Smart City - Intelligent Intersection

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Qamcom Research and Technology Stockholm

Big Data Analytics Summer School 2019

Qamcom Research and Technology

About Qamcom

- Product development and research, specialist service provider

Focus Areas

- Wireless Connectivity, Autonomous Systems and Industrial IoT

Key Competencies

- Signal and image processing. AI. Embedded systems. Communication systems. Sensors. Functional safety…
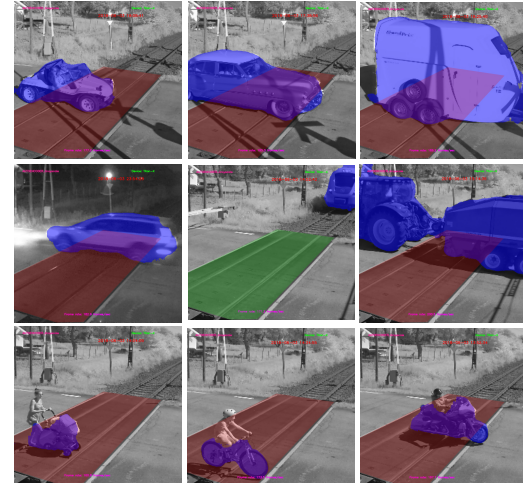
Unity of Technology Application Experts

- 150 outstanding developers in Gothenburg, Stockholm, Linköping, Wellington (NZ) and Greensboro (USA)
- PhDs (40 %) and engineers with an average of 16 years of industry experience
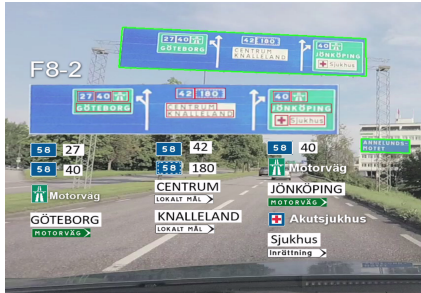
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FlexRay – 77 GHz radar system with QR77SAW

- 4 dimensional high-performance 77 GHz radar system

- Detection and Tracking of objects, 3D scanning

- Automatic obstacle detection at level crossings

- On-path obstacle detection using Lidar and Radar

TRAFIKVERKET

SIEMENS

Winner ECS Award 2017 Enterprise Category

Lane change RADAR

Side collision RADAR

Park assist RADAR

Long-range RADAR + LIDAR + Camera

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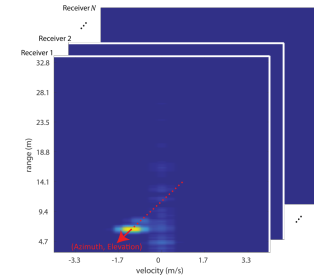# Applying Artificial Intelligence on Various Applications

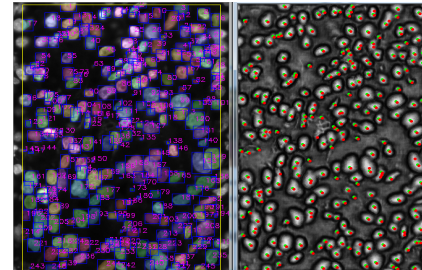Traffic sign analysis

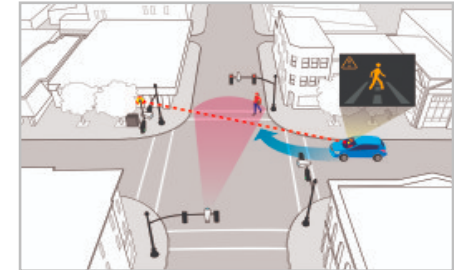Vehicle detection

Biomass counting

Radar signal analysis

People detection

Power line inspection using drones

Bioimaging analysis

Smart City – Intelligent traffic analysis

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Challenges of using AI in Industrial Products

- Dimensions of the neural network and hyper parameters

- Unpredictability in project schedule due to iteration

- Large amount of data: Collection, cleaning, annotation and pre-processing

- Evaluation and validation of AI products

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Edge to Cloud Continuum: System Tradeoffs

