Initialization of Model-Based Vehicle Tracking in Video Sequences

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Abstract

- Using 15 minutes of Sequences video
- Automatically initialization for 3D model based vehicle tracking
- Based on Edge-Element and Optical-Flow
- Compare Output of Initialization tracking vehicles from early researches.

Introduction

- There are two alternatives from a larger set of options which comprise

  - Model Free Tracking

    2D model based (Image Plane)

    3D model based (Scene Domain)

  - Hybrid

    2D-blob Vehicle from Ground plane

Introduction

- Combination with Internal and External parameters of the camera

  Allow to determine the vehicle image for any relative respect to camera

  Mismatches can be diagnosed more easily to initialization or tracking errors

Component Processes for Automatic Initialization

1. Optical-Flow-field Estimation
2. Optical-Flow-field segmentation
   (Object Image Candidates (OICs))
3. Confidence accumulation
4. A consistently trackable OIC provides velocity and orientation information for a Hough-Transform of vehicle type and location

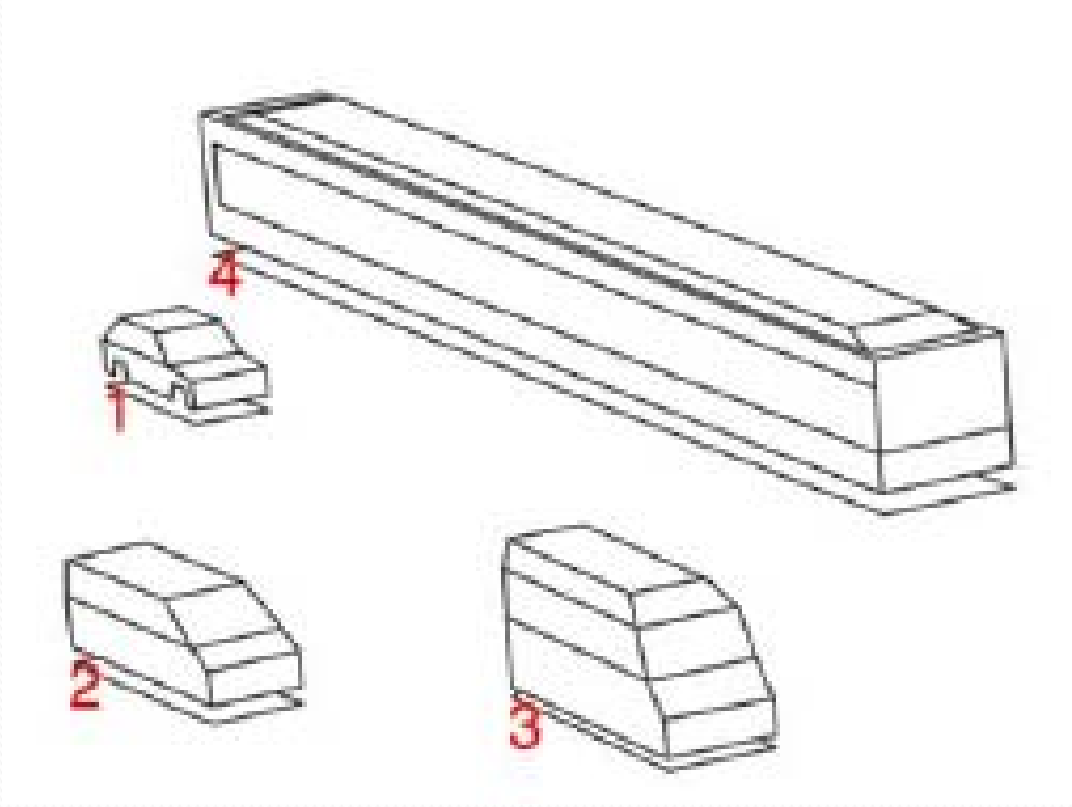
3.1 Optical-Flow-field estimation

- Based on the Gray-level Structure Tensor
- Find Masks
- Time interval – 20ms
- GST-eigen value allows to determine an OF-vector (But do not be used)
- OF-Vectors were excluded during the OF-field segmentation from incorporated into OICs.

