Revised-NODDI with conventional dMRI data enabled by deep learning

Michele Guerreri[1,2], **Hojjat Azadbakht**[2], **and Hui Zhang**[1]

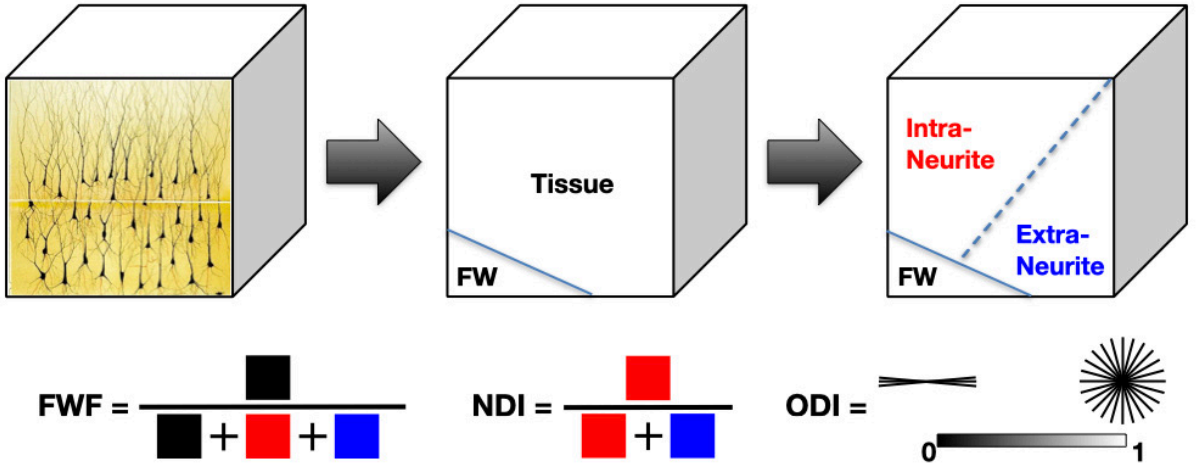
1.Department of Computer Science & Centre for Medical Image Computing, University College London, London, United Kingdom.
2. AINOSTICS, Manchester, England.

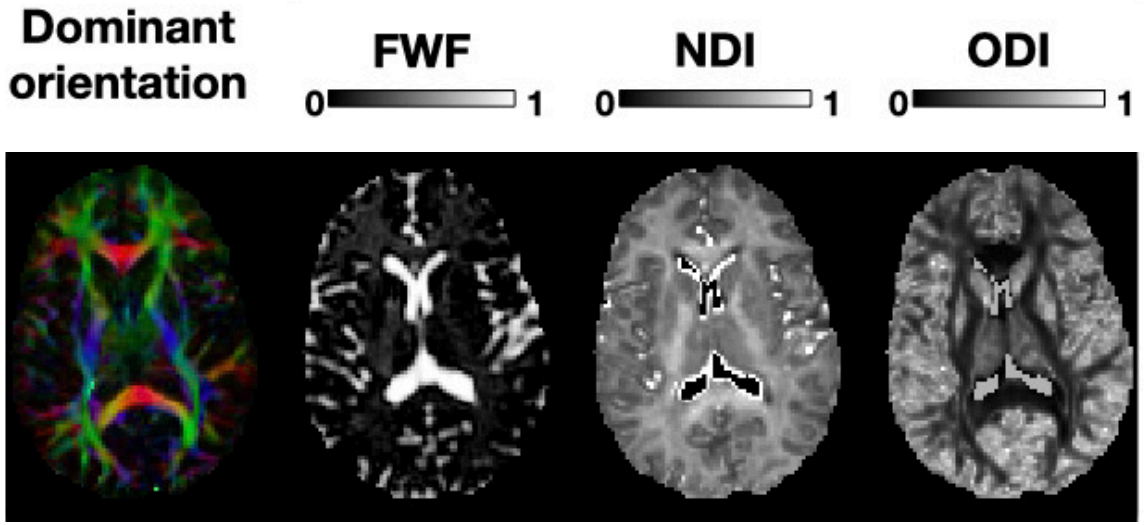
Centre for Medical Image Computing
Computational Imaging Group
Medical Research Council

Revised-NODDI a recent version of NODDI

Tissue Morphology

[1]





[1] WIKIMEDIA COMMONS. 2012. *File: Golgi 1885 Plate XVI.JPG*: https://commons.wikimedia.org/wiki/File:Golgi_1885_Plate_XVI.JPG

Why revised-NODDI?

