Real Time Pothole Detection using Android Smartphones with Accelerometers

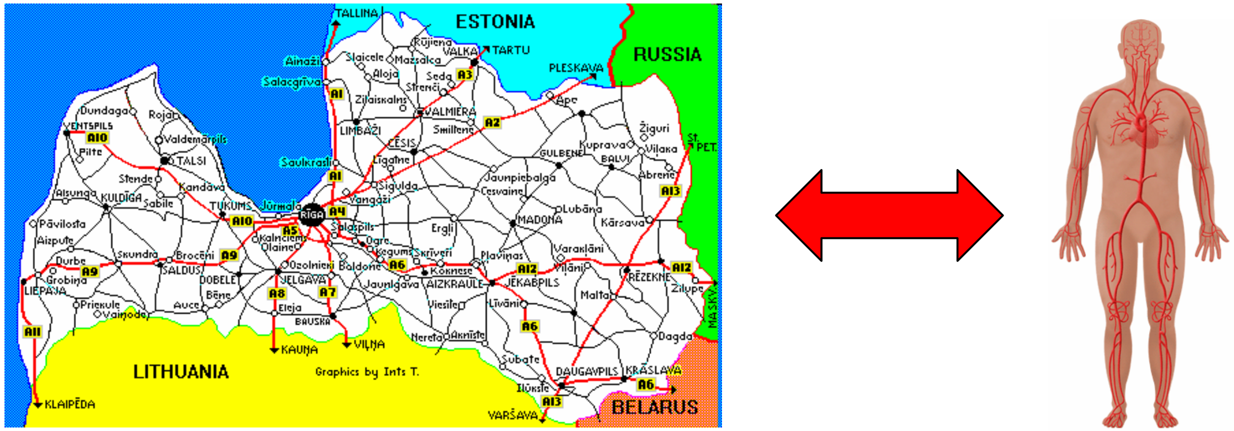
Artis Mednis[12], Girts Strazdins[12], Reinholds Zviedris[12], Georgijs Kanonirs[1], and Leo Selavo[12]
[1] Institute of Electronics and Computer Science,
14 Dzerbenes Str, Riga, LV 1006, Latvia
[2] Faculty of Computing, University of Latvia,
19 Raina Blvd., Riga, LV 1586, Latvia
{firstname.lastname}@edi.lv

ESF grants:
2009/0219/1DP/1.1.1.2.0/APIA/VIAA/020
R&D Center for Smart Sensors and Networked Embedded Systems
2009/0138/1DP/1.1.2.1.2/09/IPIA/VIAA/004
Support for Doctoral Studies at the University of Latvia

MobiSensor 2011, Casa Convalescència, Barcelona, Spain, 29.06.2011

Research domain

- Road infrastructure as blood vessels



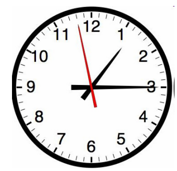
- Participatory sensing for data collection
- Manual *vs.* automatic reporting
- General purpose *vs.* customized embedded devices

Existing solutions

- Motes with accelerometers but only for data collection (BusNet)
- Embedded computers with external accelerometers for real time data processing (Pothole Patrol)
- Smartphones with external accelerometers for real time data processing but using very simple algorithms (Nericell, TrafficSense)
- Smartphones with built-in accelerometers in client-server solution with partial server side data processing (system developed at National Taiwan University)
- Offline data mining using complicated data processing algorithms (approach developed at University of Jyväskylä)

Technical requirements

- Detection of the potholes in **real time** during driving in different four-wheel vehicle types



- Different **Android OS** based smartphones with accelerometer sensors as hardware/software platform

- Enough resources for **native communication tasks** at an adequate quality level

- Calibration or self-calibration functionality for adaptation to **different vehicles**

