ROTATIONAL MOTION ARTIFACT CORRECTION IN MAGNETIC RESONANCE IMAGING

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Abstract

The body motion of patients, during magnetic resonance (MR) imaging causes significant artifacts in the reconstructed image. Artifacts are manifested as a motion induced blur and ghost repetitions of the moving structures, which obscure vital anatomical and pathological detail. The techniques that have been proposed for suppressing motion artifacts fall into two major categories. Real-time techniques attempt to prevent the motion from corrupting the data by restricting the data acquisition times or motion of the patients, whereas the post-processing techniques use the information embedded in the corrupted data to restore the image. Most methods currently in widespread use belong to the real-time techniques, however with the advent of fast computing platforms and sophisticated signal processing algorithms, the emergence of post-processing techniques is clearly evident.

The post-processing techniques usually demand an appropriate model of the motion. The restoration of the image requires that the motion parameters be determined in order to invert the data degradation process. Methods for the correction of translational motion have been studied extensively in the past. The subject of this thesis encompasses the rotational motion model and the effect of rotational motion on the collected MR data in the spatial frequency space (k-space), which is in general, more complicated than the translational model.

Rotational motion artifacts are notably prevalent in MR images of head, brain and limbs. Post-processing techniques for the correction of rotational motion artifacts often involve interpolation and re-gridding of the acquired data in the k-space. These methods create significant data overlap and void regions. Therefore, in the past, proposed corrective techniques have been limited to suppression of artifacts caused by small angle rotations. This thesis presents a method of managing overlap regions, using weighted averaging of redundant data, in order to correct for large angle rotations. An iterative estimation technique for filling the data void regions has also been developed by the use of iterated application of projection operators onto constraint sets. These constraint sets are derived from the k-space data generated by the MR imager, and available *a priori* knowledge. It is shown that the iterative algorithm diverges at times from the required image, due to inconsistency among the constraint sets. It is also shown that this can be overcome by using soft constraint sets and fuzzy projections.

One of the constraints applied in the iterative algorithm is the finite support of the imaged object, marked by the outer boundary of the region of interest (ROI). However, object boundary extraction directly from the motion affected MR image can be difficult, specially if the motion function of the object is unknown. This thesis presents a new ROI extraction scheme based on entropy minimization in the image background.

The object rotation function is usually unknown or unable to be measured with sufficient accuracy. The motion estimation algorithm proposed in this thesis is based on maximizing the similarity among the k-space data subjected to angular overlap. This method is different to the typically applied parameter estimation technique based on minimization of pixel energy outside the ROI, and has higher efficiency and ability to estimate rotational motion parameters in the midst of concurrent translational motion. The algorithms for ROI extraction, rotation estimation and data correction have been tested with both phantom images and spin echo MR images producing encouraging results.

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