

СЕКЦІЯ 1. ТЕОРЕТИЧНІ АСПЕКТИ В ГАЛУЗІ ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ

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SEMANTIC SEGMENTATION OF FETAL BRAIN ULTRASOUND IMAGES BASED ON DEFORMABLE ATTENTION U-NET NETWORK

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Introduction. In recent years, deep learning (DL), particularly convolutional neural networks (CNNs), has rapidly become a research hotspot in medical image analysis. In 2015, Long et al. [1] introduced the Fully Convolutional Network (FCN) at CVPR 2015, achieving a major breakthrough in image semantic segmentation through end-to-end learning. This has led to increased research and improvements in the field. Due to the high performance of CNNs in various image processing tasks, there has been a growing body of research and achievements in fetal ultrasound image processing within the deep learning domain. Yu Z et al. [3] proposed a deep learning-based method for recognizing standard fetal ultrasound planes. Currently, utilizing deep learning methods for fetal disease diagnosis will become the next research focus and challenge. YE Hai et al. [5] proposed a fetal brain ultrasound image segmentation algorithm based on a fully convolutional network. However, the aforementioned methods are inadequate in leveraging boundary information of fetal brain images, and the segmentation accuracy needs further improvement. To address these issues, this study proposed a semantic segmentation method for fetal brain ultrasound images based on a deformable Attention U-net network. The network is based on Attention U-net [8], uses deformable convolution with a 3x3 kernel to better learn features, and uses a gated unit to replace MaxPooling to select useful feature maps while suppressing less useful feature maps. These methods effectively solve the problem of limited medical image datasets.

Method. The improved deformable attention U-net model in this experiment adds a 3x3 deformable convolution with a kernel size based on the attention U-net model, in order to allow the network to learn features better. At the same time, the gated unit is used instead of MaxPooling to filter the feature map after convolution, retaining the good ones and suppressing the bad ones.

Following the general criteria in field of deep learning, we adopted the accuracy, Intersection over Union (IOU), and Dice as evaluation metrics, with below definitions.

$$\text{Accuracy} = \frac{TP + TN}{TP + FP + TN + FN} \quad (1)$$

$$\text{IOU} = \frac{TP}{TP + FN + FP} \quad (2)$$

$$\text{Dice} = \frac{2TP}{(TP + FN) + (TP + FP)} \quad (3)$$

Where, TP (True Positives): predicted as positive class, and correctly predicted; TN (True Negatives): predicted as negative class, and correctly predicted; FP (False Positives): predicted as positive class, but incorrectly predicted; FN (False Negatives): predicted as negative class, but incorrectly predicted.

The experiment used the U-net network; the Attention U-net network; the improved (Deformable Convolution Network, GeM pooling) Attention U-net network (i.e., Deformable Attention U-net). Figure 1 shows the experimental results of each layer of the experimental network on the fetal head circumference dataset.

As shown in Table 1, the deformable Attention U-net network that replaces MaxPooling with 3x3 deformable convolution and gate units has an IOU improvement of 2.9%, a DICE improvement of 1.8%, and an accuracy improvement of 0.9% compared to the Attention U-net. As can be seen from Figure 2 and Table 1, adding deformable convolution and gate units to the Attention U-net can effectively improve the segmentation results of fetal ultrasound images.

When these two improvements are combined, the segmentation accuracy of the network is particularly improved.

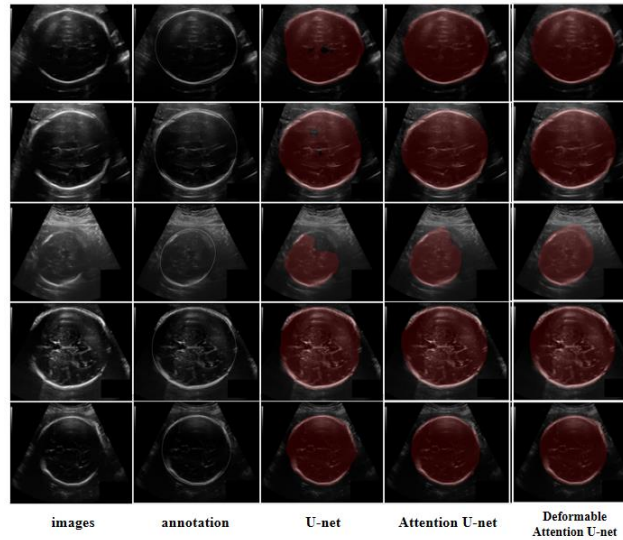


Fig. 2. Experimental results of this experimental network

Table 1. Comparison of experimental results of each layer of this experimental network

Network Structure	IOU	Dice	Accura
(%)	(%)	cy (%)	
U-net	79.2	87.0	93.2
Attention U-net	89.2	94.0	96.4
Deformable Attention U-net	92.1	95.8	97.3

Conclusions. This experiment proposes a semantic segmentation method based on a deformable Attention U-net network for fetal brain ultrasound images. Based on the Attention U-net, this network introduces a deformable convolution with a kernel size of 3x3 to better learn features; a gated unit is used instead of MaxPooling to filter the convolution feature map, retain good features, and suppress poor features, effectively solving the problem of limited medical image datasets. A large number of experiments on the fetal head circumference dataset have demonstrated the effectiveness of the algorithm, proving that the deformable Attention U-net network is highly suitable for fetal ultrasound images, and further optimizes the edge segmentation performance of fetal ultrasound images.

References

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**НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ БІОРЕСУРСІВ І
ПРИРОДОКОРИСТУВАННЯ УКРАЇНИ
ФАКУЛЬТЕТ ІНФОРМАЦІЙНИХ ТЕХНОЛОГІЙ**



**ТЕОРЕТИЧНІ ТА ПРИКЛАДНІ
АСПЕКТИ РОЗРОБКИ
КОМП'ЮТЕРНИХ СИСТЕМ**

**ЗБІРНИК НАУКОВИХ ПРАЦЬ ЗА МАТЕРІАЛАМИ
VII ВСЕУКРАЇНСЬКОЇ НАУКОВО-ПРАКТИЧНОЇ КОНФЕРЕНЦІЇ
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