Video Packet Loss Concealment Detection Based On Image Content

Annual projects day SIPL 2008

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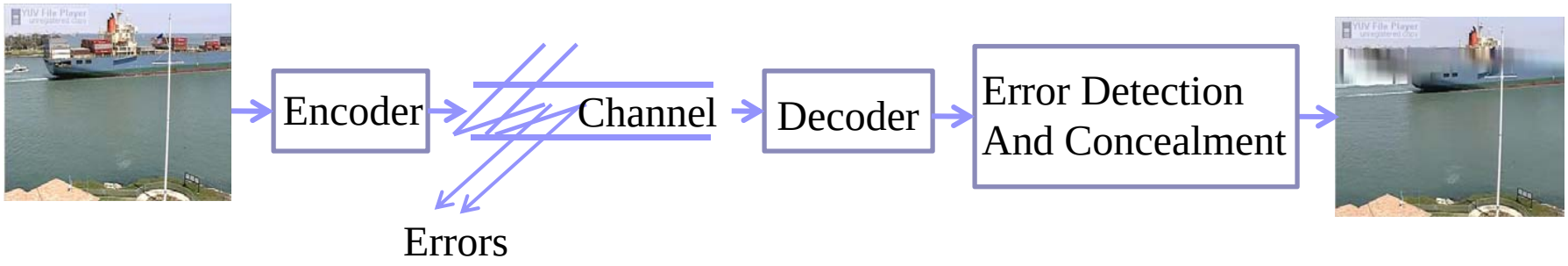
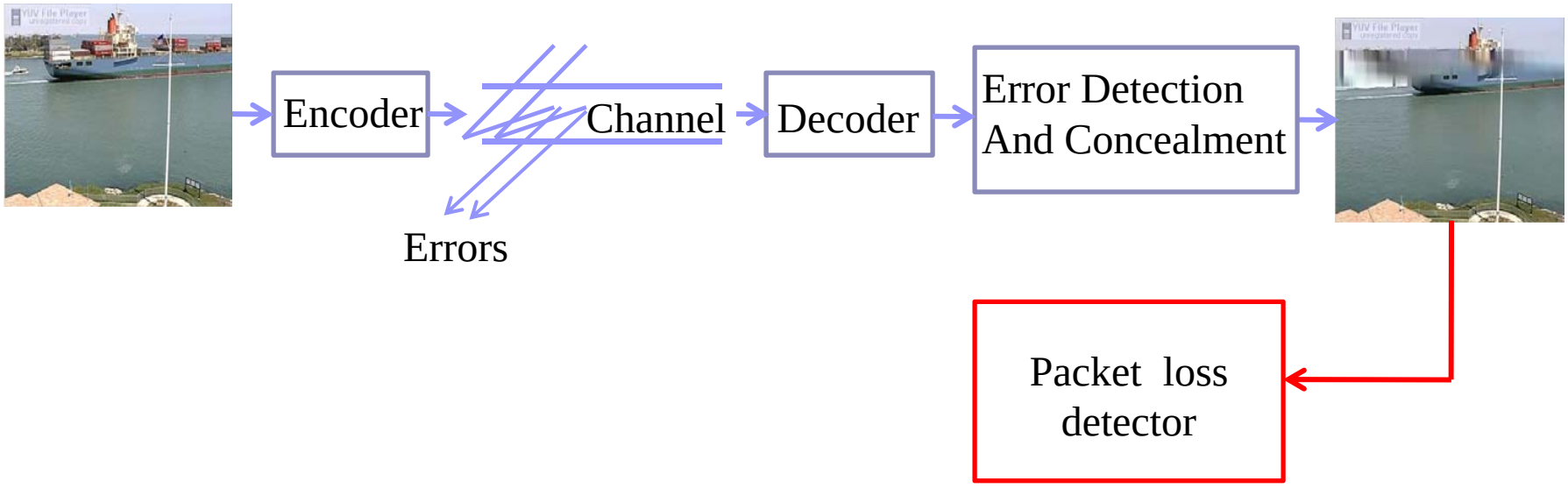
Problem Definition

- Problem: Compressed video transmitted over unreliable channels may suffer from packet loss.
- Typical solution:
  - Packet loss is detected at the transport layer.
  - Standard error concealment.
- Error concealment can still leave some noticeable impairments in the video.



