BLIND MEASUREMENT OF BLOCKING ARTIFACTS IN IMAGES

Zhou Wang, Alan C. Bovik,

and Brian L. Evans

Laboratory for Image and Video Engineering, The University of Texas at Austin

(Email: zwang@ece.utexas.edu)

Introduction

- Block transform coding is widely adopted in most coding standards
- Blocking effect – discontinuities along block boundaries
- Blocking artifact is very annoying to human eyes

- Mean squared error (MSE) is not a good measure
- Blocking effect ***can*** be and ***should*** be measured ***blindly***
- Human visual system (HVS) features need to be considered

Blocking Effect

- Most image/video coding standards use block-based DCT
- Quantization is applied to DCT coefficients to achieve low bit rate
- Decoding is lossy
- Various decoding artifacts blocking, blurring, ringing, …
- Blocking artifact is usually the most significant

Blocking Effect Measurement

- Automatic quantitative estimation of blocking effect
- Applications
  - Quality assessment of compressed digital images and videos
  - Evaluation of image and video coding systems

- Encoder: optimize parameter selection and bit allocation
- Decoder: design post-processing algorithm

- Measurement Methods
  - Mean squared error (MSE)
  - Human visual system (HVS) based methods
  - Blind measurement …

Blind Measurement

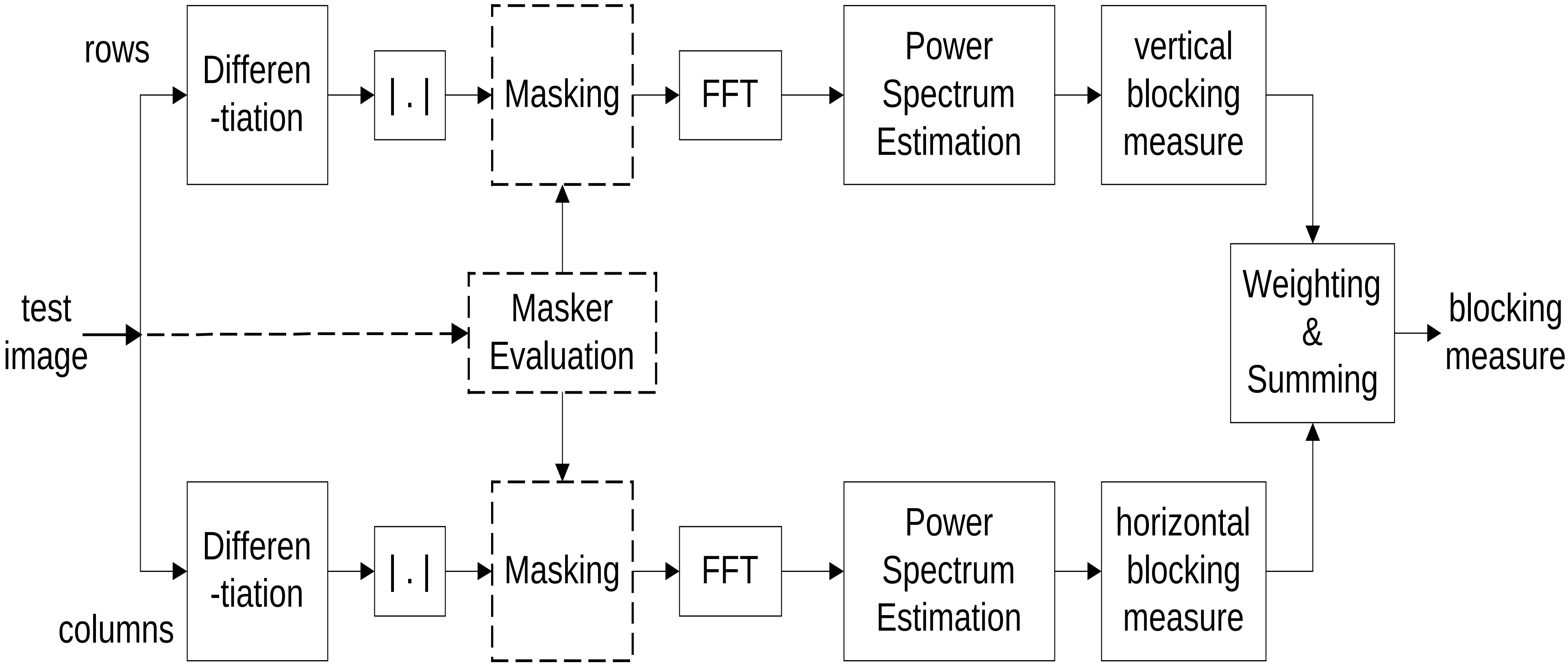
- Human eyes can easily perceive blockiness without looking at the original image
- Original reference images are not available
- Especially useful for the design of post-processing algorithm at decoder

