Vehicle detection using non-invasive wireless magnetic sensor network

Aivars Severdaks
Martins Liepins

Motivation

- Need of vehicle detection for traffic statistics

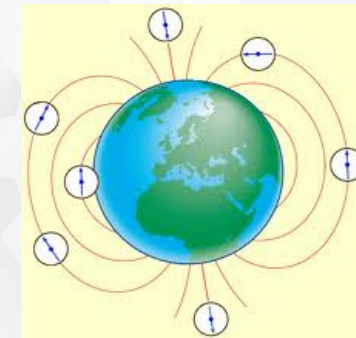- Non-invasive sensors

- Goal - efficient traffic management

# Vehicle detection

- Vehicle can be detected by it

–Appearance (video camera, laser sensor, microwave sensor)

–Sound (microphone array)

–Heat (PIR sensor)

–**Metal body and engine** (**magnetometer**, induction loop)

–Weight (pressure sensors)

Magnetic sensors

- Any metal object creates Earth's magnetic field distortions

- Magnetic sensor registers Earth's magnetic field local distortions

- Magnetic field emitted by electronic devices from the car is very small
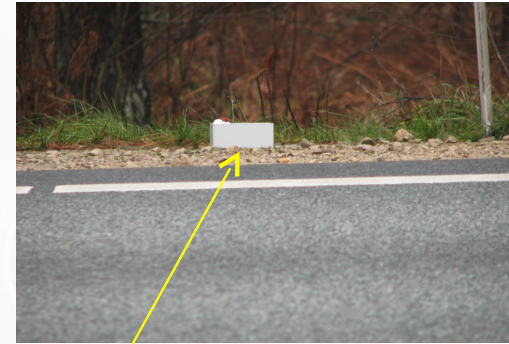
- Indirect measurement
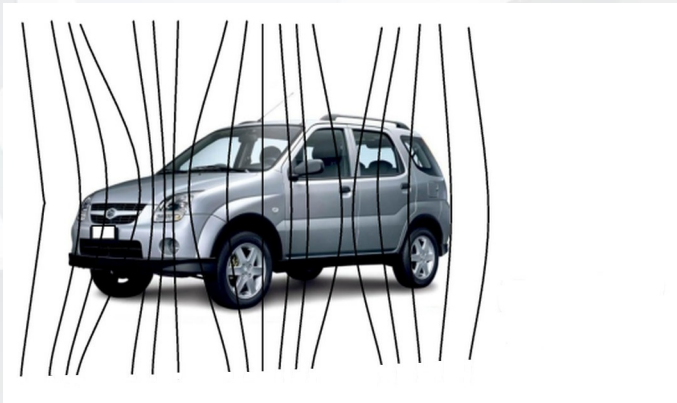
Proposed solution

- Sensors are placed on both sides of the road opposite to each other
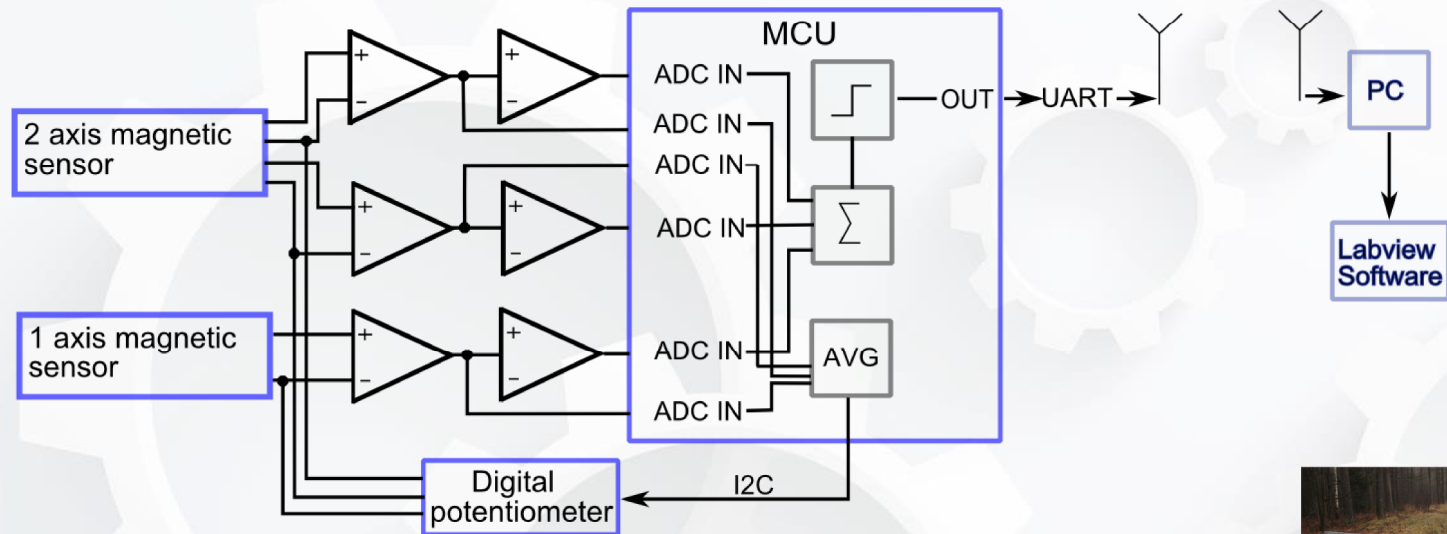
Benefits

