

AAPM Task Groups in Interventional Ultrasound Imaging & Therapy

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AAPM 2015 Ultrasound Symposium
Anaheim, CA

Technology Assessment Committee (TAC)

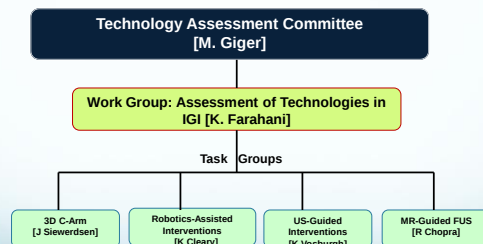
TAC - responsible for technology assessment efforts of the AAPM, including assessment of imaging and therapy technologies and other activities that enhance the research potential and quality assessment capabilities of medical physicists.

- Under the AAPM Science Council

Work Groups:

1. Computer Aided Diagnosis
2. CT Nomenclature and Protocols
3. Optimization of Medical Imaging Systems
4. Model QA programs in Radiation Oncology
5. Assessment of Technologies in Image-Guided Interventions (IGI)

AAPM – TAC – IGI



Task Groups: Past Examples

- TG 100 – Methods for evaluating QA needs in radiation therapy
- TG 150 – Acceptance testing and quality control of digital radiographic imaging systems
- TG 185 – Clinical commissioning of proton therapy systems
- TG 201 – Quality assurance of external beam treatment data transfer
- TG 117 – Use of MRI Data in Treatment Planning and Stereotactic Procedures – Spatial Accuracy and Quality Control Procedures

AAPM Task Group 241: MR-guided Focused Ultrasound

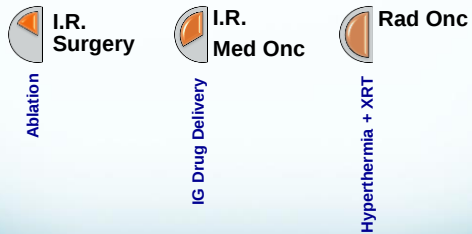
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MRgFUS in Cancer: Potential Applications

- Debulking
- *in situ* treatment (thermal and non-thermal)
- Combined treatments (e.g., radiation, chemo)
- Targeted drug or gene delivery
- Immunomodulation
- Palliative treatment for pain

FUS: Range of Clinical Applications



MRgFUS: Obstacles to Clinical Translation

1. Technologic diversity and complexity
2. Limited consensus on techniques/standards
3. Limited QA for clinical applications
4. Compatibility requirements
5. Clinically robust interactive monitoring
6. Workflow
7. Imaging – pathology correlation
8. Regulatory & Reimbursement
9. Competing technologies
10. Other economic factors

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AAPM TG-241: MRI-guided Focused Ultrasound

- Charge: Describe methodology, phantoms, and software for performance assessment of clinical MR-guided Focused Ultrasound (MRgFUS).
- Emphasis on intrinsic MRgFUS characteristics, quantitative metrics, and identification of quality assurance measures and procedures.

Task Group 241: Members

- | | |
|--|----------------------------|
| • Chopra, R (UTSW) - Chair | • Moonen, C (Utrecht) |
| • Stafford, J (MD Anderson) - co-Chair | • Moros, M (Moffitt) |
| • Farahani, K (NCI) - co-Chair | • Parker, D (U Utah) |
| • Alickacem, N (InSightec) | • Partanen, A (Philips) |
| • Benedict, S (UC Davis) | • Payne, A (U Utah) |
| • Butts-Pauly, K (Stanford) | • Sammet, S (U Chicago) |
| • Carson, P (U Michigan) | • Schliesinger, D (U VA) |
| • Chen, L (Fox Chase) | • Staruch, R (Philips) |
| • Diedrich, C (UCSF) | • Ter Haar, G (ICR-UK) |
| • Hananel, A (FUS Foundation) | • Wear (FDA) |
| • King, R (FDA) | • Zadicario, A (InSightec) |
| • Maruvada, S (FDA) | |
| • McDannold, N (Harvard) | |

