# VISUAL AI INSPECTION FOR SMART MANUFACTURING

## CONTEXT

Visual inspection is commonly used in both manufacturing and non-production environments which can span from traditional human visual inspection to fully automated detection of detects, in a single or multi-site. This is a critical process as there are high consequence in terms of inspection errors – injury, loss of expensive equipment, rework etc. As such, manufacturer of industrial components are especially cautious and stringent in the checks, as faulty components could result in high-maintenance cost and high downtime during repair for their clients.

Today, most industrial manufacturers of such components have a high-volume high mix inventory, manufactured from a range of equipment. In order to inspect in quality and in scale, they face with the following challenges:

1. Visual human inspection for critical components is time-consuming and heavily relies on engineers with the know-how, usually done manually piece by piece with heavy reliance on expert knowledge.

2. Components are in different sizes, geometry, profiles and specifications. Manufacturers require to either train the engineer to cover the spectrum of inspection or hire more subject matter experts. The components can vary from 2mm to 3m in length and each specification has different high-risk area of failure point. As such, the inspection process requires a lot of tacit knowledge from subject matter experts.

Companies have tried laser scanning, off-the-shelf computer vision solutions but faced with limitations. Current camera systems are mostly only able to capture images of the top and bottom of the components. It often lacks in capturing the 3D dimensions of the components for proper inspection and quality control.

Hence, there is interest to seek for a smart visual AI inspection solution that can help manufacturers easily capture and understand components and inserts, possibly compare with technical drawing for accuracy. The solution could take in the learnings of typical failure points and highlight the possible defects based on first view inspection, flagging out high-potential parts for human inspection. Industrial manufacturers can then focus in enhancing product quality and build greater products. By automating the visual inspection process, manufacturers can access quality inspection results fast enough to make a difference in future product quality. By leveraging on technology to effectively ensure the quality of each component, industrial machine and components manufacturers can better maintain customer satisfaction, minimize waste and recall and improve overall productivity and bottom line in a time of dire need.

This **ARTC Startup Challenge 2022** is organized by the Advanced Remanufacturing and Technology Centre (ARTC) in partnership with IMDA and A*StarCentral. The theme for the ARTC Startup Challenge 2022 is "**Automation 4.0**", and there are three challenges launched with IMDA's Open Innovation Platform.

The Advanced Remanufacturing and Technology Centre (ARTC) is led by the Agency for Science, Technology and Research (A*STAR), in partnership with the Nanyang Technological University, Singapore (NTU Singapore), with a membership consortium with over 80 members.

## PROBLEM STATEMENT

How might we automatically capture a 360-degree image of industrial manufacturing components sufficient enough for smart inspection?

## WHAT ARE WE LOOKING FOR?

A working prototype solution smart visual inspection solution that is able to match the following criteria:

**1. Automatic, Accurate, and Holistic Image Capturing**

- The solution must include a 360-degree rotational system/camera rig to rotate the cameras or parts to be inspected, in order to capture multiple profiles of the part and achieve a full rotational analysis. Camera system must be able to capture different geometrical profiles and shapes, like sharp and/or rounded corners, and capture different geometrical profiles and shapes.
    - Problem solvers are welcomed to propose different methods to rotate the cameras or parts to be inspected for holistic image capturing. Companies have tried using robotic arms but those are not preferred due to the cost and scalability concerns.
- The solution must be able to capture color of parts as part of inspection process
    - Problem owners have previously explored laser scanning and 3D modelling systems, but they were not effective due to:
        - Inability to capture color, only in gray scale
        - Inaccurate/cannot achieve 5-micron accuracy range
        - High noise level affecting 3D models and images
- The size of components is usually in the range of 2mm – 15cm. As the components have certain profiles (unevenness) on their surface, the depth of focus should be larger than 2 mm.
    - The images must be sharp, accurate, and have low noise levels for accurate dimension measurement/analysis and defects identification subsequently

**2. Intelligent Dimension Measurements with Smart Search Capabilities**

- The solution must be able to accurately generate the exact dimensions of a part/an insert, including length, width, height, depth, slant angles, etc. Dimension measurements must include linear and geometrical measurements.
- The solution must include an image database and a defect database, through the collection and storage of images of different parts
    - These databases will serve as training data to improve the accuracy of AI analysis of dimensions and defects identification
    - Over time with large volumes of training data, the solution should be able to provide recommendations for:
        - Repair actions required for different types of part damages

- Design improvements that can be made to parts to prevent damages or defects

**Overall Performance Requirements**

The problem solver should meet the following performance criteria in their proposal:

- **Accurate and fast** - The solution must have a high throughput rate, being able to accurately capture 360-degree images of an item under 1-minute.
- **Cost-effective** – The solution must be cost-effective so as to support the solution to scale across the wider manufacturing process.
- **Seamless** – The solution's output should be able to be seamlessly exported for further analysis as needed (e.g. Defects detection or Smart repair identification).

