# Moving Object Tracking for Aerial Video Coding using Linear Motion Prediction and Block Matching

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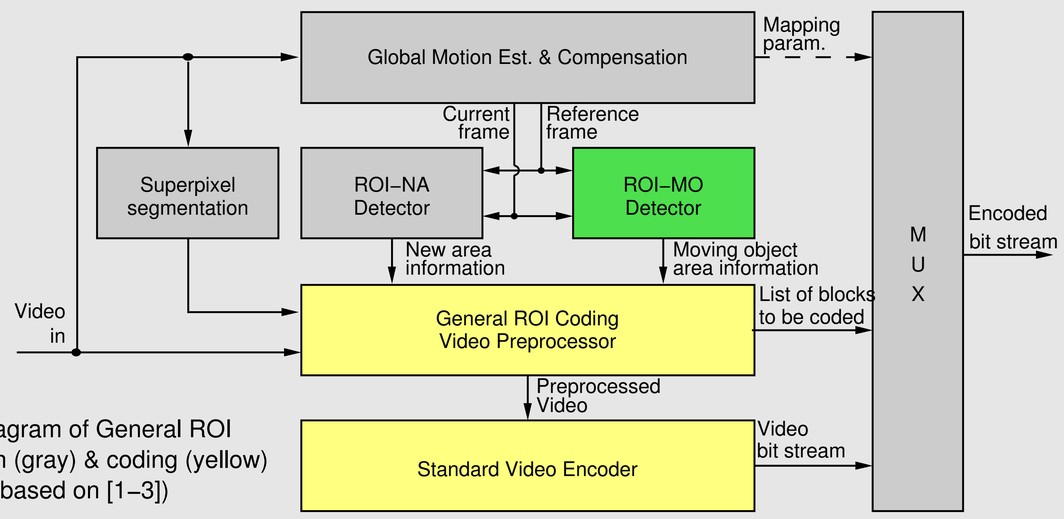
## Problem and Goal

- ROI coding for aerial video ⟶ bit rate reduction
- Background reconstruction from new areas (ROI–NA) of each image with global motion compensation (GMC)
- **Moving objects are additional ROIs**
- Fully–automatic detection of moving objects needed

**Goal: Reliable moving object detection**




Block diagram of General ROI detection (gray) & coding (yellow) system (based on [1–3])

## Block Matching Supported Moving Object Tracking

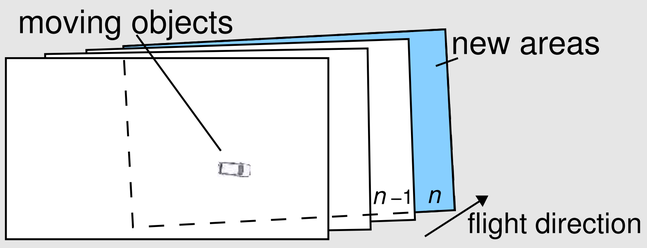
### I. Proposed Moving Object Detector (MOD)

1. Calculate two difference images with different thresholds
2. Build trajectory for each blob in low threshold difference–image with linear motion prediction–controlled mask block matcher
3. Verify blobs in high threshold noise–filtered difference image

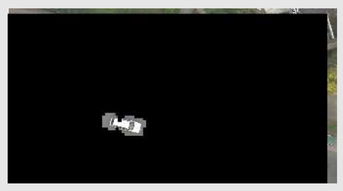
### II. Tracking–by–Detection [4]

- Generate long–term trajectories with hierarchical minimum cost arborescence (MCA) tracker

### III. Coding [2][3]




Preprocessed image:



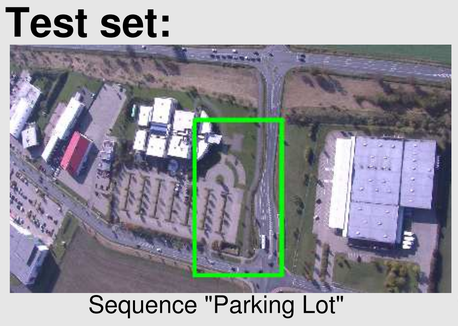
### IV. Video reconstruction at the decoder [2][3]

- Panorama image generation from new areas using GMC
- Video reconstruction from panorama image
- Insertion of moving objects into video




## Experimental Results

### Test set:



Sequence "Parking Lot"

