In the name of GOD

Digital Image Processing Applications in Intelligent Transportation Systems

Presenters:

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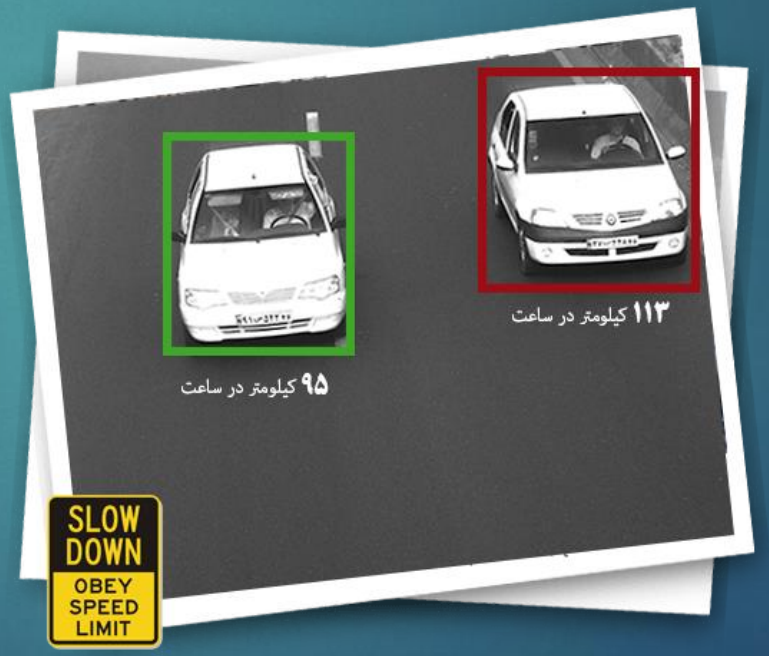


Scopes

- Preface
- Intelligent Transportation Systems
  - Beneficiaries
  - Environmental Factors
  - Data Sources/Gathering
- Vision-based ITS
  - Introduction
  - Region of Interest
  - Pre-processing

Scopes

- Vision-based ITS Applications
  - Automatic License-plate Detection
  - Speed Measurement
  - Vehicle Count
  - Traffic Flow Estimation
  - Vehicle Type Classification
  - Incident Detection
  - Violation Detection
  - Roadway Scan
  - In-vehicle Alarms

Scopes

- Vision-based ITS Applications (Cont'd)
  - Autonomous Driving
- Vision-based ITS Challenges
- Conclusions
- References

Preface

Transport/ Transportation:

- A particular movement of an organism/thing from point A to B
- Enables trade between people
- Common types of transport:
  - Air
  - Land
    - Roads
    - Rails
  - Water
  - Cable
  - Space

Preface

- Population growth and transportation demands
- Result: traffic jams and occlusions
- Effects of traffic:
  - Environmental pollution
  - Noise
  - Casualties and financial damages
  - Fuel consumption
  - Exceeding the speed limits in low-traffic roads!!!

Preface

- Traffic jam in Tehran, an increasing problem!

- Solution?

Preface

Traditional Transportation Systems Attitude

- Building new roadways and infrastructures to solve traffic-related problems
- Hiring more human resources for better control and management
- Focusing on urban development instead of security and efficiency
- Keep using old technologies/instruments/solutions/policies
- No connection to Information Technology field

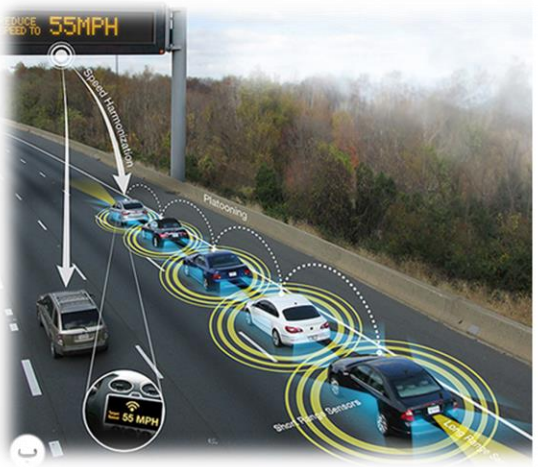
Solution?

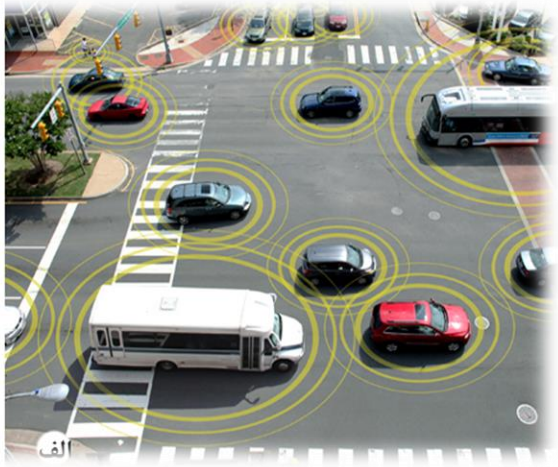
- Intelligent Transportation Systems (ITS)

Intelligent Transportation Systems

- Also known as I.T.S
- Applying modern methodologies to solve traffic-related problems
- Innovative services relating to traffic management
- Aim: provide safer, smarter and efficient travels (especially in cities)

- Vehicles are communication with infrastructures in ITS.





- Vehicles are communication with each other in ITS.

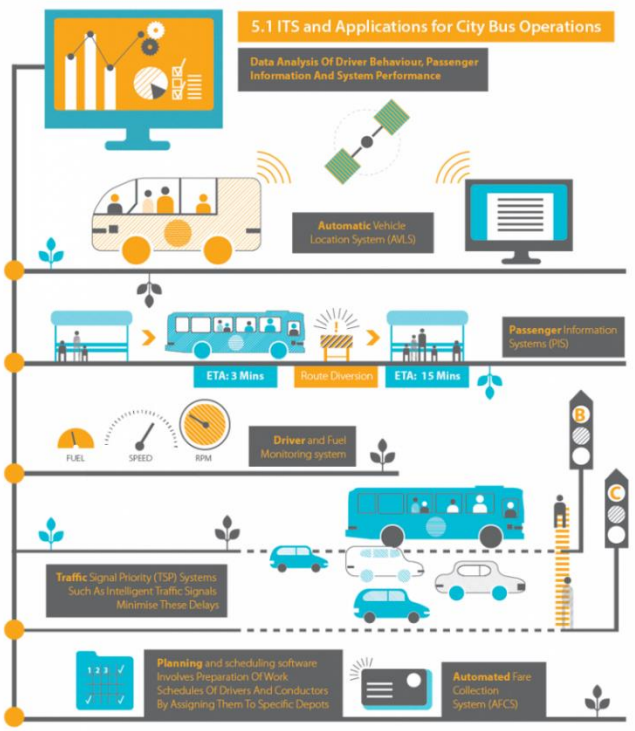
Intelligent Transportation Systems

Samples:

Top-left to Bottom-right: Intelligent buses, Automatic trains, Variable signs, Bus arrival countdown bars, and Speed measurement.

Intelligent Transportation Systems

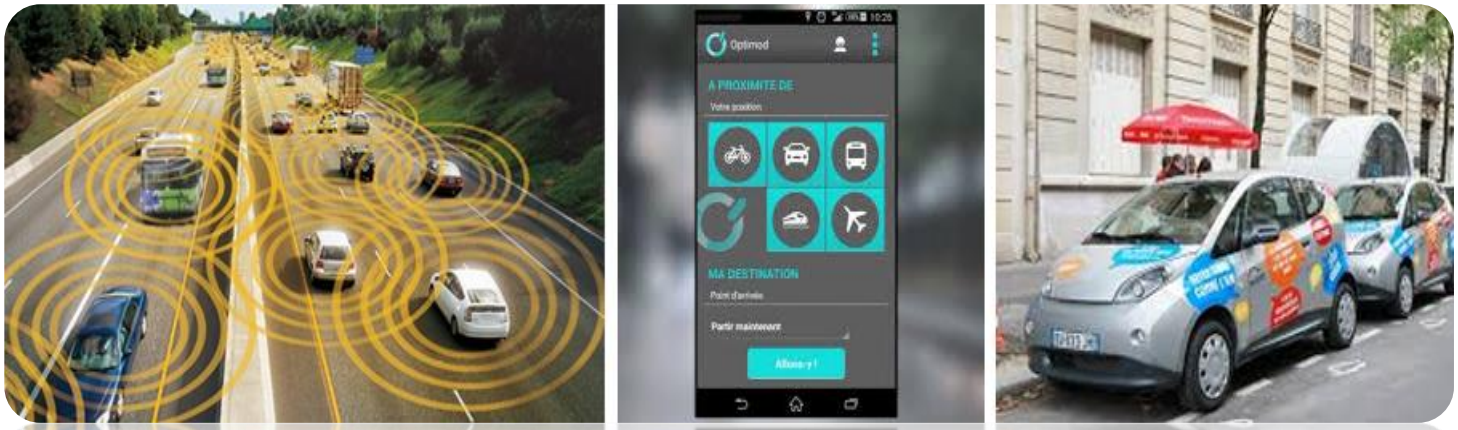
- More samples:
  - Traffic signal control systems
  - Container management systems
  - Variable message signs
  - Automatic number plate recognition
  - Speed cameras
  - Etc.



- A brief sample of ITS applications.

Intelligent Transportation Systems

- Applying Information and Communication Technologies (ICT) in the field of road transport
- Developed countries' main policy



Left to right: Communicating vehicles, ITS mobile applications, and Autonomous cars.

Intelligent Transportation Systems

ITS worldwide:

- USA/Canada
  - Automatic Toll Collection in more than 98% stations
  - Camera monitoring in more than 58% highways
  - Driverless vehicles policies and infrastructures
  - Commercial Vehicle Safety Plan (CVSP) in Michigan
- Europe
  - PReVENT project (avoid accidents by using in-vehicle systems)
  - DELTA project (in-vehicle applications and tools)
  - Connect project (traffic data providers collection)
  - AGILE project (developing location-based applications)

Intelligent Transportation Systems

ITS worldwide:

- Eastern Asia
  - Panasonic project in Japan (detect pedestrians and vehicles in junctions)
  - EMAS project in Singapore (highway monitoring and control system)
  - City-Brain in China (collecting urban environment data using A.I.)
  - Intelligent Highway in South Korea
- Australia and New-zealand
  - WestConnex project (congested traffic prediction system)
  - InfoConnect project (traffic incident reports)
  - RTPIS project (real-time passengers notification)
  - DCU project (real-time drivers notification)

Intelligent Transportation Systems

ITS worldwide:

- Islamic Republic of Iran
  - Approval of ITS program in 2014
  - Institute of Intelligent Transportation Systems in Amir-Kabir university
  - Holding 1st National Congress on ITS in 2014
  - Camera-based entrances control of traffic restricted area in Tehran
  - Cameras for recording violations of passing through red-lights
  - Modern informative systems for offenders

Intelligent Transportation Systems

Beneficiaries:

1. Governmental Organizations:
   - Provincial Government, Municipality, etc.
2. Commercial Operators:
   - Commercial Vehicles, Transporting, etc.
3. Industrial Operators:
   - Facilities, Machinery, etc.
4. Service Providers:
   - Alarms, Notices, Value-Added Services.
5. Institutions:
   - Data, Applications, Statistics, Services.

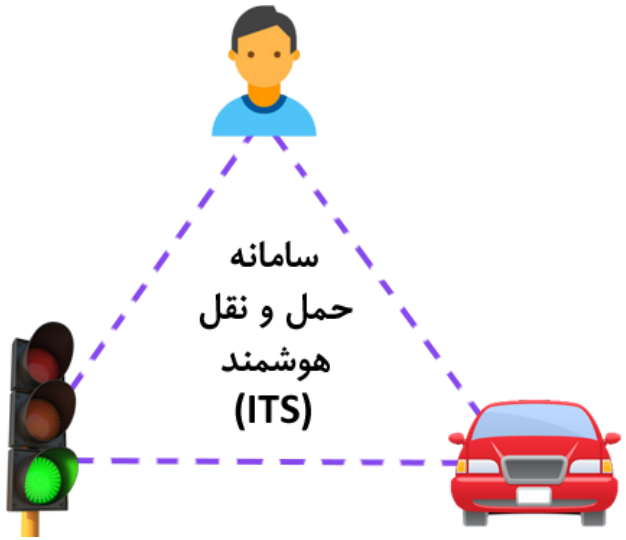
- Commercial vehicles.

- Transporting commodities.

Intelligent Transportation Systems

Environmental Factors:

1. **Human**
   - Drivers, pedestrians, police officers, etc.
2. **Vehicle**
   - Bikes, cars, vans, buses, etc.
3. **Infrastructure**
   - Roads, cameras, counters, etc.



- Three main factors of ITS.

Intelligent Transportation Systems

Environmental Factors:

- **Human-related Applications** (1st factor)
  - Web-based/Mobile applications
  - Navigation
  - Information websites
  - Automation
  - Peer-to-peer ridesharing
  - etc.

Intelligent Transportation Systems

Environmental Factors:

- **Vehicle-related Applications** (2nd factor)
  - Autonomous vehicles
  - VANETs
  - Inter-vehicle systems
  - Accident detection and messaging
  - Automatic-steering system
  - etc.

- A vehicle is automatically stopped after an accident.

Intelligent Transportation Systems

Environmental Factors:

- **Intelligent Infrastructures Applications** (3rd factor)
  - Traffic Monitoring
  - Highway/roadway traffic management
  - Violation detection
  - Automatic Toll Collection (ATC)
  - Urgent Conditions Management (UCM)
  - Safety tools
  - etc.

- A CCTV camera.

Intelligent Transportation Systems

Other Categories:

- Categorization based on Application Areas

1. Traffic Management Systems (urban/roadway)
2. Payment Collection Systems
3. Public Transportation Systems
4. Travel and Transportation Information
5. Emergency and Security Systems

Intelligent Transportation Systems

Other Categories (Cont'd):

- Categorization based on Implementation

1. Software-based Systems
   - Speed Measurement
   - Automatic License-plate Detection
   - Parking Management
2. Hardware-based Systems
   - CCTV/Image Sensors
   - Intelligent Licenses
   - Autonomous Vehicles

Intelligent Transportation Systems

Other Categories (Cont'd):

- Categorization based on Data Management

1. Vision-Driven Systems
   - Such as drivers' behavior analysis
2. Multisource-Driven Systems
   - Such as GPS, laser, sensors, etc.
3. Learning-Driven Systems
   - Such as online-training or data mining
4. Visualization-Driven Systems
   - Such as statistical/analytical systems

Intelligent Transportation Systems

Data Sources:

- Traffic data
- Transportation data
- Toll payment data
- Environmental data
- Commercial vehicles' data
- Infrastructure data
- User data
- etc.

