Extending HEVC by an affine motion model

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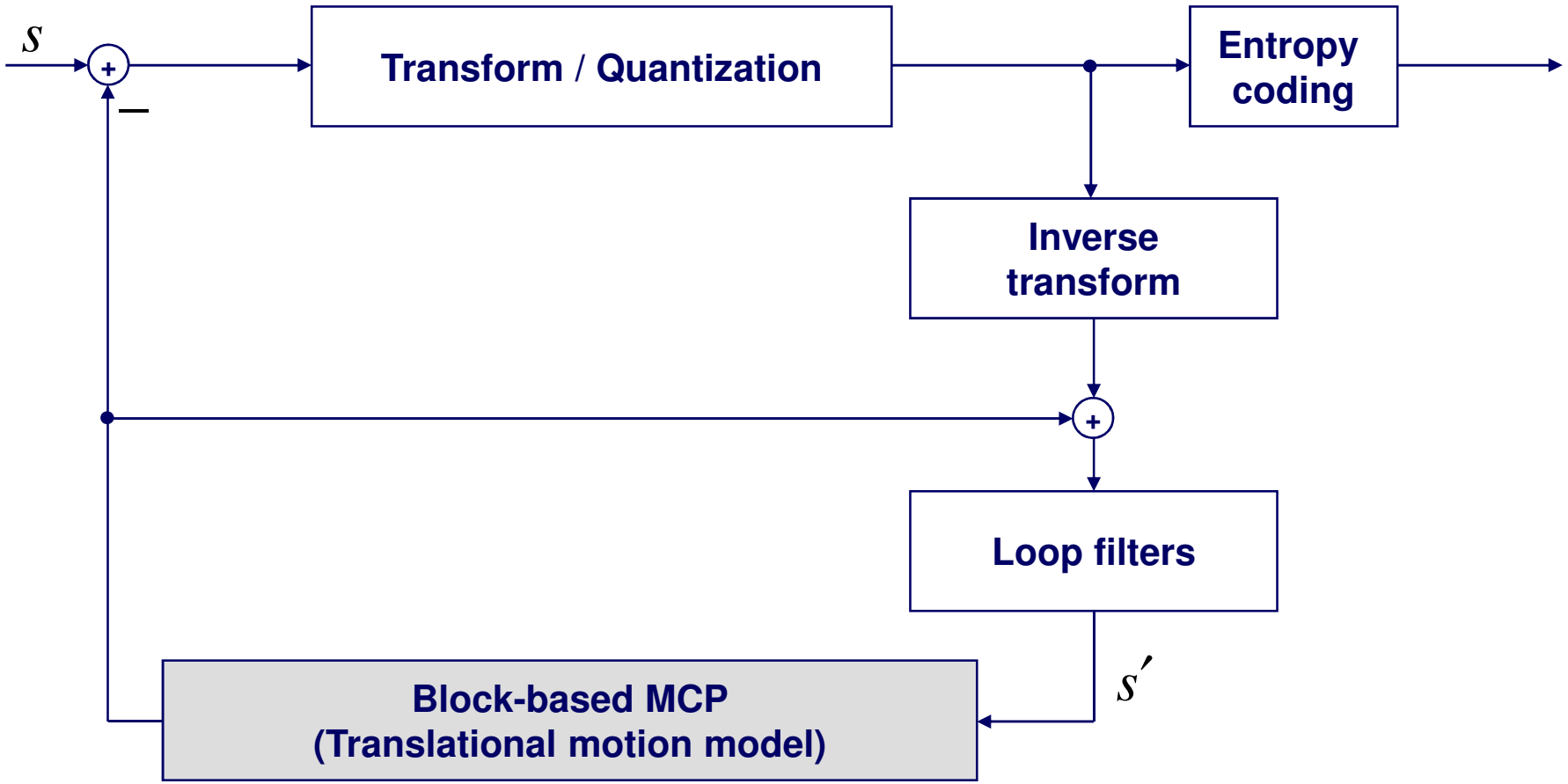
Outline

