3D ULTRASOUND-GUIDED PROSTATE INTERVENTIONS

Disclosure

Mechanical 3D US guided prostate biopsy technology has been licensed to Eigen Inc (California, USA)

Prostate Cancer Statistics

- Prostate cancer is the most common non-skin cancer in men accounting for up to 9% of all cancer deaths.
- If diagnosed at an early stage, the disease is curable.

Prostate Cancer Diagnosis

Diagnostic Tests

- Digital rectal exam (DRE)
- Prostate Specific Antigen (PSA)
- Gold Standard → Needle biopsy using 2D transrectal US guidance
Challenges

Detection of Prostate Cancer

- Early stage prostate cancer not visible in ultrasound.

- Physicians target regions with high probability of harboring the disease.

- Transrectal ultrasound biopsy leads to a false negative as high as 34%.

Repeat Biopsy

Some cases requiring repeat biopsy:

- Suspicious PSA or DRE, despite –ve biopsy
  - Must biopsy new locations

- Atypical, small acinar proliferation (ASAP)
  - Inconclusive traces of atypical cells in histology
  - Must biopsy exact location of previous biopsy

Prostate Cancer Diagnosis

Biopsy Limitations

- Confined to 2D

- Few anatomical reference points to guide needle

- Pathology rarely visible → High rebiopsy rate

- Cannot easily use other modalities for Bx guidance

Challenges

Where to re-biopsy?
Emerging Imaging Tools

- MR DCE
- MR Spectroscopy
- MR Diffusion
- PET

Potential Benefit:
- Identify and target Bx to suspicious zones

GOAL: 3D US Guided Biopsy

- Combine 3D ultrasound imaging with real-time guidance to form a 3D prostate biopsy system, capable of:
  - Prostate biopsy planning,
  - Recording of biopsy locations in 3D,
  - Targeting lesions identified from other modalities.

Mechanical Guidance System

- Tracking mechanism
- Ultrasound Probe

Rotational Mover (End Fire)
**Rotational 3D Scanning**

- 3D Motorized or manual Scan
- Digitize 2D Images
- 3-D Reconstruction
- 3-D Volume Image

**3D ULTRASOUND: Approach**

- Rotate US probe ~180 deg (manual or motor) in about 6 sec
- Digitize 2D images as probe rotates
- Reconstruct 3D image in real-time
- 3D prostate image available immediately

**3D Prostate Ultrasound**

**3D Prostate Segmentation**
Prostate Segmenting in 3D

QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.

3D Prostate Model + Biopsy Navigation

Biopsy Procedure
Record of Core Locations

In Vitro Targeting Accuracy

Experimental Setup
- Biopsy multimodal CT/US prostate phantom.
- Simulated prostate embedded within agar.
- Selected biopsy targets and perform biopsy.
- Use of high resolution CT to determine location of biopsy cores.

RESULTS: Biopsy of test phantom

Needle-guidance Error: Biopsy: 2.1 ± 1.3 mm

RESULTS: Biopsy of test phantom

Navigation Error: n=30

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<thead>
<tr>
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<th>Targeting (mm)</th>
<th>Recording (mm)</th>
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<tr>
<td>Mechanical Tracking</td>
<td>2.1 ± 1.3</td>
<td>1.5 ± 0.9</td>
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NON-RIGID 3D REGISTRATION OF 3D US to 3D MR IMAGES

3D MR - US non-rigid registration

QuickTime™ and a Microsoft Video 1 decompressor are needed to see this picture.

3D MR - US Guided Biopsy

Pre-Biopsy MRI

Axial View

Coronal View
SUMMARY

We have developed a 3D ultrasound navigation system to allow:
• Recording of core locations in 3D
• Guide biopsy to desired location
  – To previous biopsy location
  – To location identified with MRI
• Clinical trials in progress

Thank You

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3D MR - US non-rigid registration