- Non – invasive to the road surface

- Mobile solution (highly portable)

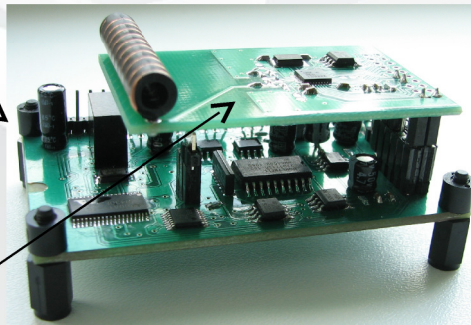- Easy to service

Disadvantages

- Limited vehicle classification possibility

   (light, heavy)

- Inaccurate speed detection
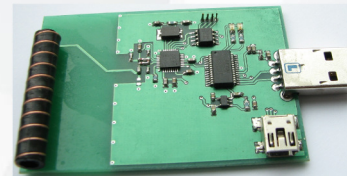
Designed system hardware I
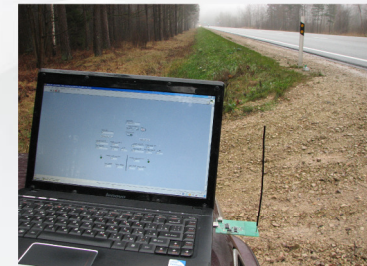

Magnetic sensor mote

Wireless transceiver
Nordic 9E5(433MHz)

Wireless receiver

PC

Designed system hardware II

- 3 axis magnetic sensor mote (HMC1001, HMC1002 sensors)

- Two amplifier stage (signal gain 11950)

- Magnetic sensors demagnetizing stage (voltage boost converter, analog transistor circuit)

- MCU – MSP430f2274 micro controller

- ADC sampling frequency 208Hz

- Digital potentiometer(MAX5392)

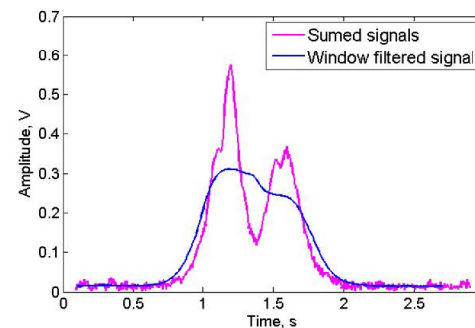- Wireless data transmission – Nordic NRF9E5(433MHz)

Vehicle detection algorithm (on mote)

Mote detects vehicle signature maximum value and pulse width (sample count above defined level)

Maximum value and pulse width is sent to PC

Vehicle detection algorithm (on PC)

