Real Time Vehicle Country of Origin Classification Based on Computer Vision

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* LUNDS UNIVERSITET, SWEDEN

- **University of Zagreb, Croatia**
  - Established in 1669.
  - 29 faculties and 3 academies
  - 4.850 research staff members and 50.000 students
- **Faculty of Transport and Traffic Sciences**
  - Established in 1984.
  - 15 departments
    - Cover all transport modes, logistics, ITS, aeronautics
  - 100 research staff members / 2.200 students
  - Publisher of the journal
  - PROMET – Traffic & Transportation
    - Cited in SCIE, TRIS, Geobase, FLUIDEX, and Scopus

Outline

- Introduction
- Problems and approaches
- Vehicle classification
- Vehicle detection and license plate recognition
- Vehicle detection speed up
- Experimental results
- Conclusion and future work

Introduction

- **Faculty of Transport and Traffic Sciences - Computer Vision Group**
  - Developing algorithms for road traffic analysis based on computer vision
- **Applications**
  - Traffic management
    - Dynamic behaviour of a road traffic system derived from known parameters
      - Traffic flow between nodes in a traffic network
    - Driver information system
  - Origin-Destination analysis of traffic on highways
    - Computation of current and estimated OD matrices of a road traffic network
    - Possibility to estimate the route of a traced vehicle

- **Problems of manual measurement of traffic parameters**
  - Inaccurate data due to human error
  - Impracticable to measure data 24/7
  - Measuring number of passed vehicles on complex intersections requires a large number of people for counting
    - Increase need in human resources
  - Impracticable to measure complex traffic parameters (vehicles queue, vehicle velocity, distance between vehicles)
- **Sensors for measuring traffic parameters**
  - Pneumatic road tube sensors and piezoelectric sensors
  - Inductive loops and magnetic sensors
  - Radars, LIDARs
  - Video cameras (color, IR, multi-spectral)

- **Current commercial systems use one camera per lane**
- **Detection and tracking of vehicles**
  - Based on performing segmentation between objects of interest and noninterest objects using various image processing methods (Fg/Bg image segmentation, optical flow, Haar method, Hough method)

