Patient-based Classification of Clear Cell Renal Cell Carcinoma through Computed Tomography Texture Analysis

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INTRODUCTION

- **Clear Cell Renal Cell Carcinoma (CCRCC)** is the most common type of renal cell carcinoma (RCC) originating from the renal parenchymal urothelial system.

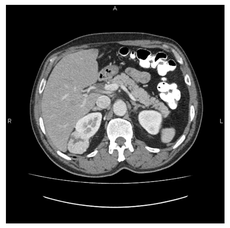


Figure 1: CT scan of the abdomen

Figure 2: CT scan of the abdomen (tumor circled)

- The pathological characteristics of CCRCC can be classified into **four grades** according to the **Fuhrman nuclear grading system**. The major requirement to correctly treat tumors is knowledge of their sub-type, location, and aggressiveness.
- **Computed tomography texture analysis (CTTA)** is a method to quantify a tumor's heterogeneity, which contains information about the nature of the tumor.

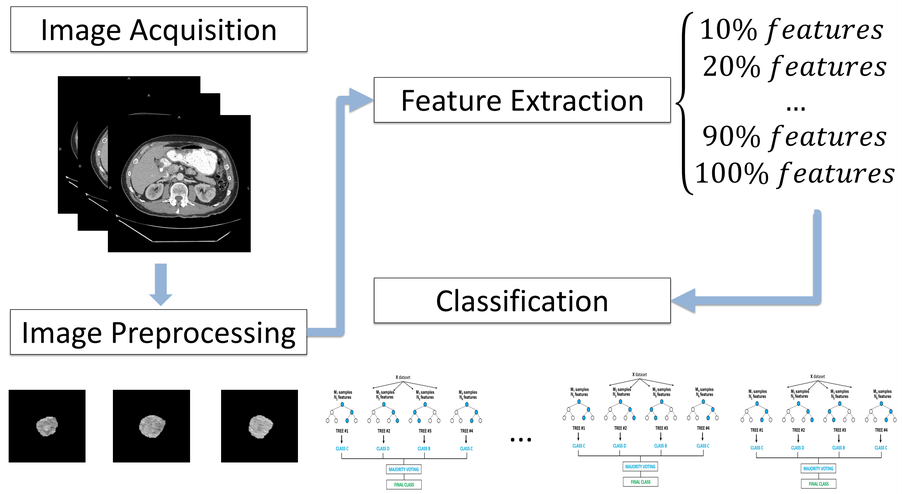
OBJECTIVES

- Extract texture features and histogram-based features from CT scans of CCRCC .
- Classify into sub-types using a trained classification model.
- Determine whether this could be a reference for physicians to define the types of tumors and thus to provide suitable treatment. A reliable CT-based grading method could reduce the number of kidney biopsies required prior to therapy.

PATIENT & TUMOR DEMOGRAPHICS

Patient N = 24	Male: 14 Female: 10
	Mean Age: 57.7 (range: 25-87)
CCRCC Tumors N = 26	Grade 1: n = 2 Grade 2: n = 11
	Grade 3: n = 12 Grade 4: n = 1
	Mean size = 2.6 cm ± 0.8 cm (1.2 – 3.9 cm)

METHODS



- Each tumor had three slices – one each from the superior, mid, and inferior aspects of tumor.
- The tumor region was cropped by an experienced radiologist. Each image of a tumor is centered in an image of size 100 by 100 pixels.
- 44 **texture features** (GLCM, GLRLM, Hu's Moments) and **histogram-based features** are extracted from normalized tumor images (mean, variance, kurtosis, skewness, energy).
- Rank the features by **AUC value** (area under the ROC curve).
- A **random-forest (RF) classification** algorithm was developed to classify the grade of CCRCC.
- Use **patient-based** 5-fold cross validation.
- The RF classifiers were trained to classify CCRCC.
- The final AUC values after classification were calculated in the **patient-based case** by adjusting the cost matrix in the random-forest algorithm.
- Run 20 times to get final results for each trial.

RESULTS

- Grades 1 and 2 are combined as a "low-grade" group; grades 3 and 4 were combined as a "high-grade" group.
- We treat each patient as a unit to do experiments.
- If two or more slices are correctly classified, then we decide that patient is correctly classified.

	Patient-based (2/3 correct)	
G2 VS G3	Correct rate	AUC
10%	0.76	0.78±0.05
20%	0.75	0.75±0.05
30%	0.75	0.68±0.04
40%	0.69	0.67±0.07
50%	0.71	0.66±0.06
60%	0.72	0.66±0.08
70%	0.74	0.65±0.07
80%	0.66	0.65±0.06
90%	0.70	0.65±0.06
100%	0.65	0.64±0.07

	Patient-based (2/3 correct)	
Low VS High	Correct rate	AUC
10%	0.83	0.80±0.06
20%	0.73	0.72±0.07
30%	0.73	0.67±0.05
40%	0.64	0.66±0.06
50%	0.64	0.64±0.05
60%	0.67	0.63±0.06
70%	0.65	0.62±0.05
80%	0.63	0.61±0.09
90%	0.65	0.62±0.06
100%	0.66	0.64±0.06

CONCLUSION & FUTURE WORK

- The random forest classifier has the potential to classify CCRCC accurately.
- 'Low VS High' got better results than 'Grade 2 VS Grade 3'.
- We expect further improvement as more data are acquired and other classification methods are evaluated.

REFERENCES

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[2] https://emedicine.medscape.com/article/1612043-overview#a1