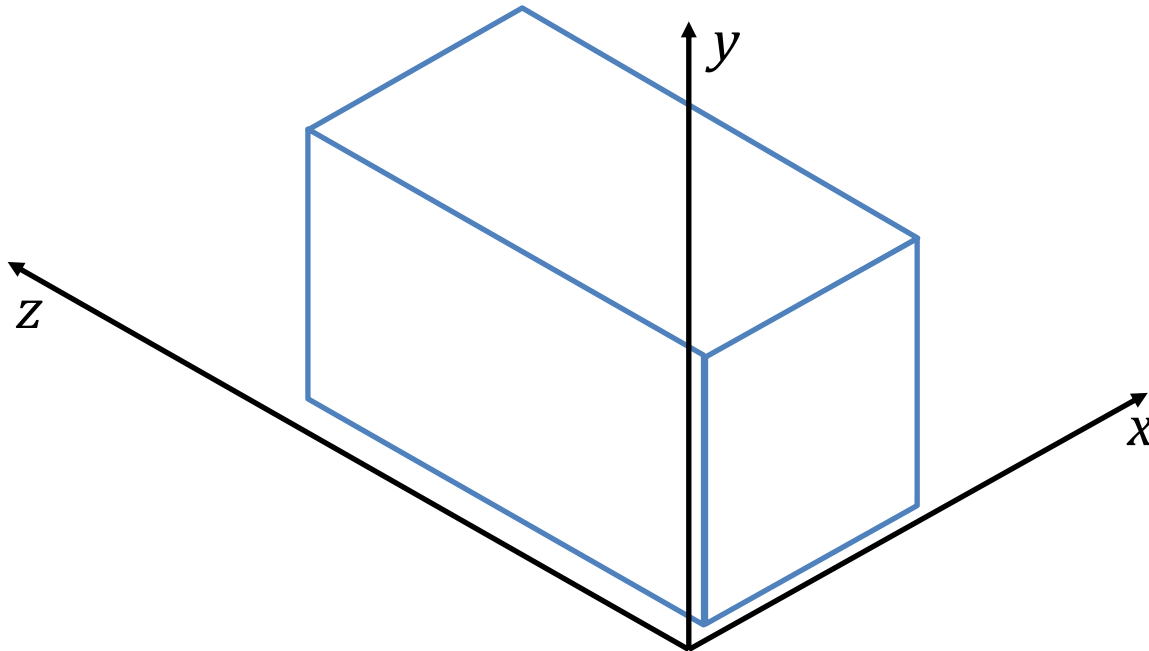


Image registration problems: geometry inconsistencies

1. Movements among different series in the same study (MR)

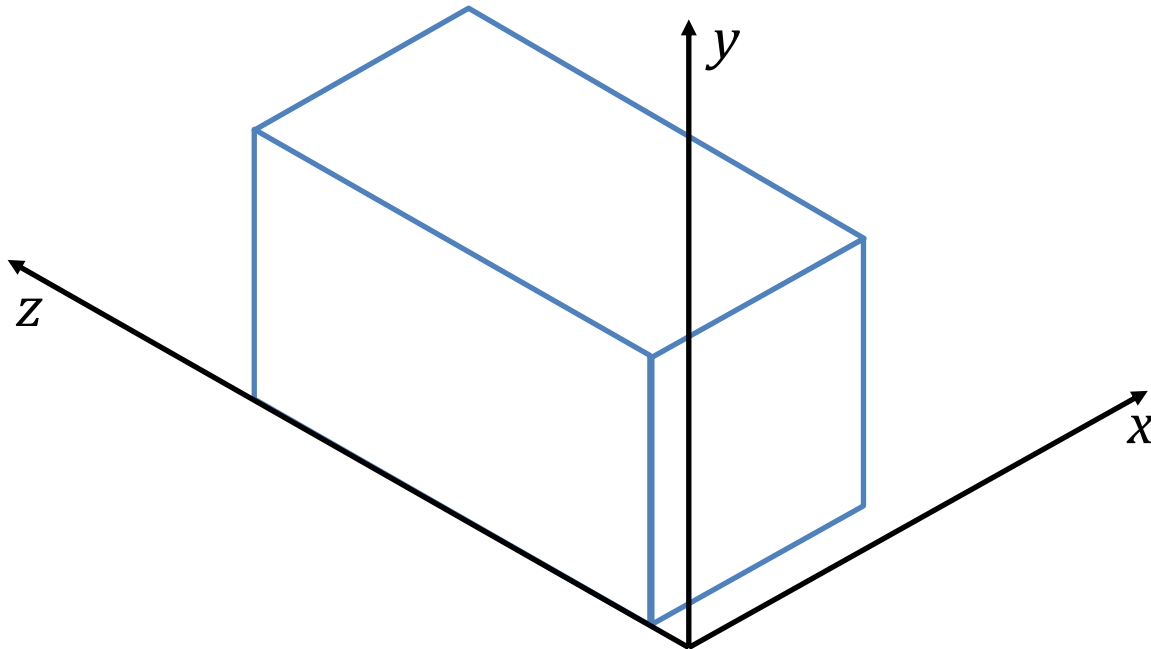


Image registration problems: geometry inconsistencies