Intelligent Transportation Systems

Data Gathering:

- Automatic Systems
  - Inductive loops
  - CCTV
  - Radar/Lidar
  - Ultrasound Doppler
- Human-Oriented
  - Manual traffic counters

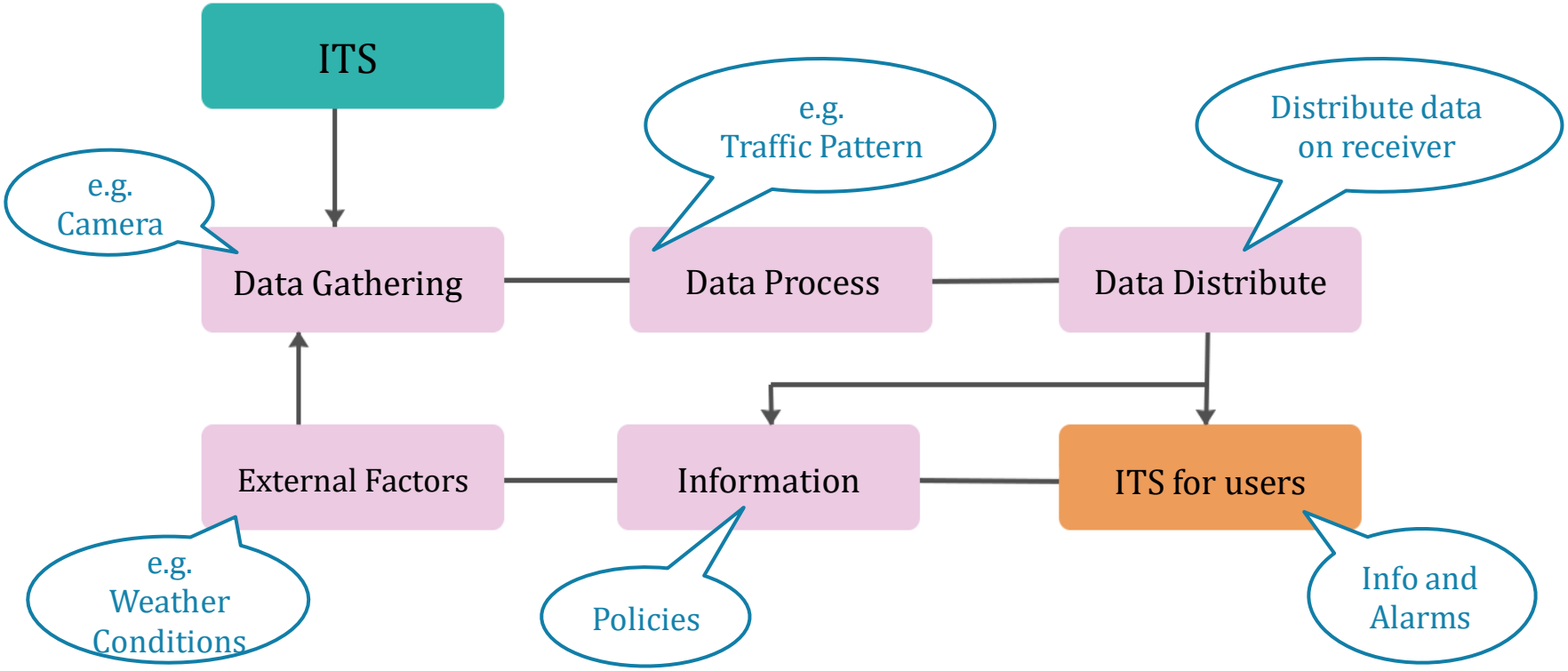
- CCTV cameras.

- A radar speed detector.

- A manual counter.

Intelligent Transportation Systems

Information chain:



Intelligent Transportation Systems

Economical Aspects – ITS-based Systems (2017):

Instrument/Equipment	Cost ($K)	Lifetime (years)	Description
Parking Monitoring System	14-46	10	Includes installation, detectors, and controllers
Tag Readers	2-5	10	Readers support electronic payment scheme
Inductive Loop	2-6	5	Double set (four loops) with controller
Machine Vision Sensor	16-22	10	One sensor both directions of travel
Passive Acoustic Sensor	4-11	-	Four sensors, four-leg intersection
Traffic Microwave Sensor	7-10	10	One sensor both directions of travel
Infrared Sensor Active	4-5	-	Sensors detects movement in two directions
CCTV Video Camera	7-15	7	Color video camera with pan, tilt, and zoom (PTZ)
Pedestrian Detection Microwave	0.4	-	Cost is per device

Source: https://www.itscosts.its.dot.gov

Intelligent Transportation Systems

Economical Aspects – ITS-based Systems (2017) (Cont'd):

Instrument/Equipment	Cost ($K)	Lifetime (years)	Description
Traffic Camera for Red Light	55-99	-	Low capital range is for a 35-mm wet film camera
Traffic Signal	50-80	-	Includes installation for one signal
Software for Lane Control	26-51	20	Software and hardware at site
Anti-icing System	35-346	12	-
Hardware, Software for Traffic Surveillance	138-169	20	Processor and software
In-Vehicle Display	0.03-0.1	-	In-vehicle display/warning interface
GPS/DGPS - VS	0.2-0.3	7	Global Positioning System
Vision Enhancement	2-2.1	7	In-vehicle camera, software & processor
Roadside Message Sign	30-45	20	Fixed message board for HOV and HOT

Source: https://www.itscosts.its.dot.gov

Intelligent Transportation Systems

Economical Aspects – ITS-based Systems (2017) (Cont'd):

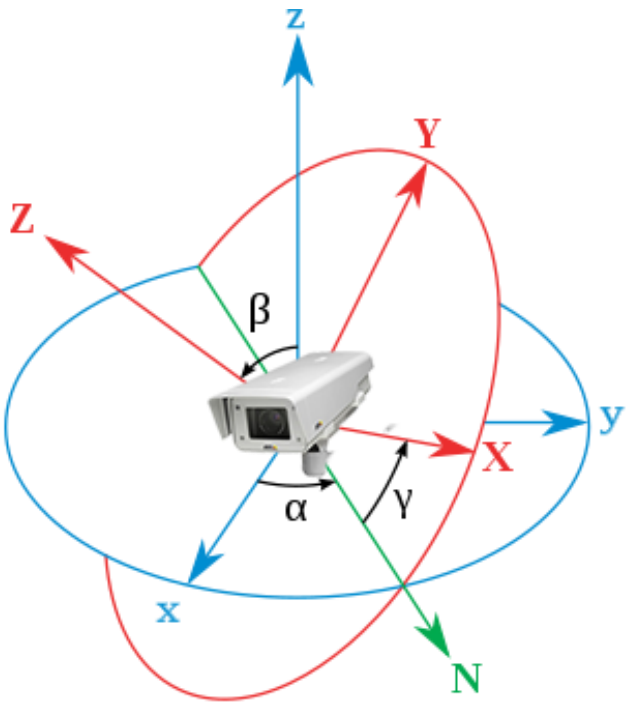
- Planned CCTV Installations (2014-2017) – Wisconsin, U.S

Device	Region	Total as of 2013	2014 New	2015 New	2016 New	2017 New	Total
CCTV	NC	6	1	0	0	0	7
	NE	39	1	18	2	0	60
	NW	14	18	0	0	0	32
	SE	174	13	23	1	0	211
	SW	60	26	14	0	0	100
	Total Units Statewide	293	59	55	3	0	410
	Maintenance Costs	$289,013	$58,244	$54,505	$2,973	$0	$404,735
	Power Costs	$86,435	$17,405	$16,225	$885	$0	$120,950

Source: https://www.itscosts.its.dot.gov

Vision-based ITS

- Utilizing Digital Image Processing (DIP) in ITS applications
- Related issues:
  - Artificial Intelligence (AI)
  - Image/Video Processing
  - Motion Detection/Tracking
  - Classification (Data-mining)
- Requirement:
  - CCTV/Image Sensor



- Different angles of camera that should be calibrated.

Vision-based ITS

- Types:
  - Fixed camera systems
  - Mobile camera systems (installation on vehicles)

- A mobile vision-based system.

- A fixed vision-based system.

Vision-based ITS

- Our contribution:

Mosalla Roundabout, Rasht, Iran

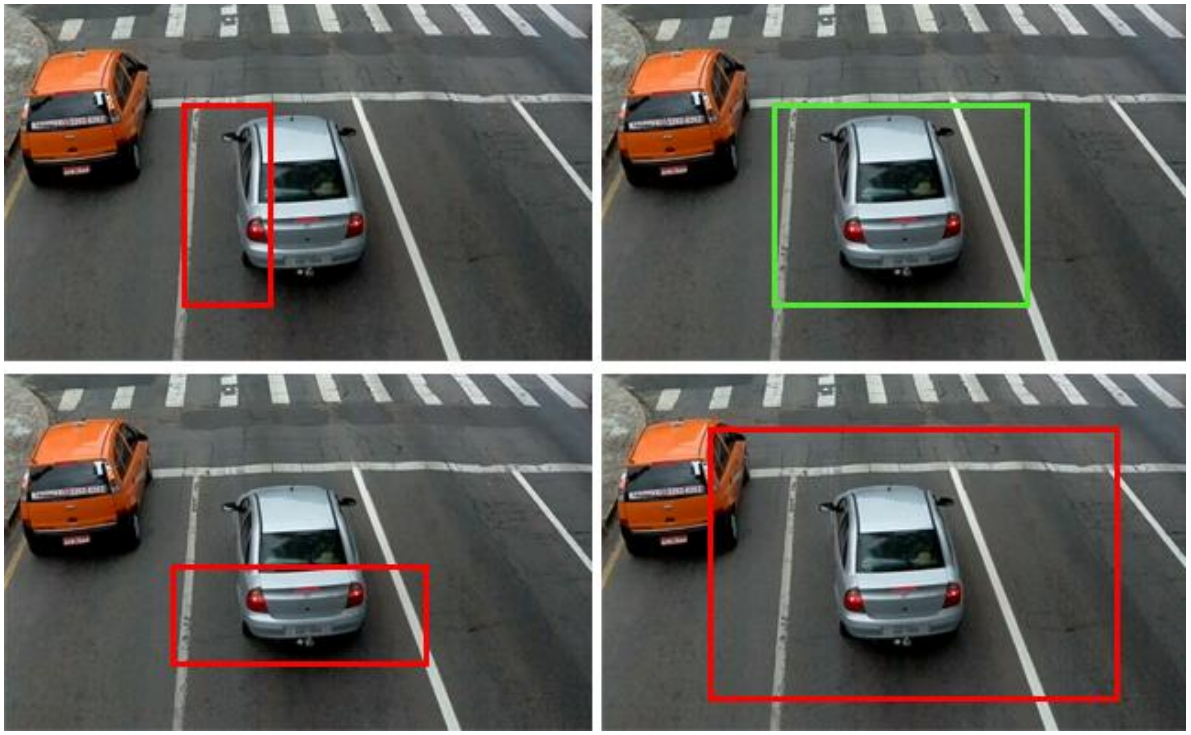
Guilan University, Rasht, Iran

Vision-based ITS

Sample camera outputs:

Vision-based ITS

What is a Region of Interest (ROI)?!

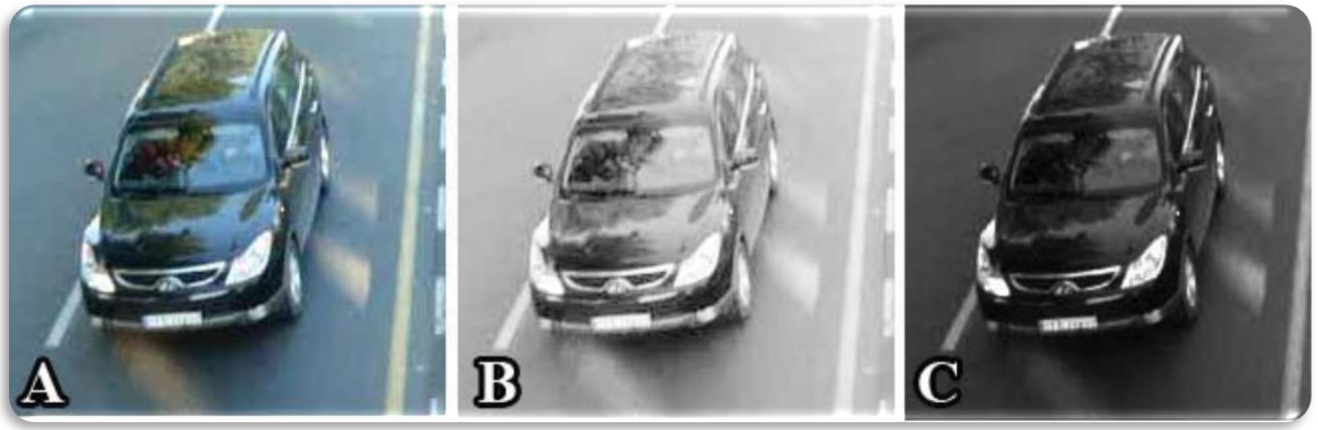


- Samples of appropriate (green)/inappropriate (red) ROIs.

