technische universität dortmund

isas Leibniz-Institut für Analytische Wissenschaften – ISAS – e.V.

SFB 876 Providing Information by Resource-Constrained Data Analysis

Project B2

Resource-aware real-time analysis of artefact afflicted image sequences for the detection of nano-objects

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Problem

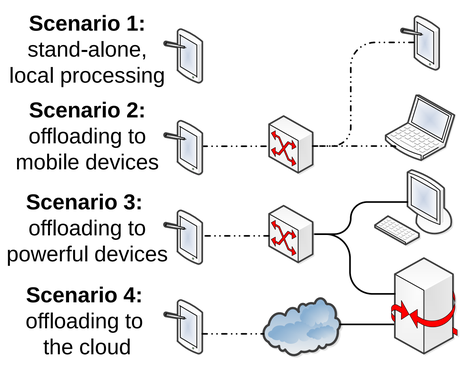
Long-term goals:

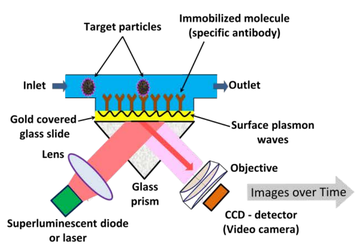
- Analysing data-intensive, noisy and artefact afflicted image sequences from sensor systems
- (Soft) real-time detection of specific nano-objects
- Multi-objective optimisation regarding varying demands (detection quality, energy and time efficiency)

Challenges phase 2

- (Soft) real-time processing under different scenarios
- Resource constraint distributed sensing and analysis
- Cooperative analysis with distributed sensor units
- Mobile sensor unit with wireless communication
- Simultaneous detection of different nano-objects
- Estimation of particle size distributions

Distributed processing and analysis of PAMONO sensor data





Sensor setup

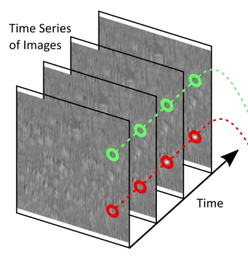
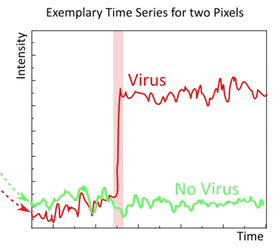


Image sequence



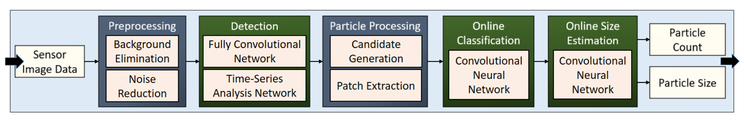
Real-time data processing

Methodology

Functional performance enhancement of image and data analysis methods

Globally controlled image analysis & optimisation

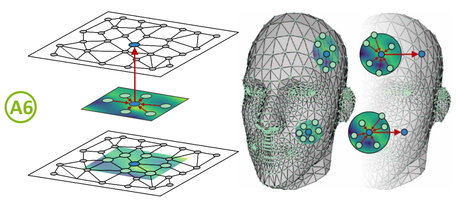
- Parameterisable GPU algorithms for the detection of nano-object signals in images
- SynOpSis: synthesis, optimisation and analysis
- Efficient CNNs for particle detection, classification and estimation of size distributions



B2 (7 project members): [Lenssen etal. 2018]

Context-sensitive algorithms

- SOG-PSE and SOG-DSE: single-objective GPGPU parameter and design space exploration
- Parametrisable data-flow graphs for resource-aware OpenCL deep neural network inference
- SplineCNN: generalisation of the convolution operator of CNNs (A6)

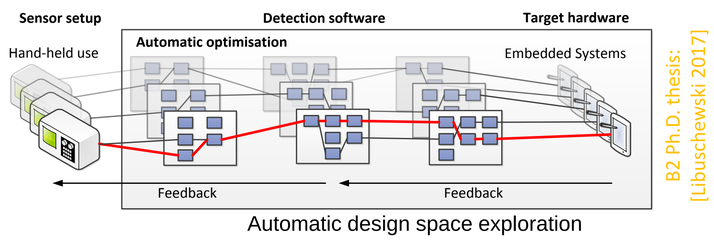


B2(3)/A6(1) cooperation: [Fey etal. CVPR 2018]

Paradigm development on algorithms and execution level

Resource optimisation on program & platform level

- MOGEA-DSE: combined, hybrid parameter, and design space exploration
- Multi-objective, energy-aware, measurement-based or simulation-based exploration of CPS

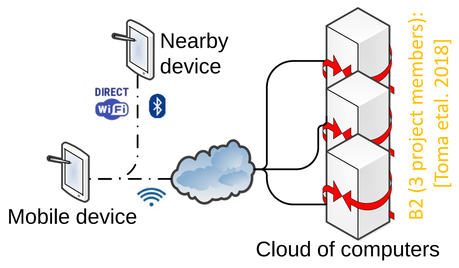


B2 Ph.D. thesis: [Libuschewski 2017]

Automatic design space exploration

Collaborative computing

- Techniques for analysing schedulability
- General-purpose middleware for offloading
- Partitioning algorithms for suspending tasks

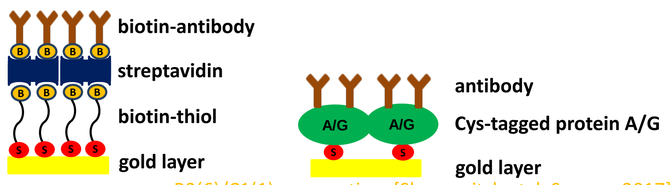


B2 (3 project members): [Toma etal. 2018]

