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Environmental Monitoring

Event Detection and Distributed Scenario Modeling

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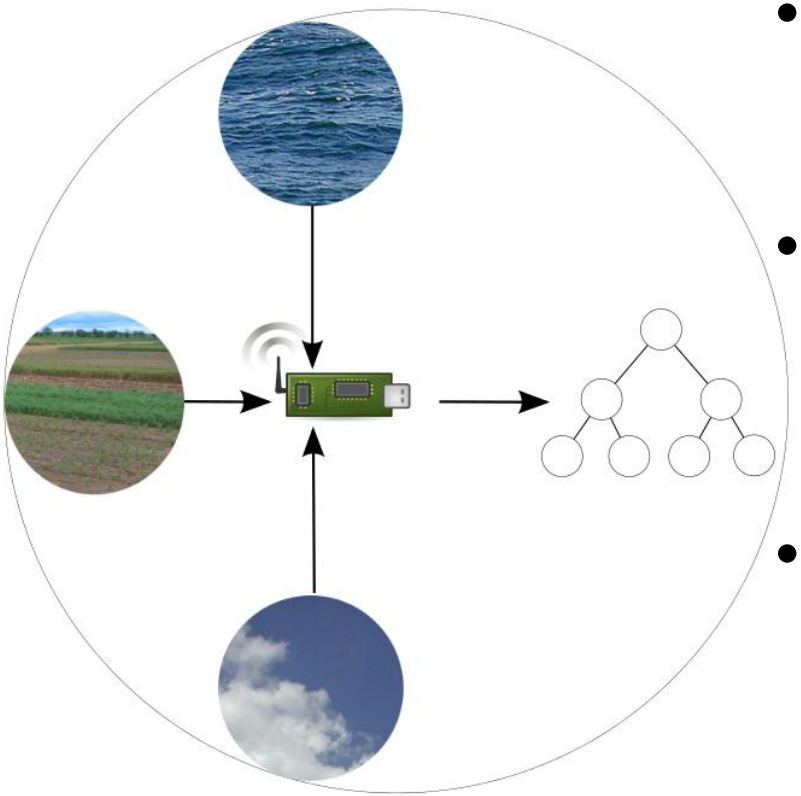
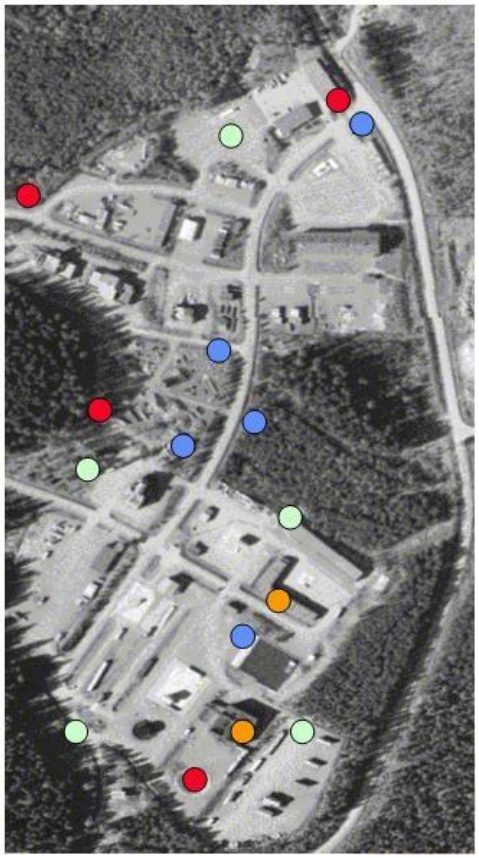
Introduction
Environmental monitoring



- Monitoring the environment
  - Variables of water, land, air
  - Sensor networks for data collection
- Obtain knowledge
  - Environmental awareness
  - Comprehension and understanding
  - Ontology rather than raw data
- Challenges
  - Data storage, retrieval, integration
  - Data formats, transmission protocols
  - From data to ontology

Introduction
Environmental monitoring: Our testbed

- Emergency Services (Kuopio) training area
- Development platform for systems to monitor the operational environment
- Sensor network for the detection of
  - Chemical emissions in (indoor) air and water
  - Vehicle activity and identification
- Sensor types
  - Weather, particles, gases, water
  - Vibration, cameras
- Software system
  - Data integration, storage, retrieval