Case 1 — Light vehicle false negative

Case 2 — OK

Case 3 — OK

Case 4 — OK
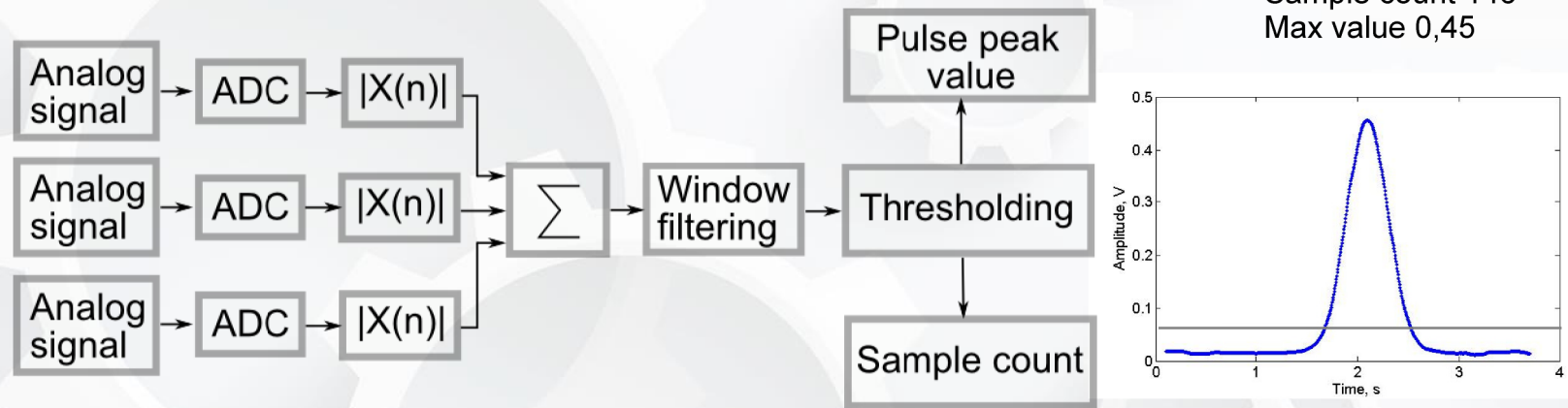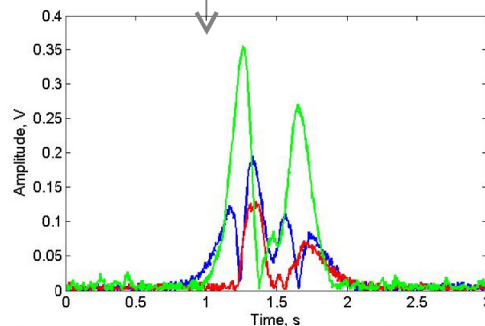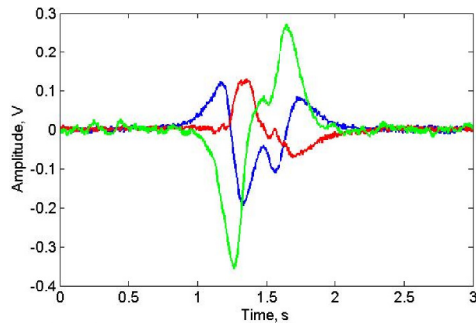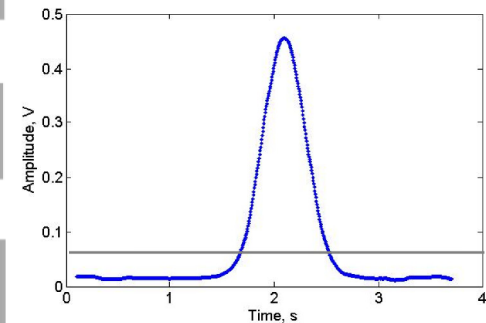
mote1, mote2, PC
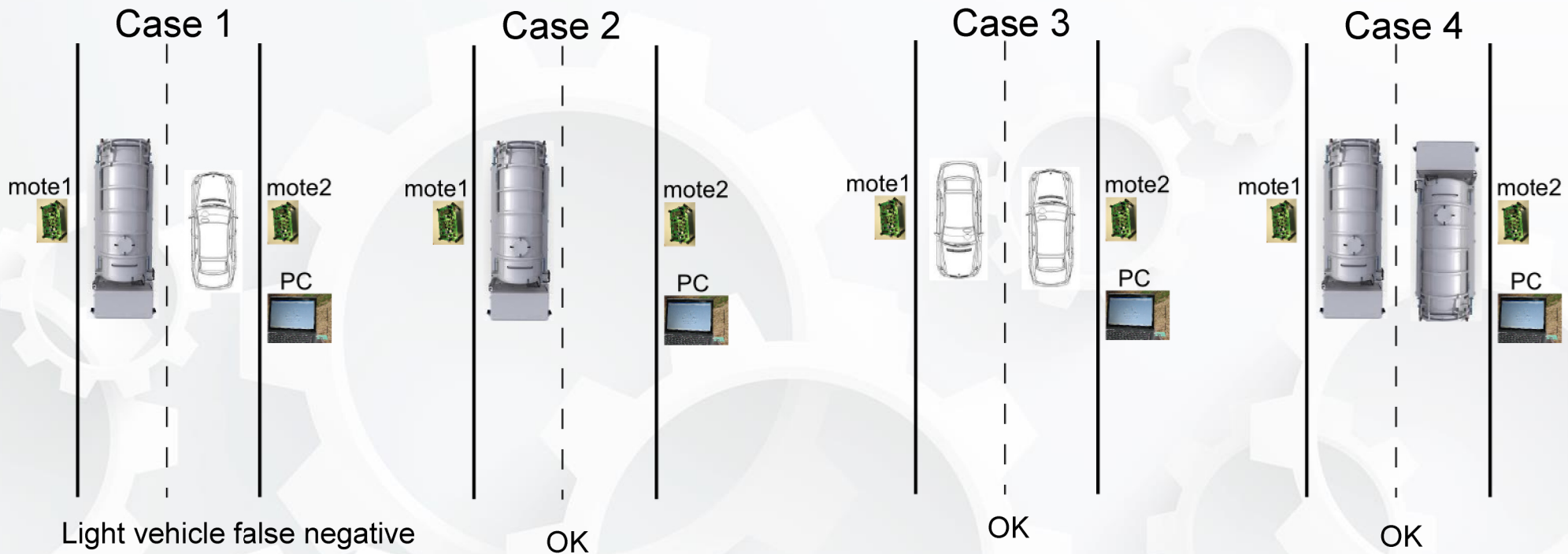
- PC receives vehicle magnetic signature pulse max value and sample count
- Software on PC compares vehicle magnetic signature data from both motes