Generalisation and miniaturisation of the PAMONO sensor

Generalised nano-object detection

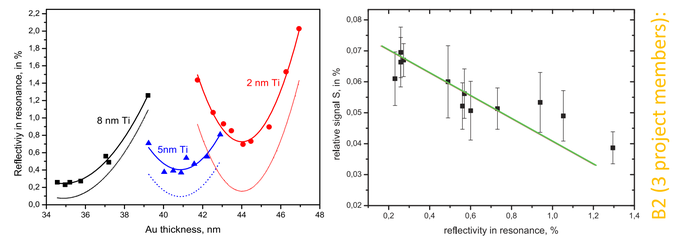
- Concepts to identify different types of particles on one sensor chip
- Extended sensor surface functionalisation via application of different SAMs (C1)



B2(6)/C1(1) cooperation: [Shpacovitch etal. Sensors 2017]

Increasing the technical efficiency

- Miniaturised and mobile prototype
- Experimental and theoretical work concerning optimal imaging conditions



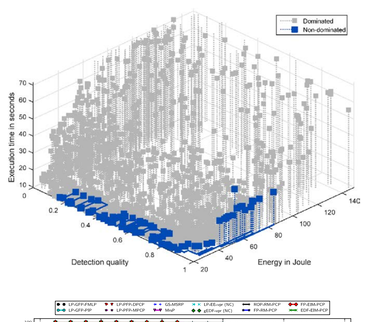
B2 (3 project members): [Zybin etal. 2017]

Results

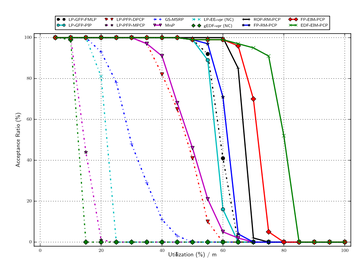
Resource-aware algorithms and concepts

Resource-aware optimisation

- MOGEA-DSE: speedup of 4.1 and 84 % energy saved on mobile embedded system hardware
  B2 (4 project members): [Neugebauer etal. 2015]
- Comparison with model-based optimisation (A3)
- Approximate computing in embedded systems (A3)
  B2(1)/A3(1) cooperation: [Neugebauer etal. 2017]
- Fusion of multi-objective optimisation and LTE context-aware power consumption model (A4)
  B2 Ph.D. thesis: [Libuschewski 2017]
- Resource sharing in multi-core systems
  B2 (2 project members): [Huang etal. 2017]
- Analysis of offloading using auxiliary resources
  B2 (3 project members): [Toma etal. 2018]



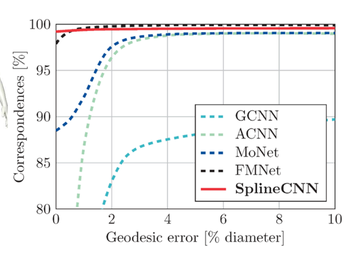
B2 (4 project members): [Neugebauer etal.2015]



B2 (3 project members): [Brüggen etal. 2017]

CNN generalisation

- SplineCNNs: state-of-the-art performance on irregularly structured and geometric data (A6)
  B2(3)/A6(1) cooperation: [Fey etal. CVPR 2018]
- DeepRacin: OpenCL CNN inference
  https://github.com/mrjel/deepracin/

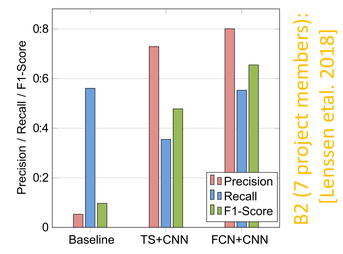


B2(3)/A6(1) cooperation: [Fey, Lenssen, etal. CVPR 2018]

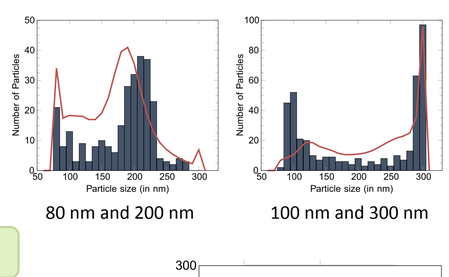
PAMONO sensor results

Data processing

- Automated data synthesis, optimisation, and analysis
  B2 Ph.D. thesis: [Siedhoff 2016]
- Real-time deep neural network pipeline can handle approx. 42 % lower SNR
  B2 (7 project members): [Lenssen etal. 2018]
- Enabled estimation of particle size distributions for given suspensions
  B2 (4 project members): [Lenssen etal. 2017]
- Enabled analysis of biological and non-biological objects of different types
  B2 (2 project members): [Shpacovitch etal. 2015]



B2 (7 project members): [Lenssen etal. 2018]

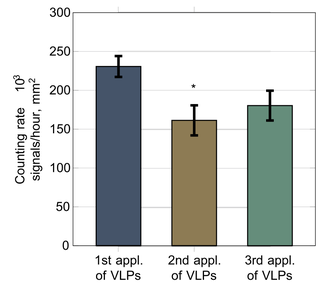


80 nm and 200 nm | 100 nm and 300 nm

B2 (6 project members): [Lenssen etal. 2017]

PAMONO sensor

- Obtained a reusable sensor surface by using the Cys-Protein A/G (C1)
  B2(6)/C1(1) cooperation: [Shpacovitch etal. Sensors 2017]
- Detection of virus-like particles and microvesicles/extracellular vesicles (C1)
  B2 (2 project members): [Shpacovitch etal. 2018]
- Detection of nano-objects in gas media



B2(6)/C1(1) cooperation: [Shpacovitch etal. Sensors 2017]

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