Detection of Fetal Spine Abnormolities Using Image processing Technique

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ABSTRACT

Prenatal screening is an important part of prenatal survey for early detection of fetal abnormalities. Prenatal screening means testing the fetus before birth (prenatally) to identify whether the fetus has certain abnormalities. Among several methods of prenatal testing, prenatal sonography is an appropriate and cost-effective screening method for early detection of fetal abnormalities. Sonographic evaluation of fetal spine is an important aspect of prenatal fetal evaluation for both high-risk and low-risk patients. Fetal spine abnormalities can be detected in the second trimester (less than 24 weeks). Early detection of spinal anomalies helps in safer termination of pregnancy. The overall occurrence of spinal anomalies in our population undergoing sonographic evaluation was 1 in 426.The fetal spine is very difficult anatomic structure to examine because of its length and is greatly affected by fetal flexion, extension and rotation. The fetal spine is technically difficult to examine because the entire spine must be visualized in axial and sagittal projections. Allowing only a limited sonographic scanning approach that is highly dependent on fetal lie and may be limited by overlying ribs, bowel gas or surgical scars. Finally, fetal spine defects are extremely difficult to detect even with excellent scanning technique. There is a need for enhancement of fetal spine image for accurate detection of abnormality. In existing methods, selecting the rectangular Region of Interests (ROI) are manually done. Thus, there is a need for an automated segmentation method and enhancement techniques to bring quality in objects for future analysis without any wrong assumption about the object's topology . Future, work will focus on the auto-selection of ROIs for the fetal spine.

Keywords : Image processing techniques, Fetal abnormalities, Prenatal screening and tools, Fetal spine anomalies, Auto selection of ROI

I. INTRODUCTION

Prenatal Screening is an important part of prenatal survey. Prenatal screening helps to identify fetal anomalies in early stage. Early detection of fetal abnormality helps in safer termination pregnancy. The fetal spine is technically difficult to examine because the entire spine must be visualized in axial and sagittal projections. Quality of the fetal spine image is highly dependent on fetal lie and may be limited by overlying ribs, bowel gas or surgical scars. So, there is a need for enhancement of fetal spine image for accurate detection of abnormalities. The existing methods for segmentation and enhancement of fetal spine are manual or semi-automatic methods. Selecting the rectangular Region of Interests (ROI)

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are manually done in existing methods. Thus, there is a need for auto-selection of ROIs, automated segmentation and enhancement techniques to bring quality in future analysis without any wrong assumption.

II. Image Processing Techniques

Image processing means any form of signal processing for which the input is usually an image. Perform image processing on digital images using computer algorithms is known as digital image processing. Satellite imaging, medical imaging, video-phone, character and face recognition and photograph enhancement are some popular application areas of digital image processing. The technique and process used to create images of the human body for clinical purposes is medical imaging. Various image processing techniques are image representation, image segmentation, filtering, image preprocessing, image enhancement, image restoration, image analysis, image reconstruction and image data compression.

Image representation means representing an image with its internal (pixel comprising the region) and external (boundary) characteristics. Representation means compaction of segmented data into representations that facilitate the computation of descriptors. External representation focuses on shape characteristics.Internal representation focus on regional properties such as color, texture and intensity etc.

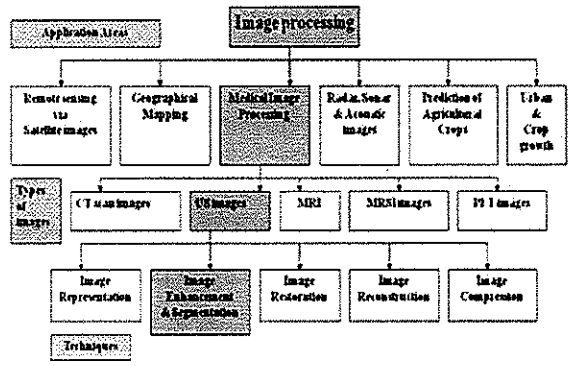

Figure 1

Image processing techniques & tools

The figure 1 provides various image processing techniques, tools and application area of image processing. Image techniques are

Image segmentation techniques are used to extract the desired object from the entire scene. Quantitative measurements of object features allow classification and description of the image.

Image enhancement means bringing out clarity in certain image features for subsequent analysis or for image display. Image enhancement include contrast stretching and edge enhancement, noise filtering, histogram modification, edge sharpening and magnifying. Image enhancement is mainly applied in feature extraction, image analysis and image display.

Image restoration means removal or minimization of degradations in an image. Degradation may be caused by de-blurring of images because of the limitations of sensor or its environment, noise filtering and correction of geometric distortion or non-linearity due to sensors. Restoring Image to its original quality

by inverting the physical degradation is image restoration.

