Lincotek Medical

Why implementing AI in QC controls?

Project 03237
a.k.a. AQCAI

About our Group

Lincotek Surface Solutions

- Commercial and helicopter aircrafts parts processing.
- Hot gas and compressor section coatings.
- Small to large Gas Turbine (4 to 567MW).
- Hot gas section coatings (Airfoils, HS, Combustion parts).

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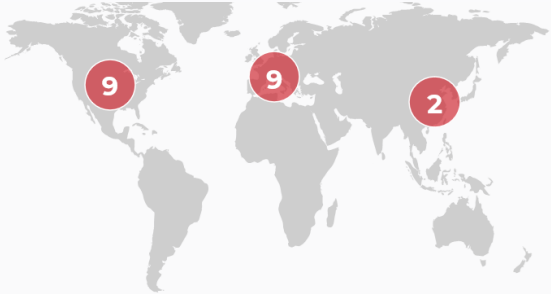
- Product development
- Machining
- Forging
- Casting
- AM
- Vacuum and air plasma spray coating of implants.
- Finishing and final packaging of products.

Lincotek Equipment

- Custom design & mfg with high degree of automation.
- Superior quality and productivity targets.



- Contract Manufacturer with specific focus on Integrated Supply Chain
- Segments: Medical, Aerospace and IGT.
- 50+ years in thermal spray coatings
- 20 manufacturing sites globally
- 1.700+ employees
- Double digit % sales growth last 10 years
- > 15% Revenue invested in CAPEX
- 60+ thermal spray systems
- 38 additive printing units in production
- 125 precision machining centers
- Forging, Casting, Anodizing
- 7 R&D Centers globally
- Privately owned

Leading end-to-end service offering

PRODUCT DEVELOPMENT

ADDITIVE MANUFACTURING

CASTING

FORGING

COATING SOLUTIONS

MACHINING

FINISHING AND POLISHING

ELECTROCHEMICAL TREATMENTS

CLEANING AND PACKAGING

HA SPRAY POWDER

Comprehensive Development & Manufacturing Expertise

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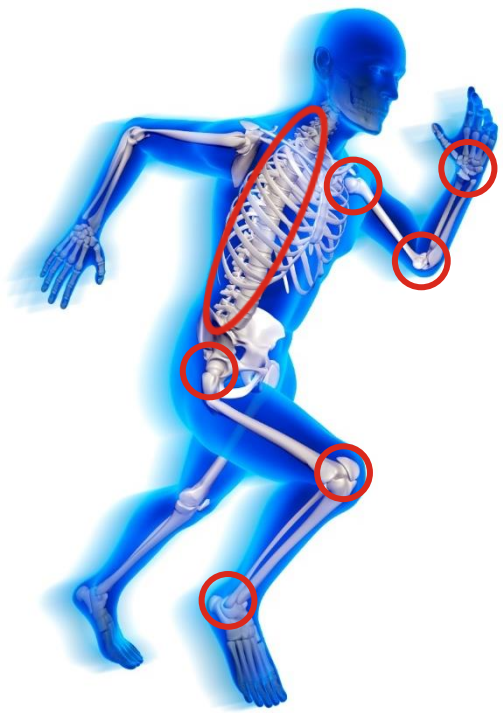
Spine Solutions

Reconstruction



Sport Medicine & Trauma

Extremities

Medical global footprint

Surface treatments - Danco Medical:
Warsaw, Indiana U.S.A
Changzhou, China.

R&D / Product Development:
Logan, UT – U.S.A.
Bologna, Italy
Trento, Italy

Additive Manufacturing:
Trento, Italy
Memphis, TN –U.S.A.

Casting:
Portland, OR – U.S.A.

Forging:
Torino, Italy

Precision Machining:
Bologna, Italy
Logan, UT – U.S.A.
Dayton, OH – U.S.A.
Portland, OR – U.S.A. (Femoral Grinding/Finishing)

Coating:
Trento, Italy
Salerno, Italy
Wuxi, China
Memphis, TN – U.S.A.

