Texture Analysis (TA)

Alvin C Silva, MD, FSAR

Mayo Clinic, Scottsdale, Arizona

Liver Fibrosis

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Introduction

Texture Analysis (TA) is a noninvasive, computer-based method for extracting more information from medical images than that achievable by visual inspection alone. It utilizes mathematical and statistical modeling to quantify the spatial variation of pixel/voxel intensities in order to objectively characterize image "texture." [1,2] This technique has potential for broad clinical application, with active research that includes anatomic segmentation; lesion detection and prognosis; discrimination between healthy and pathologic tissue; and radiogenomic associations. [1,3]

TA can be classified into four categories: structural, model-based, statistical, and transformation-based methods. (Fig 1) Statistical-based modelling has more commonly been applied to medical images; computing a set of first-order (eg, mean intensity; skewness; kurtosis); second-order [eg, gray level co-occurrence matrix (GLCM) and local binary patterns (LBPs)]; or even higher-order statistics [eg, grey-level run length method (GLRLM)]; from the spatial distribution of intensity values at each pixel/voxel. [1,4,5] (Fig 2)

When and how to use Texture Analysis

TA can be performed on routine clinical images using any modality. Following image acquisition, TA workflow includes up to four main steps [1]:

1. ROI placement +/- optional normalization or filtration (eg, bandpass filter)
2. Texture feature extraction (eg, GLCM, LBPs, Gabor filters)
3. Feature dimension reduction [eg, principal component analysis (PCA)]
4. Machine learning data analysis algorithms for predictive model development (Fig 3)

Accuracy of Texture Analysis

TA diagnostic performance is highly variable, dependent on the imaging modality [6,7]; acquisition parameters [8-11]; scanner platform [12-13]; TA algorithm [8]; and intravenous contrast and dynamic phase utilized [6,14]. Early work suggests that 3T MR (AUC 0.720) > 1.5T MR (AUC 0.681) > CT (AUC 0.668) for classifying liver fibrosis [6], and that contrast-enhanced (equilibrium-phase best) > nonenhanced images [6,14]. TA techniques may be useful for excluding fibrosis (AUC 0.91)[15] and detecting advanced stages (AUC 0.94)[16], but currently performs only modestly for earlier stages (F≥2; AUC 0.64-0.80)[16-18].

Limitations of Texture Analysis

Although TA has exciting promise, there is currently no consensus software platform; imaging acquisition protocol/modality; segmentation technique; TA algorithm/feature analysis method; or reporting convention to allow comparison between studies and assess reproducibility and reliability. Overcoming these challenges with validated standardization will be required for practical implementation of texture analysis into clinical practice.

Fig.1

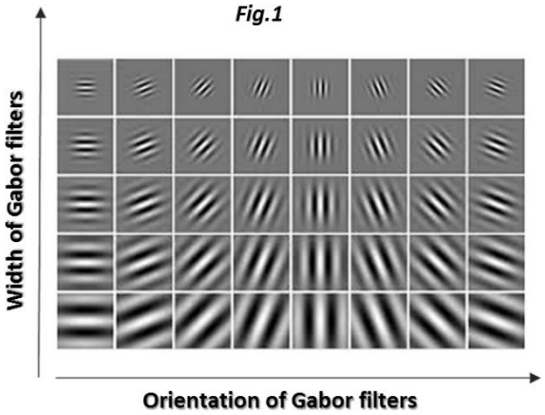


Fig.2 Heat Map showing differences in texture features between normal and fibrotic liver

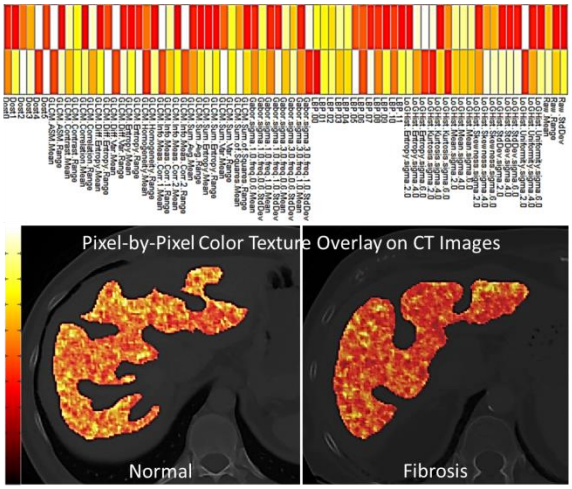
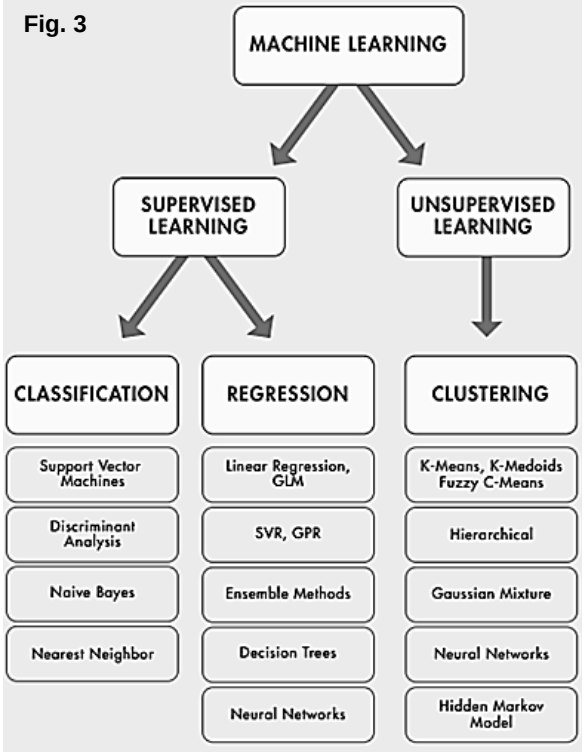


Fig. 3



Reference: https://www.mathworks.com

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