# Abstract

The contributions in this dissertation are motivated by the inadequate geometric accuracy of MRI in the context of stereotaxic surgery. Because of these contributions, the accuracy of MRI is now about 1 mm, a figure comparable to that for CT and sufficient for current stereotaxic procedures.

I present a new *in-vivo* method to correct the non-linear, object shape-dependent spatial distortion in MR images caused by magnetic susceptibility variations. This distortion across the air/tissue interface before and after the correction is quantified using a phantom. The results are compared to the "distortion-free" CT images of the same phantom by fusing CT and MR images using fiducials, with a registration accuracy of better than a millimeter. Magnetic susceptibility of cortical bone is measured using a SQUID magnetometer and found to be -8.86 ppm (with respect to air) which is quite similar to that of tissue (-9 ppm). As expected, the distortion at the bone/tissue boundary is negligible compared to the typical MRI resolution, 1 mm, while that at the air/tissue boundary creates displacements of about 2.0 mm (for $B_0 = 1.5$ T and $G_x = 3.13$ mT/m), a significant value compared to the image resolution, 1 mm, if MRI is to localize targets with the high accuracy expected for stereotaxic surgery. I also present a new method to estimate magnetic susceptibility of materials from MR images.

Geometric distortion in MR images caused by gradient field non-linearity is quantified accurately using a 3D phantom before and after a commercial correction scheme. This correction scheme improves the accuracy of MR images from about 4 mm to better than 1 mm everywhere within a $200 \times 200 \times 200$ mm$^3$ cubic volume of interest centered at the gradient isocenter. This volume corresponds to the typical size of a human head. A computer vision technique is used to automate the distortion quantification process.

Image segmentation is required in medical imaging to extract anatomical structure from edge-data. I present two new image segmentation schemes. The first one detects regions of symmetry in images faster than before. The second one builds edge-graphs from edges in images by completing fragmented edges and missing junctions.