Problem Definition

- No-reference video quality assessment requires concealed errors detection.
- Detection is based only on image content.



Problem Definition

- Two approaches for packet loss error concealment.
  - Temporal concealment.
  - Spatial concealment.

Temporal Concealment

Spatial Concealment

Temporal Concealment

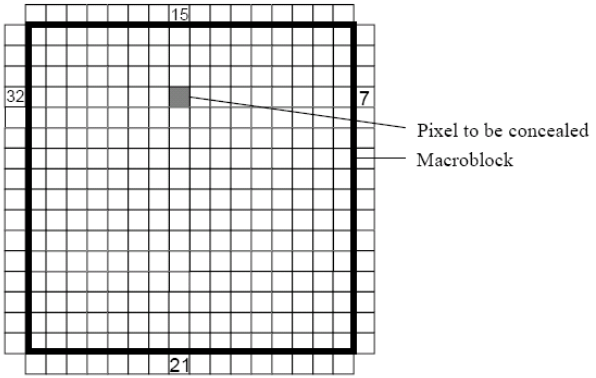
- Temporal concealment fills in missing macroblocks by copying regions from previous frame.
- Most common - zero motion vector.

Foreman.cif

Highway.cif

Spatial Concealment

- A corrupted MB is usually interpolated using boundary pixels surrounding it.
- Most common - bilinear interpolation.



Tempete.cif

Container.cif

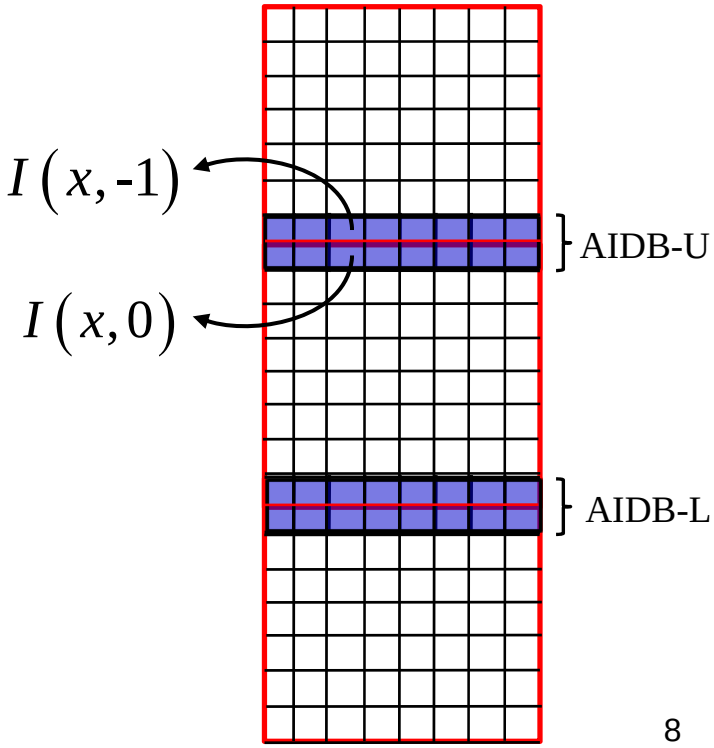
Proposed Solution – Temporal Concealment

- The method rely on two main properties.
  - The difference between consecutive frames is negligible at concealed region.
  - Discontinuity across the boundaries of the concealed region.