Vision-based ITS

Pre-processing:

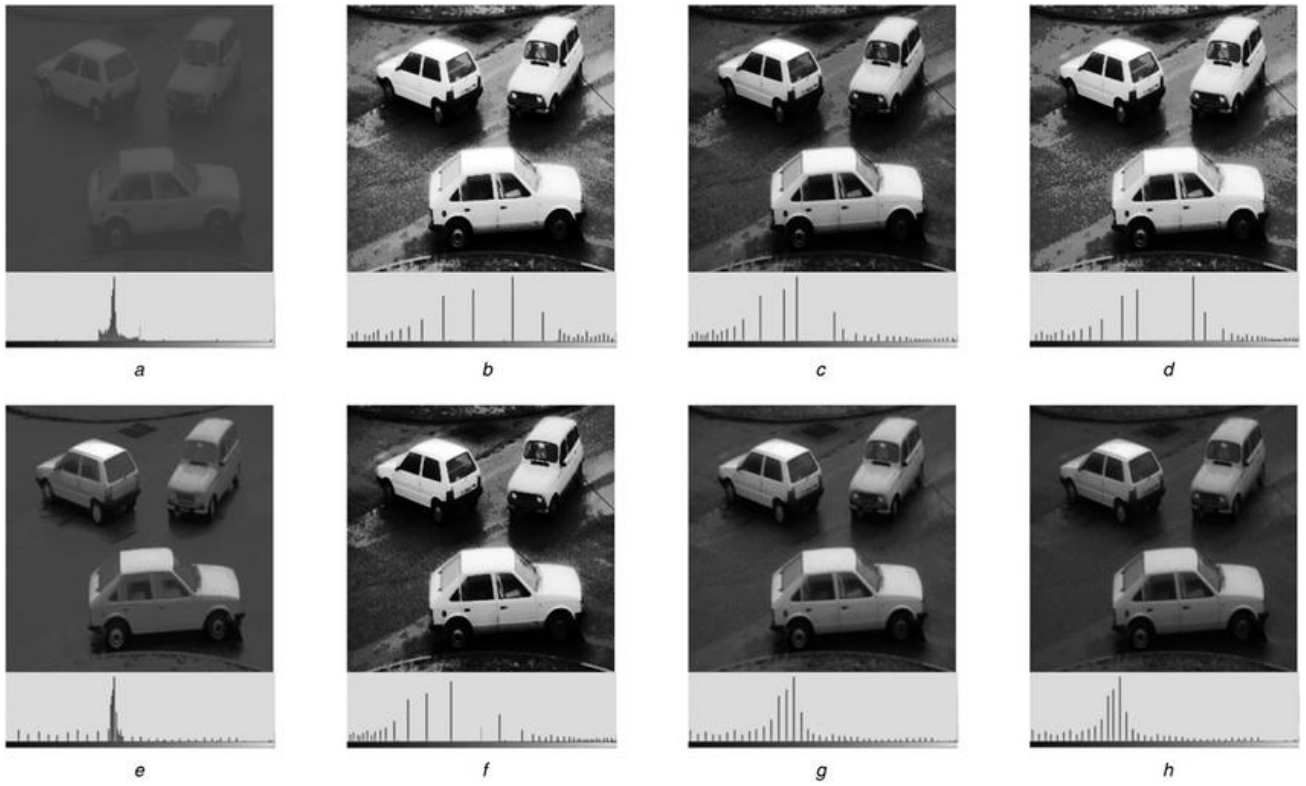
- Image Enhancement
- Removing existed noises
- Prevention of performance decrease



- Image enhancement using Gamma-correction.

Vision-based ITS

Pre-processing (Cont'd)



- Different Histogram modifications as pre-processing

Vision-based ITS Applications

Automatic License-plate Detection – Intro:

- ALPR/ANPR
- Steps:
  - License-plate area detection
  - Characters segmentation
  - Optical Character Recognition (OCR)
- Goal:
  - Providing Vehicle Location Data (VLD)
  - Other approaches: RFID tags, GPS

- Two common types of Iranian license-plates used in free zone.

Vision-based ITS Applications

Automatic License-plate Detection – Intro (Cont'd):

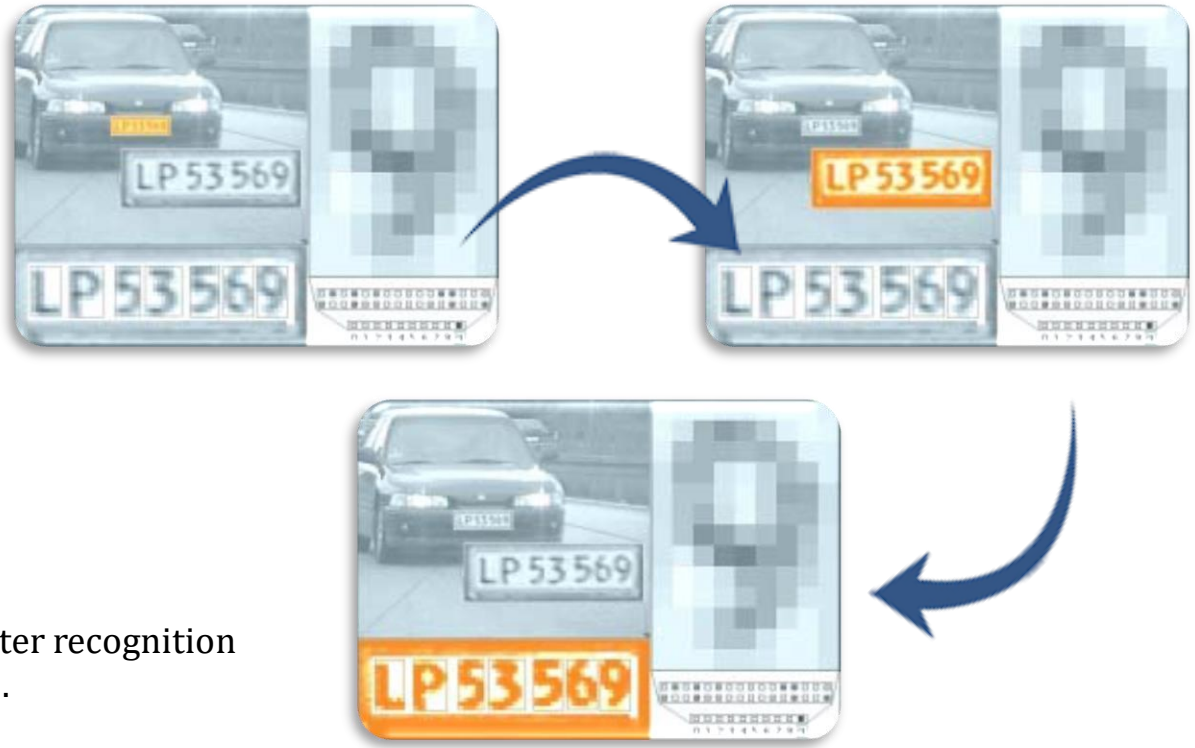
- Commonly needs IR-camera outputs
- Main challenges:
  - Various License-plate structures
  - Sensitivity to:
    - Illumination conditions
    - Weather conditions
    - Noise
    - Angle

- An Iranian license-plate.

Vision-based ITS Applications

Automatic License-plate Detection – Structure:

Detection



Segmentation

OCR

- Cycle of character recognition in license-plates.

Vision-based ITS Applications

Automatic License-plate Detection – Structure (Cont'd):

- Color-based approach:
  - Detection of special color in ANPR
  - Computationally intensive
    - Several color channels
  - Change of colors in various illuminations

- A color-based approach to find blue-green part of Iranian license-plates.

Vision-based ITS Applications

Automatic License-plate Detection – Structure (Cont'd):

- Hough-transform approach:
  - Detection of license-plate rectangular shape
  - Computationally intensive
    - Huge amount of candidates
    - Matching aspect-ratio

- A Hough-transform approach to find overall shape of the license-plate.

Vision-based ITS Applications

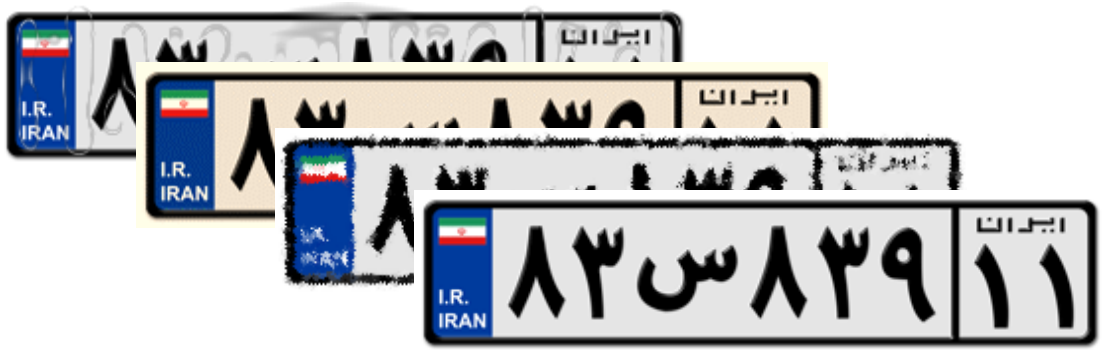
Automatic License-plate Detection – Structure (Cont'd):

- Edge detection-based approach:
  - Detection of license-plate's edges/boundaries
  - Complementary for Hough-transform approach
    - Needs candidate matching
    - High error-rate form standalone usage

Vision-based ITS Applications

Automatic License-plate Detection – Structure (Cont'd):

- Fuzzy approach:
  - Detection of license-plate by visual features
    - Width-Height ratio
    - Bluish-Whiteness ratio
  - Highly computationally intensive



Vision-based ITS Applications

Automatic License-plate Detection – Application:

- Speed Measurement
- Vehicle detection
- Toll payments
- Violation detection
- Suspicious vehicle detection
- Border controls
- etc.

- Police officers analyzing a suspicious vehicle.

Vision-based ITS Applications

Automatic License-plate Detection – Application (Cont'd):

Automatic Toll Payment
Highway 407, Toronto, Canada

Vision-based ITS Applications

Automatic License-plate Detection – Challenges:

- Various license-plate types

Samples of different license-plates: U.K., France, Russia, the Netherlands, Iceland and Ireland.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Various license-plate types

Samples of different license-plates of different states of the U.S.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Various license-plate types (Iran)

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Various license-plate types (Iran)

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Low quality/contrast images

Samples of unreadable license-plates in real conditions.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Blurred images

Samples of blurred/noisy images of license-plates due to low quality of camera.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Unreadable/occluded images

Samples of unreadable/dirty license-plates.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Unusual license-plates installations

A truck with two license-plates in Iran.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Unusual license-plates installations

Unusual installation of license-plates on two trucks.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Unusual license-plates installations

Placement of vehicle license-plate on unusual parts.

Vision-based ITS Applications

Automatic License-plate Detection – Challenges (Cont'd):

- Personal license-plates

A personal license-plate found in the U.S.

Vision-based ITS Applications

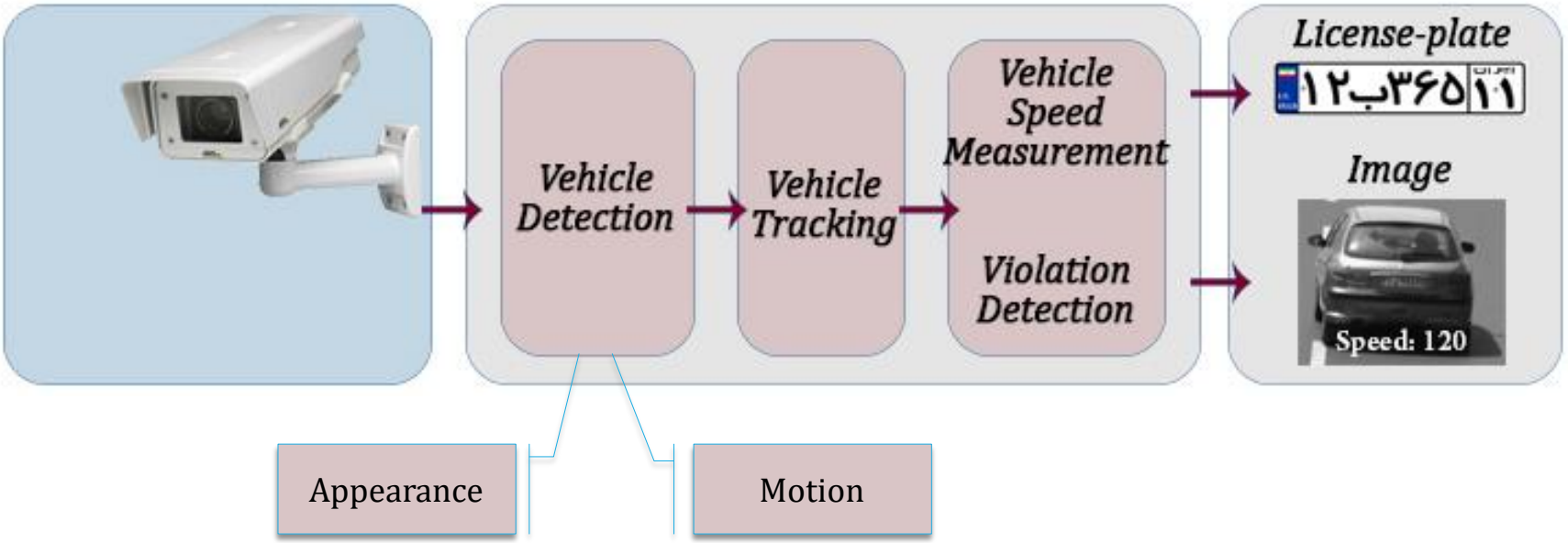
Vehicle Speed Measurement – Structure:

- Processing video-cameras' outputs to measure vehicle speed
- Over-speeding detection and automatic fine
- Main parameters:
  - Resolution
  - FPS
  - Quality
- Methods:
  - Appearance-based approaches
  - Motion-based approaches

Vision-based ITS Applications

Vehicle Speed Measurement – Structure (Cont'd):

- Common approaches:



The block diagram of a common Vision-based Speed Measurement system.

