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Characterization of Renal Parenchymal Lesions on Computed Tomography Images using first order texture features

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Abstract:
Background*:Renal parenchymal disease is one of the most common pathologies that affect 12 to 14 percent of the general population annually, that makes studies that aids effective diagnosis a necessity; as the analysis of texture parameters is a useful way of increasing the information obtainable from medical images, hence it has been chosen by the researcher to study renal parenchymal diseases baring in mind there is only few previous studies considered the method .*
Materials and Methods*: In this retrospective case series study, 400 computed tomography renal images of normal renal parenchyma individuals, cyst affected group and follow up renal cell carcinoma patients; the data afterwords processed using Interactive data language program (IDL) utilizing first order statistics.*
Results*: the classification showed high discrimination power of the textural features (variance, energy, entropy) is 96.5% accurate in defining the groups under-study.*
Results also showed high sensitivity in discriminating normal renal parenchyma (97.3%), (96.9%) in discriminating renal cysts and finally (94%) for renal cell carcinoma.
Conclusion: *The three groups under study (normal, cyst affected and renal cell carcinoma group) were classified correctly by 96.5% using first order textural features*
Key Word*: **texture analysis; renal cell carcinoma; renal cyst; computed tomography; CT.***

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I. Introduction

Renal parenchymal disease is defined as a disease that involves one or more compartments of the renal parenchyma. different segments of the nephron, the interstitium, and the vasculature may be affected simultaneously or may become secondarily involved.(1)

The overall prevalence of Choronic Kidney Disease increased from 12 percent to 14 percent between 1988 and 1994 and from 1999 to 2004 but has remained relatively stable since 2004.(2) ; this in contrast to all diseases that affects population.

The analysis of texture parameters is a useful way of increasing the information obtainable from medical images. It is an ongoing field of research, with applications ranging from the segmentation of specific anatomical structures and the detection of lesions, to differentiation between pathological and healthy tissue in different organs. Texture analysis uses radiological images obtained in routine diagnostic practice, but involves an ensemble of mathematical computations performed with the data contained within the images. (3). However, texture analysis is most important for those cases in which change cannot be detected by direct inspection of the image. For example, in some conditions the tissue of associated anatomical structures suffers alterations. These can normally be detected by histological examination, but sometimes not by visual inspection of the image of the tissue, whereas they may be demonstrated by statistical analysis of the pixel distribution in the image of the structure. (3)

As texture analysis becomes a highly effective tool in diagnosing medical images and the available data about normal kidneys or renal parenchymal disease is very few this research becomes necessity to provide such valuable data to medical community.

II. Material And Methods

This retrospective case series study, 180 computed tomography renal images of individuals with normal renal parenchyma, cyst affected group and pretreatment renal cell carcinoma patients; the data afterwards processed using Interactive data language program (IDL) utilizing first order statistics, data collected from 2019 to March 2020.

Study Design: retrospective case series study
Study Location: study conducted at Ibn sina specialized hospital radiology department.
Study Duration: June 2019 to March 2020.
Sample size: 180 computed tomography images.
Sample size calculation: The sample was convenient random sample.
Subjects & selection method:
Inclusion criteria:
Computed tomography images at the kidneys level for individuals with normal renal parenchyma, renal cyst or renal cell carcinoma.
Exclusion criteria: Computed tomography images for the same individuals which doesn't contain any of the region of interest (renal parenchyma) or not deferentially diagnosed to be normal, affected with renal cyst or renal cell carcinoma.

Procedure methodology

After written informed consent was obtained with the radiology department staff, CT images for the target sample individuals has taken using CD-roms, then transferred to dedicated CT work station to be processed using RadiAnt DICOM Viewer (32-bit) and then texture features were extracted using interactive data language program (IDL) the quantitive features chosen were (mean, variance, skewness, kurtosis, energy, entropy).

