

# UMMDiffusion: An OsiriX plug-in for ADC and IVIM Analysis in Clinical Routine

Frank G Zöllner<sup>1</sup>, Sven Kaiser<sup>1</sup>, Gerald Weisser<sup>2</sup>, and Lothar R Schad<sup>1</sup>

<sup>1</sup>Computer Assisted Clinical Medicine, Medical Faculty Mannheim, Heidelberg University, Mannheim, Baden-Württemberg, Germany, <sup>2</sup>Institute for Clinical Radiology and Nuclear Medicine, Medical University Center, Heidelberg University, Mannheim, Baden-Württemberg, Germany

## Introduction

Intra-voxel incoherent motion (IVIM) diffusion weighted imaging (DWI) is an emerging method to derive microscopic structural information non-invasively [1]. Research tools that allow calculations of IVIM parameters are developed often as offline solutions and the clinician has to transfer the large image data sets to a separate workstation for analysis [2,3]. Furthermore, within the clinical workflow, results have to be transferred back into the diagnostic system. However, results obtained from most research software are stored in various formats that could not easily be converted to DICOM objects to be stored in picture archive and communication systems. Commercial software solutions for DW imaging exist. They allow (partial) integration into the clinical environment, especially if provided by the vendors of the MR scanners. However, such software is expensive which prevents ubiquitous usage, i.e. only few licenses or dedicated workstations are usually purchased. In this work, an Open Source OsiriX plug-in was developed to submit the DWI analysis and specific the IVIM model for integration in the clinical routine diagnostics.

## Materials and Method

The main functionality of the plug-in is the calculation of the ADC and the IVIM model parameters diffusion coefficient (D), pseudo-diffusion coefficient (D\*) and perfusion (f), either region of interest (ROI) based or as a parametric map. For a ROI analysis, fits can be compared in a separate display window. We also implemented a report that records all parameter settings (initial fit parameters, ROI locations, etc.) and results. It is saved together with the calculated parametric maps with the patient record as DICOM file. The plug-in was implemented using Objective-C and tested with OsiriX 3.9.4. Non-linear fitting is performed using the Levenberg-Marquardt algorithm [4]. Based on 30 data sets recorded at a 3T MR scanner using a 2D SE-EPI diffusion sequence (TR/TE = 3500/67 ms, FOV = 204x204 mm<sup>2</sup>, Matrix = 136x136, 14 slices, slice thickness 3 mm, b-values = 0, 50, 500, 800 s/mm<sup>2</sup>), a validation of the parameters ADC, D, D\* and f was performed. Possible differences to an already existing MATLAB implementation [3] were investigated using a t-test.

## Results

The t-test revealed that there was no significant difference (P < 0.05) between the two implementations. Table 1 summarizes the results. Fig.1 shows a report generated for logging parameter settings, goodness of fit and results of a DWI analysis. Fig. 2 shows a display for comparative DWI ROI analysis. In Fig. 3, parametric maps calculated by our plug-in are shown as an example.

## Discussion

Based on our results, we conclude that our implementation is technical correct. The report offers the possibility for quality assurance while analysing DW images. Being Open Source, the plug-in is freely available (<http://www.opossum.de>) and can be extended for other kinds of DWI analysis. In conclusion, by our plug-in IVIM analysis can be implemented within a clinical routine setting.

## References

- [1] Le Bihan D et al., Radiology, 168:566-567, 1988 [2] Andreou I et al., Eur Radiol, DOI: 10.1007/s00330-012-2604-1, 2012 [3] Döpfert J et al., Magn Reson Imaging, 29:1053-1058, 2011 [4] Markwardt CB, Astro Data Analysis Software and Systems XVIII, 411:251, 2009

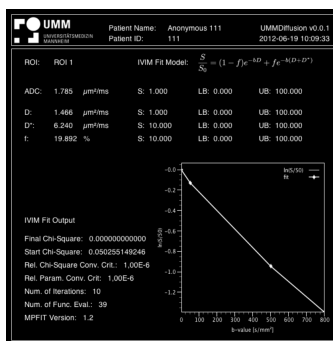


Fig. 1: Example of a report generated automatically while performing a DWI analysis.

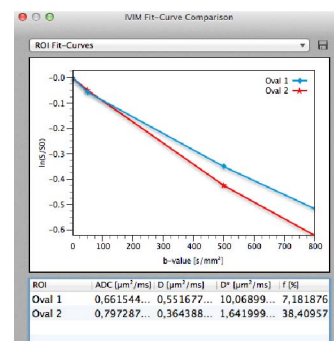


Fig. 2: Comparative ROI analysis of DWI data.

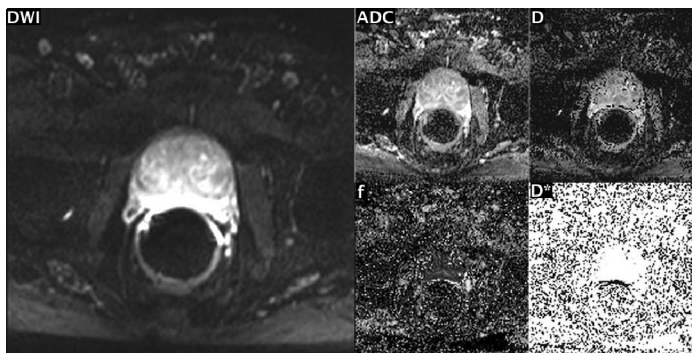


Fig. 3: Example of DW image and corresponding parametric maps calculated by the plug-in.

Diffusion parameter	UMMDiffusion	Reference implementation
ADC [ $\mu\text{m}^2/\text{ms}$ ]	$1.4 \pm 0.3$	$1.4 \pm 0.2$
D [ $\mu\text{m}^2/\text{ms}$ ]	$1.0 \pm 0.3$	$1.0 \pm 0.2$
D* [ $\mu\text{m}^2/\text{ms}$ ]	$6.3 \pm 2.3$	$6.3 \pm 2.3$
f [%]	$24.8 \pm 11.4$	$24.3 \pm 10.6$

Table 1: Pixel-wise comparison of diffusion parameters calculated by both implementations.