A STRUCTURE-GUIDED CONDITIONAL SAMPLING MODEL FOR VIDEO RESOLUTION ENHANCEMENT

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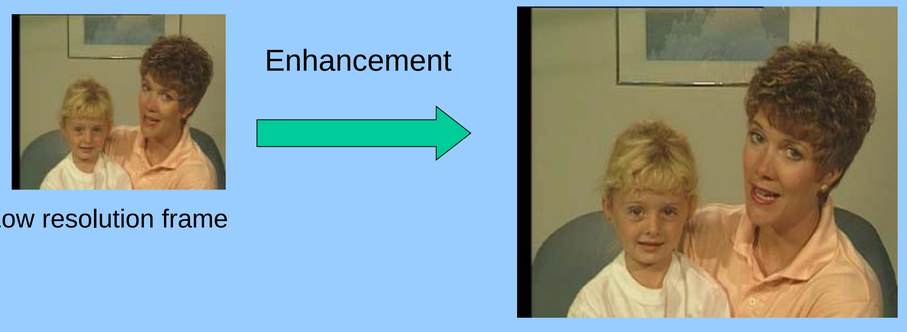
Motivation

We wish to enhance video resolution with hybrid models to handle strongly and weakly structured regions.



Low resolution frame

High resolution frame

To accomplish this, a binary hidden field *U* indicating image structure is introduced into the conditional reconstruction process for estimating the High Resolution (HR) video frames from the Low Resolution (LR) video frames. The main issues:

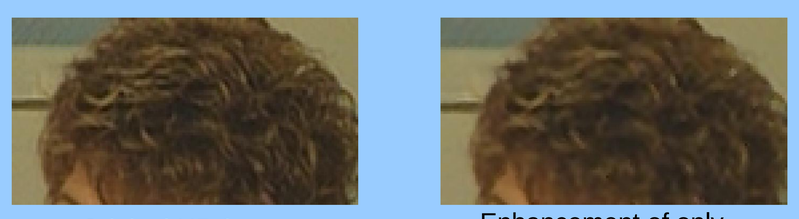
- Given an auxiliary hidden field *U*, a conditional sampling model *p(x|u)* is proposed for finding HR frames.
- Strongly structured regions and weakly structured regions are independently sampled given the hidden field *U*.

Related Methods

Original HR frame

Example-based method

A conventional example-based approach [1] is a nonparametric method, which tries to do enhancements on the basis of small patches from the image dataset rather than depending on a model. However, without further constraints, the method may not preserve strongly structured regions in the reconstructed HR image, as shown in above.



Original HR frame

Enhancement of only strongly structured regions

On the other hand, only enhancing strongly structured regions will lead to a visible degradation in textured, weakly structured regions.

Proposed Method

In the proposed approach, we emphasize structured regions by introducing a hidden field *U* [2] to label such regions. A gradient field *G* is first constructed from an interpolation X^0 of the LR field *Y*.

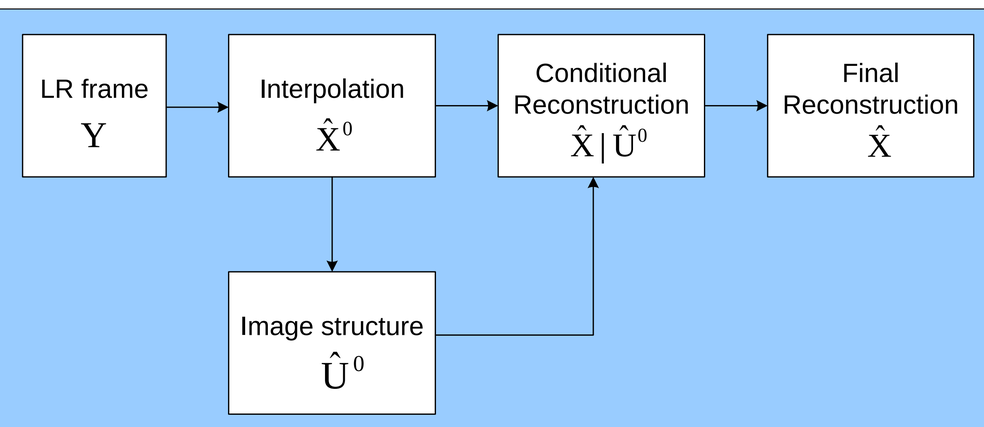
$$\hat{u}_s = \begin{cases} 1 & \text{if } G_s > \xi, \quad \forall s \in S_H \\ 0 & otherwise. \end{cases}$$

We propose a conditional sampling model with hybrid models to handle the enhancements of strongly structured regions and weakly structured regions separately. The strategy of the proposed enhancement method is illustrated in Fig 1.

First, we generate *X* from *Y* by sampling a conditional field model $\hat{x} \leftarrow p(x|\hat{u}, y)$

then, the HR estimated patch $\hat{x}_p^i$ can be generated as

$$\hat{x}_p^i \leftarrow p(y_p^i|x_p^i, \hat{u}_p^i)p(x_p^i|\mathcal{N}_{x_p^i}, \hat{u}_p^i).$$



In practice, we directly sample a HR patch from the training data based on a matching process. A group of close matches are selected:

$$\Lambda_{\bar{x}_p^i|\hat{u}_p^i} = \{\bar{x}_p^i | \hat{u}_p^i \; | d_p^i(k) < (1+\tau) \cdot d_p^i(k^*)\}$$

then, the HR patch is sampled randomly from the match set: $\hat{x_p^i} \leftarrow \Lambda_{\bar{x}_p^i|\hat{u}_p^i}$.

Results

Bicubic interpolation

Structure-only enhancement

Proposed method

In the above tests, the hair regions are noticeably enhanced; the brick wall and the tree in the background are noticeably enhanced by the proposed method.

Bicubic interpolation

Proposed method

In the 'mother' test sequence, the proposed method provides improved visual details in both strong structured regions and texture regions, such as the wrinkles in the clothes and the hairs.

Conclusions

- Strengths: a binary auxilary field introduced, strongly structured and weakly structured regions enhanced separately, visible artifact and degradation reduced.
- Weaknesses: frame-based, without considering temporal constraints, only suitable for the sequences not containing significant temporal changes.

References

1. W. T. Freeman, T. R. Jones, and E. C. Pasztor, "Example-based super-resolution," *IEEE Computer Graphics and Applications*, vol. 22, no. 2, pp. 56–65, 2002.
2. Benboudjema, D., Pieczynski, W.: Unsupervised statistical segmentation of non-stationary images using triplet Markov fields. *IEEE Trans. PAMI* 29(8) (2007) 1367-1378.