

The Intrinsic Manifolds of Radiological Images and their Role in Deep Learning

Nicholas Konz^{1*} Hanxue Gu¹ Haoyu Dong² Maciej Mazurowski^{1,2,3,4}

¹Department of Electrical and Computer Engineering, ²Department of Radiology, ³Department of Computer Science, ⁴Department of Biostatistics & Bioinformatics, Duke University, North Carolina, USA



Introduction

The Manifold Hypothesis

Objectives

1.

Datasets and Tasks

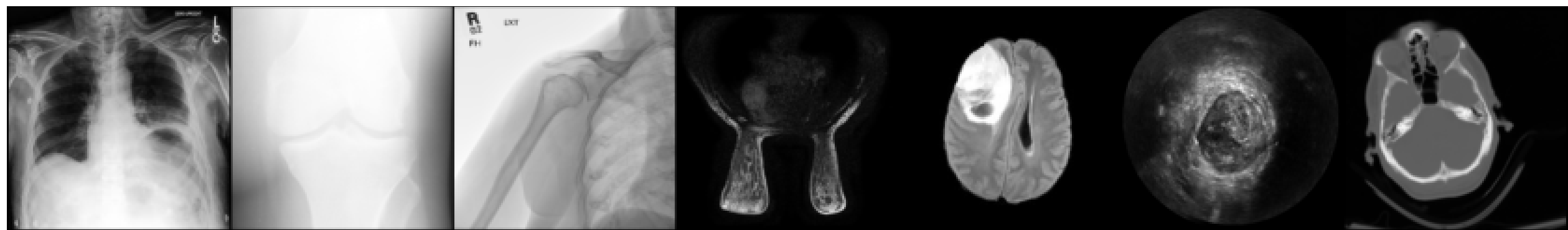


Figure 1: Samples from our evaluated datasets.

- ▶ Vestibulum nisl, quis euismod velit eros in ligula.
- ▶ Cras rhoncus quam et augue convallis in elementum urna tincidunt.
- ▶ Proin ut vestibulum augue.
- ▶ Donec dapibus sagittis neque eu ultrices.
- ▶ Curabitur sapien ligula, faucibus in feugiat quis, vestibulum a turpis.
- ▶ Phasellus quis nunc neque. Suspendisse mauris diam, suscipit non gravida in, placerat id enim. Ut nec ipsum in lectus ultrices sagittis.
- ▶ Ut nec ipsum in lectus ultrices sagittis.
- ▶ Phasellus quis nunc neque.

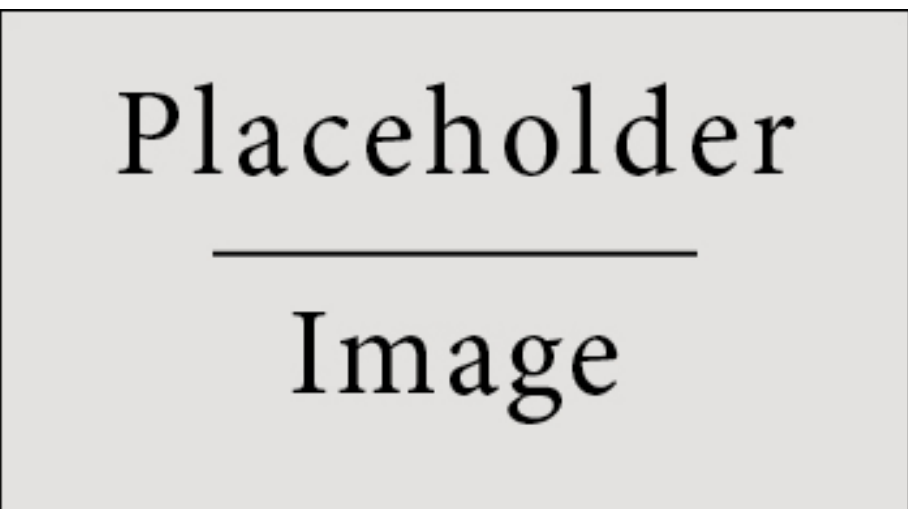


Figure 2: Figure caption

Estimating Intrinsic Dimension

- ▶ Maecenas Ultricies Feugiat Velit Non Mattis.