- Previous method :

  Use weighted difference along block boundaries.

  – Cannot distinguish blockiness and the oscillation in the original signal
  – Sensitive to phase shift: Location of block boundaries must be exactly known

The Measurement System

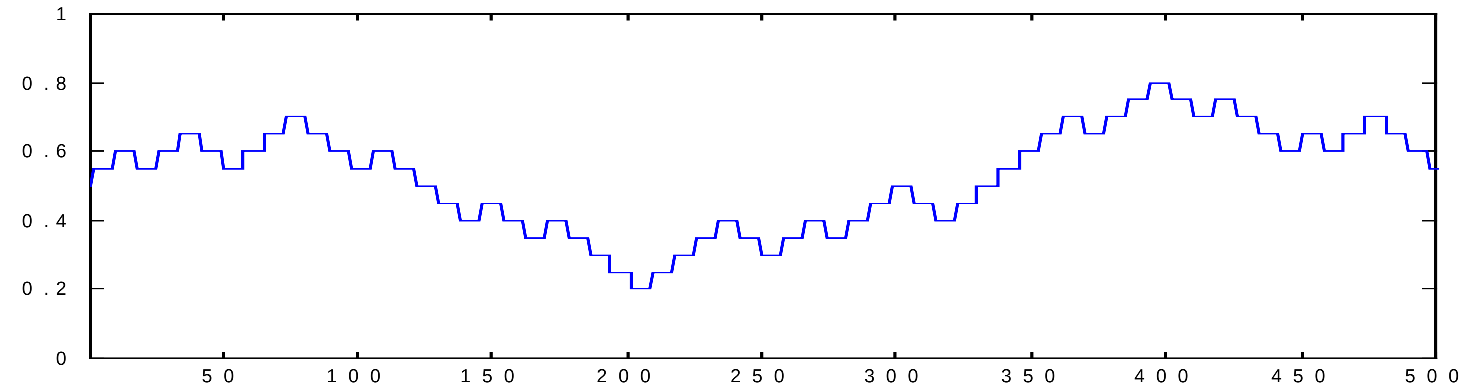


- Blocky Signal Modeling:

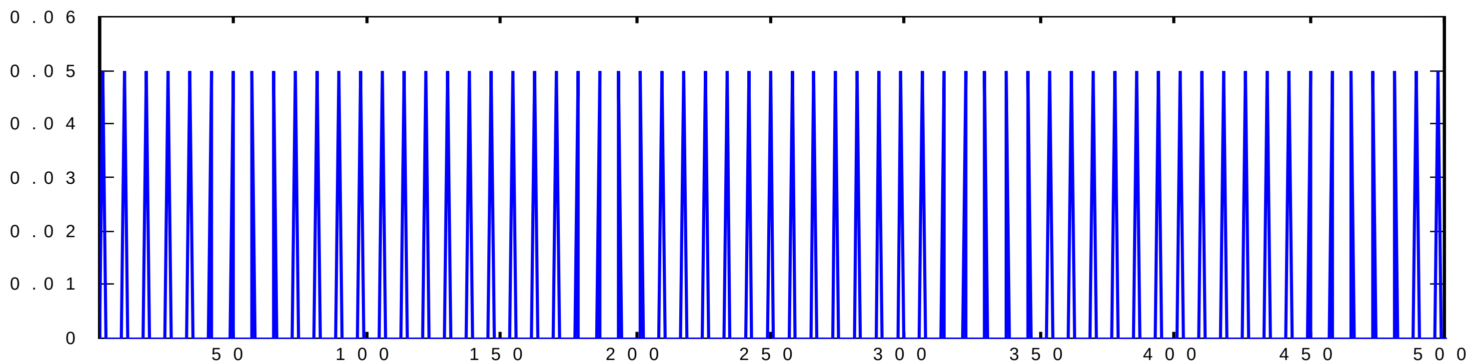
  Blocky signal = Original signal
  + Ideal blocky signal

