Artificial Intelligence-Enhanced Detection and Analysis of Brain Edema From Histopathological Mice Slices

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INTRODUCTION

Stroke remains a predominant cause of mortality across the globe, accounting for numerous fatalities each year and maintaining its position as the second leading cause of death. Animal-based studies take a crucial part in stroke studies to understand molecular pathophysiology and develop treatment. In these studies, stroke severity is determined by staining the NISSL body in the brain, followed by calculating the edema percent in total brain as well as infarct area. These measurements, which are quite time-intensive, are conducted manually by experts.

MATERIALS METHODS

- Data was collected from Istanbul Medipol University stroke research laboratory.
- 6000 NISSL body-stained brain slices were isolated from images by using Yolov7 object detection model.
- 300 brain images from different brain levels were annotated for striatum and hemisphere by experts.
- Labeled images were aligned to DeepSlice algorithm to determine their position in the brain.
- Swin-Unet, a visual transformer model, was used to segment striatum and hemispheres. Position tokens fed into model to improve segmentation.
- Brain and striatal edema were calculated using segmentation information.

RESULTS

The pipeline of edema detection and calculation

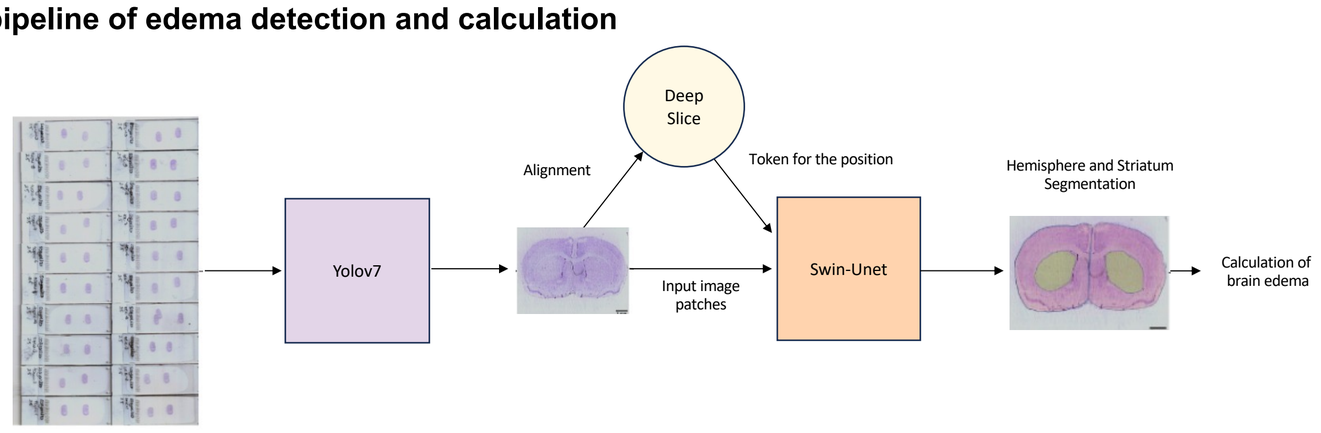

Figure 1. Experimental design

