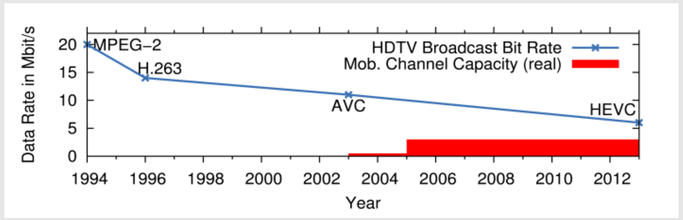
Optical Flow Clustering for ROI Coding

Holger Meuel · Marco Munderloh · Matthias Reso · Jörn Ostermann

Problem and Goal

Goal: Transmission of HDTV video over narrow bandwidth channels

- 622 Mbit/s PCM data rate for HDTV video, >5 Mbit/s with standardized encoders
- Very small bandwidth channels
- Need for an encoder employing characteristics of airborne video



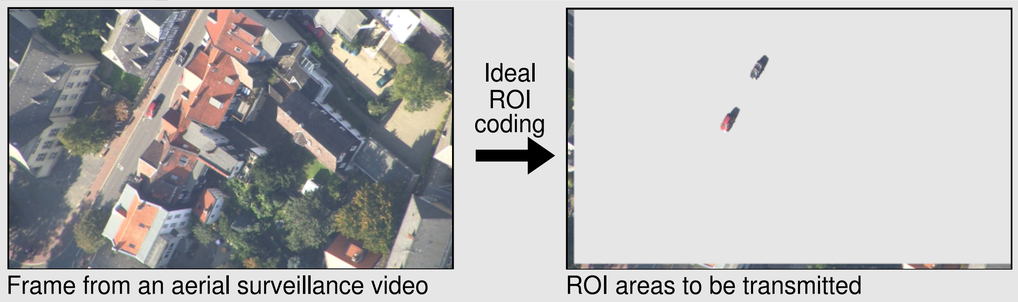
Transmission capabilities of standardized video encoders and channel capacity

Region of Interest (ROI)−based Coding System

ROI Coding System for Planar Landscapes

- Global Motion Estimation/Compensation (GME/GMC) [1]
- New Area (NA) calculation based on GME parameters [1]
- Moving Object (MO) detector detects (local) motion not matching the global one (difference image−based) [1]
- Superpixel segmentation for MO shape information refinement [2]
- Transmission of NAs and MOs only (example right) [1, 2]

Problem: Planar landscape does not fit reality, thus lots of non−moving objects are wrongly detected as moving



Frame from an aerial surveillance video in HDTV resolution (750m flight height)

ROI areas to be transmitted for one HDTV frame (i.e. 5%).

Reference: [1] Meuel et al.: Low Bit Rate ROI Based Video Coding for HDTV Aerial Surveillance Video Sequences, CVPR−W 2011: WAVP
Reference: [2] Meuel et al.: Superpixel−based Segmentation of Moving Objects for Low Bitrate ROI Coding Systems, AVSS 2013

Mesh−based Motion Compensation and Moving Object Detection

Idea: Replace one global motion compensation (one plane) by several local motion compensations (many planes) [3]

Mesh−based Motion Estimation

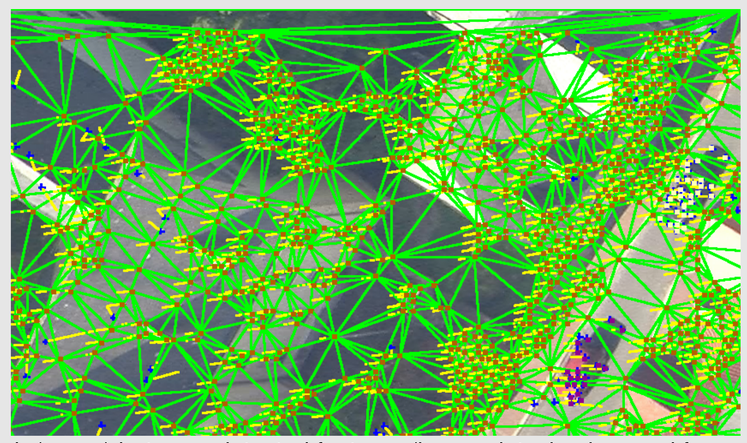
- KLT−based optical flow estimation
- Assumption: Smooth background motion vector field:
  - Cluster similar displacement vectors in optical flow (locally smooth change)
  - Largest cluster defined as background

Mesh−based Motion Compensation

- Delaunay triangulation for mesh creation
- Individual affine transform for every mesh patch defined by triangle corners
- Better adaption to 3D landscape shapes

Mesh−based Motion Detection

- Moving Objects (MOs) = (local) discon−tinuities in the optical flow
- Difference image−based MO detection



Mesh (green) between detected features (brown dots: background fea−tures, blue crosses: MO candidates incl. outlier, purple/white dots: two MOs after cluster filter), trajectories (yellow) in the motion comp. frame

