National Physical Laboratory

Texture algorithms for human perception of naturalness

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Introduction

Texture analysis is a very powerful tool in many areas of computer vision science, and this has led to the development of a range of texture analysis algorithms. Methods for texture feature extraction, image segmentation and object recognition are well developed. But can classification based on surface textural features be used to classify an object not in terms of the actual material type, but in terms of subjective human observation of an abstract property such as naturalness? This is being investigated in an EU project on Measurement of Naturalness (MONAT).

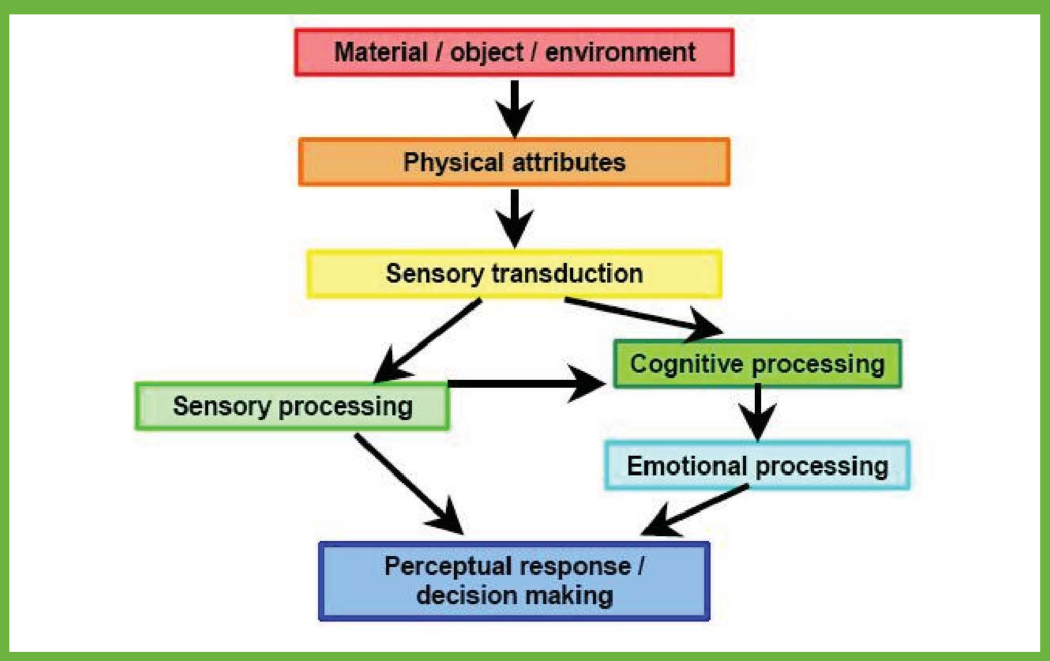

Figure 1. The perceptual process

Our approach

Images of a range of natural and synthetic wood and textile samples have been captured under robust metrological conditions. The results of the texture analysis are then correlated with perceived naturalness results from psychophysical studies.

Figure 2. Wood samples

The aim is to create a metrologically-sound predictive model of the perceived degree of naturalness, by determining relationships between these objective and subjective assessments.

Texture features are obtained from:

- Haralick co-occurrence matrices
- Biologically related Gabor filters
- Wavelet analysis
- Heterogeneity measures

Two approaches to data modelling are being tested:

- Classification, where the definition of the classes is based on the psychophysical studies
- Regression, $y = \beta x + \varepsilon$ where y values are derived from subjective human observation of the degree of naturalness and x values are the texture feature vectors.

