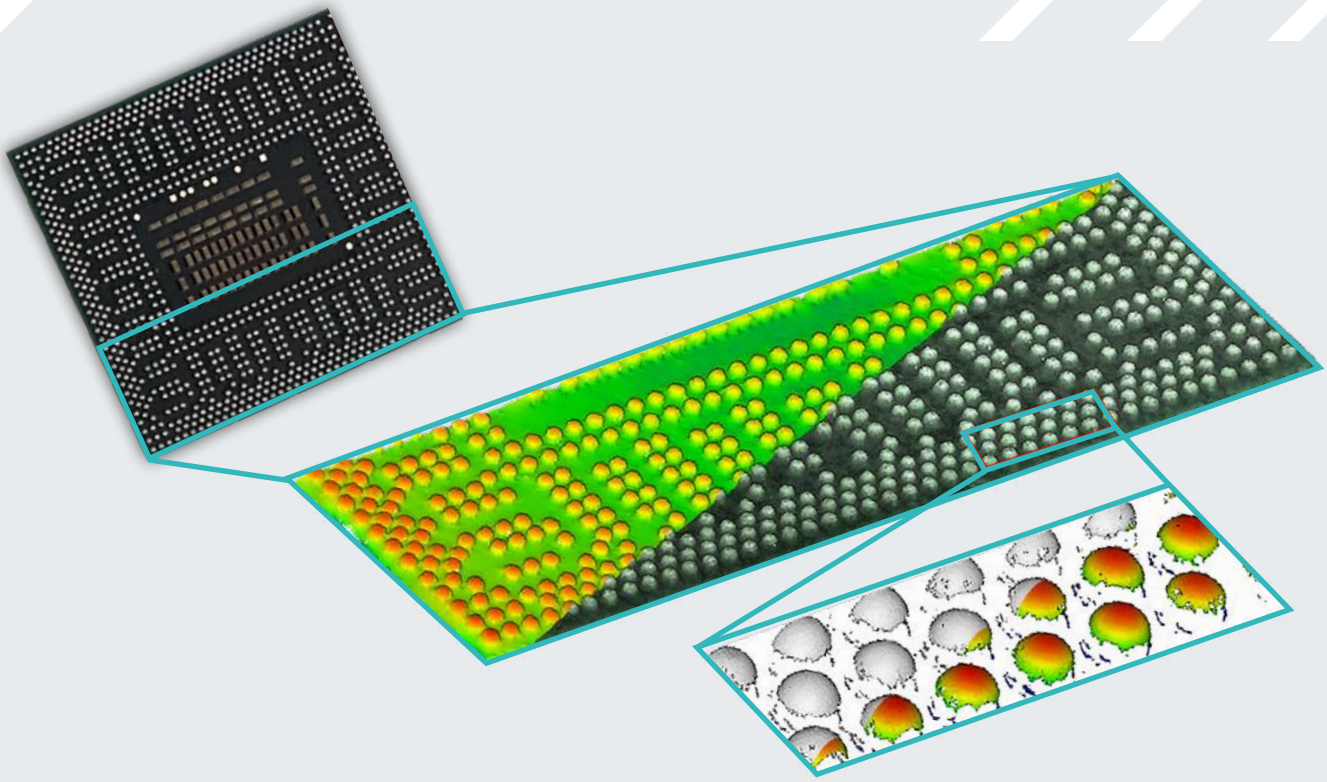
CENTER FOR
VISION, AUTOMATION & CONTROL

AUSTRIAN INSTITUTE OF TECHNOLOGY

HIGH-PERFORMANCE VISION SYSTEMS FOR AUTOMATION OF COMPLEX PRODUCTION PROCESSES

Computational Imaging – From Quality Inspection to Quality Control



FROM NEEDS TO RESEARCH AND INNOVATION

THE JOURNEY BEGAN, when it became evident that our world leading inline-inspection system for banknotes could also be used in other fields of applications. Particular the need for fast 3D surface information to distinguish real defects from pseudo defects inspired us to develop specialized hardware, software and algorithms for a novel class of inspection systems.
As a partner of industry, we have developed answers to address the main challenges of current inspections systems: high-performance, flexibility and robustness.
TODAY, we can present various technology elements and complete systems for novel industry applications that outperform existing solutions in speed and adaptability.
TOMORROW, we will combine our high-performance vision system with our advanced control methods to achieve automation of complex processes and pave the way from quality inspection to quality control.

