Depth Reconstruction from Projection Images for 3D Visualization of Intravascular MRI Probes

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Introduction:

Recent works indicate that MR-Fluoroscopy methods could provide image acquisition frame rates that can help achieve real-time imaging of intravascular MRI probes (1). Fluoroscopic projection images lack depth information and may appear sometimes misleading when presented with road map MRI images. The capability of MR to acquire images in 3D could be exploited to restore the depth information about the intravascular MRI probe placement. The challenge however would be to find an effective trade-off between maintaining the real-time image acquisition frame rates and the resolution of the 3D information required for visualization. This abstract presents a method to recover the depth information that is lost during the integral projection without significant loss of the frame rates needed for real-time imaging.

Methods:

Computing 3D shapes from a pair of 2D integral projection is a well-studied problem in literature. In many of these studies limited knowledge about the geometric features that need to be extracted, resulted in the development of techniques that required some form of user intervention. In contrast, we focused our study on approaches that are well suited to the imaging of intravascular MRI probes by taking advantage of the apriori knowledge about the problem. They are a) the probe is relatively thin one dimensional object with uniform thickness b) the probe is single continuous object with no branches and c) integral MR projection gives geometrically accurate fluoroscopic images.

We investigated two possible approaches to solve the problem. In the first approach we employ the traditional bi-planar approach, i.e., using images acquired at two different angles. In the second approach we consider the issue as an image reconstruction problem and use "sweep" Fluoroscopy images to perform back projection reconstruction.

The key issue in the first approach is to identify correspondence between two images to be able to compute the depth. This is done three steps. 1) Identifying the points that lie along the center line of the probe in each of the images. 2) Computing the center line that passes through these points with loops and knots resolved using the no-branch criteria. 3) Combining the 2-D centerlines from each of the images to obtain a 3-D center line. Correspondence points in the two views are determined using the free end points as the reference point followed by the registration of all other points. Ambiguous points that have 'one-to-many' mapping between the two views are resolved based on their location relative to the reference point. In the second method based on back-projection, we studied a new approach that uses the graphics hardware for texture mapping to do the reconstruction. The second approach is effective in situations where real-time performance is not critical and the two views may not be able to resolve certain loops or knots. Fig 1 shows the bi-planar views used for this study. The coronal and sagittal projection images of the intravascular MRI probes were obtained using an SPGR pulse sequence with no slice selection. 4mW power was applied to a loopless catheter antenna (2). The entire length of the antenna was visualized. Other imaging parameters were: 256x256; 36cm FOV, TR/TE: 5.2/1.5msec, BW: 64kHz. Depth reconstruction results are shown in Fig 1 as a 3D wire-frame model (for illustration purpose a larger radius is used)

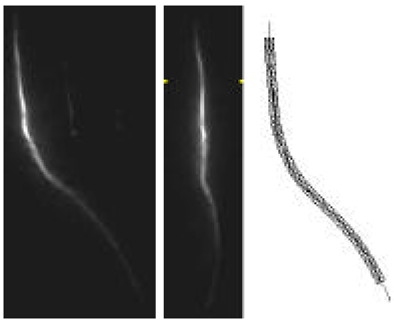

Fig 1. Coronal and sagittal views of an intravascular MRI probe and its 3D reconstructed wire-frame model.

3D Visualization:

Fig 3. 3D image of the probe using back-projection reconstruction method. 18 projection images covering a 180 deg. sweep angle were used.

Fig 2. 3D model of the probe with roadmap MRI image

The clinical usefulness of recovering the depth information is to visualize the probe along with the roadmap images, which can be presented either as a slice image or if real-time response is not critical as a 3D volume rendered image. The probe in both cases is presented as a 3D object. Fig 2 shows a coronal slice as a roadmap image, and the probe passing through the plane of the image. To further enhance the visual realism, the fluoroscopy image is mapped on the wire-frame model as texture. The coronal image is blended semi-transparently with the synthetic fluoroscopy image so that the probe below the image slice appears dim, while the part above the image slice appears bright. The software is developed on a SGI workstation to make use of its 2 and 3-D Texture mapping features for high-performance visual computing.

Conclusion:

We have shown that the problem of depth reconstruction for MR Fluoroscopy images can be addressed in two ways. The first method is more conducive to real-time performance, where the challenge we have overcome is to find an efficient and optimal way of resolving the correspondence problem. In the second method, that is currently under investigation, we are using a graphics intensive approach of reconstructing the 3D shape by performing accelerated back-projection reconstruction over a limited set of sweep fluoroscopy images (Fig 3). Finally, we have shown that the visualization of the intravascular MRI probe with the restored depth information when displayed with roadmap image helps to eliminate disturbing depth anomaly that occurs when integral-projection fluoroscopy image is displayed on the roadmap image.

References

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