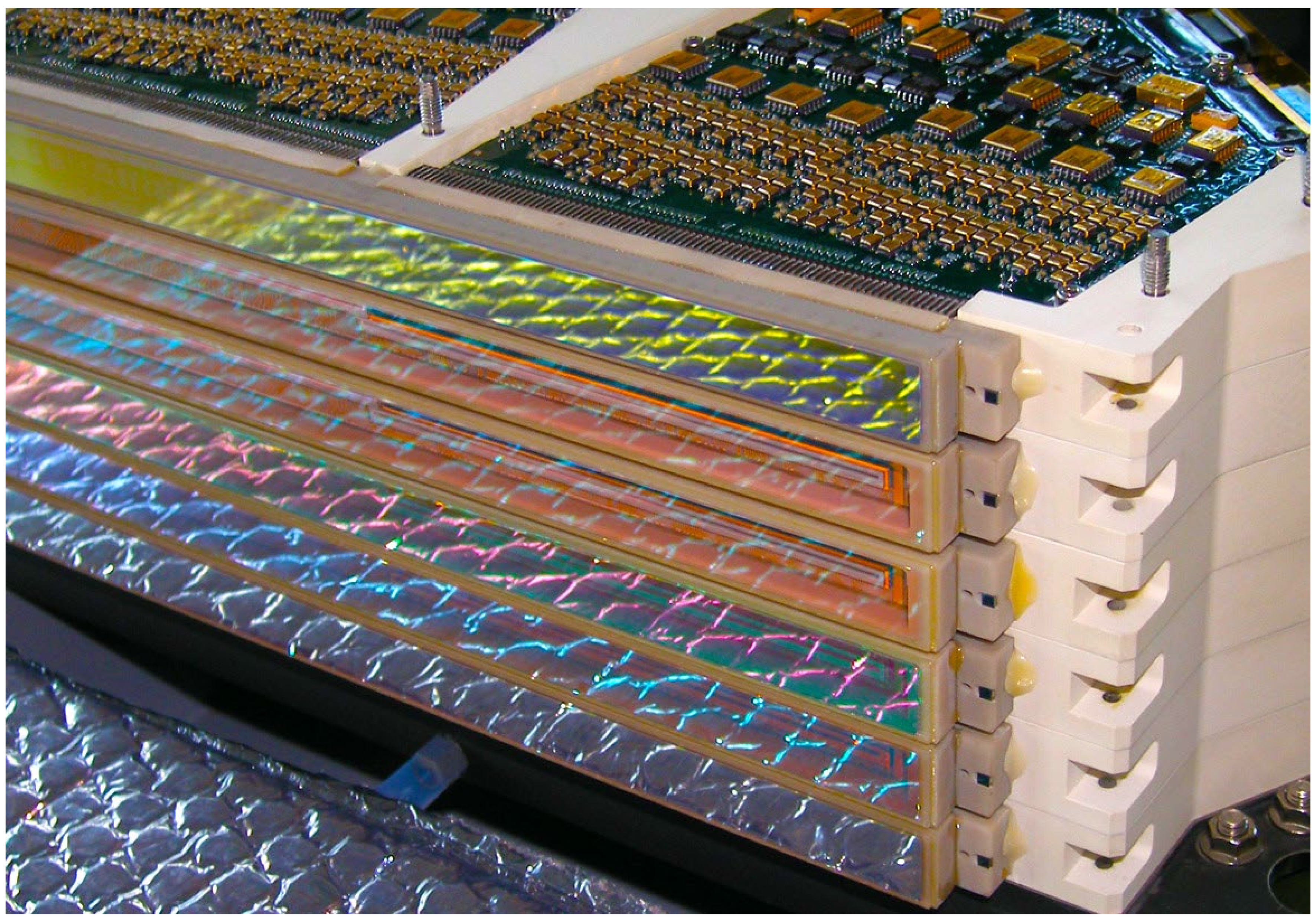
QCOptSens
Quantum Computation for Optical Sensor Design

