Determining Spatial Resolution from Brain Imaging for Automated Quality Assurance of Magnetic Resonance Imaging

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INTRODUCTION

- Current recommendation from TG-284 for MRI quality assurance (QA): Evaluate image quality metrics from phantom scans (1).
- Phantom-based QA has limitations:
  - Clinical imaging sequences are not tested during QA.
  - Phantom-based QA requires staff time for scanning phantoms.
- **The limitations of phantom-based QA could be solved by evaluating QA metrics directly from patient imaging.**
- This strategy requires developing techniques to measure image quality metrics from *in vivo* MRI (2).
- This abstract: An automated approach to estimate spatial resolution in brain MRI.

METHODS AND MATERIALS

Algorithm

- Intensities over an image patch containing the genu-ventricle interface were projected onto an axis perpendicular to the edge (**Figure 1**).
- The theoretical edge-spread function was fitted to the profile (3).
- To account for systematic errors that create positive bias, the minimum spatial resolution estimate across many patches defined algorithmically was chosen (**Figure 2**).
- The resolution was assumed to be isotropic in-plane.

Cohort (N=30)

- Central nervous system tumour patients
- Scans:
  - 1.5T Unity MR-Linac (N=15)
  - 0.5 T Synaptive Evry (N=5)
  - 1.5 T Philips Ingenia (N=5)
  - 3 T Philips Achieva (N=5)
- T1-weighted, diffusion-weighted, and multi-echo spin echo imaging with voxel sizes ranging from 1.0-3.0 mm.
- Repeatability measured from MRL scans.

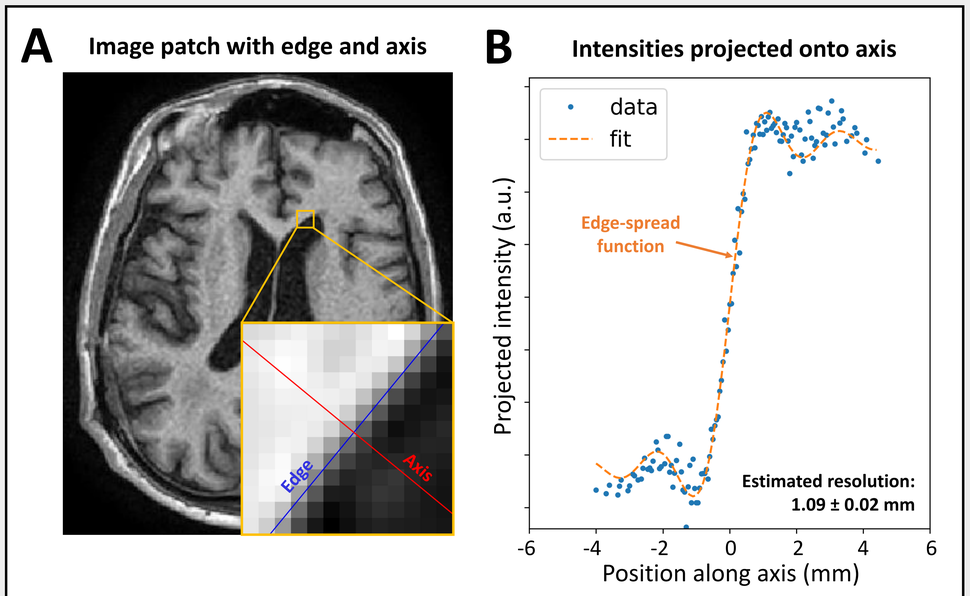

Figure 1 – Spatial resolution measurement from (A) an automatically selected image patch and (B) the resulting model fit and resolution estimate.