Vision-based ITS Applications

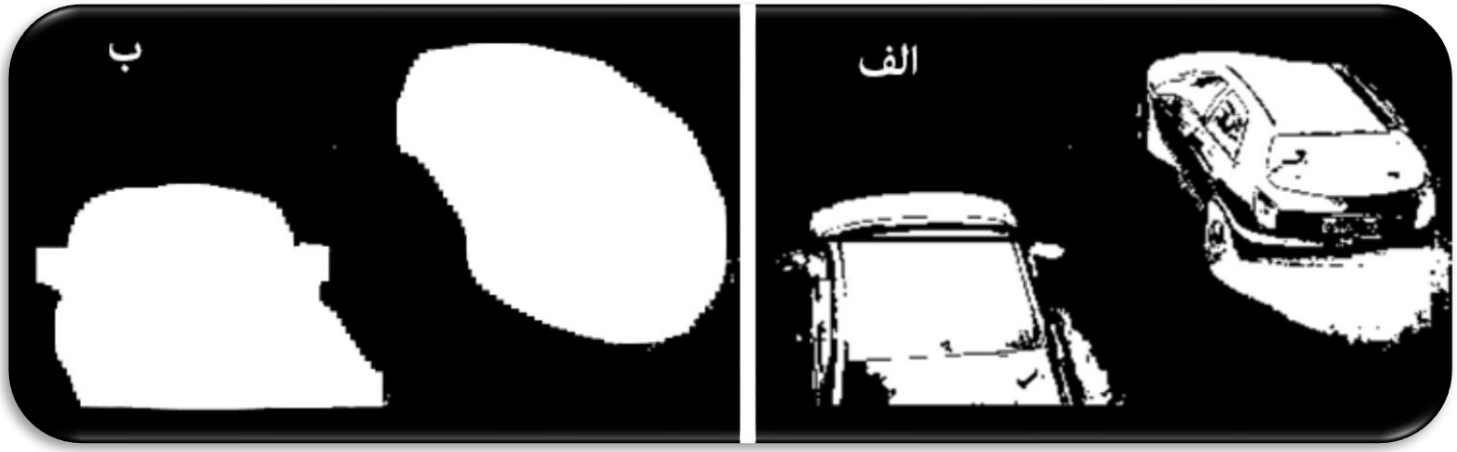
Vehicle Speed Measurement – Structure (Cont'd):

- Methods:
  - **Appearance-based approaches**
    - Require visual-features (License-plate, windscreen, headlight, etc.)
    - Better accuracy due to dependence to unique features
    - More computational costs
  - **Motion-based approaches**
    - Simpler detection (Only based on motion vectors)
    - Simpler tracking
    - Faster performance

Vision-based ITS Applications

Vehicle Speed Measurement – Structure (Cont'd):

- Methods:
  - Motion-based approaches

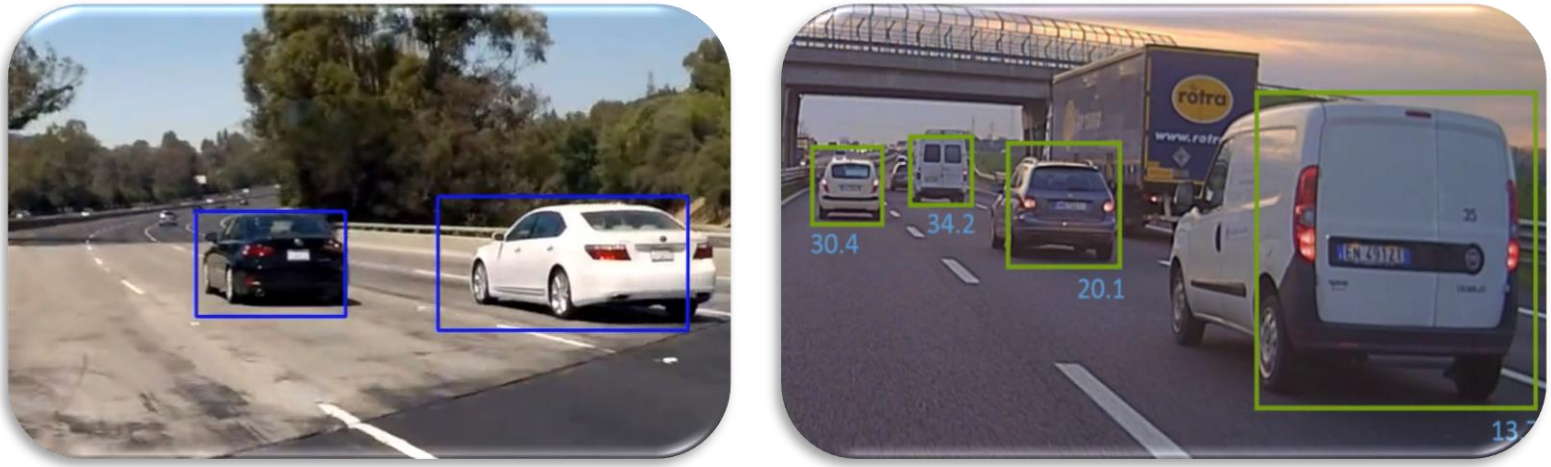


Detected moving vehicles in background subtraction (right) and after morphological transforms (left).

Vision-based ITS Applications

Vehicle Speed Measurement – Structure (Cont'd):

- Methods:
  - Appearance-based approaches

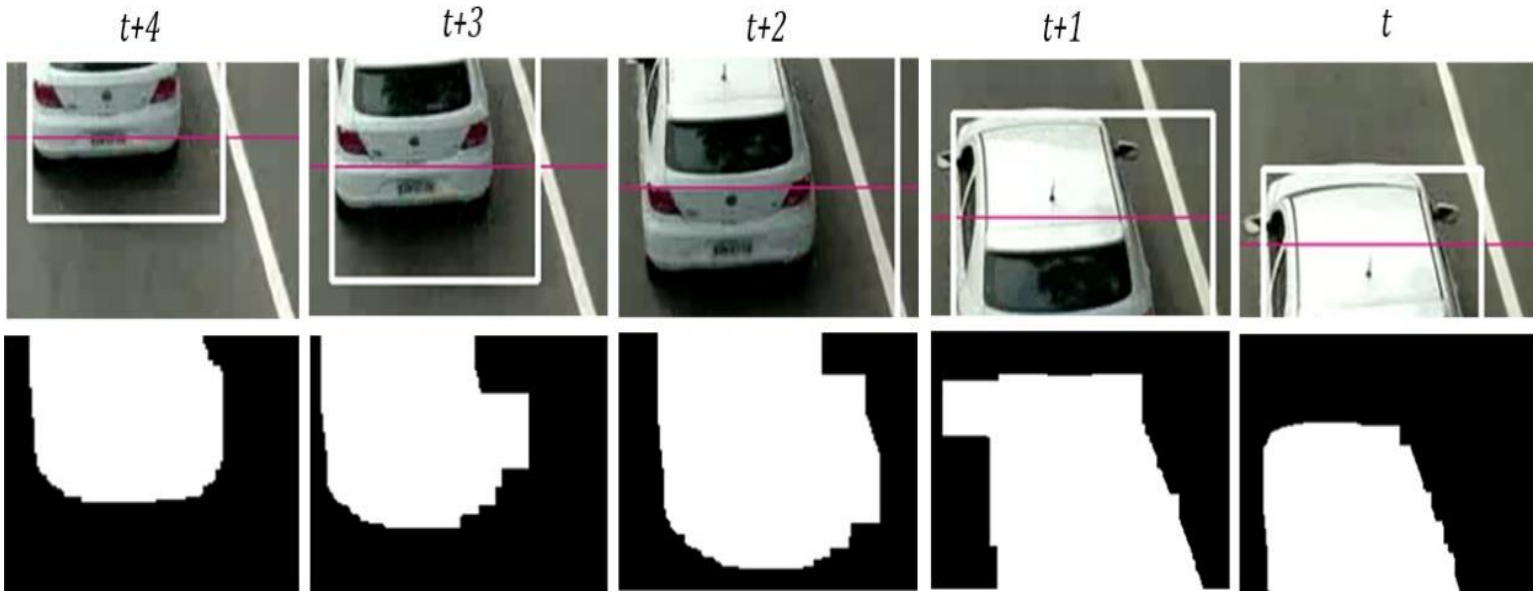


Samples of vehicle detection and speed measurement softwares.

Vision-based ITS Applications

Vehicle Speed Measurement – Structure (Cont'd):

- Tracking of vehicles in sequential frames:

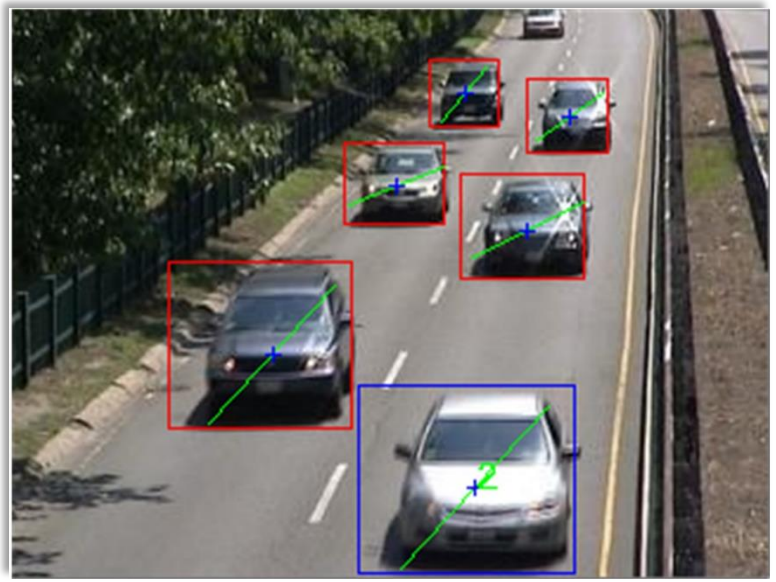


Tracking a vehicle in sequential frames: top) main image, bottom) blobs.

Vision-based ITS Applications

Vehicle Speed Measurement – Techniques:

- Vehicle Detection:
  - Background Subtraction
  - Points/Corner Detection
  - Frame Differencing
  - Optical Flow
  - Supervised Learning
  - Statistical Approach



A vehicle speed measurement which calculates the speed of vehicles based on tracking information.

Vision-based ITS Applications

Vehicle Speed Measurement – Techniques (Cont'd):

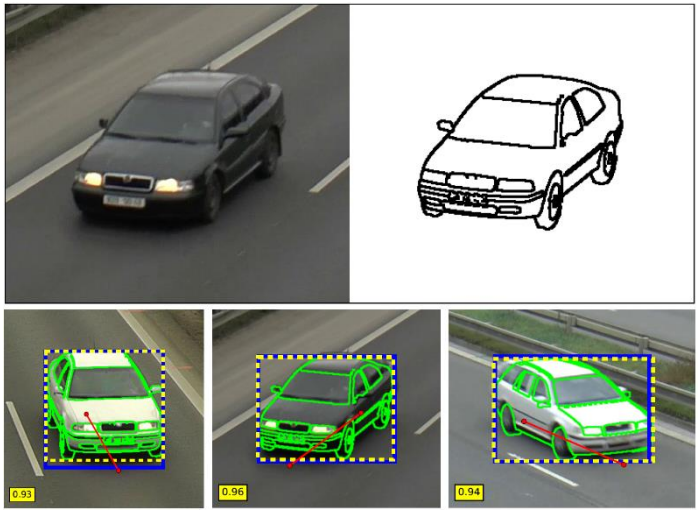
- Vehicle Tracking:
  - Boundary/Edge-based Tracking
  - Mean Shift
  - Kalman Filtering
  - Lucas-Kanade (LK)
  - Kanade-Lucas-Tomasi (KLT)
  - Condensation
  - Tracking-Learning-Detection

A KLT vehicle tracker.

Vision-based ITS Applications

Vehicle Speed Measurement – Applications:

- Average/Instantaneous speed calculation
- Speeding violation detection
- Segmentation of vehicles as:
  - Vehicle type
  - Road lane
- Min/Max speed definition (highways)
- Automatic fine



Using edges of vehicles for speed measurement.

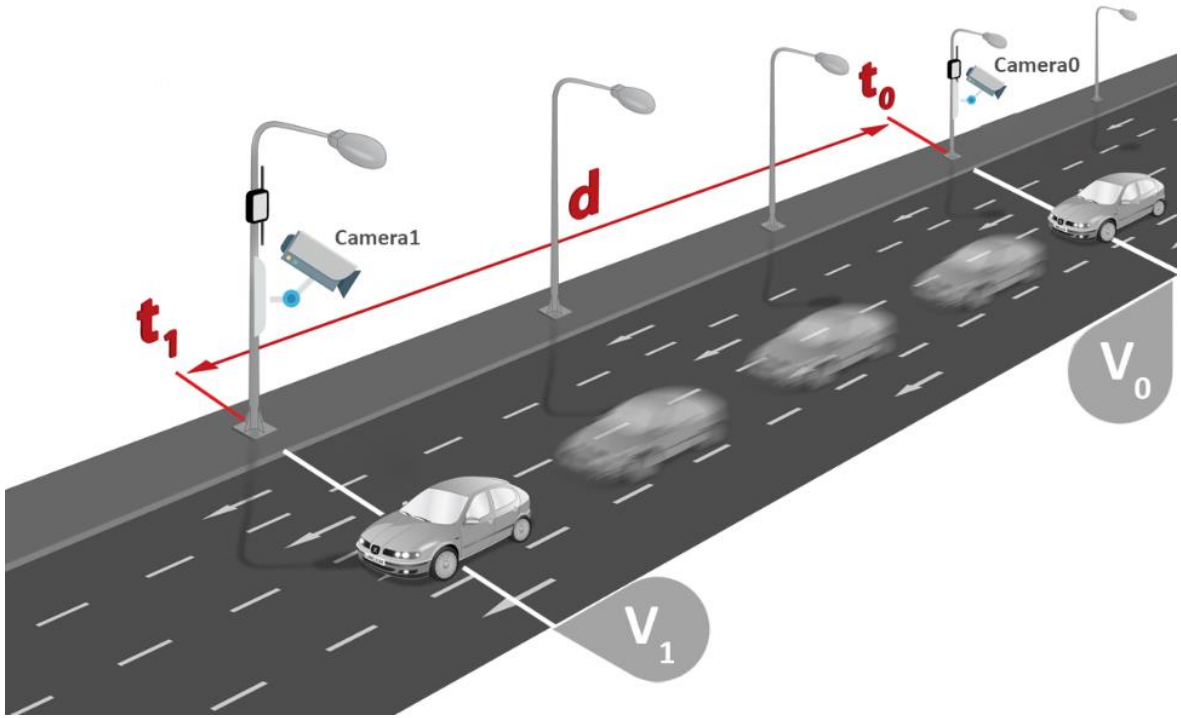
Vision-based ITS Applications

Vehicle Speed Measurement – Applications (Cont'd):

- Average/Instantaneous speed calculation

- Average speed: the speed of vehicle between Camera0 and Camera1 locations

- Instantaneous speed: the speed of vehicle in every second of displacement



Vision-based ITS Applications

Vehicle Speed Measurement – Applications (Cont'd):

- Developed vehicle speed measurement software

Vision-based ITS Applications

Vehicle Count – Intro:

- Extremely better than manual counters!
  - Boring job?!
- Common methods
  - Pressure sensors
  - Inductive loops
  - Ultrasound tools
- Video counters
  - Real-time
  - Online/Offline

A manual counter

Inductive loops

Vision-based ITS Applications

Vehicle Count – Intro (Cont'd):

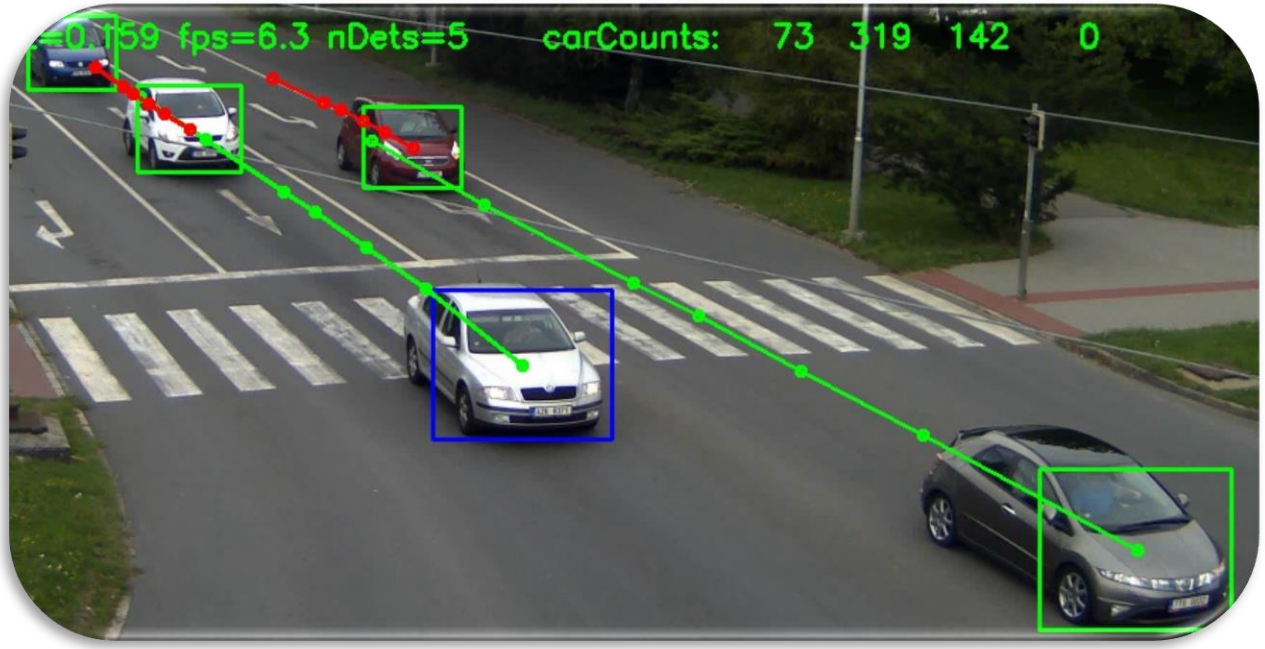
- Analysis using Statistical Approaches
- Main challenges:
  - Long shadows
  - Low illumination
  - High congestion

- Utilizing background subtraction for counting purposes.