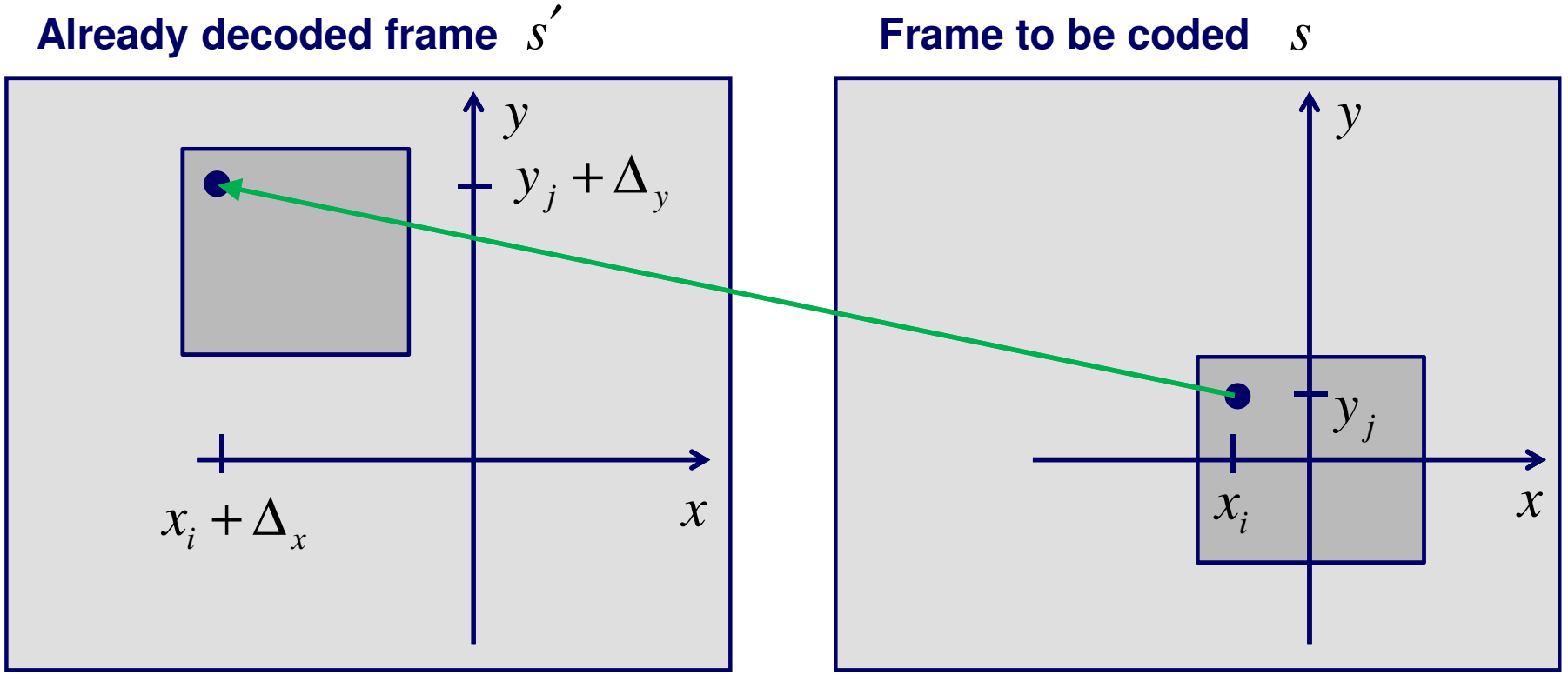
- Introduction
- Extending HEVC by an affine motion model
- Experiments and results
- Conclusion