Facts & Figures

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- Contract Manufacturer with focus on medical devices and medical instruments
- 900+ employees worldwide | Danco Medical included
- Over 700 customers served worldwide: Europe, US, Asia
- Approximately 27M devices processed annually
- 18% CAGR 2010-2019 from organic growth
- ISO 13485, FDA, NMPA and JMHLW registered sites
- Around 400,000 square feet of capacity globally
- Global leader in thermal spray coatings services
- Global Precision Machining, Forging & Casting with > 125 precision machining centers
- Additive Manufacturing Pioneer with 25+ production units installed globally
- 800K + implantable devices produced with additive manufacturing, 100K+ per year
- 30+ Master Files registered with FDA
- Dedicated teams to drive R&D and Innovation

Plasma spray coatings and Quality Controls

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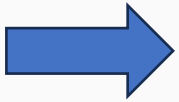
Quality controls divided in:

- Coating Properties
  - Destructive test, process controls on dummies
  - Mechanical Properties
  - Chemical Properties
  - Morphology

- Coating Dimensions
  - Non destructive tests
  - Measurement on devices or dummy

- Visual Inspection 100%
  - Batch number
  - Coated area visual inspection
  - Uncoated area visual inspection



Coated area	Uncoated area
• Black spot • White spot • Missing coating • Stain • Chipping • Coating clusters	• Scratch • Dent • Stain • Over spraying • Coating position out of spec

Examples of defect

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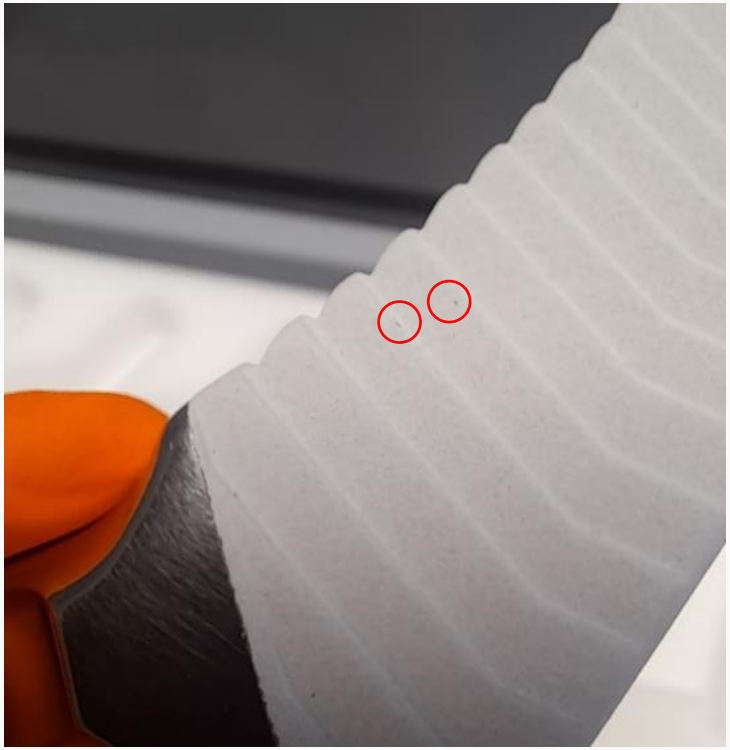

Human Visual Quality Controls

- Defects could be very small
- Subjective
- Dependent to light conditions
- Fatigue could lead to loss of efficacy
- Hard to cope with different acceptance criteria
  - Each customer has its own acceptance criteria
  - Each product family (belonging to the same customer) can have different acceptance criteria (defect catalogue)
  - 80 active customer, 1600 active product families
- Time consuming

