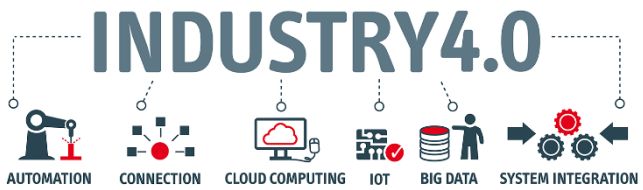
VisiConsult

X-ray Systems & Solutions



Automated RT interpretation through Artificial Intelligence (AI)

Where we come from traditionally

- Highly manual acquisition processes that are hard to scale
- Usage of analog film requires manual evaluation and physical archiving
- High consumable costs and extensive use of chemicals
- NDT is a major bottleneck in most operations

The transformation path in NDT

Load part → Place IQIs, Lead … → Expose film → Remove film + IQI → Develop film → Evaluate film

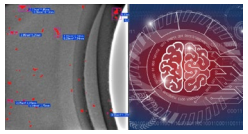
NDT 1.0

Load part → Move cart → Unload part → Evaluate images

NDT 2.0

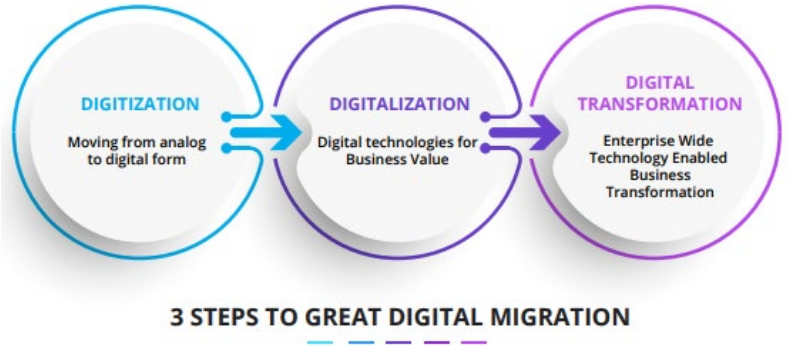
Load part → Unload parts → Evaluate images

NDT 3.0

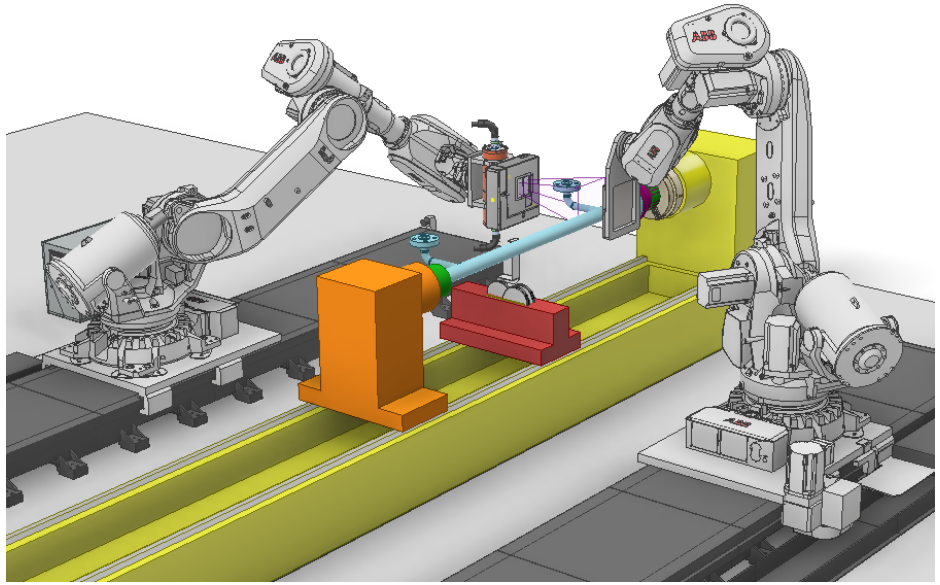


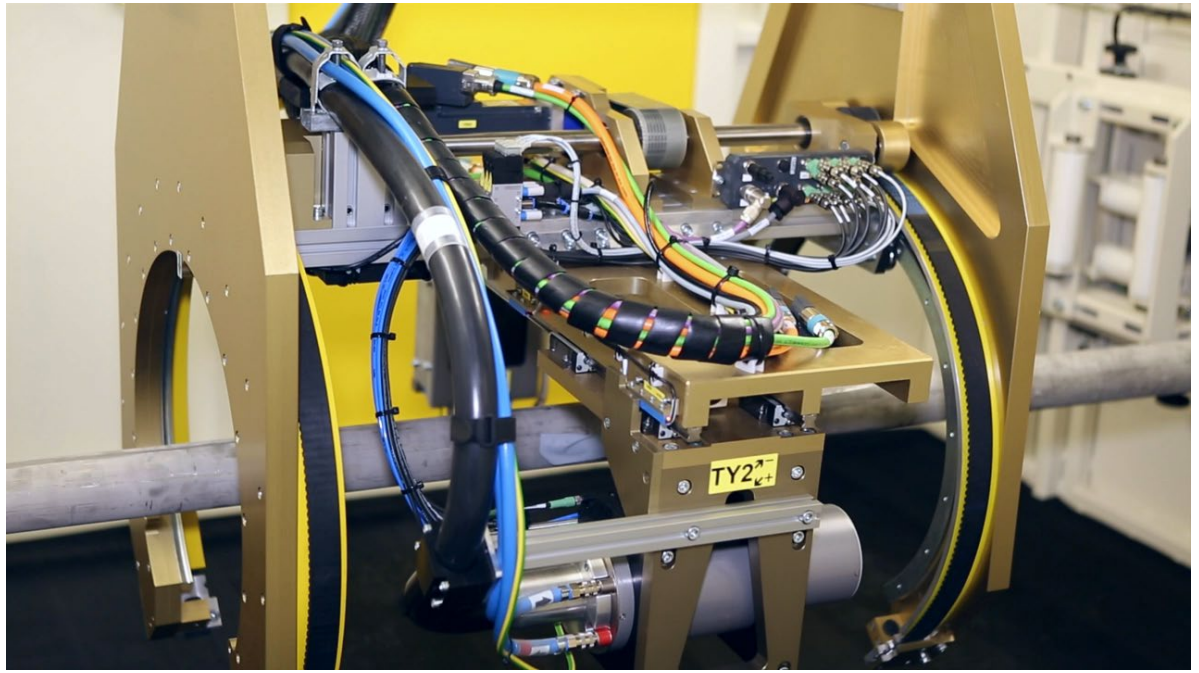
Load part → Unload parts

NDT 4.0



Highly automated inspection machines





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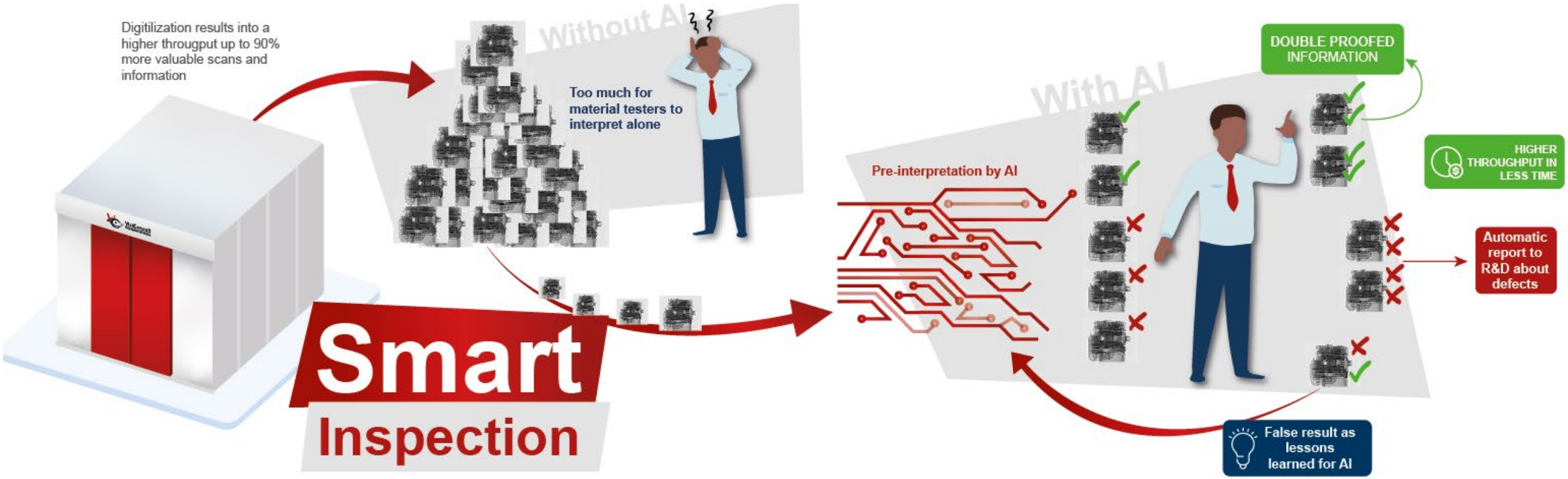
Digitalization challenges

- Overwhelming amounts of data
- Information is covered by noise
- Lack of skilled personnell for interpretation

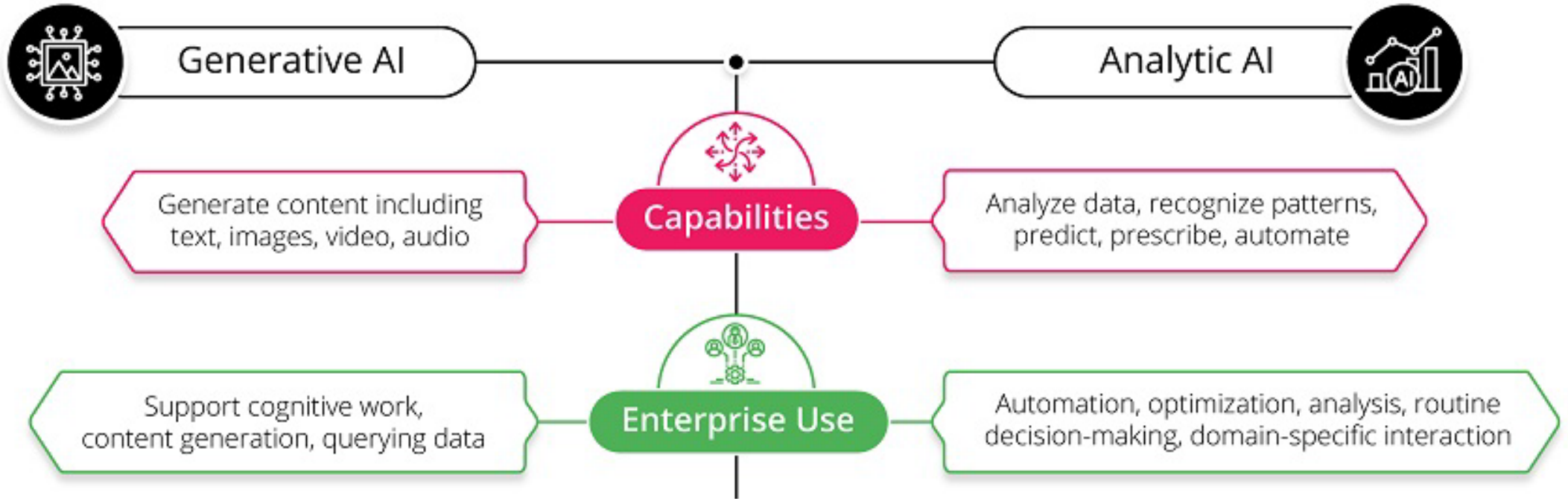
Digitalization of decision making

- Bottle neck shifted from the physical into the digital space
- Employees require smart tools to help with decision making
- Shorter delay until decision increases value



Who has tried ChatGPT?

That is not what we are talking about !



