T212

Available soon !

QFib: Fast and Efficient Fiber Tracking Dataset Compression

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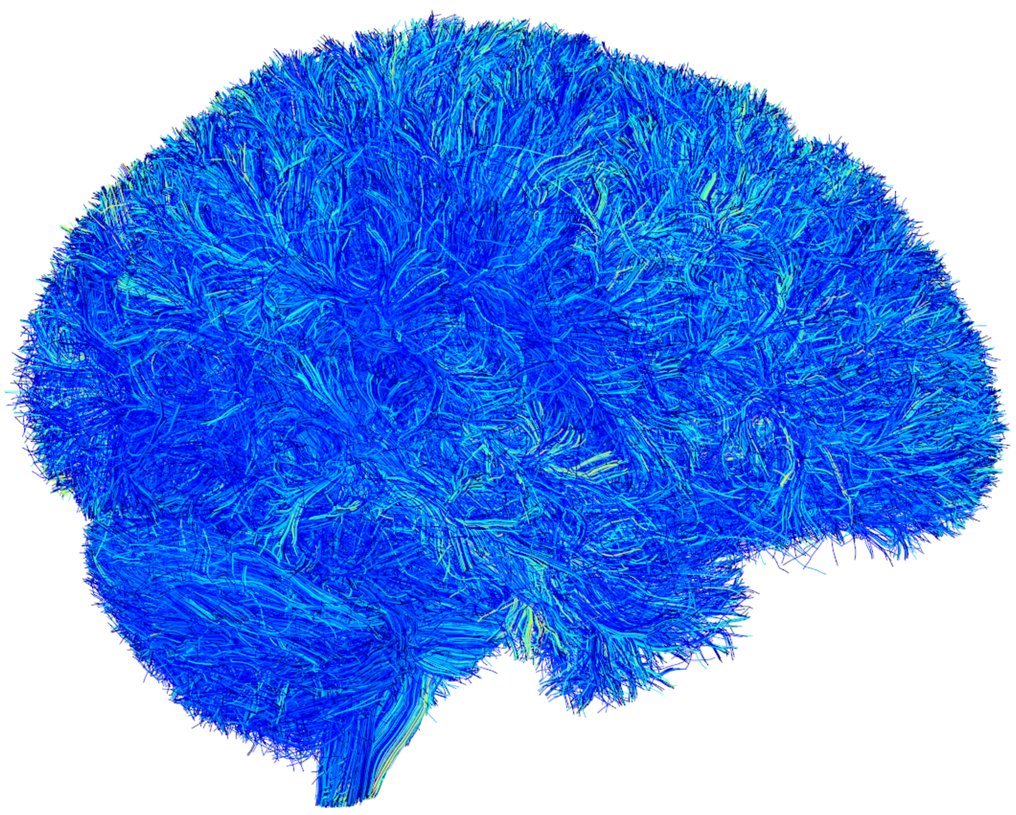
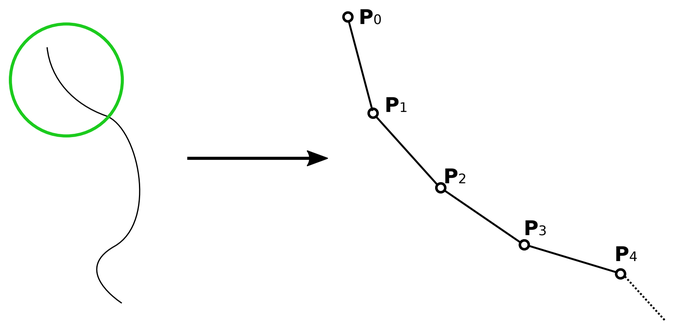


Abstract

Diffusion MRI fiber tracking datasets contain millions of 3D streamlines, their representation weight tens of gigabytes of memory. These sets of streamlines are called tractograms and are often used for clinical operations or research. Their size makes them difficult to store, visualize, process or exchange over the network. We propose a new compression algorithm well-suited for tractograms.

