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INSTITUTE OF ELECTRONICS AND COMPUTER SCIENCE

Vehicle classification in video using virtual detection lines

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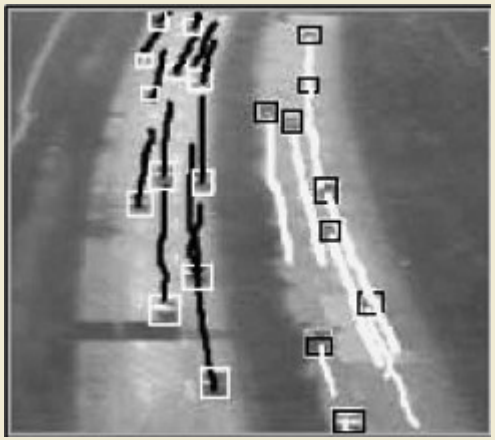
Motivation

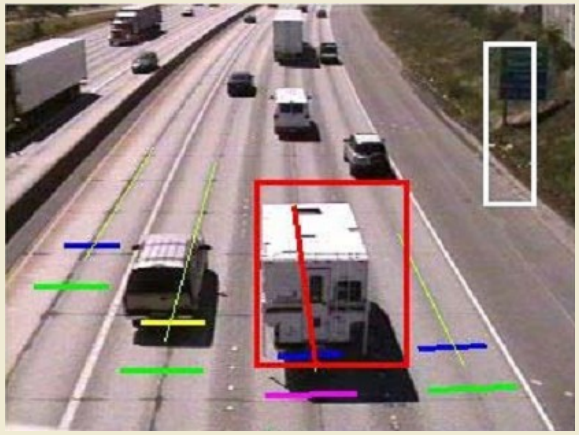
- Safety - distinguishing between humans and vehicles
- Detection of trucks allows:
  - improving traffic planning and road pavement maintenance
  - differentiating charges in auto-toll systems
  - warning too high vehicles before bridges
- Speed detection allows find speed limit violations

- Use of cameras allows detecting more parameters than inductive loops in the pavement and other sensors

Prior work 1



[1]



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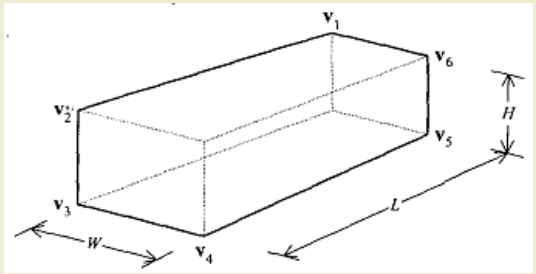
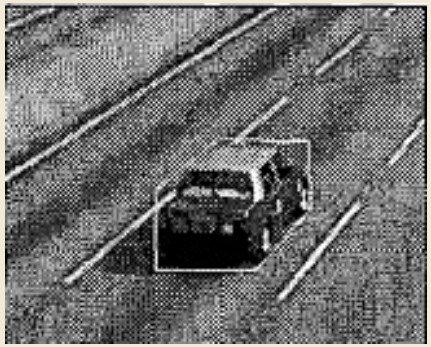


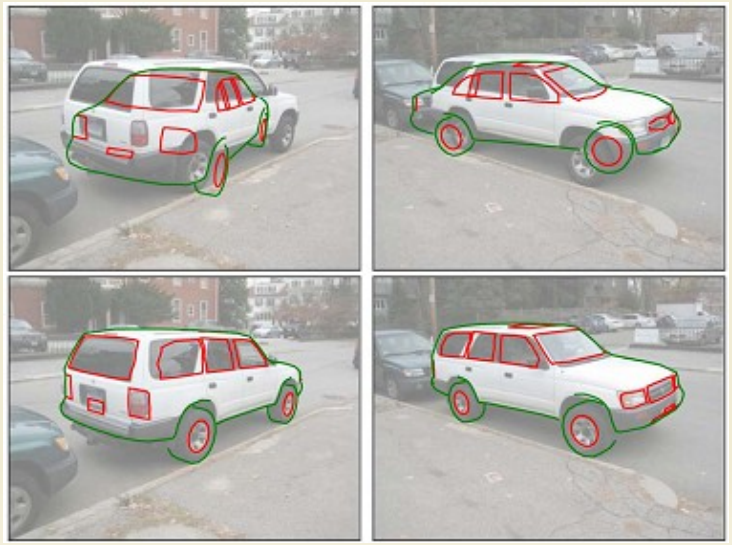


[3]

