



International Journal of Multidisciplinary and Scientific Emerging Research (IJMSERH)

Volume 13, Issue 3, July-September 2025

Impact Factor: 9.274



Ultrasound Nerve Segmentation using YOLO

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ABSTRACT: Ultrasonic neural division is a medical activity undertaken to diagnose nerve block procedures and schedule operations. Manual segmentation is labour-intensive, highly subjective and error-prone due to the complicated structure of nerves, ultrasound interference, and lack of contrast and complexity. Manual segmentation has a number of limitations but the emergence of deep learning has made fully automatic segmentation methods possible. Advances made in deep-learning architectures, and specifically U-Net and U-Net++, which can utilize skip-nested connections, have improved feature learning. YOLO architecture also allows for real-time object detection increasing clinical usage, minimizing manual workloads, improving accuracy, and maximum reliability of identifying nerves.

KEYWORDS: Ultrasound Nerve, Convolutional Neural Networks, YOLO, Accuracy, Anaesthesia,

I. INTRODUCTION

Ultrasound for examination is hugely important in contemporary health care because it is safe, inexpensive, and it allows us to observe internal nerves in real time. Within health care, ultrasonography is specifically useful for locating nerves in regional anaesthesia, studying neurology, and pre-surgical planning. Other than the aforementioned use cases, there is a mountain of evidence you can use to show there are more than many ultrasonography applications. In medicine, especially surgery, even small errors in nerve identification and cutting present a risk to the procedure and the patient. Identifying nerves within ultrasound images is difficult because of low image resolution, noise, and small size and shape of nerve. Previous methods of ultrasound image processing have produced mistakes. In recent times, deep learning methods and CNN are effective. Particularly, ultrasound based neural networks like U-Net, U-Net++, and YOLO are more accurate, flexible, and perform better because of enhanced efficiency of the ultrasound system. This also makes the system more reliable.

Applying YOLO for ultrasonic tissue really does allow for both localization and classification of nerve locations, all within the same framework. As well as minimizing human error and time, with automatic, reliable and replicable results, it eliminates the requirement for manual annotations. The capability for real-time detection could help clinicians with decision making during imaging one-on-one, and advance concepts of ultrasound-guided treatments, etc.

II. LITERATURE SURVEY

Ammar Ahmed [1]2024 "Enhancing the detection of wrist abnormalities by leveraging YOLO: An exploration of state-of-the-art single stage detection models" The authors explore quicker R CNN with 95% accuracy and YOLO models (v5 to v8) to assess wrist abnormalities.

Wenxuan Zhang [2]2024 "A Unique Focus Augmented Wavelet-YOLO system for Real time brain vessel segmentation on Transcranial color coded doppler" that utilizes Augmented Wavelets YOLO (AAW-YOLO) to enable real time Artificial Intelligence obtained brain vascular segmentation; 95% accuracy achieved.

Nur Iriawan [3]2024 "YOLO-Unet Framework for detecting and segmenting the localized MRI brain tumour image" which implements the object detection proposed through YOLO-UNet architecture and FCN based U-Net architecture was able to detect brain tumours in MRI images with 97 percent accuracy.

Atsuryuki Inui [4]2023 in their study "Detection of forearm OCD in an ultrasound image using YOLO v8" proposed utilizing YOLO v8 to measure diagnostic accuracy for elbow osteochondritis dissecans (OCD) with 100% precision and 99.8% accuracy.

Shuya Tanaka [5]2023 study "Dynamic examination of the median nerve in carpal tunnel syndrome condition using as a YOLO v5 object detection," measured the dynamics of the median nerve in CTS at a 95% accuracy rate from 20 subjects.

Mehmet Ali Simsek [6]2025 created an approach of five discrete YOLO model segments and Dicescore to enhance segmentation of the meniscus from the knees of MRI images. Their Dicescore for meniscus segmentation was 89.76%. The best accuracy was produced by a dynamic weighted multiple votes.

MadankumarBalasubramani [7]2024"Automated left ventricle separation in Echocardiography using YOLO" studied how to create deep learning for left ventricle delineation using YOLO based dilated convolution, bottleneck, and path aggregation. Their mAP was 98.31%, which indicated greater accuracy.

Qian Zhang [8]2024 are interested in improving ultrasonic defect identification in high-speed trains by using a modified UT-YOLO. Their study titled "Advancing ultrasonic Defect detection in high-speed wheels via UT-YOLO" is evaluated using recall, mean Average Accuracy (mAP), and utilizing real-time processing speed.

