Protocol Optimization Focused Scanner Characterization in CT: Noise and Spatial Resolution

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Purpose

To demonstrate an approach to characterize the spatial resolution and noise of a scanner in clinical settings, as opposed to the traditional method that uses non-clinically optimized scan modes (axial scans, with dose levels and kernels not suited for real patients) [1-2]

Material & Methods

Phantoms:
- Catphan 500 (The Phantom Laboratories)
- Triple Modality 3D Abdominal Phantom (CIRS)
- A cadaveric head phantom

Scanner: GE Discovery CT750 (GE Healthcare, Waukesha, WI)

Scanning parameters: tube potential = 120 kV, current = 400 mA, slice thickness = 1.25 mm, dose ($CTDI_{vol}$) = 35.3 mGy, scanning FOV = large body.

Reconstruction parameters:
- Matrix size = 512 x 512
- Kernels: soft tissue, standard, lung, chest, detail, bone, boneplus, edge
- RFOV: diameters = 10, 15, 20, 25, 30, 32, 35, 36, 40, 45, 50 cm

Measurements:
- Catphan 500: Spatial resolution (lp/cm) and noise SD (HU) in a uniform ROI with a fixed physical area at the central slice
- Abdominal Phantom: noise SD in three different ROIs (liver, high contrast, low contrast)
- Head: noise SD at the central slice

Results

- The spatial resolution is limited by both RFOV and kernel selection (Fig.1.a & Fig.3)
  - In kernel limited region, the selection of higher resolution kernels improves spatial resolution
  - In pixel limited region, the use of high-resolution kernels has limited ability to improve spatial resolution
- The noise SD for a selected kernel is roughly a constant in small RFOV (<35 cm) but decreases in large RFOV (Fig.1.b).
- The selection of RFOV and kernel significantly influence the visual quality and diagnosis capability of the images (Fig.2).

Conclusion & Discussion

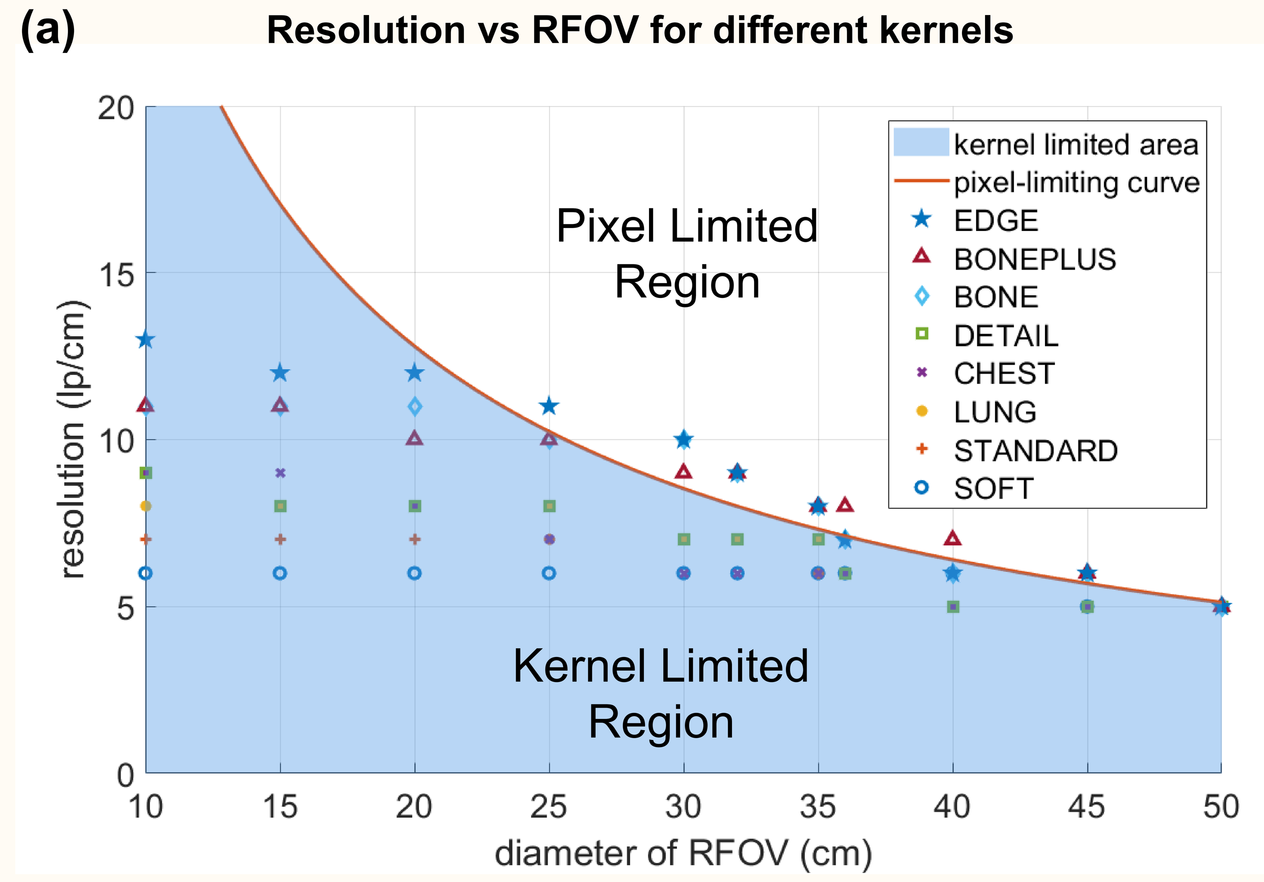
- The pixel-limiting curve provides an estimate of the maximum resolution of a selected RFOV
- The use of large RFOV for a selected kernel allows data being spatial averaged; this produces two effects: (1) decreased noise and (2) decreases spatial resolution
- This characterization provides actionable guidance on kernel and RFOV selection in clinical settings: it is recommended to select kernel and RFOV settings that keep images pixel limited so resolution is not lost while noise aliasing persists