3.2 OF-Field Segmentation

- OF-field is segmented for each frame. In order to initializations for the same vehicle.
- OF-Vectors is reports to create 3D model-vehicle

Output from OF-Segmentation at frame 511



Vehicles have been created from OF-Vectors

Spatiotemporal Analysis of OF-Field Segments

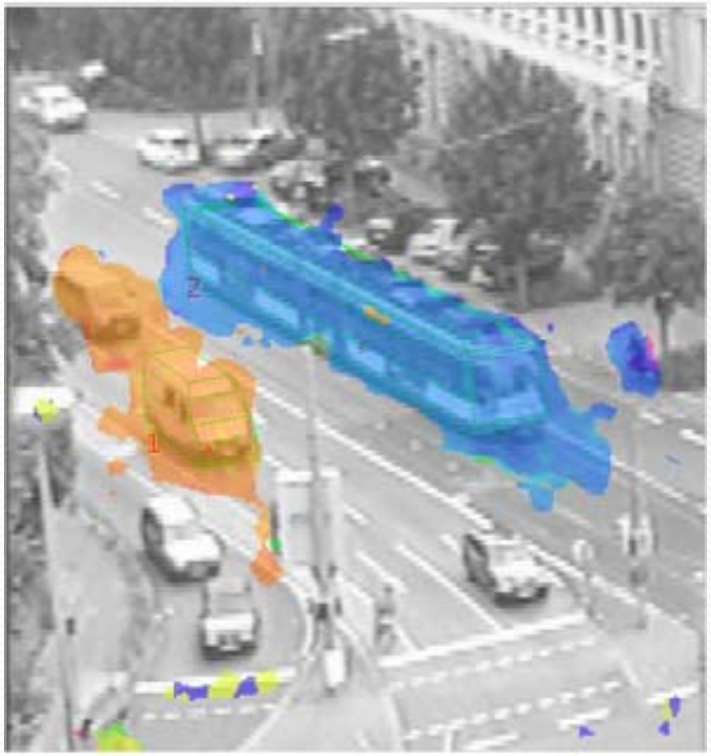
- Minimum Overlap 90% is allowed
- To determine the vehicle
  - OF-segment can be tracked for several consecutive frames
  - The size of vehicle almost constant

Vehicle Localization

1. Estimated Projecting the mean OF-vector of the OF-segment, positioned at its centroid in 3D Scene. → Output – Edge segments (EEs)
2. Orientations of EEs are determined by calculating the derivative of the tessellated.
3. Hough-Transform finds a centroid of the model.

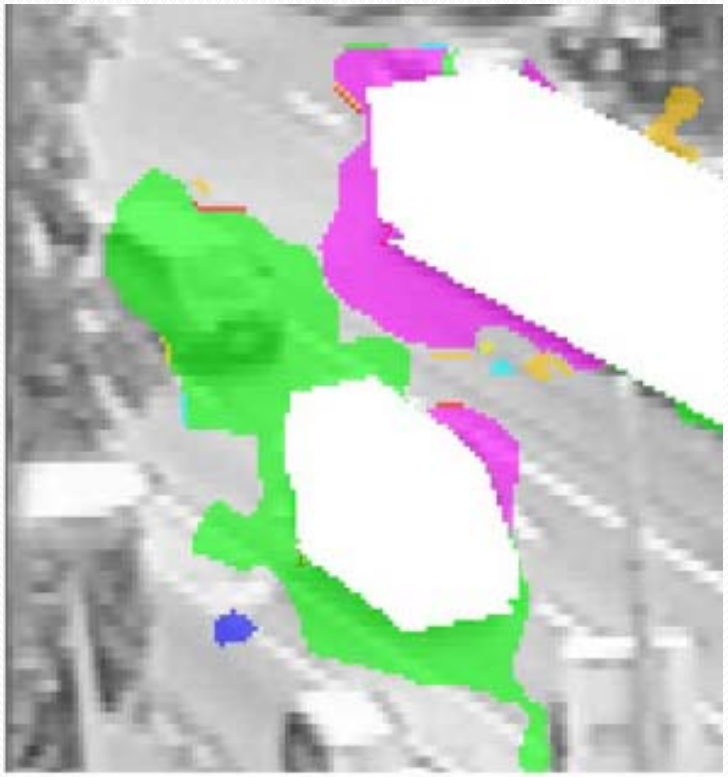
(a)

