EFFECTIVE AND ACCURATE VIDEO-BASED DEFECT DETECTION

CHALLENGE OWNER

This problem statement is co-owned by two companies.

Challenge Owner 1
The Challenge Owner is a company specialising in the maintenance, repair and overhaul (MRO) of aircraft engines. They provide comprehensive MRO services which include engine overhaul, engine repair, engine testing, component repair and on-wing services. The Challenge Owner has a staff strength of over 2,000 and they serve the global aviation industry, primarily working with major airlines, aircraft leasing companies and engine Original Equipment Manufacturers (OEMs).

Challenge Owner 2
The Challenge Owner is a company specializing in the development and application of tungsten carbides, ceramics, and super-hard materials used in metal cutting and wear protection. They provide comprehensive solutions, including tooling systems, engineered components, and surface technologies. The Challenge Owner employs a workforce of over 8,000 and serves diverse industries such as aerospace, earthworks, energy, general engineering, and transportation. They primarily work with major industrial manufacturers, automotive companies, and energy producers, delivering advanced materials and solutions to enhance productivity and efficiency.

This sector-wide challenge is supported by the Advanced Remanufacturing and Technology Centre (ARTC), as part of the **A*STAR Advanced Manufacturing Startup Challenge 2024**, focusing on the theme of “Artificial Intelligence in Manufacturing”. ARTC is led by the Agency for Science, Technology and Research (A*STAR), in partnership with Nanyang Technological University Singapore. ARTC’s expertise in advanced manufacturing and remanufacturing accelerates the transfer of innovation from applied research to industrial applications and solutions, building capabilities through collaboration with their industry members. A*STAR aims to catalyse startup challenge winners to co-innovate and co-deploy advanced manufacturing solutions through ARTC's consortium.

CONTEXT

Both Challenge Owners have existing defect detection protocols supported by technology but are still heavily reliant on skilled personnel. They operate in industries that inspect high volumes of parts made from various materials, all subject to stringent quality and safety standards.

By adopting video-based inspection solutions, the owners aim to enhance defect detection, ensuring consistent accuracy to meet growing production demands while minimizing human and organizational risks. However, they face challenges in implementing video-based defect inspection due to the complexity and resource intensity of developing effective AI models.

Specialised Deep Learning Networks	Developing AI models for video-based defect inspection requires specialized deep learning networks to accurately analyse online video feeds and detect defects, involving complex algorithms to handle video data variability.
Time-Consuming Annotation Processes	Requires a large volume of annotated data. Annotating video frames for defect detection is time-consuming and labour-intensive, often requiring significant manual effort.
Accuracy and Efficiency	Inaccurate models can cause false positives or missed defects, while inefficient models may not work quickly enough for online use.
Integration and Deployment	Integrating AI models in an industrial environment is challenging. They must be robust to handle various shop floor conditions and seamlessly integrate with existing systems.

Challenge Owner 1

The Challenge Owner conducts inspections to assess the condition of critical aircraft parts, identify potential defects, and ensure the integrity and safety of the aircraft. In order to visually inspect narrow and difficult-to-reach areas without the need for disassembly, a borescope is used.

The current inspection and borescope operation process is as follows:

- Preparation and insertion. The technician inserts a borescope (an optic fibre with a camera and light source at its tip) into the access ports, guiding it to the areas of interest such as the turbine blades, compressor stages, or other critical engine components.
- Inspection. The technician manoeuvres the borescope to thoroughly inspect the internal surfaces and structures. A monitor displays the live video feed transmitted from the borescope camera for real-time inspection and defect detection. The technician records and captures images or videos of any anomalies, defects, or areas requiring further attention.
- Analysis and documentation. The technician examines the captured images and videos for signs of wear, cracks, corrosion, foreign object damage (FOD), thermal damage, and other defects. Inspection results are documented, including detailed descriptions of any defects found. The technician provides recommendations for repairs, replacements, or further inspections based on the findings.

Such an inspection poses the following challenges:

- Physically challenging. The technician often needs to navigate and manoeuvre the borescope around the engine, at times rotating the engine to insert the borescope at various angles, which is physically challenging.
- Inconsistent results. The effectiveness of identifying defects relies heavily on the technician's experience. As the quality of images captured by the borescope cameras is relatively low due to the lighting and field-of-view, accurately recognising defects and anomalies is often based on the technician's accumulated experience and previous encounters with similar issues.
- Time-consuming. Borescope inspections of aircrafts typically taking an average of 1.5 days to complete.

