# Perception-inspired spatio-temporal video deinterlacing

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Proposed deinterlacing system

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# INTRODUCTION

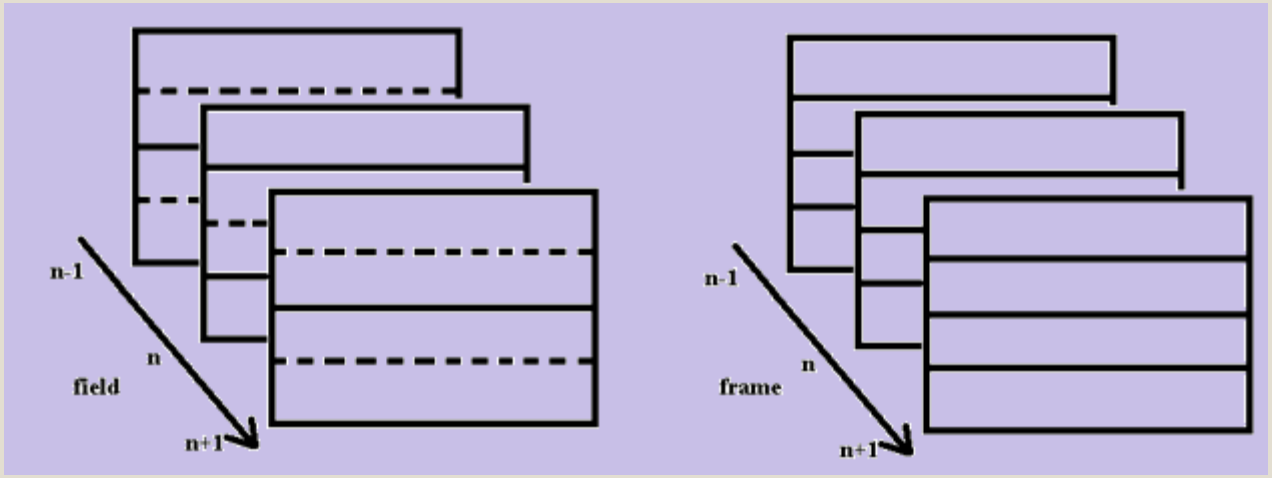
Interlaced Videos:- Given frame of ‘N’ rows, only ‘N/2’ alternate rows are present in one field.

Remaining rows are present in the next field

# INTRODUCTION

Deinterlacing :-

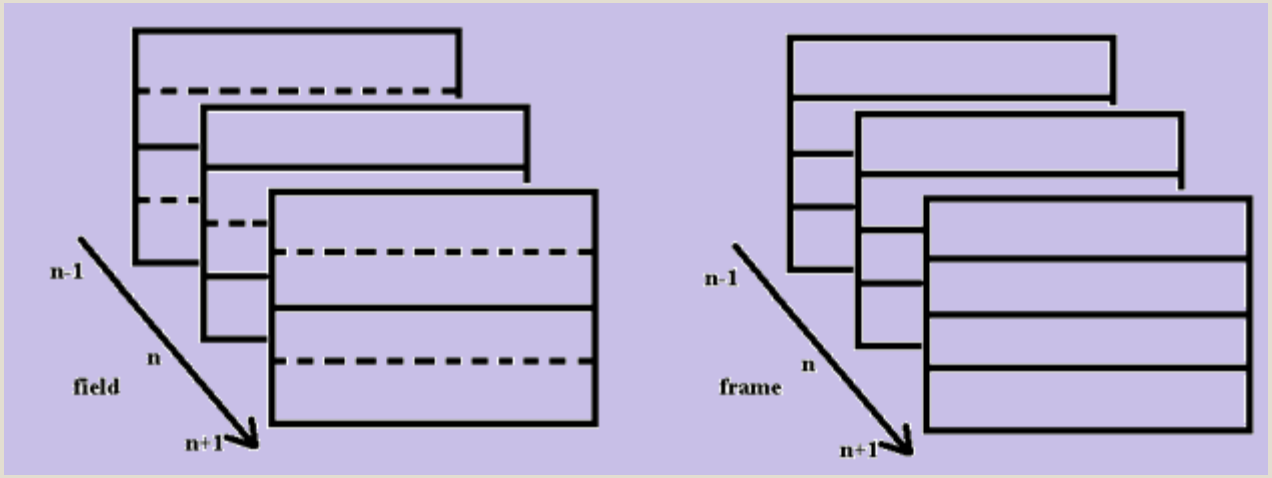
- Convert Interlaced Videos to Deinterlaced Videos
- Convert Fields to Frames.



