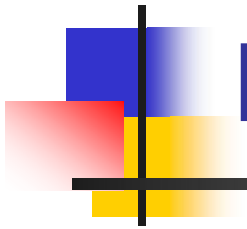
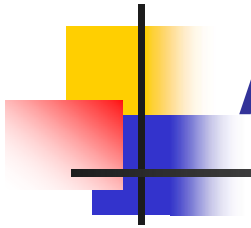


Methods of artifacts reduction in DCT-based mobile video coding

A. Veselov

I. Grohotkov

M. Gilmutdinov



Agenda

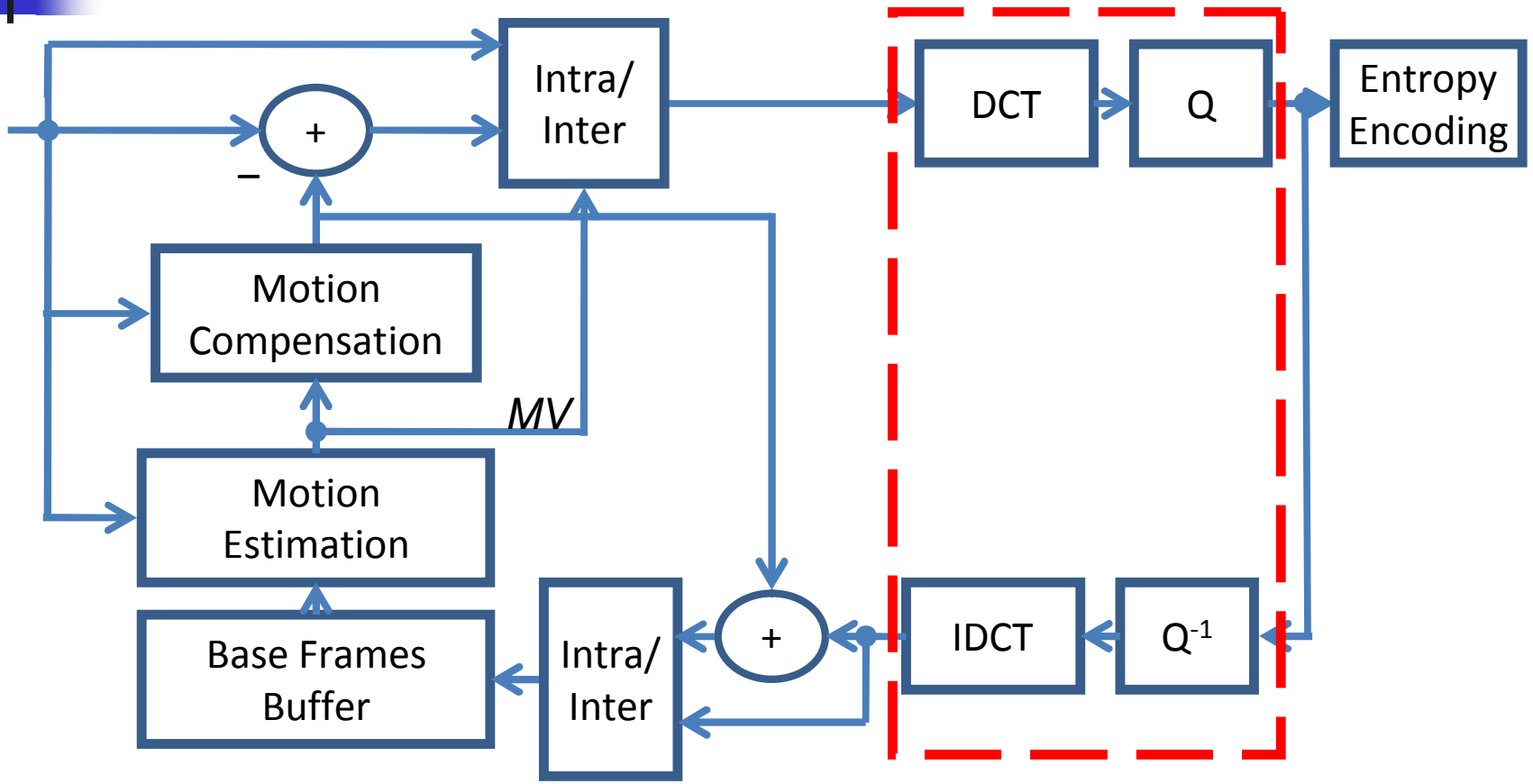
- Main Features of Mobile Video
- Artifacts Nature and Classification
- Artifacts Estimation
- New Type of Artifacts Definition
  - Nature
  - PSNR Gain for “perfect” artifact reduction method
- Further Investigations