We aim to improve optical instruments in aerospace by globally optimizing diffractive structures under manufacturing constraints and transforming thematic information extraction AI-supported to quantum machine learning algorithms

- Identification of DRL-OS-specific use cases for quantum computing and know-how/tools/pipeline
- Instrument design: Diffractive structures and corresponding inverse problems
- Software design: Code transformation and methods for hybridization



DLR OS Core Competencies

- Electronics for focal planes & camera systems
- Data processing and information extraction
- Development of instruments for space
- IR, THz, LIBS and Raman spectroscopy
- Applications for security

Motivation and Challenges

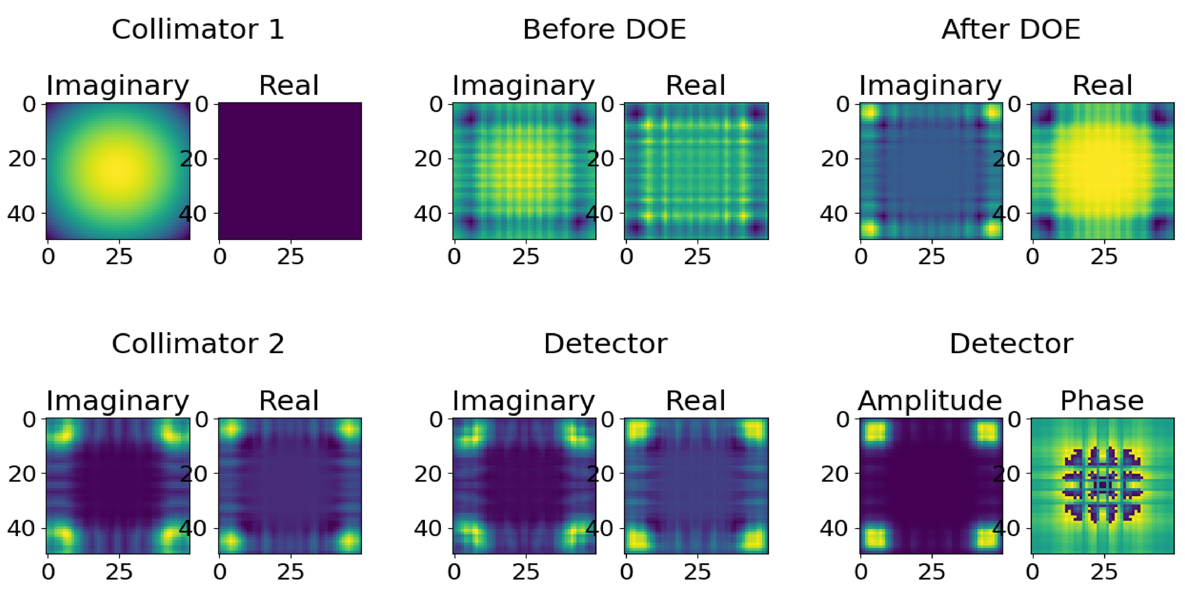
DLR-OS develops highly complex multi- and hyper-spectral camera systems and spectrometers for space, aviation, security and transportation

- Challenging environments: Temperature, vacuum, radiation exposure, mass and energy consumption, data processing...
- Optimal design currently not possible, too many parameters (geom., electrical, thermal, mechanical and optical), depending on temperature, pressure, radiation...
- Information extraction from sensor data (thematic and with reliable uncertainty estimation)
- Sensor-related AI, inverse problems and computational sensing & imaging