# INTRODUCTION

Deinterlacing :-

$$F_0(\vec{x}, n) = \begin{cases} F(\vec{x}, n), & y \bmod 2 = n \bmod 2 \\ F_i(\vec{x}, n), & otherwise \end{cases}$$



# INTRODUCTION

- Static region of video → Temporal deinterlacing
- High motion in the video → Spatial deinterlacing
- Sports is broadcast over 1080i rather than the usual 720p or 1080p. This is followed by ESPN/Star, Sky, BBC sport.

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# Literature Review

Linear Deinterlacers

- Spatial Deinterlacers
- Temporal Deinterlacers
- Spatio-Temporal Deinterlacers

Non-Linear Deinterlacers

- Inter-Frame Deinterlacers
- Intra-Frame Deinterlacers
- Adaptive Deinterlacers

# Literature Review

Linear Deinterlacers:-

$$\widehat{F_n}(i,j) = \begin{cases} F_n(i,j)\,, & (j\ mod 2 = n\ mod 2) \\ \sum_m \sum_k F_{n+m}(i, j+k)\, h_m(k)\,, & (otherwise) \end{cases}$$

# Literature Review

Line Averaging (LA):-


# Literature Review

Spatial Linear Deinterlacers:-

- All pass on the temporal.
- Even after low pass, aliasing components are preserved.

Temporal Linear Deinterlacers:-

- All pass on the vertical.
- This is the best solution for a static image as all the vertical frequencies are preserved

# Literature Review

Temporal Linear Deinterlacers:-

# Literature Review

Vertical Temporal Filter (VTF) [Wes98]:-

$$\widehat{F_n}(i,j) = \begin{cases} F_n(i,j), & (j\ mod 2 = n\ mod 2) \\ \sum_m \sum_k F_{n+m}(i, j+k)\, h_m(k), & (otherwise) \end{cases}$$

$$h_m(k) = \begin{cases} \frac{1}{2}, \frac{1}{2} & , (k = -1,1 \quad m = 0) \\ -\frac{1}{16}, \frac{1}{8}, -\frac{1}{16} & , (k = -2,0,2 \quad m = -1,1) \end{cases}$$

# Literature Review

Non- Linear Deinterlacers:-

- Inter-Frame Deinterlacers
- Intra-Frame Deinterlacers
- Adaptive Deinterlacers

# Literature Review

Non- Linear Deinterlacers:-

- Inter-Frame Deinterlacers
  - Edge based Line Averaging
- Intra-Frame Deinterlacers
  - Spatio-Temporal edge based median filtering
- Adaptive Deinterlacers
  - Content adaptive vertical temporal filtering.

# Literature Review

Method switching algorithms (MSAs)

Method switching ELA [Hon11]

- Choses between LA, ELA and STELA.

Content adaptive VTF CAVTF [Lee13]

- Adaptively ‘learn’ the filter weights of VTF based on video content
- Uses Adaptive dynamic range encoding (ADRC)
- Each code gets a different weight
- Latest paper there is on deinterlacing
- Considered to be benchmark for our tests.

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# Deinterlacing System

Region of video that has no motion or a static region.

- This requires a purely temporal deinterlacer.

Region of video that has moderate motion.

- This requires a spatio-temporal deinterlacer

Region of video that has very high motion.

- This requires a purely spatial deinterlacer.

# Deinterlacing System

$$\widehat{F}_n(i,j) = \begin{cases} F_n(i,j)\,, & (j\ mod 2 = n\ mod 2) \\ a, A & \\ b, B & \end{cases}$$

# Deinterlacing System

Solving for Region A :-

Difference image will give static regions

$$d_n = \|F(n+1) - F(n-1)\|$$

Threshold to 1 bit-depth.

Condition a: $d_n(i,j) < t_1$ where $t_1$ is 1 bit.