Vision-based ITS Applications

Vehicle Count – Applications:

- Counting based on lanes



Counting of vehicles based on defined lanes.

Vision-based ITS Applications

Traffic Flow Estimation– Applications:

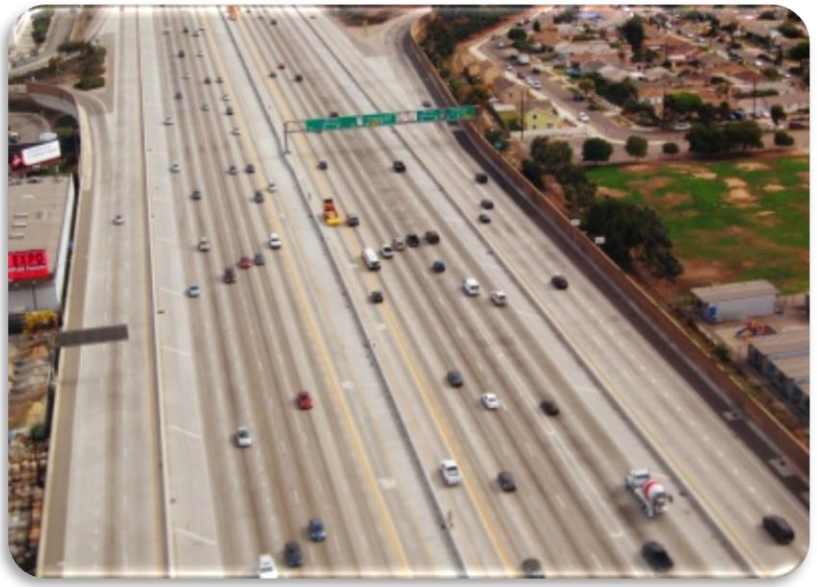
- Especial case:
  - Junctions for Traffic Light
  - Straight roads
- Outputs:
  - Traffic peak-times in urban roadways
  - Classification of Traffic states
  - Best possible signal changing rates
  - Major reasons of traffic congestion
  - Average traffic speed

A dense traffic situation.

Vision-based ITS Applications

Traffic Flow Estimation– Applications (Cont'd):

- Based-on traffic counts
- Traffic density types:
  - No traffic
  - Wide-spaced high speed flow
  - Low traffic
  - Normal continuous flow
  - Traffic jam
    - Congested
    - Forced low-speed flow



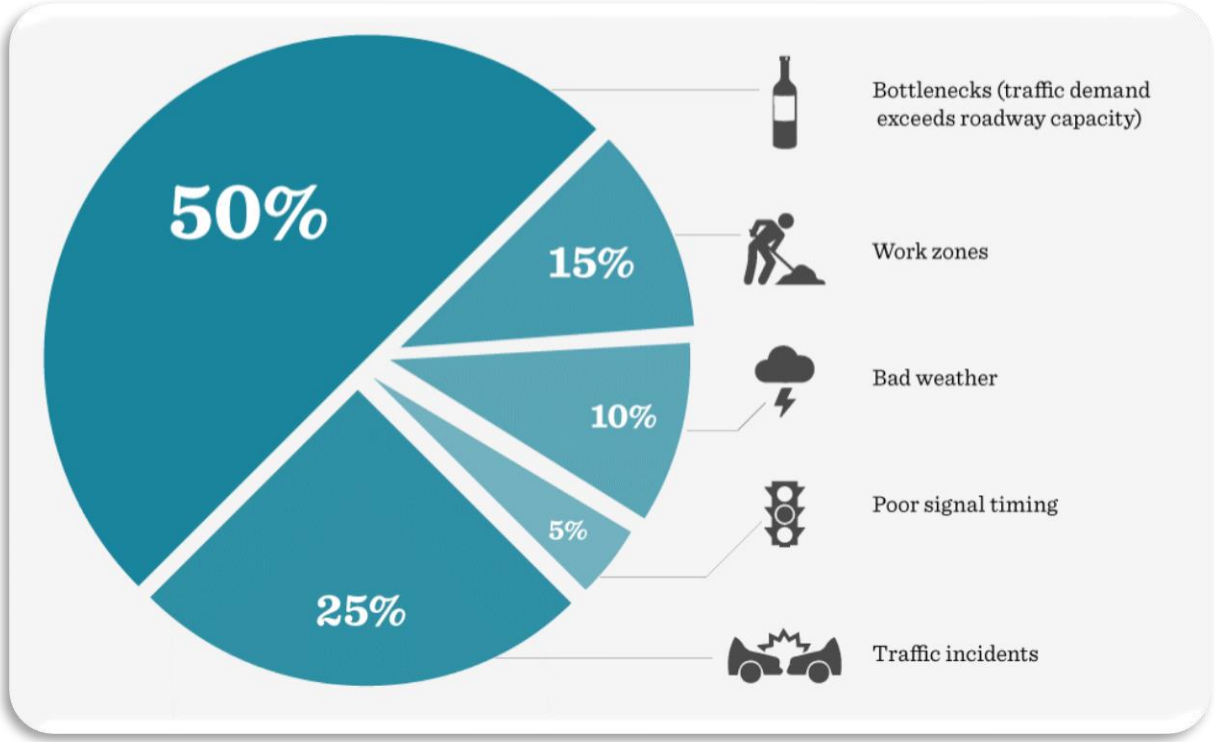
A top view of the highway with distinguishable features.

Vision-based ITS Applications

Traffic Flow Estimation– Applications (Cont'd):

- Detection of major causes of traffic congestion (www.highways.org):

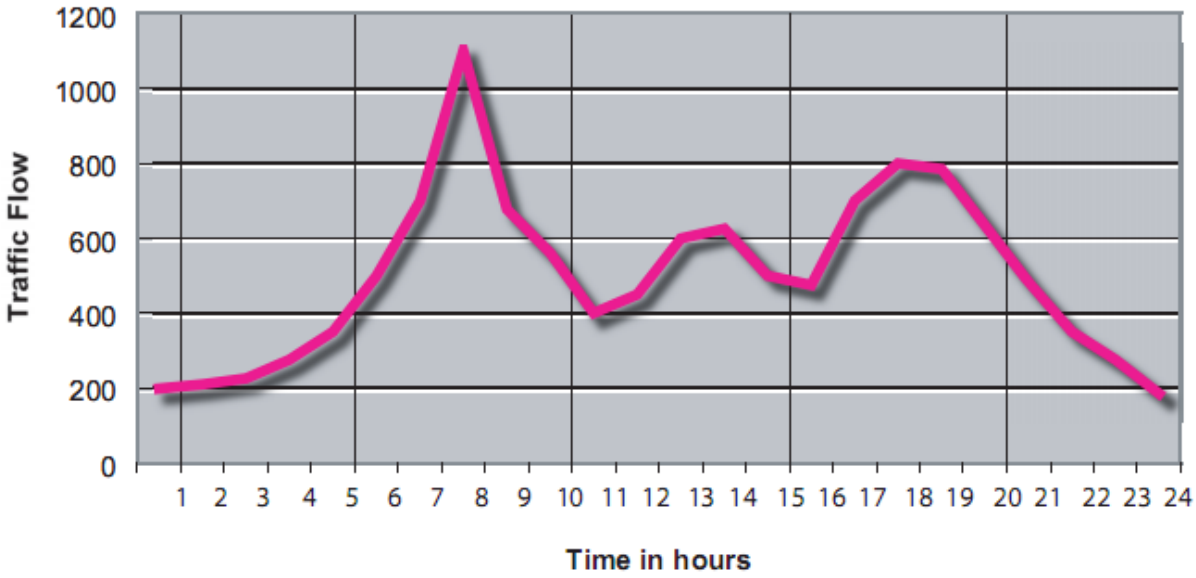
- Main causes of traffic jams.



Vision-based ITS Applications

Traffic Flow Estimation– Applications (Cont'd):

- Presentation of congestion frequency – hourly pattern:

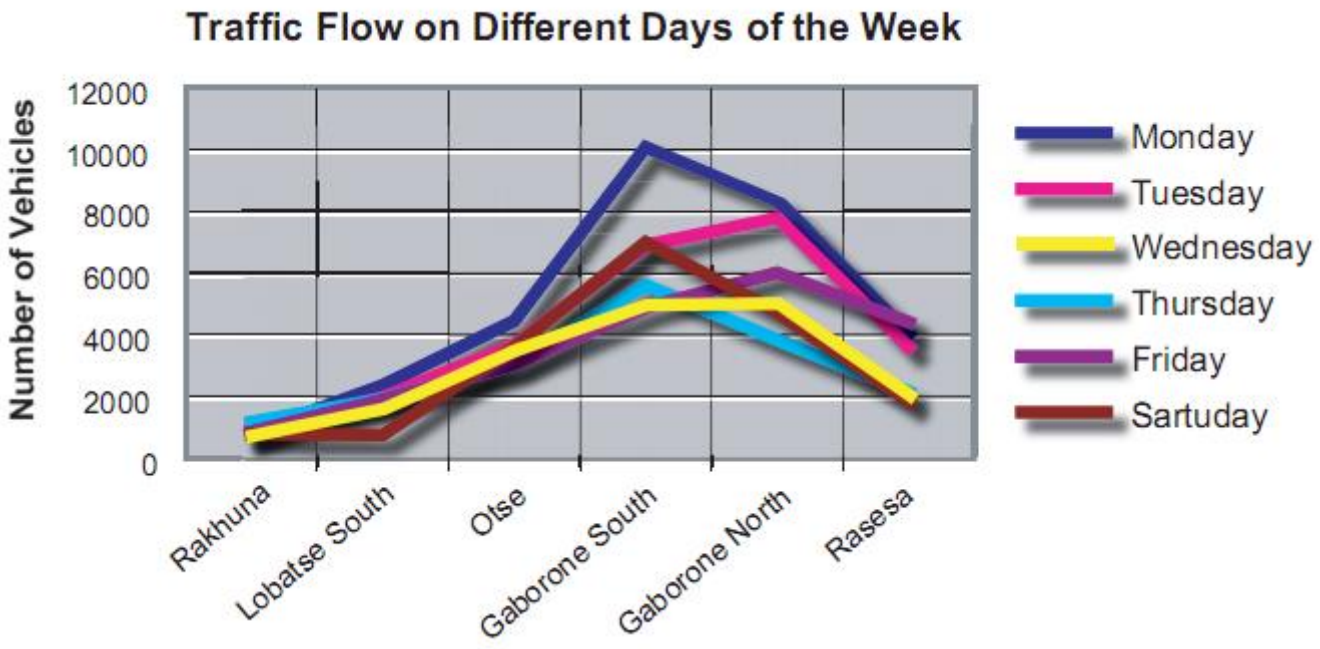


An hourly traffic pattern.

Vision-based ITS Applications

Traffic Flow Estimation– Applications (Cont'd):

- Presentation of congestion frequency – daily/weekly/monthly pattern:

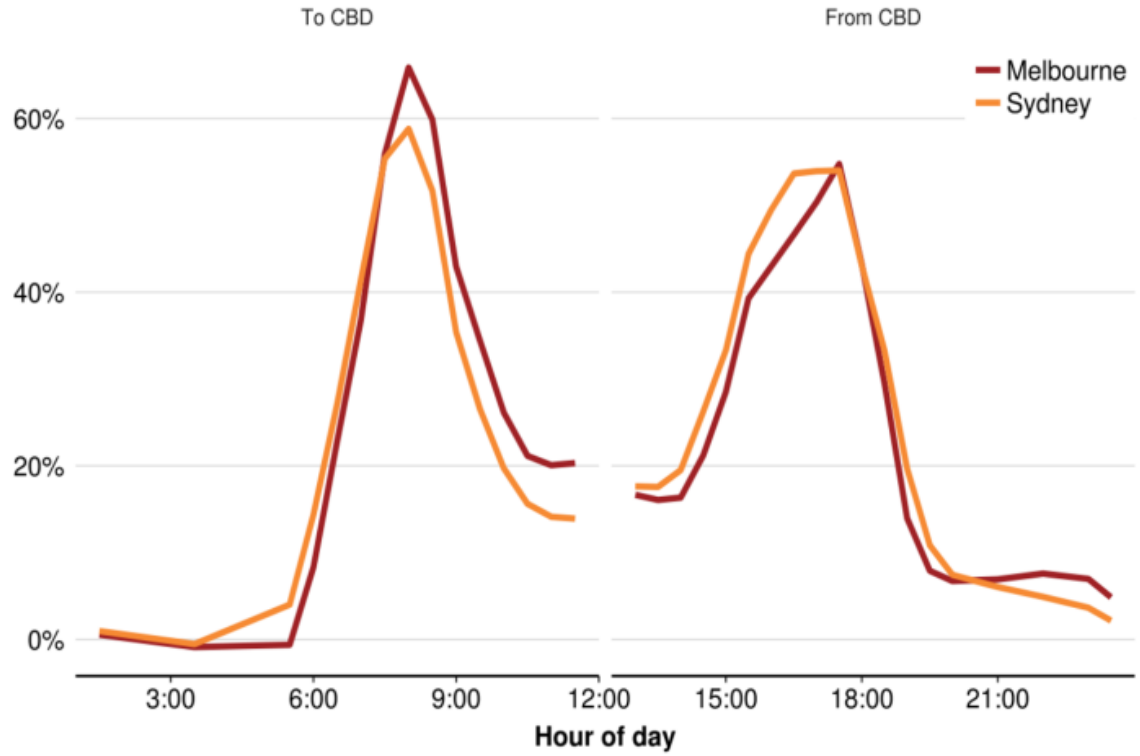


A daily traffic pattern.