Data



A fiber is a set of equally spaced ordered points. The distance between two points is δ.

$$P_i = P_{i-1} + \delta \frac{\overrightarrow{P_{i-1}P_i}}{||\overrightarrow{P_{i-1}P_i}||}$$

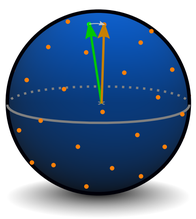
Quantization

$$P_i = P_{i-1} + \delta \frac{\overrightarrow{P_{i-1}P_i}}{||\overrightarrow{P_{i-1}P_i}||}$$

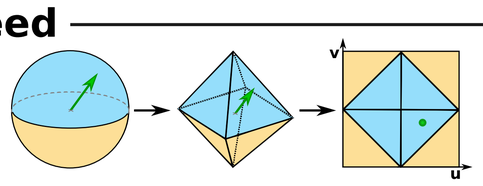
Unit Vectors Quantization [3]

Precision

Spherical Fibonacci Quantization [7]

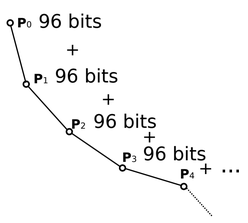


Speed



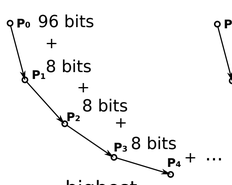
Octahedral Quantization [4]

Original :



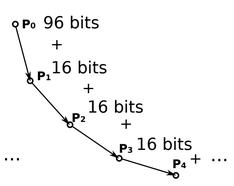
Compressed :

8 bits



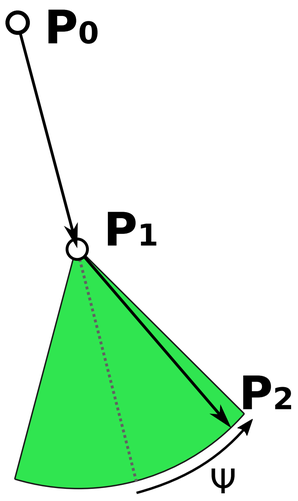
highest compression ratio

16 bits



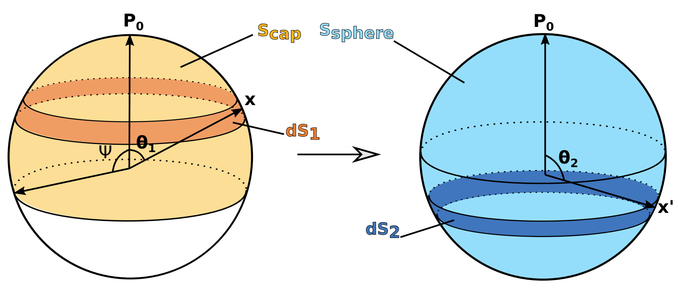
highest precision

Mapping [2]



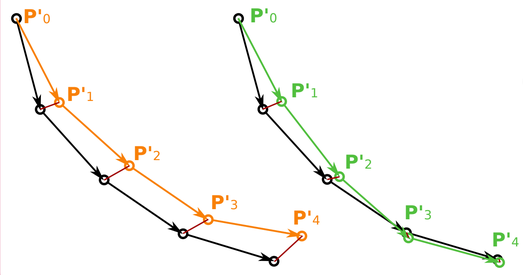
Tractography algorithms set a maximum angle Ψ between consecutive segments of a fiber.

Due to that angle a unit vector can only be defined on the surface of a spherical cap and not the whole unit sphere.



We use a mapping [2] to relocate them on the surface of the whole unit sphere .