Mobile Video: Main Features

- Concerns mobile phones, smart phones, PDAs etc.
- Main mobile video features:
  - High compression ratio
  - Low video quality
  - Low complexity implementations of standards
    - MPEG-2
    - MPEG-4

Lossy Standards

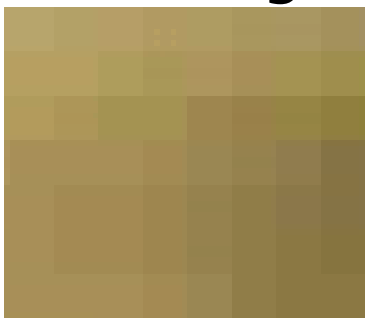
Typical Lossy Coder Scheme



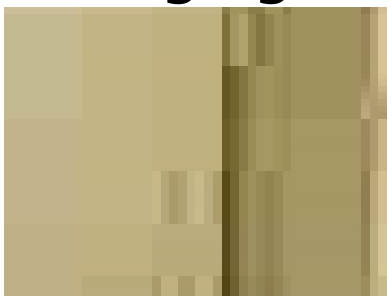
Artifacts Classification

Artifact - visual effect of quantization noise

- Blocking

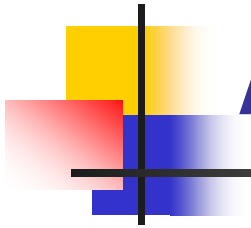


- Ringing



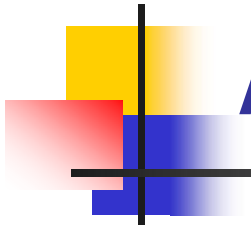
- Mosquito

Goal: artifacts estimation and reduction



Artifacts Reduction Methods

- Usage of Video Filters
  - General Purpose Filters
    - Spatio-Temporal Filters
  - Specialized Filters
    - **De-Blocking Filters**
    - De-Ringing Filters
    - De-Mosquito Filters

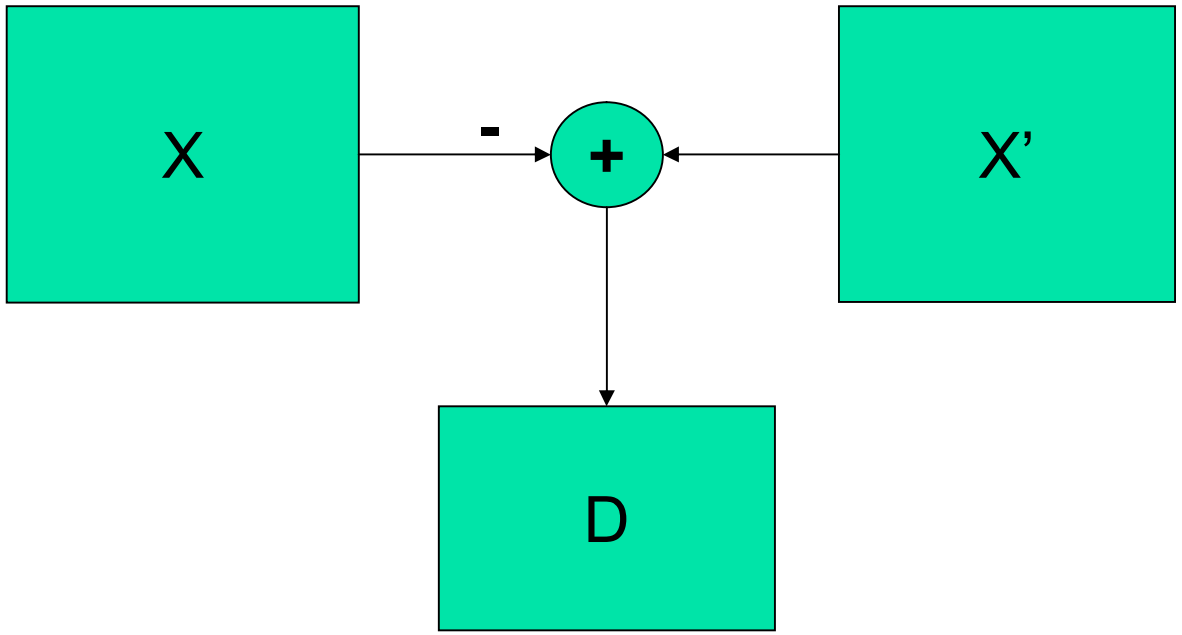


Artifacts Estimation

- Conventional Techniques (like PSNR, SSIM etc.)
- Non-conventional techniques:
  - 2D Variance (for research purposes)