# Deinterlacing System

$$\widehat{F_n}(i,j) = \begin{cases} F_n(i,j), & (j\ mod 2 = n\ mod 2) \\ F_{n-1}(i,j), & d_n(i,j) < t_1 \\ b, B & \\ c, C & \end{cases}$$

# Deinterlacing System

Solving for Region B :- Spectral residue.

$$q^n = Ch_1^n + Ch_2^n \mu_1 + Ch_3^n \mu_2 + Ch_4^n \mu_3$$

$$Q_i^n[u,v] = \frac{1}{\sqrt{WH}} \sum_{y=0}^{W-1} \sum_{x=0}^{H-1} e^{\mu_1 \, 2\pi\left(\frac{yv}{W}+\frac{xu}{H}\right)} \, q_1^n(x,y)$$

$$q_i^n[x,y] = \frac{1}{\sqrt{WH}} \sum_{v=0}^{W-1} \sum_{u=0}^{H-1} e^{\mu_1 \, 2\pi\left(\frac{yv}{W}+\frac{xu}{H}\right)} \, Q_1^n[u,v]$$

# Deinterlacing System

Solving for Region B :-

$$Q_p = Q / || Q ||$$

Phase spectrum of the transform.

# Deinterlacing System

Solving for Region B :-

$$Q_p = Q / || Q ||$$

Gaussian smooth the Phase spectrum of the transform.

$$S_n(i,j) = g * q_p$$

# Deinterlacing System

2D Control Grid Interpolation :

$$2DI[\mathrm{i},\mathrm{j},k] = I(\mathrm{i} + d_1[i,\mathrm{j},k], j + d_2[\mathrm{i},\mathrm{j},k], k + \partial k)$$

[Frakes08]

# Deinterlacing System

1D control grid interpolation:

$$I(i,j) = I(i+\alpha, j+1)$$

Two uni-directional estimates:-

$$I(i,j) = I(i+2\alpha, j+2)$$
$$I(i,j+2) = I(i+2\alpha, j)$$

$$1DI = I(i+\alpha, j+1) = \frac{1}{2}[I(i,j) + I(i+2\alpha, j+2)]$$

# Deinterlacing System

$$\widehat{F}_n(i,j) = \begin{cases} F_n(i,j), & (j\ mod 2 = n\ mod 2) \\ F_{n-1}(i,j), & d_n(i,j) < t_1 \\ 2DI[\mathrm{i},\mathrm{j},k](1 - S_n(i,j)) + 1D[i,j]S_n(i,j), & d_n(i,j) \geq t_1 \end{cases}$$