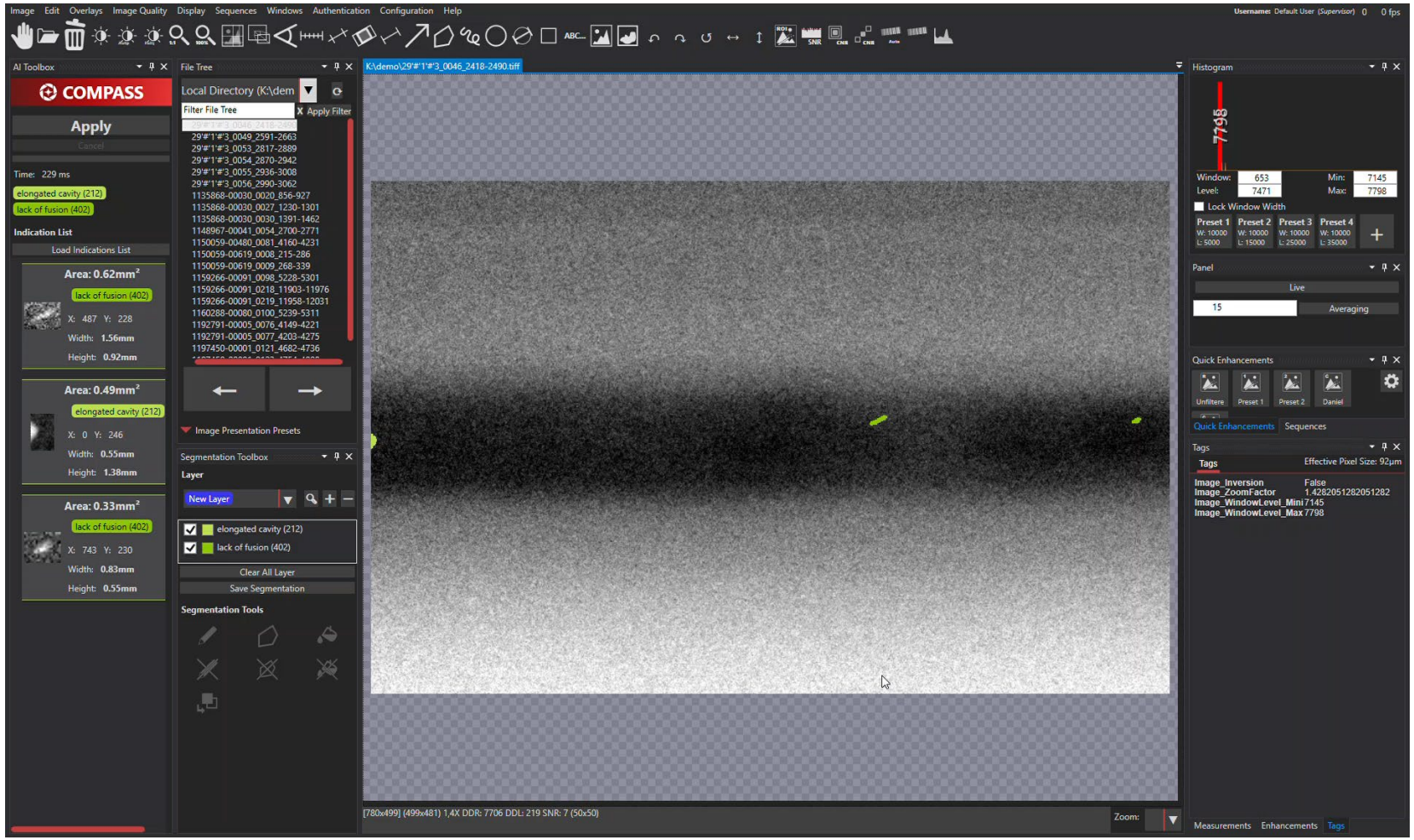


Image Edit Overlays Image Quality Display Sequences Windows Authentication Configuration Help
AI Toolbox
COMPASS
Apply
Cancel
Time: 229 ms
elongated cavity (212)
lack of fusion (402)
Indication List
Load Indications List
Area: 0.62mm²
lack of fusion (402)
X: 487 Y: 228
Width: 1.56mm
Height: 0.92mm
Area: 0.49mm²
elongated cavity (212)
X: 0 Y: 246
Width: 0.55mm
Height: 1.38mm
Area: 0.33mm²
lack of fusion (402)
X: 743 Y: 230
Width: 0.83mm
Height: 0.55mm
File Tree
Local Directory (K:\dem
Filter File Tree
Apply Filter
29'#'1'#'3_0049_2591-2663
29'#'1'#'3_0053_2817-2889
29'#'1'#'3_0054_2870-2942
29'#'1'#'3_0055_2936-3008
29'#'1'#'3_0056_2990-3062
1135868-00030_0020_856-927
1135868-00030_0027_1230-1301
1135868-00030_0030_1391-1462
1148967-00041_0054_2700-2771
1150059-00480_0081_4160-4231
1150059-00619_0008_215-286
1150059-00619_0009_268-339
1159266-00091_0098_5228-5301
1159266-00091_0218_11903-11976
1159266-00091_0219_11958-12031
1160288-00080_0100_5239-5311
1192791-00005_0076_4149-4221
1192791-00005_0077_4203-4275
1197450-00001_0121_4682-4736
Image Presentation Presets
Segmentation Toolbox
Layer
New Layer
elongated cavity (212)
lack of fusion (402)
Clear All Layer
Save Segmentation
Segmentation Tools
K:\demo\29'#'1'#'3_0046_2418-2490.tiff
[780x499] (499x481) 1,4X DDR: 7706 DDL: 219 SNR: 7 (50x50)
Zoom:
Histogram
7798
7145
Window: 653
Level: 7471
Min: 7145
Max: 7798
Lock Window Width
Preset 1 W: 10000 L: 5000
Preset 2 W: 10000 L: 15000
Preset 3 W: 10000 L: 25000
Preset 4 W: 10000 L: 35000
Panel
Live
15
Averaging
Quick Enhancements
Unfiltere
Preset 1
Preset 2
Daniel
Quick Enhancements
Sequences
Tags
Tags
Effective Pixel Size: 92µm
Image_Inversion False
Image_ZoomFactor 1.4282051282051282
Image_WindowLevel_Mini 7145
Image_WindowLevel_Max 7798
Measurements
Enhancements
Tags


AI Toolbox
Model:
CASTING
Launch COMPASS
HIGH dense material
LOW dense material
SHRINKAGE sponge
GAS hole
Segmentation Toolbox
Layer
HIGH dense material
LOW dense material
SHRINKAGE sponge
GAS hole
Segmentation Tools
SHRINKAGE sponge
Area:
4,76 mm²
Width:
3.75 mm
Area (Pixel):
1149 pix²
Height:
3.5 mm
COMPASS
The X-ray CO-PILOT
Make better decisions faster!

Drivers for AI in NDT

- „Leadership askes me to hire 100 new X-ray techs for all sites in the next months. We will be going to every single recruitment event in the respective areas, but I have no hopes that we will fill all positions“
  -- A Level III of a major Tier 1 aerospace supplier

  → Lack of skilled labor

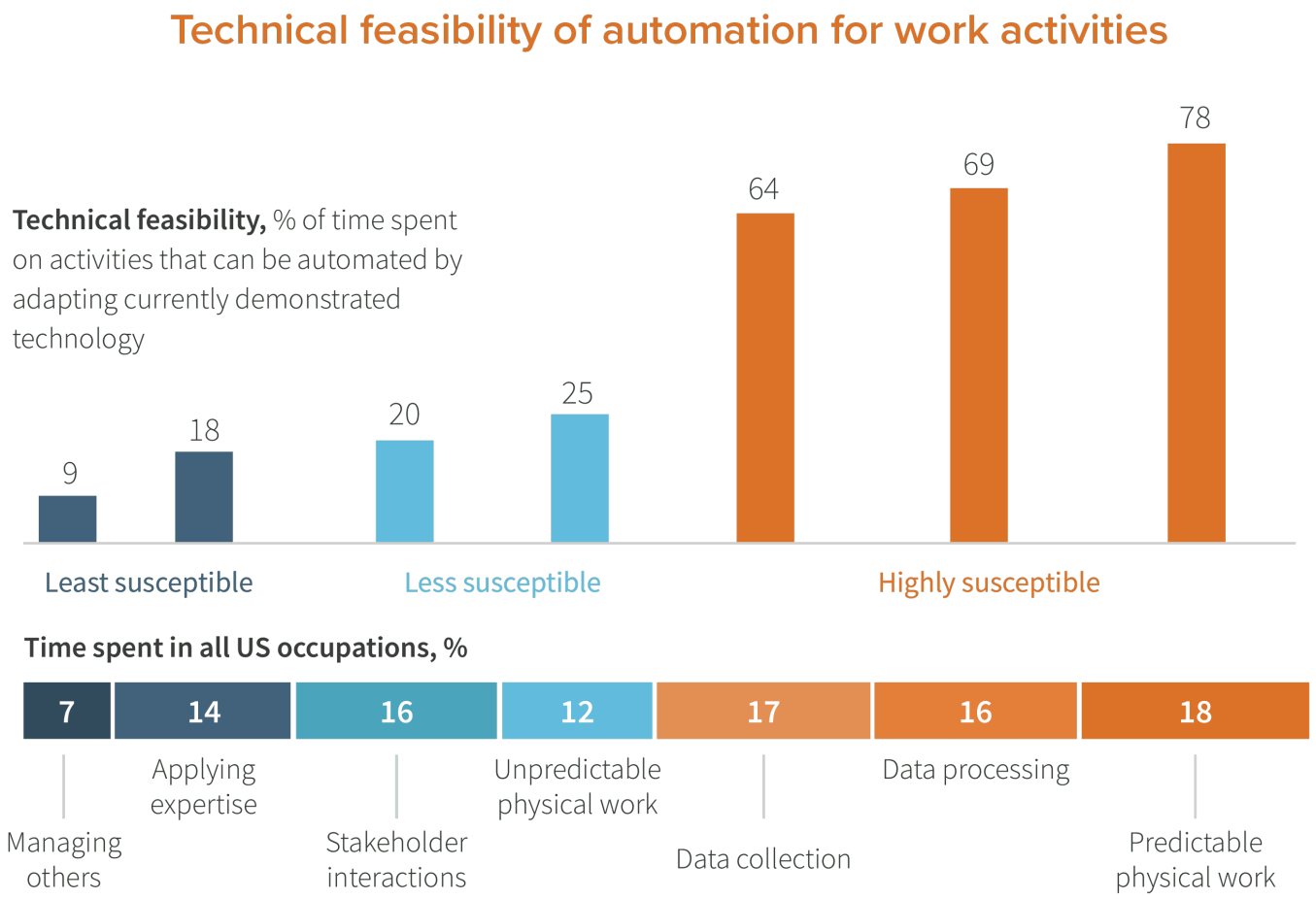
- Quality issues and customer complaints from escape parts

  → Need for increasingly higher quality standards

- Throughput increases due to volume increases

  → Efficiency and cycle time demands

Why is AI/ADR worth to consider?



Source: *https://www.mckinsey.com/business-functions/people-and-organizational-performance/our-insights/the-moment-of-truth-in-customer-service*

Why is AI/ADR worth to consider?

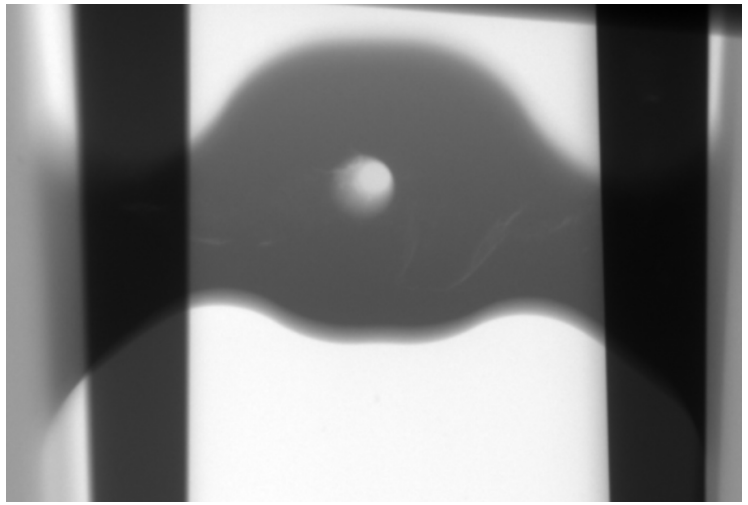
- Quality (based on studies)
  - Agreement rate of operators with themselves: 70% - 90%
  - Agreement rate of operators with each others: 60% - 85%

  - AI agreement rate with itself: 100%
  - Average AI accuracy > 98%

  - Human inspectors have fluctuating probability of detection (POD) depending on internal and external factors
  - Human POD decreases over time (Fatigue)
  - AI has constant POD

- Efficiency
  - Average human operators need 20s - 60s to evaluate a single X-ray image (depending on the part)
  - AI requires less than 0.2s to evaluate a single X-ray image
  - AI assisted operators require on average 7 seconds per image

