ISSN: 2664-9640

An ultrasonic image segmentation method for pubic symphysis structure

Jianguo Qi[1, a], Mengqiang Zhou[1, b]

[1]School of Information science and technology, Jinan University, Guangzhou 510632, China.

[a]qijianguo2004@126.com;

[b]zmq0911@stu2020.jnu.edu.cn.

Abstract

The position of fetal head is one of the main criteria for evaluating the progress of delivery. Its dynamic monitoring helps to understand the intrauterine fetal condition and timely respond to it, thus effectively reducing the risk of delivery, reducing unnecessary cesarean section and reducing maternal and fetal injuries. Automatic measurement of descending Angle of fetal head requires automatic segmentation of pubic symphysis structure. This study introduces the ultrasonic image segmentation method of pubic symphysis structure. At present, there is no relevant research on automatic segmentation of pubic symphysis structure. The characteristics of pubic symphysis structure in ultrasonic images are not obvious, the morphological differences are large, and the edge loss is serious. Traditional image processing methods and current popular machine learning algorithms are difficult to achieve effective segmentation. Aiming at the difficulty of pubic symphysis segmentation, this paper proposed a method of pubic symphysis segmentation based on medical prior knowledge.

Keywords

Automatic measurement; Algorithm. Fetal head station; Angle of Descend.

1. Introduction

With the development of medical ultrasound imaging technology, ultrasound technology has gradually become an indispensable imaging diagnostic technology in obstetrics and gynecology examination[1]. Due to the characteristics of real-time imaging, such as low cost, non-invasive and non-radiation, ultrasound imaging technology has been widely used in clinical diagnostic analysis Kalache[2] et al proposed an Angle of Progression based on Transperineal Ultrasound (TPU). AoP), and confirmed that there is a definite relationship between AoP and fetal head position [3-4] ultrasonic scan position of the Angle of labor progression. In order to measure the Angle of labor progression, both the pubic symphysis longitudinal sagittal plane and fetal head structure need to be observed on ultrasound images. The tire head profile in the section of ultrasonic image obtained by this method is usually an incomplete elliptic shape. The Angle of labor progression is defined as the Angle formed by the tangent of the central axis of the symphysis pubis to the fetal head profile at the lower end of the symphysis pubis where the central axis of the symphysis pubis is connected by the initial and terminal points of the symphysis pubis. At present, there are few researches trying to solve the challenging task of AoP automatic measurement. Conversa et al. [5] attempted to measure the Angle of labor progression by using the center of the symphysis pubis. They visualized an oval region on the interface of image acquisition. The operator needed to adjust the probe parameters and position to make the complete pubic symphysis appear in the fixed oval region on the interface and then freeze the image. Then the pubic symphysis center and fetal head region were located by morphological filter, and the fetal head region was fitted by circular curve. However, this

method requires ultrasonic scan operators to have rich ultrasonic experience and operation skills, which raises the threshold of operation and fails to make good use of local and global information in the image. In addition, because the fetal head contour shape is closer to ellipse than a standard circle, it is difficult to fit the real fetal head contour with circular curve[6-7]. The morphology and position of pubic symphysis and fetal head in ultrasonic images vary greatly, which leads to poor measurement results by using morphological filters. At present, there are few researches on the automatic measurement algorithm of ultrasonic AoP in labor, but many medical image analysis and processing methods are common. Therefore, we can use the image processing algorithms of other medical images or natural images to process and analyze the ultrasound images in labor.

2. Algorithm design

2.1. Pubic symphysis texture was extracted by Gabor filtering

According to clinical experience, the position of the symphysis pubis is generally located in the upper left corner of the ultrasound image. According to this information, we first use a fixed-size window to intercept the image, which on the one hand reduces the noise and on the other hand reduces the amount of calculation of the subsequent algorithm. According to the texture characteristics of pubic symphysis, this paper proposes to use Gabor filters in five directions to capture the texture, enhance the information of pubic symphysis in the image, and facilitate subsequent segmentation operations. The Gabor filter is obtained by modulating the sine wave with a Gaussian function. According to the convolution theorem, the impulse response of Gabor filter is the convolution of the Fourier transform of harmonic function and the Fourier transform of Gaussian function. The filter consists of a real part and an imaginary part and can be used to represent the orthogonal direction. The real and imaginary parts of the filter can provide information separately. Since the expansion and direction of Gabor wavelet can be changed, the parameters of Gabor filter are directly related to Gabor wavelet. However, in general, Gabor wavelet will not adopt the expansion change, because the calculation process of expansion is very time-consuming. Therefore, for the construction of Gabor filter, we only use filter bands with different scales and directions.