1. Movements among different series DICOM coordinates registered images (PET-CT)

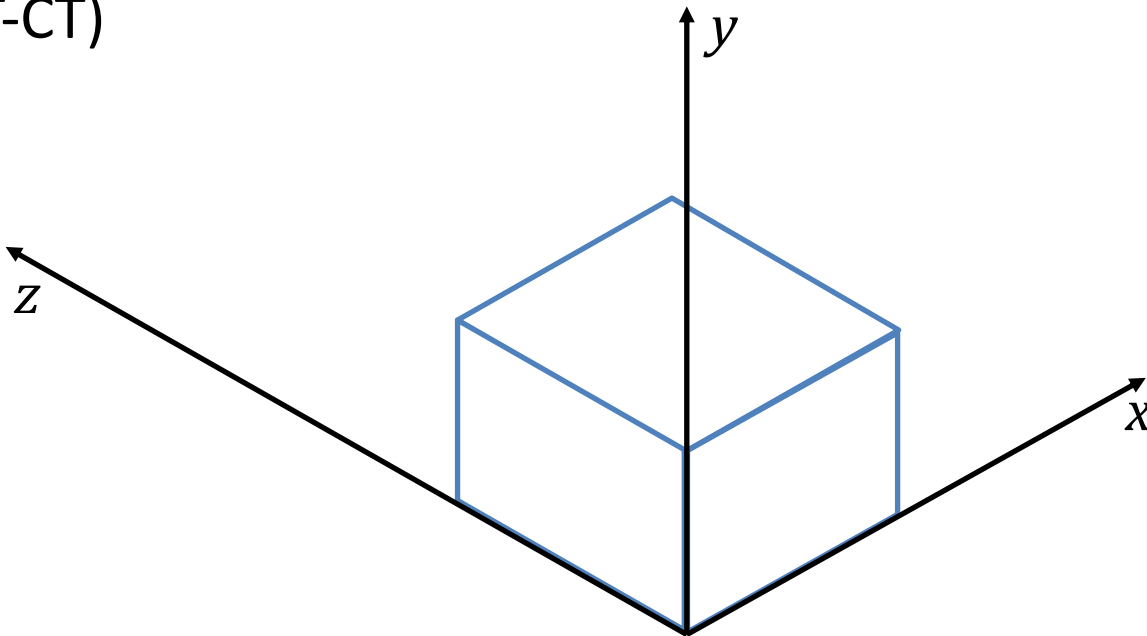


Image registration problems: geometry inconsistencies

1. Movements among different series DICOM coordinates registered images (PET-CT)

