BIOMETRIC FOETAL CONTOUR EXTRACTION USING HYBRID LEVEL SET

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ABSTRACT

In medical imaging, accurate anatomical structure extraction is important for diagnosis and therapeutic interventional planning. So, for easier, quicker and accurate diagnosis of medical images, image processing technologies may be employed in analysis and feature extraction of medical images. In this paper, some modifications to level set algorithm are made and modified algorithm is used for extracting contour of foetal objects in an image. The proposed approach is applied on foetal ultrasound images. In traditional approach, foetal parameters are extracted manually from ultrasound images. Due to lack of consistency and accuracy of manual measurements, an automatic technique is highly desirable to obtain foetal biometric measurements. This proposed approach is based on global & local region information for foetal contour extraction from ultrasonic images. The primary goal of this research is to provide a new methodology to aid the analysis and feature extraction from foetal images.

KEYWORDS

Active contour, Region-based, Edge-based, Hybrid Approach, Foetal images.

1. INTRODUCTION

Image segmentation plays significant role in medical image processing and computer vision. It permits visualization of organs and structures in the body, analysis of the shapes and sizes of these organs to clinicians, and diagnosis of pathologies more quickly and accurately. Physical segmentation is a tiresome, time consuming process and most of the times it is not accurate. It is subjected to high variations from one expert to another due to its dependence on physician's subjective knowledge and his experience. The information generated from the computerized analysis of medical images can be used as a second opinion in making diagnostic decisions by physicians.

Foetal biometric ultrasound measurements pose an interesting problem due to presence of inhomogeneous intensity profile, strong speckle noise and shadows making it difficult to properly segment the correct positions and shapes of interesting regions. In addition to this, edges are poorly defined and are close to other foetal structures making segmentation task difficult using standard active contour models. The proposed work aims at developing a novel segmentation technique to extract foetal contour accurately with reduced dependence on initial curve placement [9].

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2. IMAGE SEGMENTATION TECHNIQUE

There are two approaches to segmentation similarity-based and discontinuity-based. In similarity-based approach, image is partitioned based on uniformity in intensity and texture. These methods create more coherent regions compared to discontinuity-based methods. In this approach, segmentation is performed based on the grey value of pixels without taking account of connectivity property. Thresholding, Region growing methods fall into this category. Discontinuity-based approach partitions image based on sudden intensity changes. At the point of intersection of two regions, intensities vary. In images, object boundaries represent edges. The traditional methods employ Sobel, Robert and Prewitt operators for edge detection. Another discontinuity-based approach involves use of deformable model.

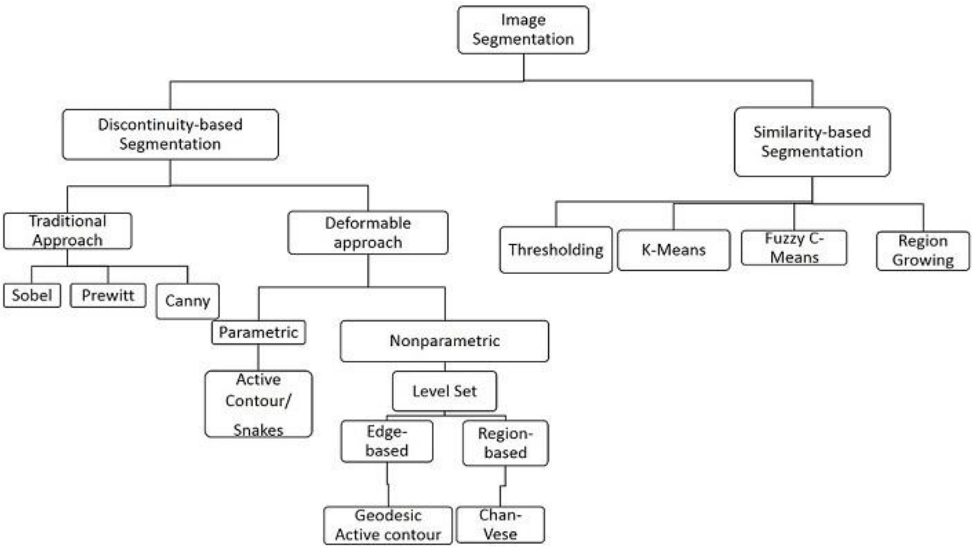

Figure 1: Image Segmentation Algorithm classification

Deformable models possess ability to directly generate closed parametric curves or surfaces from images and are robust to noise and spurious edges [2]. Deformable models can be categorized into the parametric deformable models and the geometric model depending on way of evolution.

