LATVIJAS UNIVERSITĀTE
ANNO 1919

Specseminārs

Kiberfizikālās sistēmas, tai skaitā sensori, iegultas iekārtas, to programmēšana un robotika

12.12.2013

Artis Mednis
Leo Seļāvo

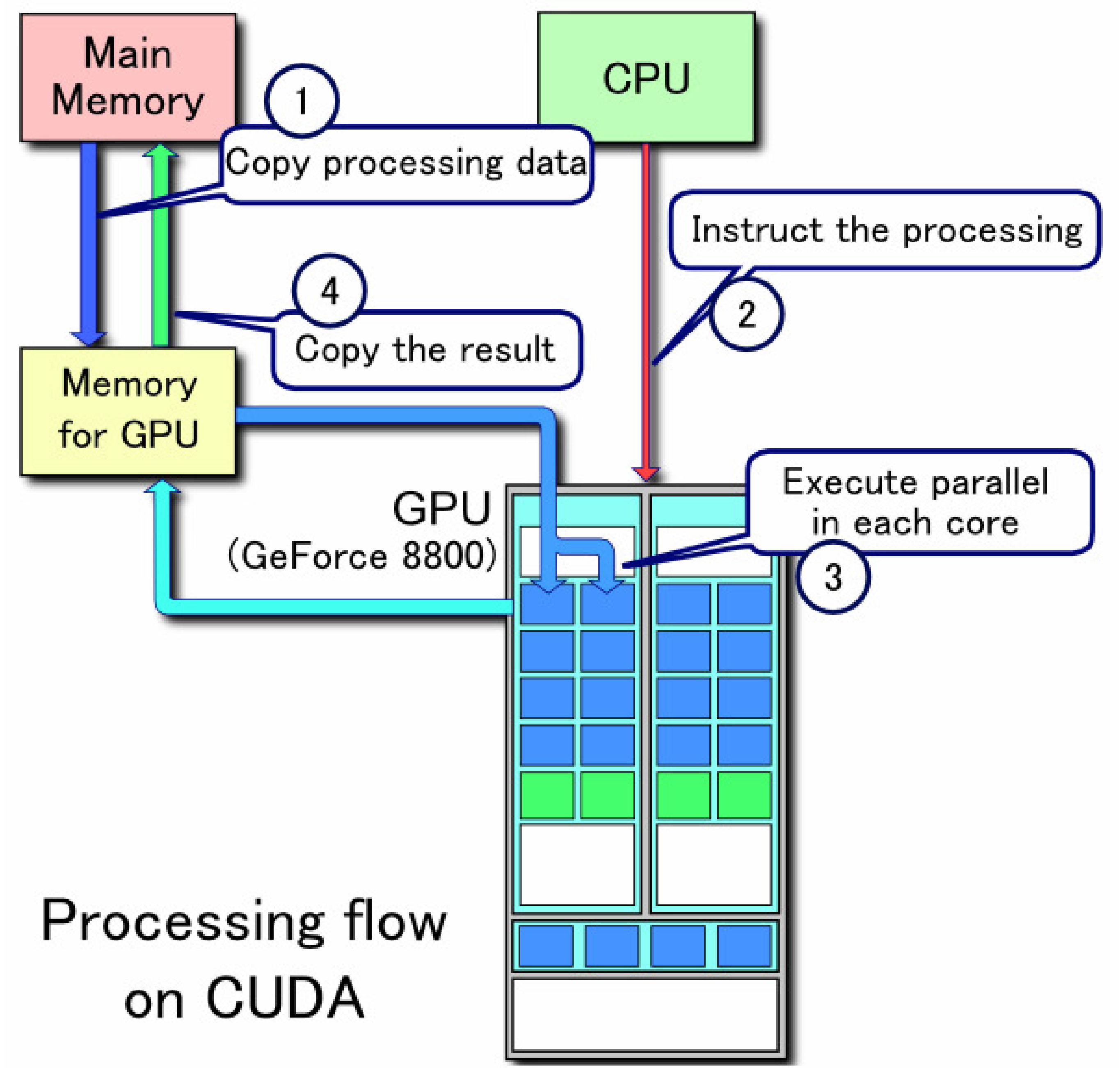
Compute Unified Device Architecture (CUDA)