1. Rad R., Jamzad M.: Real time classification and tracking of multiple vehicles in highways. Pattern Recognition Letters. 26, 1597-1607 (2005)
2. Zhang J., Wang F-Y., Wang K., Lin W-H., Xu X., Chen C.: Data-Driven Intelligent Transportation Systems: A Survey. IEEE Transactions on Intelligent Transportation Systems, 12(4), 1624-1639 (2011)
3. Lai A. H. S., Fung G. S. K., Yung N. H. C.: Vehicle Type Classification from Visual-Based Dimension Estimation. IEEE Intelligent Transportation Systems Conference Proceedings. 201-206 (2001)

Prior work 2

4. Leotta M. J., Mundy J. L.: Vehicle Surveillance with a Generic, Adaptive, 3D vehicle Model. IEEE Transactions on Pattern Analysis and Machine Intelligence. 33(7), 1457-1469 (2011)



[4]

- Detected parameters may be compared to known values of real vehicles. Different classification algorithms may be used – vector machines, k-nearest neighborhood, neural networks

Vehicle detection

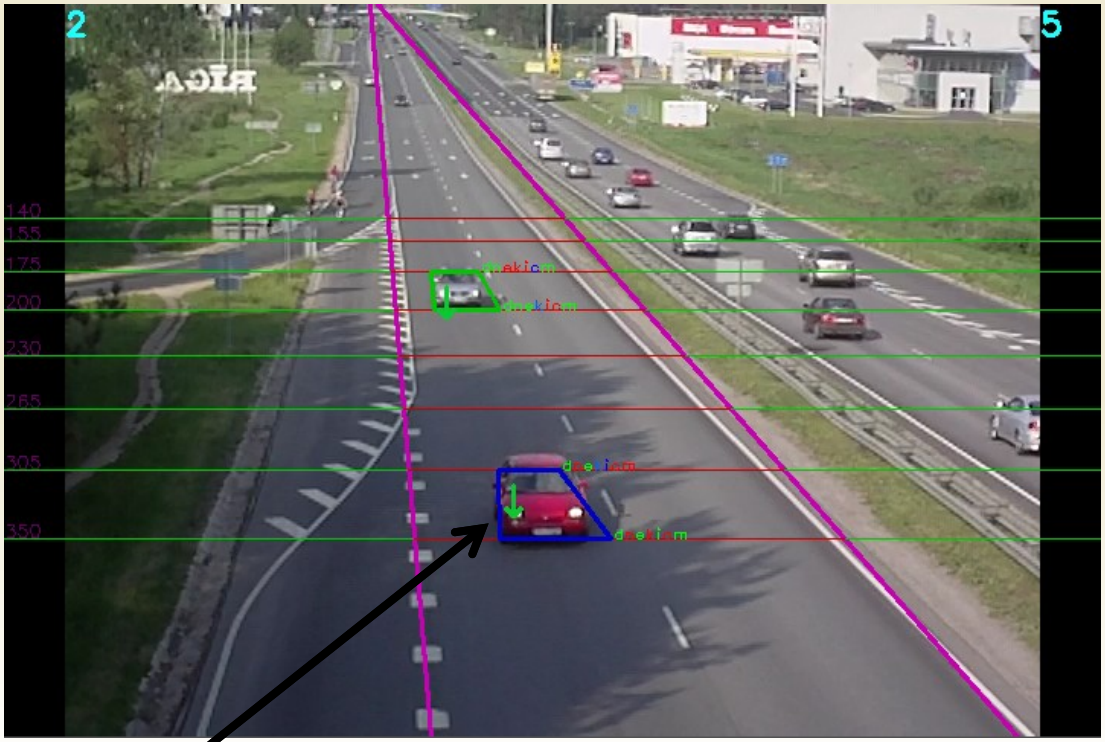
5. R. Kadiķis and K. Freivalds, "Efficient video processing method for traffic monitoring combining motion detection and background subtraction," Proc Fourth International Conference on Signal and Image Processing 2012. 131-141, (2013)

- Virtual detection line in the frame is perpendicular to the road
- Vehicles that cross the detection line are detected by combining motion detection and background subtraction methods
- Intervals are created on detection line, denoting segments covered by vehicles. Interval is closed when vehicle leaves
- Line crossing vehicles are detected and counted