Section of Frame 99 With tracking results



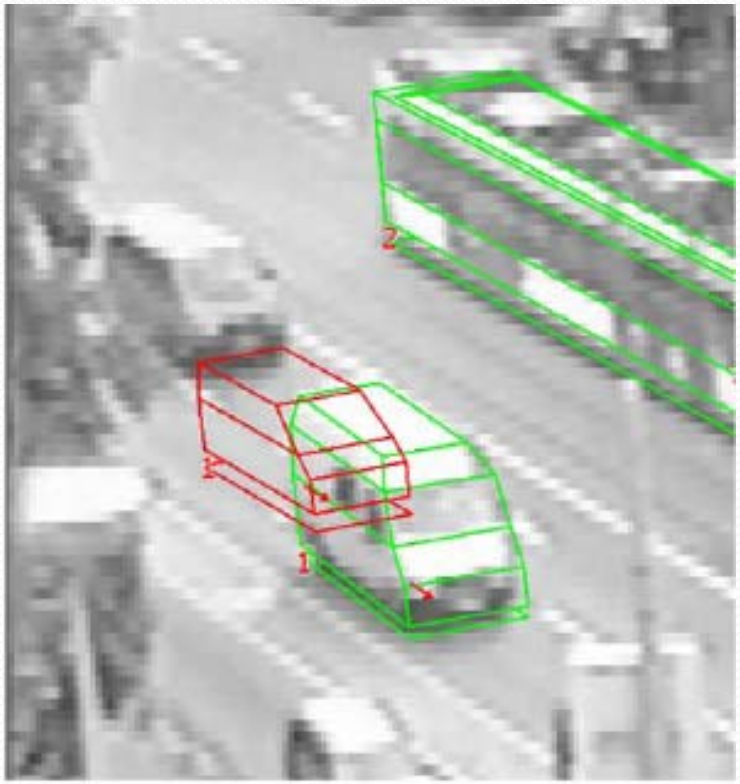
(b)

OF-Vectors in minimum field



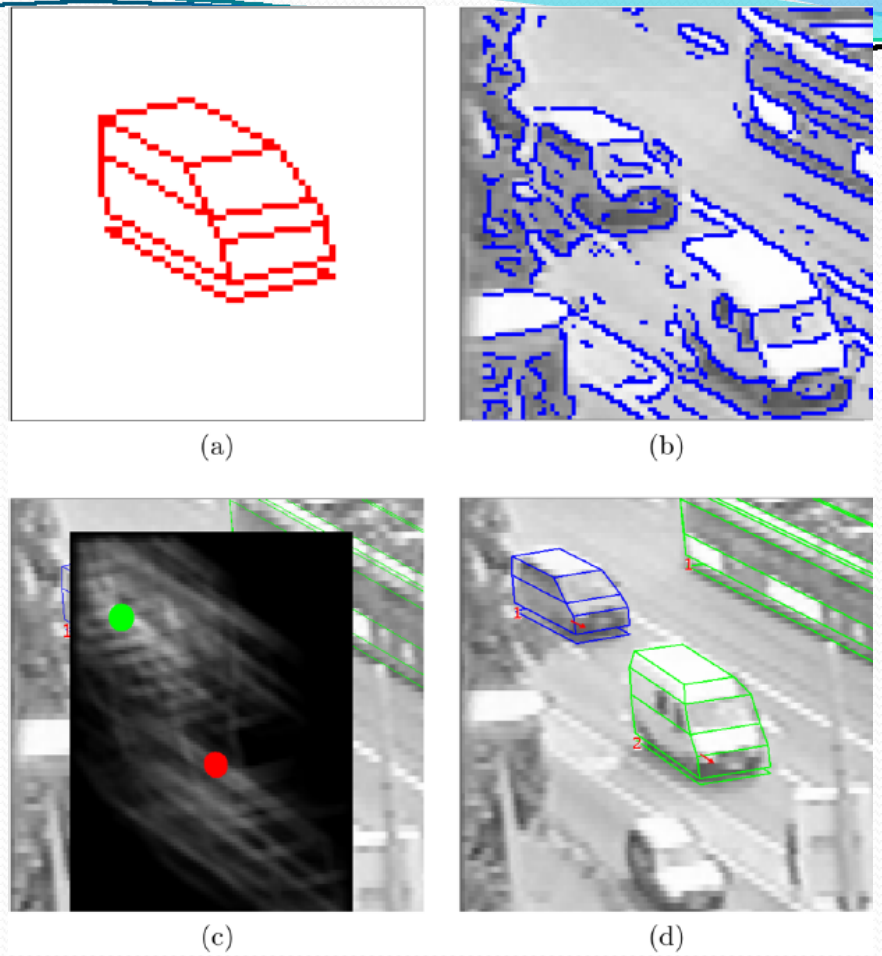
(c)

