3D breast segmentation for image based shimming

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Introduction: Breast cancer is the second leading cause of cancer deaths in women today. To oppose this threat, breast screening and follow up with non-ionizing imaging techniques is of critical relevance. Fat suppressed MR imaging is considered to be important for diagnosis of pathology in breast. However, optimal fat suppression requires a homogeneous static B0 field. Image based B0 shimming (IBS) has been introduced to optimize the B0 field during acquisition[1]. In IBS, a low resolution phase unwrapped[2] B0 map is calculated from Fast Field Echo images before clinical imaging. A region in the map is outlined by a user defined ROI -which is time consuming- and used to calculate shim parameters. **To facilitate clinical workflow we propose a fully automated 3D breast segmentation algorithm, including implants, which is fast and accurate enough for calculation of shim parameters by IBS.**

Methods: **a;** The FFE image from which the B0 map is constructed is used. Image intensity is increased linearly from A(nterior) to P(osterior) to correct for coil sensitivity. Then, the L(eft) and R(ight) side of the 3D image are separately normalized to have a mean of one, and the outer surface of the breast (air / skin) is outlined by setting a threshold on the pixel intensity. **b;** An in house developed edge follow method is executed from the approximate nipple position to find a path between thorax and arms if parallel to the body (Fig. 1; blue path). The edge follower decides locally on the next target point using gradient strength and taking into account restrictions on the angle between previous and next point. **c;** The location of the lung wall is found at the sternum for 5 equidistant transverse slices which cover the breast feet-head FOV, by detecting a rapid intensity decrease when going from sternum to lung. From each of the lung wall locations, the edge follower finds the L and R side of the lung wall (Fig. 1; green path). All points on the lung wall are combined to construct a 'lung plane'. **d;** Implants are recognized in the following way: construct an implant contour image from the transverse image going through the nipples using a line filter that assumes high intensity in breast, low intensity in implant wall and medium intensity inside the implant. Presence of an implant is detected based on the contour shape and size. **e;** If detected, the implants are segmented on coronal views using a threshold and an elliptic fitting technique.

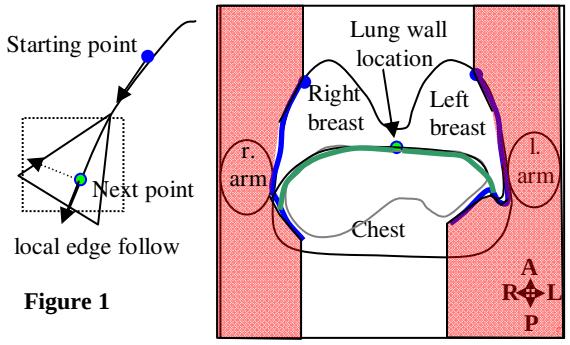
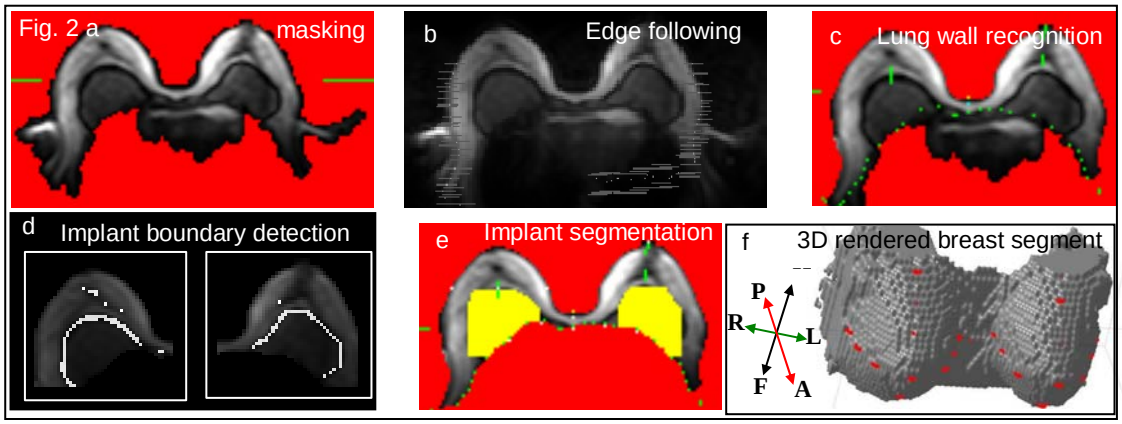
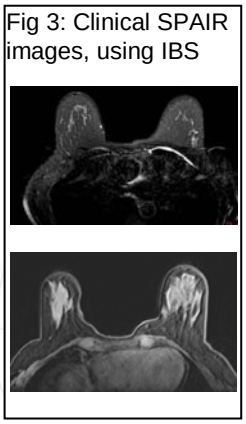


Figure 1

Results: Fig. 2a-f visually explains the method on an example case. Fig. 3 shows image based shimmed clinical SPAIR images from two cases. The breast segmentation has been developed on 100 cases and visually evaluated on another 100 cases, with 100% success rate. In 48 clinical images obtained on Philips 1.5T, 3T and High Field Open MR, the visual comparison between routine shimming and image based shimming showed an improvement of fat suppression and image quality in 26 cases and a decrease in 3 cases. Implant segmentation is difficult with 18 of 25 positives and 2 of 100 false positives. Unfortunately no clinical images with implants are available until now.





Discussion / conclusion: B0 maps are low in resolution, have scan time limitations and are prone to error due to motion, and thus pose a challenge for segmentation. The proposed method is robust enough to deliver segments for IBS, is fast (4 seconds), and includes the important axillea region. Sometimes the lung wall is not robustly found because of the interference of the heart, but this is never severe enough to reject the breast segment for IBS purposes. We have found that inclusion of the axillae in the segment improves fat suppression in that region for many cases. The implant segmentation prevents this volume to be used by IBS, and therefore avoids suboptimal shim settings caused by the deviating proton frequency of silicones. Segmentation of the implants needs additional research, but is sufficiently accurate for the current application.

The full potential of automated image based shimming is exploited using our proposed segmentation, thus enabling image based shimming for routine clinical use.

References: [1]: Magn Reson Med. 2004 Apr; 51(4): p799-806 [2]: Magn Reson Med. 2002 Dec; 49(1): p193-197