Applications of DECT: Tissue differentiation, Treatment response, and function assessment

Jessica Miller
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Learning objectives

• Discuss dual-energy CT derived images

• Highlight several application of DECT images within the radiation therapy space
  • Tumor and healthy tissue segmentation
  • Tumor characterization
  • Treatment response assessment using DECT
  • Functional tissue segmentation
DECT in radiation therapy

Mixed – 120 kVp equivalent image
Effective atomic number and electron density images
Material decomposition

True Contrast Image

Iodine Map

Virtual Non-contrast
Virtual Monoenergetic Images (VMI)
Radiation therapy applications:

Tumor identification, characterization and delineation
Tumor delineation for head and neck cancer


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Tumor delineation for pancreatic cancer

FBP

Admire 2

Mixed

57 keV

40 keV
Quantifying CNR gains in DECT pancreatic images

Tumor delineation for lung cancer
Bone lesion delineation

- CNR = 2.77
- CNR = 8.53
- CNR = 14.9

M. Lawless et al. 2018 Annual Meeting of the American Association of Physicists (Abstract # SU-F-205-4).

Spectral Hounsfield unit attenuation curves (SHUACs)
SHUACs – identifying malignant tissue

Spectral Hounsfield Unit Attenuation Curve


Material decomposition – iodine map


Iodine concentration: 2.3 mg I/ml

Incorporating multiple images to characterize tumor


Radiation therapy applications:

Treatment response assessment
Treatment response with DECT iodine maps


**Texture analysis in radiation therapy**

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CRT, chemoradiotherapy; DCE-MRI, dynamic contrast-enhanced MRI; EBRT, external beam radiotherapy; IMRT, intensity-modulated radiotherapy; MP-MRI, multiparametric MRI; PET, positron emission tomography; RT, radiotherapy; SABR, stereotactic ablative radiotherapy; SRT, stereotactic radiotherapy; T2r, T<sub>2</sub> weighted.
Treatment response with DECT texture features


Radiation therapy applications:

Normal tissue segmentation
Normal tissue delineation

Supratentorial white matter/basal ganglia
50 keV to 70 keV

Posterior fossa
Higher energies

Normal tissue segmentation

Chen et al. 1st Conference on Medical Imaging with Deep Learning (MIDL 2018).

Radiation therapy applications:

Functional normal tissue segmentation and toxicity
Motivation for functional imaging in radiation therapy

- Typical radiation therapy treatment plans assess radiation dose to the entire lung volume
  - Mean lung dose, V5, V20, V30, etc.

- More than half of lung cancer patients have concomitant pulmonary disease

- Functional lung volume is a better metric than anatomical lung volume for predicting lung toxicities

- Need for accessible functional lung imaging techniques which can be incorporated in the radiation therapy workflow

Functional lung imaging: ventilation

Clinical Trial NCT02843568

Image provided by Dr. John Bayouth
Functional lung treatment plans

Conventional Plan

Optimized Plan (spares high ventilation regions)

Clinical Trail  NCT02843568 : Improving Pulmonary Function Following Radiation Therapy

Image provided by Dr. John Bayouth
Preserving lung function post-RT

Clinical Trial: NCT02843568

Image provided by Dr. John Bayouth
DECT-derived functional lung

**Ventilation**
- Xenon inhalation

**Perfusion**
- Iodine injection

Lung perfusion using dual-source DECT

Lung perfusion using split-filter DECT


$r = 0.925$

$P < 0.00001$
Functional bone marrow

Case 1

Case 2

Conventional

Functional

DECT-derived functional bone marrow

8 years old  24 years old  48 years old  54 years old  64 years old  79 years old

8 years old RMF: 97%
54 years old RMF: 47%

Radiation-induced changes to active bone marrow

Pre-treatment | 1 week post-treatment | 4 weeks post-treatment

FLT PET

Virtual non-calcium (DECT) HU-map


Qihui Lyu et al. 2020 Joint AAPM/COMP Virtual Meeting (Abstract #: TH-CTrack 1-5).
DECT-derived functional liver tissue

Conclusions

• Dose calculation accuracy

• Tumor identification, characterization, and delineation

• Treatment response assessment

• Normal tissue segmentation

• Functional normal tissue toxicities
Thank you

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