# Non-parametric Bayesian Estimation of Apparent Diffusion Coefficient from Diffusion-Weighted Magnetic Resonance Imaging Data

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## Abstract

A promising approach to prostate cancer diagnosis is diffusion-weighted MRI. Using multiple diffusion-weighted MR acquisitions, the apparent diffusion coefficient (ADC) is calculated and can be used to identify tumours in the prostate. A novel Non-parametric Estimated ADC (NEstA) algorithm is proposed which uses a Monte Carlo strategy to learn the inherent measurement distribution model based on the underlying statistical behaviour of the DWI measurements to estimate the ADC values.

## Introduction

- Diffusion-weighted imaging (DWI) can be used to differentiate between healthy and cancerous tissues in the prostate gland using a diffusion gradient (with specific *b*-value)
- ADC value associated with each imaged tissue is derived from diffusion-weighted images and used to locate cancer

## Problem

- Most common method to obtain ADC from DWI measurements is least squares
- Does not perform well when the fixed measurement distribution models do not fit with underlying measurements

## Objective

To determine the ADC values using a Non-parametric Estimated ADC (NEstA) strategy, which employs a Monte Carlo techniques to learn the inherent measurement distribution model.

## Methodology

- ADC estimation ($\hat{A}$) is formulated as a Bayesian estimation problem, given a collection of DWI measurements ($M$) and hypothetical true DWI signals ($S$)

$$\hat{A} = \arg\max_A P(E(S|M)|A)$$

- Random noise and other unknown processes that affect the measurements are characterized as $\eta$

$$M = S + \eta$$

- Conditional mean can be expressed as:

$$E(S|M) = \int S\, P(S|M) dS$$

- Monte Carlo sampling strategy employed to estimate posterior distribution of $S$ given $M$
- If a collection of DWI images is used, we assume that:

$$P(\cdot\,|A) \sim N(S_\alpha e^{-(b_i - b_\alpha)A}, \sigma^2)$$

## Experimental Results

### Fisher's Criterion

- Fisher's Criterion ($J$) is a measure of class separability (cancerous vs. healthy tissue) using sample class means ($m$) and variances ($s^2$)

$$J = \frac{|m_1 - m_2|^2}{s_1^2 + s_2^2}$$

- Experimental results indicate that cancerous tissue is better separated from healthy tissue, with an average improvement of Fisher's Criterion over least squares of **7.86%**

## Example Patient Cases

Original NEstA

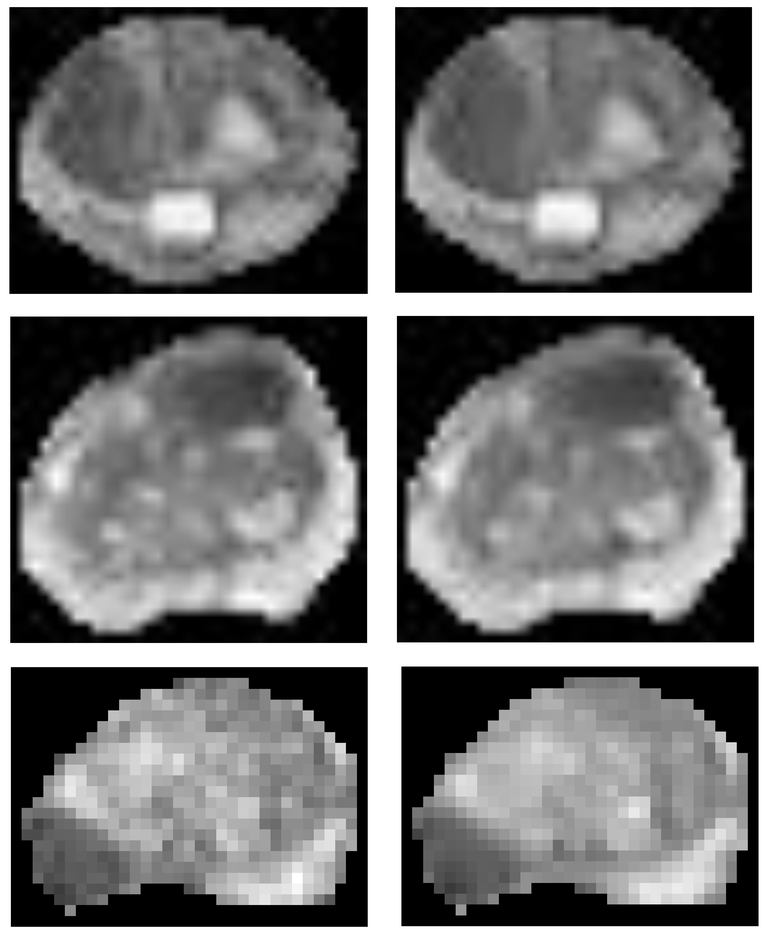

Fig. 1: Example ADC slices of prostates containing tumours.

Original NEstA

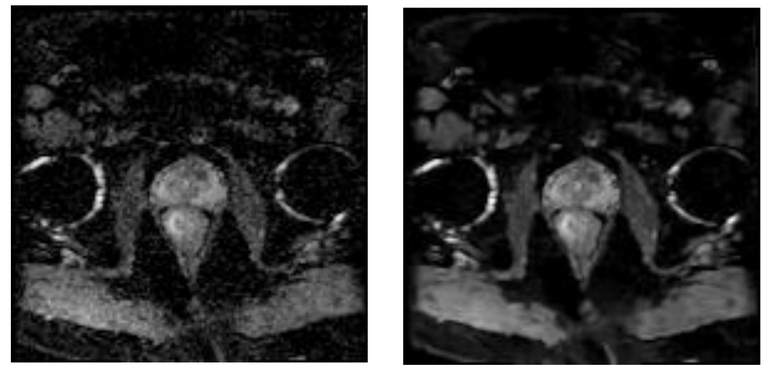

Fig. 2: Full-size comparison of LS and NEstA estimations showing improved contrast between prostate and surrounding tissue.

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