Table 1: Comparison of parametric and nonparametric methods

Parametric	Non-parametric/geometric
use explicit representation based on Lagrange formulation	represents the contour implicitly and evolves according to the Euler formulation
Initialization sensitive	Initialization sensitivity is less compared to parametric ones.
Fail to converge to concavities	Affected by weak edges
Top-down approach	Multiple boundaries at a time can be found.
Prior knowledge can be easily incorporated	Are able to handle high curvature regions.
Less human intervention.	reduces the time required for image analysis and subjectivity associated with manual delineations and measurements [6].
Prior boundary information is available.	No prior information is available.

3. IMAGE SEGMENTATION BASED ON LEVEL SET

It is proposed by Stanley Osher and James Sethian. Prior information regarding shape and the initial locations of the region to be segmented is not needed in this approach. It is widely used for medical, satellite and natural image segmentation, analysis and boundary extraction. It can handle corner, inflexion and topological structure changes and can also segment regions with irregular shape. It is initialization insensitive [3]. It can segment objects with deep concavities and can detect multiple objects [4].

Any segmentation problem can be solved by converting it into a PDE framework and employing finite difference methods. Let C represents contour evolving by the time t in the normal vector direction N with the speed function F (K) which depend on the curvature of the contour. The contour deformation using PDE can be written as,

$$\frac{\partial c}{\partial t} = F(K).N$$

In a high curvature area, contour propagation speed is higher compared to a low curvature area [8]. In level set method, speed and direction of the propagation depends on image intensity gradient and the curvature. Internal and external energies along the boundary of curve are minimized by deforming the curve along its shape [11].

For a closed curve C which is dividing plane into two regions, signed distance function (SDF) is given ϕ (x, y). For point lying inside the curve C, $\phi(x, y) > 0$; for outside point, $\phi(x, y) < 0$; $\phi(x, y) = 0$ for the point lying on C [7]. To deal with topological changes naturally following equation is used:

$$\frac{\partial \emptyset}{\partial t} + F(k)|\nabla \emptyset| = 0$$

It is not able to detect objects in images with low-contrast boundaries [5]. The geometric active contour models are classified into edge-based and region-based models. Edge-based active contour models use local edge information for curve evolution whereas region-based active contour models use statistical information. In traditional level set method**,** the leaking problem appears due to presence of a fuzzy or discrete boundary in the region. The iteration time is affected by too large or too small initial contour [13].

Table 2: Edge-based and Region-based Comparison

Edge-based	Region-based
an edge stopping function is based on image gradient.	the motion of the contour relies on region descriptor
Highly sensitive to noise, affected by fuzzy or blurred boundaries.	Insensitive to noise. It is less affected by fuzzy or blurred boundaries.
Affected by initial curve placement. Can segment heterogeneous objects	robustness against initial curve placement. not ideal for segmenting heterogeneous objects.
Uses local edge information	Uses statistical region information
Have high segmentation precision since it allows user to mark boundary directly.	Can detect interior and exterior boundaries simultaneously.

4. LEVEL SET IMAGE SEGMENTATION IMPROVEMENT

Motivated by the work of [17], a hybrid segmentation approach which aims to blend the benefits of global and modified local region-based approaches to improve the quality of segmentation is proposed. It is a two-stage method which uses local and global intensity information.

Region-based level set approach is classified into global and local region-based approach. Initially, contour for foetal image is specified and global region-based approach is applied to it. Global approach is fast and stable with homogeneous regions. But our foetal images contain inhomogeneous regions and contour that is extracted is not proper. Hence, the output of this stage is given as input to modified local region-based approach which employs square window to give exact contour.

