

Validation of MRI-Based Fiber-Tracking Results

Il'yasov K., Konopleva L., Nedopekin O.

Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia

Abstract

© 2017, Springer-Verlag Wien. A new approach to estimating the probability of the fiber-track existence has been developed and validated on the basis of digital phantoms and diffusion-weighted magnetic resonance imaging measurements on human brain. The proposed approach includes two parameters—the local probability of the tract direction and the Shannon entropy. The local probability of the tract direction characterizes how well tracts “fit” the direction information in a voxel. The Shannon entropy characterizes the shape of diffusivity in the voxel. Calculations on digital phantoms and in vivo data showed that the combination of these parameters makes it possible to verify fiber-tracking results.

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References

- [1] S. Mori, P.C.M. van Zijl, *NMR Biomed.* 15, 468–480 (2002)
- [2] J.H. Jensen, J.A. Helpert, A. Ramani, H. Lu, K. Kaczynski, *Magn. Reson. Med.* 53(6), 1432–1440 (2005)
- [3] V.G. Kiselev, in *Diffusion MRI: Theory, Methods, and Applications*, ed. by D.K. Jones (Oxford University Press, Oxford, 2011), p. 152
- [4] B.W. Kreher, J.F. Schneider, I. Mader, E. Martin, J. Hennig, K.A. Il'yasov, *Magn. Reson. Med.* 54, 1216–1225 (2005)
- [5] V.J. Wedeen, R.P. Wang, J.D. Schmahmann, T. Benner, W.Y.I. Tseng, G. Dai, D.N. Pandya, P. Hagmann, H. D'Arceuil, A.J. de Crespigny, *Neuroimage* 41, 1267–1277 (2008)
- [6] J.-D. Tournier, C.-H. Yeh, F. Calamante, K.-H. Cho, A. Connelly, C.-P. Lin, *Neuroimage* 42, 617–625 (2008)
- [7] L.R. Frank, *Magn. Reson. Med.* 47, 1083–1099 (2002)
- [8] D.C. Alexander, *Inf. Process. Med. Imaging* 19, 76–87 (2005)
- [9] V.J. Wedeen, P. Hagmann, W.-Y.I. Tseng, T.G. Reese, R.M. Weisskoff, *Magn. Reson. Med.* 54, 1377–1386 (2005)
- [10] M. Reisert, I. Mader, C. Anastasopoulos, M. Weigel, S. Schnell, V. Kiselev, *Neuroimage* 54, 955–962 (2011)
- [11] P. Fillard, M. Descoteaux, A. Goh, S. Gouttard, B. Jeurissen, J. Malcolm, A. Ramirez-Manzanares, M. Reisert, K. Sakaie, F. Tensaouti, T. Yo, J.-F. Mangin, C. Poupon, *Neuroimage* 56, 220–234 (2011)
- [12] L.-A. Harsan, C. Dávid, M. Reisert, S. Schnell, J. Hennig, D. von Elverfeldt, J.F. Staiger, *Proc. Natl. Acad. Sci. USA* 110, E1797–E1806 (2013)
- [13] M.L. Mandelli, M.S. Berger, M. Bucci, J.I. Berman, B. Amirbekian, R.G. Henry, *J. Neurosurg.* 121, 349–358 (2014)
- [14] T.R. Knosche, A. Anwender, M. Liptrot, T.B. Dyrby, *Hum. Brain Mapp.* 36, 4116–4134 (2015)
- [15] M. Axer, D. Grassel, M. Kleiner, J. Dammers, T. Dickscheid, J. Reckfort, T. Hutz, B. Eiben, U. Pietrzyk, K. Zilles, K. Amunts, *Front. Neuroinform.* 5, 34 (2011)
- [16] M.-A. Cote, G. Girard, A. Bore, E. Garyfallidis, J.-C. Houde, M. Descoteaux, *Med. Image Anal.* 17, 844–857 (2013)
- [17] ISMRM. Diffusion Study Group meeting (2015). http://www.tractometer.org/ismrm_2015_challenge. Accessed 31 Oct 2016
- [18] M.A. Koch, D.G. Norris, M. Hund-Georgiadis, *Neuroimage* 16, 241–250 (2002)
- [19] C.E. Shannon, *Bell Syst. Tech. J.* 27, 379–423 (1948)

- [20] D.C. Alexander, G.J. Barker, S.R. Arridge, *Magn. Reson. Med.* 48(2), 331-340 (2002)
- [21] J.D. Tournier, F. Calamante, A. Connelly, D. Gadian, *NeuroImage* 23, 1176-1185 (2004)
- [22] J.D. Tournier, F. Calamante, A. Connelly, *NeuroImage* 35, 1459-1472 (2007)
- [23] K.A. Il'yasov, G. Barta, B.W. Kreher, M.E. Belleman, J. Hennig, *Appl. Magn. Reson.* 29, 107-122 (2005)
- [24] H. Gudbjartsson, S. Patz, *Magn. Reson. Med.* 34, 910-914 (1995)
- [25] K.A. Il'yasov, J. Hennig, *J. Magn. Reson. Imaging* 8(6), 1296-1305 (1998)
- [26] K.A. Il'yasov, *Uchenye Zapiski Kazanskogo Universiteta. Seriya Fiziko-Matematicheskie Nauki* 153(1), 17-37 (2011)
- [27] B. Kreher, J. Henning, K.A. Il'yasov, in *Proceedings of ISMRM 14th International Scientific Meeting, Seattle, USA May 2006*, 2758
- [28] S. Mori, B.J. Crain, V.P. Chacko, P.C. van Zijl, *Ann. Neurol.* 45, 265-269 (1999)
- [29] B.W. Kreher, S. Schnell, I. Mader, K.A. Il'yasov, J. Hennig, V.G. Kiselev, D. Saur, *Neuroimage* 43, 81-89 (2008)
- [30] D.K. Jones, *Magn. Reson. Med.* 49, 7-12 (2003)
- [31] E. Ozarslan, B.C. Vemuri, T.H. Mareci, *Magn. Reson. Med.* 53, 866-876 (2005)
- [32] T. Neuvonen, E. Salli, in *Proceedings of the 27th IEEE Eng. Med. Biol. Soc. Ann. Conf. Shanghai, China, September 2005 (IEEE, Shanghai, 2006)* pp. 5798-5801
- [33] M. Farzinfar, I. Oguz, R.G. Smith, A.R. Verde, C. Dietrich, A. Gupta, M.L. Escobar, J. Piven, S. Pujol, C. Vachet, S. Gouttard, G. Gerig, S. Dager, R.C. McKinstry, S. Paterson, A.C. Evans, M.A. Styner, *Neuroimage* 82, 1-12 (2013)
- [34] L.R. Frank, V.L. Galinsky, *Phys. Rev. E: Stat. Nonlin. Soft. Matter. Phys.* 89, 032142 (2014)
- [35] V.L. Galinsky, L.R. Frank, *IEEE Trans. Med. Imaging* 34, 1177-1193 (2015)
- [36] B. Jeurissen, A. Leemans, J.-D. Tournier, D.K. Jones, J. Sijbers, *Hum. Brain Mapp.* 34, 2747-2766 (2013)