Bidirectional, Occlusion-Aware Temporal Frame Interpolation In a Highly Scalable Video Setting

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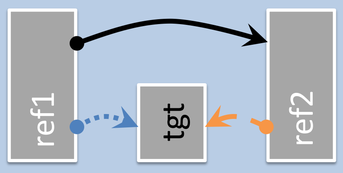
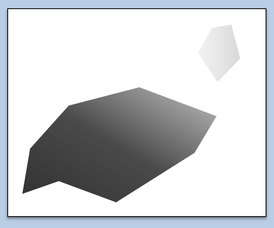
Overview

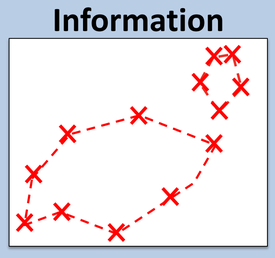
Hierarchical Anchoring from HSVC Coder



Piecewise smooth motion fields



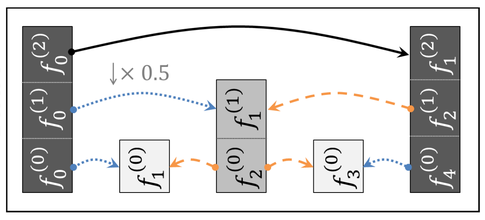
Discontinuity Information



- **Geometrically consistent bidirectional prediction**
- **Obtain disocclusion map** → Allows to guide bidirectional prediction
- If used with our **BIHA coding scheme**, **no (re)estimation** of motion fields necessary

1 Construction of Motion Fields

:: **Bidirectional hierarchical anchoring (BIHA) [1]** of motion fields at reference frames allows to **reuse** them at finer temporal levels.

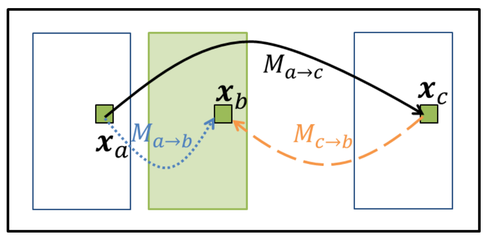


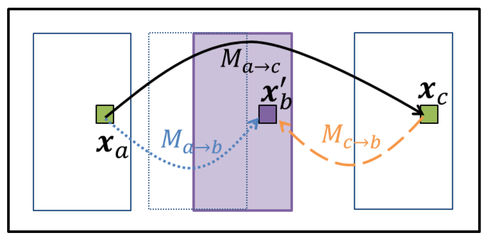
Scaling of Motion fields

$$\hat{M}_{a\to b} = \alpha M_{a\to c}$$

Inferring of Motion fields

$$\hat{M}_{c\to b} = M_{a\to b} \circ (M_{a\to c})^{-1}$$

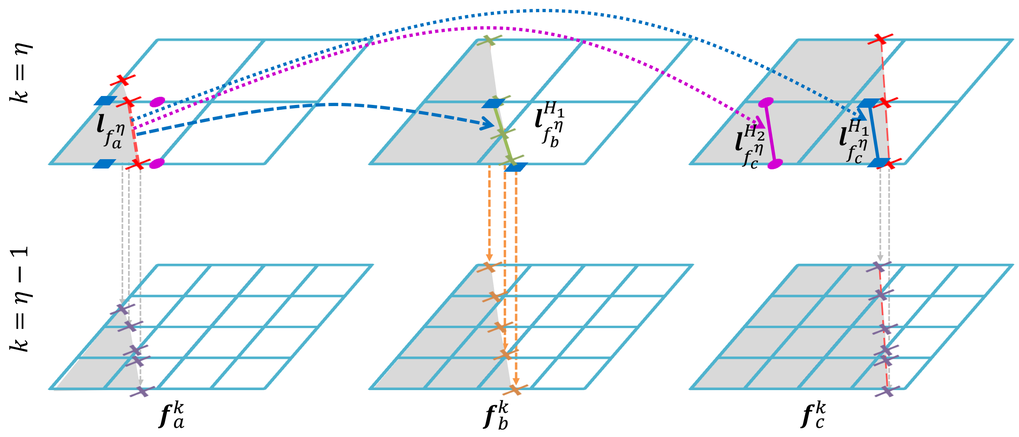




Inferred motion fields **"follow"** their **scaled** sibling
→ **Geometrically consistent prediction.**