The Challenge Owner is seeking to transition to an automated inspection process. However, automated solutions in the industry are not able to meet their needs due to the following:

- Limited accuracy. The solutions that the Challenge Owner had tried only had accuracy levels of about 40%.
- Lack of real-time analysis. Some solutions require the videos captured to be uploaded for video analysis to detect defects instead of providing real-time defect detection.
- Lack of good training data. Many AI-powered detection solutions rely on static image data to train their AI model. However, images generated by the borescope are of low quality and are

primarily in video format. The nature of the MRO work is also high-mix low-volume. This results in low volume of training data available across the wide range of defects across different parts.

Challenge Owner 2

The Challenge Owner specializes in high-performance tooling solutions which includes drill bits. Currently, the inspection of these components is conducted manually, focusing on defects such as chipping, flaking and globs formed on the drill bits. The owner is seeking to transition from manual inspection to an automated, video-based defect inspection process to enhance accuracy and efficiency.

The current inspection process is as follows:

- Manual Visual Inspection. Skilled technicians manually inspect each drill bit for visible defects. This includes checking for chipping, flaking and globs.
- Dimensional Verification. Technicians use precision measuring tools to verify that the dimensions of the components meet the required specifications.
- Documentation. Any defects found during the inspection are documented, and the components are either sent for rework or scrapped.

Such an inspection poses the following challenges:

1. Manual Process Limitations
    - Inconsistency. The accuracy of defect detection is highly dependent on the skill and experience of the technician, leading to potential inconsistencies.
    - Time-Consuming. Manual inspection is labour-intensive and time-consuming, limiting the number of components that can be inspected in each timeframe.

2. Physical Strain
    - Ergonomic Issues. The manual inspection process can be physically demanding, leading to fatigue and potential oversight of defects.

3. Complex Defects
    - Detection Challenges. Some defects, such as internal cracks or subtle surface irregularities, may be difficult to detect through visual inspection alone.

The Challenge Owner is currently exploring defect detection using static images however would like to expand their scope to video based defect detection as well.

This problem statement is backed by two different problem statement owners, each with distinct use cases for the potential solution. When submitting your proposal, please indicate clearly which challenge owner you are addressing. If your solution is capable of addressing both use cases, you are welcome to indicate both.

PROBLEM STATEMENT

How might we develop a flexible solution for video-based defect detection that can successfully detect defects based on limited image and video data input?

WHAT ARE WE LOOKING FOR?

Challenge Owner 1

The Challenge Owner is looking for a solution for video-based defect detection of the maintenance and repair of aircraft engines.

The solution should meet the following criteria:

- Video-based defect detection. A solution that can detect anomalies and defects such as cracks, dents, corrosion, etc. based on video inputs. For the purposes of the prototype, the solution only needs to detect, and does not need to name and identify the different types of detected defects.
- Online detection. Provide online defect detection during inspections, enabling immediate action and decision-making.
- Effective learning with limited data. The solution must have the capability to be effectively trained with limited data input due to the high-mix low-volume nature of the parts being handled.
- Adaptability to new data. The solution should be able to adapt quickly to new data types and defect categories. This includes the ability to incorporate new defect types and aircraft parts with minimal retraining as well as the ability to pick up abnormalities.
- Allows high mobility. The solution should be portable and allow the user to be mobile while providing the same quality of inspection.

Challenge Owner 2

The Challenge Owner is looking for a solution for video-based defect detection for drill bits.

- Defect Detection. The solution must accurately detect various defects, including chipping, flaking and globs real-time.
- Instant Feedback. Provide real-time feedback and defect detection to streamline the inspection process.
- Video-Based Training. Utilize high-quality video data for training AI models, addressing the limitations of static image-based training.
- Multiple Sizes and Types. The solution should be scalable to inspect various sizes and types of drill bits produced by the owner.

A close-up of a drill bit. This image is used for illustration purposes and the exact type of drill bit used during the prototyping may vary

OVERALL PERFORMANCE REQUIREMENTS

Challenge Owner 1

- Accuracy. Achieve high accuracy in defect detection that is benchmarked to the human eye. The smallest defect that the technician can detect is around 0.5mm. The solution should have high sensitivity to ensure that all defects are captured. A higher false positive rate is preferred over any false negatives.

- Platform-agnostic. The solution should be able to work on different video-capturing devices without significant re-development. The long-term goal is for the solution to be able to detect defects with any input-capturing hardware such as a mobile phone.
- Scalability. Ensure that the solution is scalable so that once it is validated on the initial parts, it can be efficiently extended to other parts from large components like fan cases to small components like bolts and nuts and to a wide range of defect types.

