Image Enhancement Using Information Measures

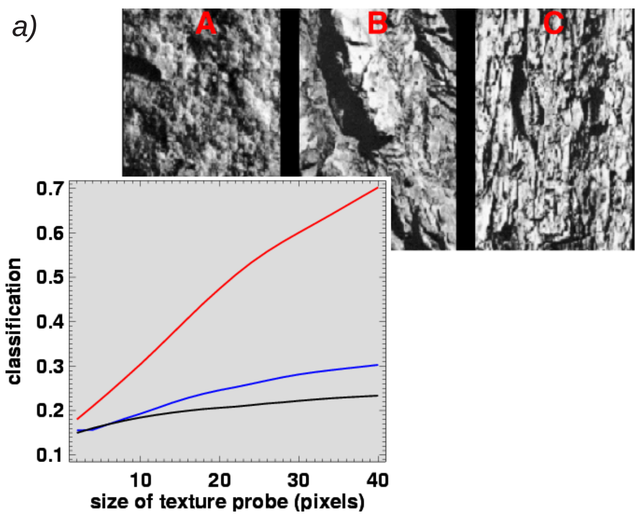
An image can be represented as a point distribution in a state space that is made up by the pixel and colour coordinates. In order to characterise the structural or textural content of an image the calculation of the local scaling properties in this state space is often very helpful. However, this approach implies a relation between the spatial scale and colour scales, which is usually not given a priori. We developed a procedure, which objectifies and optimises the partitioning and scaling of the state space by means of the structural information content. This remapping yields in many cases images of enhanced significance and improve the quantitative results by the use of scaling property techniques with respect to the structural content.

Structural or textural elements of an image are recognised by its locally increased correlation function. One way to assess these correlations is the investigation of the local structural information content. The surrounding of each pixel is scanned by applying a two-dimensional shift operator. As a result of this procedure one obtains a two-dimensional distribution of colour-colour transitions associated with structural elements of the image. This two-dimensional distribution is evaluated using mutual information which results in a specific averaged information content of each colour value. In this way the specific contribution to the total information content of the image can be assigned to each colour value. Finally a non-linear rescaling of the colour values is achieved by an homogenous partitioning of the respective information space. This technique gives enhanced images with a better visual impression but is used in particular as a preprocessing step to the calculation of local scaling properties.

The following examples show applications of this method for a classification problem and image enhancement. Fig.1a displays three different Brodatz textures (A, B, C) with equal mean and standard deviation. The classification relies primarily on the different structural properties. After rescaling of the colour scale, local scaling properties are computed using the scaling index method. The classification performance as a function of the size of the texture probe is plotted for three different cases: The black curve denotes a simple gray value-based thresholding procedure. The two other curves represent the classification based on the scaling index method: The texture classification using the information-optimized images (red curve) is superior to the original images (blue curve) as input.

In Fig.1b the effect of this method on an image of a skin lesion is demonstrated: The structure of the lesion is enhanced (lower image) compared to the original image.

a)



b)

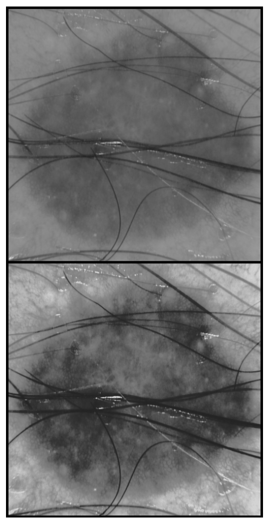


Fig.1a: The curves show the classification performance as a function of texture probe size for a simple gray value thresholding procedure (black curve) and for an analysis based on the scaling index method (red and blue curve). The scaling indices applied to the enhanced images (red curve) yields better classification results compared to the scaling index method executed on the original images (blue curve). Fig.1b: Image enhancement applied to an image of a skin lesion (upper image: original, lower image: structure enhanced version)

This technique will be extended to multi-parameter problems, where a “natural” relation of the different scales of the state space axes is missing.

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