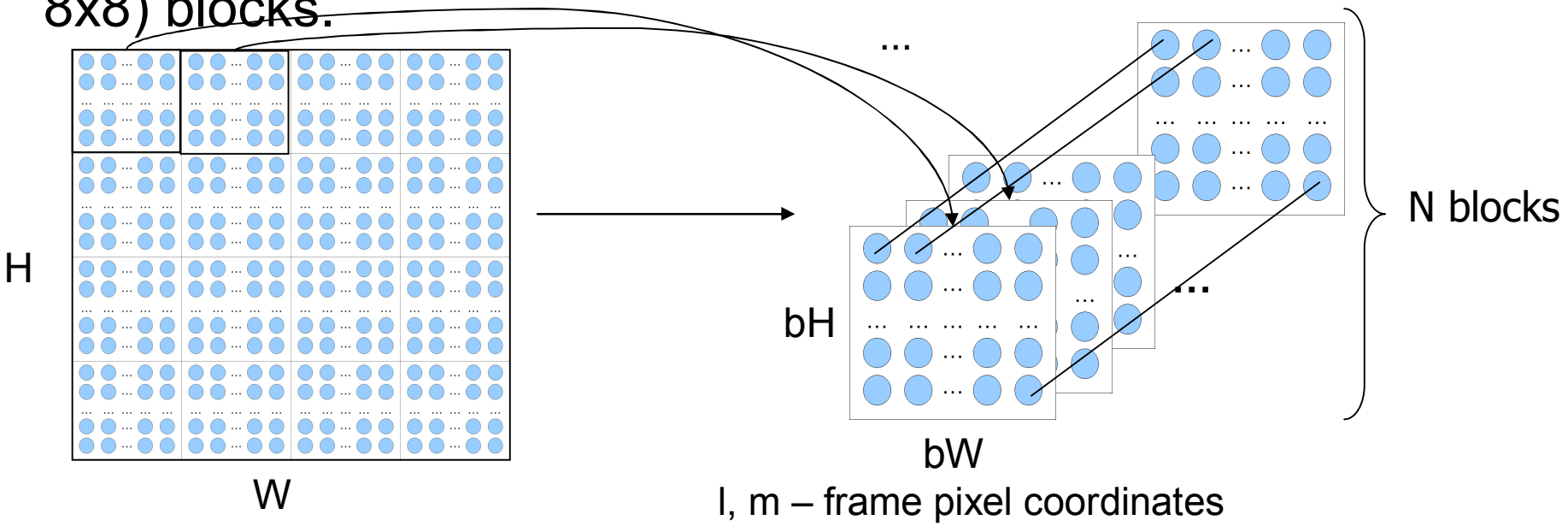
2D Variance

1. A difference frame D between reference frame X and estimated frame X’ is calculated



2D Variance

2. **W**x**H** frame D is divided into non-overlapping **bW**x**bH** (e.g. 8x8) blocks.



New pixels enumeration:

$$d(l,m) \Rightarrow d(i,j,k)$$

l, m – frame pixel coordinates
i, j – block pixel coordinates
k – block number

2D Variance

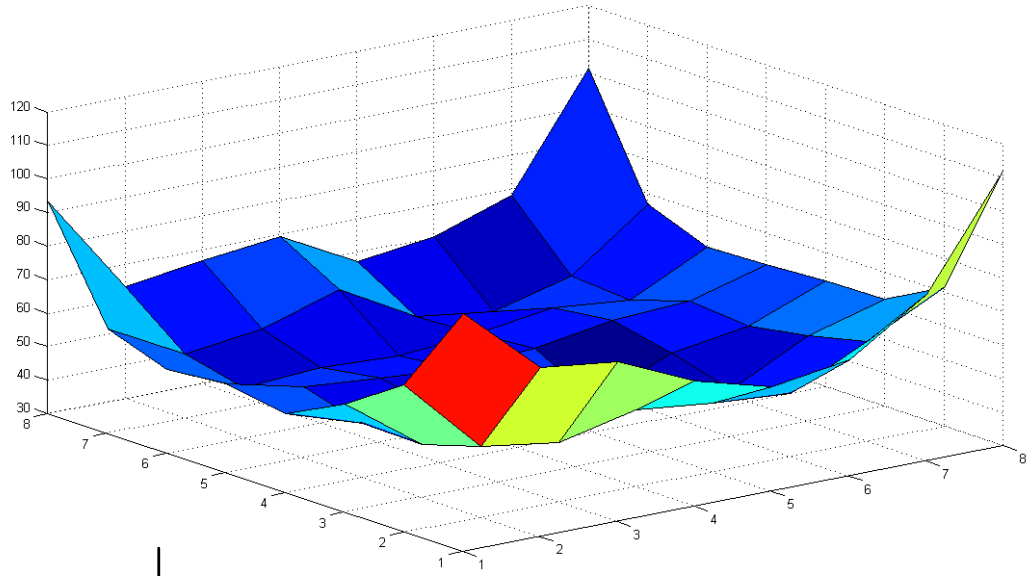
3. Calculation of the 2-nd order initial moment (mean squared error for pixels) for the pixels located on the same positions in different blocks of the frame.