AI – Practical Example



Raw image

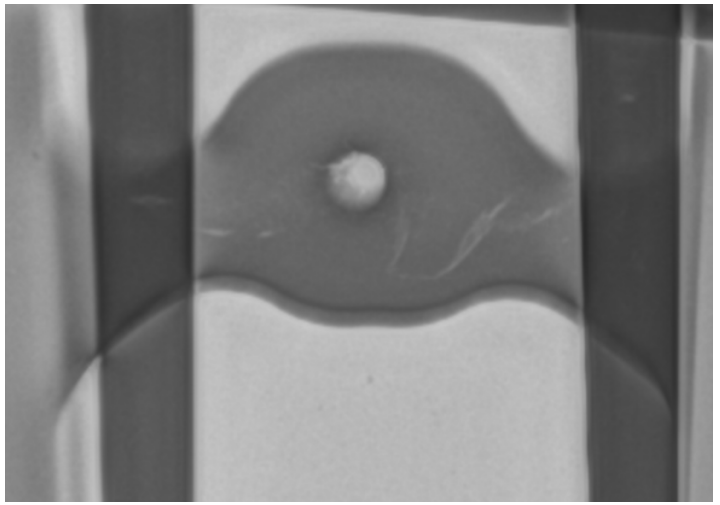
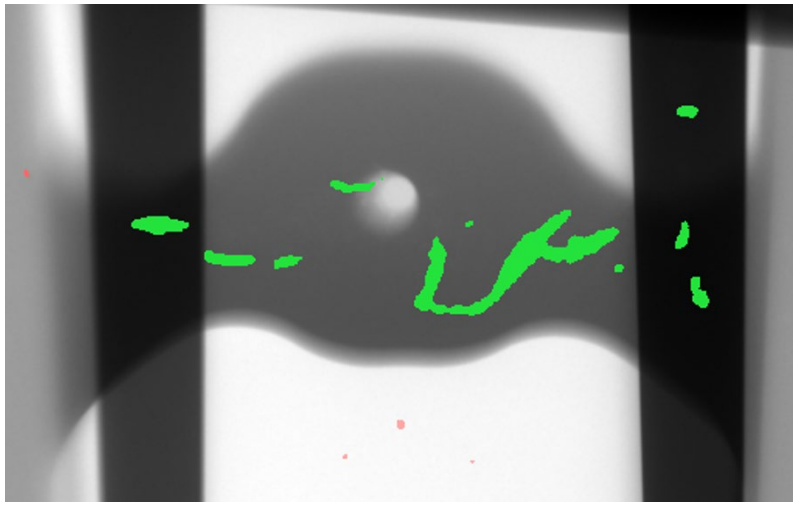


Image with filter



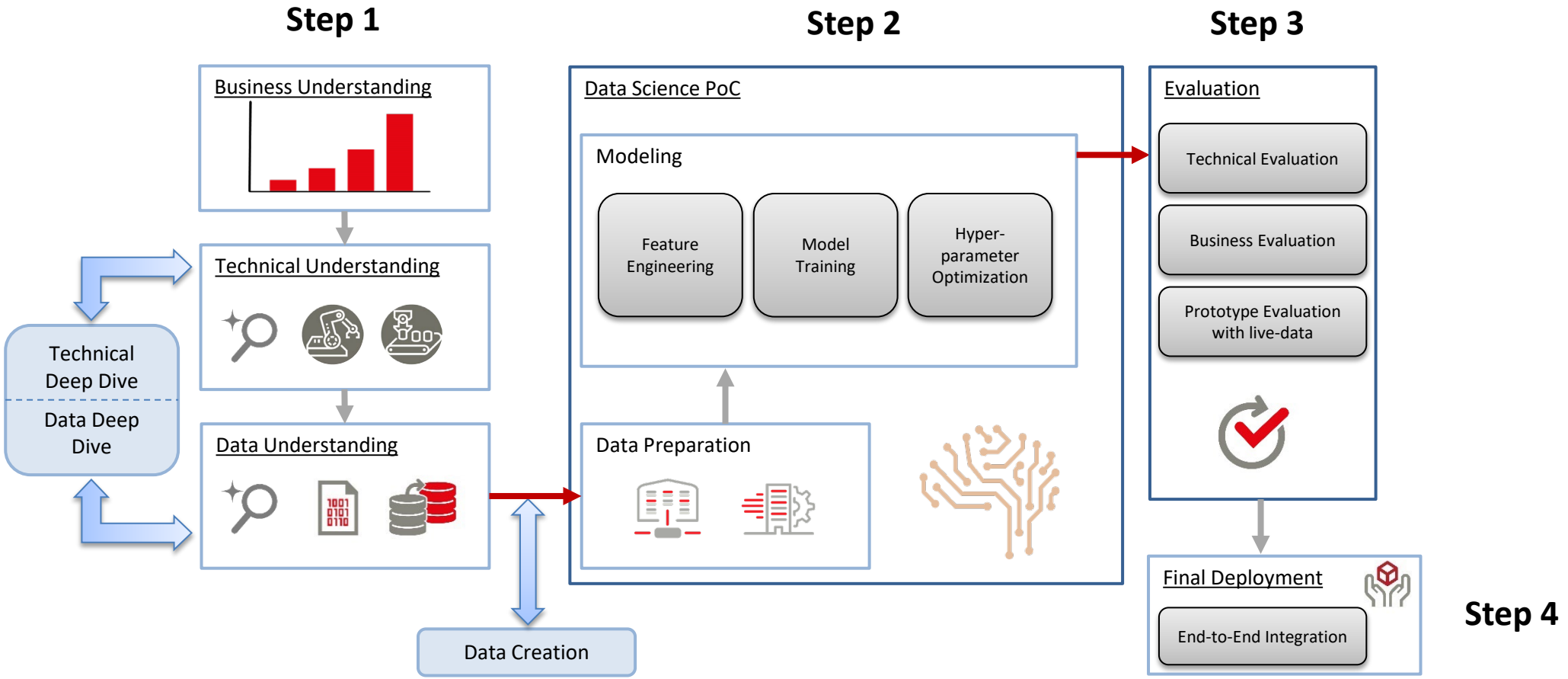
Result

Summary – tasks done by AI tool

- Indication localization
- Indication classification (defect type)
- Indication measurements (diameter, area, etc.)
- Probability for each indication
- Generation of sorted indication list

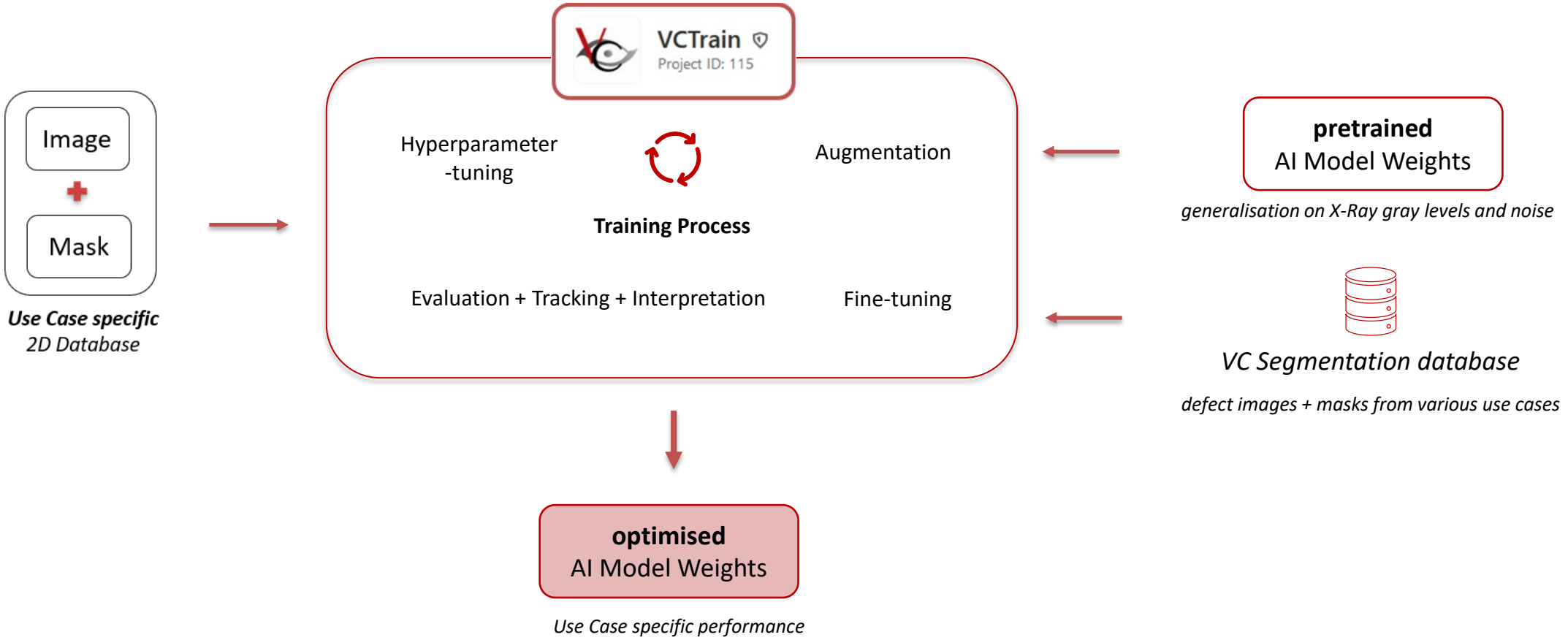
→ **100 - 200 ms cycle time**

Path to an AI Solution: Process for new cases



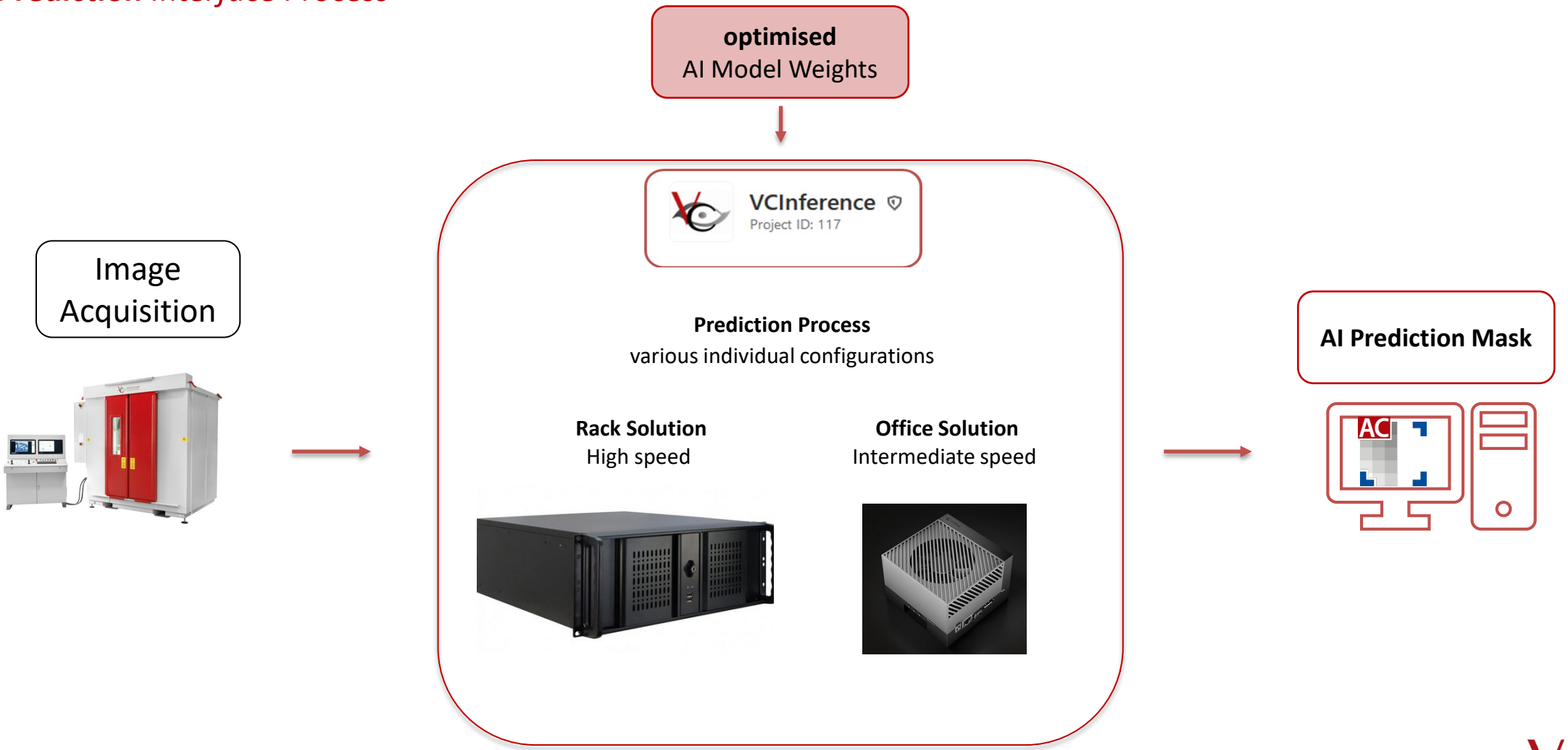
General AI Workflow – Segmentation Framework

