A Review on Reconstruction of Fetal MRI Images

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Abstract - *Magnetic resonance imaging are very important for foetuses and neonates. Motion corruption is one of the problems which can adversely affect the quality of the scan image. It occurs due to the movement of the fetus in the uterus. In order to get a clear output scan image, it is important to remove those motion corruption. For this purpose, volume reconstruction is done for the obtained scan image. The volume reconstructed images are more clear and less corrupted when compared with the original scan image. The main steps for the reconstruction of an image are image registration and image reconstruction. For the image registration, there are different kinds of methods. Mostly used method is slice to volume reconstruction (SVR) method. Motion in the image slices can be removed by using this method. SVR followed by super resolution reconstruction is an efficient motion correction method. The SVR method which are widely used nowadays for motion correction of fetal brain.*

***Key Words*:** Magnetic Resonance Imaging, Motion correction, Fetal motion, Slice to Volume reconstruction, Image registration etc.

1. INTRODUCTION

Magnetic resonance imaging of the fetal brain is important in these years due to its various applications. The need of MRI of both the neonatal and fetal brain is important. When a motion is occurred, it affects the quality of the scan. The MRI scans are used for analysing the fetal brain. Image quality is affected by the SNR and the motion artefacts. The reconstruction of motion corrupted images is a difficult process. The reconstruction of images need pre processing steps, which are inevitable. In traditional method, correction is done by applying rigid body registration to the successive image slices. Recent methods proposes different methods to reconstruct the volume from 2D image slices. Slice to Volume registration with super resolution reconstruction is used nowadays for the motion correction. Motion can be classified into two categories: macroscopic motion and microscopic motion. Macroscopic motion is caused due to the subject. In the case of the fetal and neonatal MRI, the motion is random and unpredictable. For the adult MRI scans some effective methods have been proposed and applied already

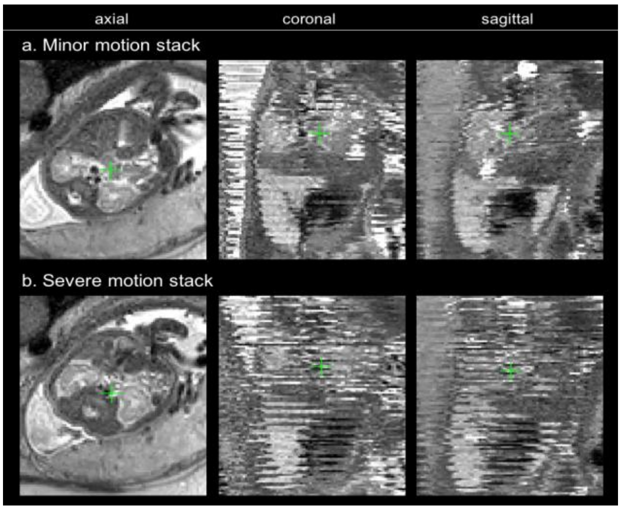

Fig-1: Fetal MRI with motion corruption

2. LITERATURE SURVEY

[1] proposes a snapshot MRI methodology. This work was motivates by the challenge of fetal brain imaging. The proposed method can be for the subjects moving at high resolution and high SNR. The image registration method used here is SVR. After imaging the target volume, image registration method is used to align the image slices. There are three main steps in this method. The first step is to achieve the required sample density. Here the slice data is obtained by a single shot technique. So there will be some signal modulation. The images will be band limited. Sampling is done after the modifications. The second step is to determine the mapping. To determine the transformation multiscale registration is used. The data is divided into multiple slices and are treated as 3D volumes. Using the rigid body transformation they are registered together. Each slice is treated in isolation. The last step is the interpolation of irregular sampled data. Due to the motion corruption, the samples might be irregularly scattered. Interpolation is needed to convert these scattered. Here the SVR reconstruction maintains the original resolution.

[2] proposes a method which includes intensity matching of the image slices. In this method, unidentified or corrupted slices are not considered. This method addresses the need for a comprehensive reconstruction method. The first step is to achieve the slice acquisition model. Different image stacks are captured at different orientation. By using the image slices, the motion caused due to the fetus can be observed.

The point spread function is used here. To obtain high quality reconstruction a good approximation of PSF is needed. Here it is treated as Gaussian function. The next step is the super resolution reconstruction of 3D volume. To achieve fast acquisition and good SNR, several stacks of thick slices is needed. The image quality of the scan is decreased as blurring is done. Edge preserving regularization can be used to minimize the smoothing effects. The last step is the motion correction. Using the volumetric rigid registration, stacks are aligned. SVR is used along with the super resolution. This proposed method can be used for practical solutions. It provides excellent results for clinical data.

