Probabilistic Segmentation of Differently-sized Brain Metastases Using an Ensemble of Neural Networks

Maggie Lee¹, Andrew Elliot², Carlo Torres³, Sarah Thrower⁴, Maguy Farhat⁵, Holly Langshaw⁶, Lily Erickson⁷, Brandon Curl⁸, Divya Yadav⁸, Caroline Chung³

Georgia Institute of Technology—Main Campus¹, Atlanta, GA
Radiation Oncology, The University of Texas MD Anderson Cancer Centerenguins, Houston, TX

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Background
- Physicians manually contour tumors to define targets for radiation therapy and to track tumor volumes
- Manual contouring is prone to inter- and intra-observer variability
- Machine learning segmentation could increase consistency

Hypothesis
We hypothesize that an ensemble including three different neural networks (each better suited for specific tumor sizes) will optimize segmentation for all sizes of brain metastases.

Methods
General Methods
- 3D post-contrast T1-weighted MRIs

Outputs from 3 neural networks combined into probability map

Small Tumors
- <0.5 cm diameter
- LSM (liquid state machine) ensemble and random forest classification
- LSM has signal separating properties to differentiate between small tumors and blood vessels

Medium Tumors
- 0.5–1.5 cm
- 3D CNN (convolutional neural network)

Large and Very Large Tumors
- Large: 1.5–3 cm; Very large: >3 cm
- U-net deep learning network is effective for detecting tumors that occupy large areas

Hypothesis
We hypothesize that an ensemble including three different neural networks (each better suited for specific tumor sizes) will optimize segmentation for all sizes of brain metastases.

Methods (continued)

Results
- LSM ensemble detected small tumors with 90-100% probability and no false positives
- Single LSM and CNN yielded false positives of 80-100% probability

Conclusions
- LSM ensemble can detect tumors <0.5cm without false positives
- CNN in development to detect medium tumors
- U-net in development to detect (very) large tumors
- Combination of these 3 neural networks can auto-segment tumors in a clinical setting
- Consistent segmentation may improve treatment outcomes in a quantitative outcomes assessment

References
1. Andrew Elliott, Cole Morgan, Carlo Torres, and Caroline Chung “Probabilistic segmentation of small metastatic brain tumors using liquid state machine ensemble”, Proc. SPIE 11597, Medical Imaging 2021: Computer-Aided Diagnosis, 115972L (15 February 2021); https://doi.org/10.1117/12.2582154