$$V_{i,j} = \frac{1}{N}\sum_{k=0}^{N-1} d_{i,j,k}^{\ 2} = MSE_{i,j}$$

i, j – block pixel coordinates
k – block number
N – number of blocks in the frame

$$2\mathrm{Dvar} = \begin{vmatrix} V_{0,0} & \cdots & V_{0,bW-1} \\ \cdots & \cdots & \cdots \\ V_{bH-1,0} & \cdots & V_{bH-1,bV-1} \end{vmatrix}$$

2D Variance: Graphical Representation



$$2\text{Dvar} = \begin{vmatrix} V_{0,0} & \cdots & V_{0,bW-1} \\ \cdots & \cdots & \cdots \\ V_{bH-1,0} & \cdots & V_{bH-1,bV-1} \end{vmatrix}$$

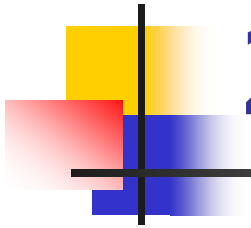
2D Variance to PSNR

1. **Calculate frame MSE through elements of 2D Variance matrix**

$$MSE = \frac{N}{H * W} \sum_{i=0}^{bH-1} \sum_{j=0}^{bW-1} V_{i,j}$$

2. **Use calculated frame MSE value in PSNR formulae**

$$PSNR = 10 * \lg \frac{255^2}{MSE}$$



2D Variance Application

- Apply 2D Variance for MPEG coded video sequence (block size is 8x8 pixels)
- Watch the performance of de-noising algorithms (e.g. de-blocking) for specific pixels

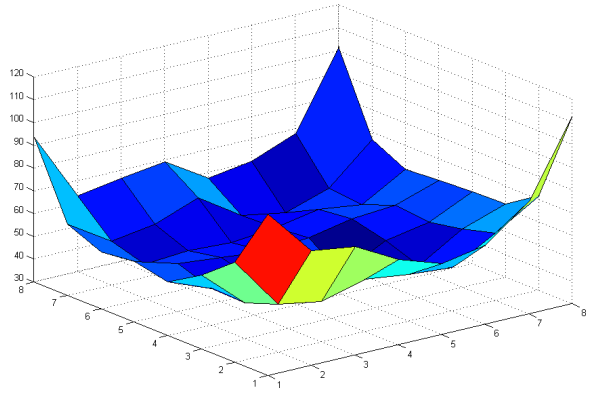
Using 2D Variance for Reconstructed Frame Noise Level Estimation: Test Images

Compressed With Q = 25

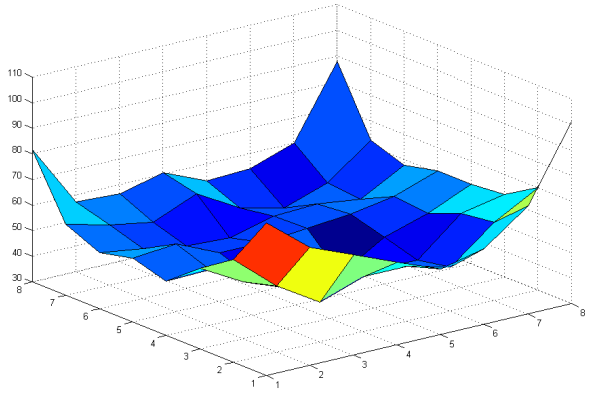
De-blocked (using Xvid De-block)

