Compensation Lossy Information of Fetal Ultrasound

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Abstract- Visualization 3D fetal ultrasound techniques in medical imaging are widely used. Congenital malformation is the main task for fetal abnormality. Signal attenuation on the travel path. Usually, it incorrect the gains equally for echoes in the same depth range. This reason is make bad quality image for visualization. In this paper present the compensation lossy information for 3D ultrasound imaging reconstruction. Statistical of intensity of image is used. The experiment shows that the results of information compensation compare with original image with lossy information are given a good quality image. This compensated image is used for 3D visualization image for further steps are more perfect.

Key word- Lossy information, Congenital malformation, 3d ultrasound, Compensation

I. INTRODUCTION

Ultrasound is widely used for pregnancy diagnosis and major focuses on development and diagnosis of fetal abnormalities [1][2]. For the analysis in clinics, the fetal development means monitoring and evaluating according to the observations and the ultrasound image as know as, "sonogram image". Congenital malformation is the main task for fetal abnormality which is performed in the first trimester of pregnancy to diagnose the malformation of some organs such as renal, neck, spina bifida, limbs, heart, etc. However, the conventional 2D ultrasound has some limitation for the diagnosis of fetal anatomy and it leads to open up the way for 3-Dimentional ultrasound in fetal imaging diagnosis.

Visualization 3D fetal ultrasound techniques in medical imaging are widely used [3]. Most of all techniques are extraction and project image features on view plane. The image can be very useful to apply on obstetric diagnosis. However, abnormalities diagnosis needs the high quality 3D image for more precise diagnosis.

Information that uses in reconstruction must be high quality to perform 3D visualization. Speckle noise is commonly known as the contaminant and messes up the quality of ultrasound image. Speckle reduction is the major task of visualization applications [4][5][6]. The conventional method, “speckle supression”, used low pass filters for adaptive smoothing to develop the enhancement of ultrasound image.

Although these techniques may give a good quality image, but may not is “optimal” for images taken at other probe orientations during the 3-D scan. Particularly, those are caused by nonuniform beam attenuation within the body that is not accounted. This problem has also been well-studied, although mainly at the radio frequency (RF) signal level, time gain compensation (TGC) technique is also used.

The function of TGC is to amplify the amplitude of echoes in order to compensate for signal attenuation on the travel path. Usually, it corrects the gain equally for echoes in the same depth range. It follows that it does not work well if regions with different attenuation properties appear at the same depth. Since, the image intensities within regions of the same tissue type often appear inhomogeneous and the intensity distributions of different tissue classes often overlap significantly. For this reason, it is important to compensate for lossy information.

In this paper is presented the compensation lossy information for 3D ultrasound imaging reconstruction. Statistical of intensity of image is used. In this paper, we organized by follow, the next section will analyze lossy information problem and introduce our idea. In Section III, describes compensation lossy information of 3D data image reconstruction. The experiment including results, the proposed method has shown compensation lossy information, section IV. The discussion is given in Section V and followed by conclusions in Section VI.

II. LOSSY INFORMATION

A. Lossy Information

Fig.1 shows the sequence of fetal face ultrasound images. The information in the first 3 frames are complete but the information in the 4th - 6th frames are absent which is remarkable with red circle of the 6th frame and the information in the last 3 frames is reappeared. To analyze intensity value; for example, the intensity value in line40 between position 50-70 of the 4th-6th frames is reduced when they are compared to the same position in the 1st -3rd frames (Fig.2). This graph shows that the interesting region is the information lost region. To determine the sequence of the image in Fig 1, it shows that the lost information is reappeared in the last 3 frames. This is the hint for using the
information in previous frame and future frame to co-determine for the lost information compensation.

Figure 1. lossy information of sequence of fetal face ultrasound images.

Figure 2. intensity of line 40th of images.

B. Intensity analysis
To analyze lossy information, consider the intensity at region that interest of each frame. Fig 3. shows that the image sequences which are defined as following:

The first image group is previous frame \( F_P \). The second group is Lossy Information frame \( F_L \). The final group is future frame \( F_F \), respectively.

The interest intensity of each frame show as Fig. 4, the intensity values in frame 25th to 30th are reduced. This is indicating for using the intensity statistic in previous frame and future frame to co-determine for the lost information compensation.

Figure 3. Image sequences.

Figure 4. Intensity of each image sequences with interest region.

III. METHODOLOGY

A. Preprocessing
This step is to prepare the image by reduction of noise. Low pass filter is selected to use for performing the suppression in every image and the average filter is used.

B. Lossy Region
In this subsection, the lossy information analysis is performed by using the Region of interest (ROI). To determine the intensity value at the interesting position, Fig 3. shows the 50frames of those interesting regions. Those are in the 25th -30th frames are reduced plentifully that shows the lost information of the images.

