TRX: A Community-Oriented Tractography File Format

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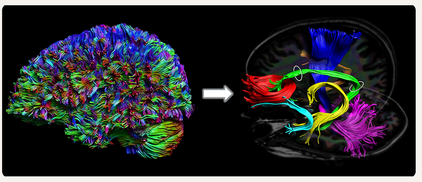
Introduction & Background:

What is Tractography

- 3D reconstruction of pathways
- Millions of lines (streamlines)
- Whole brain reconstruction (tractogram)
- Challenges in:
  - I/O Speed
  - RAM & Disk usage



What is BIDS

- Attempt to reach an agreement on data organization
- Facilitate data sharing and avoid waste of resources
- Each modality/field has its own specifications

BIDS
BRAIN IMAGING DATA STRUCTURE

Many formats & tools (interoperability)

Volumes	Surfaces	Metadata	Tabular	Tractograms
NIFTI	GIFTI	JSON	TSV	???

Why it matters

Specialist

- Well-prepared for a few occurrences
- High success for a few scenarios, high failure for the rest

Generalist

- Semi-prepared for a wide variety of occurrences
- Moderate success for many scenarios, limited failure for many scenarios

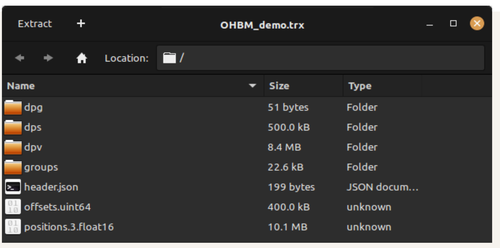
Pick "4"

Computational Efficiency	Compatibility	I/O Speed
Limited Disk Usage	Limited RAM Usage	Customizable
Optimized for Rendering	Easy to Use	Long-Term Support

Proposal:

TRX

- Harmonize existing features & functionalities into a single format
- Avoid duplicated efforts or wasted resources
- Facilitate data sharing and data re-use
- Increase compatibility across software & libraries
- Improve computational and data storage efficiency




```
OHBM_demo.trx
├── header.json
├── offsets.uint64
├── positions.3.float16
└── dpp
    ├── color_x.uint8
    ├── color_y.uint8
    ├── color_z.uint8
    └── fa.float16
└── dps
    ├── algo.uint8
    ├── clusters_QB.uint16
    ├── commit_colors.3.uint8
    ├── commit_weights.float32
└── groups
    ├── AF_L.uint32
    ├── AF_R.uint32
    ├── CC.uint32
    ├── CST_L.uint32
    ├── CST_R.uint32
    ├── SLF_L.uint32
    ├── SLF_R.uint32
└── dpg
    ├── AF_L
    │   ├── mean_fa.float16
    │   ├── shuffle_colors.3.uint8
    │   └── volume.uint32
    ├── AF_R
    │   ├── mean_fa.float16
    │   ├── shuffle_colors.3.uint8
    │   └── volume.uint32
```

https://github.com/tnp/tractography-format-ideas

Join the discussion

https://github.com/tee-ar-ex/tractoformats

September 2020

- Discussion about specifications
- Proof-of-concept (Python)
- Implementation in JS and C++
- Scripts, utilities, testing and benchmarking

OHBM 2022

- Semi-final specifications
- Incorporation to Nibabel (Python)
- Proof-of-concept in MRtrix or MI-Brain (C++)
- Unit tests and OS compatibility

WBIO 2023

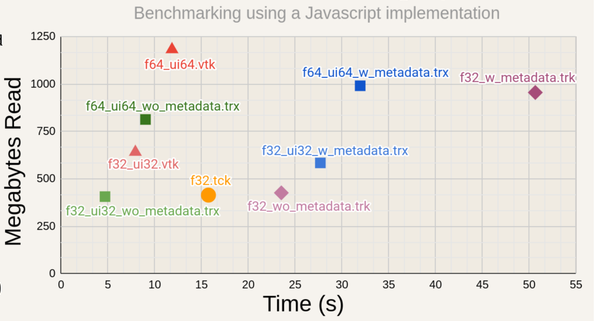
- Conversion scripts in various toolboxes
- Optional support in (some) toolboxes
- Final specifications

Inclusion in BIDS (2024)

Benchmarking:

Highlights

- Offsets + positions is more efficient than interleaved positions (VTK▲, TRX■)
- Interleaved metadata considerably slows down read speed (TRK◆, TRX■)
- Float32$_{LE}$ is the most efficient data type for positions
- Control over dps/dpv data type leads to smaller file sizes for (TRX■ v. TRK◆)
- TRX■ is **faster** than TCK (3x, ●) and TCK● is **faster** than TRK (2x, ◆)
  - TRX■ is **faster** than TRK (with and without Metadata, ◆)
  - TRX■ is **faster** than VTK (both in f32 and f64, ▲)



Conclusion & References:

The goal of TRX is to become the first/only standard amongst tractography file formats within the BIDS standard.

The TRX file format supports functionalities of existing tractography file formats and write data as contiguous blocks to achieve **greater** speed. The file format has a easily **extendable** header and support multiple data types.

We believe our proposal has the potential to **serve** the community well and the growing computational needs of our field.

[1] Pestilli, Franco, Russ Poldrack, Ariel Rokem, Theodore Satterthwaite, Franklin Feingold, Eugene Duff, Cyril Pernet, Robert Smith, Oscar Esteban, and Matt Cieslak. "A community-driven development of the brain imaging data standard (BIDS) to describe macroscopic brain connections."
[2] Gorgolewski, Krzysztof J., Tibor Auer, Vince D. Calhoun, R. Cameron Craddock, Samir Das, Eugene P. Duff, Guillaume Flandin et al. "The brain imaging data structure, a format for organizing and describing outputs of neuroimaging experiments." Scientific data 3, no. 1 (2016): 1-9.

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