Automated Visual Quality Controls

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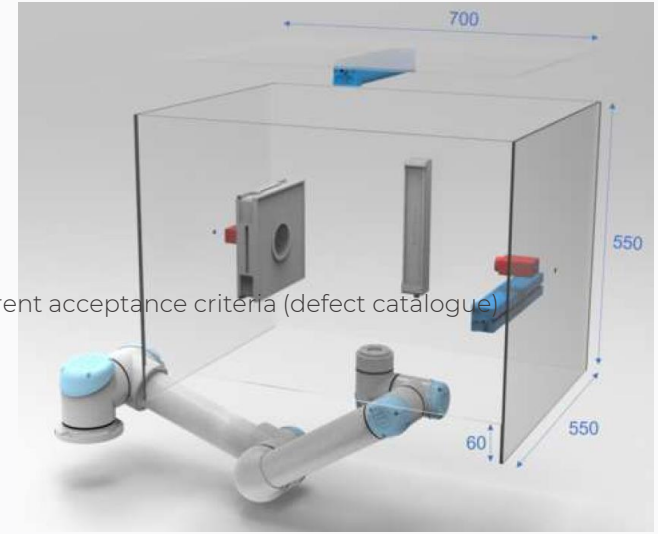
SOLVED



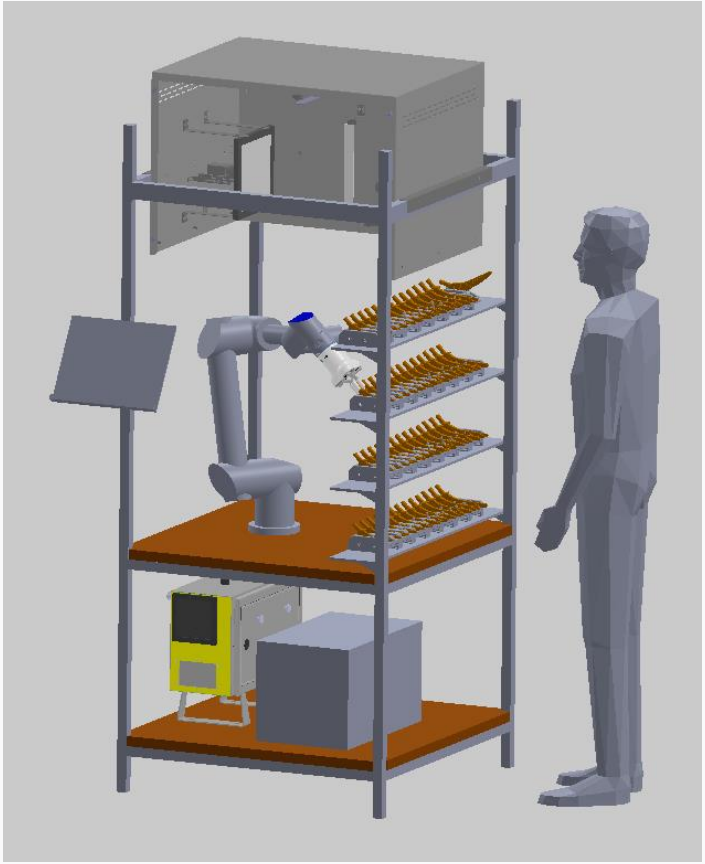
Why AI and not just Computer Vision?

- Optimal for classification
- Performs better (than others) with non standard geometries
- Capable of generalization

HW and SW

- HW setup
  - 2 high resolution cameras
  - Differents light for coated and uncoated surfaces
  - Cobot for part movements
  - Controller
  - Industrial PC

- SW setup
  - Object detection AI model based on YOLO CNN
  - Supplier proprietary web-platform
  - Integration with Cobot
  - Integration with SAP