C. Compensate Information
In this subsection, the analysis method and the information compensation evaluation are explained. The intensity value of \( F_P \) is analyzed statistically and the mean of intensity value is as the following equation;

\[
\mu_{F_P} = \frac{\sum_{n_{F_P}=1}^{m_{F_P}} I_{n_{F_P}}}{m_{F_P}}
\]

Where
- \( \mu_{F_P} \) is mean of intensity of previous frame
- \( I_{n_{F_P}} \) is intensity of previous frame
- \( m_{F_P} \) is number of previous frame

The interest intensity of each frame show as Fig. 4, the intensity values in frame 25th to 30th are reduced. This is indicating for using the intensity statistic in previous frame and future frame to co-determine for the lost information compensation.
And the standard derivative is as the following equation;

$$\sigma_{F_p} = \left( \frac{\sum_{n_{F_p}=1}^{m_{F_p}} (I_{n_{F_p}} - \mu_{F_p})}{m_{F_p}} \right)^{1/2}$$ (1.2)

Where

- $\sigma_{F_p}$ is SD of intensity of previous frame
- $\mu_{F_p}$ is mean of intensity of previous frame
- $I_{n_{F_p}}$ is intensity of previous frame
- $m_{F_p}$ is number of previous frame

Similarly, the statistic value of $F_F$ is determined the following equation;

$$\mu_{F_F} = \frac{\sum_{n_{F_F}=1}^{m_{F_F}} I_{n_{F_F}}}{m_{F_F}}$$ (1.3)

Where

- $\mu_{F_F}$ is mean of intensity of future frame
- $I_{n_{F_F}}$ is intensity of future frame
- $m_{F_F}$ is number of future frame

And the standard derivative is as the following equation;

$$\sigma_{F_F} = \left( \frac{\sum_{n_{F_F}=1}^{m_{F_F}} (I_{n_{F_F}} - \mu_{F_F})}{m_{F_F}} \right)^{1/2}$$ (1.4)

Where

- $\sigma_{F_F}$ is SD of intensity of future frame
- $\mu_{F_F}$ is mean of intensity of future frame
- $I_{n_{F_F}}$ is intensity of future frame
- $m_{F_F}$ is number of future frame

Similarly, the statistic value of $F_L$ is determined the following equation;

$$\mu_{F_L} = \frac{\sum_{n_{F_L}=1}^{m_{F_L}} I_{n_{F_L}}}{m_{F_L}}$$ (1.5)

Where

- $\mu_{F_L}$ is mean of intensity of lossy information frame
- $I_{n_{F_L}}$ is intensity of lossy information frame
- $m_{F_L}$ is number of lossy information frame

And the standard derivative is as the following equation;

$$\sigma_{F_L} = \left( \frac{\sum_{n_{F_L}=1}^{m_{F_L}} (I_{n_{F_L}} - \mu_{F_L})}{m_{F_L}} \right)^{1/2}$$ (1.6)

Where

- $\sigma_{F_L}$ is SD of intensity of lossy information frame
- $\mu_{F_L}$ is mean of intensity of lossy information frame
- $I_{n_{F_L}}$ is intensity of lossy information frame
- $m_{F_L}$ is number of lossy information frame

For the intensity of lossy frame we can assume those are appears several value of $-\sigma_{F_p}$ to $\sigma_{F_F}$. To compute difference between complete information and lossy information we define firstly for complete information as below equation;

$$\mu_C = \frac{\mu_{F_F} + \mu_{F_p}}{2}$$ (1.7)

Where

- $\mu_C$ is mean of complete information
- $\mu_{F_F}$ is mean of intensity of previous frame
- $\mu_{F_F}$ is mean of intensity of future frame

And difference between complete information and lossy information is illustrated as the following equation;

$$I_d = \mu_C - \mu_{F_L}$$ (1.8)

Where

- $I_d$ is difference intensity
- $\mu_C$ is mean of complete information
- $\mu_{F_L}$ is mean of intensity of lossy information

To compute compensation lossy information is illustrate as the following equation;

$$I_C = I_L + I_d$$ (1.9)

Where

- $I_C$ is compensation intensity
- $I_L$ is lossy intensity
- $I_d$ is difference intensity

IV. EXPERIMENT AND RESULTS

In this experiment shows the presented method by comparing the result to the lossy information image. Fig .5 shows that the results of information compensation compare with original image with lossy information and it is compensated by this method. It causes more perfect.
recovery of the image. This compensated image is used for 3D visualization image for further steps are more perfect.

V. DISCUSSION

Even though, this presented method can show that the compensated image can make the image information more perfect, the limitation is the number of $F_L$ which effects on the compensation of the information. Since this method uses the average value as a result, sometimes, there is information lost in a frame. It results in object movement which shifts exceedingly. The $\mu_{F_L}$ and $\mu_{F_L}$ are very different. The $n$ value may be different from true value so the compensation is not perfect enough.

VI. CONCLUSION

In this paper present the compensation lossy information for 3D ultrasound imaging reconstruction. Statistical of intensity of image is used. The experiment shows that the results of information compensation compare with original image with lossy information are given a good quality image. This compensated image is used for 3D visualization image for further steps are more perfect.

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