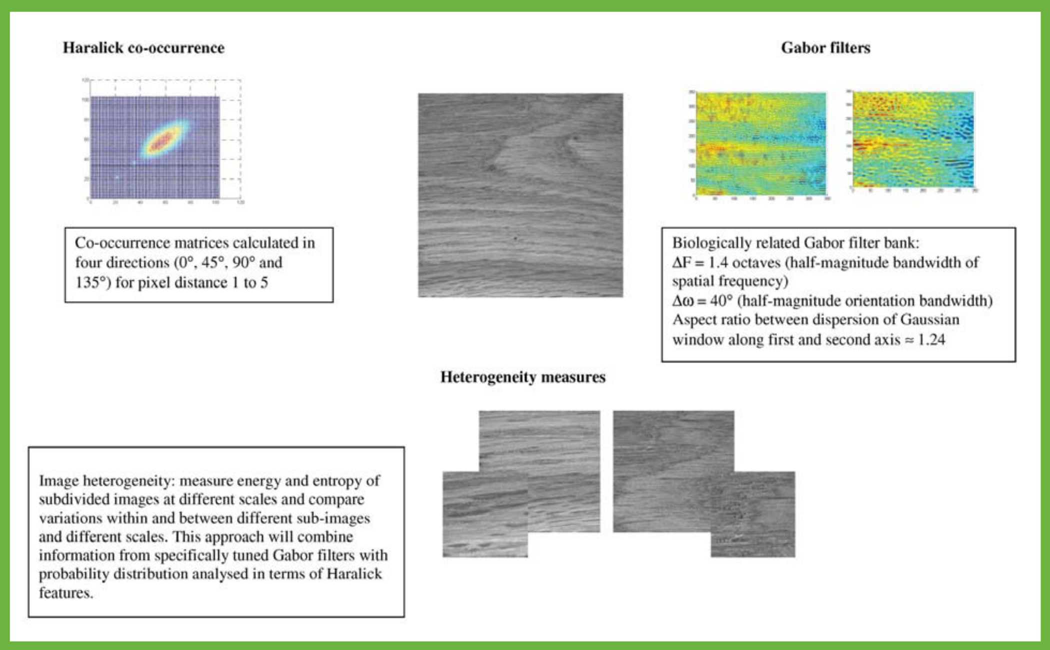

Figure 3. Texture analysis

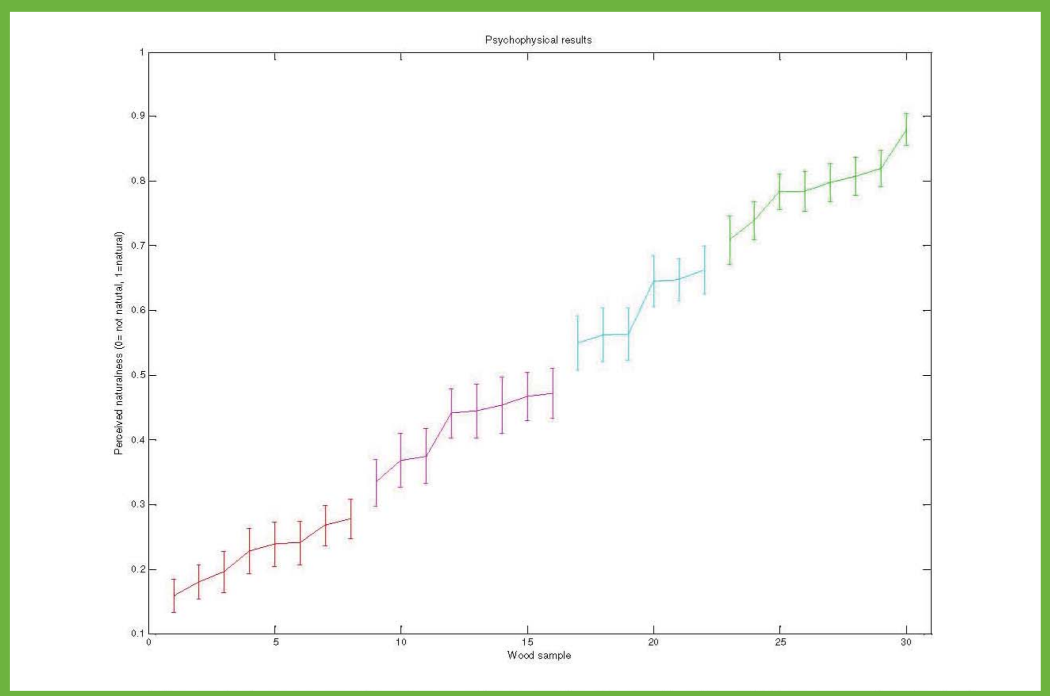

Figure 4. Average results of naturalness evaluations using four different psychophysical methods (binary decision, labelled scaling, free modulus magnitude estimation and ranked ordering). Colours correspond to the classes that were chosen for the classification analysis.