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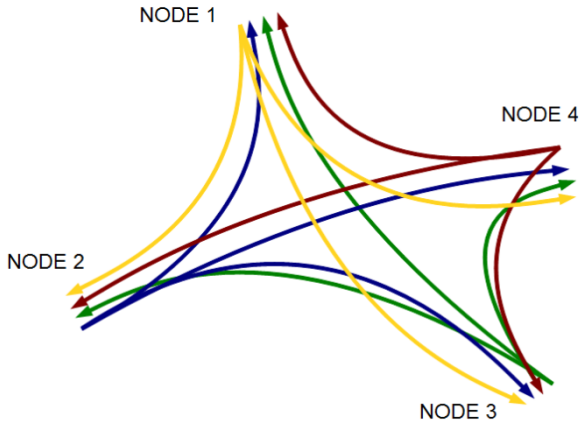
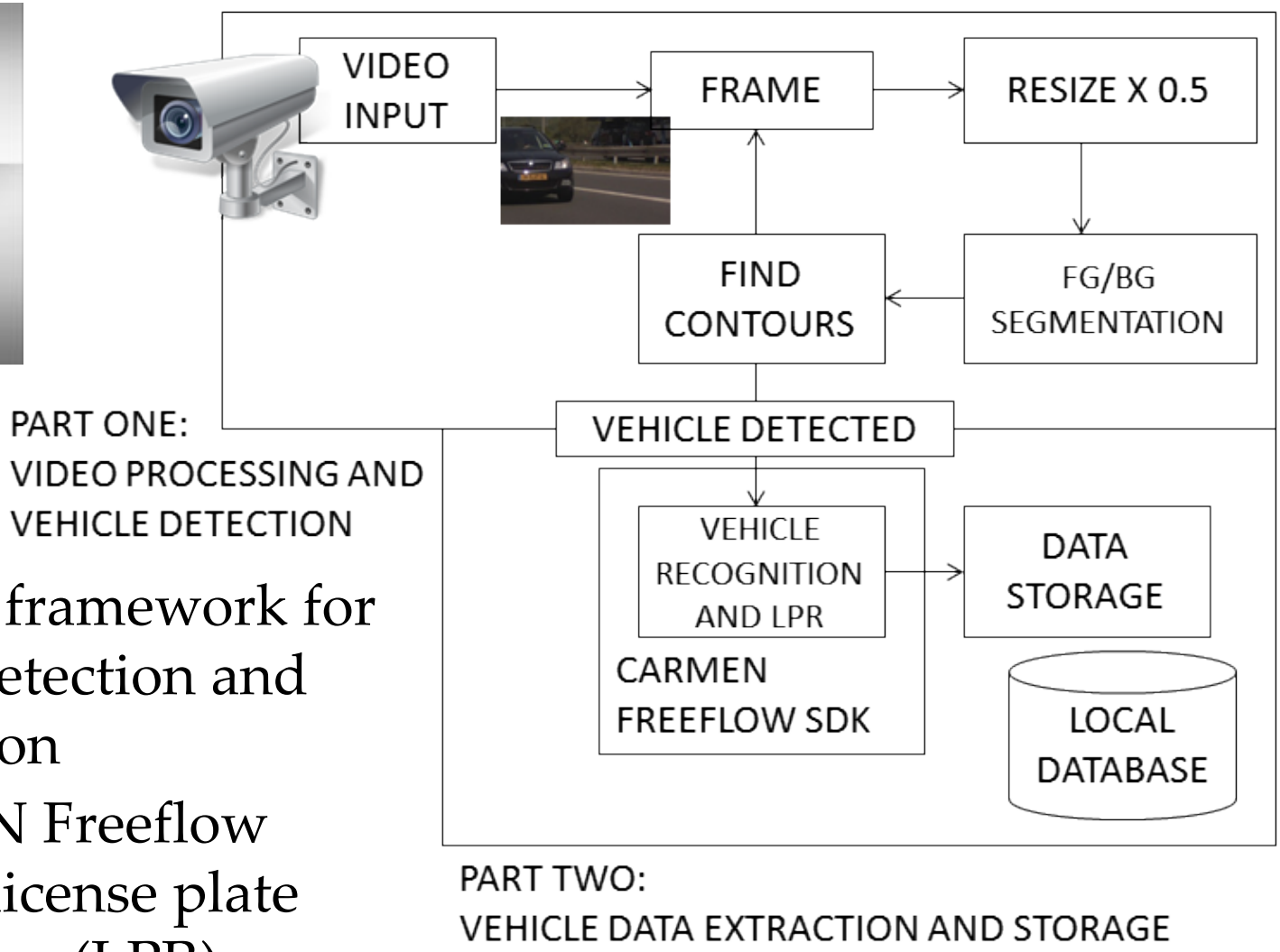
- **Estimation of vehicle trajectory**
  - Based on knowing vehicle location at certain time
  - Describing vehicle movement by mathematical models which take into account vehicle dynamics
  - Estimating next possible location (trajectory) of the vehicle

- **Trajectory of moving vehicle through road traffic network (from node A to node B)**
  - Providing unique identification to each vehicle that is passing through road traffic network using automatic number (license) plate recognition
  - Reduction of false positive/negative vehicles using additional statistical information given from origin-destination (OD) matrix





- OpenCV framework for vehicle detection and localization
- CARMEN Freeflow SDK for license plate recognition (LPR)

- **Application objectives**
  - Detection of vehicles in video
  - Tracking static vehicles (if vehicle stops to move)
  - Vehicle license plate recognition for further traffic analysis
- **Vehicle detection**
  - Pre-processing image imported from video with Gaussian blur filter
  - Passing image through foreground / background image segmentation algorithm
  - Finding contours which localize regions of detected vehicles

- **Disadvantages of currently developed application**
  - Vehicle detection depends on license plate recognition
  - High requirements for system resources (slow execution of algorithm due to sub-optimal approach)
- **Optimization approach**
  - Executing algorithms on GPU as much as possible
  - Adding support for CPU SIMD instructions to algorithms which are incapable to run on GPU
  - Performing computations using multiple threads
    - Parallelization of image processing algorithms

- **Accuracy**

Approach	Total evaluation time [min]	Real vehicle Count	Corrected Vehicles	Wrong Vehicles	Correct/Real [%]
Analysis with sharpener filter	30	534	507	27	94%
Analysis without sharpener filter	30	532	515	17	96%

