Food Research International 43 (2010) 387–395

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

The use of lacunarity for visual texture characterization of pre-sliced cooked pork ham surface intensities

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ARTICLE INFO

Article history:
Received 24 August 2009
Accepted 22 October 2009

Keywords:
Computer vision
Pre-sliced
Cooked pork ham
Gliding box lacunarity
Fractal
Surface characterization
Texture appearance
Intensity image
Colour channel

ABSTRACT

Textural patterns are often complex, exhibit scale-dependent changes in structure and are difficult to identify and describe. The lacunarity morphometric uses multiscale windowing to measure the scale dependency of spatial heterogeneity. In the current work, the objectives are to investigate the usefulness of lacunarity, using different colour scales (R, G, B, L^*, a^*, b^*, and Gray), as a quantitative descriptor of visual texture in sliced ham surfaces, and compare these results with the binary approach developed by Valous et al. (2009b). Images were acquired from three qualities of sliced pork ham, typically consumed in Ireland (200 slices/quality). Lacunarity plots reveal important textural content information that corresponds to degree of spatial heterogeneity of intensities and level of self-similar behaviour. The results of intensity lacunarity suggest that window sizes up to 10 pixels may be adequate enough to cover textural features and produce meaningful results. Once the box size is larger than 10, lacunarity curves either converge or display atypical behaviour and then decay. Investigation confirmed that both binary and intensity lacunarity approaches are useful quantitative descriptors of visual texture in sliced ham images. Moreover, potential future research directions were suggested for computing lacunarity in colour images directly.

1. Introduction

The relevance of fractal geometry in image analysis is justified by the fact that self-similarity can hardly be verified in images acquired with a finite resolution (Lopes & Betrouni, 2009). Self-similarity is not visually obvious but there may be statistical measures that are preserved across scales, ergo images may exhibit statistical fractality (Klonowski, 2000). An important goal for the characterization of visual texture using imaging technology is the quantification of spatial patterns. Various studies have shown that the fractal dimension alone is not a sufficient metric for the characterization of most textures (Moghaddam, 1991), because fractal dimension only measures how much space is filled. Lacunarity complements fractal dimension by measuring how the data fill the space (Tolle, McJunkin, & Gorsich, 2008), enabling the parsimonious analyses of textures (Wu, Thurow, & Whisenant, 2000). Textural patterns are often complex, exhibit scale-dependent changes in structure and are difficult to identify and describe (Plotnick, Gardner, Hargrove, Prestegaard, & Perlmutter, 1996). Fractal lacunarity has been applied to tackle this problem, since it quantifies the degree of translational invariance of the analyzed patterns (Rodrigues, Barbosa, & Costa, 2005). Lacunarity uses multiscale windowing to measure the scale dependency of spatial heterogeneity and anisotropy, and is sensitive to local aggregation or clustering (Henebry & Kux, 1995). Lacunarity can also describe the spatial distribution of real data sets. This is an advantage over fractal dimension and has been commonly used as a texture descriptor of images that often exhibit limited self-similarity. Moreover, translational invariance is highly scale-dependent, so lacunarity is considered a scale-dependent measure of heterogeneity (Plotnick et al., 1996). Lacunarity has several practical advantages for the assessment of spatial heterogeneity, i.e. its computation is simple to implement and it exhaustively samples the image to quantify scaling changes. Lacunarity analysis has been proposed as a general method for the analysis of a number of spatial patterns (Butson & King, 2006; Cheng, 1997; Chmiela, Słota, & Szala, 2006; Dong, 2009; Dougherty & Henebry, 2002; Einstein, Wu, & Gil, 1998; Feagin, Wu, & Feagin, 2007; With & King, 1999). Recently, Mendoza, Valous, Sun, and Allen (2009) applied multifractal techniques to characterize fat-connective tissue size distributions in different qualities of pre-sliced pork hams. Lacunarity may seem similar to the concept of multifractals; however multifractals dis-

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doi:10.1016/j.foodres.2009.10.018