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Machine Learning in Clinical Neuroimaging and Radiogenomics in Neuro-oncology

Third International Workshop, MLCN 2020,
and Second International Workshop, RNO-AI 2020
Held in Conjunction with MICCAI 2020
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MLCN 2020 Preface

Recent advances in machine learning and neuroimaging provide an exceptional opportunity for researchers to discover complex relationships between biology, brain, and behavior. Neuroimaging techniques such as structural and functional magnetic resonance imaging (s/fMRI) can measure non-invasively the morphology as well as properties related to the function of brain networks. While classical univariate statistics are unable to exploit complex patterns present in neuroimaging data, advanced machine learning approaches can be employed to benefit from this wealth of information to provide a deeper understanding of the underlying neurobiological mechanisms. Unfortunately, even though machine learning techniques were first successfully applied to clinical neuroimaging data about two decades ago, to date, there has been very limited translation to the clinic. This is mainly because of the lack of generalization of existing approaches to new populations due to 1) the underlying biological heterogeneity in both clinical and healthy populations, and 2) inherent limitations of neuroimaging data including high dimensionality and low signal-to-noise ratio.

The 3rd International Workshop on Machine Learning in Clinical Neuroimaging (MLCN 2020) was held in conjunction with MICCAI 2020 and aimed to bring together experts in machine learning and clinical neuroimaging to address two main challenges in the field: 1) development of methodological approaches for analyzing complex and heterogeneous neuroimaging data; and 2) filling the translational gap in applying existing machine learning methods in clinical practices.

The call for papers for the MLCN 2020 workshop was released on May 8, 2020, with the manuscript submission deadline set to July 10, 2020. The received manuscripts went through a double-blind review process by MLCN 2020 program committee members. Each paper was thoroughly reviewed by at least three reviewers and the top 18 papers were selected for publication. The accepted papers present novel contributions both in developing new machine learning methods and in applications of existing methods to solve challenging problems in clinical neuroimaging.

To end, we would like to thank the MLCN 2020 steering committee for their enlightening guidance in organizing this event. We also wish to thank all the authors

for their valuable contributions and the MLCN 2020 program committee for their precious effort in evaluating the submissions.

October 2020

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RNO-AI 2020 Preface

Due to the exponential growth of computational algorithms, AI methods are poised to improve the precision of diagnostic and therapeutic methods in medicine. The field of radiomics in neuro-oncology has been and will likely continue to be at the forefront of this revolution. A variety of AI methods applied to conventional and advanced neuro-oncology MRI data can do several tasks. The first essential step of radiomics generally involves lesion segmentation, which is generally preceded by image preprocessing steps including skull stripping, intensity normalization, and alignment of image volumes from different modalities. A variety of methods have been used for segmentation, ranging from manual labeling and/or annotation and semiautomated methods to more recent deep learning methods. The next step of radiomics with traditional machine learning involves the extraction of quantitative features, including basic shape, size, and intensity metrics, as well as more complex features derived from a variety of statistical approaches applied to the images, for example, histogram-based features, texture-based features, fitted biophysical models, spatial patterns, and deep learning features. A variety of different machine learning models can then be applied to the intermediate quantitative features in order to "mine" them for significant associations, allowing them to predict crucial information about a tumor, such as infiltrating tumor margins, molecular markers, and prognosis, which are relevant for therapeutic decision making. Alternatively, deep learning approaches to radiomics in neuro-oncology generally necessitate less domain-specific knowledge compared with the explicitly engineered features for traditional machine learning, allowing them to make predictions without explicit feature selection or reduction steps.

Radiogenomics has also advanced our understanding of cancer biology, allowing noninvasive sampling of the molecular environment with high spatial resolution and providing a systems-level understanding of underlying heterogeneous cellular and molecular processes. By providing in vivo markers of spatial and molecular heterogeneity, these AI-based radiomic and radiogenomic tools have the potential to stratify VI patients into more precise initial diagnostic and therapeutic pathways and enable better dynamic treatment monitoring in this era of personalized medicine. Although substantial challenges remain, radiologic practice is set to change considerably as AI technology is further developed and validated for clinical use.

The second edition of the **Radiomics and Radiogenomics in Neuro-oncology using AI (RNO-AI 2020)** workshop was successfully held in conjunction with the 23rd International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI 2020) in Lima, Peru on October 8, 2020. The aim of RNO-AI 2020 was to bring together the growing number of researchers in the field given the significant amount of effort in the development of tools that can automate the analysis and synthesis of neuro-oncologic imaging. Submissions were solicited via a call for papers by the MICCAI and workshop organizers, as well as by directly emailing more than 400 colleagues and experts in the area. Each submission underwent a double-blind review by two to three members of the Program Committee, consisting of researchers actively contributing in the area. Three invited papers were also solicited from leading experts in the field. RNO-AI 2020 featured three keynote talks and eight oral presentations. The duration of the workshop was approximately 4 hours.

We would like to extend warm gratitude to the members of the program committee for their reviews; to the keynote speakers, Prof. Ulas Bagci, Prof. Thomas Booth, and Prof. Jayashree Kalpathy-Cramer, for illuminating talks; to the authors for their research contributions; and to the MICCAI Society for their overall support.

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