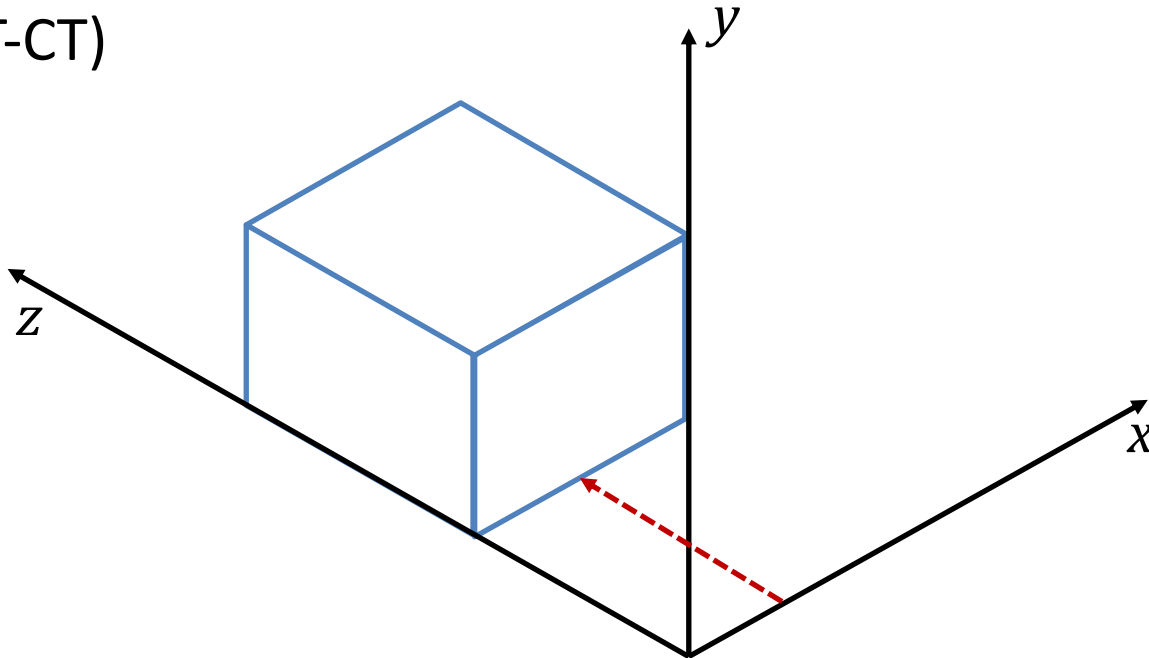


Image registration problems: geometry inconsistencies

1. Movements among different series DICOM coordinates registered images (PET-CT)

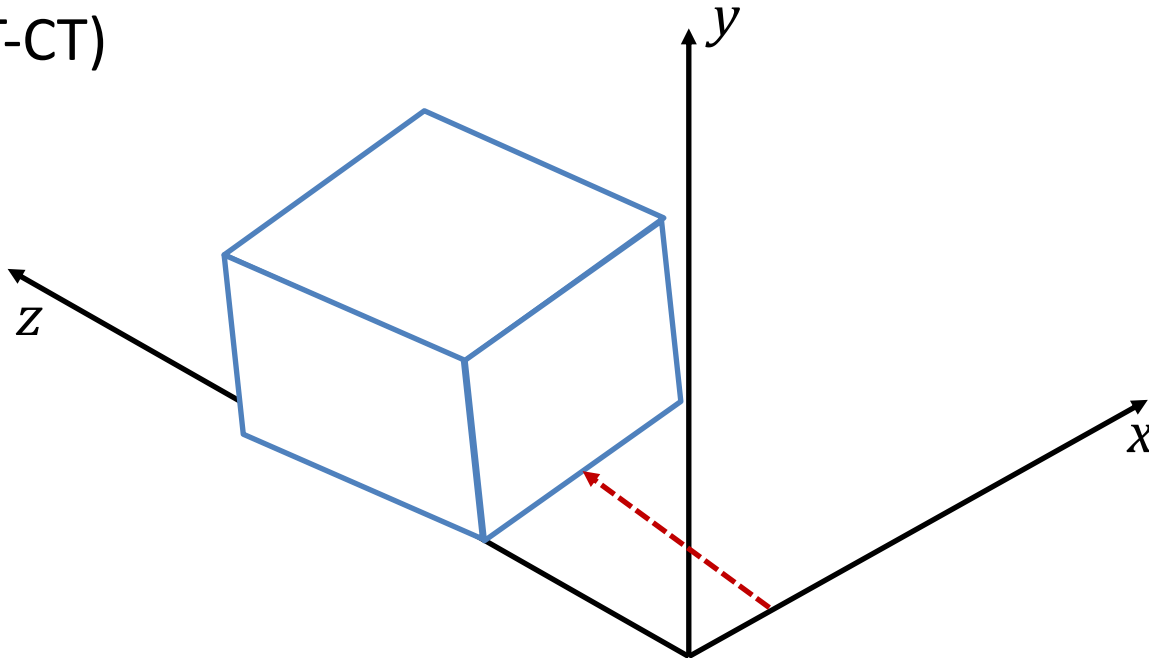
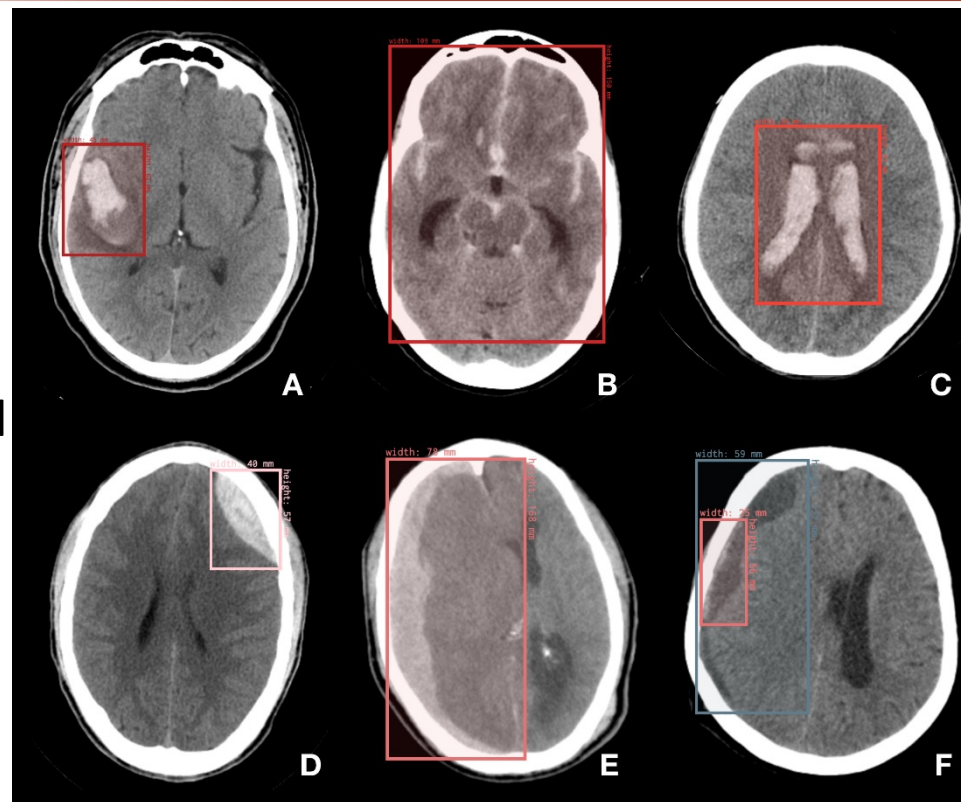