Block diagram of an HEVC encoder



MCP: Motion compensated prediction

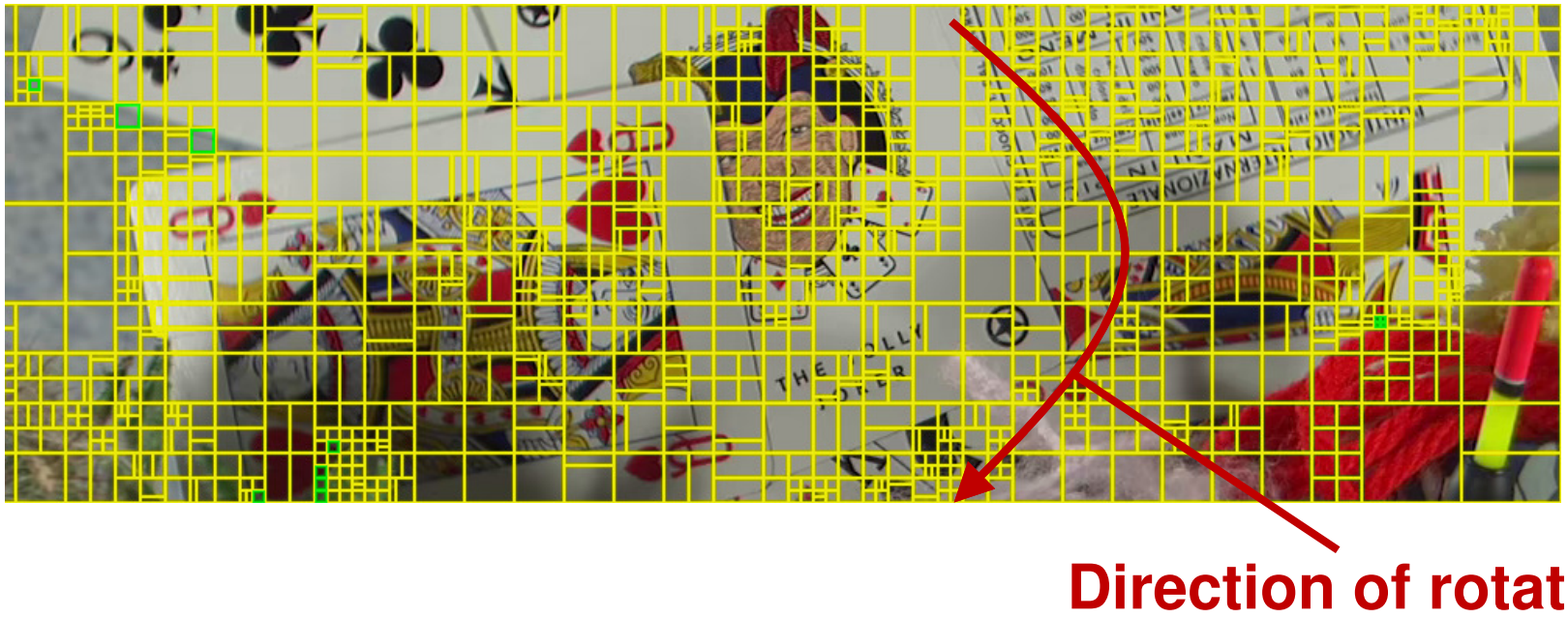
Translational motion model



Motion description by two-parameter displacement vector: $\begin{pmatrix} \Delta_x \\ \Delta_y \end{pmatrix}$