Challenge Owner 2

- Accuracy. The prototype must achieve high accuracy in defect detection, comparable to or better than manual inspection by skilled technicians.
- Scalability. The prototype should be scalable so that once it is validated on an initial set of drill bits, it can be efficiently extended to other product sizes and types.
- Speed. The inspection process should be quick, providing online feedback and defect detection to streamline operations and reduce inspection times.

There are no restrictions on the geographical location of the problem solvers who may choose to apply to this challenge. However, the problem solvers who are keen to utilize A*STAR's funding for technology development must register/have registered a private limited company in Singapore. The prototype must also be demonstrated in Singapore.

METRICS OF SUCCESS

The solution should aim to have the following desired outcomes:

Challenge Owner 1

- Increased productivity. The solution should reduce the amount of time taken to perform an inspection by 10%. It currently takes an average of 1.5 days to complete an inspection on an aircraft.

Challenge Owner 2

- Increased Accuracy. The solution should be able to correctly identify true defects. It is defined as the ratio of the total number of true defects correctly reported by the system to the total number of defects reported by the system. A high accuracy rate indicates that the system is reliable in detecting actual defects and minimising false positives.

- Low Missing Rate. The solution should have a low missing rate which is measured by the solution's failure to detect defects and is calculated as the proportion of samples where defects were missed by the solution.

POSSIBLE USE CASES

Challenge Owner 1

Streamlined defect detection process. Henry is an aircraft technician who services aircraft engines for a major airline. A typical borescope inspection of the aircraft take about 1.5 days over three shifts, where Henry relies on his vision to identify defects based on the borescope's captured live videos and images. With the new solution in place, Henry takes a video recording of the aircraft parts and the solution detects and records the defects in real-time. Immediately after inspection, Henry is able to view a list of all the defects detected by the solution and decide on the follow-up steps. Henry is now able to complete the inspection within a day.

Challenge Owner 2

Streamlined defect detection process. James, a quality control technician, previously spent hours manually inspecting drill bits for defects like chipping, flaking and globs. With the new video-based defect inspection solution, video recordings are now captured using either an industrial camera or mobile phone, and the system detects defects online, presenting a detailed list of issues immediately after recording. This automated solution allows James to quickly single out and inspect the parts with defects and make faster decisions on whether the part should be sent for rework or be scrapped, thus completing his inspections quicker and improving efficiency and productivity of the manufacturing process.

WHAT'S IN IT FOR YOU

- SGD50,000 of prize money for each winner of this challenge (see Award Model)
- SGD150,000 A*STAR funding for technology development*
- 2-year ARTC Consortium Membership
- 1 shortlisted problem solver to be fast tracked to ESG's SLINGSHOT Top 50 and can look forward to an SGD 20,000 Startup SG Grant
- Access to IMDA's PIXEL corporate innovation hub and complimentary innovation consultancies (e.g. Design Thinking, Digital Storytelling) for the prototype development and commercialisation
- Opportunity to commercialise solution for deployment and adoption by ARTC members

**To access the A*STAR funding for technology development problem solvers must register/have registered a private limited company in Singapore to utilize the funding.*

EVALUATION CRITERIA

The evaluation process shall take place over two stages. Proposals shall be evaluated based on the evaluation criteria set out for the first stage. Thereafter, shortlisted proposals shall be subjected to a second stage evaluation in the form of an interview / pitch, and the scoring shall be based on a re-defined assessment criteria for the selection of the challenge finalist(s).

Solution Fit (30%)	Relevance: To what extent does the proposed solution address the problem statement effectively?
Solution Readiness (30%)	Maturity: How ready is the proposed solution to go to the market? Scalability: Is there any evidence to suggest capacity to scale?
Solution Advantage (20%)	Quality of Innovation: Is the solution cost effective and truly innovative? Does it make use of new technologies in the market, and can it potentially generate new IP?
Company Profile (20%)	Business Traction: Does the product have user and revenue traction? Team Experience: Do the team members possess strong scientific/technical background?

AWARD MODEL

30% of the prize money will be awarded to each selected finalist at the start of the POC/prototype development process. The remaining 70% will be awarded after completion of the POC/prototype solution, based on milestones agreed between Challenge Owner(s) and the solver. Prize money will be inclusive of any applicable taxes and duties that any of the parties may incur.

Note that a finalist who is selected to undertake the prototype development process will be required to:

- Enter into an agreement with Challenge Owner(s) that will include more detailed conditions pertaining to the prototype development;
- Complete an application form with IMDA that will require more financial and other related documents for potential co-funding support.

DEADLINE

All submissions must be made by **13 Sep 2024, 1600 hours (SGT/GMT +8)**. Challenge Owner(s) and IMDA may extend the deadline of the submission at their discretion. Late submissions on the OIP, or submissions via GeBIZ, will not be considered.