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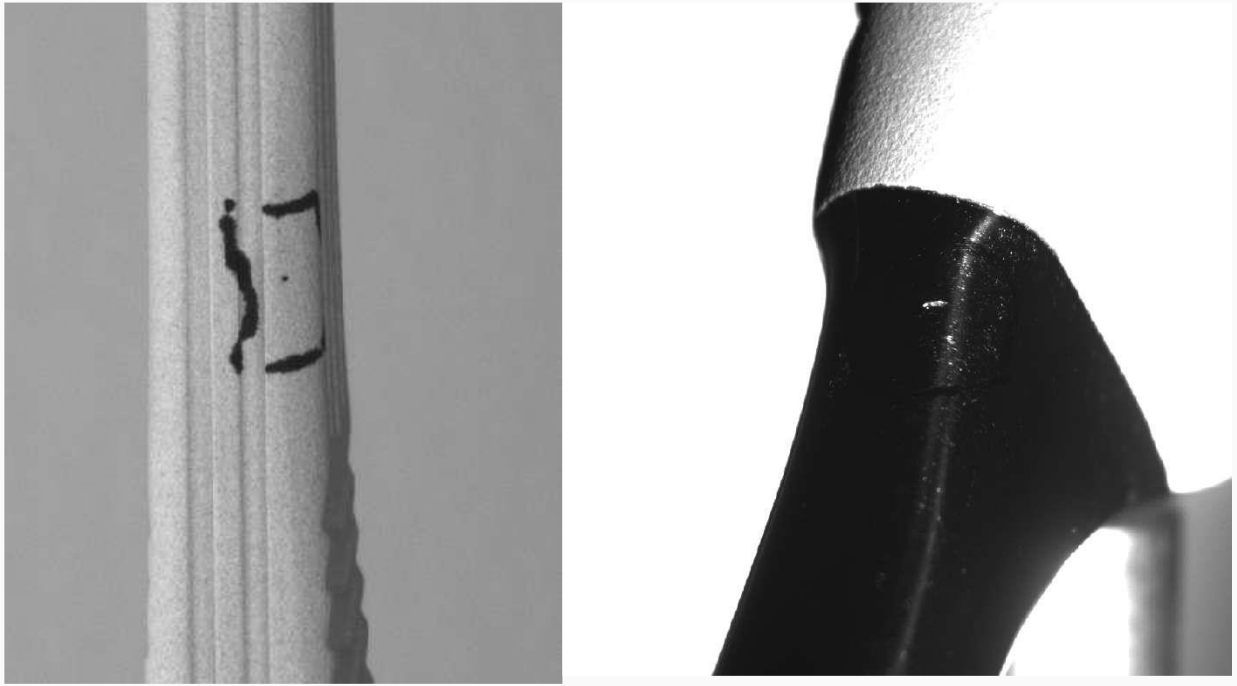
Need to capture the defect first



Parts are moved in front of the camera, continuous acquisition, several images for the same defects

AI Model evaluated

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- Anomaly detection: these AI models are trained only on «good» images, without defects, learning to identify anomaly as a difference in comparison to the reference
- Image classification: these AI models learn to classify an image with a single class lable different anomalies;
- Object detection: the widely used strategy due to its capability of identify and locate different object categories in an image

Each model brings pros and conts.

- Anomaly detection requires less images but is not working well with complicate geometries and images
- Image classification and Object detection requires way more data to teach the AI but allow preciser measurements and evaluation of the defects

