



Lightweight Neural Networks in the field:
Smart Cameras learn to monitor product quality



Contents



- Who we are
- QualiReader
- Optical Inspection
- VAX Camera
- Deep Learning Integration
- Lightweight CNNs
- Video



Experts for **Print-Inspection & Quality Control** (product/process)



25
R&D Engineers



3000+
Production lines



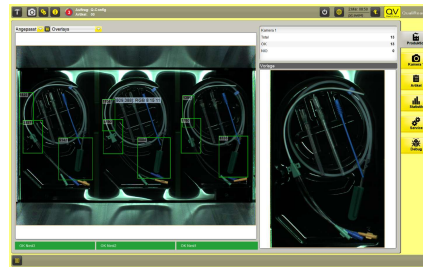
100+
Customers



25 yrs
Your Partner



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SW-Plattform

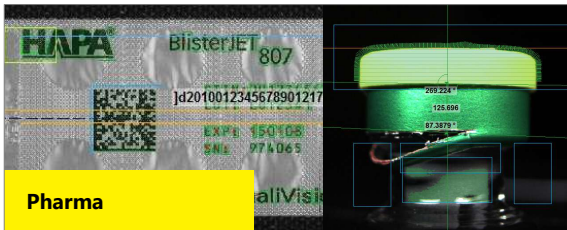


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Proven technology in different industry segments



Pharma



MedTech



Food



Retail/Packaging

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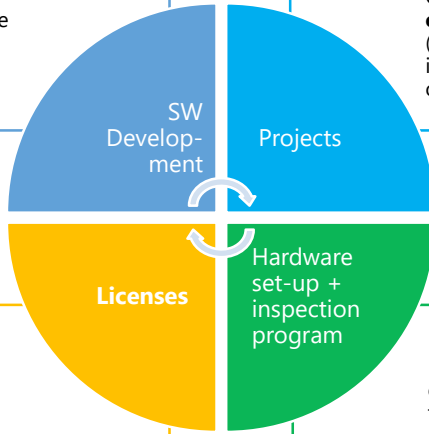
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What we do

Our **SW engineers develop the QualiReader** (our versatile inspection and control platform) and its customizations (if needed)

Our **project engineers work on customer projects** (consulting, optical set-up, inspection program, control of printer and camera,...)



Our **QualiReader** comes in 2 flavors (print or quality inspection) and has many configurable modules

If wished we deliver the complete **vision module**, the **inspection programs** and **engineering services**

➤ We deliver **validated software for Pharma + Medtech** (change control, access right management, CFR 21 Part 11,...)

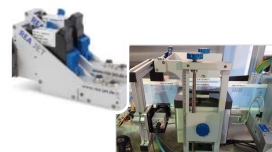
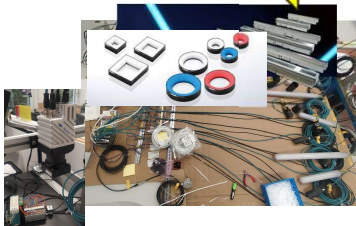
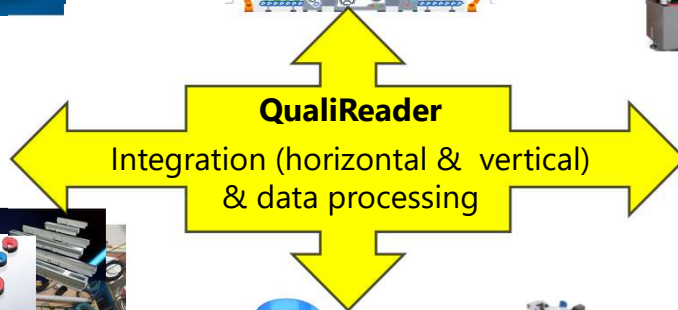
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Machine Vision and Data Processing Software



Footer

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Solutions along the complete production line

Production Planning: ERP · MES
Data Archiving, Control System

xxx QualiReader functionality

Line Management · Article and order management · Logging process data · Statistical process control

Product quality control

Monitoring of Packaging · Print & Check · Serialization

Labeling and imprint control · Aggregation

Product manufacturing

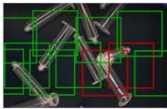
- Product Inspection
- Sorting · Separation
- Mould Inspection
- Blister Inspection

Pre-Packaging · Blister

- Inspection pre-packaging
- Packaging Material Insp.
- Preprint Inspection
- Mix up control

Single Pack · Folding box · Pallet

- Imprint Inspection
- Packaging Inspection
- Control printer
- Manual Processing
- Layout Print Template