- Parallel **computing platform** / **programming model** (NVIDIA)

- Implemented by the **graphics processing units** (GPU)

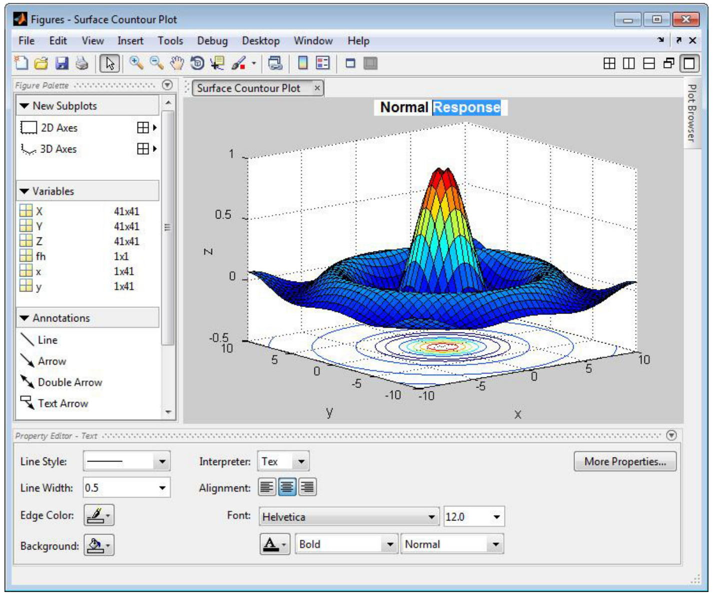
- Access ways
  - CUDA-accelerated **libraries**
  - compiler **directives**
  - **extensions** to industry-standard programming languages

http://www.youtube.com/watch?v=IzU4AVcMFys


Main Memory
CPU
1
Copy processing data
Instruct the processing
2
4
Copy the result
Memory for GPU
GPU
(GeForce 8800)
Execute parallel in each core
3
Processing flow on CUDA

MATLAB (**mat**rix **lab**oratory)

- Numerical **computing environment** / fourth-generation **programming language**
  - matrix **manipulations**
  - **plotting** of functions and data
  - implementation of **algorithms**
  - creation of **user interfaces**
  - **interfacing** with programs written in other languages

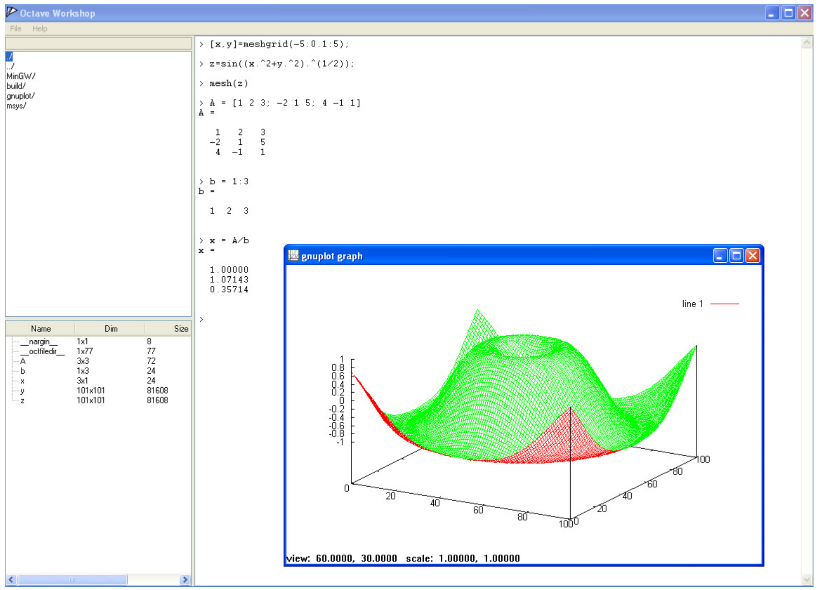


http://www.youtube.com/watch?v=hdvLbBDfgK4

MATLAB – izmantošanas piemērs

GNU Octave

- High-level **programming language**
- Intended for **numerical computations**
- Mostly **compatible** with MATLAB
- **Free** under the terms of the GNU General Public License