Anomaly detection

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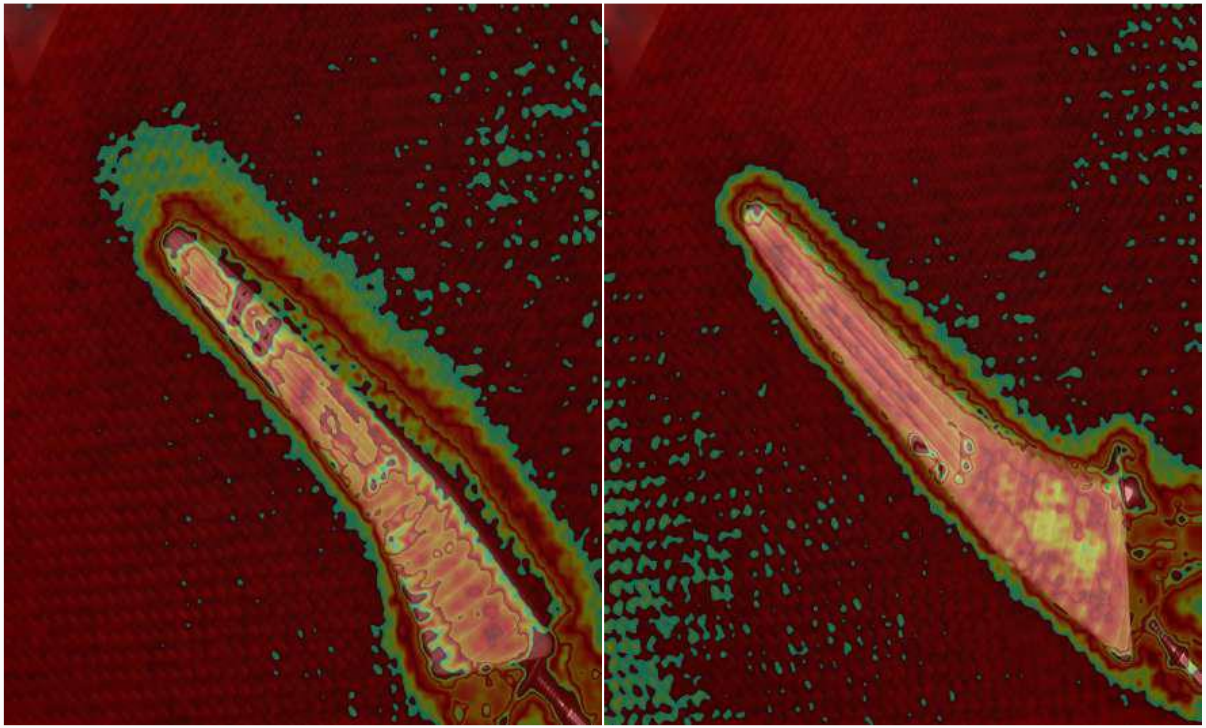
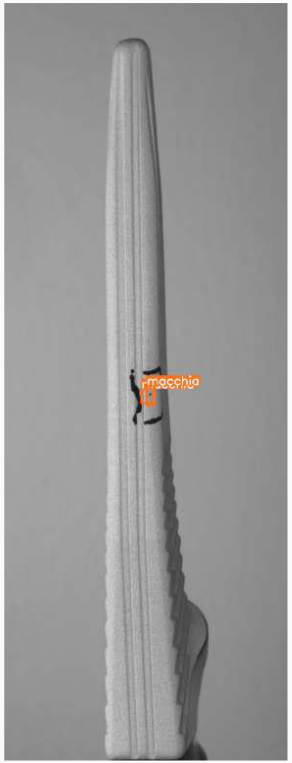


