Artificial intelligence applications in oncology to augment data and support decisions

Research Impact

Artificial intelligence (AI) has shown remarkable power in the medical field in applications such as diagnosis[1], tumor detection[2], organ segmentation[3]. However, the large data requirement and complex diagnosis processing hinders the application of AI in the clinic.

In this thesis, I studied AI applications for clinical data augmentation and how they play a role in diagnosis. These studies will have clinical, technological, societal and scientific impacts.

Clinical impact

This thesis examines the application of artificial intelligence (AI) in oncology at the level of data and decisions. Firstly, data augmentation using AI can help to improve the effectiveness of diagnostic or classification models for diseases that are not common and alleviate the problem of insufficient data to some extent (Chapter 2,3,4). Secondly, for clinical decision making, different sources of information such as medical images, clinical features and biomarkers can be valuable in the field of medical AI (Chapter 5,6). Finally, AI has great promise as an auxiliary tool to clinical diagnostics (Chapter 7). In summary, I proved that AI can generate high quality data and can support diagnostics in oncology.

Technological impact

There are several lessons that can help during Artificial intelligence (AI) model design and deployment. At the data level, Generative Adversarial Networks (GANs) are prone to gradient collapse during training due to a flaw in their fundamentals, where all generated samples are concentrated in the same class. In this case, the design of discriminators and loss functions can be effective in reducing this situation (Chapter 3). Secondly, if the quality of the images generated by the GAN is unsatisfactory, focusing on optimizing the generator such as adding an attention module or modifying the generator loss function can improve the image quality (Chapter 4). At the decision-making level, the importance and data types of the different modalities differ, and the data pre-processing part should be paid attention to before using multimodal data, unifying the different data types and magnitudes to avoid the excessive impact of a single data (Chapter 5,6,7).

Societal impact

In this thesis, I demonstrate the potential of AI for clinical applications in oncology. Data augmentation methods can lower the threshold for deployment of AI models, expanding the range of diseases to which they can be applied, reducing upfront

preparation time, and speeding up the development process. AI can significantly improve the efficiency of doctors and reduce their workload, thereby improving the efficiency of the healthcare system. Finally, this thesis presents experiments on the clinical application of AI, demonstrating that AI as a tool can significantly improve the diagnostic accuracy of clinicians and safeguard the lives of patients.

Scientific impact

First, all studies are open access and are published in scientific and professional journals with high impact factors (e.g., International journal of radiation oncology, IEEE Access, European Radiology Experimental, Precision Cancer Medicine, Journal of ovarian research) that have more influence and transmissibility in the scientific community. Second, through this thesis, I built a strong connection between the Chinese hospitals and Maastricht University, which will promote the cooperation of scientific researchers between the two countries in the future and contribute to international academic development and cooperation. Third, all the code and projects have followed the tenet of open science and open source. This may help promote interdisciplinary research, obtain technical support, reduce the time spent on academic research in the same field, and improve the productivity of researchers.

References

1. Bi WL, Hosny A, Schabath MB, Giger ML, Birkbak NJ, Mehrtash A, Allison T, Arnaout O, Abbosh C, Dunn IF, Mak RH, Tamimi RM, Tempany CM, Swanton C, Hoffmann U, Schwartz LH, Gillies RJ, Huang RY, Aerts H (2019) Artificial intelligence in cancer imaging: Clinical challenges and applications. CA: a cancer journal for clinicians 69 (2):127-157. doi:10.3322/caac.21552

2. Lin DJ, Johnson PM, Knoll F, Lui YW (2021) Artificial Intelligence for MR Image Reconstruction: An Overview for Clinicians. Journal of magnetic resonance imaging : JMRI 53 (4):1015-1028. doi:10.1002/jmri.27078

3. Hashimoto DA, Witkowski E, Gao L, Meireles O, Rosman G (2020) Artificial Intelligence in Anesthesiology: Current Techniques, Clinical Applications, and Limitations. Anesthesiology 132 (2):379-394. doi:10.1097/aln.0000000000002960