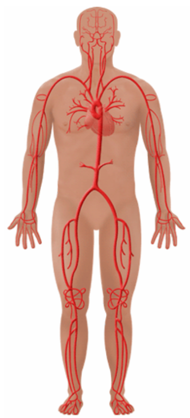
http://www.youtube.com/watch?v=d1If8XOL73c

Real Time Pothole Detection using Android Smartphones with Accelerometers

Artis Mednis[1,2], Girts Strazdins[1,2], Reinholds Zviedris[1,2], Georgijs Kanonirs[1], and Leo Selavo[1,2]
[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

Research domain

- Road infrastructure as blood vessels



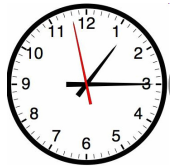
- Participatory sensing for data collection
- Manual *vs.* automatic reporting
- General purpose *vs.* customized embedded devices

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

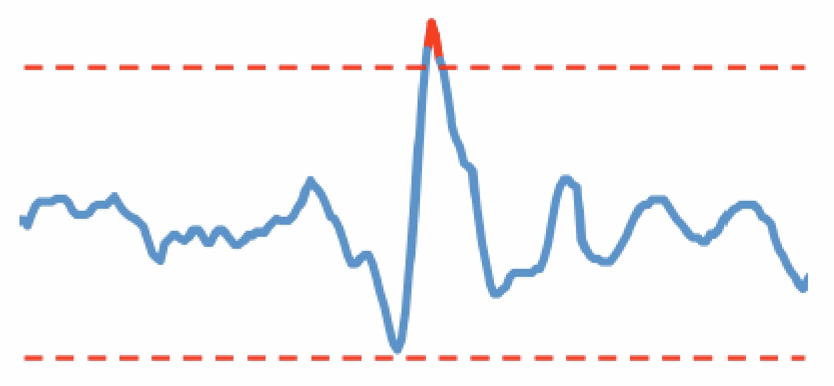
- Marking of *ground truth* using *Walking GPS* approach
- Test drive session (10 laps) with 4 different smartphones
- Processing of collected data using selected algorithms
- Statistical analysis in context of marked *ground truth* and previous developed RoadMic methodology
- Used terminology
  - true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

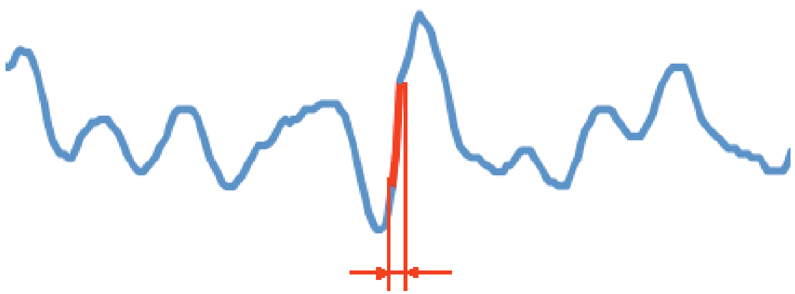
Class	24.03.2011	19.03.2010
Large potholes	3	3
Small potholes	18	18
Pothole clusters	30	30
Gaps	40	25
Drain pits	17	29
Total	**108**	**105**