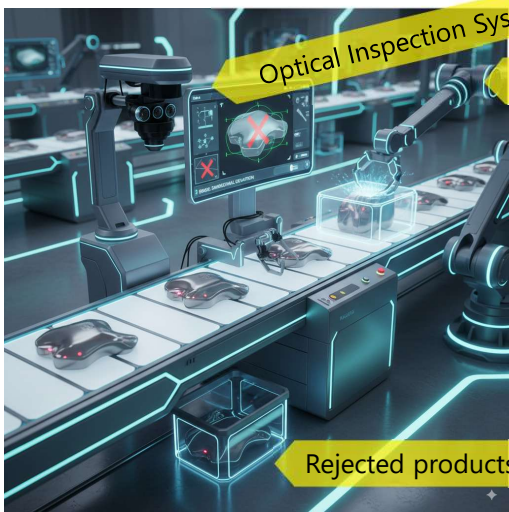
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A typical inspection task setting



- Production line runs at specific speed
- Time for optical quality check is limited
- There are a variety of errors that may occur
- The optical inspection system must trigger a rejection mechanism in time

gemini-2.5-flash-image-preview

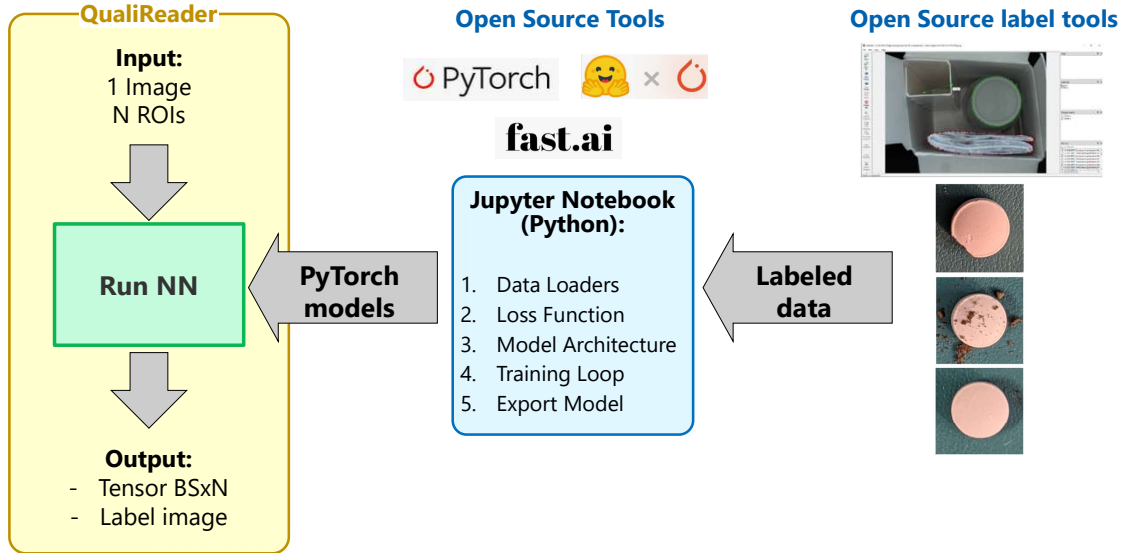
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Use conventional FOSS tools



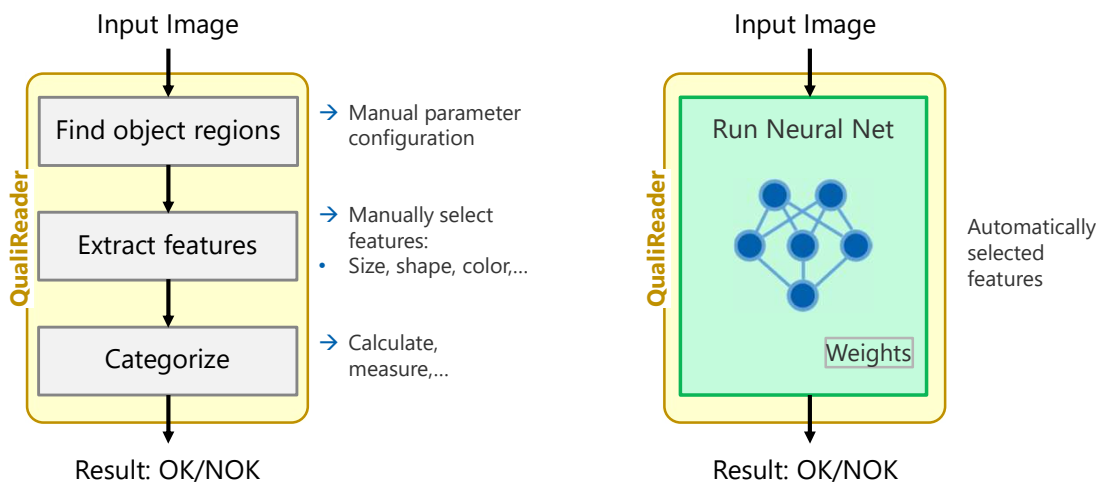
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Classical image processing vs Deep Learning



