Artificial intelligence in medical imaging

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Impact paragraph

This thesis explored various applications of AI in medical imaging for enhancing and streamlining cancer management through detection, localization, prognosis, outcome prediction, and automatic cancer segmentation. The comprehensive review articles included in the thesis provide insights into the current state of AI applications in medical imaging field, along with the existing challenges and future prospects. The methods, findings and results provided in these thesis have been externally validated, peer reviewed, and openly shared with the community to insure their reproducibility and robustness.

Scientific impacts

In **Chapter 2** we proposed a new framework that guides development of robust HRFs pipelines. In the **Chapter 3** and **4** we have demonstrated that HRFs extracted from the MRI images have complimentary value to the ML models based on the clinical, molecular, qualitative or deep features for prognosis and predicting. In **Chapter 5** we reported extensively on the different segmentation methods currently used in the medical imaging field. In **Chapters 6, 9** we provided multiple research endpoints. Firstly, we demonstrated that AI based NSCLC automatic segmentation could reach the quantitative performance comparable to clinicians. Secondly, we performed an insilico clinical trial where we estimated the variance of manual contouring of NSCLC and showed that segmentations produced by our method were preferred by the group of radiologists/radiation oncologists more often than manual segmentations. We have also estimated the tolerance parameter for the manual segmentation task of NSCLC allowing for computation of variance avare Surface DICE metric in further research. The work in chapter 6, 9 was used as a foundation for the development of the clinical application taht had received a CE marking. Lastly we have shared all the model data open source allowing the possible transfer learning applications. In **Chapter 7** we shown the potential of AI based applications to improve clinical decision aid tools, increase diagnostic specificity and minimize the time needed by a nuclear physician to assess bone scintigraphy scans. In **Chapter 8** we developed a precision medicine toolbox that aims to increase the reproducibility of quantitative medical imaging research through standartisation of data curation and pre-processing.

Societal impacts

Cancer has a major impact on society. Although the overall mortality rate has declined, it remains a leading cause of death worldwide. Advancements in cancer managment are crucial to maintain the decrease in mortality rates. Currently clinical decisions are still subjective and prone to variability (1,2). They depend on multiple factors including the level of expertise and experience of the clinicians, geographical location and clinical infrastructure. AI can help optimize the current cancer management workflows, assist clinicians with the objective decision support and make the advanced cancer management tools available for the regions with poor clinical infrastructure.

The research outcomes, findings, and tools that are presented and implemented in the **Chapter 3,4** have the potential to guide researchers and clinicians in leveraging AI technology for more efficient and effective cancer management. **Chapter 6** presents an open source AI based solution for automatic detection and segmentation of NSCLC, it can be used to assist the clinicians in detecting and segmenting the NSCLC on CT, decreasing the time and effort needed for this laborious process. It could also assist in evaluating the tumor response to treatment through automatic calculation of RECIST and volumetric RECIST. Chapter 7 proposes a method that could benefit nuclear medicine clinicians in detecting the metastatic spots on the bone scintigraphy scans. Once implemented it could help in reducing the time needed for the initial assessment and also be used as a radiologist training support tool. **Chapter 8 and 9** highlighted some of the contribution to the open science and a real clinical application for NSCLC segmentation, that subsequently received a CE marking.

The publications presented in this thesis along with the analyses and code, were peer reviewed and published in reputable open acess journals, including Nature communications, Cancers, Physics in Medicine & Biology, etc. This should increase the transparency and transmitabillity of our research. The research conducted in this thesis has been extensively shared and discussed with medical imaging and radiology community at various national and international conferences, including Big Data For Imaging conference (2018), GROW science day of Maastricht University (2018, 2020), Maastricht University Medical Center MUMC+ science day (2019), Dutch Week wan de longen (2019), the European Congress of Radiology ECR (2020) and the European SocieTy for Radiotherapy and Oncology ESTRO (2021). Additionaly the work presented in this thesis has received recognition through multiple awards, including the best research presentation in 2019 at the MUMC+ research day (Maastricht, Netherlaands) and receiving the ESTRO Jack Fowler award in 2021 (Madrid, Spain) (3).

References

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3. University award. https://www.estro.org/About/Hall-of-fame/University-award.