▶ Duis

$$\mathbf{X} \rightarrow r(\mathbf{X}) = \arg \max_c \left\{ \max_n \left\{ \sum_{\mathbf{x}_i \in \mathbf{X}} \delta(\mathbf{x}_i, \mathbf{Y}_{n,c}) \right\} \right\}$$

▶ Cras

▶ Fusce

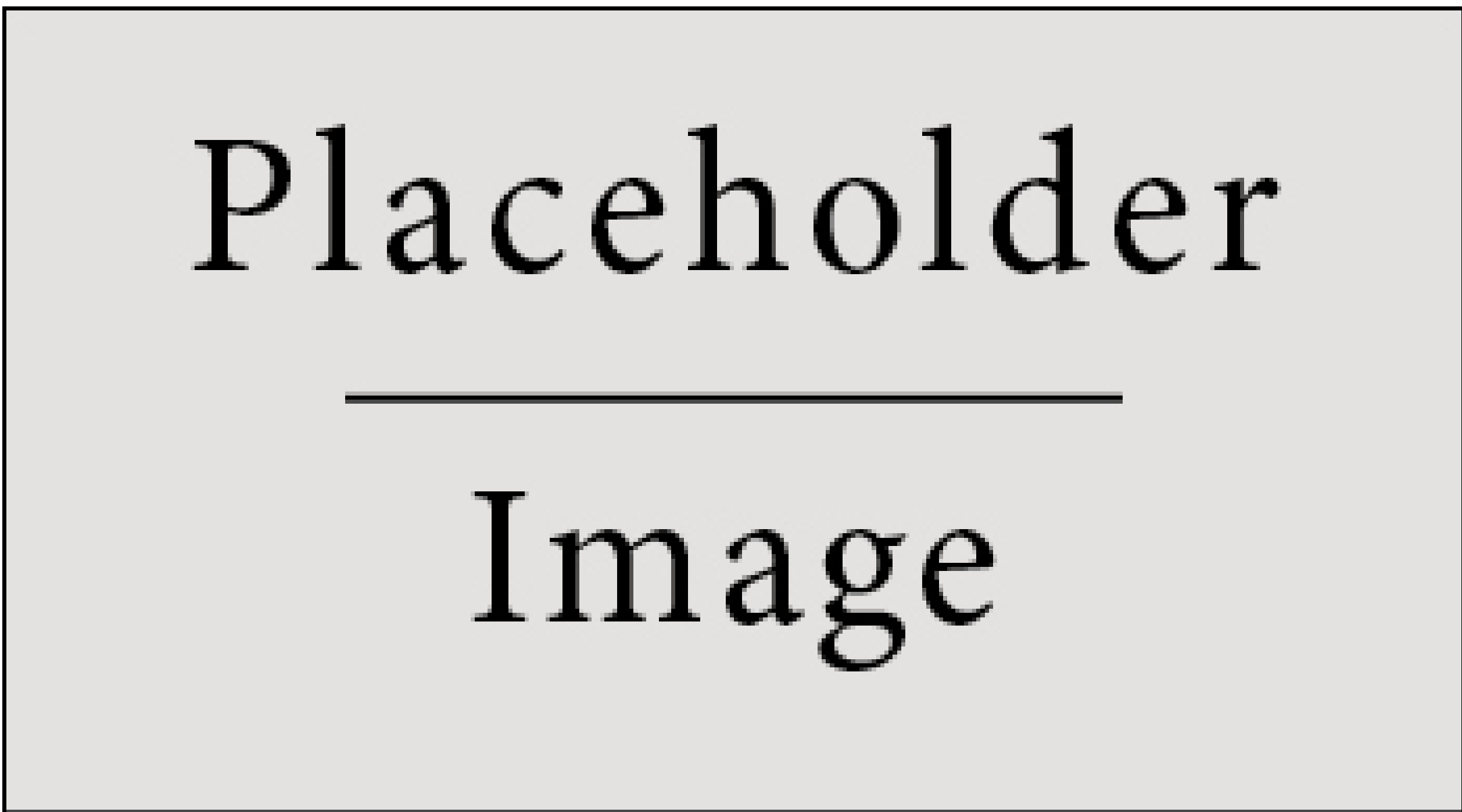


