

Software tool for the simultaneous display and automated analysis of multiparametric MRI data of the prostate


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Purpose


A multiparametric (mp) MRI examination of the prostate typically generates a large number of individual images (over 500) and MR spectra (several hundreds). Aim of this work was to develop and evaluate a non-commercial software tool for the display and analysis of mpMRI data.

Materials and Methods


The tool can be used on any standard PC using a free runtime environment (IDL Virtual Machine, Boulder, CO). After DICOM file selection, matching data from T2-weighted (T2w), diffusion-weighted (DWI), dynamic contrast-enhanced (DCE) and chemical shift imaging (CSI) are automatically searched for, read and sorted. Functionality is exemplified by a case of a 56-y.o. patient with a PSA of 5.4 ng/ml and a Gleason score of 3+3 who underwent endorectal 3-T MRI prior to prostatectomy. The user interface features four main windows that focus on a specific image parameter. Potential offsets between slices of the nearest T2w, DCE, and ADC images are displayed. Standard mouse operations allow the user to scroll through all images or intuitively change the display options (window level and width, zoom and pan). Other views will be updated on-the-fly.

**Automatic DICOM selection**

This button will open a standard file selection box displaying all files in a given directory. After selecting a particular image file, matching files (DCE, T2w, DWI, and CSI) are automatically searched for, read and sorted by the software.

**Image postprocessing**

DCE data processing over the entire FOV takes about 5 min on a standard PC (2.6 GHz Dual Core CPU with 3.2 GB RAM). The resulting pseudo color maps can be overlaid on morphologic and diffusion-weighted images at different levels of transparency (invisible to opaque).

**Save and restore**

Original and processed data can be stored to and restored from file for future use. Screenshots annotated with coordinate information may be saved for purposes like accurate treatment planning.

DCE images

Different time points of the dynamic contrast image series can be selected by using the left and right buttons on the keyboard.

T2w images

in axial or para-axial orientation covering the entire prostate and seminal vesicles.

Viewing parameters

Display field informs the user about axial offset between slice positions with respect to the current DCE image. Drop-down list to select predefined width and level settings and fields for manual input.

ADC maps

calculated from all b-values using a simple mono-exponential decay model.

CSI data

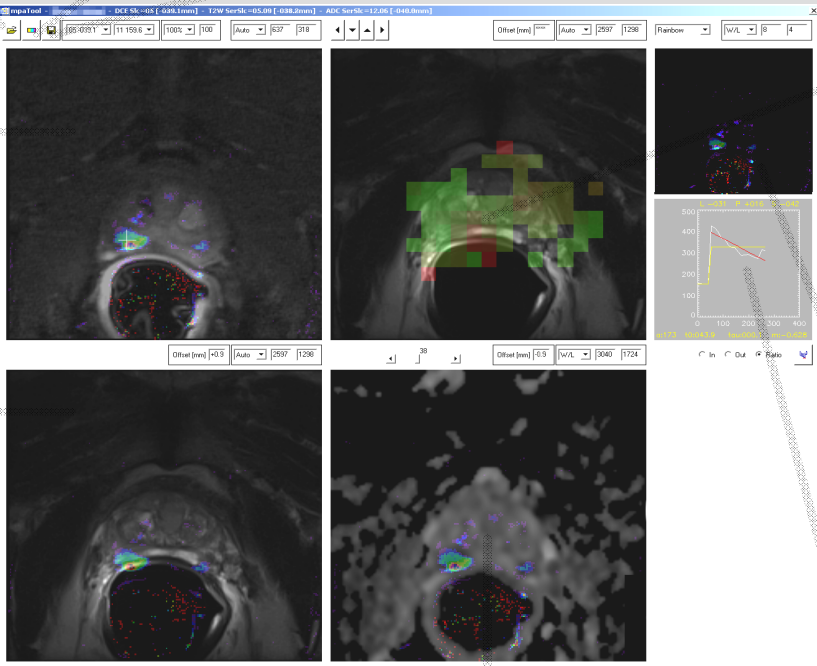
were post-processed with a commercial software (LCModel, Oakville, Canada) that fits the spectra to prostate MRS basis sets and also provides relative errors of the peak areas. Only peaks with smaller errors are then considered to compute color maps of the widely accepted (choline+creatine)/citrate metabolite ratio. The suspected degree of malignancy is color coded in shades of green (low), orange (moderate) and red (high risk) and overlaid on the nearest T2w image.

Wash-in, wash-out, ratio

Radio buttons allow the user to select one of three pseudo color maps that are transparently overlaid on ADC, T2w and DCE images.

Logistic and linear model

functions are used to estimate the wash-in and wash-out behavior from the DCE raw data (16 time points) on a pixel-by-pixel basis. Individual enhancement vs. time curves are interactively calculated as a function of the current cursor position (cross hair) in any of the image views.



Multiparametric MRI Protocol

T2w TR/TE: 4,400/126 ms, slice thickness ST: 3 mm, in-plane resolution IPR: $0.6 \times 0.6 \text{ mm}^2$, 19-22 sections, FOV: $110 \times 110 \text{ mm}^2$, FA: 135°
DWI TR/TE: 3,000/85 ms, ST: 3 mm, IPR: $1.0 \times 1.0 \text{ mm}^2$, 19-22 sections, FOV: $250 \times 250 \text{ mm}^2$, b-values: 0, 50, 400 and 800 sec/mm^2
DCE 16 acquisitions every 12 s, TR/TE: 4.7/1.7 ms, ST: 3 mm, IPR: $0.6 \times 0.6 \text{ mm}^2$, FOV: $110 \times 110 \text{ mm}^2$, FA: 14° , 15-20 ml bolus of Gd-DTPA
CSI PRESS technique, 3D chemical shift imaging covering the whole prostate in 8 slices according to standard protocols [1]

Conclusion

A dedicated software environment can be very helpful to assist the radiologist with the processing and review of multiparametric MRI data and potentially improve detection, localization and grading of prostate cancer.

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References

[1] S. Verma, A. Rajesh, J. J. Fütterer, et al. Prostate MRI and 3D MR spectroscopy: how we do it. AJR 2010;194:1414-1426.