MATLAB is used for experimentation on personal computer with Intel Core i5, 1.7 GHz and 4GB RAM. Sufficient medical images taken from authorized sonography centre are tested and after testing, result shows improvement in quality and efficiency of segmentation as compared to existing approaches. The parameters used for comparison of algorithms include Structural Similarity Index, Correlation, Mean Square Error, Peak Signal to Noise Ratio, Dice similarity coefficient, Jaccard Similarity Coefficient. The result of the evaluated values of Structural Similarity Index, Correlation, Mean Square Error, Peak Signal to Noise Ratio, Dice similarity coefficient, Jaccard Similarity Coefficient for some of the images are represented in comparison graph.

Proposed approach when tested over a large dataset of foetal images has given encouraging results. The results which are presented shows Structural Similarity index for different images using proposed approach performs 6.94% better over existing method, for Correlation it is 5.97%, MSE is decreased by 66.06%, Peak Signal to Noise ratio is improved by 16.73%, for Dice Similarity Coefficient it is 5.9% and for Jaccard Similarity Coefficient it is 29.89%. So, it is proposed after careful observations that the hybrid approach gives better performance among all other segmentation techniques.

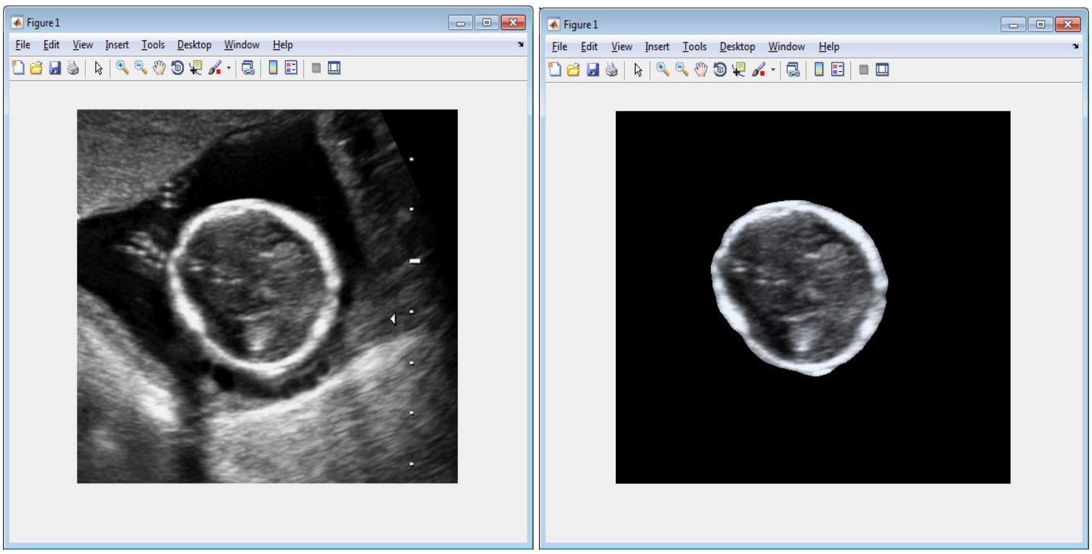

Figure 2: a) Ist Input Image b) Result of Proposed Hybrid Method

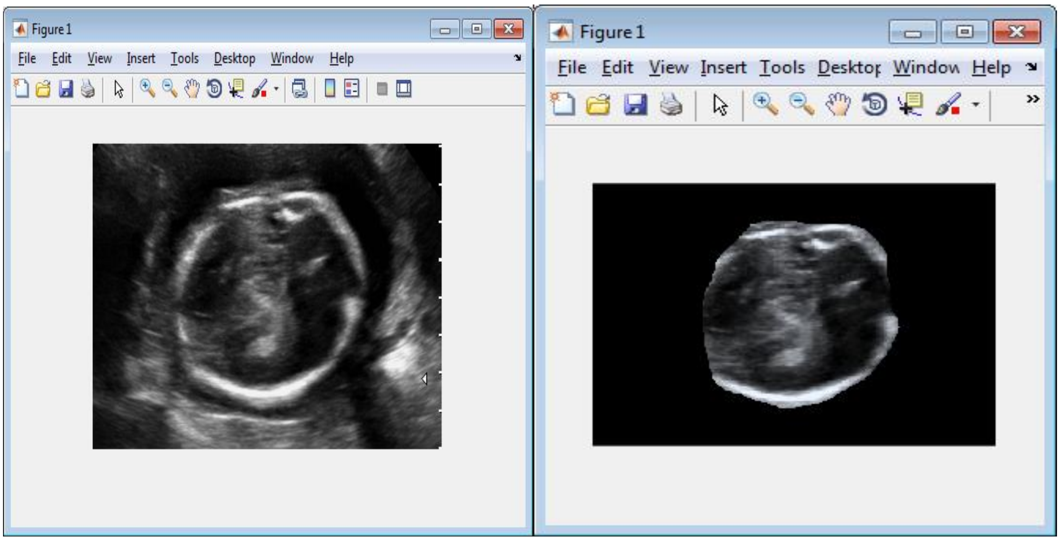

Figure 3: a) IInd Input Image b) Result of Proposed Hybrid Method

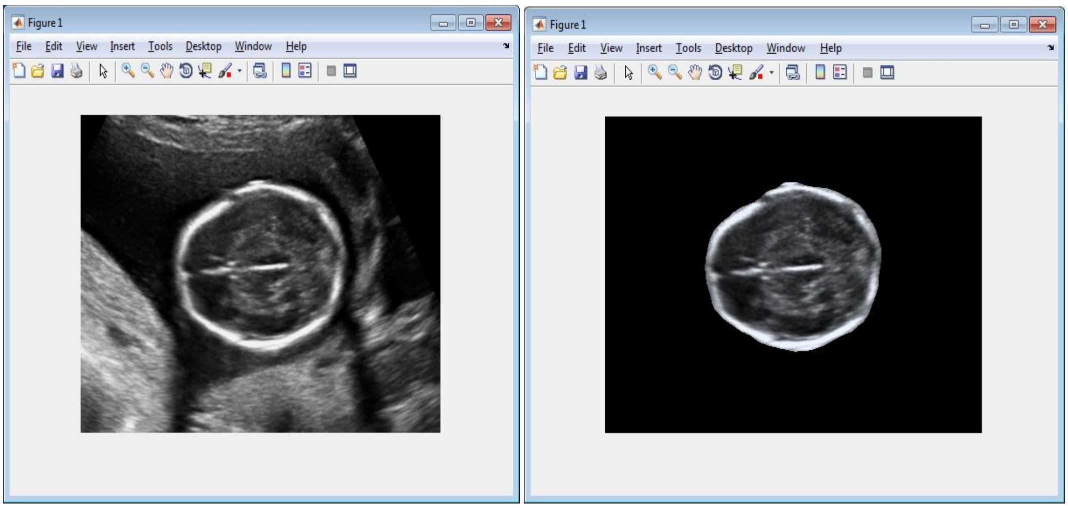

Figure 4: a) IIIrd Input Image b) Result of Proposed Hybrid Method

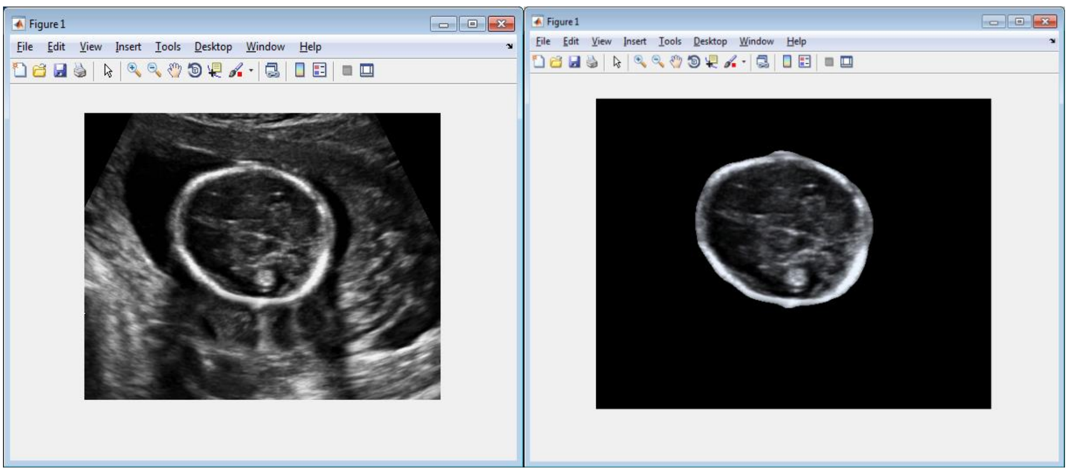