Statistical analysis

Data was analyzed using SPSS version 20 (IBM SPSS Statistics 20) stepwise method followed wilks' lambda, Canonical Discriminate Functions and fishers exact test

III. Result

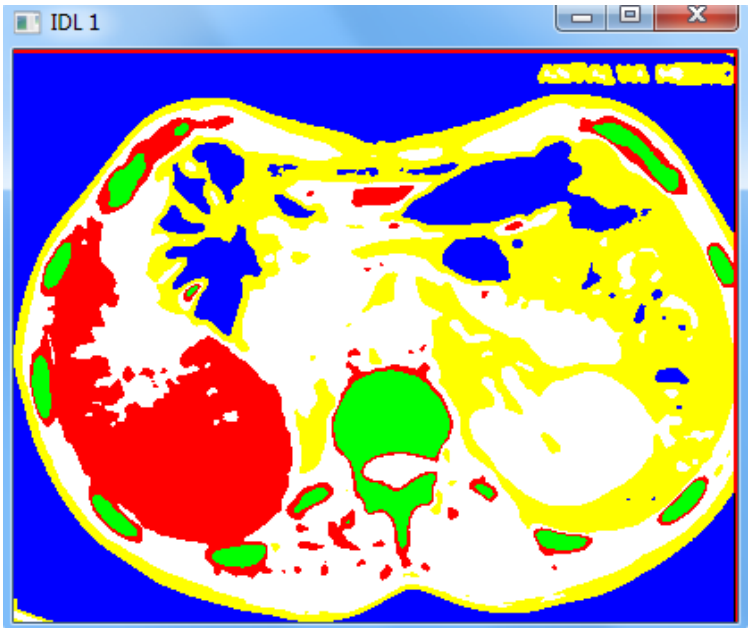

Figure (1): classification map shows the discrimination power of the classification function.

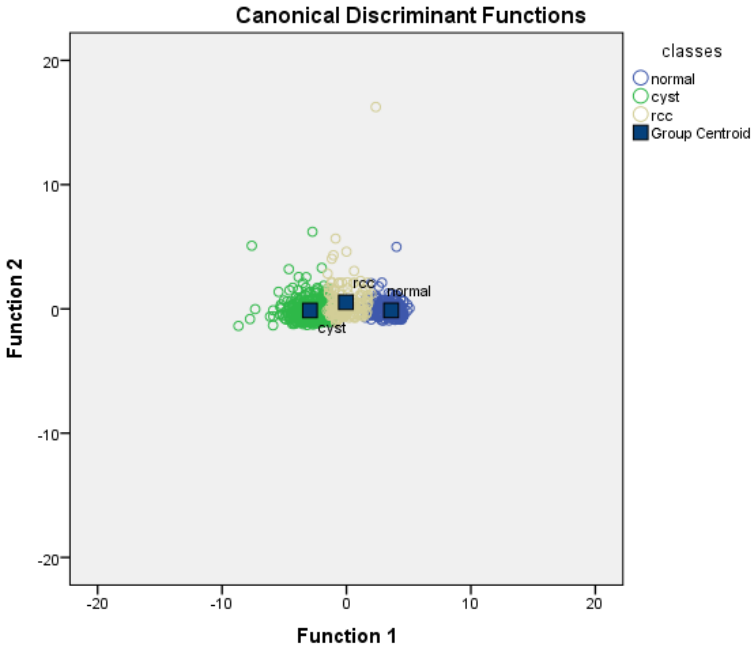

Figure (2): scatter plot shows the discrimination power of the extracted features between the three predefined groups (Normal renal parenchyma, renal cyst and renal cell carcinoma)

Table (1): Cross-tabulation table show the classification results for the three predefined groups (Normal renal parenchyma, renal cyst and renal cell carcinoma) using linear discriminate analysis.

Classification Results[a]

Classes		Predicted Group Membership			Total
		normal	cyst	Renal cell carcinoma	
%	Normal	97.3	.0	2.7	100.0
	Cyst	.0	96.9	3.1	100.0
	Renal cell carcinoma	.7	5.3	94.0	100.0

a. 96.5% of original grouped cases correctly classified.