Instrument-Design

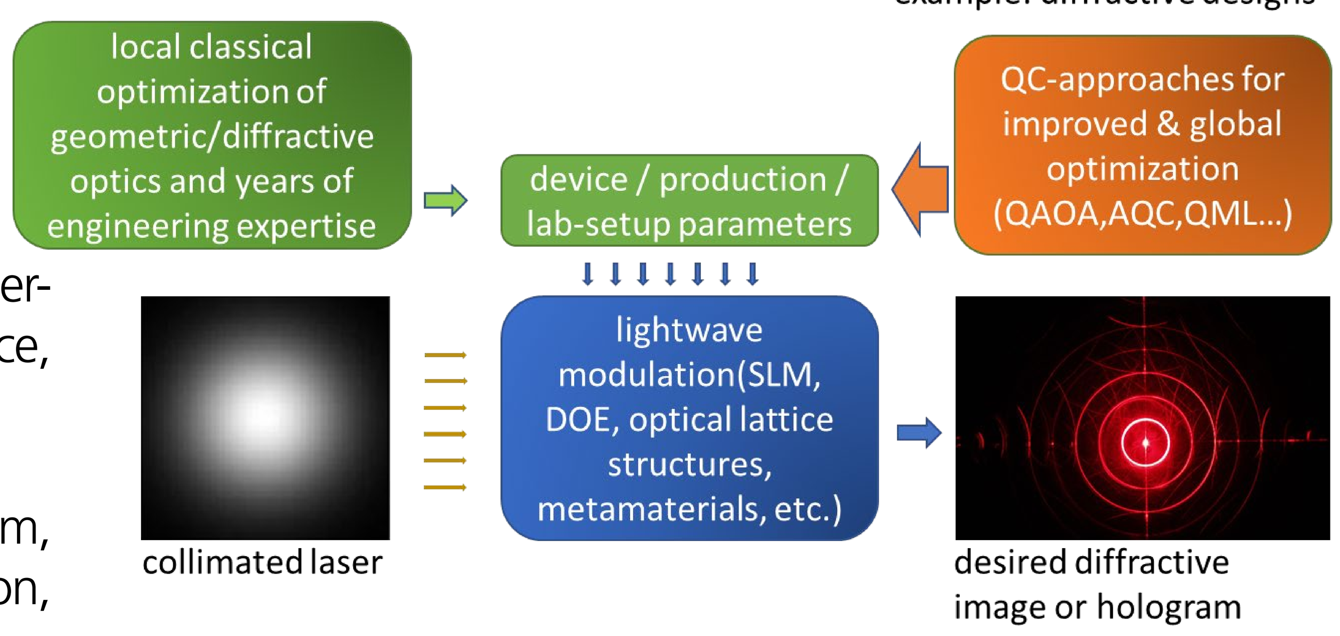
In this project, we are investigating hybrid quantum computing approaches to improve the next generation of optical instruments for aerospace applications.

For example, the calibration of high-resolution hyperspectral camera systems is performed with components such as diffractive optical elements (DOEs), which are designed to generate diffraction patterns according to strict targets. The forward model includes geometric and diffractive optical calculations at different frequencies, as well as structural and thermal properties.



Instead, efficient DOE design under manufacturing conditions leads to hard optimization and inverse problems associated with constrained phase retrieval & phase coding.

example: diffractive designs



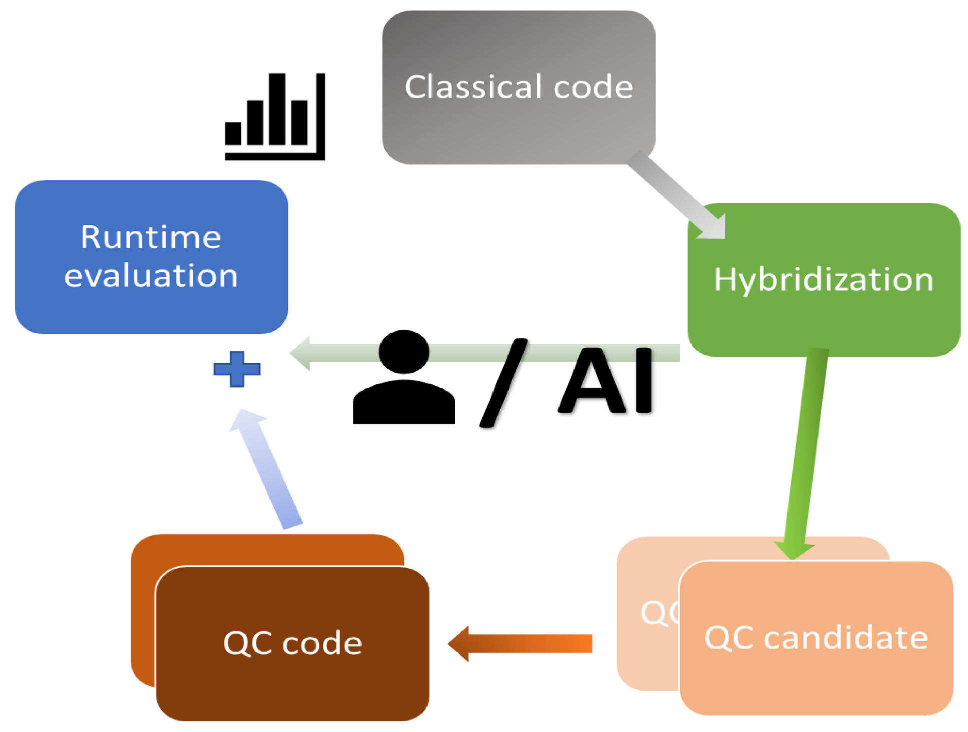
Our goal is to solve such problems by using hybrid algorithms to design diffractive structures that have a defined diffraction behavior and generate pre-defined holograms, perform targeted optical manipulations and that can be efficiently fabricated.

