Wireless hybrid passive and active tracking for automatic image plane alignment

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Purpose

Automatic image plane alignment increases heavily the time efficiency of percutaneous interventions under MRI guidance. Existing active [1,2] and passive [3,4] tracking approaches rely respectively on additional electrical hardware or on direct detection in the MR images. In this work a hybrid tracking approach for automatic image plane alignment combining detection in MR images (passive) and in images from an RGB-D sensor (active) is presented. The tracking performance is evaluated using an MR compatible testbed.

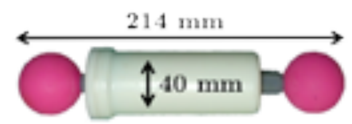

Fig.1: Hybrid tracking marker prototype consisting in a passive MRI marker surrounded by 2 colored balls.

Material and methods

All imaging experiments are performed in a 1.5T system (Siemens Aera) using an interactive, real-time, multi-slice TrueFISP sequence (Beat_IRTTT [5], Siemens Corporate Research & Technology). The hybrid tracking approach is implemented within a custom software interface on an external PC that is connected via Ethernet to the MRI console PC. The hybrid tracking marker consists in a cylindrical MR contrast-agent filled marker used for detection within MR images, equipped with 2 colored balls at its distal ends for detection within RGB-D images (Fig.1). Two orthogonal MR image planes are alternately acquired and automatically aligned to the detected marker positions. For this purpose, the detected poses of the marker from MR images and RGB-D sensor images are combined (Fig.2) using an information filter, implemented to combine data with different acquisition frequencies. In case of failed probe detection (line-of-sight obstruction / probe outside MR image plane) in one modality, the probe can still be tracked in the complementary modality. In order to translate the detected marker position from the RGB-D sensor to the MRI frame of reference, an online registration approach is implemented allowing to determine the rigid transformation between MRI and RGB-D sensor frames in the beginning of the intervention. The precision quality of the developed approach is evaluated using an MR compatible testbed on which the tracking marker can be mounted (Fig.3): the position sensor provides a ground-truth marker pose within the MRI scanner frame.

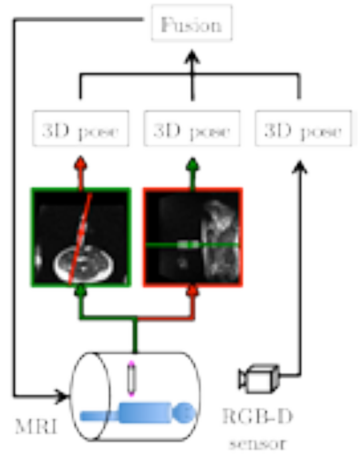

Fig.2: Hybrid workflow: pseudo axial (green) and sagittal (red) MR scan planes are alternately acquired. RGB-D sensor based and MR image based detection results are fused and scan planes are accordingly aligned to the tracking target.

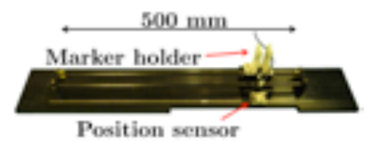

Fig.3: MR compatible testbed

Results

With a mean translation speed of 15.1 mm/s, the root mean square error between detected hybrid marker position and the ground-truth was 5.7 mm, which is on the order of the pixel size and the image slice thickness. Combination of both tracking sensors allows for robust tracking.

Conclusions

The hybrid workflow combines the tracking performance of a passive approach based on MR images with the high frequency measurements of an active approach using an RGB-D sensor. Their combination allows for flexible and reliable tracking without heavy instrumentation, and can be easily introduced into the clinical workflow. Such plastic low cost probe prototype can be chemically sterilized or made single use.

References: [1] Qing et al., ISMRM 2010; [2] Viard et al., EMBC 2007; [3] DeOliveira et al., ISMRM 2008; [4] Maier et al., ISMRM 2011; [5] Pan et al., ISMRM 2011.