Edge

Cloud

Fast data

Big data

Sensors

Gateway

On-premise Server

Network Switches

Cloud/Industrial Infrastructure

System responsiveness

Scope of data analysis

Privacy

Computing and network cost

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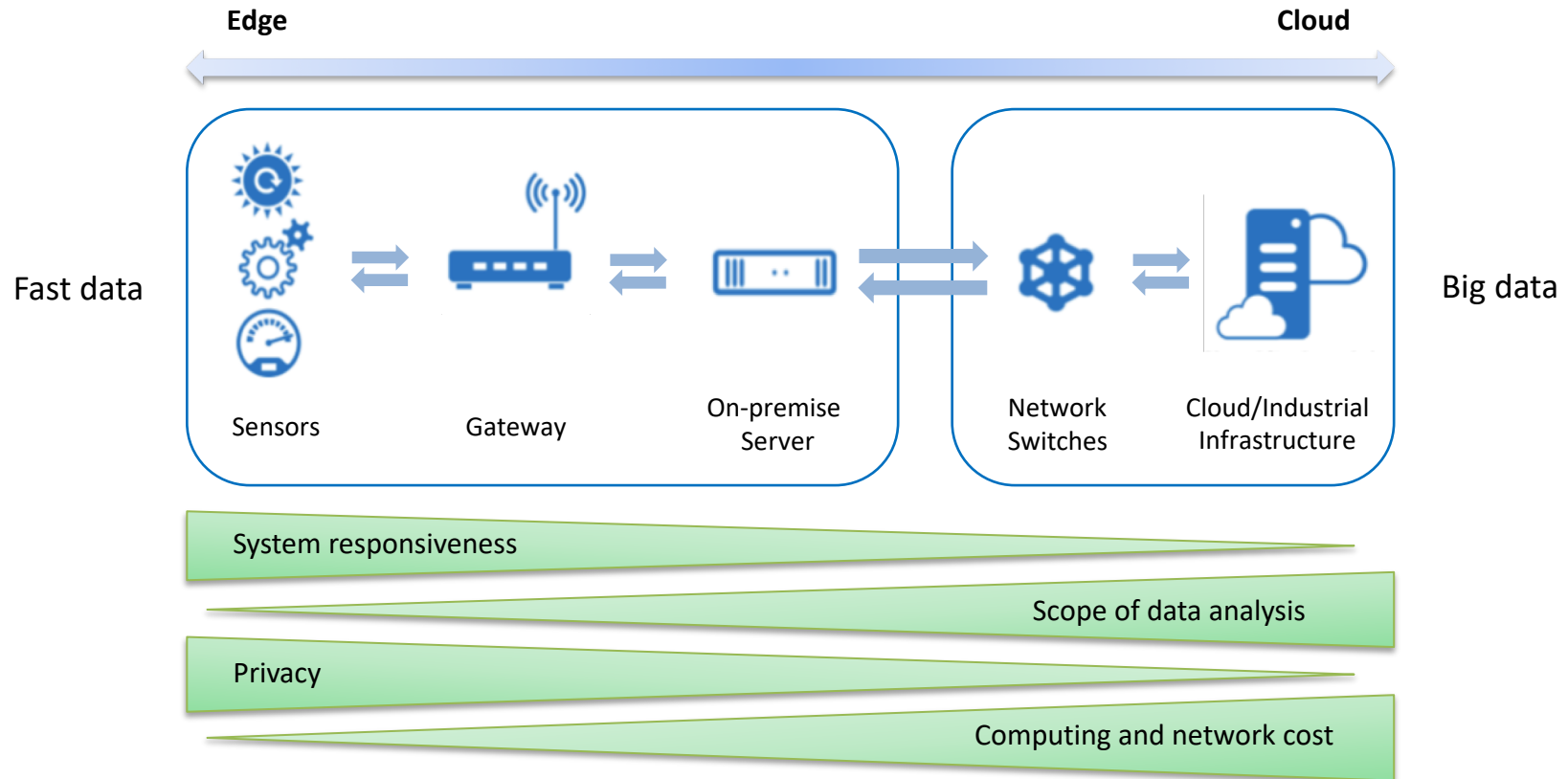
Stockholm City 2040 Vision - World's Smartest City