Perceived as fake - samples with naturalness index less than 0.3

Perceived as likely to be fake - samples with naturalness values between 0.3 and 0.5

Perceived as likely to be natural - samples with naturalness values 0.5 to 0.7

Perceived as natural - samples with naturalness values greater than 0.7

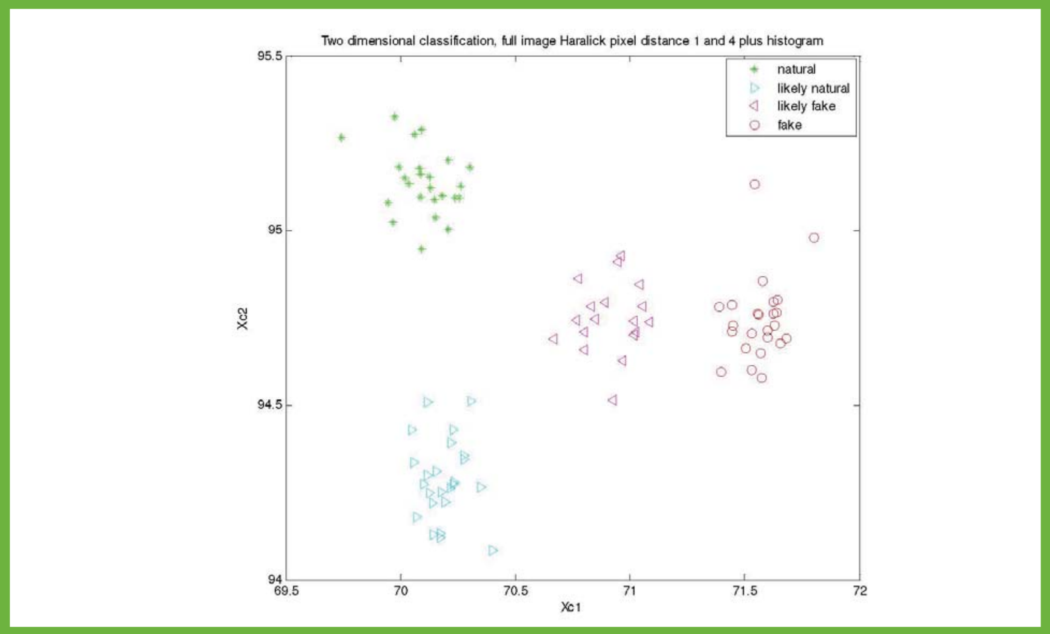

Figure 5. Classification of wood samples into four classes representing the degree of perceived naturalness as determined from the visual modality psychophysical test results. The x and y axes represent physical data related to the visual properties of the materials (visual texture features).

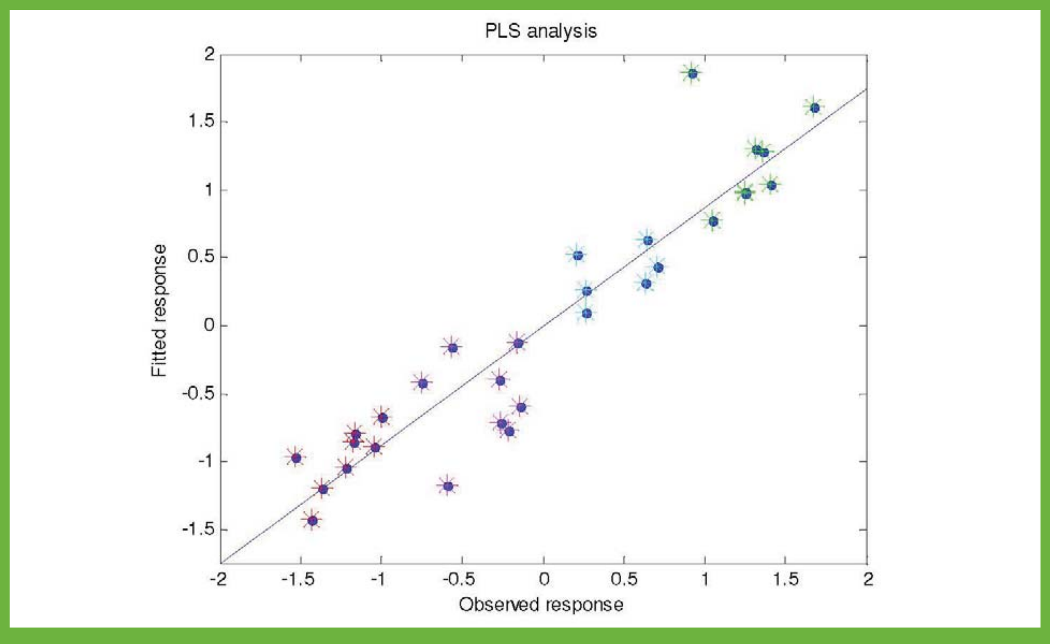

Figure 6. Partial least squares regression (R^2=0.87) on set of wood samples, using Haralick textural features