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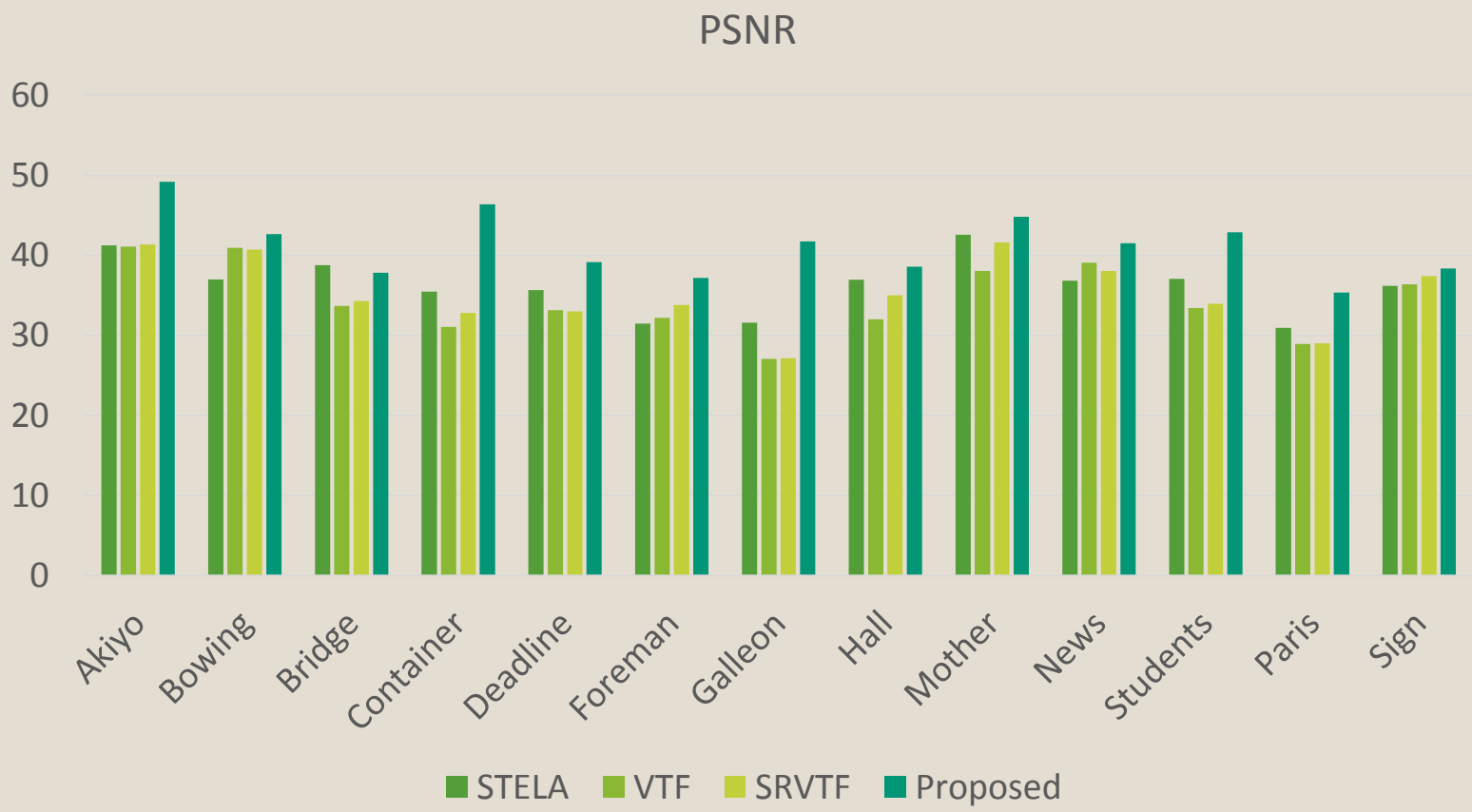
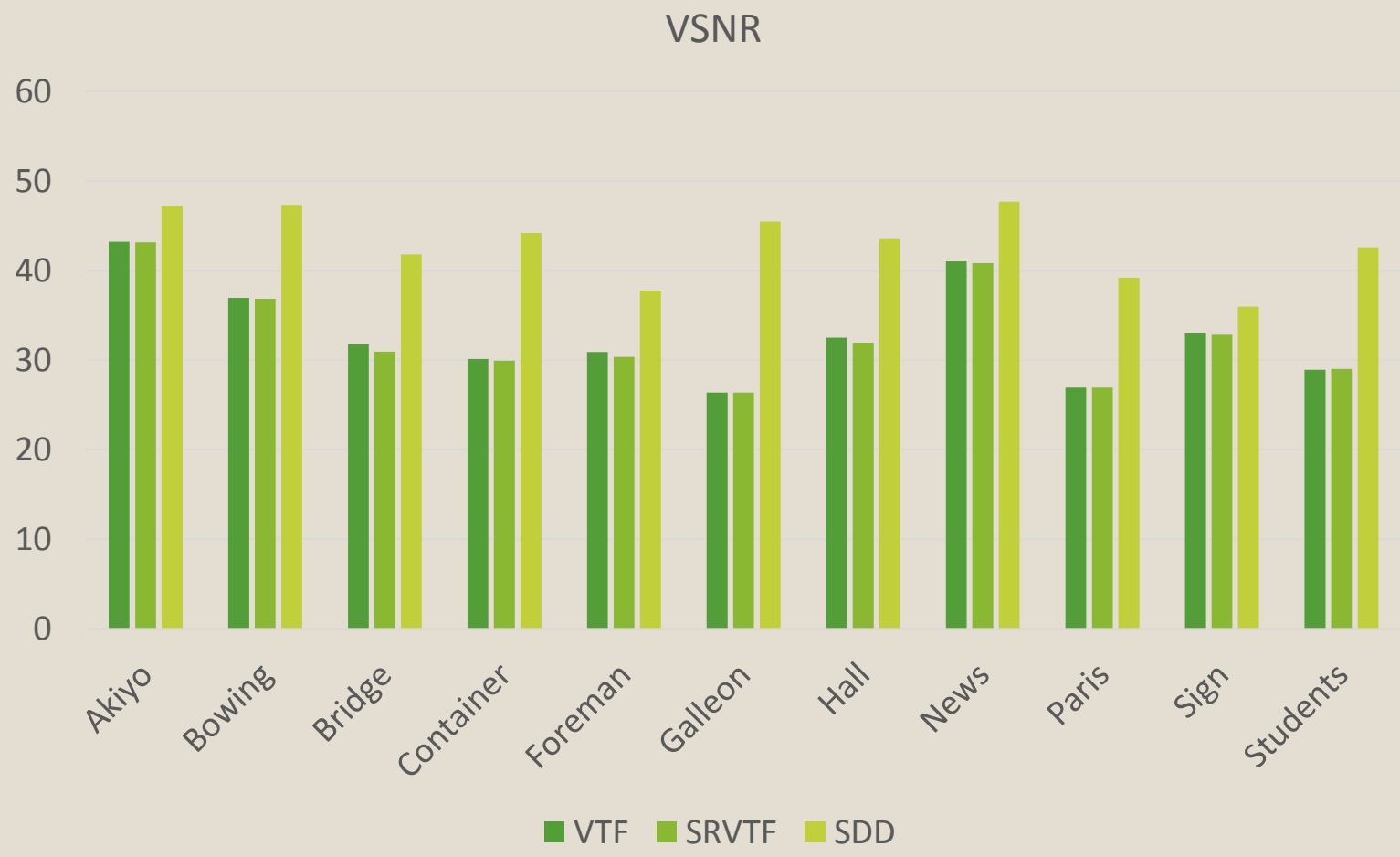
# Results