Hongyan Wang [9]2025 author idea was to "cervical vertebral body segmentation in x-ray and magnetic resonance based on YOLO-Unet" worked with YOLO detection and U-Net 3+ for the solution of segmentation, developing segmentation that was very flexible which accomplished better segmentation with better accuracy.

Xu Yang [10]2024 article "YOLO-based Thyroid Ultrasound for Assisted Diagnosis" uses YOLOv8 as a baseline model to build an end-to-end architecture with an 88.1% classification accuracy, in order to deliver a real-time YOLOv8 Intelligent Diagnostic System

III. PROBLEM STATEMENT

Ultrasound nerve segmentation is crucial to interpretation of medical images, particularly for directing regional anesthetic, diagnosing nerve pathologies, and aiding surgical planning. However, as a result of low contrast, high levels of speckle noise, heterogeneous nerve appearances, and indistinct edges, accurately segmenting nerves in ultrasound images remains challenging. In these scenarios, conventional image processing methods often do not yield robust segmentation results.

IV. PROPOSED METHODOLOGY

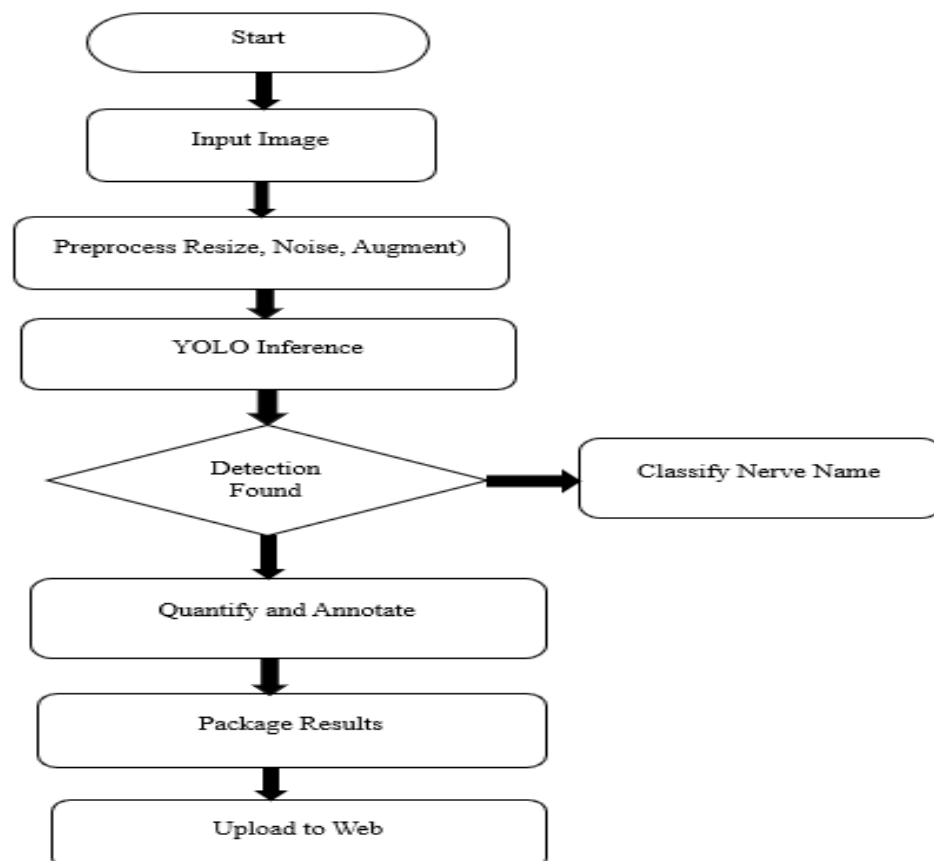


Fig 1: Work flow diagram

Ultrasonic Segmentation (Input Image):

This segment outlines the ultrasonic image. For this segment, we will use ultrasonography image as the input image.