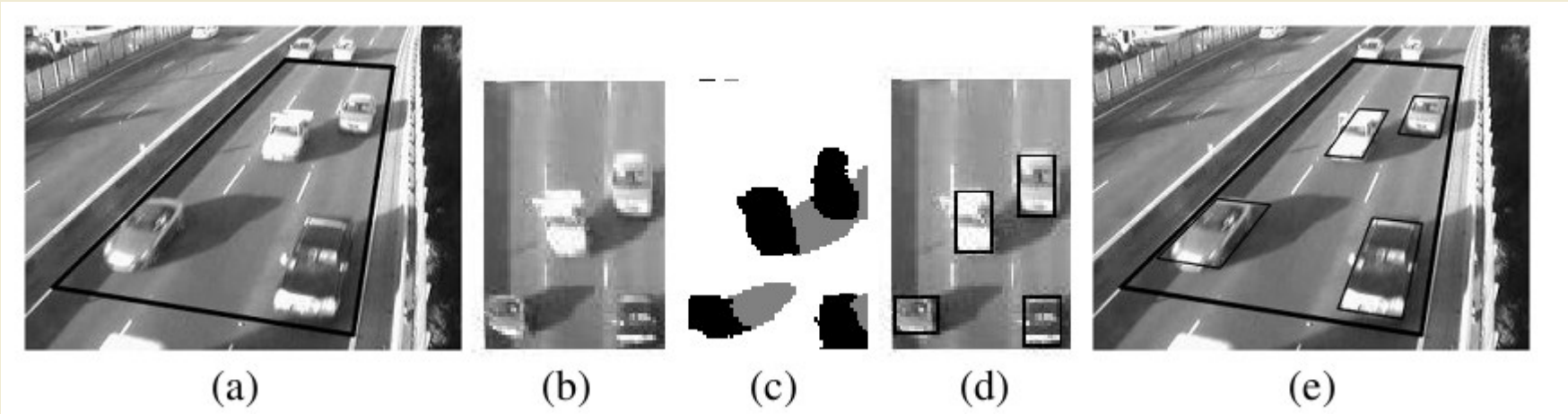
[5]

Multiple detection lines

- Multiple detection lines are placed in the frame
- Intervals from different lines are combined in to vehicle objects



Projective transform 1



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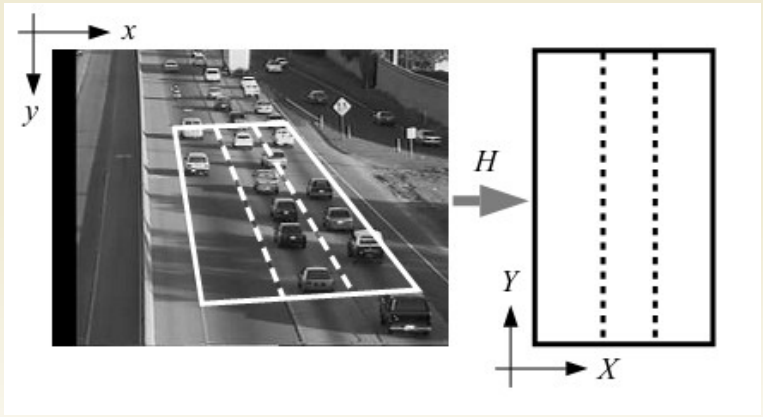


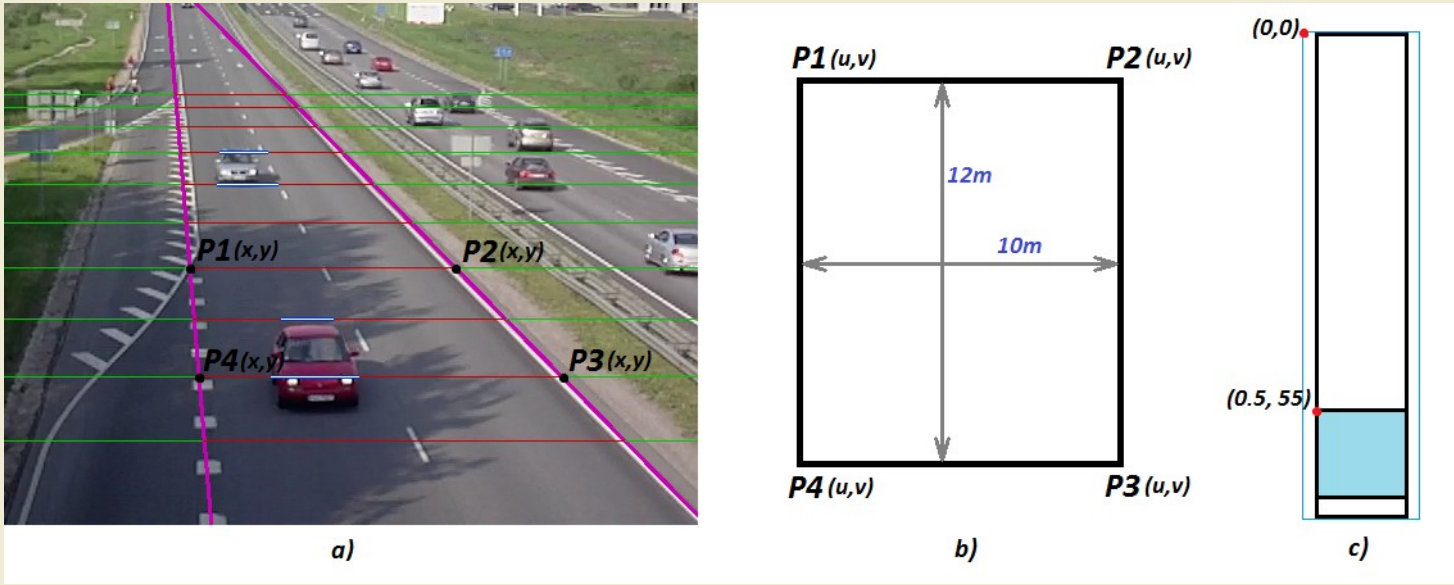
[7]