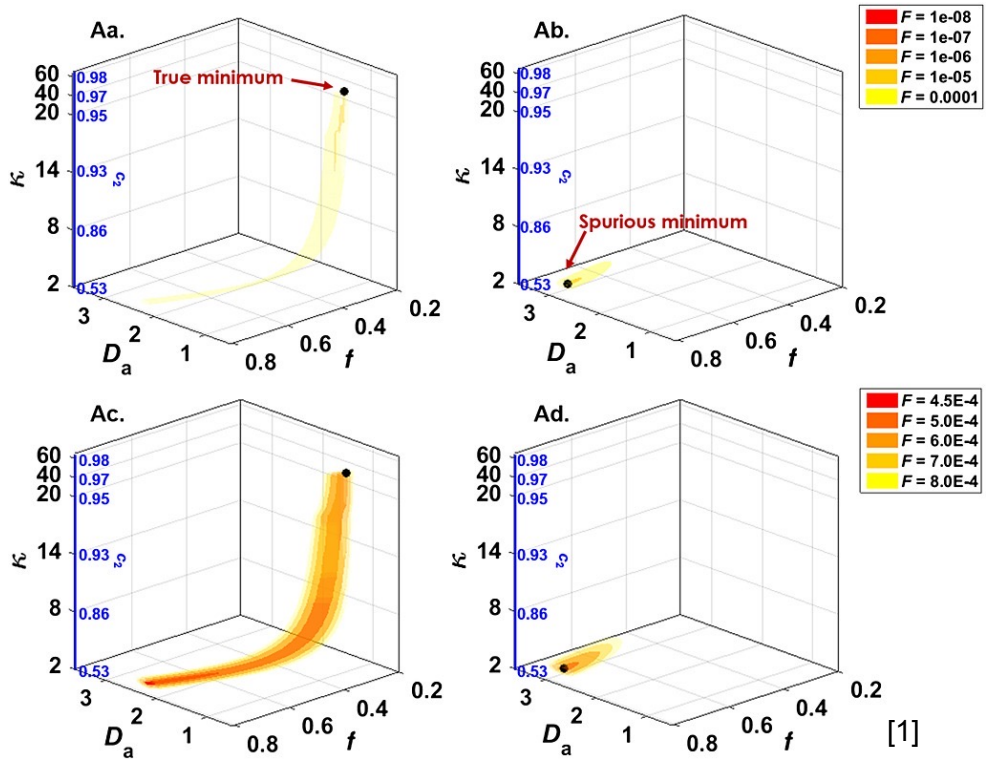
Revised NODDI has been shown to **overcome** some of the **limitations of the original version**.

Moreover, the **intra-neurite diffusivity** ($\mathbf{d_I}$) parameter can be **robustly estimated**.

Guerreri, M., et al., *ISMRM*. 2020: Virtual conference

What is the problem?

With **conventional dMRI data** alone and **using traditional fitting methods** we cannot **robustly estimate all revised-NODDI parameters**.



[1]

[1] Jelescu, Ileana O., et al. NMR in Biomedicine 29.1 (2016): 33-47.

A non-optimal alternative

Fixing the d_I value as done in the original model version **solves the degeneracy problem**.

In the presence of **natural variation of the diffusivity**, it may **lead to a biased estimation of the other parameters**.

Can we exploit DL?

DL has a demonstrated capacity to **reduce the imaging protocol requirements**.