OF-Tracking Results



(d)

Vehicle Tracking in right position (Green lines)



Hough transform output

Optical Flow Vector Coverage Rate

- OF-Vector --- u
- Displacement rate vector --- v(ζ,x)
- Pixel position --- ζ
- Current State Vector --- x
- Decay Factor --- γ

- Mahalanobis Distance M

$$M_{OF} = \Delta \mathbf{u}^T \cdot \Sigma^{-1} \cdot \Delta \mathbf{u}.$$

- Covariance Σ

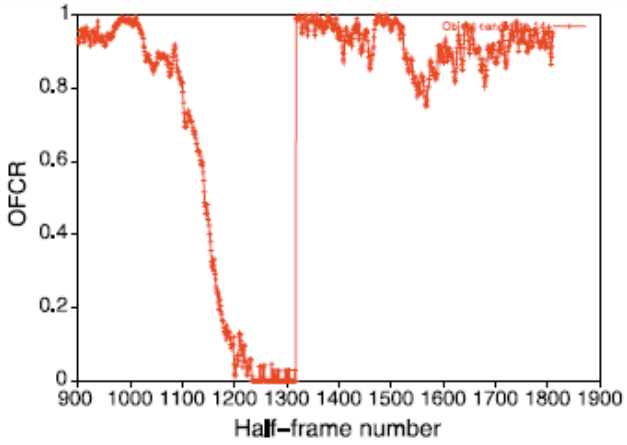
$$\Sigma = \frac{\partial \Delta \mathbf{u}}{\partial \mathbf{u}}(\mathbf{u}, \hat{\mathbf{x}}^+) \cdot \Sigma_{OF} \cdot \left(\frac{\partial \Delta \mathbf{u}}{\partial \mathbf{u}}(\mathbf{u}, \hat{\mathbf{x}}^+) \right)^T$$

$$+ \frac{\partial \Delta \mathbf{u}}{\partial \mathbf{x}}(\mathbf{u}, \hat{\mathbf{x}}^+) \cdot P^+ \cdot \left(\frac{\partial \Delta \mathbf{u}}{\partial \mathbf{x}}(\mathbf{u}, \hat{\mathbf{x}}^+) \right)^T,$$

$$= \Sigma_{OF} + \frac{\partial \Delta \mathbf{u}}{\partial \mathbf{x}}(\mathbf{u}, \hat{\mathbf{x}}^+) \cdot P^+ \cdot \left(\frac{\partial \Delta \mathbf{u}}{\partial \mathbf{x}}(\mathbf{u}, \hat{\mathbf{x}}^+) \right)^T.$$