6. Wang Y. and Ye G. Joint random fields for moving vehicle detection// Proc. British Machine Vision Conference (BMVC). – 2008.

7. Beymer D., McLauchlan P., Coifman B. and Malik J. A Real-Time Computer Vision System for Measuring Traffic Parameters// Proc. IEEE Computer Society Conference on Computer Vision and Pattern Recognition. – 1997. – 495.-501. p.

Projective transform 2

- Camera calibration



- Finding transform coefficients

$$ax_i + by_i + c = gx_iu_i + hy_iu_i + u_i$$
$$dx_i + ey_i + f = gx_iv_i + hy_iv_i + v_i$$

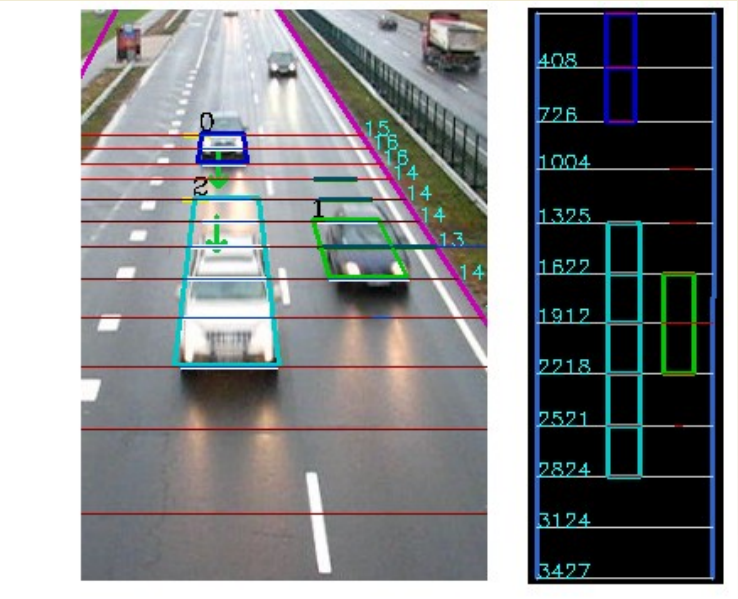
- Transformation of coordinates

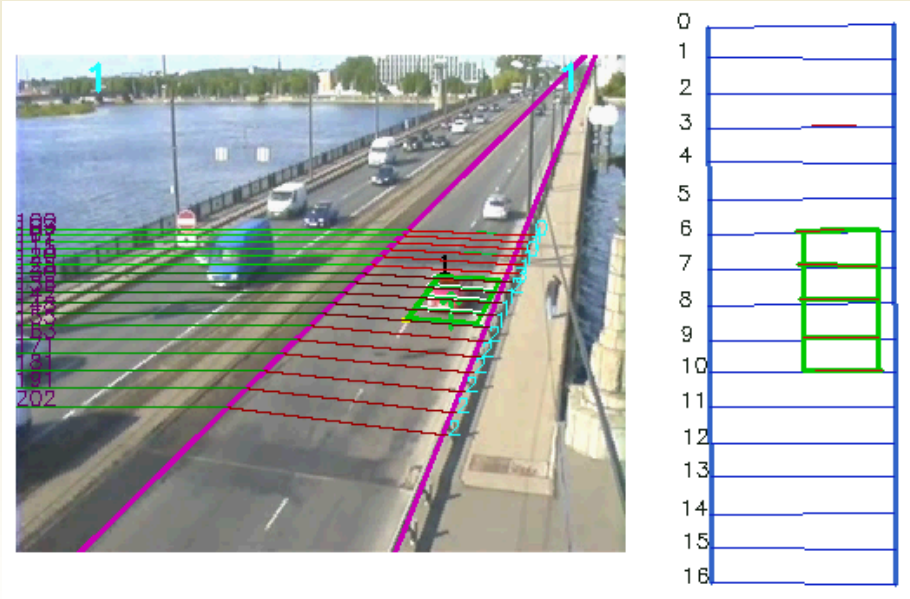
$$u = \frac{a \cdot x + b \cdot y + c}{g \cdot x + h \cdot y + 1},$$

