Towards tumor tracking in the absence of radiopaque markers

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Motivation

- Tumors in abdomen/thorax can move during respiration
- For beam tracking or gating, tumor tracking is desirable
- Can use radiopaque markers in abdomen as surrogates
- In lung, risk of pneumothorax
- Fortunately, some lung tumors can be seen in fluoroscopy
- Goal: Direct lung tumor tracking
- This talk: Preliminary results
Methods Investigated

- Fluoroscopic intensity fluctuations
- Template matching (feature based)
- Motion enhancement + template matching
- Optical Flow
Methods Investigated

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Relative Intensity Fluctuations

Moving lung tumor (~1cm SI motion)

- Captured with RPM from Varian Ximatron (10 fps)
- Intensity in lung changes
  - Like spirometry
- Can the intensity fluctuations be used to glean information?

Relative intensity, RPM amplitude and diaphragm position vs. time

- relative intensity
- RPM amplitude
- diaphragm

Phase vs. time

- relative intensity phase
- RPM phase (retro)
- diaphragm phase
Motion Enhancement

\[
\frac{\text{Frame 1} + \ldots + \text{Frame } n}{n} = \text{Average of all frames}
\]

\[
\text{Frame } i - \text{Average of all frames} = \text{Motion enhanced image}
\]
Motion Enhancement with relative intensity fluctuations

Fluoroscopic relative intensity fluctuations vs. time

- Duty cycle = 35.1%

Sample images from one cycle:
- Exhale to inhale
- End inhale
- Inhale to exhale
- End exhale
- Exhale template
Motion Enhancement

Cross-correlation score vs. time

Gating threshold 35.1% duty cycle

Exhale

Motion Enhanced Template gating signal

Beam on

Beam off
Motion Enhancement + Template matching

RPM phase-based gating signal
34.7% duty cycle

Motion Enhanced Template gating signal
35.1% duty cycle

Difference

On the same order as RPM phase/amplitude gating difference

0.7 seconds minor effect
Motion Enhanced Template Matching

• Use RPM for comparison
  • No reliable reference for “true” tumor location
• Motion enhanced template matching can reproduce RPM phase-based gating
• Relative intensity fluctuations in the ROI can serve as an additional source of phase information
• Conclusion: Gating on tumor location is feasible
• Confirm for multiple gantry angles
Future Work: from 4DCT to fluoroscopy

Moving lung tumor (~1cm SI motion)

Fluoroscopy

4DCT

Digitally Reconstructed Fluoroscopy

Provided by E. Rietzel

We can use the 4DCT to make a DRF.
Future Work: from 4DCT to fluoroscopy

- More difficult in the lateral direction

Fluoroscopy

- Use the 3-d cursor to find (contour) the tumor in the DRR
- Use visible structures to find tumor in fluoroscopy
Comparison of Ximatron with CT derived DRF’s

- Fluoroscopic intensity fluctuations follow the CT (DRF) prediction
Summary

• Marker-less tumor tracking is feasible
  • It’s just very difficult
• Better image quality helpful
  • Acuity (a-Si), on-board monoscopic (a-Si)
  • IRIS (dual a-Si)
• Information from other technologies
  • RPM
  • 4DCT
• Lots and lots of work to be done
Thank you!