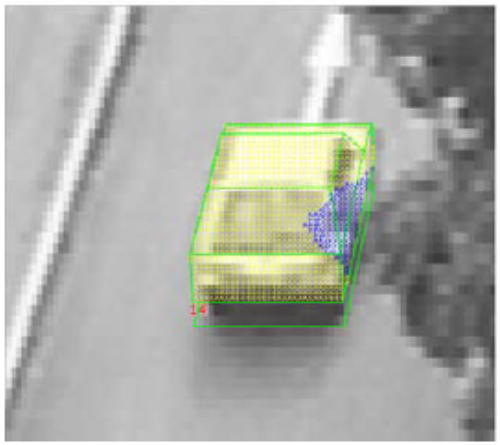
- Weight New Assessment

$$a_t = (1 - \gamma) \cdot a_{t-1} + \gamma \cdot r_t.$$



OFCR

Trajectory



1050

1150

Optical Flow vector Coverage Rate Output

Experiments With the Video Sequences

- Tracking Result are assessed as
  - Very good (++) ---- 15%
  - Good (+) ---- 23%
  - Tolerable (o)
  - Bad (-)
  - Failure (--)

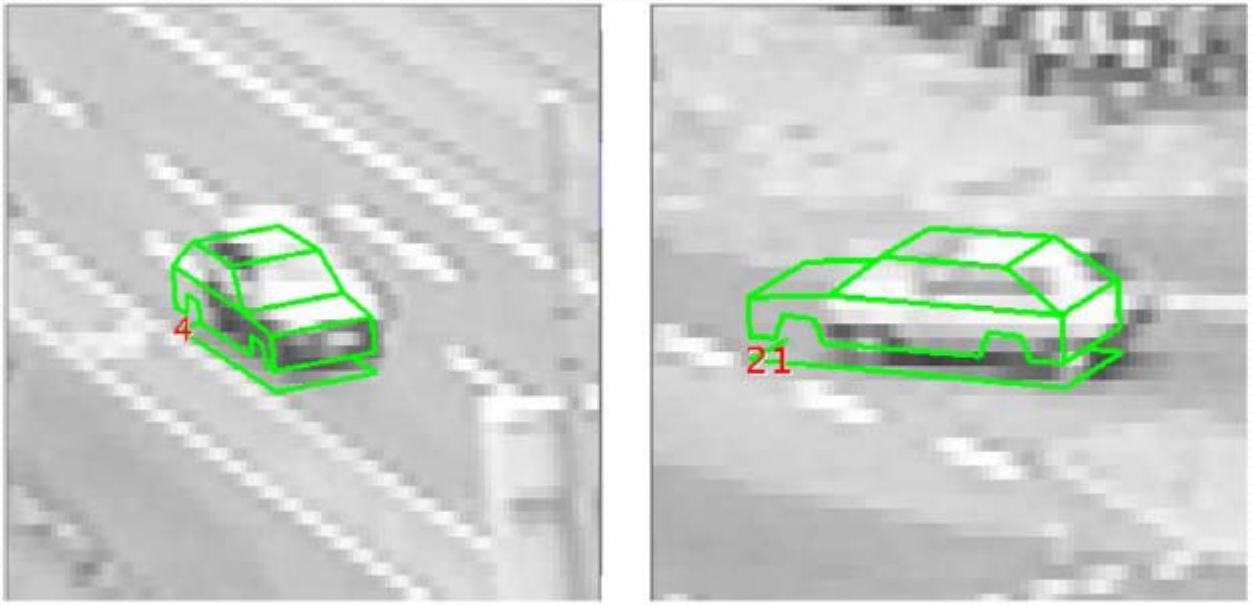
frame 757 frame 850

Very Good (++)