Image registration problems:
choosing the correct boundaries

User bounding box selection for meaningful
part of image series



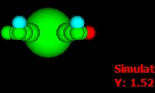
Reis, E. P., Nascimento, F., Aranha, M., Mainetti Seol, F., Machado, B., Felix, M., Stein, A., & Amaro, E. (2020). Brain Hemorrhage Extended (BHX): Bounding box extrapolation from thick to thin slice CT images (version 1.1). PhysioNet.

REGISTRATION



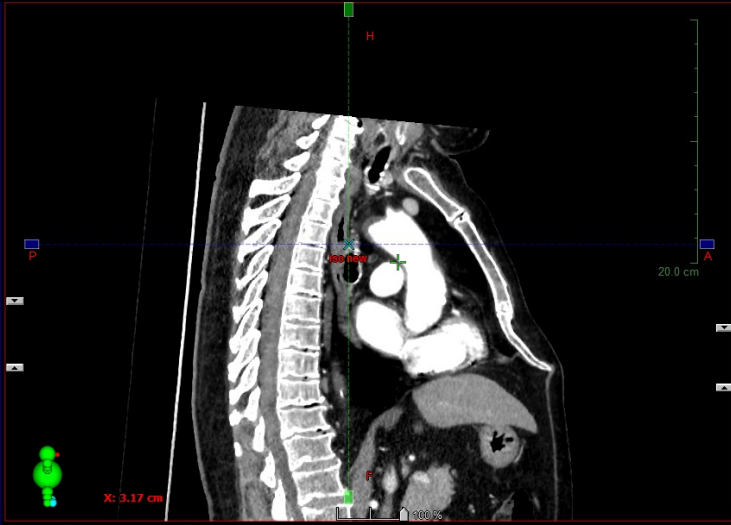
CT_RP_00	CT_RP_10	CT_RP_20	CT_RP_30	CT_RP_40	CT_RP_50	CT_RP_60	CT_RP_70	CT_RP_80	CT_RP_90	CT_RP_Mp	CT_RP_Mn	CT_RP_Ave
CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT
24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019

- CT_RP_Ave
- Arteriosa
- BODY
- Body DVH
- Bones
- ChestWall
- CouchIn...
- CouchSu...
- CTV
- Esophagus
- Heart
- LeftInne...
- LeftOut...
- Lung_L
- Lung_R
- Lungs
- PTV
- PTV LSD
- Rbs
- RightInn...
- RightOut...
- Skin
- SpinalCanal
- SpinalCof...
- Reference_P...
- X iso new
- User Origin

