FETAL SPINE SEGMENTATION AND ABNORMOLITY DETECTION IN FETUS ULTRA SOUND IMAGE USING IMAGE PROCESSING TECHNIQUES

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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 . With the development of computer science and automatization performed in numerous fields, Computer Aided Diagnosis (CAD) has supported the scientists for making decision in the field of biomedicine from Ultra Sound (US) images. Here, the fetus images are represented with external or internal characteristics of images. CAD is an interdisciplinary framework that comprises of radiological and digital image processing with machine learning. They provide clear abnormalities during embryonic development, real time imaging modalities and automated image processing tools.

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

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I. Introduction

In recent years, scientific improvements in ultrasound, biochemical screening and molecular genetics have contributed to screening for fatal defects in pregnancy. CAD is an interdisciplinary framework which comprises of radiological and digital image processing incorporated with machine learning. Similarly, automated segmentation used for segmenting the objects from Ultra Sound (US) images. If the identification of regions is wrong, then the nested objects are not belonged and falsely labels are presented in the regions with compromising the abnormality detection rate. Gabor features identify the cause of the fetus image. As a result classification of fetus images was not ensured and does not examine the constraints. Recently, many research works has been designed for detecting abnormalities in foetus. But, there is a need for effective abnormality detection method to improve the accuracy of abnormality detection at an earlier stage. Therefore, proposed methods are developed for improving the abnormality detection rate. Following are the main functionalities that may lead to detect the abnormality fetus images and that which motivated the researcher to perform a feature extraction process to enhance the system performance.

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.

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.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.

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.

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.

IV. 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.

Least Squares Support Vector Machine method was presented by Ersen Yilmaz and Caglar Kilikcier (2013) to discover the fetal state. Kuo J W et al. (2016) present Nested Graph Cut for segmenting the objects from Ultra Sound (US) images. A Computer Aided Detection system was introduced by Umut Konur et al. (2015) to extract the curvature scale space features. But, robust classification of US images was not ensured. Registration-Based Method by Hsin-Chen Chen et al. (2012) provides mechanically segmenting the fetal head from 3-D ultrasound images. Fabijanska A and Goclawski J (2015) develops random walker algorithm using an extreme amount of time and memory resources from an irregular grid of super voxels.

A method based on pixel intensity distributions and shape priors was applied by Dahdouha S et al. (2015). However, color components or local textural features are not considered. An artificial neural network based method by Vidhi Rawat et al .(2016) shows the detection of fetal abnormality. Sridevi Sampath and Nirmala Sivaraj (2014) design Fuzzy connectedness based image segmentation to detect the fetal heart structures. The detection of fetal cardiac structure was planned by Reshmi Mariam Reji Jacob et al. (2013) in which K means clustering algorithm is used to segment the region. With the support of SVM classifier, R. Sonia and V. Shanthi (2014) classify the fetus images. But, the processing time is higher. However, wrong identification of regions in US image results in failed abnormality detection rate.

The following problems were identified:

- Wrong identification of region is detected to provide better detection rate.
- Robust classification of US images is ensured.
- Colour components and local textural features are considered.
- System fails in detecting the abnormality fetus images

V. Contribution of the Research

The identification and detection of fetus abnormality images is carried out with minimum abnormality detection time. The proposed method shows the research work in three phases as explained below.

1. Segmentation using Curvelet-based Seed Point Selection method is presented for segmenting the fetal spine US images automatically.
2. Curvelet-based Seed Point Selection method is involved for frequency analysis of fetal spine images in space and time domains.
3. The Spine Texture Differentiation algorithm is developed for the identification of regions in each pixel.
4. Image Representation through Texture Feature Descriptor method presents the fetus images with texture features.
5. Boundary descriptor gives fetus images based on area and length of an appearance.

6. Texture Feature Descriptor is implemented for representing the texture feature.

7. Empirical model decomposition based Support Vector Machine classifier technique improve the fetus abnormality detection rate and minimize the abnormality detection time.

A new method is presented for automatic segmentation of fetal spine US images for improving abnormality detection. The Segmentation using Curvelet based Seed Point Selection (S-CSPS) method is proposed for providing an efficient segmentation of fetus spine US images. Initially, Spine Texture Differentiation algorithm is developed for the correct identification of regions for each pixel. It is obtained through seed point evaluation by reducing the speckle and it results in improved abnormality detection rate. Next, K-Means Segmentation algorithm is applied to perform segmentation process on each seed point that detected through Spine Texture Differentiation algorithm. K-Means Segmentation algorithm identifies seed point that not only preserves the desired information but also limits the cost factor. Therefore, the correct identification of regions for each pixel in US images that obtained through seed point evaluation reduces the speckle and therefore resulting in the improvement of abnormality being detected.

Next, Image Representation through Texture Feature Descriptor (IR-TFD) method is developed for presenting the fetus images with their texture features. Initially, segmented raw data is provided with image pixels along with image boundary or image regions. After providing the segmented images, Splitting technique is used for the detection of normal or abnormal fetus images. Based on bimodality parameter and homogeneity factor, image regions are split the images for text representation. Subsequently, separated fetus images are identified based on area and length of an appearance given by the boundary descriptor. Finally, Texture Feature Descriptor is implemented for representing the texture feature. Therefore, IR-TFD method improves the abnormality detection rate and also reduces the abnormality detection time in a significant manner.

Finally, Empirical Model Decomposition based Support Vector Machine Classifier (EMD-SVMC) technique is proposed. The EMD-SVMC technique is proposed for improving the abnormality detection rate and to reducing the abnormality detection time. Initially, EMD-SVMC technique performs the preprocessing task with aim of removing the noise data in US images and obtaining the Region of Interest (ROI) of US image. Next, Curvelet based Feature Extraction model is used in EMD-SVMC technique for extracting the features of fetus in US images. Finally, EMD-SVMC technique used the SVM Classifier for detecting the fetus abnormality presented in US images which results in improved abnormality detection rate.

VI. Conclusions

- Segmentation using Curvelet-based Seed Point Selection method is presented initially for abnormality detection in fetus spine US images.
- Curvelet-based seed point selection selects the seed points based on the spinal portion between the two neighboring pixels to reduce the noise.
- Spine Texture Differentiation algorithm identifies the correct regions for reducing the segmentation time. K-Means Segmentation algorithm based on the pixel labeling improves the abnormality detection rate for fetal spine in ultra sound images.
- Next, Image Representation through Texture Feature Descriptor method is developed for image representation along with texture features.
- Splitting technique categorizes the fetus images that is normal or abnormal fetus images. Therefore, Texture Feature Descriptor improves the Texture Feature representation accuracy.
- Finally, Empirical Model Decomposition based SVM Classifier technique enhances the foetus abnormality detection rate and reduces the abnormality detection time.
- Curvelet based feature extraction is performed for providing efficient classification of foetus US images. SVM Classifier efficiently detects the abnormality foetus US images which results in improved abnormality detection rate.
- Experimental results prove that it increases the abnormality detection rate with lesser abnormality detection time.

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