Proposed Solution – Temporal Concealment

- Detection is based on two measurements.
  - MAD – Mean Absolute Difference with the previous frame for each macroblock.
  - AIDB-U/L – Average of Intersample Difference across the macroblock Upper/Lower Boundary.

$$AIDB\text{-}U = \frac{\sum_{x=0}^{N\text{-}1} \left| I(x,0) - I(x,\text{-}1) \right|}{N}$$



Proposed Solution – Temporal Concealment

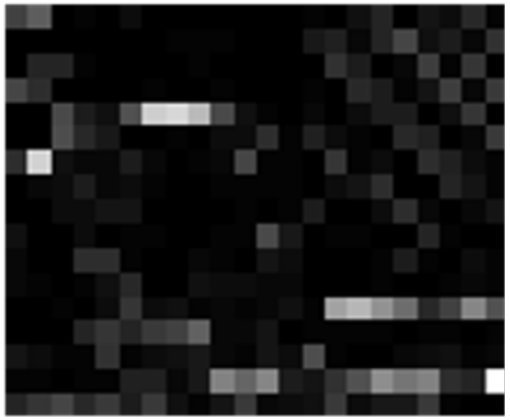
Input Frame

MAD

Suspicious Regions

AIDB

Temporally Concealed Regions

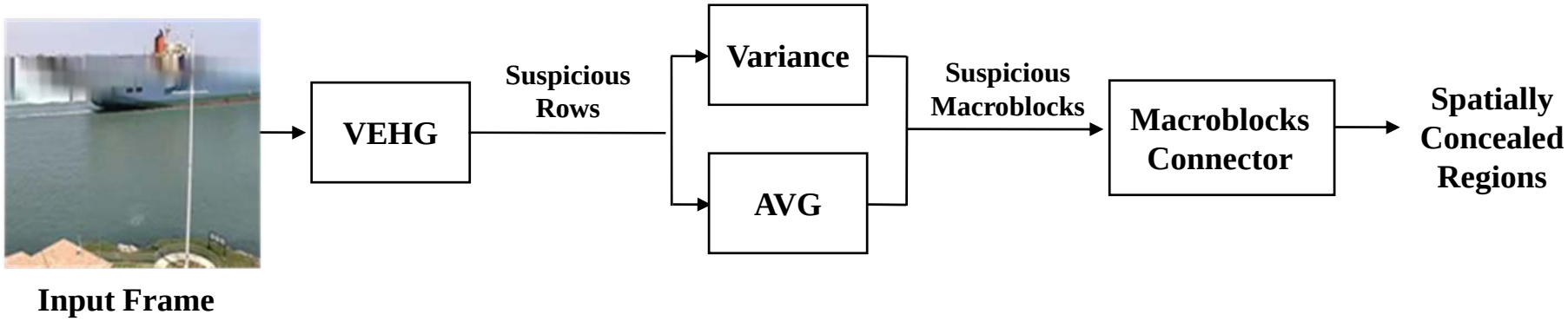


Proposed Solution – Spatial Concealment

- The concealed macroblock satisfies a smoothness property.
- This results: ‘vertical bars’- a region that is vertically smooth and contains horizontal discontinuities.

Proposed Solution – Spatial Concealment

- Three measures are used for spatial concealment detection.
  - VEHG – Vertical Edge detection in the macroblock's Horizontal Gradient.
  - AVG – Average Vertical Gradient.
  - Variance.



Proposed Solution – Spatial Concealment

- Vertical Edge detection in the macroblock's Horizontal Gradient (VEHG) example.