2D Variance For Hall

Compressed With Q = 25



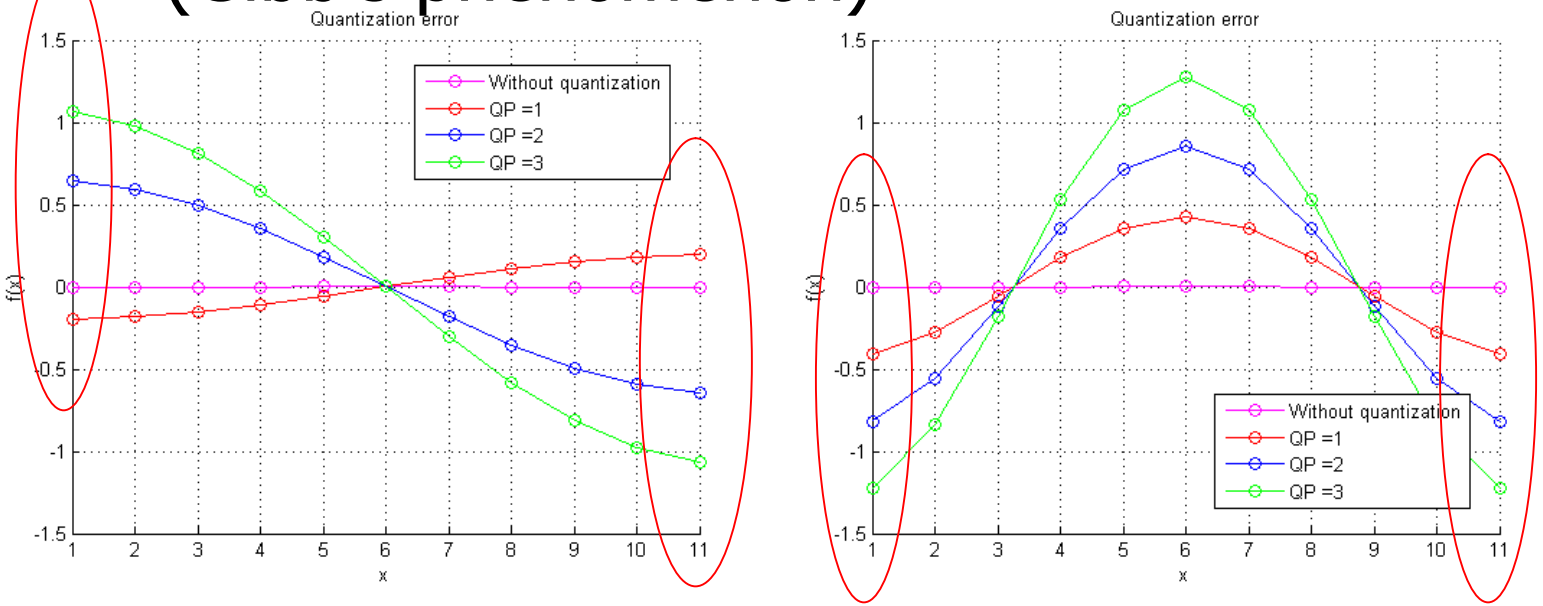
De-blocked

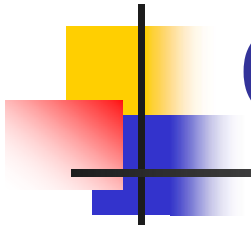


- De-blocking algorithm reduces 2D variance on block borders (average gain for borders is about 5)
- De-blocking algorithm poorly processes corners of the block

Peakes Nature

- For “real” images energy is concentrated in low-frequency components of DCT. Their quantization lead to severe errors in borders (Gibb’s phenomenon)