- Use digitalization and technology to
  - Create a smart, connected and sustainable city
  - Enhance life for residents, visitors, and entrepreneurs
- A number of innovative projects:
  - Smart traffic control
  - Smart and connected lighting
  - Collect and share traffic data

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# Traffic Surveillance System – Smart Intersection

- Multifunction sensor to enable automatic traffic light control
  - Above the ground detection of vehicles, pedestrian, and bicycles
  - Traffic measurement and collection of traffic data
  - Sharing traffic data to other operating systems and the city's central IoT platform
  - Video stream sharing to other activities within the city
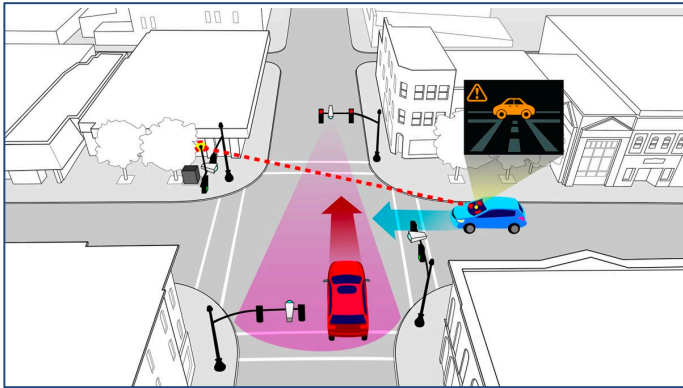
High performance edge computing platform

Low-latency video analysis and decision making at crossing

Independent of connectivity to the internet/cloud

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Requirements and Challenges

- Real-time functionality

  - Provide input to the traffic light control box with max latency of 100ms

- Advanced and reliable object detection/classification and tracking

  - Direction estimation of moving objects

  - Calculate their speed (km/h) with margin error of 10%

  - Count number of objects by category with 95% accuracy

  - Reliable in bad weather conditions and darkness

  - Support for of 10 Region of Interest (RoIs)

  - The ROI can be 30m wide and 50 meters long

- Edge Computing need to self-contained

- Competitive price

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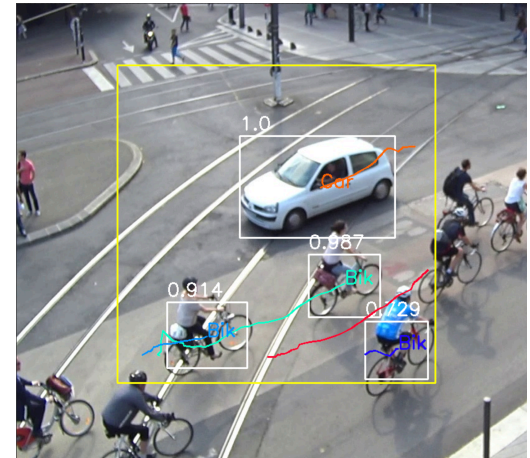
Smart Intersection Overview

- Traffic signal control
  - Change the traffic light based on vehicle detection/classification
  - The length of vehicle queues at different lanes at the crossing
- Traffic analysis in real time
  - Classification of vehicles based on registration plates
  - Traffic flow rate and density
  - Collect and share data for local and global traffic analysis

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Potential Smart Intersection Features