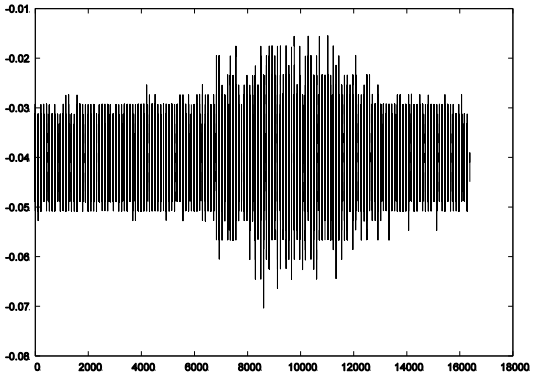


Introduction
Environmental monitoring: On-road vehicles

- On-road vehicle detection
  - Know there is a vehicle “now”
- On-road vehicle classification
  - Know what type of vehicle it is
- Using vibration sensor data
  - Vehicle-induced onto road
- Upon event
  - Call distributed modeling service(s)
- Scenario
  - Model vehicle reachability

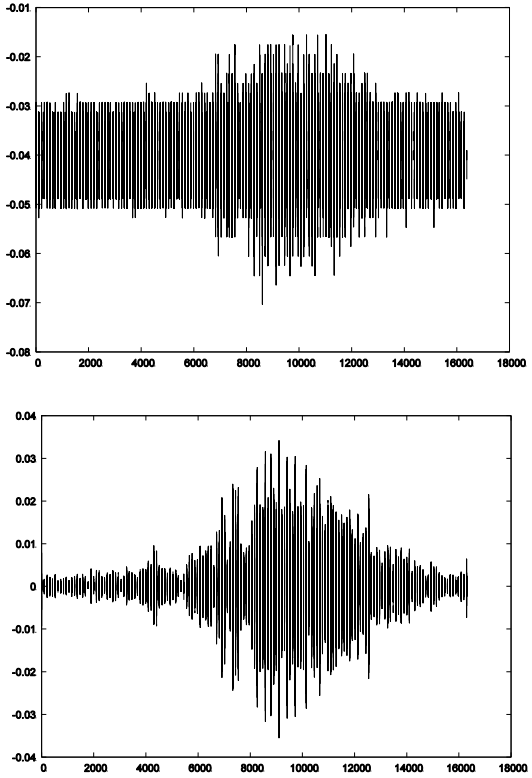
Collecting sensor data
Vibration and camera sensors

- Vibration sensor
  - Measures acceleration of monitored objects
  - The vibration induced by road vehicles
  - Sampling frequency 2000 Hz
    - Thus, 2000 measurements every second
- Camera sensor
  - Delivers a variable 1-3 frames per second
  - 640x480 pixel resolution
- "Big data", 1 month continuous monitoring
  - 5 billion measurement values
  - 1.7 Tb data



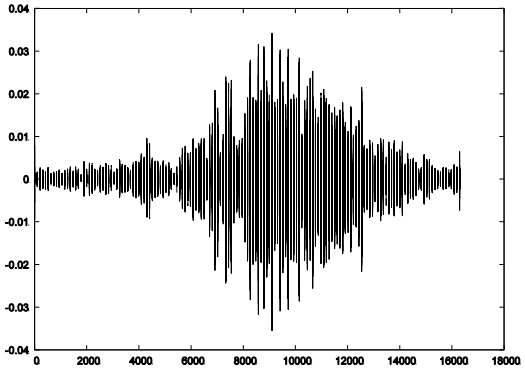
Processing vibration data
Event detection

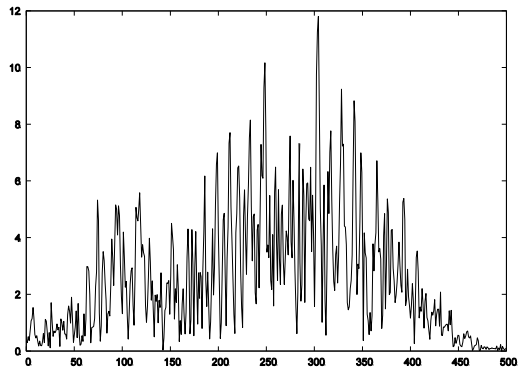
- Sensor data often contains “noise”
  - E.g. electrical current at 50 Hz
- Problematic for (reliable) event detection
  - Signal may be “hidden” in noise
- Apply filters to enhance signal (of interest)
  - Spectral energy in 80-130 Hz for vehicles
    - Discovered experimentally using stored data
  - Band-pass filter
    - Attenuate frequencies not in 80-130 Hz



