Finding Needles in Interventional Oncology Images

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National Center for Image Guided Therapy

NIH Funded Biotechnology Resource Center P41EB015898
PI Clare Tempany, MD
www.ncigt.org
Advanced Multimodality Image-Guided Operating suite, AMIGO

Launched in 2011
5700 square feet (~530 sq m)
MR, Angio, PET/CT
Mass Spectrometry
Ultrasound, Navigation
Microscope
3D Slicer +
Precise Localization of Tumor Boundaries for Therapy
# 2129 AMIGO Procedures

08/30/2011 – 3/12/2019

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<td>Brain Tumor Resection</td>
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| Breast Conserving Surgery                         | 35  |
| Video-Assisted Thoracoscopic Surgery              | 31  |
| Laparoscopic Intra-abdominal Biopsy               | 5   |
| Endocrine Surgery                                 | 9   |
| Spine Discectomy and Fusion                       | 2   |
| Cardiac EP Ablation                               | 7   |
| Radiation Oncology                                | 144 |
| Gynecologic HDR Brachytherapy                     | 133 |
| Prostate VLDR Brachytherapy                       | 11  |

## Interventional Radiology

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<td>Head &amp; Neck</td>
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## BIOPSY

| MR Prostate                                         | 446  |
| MR, PET CT Lung                                     | 27   |
| Transarterial Chemoembolization                     | 1    |
Prostate Cancer

1 in 8 American men will be diagnosed during his lifetime.

174,650
Estimated New Cases in 2019

31,620
Estimated Deaths in 2019

What is the optimal therapy or surveillance for each one?
Increasing Role of Prostate MRI

MRI-targeted or standard biopsy for prostate-cancer diagnosis.

The Lancet (2017)
Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): a paired validating confirmatory study.
Needle Segmentation

Alireza Mehtrash et al. (IEEE Transactions on Medical Imaging, 2018)
Automatic Needle Segmentation and Localization in MRI with Convolutional Neural Networks: Application to MRI-Guided Prostate Biopsy

Mehrtash
3D Convolutional Neural Network

- 3D Fully Convolutional Neural Network (FCN)
- Training: Data augmentation, 5-fold cross-validation.
- Loss: Negative of Dice.
Training Data and Annotations

- Ground Truth: needles marked by rater on 583 MRI (71 patients)
- MRI divided: 50 train-validation, 21 test
- Observer study: second rater blinded to the ground truth
Results Summary

- Less than 3mm localization error in tip and trajectory in axial plane
- Less than 2 slice error in 92% cases along the transaxial plane

Alireza Mehtrash et al. (IEEE Transactions on Medical Imaging, 2018)
Automatic Needle Segmentation and Localization in MRI with Convolutional Neural Networks: Application to MRI-Guided Prostate Biopsy
Open Deployment in 3D Slicer DeepInfer
Gynecologic Cancers

Cervical, Uterine, Vaginal, Vulvar, Ovarian

4th leading cause of death in women in the US

- 109,470 estimated cases in 2019
- 33,100 estimated deaths in 2019

Treated with chemo-radiation, high dose rate brachytherapy
• 30% outcome improvement over chemo-radiation
• MRI preferred

2012-2017

54 Patients
760 Needles
93% accuracy
3 seconds/needle


2018-2019

Zaffino  Spadea  Pernelle  Mehrbash
Image-Guided Liver Biopsies

Worldwide
1,000,000 annually, 4% growth rate

Brigham and Women’s Hospital
600 liver biopsies annually
30% parenchymal, 70% focal
50% focal use ultrasound, 50% CT
For ultrasound guided biopsies
99% freehand

www.medgadget.com
Ultrasound guided Liver Biopsy
Ultrasound guided Liver Biopsy

Needle insertion using real-time ultrasound guidance.
Why should we work on this?

- **Better** accuracy in fewer needle sticks
  - less pain, bleeding and complication risk
- **Shorter** procedure time
- **Shorter** learning curve for physician training
- **Lower cost** modality, no radiation (vs CT)
Challenges

Low reimbursement

Little room for adding
  ▪ Time, complexity, incremental cost

Available alternatives not adopted
  ▪ navigation with tracking hardware
  ▪ needle guides
  ▪ needles with echogenic tips
Goal
Goal
Join us for Hands-on Projects

31st Project Week, June 24-28, 2019, MIT, Boston
32nd Project Week, July 15-19, 2019, Robarts, London, Canada
33rd Project Week, January 20-24, 2019, Gran Canaria, Spain

na-mic.github.io/ProjectWeek/