Respiratory Motion Correction for Subtraction Images during Passive Endovascular Device Tracking

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Introduction

Various tracking strategies for MR-guidance of endovascular catheter manipulations have been reported in the literature, that can be categorized into *local detection methods*, where the catheter itself or part of it is used as the receive antenna for the MR signal, and *global detection methods*, that rely on the direct visualization of the devices based upon the signal alterations these cause in MR fluoroscopic images[1]. Though promising and versatile, local detection techniques, often referred to as active tracking approaches, are not yet ready for use in human patients, since no safe local detection techniques have been presented so far. Global detection techniques can be made inherently safe, but the need to acquire a whole new image to get an update of the device position demands for a compromise between marker visibility, spatial and temporal resolution. In susceptibility-based passive device tracking, susceptibility artifacts caused by markers on the endovascular devices are used to depict the instruments in fluoroscopic MR images[2]. Subtraction of a reference image without any markers in it from thick-slab tracking images, with the possibility to overlay the resulting subtraction images onto a previously acquired road map angiogram, has been shown to be a valuable tool for increasing marker visibility[3]. However, subtraction and overlay techniques as described above are very sensitive to motion and can therefore only be applied in regions of the anatomy that lie still and that do not change much during the intervention. In the abdomen, the major source of tissue motion is respiration. Since the speed of the reconstructor of our MR scanner has become high enough to exploit SENSE in our dynamic tracking scans, the frame rate achievable now allows the acquisition of multiple images during one respiratory cycle. We propose a technique to compensate for respiratory motion by automatically finding the best of a series of reference images for subtraction during dynamic scanning. *In vivo* tracking results in a pig aorta are shown.

Materials & Methods

All experiments were performed on a clinical 1.5-T scanner (Gyroscan NT Intera, Philips Medical Systems, Best, The Netherlands). Dedicated catheters and guide wires equipped with paramagnetic dysprosium-oxide ring markers were tracked using a fast dynamic gradient echo scan making use of SENSE factor 2. The resulting frame rate was 2 images per second. A tracking experiment is schematically shown in Figure 1. During the actual tracking phase (blue), an image processing PC operating under Linux connected to the MR scanner's reconstructor runs an algorithm to automatically trace the best reference image for subtraction from the tracking image under consideration (see Figure 2). On-line subtraction of both images is performed and the subsequent subtraction images are shown on an LCD screen inside the MR suite. The most straightforward method to select a reference mask image for subtraction would be to monitor the respiration signal and relate the mask image number to the phase during the respiratory cycle. However, since the respiratory signal cannot yet be made available on-line on our scanner, we have currently implemented an image-content-based algorithm for finding the best matching reference image. In this approach, the best mask image is determined solely using the grey value information in the tracking and mask images. The algorithm calculates the sum of squared differences between all pixel grey values in a dynamic tracking image and each individual mask image. The mask image that gives the lowest sum of squared differences is the best candidate for performing the subtraction. The proposed method was tested *in vivo*. A catheter equipped with three paramagnetic ring markers was tracked from the iliac arteries, via the aorta into the renal artery of a living pig.

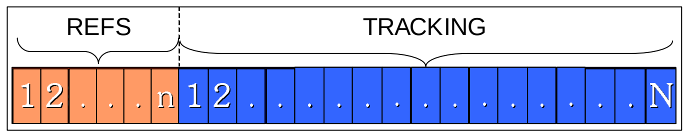

Figure 1: Acquisition scheme for reference and tracking images. During the first phase *n* reference images are acquired over a number of respiratory cycles. After that, dynamic tracking is performed (tracking phase).

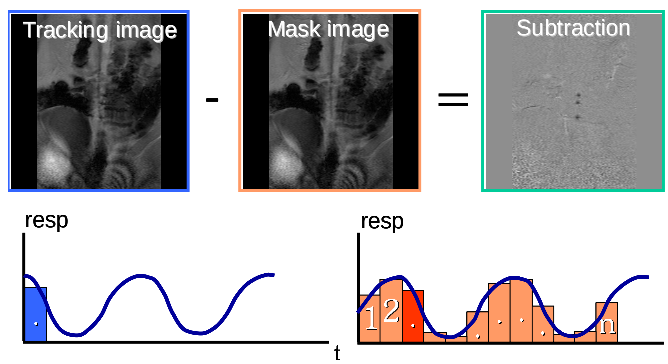

Figure 2: On-line selection of the best matching reference mask image (dark red bar) for a certain tracking image (blue bar).

Results & Discussion

Our experiments showed that the on-line motion correction technique improved marker conspicuity in the abdominal vessels of a living pig. As long as the major changes in the tracking images over time are related to respiratory motion, the correction algorithm will result in smooth subtraction images that can easily be overlaid onto a road-map angiogram. However, other undesired changes in grey value, for instance due to peristaltic motion or moving air through the bowels, cannot be corrected for. Still, applying the correction algorithm resulted in cleaner subtraction images in which the markers could much easier be identified because far less disturbing motion-related subtraction artifacts were seen.

References

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