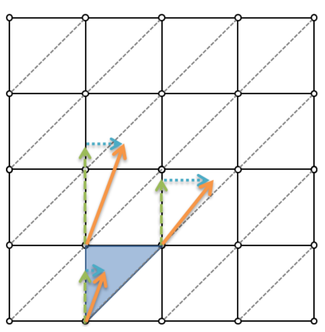
2 Temporal Breakpoint Induction

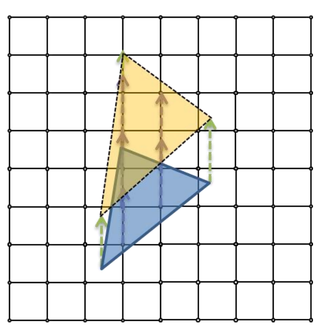
:: **Warp motion discontinuity information** from reference **to target frame.**



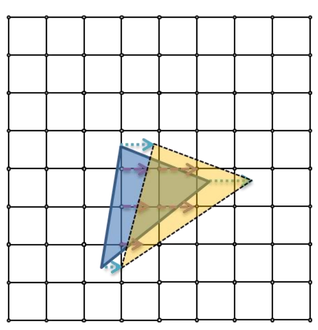
3 Motion Field Inversion

:: Warp motion fields **from reference to (interpolated) target** frames using a **cellular affine warping** process, which is guaranteed to leave no holes.





Vertical Component

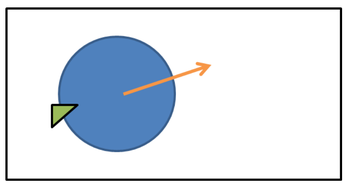


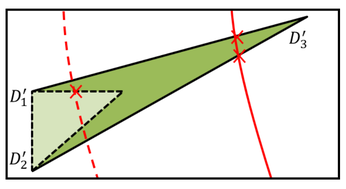
Horizontal Component

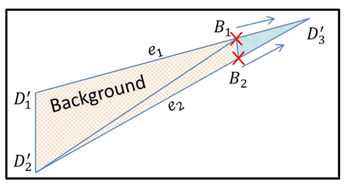
The motion field **inversion process** allows to **discover important properties** the motion is undergoing.

Handling Disoccluded Regions for Inferred Motion

:: Use **breakpoints** to **identify fore-/background motion**. The **background** motion is then **extrapolated** in the disoccluded region.

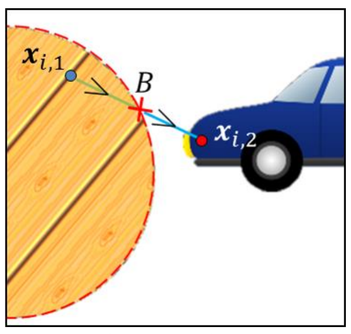




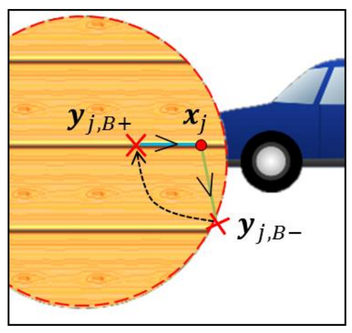


Resolving Double Mappings

:: The **foreground motion** is the one which **maps the motion discontinuity B closer to a discontinuity** in the target frame.



Reference frame



Target frame

4 Frame Interpolation

:: Frames are interpolated using **bidirectional prediction**, **guided** by **disocclusion maps *S***.

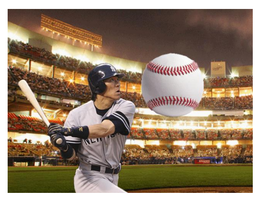
$$\hat{f}_b(\mathbf{x}) = \begin{cases} \dfrac{S_{b\to a}(\mathbf{x}) f_{a\to b}(\mathbf{x}) + S_{b\to c}(\mathbf{x}) f_{c\to b}(\mathbf{x})}{\kappa(\mathbf{x})} & \kappa(\mathbf{x}) > 0 \\ 0.5\big(f_{a\to b}(\mathbf{x}) + f_{c\to b}(\mathbf{x})\big) & \kappa(\mathbf{x}) = 0 \end{cases},$$

where $\kappa(\mathbf{x}) = S_{b\to a}(\mathbf{x}) + S_{b\to c}(\mathbf{x})$.

Use **disocclusion maps** to **guide the bidirectional prediction of the interpolated frame.**

Experimental Results

:: Experiments on **synthetic data** show **improved performance** over current state-of-the-art TFI methods, in **particular in occluded** regions.