Our approach

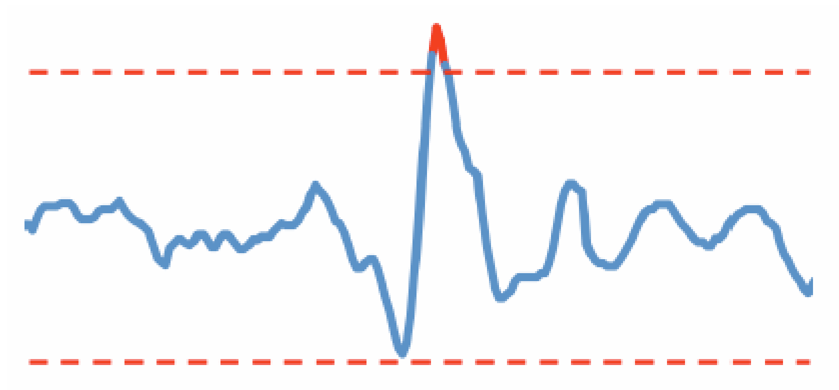
- Marking of *ground truth* using *Walking GPS* approach
- Test drive session (10 laps) with 4 different smartphones
- Processing of collected data using selected algorithms
- Statistical analysis in context of marked *ground truth* and previous developed RoadMic methodology
- Used terminology
  - true positives - >=4 events during 10 laps within <= 15m radius
  - true hits – events detected within <=15m to nearest *ground truth* item

Class	24.03.2011	19.03.2010
Large potholes	3	3
Small potholes	18	18
Pothole clusters	30	30
Gaps	40	25
Drain pits	17	29
Total	**108**	**105**

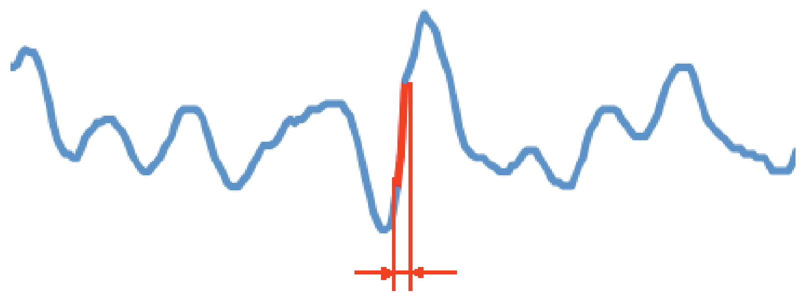
4.4km long test track with marked and classified *ground truth*

Algorithms I

- **Z-THRESH**
  - thresholding the acceleration amplitude at Z-axis
  - events represented by values exceeding specific thresholds
  - information about Z-axis position of accelerometer is known

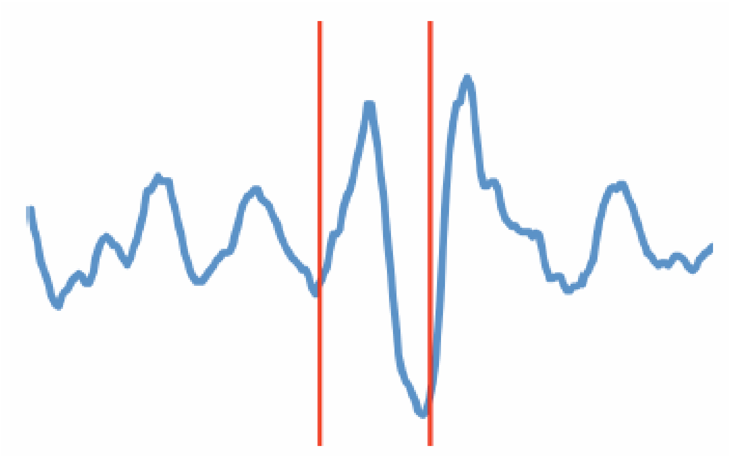


- **Z-DIFF**
  - fast changes in vertical acceleration data
  - events represented by two consecutive measurements with difference between the values above specific threshold level

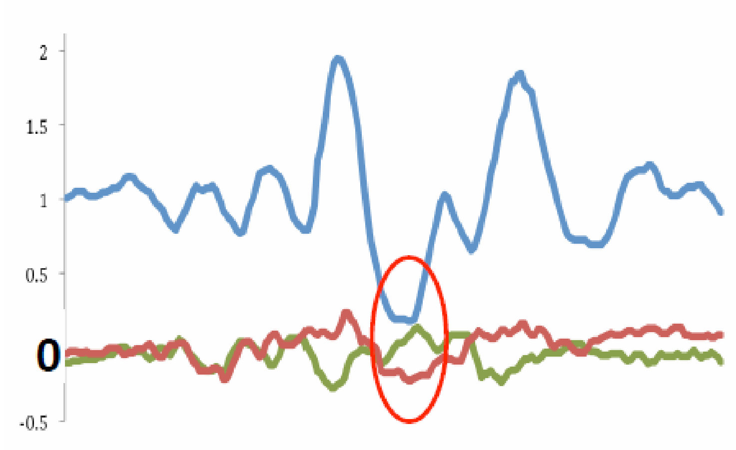


Algorithms II

- **STDEV(Z)**
  - standard deviation of vertical axis acceleration
  - previously used for data post processing
  - the window sizes and specific threshold levels had to be determined