2.2. Pubic symphysis segmentation based on K-means clustering algorithm

After Gabor filtering, the pubic symphysis structure information of the image was enhanced. In this paper, k-means clustering algorithm based on gray value was used to segment the filtered image. Clustering algorithm for ultrasonic image segmentation has been proved to be an effective method, but the ultrasonic image segmentation based on clustering algorithm is prone to be affected by speckle noise, which leads to the segmentation effect is not ideal. In this paper, Gabor filtering is used to enhance the image, but also suppress the speckle noise. It should be noted that the choice of K has a great influence on the segmentation effect. If k is too small, the segmentation result always contains more noise; if k is too large, the segmentation result is easy to lose useful information. In this paper, k = 5 is selected, and the segmentation effect of pubic symphysis structure information is well retained, but the image still contains the fetal skull information and the segmentation results of a small part of speckle noise.

2.3. locating the superior and inferior margins of symphysis pubis

After the position of the symphysis pubis was determined by combining with the localization method of the symphysis pubis structure in the ultrasound image, a relatively small rectangular frame was used to intercept the image, and the image was recorded as Z-POS. The objective is to preserve part of the pubic symphysis and remove most of the noise. Then, morphological reconstruction is used to reconstruct the pubic symphysis. Finally, elliptic fitting algorithm based on least square method is used to fit the pubic symphysis.

In order to find the position of the upper and lower margins of the symphysis pubis, after the partition of the pubis is achieved, it is necessary to fit the contour. In this study, a fast fitting algorithm based on the least square method was used to fit the symphysis pubis.

2.4. Experimental results and analysis

We evaluated the algorithm using the Dice parameter. Since the segmentation of the pubic symphysis is the focus of our task, the experimental results will not involve the segmentation evaluation of the background region. Then, we evaluated the segmentation results using hausdorff distance and average Hausdorff distance. In this experiment, due to the lack of depth information in the collected ultrasonic images, both the Hausdorff distance and the average Hausdorff distance in this experiment are in pixels, and the resolution of the ultrasonic images used in the experiment is 320*256. The evaluation results are shown in Table 1. It is important to note that this experiment in the calculation results and the manual segmentation tags and average of hausdorff distance between hausdorff distance before made based on the analysis of the connected domain for image target area selection operation, only selected the segmentation results of all kinds of don't connect with the largest area calculation, parts of the filter in addition to the segmentation result error.

Table 1 Comparison of results of pubic symphysis segmentation

	Dice(%)	HD1	AHD1
Morphology	87.55	6.64	0.22
K-Means	90.13	5.56	0.18
K-means+Garbor	91.21	5.59	0.15

According to the above experimental results, it can be seen that K-Maens +Garbor has higher accuracy than Morphology and K-Means in the pubic symphysis segmentation task. K Maens is higher than traditional Morphology. The effectiveness of the proposed method is demonstrated.

3. Conclusion

In this paper, aiming at the problems of insignificant structural characteristics and great morphological differences of the pubic symphysis, it is proposed to use Gabor filter to enhance the pubic symphysis structure, and then use K-means combined with priori knowledge of the pubic symphysis position to achieve the segmentation of the pubic symphysis. Starting from the characteristics of pubic symphysis structure, this study introduced the methods of Gabor filtering to extract texture and K-means image segmentation in detail. In this paper, an automatic segmentation method of pubic symphysis is proposed, and the experimental results show that the method is effective.

References

[1] Benediktsdottir S, Salvesen K Å, Hjartardottir H, et al. Reproducibility and acceptability of ultrasound measurements of head–perineum distance[J]. Acta obstetricia et gynecologica Scandinavica, 2018, 97(1): 97-103.

[2] Eggebø T, Gjessing L, Heien C, et al. Prediction of labor and delivery by transperineal ultrasound in pregnancies with prelabor rupture of membranes at term[J]. Ultrasound in obstetrics & gynecology, 2006, 27(4): 387-391.

[3] Zhang L, Ye X, Lambrou T, et al. A supervised texton based approach for automatic segmentation and measurement of the fetal head and femur in 2D ultrasound images[J]. Physics in Medicine & Biology, 2016, 61(3): 1095.

ISSN: 2664-9640

[4] Li J, Wang Y, Lei B, et al. Automatic Fetal Head Circumference Measurement in Ultrasound Using Random Forest and Fast Ellipse Fitting[J]. IEEE journal of biomedical and health informatics, 2018, 22(1): 215-223.

[5] Youssef A, Salsi G, Montaguti E, et al. Automated measurement of the angle of progression in labor: a feasibility and reliability study[J]. Fetal diagnosis and therapy, 2017, 41(4): 293-299.

[6] Arthur D, Vassilvitskii S. k-means++: The advantages of careful seeding[C]. Proceedings of the eighteenth annual ACM-SIAM symposium on Discrete algorithms, 2007: 1027-1035.

[7] Kurmanavicius J, Wright E M, Royston P, et al. Fetal ultrasound biometry: 1. Head reference values[J]. BJOG: An International Journal of Obstetrics & Gynaecology, 1999, 106(2): 126-135.