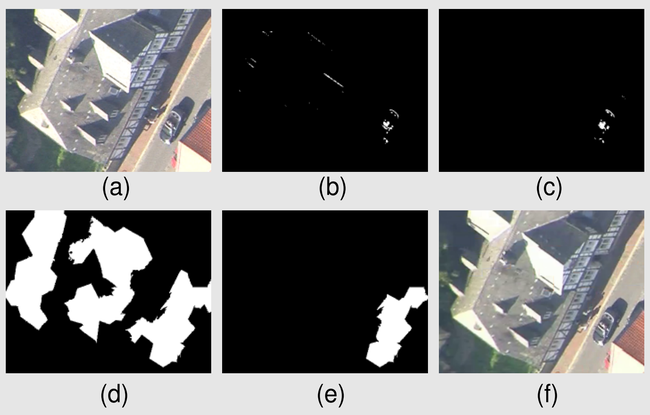
Reference: [3] Munderloh et al.: Mesh−based Global Motion Compensation for Robust Mosaicking & Detection of Moving Objects in Aerial Surveillance, CVPR−W 2011: WAVP

Superpixel−ROI Coding System with Mesh−based MO Detector

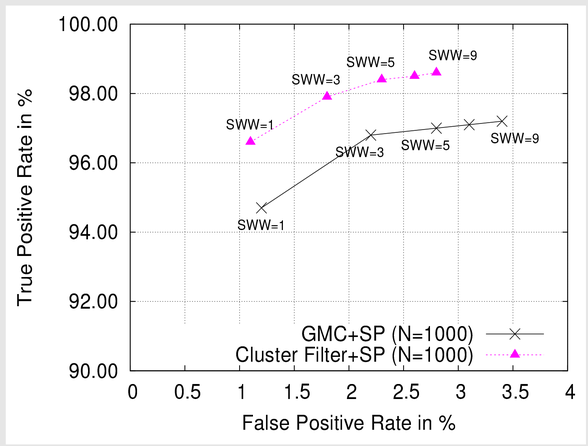
Decrease false positive (FP) rate by mesh−based MO detector & cluster filtering

Increase true positive (TP) rate using (temp. consistent) superpixels

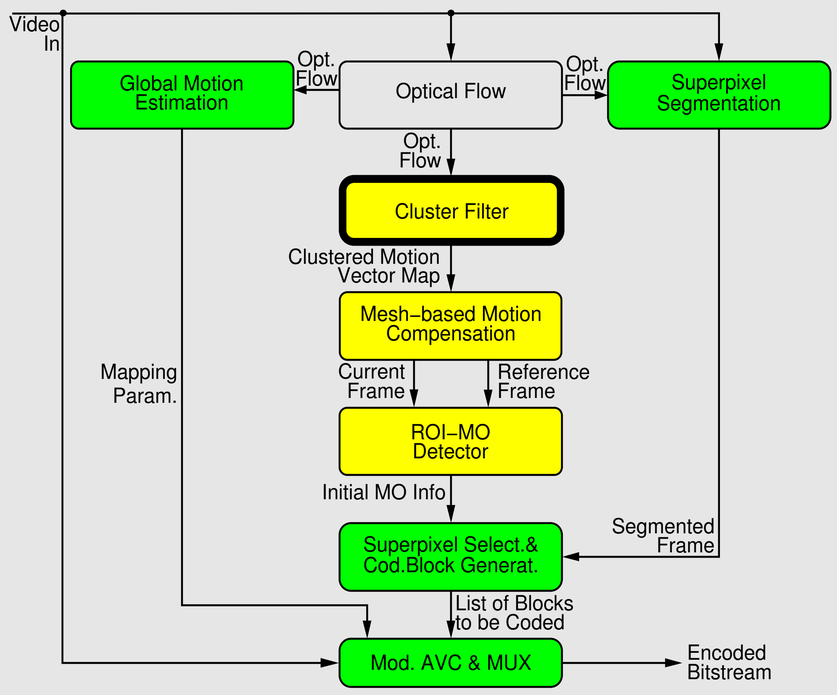
- Superpixel segmentation to improve MO spatial detection gaps
- "Temporally Consistent Superpixels" (TCS) [4] to fill MO temporal detection gaps (Sliding Window)



MOs of diff.−image− (b) and mesh−based−MO detector (c) and after superpixel enlargement (d, e). Original in (a), decoded result in (f).



ROC curve of diff.−image− and mesh−based−MO detector (SWW=Sliding Window Width)



Block diagram: enhanced ROI en−coder for planar aerial sequences

Reference: [4] Reso et al.: Temporally Consistent Superpixels, ICCV 2013

Conclusions

Optical Flow Cluster Filter Supported ROI−based Coding System for Airborne Video Sequences

- (Fully automatic) Aerial HDTV video coding with <2 Mbit/s
- Encode only New Areas (NA) & Moving Objects (MOs) from aerial video sequences
- Mesh−based local motion compensation for MO detection
- Superpixels to increase TP rate by context−aware MO area enlargement
- Cluster filter to decrease FP rate of MO detections (up to 18 %)
- Data rate savings up to 24 % for moving object areas (4 % overall) compared to global motion compensation−based MO detector system

Institut für Informationsverarbeitung
Holger Meuel
meuel@tnt.uni-hannover.de
http://www.tnt.uni-hannover.de/staff/meuel

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