Optimization of registration of parametric Gd-DTPA MR with parametric F-18-FDG PET/CT images for improved breast cancer detection

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Aims: To select best method for registration of parametric Gd-DTPA MR with parametric F-18-FDG PET/CT images for improved breast cancer detection via application of fused parametric MR/PET images

Materials and Methods:

Twelve subjects under approved IRB protocol were imaged.

Dynamic MR breast imaging was performed on a Philips Intera 1.5 T MRI system with a standard Philips clinical breast coil. The patients were prone with both breasts suspended in a single well housing the receiver coil. A gradient recalled echo sequence was used. After acquisition of the pre-Gd images the contrast (0.15 mmol/kg of Gd-DTPA) was delivered and 12 time frames (90 s each) were acquired. The signal intensity vs. time was fitted to a realistic two-compartment Brix model for each voxel of the breast volume. Three parameters for this model were fitted: rate of Gd exiting the compartment representing the extracellular space of a lesion (K_{PS}), rate of Gd exiting the blood compartment (F), and a parameter that characterizes the signal intensity strength. Initial values of fitted parameters were estimated for each voxel, assuming realistic average physical tissue properties. The best-fit parameters were used to create K_{PS}/F parametric image for each patient because they best correlate with presence of breast cancer [Ref. 1].

Dynamic PET/CT imaging was performed on GE Discovery ST scanner with 4-slice CT. Patients were prone with breasts freely suspended. PET/CT imaging was performed after a 10-s CT scan immediately after intravenous administration of 10 mCi F-18-FDG using a 50-frame protocol (N=50 frames of 1 minute each). A realistic two-compartment kinetic Patlak model was fitted to time-activity curve for each voxel of the breast volume. Three parameters for this model were obtained: two of them describe the activity levels in the blood and in the cellular compartment, while the third characterizes the washout rate of F-18-FDG from the cellular compartment. Because it is now accepted that the kinetic parameters describing cellular compartment are well correlated with presence of breast cancer they were used to obtain two kinds of parametric images: Patlak slope and intercept image or each patient [Ref. 2]

Two strategies of registration of MR and PET parametric images were considered: intensity based using free-form deformation (FFD) and geometry based using finite element method (FEM) with fiducial skin markers placed on patients' breasts and visible in MR and PET imaging. The FFD registration was performed via the CT images that were obtained during PET/CT scans.

Results: We investigated registration quality by comparing accuracy of registered breast surfaces and internal tissue morphology (Fig. 1).

In addition target registration error (TRE) analysis for FEM method was performed by implementing FEM registration without one of the markers and then measuring the distance between observed locations of this marker in the source (MR) and target (PET) images. This process was done for each FSM. The TRE analysis was done for the FFD results by measuring the distance between the images of FSM visible in PET and registered MR images (Table. 1).

Conclusions: Even though, the TRE is comparable for each method (Table 1), FFD performs better than FEM, as can be seen in Fig. 1 by analyzing co-registration errors of outlined contours of the ductal tissue and of the breast surface. Further, FFD does not require FSMs, therefore it can be applied retrospectively. It can be performed faster than FEM and with only minimal human involvement. FEM method can be only applied prospectively and requires more complicated study protocol due to necessity of using FSM. We conclude that FFD should be used for nonrigid registration of parametric MR to parametric PET breast images via CT images for improved breast cancer detection.

TABLE I
COMPARISON OF TARGET REGISTRATION ERROR (TRE) OF FINITE ELEMENT METHOD (FEM) AND AREA RGISTRATION ERROR (ARE) OF FREE-FORM DEFORMATION (FFD) REGISTRATION OF PARAMETRIC MR IMAGE TO PARAMETRIC PET FOR THREE SUBJECTS

TRE for FEM or ARE for FFD						
		Volume of Interest				
		Average (mm)	**Standard Deviation (mm)**	**Max (mm)**	**Min (mm)**
Subject 1	FEM	12.7	5.8	22.3	2.3
	FFD	13.1	7.3	31.4	3.2
Subject 2	FEM	12.5	4.5	23.3	2.7
	FFD	12.9	7.5	29.9	4.0
Subject 3	FEM	13.4	7.2	31.3	3.8
	FFD	15.6	8.7	30.2	2.1

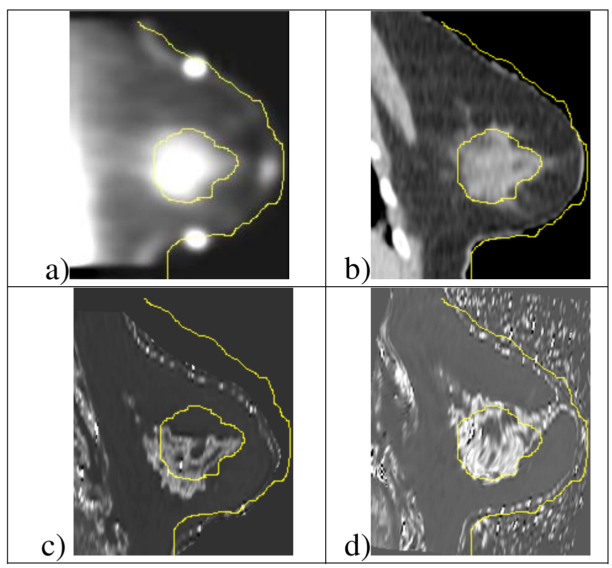

Fig. 1. a) Parametric PET image displaying Patlak slope. b) CT image registered to parametric PET image. c) Parametric MR image registered to parametric PET image using FEM. d) Parametric MR image registered to parametric PET image using FFD. Both c) and d) are displaying a parameter of the Brix model that relates to the signal intensity strength. The yellow lines outline ductal tissue and the breast surface.

REFRENCES:

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