TOMORROW TODAY.

WE OFFER

- feasibility studies for novel imaging or inspection approaches
- development of novel technologies such as high-speed cameras and flashes, novel algorithmic approaches and Deep Learning
- concepts and deployment of challenging high-performance vision systems
- independent benchmark studies for technology comparison
- integration of vision solutions to solve novel automation challenges

OUR PARTNERS ENJOY

CUSTOMISED SOLUTIONS TO FIT THE APPLICATION NEEDS

- industrial standards
- concepts based on sectoral knowledge and customer needs
- innovative technologies for demanding tasks of fast image acquisition and processing
- fast and easy deployment, configuration and customization of systems and solutions

FIELDS OF APPLICATION

2D and 3D surface inspection of different sizes

- metallic surfaces
- electronics
- ceramics
- complex materials
- paper & foils

and many more.

XPOSURE FAMILY – OUR HARDWARE COMPONENTS & SOLUTIONS

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xposure:photometry p. 2

Industrial Use Cases for High-Performance Inspection p. 2

ICI INLINE COMPUTATIONAL IMAGING – OUR SOFTWARE SOLUTIONS

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DEEP LEARNING & INTELLIGENT ALGORITHMS – OUR RESEARCH

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XPOSURE FAMILY - OUR HARDWARE COMPONENTS & SOLUTIONS

//01 xposure:camera – world's fastest line-scan camera (600 kHz)

//01

//02 xposure:flash – LED line light with 24 LEDs strobing at 600 kHZ

//02

xposure:camera

- 600.000 lines per second monochrome
- 200.000 lines per second RGB color
- high sensitivity / low noise
- digital output 1,2 Giga-Pixel per second (10 bit)

xposure:flash

- ultra fast LED strobing technology
- high illuminance and high homogeneity
- maximum illumination stability
- compact size allows tightest installation conditions

HIGH SPEED SENSING WITH WORLD'S FASTEST LINE-SCAN CAMERA & FLASH

The xposure family is based on an AIT development resulting in the world's fastest line-scan camera with 600 kHz line rate. This extremely high frequency and the smart on-board features of the xposure:camera enables

- high resolutions and extreme speeds - examples are 50 µm at 10 m/s (colour), or 0.1 mm at 216 km/h (mono)
- multi spectral sensing with a single sensor (explained in the following)
- surface scanning for 3D surface defects (explained in the following)
- inline surface scanning in full 3D: using two xposure:cameras in stereo configuration; the full 3D information can be derived – examples are 50 µm at 100 km/h.

SINGLE CAMERA MULTI SPECTRAL SOLUTION

The innovation for multi spectral imaging
By combining xposure:camera with multiple LED line light - e.g. xposure:flash - with different illumination wavelength in time-multiplex a multi spectral high speed imaging system - e.g. 4 wavelength (RGB, IR) with 50µm at 7.5 m/s - is realized with **only a single camera**.

Xposure enables high speed sensing
- single camera multi spectral systems (e.g. VIS, NIR, UV...)
- single camera multiple illumination systems (e.g. bright field, dark field, transmission...)
- compact and easy to use

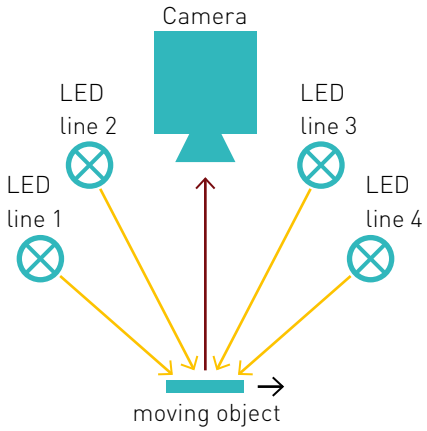
Test banknotes courtesy of OeBS

VIS (top) and NIR (bottom) data stream from a test banknote acquired with xposure with multispectral setup at 100k RGBI lines per second

