CEMMTAUR : CT synthEsis from Multicentric and Multisquence MRI daTA with qUality assessment for image-guided Radiotherapy

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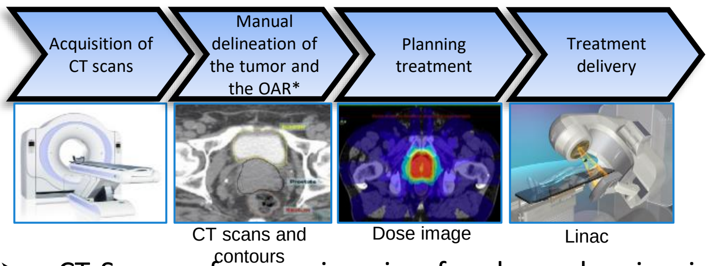
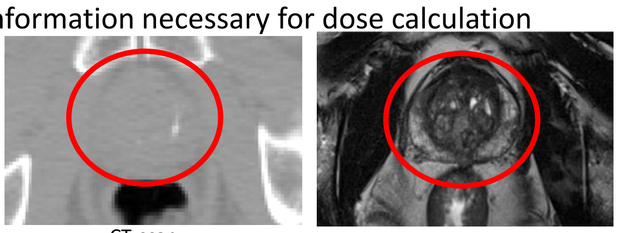
Scientific context

Cancer leading cause of death worldwide (10 million deaths in 2020), radiotherapy is one of the cancer treatment.

Workflow of external radiotherapy (RTE)

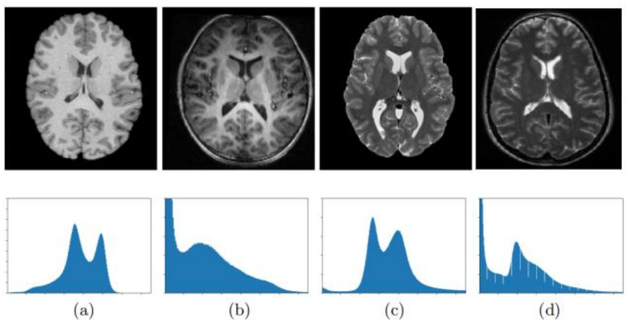


- CT-Scan: reference imaging for dose planning in radiotherapy (RT)
  - poor contrast in soft tissues and ionizing imaging
  - imprecise delineation of the tumor and the organs at risk (OARs)
  - limiting the quality of the daily patient treatment positioning
- MRI: better soft tissue contrast compared to CT
  - but MRI do not provide electronic density information necessary for dose calculation



Limitation of DLM-based MR-to-CT synthesis

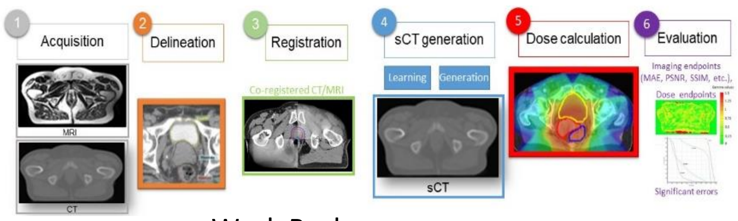
- variety of image acquisition systems (manufacturers, calibration, acquisition parameters, magnetic field, etc.)
  - training data specific to CT/MRI device



Goals

- Generation of synthetic CT (sCT) from MRI, based on DLM
- Development of a generic approach, a non-specific center/device, taking into account the variety of image acquisition systems
- Accurate dose calculation from MRI (with sCT)
- Develop supervised and unsupervised learning

Workflow of the study

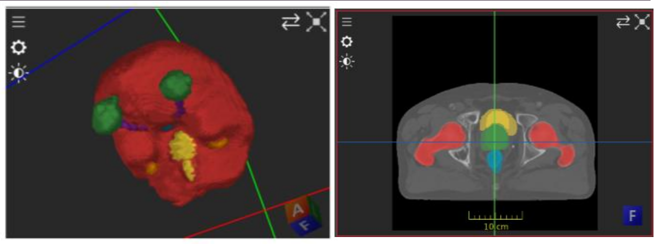


Work Packages

Segmentation and uncertainty WP2

Automatic segmentation (LS2N, Nantes)

- Anatomical regions:
  - prostate + OARs (rectum, bladder) and
  - brain + OARs (medulla, brainstem, pituitary gland, lens, eyes, retina, chiasm, optic nerve).
- Data: MR (T1 and T2, LavaFLEX) and CT
- Challenges: dataset size, unnormalized and incomplete annotations, misalignment
- **Internship1** : Amel Bakouche (2023) :
  - Baseline segmentation with a U-NET under mono and multi-modal scenarios for 6 OARs of the **brain**.
  - First encouraging DICE/Haussdorff distance results on each modality.
  - Scores still dependent on the organ size.
- **Intership2 :** Armena Kojasevich (2024):
  - Automatic preprocessing for the prostate data.
  - Baseline 3D segmentation with Unet
  - State of the Art of implicit segmentation.



