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Supervised neural network classification of pre-sliced cooked pork ham images using quaternionic singular values

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ABSTRACT

The quaternionic singular value decomposition is a technique to decompose a quaternion matrix (representation of a colour image) into quaternion singular vector and singular value component matrices exposing useful properties. The objective of this study was to use a small portion of uncorrelated singular values, as robust features for the classification of sliced pork ham images, using a supervised artificial neural network classifier. Images were acquired from four qualities of sliced cooked pork ham typically consumed in Ireland (90 slices per quality), having similar appearances. Mahalanobis distances and Pearson product moment correlations were used for feature selection. Six highly discriminating features were used as input to train the neural network. An adaptive feedforward multilayer perceptron classifier was employed to obtain a suitable mapping from the input dataset. The overall correct classification performance for the training, validation and test set were 90.3%, 94.4%, and 86.1%, respectively. The results confirm that the classification performance was satisfactory. Extracting the most informative features led to the recognition of a set of different but visually quite similar textural patterns based on quaternionic singular values.

1. Introduction

Computer vision has been implemented for quality assessment in meats and meat products, overcoming most of the drawbacks of traditional methods, e.g. human inspection and instrumental techniques (Kumar & Mittal, 2009; Quevedo & Aguilera, 2009; Quevedo, Aguilera, & Pedreschi, 2009). For quality grading purposes, image analysis techniques need to take into account the high variability in colour and visual texture of pork hams. Although gray level images can be quite satisfactory from the pattern recognition perspective, colour images alternatively do seem to be perceptually richer. There is no doubt that colour contains very useful information that can help to improve the accuracy of pattern recognition systems (Villegas & Paredes, 2007). Different from gray level images, colour data representations are usually ternary, e.g. ham slice colour image data from a digital camera in the RGB colour space.

Over the last decade, growth has been witnessed in both the diversity of techniques and the range of applications regarding colour image analysis (Sangwine & Horne, 1998; Kaya, Ko, & Gunasekaran, 2008; Fathi, Mohebbi, & Razavis, 2009). There are operations in image processing which have been known and understood for many years; however they have not been generalized considerably to colour images (Sangwine & Ell, 1999). Several approaches have been followed to deal with colour images. One of the typical is to process each colour channel separately (Mendoza et al., 2009; Valous, Mendoza, Sun, & Allen, 2009a). A quite recent approach is to encode the three channel components on the three imaginary parts of a quaternion (Denis, Carre, & Fernandez-Maloigne, 2007). There is a growing interest in the applications of quaternion numbers to colour image processing (Smolka & Venetsanopoulos, 2006; Trémeau, Tominaga, & Plataniotis, 2008). Many problems in the area of quaternion-based image processing are still open (Cai & Mitra, 2000). In general, quaternions are an extension of complex numbers to four dimensions and play an important role in colour image processing. They are considered as complex numbers with a vector imaginary part consisting of three mutually orthogonal components. In Cartesian form, quaternion numbers can be represented as follows:

$$q = a + ib + jc + kd, \tag{1}$$

where a, b, c and d are real numbers, and i, j and k are orthogonal imaginary operators. A pure quaternion has a zero real part and a full quaternion has a non-zero real part. Thus, a quaternion number

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