XPOSURE:PHOTOMETRY

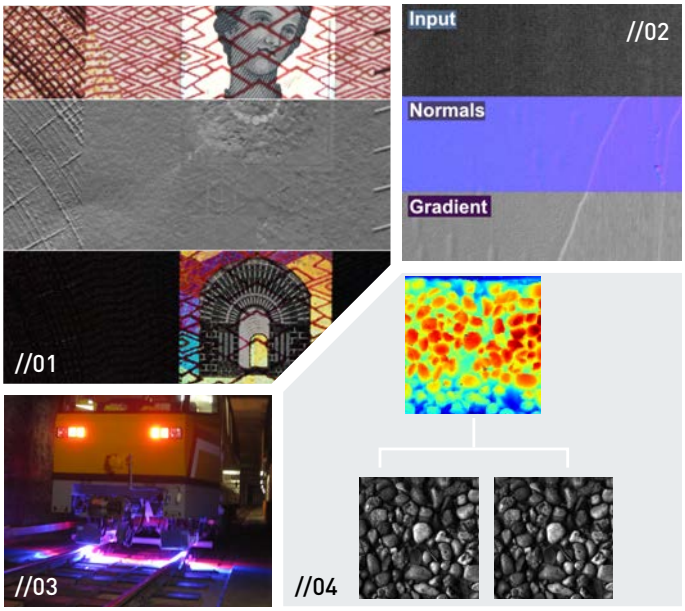
The innovation for 3D inline surface scanning
The fast inline 3D surface scanner delivers simultaneously 2D grey scale images and surface gradients (photometric stereo with 600 million pixel/s). This enables for high speed surface inspection with robust detection quality.

The core of the innovation is the xposure:camera combined with the xposure:flash illumination. Together with the new FPGA module for photometry, which realizes the synchronization and calculation, the result is xposure:photometry - an innovative and industry-ready smart camera for high-speed photometry.



Photometric stereo setup as used for xposure:photometry (functional principle)

INDUSTRIAL USE CASES FOR HIGH-PERFORMANCE INSPECTION



2D & 3D inspection of colours & surface structures

//01 Print, paper, foil
Linescan and photometric stereo
speed: 10 m/s, resolution: 0.05 mm/px

//02 Battery or photovoltaic foils
Linescan and photometric stereo
speed: 2 m/s, resolution: 0.05 mm/px

//03 Rail Surface
Linescan and photometric stereo
speed: 200 km/h, resolution: 0.2 mm/px

3D inspection of surface structures

//04 Large infrastructures (road and rail)
Linescan and 3D-stereo
speed: 100 km/h, resolution: 0.05 mm/px

ICI INLINE COMPUTATIONAL IMAGING – OUR SOFTWARE SOLUTIONS

THE NEXT GENERATION OF INDUSTRIAL INLINE INSPECTION

ICI Inline Computational Imaging is a novel single sensor technology capable for simultaneous 2D and 3D inline inspection.

We at AIT developed ICI to meet the requirements for modern industrial inspection with respect to high resolution and high speed. With ICI we brought an imaging system to market that fulfils complex inspection tasks where previously traditional systems used to fail.

inVISION TOP INNOVATION

inspect award 2020 nominee

ICI delivers

- enhanced 2D images together with high-definition 3D point clouds from objects moving at high speeds
- robustness in image quality for challenging reflection properties of object materials (glossy, matt, low texture)
- flexibility and easy scale adaptation from micro to macro.

IMAGE ACQUISITION & PROCESSING

ICI is a new image acquisition system with smart algorithms. It combines the advantages of light field imaging and photometric stereo into one compact solution.

ICI Sensor System
Single Sensor Technology for Simultaneous Light Field and Photometric Stereo Capture

ICI Image Stack

ICI Software Modules
Generic Computational Imaging Library for 2D/3D Tasks

Truely inline method:

- continuous image acquisition while sample moves under the sensor system
- illumination changes for each image in predefined order
- ICI image stack contains light field and photometric stereo information.

The AIT ICI algorithms have been designed specifically to work with the ICI sensor system

- highly optimized for high processing speed and best results quality
- independent from computer and imaging platforms
- support decentralized processing and reporting.