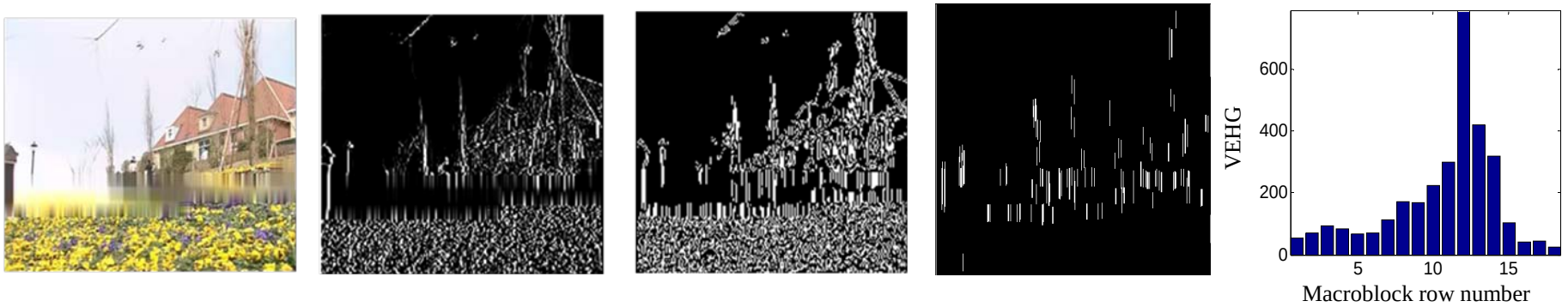
(a) – Concealed frame.

(b) – Horizontal gradient contains vertical edges.

(c) – Canny edge detection in the horizontal gradient image emphasizes edges.

(d) – Morphological image opening leaves only vertical bars.

(e) – Mean VEHG values per macroblock row.



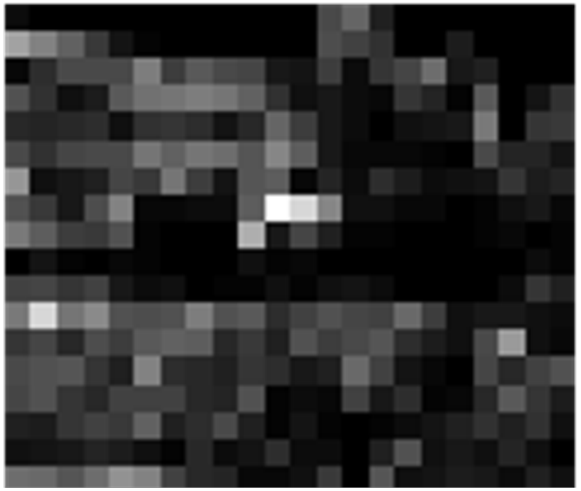
(a) (b) (c) (d) (e)

Proposed Solution – Spatial Concealment

- Average Vertical Gradient (AVG) example.