ELSEVIER

NeuroImage

Volume 244, 1 December 2021, 118601

Neural networks for parameter estimation in microstructural MRI: Application to a diffusion-relaxation model of white matter

João P. de Almeida Martins [a, b, 1], Markus Nilsson [a, 1], Björn Lampinen [c], Marco Palombo [d], Peter T. While [b, e], Carl-Fredrik Westin [f, g], Filip Szczepankiewicz [a, f, g]

- DL can **partially alleviate degeneracy problems**.
- In the presence of parameter-specific modulations, the **other parameter estimation via DL is marginally affected**.

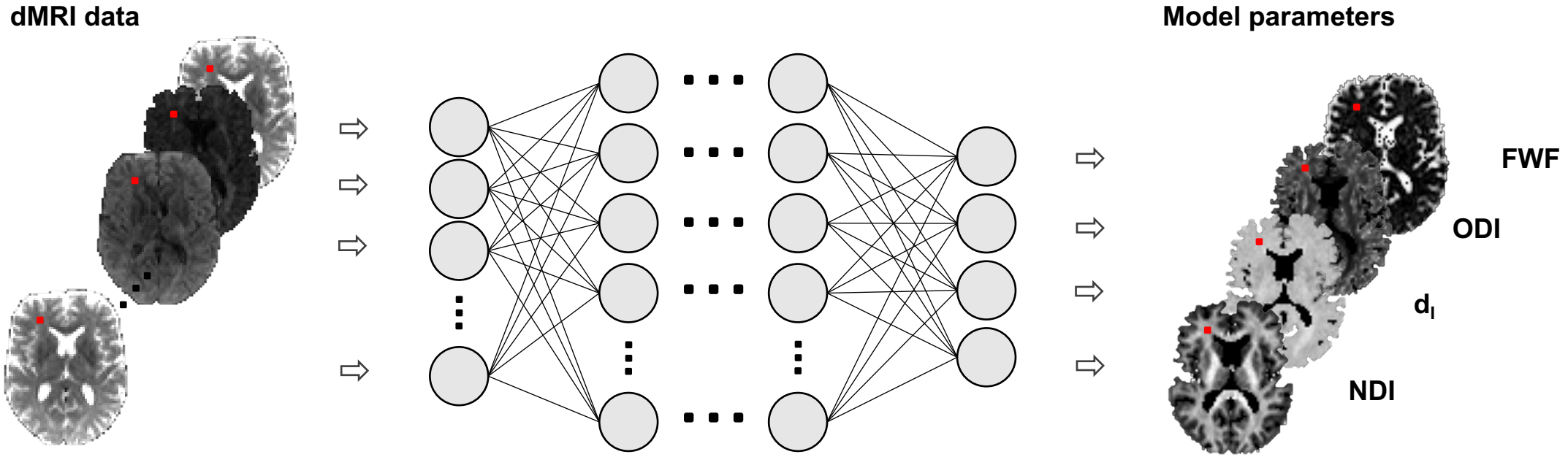
Aim of the work

1. **Can we alleviate revised-NODDI degeneracy problems from conventional dMRI data alone, via DL?**

2. **Can DL reduce parameter estimation bias in the presence of d_I fluctuations, compared with a conventional fitting approach using fixed diffusivity?**

