

Discovery Radiomics for Imaging-driven Quantitative Personalized Cancer Decision Support

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Abstract

In this paper, we describe the underlying methodology behind discovery radiomics, where the ultimate goal is to discover customized, abstract radiomic feature models directly from the wealth of medical imaging data to better capture highly unique tumor traits beyond what can be captured using hand-crafted radiomic feature models. We further explore the current state-of-the-art in discovery radiomics and their application to various forms of cancer such as prostate cancer and lung cancer, and show that discovery radiomics can yield significant potential clinical impact.

1 Introduction

Radiomics [1, 2], which involves the high-throughput extraction and analysis of a large amount of quantitative features from medical imaging data to characterize tumor phenotypes in a quantitative manner, is ushering in a new era of imaging-driven quantitative personalized cancer decision support and management. A large number of studies have been conducted showing the efficacy of radiomics for various forms of cancers such as lung [1, 3], head-and-neck [3], and prostate [4, 5].

While extremely powerful with the potential to make a tremendous clinical impact, one of the limitations of the current state of radiomics is that they rely entirely on existing, hand-crafted imaging-based feature models based on aspects such as intensity, texture, and shape. This can greatly limit its ability to fully characterize the unique traits of different forms of cancer that may be not well characterized by such hand-crafted feature models. As such, an alternative strategy for identifying and uncovering imaging-based feature models that are tailored to characterizing such unique tumor phenotypes is highly desired.

Motivated to take radiomics to the next level in personalized cancer quantification and characterization of unique tumor phenotypes for different forms of cancer, the novel concept of *discovery radiomics* was introduced, where the notion of predefined, hand-crafted radiomic feature models is forgone in favor of discovering customized, abstract radiomic feature models directly from the wealth of medical imaging data already available for different forms of cancer. Discovery radiomics enables an unprecedented level of understanding and characterization of the unique cancer phenotypes associated with different forms of cancer, allowing for the identification of a large amount of abstract imaging-based features that capture highly unique tumor traits and characteristics beyond what can be captured using predefined feature models.

In this paper, we will describe the underlying methodology behind discovery radiomics in hopes of providing insights on its efficacy for improved quantification of tumor phenotypes that is fully tailored for specific forms of cancer, as well as further explore the current state-of-the-art in discovery radiomics and their application to various forms of cancer.

2 Methodology

The general discovery radiomics framework consists of the following key steps (see Fig. 1). First, a wealth of standardized medical imaging data from past patients are fed into a radiomic sequencer discovery process, where a customized radiomic sequencer is constructed based on a large number of customized, abstract radiomic features that were discovered to capture highly unique tumor traits and characteristics tailored for a particular form of cancer. Second, for a new patient case, the discovered radiomic sequencer is then used to extract a radiomic sequence composed of customized, tailored imaging-based features from the medical imaging data of the new patient case for comprehensive, custom quantification of the tumor phenotypes.

3 Results and Discussion

Given the potential of discovery radiomics in delivering a more comprehensive quantification of cancer phenotypes derived directly

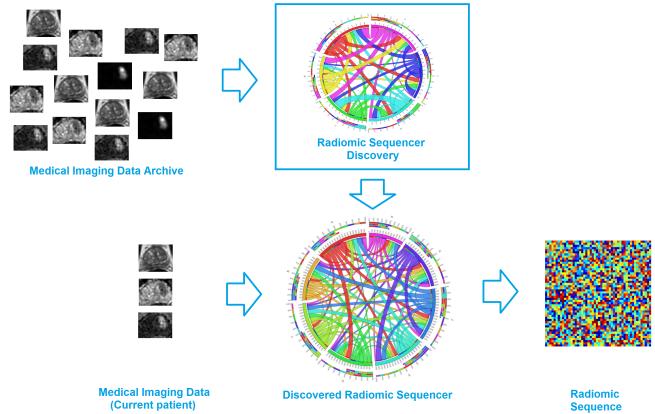


Fig. 1: An overview of the general discovery radiomics framework

from the wealth of medical imaging data being collected by clinicians, a number of state-of-the-art discovery radiomics frameworks have been investigated recently and have shown great promise for application to various forms of cancer. Chung et al. [6] introduced a discovery radiomics framework for prostate cancer detection using multi-parametric MRI data. The framework revolves around a very deep stochastic convolutional radiomic sequencer, which is discovered using multi-parametric MRI data from past patients. Experimental results showed that the discovered radiomic sequencer using [6] achieved an accuracy of 73.7% on a clinical dataset, which exceeded the state-of-the-art radiomic sequencer presented in [4]. Kumar et al. [7] introduced a discovery radiomics framework for lung cancer detection using CT data. The framework revolves around a convolutional radiomic sequencer, which is discovered using a wealth of CT data from past patients. Experimental results showed that the discovered radiomic sequencer using [7] achieved an accuracy of 77.52% on the LIDC-IDRI dataset based on diagnostic results, which exceeded existing state-of-the-art radiomic sequencers. It can be observed from these studies that discovery radiomics can yield significant diagnostic benefits and can have tremendous potential clinical impact.

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