Optimized diffraction patterns are highly relevant for the geometric calibration of the next high-resolution and hyperspectral camera systems, e.g. the successors of DESIS, EnMAP or KompSat:

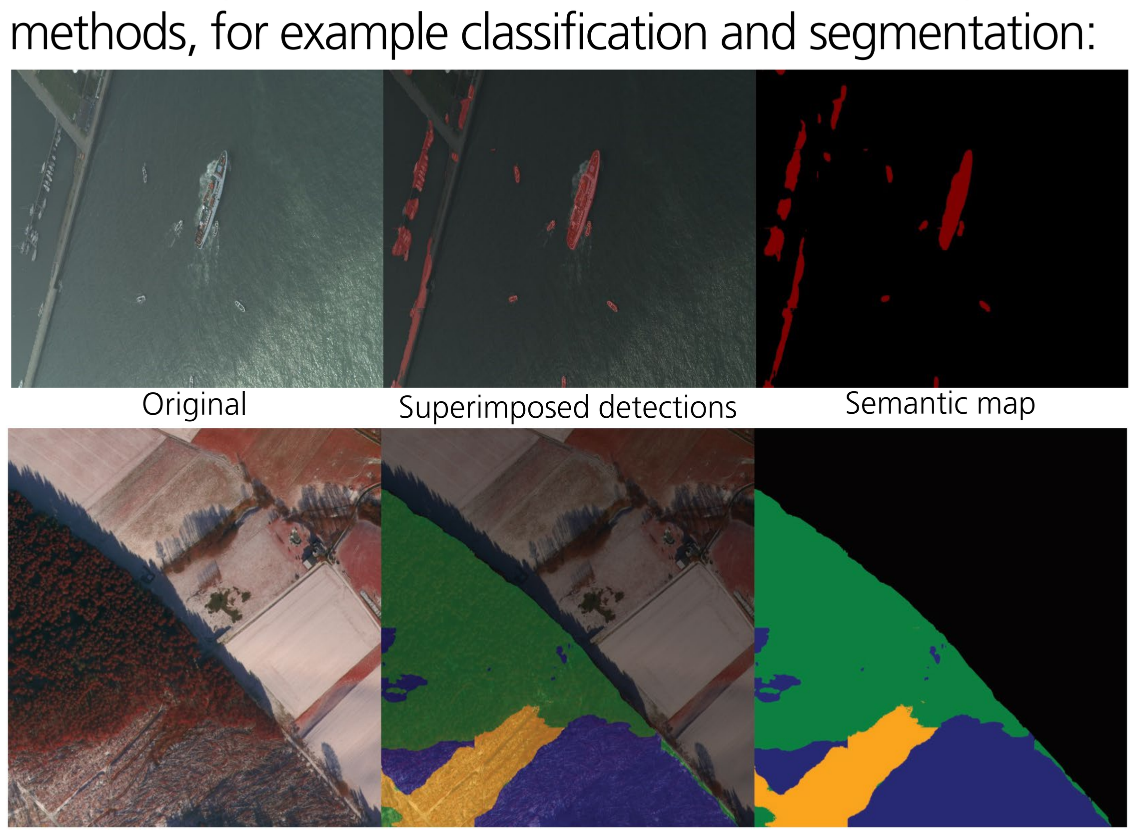
Software-Design

In this part of the project we investigate approaches to transform existing classical algorithms and information extraction methods used at DLR-OS. We aim at novel methods that are partially automated and (i) work directly on the source code, (ii) use AI-based methods with a human in the loop, and (iii) include runtime behavior.

