Fluoroscopic Lung Tumor Tracking without Implanted Fiducial Markers

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How Do We Treat a Moving Tumor?

Tracking based on External Surrogates
Varian RPM CyberKnife Synchrony

Gating based on External Surrogates

Tracking using Implanted Fiducial Markers

Varian RPM CyberKnife Synchrony

Image Intensifier X-ray Tube Calypso 4D Localization System

Mitsubishi/Hokkaido RTRT System

Kanoulas, Aslam, Shary, Berbeco, Nishioka, Shirato, and Jiang
Wu, Zhao, Berbeco, Nishioka, Shirato, Jiang
Implantation of Fiducial Markers

- CT guided implantation
- US guided implantation

Direct Lung Tumor Tracking w/o Markers

- Multiple Template Tracking
- Active Shape Model Tracking
- Optical Flow Tracking

Indirect Fluoroscopic Tracking

- Issues with direct tracking
  - Directly tracking of the tumor sometimes is impossible due to poor image quality and low target contrast
  - Common tracking methods used in computer vision often fails since tumor has no color, no texture, and often no clear shape
- We proposed an indirect tracking approach
  - Tracking invisible tumor by tracking visible surrogate features

Diaphragm as an Internal Surrogate

Mean error ~ 1 mm
Maximum error (e95) ~ 2 mm

Diaphragm Does Not Always Work
Future work: building a comprehensive tracking system

X-ray
(Only when necessary)

Surface Tracking Camera
(Always on)

Tumor Tracking during Arc Therapy

Courtesy of Elekta

Reconstruct Tumor Trajectory from CBCT Projections

Phase Binned Trajectory Reconstruction

Preliminary Results: Digital Phantom (NCAT)
Preliminary Results: Physical Phantom

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