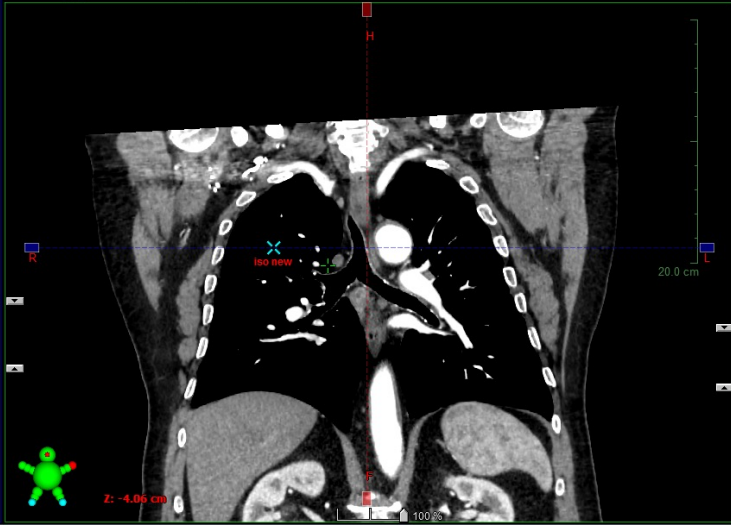


Simulatore Virtuale, HFS
Y: 1.52 cm

100%



Frontal - CT_RP_Ave - Arteriosa - 30/04/2019 17.24



Z: -4.06 cm

100%

REGISTRATION



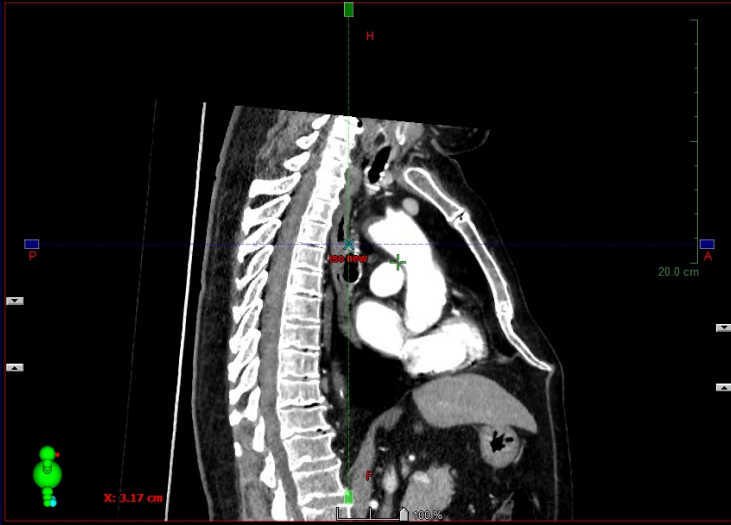
CT_RP_00	CT_RP_10	CT_RP_20	CT_RP_30	CT_RP_40	CT_RP_50	CT_RP_60	CT_RP_70	CT_RP_80	CT_RP_90	CT_RP_Mp	CT_RP_Mn	CT_RP_Ave
CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT	CT
24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019	24/05/2019

- CT_RP_Ave
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- Rbs
- RightInn...
- RightOut...
- Skin
- SpinalCanal
- SpinalCof...
- Referentie_P...
- X iso new
- User Origin

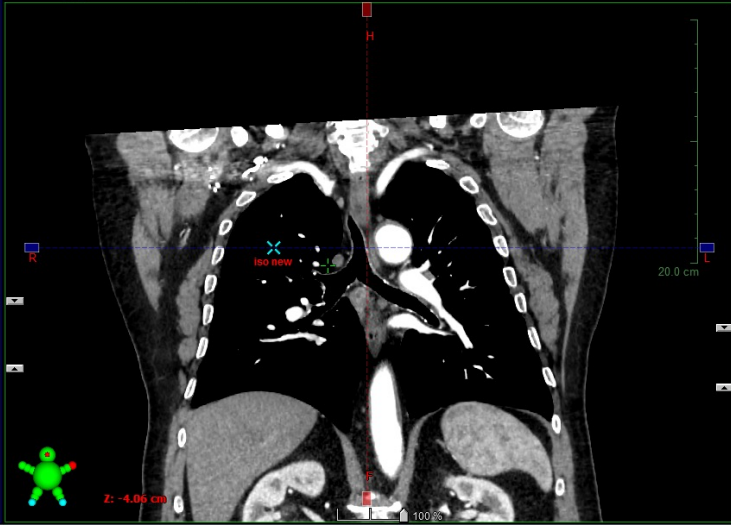


Simulatore Virtuale, HFS
Y: 1.52 cm

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Frontal - CT_RP_Ave - Arteriosa - 30/04/2019 17.24



Z: -4.06 cm

100%