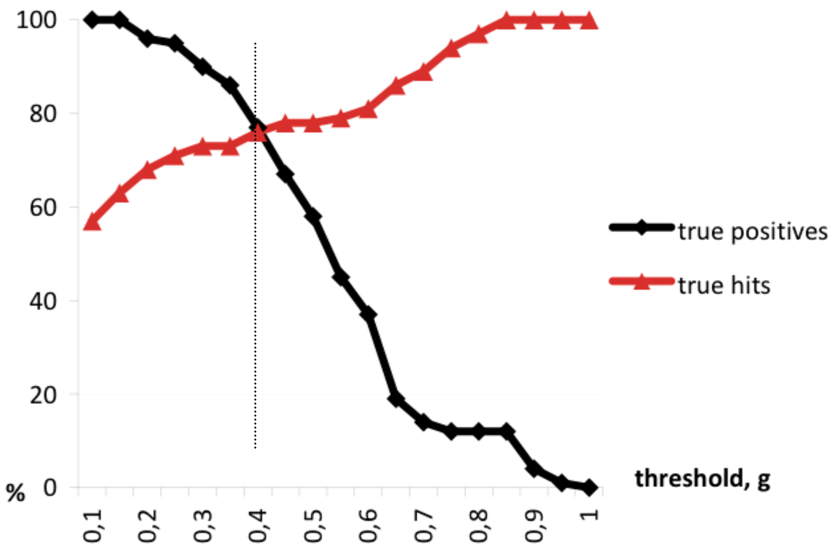
- **G-ZERO**
  - events characterized by specific measurement tuple
  - vehicle in a temporary free fall
  - data could be analyzed without information about exact Z-axis position of the accelerometer

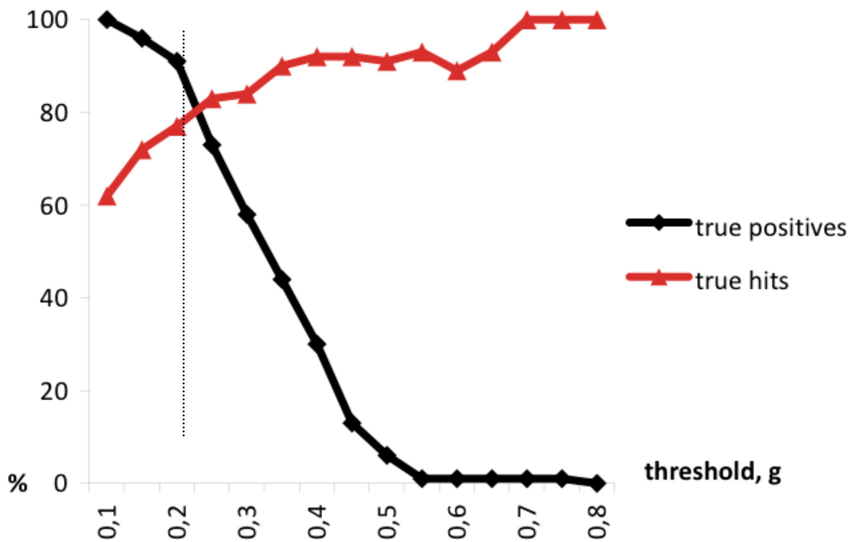


Evaluation I

- **Z-THRESH**
  - optimal value 0.4g
  - 78% true positives
  - 76% true hits
- **Z-DIFF**
  - optimal value 0.2g
  - 92% true positives
  - 77% true hits

Class	Z-THRESH	Z-DIFF
Large potholes	3 (100%)	3 (100%)
Small potholes	15 (83%)	16 (89%)
Pothole clusters	25 (83%)	27 (90%)
Gaps	31 (78%)	36 (90%)
Drain pits	10 (59%)	17 (100%)
Total	**84 (78%)**	**99 (92%)**

