Image-based spatial HIFU transducer calibration for MRgFUS

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Background

In MRgFUS applications with movable transducers it is a common problem to establish a connection between scanner- and transducer-coordinate systems (spatial calibration). Vendor calibration tools are often only available in proprietary software and not accessible in research applications. Thus, transducer position and orientation are often prescribed in a tedious and error prone manual process.

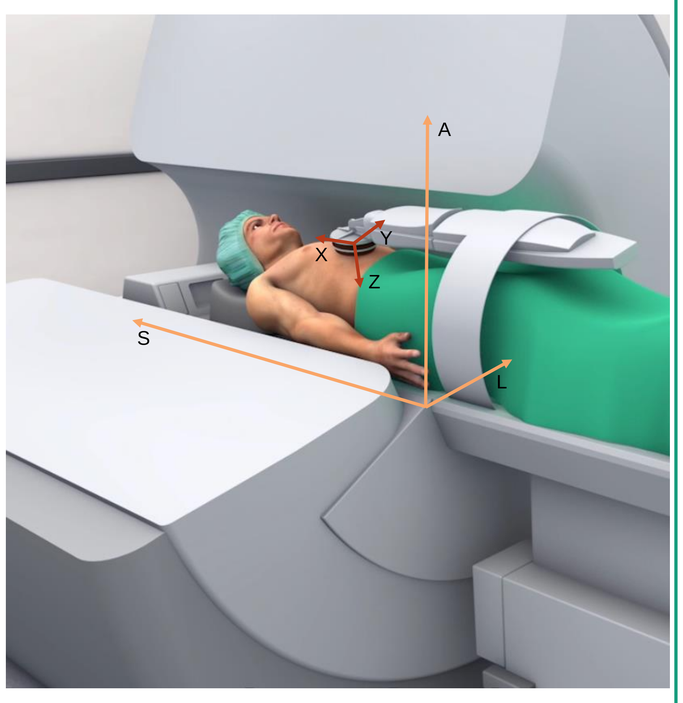
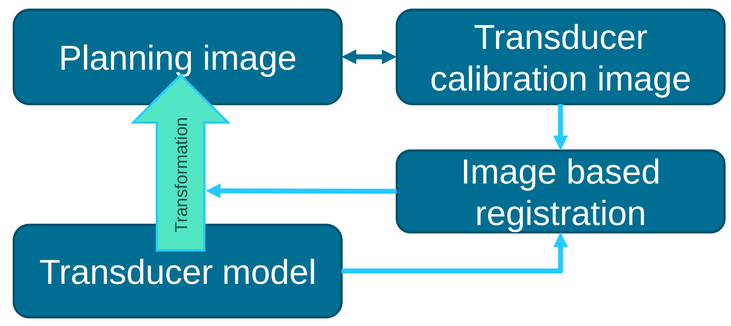


Image Based Spatial Calibration

The current work presents an image-based spatial transducer calibration method that transforms a transducer model automatically into a given setup. Our method is based on the idea, that the water systems tubes are typically well visible in MR imaging and attached to one side of the transducer, giving information on the transducers position and orientation. An MR image of the transducer and its periphery (Transducer calibration image) can thus be used for an automatic calibration method.

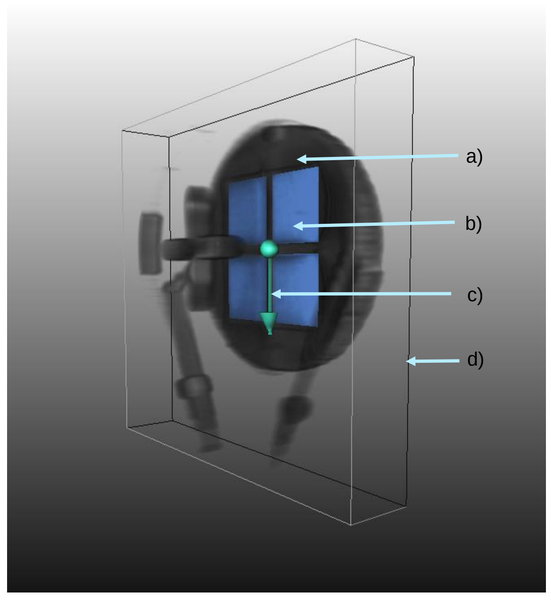


The method may be provided as a MeVisLab add-on for research purposes (jan.Strehlow@mevis.fhg.de)

Transducer Model

A transducer model has to provide the following information:

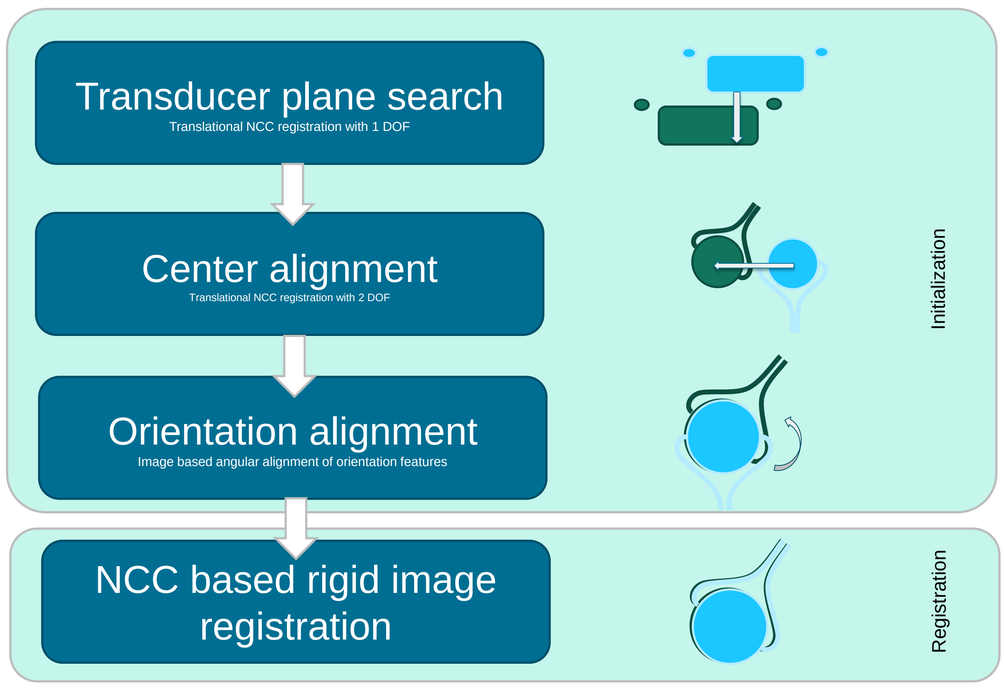
a. An Image of the transducer with slice orientation roughly parallel to the transducer surface
b. All relevant transducer information, s. a. element positions and size
c. Transducer center and orientation vector
d. A set of model image slices that contain transducer features describing the orientation, e.g. cooling system cables



Exemplary transducer model of an InSightec Conformal Bone System 2000 transducer

Image Based Registration

The transducer calibration is implemented as two-step process: An initialization is used to coarsely align setup and model image, a subsequent image registration aligns the images precisely.



Evaluation

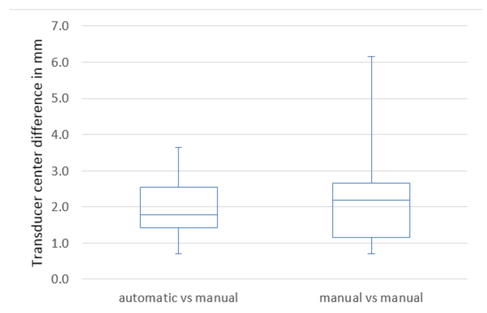
The method was evaluated on 10 random transducer calibration images that were acquired in phantom and animal experiments over the last year.
The automatic calibration is compared to a manual calibration by the following criteria:

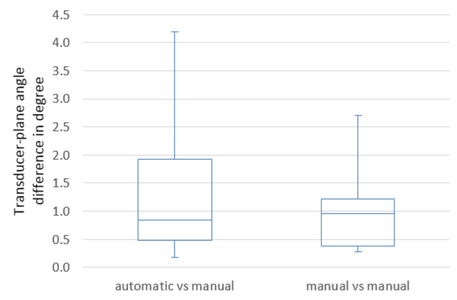
- Difference in transducer center in mm
- Angle difference of transducer up vector
- Angle difference in transducer in-plane rotation

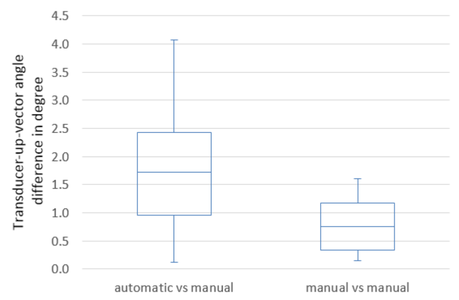
Further the manual calibration is compared to a second manual calibration to estimate the inter-observer-variability (IOV)

Results

The significant inter-observer-variability indicates that manual transducer calibration is susceptible to errors. The accuracy of the automated method is mostly within this ground truth uncertainty. The higher transducer up-vector deviation is being analyzed and is subject to discussion.







Acknowledgements

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