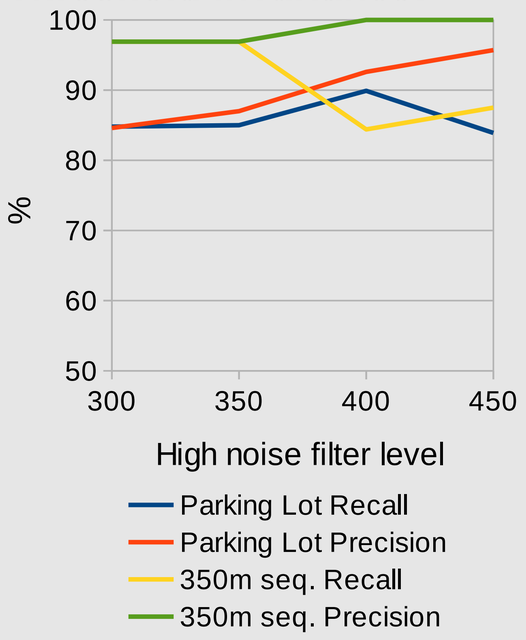
"350m sequence" from TAVT, available at:
https://www.tnt.uni-hannover.de/project/TNT_Aerial_Video_Testset

### Improved masks:

a) b) c) d) e)

a) Binarized difference image
b) MOs & lots of false positives (building up left)
c) Result after mask matching
d) Shape refinement with superpixels
e) Decoded and reconstructed video frame (outtake)

### Threshold invariance:




### Detection & tracking results:

| Seq. | Input image | Recall | Prec. | FP | FN |
|---|---|---|---|---|---|
| Parking Lot | diff2Image | 76.3 | 26.8 | 985 | 112 |
| | diff2Image & SP | 93.4 | 37.0 | 753 | 31 |
| | **diff2Image & SP & TbD** | **94.7** | **38.9** | **704** | **25** |
| | diff2LNFimage | 95.3 | 15.9 | 2380 | 22 |
| | diff2 images &mask matcher | 86.7 | 65.6 | 215 | 63 |
| | diff2 images &mask mat.&SP | 86.0 | 90.8 | 41 | 66 |
| | **diff2 imgs. &mask mat.&SP&TbD** | **89.9** | **92.6** | **34** | **48** |
| 350 m | diff2Image | 100.0 | 7.8 | 377 | 0 |
| | diff2Image & SP | 96.9 | 12.7 | 214 | 1 |
| | **diff2Image & SP & TbD** | **96.9** | **12.5** | **217** | **1** |
| | diff2LNFimage | 96.9 | 5.9 | 492 | 1 |
| | diff2 images &mask matcher | 96.9 | 26.3 | 87 | 1 |
| | diff2 images &mask mat.&SP | 96.9 | 70.5 | 13 | 1 |
| | **diff2 imgs. &mask mat.&SP&TbD** | **96.9** | **83.8** | **6** | **1** |

### Bit rates:

| | Parking Lot sequence | | 350 m sequence | |
|---|---|---|---|---|
| | Bit rate [kbps] | ROI-PSNR [dB] | Bit rate [kbps] | ROI-PSNR [dB] |
| HEVC | 20576 | 37.1 | 8575 | 40.8 |
| ROI HEVC | 4899 | 37.1 | 2597 | 41.0 |

## Conclusions

- Robust dual–threshold moving object detector proposed
- Modified block matcher to retrieve moving object trajectories
- Detection and tracking of small moving objects, e.g. pedestrians
- Recall/Precision increased by tracking–by–detection
- Bit rate reduction about 70% compared to HEVC using the general ROI coding framework

References: [1] H. Meuel, M. Munderloh, J. Ostermann: Low Bit Rate ROI Based Video Coding for HDTV Aerial Surveillance Video Seq., IEEE CVPRW, 1st Workshop of Aerial Video Proc. (WAVP), Colorado Springs, CO, USA, 2011
[2] H. Meuel, M. Munderloh, M. Reso, J. Ostermann: Mesh–based Piecewise Planar Motion Compensation and Optical Flow Clustering for ROI Coding, APSIPA Transact. on Signal and Information Proc., Vol. 4, Oct. 2015
[3] H. Meuel, M. Munderloh, F. Kluger, J. Ostermann: Codec Independent Region of Interest Video Coding using a Joint Pre– and Postprocessing Framework, IEEE Int. Conf. on Multim. & Expo (ICME), Seattle, WA, USA, Jul. 2016
[4] R. Henschel, L. Leal–Taixé, B. Rosenhahn: Efficient Multiple People Tracking using Minimum Cost Arborescences, German Conference on Pattern Recognition (GCPR), Münster, Germany, Sept. 2014

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