Both item features and defect were identified as anomalies

Object detection



Object detection

Instance segmentation

Project Status

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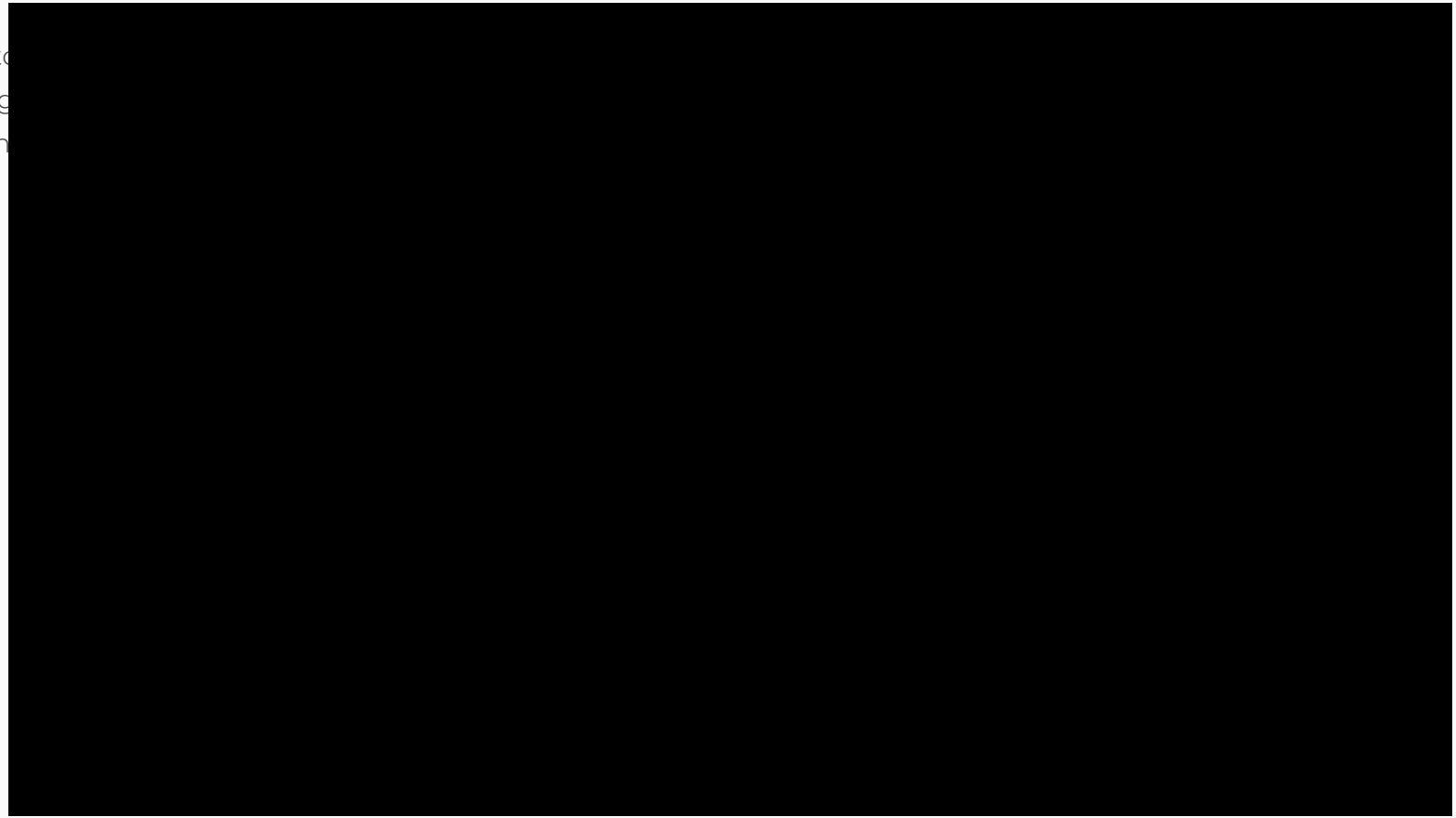
- Proto
- Imag
- Train



Is all that glitters gold? (.....is this a Stairway to heaven?)

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1. Is AI infallible in QC?
2. Is AI better than humans in QC?
3. Can AI replace humans in QC?

Is all that glitters gold? (.....is this a Stairway to heaven?)

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1. Is AI infallible in QC?
2. Is AI better than humans in QC?

Precision	80%	90%	95%	96%	97%	98%	99%
Instances per defect class	400	1200	3000	4000	5000	8000	15000
Instances per defect class with data augmentation	280	840	2100	2800	3500	5600	10500

Coated area	Uncoated area
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1. No, 100% is mathematically not achievable
2. AI can be more reliable than humans in a longer period (humans escape rate 0,06%), but requires a considerable effort to get there. Generalization capability still to be evaluated

Is all that glitters gold? (.....is this a Stairway to heaven?)

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3. Can AI replace humans in QC?

Not today:

- AI can be huge support to Human control with repeatable and objective measurements
- VALIDATIONS issues

But tomorrow....

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Thank you