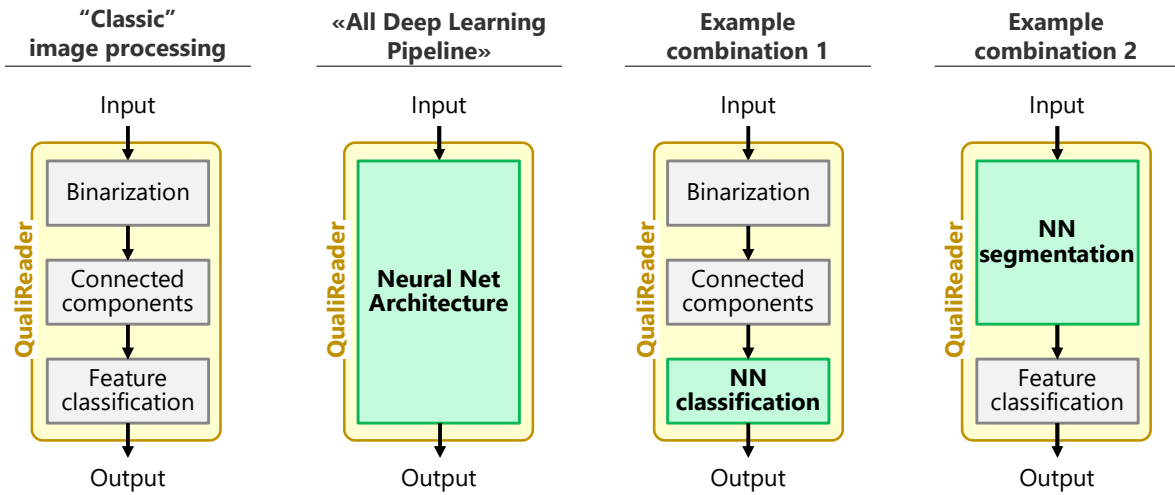
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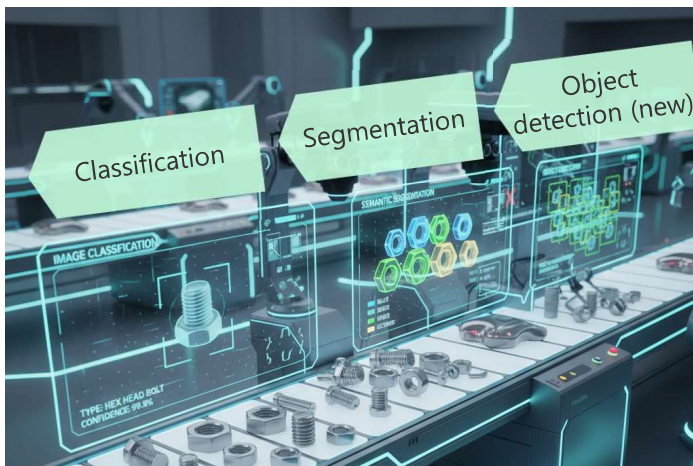
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Classical methods in combination with Deep Learning



Supported (main) modes



Other modes possible!

Example segmentation



Example classification





AX Smart Camera from Baumer

High-quality industrial camera
with standard C-mount

Powerful with
NVIDIA® Jetson™ modules

Industrial housing
with IP 67 option

Hardware trigger
and lighting controller



Flexible connected
Ethernet, RS232, USB,
HDMI, SD card

Baumer Software
SDKs and NVIDIA®
Linux® / Jetpack™

Can run QualiReader
including running Neural Nets

➤ AX Smart Camera enables AI experts to easily implement projects for industrial environments