Figure 3: {some visualization of intrinsic manifold dimension}

Result 1: Radiological vs. Natural Image Intrinsic Dimension

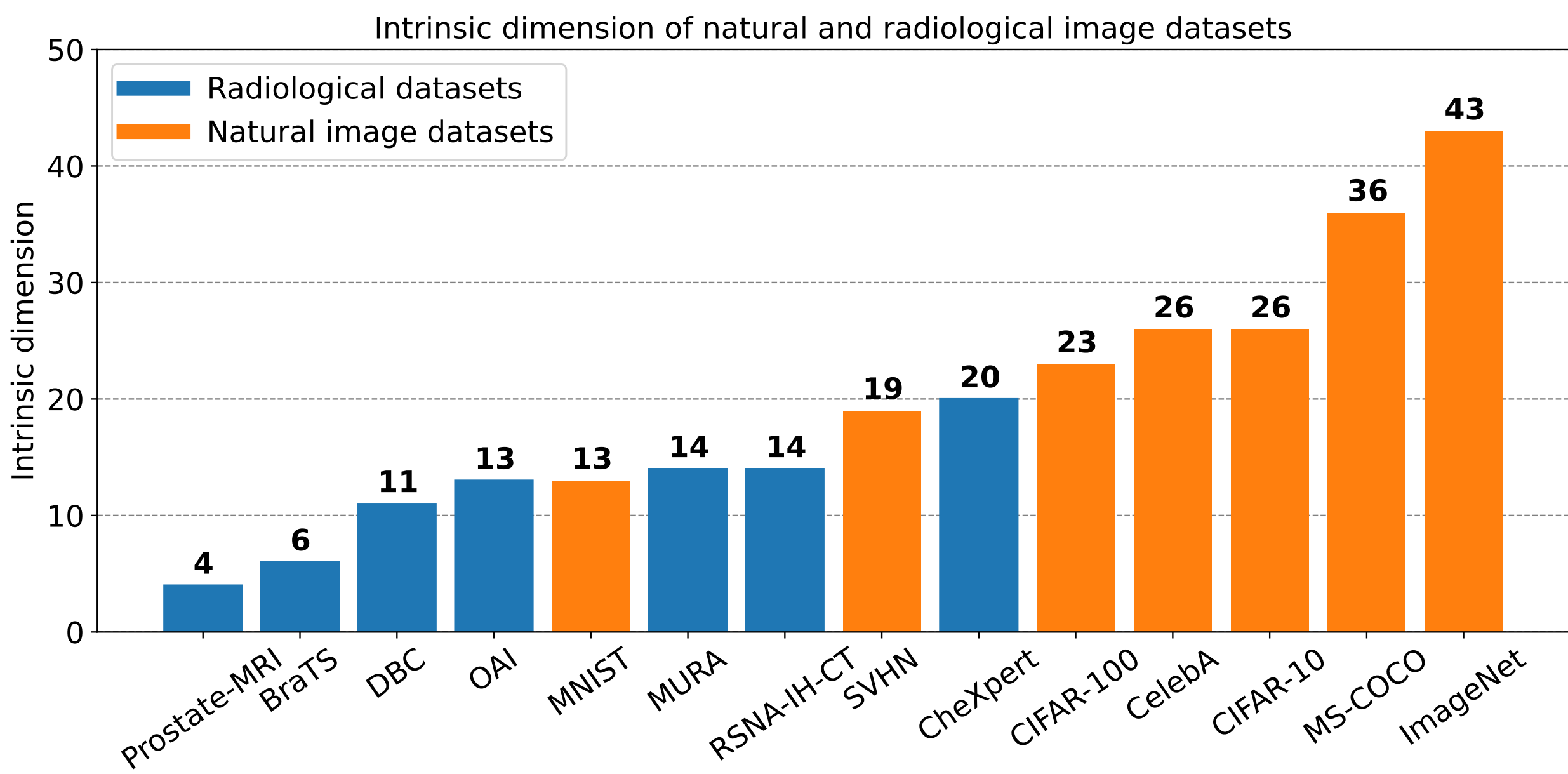


Figure 4: Intrinsic dimension of radiological and natural [1] image datasets.

