A spectral quality control algorithm for 3D ^{1}H MRSI data of the prostate

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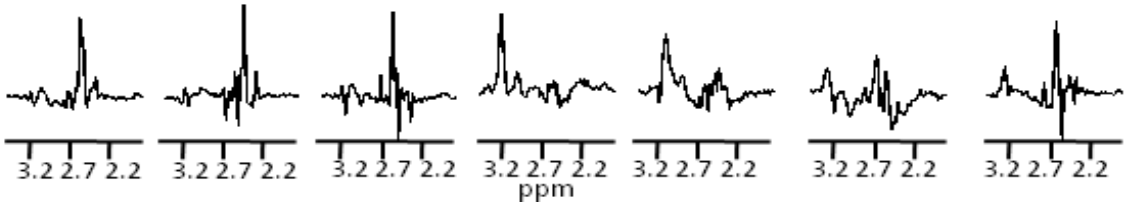
Introduction: Three dimensional MRSI data sets of prostate cancer (PCa) patients provide useful clinical information for detection, localization and staging of this disease. A major bottleneck preventing transference of this technique to routine clinical practice is the expertise required in analysis. Replacing experienced readers of spectroscopic data with an automated procedure will require an accurate quality control step, because one of the expert's key-decisions is whether a spectrum is of sufficient quality for accurate subsequent analysis. Spectral quality can be inferred from signal-to-noise ratio, line-width and the estimated fitting accuracy of model resonances (1) but these measurements do not account for baseline variations, changes in line shape and they won't necessarily reveal errors of fitting. Previously, an automated quality assessment of ^{1}H-MR spectra of the brain, using Independent Component Analysis (ICA), was developed (2) which used multiple experts and defined a "Gold Standard" of quality when they all agreed on a spectrum as being acceptable or unacceptable. Here we have developed and tested an automated Quality Control for 3D MRSI data of the prostate that accurately reproduces expert decisions of acceptability and unacceptability.

Methods: ^{1}H-MRSI data of 15 PCa patients was acquired at 3T (MAGNETOM Tim Trio, Siemens, Erlangen, Germany) with combined endo-rectal and surface array coils at 3T. The spectra were divided into 3 sets: a Training, Optimization and Test Set. Spectra were graded by 4 experts as good, satisfactory or unacceptable and the data sets were reduced to those where *all* experts agreed data was either acceptable (i.e good or satisfactory) or unacceptable. The *good* spectra from the Training and Optimization Sets were used to generate Independent components (ICs). Fitting these ICs to each spectrum produced 2-10 coefficient scores (2). These coefficients of the Training Set were classified by a Support Vector Machine (SVM) according to whether a spectrum was found by the experts to be unacceptable or acceptable quality. The classifier was then applied to the Optimization Set to tune the hyper-parameters of the SVM and determine which number of coefficients produced the best classifier. The classifier with the highest area under the receiver operator characteristic curve (AUC) for the Optimization Set data was judged to be the best. This optimised classifier was applied to the Test Set spectra to compare with expert classifications. A similar classifier was generated for LCModel fittings of the same data using 10 input parameters to the SVM: concentrations and fitting error estimates (Cramér Rao Lower Bounds) of 4 metabolites (choline, spermine, creatine and citrate) and a general SNR and average line width estimate.

Results: The highest AUC was found for the coefficients of 7 ICs. The algorithm was applied to a subset of the Test Set where all experts agreed on the quality of each spectrum. These 4299 spectra were separated for quality by the algorithm with 95% sensitivity, 95% specificity and an AUC of 0.98. LCModel fitting parameters generated a classifier that separated the Test Set spectra with a significantly poorer AUC of 0.72. The decisions of each individual expert on the entire Test Set of 5415 spectra were compared and it was found that pairs of experts agreed spectra were either acceptable or unacceptable in 89±4% of the time. The algorithm results from all 5415 spectra of the Test Set agreed with each expert in 87±1% of cases which was not significantly different from inter-expert agreement.



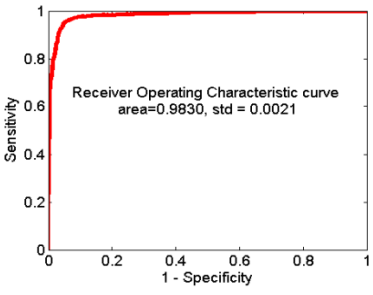


Figure. Above: The 7 Independent Components which were found to give the best separation between acceptable and unacceptable spectra. The ICs contain features similar to peaks expected in spectra from normal prostate tissue or tumour as highlighted by adding a chemical shift scale to each one. Right: The receiver operator characteristic curve of the Test Set showing excellent separation of data for which experts were in agreement of acceptable or unacceptable.

Discussion: ICA can be used for automatic separation of acceptable quality ^{1}H prostate spectra from unacceptable. This has high accuracy (sensitivity and specificity = 95%) for the gold standard data where experts agreed. The algorithm also gives decisions consistent with those of an expert spectroscopist because there is no difference between the frequency of agreement between the algorithm and each expert and amongst the experts themselves.

References: 1.Weiland E, *et al. proc. ISMRM.* 2007. 2.Wright A.J. *et al. MRM* 59:1274. 2008.