DCE-MRI tumor registration by using TV-L1 optical flow

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Introduction

Dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) is an important method for tumor diagnosis and treatment monitoring. For many applications registration of the dynamic images is needed to compensate physiological and unintentional motion. For DCE-MRI this is a difficult task as contrast media uptake changes the image contrast of the dynamic time series. To get a better quantification of DCE-MRI data, non-rigid image registration independent against contrast changes, especially during the wash-in and wash-out phase, is needed. Therefore, a TV-regularized optical flow approach with structure extracting preprocessing was investigated.

Materials and Methods

Each image of the DCE sequence (target images) (see **Fig. 1a**) is registered to a template image (see **Fig. 1b**), which is determined by using the first component of the principal component analyses (PCA) [1]. From every image of the DCE sequence, including the template image, a structure image is created by subtracting homogenous background information calculated by an anisotropic diffusion approach (TV-L2) [2] from the original image. This leads to contrast invariant structure images. A duality based algorithm for TV-L1 optical flow computation [2,3] is used for the registration stage by solving the following optimization problem

$$\min_{\vec{u}}\left\{\int_{\Omega}|\nabla u_1|+|\nabla u_2|d\Omega+\lambda\int_{\Omega}|I_1(\mathrm{x}+u(x))-I_0(x)|d\Omega\right\}$$

where I_0 and I_1 is the structure image pair, $\boldsymbol{u}=(u_1(x),u_2(x))^T$ is a two-dimensional displacement field and λ is a free parameter which weights between the data fidelity and the regularization force. Ω denotes the image domain. The computed displacement fields (see **Fig. 1c**) of the structure images are then applied to the original images.

Results

The performance of the proposed DCE image registration algorithm was evaluated using three real patient DCD-MRI tumor sequences, each including 39 frames. The results show that movement artifacts of the tumor and surrounding tissue could be markedly reduced. Thus, the artifacts of the time signal course were significantly decreased which subsequently improved quantification of dynamic MRI data (see **Fig. 1d**).

Discussion

The algorithm shows good performance for small motion artifacts (5-8 pixels) but must be still improved for wide range movements. Currently, the registration of 2 images takes 8 seconds on an Intel® Dualcore (2.4GHz, 2 GB of RAM) workstation. A GPU-based implementation of the algorithm using CUDA is planned which leads to a speed up factor of 30.

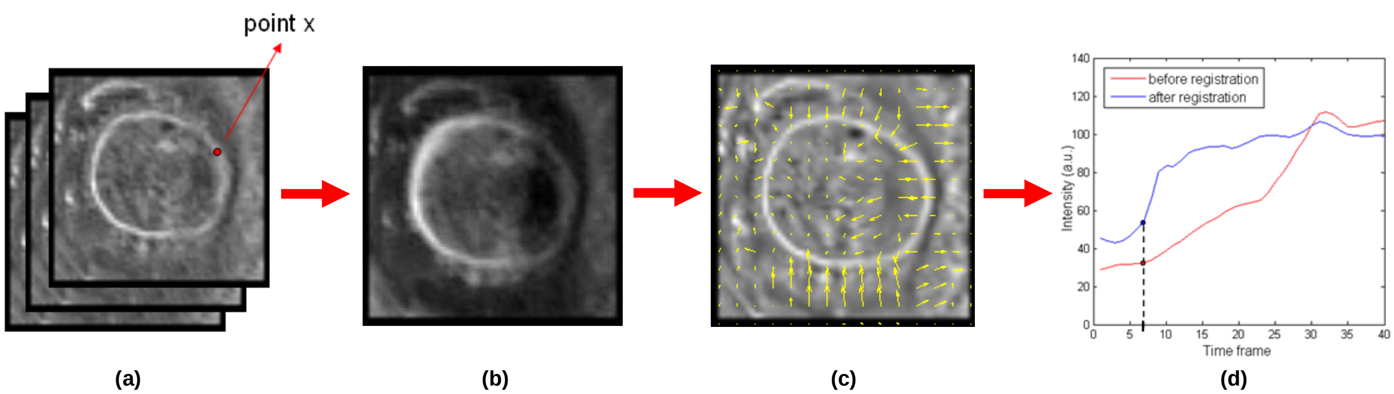

Fig. 1: Workflow of the registration procedure: (a) preprocessed structured images using anisotropic diffusion (target images), (b) first component of the PCA (template image), (c) calculated displacement field of the registration of one target image onto the template image in (b), (d) time dependence of signal intensity at point x in (a) before and after registration of every target image to the template image (wavelet denoised).

References

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