Project B2
Resource-aware real-time analysis of artefact afflicted image sequences for the detection of nano-objects

Prof. Dr. Jian-Jia Chen, Dr. Roland Hergenröder, Prof. Dr. Heinrich Müller

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

Problem

Methodology

Resource-aware algorithms and concepts

MOGEA-DSE: speedup of 4.1 and 84 % energy saved on mobile embedded system hardware
Comparison with model-based optimisation
Approximate computing in embedded systems
Fusion of multi-objective optimisation and LTE context-aware power consumption model
Resource sharing in multi-core systems
Analysis of offloading using auxiliary resources

PAMONO sensor results

Data processing
Automated data synthesis, optimisation, and analysis
Real-time deep neural network pipeline can handle approx. 42 % lower SNR
Enabled estimation of particle size distributions for given suspensions
Enabled analysis of biological and non-biological objects of different types

Biological objects of different types

Biological objects of different types

Bio-nano objects of different types

Molecular objects of different types

Molecular objects of different types

Detection of viral-like particles and microvesicles/extracellular vesicles
Detection of nano-objects in gas media

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

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

Collaborative computing

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

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

Increasing the technical efficiency
Miniaturised and mobile prototype
Experimental and theoretical work concerning optimal imaging conditions

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

Paradigm development on algorithms and execution level

Sensor setup Image sequence Real-time data processing

Paradigm development

Biological objects of different types

Biological objects of different types

Molecular objects of different types

Molecular objects of different types

Detection of nano-objects in gas media

Biological objects of different types

Biological objects of different types

Molecular objects of different types

Molecular objects of different types

Detection of viral-like particles and microvesicles/extracellular vesicles
Detection of nano-objects in gas media

Biological objects of different types

Biological objects of different types

Molecular objects of different types

Molecular objects of different types

Detection of nano-objects in gas media

Biological objects of different types

Biological objects of different types

Molecular objects of different types

Molecular objects of different types

Detection of viral-like particles and microvesicles/extracellular vesicles
Detection of nano-objects in gas media

Biological objects of different types

Biological objects of different types

Molecular objects of different types

Molecular objects of different types

Detection of nano-objects in gas media