Image reconstruction is an image restoration technique. In this method, two-direction and three-direction images are reconstructed using iterative computer algorithms

Image analysis is a technique used for extraction of certain features from the image that aid in the identification of the object. Image segmentation and image classification are image analyzing techniques.

Image compression means reducing the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. Image compression may be lossy or lossless compression. This is an essential tool for archiving image data, image data transfer on the network. The most popular compression techniques are JPEG and MPEG.

III. Fetal Spine Abnormalities

Any deviation from the normal development of structural features of an organism or part constitutes an anomaly. The anomaly may be major anomaly or minor anomaly. Major anomalies malformations that affect viability and the quality of life. Minor anomalies are also malformations that are definitely present but are usually have no functional significance.

Prenatal diagnostic testing involves testing the fetus before birth (prenatally) to determine whether the fetus has certain abnormalities. Sonograpic evaluation of fetal spine is an essential part of prenatal survey. The normal fetal spine has a "railroad track" appearance. Fetuses with a spinal abnormality diagnosed prenatally in the first-trimester of sonographic evaluation. The common fetal spine abnormalities are Neural Tube Defects, Spina Bifida and Meningocele.

Neural Tube Defects are the malformation of central nervous system. This Neural Tube Defects are hard to treat and hard to detect in ultrasound tests during the first four weeks of pregnancy. Figure 2 shows abnormal fetus with disclosure of Neural Tube

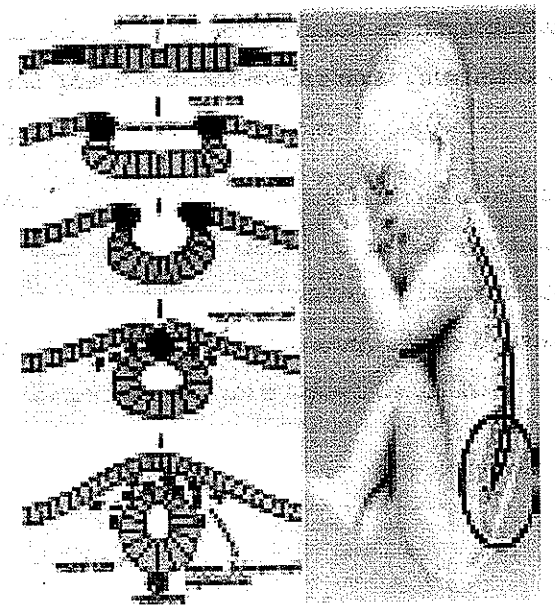

Figure 2

Neural Tube Defect

Spina Bifida is a Latin term meaning 'open spine'. Medically it refers to a congenital abnormality where the spine does not form completely. The spina bifida defect may leave several vertebrae deformed in such a way as to expose the spinal cord. The exposure of spinal cord usually results in some damage at the point of exposure which may limit brain signals to and from muscles and body organs. Figure 3 shows abnormal fetus with spina bifida.

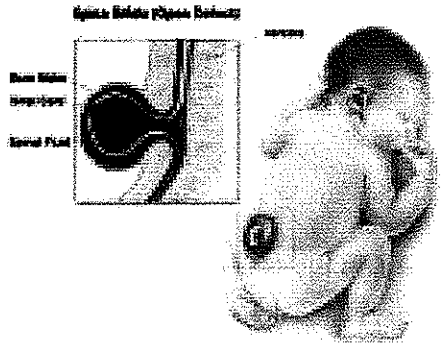

Figure3

Spina Bifida

Meningocele is considered less severe that myelomeningocele because the spinal cord doesn't' leave the protective bone tube. It is just a mussel cyst on spine. There is still a sack on the back, but the nerves of the spinal cord are not in it. The nerves remain protected and therefore are not as badly damaged. A person with Meningocele will usually have better physical development and bowel and bladder control. Figure 4 shows abnormal fetus with Meningocele.

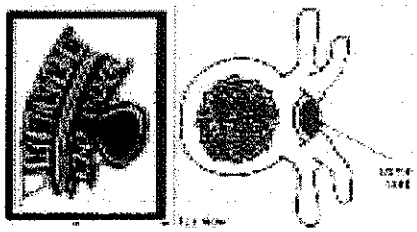

Figure 4

Meningocele

IV. Tools for Fetal Spine Evaluation

Computer Aided Diagnosis (CAD) helps to take accurate decisions in the field of biomedicine. CAD is an inter-disciplinary framework which includes radiological and digital image processing incorporated with machine learning. Images used for diagnosis are CT Scan images, US images, MRI images, MRSI images and PET images. Prenatal diagnostic testing involves testing the fetus before birth (prenatally) to determine whether the fetus has certain abnormalities. Several methods of prenatal testing are performed using different tools. Common and popular tools used for prenatal care are Ultrasound (US) and Magnetic Resonance Imaging (MRI).