$$v = \frac{d \cdot x + e \cdot y + f}{g \cdot x + h \cdot y + 1},$$

Uniform placement of lines

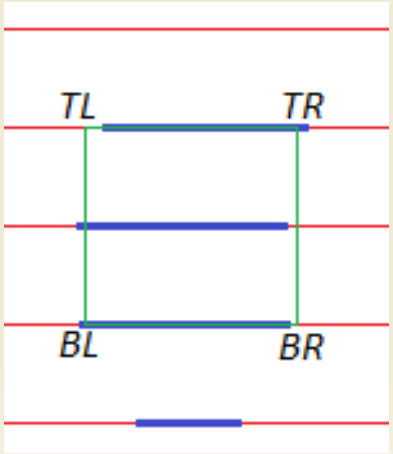
- Detection lines in the world plane are positioned parallel to each other, perpendicular to the road and equidistant
- Algorithm automatically computes according placement and incline of detection lines in the frame plane

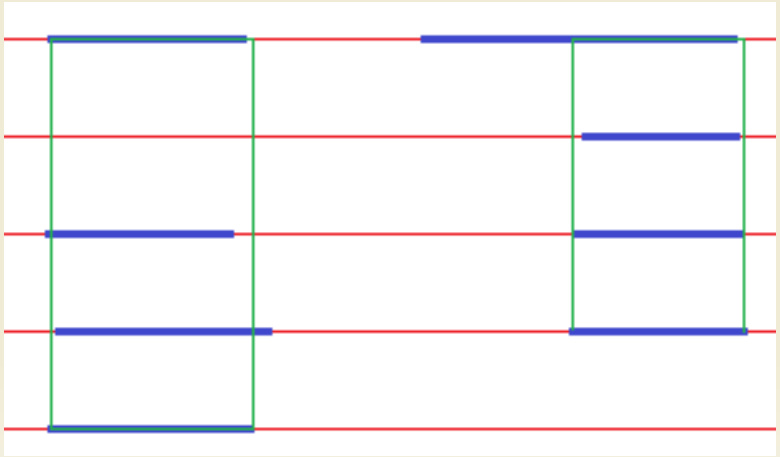




Vehicle tracking

- If intervals appear shortly on adjacent detection lines and their coordinates are close, they are combined in to new vehicle object

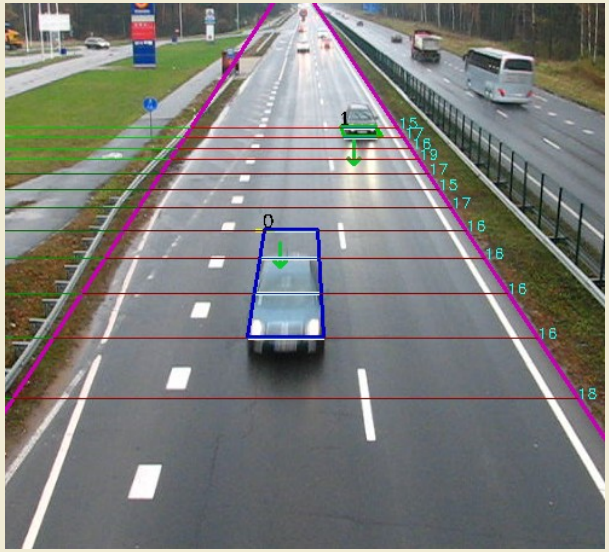




- New intervals may be added to existing vehicles
- Deletion and addition of intervals changes coordinates of vehicle
- Outcast intervals are removed from vehicle

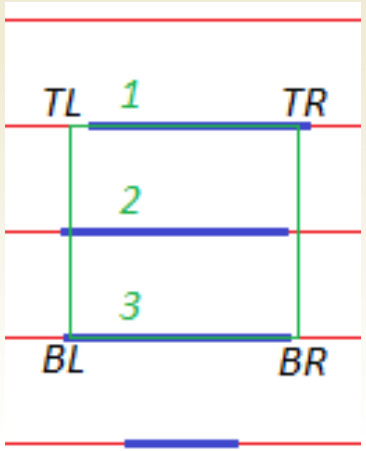
Detection of parameters

- If vehicle first appears on the upper detection lines, initial **direction** of vehicle is assumed to be from top to bottom
- Acquired direction may change



- **Width** of intervals approximately correspond to the width of the vehicles

- **Speed** is determined by counting frames between additions of new intervals to the vehicle object



- **Length** of vehicle is equal to multiplication of vehicle speed and a lifespan of vehicle intervals

