Accelerate your digital transformation with the unique FUJITSU HXD approach
AI 3D Automated Surface Defect Recognition for Aerospace Applications

Sachiko FURUYA \textsuperscript{1a}, Shota TANAKA \textsuperscript{1b}, Kah Khoon GOH \textsuperscript{2}, Sean KOH \textsuperscript{2}, Michael DUSSERE \textsuperscript{1c}, Julien WALLART \textsuperscript{1c}, Peter CHOW \textsuperscript{1d}, Ian GODFREY \textsuperscript{1c}, Boon Choon LIM \textsuperscript{2} and Satoshi EMOTO \textsuperscript{1a}

\textsuperscript{1} Fujitsu – \textsuperscript{a} Japan, \textsuperscript{b} Singapore, \textsuperscript{c} France, \textsuperscript{d} UK
\textsuperscript{2} Hexagon Metrology Asia Pacific Private Limited, Singapore
Outline

- Project Introduction
- Current Aviation FPI Process and Challenges
- Integrated System - AI and 3D Metrology Scanners
- Test Objects and Results
- Conclusion
Project Introduction

#1 maintenance, repair, and overhaul

- **AI for NDT:** 3D surface defect recognition for industrial environments
- **Focus:** Aviation MRO#1 fluorescent penetrant inspection (FPI) on large complex parts
- Hexagon – 3D Industrial Metrology inspection domain expert and data acquisition
- Fujitsu – AI domain expert, algorithm, model training and testing

Hexagon solutions cover:
- 75% of cars produced
- 90% of aircraft produced
- 85% of smartphones produced

“Enabling a Human Centric Intelligent Society through a Human Centric approach to Digital Co-Creation”
Current Aviation FPI Process

- Inspection of engine components for surface defects and geometries e.g. engine casing, blades and vanes
- Often performed by a team of scarce and highly skilled technicians
- Lacks efficiency and effectiveness, scalability bottlenecks
Inspection Process Challenges

- **Human Inspection**: Inspections and recording of defects conducted by human visual method. It is labour intensive, tedious and require long hours to complete.

- **Inconsistent**: Detection rate, accuracy and integrity of the detection results are very human-dependent and inconsistent. Overlooking of defects during initial inspection is not uncommon and these errors can be very costly.

- **Insufficient Documentation**: Documentation of defects is often paper based. The process of passing information between different operators, stations and departments can be errors-prone and highly inefficient.

- **Scheduling bottleneck**: Repairing process requires repeated in-process defects inspection to ensure an almost 100% detection and repaired rate. The need for numerous repeated in-process inspections is often a key cause of process bottleneck in the entire maintenance schedule.

- **Inefficient**: Without a proper digital data of the defects’ profiles (e.g. defect type, size, positions and correlations of the defects to the component design), the maintenance process will remain grossly inadequate for any future automation and quality analysis of the aerospace components and its performance. Such inadequacies will hamper the future development of any predictive and prescriptive quality maintenance solutions.
Fujitsu Advanced Image Recognition (F|AIR)

- **Artificial Intelligence** to support customers and automate critical inspection processes
- Evolved from Fujitsu’s **30 years of AI expertise** the pioneers in this sector
- Replicates the vision and judgement only employees could previously provide
- Enables customers to achieve **80% efficiency savings**, with **99% detection accuracy**

www.fujitsu.com/FAIR
Integrated Configuration System

[Diagram showing the process of 3D scanning, defect detection, and AI integration for configuration systems.]
Fujitsu’s Imagification tool to create a range of 2D images for F|AIR

Compute correspondence maps between the image pixels and the spatial position of the 3D surface with the purpose of results by F|AIR projected back precisely
Advanced 3D Structured-light Scanners

- Hexagon’s 3D structured-light scanners are fast and highly accurate in capturing 3D physical surface data of both large and small aerospace components with complex geometries.

- When arranged in automated cell configuration (i.e., Hexagon PartInspect L), these scanners can autonomously operate in challenging workshop conditions without the use of markers.

- Hexagon 3D scanners offer a “back projection” function to highlight detected defects on the real component surface for identification and marking.
Test Objects

- Two objects were used to evaluate the performance of AI defect recognition
  - **Object 1** was a metal plate, folded at various angles along on a common axis, and pierced with multiple holes of differing shape and position
  - **Object 2** was a solid 3D printed metal body comprising angled and curved external surfaces, recesses and holes of different diameters and depth
- Artificial defects were created in many surfaces locations
- Variance in size, depth and angle was introduced to ensure the system was unbiased to the scanner observation position
Object 1 Result

- **2D projection**
  Precision = 92.0%, Recall = 76.6%

- **3D projection**
  Precision = 97.3%, Recall = 93.6%

Multiple 2D overlays aggregation

Close-up view of identified defects on 2D images

Detected defect from 2D images projected onto 3D surface

Precision = TP/(TP+FP)
Recall = TP/(TP+FN)

For values of True Positive (TP), False Positive (FP) and False Negative (FN)
Object 2 Result

- Similarly, detection accuracy on this object was 98.2%
Estimated Process Improvement

- From test objects allow us to project inspection time saving of 80%
Conclusion

- Presented a SDR solution for open environments
- Result shows productivity improvement of 80% on the cases studied
- Detection of cracks and dents from width size of 0.030 mm onwards
- Without the need of markers, FPI process and darkroom
- Initial evident supporting tangible benefits to the aerospace MRO industries and towards automated digitised inspection
- Opens up other opportunities e.g. repair automation and quality analysis