- Increased intersection safety

  - Sidewalk accidents and activities

  - Detect traffic violation

- Support for smart mobility

  - Early warning to drivers/cars about hazards

- Environmental monitoring

  - Measuring climate, air quality, and noise, …

- …

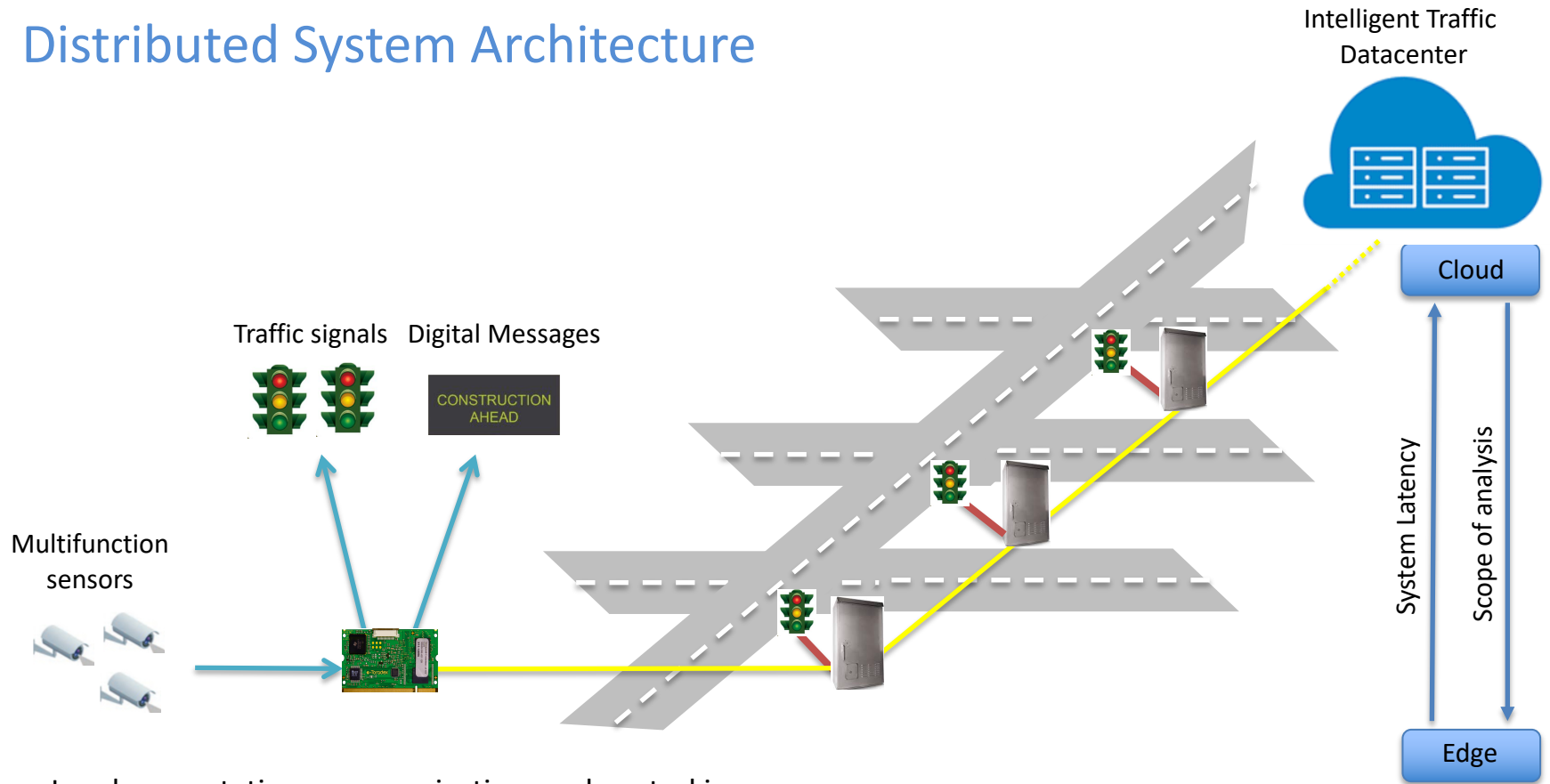Qamcom Research & Technology Stockholm

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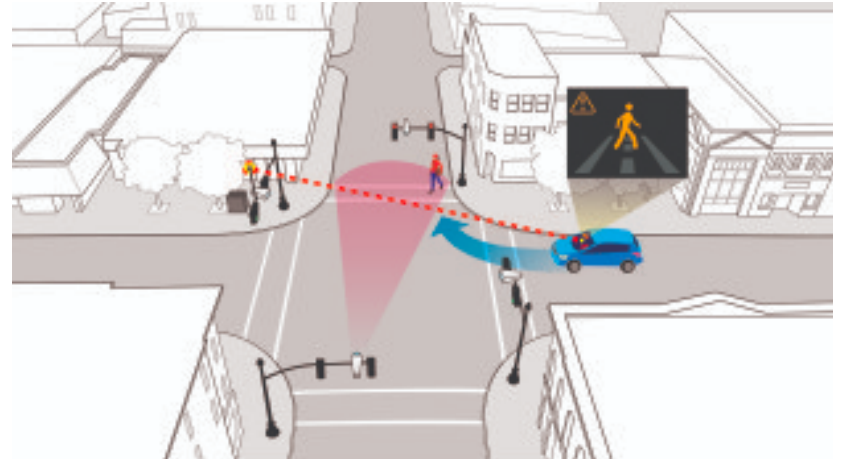
Multifunction Sensor

- Camera with support for night vision
    - Traffic signal control
    - The length of vehicle queues at different lanes at the crossing
    - Classification based on registration plate
    - Traffic flow rate and density
    - Detect traffic violation
    - Sidewalk safety and surveillance
    - Safety of the pedestrians
- Radar
    - Instantaneous traffic speed
    - Supporting system in bad weather