Vision-based ITS Applications

Traffic Flow Estimation– Applications (Cont'd):

- Presentation of congestion frequency (www.abc.net.au):

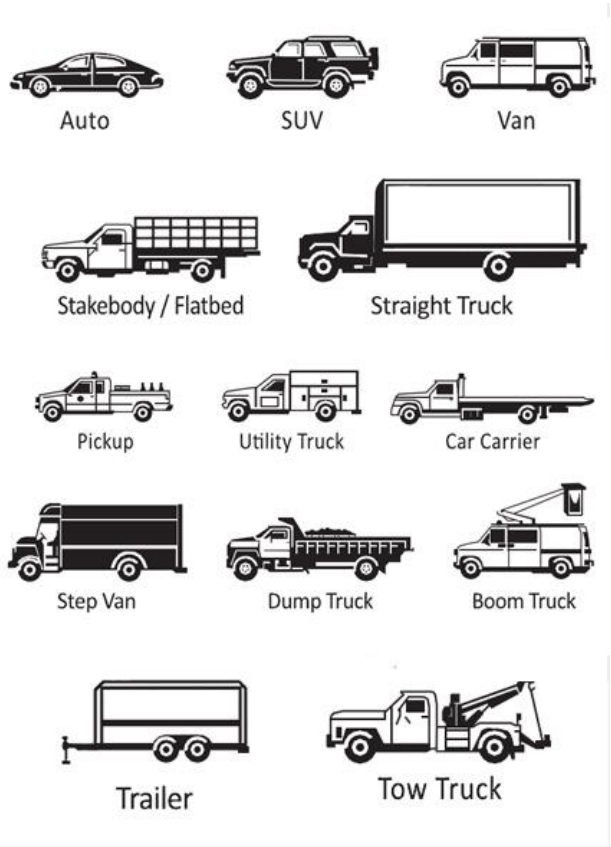


- Traffic jams in two important cities of Australia.

Vision-based ITS Applications

Vehicle Type Classification– Structure:

- Classification parameters:
  - Number of axles
  - Axle spacing
  - Vehicle length
  - Chassis height



- Different types of vehicles.

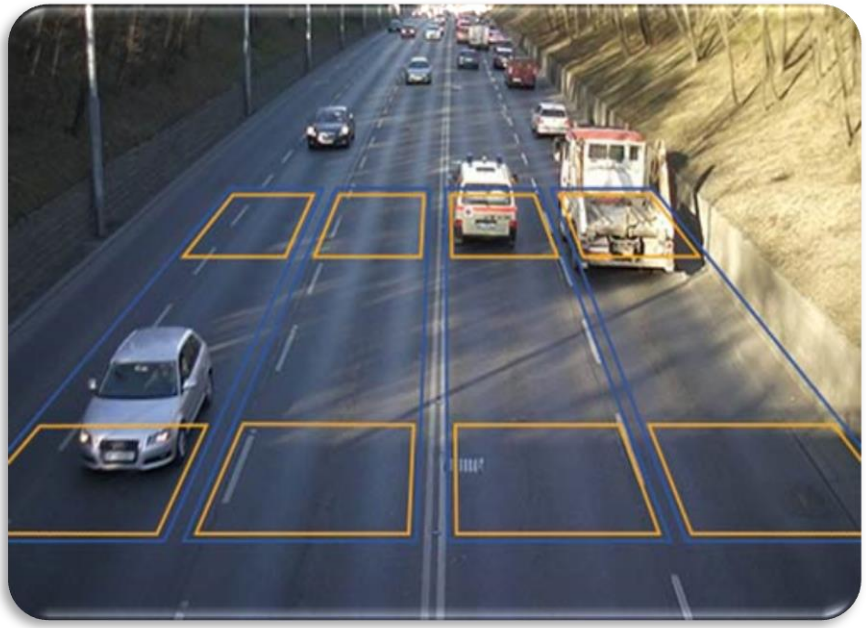
Vision-based ITS Applications

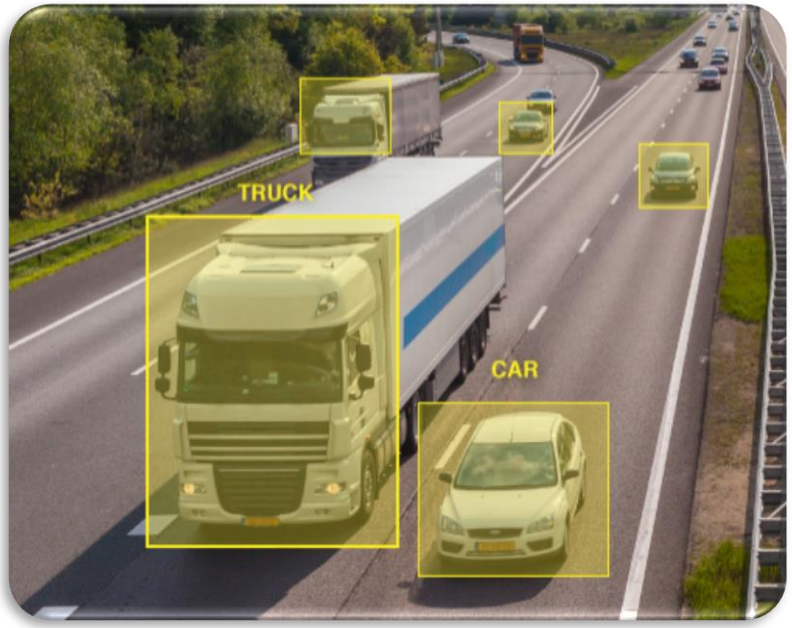
Vehicle Type Classification– Structure (Cont'd):

Different types of vehicles.

Vision-based ITS Applications

Vehicle Type Classification– Applications:

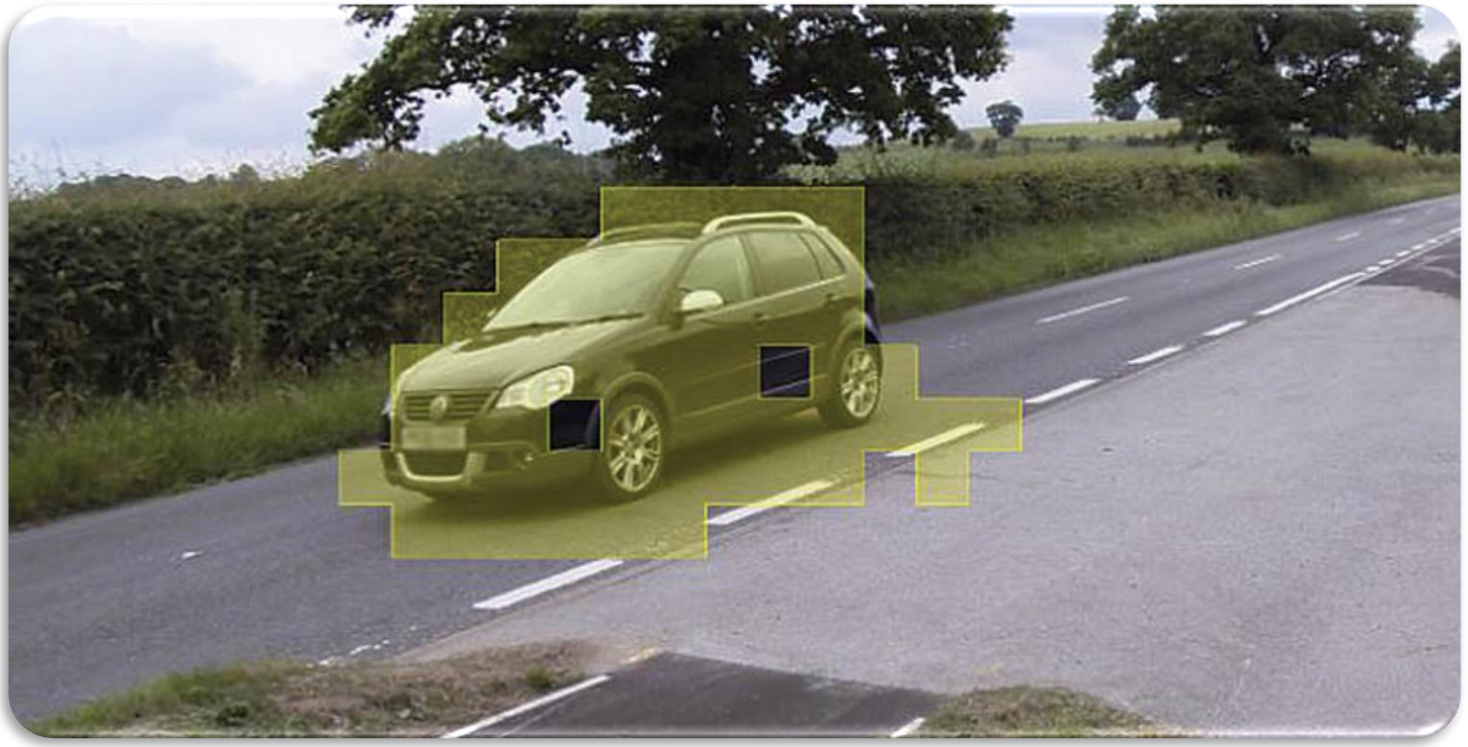




Two common approaches to detect vehicle types: 3D (left) and 2D (right)

Vision-based ITS Applications

Vehicle Type Classification– Applications (Cont'd):



Vehicle type detection based on pixel grids.

Vision-based ITS Applications

Incident Detection – Structure:

- Level 1:
  - Vehicle on shoulder
- Level 2:
  - Vehicle in lane
- Level 3:
  - Minor crash/debris (no injury)
- Level 4:
  - Injury crash
  - Fire/debris

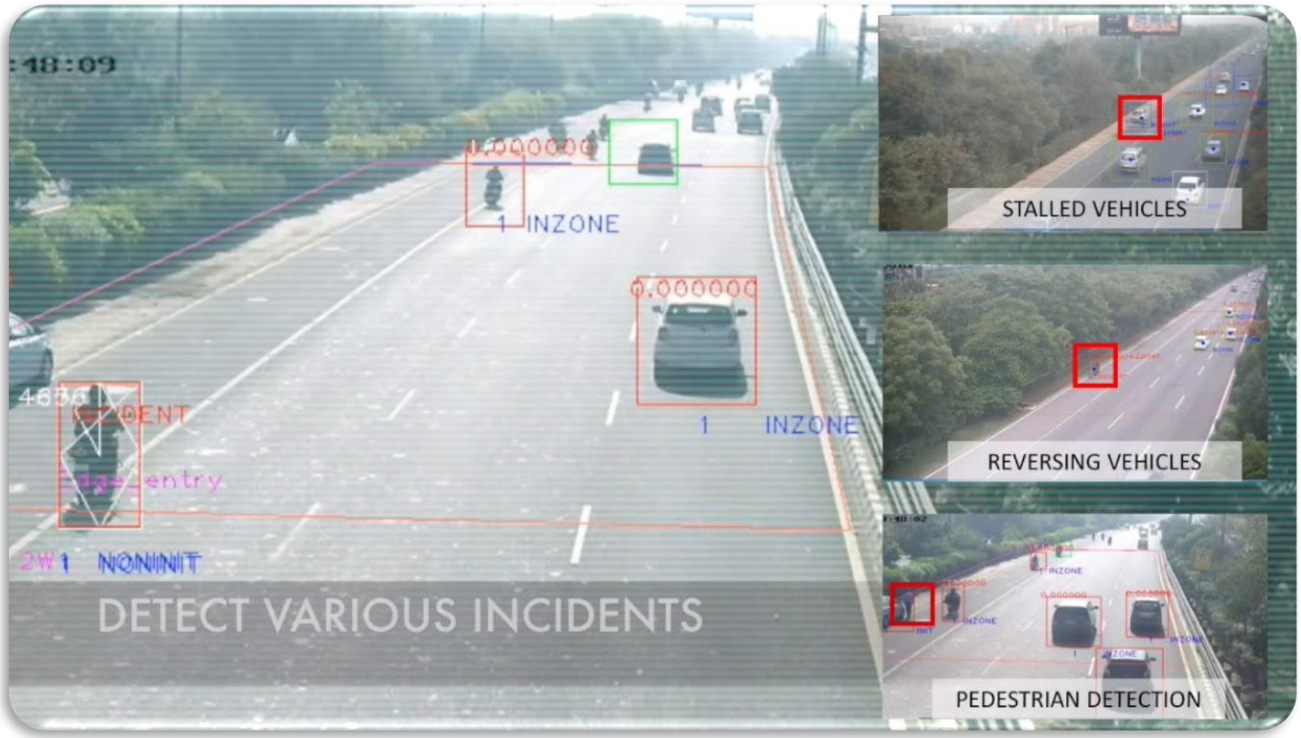
Vision-based ITS Applications

Incident Detection – Applications:

Incident detection application in tunnel.