*Finetuning **Training** Process*

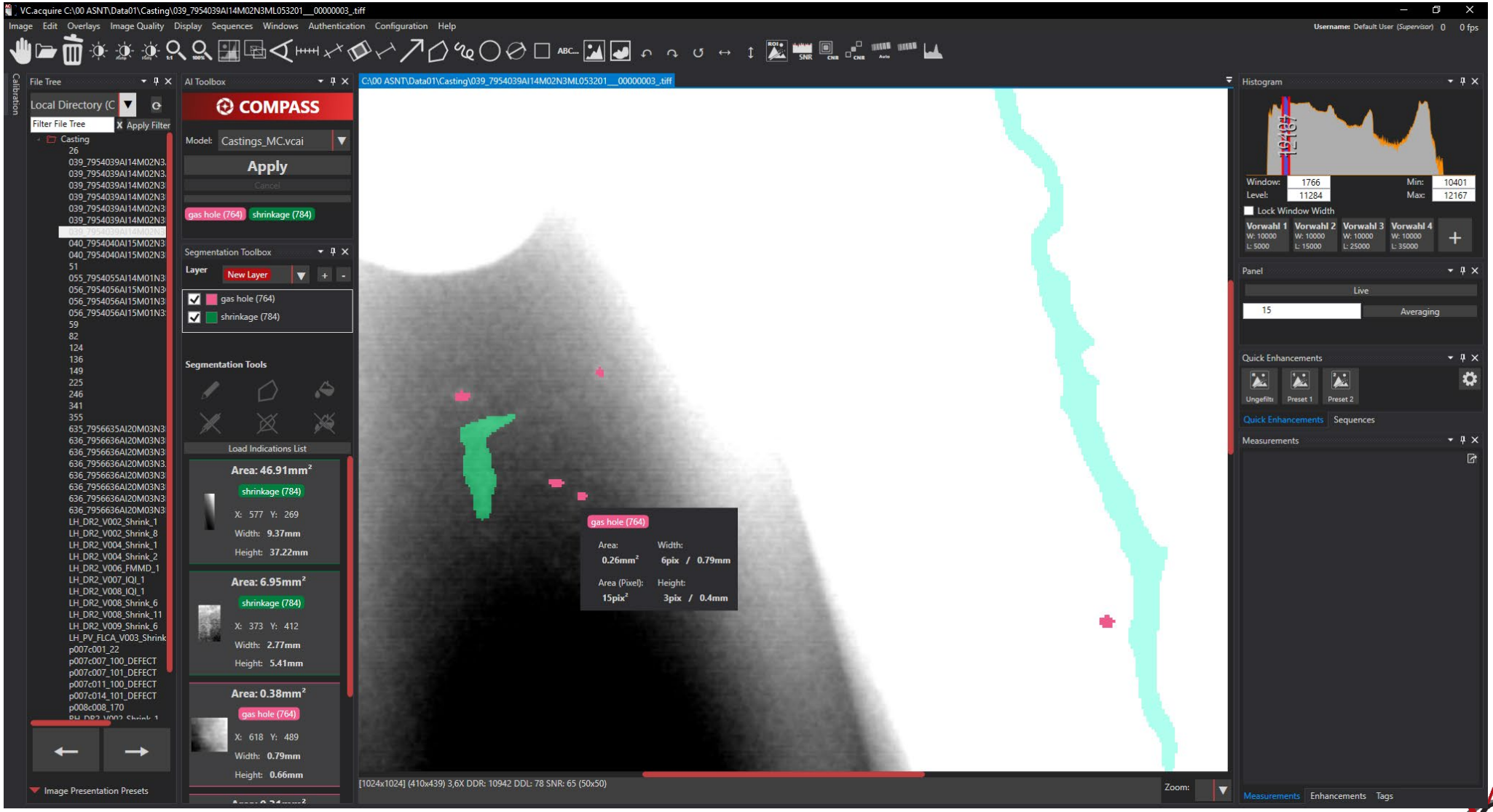


General AI Workflow – Image Pipeline

***Prediction** Interface Process*



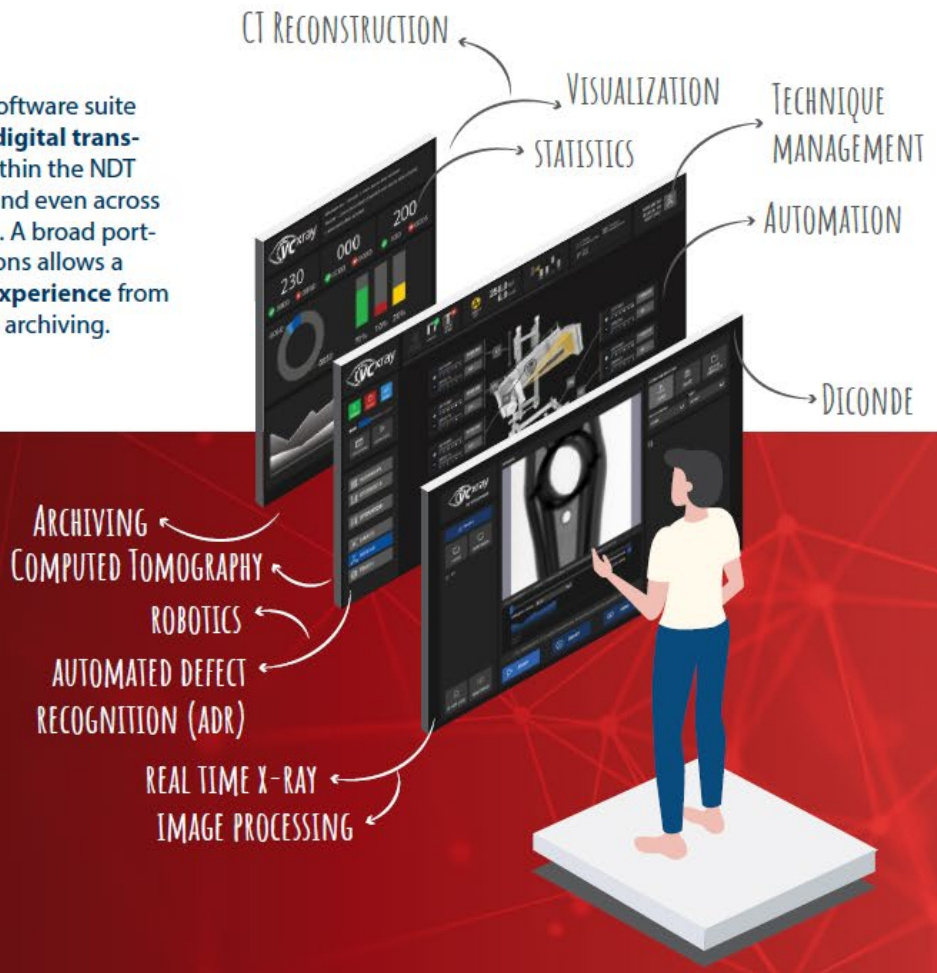
The outcome


COMPASS
Model: Castings_MC.vcai
Apply
gas hole (764)
shrinkage (784)
Segmentation Toolbox
Layer
New Layer
Segmentation Tools
Load Indications List
Area: 46.91mm²
Area: 6.95mm²
Area: 0.38mm²
Histogram
Panel
Live
Averaging
Quick Enhancements
Measurements
Area: 0.26mm²
Width: 6pix / 0.79mm
Height: 3pix / 0.4mm

The x.OS

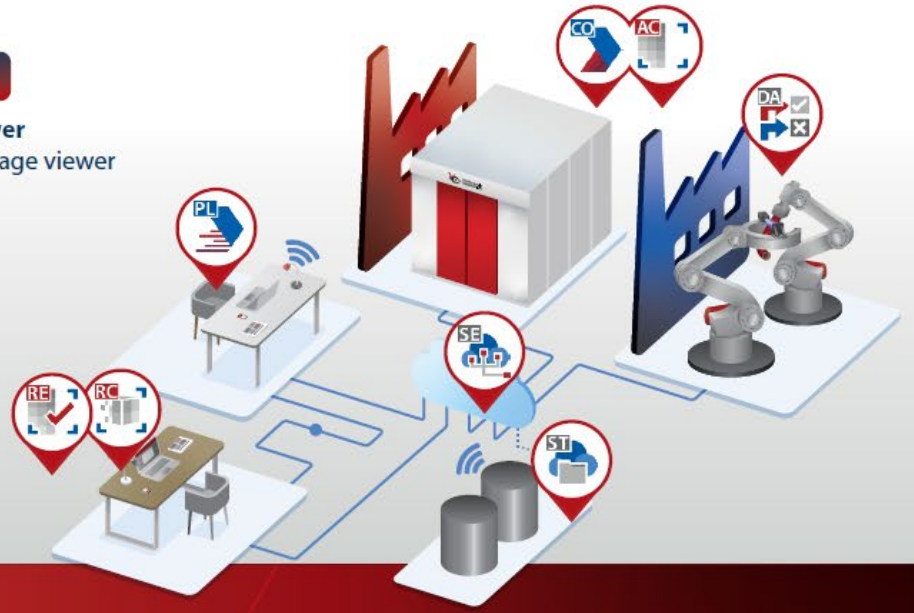
What is the x.OS?

The leading software suite that enables **digital transformation** within the NDT department and even across organizations. A broad portfolio of solutions allows a fully **digital experience** from acquisition to archiving.



FREE

VC.viewer
X-ray image viewer



VC.control
System control and automation software

VC.planner
Offline programming solution for systems and technqiues

VC.acquire
Image acquisition and enhancement software

VC.review
Image review and post processing software

VC.recomanager
CT-scan reconstruction and management software

VC.server
Central management and connectivity server

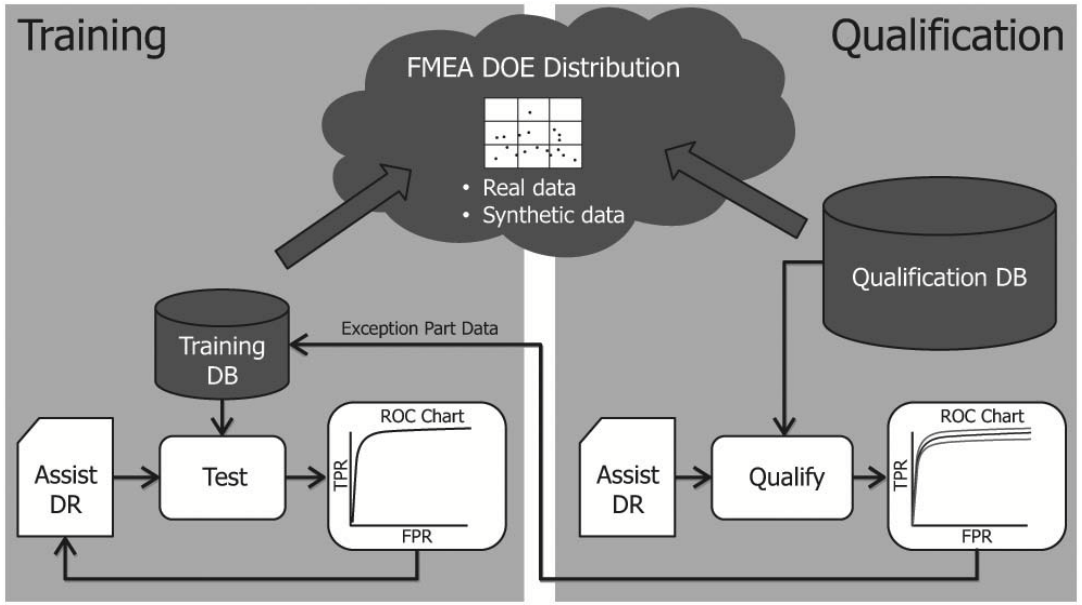
VC.storage
Long-term storage and X-ray image archive

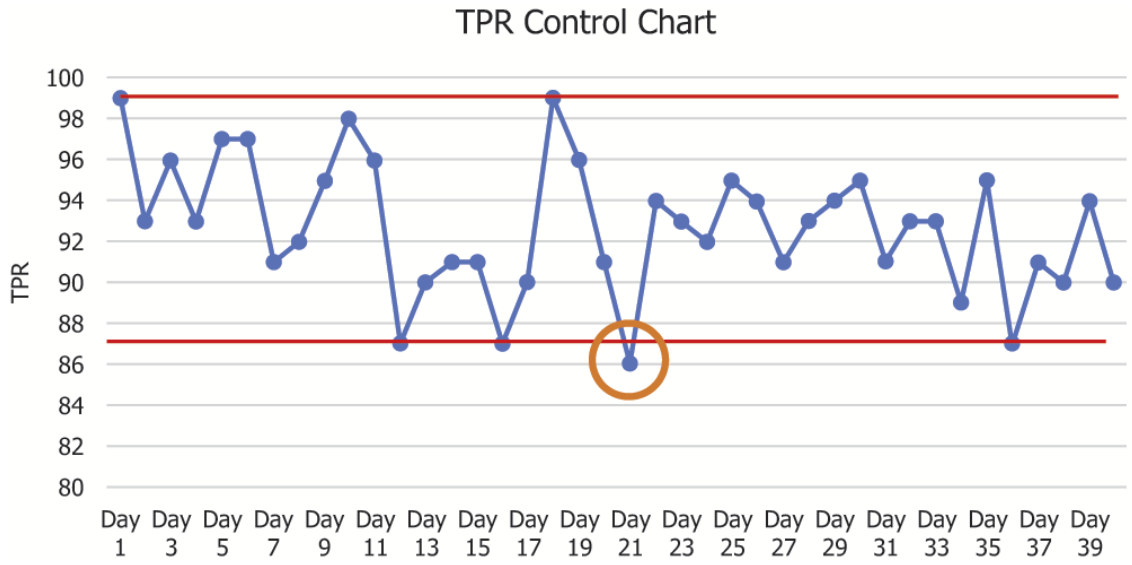
VC.dashboard
Visualized status real-time visualisation of inspection status