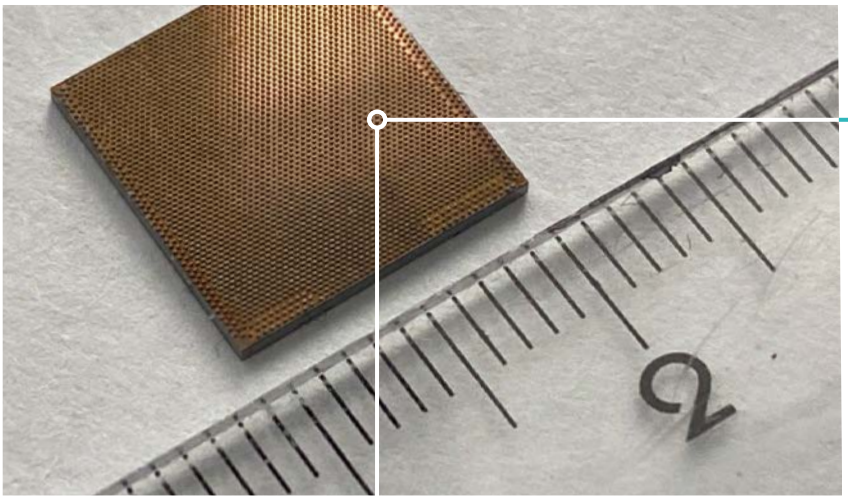
FROM MICROSCOPY TO LARGE SCALE INSPECTION

The AIT AreaICI is applicable from microscopic to large inspection problems

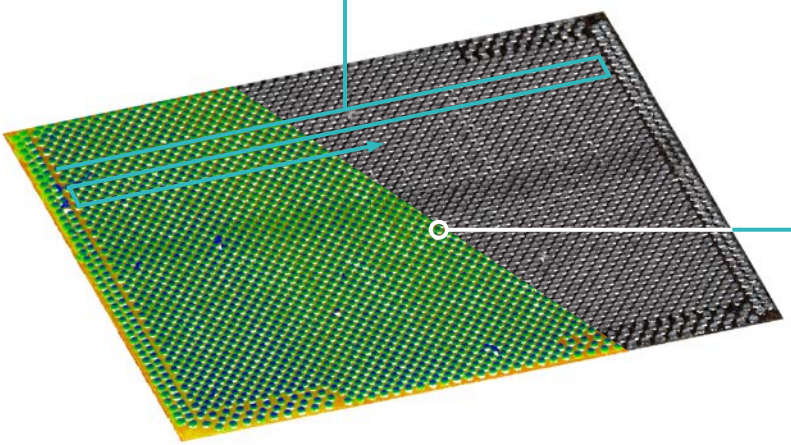
AIT ICI can be
- scaled down to 700 nm/pixel with 1,6 mm FOV or larger;
- scaled up to e.g. 100 µ/pixel with 232 mm FOV or larger.

Due to the fast acquisition principle large areas can be acquired by stitching adjacent scanning paths.

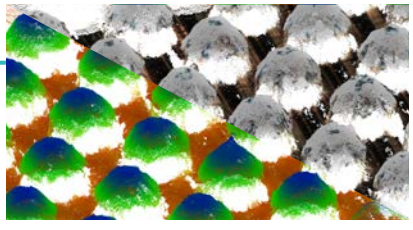
Application example:
100 mm² BGA with 200M 3D Points in < 15 s