The DL model

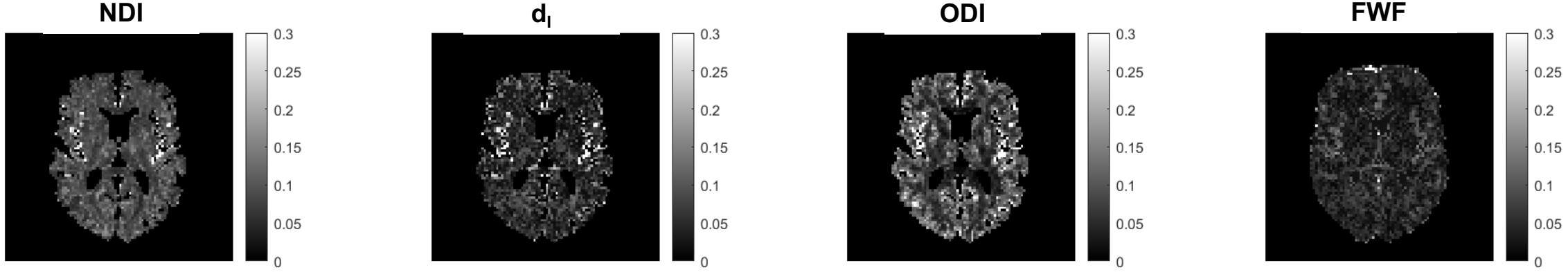
We design a **multi-layer perceptron** which takes **single voxel conventional dMRI data as input** and **outputs revised-NODDI rotation-invariant parameter** estimations.



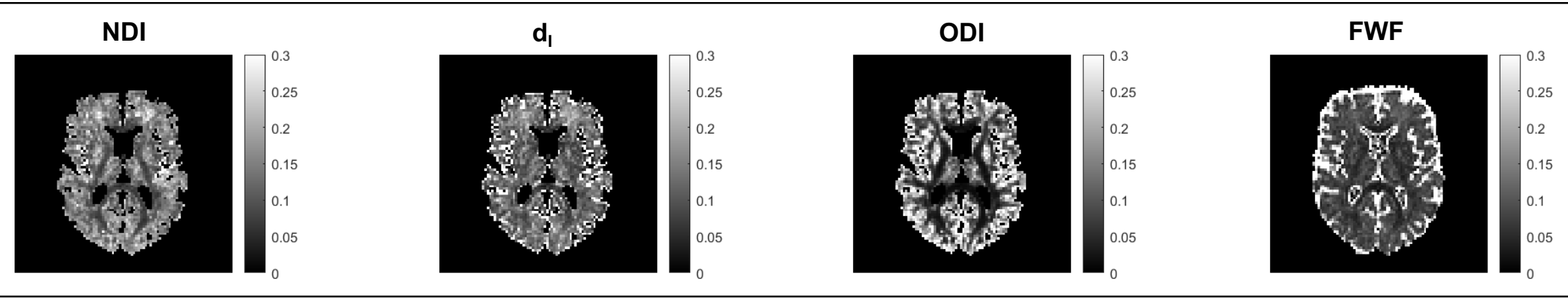
We train the network on synthetic data.