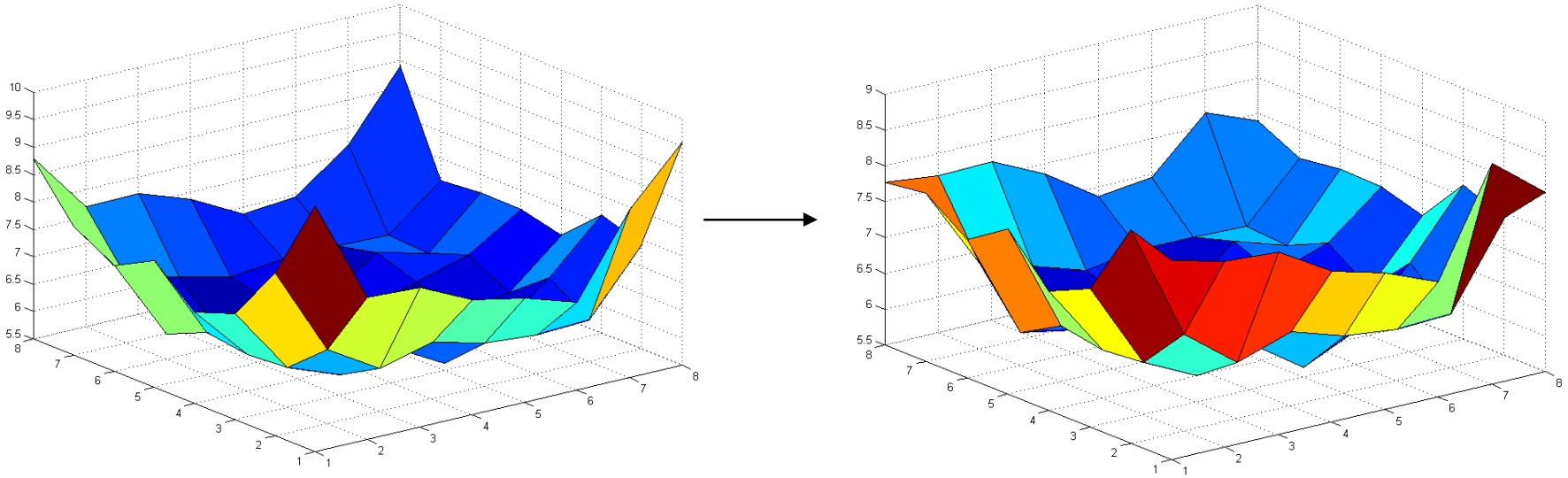
Corner Outliers

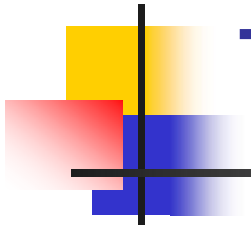
- For “real” images 2D Variance has 4 peakes in corners
- These peakes remain after filtration by the existing de-blocking algorithms (e.g. Xvid)
- A new type of artifacts – **corner outliers***

* “Detection Method and Removing Filter for Corner Outliers in Highly Compressed Video”, Jongho Kim, Kicheol Jeon, and Jechang Jeong, 2006

PSNR Gain Calculation

Consider an “ideal” filter for corner outliers reduction:

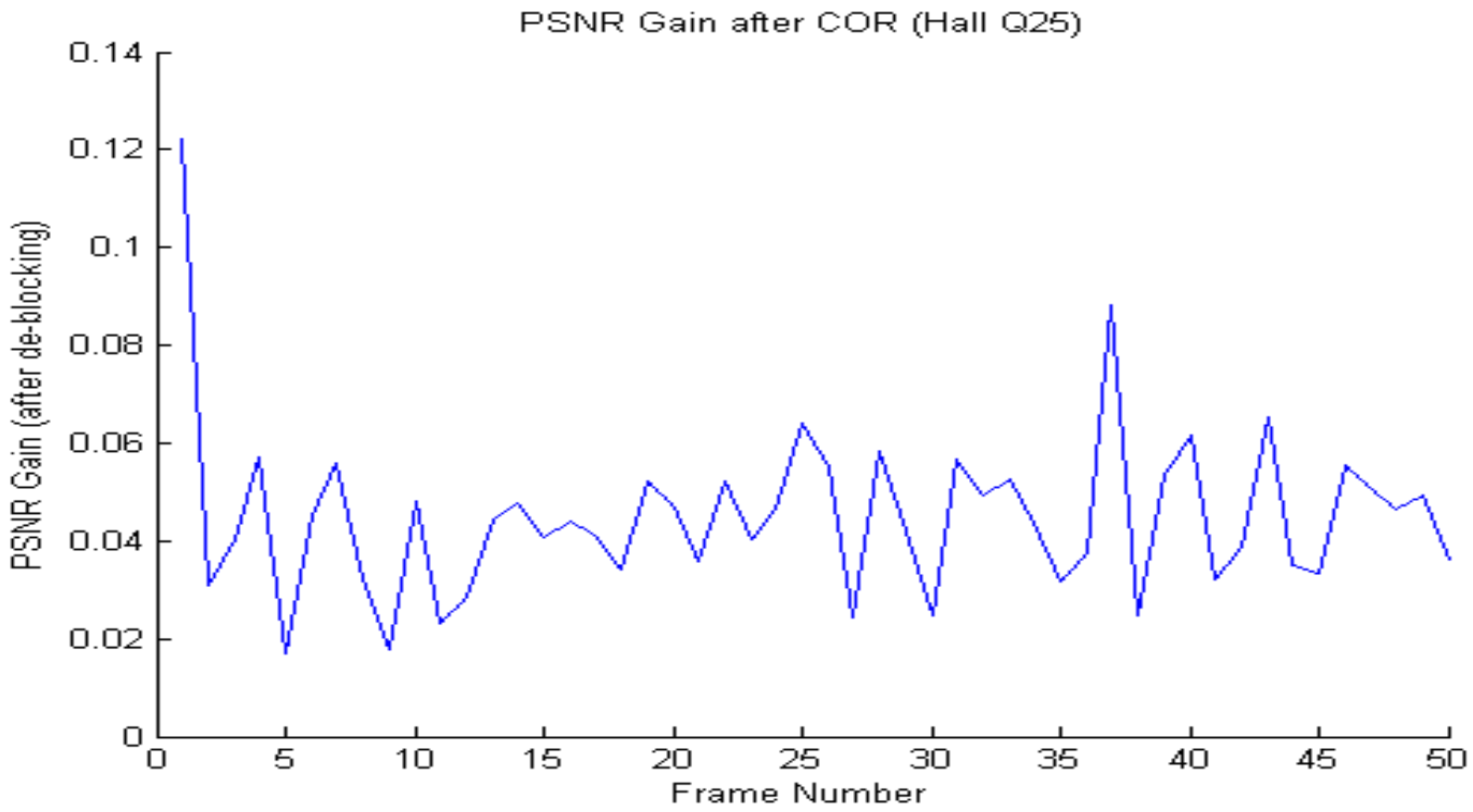




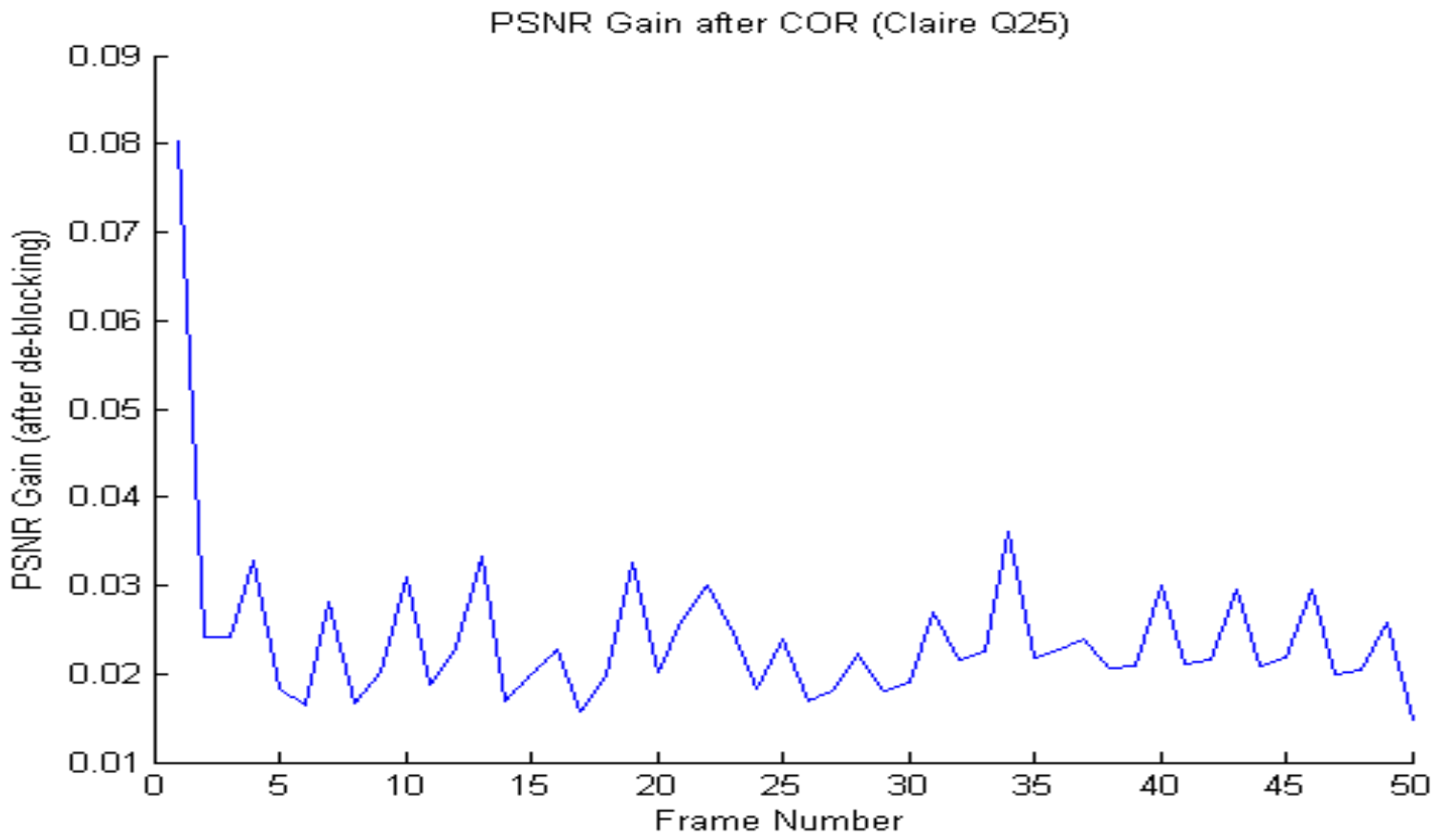
Test Set

- Hall
  - Mainly static
- Deep
  - Mainly non-static
- Claire
  - Static background
  - Movement in center