There are no restrictions on the geographical location of the problem solvers who may choose to apply to this challenge. However, the prototype must be demonstrated in Singapore.

Problem solvers should be start-ups with less than 5 years in operation.

## POSSIBLE USE CASES

1. **Smarter inspection of small components**– Kendrick works at a manufacturing plant, whose main job is to inspect and ensure that the flanks are fit for manufacturing processes. Typically, there is a digital image capturing solution that would capture the top and bottom image of the components and automatically detect for possibly defects. However, flanks are more complicated as they are multi-faceted (about 4-6 sides per flank) and cutting inserts are small in the range of a few cm or mm. Hence, Kendrick would need to visually inspect and capture the different sides of the flank as pre-manufacturing inspection. While a crucial step in ensuring quality products, this process is time-consuming and tedious for Kendrick.

   With the new solution, it automatically captures a robust 360-degree image of the flank. This includes taking a clear record of the profiles of the different cutting tips (e.g. circular or rounded), with a high resolution and coloured images for further processing. These images are able to be fed into the existing defects detection solution, to flag out any sub-standard flanks are not used for manufacturing. This solution allows Kendrick to spend more time on monitoring the actual inspection process, rather than manually taking and consolidating pictures of each component. With faster and more accurate flank images, the current defects detection system is also able to identify defects with greater speed and productivity. Overall, the factory is able to reduce its defects rate and guarantee customers with longer-lasting, higher performance industrial equipment.

2. **Automated inspection of multiple components –** Jasper works at a manufacturer of welding parts for industrial equipment. With over 20 years of industry experience, his job is to inspect the integrity of critical incoming components, to ensure that each are fit for assembly. As the types of components used varies greatly, this process is largely dependent on Jasper's tacit understanding of the industry and while crucial, is not the best use of Jasper's skills and experience.

With the new solution, it automatically captures a robust 360-degree image of the critical component parts to determine its integrity. It takes a clear record of the item profile and automatically measures key dimensions of the product. These images are fed to a separate smart algorithm, where it analyses if the component is fit for assembly. Instead of manually inspecting and taking pictures of individual parts, Jasper is able to focus on monitoring the overall manufacturing process from his office. Not only does this make better use of Jasper's skill and time, but there is also greater productivity and quality assurance on the manufactured equipment.

## WHAT'S IN IT FOR YOU

- SGD 50,000 of prize money for each winner of this challenge (see Award Model)
- 2-year Tier 3 ARTC Membership
- SGD 100,000 A*Star Innovation Voucher
- 4-month Accelerator Programme
- Gain access to IMDA's Technology resources and facility for prototyping
- Co-innovate with ARTC with access to their expertise in developing the solution
- Opportunity to commercialise solution for deployment and adoption by the sector members

## EVALUATION CRITERIA

The Applicants shall be evaluated in accordance with the evaluation criteria set out below.

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| **Solution Fit** | • To what extent does the proposed solution address the problem statement effectively? |
| **Solution Readiness** | • How ready is the proposed solution to go to the market?<br>• Is there any evidence to suggest capacity to scale? |
| **Solution Advantage** | • Is the solution cost effective and truly innovative?<br>• Does it make use of new technologies in the market, and can it potentially generate new IP?<br>• To share estimated cost for pilot trial, deployment and software support. |
| **Company Profile** | • Does the product have user and revenue traction?<br>• Do the team members possess strong scientific/technical background?<br>• Is the company able to demonstrate financial capability and resources to complete the prototype? |

## AWARD MODEL

30% of the prize money will be awarded to each selected finalist at the start of the POC/prototype development process, with the remainder 70% to be awarded after completion of the POC/prototype solution, based on milestones agreed between Problem 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 Problem 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 the co-funding support.

Teams with public research performers are required to seek an endorsement from their respective innovation and enterprise office, and submit the attached IEO form together with the proposal.

## DEADLINE

All submissions must be made by **28th January 2022, 1600 hours (SGT/GMT +8)**. Problem 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.