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Block based image compression with visually tolerable quality degradation

Differential pulse code modulation (DPCM) or Golomb-Rice coding methods are often used to reduce data rates across memory interfaces. At the same time, performance remains questionable with regard to cost and image quality. Transform based image compression (DCT, Wavelet) is also widely used in video stream encoding and decoding. However, it is rarely used for on-chip bandwidth/bitrate reduction, due to low efficiency with regard to local memory requirements as well as number of operations per pixel multiplied by their associated number of bits.

As image size and resolution increases, bandwidth/bit rate reduction for image data is increasingly desirable for external memory accesses, internal local macro-block, line, and frame buffers. Therefore, we are interested in finding methods that enable optimizing efficiency as a function of image block size. When combined with algebraic and nonlinear functions, such as clustering by classification, sorting within small clusters, morphological functions, projection into hyper-/feature spaces, quantization with error minimization, parametric functional approximation (linearization ?), etc.

Nonlinear amplitude, spatial, and spectral system behavior is much more tolerated by the human visual system than currently described by linear mathematics widely used in image processing (convolution, Fourier transform). However, while exploring nonlinear feature spaces, one must carefully minimize integral errors in the context of visual perception. For example, simple truncation of amplitude resolution often leads to phantom contours (color banding). Normalization to local contrast provides a powerful counter measure since the human visual system itself performs local contrast adaptation. In addition, local errors, such as maximum amplitude error and variance shall be kept close to threshold of visual detection (visual threshold). The contrast sensitivity function (CSF) often serves as a reliable reference.

Summary

A memory compression method based on parametric functional approximation interdependently linked with sorting, quantization, and error estimation techniques.

Challenges

How could one suitably sort into clusters with minimal number of bits to represent cluster elements within image block? How could one excellently combine (nonlinear) quantization and functional approximation? How could one obtain an appropriate low cost error estimation method?

Reasonable constraints:

- image block size selectable between 1 pixel to N x M pixels (with N x M <= 32)
- cluster size CS <= 16 pixels
- sorting of clusters in ascending order of amplitude values
- compression ratio ca. 2x (no. of input bits / no. of output bits @ 10bit per pixel amplitude)
- minimum number of operations per pixel
- no inter-block prediction at decoder
- inter-block error tracking and correction at encoder

Some links providing background information:
http://en.wikipedia.org/wiki/Visual_system
http://en.wikipedia.org/wiki/Category:Vision
http://en.wikipedia.org/wiki/Contrast_(vision)#Contrast_sensitivity
http://en.wikipedia.org/wiki/Photopic_vision
http://en.wikipedia.org/wiki/Adaptation_(eye)

http://en.wikipedia.org/wiki/Retina
http://en.wikipedia.org/wiki/Visual_acuity
http://en.wikipedia.org/wiki/Spatial_frequency

A recent proposal of block based compression in time domain:

Fritz Lebowsky: " Optimizing color fidelity for display devices using contour phase predictive coding for text, graphics, and video content ", *Proc. SPIE* 8652, Color Imaging XVIII: Displaying, Processing, Hardcopy, and Applications, 86520X (February 4, 2013);
doi:10.1117/12.2006775; **http://dx.doi.org/10.1117/12.2006775**