frame 3400

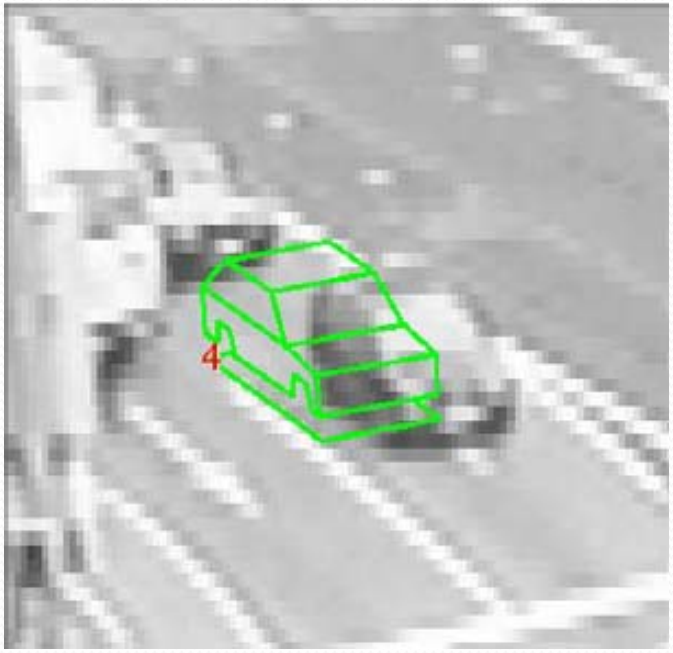
frame 3600

Good (+)



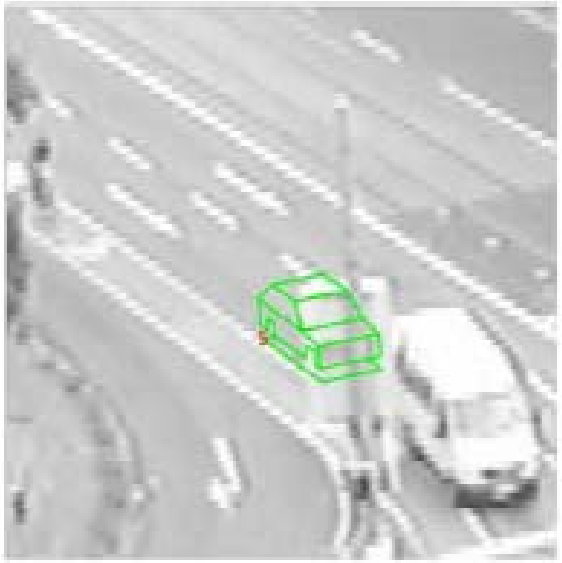
OC 4 in frame 351 OC 21 in frame 2133

Tolerable (o)



Bad (-)

369



500

3410

Failure (--)

Results

Assessment	1	2	3	4	5	6	7	8	9	10	11	12	∑
++	3	3	6	5	5	5	4	6	4	4	4	4	53
+	4	7	11	2	6	9	3	12	3	6	10	12	85
o	10	5	4	3	10	16	3	15	5	7	17	3	98
–	11	9	6	7	3	6	2	6	3	10	14	12	89
--	4	1	2	4	1	1	2	3	3	8	6	1	36
++/+/o	17	15	21	10	21	30	10	33	12	17	31	19	236
													(65%)
∑	32	25	29	21	25	37	14	42	18	35	51	32	361

Results

Table 2 *Tolerant* assessment (see text for detailed explanation)

Assessment	1	2	3	4	5	6	7	8	9	10	11	12	∑
++	3	3	6	5	5	5	4	6	4	4	4	4	53
+	4	7	11	2	6	9	3	12	3	6	10	12	85
o	15	8	6	3	12	18	5	20	7	13	21	8	136
–	6	6	4	7	1	4	0	1	1	4	10	7	51
--	4	1	2	4	1	1	2	3	3	8	6	1	36
++/+/o	22	18	23	10	23	32	12	38	14	23	35	24	274 (76%)
∑	32	25	29	21	25	37	14	42	18	35	51	32	361
Initialization failure (multiple countings)													
no initialization at all	0	0	1	1	0	0	0	0	0	1	0	0	3
multiple	2	1	0	1	0	1	1	3	1	2	4	0	16
localization	8	5	4	2	7	11	1	9	2	7	13	4	73
late	8	5	5	7	1	4	0	1	1	3	7	6	48
Other failure reasons (multiple countings)													
wrong model	8	3	4	0	4	3	2	6	4	9	9	6	58
undetected tracking failures	3	0	2	3	0	0	1	1	1	2	5	1	19
tracking failure	0	1	0	0	2	5	2	6	3	3	2	2	26