Quantitative imaging analysis

Impact Paragraph

The rise of artificial intelligence (AI) in medicine has been aided by the development of computer sciences, the prevalence of large quantities of data, and advancements in evidence-based clinical care. While prospects for AI and machine learning applications are expanding across different specialties and clinical services, radiology has led the way, with AI algorithms employed for various tasks going from scanning procedures and disease identification, prognostication, predictive biomarkers to referral systems and workflow optimization. It can be argued that AI's main objective is to deliver rapid, accurate, and cost-effective tools to help physicians make personalized decisions in much less time. The types of AI used in this thesis were: handcrafted radiomics and deep learning used separately or together. The primary goals for handcrafted radiomics were to study the influence of imaging parameter changes on the reproducibility of handcrafted radiomic features (HRFs) and to investigate its potential for discriminating between different forms of lung disease. In regard to deep learning, its potential applications for classifying different lung disorders were investigated.

Scientific impacts

1. Most of the studies in this thesis are published or under review in well-cited open access scientific journals (e.g., Cancers, Respiration, BJR, Journal of personalized medicine, Plos One, and Frontiers in Medicine), which will facilitate dissemination in academic communities. In addition, other groups world-wide will be able to reuse the methodology utilized in this thesis.

2. The experiments in Chapters 4 employed patient data to investigate the effect of different imaging phases (arterial and portal venous) on the reproducibility of HRFs. This knowledge can be reused for future studies where HRFs can be interchangeably used between arterial and portal venous phases, and these can be used to increase data points in retrospective imaging studies.

3. Chapters 3,5, and 6 are phantom investigations that aimed to improve knowledge of how changes in imaging parameters impact HRF reproducibility and how harmonization approaches, such as image resampling, Reconstruction Kernel Normalization (RKN), and ComBat harmonization, work in different contexts. Until now most of the groups, including ours, were using Combat harmonization alone we hope that this paper will convince group to use both approaches and that will lead to better results.

4. Chapters 2 and 7 cover the existing state of research, challenges, and future prospects of radiomic research and deep learning in various diseases. This knowledge dissemination may serve as a basis for future research and to write grants trying to fill knowledge gaps.

5. Chapter 8 examines the potential use of HRFs to differentiate between various interstitial lung diseases (ILDs), as well as the use of trachea volume as a novel HRF to categorize ILDs. Trachea volume is a new feature very explainable that should be used more systematically in the future chronic lung diseases.

6. In chapter 9, the potential application of HRFs and deep learning in classifying different lung disorders, including idiopathic pulmonary fibrosis (IPF), interstitial lung diseases (ILD) other than IPF subjects. This signature could be taken over by companies working of AI-based diagnostic clinical grade software. This could be particularly useful in understaffed department or areas in the world without radiologists to make a first screening of the patients needed immediate attention.

7. The combined model (ensemble learning), comprising both HRFs and deep learning, achieved the highest accuracy and precision for five-fold cross-validation and external test sets. Consequently, HRFs and deep learning models complement each other, resulting in improved performance. We hope that this combined approach will become the new standard: using several AI algorithm. The Department of Precision Medicine intend to revisit some of their published papers with this new approach.

Social impacts

1. Radiomics has the ability to speed up clinical work, reduce the workload of clinicians, and making healthcare more cost-effective.

2. Diagnostic radiomics signatures could be used in understaffed radiology department or in remote areas of the world without radiologists.

3. Diagnostic radiomics signatures could be used to support training of young radiologists.

4. The standardization of handcrafted radiomic features will aid in the generalization of radiomic signatures across institutions.

5. The development of generalizable and robust radiomic signatures will facilitate their inclusion into clinical decision-support systems.

6. Radiomics offers the potential to enhance patient care by directing personalized management rather than a one-size-fits-all approach. This can lead to less invasive methods, such as reducing the need for surgical autopsies.

7. Personalized clinical decisions are able to maximize public medical resources while lowering patient expenditures.

8. Accurate classification of interstitial lung diseases can reduce the mortality rate by allowing an earlier diagnosis for example in small center with limited experience with this rather rare diseases and aid in finding the right treatments.

Target groups

This dissertation seeks to extend and enhance our understanding of handcrafted radiomics and deep learning applied to medical imaging and potential applications. The main potential target groups are:

1. The scientists who are conducting handcrafted radiomics experiments in order to increase the awareness of the limitations associated with the field. Moreover, we anticipated that the results of our work would be useful as a reference for future researchers using handcrafted radiomics and/or deep learning.

2. The radiologists who is specializing in the thoracic imaging. The diagnosis of idiopathic pulmonary fibrosis using HRCT is a difficult task with considerable inter-observer variability even among experienced radiologists. Therefore, such methods might help the radiologist to achieve an accurate diagnosis.

3. The companies selling AI to deliver technological solutions and services for healthcare organizations and practitioners, diagnostic, and research centers.

4. The medical insurance can benefit from the use of AI and machine learning. It has the potential to detect at-risk individuals while also reducing growing healthcare expenses. In addition, the crucial aspect of a successful AI and machine learning system is its ability to develop efficient reasoning and intuitively read and understand trends.

5. Better treatment personalization will have the greatest impact on patients since they will be provided the best possible treatment to maintain a high quality of life, as well as facilitating consistent and rapid stratification of patients in drug trials.

6. The medical communities in poorer countries where thoracic imaging expertise is unavailable.