Reference

[1] Ehsan Samei et al. The Report of AAPM Task Group 233: Performance Evaluation of Computed Tomography Systems. 2019.

[2] Kawashima, Hiroki, Aria M. Salyapongse, Giuseppe V. Toia, Katsuhiro Ichikawa, and Timothy P. Szczykutowicz. "Efficacy of CT spatial resolution metrics in clinical settings." Medical Physics 53, no. 5 (2026): e70505.

Results



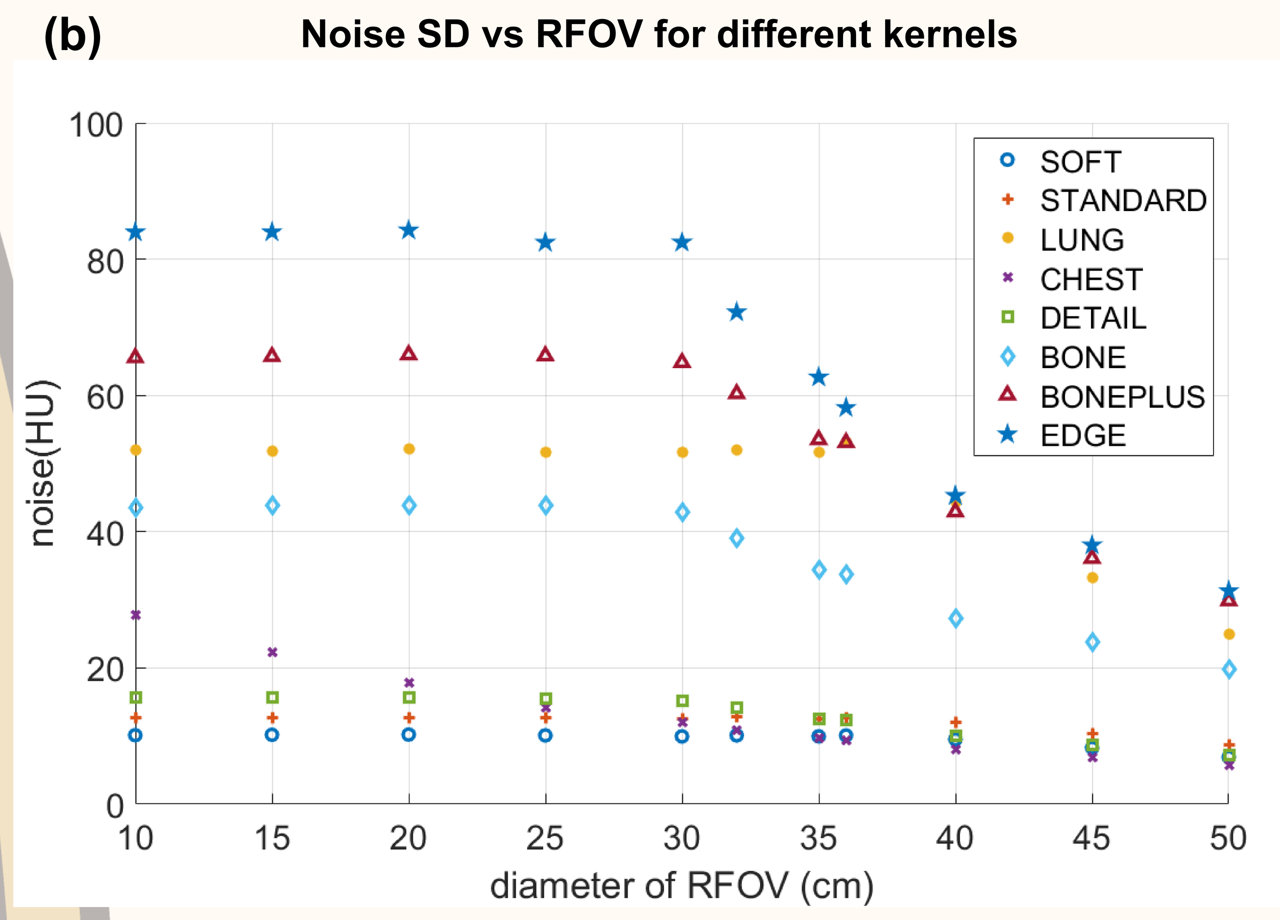


Fig.1. The above two figures demonstrate the fundamental trade-off between the noise and spatial resolution: as resolution decreases due to large voxel size, noise also decreases.