Figure 5: a) IVth Input Image b) Result of Proposed Hybrid Method

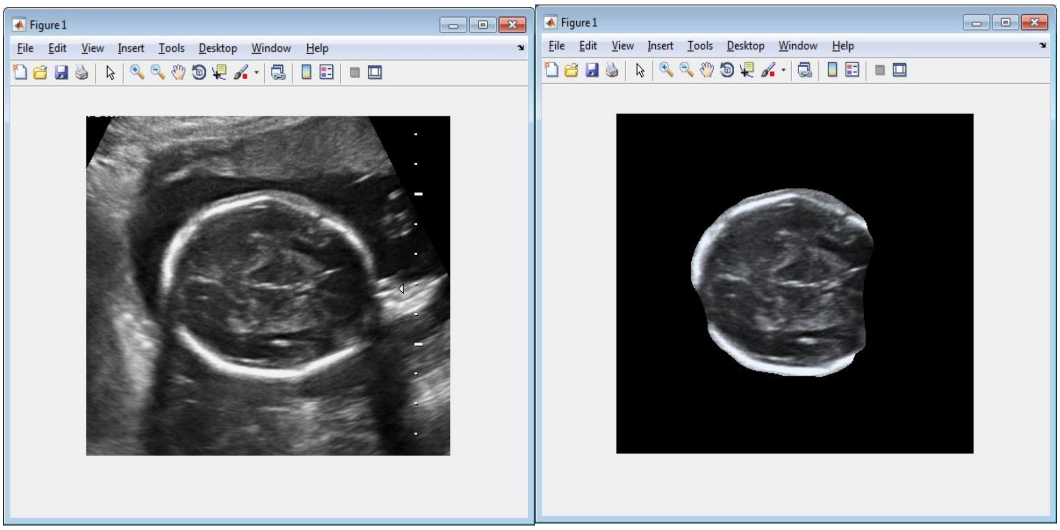

Figure 6: a) V^{th} Input Image b) Result of Proposed Hybrid Method

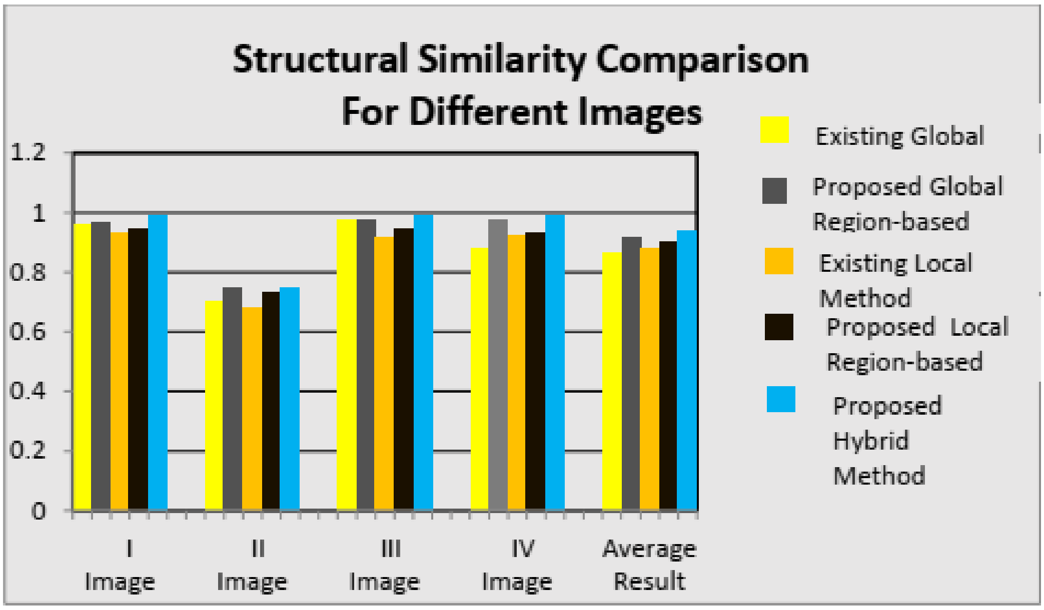

Figure 7: Structural Similarity Comparison for different images

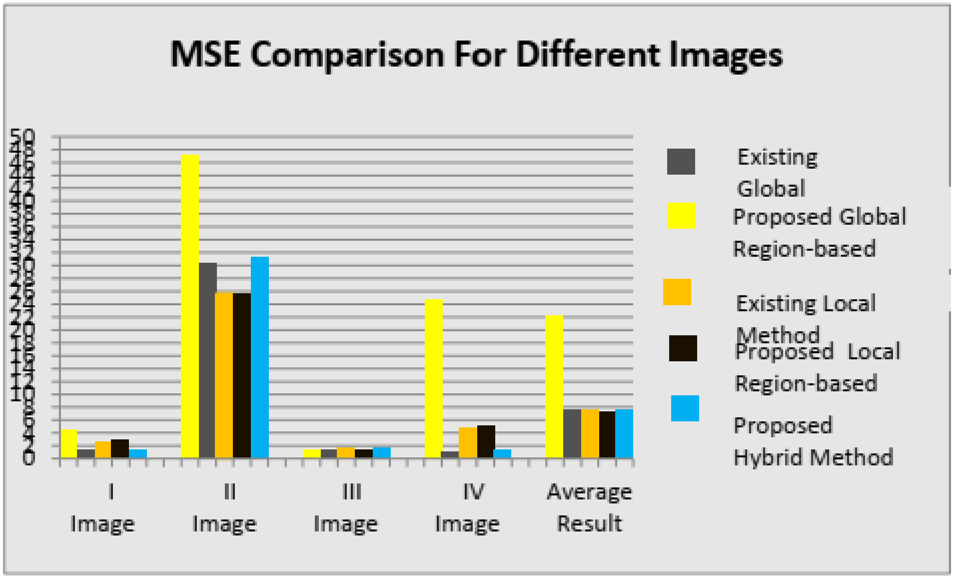

Figure 8: MSE Comparison for different images

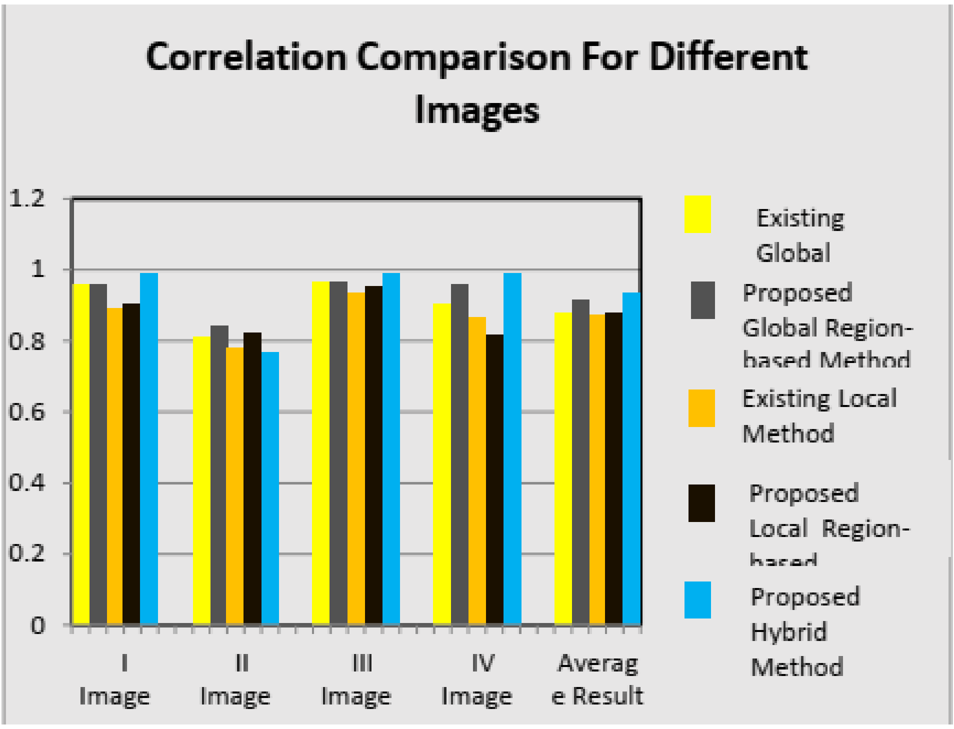

Figure 9: Correlation Comparison for different images

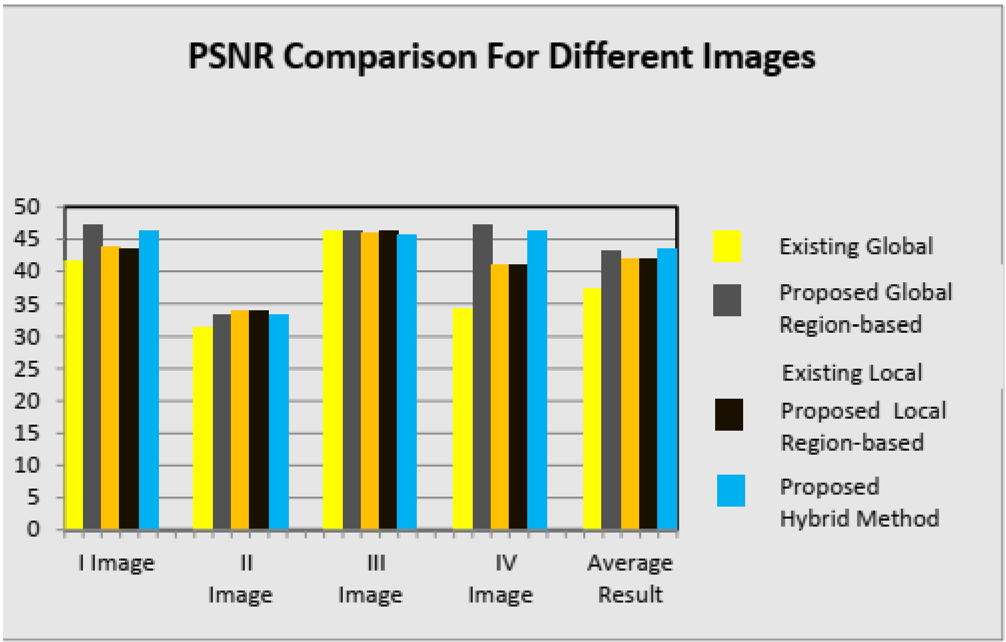

Figure 10: Peak Signal to Noise Ratio Comparison for different images

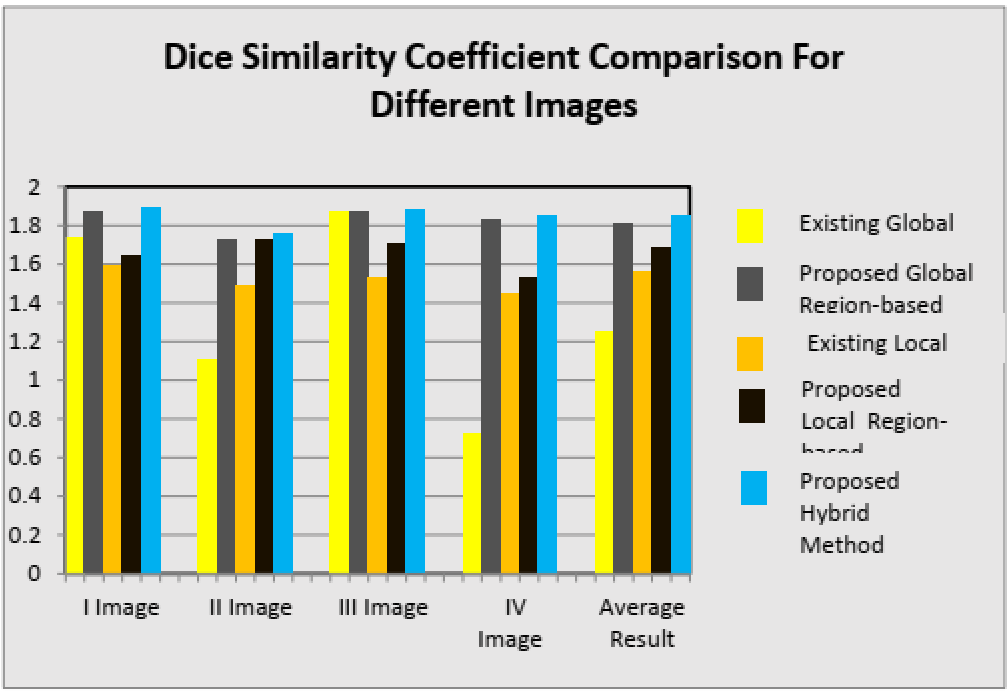