10 x 10 mm² microelectronic ball grid array



2D and 3D overview image



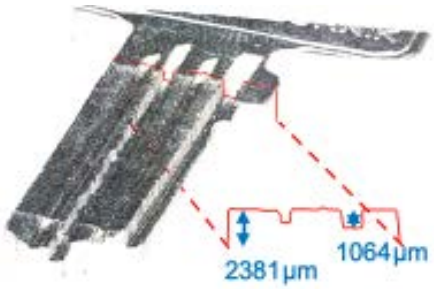
Detail down to 700 nm / pixel

PRECISE 3D RECONSTRUCTION & MEASUREMENT

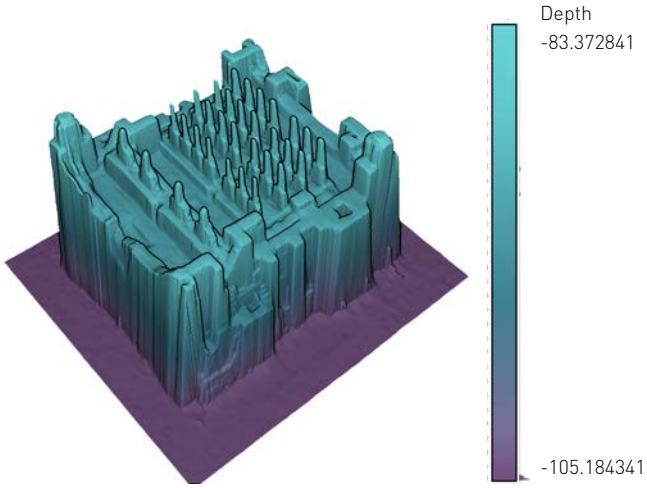
ICI generates simultaneously

- a high-definition 3D depth model (depth map, point cloud)
- enhanced 2D texture images registered onto the depth model.

The highly precise results support the 3D inspection of objects of different sizes in real time as well as the inline measurements of their structures.



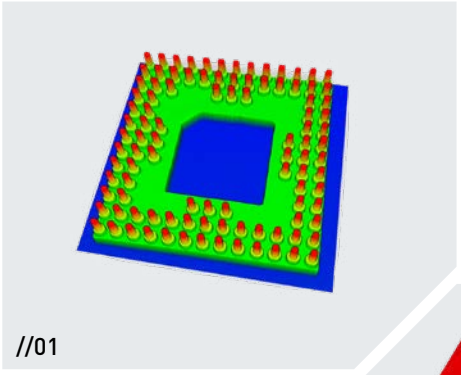
Precise inline height measurement



3D reconstruction of scalable objects in real time

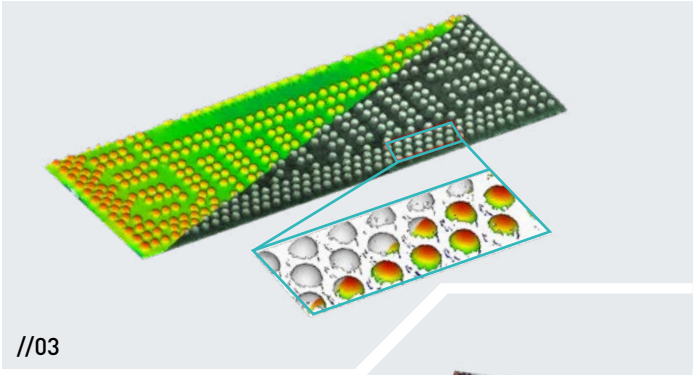
INDUSTRIAL USE CASES FOR INLINE INSPECTION WITH ICI

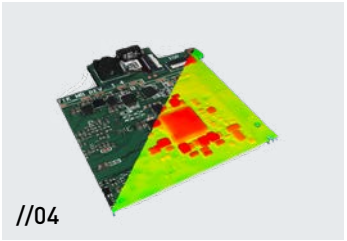
//01 Electronic parts



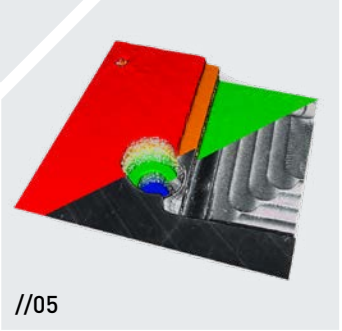
//02 Crack detection

//03 Ball grid arrays





//04 Printed circuit boards



//05 Metal parts

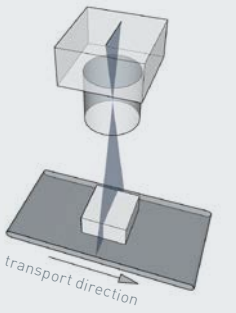
//06 Coins

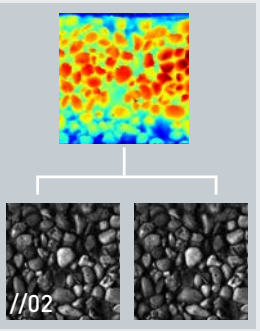
//07 Security print / OVD

THE RIGHT INSPECTION TECHNOLOGY FOR EVERY TASK

Depending on the task at hand, we choose the appropriate approach to meet the requirements and cost-effectiveness. We combine our innovative solutions with modern technologies to achieve outstanding results for our customers and partners.

