

# AMICO-VERDICT: Ultrafast fitting algorithm for cancer microstructure characterization, a prostate cancer application.

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## Introduction

Histology remains as the gold standard for prostate cancer diagnosis and grading. VERDICT, a multi-parametric MRI model-based technique designed to characterise microstructural tissue parameters, has shown promise in preclinical studies [1] and in a pilot clinical setting [2] for discriminating normal and malignant prostate tissue in a non-invasive manner. However, VERDICT uses a computationally expensive non-linear fitting procedure, which limits its use in large cohort studies and real-time clinical applications. Recently, ultrafast fitting algorithms, such as the AMICO [3] framework, have been developed to address the computational cost of model-based microstructure-imaging techniques. The aim of this study is to extend the AMICO framework to the VERDICT model and evaluate its performance in prostate cancer.

## Methods

4 subjects suspected for prostate cancer (a biopsy after scan confirmed cancer with Gleason scores of 3+4) were scanned for VERDICT analysis. For each subject DW-MRI was performed using a 3T scanner (Achieva, Philips Healthcare, Netherlands), imaging details in [4]. Data was normalised for every echo time to avoid T2 dependence. Scans were repeated after a 2-minute interval. MR datasets were analysed with Osirix Version 7.0 (Bernex, Switzerland). For each subject a board certified radiologist (EJ) manually contoured regions of interest (ROIs) for normal and tumour tissue.

The VERDICT model was fitted to the data in each voxel using both the original non-linear fitting algorithm (ORIGINALVERDICT) and the AMICO framework (AMICOVERDICT).

## Results

Parametric maps show similar behaviour with both fitting methods, in both cases  $f_{IC}$  (Intracellular volume fraction) is higher and  $f_{EES}$  (Extracellular-Extravascular volume fraction) is lower in tumour tissue compared with normal tissue. Both fitting procedures show similar repeatability performance although the estimated values seem more stable for the AMICOVERDICT fitting. Results for one subject are illustrated in Figure 1. Simulation results (omitted) showed the same tendencies. The computation time is reduced from 1.13s/voxel to 1.38ms/voxel.

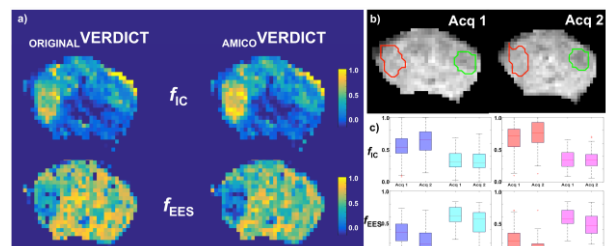
## Discussion

AMICO framework provides an acceleration factor of several orders of magnitude compared with non-linear fitting and may also achieve more robust and repeatable parameter estimates. AMICOVERDICT reflect the microstructural differences between tumours and normal tissue in a clinically practical time. Results should be evaluated in larger cohorts to test the parameters correlation with cancer grade.

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## References

[1] Panagiotaki et al, 2014, "Noninvasive quantification of solid tumor microstructure using VERDICT MRI", *Cancer Res*, 74(7), pp 1902–12. [2] Panagiotaki et al, 2015, "Microstructural Characterization of Normal and Malignant Human Prostate Tissue With Vascular, Extracellular, and Restricted Diffusion for Cytometry in Tumours Magnetic Resonance Imaging", *Invest Radiol*, 50(4), pp 218-27. [3] Daducci et al, 2015, "Accelerated Microstructure Imaging via Convex Optimization (AMICO) from diffusion MRI data", *NeuroImage*, 105, pp 32-44. [4] Panagiotaki et al, 2015, "Optimised VERDICT MRI protocol for prostate cancer characterisation". 23rd ISMRM, Toronto, Canada.



**Figure 1: VERDICT comparison for both fitting techniques for one subject. a) VERDICT maps (acquisition 1) for  $f_{IC}$ ,  $f_{EES}$  and  $R$ . b) ROIs outline in one of the original DW-MRI for the two different acquisitions (red: tumour tissue, green: normal tissue). c) Estimation of the same parameters for all voxels within ROIs for both scans.**