Kidney Cancer Detection and Analysis from CT Using Deep Learning
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Abstract:

Kidney cancers account for an estimated 140,000 global deaths annually. According to the Canadian Cancer Society, an estimated 6,600 Canadians were diagnosed with kidney cancer and 1,900 Canadians died from it in 2017. Computed tomography (CT) imaging plays a vital role in kidney cancer detection, prognosis, and treatment response assessment. Automated CT-based cancer analysis is benefiting from unprecedented advancements in machine learning techniques and wide availability of high-performance computers. Typically, kidney cancer analysis requires a challenging pipeline of (a) kidney localization in the CT scan, (b) tumor detection within the kidney, and (c) cancer grading. In our project, we developed deep learning techniques for automatic kidney localization, segmentation-free volume estimation, cancer detection, as well as CT features-based gene mutation detection and Fuhrman cancer grading. Our convolutional neural network (CNN)-based kidney localization approach produces a kidney bounding box in CT, while our CNN-based direct kidney volume estimation approach skips the intermediate segmentation step that is often used for volume estimation at the cost of additional computational overhead. We also proposed a novel collage CNN technique to detect pathological kidneys, where we introduced a novel image augmentation procedure within a multiple instance learning framework. We further proposed a multiple instance decision aggregated CNN approach for automatic detection of gene mutations, and a learnable image histogram-based deep neural network approach for Fuhrman kidney cancer grading. These approaches could be alternatives to renal biopsy-based whole genome sequencing and cancer grading, respectively.