[3] proposes a semiautomatic method for the analysis of fetal thorax in 3D volume. In this paper, the spine and lungs of the fetus is localized. Here it uses fast rotation invariant spherical harmonics image descriptors. Image registration is based on super resolution. The reconstructed volume is aligned using PSF. To homogenize structures TV denoising is applied. As the lungs are more complicated and complex in shape, the method which is used for spinal cord localization cannot be used. The time required for the reconstruction takes about 5-10 min depending on the number of input stacks. By the help of some minor changes, the proposed method can be applied to two different MRI field strengths. The localization of spinal cord and lungs can be used as the basis for the further diagnosis and analysis.

[4] proposes a fast multi GPU accelerated framework for the reconstruction. The existing algorithms then where slow and used for specific applications. This method uses automatic outlier rejection and intensity bias correction. For selecting the image stack a fully automatic procedure is introduced. The correct estimation of the alignment between the slices is an important step for all the reconstruction methods. Without an initial registration template, the optimization can be done. 3D rigid registration is done between all the image stacks. PSF is implemented during the computing as a continuous sampled function. Each image slice can be classified info in liners and outliners. Cross correlation function is used, it normalizes mutual information. By comparing with the other methods, this approach is fast and accurate. The movements more than 90° cannot be solved using this method.

[5] proposes an atlas construction method. It uses the diffeomorphic image registration. This image registration is the simplest image registration method which involves estimating a smooth continuous mapping between the points in one image with those in another image. Using the parameters that encode mapping, the relative shaped of the images can be determined.. Here it utilizes numerous pair wise inter subject transformations. Here in this paper, they used 118 brain images to construct the atlas.

[6], proposes a learning based image registration method where it is used to predict the 3D rigid transformation of the 2D image slices. In this method, only the image intensity information is needed. SVR is used for the image registration. This step is followed by super resolution. Here convolutional neural network (CNN) is used to predict the transformation. Organ localization is the first step. It is followed by an estimation of canonical slice orientation and then volume reconstruction. This method utilizes the standard image processing metrics. For simulated data, an average error of 7mm was obtained. This method is effective for 2D/3D image registration problems. They can be used for real time applications.

In [7], a fully automatic method is proposed to segment the plasma and it's blood vessels. The first step is to make a super resolution reconstruction of the uterus. By using 3D Gabor filter, placenta is segmented. This proposed method outperforms all the other CNN approaches. Pre processing and super resolution is done as the initial step in which it utilizes a uterus mask before the reconstruction. This method becomes less suitable for the real time applications as the total execution time is increased. Next is the placenta localization in which the feature extraction, edge based detection and classification is done. It uses adaptive histogram equalization to highlight the edges and corners

[8] proposes an advanced form of SVR. Existing SVR methods are only applicable for rigid body transformation. Deformable SVR(DSVR) is the method which can be used for the non rigid motion correction. In addition to this, it uses outliners to minimize the impact of registration errors. In this method it uses weighted Gaussian reconstruction and iterative super resolution.

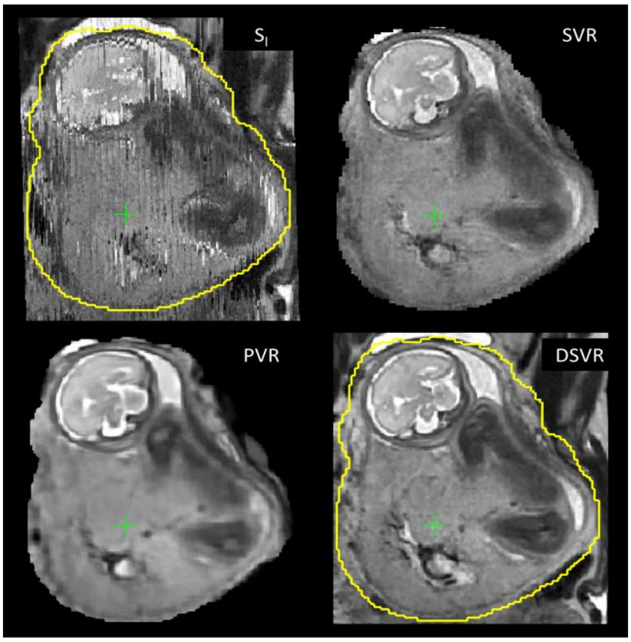

Fig- 2: Motion corrupted stack, SVR, PVR and DSVR+S reconstructed volumes (coronal plane).

3. CONCLUSIONS

Motion compensation holds a very important role in neonatal and fetal MRI scan. In Both fetal and neonatal MRI, motion causes unique patterns, and decreases the quality of the image. Even though there are different methods for motion correction for adults, there are no such techniques for neonates and fetuses. Motion- correction methods which are used for adults cannot be used for neonates and fetuses. Even after taking various precautions, some motion error can be occurred. It can also be caused due to the machine. Such errors can be removed using outliners rejection. To get more clear output image scan, volume reconstruction is needed. Some of the methods which are used for this is discussed in this article. Much future advancement can be done on this topic. Parallel imaging with motion correction can be done for further advancement.

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