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AUTOMATIC ESTIMATION OF FETAL HEAD CIRCUMFERENCE USING UNET AND HOUGH TRANSFORM

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***Abstract*—**Automatic segmentation of fetal biometrics like head circumference in the disec images are used to monitor growth and evaluate the gestational age. Manual methods are known to be time consuming and operator-dependent, hence there have been numerous researches on automated methods. However, existing automated methods are not satisfactory in terms of accuracy and reliability, owing to difficulties in dealing with various features in ultrasound images. To overcome these difficulties, we propose a deep-learning-based methodology named U-Net that greatly enhances deep neural networks capability of segmenting the ultrasound image. This model takes the required features from the ultrasound images and performs segmentation and acquires the fetal head circumference with higher accuracy. In the segmented images. The main motive of this research is to identify fetal head circumference in an ultrasound image by segmentation and perform ellipse fitting by using circular Hough Transform(CHT).

***Index Terms*—Automatic Segmentation, Deep Learning, Circular Hough Transform.**

I. INTRODUCTION

Ultrasound (US) imaging is a safe, non-invasive procedure for diagnosing fetal biometrics, such as the baby's abdominal circumference, head circumference, biparietal diameter, femur and humerus length, and crown-rump length. Amongst the fetal parameters, the head circumference (HC) is the most significant one to estimate the gestational age, monitor growth and detect fetus abnormalities if any. In recent times, Ultrasound imaging is the most preferred tool for medical monitoring, follow up and diagnosis owing to its low cost and reliability. However, ultrasound images suffer from a range of drawbacks including acoustic shadow, motion blurring, and low signal-to-noise ratio, making the identification of standard planes a challenging task for sonographers.

In the last decade, automatic methods for fetal biometric measurements have been investigated. Development of these automated methods has improved the work flow efficiency by reducing the examination time and number of steps necessary for standard fetal measurements.

Generally, deep learning is the most opted approach in the field of medical imaging. In the last decade, there has been A lot of automated methods that were adapted to estimate the fetal biometrics. Development and intense research of these automated methods has improved the workflow efficiency by reducing time constraints.

In previous studies, convolutional neural networks (CNN) have rapidly become a compelling choice for several image processing tasks such as classification, object detection, segmentation, and registration. For instance, [4] applied fully convolutional networks for skull segmentation in fetal 3D US images. Another journal applied fully convolutional network which can be used to compare the semantic and appearance information obtained from the architecture to produce accurate and detailed segmentation. In fully convolutional network the modern classification convents are special case that is combined with multiresolution to improvise the speed and the efficiency. Another research applied a U-Net network to perform segmentation on biomedical images[1]. UNET model inspired us to apply it on fetal ultrasound images. Our aim was to perform segmentation for detecting the head circumference with better accuracy.

II. PROPOSED METHOD

Unet has already been applied for segmenting the fetal head circumference[2]. But the existing UNET method is not satisfactory in terms of segmentation, hence circular hough transform is applied on the segmented images to localize the head circumference and fit the ellipse.

A. UNET

Unet is generally used for quick and accurate segmentation of images. For past five years, it's known to be one of the best automated deep learning technique in the field of biomedical imaging. It evolved from the traditional convolutional neural network, it was initially designed and applied to process biomedical images in 2015. As a general convolutional neural network focuses its task on image classification, where input is an image and output is one label, but in biomedical cases, it requires us not only to distinguish whether there is a disease

but also to localise the area of abnormality. Unet is a dedicated network used to localise and differentiate the borders by performing classification and segmentation on every single pixel.

B. NETWORK ARCHITECTURE

The architecture of UNET consists of three major parts i.e left part is the contracting path and right part is the expansive path. Each unit in downsampling part consists of 3x3 convolutional layer followed by an activation layer like ReLu for determining the output with greater accuracy and max pooling is used to reduce the dimension of the images. The expansive path is used for upsizing the image to its original size. The bottommost part mediates between the contractive and the upsampling path.