- Measurement – Detect and estimate the power of the blocky signal in the blocky image

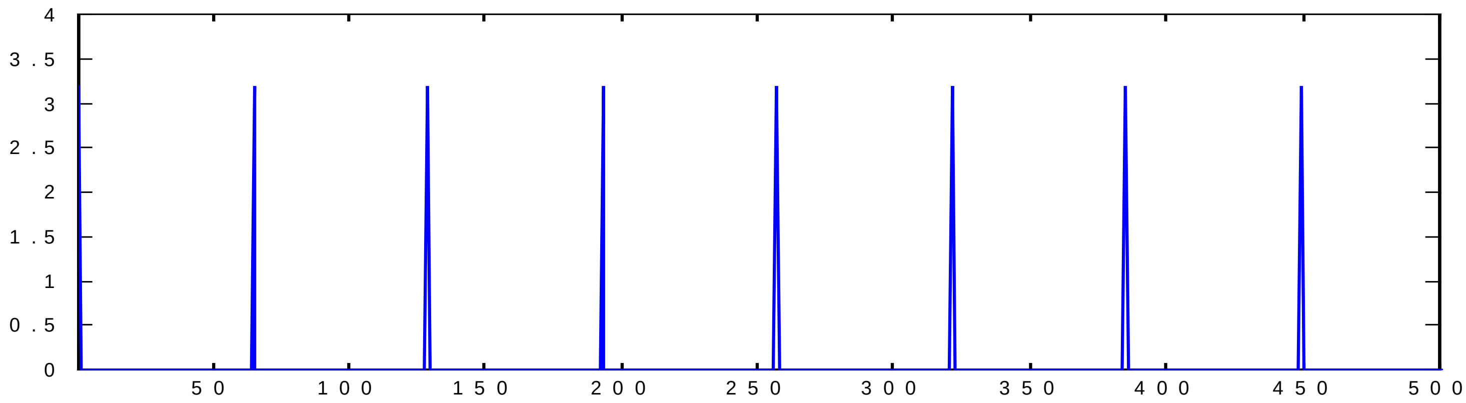
Ideal Blocky Signal



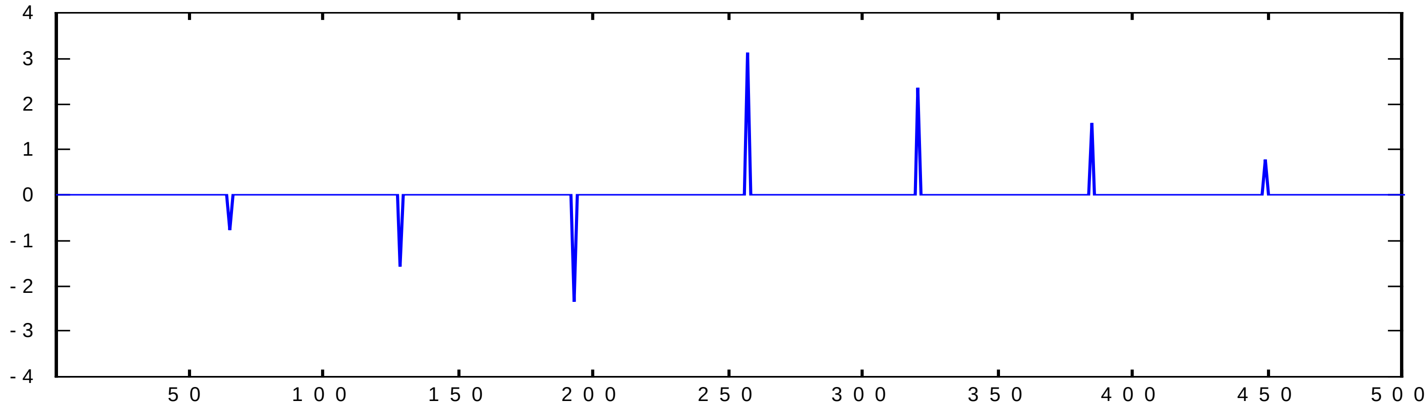
Ideal 1-D blocky signal



Absolute difference signal

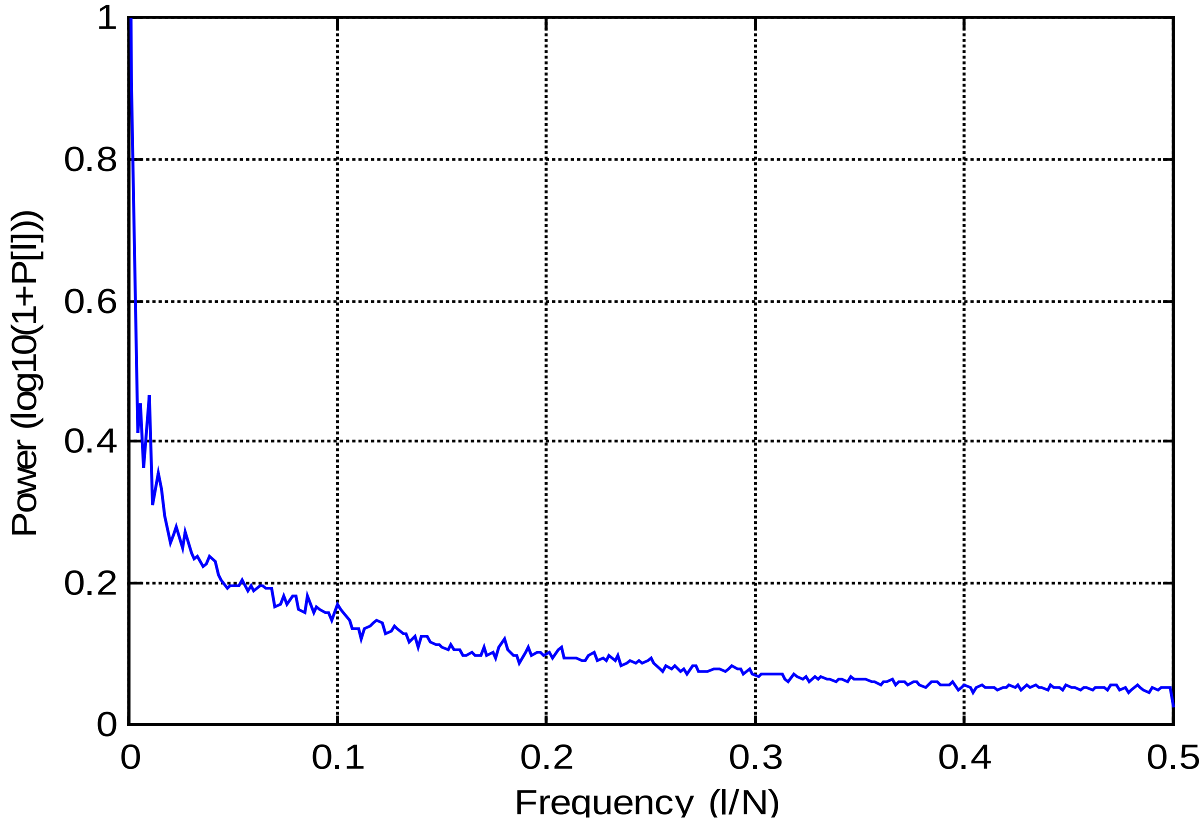


Magnitude of FFT result

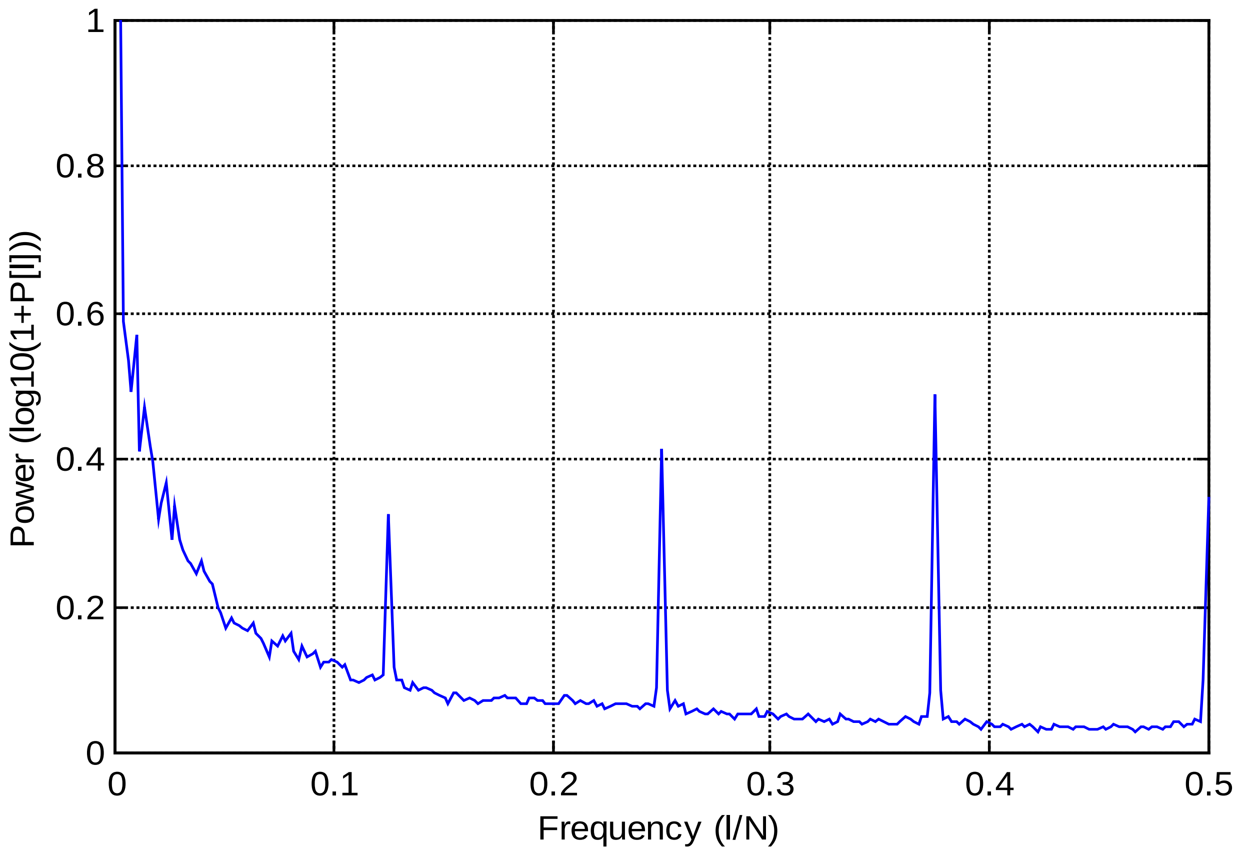


