# Automated Breast Lesion Segmentation in Ultrasound Images Using Attention U-Net Architectures

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## Abstract

*Background*: In Romania, breast cancer remains the leading type of cancer and third cause of cancer-related deaths among women, according to the National Institute of Public Health (NIPH 2024). Consequently, breast cancer continues to be a major challenge in the Romanian healthcare system, making the early discovery of foreign masses within the internal breast tissue vital. This study aimed to implement an automated segmentation system for breast tumors to provide clinicians with precise, objective decision support, optimizing the oncological diagnostic workflow. *Methods*: The proposed research uses the open dataset available at Egyptian Breast Ultrasound Images (BUSI), comprising 780 ultrasound images categorized as normal, benign or malignant. Data was split using an 80/20 Pareto ratio for training and validation. To address class imbalance, where the lesion typically occupies less than 7% of the image area, an Attention U-Net architecture was implemented. This model employs "Attention Gates" to prioritize pathologically significant regions while suppressing acoustic noise from surrounding healthy tissue. The model was trained for 17 epochs, utilizing an early stopping strategy to prevent overfitting. Images were resized to 256×256, normalized, and subjected to data augmentation (rotation/zoom) to enhance model robustness and generalizability. *Results*: On the validation set, the system achieved a pixel-level accuracy of 98.29%. However, given the large background area, the Intersection over Union (IoU) score of 0.4909 (equivalent to a Dice Coefficient of 0.66) provides a more realistic measure of segmentation overlap. A key strength of the model is its intrinsic Explainable AI (XAI) capability; qualitative assessment of the internal Attention Maps demonstrates a precise spatial focus on the lesion core. By highlighting the specific features used for boundary delineation, the model provides a transparent decision-making process that aligns with morphological reasoning employed in clinical diagnostic protocols. *Conclusions*: Based on the achieved 98.29% accuracy and 0.4909 IoU, the integration of attention mechanisms into medical segmentation architectures effectively localizes lesions despite significant class imbalance. This approach allows for precise lesion localization and volumetric measurement, providing a highly scalable solution for high-volume clinical settings where expert radiologists may be overworked. By automating the contouring process, the system reduces human error and provides a standardized tool. Therefore, early-stage tumors can be identified more effectively, significantly increasing survival rates for women by facilitating timely medical intervention.

**Keywords:** Breast cancer; Attention U-Net; Medical image segmentation; Class imbalance; Explainable AI (XAI); Ultrasound imaging.