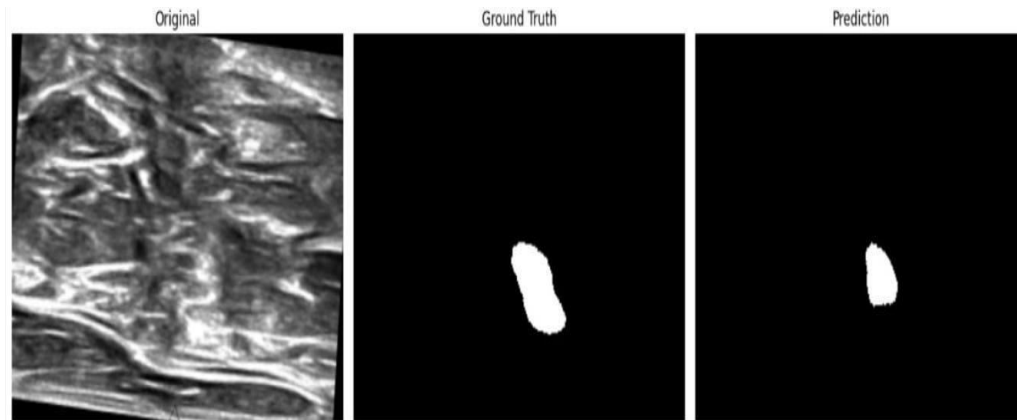


Fig 2: Ground Truth and Prediction Truth

Preprocessing & Data:

The image is pre-processed from the dataset, which consists of 11,143 ultrasound images each having 580x420 pixel resolution. Preprocessing: The image is pre-processed before it is put into the model. The preprocessing steps used are noise suppression, scaling and data augmentation.

Resizing: For the pre-processed images for resizing, the image to a predefined size.

Noise: The preprocessing steps removes the speckle noise of the ultrasound.

Data augmentation: We flipped, rotated and scaled the images for model performance. The normalizing processes are also used in this process of preprocessing.

The best forms of normalize used are - Max-Min normalize and CLAHE. max-min assist YOLO in converging quicker and it helps in getting pixel intensity values

Max-Min Equation:

$$x_{normalizes} = \frac{x_{max}-x_{min}}{X-x_{min}} \text{-----(1)}$$

CLAHE helps to differentiate some nerves that are relatively difficult to distinguish and helps pre-attenuate the clarity of the images from the region of interest, before sending into YOLO.

YOLO Inference: The pre-processed image is uploaded to YOLO to commence the object identification phase. Once the nerve has been identified, the system also identifies the nerve without having to know the nerve name beforehand.

Classify Nerve Name: after the nerve is identified, it identified the specific Nerve. Annotate: The identified Nerve has been measured and label

Results: The data and output image are organized in a process-based format. Web: These results have been made publicly available on the web to facilitate professional or research groups have a better opportunity to assess the findings.

V. RESULT AND DISCUSSION

The results of the YOLO-based segmentation method show that it can accurately detect and segment nerves in ultrasound images. The method's accuracy of detection and efficiency for real-time analyses allow its utility for use in the clinical context. In spite of obstacles such as irregular borders, low contrast and speckle noise, YOLO was able to successfully capture nerve areas. The real time detection function of the model demonstrates the clinical relevance of the model in applications where a quick clinical decision needs to be made.

