Background:

Intracardiac echocardiography (ICE) systems are routinely used in percutaneous cardiac interventions for surgical navigation. Conavi's Foresight ICE is a new ICE system that uses a mechanically rotating transducer to generate a 2D conical surface image in 3D space, thus we refer to them as 2.5D. To combine this probe for with magnetic tracking technology and use in an image guidance system, this unique imaging geometry poses new calibration challenges and opportunities. Existing ultrasound calibration methods are designed for 2D planar images and cannot be applied to 2.5D conical images. In this work a spatial and temporal calibration technique applied to the unique case of conical ultrasound image data is described and validated.

Evaluation:

Spatial calibration is performed using needle-phantom method developed by Chen et. al (2017). A Foresight ICE probe was augmented with a magnetic tracking sensor rigidly attached to the outer sheath close to the probe tip. Image data is acquired from the console using a frame-grabber. Since the acquired image is a 2D projection of the cone, an additional step is required to reconstruct the image back to its 3D form. Temporal calibration is performed using D. Gobbi’s method (2003). This approach compares the positions of a tracked, line-shaped object to the positions of its reflection in the images to find the temporal offset between the tracking system and the ultrasound system. Calibration is validated using a point source and sphere phantom to perform point reconstruction accuracy and sphere’s centroid calculation. Ground truth is established by high resolution the CT scan of the phantom.

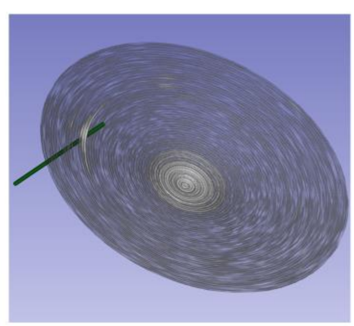
Discussion:

Qualitative assessment in virtual environment validates the calibration as the needle passes through the needle reflection seen in the image. For quantitative results, we report a spatial calibration accuracy of 1.74 mm. Temporal calibration measures a mean temporal offset of 93 ms. We observe mean error of 4.7mm for point source localization and 1.53 mm for sphere’s centroid localization.

Conclusions:

The reported error is slightly higher than the usual calibration methods. Errors in the system are possibly due to large beam profile, interchanging coordinate systems and uncertainty in the imaging angle that is displayed on the ultrasound console. However, the results are promising and satisfy the accuracy required by most intracardiac interventions (Linte 2010). Temporal offset is small enough that generally, it does not need to be corrected for percutaneous cardiac interventions.

Conavi Foresight ICE Probe



Spatial Calibration Validation