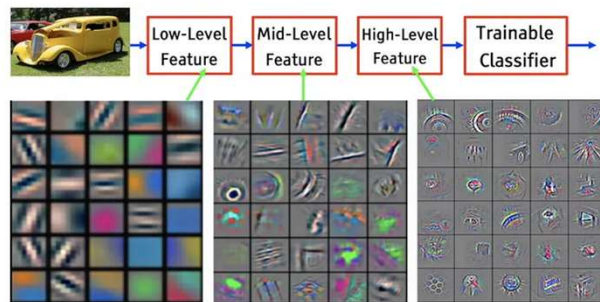
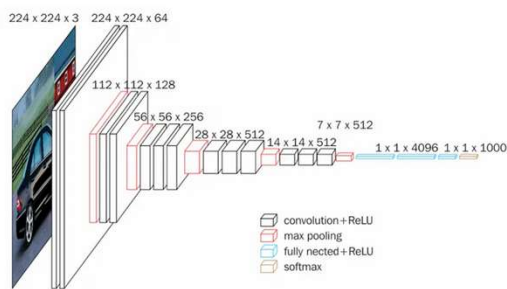
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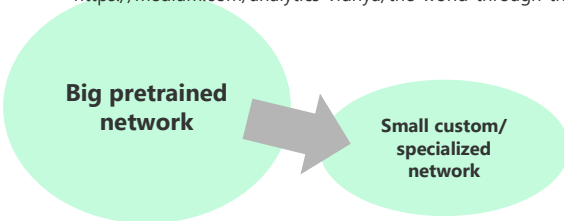
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A typical convolution architecture & reduction methods



<https://medium.com/analytics-vidhya/the-world-through-the-eyes-of-cnn-5a52c034dbeb>



<https://huggingface.co/timm>



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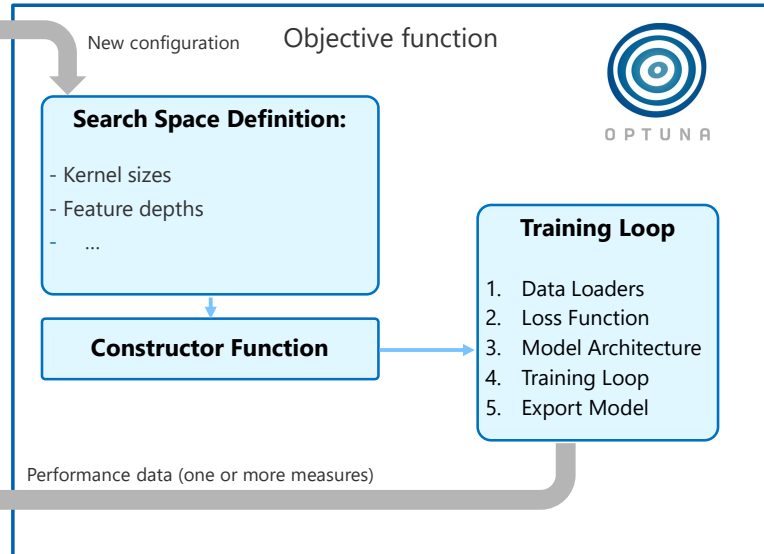
We seek small and fast architectures!

- Small «base» architecture
- Distillation/Quantization reduction
- Neural Architecture Search

Neural Architecture Search to find Lightweight CNNs

«Black Box» Optimization (e. g. Optuna):

- Objective function includes search space (very simple «pythonic» setup of objective function)
- Samplers choose clever configuration proposals
 - Simple: Random sampler
 - «Intelligent»: e.g. TPESampler, CMASampler, Autosampler
- Pruners may early reject hopeless configuration
- Tools: Web dashboard (statistics, feature importance, ...), DBs for experiments, ...



Neural Architecture Search to find Lightweight CNNs (Example): Classification Cigarillos

2000 NOK examples



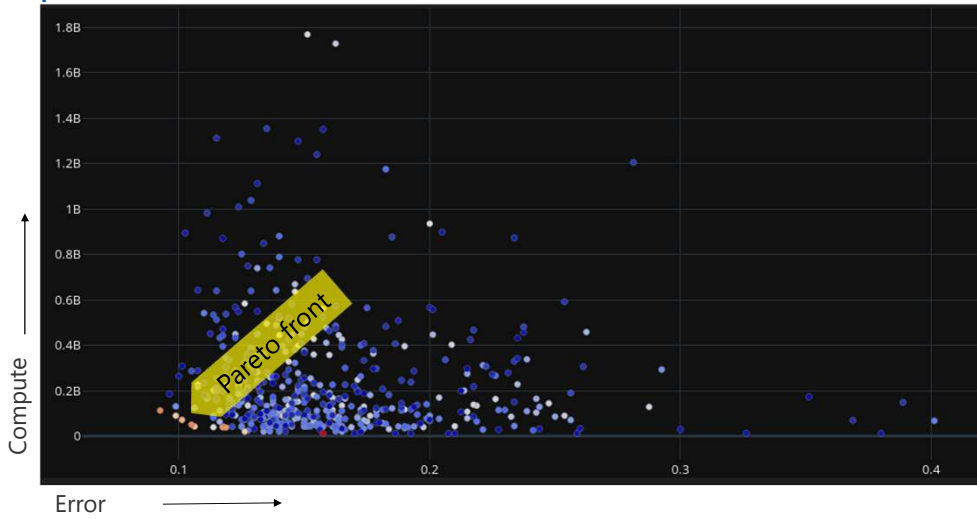
6000 OK examples



- Dramatically varying defects are difficult to describe with classical methods



Neural Architecture Search to find Lightweight CNNs (Example)



