Texture Descriptors From Compressed Images

Rachel Westwood

Texture is an important factor in visual perception and discrimination of image content. On this basis, texture features are used within a range of applications, including identification of landmarks, such as mountains and lakes in ariel photography [1]. Texture descriptors are used to describe areas within an image where different textures occur.

Images can be compressed in multiple ways. The new JPEG2000 standard uses an algorithm called EBCOT and the Discrete Wavelet Transform, while the ordinary JPEG standard uses the Discrete Cosine Transform (DCT). Other compression methods use frequency-domain analysis with Gabon Filters, Radon Filters and other Wavelet Filters. Sim et al.[2] present an algorithm for obtaining texture descriptors of compressed images in the DCT domain. This site will explain how to obtain texture descriptors from an image compressed using wavelet filters and makes use of spatial-frequency domains. This method could also be used on images compressed using DWT.

When an image is compressed, it is split into subbands corresponding to different spatial-frequencies. An example of such an image and corresponding subbands is shown in Figure 1, in this case the QMF wavelet is used on the image.

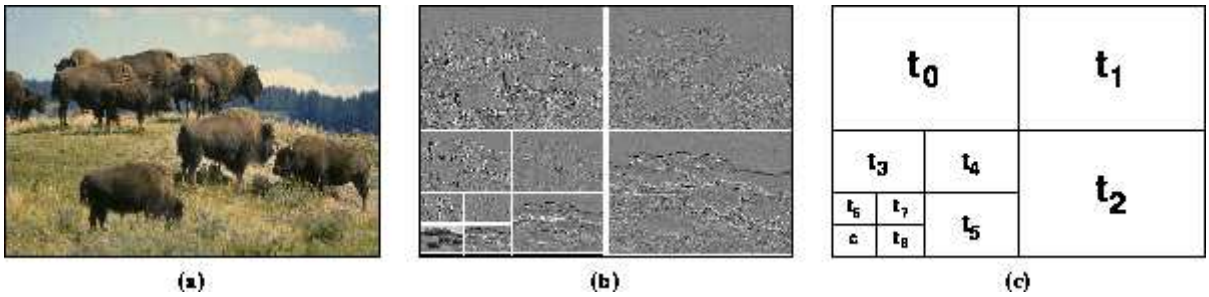

Figure 1. (a) Original image of Buffalos (b) QMF wavelet transformed image (c) Subbands yielding texture given by t_k. [1]

Significance Maps

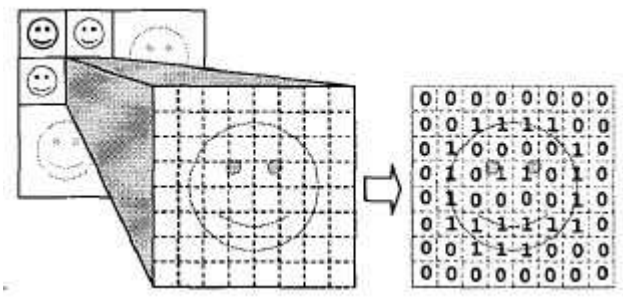

Figure 2. An example significance map. [3]

A significance map is a binary map of significant coefficients and is obtained as follows.
Let $m_0, m_1 \ldots m_n$ be the magnitudes of the coefficents obtained from the wavelet transform.

It is possible to obtain a series of thresholds $\tau_0, \tau_1 \ldots \tau_l$ such that

$$\tau_0 = \frac{1}{2}\max_n m_n \text{ and } \tau_l = \frac{\tau_{l-1}}{2} \quad l = 1 \ldots L.$$

A coefficient X is said to be significant if it's magnitiude is greater than τ_l, that is $m_X > \tau_l$.
A significance map (Figure 2) for subband *k* is defined as

$$b_k[x,y] = \begin{cases} 1, & \text{if the coefficients at coordinate } (x,y) \text{ are significant} \\ 0, & \text{otherwise} \end{cases}.$$