Vision-based ITS Applications

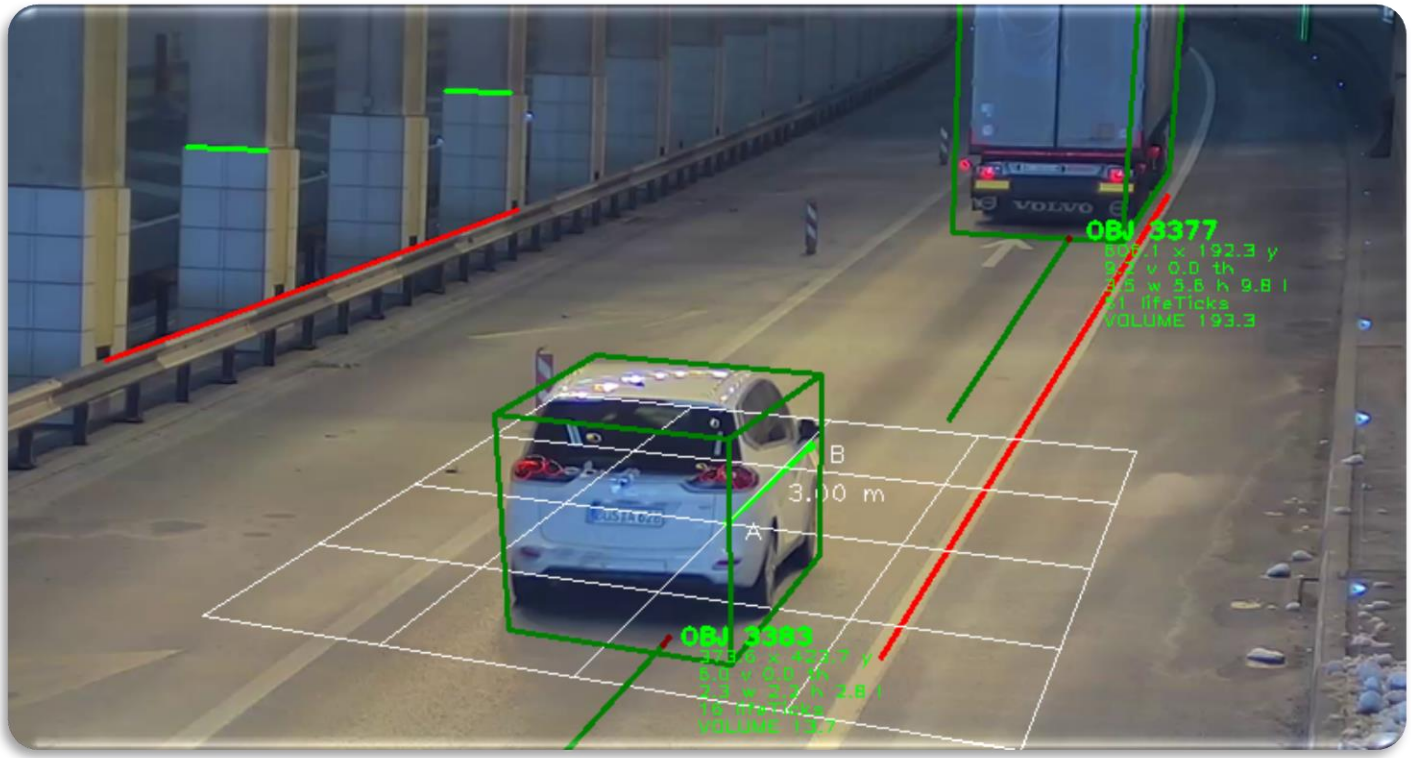
Incident Detection – Applications (Cont'd):



Incident detection application in roadways: stalled vehicle, reversing vehicle and pedestrian detection.

Vision-based ITS Applications

Incident Detection – Applications (Cont'd):



Detecting the reason of accident by analyzing inter-vehicle space.

Vision-based ITS Applications

Traffic violation detection – Structure:

- General architecture

No entrance violation detection.

Vision-based ITS Applications

Traffic violation detection – Structure (Cont'd):

- General architecture

Providing information about the violator.

Vision-based ITS Applications

Traffic violation detection – Applications:

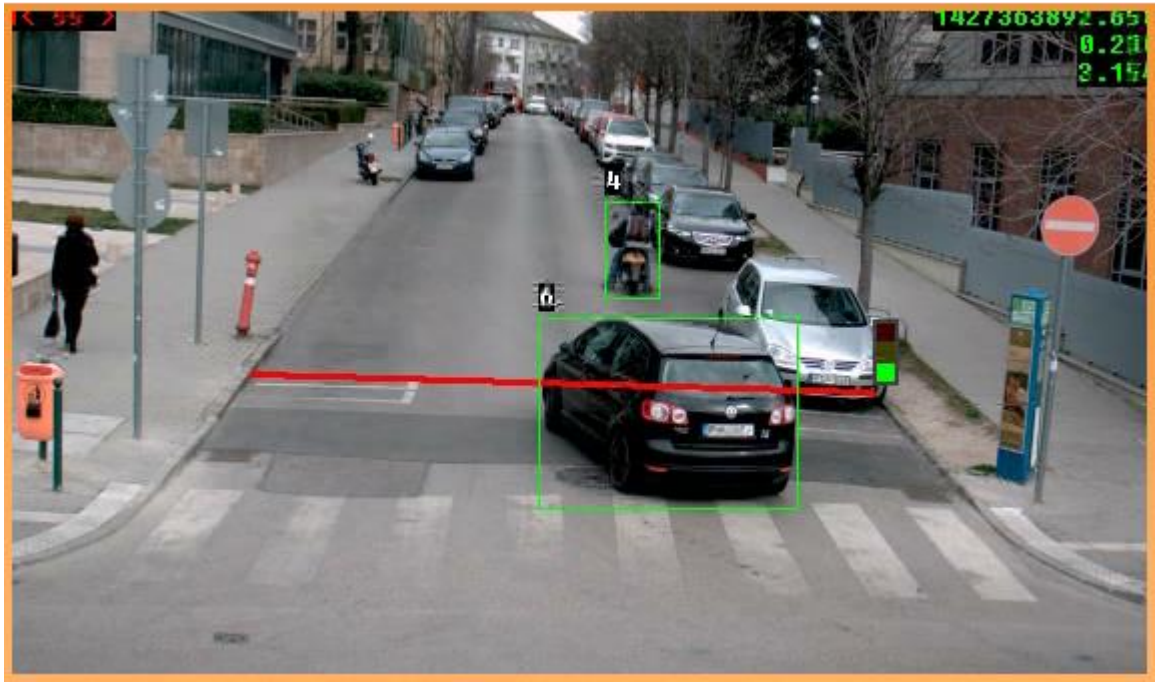
- Red-light violation

Red-light violation detection system.

Vision-based ITS Applications

Traffic violation detection – Applications (Cont'd):

- One-way traffic violation



Incident detection based on vehicle trajectories.

Vision-based ITS Applications

Roadway Scan – Intro:

- Automated Road Analyzer
- Detection of roadway freezes
- Connect to:
  - Intelligent Active Road Sensors (IARS)
  - Anti-freeze sprayer

- An anti-freeze sprayer

- An IARS vehicle

Vision-based ITS Applications

Roadway Scan – Intro (Cont'd):

- Attributes:
  - Pavement/roadway smoothness
  - Pavement/roadway surface macro-texture
  - High-definition images
  - Automated crack detection
  - Asphalt quality estimation

A road crack.

Vision-based ITS Applications

In-vehicle Alarms – Applications:

- Embedded Vision alliance
- Capturing outside environment
  - Traffic sign detectors
    - Speeding alarms
    - Braking alarms
  - Routing alarms
- Capturing inside the vehicle
  - Sleeping driver alarms
  - Safety alarms
  - Mobile-phones usage alarms

- An in-vehicle camera.

Vision-based ITS Applications

In-vehicle Alarms – Applications:

- Capturing outside environment
  - 360 view
  - Parking camera
  - Object detectors

A 360 camera parking assistance.

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

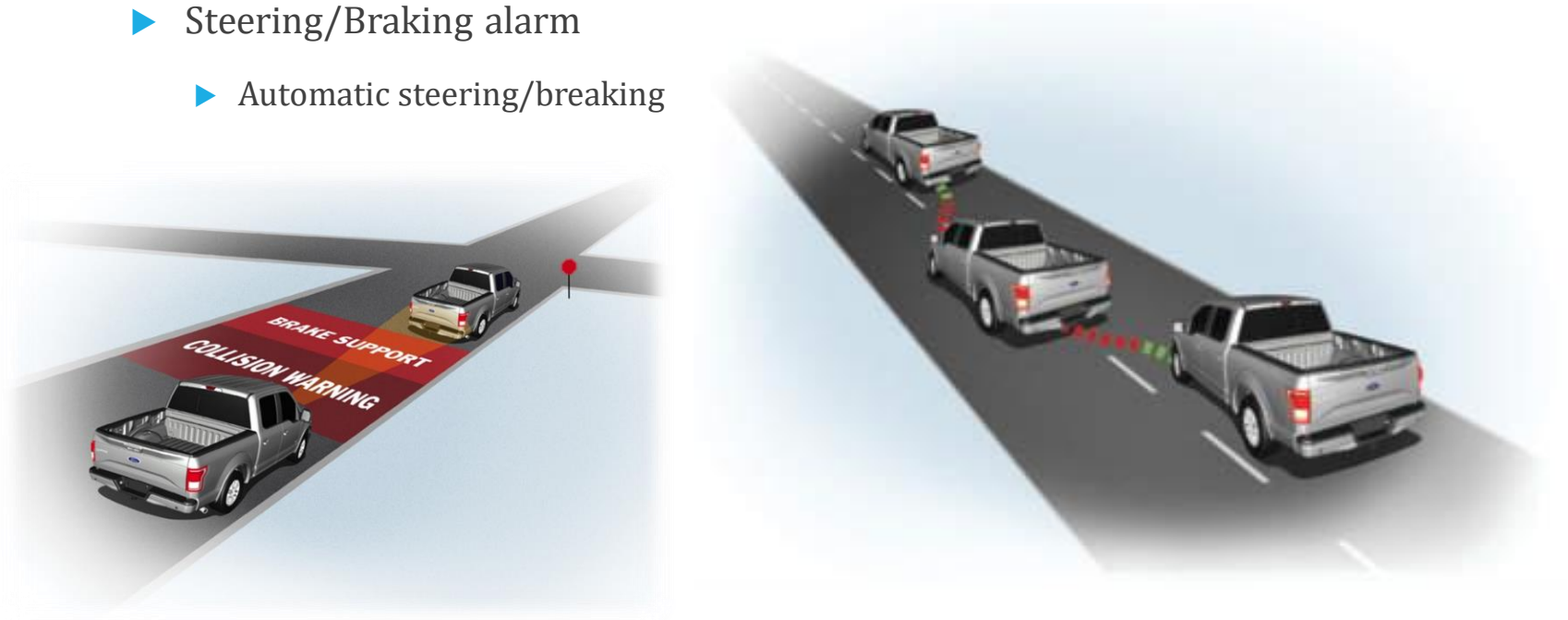
- Capturing outside environment
  - Intelligent rear-view mirrors

Detection of the bicycle by the rear-view camera.

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

- Capturing outside environment
  - Steering/Braking alarm
    - Automatic steering/breaking



Automatic braking (left) and steering (right) systems based on image processing.

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

- Capturing outside environment
  - Traffic sign alarm

- An automatic traffic sign detection

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

- Capturing outside environment
  - Traffic sign alarm

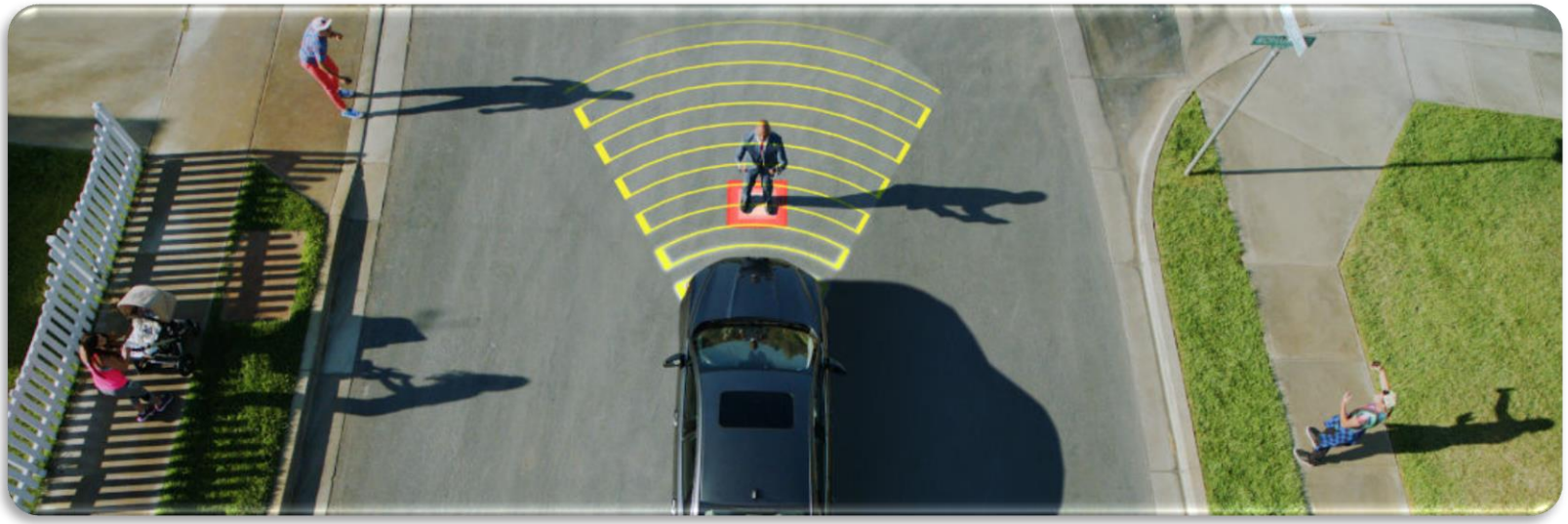
Automatic traffic sign detection systems.