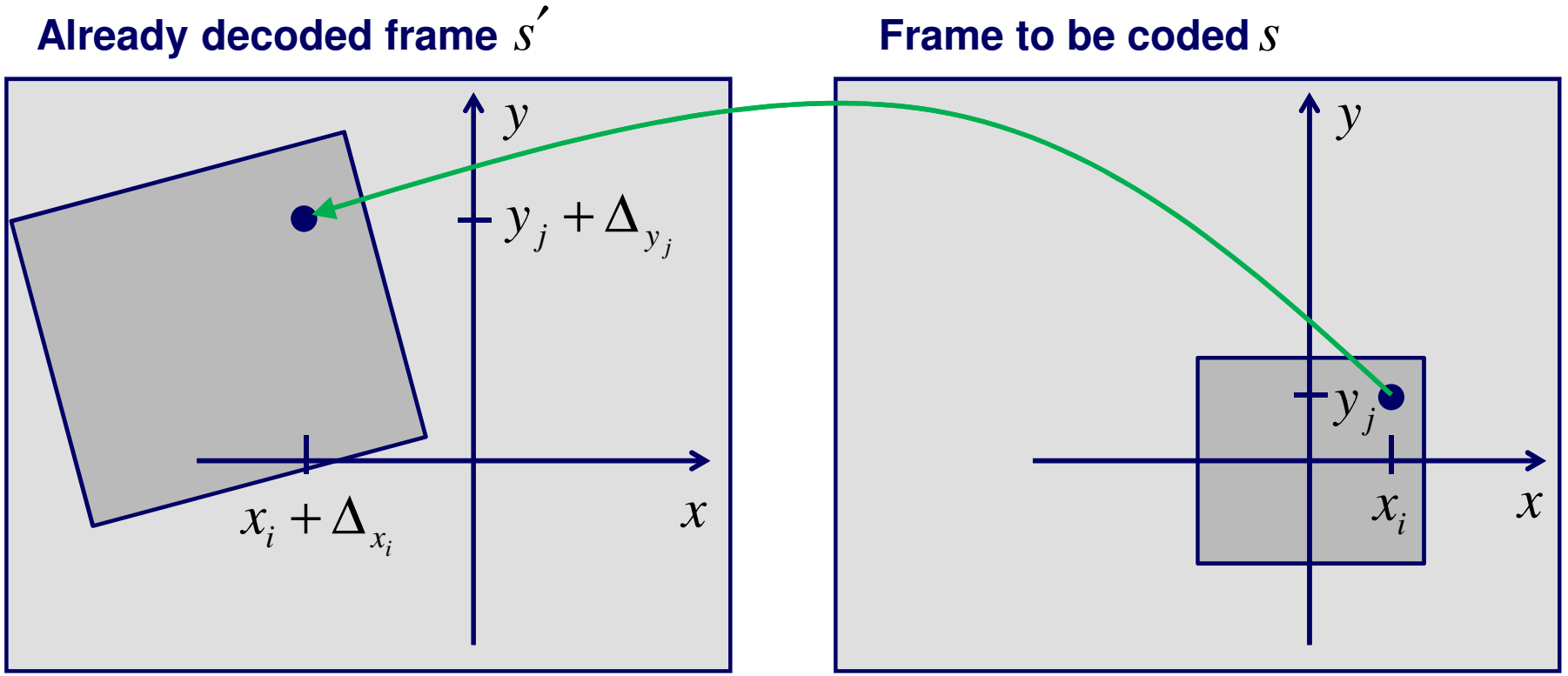
Not possible to describe complex motion as rotation, zoom

HEVC block partitioning in case of rotation



- Numerous small blocks to approximate description of rotation
- **Problem**: High data rate due to transmission of
  - Displacement vector for each of the numerous small blocks
  - Large prediction error resulting from inaccurate description of motion

Affine motion model to describe complex motion



$$\Delta_{x_i} = a_1 + a_3 \cdot x_i + a_5 \cdot y_j$$

$$\Delta_{y_j} = a_2 + a_4 \cdot x_i + a_6 \cdot y_j$$

Description of complex motion with six-parameter vector:

$$\begin{pmatrix} a_1 \\ \vdots \\ a_6 \end{pmatrix}$$

Motivation

- **State of the art**
  - HEVC applies block-based MCP with a translational motion model, which cannot describe complex motion
  - Affine motion model can describe complex motion and has been investigated for block-based and global MCP on standards preceding HEVC with block sizes limited to 16x16 samples

