Model-based Reconstruction meets Neural Networks: Non-linear Operators in BART

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BART: Software Toolbox for Computational MRI

Purposes

- rapid prototyping
- reproducible research
- clinical translation

Availability

- Linux, MacOS X, Windows
- BSD license (free for commercial use)
- `https://mrirecon.github.io/bart/`

Command line tools for MRI reconstruction

- calibration methods
  - ESPIRiT, RING, ...
- compressed sensing and parallel imaging
- calibration-less parallel imaging: SAKE and ENLIVE
- ...

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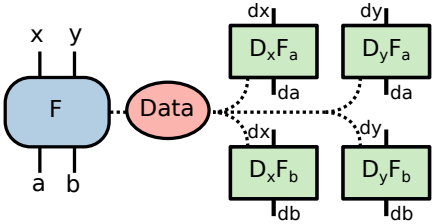
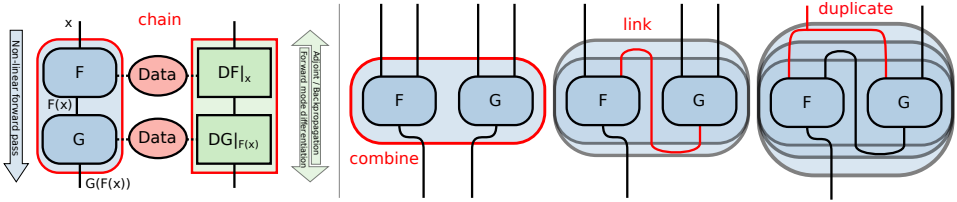
BART

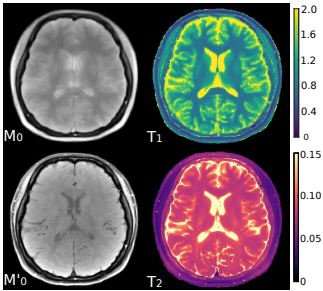
Non-linear Operators in BART



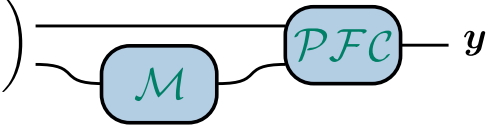
- Automatic differentiation
- Compose complex operators from basic ones



PART I: Non-linear Operators for Model-based Reconstruction



$$\boldsymbol{x} = \begin{pmatrix} x_c \\ x_p \end{pmatrix}$$



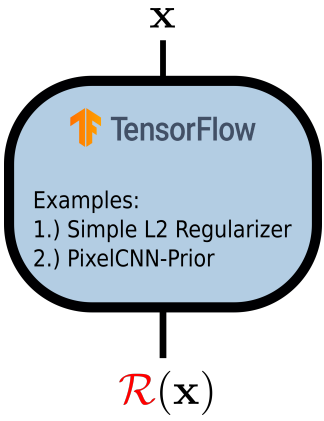
Reconstruction

$$\hat{\boldsymbol{x}} = \arg\min_{\boldsymbol{x}} \|\mathcal{PFC}(x_c, \mathcal{M}(x_p)) - \boldsymbol{y}\|^2 + \mathcal{R}(\boldsymbol{x})$$

Wang (Phil. Trans. R. Soc. A, 2021); Program: #0753, #3598

PART II: TensorFlow-Regularizer + BART Reconstruction

1.) Train a regularizer with TensorFlow



2.) Use BART for reconstruction

BART command

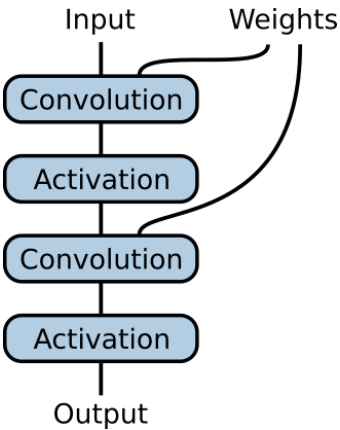
```
$ bart pics                                \
    -R TF:{<graph_path>}:...               \
    <kspace> <coils> <reco>
```

Reconstruction

$$\hat{\boldsymbol{x}} = \arg\min_{\boldsymbol{x}} \|\mathcal{P}\mathcal{F}\mathcal{C}\boldsymbol{x} - \boldsymbol{y}\|^2 + \mathcal{R}(\boldsymbol{x})$$

Luo (MRM, 2020); Program: #1756

PART III: Neural Networks in BART

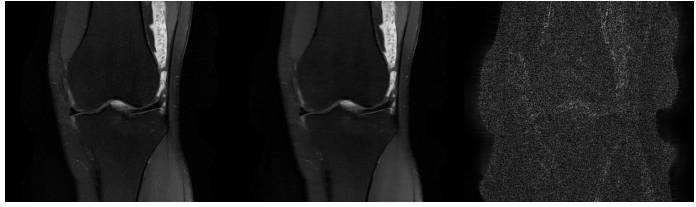


Train and apply neural networks with BART

1. Simple MNIST-Example
2. Variational Network[1] and MoDL[2]

BART command

```
$ bart reconet --network=varnet --apply \
  <kspace> <coils> <weights> <out>
```



[1]Hammernick (MRM, 2018); [2]Aggarwal (IEEE TMI, 2019); Program: #1754

Summary

1. Introduction: Non-linear Operators in BART
   Moritz Blumenthal
2. Non-linear Operators for Model-based Reconstruction
   Xiaoqing Wang and Zhengguo Tan
3. TensorFlow-Regularizer + BART Reconstruction
   Guanxiong Luo
4. Neural Networks in BART
   Moritz Blumenthal

See you at the BART software demo: **Sunday, May 16, 7pm** UTC
`https://www.ismrm.org/21/program-files/T-13.htm`