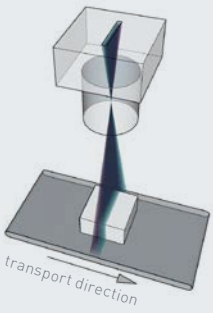
LINE SCAN

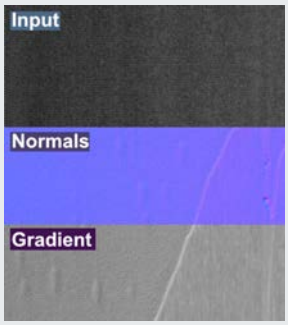




//01 2D & 2.5D **//02** 3D

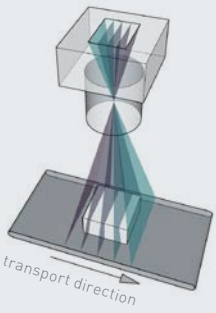
DENSE MULTI-LINE SCAN

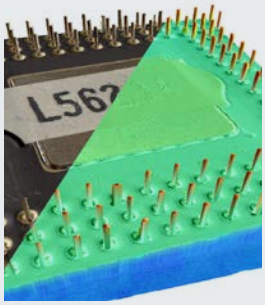




2D & 2.5D

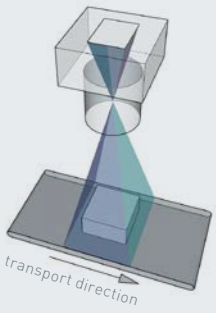
SPARSE MULTI-LINE SCAN

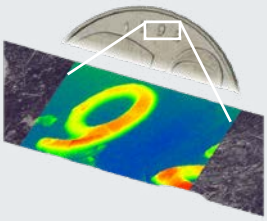




2D & 2.5D & 3D

AREA SCAN





2D & 2.5D & 3D

DEEP LEARNING & INTELLIGENT ALGORITHMS – OUR RESEARCH

Our research in the field of Deep Learning aims at

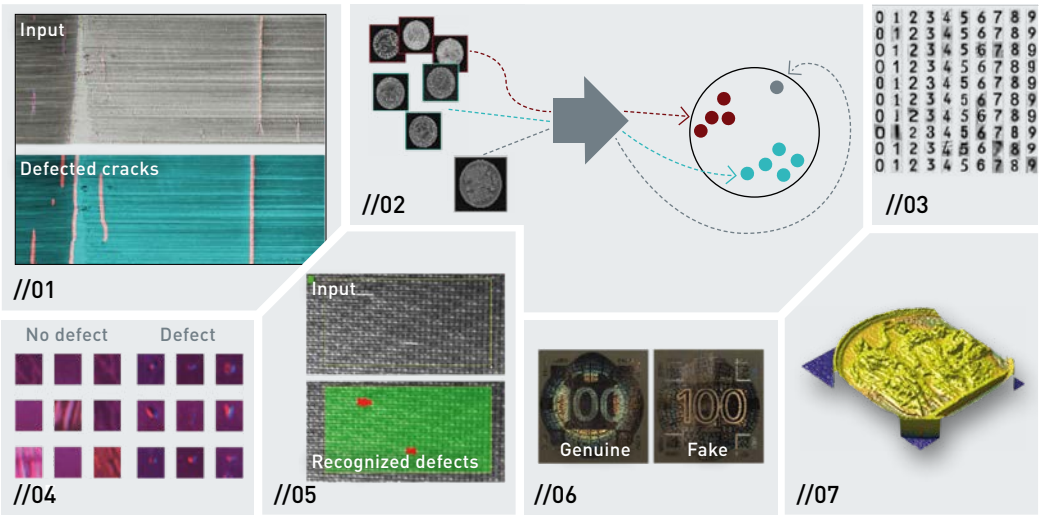
- minimizing of costly and labor intensive processes
- increasing speed and accuracy of quality inspection
- keeping Deep Learning solutions as simple as possible
- ensuring deployability and high processing speed
- overcoming the industrial challenges
- combination of model-based algorithms with AI methods.

DEEP LEARNING - A POWERFUL STATISTICS TOOL

As a powerful statistics tool Deep Learning depends on data and learns from data only. The Deep Learning - decision making depends on training data

- amount of data
- coverage of all cases
- balance of representation
- everything not represented in the data stays unknown to the network.