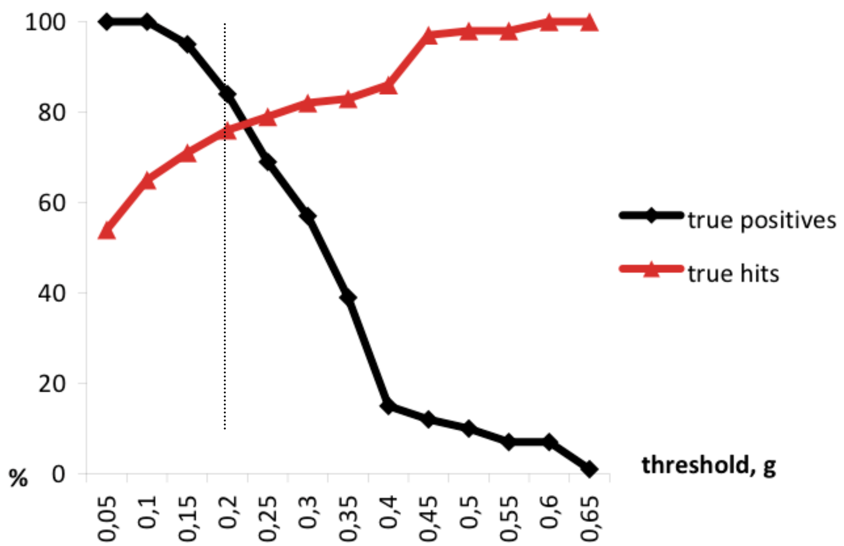


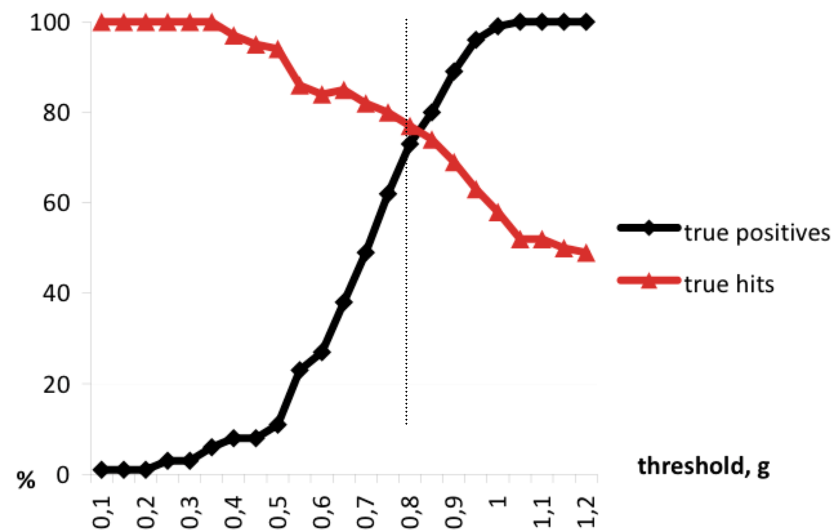


Evaluation II

- **STDEV(Z)**
  - optimal value 0.2g
  - optimal window size 20
  - 81% true positives
  - 76% true hits
- **G-ZERO**
  - optimal value 0.8g
  - 73% true positives
  - 76% true hits

Class	STDEV(Z)	G-ZERO
Large potholes	3 (100%)	3 (100%)
Small potholes	16 (89%)	14 (78%)
Pothole clusters	27 (90%)	27 (90%)
Gaps	30 (75%)	27 (68%)
Drain pits	11 (65%)	8 (47%)
Total	**87 (81%)**	**79 (73%)**





Conclusions

- Different algorithms - different true positive values for several ground truth item classes – it could be useful during combination of algorithms
- Potholes in street junctions with low driving speed escapes from such detection approach
- Accelerometers used in the smartphones are appropriate sensors – 50% of all small potholes were detected during all 10 test drive laps
- Some pictures from our field experiments:

Marking of *ground truth*

Android smartphones

RoadMic equipment

ERAF EIROPAS REGIONĀLĀS ATTĪSTĪBAS FONDS

IEGULDĪJUMS TAVĀ NĀKOTNĒ

EIROPAS SAVIENĪBA

Acknowledgments: this presentation was supported by ERAF funding under agreement No. 2010/0309/2DP/2.1.1.2.0/10/APIA/VIAA/012