Rotate Intra Block Copy for Still Image Coding

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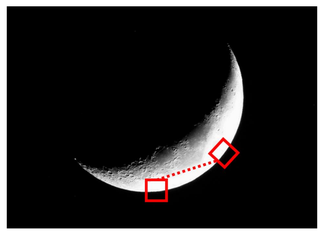
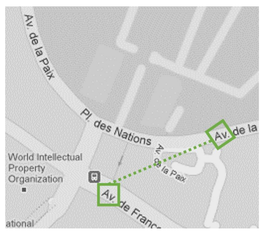
Summary



Natural Image

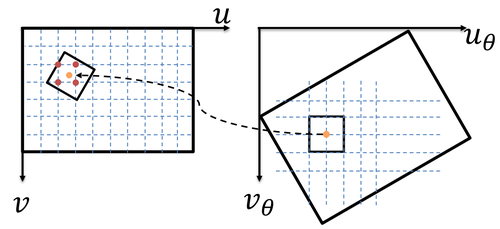


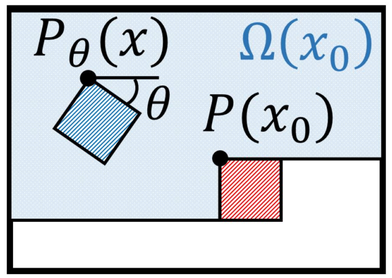
Screen Content

- ❑ A rotated predictor to reduce the residual energy by **20%** over HEVC + intra block copy (even higher gain across HEVC only)
- ❑ A method to code rotated motion vector
- ❑ Coding gains in BD-rate of **3.4%**

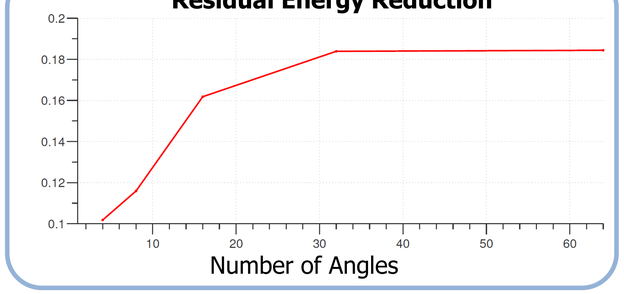
Formulating Rotate Intra Block Copy

Rotate an Image Patch





Residual Energy Reduction



$$\min_{\theta, x \in \Omega(x_0)} \|\boldsymbol{P_\theta(x) - P(x_0)}\|_F^2$$

$P(x_o)$: target patch

$P_\theta(x)$: candidate patch

$\Omega(x_0)$: reconstructed regions

Solution

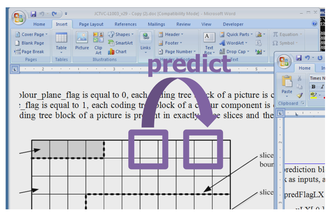
1. Discretize θ into $0{:}\frac{\pi}{N}{:}\pi$
2. For each θ_i, solve
   $x^*_{\theta_i} = \text{argmin}_x \left\|P_{\theta_i}(x) - P(x_0)\right\|_F^2$
3. Find the optimal
   $(x^*, \theta^*) = \text{argmin}_i x_{\theta_i}$

HEVC HEVC + BC HEVC + ROTATE

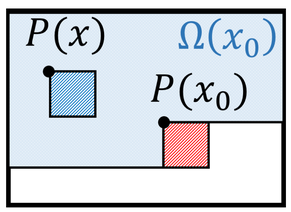
Reduction of residual energy (SSD) on **PartyScene**
40% over HEVC
27% over HEVC + intra block copy

Previous Work

Intra Block Copy



Illustration



Formulation

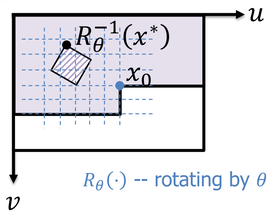
$$\min_{x \in \Omega(x_0)} \|\boldsymbol{P(x) - P(x_0)}\|_F^2$$

$P(x_o)$: target patch
$P(x)$: candidate patch
$\Omega(x_0)$: reconstructed regions

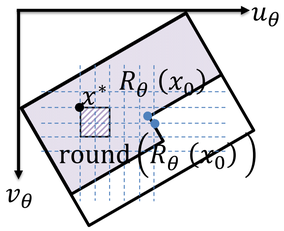
- ❑ Use one block to **predict** repetitive blocks
- ❑ Only encode the **difference (residual)**

Motion Vector Coding

Representing x^* by "motion vector"



$R_\theta(\cdot)$ -- rotating by θ

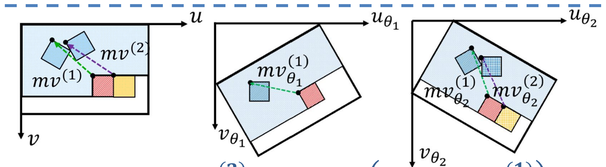


x_0 -- known to both encoder and decoder

Encoder: $mv = x^* - \text{round}(R_\theta(x_0))$, signal mv, θ

Decoder: From mv, θ, decode $x^* = mv + \text{round}(R_\theta(x_0))$

Transform the motion vectors of neighboring block to the same coordinate system to increase correlation to reduce motion vector bits by 25%



$mv_{\theta_2}^{(2)}$ **is encoded as** $mv_{\theta_2}^{(2)} - \text{round}\left(R_{\theta_2-\theta_1} mv_{\theta_1}^{(1)}\right)$

Coding Gain Evaluation

Encoder Configuration

- ❑ **Intra prediction**: DC, Planar, 33 Angular without intra smoothing, intra BC, rotate intra BC
- ❑ **Vectorization**: DCT, zig-zag scan and run-length-encoding
- ❑ **Entropy coding**: Huffman coding
- ❑ **Tree split**: From 4x4 to 16x16
- ❑ **Rate distortion optimization**: Objective function $f = D + \lambda \cdot R$
- ❑ **Other optimizations**: Restrict the search to ±128 around target patch

Signaling

- ❑ **Pictures**: height, width, QP, CTU size, max CU depth, encoding mode, rotation range and resolution
- ❑ **Block Structure and Prediction**: split flag, enable intra block copy or rotate intra block copy, HEVC intra prediction mode, motion vector info(motion vector prediction enable flag, motion vector/motion vector difference), rotate angle index
- ❑ **Residual**: run, length

HEVC + Rotate vs **HEVC + intra block copy**

	Sequence	Residual reduction	BD-rate
Class C	RaceHorse	23.66%	-4.54
	PartyScene	27.64%	-4.45
	BQMall	17.92%	-2.63
	BasketballDrill	22.12%	-3.40
Class D	BQSquare	30.82%	-4.99
	BasketballPass	15.44%	-1.84
	BlowingBubbles	7.59%	-2.81
	RaceHorse	28.97%	-4.42
Class E	FourPeople	18.09%	-2.54
	Johnny	12.79%	-2.35
	KristenAndSara	15.67%	-2.43
Class F *screen content*	BasketballDrillText	21.15%	-3.64
	SlideShow	29.01%	-7.43
	SlideEditing	19.12%	-0.74
Class C Average		22.83%	-3.76
Class D Average		20.70%	-3.52
Class E Average		15.52%	-2.44
Class F Average		23.09%	-3.94
Overall Average		20.71%	-3.44

Energy-Efficient Multimedia Systems Group
(www.rle.mit.edu/eems)

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