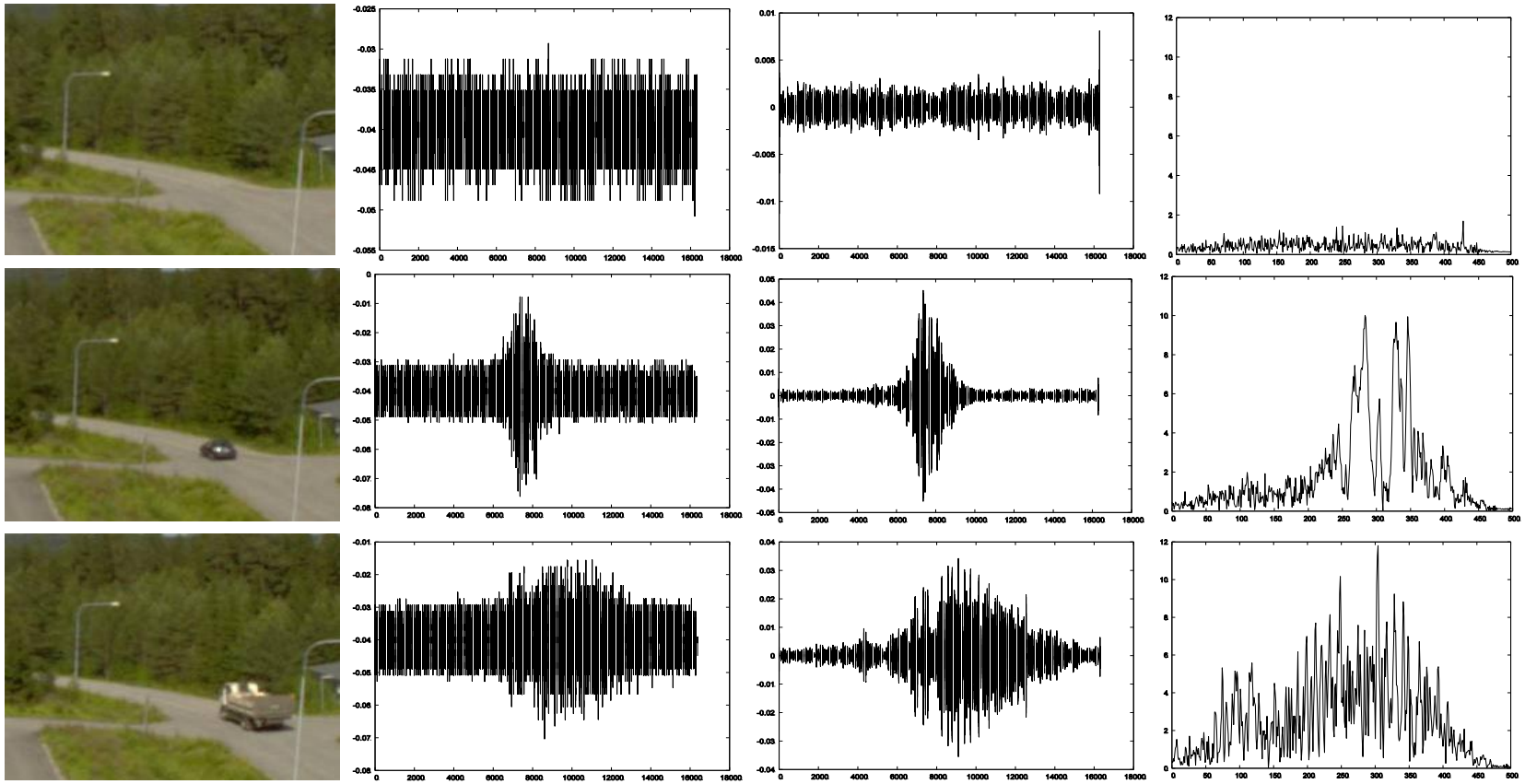
Processing vibration data
Event "fingerprint"

- Frequency profile as event "fingerprint"
  - Fourier transform of filtered signal
  - Extract frequency profile in 80-130 Hz
- Hypothesis
  - It is possible to classify vehicles based on the corresponding event "fingerprint"
  - To what accuracy?



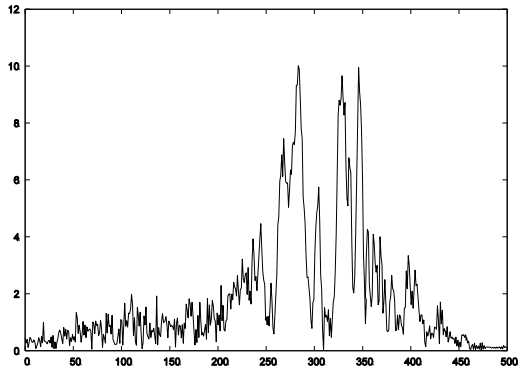


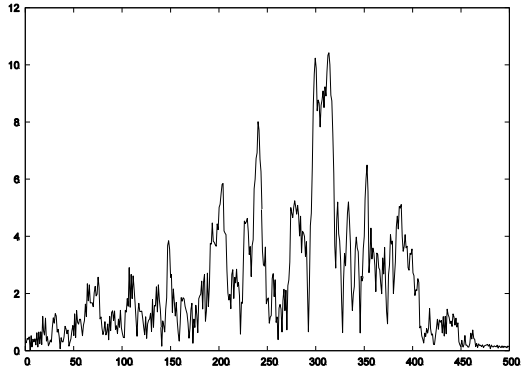
Event detection
A comparison with background