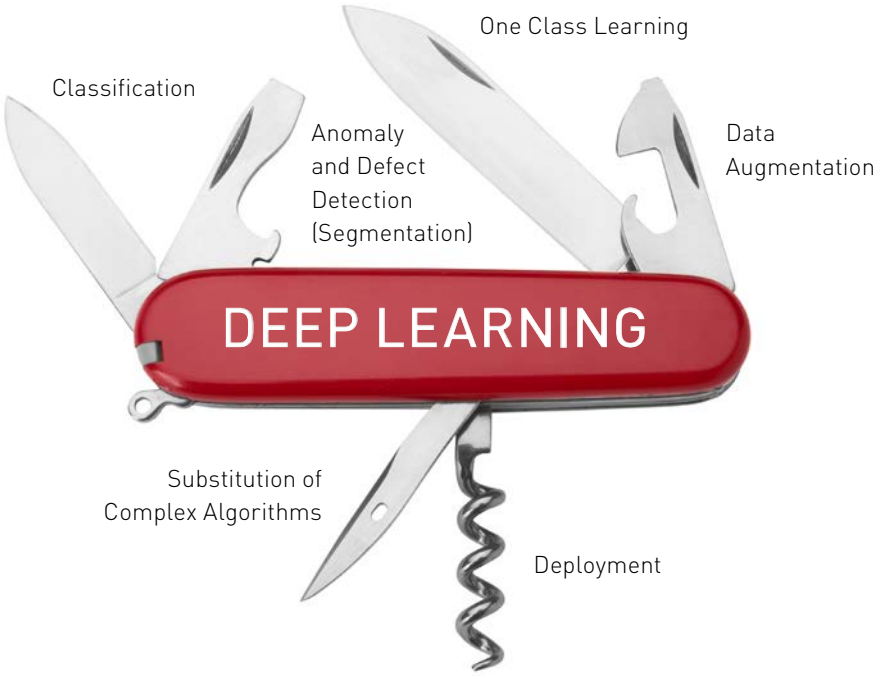
INDUSTRIAL USE CASES WITH DEEP LEARNING



//01 Crack segmentation
//02 Coin classification
//03 Pattern recognition for serial numbers
//04 Rail defect classification
//05 Fabrics inspection for anomalies
//06 Security print authentication
//07 Speed optimisation for 3D processing

ENABLING DEEP LEARNING FOR INDUSTRIAL APPLICATIONS

We use Deep Learning as a Swiss army knife applying the right tool for the corresponding challenge:



Industrial challenges that can be solved with Deep Learning and AIT research & solutions

Classification
Distinction between real and pseudo defects.
→ Deep Learning classificator increases classification performance.

Data Augmentation
Only limited data are available.
→ Deep Learning methods with GAN enables data augmentation.

Substitution of Complex Algorithms
Complex classical image processing algorithms are sometimes too complex or their runtime is not deterministic.
→ Deep Learning methods can substitute complex algorithms to guarantee execution time and to reduce complexity.

One Class Learning
Only data from one class are available.
→ Deep Learning methods for one-class learning find non-uniformity of data from defects.

Anomaly and Defect Detection (Segmentation)
Segmentation of defects is not achievable with standard methods.
→ Deep Learning segmentation increases segmentation quality.

Deployment
Industrial application has unknown defect classes.
→ Deep Learning methods with novelty-aware learning enables the recognition of additional, untrained classes.

AUSTRIAN INSTITUTE OF TECHNOLOGY

THE AIT AUSTRIAN INSTITUTE OF TECHNOLOGY – AUSTRIAS'S LARGEST RESEARCH AND TECHNOLOGY ORGANISATION

1,400 RESEARCHERS
9 LOCATIONS
7 CENTERS

HIGH-PERFORMANCE VISION SYSTEMS

Our research group High-Performance Vision Systems at the AIT Austrian Institute of Technology consists of an inter-disciplinary team and combines a wide range of skills and competences. We foster a holistic approach to enable high-performance vision.

As part of the AIT Center for Vision, Automation & Control we develop technologies and solutions for high performance industrial image processing, covering all aspects of automated optical inspections.

WE FOCUS ON

- high-speed sensing and embedded computing
- computational imaging for simultaneous 2D & 3D imaging
- Deep Learning / AI for industrial inspection

TOGETHER WITH YOU

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