Example segmentation predictions for the brain (left) and prostate (right)

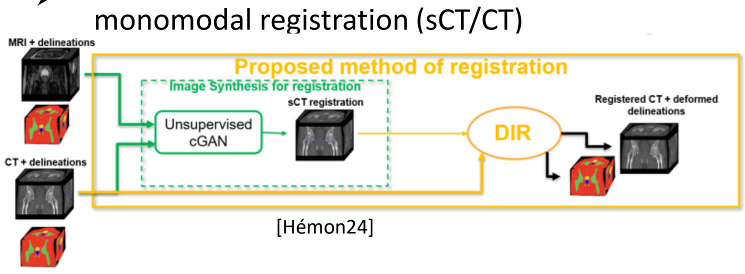
- **Intership3 :** Dalal Chamssedine (2024):
  - Segmentation as label transfer: registration
  - Applying recent pairwise registration method based on implicit neural representations
  - MIND Multi-modal extension proposed
- **Upcoming work:**
  - 10m postdoc (2025) Mathilde Monvoisin
  - 1 master students 2025: open
  - Extend registration to a population.
  - Joint implicit registration and segmentation approach.

Multimodal registration WP3

Image registration (LS2N and LTSI)

Novel Deformable MR/CT Registration approach that incorporates an unsupervised DL based generation step of an intermediary image (sCT)

- reduce multimodal registration (MR/CT) into monomodal registration (sCT/CT)



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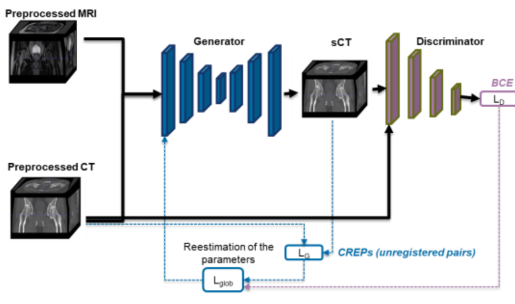
MRI-CT synthesis WP4

- Proposed method, generate the sCT from the content of the MRI by applying the CT style:
  - PL loss: ConvNext (pre-trained on ImageNet) recent low cost and high performance classification network.
  - Architecture: cGAN (Resnet-6 blocks+PatchGAN)
  - Dimensions: 3D patch
  - Training method: Unregistered pairs



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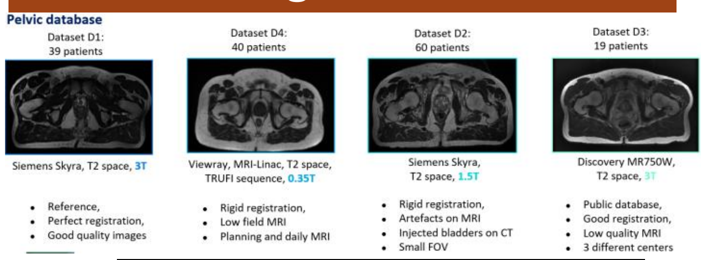
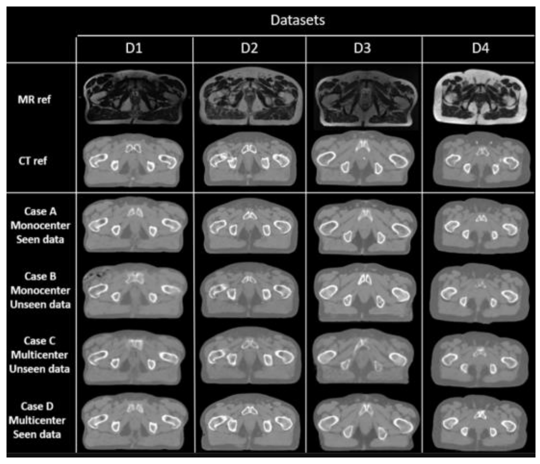
Multicentric generation WP4





[Texier23]

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