Texture Descriptor Vector

The number of significant coefficients in a subband define it's significance, defined as N_i.
Hence, for the *i*th subband, S_i and the magnitude of the *n*th coefficient, m_n

$$N_i(\tau_l) = |\{m_n \in S_i : m_n > \tau_l\}|.$$

The texture vector can now be defined as

$$T = \{b_1,\ b_2, \ldots b_i\}, \text{ where } b_i = \frac{N_i}{\sum_i N_i}.$$

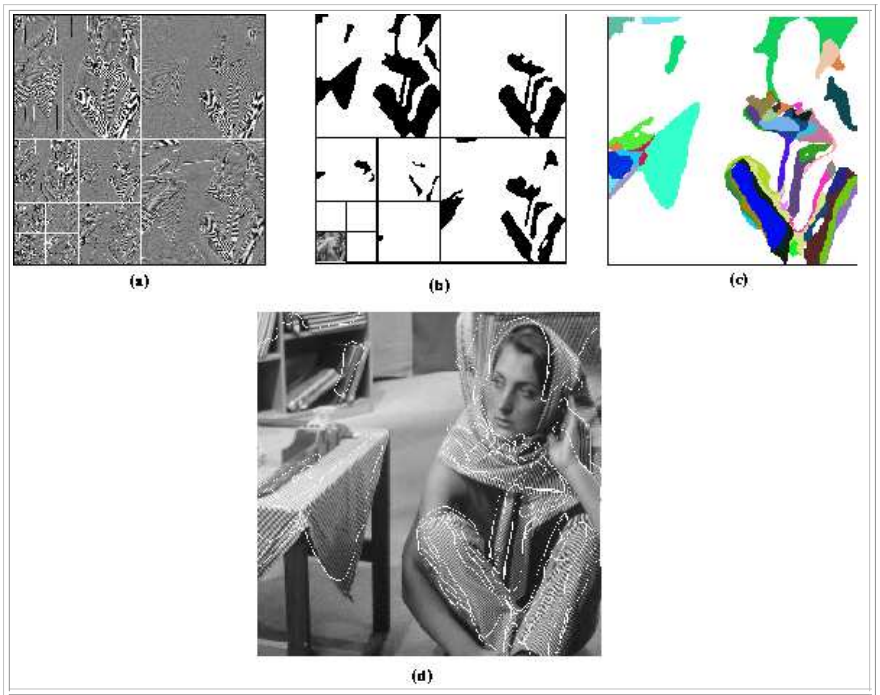

Figure 3. Texture extraction from an image. (a) QMF wavelet transformed image. (b) After thresholding. (c) Labeled textures. (d) Outlined texture regions. [1]

Further Information

Texture Descriptures from images

J. R. Smith and S-F. Chang. *Automated binary texture feature sets for image retrieval*. In Proc. Int. Conf. Acoust., Speech, Signal Processing, Atlanta, GA, May 1996.
http://www.ctr.columbia.edu/~jrsmith/html/pubs/abtfsfir/bintexture.html

K-C. Liang and C-C. Jay Kuo. *WaveGuide: A joint wavelet-based image representation and description system.* In Trans. on Image Processing **8**(11), pp. 1619-1622, November 1999.
http://viola.usc.edu/newextra/Publication/PDF/selected/1999_IEEE-TIP_Liang.pdf

Information relating to compression methods

- http://en.wikipedia.org/wiki/Discrete_cosine_transform
  This site contains a good explanation of DCT, with formal definitions and comparison of DCT to the Discrete Fourier Transform.
- http://www.stanford.edu/~esetton/wavelet.htm
  This site contains an explanation of DWT. Relevant filterbanks are shown and examples of using DWT with images are presented.
- http://www.wavelet.org
  This site contains general information on wavelets, with a forum and tutorials.
- http://www.jpeg.org/jpeg2000/
  This is the official website of the JPEG2000 standard. It contains links to the official standard and a FAQ section on the standard.

References

[1] J. R. Smith and S-F. Chang. *Automated image retrieval using color and texture*. Technical Report CU/CTR 408-95-14, Columbia University, July 1995.
http://www.ctr.columbia.edu/~jrsmith/html/pubs/PAMI/pami_final_1.html

[2] D-G. Sim, H-K. Kim and R-H. Park, *Fast texture description and retrieval of DCT-based compressed images*. Electronic Letters **37**(1), pp. 18-19, January 2001.

[3] G. Voulgaris and J. Jiang, *Texture-based image retrieval in wavelets compressed domain*. In Proc. Image Processing **2**(2), pp. 125-128, 2001.