Quantitative imaging in radiation oncology

Summary

Medical imaging plays a key role in radiation oncology. Patients' scans are used for diagnosis and tumour staging, treatment planning, delivery and monitoring; and disease follow up. They offer a non-invasive tool to extrapolate not only biological properties of the tumour, but also the relations between cancer cells and surrounding tissues, which are important for example to evaluate the risk of treatment-induced toxicities. Unfortunately, we are still facing a sub-optimal use of medical imaging. Radiological findings from medical images are mainly analysed in a (semi)qualitative fashion using visual inspections. Medical images are then discarded when a specific task is completed. In recent years, the research community has started to re-think the role of medical imaging, considering patients' scans as a source of big data. The hypothesis is that medical images contain quantitative information that is invisible to the human eye, referred to as "radiomics". The availability of automated imaging processing pipelines, based on the AI (Artificial Intelligence) branches of ML (Machine Learning) and DL (Deep Learning), will allow to retrieve this information and use it to develop non-invasive image-derived biomarkers. These biomarkers represent a fingerprint of our patients, and when translated into DSSs (Decision Support System) can move patient care towards personalized treatment. After the rapid hype following the introduction of this technology in radiation oncology, a bottleneck has been reached since several issues limit the rapid translation of radiomics-derived models in the clinic as DSSs. This thesis identifies and proposes solutions to three of these major challenges: A) the lack of robustness of developed biomarkers; B) the absence of a robust methodology for ML in radiomics, and C) privacy-related barriers that impede the validation of developed biomarkers. The work poses a new paradigm to re-think the role of AI in medical imaging, to open a new era for a *radiomics-renewal*.