Result 2: Radiological vs. Natural Image Intrinsic Dimension

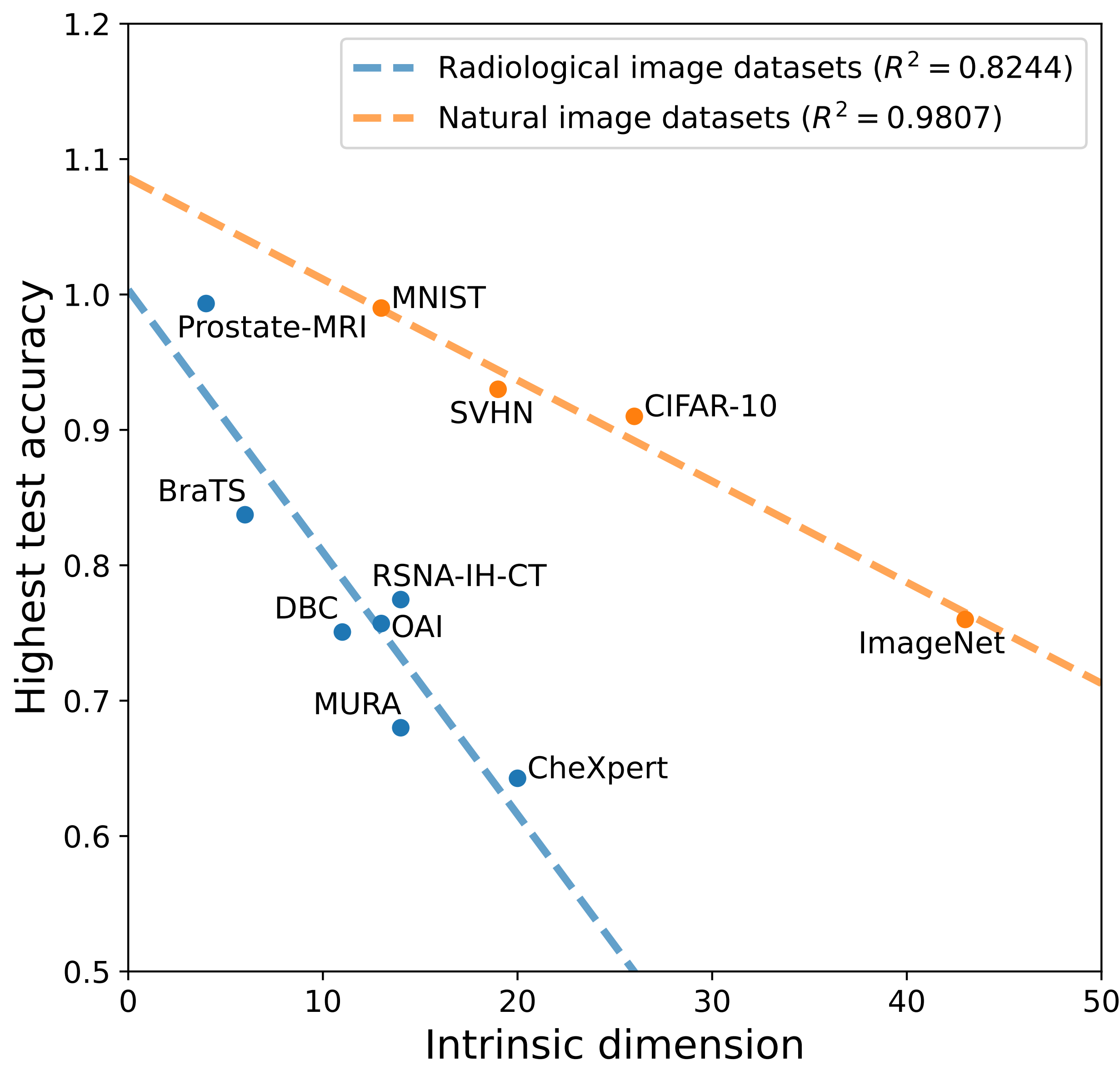


Figure 5: Linearity of model generalization ability with respect to dataset intrinsic dimension, for radiological and natural image datasets ($N_{\text{train}} = 2000$ on ResNet-18).

{numerical evidence showing how these relationships didn't change with model, dataset size, task, etc (see paper)}

Open Questions

- ▶ Opet volutpat ligula.

References

[1] Phillip Pope, Chen Zhu, Ahmed Abdelkader, Micah Goldblum, and Tom Goldstein. The intrinsic dimension of images and its impact on learning. In *9th International Conference on Learning Representations, ICLR 2021, Virtual Event, Austria, May 3-7, 2021*. OpenReview.net, 2021.

Contact Information

- ▶ Web: {lab website}
- ▶ Email: nicholas.konz@duke.edu