Error reduction



To avoid the propagation of the error, we use instead:

$$P_i = P'_{i-1} + \delta \frac{\overrightarrow{P'_{i-1}P_i}}{||\overrightarrow{P'_{i-1}P_i}||}$$

Encoding format

Compressed File (.qfib)

Header
- Version nb: uint8
- Nb. of fibers: **uint32**
- Ratio: **float32**
- Quantization: uint8
- Precision: uint8

Content
- The compressed fibers

Compressed Fiber
- First point: 3 × **float32**
- Second point: 3 × **float32**
- Nb. of compressed points: **uint16**
- Compressed points:
  - int8 for each point (8bits)
  - int16 for each point (16 bits)

Algorithm

Mapping → Quantization → Encoding

Results

We compare our results to zfib [1]. We use two methods in MRtrix [6] to generate the datasets, SD_STREAM (deterministic) and IFOD1 (probabilistic) from the Human Connectome Project [5]. N/A values are the ones for which the algorithm was not able to compress and decompress the file.

Stepsize δ		0.1 mm		0.2 mm		0.5 mm	
Nb. of fibers		500k	3M	500k	3M	500k	3M
Compression time (s)							
Deterministic	qfib (fibo)	24.1	144	12.8	74.8	5.49	32.0
	qfib (octa)	7.83	46.5	3.81	22.6	1.67	9.76
	zfib	702	4243	387	2284	387	2373
Probabilistic	qfib (fibo)	27.9	167	15.3	90.6	8.27	49.7
	qfib (octa)	8.61	54.7	4.86	29.0	2.53	15.5
	zfib	910	N/A	1052	N/A	1418	N/A
Decompression time (s)							
Deterministic	qfib (fibo)	4.98	30.1	2.61	15.4	1.14	6.79
	qfib (octa)	3.56	20.7	1.90	11.3	0.88	5.30
	zfib	12.1	72.7	12.9	77.1	17.3	103
Probabilistic	qfib (fibo)	5.77	34.9	3.23	18.9	1.75	10.3
	qfib (octa)	4.08	24.3	2.24	13.3	1.29	7.47
	zfib	28.5	N/A	43.0	N/A	60.8	N/A

Stepsize δ		0.1 mm		0.2 mm		0.5 mm	
Nb. of fibers		500k	3M	500k	3M	500k	3M
Maximum error ($\times 10^{-2} mm$)							
Quantization	Precision	Deterministic					
Fibonacci	8 bits	4.94	5.30	10.3	10.6	33.2	34.1
	16 bits	0.50	0.57	0.28	0.28	0.39	0.38
Octahedral	8 bits	7.53	8.03	16.5	16.5	46.7	51.0
	16 bits	0.50	0.56	0.27	0.29	0.50	0.52
Quantization	Precision	Probabilistic					
Fibonacci	8 bits	3.04	2.95	5.86	5.91	19.7	20.6
	16 bits	0.13	0.14	0.14	0.16	0.69	0.72
Octahedral	8 bits	4.79	4.90	8.55	9.38	29.8	31.7
	16 bits	0.13	0.14	0.17	0.19	0.87	0.93

zfib default error : 20×10^{-2}mm

[1] Presseau et al. (2015), "A new compression format for fiber tracking datasets", NeuroImage, vol. 109, pp. 73--83
[2] Rousseau et al. (2017), "Fast Lossy Compression of 3D Unit Vector Sets", SIGGRAPH Asia 2017 Technical Briefs, pp. 23:1--23:4
[3] Cigolle et al. (2014), "A Survey of Efficient Representations for Independent Unit Vectors", Journal of Computer Graphics Techniques (JCGT), vol. 3, pp. 1--30
[4] Meyer et al. (2010), "On Floating-point Normal Vectors", Proceedings of the 21st Eurographics conference on Rendering, pp. 1405--1409
[5] Van Essen et al. (2012), "The Human Connectome Project: A data acquisition perspective", NeuroImage, vol. 62, pp. 2222--2231
[6] Tournier et al. (2012), "MRtrix: Diffusion tractography in crossing fiber regions", International Journal of Imaging Systems and Technology, vol. 22, pp.53--66
[7] Keinert et al. (2015), "Spherical Fibonacci Mapping", ACM Transaction on Graphics, 34(6), pp. 193:1--193:7

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