# Deep learning for analysis of diffusion-MRI based white matter tractometry

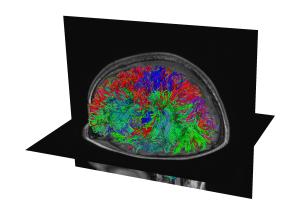
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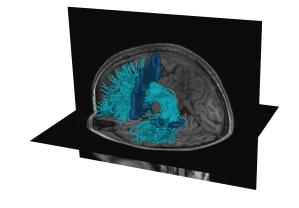
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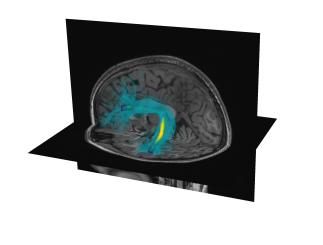


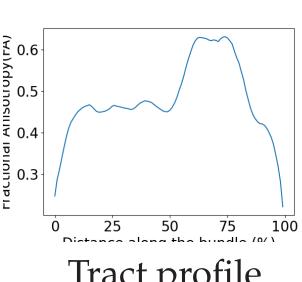
# Introduction

- Tractometry uses diffusion MRI (dMRI) to quantify brain tissue properties within white matter connections *in vivo* [1].
- The Healthy Brain Network Processed Open Derivatives (HBN POD2) is a large (n>2,000) pediatric dMRI dataset that has been processed and automatically QC'd[2, 3]
- The pyAFQ software was used to create tract profiles for statistical analysis [4].
- In previous work, we demonstrated that regularized regression provides accurate predictions of individual age in HBN from tractometry data (WM-based "brain age")[5].









Whole brain Selecting a bundle tractography with ROIs

Extracting values along the length of the tract

Tract profile

Question: Would convolutional neural networks provide improvements in inferences from tractometry?