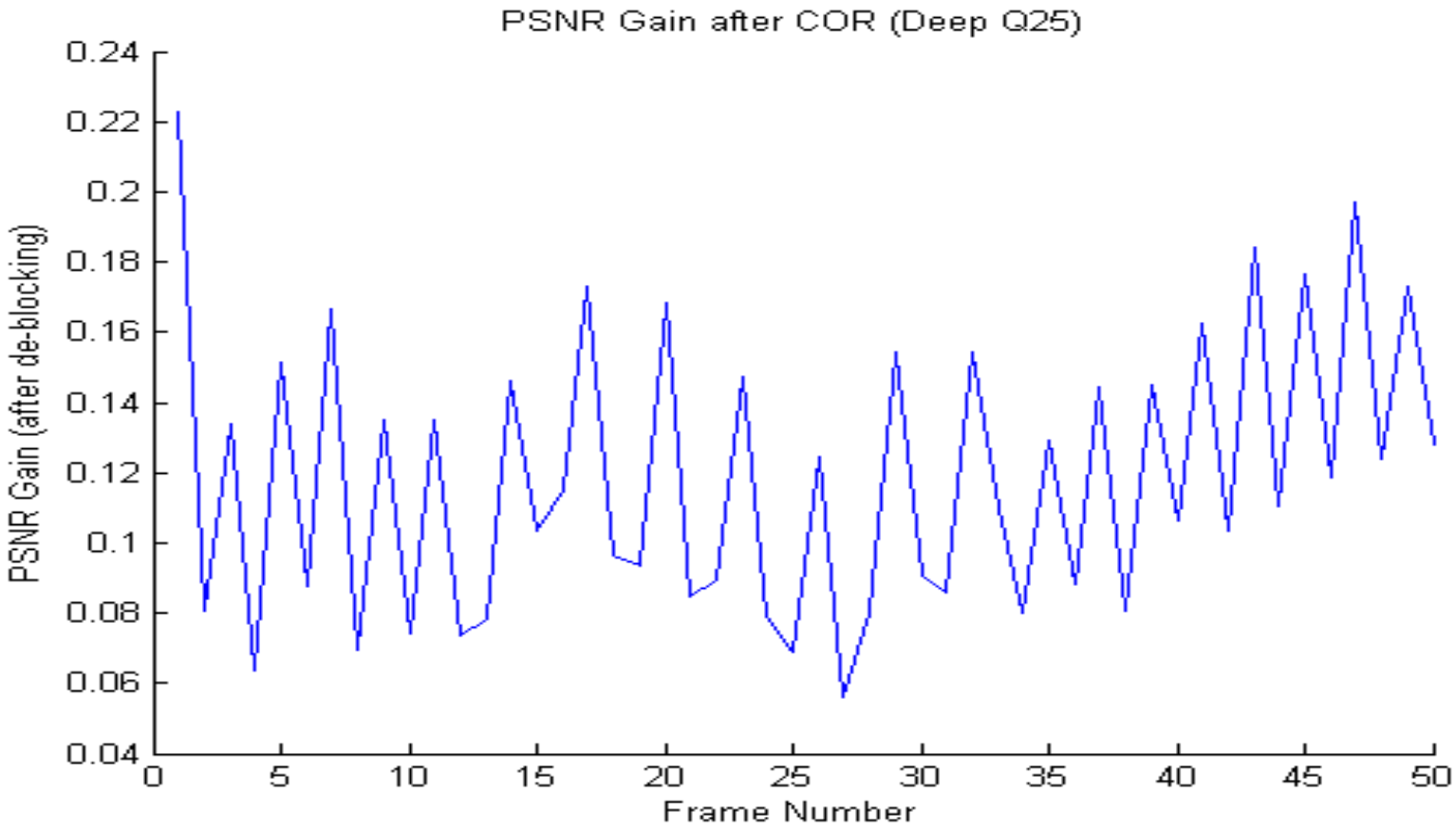
PSNR Gain (Hall)

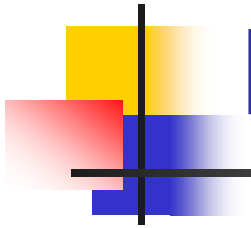


PSNR Gain (Claire)



PSNR Gain (Deep)





Future Plans

- Further research of the artifacts nature
- Research and implementation of quality estimation techniques
- Research and implementation of de-noising algorithms

Thank You For Your Attention.

Questions?