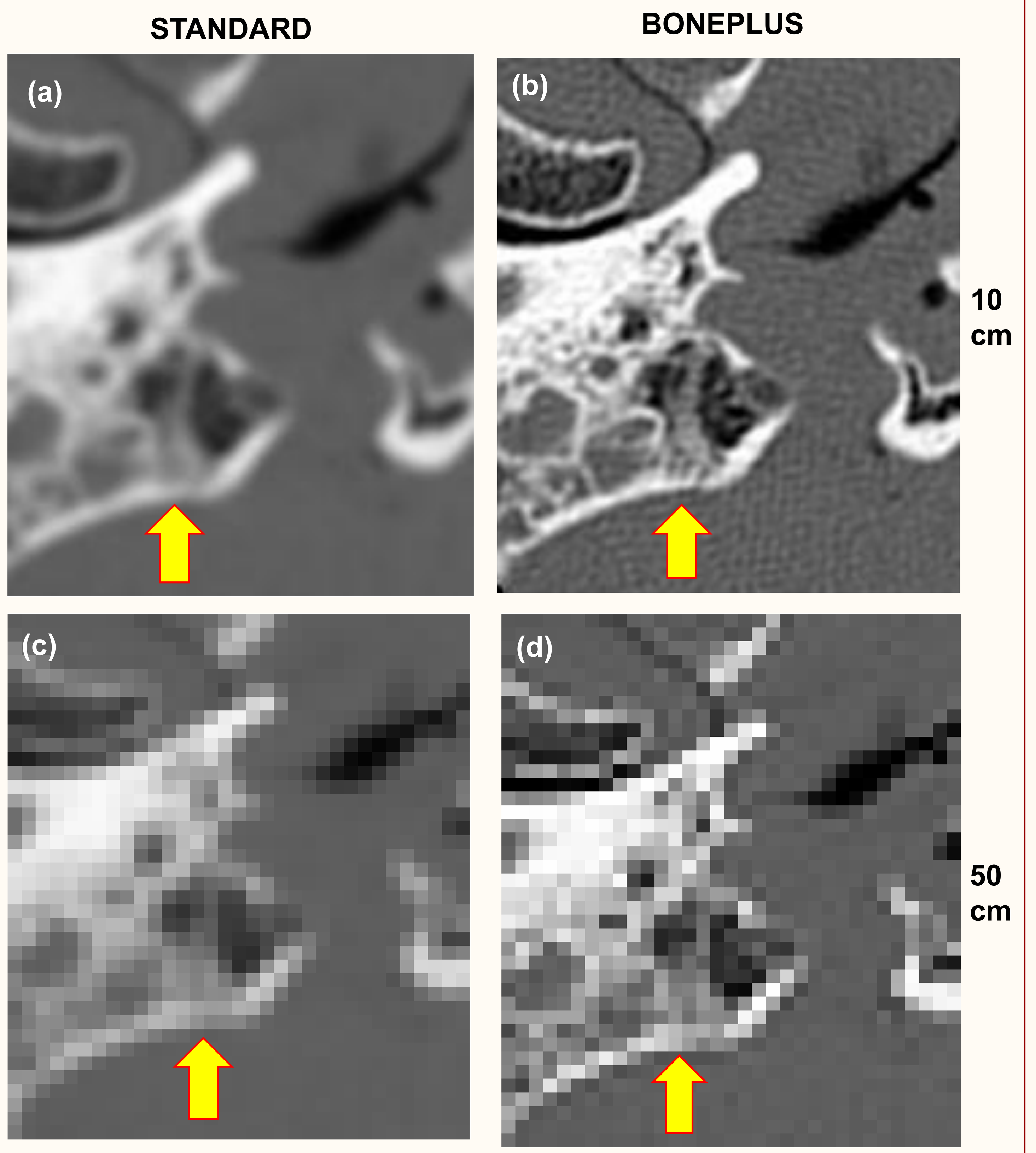


Fig.2. A visual comparison of the cadaveric head using the standard and the boneplus kernel reconstructed in 10 cm and 50 cm. With a 50 cm RFOV, the boneplus kernel exhibits higher noise than the standard kernel while achieving a similar resolution; fine trabecular bone details are not resolvable (c and d).