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

- Capturing outside environment
  - Pedestrian detection alarm
    - Automatic braking/steering

- An automatic pedestrian detection

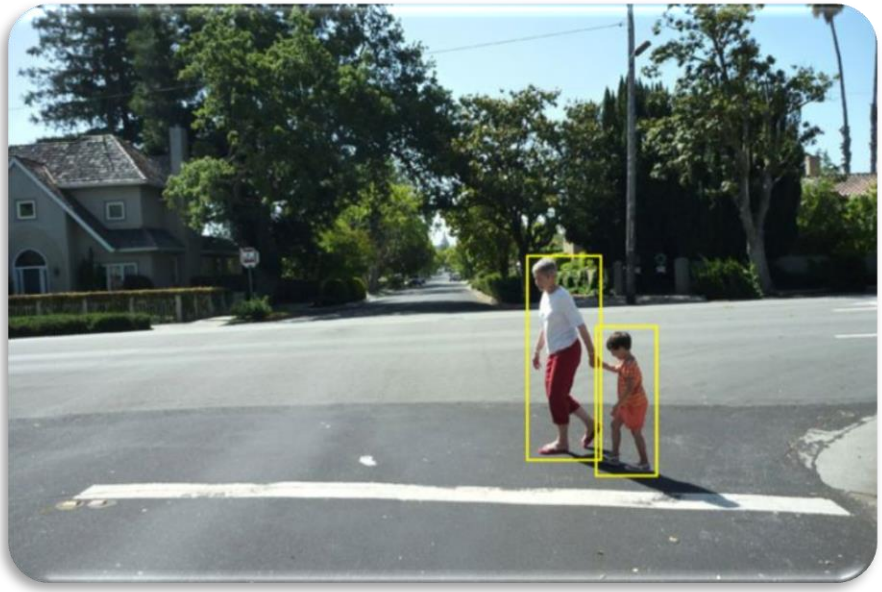


Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

- Capturing outside environment
  - Pedestrian detection alarm

- Automatic pedestrian detection systems



Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

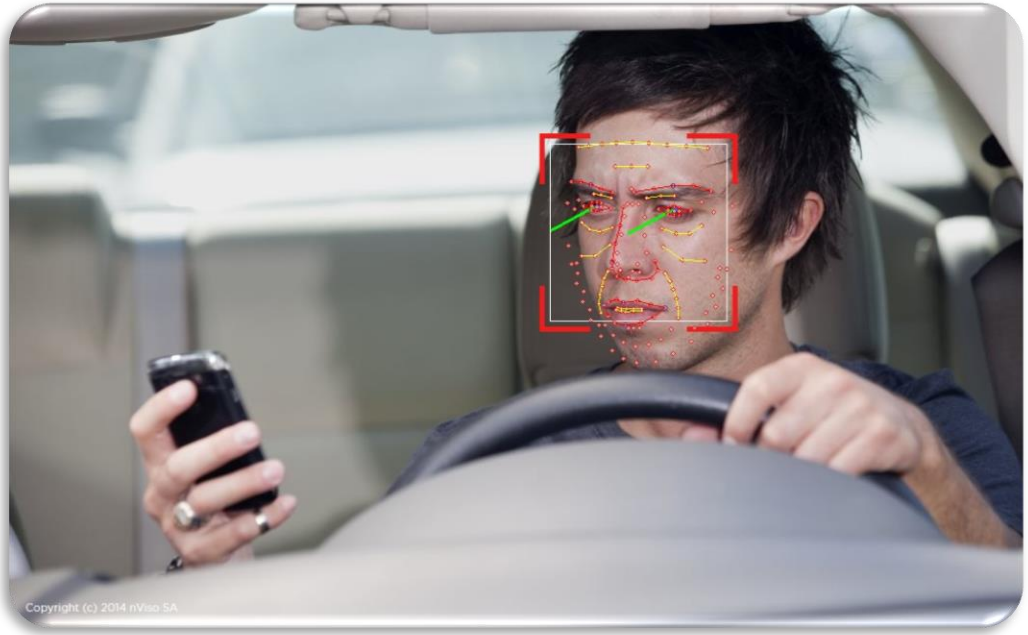
- Capturing inside the vehicle
  - Sleeping driver (fatigue driver detection)

- A pupil analyzer to detect driver's drowsiness

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd):

- Capturing inside the vehicle
  - Mobile-phones usage alarms



- A pupil analyzer for driver's vigilance estimation

Vision-based ITS Applications

In-vehicle Alarms – Applications (Cont'd)

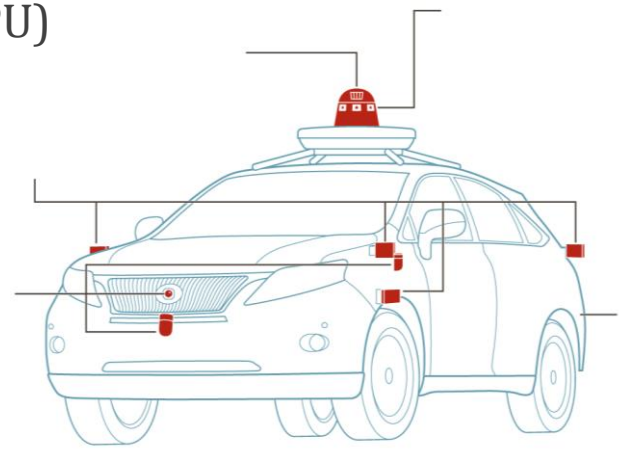
- Capturing inside the vehicle
  - Safety alarms
    - Baby cameras

- Motion-based baby cameras.

Vision-based ITS Applications

Autonomous Driving – Intro:

- Using cameras inside/outside vehicles for decision making
  - Automatic steering/break/route
  - Detection of driving objects in the surroundings
  - Self driving
- Main hardware: Vision Processing Unit (VPU)
  - Myriad VPU line from Intel Corporation
  - Eyeriss from MIT
  - 7-way VLIW Vision Processor by NVidia



Vision-based ITS Applications

Autonomous Driving – Applications:

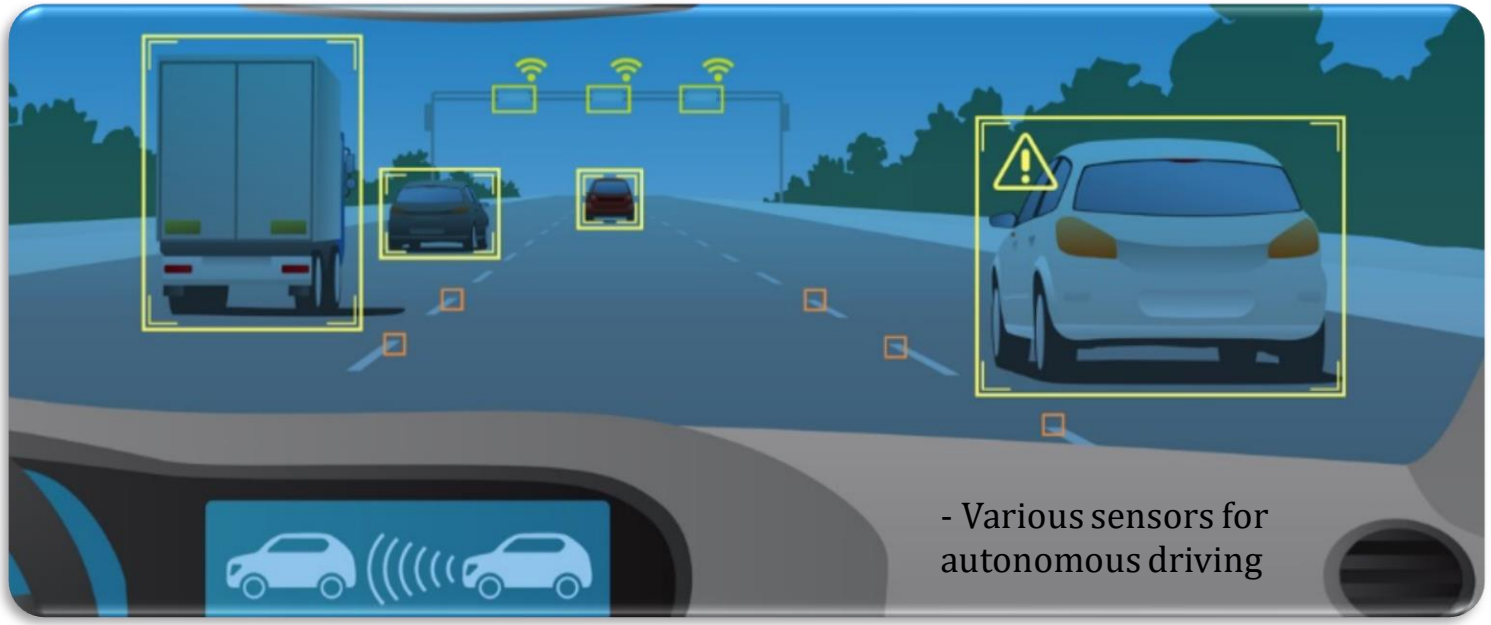
- Decision making based on multiple sensors (including camera)

- Various sensors for autonomous driving

Vision-based ITS Applications

Autonomous Driving – Applications (Cont'd):

- Detection of different roadway objects (infrastructure, vehicle, lane, etc.)



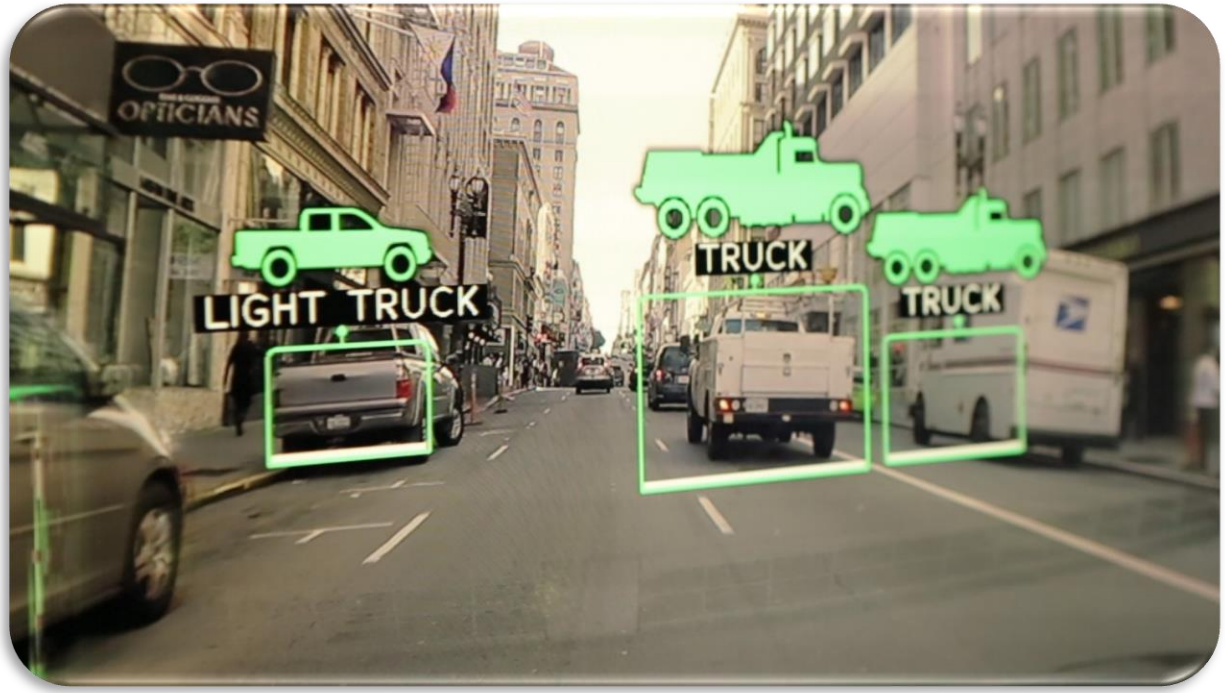
- Various sensors for autonomous driving

Vision-based ITS Applications

Autonomous Driving – Applications (Cont'd):

- Detection of various vehicle types

- Various sensors for autonomous driving



Vision-based ITS Applications

Autonomous Driving – Applications (Cont'd):

- Detection of various environmental parameters

- Various sensors for autonomous driving

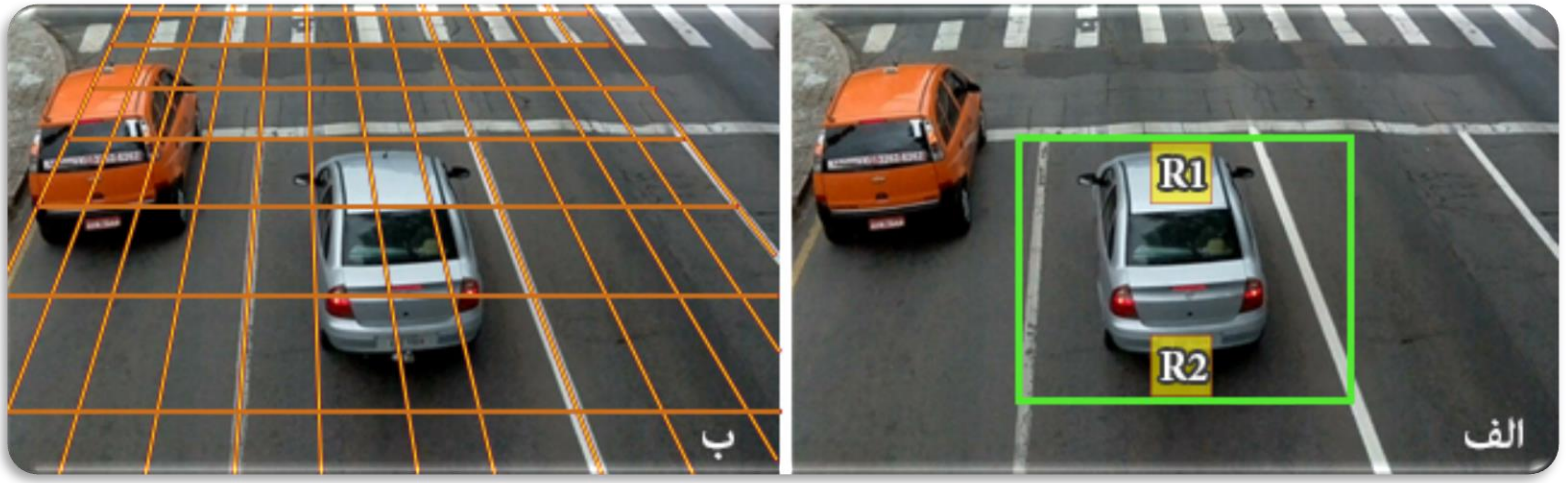
Vision-based ITS Challenges

Challenges:

- Camera shakes (due to environmental conditions like wind)
- Vehicles' camouflages (due to colors similarities)
- Various illumination conditions (effect of light and shadows)
- Various weather conditions (rain, mist, snow, etc.)
- Traffic jam and occlusion
- Capture/transfer noises
- Quality of lens
- Low/inadequate FPS

Vision-based ITS Challenges

Challenges – Perspective Effect:



Left to right: Grid-based perspective illustration, Pixel-based (R1 and R2) approach.

Vision-based ITS Challenges

Common Challenges:

- Common challenges of vision-based ITS including pedestrians presence, blurring, traffic jam, low quality video, etc.

Conclusions

1. ITS are the best possible solutions to overcome traffic-related issues.

2. There are a wide variety of vision-based ITS tools which can provide optimal solutions for in different fields of applications.

3. In most of the cases, vision-based applications can reduce overall cost in comparison with existed ITS instruments.

4. Video-base ITS are faced with some challenges that can be handled by applying correct image processing algorithms and methods.

5. DIP is one of the best possible tools to cooperate with ITS and play an important role in developing common transportation systems.

6. We need to take some actions in deploying vision-based ITS application in our country.

Questions?

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