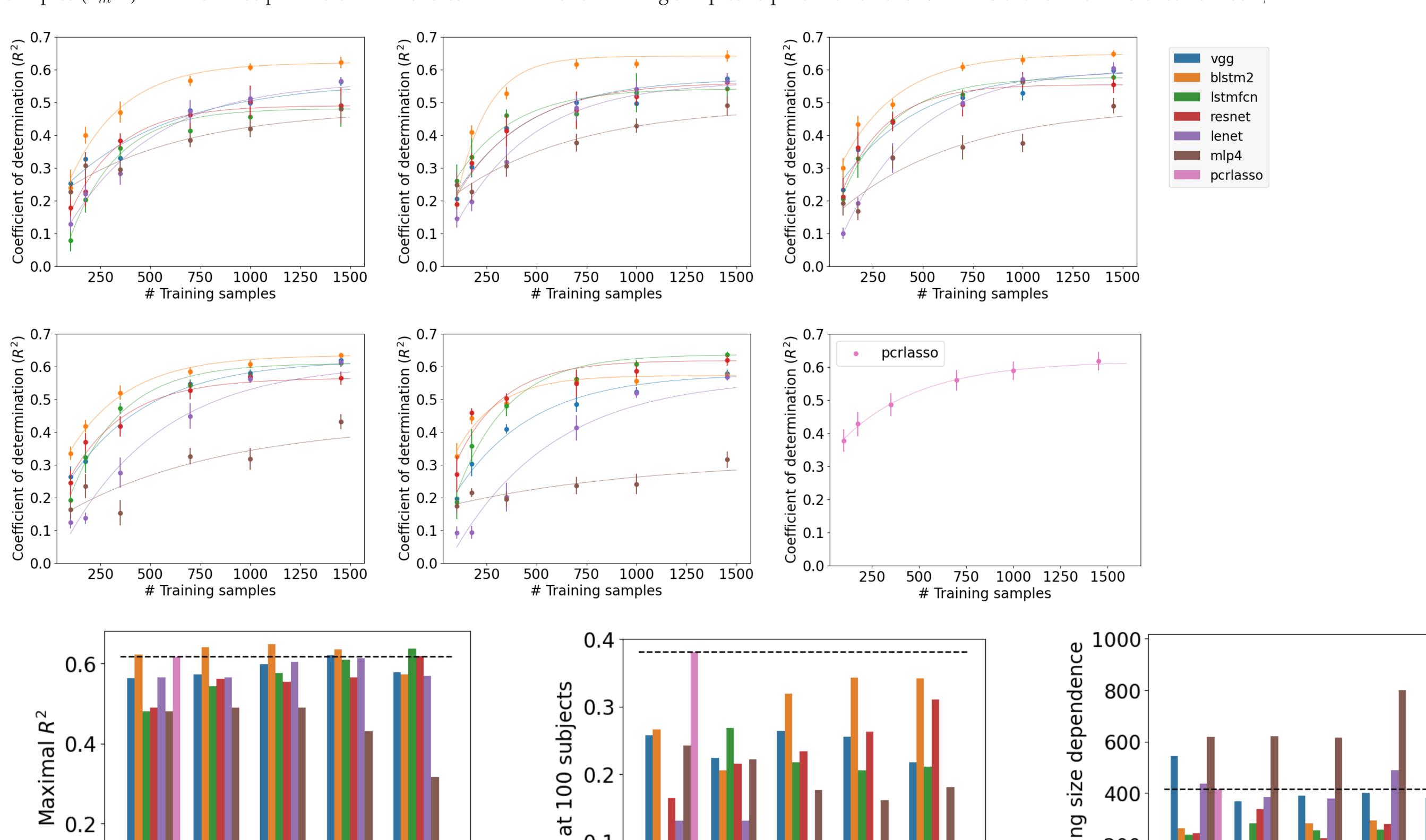
# Methods A B C

- (A) In a linear tractometry model,  $\mathbf{y} = \beta X$ . (B) To move towards a convolutional neural networks, we stack the data from different tracts and metrics (FA, MD, MK) as different measurement "channels". (C) Training samples are then passed to a network (here as schematic)
- We used the 1817 subjects from HBN POD2 that had passing QC scores and age information.
- A variety of convolutional neural networks were implemented in AFQ-Insight (https://richiehalford.org/AFQ-Insight)
- To evaluate the models, we set aside a test set of 20% of the subjects (363 subjects)
- To compare model dependence on training set size, we trained with variable train set sizes (100, 175, 350, 700, 1000, 1453 subjects)

### Results

Model performance was quantified as the coefficient of determination,  $\mathbb{R}^2$ 

 $R^2$  was modeled as:  $\alpha - (\alpha - \beta)e^{-\frac{x-x_{min}}{\kappa}}$ , where x is the number of training samples,  $\alpha$  is  $R^2$  at the maximal number of training samples,  $\beta$  is  $R^2$  at the smallest number of training samples ( $x_m in$ ) and  $\kappa$  is a free parameter that denotes that number of training samples required to achieve  $R^2$  that is 67% of the difference between  $\beta$  and  $\alpha$ .



0.025 0.05

Augmentation scale

### Conclusion and future work

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Neural network models (NNs) improve accuracy of tractometry analysis

0.1

- NNs are very data hungry
- Tuning and training these models is complicated and time-consuming
- Differences can be much more important in some cases (see poster # XXX)

### References

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- [2] Adam Richie-Halford, Matthew Cieslak, Lei Ai, Sendy Caffarra, Sydney Covitz, Alexandre R Franco, Iliana I Karipidis, John Kruper, Michael Milham, Bárbara Avelar-Pereira, Ethan Roy, Valerie J Sydnor, Jason D Yeatman, The Fibr Community Science Consortium, Theodore D Satterthwaite, and Ariel Rokem. An analysis-ready and quality controlled resource for pediatric brain white-matter research. *Scientific Data*, 9(1):1–27, October 2022.
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- [4] John Kruper, Jason D. Yeatman, Adam Richie-Halford, David Bloom, Mareike Grotheer, Sendy Caffarra, Gregory Kiar, Iliana I. Karipidis, Ethan Roy, Bramsh Q. Chandio, Eleftherios Garyfallidis, and Ariel Rokem. Evaluating the reliability of human brain white matter tractometry. *Aperture*, 1:10.52294/e6198273–b8e3–4b63–babb–6e6b0da10669, 2021.
- [5] Adam Richie-Halford, Jason D. Yeatman, Noah Simon, and **Rokem, A.** Multidimensional analysis and detection of informative features in human brain white matter. *PLoS Computational Biology*, in press(6):1–24, 06 2021. PMC5838108[pmc.

## Acknowledgments







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