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Automatic tumour segmentation in brain MR images: moving towards clinical implementation

Akademisk avhandling

Som för avläggande av medicinsk vetenskap doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i hörsal Arvid Carlsson , Medicinaregatan 3, den 7 oktober 2022, klockan 13:00.

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I. **Gryska, E. A.**, Schneiderman, J., & Heckemann, R. A. Automatic brain lesion segmentation on standard MRIs of the human head: a scoping review protocol. BMJ open 2019; 9(2), e024824.

II. **Gryska, E.**, Schneiderman, J., Björkman-Burtscher, I., & Heckemann, R. A. Automatic brain lesion segmentation on standard magnetic resonance images: a scoping review. *BMJ open, 2021; 11(1), e042660.*

III. **Gryska, E.**, Björkman-Burtscher, IM., Jakola, A. S., Dunås, T., Schneiderman, J., & Heckemann, R. A. Deep learning for automatic brain tumour segmentation on MRI: evaluation of recommended reporting criteria via a reproduction and replication study. *BMJ open, 2022; 12, e059000*

IV. **Gryska, E.**, Hoefling, N., Laesser, M., Heckemann, R. A., Schneiderman, J., & Björkman-Burtscher, IM. Evaluation of contrast-enhanced tumour volume increase in glioblastoma patients: radiologists' perception of tumour segmentation and volumetry. *Submitted to European Radiology*

V. Bergquist, M., Rolandsson, B., **Gryska, E.**, Laesser, M., Hoefling, N., Heckemann, R. A., Schneiderman, J., & Björkman-Burtscher, IM. Trust and stakeholder perspectives on the implementation of AI tools in clinical radiology. *Submitted to European Radiology*

SAHLGRENSKA AKADEMIN
INSTITUTIONEN FÖR KLINISKA VETENSKAPER

GÖTEBORGS UNIVERSITET

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Abstract

The aim of this thesis was to examine and enhance the scientific groundwork for translating deep learning (DL) algorithms for brain tumour segmentation into clinical decision support tools. In **Paper II**, a scoping review was conducted to map the field of automatic brain lesion segmentation on magnetic resonance (MR) images according to a predefined and peer-reviewed study protocol (**Paper I**). Insufficient preprocessing description was identified as one factor hindering clinical implementation of the reviewed algorithms. A reproducibility and replicability analysis of two algorithms was described in **Paper III**. The original validation results were reproduced and replicated for one algorithm. Failure to reproduce the results of the second algorithm led to a suggested update to a commonly-used reproducibility checklist to highlight the importance of a thorough description of preprocessing. In **Paper IV**, radiologists' perception of DL-generated brain tumour labels in tumour volume growth assessment was examined. Ten radiologists participated in an MR examination reading/questionnaire session of 20 cases. The readers were confident that the label-derived volume change is more accurate than their visual assessment, even when the inter-rater agreement on the label quality was poor. In **Paper V**, the broad theme of trust in artificial intelligence (AI) in radiology was explored in a semi-structured interview study with twenty-six AI implementation stakeholders. Four requirements of the implemented tools and procedures were identified that promote trust in AI: reliability, quality control, transparency, and inter organisational compatibility. The findings indicate that current strategies to validate DL algorithms do not suffice to assess their accuracy in a clinical setting. Despite the recognition from radiologists that DL algorithms can improve the accuracy of tumour volume assessment, implementation strategies require more work and the involvement of multiple stakeholders.

Keywords: brain tumour segmentation, implementation, deep-learning, radiology

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