A Time efficient IVIM analysis method using fuzzy clustering algorithm

Kaining Shi[1], He Wang[2], Guang Cao[3], Ying Qi[4], and Xiaoming Wang[4]

[1]Imaging Systems Clinical Science, Philips Healthcare (China), Beijing, China, [2]Philips Research (China), Shanghai, China, [3]Imaging Systems Clinical Science, Philips Healthcare (China), Hongkong, China, [4]Radiology Department, Shengjing Hospital of China Medical University, Shenyang, Liaoning, China

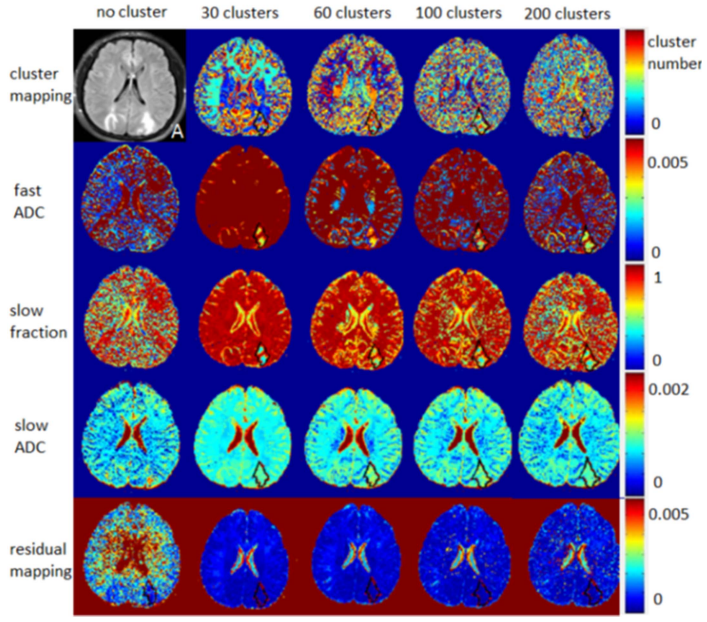

Fig.1. Patient 1's Cluster and IVIM parameter mapping with and without fussy clustering approach. ROI is drawn according to FLAIR(A).

		No cluster	30 clusters	60 clusters	100 clusters	200 clusters
PA1	fastADC	0.051964	0.0080117	0.010871	0.013081	0.0095587
	Fra slow	0.56955	0.71378	0.76049	0.73069	0.70613
	Slow ADC	0.00087996	0.00092383	0.00092846	0.00090449	0.00088042
	Residual	0.0010233	0.00021295	0.00022167	0.00022292	0.00022096
PA2	fastADC	0.14277	0.045881	0.054057	0.066538	0.05164
	Fra slow	0.76176	0.96579	0.96279	0.93346	0.89802
	Slow ADC	0.00064663	0.00079836	0.00078739	0.00076618	0.00074359
	Residual	0.0018923	0.00021551	0.00023671	0.00024771	0.00028863
Ctl1	fastADC	0.10365	0.10857	0.035764	0.052016	0.030935
	Fra slow	0.74955	0.84722	0.74237	0.81654	0.80474
	Slow ADC	0.00058069	0.00068157	0.0006076	0.00064267	0.0006087
	Residual	0.016718	0.0065838	0.0059948	0.0070817	0.008707
Ctl2	fastADC	0.12705	0.031081	0.079544	0.038657	0.068741
	Fra slow	0.76136	0.84123	0.73849	0.75397	0.78019
	Slow ADC	0.00060569	0.00070215	0.00063166	0.00062189	0.00066337
	Residual	0.011999	0.009479	0.0067581	0.0071209	0.0060866
Calculation time		501.193086	6.809466	10.046394	12.951373	16.588713

Table.1. Bi-exponential analysis result. Residual of curve fit and calculation time is also exhibited.

Background: The bi-exponential analysis in Intravoxel Incoherent Motion (IVIM) model [1], with the ability of separating perfusion effects caused by microscopic circulation with pure diffusion, has been applied in many organs and many diseases [2-4]. However, the nonlinear bi-exponential curve-fitting is sensitive to noise, which usually comes from the use of high b values or the compromise to scan time, and time-consuming, especially for high resolution scan. Fussy clustering techniques can sort plenty of curves into several types, and has been successfully applied in the breast DCE-MRI [5-6].

Purpose: To develop a robust and time efficient bi-exponential IVIM analysis method by combining fussy clustering algorithm.

Method: 16 b values(0,10,20,40,80,110,140,170,200,300,400, 500, 600,700,800,900) DWI data from 2 PRES patients and 2 volunteers, scanned in a whole 3T scanner (Achieva TX, Philips Healthcare, Best,, the Netherland) with an 8-channel head coil with a 256x256 matrix and 9 slices, was used for the bi-exponential analysis with and without fussy cluster.. T1 FLAIR was scanned to reveal lesions. ROI was drawn on the common lesion location between 2 patients. 30, 60,100and 200 clusters were used in the clustering analysis to test the cluster number's effect. The analysis was run on a 64 bit laptop with 1.9GHz CPU and 4G RAM

.**Result:** Fussy-clustering bi-exponential analysis approach achieved brain segmentation successfully (Fig.1) and worked out similar parameters as the pixel-by-pixel approach (Table.1), with 1.3-3.3% time cost and 11.4~79.0% curve-fit residual.

Discussion: The lack of 'gold standard' of IVIM makes numerical parameter comparison meaningless. More data needs to be collected to evaluate new approach's utility effect. More clusters provide more refined segmentation, at the cost of robust. The number of clusters should be chosen according to the organ and disease.

References: [1] Le Bihan D, et al. Radiology 1988;168:497–505. [2] Federau, et al. Radiology 2012;265:847-881. [3] Callot V,et al. MRM 2003;50:531–540. [4] Guiu et al. Radiology 2012;265:96-103.[5]J Li, et al. Med Phy 2009;36:3786-3794. [6] W. Chen, et al. Academic Radiology 2006;13:63-72.