- Environmental and air quality sensors
   - Measuring climate, air quality, and noise

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Distributed System Architecture

Intelligent Traffic Datacenter

Traffic signals Digital Messages

CONSTRUCTION AHEAD

Multifunction sensors

Cloud

System Latency

Scope of analysis

Edge

Local computation, communication, and control in traffic signal control cabinet for increased robustness

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Camera as the Detector

- Selection of suitable camera: Full day surveillance/close-view, weather proof, lens

- Installation of camera devices: Number of cameras, position, height, rotation, field of view, tilt

- Functionality and camera feature trade-offs
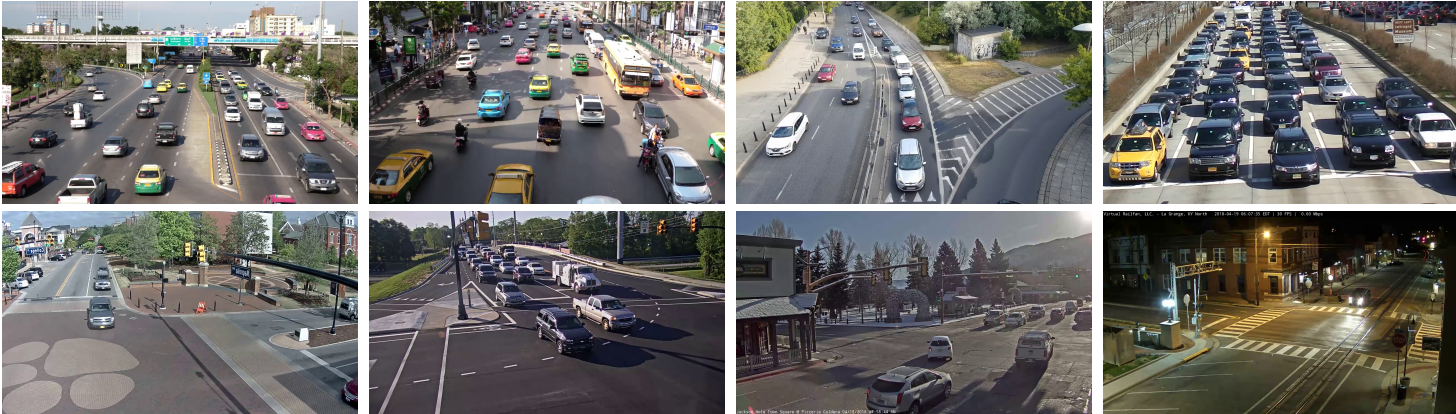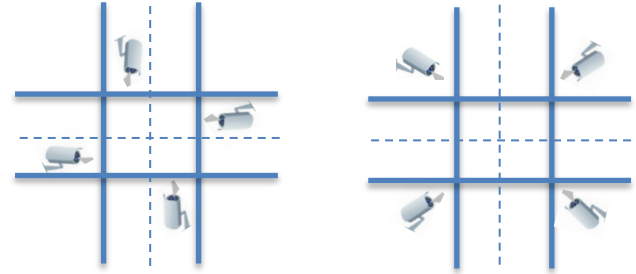
(images from Qamcom database)

