Department of Neurosurgery
University of Marburg

Chairman: Prof. Dr. med. Ch. Nimsky

CMBB Day 2025

Center for Mind, Brain and Behavior
CMBB

AUTOMATIC DETECTION AND SEGMENTATION OF BRAIN METASTASES

Thrun L, Altinok L, König T, Arafat AR, Nimsky C, Grote A, Bopp M

Background

Early detection and segmentation of brain tumors represents a persistent challenge in the domain of medical imaging. Manual detection and segmentation are currently considered the gold standard but are complex, time-consuming, and user-dependent. The necessity for reliable, precise, and efficient procedures to detect and outline brain tumors for diagnostic purposes, therapy planning, and disease monitoring is paramount. The utilization of semi-automatic, AI-based algorithms can facilitate these processes.

Methods

For automated detection and segmentation of brain metastasis with its surrounding edema and contrast-enhancing parts to further quantify characteristics of the lesion itself, modified nnU-Nets, an adaptation of a U-Net, a convolutional neuronal network for image segmentation, were utilized in a 2D and 3D manner for deep learning-based self-adapting image segmentation. The nnU-Net was trained with data from the BRATS 2023/2024 Brain-MET Challenge and validated within the presented pilot study. Manual segmentations of the lesion and its surrounding edema were performed in magnetic resonance imaging (MRI) data of 11 patients with singular or multiple brain metastasis from malignant melanoma and compared to the presented automated approach's results utilizing the Dice coefficient, a measure of spatial overlap routinely used in analysis of segmentation performance.

Results

The automated approach detected all metastases, yielding a mean lesion volume of 6.24 ± 8.64 cm³. The integrated 2D segmentation approach yielded Dice Coefficients of 0.84 ± 0.09 (tumor) and 0.85 ± 0.06 (edema). The integrated 3D approach yielded Dice coefficients of 0.85 ± 0.07 (tumor) and 0.86 ± 0.07 (edema). The automated analysis was completed within approximately five minutes for image preprocessing and less than two minutes for detection and segmentation with the 2D and 3D model.

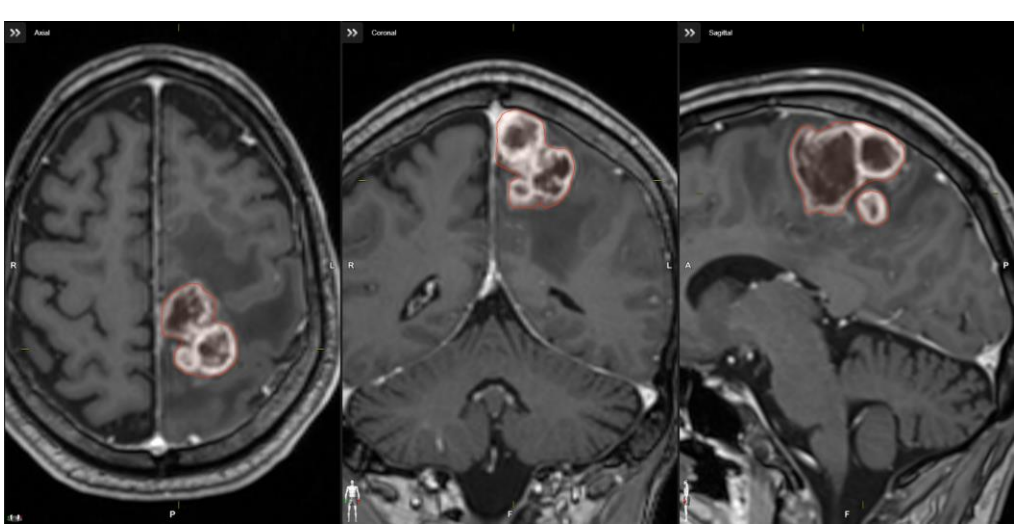

Figure 1. Manual segmentation of the lesion based on T1-weighted contrast enhanced MR imaging in axial (left), coronar (center) and sagittal view (right).

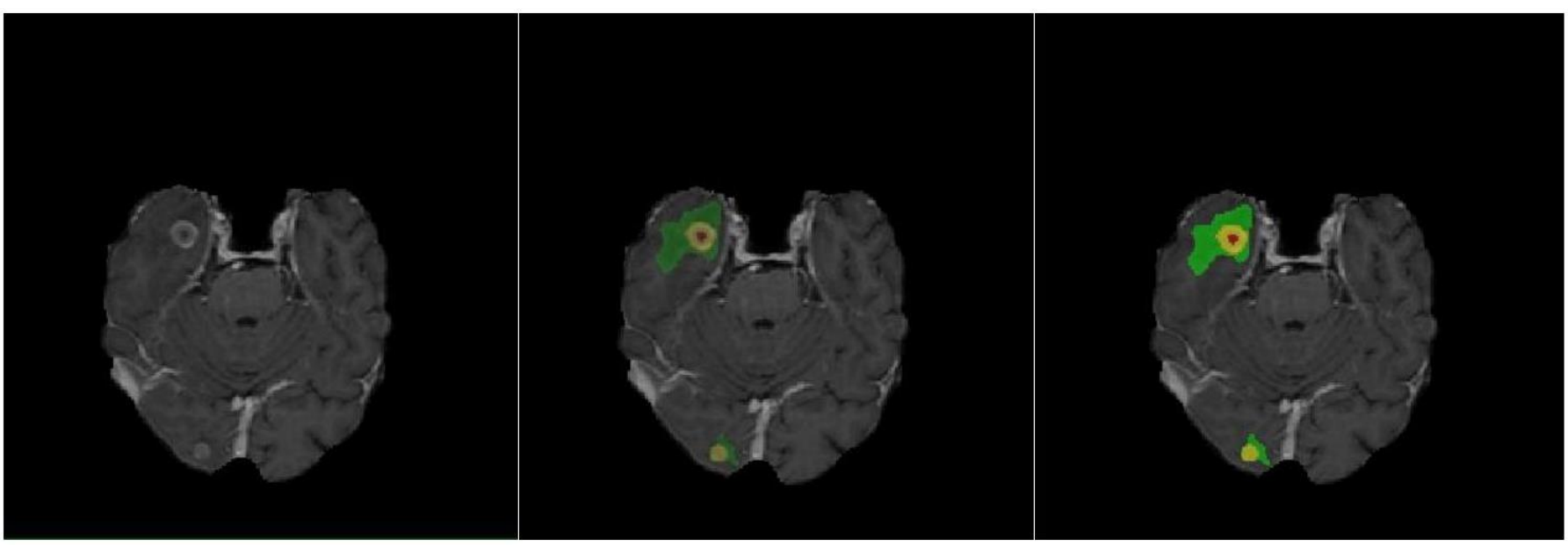

Figure 2. Visualization of AI generated masks of the contrast enhancing part of the tumor (yellow), necrosis (red) and peritumoral edema (green) overlaid onto axial MRI data after skull stripping.

Conclusions

The modified nnU-Net approach, tuned for metastases detection and segmentation, demonstrated very good to excellent Dice coefficients, providing promising results on automatic lesion detection and segmentation, allowing for further investigations in image-based characterization of brain metastases.

Philipps Universität Marburg

Correspondence:
Department of Neurosurgery, University of Marburg, Baldingerstrasse, 35033 Marburg, Germany

Prof. Dr. M. Bopp
bauermi@med.uni-marburg.de

www.neurochirurgie-marburg.de

UKGM UNIVERSITÄTSKLINIKUM MARBURG