Task Group 241: Deliverables

- Task Group Report
- Open Tools (QA phantom and procedure)

Task Group 241: Report

- Current clinical MRgFUS body systems
- Quantitative metrics
- Sources of uncertainty
- Safety
- Quality assurance
- Nomenclature
- Training in Medical Physicists

QA Subgroup

- Why QA?
 - Enhance precision and consistency
 - Enable inter-comparison of methods
 - Increase overall quality of procedures
 - Facilitate clinical acceptance and translation
- What parameters?
 - Imaging vs. image-guidance vs. therapy
 - Compare multiple platforms using a generic phantom

Next Steps

- QA sub-group – Sept 2015
- Submit draft of TG report to TAC and the Science Council: March 2016
- Submit to Medical Physics prior to 2016 annual meeting

Task Group 240 Ultrasound-guided Therapy

Kirby Vosburgh, PhD,
Brigham & Women's Hospital

Emad Bector, PhD,
Johns Hopkins University

Task Force Members (specialty area)

- Kirby Vosburgh (Chair, intra-corporeal ultrasound)
- Emad Bector (co-Chair, calibration)
- Ivan Buzurovic (US-guided RT)
- Aaron Fenster (needle guidance)
- Philip Pratt (intraprocedural registration)
- Gabor Fichtinger/Andras Lasso (platforms)
- Florence Sheehan (training)
- Kai Thomenius (technology trends)
- Andy Milkowski (product trends)

IGRT

- US-Guidance Applications
 - Prostate brachytherapy
 - High dose rate (HDR) gynecologic brachytherapy
 - HDR cutaneous treatments
 - Guided implantation of dosimeters and fiducials
- Active R+D programs
 - Conventional and HDR prostate brachytherapy
 - Breast brachytherapy
- Concerns
 - Corrections for sound velocity changes (water vs. tissue)
 - Proper QA: For example, in prostate brachytherapy, observers have noted poor US image quality, template positioning errors, and alignment errors. See AAPM TG1.

Guided Needles

- Ultrasound-guided needles are used in a wide range of procedures. Despite decades of effort and many clever ideas (which often work in the research setting but lack robustness and increase costs when used clinically), continuing challenges include:
 - Out of plane tip motion with only 2D guidance.
 - Needle deflection
 - Precise 3D tip localization
- Approaches to address these issues concerns include
 - Needle coatings to simplify visualization and localization
 - 3D/4D transducers and real-time signal processing to enhance needle display
 - Electromagnetic, optical, and acoustic techniques and also intra needle transducers to provide additional signals "from the needle" which may be fuse with the ultrasound display.
 - Attempts to improve needle segmentation by processing Ultrasound signals at the RF stage
- The challenge is to improve needle visualization without losing the advantages of everyday ultrasound systems in flexibility, lower costs, convenience, real-time response, etc.,

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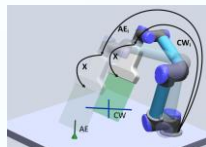
Calibration and Targeting: Understanding Limitations and their Clinical impact

- Precision calibration is vital for targeted interventions such as needle biopsy of small deep targets, but good calibration is always important.
- There are many methods used for ultrasound calibration.
 - Closed form methods and phantoms generally rely on the mechanical precision of the phantom and usually collect few ultrasound images.
 - Iterative methods tend to rely on motion of a tracked ultrasound transducer.
- We lack a methodology to compare different calibration phantoms, primarily due to variation in probe motions.
- Operator skill affects results
 - Proper management of probe position to optimize signal variation due to beam thickness is key.
- The accuracy of trackers
 - Properly maintained systems with integral tracking are quite good
 - Systems used with independent trackers have more variability in results

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Suggestions for Future Study

- Compare various phantom based calibration approaches with robotic probe drive to quantify absolute performance and compare strengths and weaknesses.



