Lifting-based Illumination Adaptive Transform (LIAT) using Mesh-based Illumination Modelling

Maryam Haghighat, Reji Mathew, Aous Naman and David Taubman

University of New South Wales, Australia

ICIP 2017 BEIJING, CHINA

THE MAIN IDEA

Illumination compensation for **lifting-based** temporal transforms. Suitable for scalable video compression applications.

Avoiding Piecewise Constant (i.e. block) illuminations models which produce block boundary artefacts!

Employing Piecewise Smooth illumination models using mesh-based affine models!

The contributions of this work are:

1. A lifting-based illumination adaptive transform (LIAT) to exploit inter-frame redundancy in the presence of illumination variations;
2. Modelling illumination changes with a mesh-based affine model which does not impose artificial block boundaries;
3. A highly scalable, embedded compression framework with rate-distortion optimal termination points for frames and illumination information.
4. Exploiting illumination change in the context of richer transforms, incorporating both predict and update steps is more beneficial.

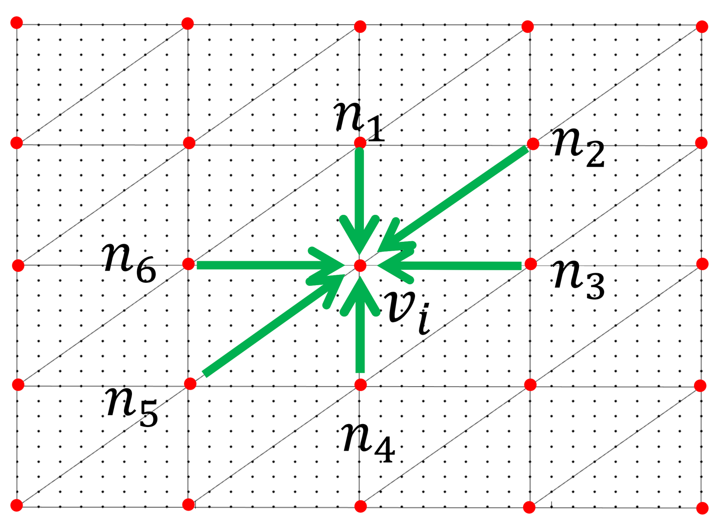
Illumination Modelling

$$\hat{f}_1[x] = \boldsymbol{\alpha}[\boldsymbol{x}].f_0[x] + \boldsymbol{\beta}[\boldsymbol{x}]$$

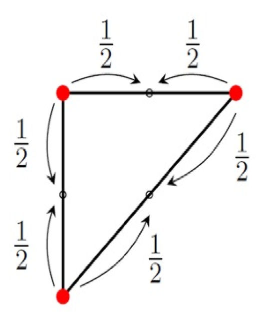
Representation of $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ should be compact!

We achieve this by:

- ✓ Using a coarse mesh to model α and β,
- ✓ Incorporating regularization into the estimation algorithm.