Qualification and Statistics

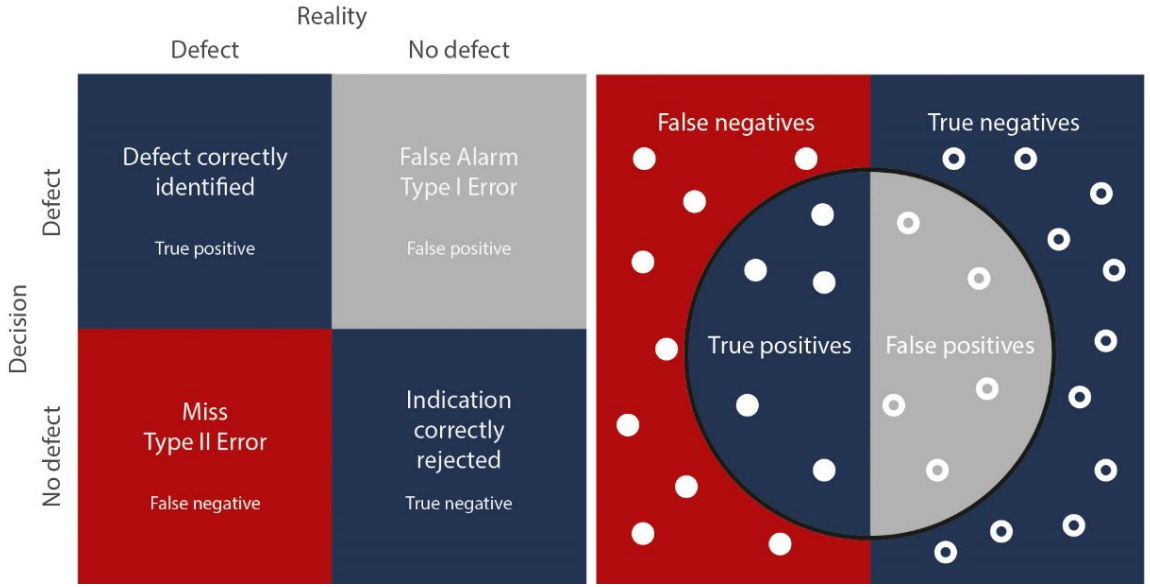
Designation: E3327/E3327M – 21

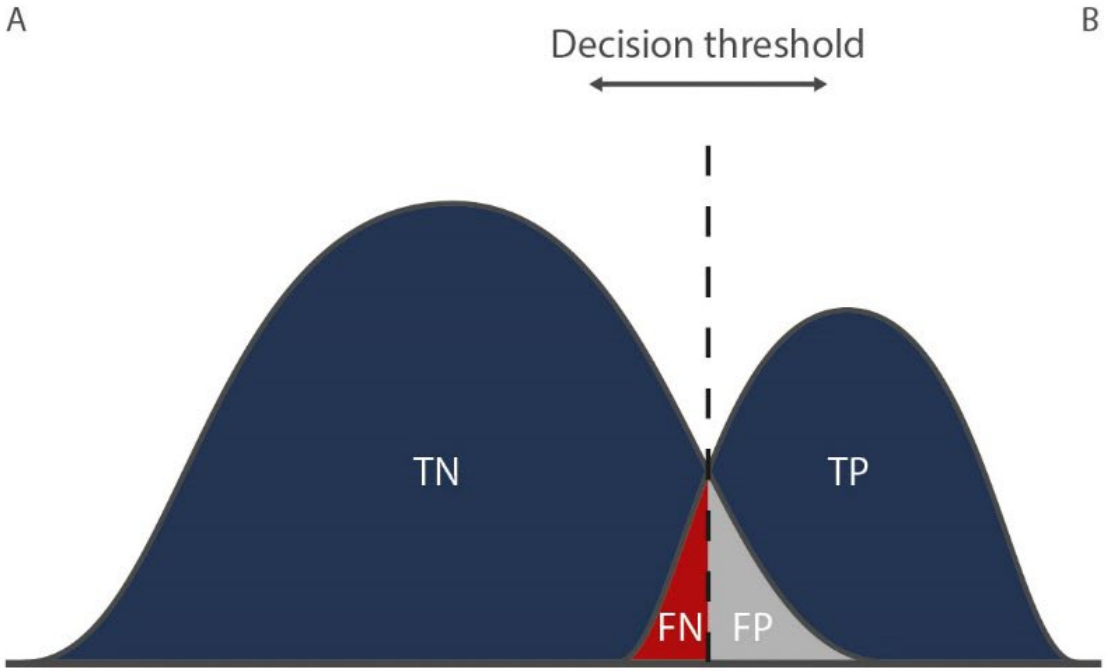
Standard Guide for the Qualification and Control of the Assisted Defect Recognition of Digital Radiographic Test Data[1]

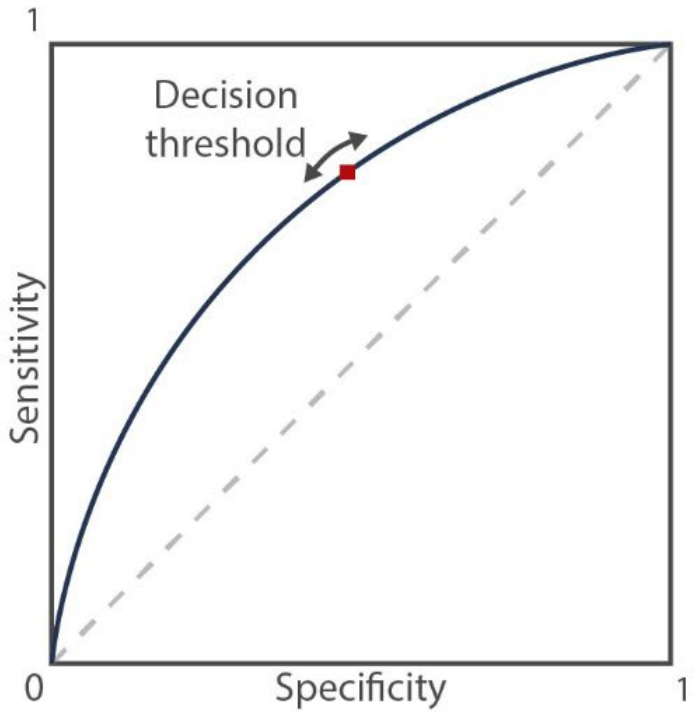




Confusion matrix – proving quality







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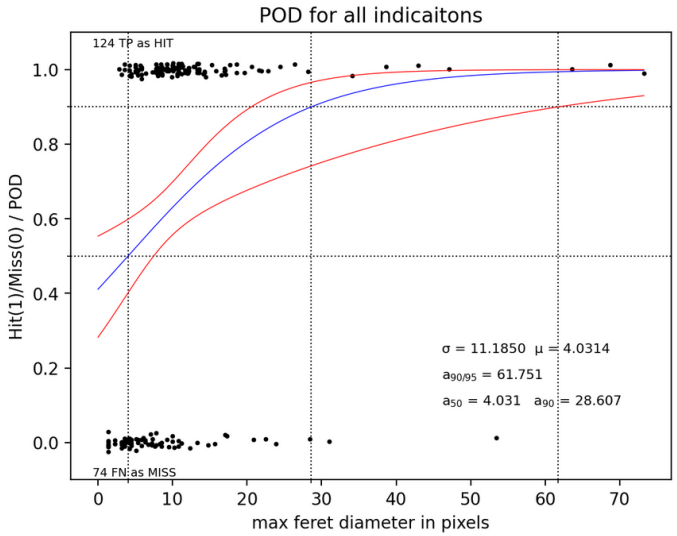
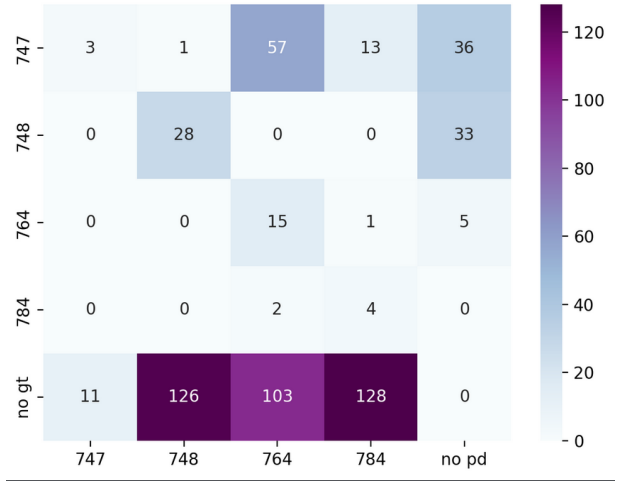
Evaluation on Test DataSet

Probability of Detection



Class Comparison Confusion Matrix



Indication specific Performance

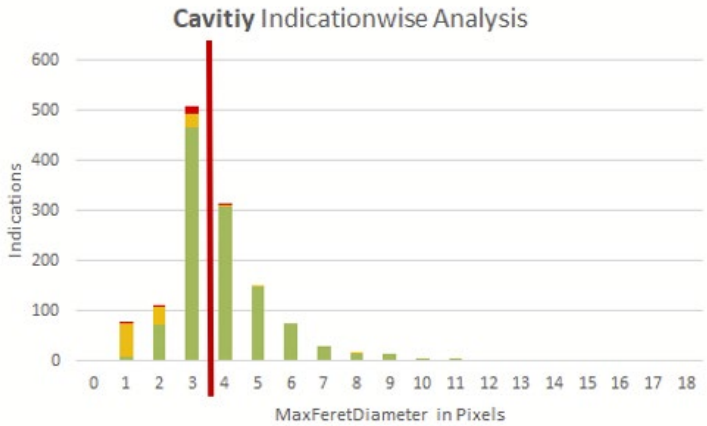
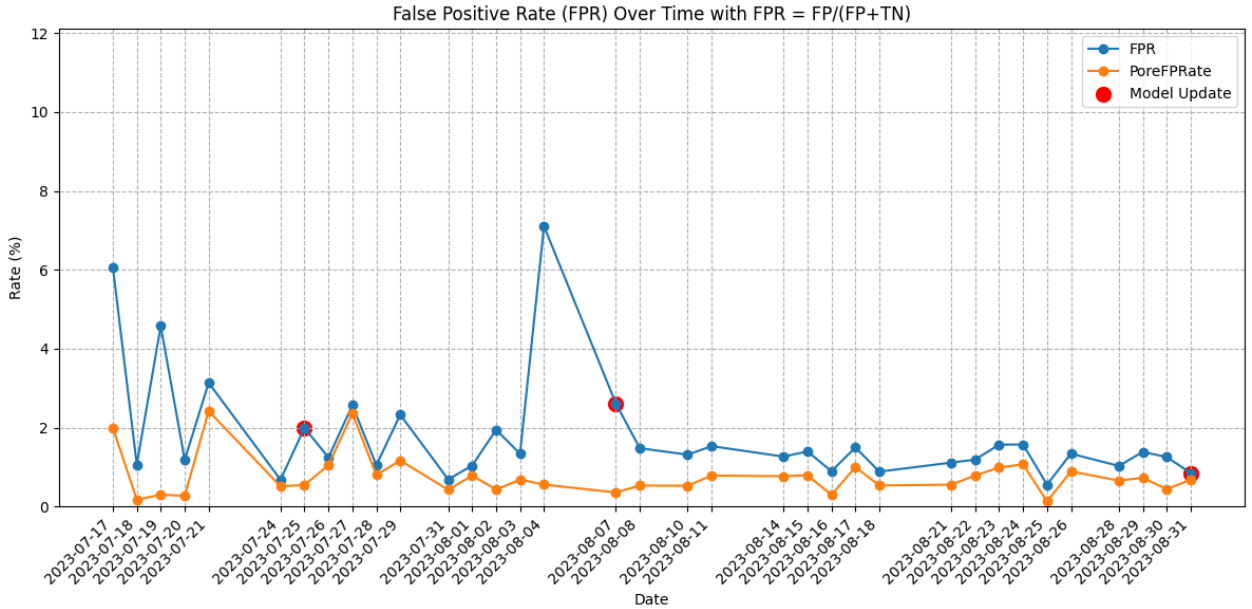