- **Problems**
  - Block-based MCP:

    For small blocks, the data rate increase due to additional model parameters is often larger than the data rate reduction achieved by more accurate prediction

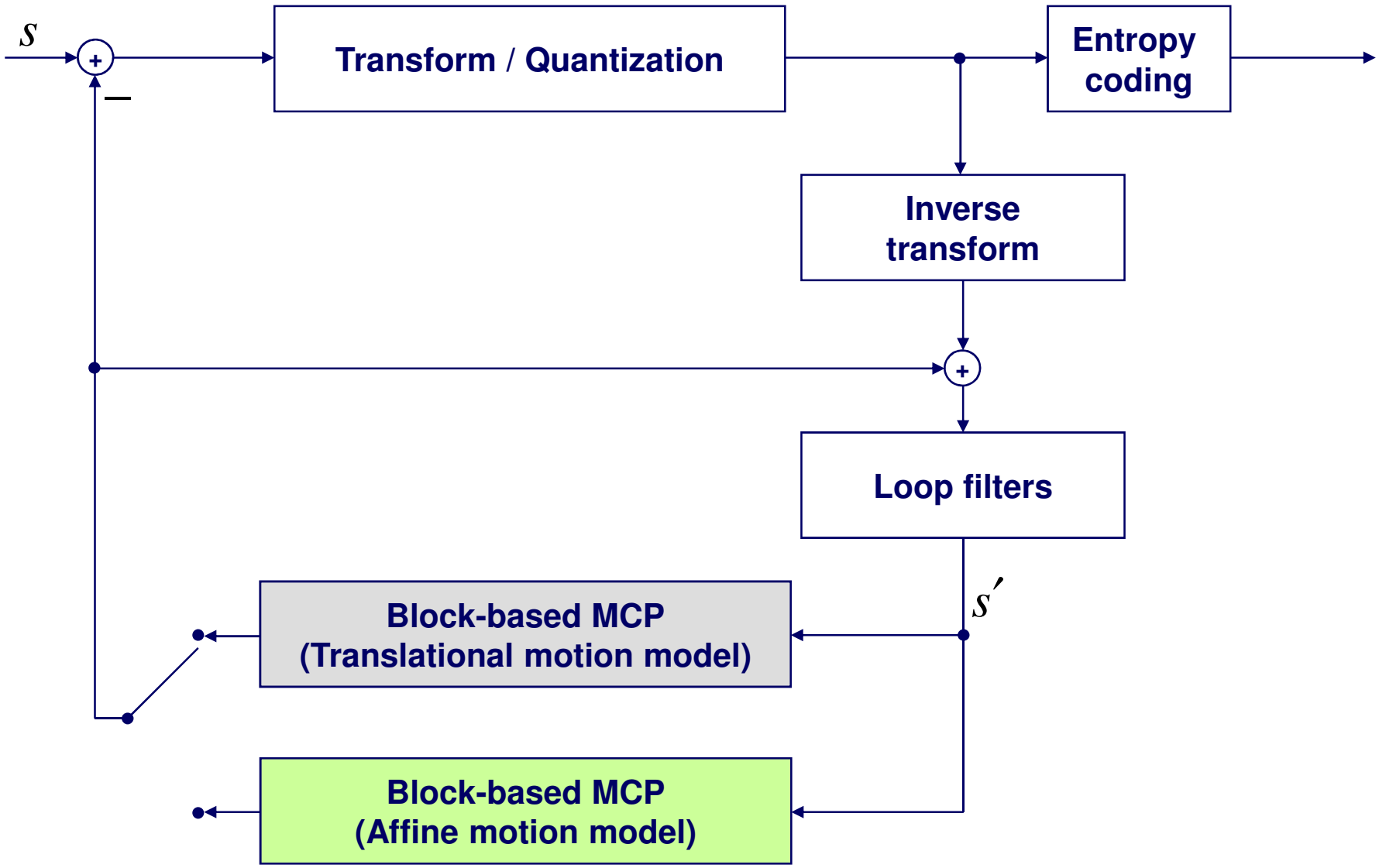
  - Global MCP:

    Inaccurate prediction in the case of diverse local motion

- **Investigation**

  Block-based MCP with affine motion model based on HEVC, which uses increased block sizes of up to 64x64 samples

Block diagram of the investigated encoder



Encoder control for each block

- Iterative estimation of affine model parameters by minimizing estimated RD costs (Convergence best for small motion)

- Motion model is selected by minimizing estimated RD costs

Coding

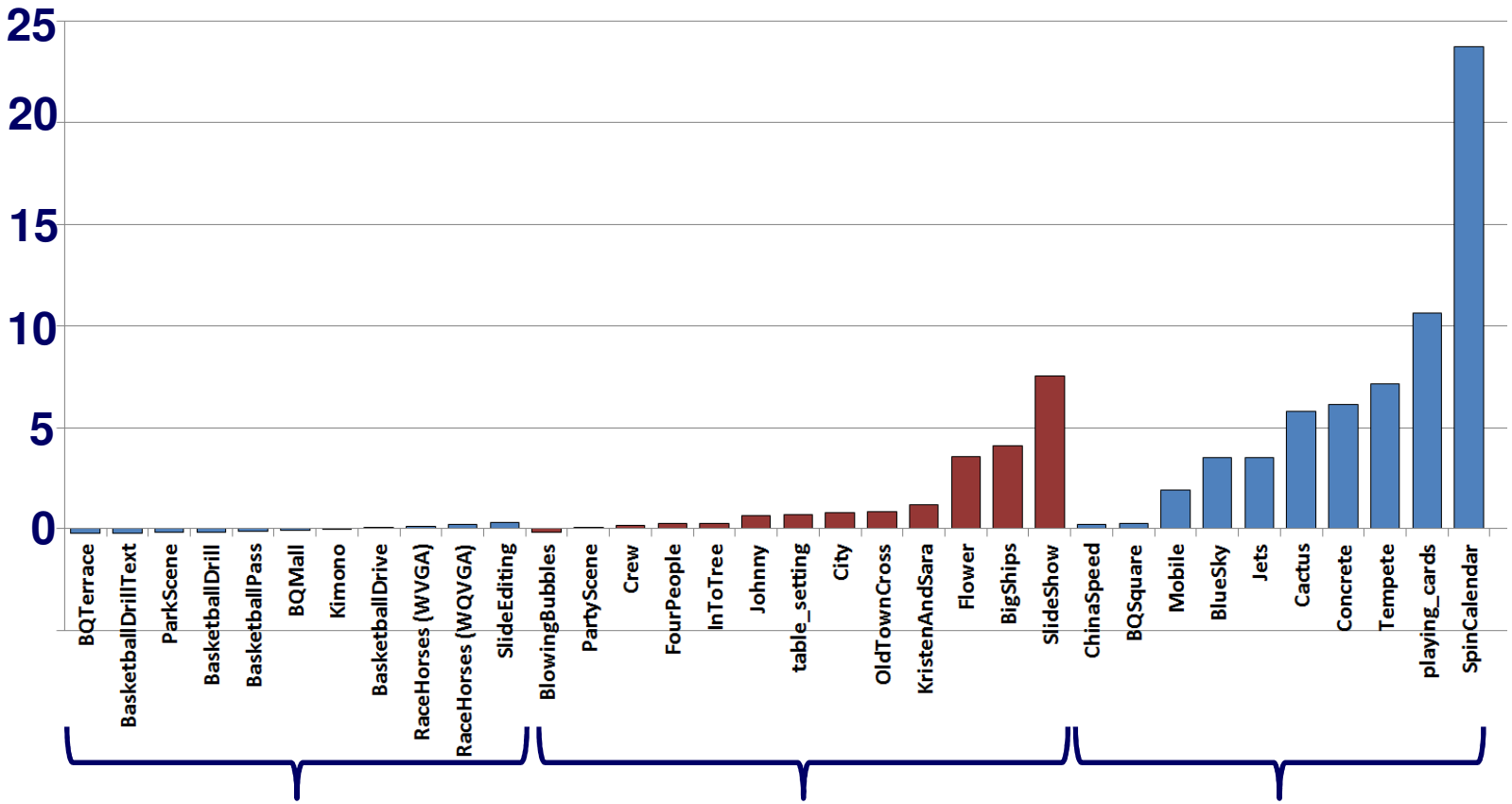
- Estimated parameters of the affine model
  - Uniform quantization with step sizes
    - 1/16 for a_1, a_2
    - 1/512 for $a_3, \ldots, a_6$
  - Prediction followed by CABAC of prediction error
- Selected motion model: CABAC