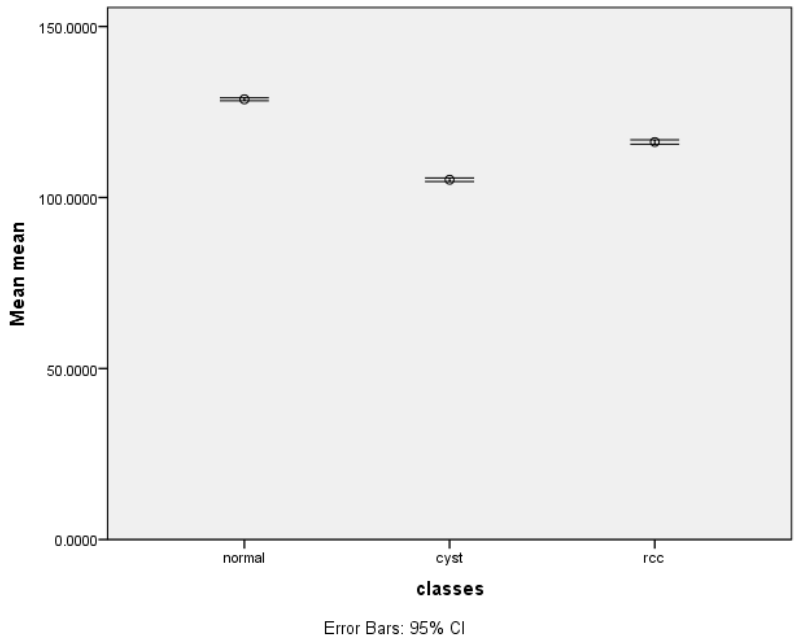

Figure (3): error bar plot shows the discrimination power of mean textural feature for the selected classes.

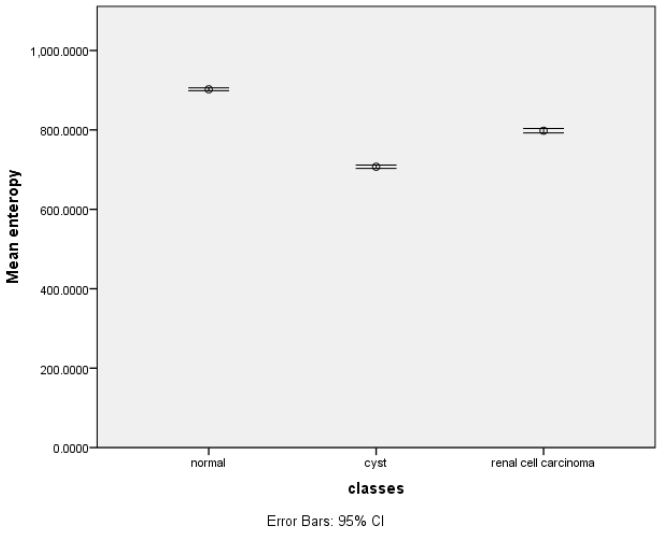

Figure (4): error bar plot shows the discrimination power of entropy textural feature for the selected classes.

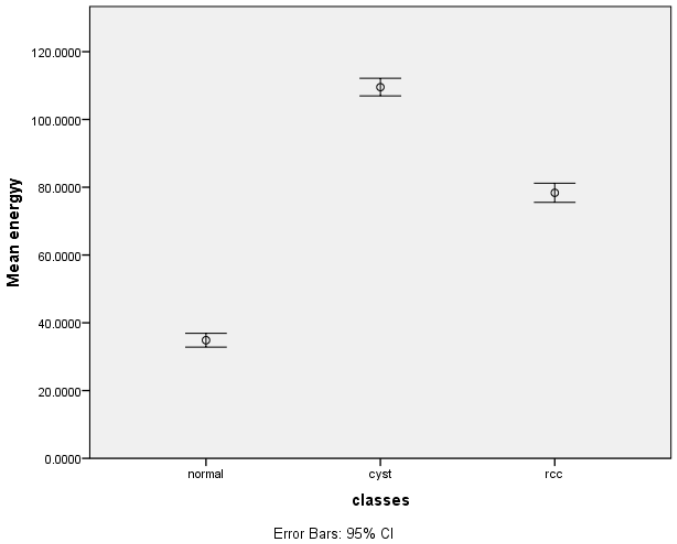

Figure (5): error bar plot shows the discrimination power of energy textural feature for the selected classes.