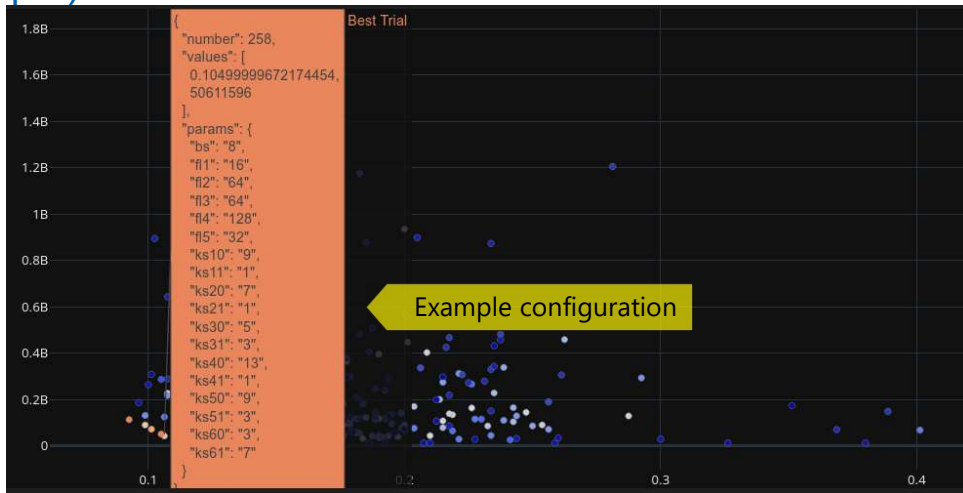
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Neural Architecture Search to find Lightweight CNNs (Example)



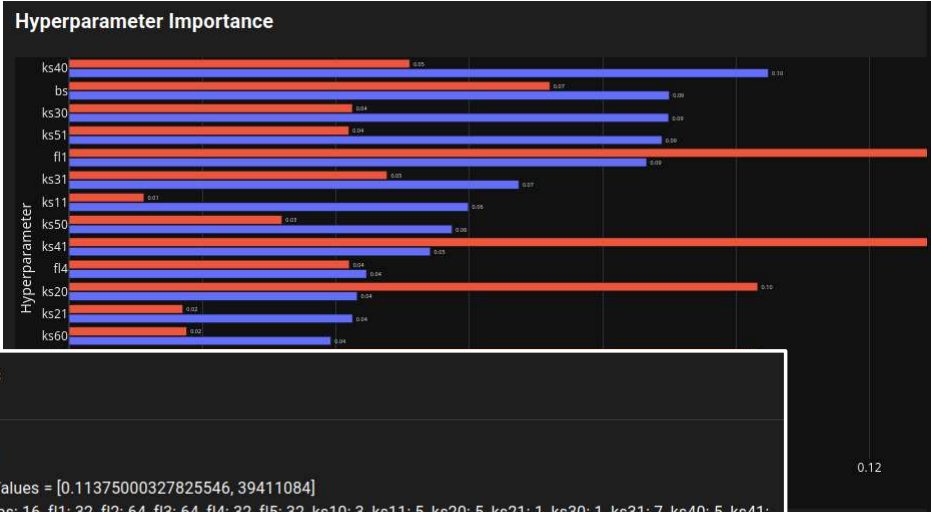
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Neural Architecture Search to find Lightweight CNNs (Example)



Best Trials

Trial 50
 Objective Values = [0.11375000327825546, 39411084]
 Params = [bs: 16, f11: 32, f12: 64, f13: 64, f14: 32, f15: 32, ks10: 3, ks11: 5, ks20: 5, ks21: 1, ks30: 1, ks31: 7, ks40: 5, ks41: 3, ks50: 9, ks51: 1, ks60: 3, ks61: 7]



Video Example Application



Summary



- We build and integrate optical quality inspection systems
- QualiReader in conjunction with a Smart Camera can run Neural Networks (with or without classical vision algorithms)
- Lightweight / specialized Neural Networks are needed in optical inspection systems in production
- Lightweight Neural Networks can be found by Neural Architecture Search

Questions?

