Measurement of Fetal head circumference using Ultrasound

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Abstract

This project focuses on automating the measurement of fetal head circumference using ultrasound images. The UNET model, a convolutional neural network architecture, is utilized for accurate and reliable measurements. Training the model using the dataset of annotated ultrasound images provided by the HC18 Grand Challlenge.

Evaluation is performed on a separate dataset, comparing predicted segmentations with ground truth using the Dice score. Results indicate promising performance, with the UNET model achieving a Dice score ¿ 0.7. This suggests its potential for accurate measurements to aid in monitoring fetal growth and identifying abnormalities during pregnancy.

1 Introduction

The term "fetal" refers to the unborn offspring in the womb during pregnancy. The fetal head, as a vital part of the developing fetus, plays a crucial role in monitoring fetal growth and assessing overall health. Fetal head circumference, a key parameter, serves as an important indicator of fetal well-being and development. Ultrasound, a non-invasive imaging technique that uses high-frequency sound waves, has become a standard tool in prenatal care. It provides real-time visualization of the fetus, allowing healthcare professionals to assess various fetal characteristics, including fetal head measurements. The use of ultrasound for fetal head circumference measurement offers advantages such as safety, accessibility, and the ability to monitor growth throughout pregnancy. Machine learning, a branch of artificial intelligence, involves the development of algorithms that enable systems to learn and make predictions from data without explicit programming. Applying machine learning techniques to measure fetal head circumference using ultrasound images allows for automation and standardization of the process, reducing the reliance on subjective manual measurements. The application of machine learning models, such as convolutional neural networks like UNET, in fetal head circumference measurement brings promising possibilities. These models can learn from a vast collection of annotated ultrasound images to accurately segment and measure the fetal head region. By leveraging machine learning, healthcare professionals can obtain precise and reliable measurements, aiding in the identification of potential abnormalities and providing better care for both the fetus and the expectant mother. In summary, the introduction highlights the importance of fetal head circumference measurement, the role of ultrasound in this process, and the potential benefits of applying machine learning techniques. This research aims to explore the integration of machine learning algorithms with ultrasound imaging to enhance the accuracy and efficiency of fetal head circumference measurement, ultimately contributing to improved prenatal care and patient outcomes.

2 Background

2.1 Fetal head circumference

Fetal head circumference is a critical measurement taken during prenatal checkups and after birth to assess the newborn's growth and development. It is a measure of the size of the newborn's head, specifically the distance around the largest part of the baby's head. The measurement is taken from the top of the baby's head, following the curve of the skull around to the back of the head, and then around to the front again. The measurement of fetal head circumference is essential for tracking the baby's growth and development throughout pregnancy and after birth. During pregnancy, healthcare providers use ultrasound to measure the fetal head circumference to monitor the baby's brain development and overall growth. After birth, healthcare providers continue to measure the newborn's head circumference to ensure that it is growing at a healthy rate. An abnormal fetal head circumference measurement can indicate various health issues, such as developmental delays, genetic disorders, or brain abnormalities. A larger-than-average head circumference may indicate hydrocephalus, a condition characterized by the accumulation of fluid in the brain, while a smaller-than-average head circumference may indicate microcephaly, a neurological disorder that affects the baby's brain development.

2.2 Approach Analysis

In this project, we utilized CNN and a modified U-Net architecture to automate fetal head circumference measurement from ultrasound images. The CNN model captures complex spatial patterns, while the U-Net architecture improves segmentation accuracy by preserving spatial details. We also introduced a double CNN based on U-Net for enhanced performance. Training involved optimizing model parameters using a loss function such as Dice loss. Performance evaluation utilized metrics like IOU scores and accuracy. Our approach aims to provide accurate measurements for monitoring fetal growth and detecting abnormalities during pregnancy. The U-Net architecture is a CNN model specifically designed for image segmentation tasks. It consists of an encoder pathway and a decoder pathway. The encoder pathway captures high-level features and global context by using convolutional layers with downsampling operations. The decoder pathway recovers spatial details and performs segmentation by using upsampling operations and convolutional layers. It also includes skip connections that connect corresponding layers between the encoder and decoder. These skip connections enable the U-Net model to combine both global context and local information, resulting in accurate and detailed segmentation results.

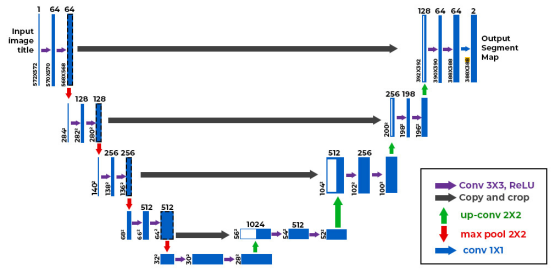

Figure 1: UNET architecture

The U-Net architecture is commonly used in medical image segmentation tasks, including fetal head circumference measurement from ultrasound images, due to its ability to handle limited training data and imbalanced class distributions.

3 Methodology

My desire when creating this architecture is to make a simple one. Due to the limitations of hardware(I use Kaggle with GPU P100 16GB), I have to drop my network from 4 types of kernel size which are [64,128,256,512] to [64,128,256]. The number of parameters go down from 33M to over 7.7M.