An Open Science Framework for Assessment of Technologies In Image-Guided Interventions

Keyvan Farahani, PhD
Image-Guided Interventions Branch
Cancer Imaging Program
National Cancer Institute
National Institutes of Health

Outline

1. Background

2. IGI Open Science Framework
   - Extramural Collaborations
   - Technology Assessment IGI Work Group → Task Groups

Overarching Goal in IGI

- Perform better informed, more accurate and less invasive focal treatments
  - Imaging: Anatomic, Functional, Molecular
  - Guidance: Image fusion, tracking, robotics, dose painting, and feedback
  - Interventions: Needles, catheters, energy sources, targeted drug nanocarriers, surgery
Image-Guided Procedures

1. Biopsy: tumor heterogeneity and TME, ‘omics’ studies, drug development, and response evaluation
2. Surgical oncology
3. Minimally invasive therapies (e.g., laser, FUS, RT)
4. Focal drug delivery: Catheter, micro and nanoplatforms, including theronostics

Integrated Solutions

- Image-Guided Surgery

- Goal:
  - Complete resection
  - No functional deficit

- Surgeon needs to see:
  - Lesion and define margins
  - Critical structures
  - Relationship between lesion and normal areas

- Tools required for:
  - Pre-operative planning
  - Surgical decision-making
Robot Assisted Prostate Surgery

da Vinci® System - Intuitive Surgical
High resolution
Magnified images
Specialized equipment: micro-dissection
Minimally Invasive
Decreased Pain / Blood Loss / Hospital Stay
Improved visualization and protection of NVB and neighboring structures
Est. >100,000 procedures / year

Image Registered Endoscopies

Vosburgh (Harvard)

US

CT + US

3D CT-Guided Endoscopic Ultrasound

Segmented 3D CT for Orientation of probe. Icon shows probe tip, CT field of view, and biopsy needle track.

Oblique CT plane corresponding to ultrasound image for feature identification.

Endoscopic US Image
Fluorescence-Assisted Resection

**FLARE System**

MR-guided Focused Ultrasound

Convergence of multi-modality imaging, molecular and IG1; informatics sciences toward individualized treatment of cancer
Foundations of IGI

Technology-driven multi-disciplinary field

Why an Open Science Approach in IGI?

- Technology-driven multi-disciplinary field
- Innovation inflation: Variety of options and approaches
  - Need for multi-center assessment of technologies
  - Need for more seamless translations

Collaboration on an Open Science Framework for Assessment of Technologies in IGI
• Technology Assessment Committee
  – Work Group: Assessment of Technologies in IGI

Technology Assessment

1. Identification of assessment topic & objectives
2. Validation data sets: simulation, phantom, pre-clinical, clinical
3. Validation metrics
4. Common terminology & methodology for validation procedures
   ➢ ID sources of uncertainty
   ➢ Quality assurance
   ➢ Improved clinical translation & clinical Trials

IGI Technology Clouds
Initial Projects & Task Groups

3D C-Arm
- Howard (Johns Hopkins) - Fei (Stanford)

Robot-assisted Biopsy
- Doer (Children's, DC) - Siewerdsen (Hopkins)

US-guided Surgery
- Vosburgh (Harvard) - Schlesinger (UVA)

Focused Ultrasound
- Gupta (UTMB) - Corbin (UVA) - Siewerdsen (UW)

Products: TG Reports + Open Tools

3D US-Guided Surgery: Validation Phantom

Multi-modality Ground-Truth Phantom. (A) Phantom model. The physiological phantom is embedded between the triangular blades. (B) Gross pathology slice showing liver with RF ablation region and triangle-blade sections in the surrounding gelatin. (C) CT reconstruction slice corresponding to gross pathology cut. (D) 3D-B-mode reconstruction with fiducials triangle and plane intersections visible.

Boctor (Hopkins)

Future Task Groups

- IG Radiation Therapy
- Optical IG-surgery
- IG Drug Delivery
Goals of TAIGI Work Group:

1. Establish Task Groups through AAPM
2. Establish the IGI Technology Cloud
   • Explore Grand Challenges in IGI
3. Develop an open science framework for IGI

Acknowledgments

- Russ Taylor, PhD
- Stanford
  - Kim Butta-Pauly
  - Rebecca Fahlvig, PhD
  - Sanjiv Gambhir, MD, PhD
  - Sandy Napel, PhD
- AAPP
  - Bill Hendee, PhD

- CIP/NCI
  - Larry Clarke, PhD
  - Paula Jacobs, PhD
- CC/NCI/NIH
  - Peter Choyke, MD
- Johns Hopkins
  - Emad Boctor, PhD
  - Zaver Bhujwalla, PhD
  - Justin Hanes, PhD
  - Jonathan Lewin, MD
  - Marty Pomper, MD, PhD
  - Jeff Sieverdsen, PhD
  - Dan Stolarovic, PhD