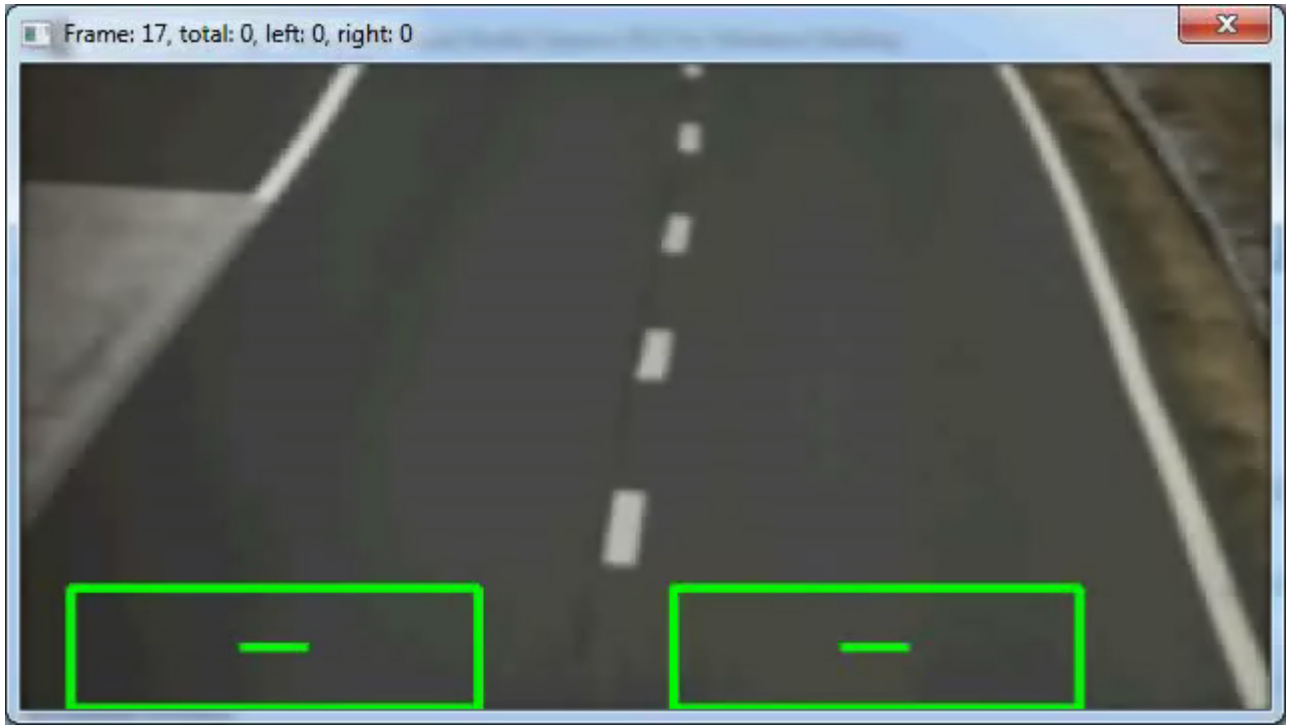
- **Execution time**

Approach	Contours for loop		Processing time of an image with vehicle	
	Avg time [ms]	Min time [ms]	Avg time [ms]	Min time [ms]
Single-thread	909	100	904	100
Multi-thread	5	4	14	13

- **Extracted classification of vehicles by its country of origin**
  - Test video length - 30 [min]

COUNTRY	NUMBER OF VEHICLE	RATIO [%]
Germany	166	31.2
Poland	88	16.5
Austria	83	15.6
Czech Republic	72	13.5
Croatia	47	8.8
Slovenia	17	3.2
Turkey	13	2.4
Slovakia	11	2.0
Others	35	6.8
Total	**532**	**100**

- Overlapping vehicles cause false positive and false negative detections
- Environment conditions (sun reflection, rapid lighting changes), camera vibrations caused by strong wind or passing of large vehicles



- **Developed application has shown possibility of extracting a large number of information from video footage**
  - License plate number – vehicle country of origin, vehicle trajectory, flow, number of vehicles, etc.
- **One camera can be used for multiple lanes**
- **First results promising**
- **Further development of the application is currently in progress and it consists of following goals**
  - Estimation of vehicle trajectory on a road traffic network
  - Detection and analysis of vehicle queue
  - Determination of vehicle velocity
  - Computation of origin-destination matrix of large road traffic network for purposes of traffic modelling

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  - Leading institution University of Zagreb, Faculty of electrical engineering and computing
- **University of Zagreb, Faculty of Transport and Traffic Sciences**

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