Event classification

- Problem
  - Two cars do not have the “same” fingerprint
- Data-driven methods
  - E.g. K-means, Neural Networks, Naïve Bayes
  - Learn how to “distinguish apple from banana”
  - Train a classifier with labeled dataset
    - Built semi-automatically
      - Automatic event detection
      - Manual label assignment using images
    - 13 vehicle classes, 1169 events
- Accuracy (preliminary results)
  - ~75% using 4 classes and Naïve Bayes



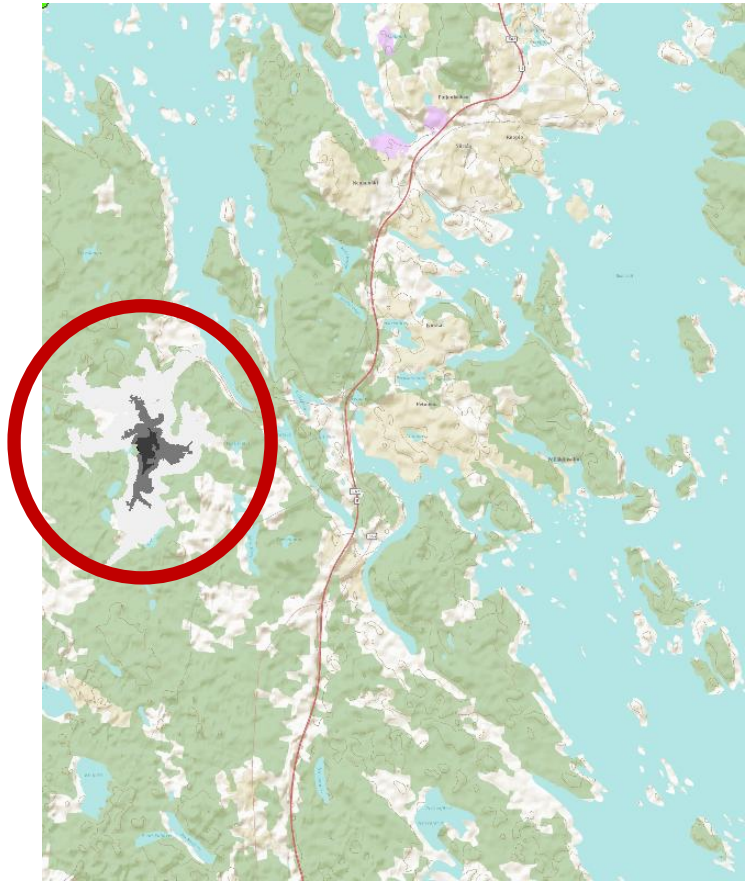


Scenario modeling

- Given detected and classified event,
  - Orchestrate calls to one (or more) distributed modeling service(s)
  - Integrate modeling results from multiple services
  - Present the result to the user
  - Services may be remote (Internet) and of third-party providers
  - Interacting services must “understand” each other

Scenario modeling
Vehicle reachability

- Reachability
  - Where could the vehicle be in 60, 120, 240 seconds?
- Consider
  - Vehicle velocity, speed and driving direction (requires more sensors)
  - Local terrain
  - Road and weather conditions
- Present reachability map to user



Cooperation
Nanjing and UEF

- Based on the proposal presented earlier
  - Lake and fresh water reservoirs monitoring
- Technical knowledge transfer, e.g.
  - Collecting data from different sensors, e.g. for water monitoring
  - Efficient storage and retrieval of time series and geospatial data
  - Develop data access interfaces, Data-as-a-Service
  - Towards ontology to model domain knowledge, Meaning-as-a-Service

Conclusions

- Environmental monitoring to collect and process data to monitor the quality of the environment
- Emergency Services training area as a development platform
- Vibration sensor for detection and classification of on-road vehicles
- Detection of vehicles in vibration data
- Classification of vehicles based on their frequency profile
- Use of data-driven methods to learn a classifier
- Given classified event orchestrate distributed modeling services