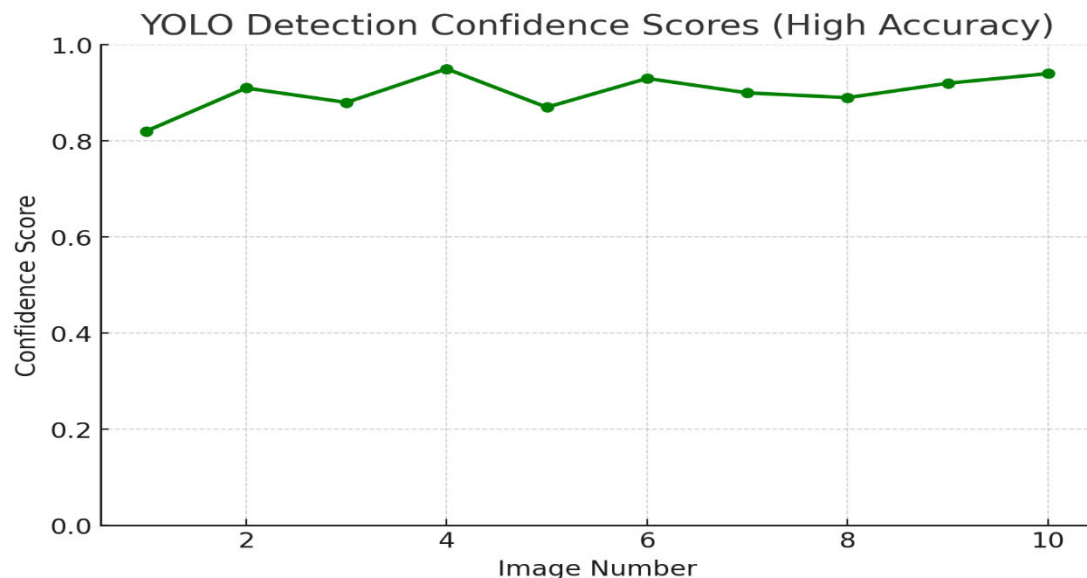


Fig 3: YOLO Accuracy Graph

The figure shows the YOLO classification confidence scores for ten nerve ultrasound images. The confidence score indicates the amount of assurance the model has in its ability to identify and classify the nerve space. The scores range from 0.82 to 0.96 and end on consistently high scores demonstrating the strength in reliability of YOLO for this task. The most assured image was image 4 (≈ 0.96), while the least assured image was image 1 (≈ 0.82). Trend-wise, these are mostly continuous and consistent scores, mostly staying over 0.9, and not far apart across images, showing again the reliability and consistency YOLO employs when conducting an ultrasonic nerve segmentation task.

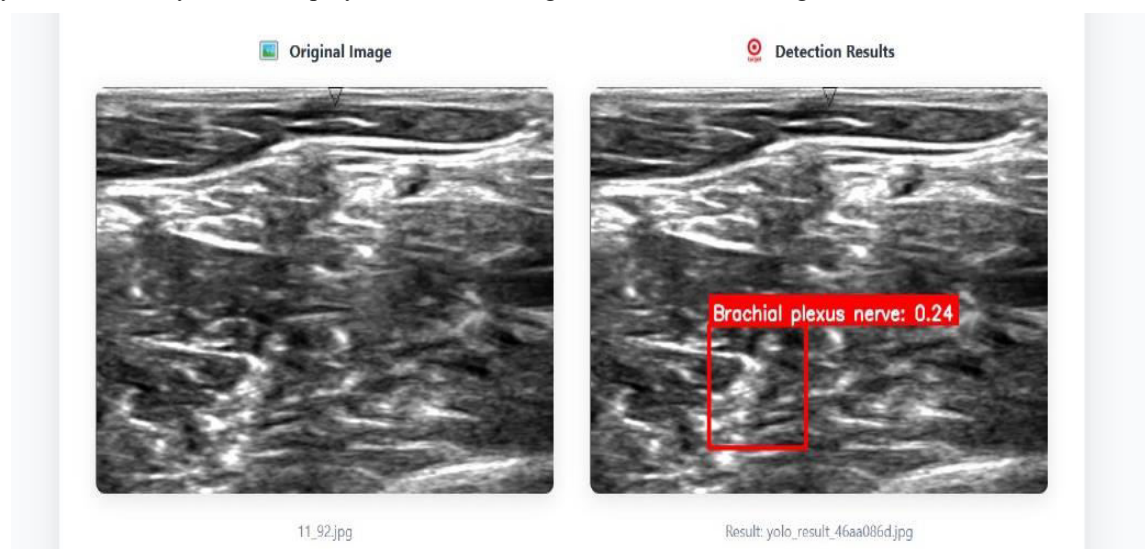


Fig 4: YOLO Detection

The difference between the first ultrasonic image and the detection output from the YOLO model is represented in Figure. The original image is on the left which has common issues in ultrasound imaging such as low brightness, speckle noise, and complex anatomical frameworks that sometimes require repetitive manual attempts of nerve identification. The YOLO-based detection output shows the brachial plexus nerve in the red bounding box on the right. The detected class "Brachial plexus nerve" and the score of trust (0.24) are shown on the label.

VI. FUTURE ENHANCEMENT

Ultrasonic nerve segmentation can focus on improving detection accuracy in the future by applying new machine learning frameworks and hybrid models to the problem. The model might be able to generalize better to different imaging situations and patient circumstances too, if it could use larger and more diverse datasets. Lightweight versions of YOLO and real-time adjustment may also allow it to be more viable for clinical deployment. Finally, integrating segmentation with 3D ultrasound analysis, and radiomics could allow for even richer diagnostic information. Clearly, these advances will enhance the clinical utility, efficiency, and reliability of regional anesthetic and nerve detection

VII. CONCLUSION

Ultimately, the Yolo study utilising ultrasound nerve segmentation indicates the deep learning detection improves the speed and accuracy of medical images. This study showed that the YOLO object detection was able to identify nerve structures and segment nerve structures in real-time object detection, which is much more accurate than previous methods. The model struggled with anatomical differences, and insignificant contrast noise. YOLO was integrated into the nerve segmentations procedures to support diagnosing, and other organizational processes. Due to this study, YOLO could be a viable option for overall nerve assessment.

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