PSNR
60
50
40
30
20
10
0
Akiyo
Bowing
Bridge
Container
Deadline
Foreman
Galleon
Hall
Mother
News
Students
Paris
Sign
STELA
VTF
SRVTF
Proposed

# Results


VSNR
60
50
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30
20
10
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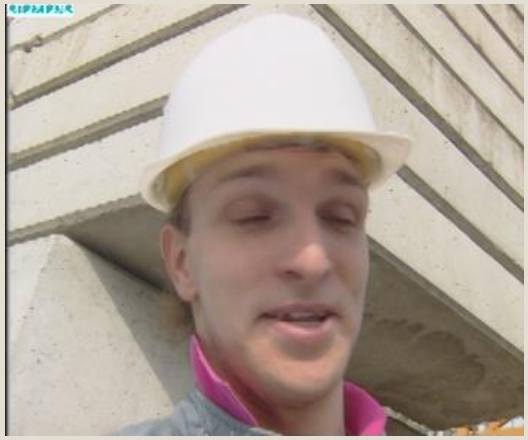
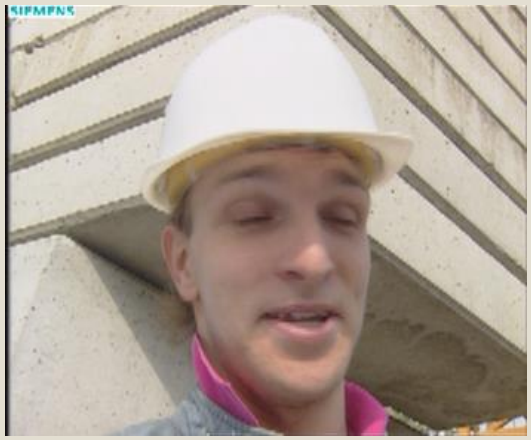
Akiyo
Bowing
Bridge
Container
Foreman
Galleon
Hall
News
Paris
Sign
Students
VTF
SRVTF
SDD

Original

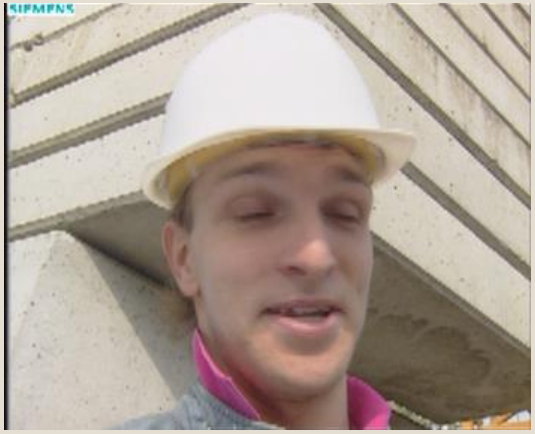

ELA



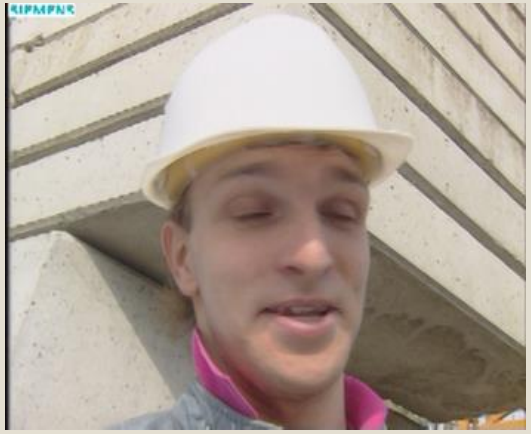
STELA



VTF



SRVTF



Proposed

CAVTF [Lee11]

Proposed

# Thank You.

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