Tests

•Tests where performed about 400m from regulated intersection in real traffic flow outside the city

•Sensors where placed on both sides of the two line road opposite to each other

•Ground truth data obtained from video recordings

Results

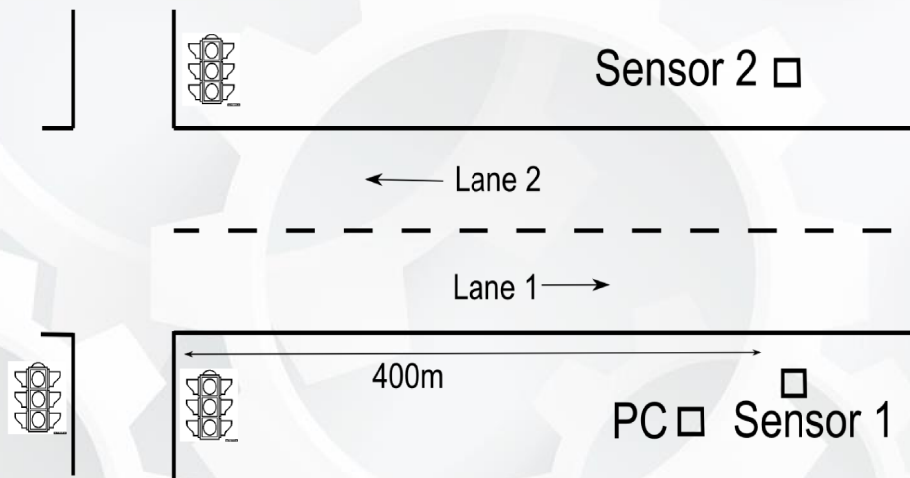| Lane 1 (Vehicle classification)		
	Heavy vehicle	Percents
Ground truth	388	100%
False positive	16	4,1%
False negative	20	5,1%
	Light vehicle	Percents
Ground truth	560	100%
False positive	35	6,2%
False negative	91	16,2%

Lane 2 (Vehicle classification)		
	Heavy vehicle	Percents
Ground truth	283	100%
False positive	17	6%
False negative	7	2,47%
	Light vehicle	Percents
Ground truth	364	100%
False positive	27	7,4%
False negative	24	6,6%

Vehicle detection (lane 1 and lane 2)		
	Vehicle count	Percents
Ground truth	1595	100%
False positive	8	0,5%
False negative	83	5,2%

Conclusions

- Proposed non-invasive vehicle counting system may be used on one or two lane roads

- Tests show poor light vehicle detection if it follows close (less then 10 m) to heavy vehicle

- It is hard to distinguish two or more closely one after the other traveling heavy vehicles from each other if the distance between them is smaller than 7 meters

- Poor performance on the roads with intensive heavy vehicle flow in one of lanes at the same time with intensive light vehicle flow in opposite lane

- Proposed system shows good performance in rural, non-urban areas where simple and non - invasive solution is needed

- System is useful in construction places as traffic light sensor or other places where traffic monitoring or intersection regulation is temporary used