Experiments

- Reference: HEVC (HM7)
- Investigated: HEVC (HM7) + Affine motion model
- JCT-VC test conditions
  - Prediction structures: Low Delay, Random Access
  - 4 different quantization step sizes for each sequence
  - Calculation of average bit rate reduction at the same PSNR according to the method proposed by Bjontegaard

Results of experiments for Low Delay prediction structure

Average bit rate reduction at the same PSNR [%]



Sequences of mainly translational motion

Average: 0%

Sequences of mixed motion, translational and non-translational

Average: 1.5%

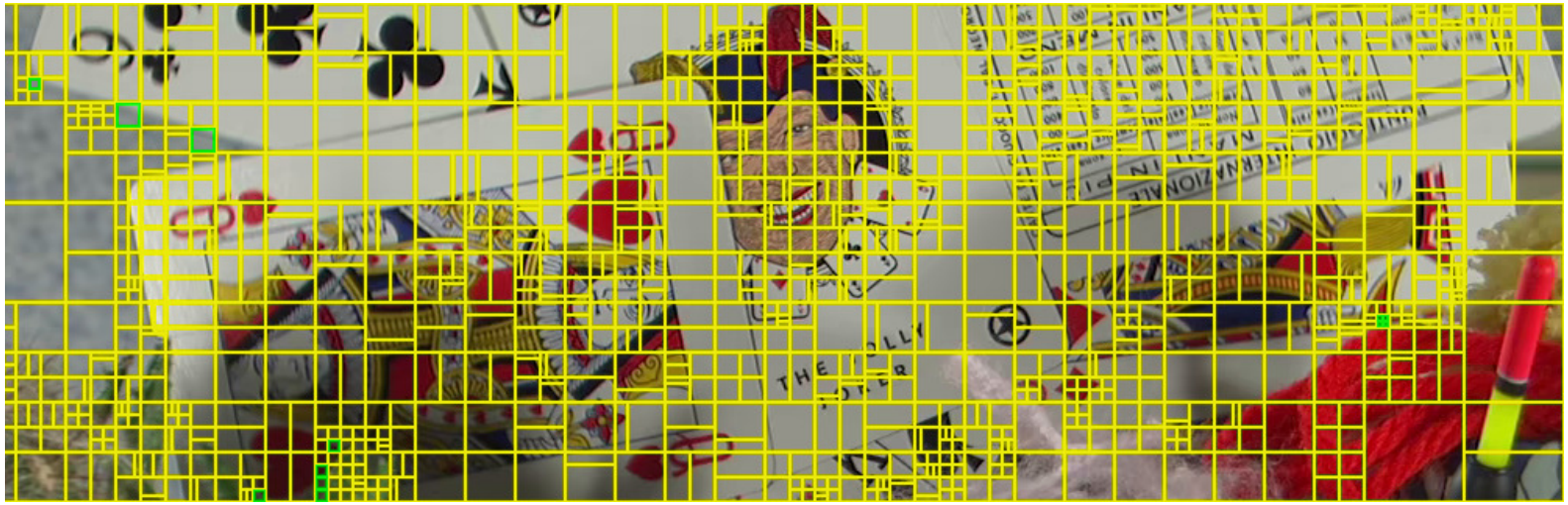
Sequences of mainly non-translational motion