- Explore use of active transponders to provide ground-truth validation
- Your suggestions are welcome!

Target Registration

- Effective guidance depends on specifying the geometric relationship between features in the ultrasound image and the desired therapeutic target, as well as other important anatomic structures. Work in this area continues to improve clinical capability, but more remains to be accomplished.
- When high quality, current volumetric data from CT, MRI, etc. are available,
 - Advantages include the use of the 3D slice data or models for probe navigation, and the use of 3D models to guide navigation and targeting.
 - Challenges include: target motion, errors due to patient position changes, uncertainties in ultrasound and volumetric data interpretation, calibration errors (see above), artifacts, signal noise, etc.
- When the 3D data are not current, targeting (or identification of fiducial markers) involves:
 - Correcting for target position changes which may, for example, be due to changes in a tumor due to therapy.
 - Developing techniques which robustly accommodate noise (due, for example, to sparse data sets), allow for differences in target segmentation due to changes in tissue characteristics, and speed up offline processing.

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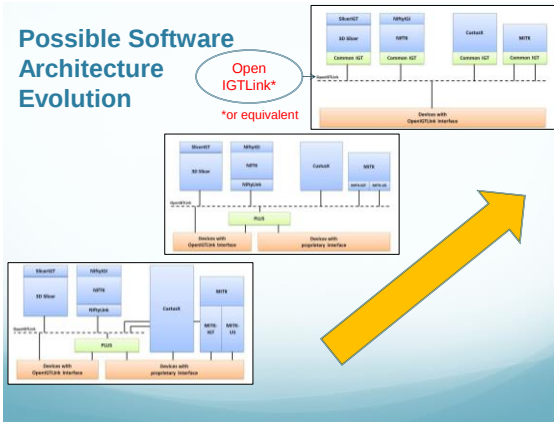
Commercial Systems for Tracked Ultrasound Guidance

- Applications:
 - MRI/CT images fused with real-time ultrasound: for neuro-navigation and prostate and liver biopsy and ablation
 - Needle guidance: for nerve block, vascular access. Etc.
- Typical commercial systems:
 - Ultrasound devices: Siemens eSie Fusion/Guide, GE Logiq E9, Philips PercuNav, Analogic/Unisonix SonixGPS, Esaote Virtual Navigator, etc.
 - Surgical navigation systems: BrainLab Ultrasound, Medtronic SonoNav, Pathfinder Explorer
- Although tracked ultrasound guidance systems have been available for several years now, they are still not used widely. A tipping point may be near.
- Lack of common software and hardware interface for trackers and ultrasound systems puts a huge burden on system developers.

Tracked Ultrasound Research Platforms

- Consolidation is happening at data acquisition toolkit level:
 - OpenGTLINK is supported by all data acquisition toolkits and application frameworks
 - PLUS is becoming the most widely used toolkit for tracked ultrasound data acquisition
- Various application frameworks have different advantages, but consolidation would be preferred to reduce parallel efforts
- Closed-source or not actively developed toolkits (Stradwin, MUSiC, IGSTK) may become irrelevant due to free availability of high-quality alternatives.

Possible Software Architecture Evolution



Training

- Despite technical advances, skill and experience are required to give reproducible, clinically correct results.
 - Imaging findings, such as the assessment of the position and shape of the liver, are very difficult to validate systematically.
- Human proctors to assess operator capability will continue to be necessary in many areas.
- Virtual reality systems which use navigable real case data are gaining traction for measuring Doppler imaging competency, in the context of didactic teaching and expert mentorship.
 - Potential use by cardiology community for certification and re-certification, as a practical alternative to extensive one-on-one tutoring.

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Summary

- Ultrasound is used to guide many types of procedures, spanning a large range of clinical specialties.
- There is lots of activity to improve and extend the role of ultrasound in the clinic.
- Stay tuned for the final report.
- We welcome suggestions:
 - What have we missed, what is not quite correct?
 - Send to kirby@bwh.harvard.edu

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