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

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

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

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