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Image processing: Detection of the Vehicles at Different Lanes

- Real-time detection and understanding of the position of vehicle in each lane

- Estimation of the vehicle heading direction

- Combining information from difference cameras for understanding the vehicle movements

- Challenges

  - Camera position

  - Varying lighting conditions

  - Weather interference, e.g., rain drops, fog

  - Occlusion among vehicles

    - Front vehicle might occlude vehicle behind
    - Big vehicle might occlude vehicles by the side

 - Real-time computation requirement

Original image   Vehicle detection

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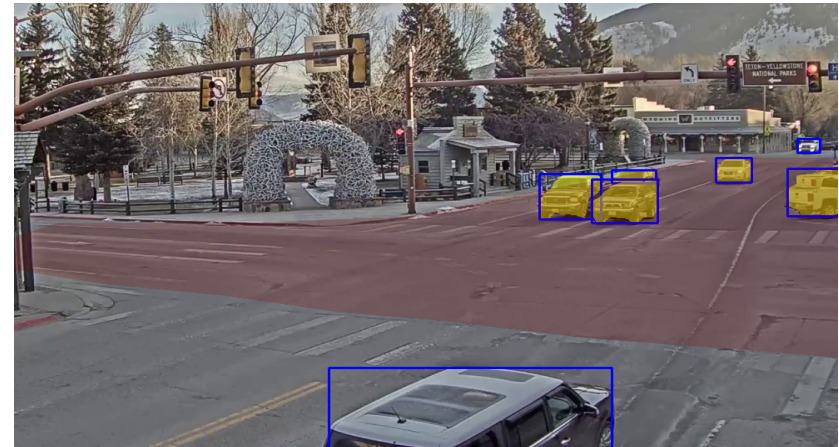
Automatic Number-Plate Recognition (ANPR)

- Automatic number-plate detection and localization in image

- Number-plate recognition (text-symbol mixed)

- Classification of number-plates

- Bird-view and rear-view are usually used for ANPR

- Challenges
  - Various lighting conditions
    - Vehicle headlights over exposing the image
  - Mixed types of number plates
    - Swedish number plates
    - International number plates
  - Different requirements for reading registration plates and capturing the global view
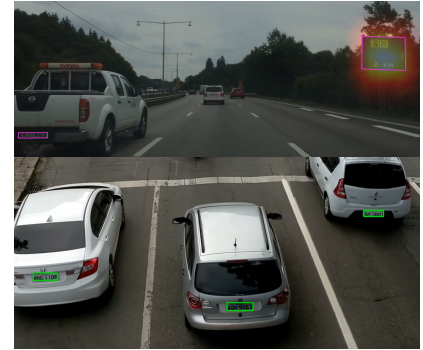
Bird-view and rear-view ANPR

headlights over expose

Infrared light reflecting

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Reliability and Maintenance: Image Quality Assessment (IQA)

- Qamcom IQA system can estimate the availability of camera acquisition system

  - In different lighting conditions

  - In different season, weather conditions

  - In case of dirty or rain drops on the camera lense

Image quality degrade

IQA value increases

IQA 18.0

IQA 30.3

IQA 26.5

IQA 27.6

IQA 41.1

IQA 28.1

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Detection of People

- Detection and counting of people in regions of interest

- Pedestrian behavior analysis
  - Pedestrian movement and intention at and around crossings

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Security and Privacy

- Data need to be encrypted at rest (stored) or in transit (communicated)

- Data can be analyzed, but cannot be stored.

- Detection/tracking results shall contain no sensitive personal data

- Secure multifactor authentication mechanism

- Role based authorization

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Takeaways

- Interesting applications can be enabled by AI

- Development of products based on AI can be challenging
  - Large amount of data (a lot if manual work)
  - Unpredictability due to iterations
  - Ground truth for validation

- Do consider edge-to-cloud system tradeoffs
  - Flow of data and intelligence
  - Security, privacy, latency, cost, and scope of analysis

- Smart city – Multifunction sensor to enable smart intersection
  - Strict functional, performance, and security requirements

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Thank You!

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