Average: 6.3%

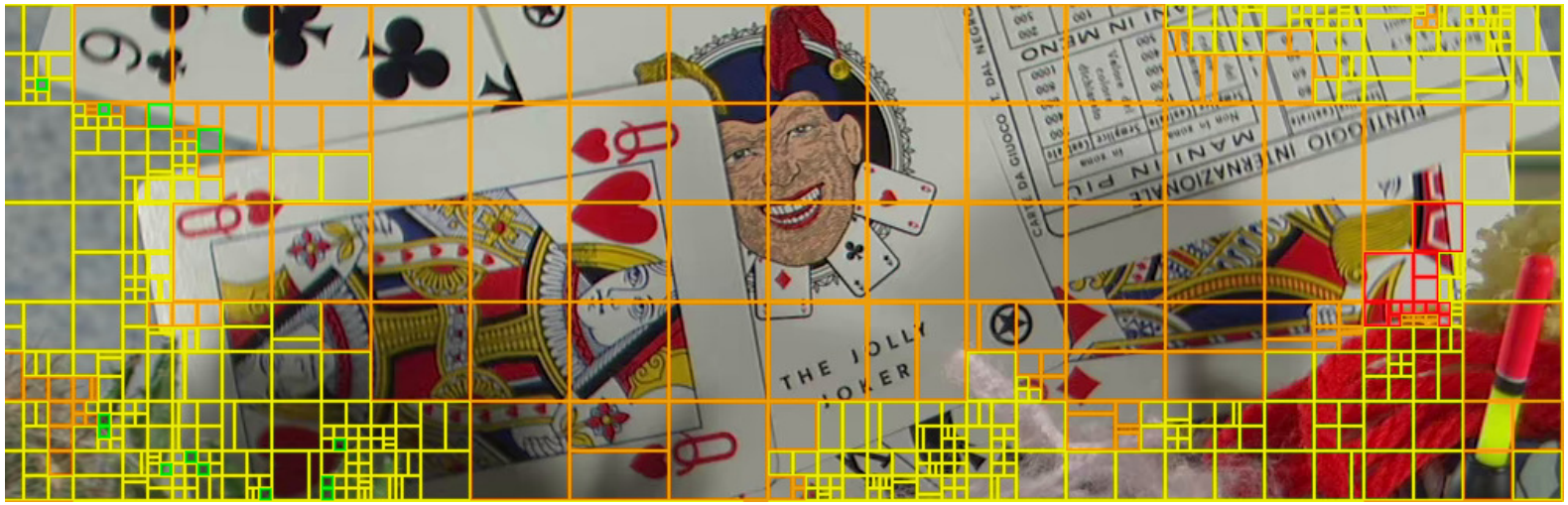
Random Access: 3.7% on average

Block partitioning in case of rotation

HEVC



HEVC
+
Affine
motion model



➡ **Motion can be efficiently described with small number of large blocks**

Data rate reduction versus maximum block size

Maximum applied block size [Samples x Samples]	Defined in HEVC		Beyond HEVC
	16 x 16	64 x 64	128 x 128
Average data rate reduction achieved by affine motion model [%]	0.1	6.3	7.6

Block-size increase benefits the use of an affine motion model

Conclusion

- Investigated an extension of HEVC by an affine motion model

- Results
  - Average bit rate reduction at the same PSNR for sequences of mainly non-translational motion:
    - Low Delay: 6.3%, Random Access: 3.7%
    - For particular sequences: Up to 24%
  - Block size enlargement from 64x64 to 128x128 samples further increases average bit rate reduction from 6.3% to 7.6%

- Application

  Affine motion model together with further increased block sizes could be one direction towards a future video coding standard