Image wise Performance Tracking

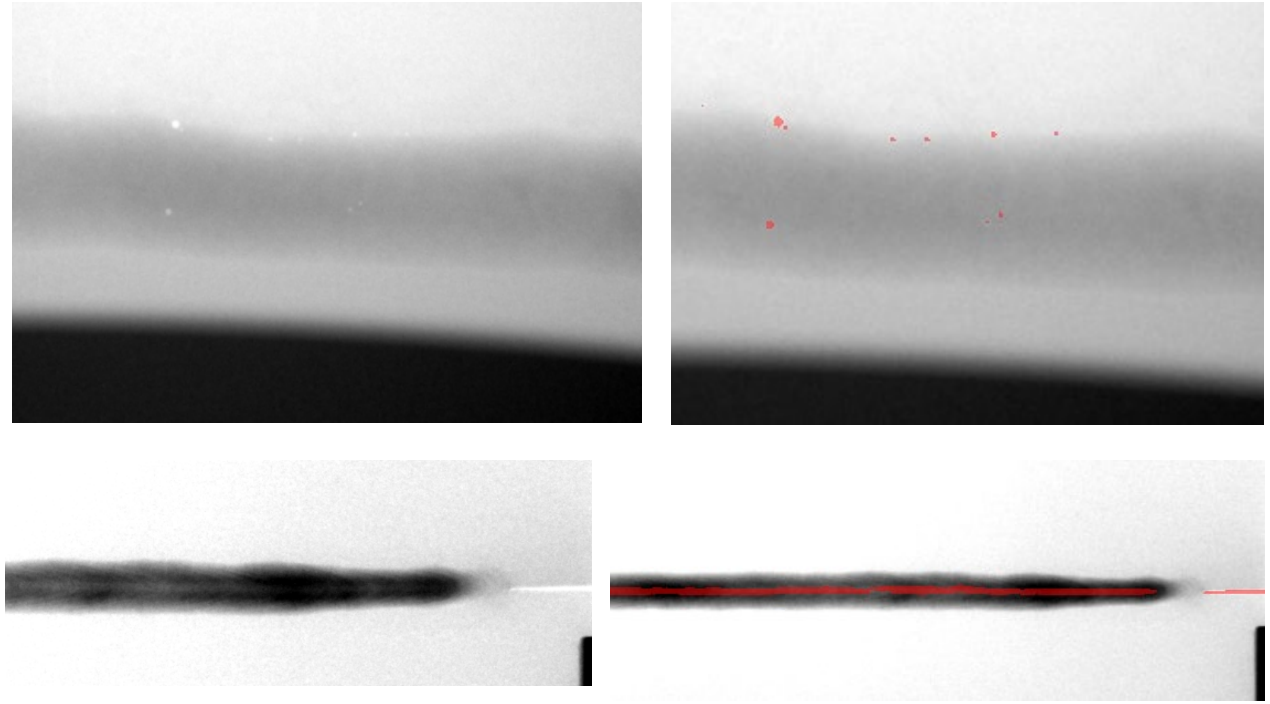


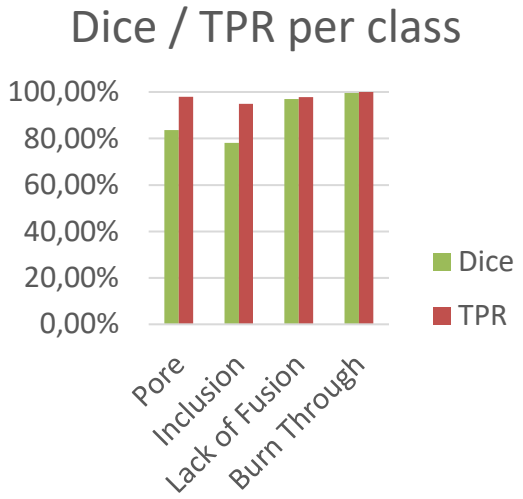
Aerospace Welds

Multiclass defect segmentation on welds

4 customer-specific classes:

1. cavity,
2. foreign material,
3. burn through,
4. lack of fusion





Eval Data	Pore	Inclusion	Lack of Fusion	Burn Through
Indication TPR	**97,94%**	**94,92%**	**97,88%**	**100%**
ø Dice-Score	**83,6%**	**78,17%**	**96,98%**	**99,69%**
No. Indications	1302	301	158	71
TP	1142	187	139	68
FN	24	10	3	0
FP	136	104	16	3

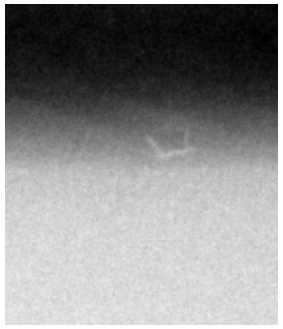
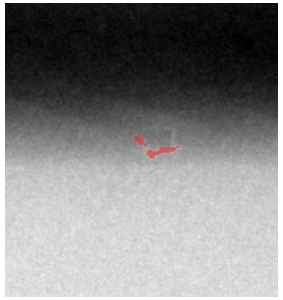
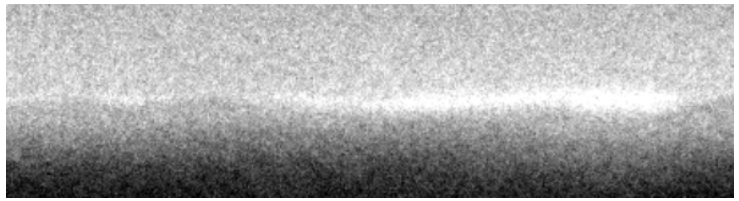
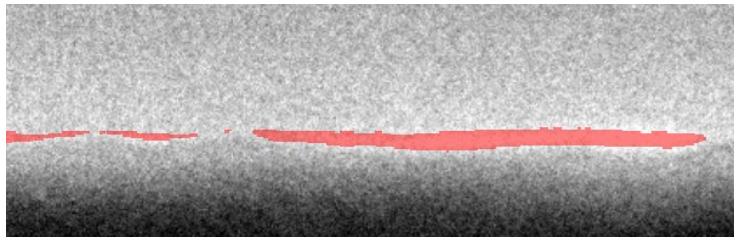
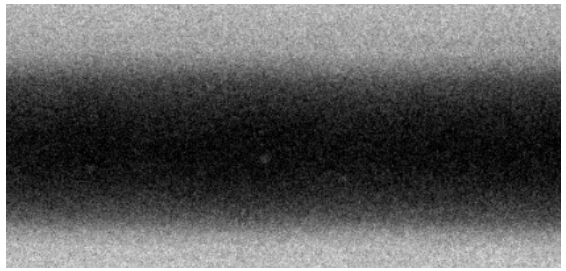
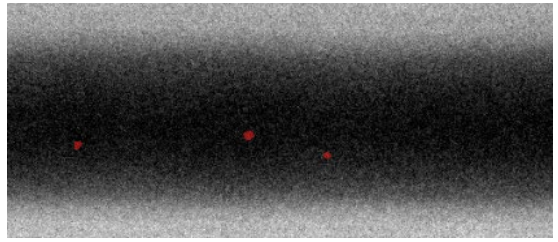
Oil & Gas Welds

Multiclass defect segmentation on welds
Classes according to DIN EN ISO 6520-1:2007
Grouped to 12 "head"-classes:

1. Cracks,
2. Low density inclusions,
3. Elongated cavities,
4. Solid inclusions,
5. Lack of fusion,
6. Lack of penetration,
7. Imperfect shape and dimension,
8. Undercuts,
9. Excessive weld metal,
10. Burn-trough,
11. Incomplete filled groove,
12. Spatter

Groundtruth information

EI no.	Record carrier	IQI sensitivity location: S			Result references no. according to DIN EN ISO 6520-1 [3]	Remarks [2]	Result	Indications from - to (mm)	BK no. [1]	Date
01		W 15	H 5	10D	WIRR		a		85	12.06.21
01		W 15	H 5	10D	2011		na	1900 - 1920	85	12.06.21
01		W 15	H 5	10D	TNW		a		85	12.06.21
01		W 15	H 5	10D	2014		na	2520 - 2590	85	12.06.21

Automotive Castings

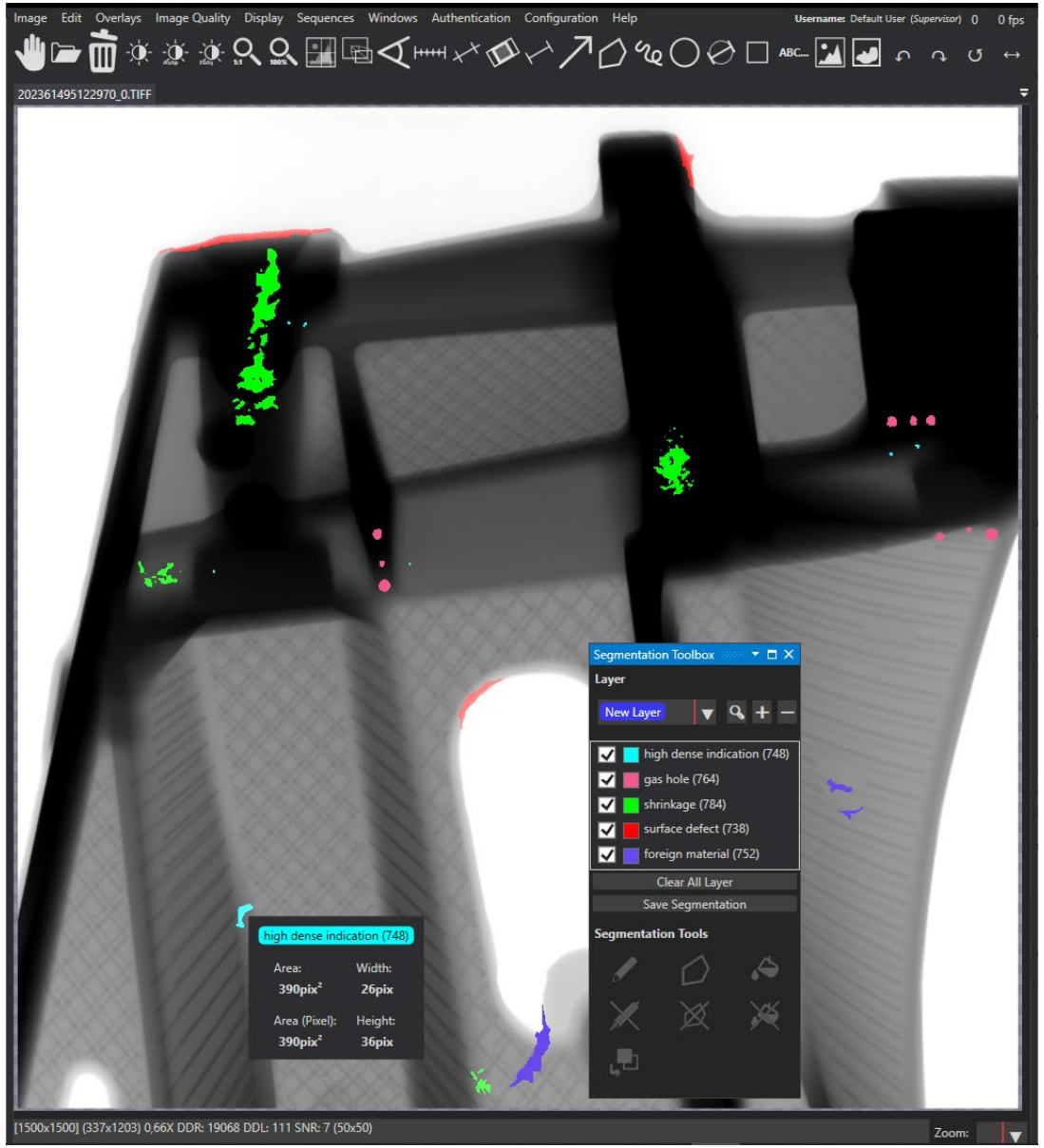
Multiclass defect segmentation on castings
Classes: according to ASTM references
Clustered to 6 "head"-classes:

1. Foreign material,
2. Gas hole,
3. Gas porosity,
4. Cold fill,
5. Shrinkage cavity,
6. Shrinkage filiament

Database:
Pretrained model weights

In progress:
Pretrained model weights
+ 7945 **multiclass** images
+ 7TB of data data