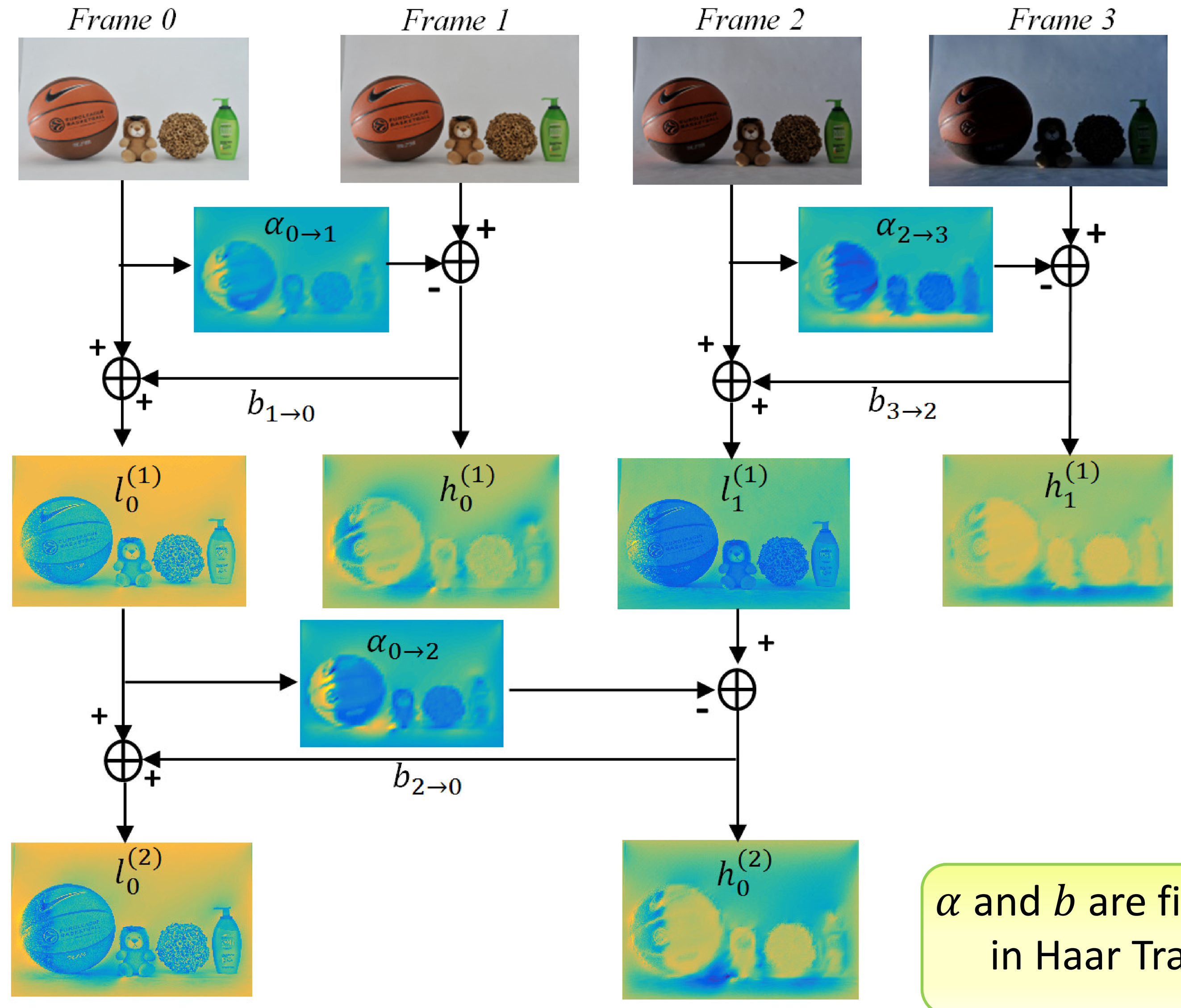


Mesh size = 2^l



Affine interpolation

Lifting-based Illumination Adaptive Transform (LIAT)



α and b are fixed values in Haar Transform

$$h[x] = f_1[x] - P(f_0[x]),\ P(f_0[x]) = \alpha[x].f_0[x]$$

$$l[x] = f_0[x] + b[x].h[x],\ b = \frac{\alpha[x]}{1+\alpha^2[x]}$$

b minimizes temporal synthesis energy gain

Rate-Distortion Optimization for Highly Scalable Compression

- Post-compression R-D optimization is applied for LIAT sub-band frames: Temporal high-pass (*h*), low-pass (*l*) and illumination field (α).
- The rate-allocation problem is to find the optimal truncation points in Embedded Block Coding with Optimized Truncation (EBCOT) so as to minimize overall distortion s.t. an overall bit-rate constraint:

$$\min\ J(\lambda_j) = D(\lambda_j) + \lambda_j \textstyle\sum_s R_s(\lambda_j)$$

λ_j= Lagrangian multiplier associated with the quality layer j.

Compressed sub-band samples → EBCOT JPEG2000 for Highly scalable compression

- R_h → High-pass frame (h)
- R_l → low-pass frame (l)
- R_α → Illumination field (α)

Estimation of α and β

$$\min_{\alpha,\beta}\ C = \|f_1 - \hat{f}_1\|_2^2 + \gamma(\alpha^T L\alpha + \beta^T L\beta)$$