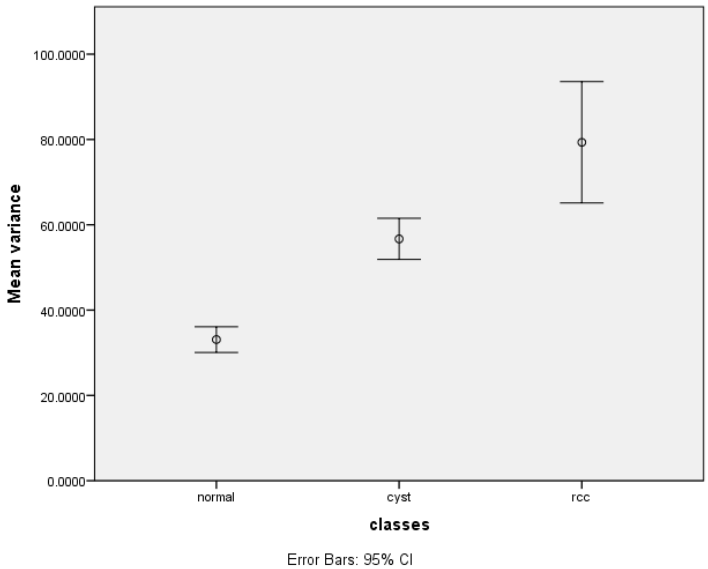

Figure (6): error bar plot shows the discrimination power of variance textural feature for the selected classes.

IV. Discussion

The study was focused on characterization of renal parenchymal lesions using first order statistical textural features extraction (mean, variance, skewness, kurtosis, energy, entropy), as shown in (**Table (1)**) the classification showed high discrimination power of the textural features (variance, energy, entropy) is 96.5% accurate in defining the groups under-study following these Linear equations:

Normal renal parenchyma = (variance * .004) (energy * .058) (entropy * .697) -316.475
Renal cyst = (variance * .014) (energy * .227) (entropy * .544) -206.270
Renal cell carcinoma = (variance * .021) (energy * .156) (entropy * .615) -253.305

The results also showed high sensitivity in discriminating normal renal parenchyma (97.3%), (96.9%) in discriminating renal cysts and finally (94%) for renal cell carcinoma (As in **Table (1)).**

Scatter plot for the study groups **(Figure (2))** proved that no interference between cyst and normal tissue in classification with a very minor interference between RCC group and both normal and cystic lesions.

(Figure (3)) manifested that mean as a textural feature has differentiated the three studied groups with no interference and with confidence interval of (95%). **(Figure (4))** exhibited matching results for entropy feature with the cyst possessing the minimum mean textural feature, RCC occupying the middle level and the normal owning the highest value.

(Figure (5)) conveyed that the no intersecting points between the classes when employing energy textural feature with normal group holding the minimum energy values, RCC the middle values and cyst the highest values.

(Figure (6)) exhibited the no intercession between groups and values arranged from the minimum to the maximum as follows: normal tissue, cystic lesion, RCC.

In contrast to previous studies the current work fills the knowledge gab by providing a linear equations for the normal renal tissue and the underlying lesions, all the previous studies extracted the textural features as a part of their work and used the data to compare between the quantitative textural features approach with the qualitative imaging features as in (4), or evaluated the texture analysis method ability to give conclusive diagnosis as in (5) (6) (7) (8) (9) (10).

V. Conclusion

The three groups under study (normal, cyst affected and renal cell carcinoma group) were classified correctly by 96.5% using first order textural features.

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