Prediction speed:
1024 x 1024 : 226ms
256 x 256: 120ms



Food Industry

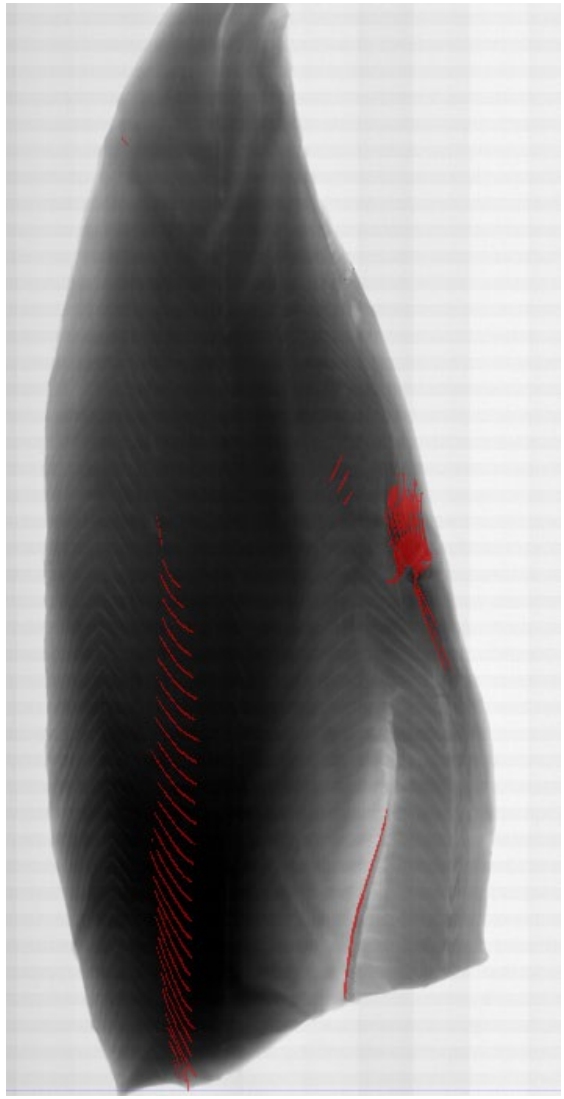
Binary fishbone segmentation on fillets

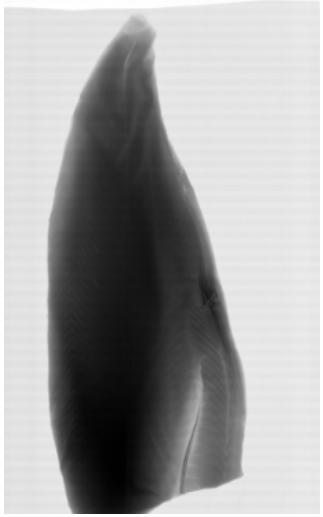
Database:
Pretrained model weights (of inclusion defects)
5 high-res images with GT masks (4096 x 6144)

256 x 256 Tiles – size independant prediction

Prediction speed:
4096 x 6144 : 4000ms
256 x 256: 120ms

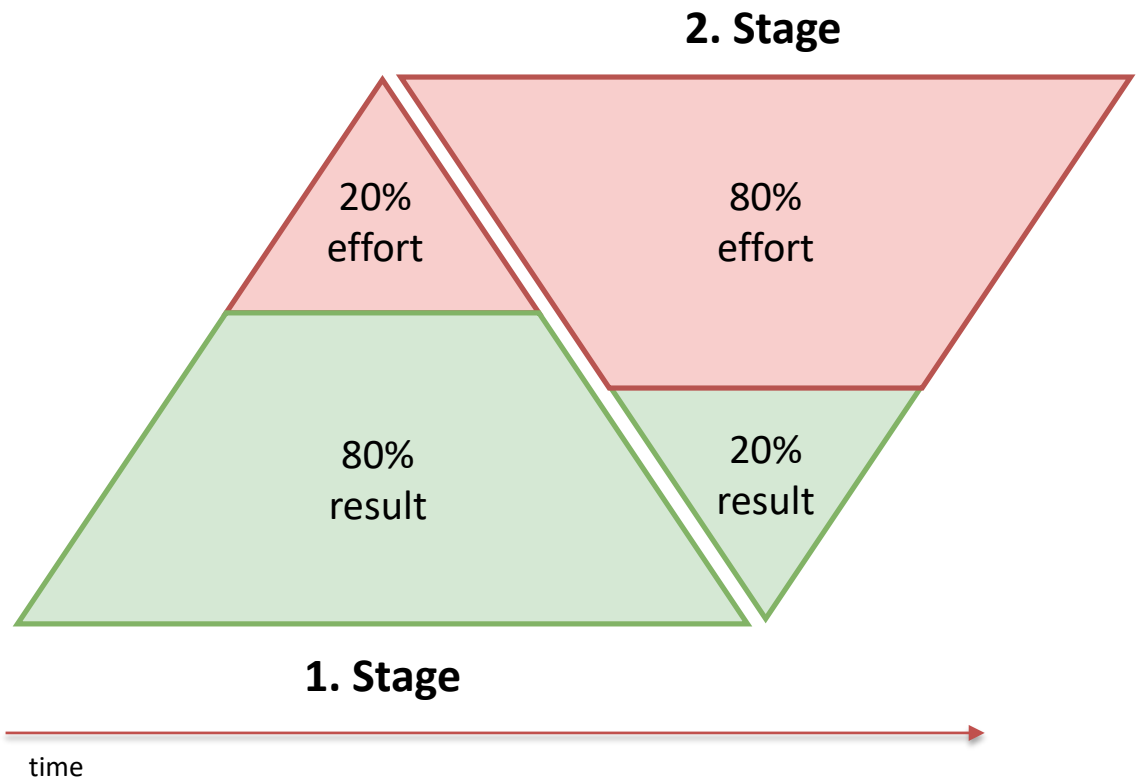
> 99% detection accuracy

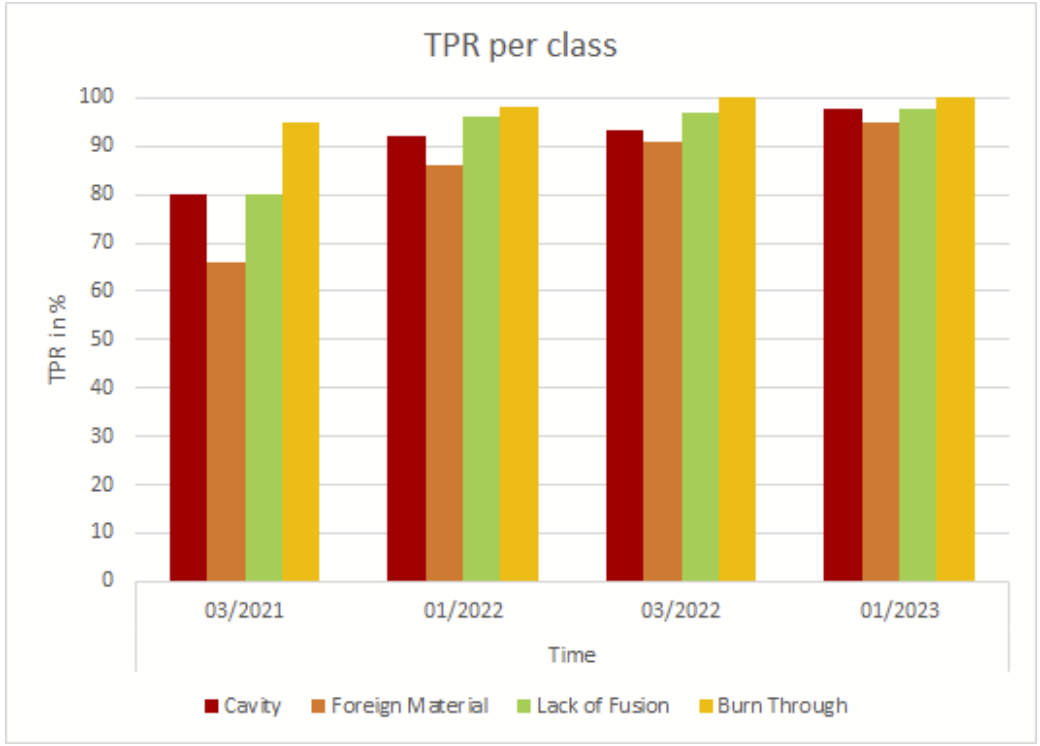




It is a marathon, not a sprint …

- 20% workload for 80% result
- 80% additional workload for additional 20% result





Implementation phases

Phase 1: Assisted AI

- AI supports decision making
- AI segments and measures all indications
- Operator performs final decision

→ **> 60% performance increase**

Phase 2: Assisted AI + Sorting

- AI supports decision making
- AI segments and measures all indications
- Operator performs final decision
- AI sorts out OK images (automatic OK)

→ **50% less images**

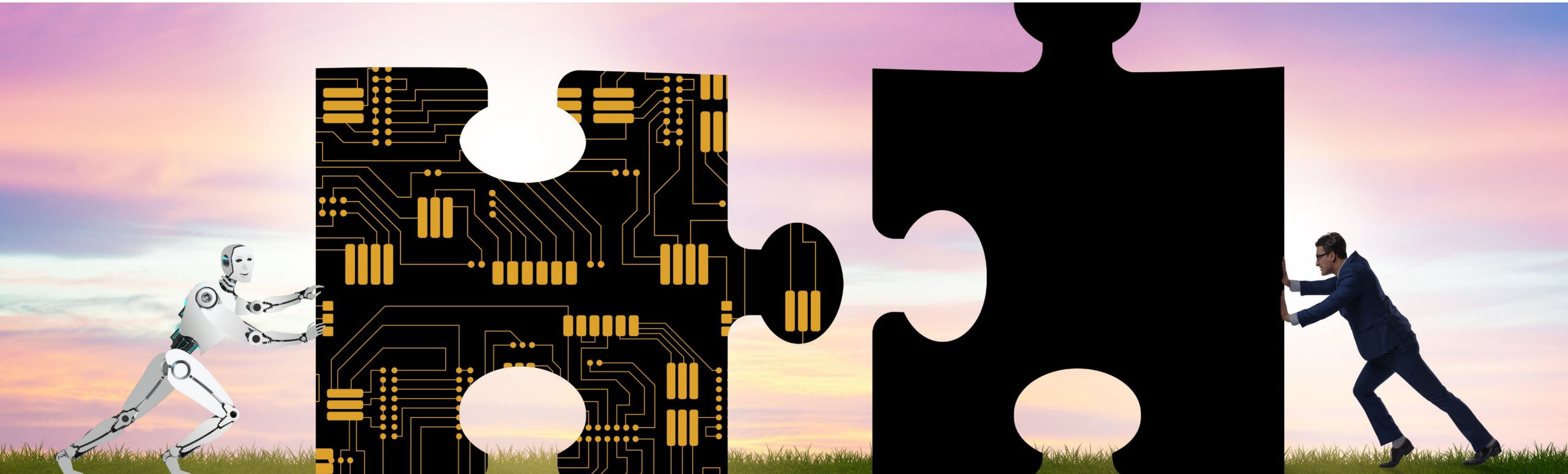
Phase 3: Full AI

- AI performs decision making
- AI segments and measures all indications
- Operator only supervises and assists AI where necessary

→ **Fully automated**

Human – Machine collaboration

- Smart usage of data to gain insights
- Application of AI to screen huge data pools
- Assisted application of AI to enhance human performance



