Computer-Aided Fetal Cardiac Scanning using 2D Ultrasound: Perspectives of Fetal Heart Biometry

N. Sriraam, M.S. Ramaiah Institute of Technology, India
S. Vijayalakshmi, Department of Biomedical Engineering, Rajalakshmi Engineering College, Chennai, India
S. Suressh, Mediscans Pvt Ltd, Chennai, India

ABSTRACT

Fetal heart biometry is an indicator for providing information about the presence of heart chambers, their growth, and well being. As a clinical routine, ultrasonic scanning based fetal biometry is performed during the second trimester by skilled specialists. Such procedures are often considered tedious and time consuming. Detection of congenital heart abnormalities, such as septal defects, affects the proper functioning of the heart during the growth of the fetus, and such defects can be identified if the fetal heart structure and its features like size, shape, and symmetry are monitored. Recently, attempts have been made to provide computer-aided automated procedure where the performance depends on the efficacy of the developed algorithms. This work focuses on computer aided automated fetal cardiac scanning using 2-D ultrasonic imaging from fetal heart biometry. The process involves extracting frames from the cine-loop sequences followed by removal of noise using morphological filters. The chamber region is recognized by introducing automated region of interest (ROI). Experimental simulation study demonstrates the efficiency of algorithm in detecting the shape of each chamber. The identified chamber shape will further facilitate in automated measurement of fetal heart chamber and thus reduces the qualitative visualization errors.

Keywords: Fetal Biometry, Heart Chamber, Region of Interest (ROI), Segmentation, Ultrasonic Imaging

INTRODUCTION

Ultrasonic imaging is considered as a primitive tool for recognizing the status of human fetus (from the first few weeks of gestation till the time of birth). The scanning procedure generally provides the vital anatomical details of the status of fetus. The complex anatomy of the fetal heart is well reviewed by four chamber view, where the structural abnormalities can be detected by the specialists through visual inspection. Figure 1 shows the typical four chambers view and describe the functionalities to be carried out to confirm the well being of the fetal heart. For clinical community, qualitative diagnosis of recognizing minute abnormalities in fetal heart is quite challenging.
Congenital heart disorders become increasingly pre-dominant in newborns due to lack of detection of such malformations at the early gestation weeks. Early detection of heart malformations and abnormalities pave way for prevention and relief from these congenital disorders. In clinical practice, there are many ways of detecting the malformations. Structural abnormalities have now been described in nearly every system of the fetus including the cardiac, hepatic, cephalic and the femur region. Using high-resolution trans-vaginal ultrasonography, Achiron et al. (1994) were able to detect fetal tachycardia, ectopic cordis with ventricular septal defect, atrioventricular septal defect, ventricular septal defect with persistent truncus arteriosus, tetralogy of Fallot, and large right atrium with unguarded tricuspid valve. The measurement of fetal heart chamber is being performed manually by expert sonographers so far. Hence there is a need for automation to recognize the chamber region as well as for automatic measurement of fetal heart chambers. This will ensure accurate measurements of the chamber diameters and eventually will lead to better identification of the symmetricity between the left and right chambers during different gestation weeks. Due to high skills requirement and prolonged time period for visualizing the defects, manual screening of fetal heart chambers is found to be cumbersome. The challenging role for the biomedical community is to introduce efficient automated screening method while maintaining the required clinical diagnostic measures. Although several computer aided algorithm have been proposed recently, a complete automated method has not been explored. This paper attempts to provide computer aided automated screening of second trimester fetal chambers using 2D ultrasound cine loop sequences by introducing automated location of fetal heart chamber with histogram-based segmentation.

IMPORTANCE OF FETAL CHAMBER REGION DETECTION

In most of the congenital heart defects as reported by Achiron et al. (1994), the pre-dominant heart defects constitute the septal defects, atrial and ventricular’s wall size related defects. In order to recognize the level of abnormality, the position, shape, size and symmetry in the fetal heart chambers (Right and left ventricles and atria) need to be exploited. To perform the detection of the chamber region, it is important to...
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