Future work

- Model validation by testing their performance with 'new' samples i.e. samples of the same type (wood or textile) but which have not been used to develop the classification or regression algorithms.
- Development of improved feature extraction procedures, in order to identify the physical parameters that are most significant in the classification.
- Refinement of the data analysis and modelling procedures, giving increased weight to the key physical parameters.
- Accounting in the models for the effects of uncertainties associated with the physical measurements and with the results of the psychophysical studies
- Developing methods for texture analysis of 2D and 3D objects imaged at varying angles of view. This will use images from a novel multi-spectral goniometric system, known as IRIS/GASP (image replication imaging spectrometer and gonio-apparent spectrophotometer), which has been specially designed at the National Physical Laboratory (NPL) in order to capture spatial, spectral and texture information across the full sample area.

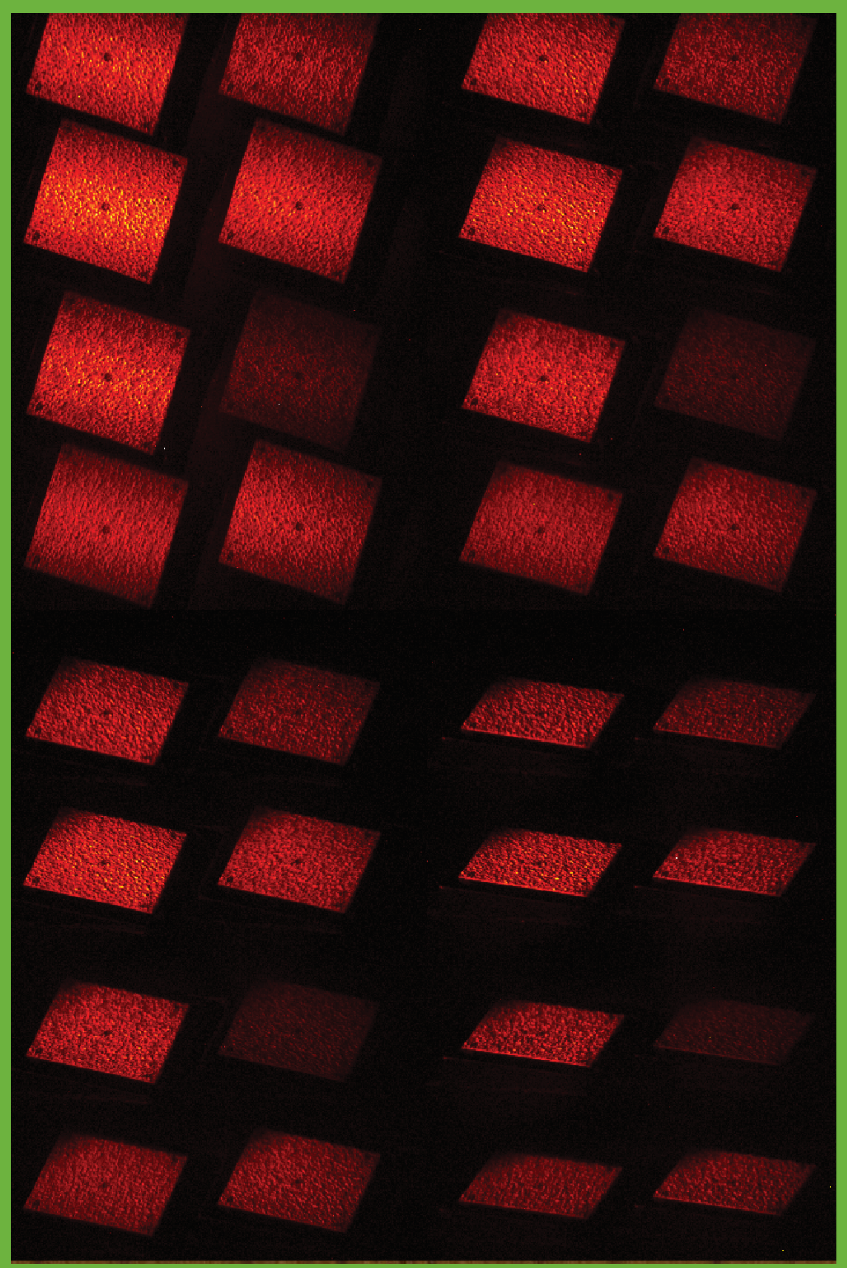

Figure 7. Example of the images from IRIS/GASP. Each group of 8 sub-images is for the same object viewed at one of four different angles of view; sub-images within each group of 8 give the reflected light in one of 8 narrow spectral bands.

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