Quality, efficiency and satisfaction gain

Figure 1: Treatment Effects on Productivity

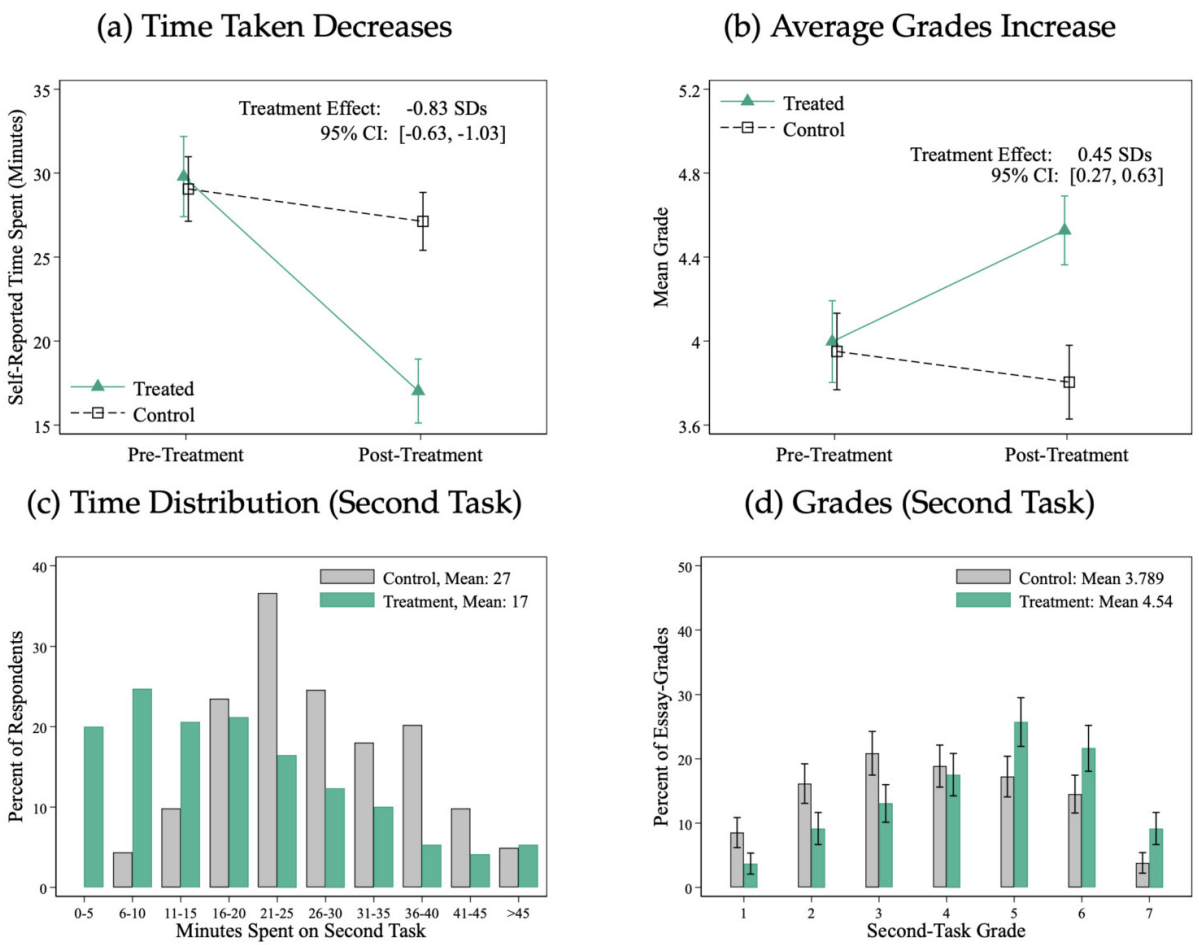
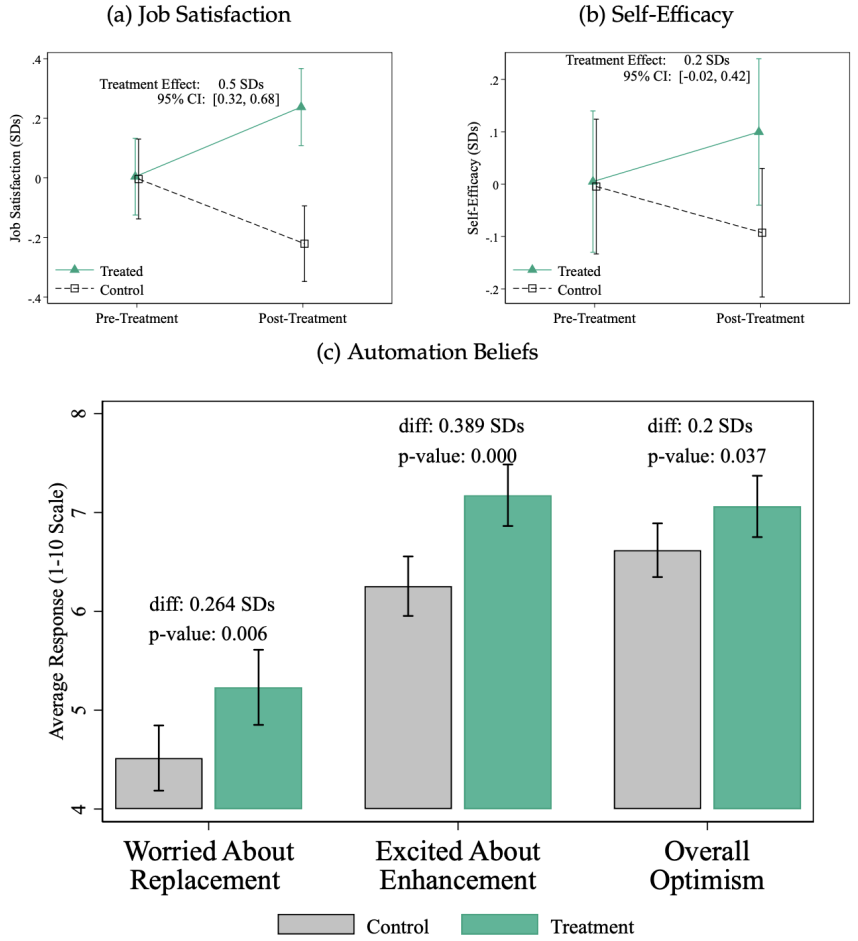


Figure 4: Effects on Subjective Outcomes



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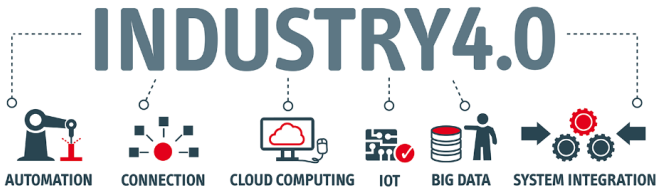
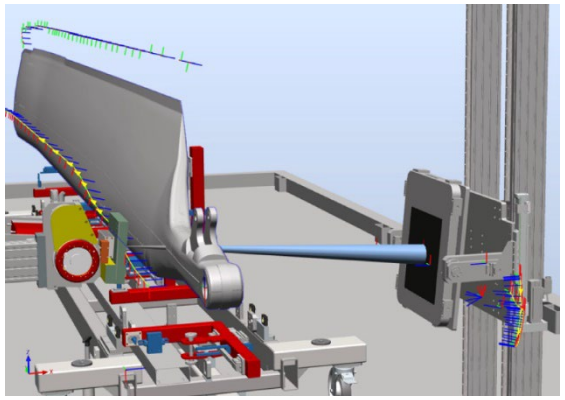
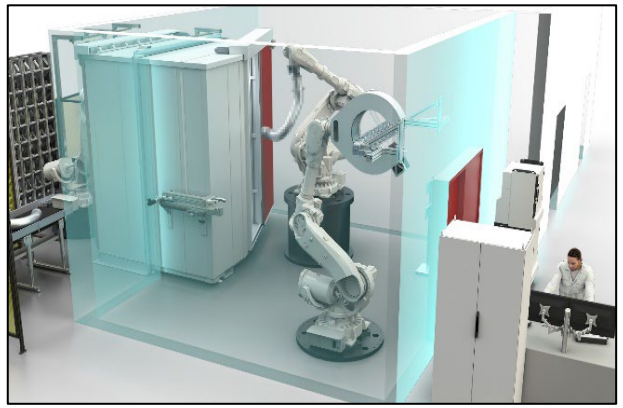
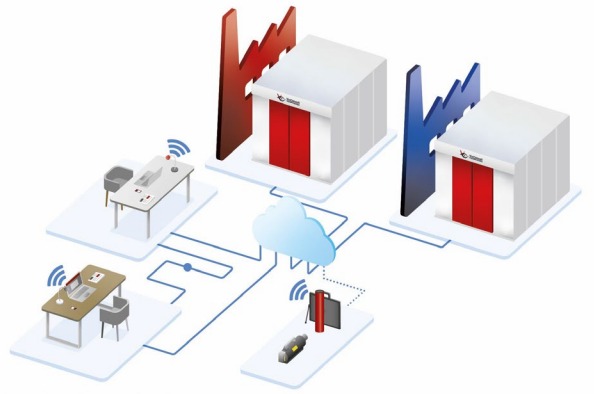




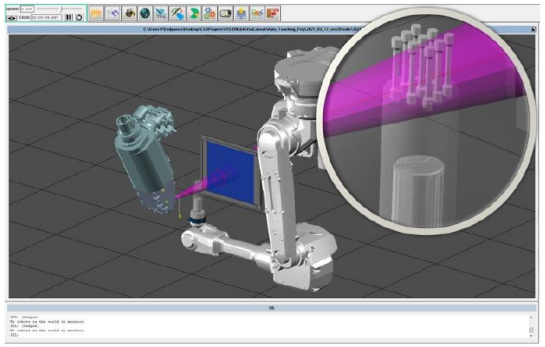
Automation



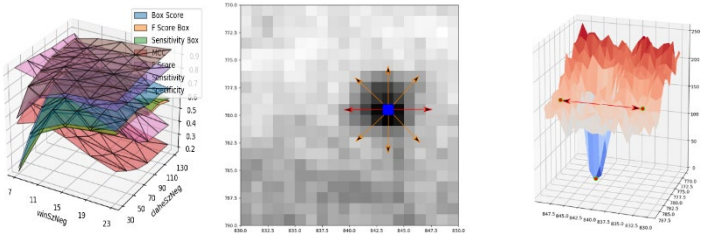
Robotics



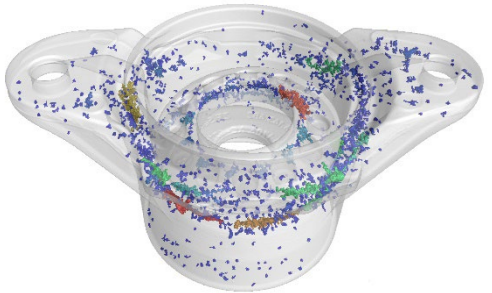
Cloud

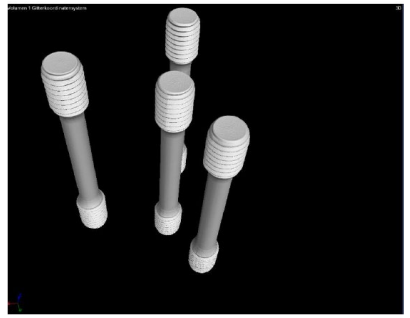


Simulation



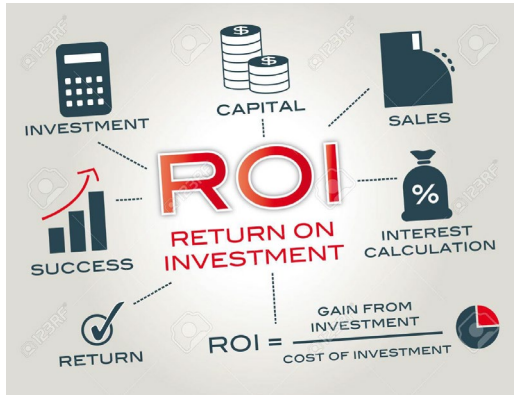
Artificial Intelligence





Computed Tomography

Thanks for your attention



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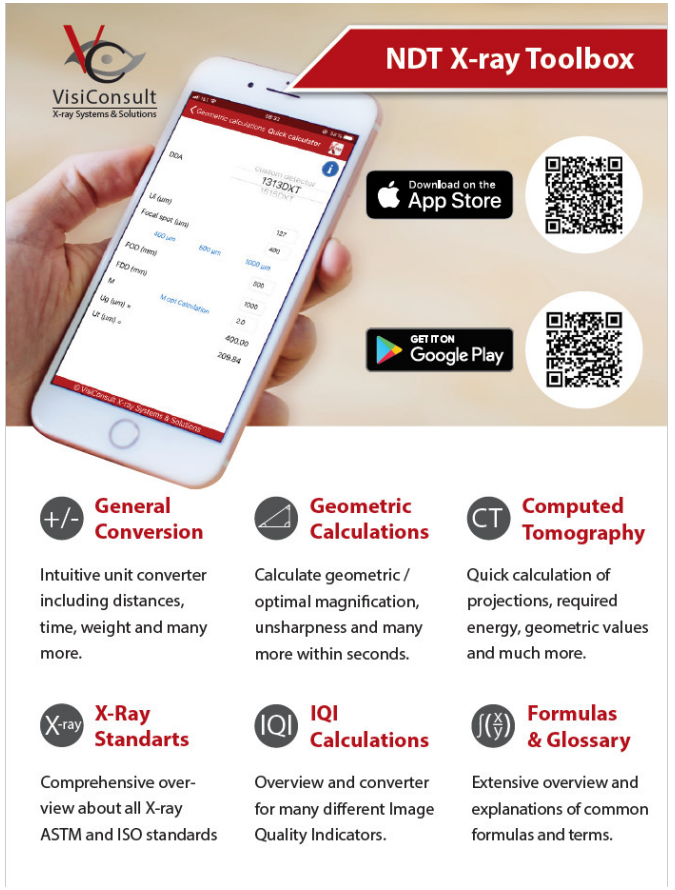

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Any questions?