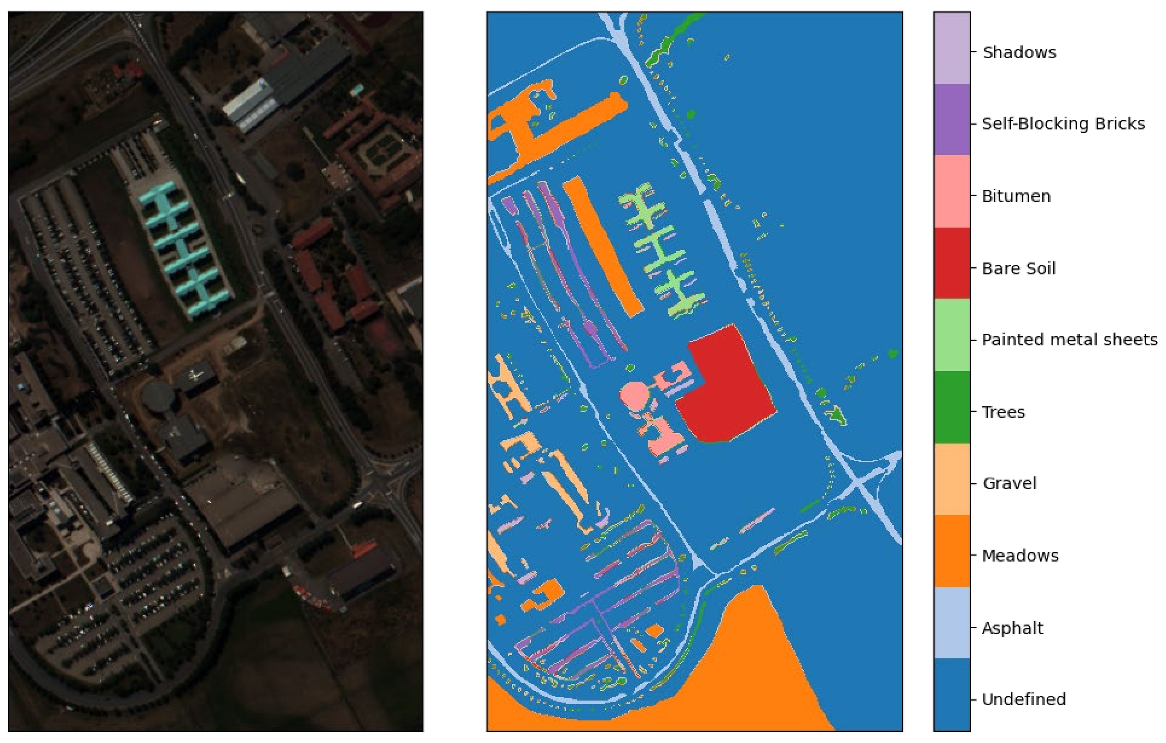
Such methods perform decomposition and quantum computing hybridization of relevant software components („cross compilation")



Cross-compilation will be tested on DLR-OS-specific AI methods, for example classification and segmentation:



The results will be compared to handwritten QC-code:



Pavia dataset / 3 Qubits / QSVM
mit ZZ-feature-map / 76%

A project of

DLR Institute of Optical Sensor Systems

Contractors

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Get in touch.
We enable quantum!

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