Detection of parameters - height

- Information about vehicle height remains in a frame plane

$$h = H \frac{w_b}{w_b + w_s}$$

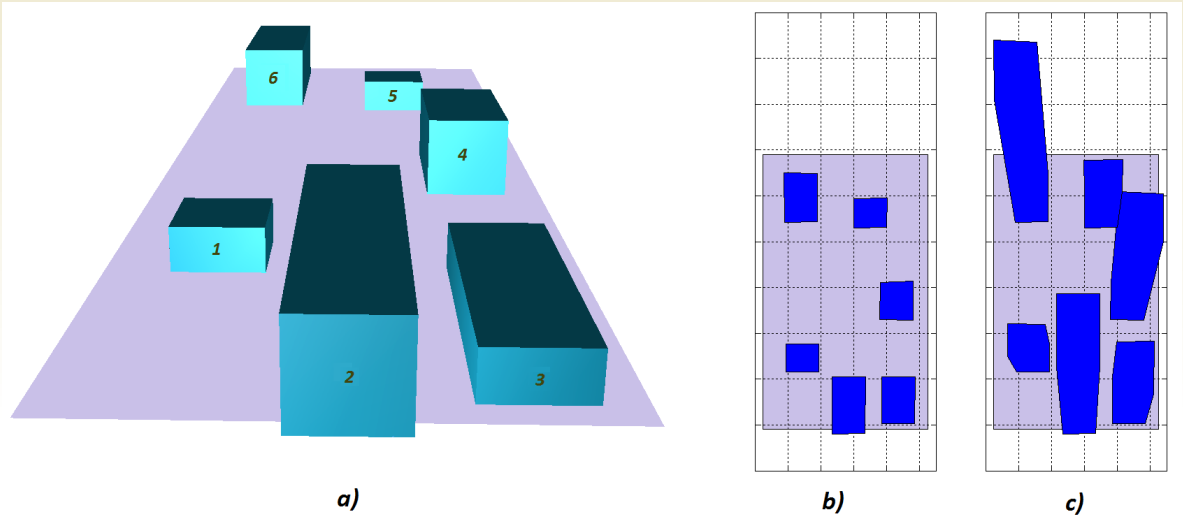
h – height of vehicle

H – height of camera

w_b longest interval

w_s – shortest interval

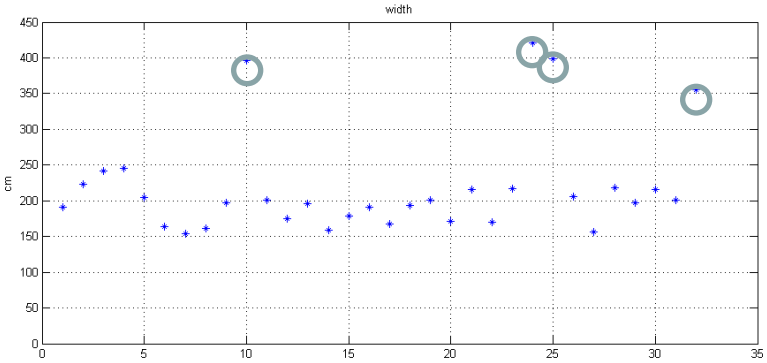
- Height of vehicle is proportional to changes of width of intervals in projective transform plane