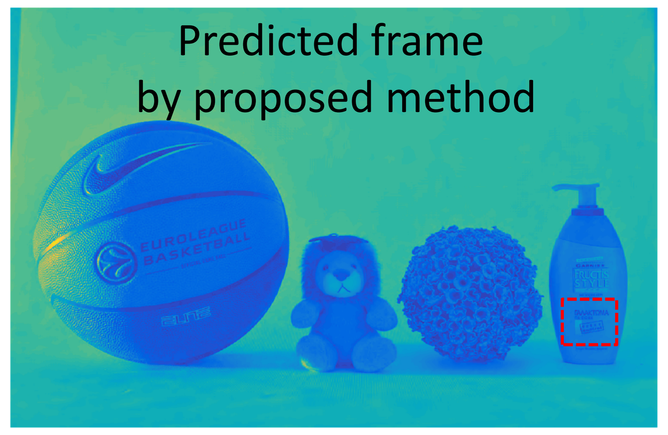
$$\hat{f}_1 = D_0 A\alpha + A\beta$$

A: Sparse affine interpolation matrix

D_0: Diagonal matrix of the elements of f_0, i.e. $(D_0)_{ii} = (f_0)_{ii}$

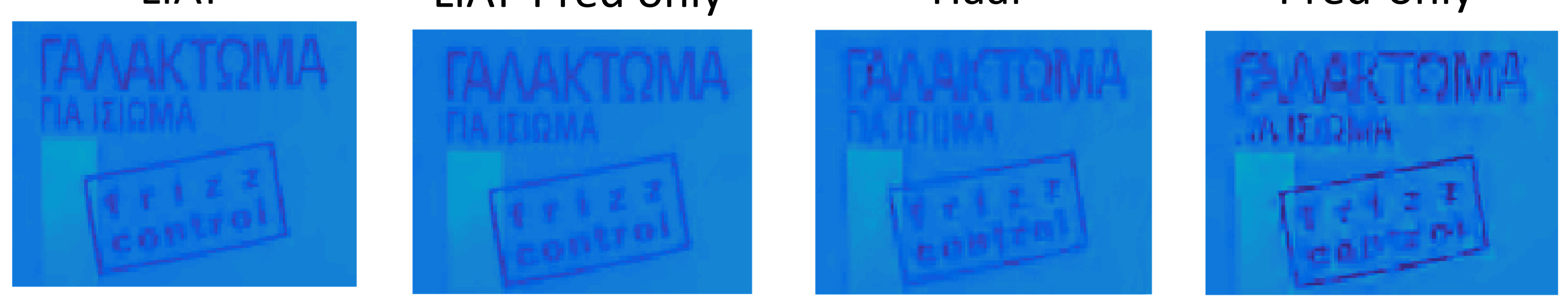
$$L_{ij} = \begin{cases} \deg(v_i) = 6, & \\ -1, & \text{if } i \neq j \text{ and } v_i \text{ and } v_j \text{ are adjacent} \\ 0, & \text{Otherwise} \end{cases}$$

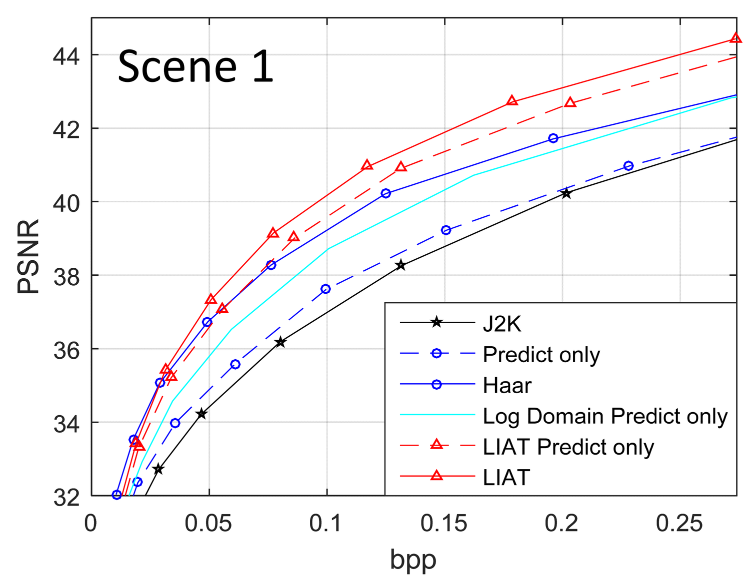
Results

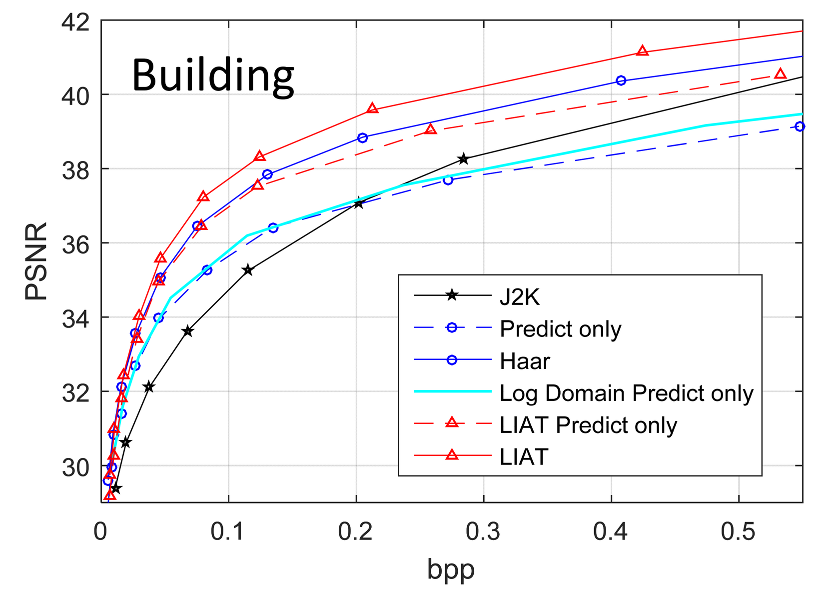


Original

LIAT | LIAT-Pred only | Haar | Pred-only







- ✓ Illumination compensation improves video compression.
- ✓ Transforms with predict+update steps are more beneficial.

Contacts: maryam.haghighat, reji.mathew, aous, d.taubman{@unsw.edu.au}