A. Ultra Sound Scan

Ultrasound imaging uses high frequency sound waves that pass through the body. The sound waves are reflected or bounced off internal organs and tissues, and the waves are recorded and displayed by a computer. Sound waves produced with a frequency greater than the upper limit of the human hearing range (<20 kilohertz). Ultrasound devices operate with frequencies from 20 kHz up to several gigahertz. Patient is never exposed to ionizing radiation during an ultrasound. Only sound waves are used. Even pregnant women can use this imaging technique. Most ultrasound exams are quick and painless. Ultrasounds do not cause any health problems and there are no known harmful effects to humans. Ultrasound scanning is noninvasive. It has given long record of safety, utility and cost-effectiveness. Ultrasound is the first modality used for screening. Noise produced cannot be heard by human ears. Ultrasound is easy to use and widely available. Figure 5 is an US Scanner

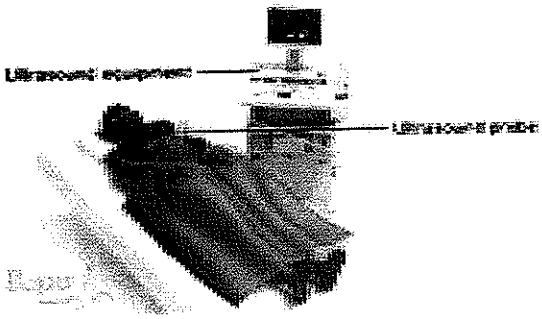

Figure 5

US Scanner

B. Magnetic Resonance Imaging (MRI) Scan

In MRI, the patient is inserted into a large chamber which generates magnetic field and radio waves, agitating hydrogen atoms in the patient's body. The MRI machine reads the changes in the body's magnetic field and uses these changes to build a picture. Even though MRI can provide better results and options than Ultra sound scan, there are a number of drawbacks in MRI.MRI scanners are very expensive. A single scanner can cost over £1 million. This scanner is not easily affordable by small hospitals.MRI technicians have the additional responsibility of protecting their patients from the magnetic field created by MRI scanners. During MRI scan patient may have to remain motionless for up to an hour, which can be difficult.MRI scanners can be affected by movement, making the image unsuitable for investigating problems. The loud noises that are made by the magnets can make some people feel claustrophobic while they are having a MRI scan. There have been a number of accidents where unsecured metal objects, such as mops or oxygen cylinders, were pulled towards the MRI scanner when the magnetic field was turned on.. Figure 6 is an MRI Scanner

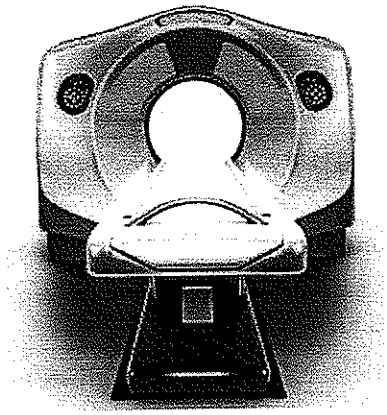

Figure 6

MRI Scanner

Due to the risk of projectile accidents, the Medicines and Healthcare products Regulatory Agency (MHRA) issued guidelines in 2007 that set strict rules about the location and storage of any metal objects near MRI scanners. An allergen is a substance that reacts with the body's immune system and causes an allergic reaction.The primary issue with magnetic resonance imaging is that the MRI machine will interact with magnetic objects in the room, and these objects can cause damage to the machine. MRI studies are especially dangerous for people with devices implanted in and around their hearts (like phase maker). The use of MRI scans is not recommended during the first trimester of pregnancy

A. Comparative Study on MRI & US Scan

Even though MRI can provide better results and options than Ultra sound scan, there are a lot difference between MRI and US Scan.

MRI SCAN	US SCAN
Uses Magnetic & Radio waves	Uses Only Ultra Sound waves
In MRI some time dye is injected	Ultrasound scanning is non invasive
Loud noise is produced	Noise produced cannot be heard by human ears
MRI images may be affected by patient's movement	US images won't be affected by movement
Dangerous for people with devices implanted in and around their hearts	It has given long record of safety
Substance used may cause an allergic reaction.	No side effects caused
There have been a number of accidents where unsecured metal objects	It has given long record of safety
MRI Scanner is not easily affordable by small hospitals	easy to use and widely available
very expensive Even pregnant women can use this imaging technique	cost-effective MRI scans is not recommended during the first -trimester of pregnancy

Table 1

MRI Vs US Scan

Table 1 provides the Comparative Study on MRI and US Scan.Several methods of prenatal testing, including prenatal sonognaphy, currently are being investigated as appropriate and cost-effective screens for early detection of fetal abnormalities. Sonographic evaluation of the spine is considered as safer method of prenatal fetal evaluation for both high- and low-risk patients in the first trimester.