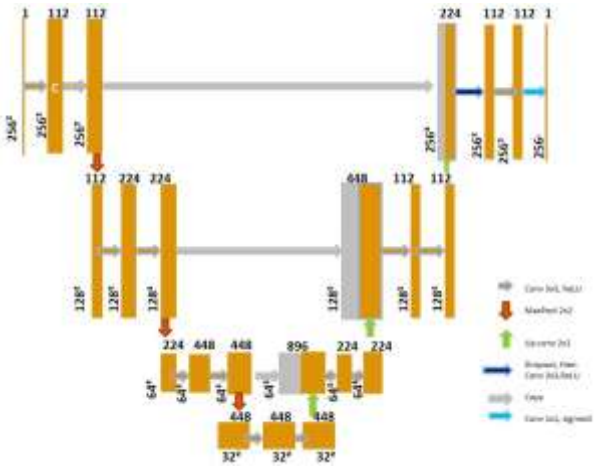

Fig. 1. Architecture of UNET.

C. HOUGH TRANSFORM

Object detection and recognition in noisy and cluttered images is a challenging problem in computer vision. Hence, Hough transform was introduced and it has been widely used in numerous applications due to its noise immunity, the expandability of the transform and the ability to deal with occlusion. Hough transform was initially used to detect straight lines in binary images. Due to various research efforts, many variations of it have evolved. They cover a whole spectrum of shape detection from lines to irregular shapes. Once the images are segmented using the UNET model, it is possible for loss of data in images. The head circumference may or may not be clearly visible to estimate the size of it. Hence, it is always preferred to fit the ellipses to determine the actual and accurate size of it. The rate of detection is efficiently increased and the computational complexity has been decreased.

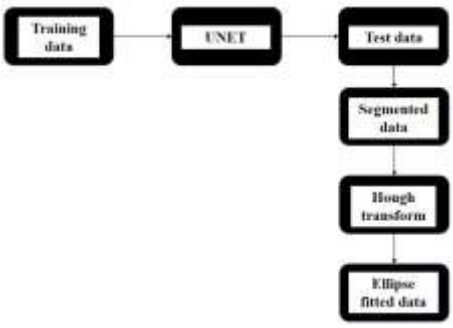

Fig. 2. Workflow.

III. EXPERIMENTS AND RESULTS

A. DATASET

The performance was evaluated on 1998 images of the HC18 dataset{1663 training pictures & 335 test pictures}. For segmentation, we achieved a success rate of 98.31% of accuracy and 0.381% of loss.

B. TRAINING DATA

UNET model is used to train the data in order to estimate the loss and accuracy. Based on the obtained loss and accuracy, the parameters of the model will be adjusted. The aim is to reduce bias and fit the data. During each epoch, the model will trained continuously to make sure the machine recognize patterns and learns about features in the ultrasound image.

C. TESTING DATA

It is used to provide a neutral evaluation of a final model fit on the training dataset. Based on the training images, testing is used to see how well the machine can predict new answers.

D. SEGMENTATION

In computer vision, Image Segmentation is the process of subdividing a digital image into multiple segments{sets of pixels, also known as super pixels}. Image Segmentation is the process of partitioning an image into non-intersecting region to locate and identify objects and boundaries{lines, curves, etc}in an image. Segmentation accuracy determines the eventual success or failure of computerized analysis procedure. The segmented image is displayed below.

CONCLUSION

We presented an automated system for localization and segmentation of fetal head circumference in the ultrasound images. It outperforms the existing automated systems by providing better results with higher accuracy. We have also used Hough Transform which is one of the most opted methodologies to detect and fit an ellipse in a image.

Nowadays, many applications have made use of the Hough transform in various fields such as medical applications,

Fig. 3. After Applying UNET.

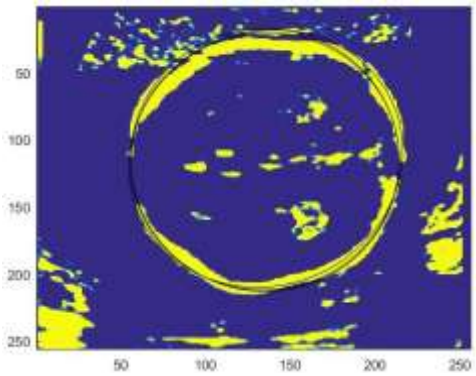

Fig. 4. After Applying Hough Transform.

Object recognition and tracking, industrial and commercial applications.

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