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

Algorithms I

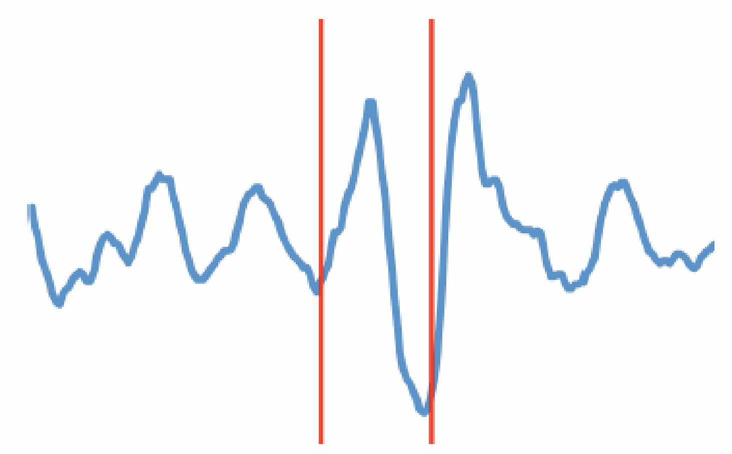
- **Z-THRESH**
  - thresholding the acceleration amplitude at Z-axis
  - events represented by values exceeding specific thresholds
  - information about Z-axis position of accelerometer is known
- **Z-DIFF**
  - fast changes in vertical acceleration data
  - events represented by two consecutive measurements with difference between the values above specific threshold level