Phase of FFT result

Power Spectrum Analysis

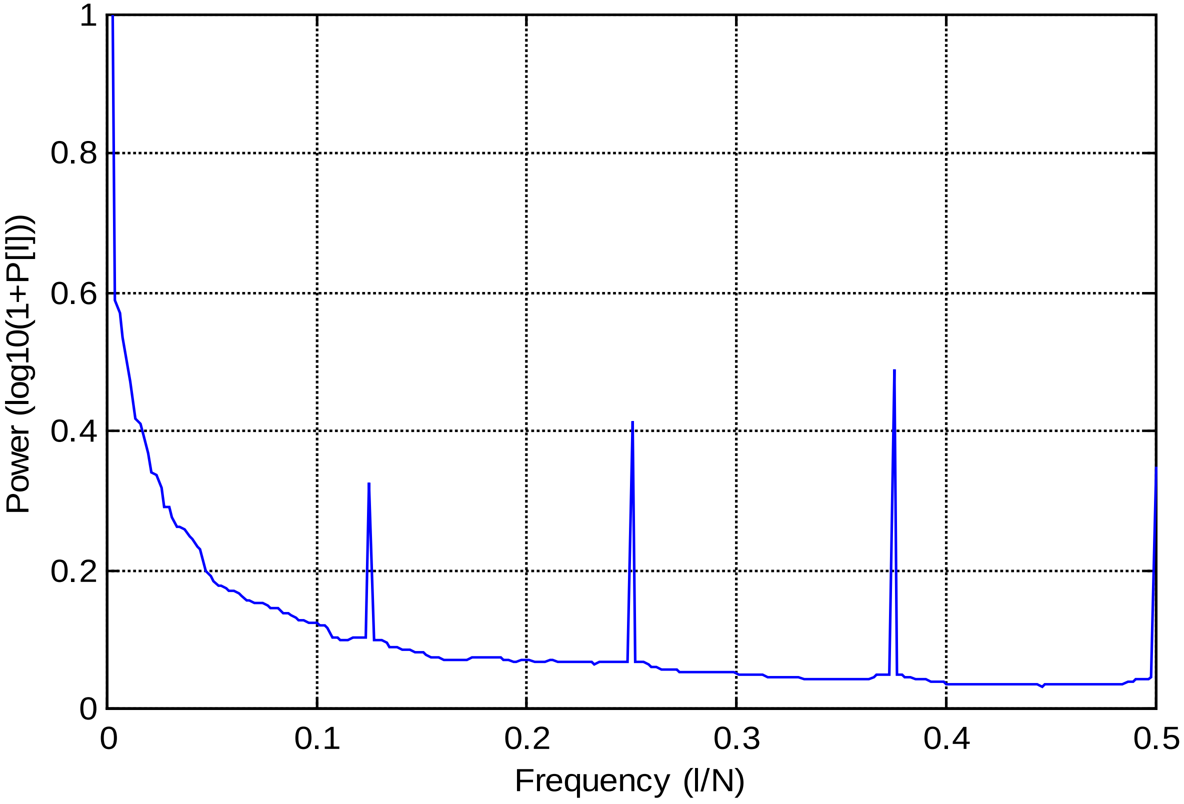


Power spectrum of the original image



Power spectrum of the blocky image

Power Spectrum Analysis (Cond.)



Smoothed power spectrum of the blocky image

- Power Spectrum $\boldsymbol{P}$:

$$\boldsymbol{P} = \{P[l];\ 0 \le l \le N/2\}$$

- Median Filtered Power Spectrum $\boldsymbol{P}_M$:

$$P_M[l] = Median\{P[l-K], \cdots, P[l], \cdots, P[l+K]\}$$

- Smoothed Power Spectrum $\boldsymbol{P}_M$:

$$P_S[l] = \begin{cases} P[l] & l = N/8,\ 2N/8,\ 3N/8,\ or\ 4N/8 \\ P_M[l] & otherwise \end{cases}$$

Blockiness Measure

- Power of blockiness:

$$M_{Bv} = \sum_{i=0}^{4} (P[\frac{iN}{8}] - P_M[\frac{iN}{8}])$$

- Energy of natural images highly concentrates on low frequency bands – disturb the blockiness measure at 0 frequency.

- To avoid disturbance and maintain total power, define:

$$M_{Bv} = \frac{8}{7}\sum_{i=1}^{4}(P[\frac{iN}{8}] - P_M[\frac{iN}{8}])$$

- Overall Blockiness Measure – average of horizontal and vertical measure:

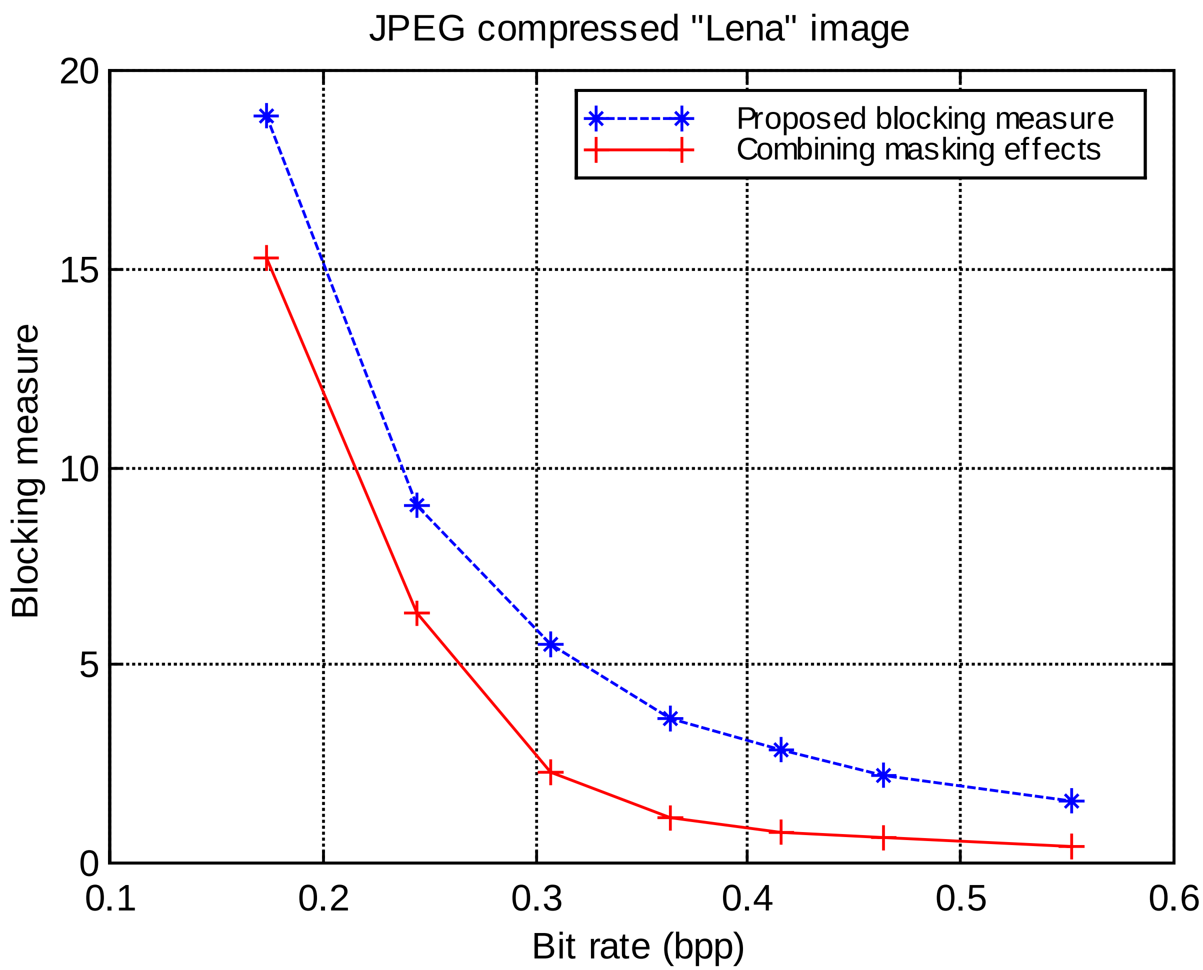
$$M_B = 0.5(M_{Bv} + M_{Bh})$$

Masking Effect

- Masking – Reduction in the visibility of one image component (the target) due to the presence of another
- Two kinds of masking effect – texture masking and luminance masking

- Our system is flexible to incorporate masking effect
  - Masker evaluation results in a masker map for each pixel in the image
  - The masker map is then used to scale the image.
  - Other components of the system keep unchanged.

Results


JPEG compressed "Lena" image
Blocking measure
Bit rate (bpp)
Proposed blocking measure
Combining masking effects
0
5
10
15
20
0.1
0.2
0.3
0.4
0.5
0.6

Blocking effect measurement result for JPEG compressed “Lena” image

- The blocking effect decreases very fast with increasing bit rate – almost no visible blockiness at 0.5bpp or higher
- The same algorithm is applied to non-blocky images (e.g. wavelet coded images) – zero blockiness

Conclusions and Future Work

- We propose a new blocking effect measurement algorithm with the following features:
  - Blind measurement
  - Can distinguish blockiness and discontinuities in the original signal

- Insensitive to phase shift

- Future work
  - Use higher-order statistics
  - Fast implementation
  - Combine with image and video coding algorithms
  - Design post-processing algorithms