V. Related Work

Literature on fetus image processing has been reviewed and presented in this section. Various methods used to segment fetal spine images, advantages and drawbacks in existing works are also discussed.

A. Fetal Lung Segmentation using Texture-Based Boundary Enhancement and Active Contour Models [1]

In this paper, the author has developed, a novel method using the texture-based boundary enhancement and active contour model. In which, it semi automatically segments the fetal lung from fetal chest ultrasound images. the author suggested that future work will focus on the auto-selection of ROIs for the fetal heart and the fetal spine. In this method, the author concluded that Rectangular Region of Interests (ROIs) is selected manually. So, this is a semi-automatic method to segment and enhance fetal lung.

B. Sonography of the Fetal Spine: Technique, Imaging Findings, and Clinical Implications [2]

In this paper, the author explained that the Sonographic evaluation of spine is an important aspect of prenatal fetal evaluation for both high-risk and low-risk patients. Several methods of prenatal testing, including prenatal sonography are being investigated as appropriate and cost-effective

screens for early detection of fetal abnormalities. Sonographic evaluation of the fetal spine depends on visualization of the ossification centers within the fetal vertebrae. Three planes of imaging are commonly used to assess the fetal spine: coronal, parasagittal and transverse. The detailed knowledge of fetal spinal anatomy afforded by sonography permits early diagnosis of defects. The author explained the importance of examining fetal spine and concluded that there is no full-fledged system is developed to improve image analysis.

C. Improved Sonographic Visualization of the Fetal Spine with the mother seated [3]

The author explained that evaluation of the fetal spine is an essential part of obstetric sonography; however, many technical factors may limit this examination. The purpose of study was to determine if having the mother seated during sonography could significantly improve visualization of the fetal spine. In conclusion, sonography performed with the mother seated upright is a simple technique that can significantly improve the sonographic visualization of the fetal spine when the spine is unsatisfactorily seen in the routine supine position. This technique was found to be most helpful in the third trimester but was still reasonably effective in the second trimester. So, this is not an earlier stage of gestational period. In this paper, no automated or semi automated system is introduced by the author. A simple manual technique used to enhance fetal spine.

D.Visualization of the Fetal Thoracic Skeleton with Three-Dimensional Sonography : A Preliminary Report [4]

The author discussed that evaluation of the complete anatomy of the thoracic skeleton in the developing fetus is often difficult with conventional two-dimensional (2D) sonography because of the curvature of the bones. The purpose of this work was to assess the ability of three-dimensional (3D) sonography to provide a more complete representation.The author concluded that three-dimensional sonography provides additional information about the fetal thoracic skeleton than furnished by 2D sonography. Three-dimensional sonography has the potential to provide clearer visualization of the ribs and the spine, which may assist the diagnostician in

1. Understanding fetal anatomy more easily and with more confidence
2. Determining the extent of abnormalities more completely and
3. Showing anomalies that have not been previously detected with 2D sonography.

In this paper only comparative study is made, no system is introduced to improve image analysis which assists in diagnosis. The author concluded 3D sonography is better than 2D sonography.

E. Three-dimensional Ultrasound Imaging [5]

This paper provides a brief review of the technology behind 3D and 4D ultrasound imaging.

Several areas of 3DUS have emerged that offer advantages compared to 2DUS. With 3DUS, it is possible to obtain the coronal plane of the uterus which is not possible with 2DUS. Volume rendering methods of the entire volume permit the continuity of curved structures such as liver vessels and the fetal spine to be viewed in a single image. The author compared and concluded 3DUS is better than 2DUS. No further system is discussed to improve the quality of the image to do better diagnosis.

VI. Conclusion

Sonographic evaluation of the fetal spine is an essential part of any fetal survey, for early detection of fetal abnormalities. Medical images are often blurred and consist of noise. Anamorphic image may results in wrong judgment on state of an illness, even leads to fateful consequences. The existing methods are manual or semi-automated methods to segment and enhance the ultra sound fetal spine image.So.it cannot bring accuracy. Semi-automated algorithm is used to segment fetal lung alone by selecting the Region of Interest manually. There is no fully automated algorithm to segment and enhance fetal spine. To overcome these problems, There is a need for fully automated method to segment and enhance the ultra sound fetal spine image. The proposed method will focus on the auto-selection of ROIs for segmenting and enhancing the ultra sound fetal spine image using MATLAB.

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