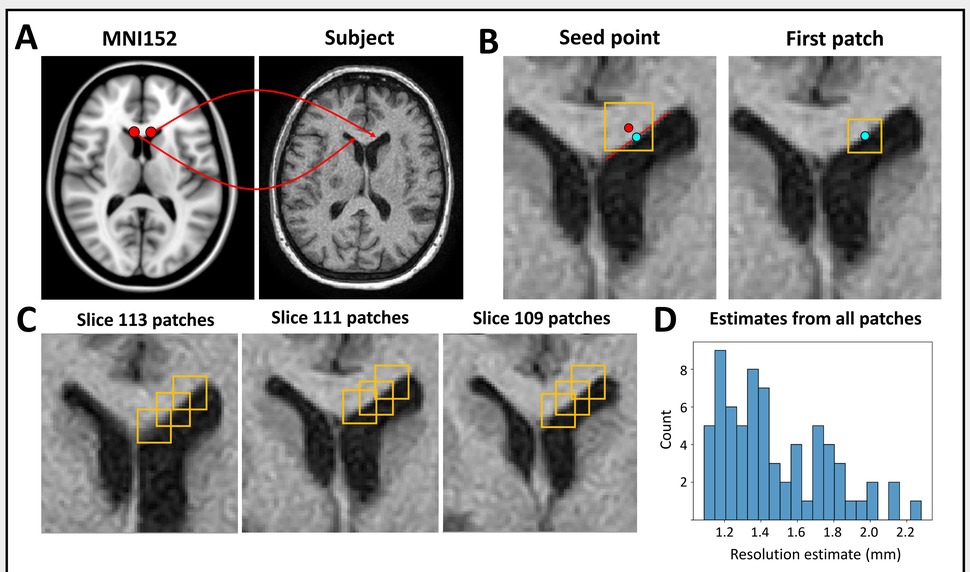

Figure 2 – Algorithm for automatic spatial resolution estimation. *(**A**) Seed points from MNI152 space are (**B**) snapped to the edge to create the first patch. (**C**) Additional patches are created by translation in-plane and cross-plane. (**D**) The minimum estimate across all patches is chosen as the definitive measurement.*

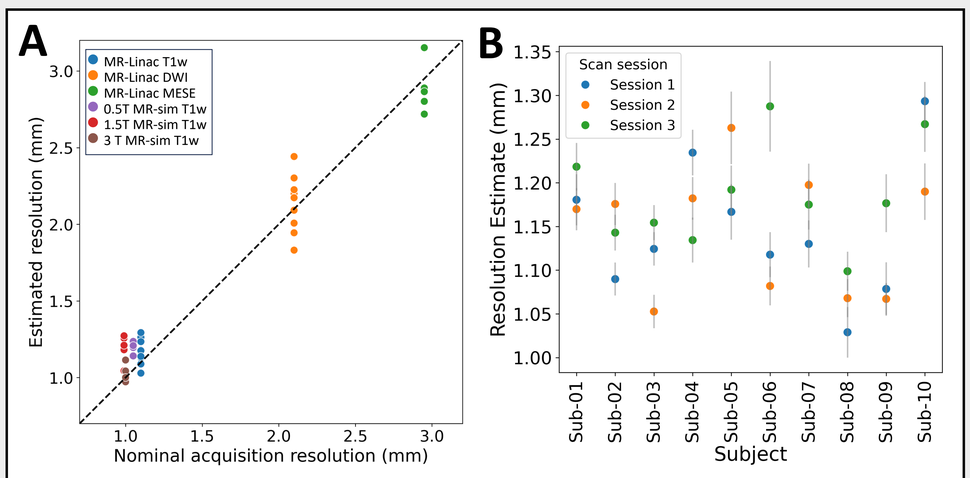

Figure 3 – Spatial resolution measurement accuracy and repeatability. *(**A**): Measured versus nominal resolution. (**B**): Repeated measurements from 10 subjects show that a resolution change of 0.15 mm is detectable.*

RESULTS

- The estimated resolution per protocol, averaged across subjects, was within 0.1-0.2 mm of the nominal resolution (**Table 1**).
- The individual estimated and nominal resolutions showed strong correlation ($r=0.98$, $p<.001$) (**Figure 3A**).
- The within-subject standard deviation was 0.056 mm, corresponding to a repeatability coefficient of 0.15 mm (**Figure 3B**) (cf. tolerance of 0.1 mm, AAPM Report 100).

Table 1 – Comparison of nominal resolution to measured resolution. *The resolution measurement assumes isotropic voxels, so only a 1D value is shown.*

Sequence	Nominal resolution (mm²)	Measured resolution (mm)
MRL T1w	1.1 × 1.1	1.17 ± 0.08
MRL DWI	2.0 × 2.2	2.2 ± 0.2
MRL MESE	3.0 × 2.9	2.9 ± 0.2
0.5 T T1w	1.1 × 1.0	1.20 ± 0.03
1.5 T T1w	0.98 × 1.0	1.19 ± 0.09
3.0 T T1w	1.0 × 1.0	1.02 ± 0.06

DISCUSSION AND CONCLUSIONS

- **First report of direct estimation of spatial resolution of MRI *in vivo*.**
- Strengths: Automated, applicable to clinically-acquired sequences.
- Limitations: Only developed for brain MRI, isotropic voxel sizes assumed.
- Future work: Extend the method to anisotropic spatial resolution.
- Potential applications in patient-specific QA from high-volume machines like MRI-linacs.

REFERENCES

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