Deep Learning-Based Prediction of Renal Cancer Grading from Contrast-Enhanced CT

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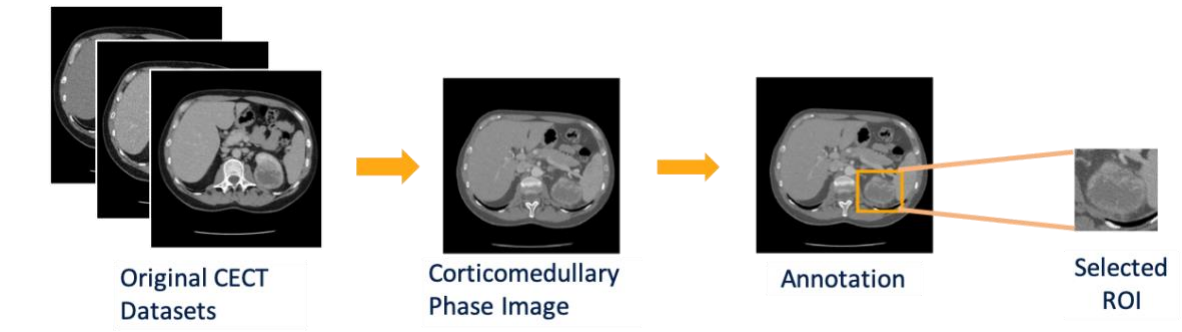
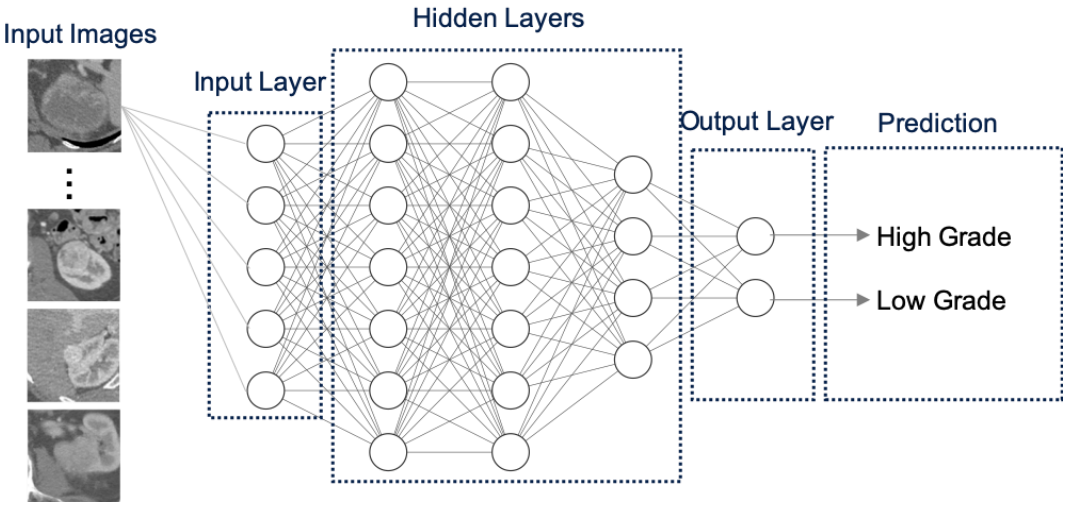
Highlights:

- Deep learning can be used to predict Fuhrman grading, a nuclear grading system for clear cell renal carcinoma, from contrast-enhanced Computed Tomography
- 40 patient datasets with 40 lesions were analyzed in this preliminary study.
- Rectangular tumor ROI were annotated, and trained on a ResNet model using transfer learning
- Best classification result: 0.67 sensitivity, 0.94 specificity, 0.84 accuracy, 0.83 AUC

Objective Tumor grading is an important prognostic parameter for renal cell carcinoma (RCC). The most popular grading scheme is called Fuhrman grading, which is based on nuclear morphology of histological materials after a surgical resection, such as radical nephrectomy. However, an invasive surgical procedure often comes with high risks including increased risk of chronic kidney disease and cardiovascular disease, and low grade RCCs might not need to be treated right away due to their low metastatic potential. Therefore, a pre-operative assessment of cancer grade malignancy is useful to apply the best treatment decisions. In recent years, deep learning-based image analysis has gained wide popularity in cancer prognosis and prediction. The goal of this study is to investigate the feasibility and performance of a deep-learning-based model for clear cell RCC grading prediction from contrast-enhance CT (CECT).
Methods With institutional review board approval, records from 945 patients were queried from institutional radiology and clinical databases. From December 2002 to October 2018, all patients received multi-phase CECT following standard protocol at our institution. All patients have Fuhrman grade confirmation from surgical pathology, with CT scan prior to the procedure. Tumors with size < 7cm with no obvious local invasion or metastasis are included only. Affected tumors were manually annotated by a trained radiology resident on corticomedullary phase CECT based on radiology reports. Rectangular ROIs were selected and used as inputs to the Deep CNN ResNet50, which was pretrained on ImageNet data and transfer learning was applied by allowing the last two convolutional layer coefficients to be modified. A binary label was assigned to each lesion, where grade 1 and 2 as negative, grade 3 and 4 as positive. Sensitivity, specificity, accuracy, AUC were calculated based on a five-fold cross-validation.
Results 40 patients with 40 clear cell RCCs were included for this study. The best performance achieved so far was: 0.67 sensitivity, 0.94 specificity, 0.84 accuracy, 0.83 AUC.
Conclusion These results prove a deep learning model can be used to predict clear cell RCC grading based on CT imaging prior to surgical procedure. We plan to improve the performance by inclusion of the full 945 patient dataset and exploring alternative networks (e.g. 3D networks) in the future.



a.



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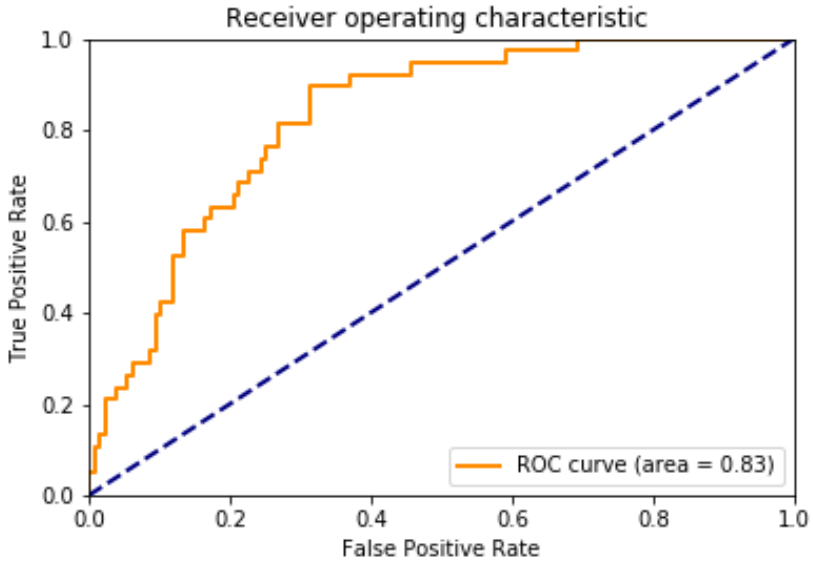

c.

Figure 1a. An example of how each tumor ROI was processed. *Figure 2b.* An overview of how a deep learning-based predictive model is built. *Figure 1c.* Receiver operating curve for the best-performance model for prediction of high vs low grade clear cell tumors off a single-phase CECT.