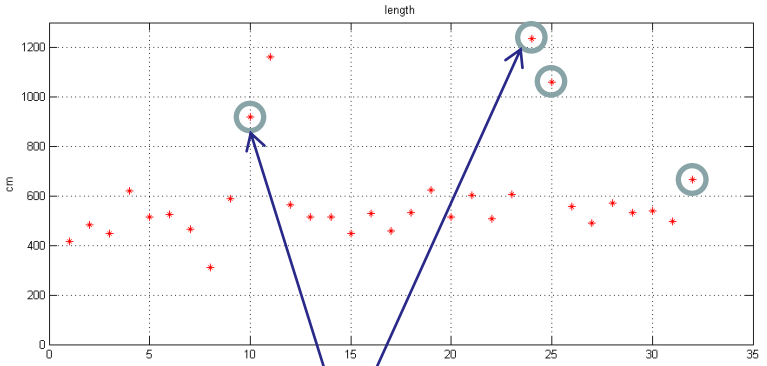
a) *b)* *c)*

Classification

width

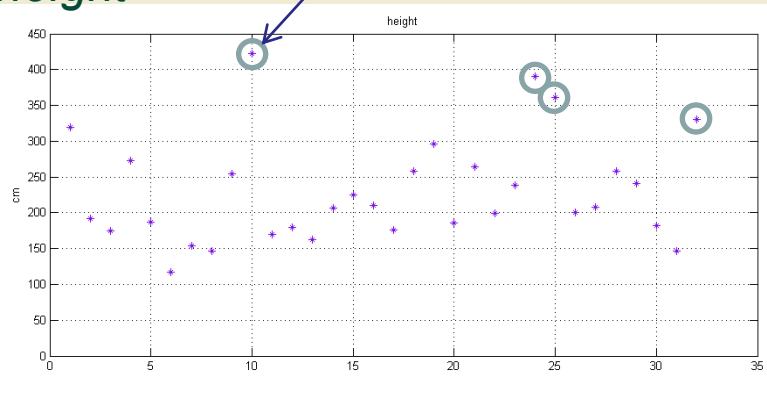


length



trucks

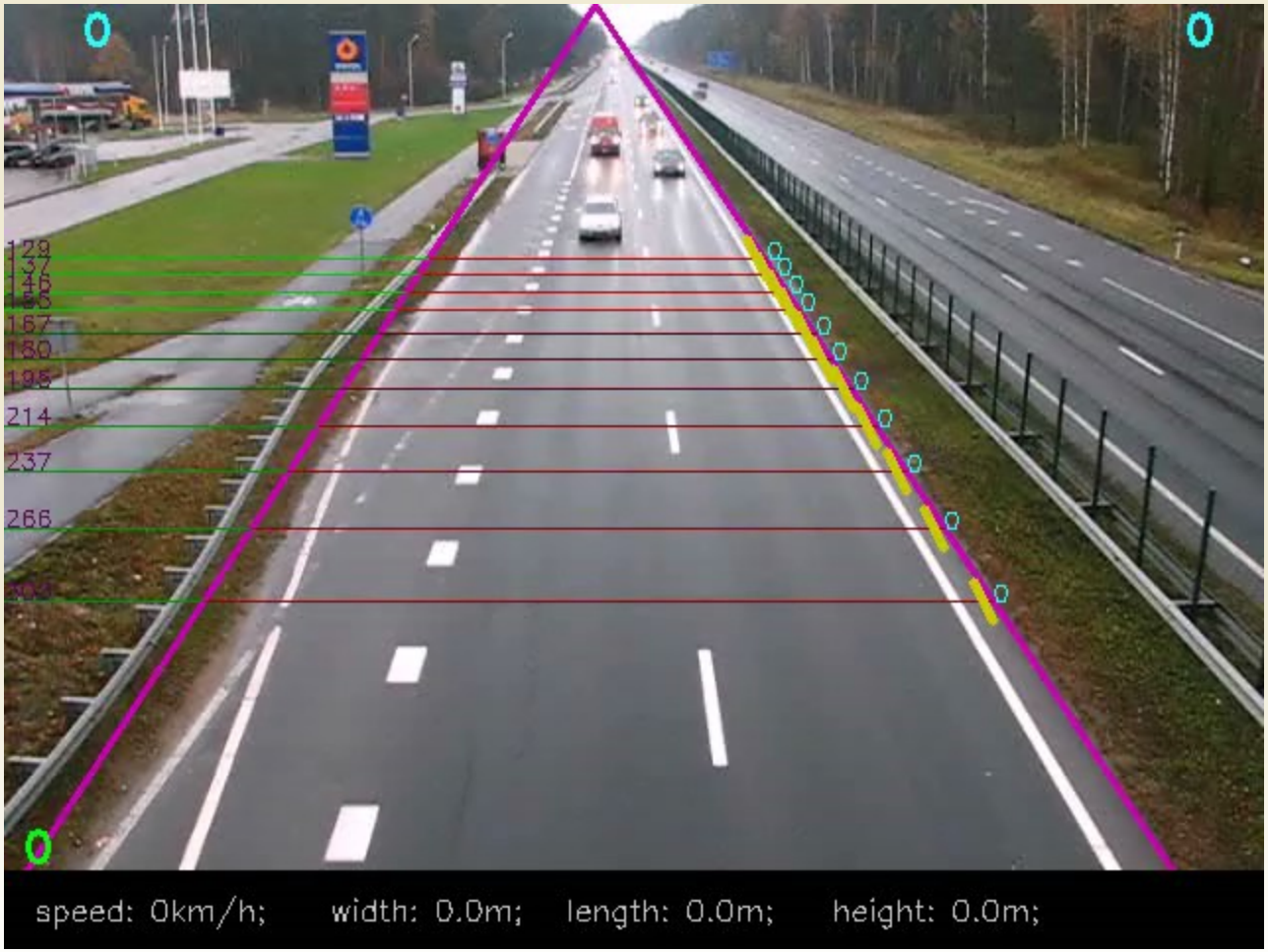
height



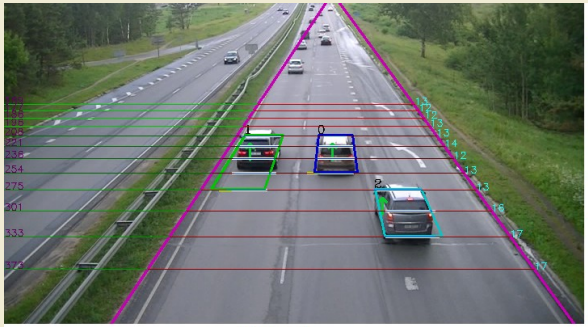
vehicle number ⟶

- Vehicle objects that are large enough and exist long enough are detected as vehicles
- Vehicles are classified as trucks if:
  - Height > 2.5m
  - Length > 7m
  - Width > 2.5m