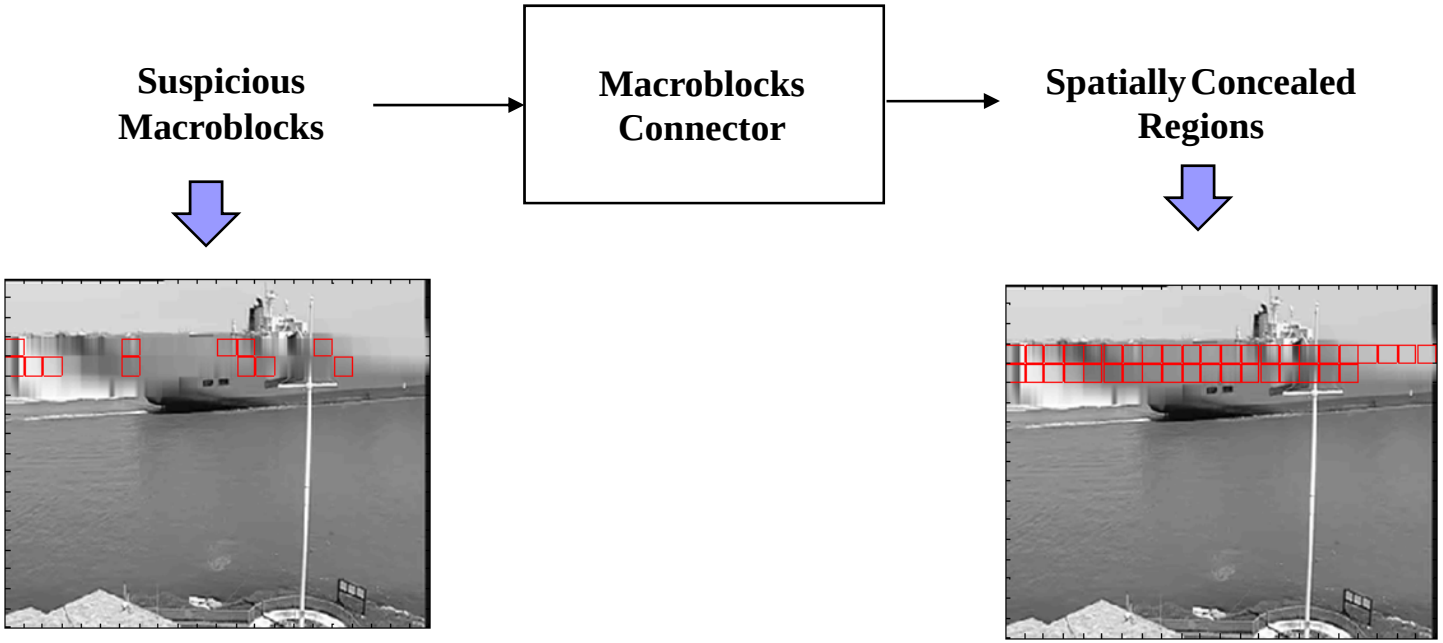
Proposed Solution – Spatial Concealment

- Macroblock variance example.



Proposed Solution – Spatial Concealment

- Detected macroblocks are connected based on less strict thresholds.



Results

- 30 videos of QCIF (176x144) and CIF (352x288) resolution were checked
- Bitrates between 100Kbps and 1Mbps.
- Packet loss ratio - 0.5%-1%.
- Packet length - 10-100 macroblocks.
- H.263 and H.264/AVC baseline encoder.

Results - Temporal Concealment

- Temporal concealment detection examples.
  (a) – Foreman CIF.
  (b) – Glasgow QCIF.
  (c) – Sign_Irene CIF.

(a)

(b)

(c)

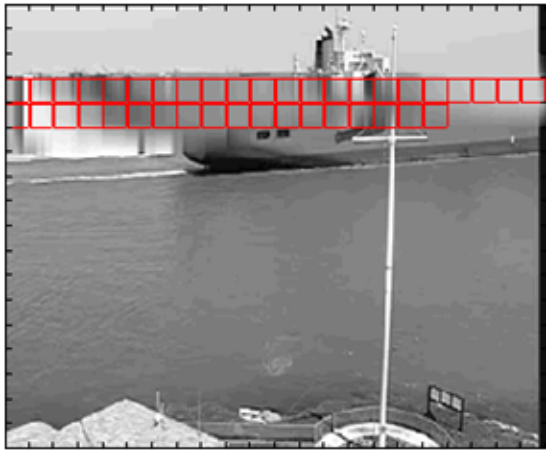
Results - Spatial Concealment

- Spatial concealment detection examples.

  (a) – Container CIF.

  (b) – Tempete CIF.

  (c) – Paris CIF.



(a)

(b)

(c)

Results

- Precision - Fraction of the detection that are correct
- Recall - Fraction of the concealments that are successfully detected.

Per packet loss:	Precision	Recall
Temporal	0.92	0.93
Spatial	0.89	0.90
Per macroblock:		
Temporal	0.90	0.91
Spatial	0.86	0.71

Conclusions

- A novel technique for packet loss concealment detection using only image properties.
  - An extensive literature survey revealed no similar solution.
- High detection precision, only few false alarms.
- This work is going to be presented this month in the EUSIPCO-2008 Conference.

THE END