Brain detection and isolation by Yolov7

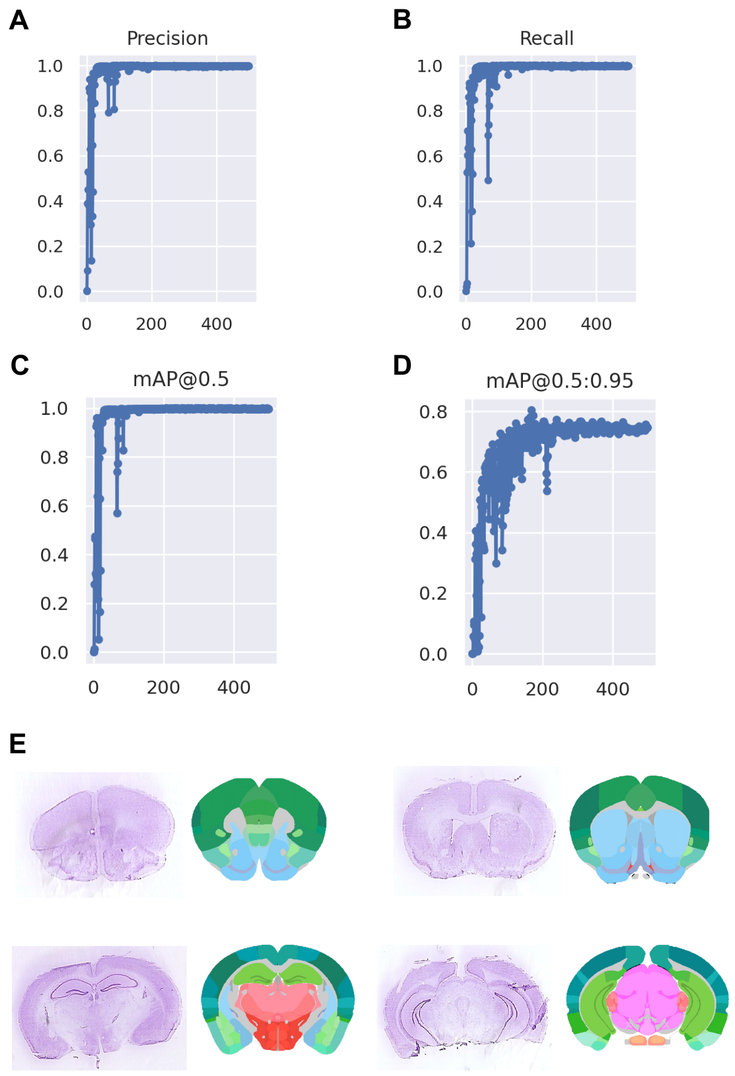

Figure 2. Yolov7 object detection model was used to isolate brain images. The model reached to a high **(A)** precision and **(B)** recall on test data. **(C)** mAP50 and **(D)** mAP50:95 values are 0.98 and 0.77, respectively. **(E)** Isolated brain images were aligned to DeepSlice algorithm. Dorsoventral and mediolateral angles were extracted from the algorithm. The distance from each slice's center point to bregma was calculated

Hemisphere and striatum segmentation by Swin-unet

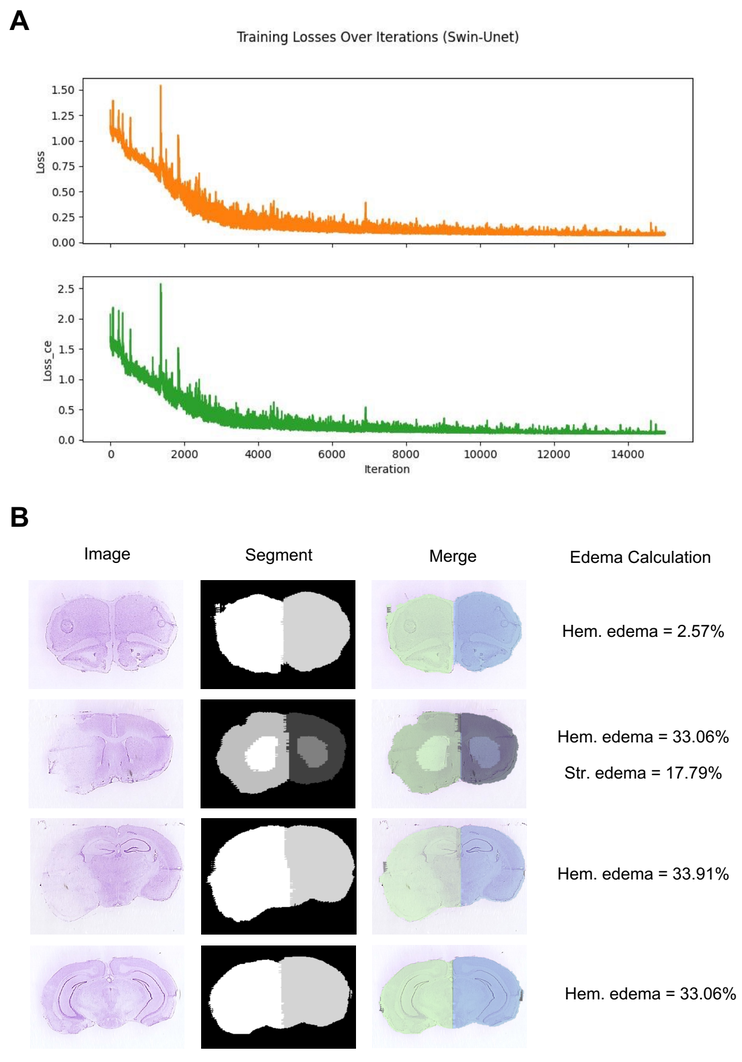

Figure 3. **(A)** The model achieved its optimal loss value upon reaching the 10,000th iteration. **(B)** Representative images from different levels of brain along with their corresponding segmentations predicted by the trained model. The calculation of edema was conducted by determining the area of each of these segmented regions. (Hem. = Hemisphere, Str. = Striatum)

CONCLUSION & DISCUSSION

In conclusion, the present study showed the utility of modern deep learning techniques in automating the analysis of cerebral injury severity in preclinical stroke studies. Our developed pipeline facilitates rapid and automatic calculation of brain edema, thereby minimizing manual workload and enhancing the efficiency of stroke studies.
These findings pave the way for the broader application of these methods in neuroscientific research and highlight potential areas for future investigation.