In contrast, with a 10 cm RFOV, the boneplus kernel provides improved spatial resolution, allowing fine trabecular bone details to be more clearly visualized (a and b).

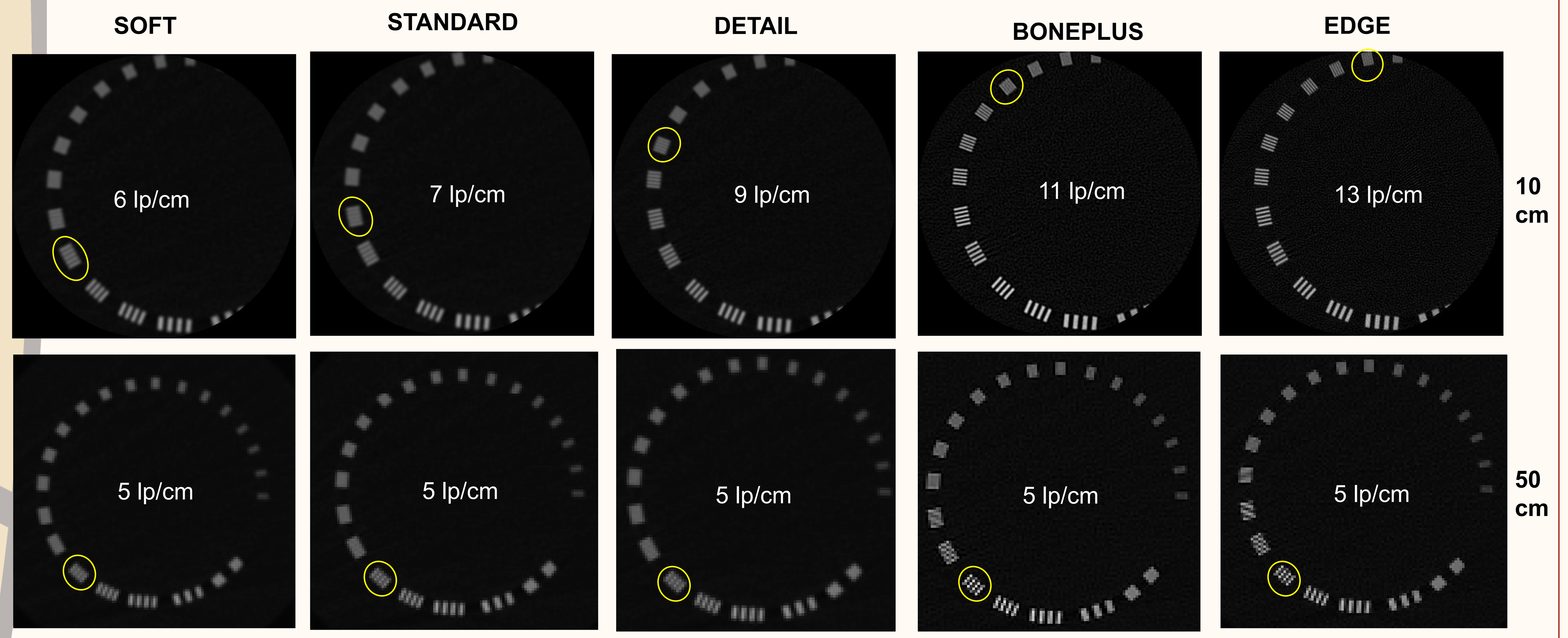


Fig. 3. A visualization of the spatial resolution influenced by RFOV and kernel. With a 50cm RFOV, the resolution is 5 lp/cm in all the kernels. With a 10 cm RFOV, the selection of high-resolution kernels improves spatial resolution.