



SAM Session: Technical and Professional Preparations for
Medical Physicists in the Upcoming MRgRT Era



Working on MRI Simulator for MP who are trained in MRI

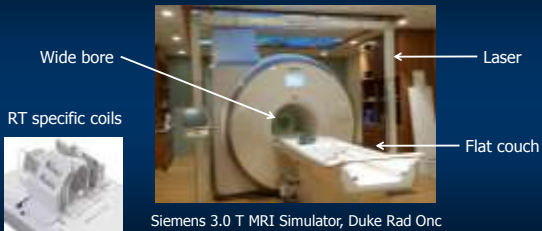
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Disclosure

No relevant conflict of interest.

MR Simulator



My Training Background

PhD in Engineering Physics, 2002-2006
Dissertation Title: "Magnetic resonance spectroscopy measurement of gas exchange dynamics using hyperpolarized Xenon-129"
Department of Radiology, University of Virginia

Medical Physics Resident, 2006-2009
Department of Radiation Oncology, University of Virginia

MRI Training



2009

2.2.7 Magnetic Resonance Imaging
The basic principles of magnetic resonance imaging (MRI) (document #18) are...
The authors believe that the most effective MRI education for the development of...
...the more commonly utilized clinical pulse sequences...
...The relative pros and limitations of MRI as a tool for physical and image-guided...
...MRI training without MR pulse sequence programming is not a good MRI training.

MRI training without MR pulse sequence programming is not a good MRI training.



- "we all fear what we do not understand" (from a RT physicist).
- Rapid growth of interest in MRI education in support of MR-assisted and/or MR-based treatment planning, assessment, and monitoring applications, as well as MR-guided treatment delivery.
- The current CAMPEP standards, ..., do not provide sufficient context and opportunity for students to connect the fundamental physical phenomena and concepts studied to the day-to-day tasks and problems they will face in supporting MRI in the clinical setting

Outline

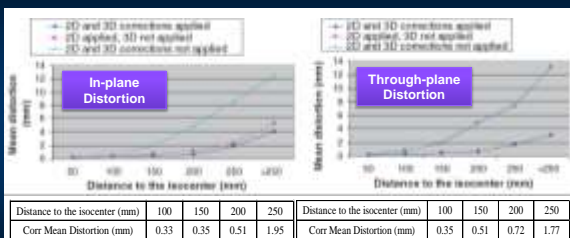
There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns– the ones we don't know we don't know.

- Rumsfeld during a Pentagon news briefing in February 2002

Known Knowns

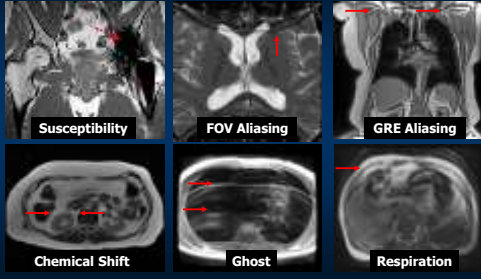
- MRI limits and functions
 - geometric distortion (now and then, DWI, etc.)
 - imaging speed of various sequences
- MR physics and sequence programming
 - root causes of image artifacts
 - imaging parameters tuning
 - real meanings of HASTE/FIESTA/TrueFISP/VIBE/FLASH.....
- Differences between MR and CT
 - MR is much more complex than CT in acquisition and recon
 - MR contains much more information than CT

MRI Geometric Distortion



Torfeh T et al. Magnetic Resonance Imaging 34 (2016) 645–653

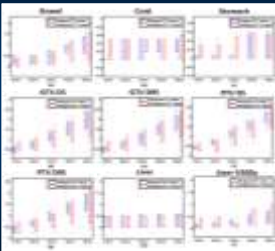
MRI Artifacts



Known Unknowns

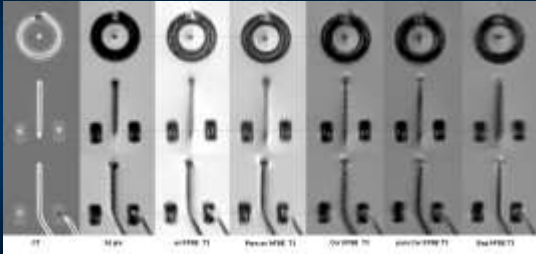
- Dosimetric effects of MR distortions
 - distortion type, body site, implants, etc.
- MR/CT registration uncertainties
 - effects on contouring/dose/image-guidance, etc.
- MRI for RT treatment planning
 - synthetic CT, 4D-MRI, segmentation, etc.
- MRI for RT response assessment
 - biomarkers, radiomics, quantitative imaging, etc.

Dosimetric Effects of MRI Distortion



- Liver SBRT
- Geometric distortion
- Dose error increases as distortion increase.
- When distortion < 2 mm, dose error < 1.0 Gy or 1% in all studied metrics.

MRI Artifacts of T&O Applicator



MR/CT Registration Uncertainty

Various MR/CT Registration Methods

TABLE 1. Reported RMS to CT registration errors for various registration methods.

| Author | Year | Method | Anatomical site | Reported average registration error (mm) |
|--------------------------------|------|----------------------------|-----------------|--|
| Alpert et al. (Ref. 13) | 1990 | Matching contours method | Brain | 1.9 |
| Robinson et al. (Ref. 14) | 1993 | Minimum gradient technique | Brain | 2 |
| Van Herten and Kroy (Ref. 15) | 1994 | Coarse (shell) matching | Brain | 1.8 |
| Koprowski et al. (Ref. 5) | 1995 | 3 anatomical landmarks | Prostate | 0.9 (40%) |
| Schwarzenberg et al. (Ref. 16) | 2002 | 4-12 anatomical landmarks | Prostate | 1.5 |
| Konijnen et al. (Ref. 18) | 2001 | Manual information | MR, CT | 1.8 (20%) |
| Brack et al. (Ref. 12) | 2006 | Various deformable | Vagina | 0.4 to 2 |

Devic S, et al, Medical Physics, 39 (11), 2012

Unknown Unknowns

Common "knowledge" of MRI:

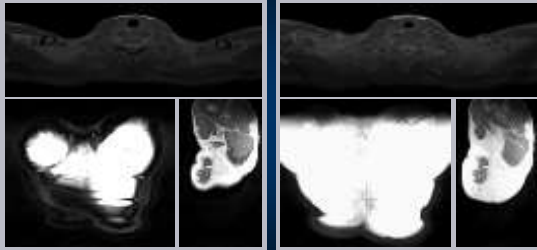
- MRI is bad for lung imaging
- MRI scan has a specific weighting contrast (T1w, T2w, etc.)

??? Can MRI be good enough for lung imaging (as good as CT)

??? Can MRI simultaneously obtains different contrasts

???

Super Quality Lung MRI



Dr. G. Wilson Miller, University of Virginia



Dr. Edward Hui, HKU

- MRI has remained largely unchanged for almost 50 years, being mainly restricted to the qualitative probing of only a limited set of the properties.
- MRF permits the simultaneous non-invasive quantification of multiple important properties of a material or tissue.
- MRF increase the sensitivity, specificity and speed of a magnetic resonance study, and potentially lead to new diagnostic testing methodologies

Summary

- Known knowns
 - broaden MRI knowledge through continues learning
 - keep up with the latest developments in MRI
- Known unknowns
 - research & development
- Unknown unknowns
 - keep your curiosity live
 - think out of the box