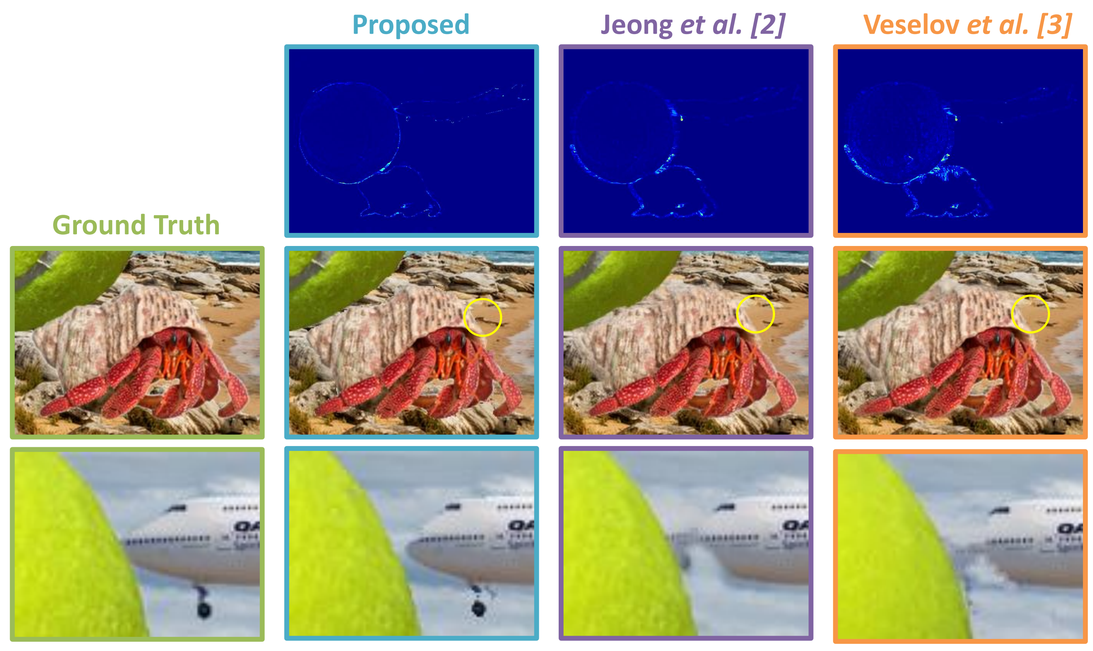


Baseball

Space

Beach

Winter



Sequence	Measure	Prop	Jeong [2]	Veselov [3]	Prop GT
baseball	PSNR	**28.21**	27.15	25.61	31.67
	occPSNR	**23.08**	21.61	19.70	26.91
beach	PSNR	31.09	**31.96**	29.23	34.00
	occPSNR	**23.86**	21.80	20.15	26.57
space	PSNR	**29.47**	28.34	28.67	30.52
	occPSNR	**25.23**	22.51	21.79	26.27
winter	PSNR	**24.33**	23.65	21.09	26.41
	occPSNR	**19.76**	17.50	15.33	22.15
Average	PSNR	**28.27**	27.77	26.15	30.65
	occPSNR	**22.98**	20.86	19.24	25.47

Conclusions and Future Work

Novel way to perform temporal frame interpolation

- **Bidirectional prediction** with **occlusion** handling
- **No (re)estimation** of motion fields needed → Fast

Key enabling features

- All **auxiliary information** (motion, discontinuities) **anchored** at **coarse temporal levels**
- Use of **motion discontinuities** to reason about scene geometry

Joint estimation of **piecewise smooth motion** fields with **breakpoints**.

References

[1] D. Ruefenacht, R. Mathew, and D. Taubman, "Bidirectional Hierarchical Anchoring of Motion Fields for Scalable Video Coding," IEEE Int. Workshop on Multimedia Signal Processing (MMSP), 2014.
[2] S. Jeong, C. Lee, and C. Kim,''Motion-compensated frame interpolation based on multihypothesis motion estimation and texture optimization,'' IEEE Trans. on Image Processing, vol. 22, no. 11, 2013.
[3] A. Veselov and M. Gilmutdinov, ''Iterative Hierarchical True Motion Estimation for Temporal Frame Interpolation,'' IEEE Int. Workshop on Multimedia Signal Processing (MMSP), 2014.