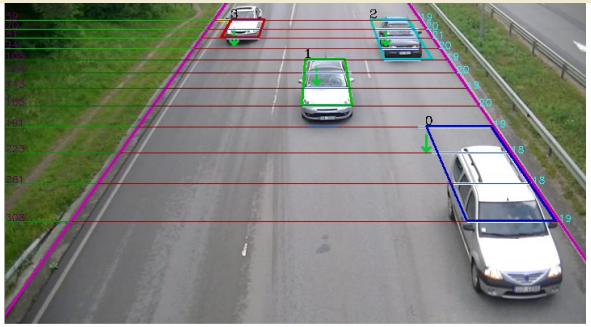
Demonstration



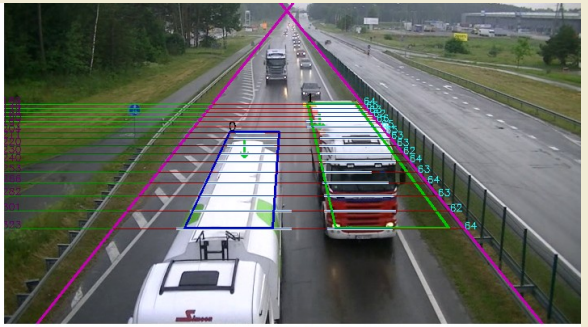
Results 1



Video 3



Video 4



Video 7

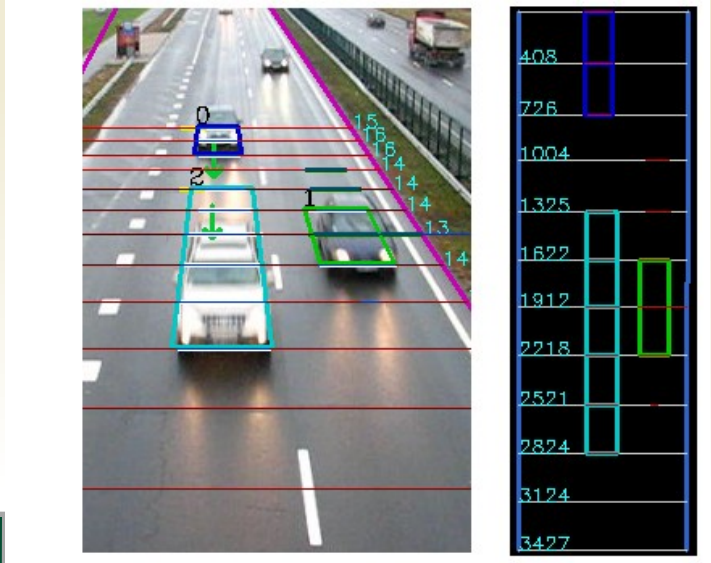
Video	Ground-truth number of all vehicles	Single line		Average of all lines		Proposed algorithm	
		count	accuracy	count	accuracy	count	accuracy
1	32	30	94%	30	94%	32	100%
2	122	121	99%	124	98%	122	100%
3	159	168	94%	164	97%	158	99%
4	43	45	95%	44	98%	44	98%
5	221	232	95%	235	94%	231	95%
6	208	209	99%	209	99%	209	99%
7	246	233	95%	239	97%	239	97%
8	117	118	99%	118	99%	116	99%
9	88	92	95%	93	94%	88	100%

Results 2

Video	Ground-truth		Trucks correctly detected	False positive trucks
	all vehicles	trucks		
1	32	4	4	0
2	122	8	8	0
3	159	8	7	1
4	43	0	0	0
5	221	12	7	0
6	208	5	5	1
7	246	12	12	3
8	117	4	4	1
9	88	7	6	0

Conclusions

- Algorithm of intervals on a virtual detection line, which is usable in different weather conditions and adapts to changes in lighting, is successfully usable for vehicle tracking, determination of parameters and classification
- Use of multiple detection lines and combination of intervals in to vehicle objects increases vehicle detection accuracy compared to single line or simple averaging indications of multiple lines



Thank you for your attention!