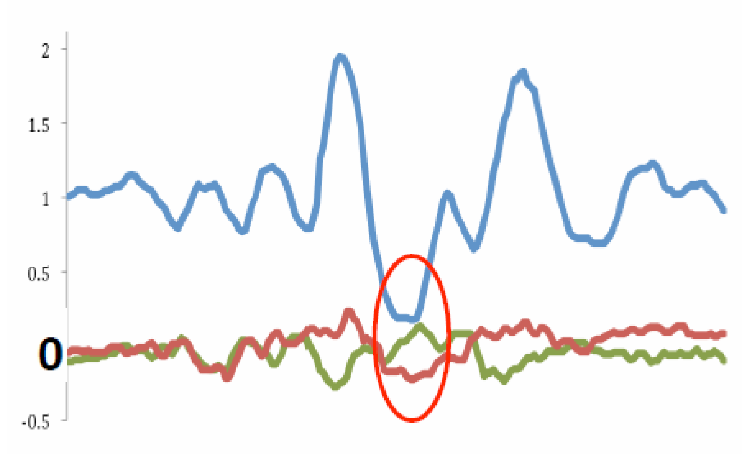




Algorithms II

- **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

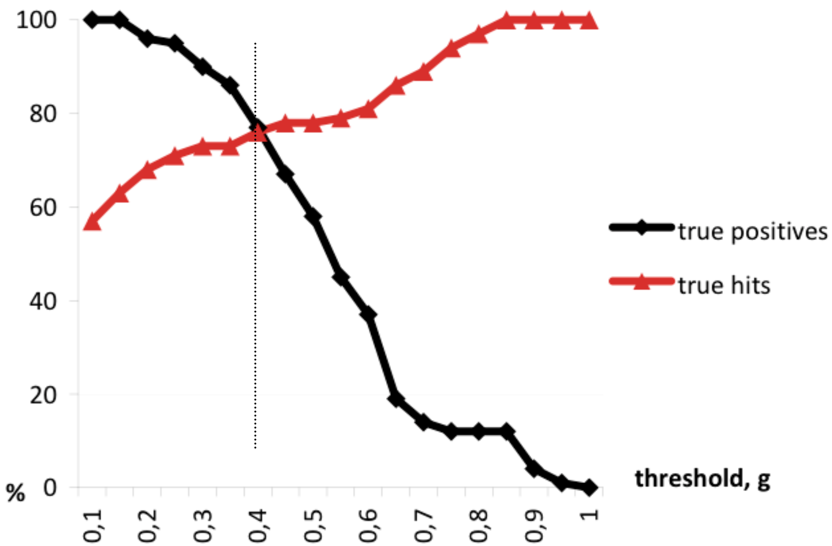


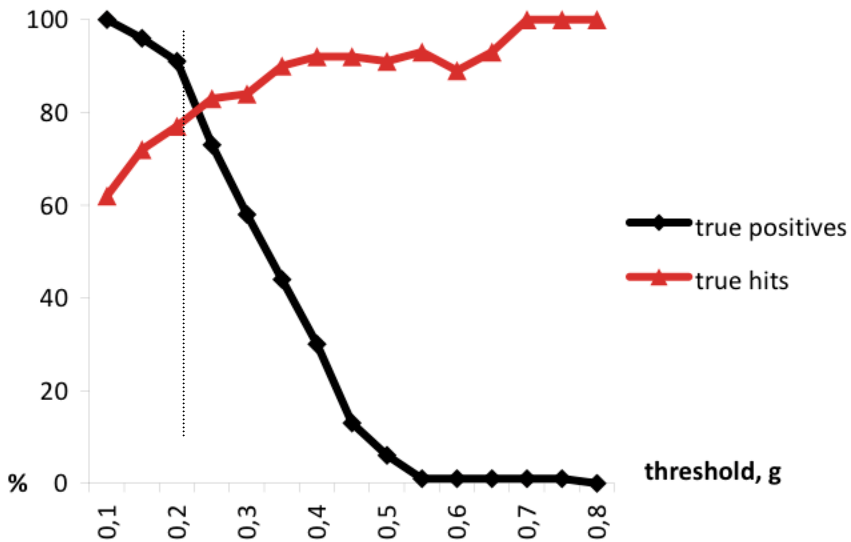


Evaluation I

- **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%)**

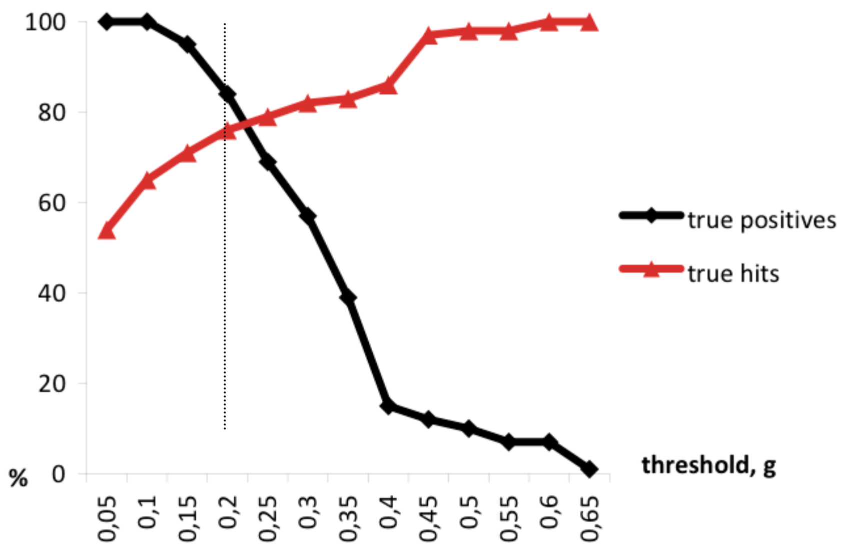


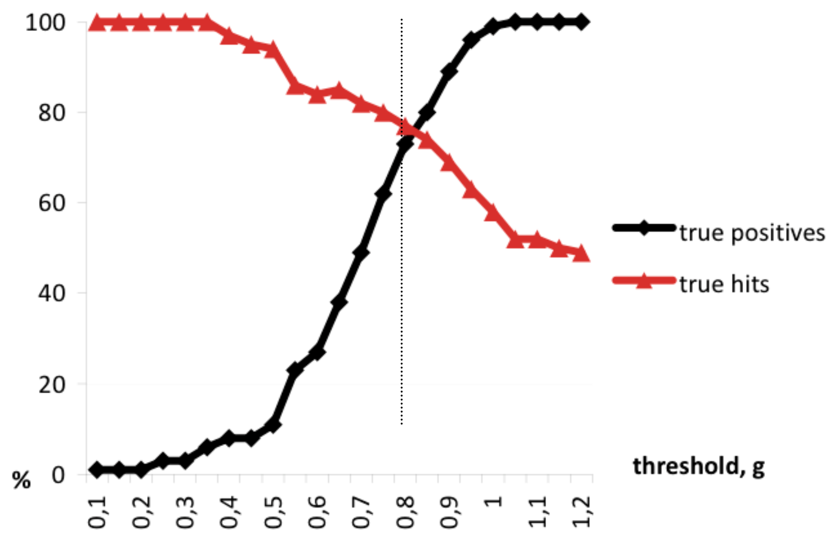


Evaluation II

- **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

Piezīmes uz tāfeles