An Integrated System for Image-Guided Radiofrequency Ablation (RFA) of Liver Tumors

Kevin Cleary, Georgetown University
Noby Hata, Brigham and Women’s Hospital
Enrique Campos-Nanez, George Washington University
Liver tumor RFA

- Liver cancer that cannot be resected due to extent and location of the disease or concurrent medical conditions.

- Introduce localized RF energy directly to tumor, typically through expanding metal tines within a small gauge insulated needle.

Before (left) and after (right) treatment (courtesy of Brad Wood, MD, NIH CC)
Project Overview

**Goal:** Develop an open source workstation for liver RFA planning and treatment based on IGSTK and Slicer.

**Specific aims:**

1. Develop and evaluate semi-automatic segmentation techniques for the liver, liver vasculature, and liver tumors. [Georgetown, BWH]

2. Develop a path planning module for evaluating alternative paths to the liver tumor and incorporating multiple overlapping placements as needed for larger tumors. [GWU]

3. Integrate the two capabilities developed above along with electromagnetic tracking of the RFA probe to provide a complete software environment for liver tumor planning, visualization, and execution. [Georgetown, BWH]

4. Validate the clinical feasibility of the system in a swine animal model. [Georgetown]
Segmentation

• Use established techniques:
  – Thresholding (bone).
  – Active Appearance Models (liver).
  – Height ridge traversal (vessels).
  – Active contour (tumor).
• Provide capabilities for manual correction of results.

• AAM – acquire training database that represents the anatomical variability (47 data sets to date).

• Want to integrate within Slicer GUI based on ITK library
• Focus of first year effort
Anonymized Database

- Collecting CT liver images from Georgetown University Hospital
- Following Health Insurance Portability and Accountability Act (HIPAA) rules for anonymization of data
- Purchased “DICOM Anonymizer Pro” software for this purpose
- Creation of database and evaluation of anonymization process
- Submitting abstract to the Computer Aided Radiology and Surgery (CARS) Conference
Path planning

- Pre-emptive goal programming approach based on integer programming techniques using a discrete set of data points representing the tumor (uniform sampling):

  1. Minimize needle insertions (trajectories), minimizes the number of punctures to the liver capsule, and the number of needle insertions.


  3. Minimizing Damage to Healthy Tissue
Integrated System

- Slicer – IO, Visualization, Interaction.

- IGSTK – Tracking, Registration, Logging, Tool Calibration.
Validation

• Animal study:
  – simulated liver tumors (agar) in swine.
  
  – perform treatment (segmentation, planning, navigation and ablation).

  – histopathological examination of serial cross section slices of the liver lobe.
Lung RFA animal study with IGSTK – Proof of concept

• Segmentation – manual, output is a text file.

• Planning – works, but the solution did not cover some of the tumor margin. Uses a commercial product (XpressMP).

• Visualization and IO – in house extension of IGSTK.

• Interaction – voice recognition (a.k.a. point and shout).

• Validation - histopathological examination.
Lung RFA (artificial nodule)
Lung RFA (segmentation)
Lung RFA (registration)
Lung RFA (navigation)
Lung RFA (validation)
Summary

• Goal is to develop an integrated system for RFA of liver tumors
• Some background work has been done but need to integrate pieces in an open source environment
• Focus of year one will be on segmentation and integration with Slicer