Results 1: DL has lower RMSE

DL

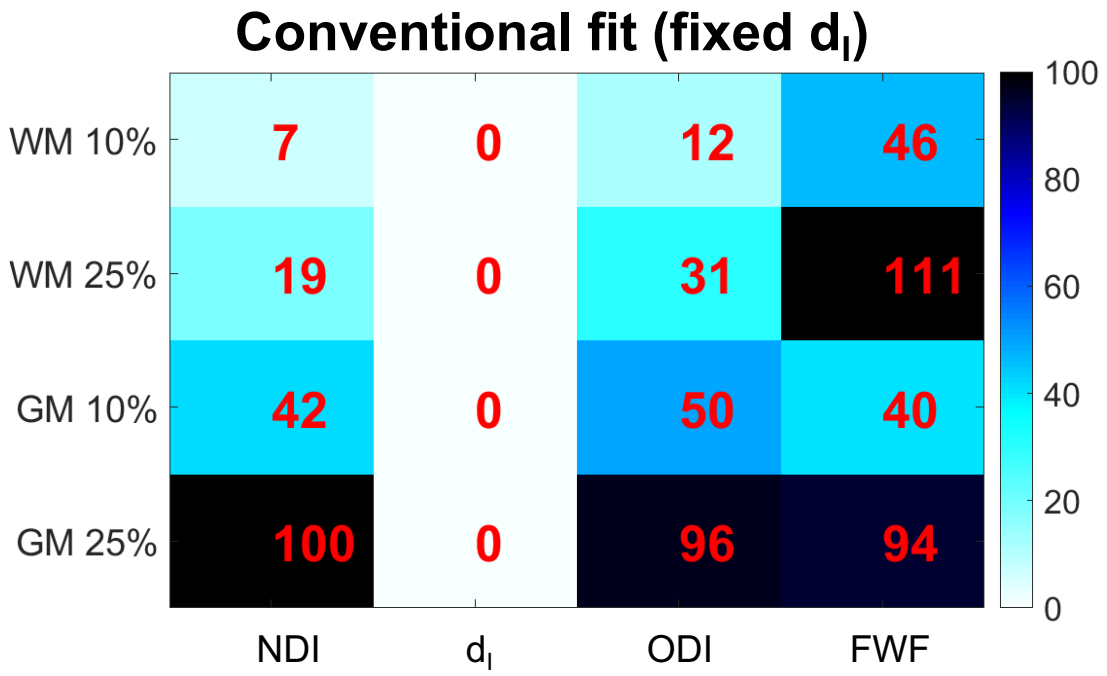


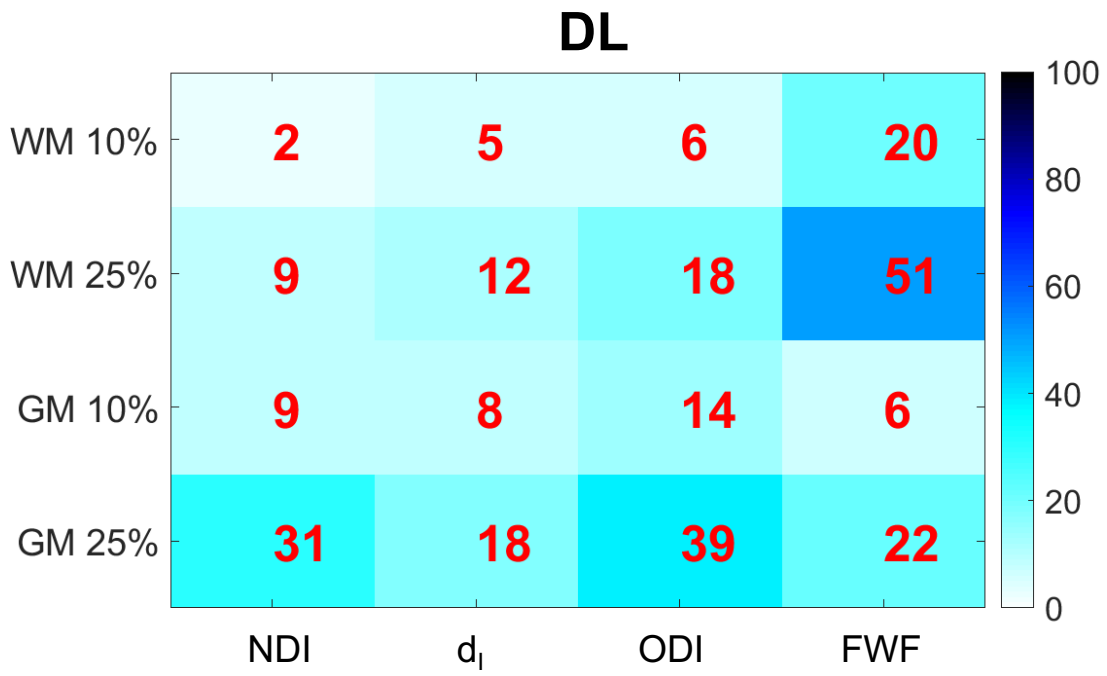
Conventional fit



Question 2: DL more robust to d_I fluctuations

Parameter estimation bias (%) linked to dI fluctuations





UCL

cmic
Centre for Medical Image Computing

CIG
Computational Imaging Group

Thank you!!

UKRI Medical Research Council

AINOSTICS™