Figure 11: Dice Similarity Coefficient Comparison for different images

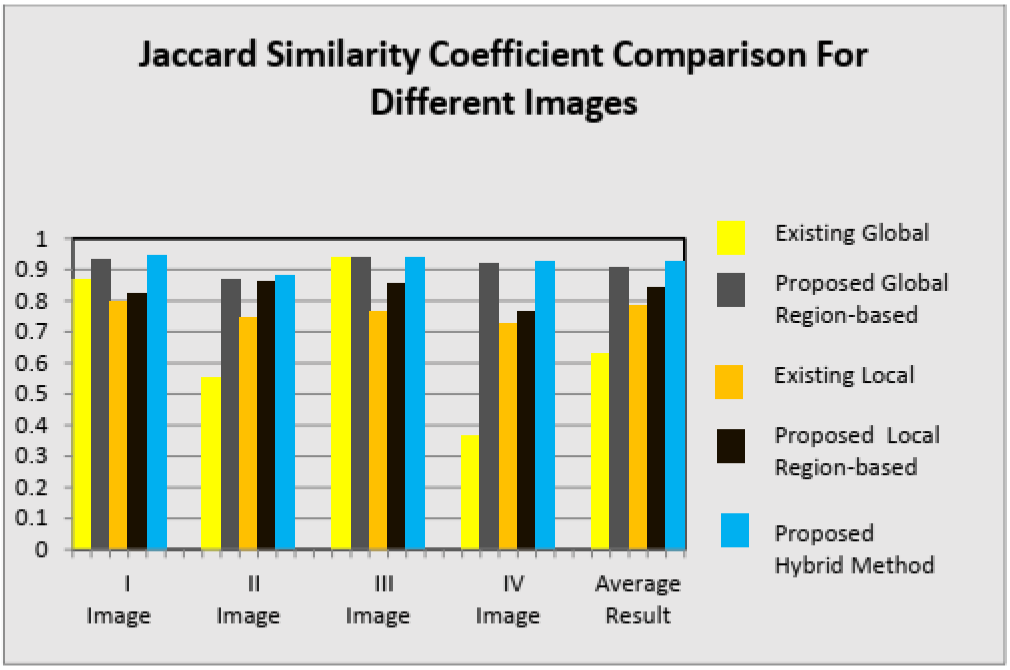

Figure 12: Jaccard Similarity Coefficient Comparison for different images

5. CONCLUSION

Perona and Malik smoothing technique is applied prior to segmentation [18]. The narrow band method is employed in the proposed approach. The proposed global region-based model is insensitive to the location of initial contour. The model could not produce correct result in presence of heterogeneous object. So, after observing the performance of global region-based approach, local region-based approach is implemented. It is a local method, so in presence of heterogeneous object or incomplete edges, this algorithm produces correct result. In order to obtain benefits of both methods, result after application of proposed global method which is rough segmentation is given as input to proposed local method for suitable initialization. The segmentation method is robust to different types of initialization and provides more accurate foetal contour which can be used for further analysis.

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