OPTIMISING SAFETY FOR HUMAN-ROBOT INTERACTIONS

CHALLENGE OWNER

The Challenge Owner is a multi-national engineering and technology company dedicated to enhancing quality of life through innovative, sustainable, and connected solutions. With a global workforce of more than 400,000 associates, the company leads in delivering high-quality products and services that meet the evolving needs of its customers, including:

- Automotive Parts and Systems: Sensors, fuel systems, brakes, and more.
- Industrial Technology: Drive and control technology, packaging technology.
- Consumer Goods: Power tools, household appliances.
- Energy and Building Technology: Security systems, heating systems, and building automation.

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**, focused 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.

To Note: Participants should approach this challenge with the intent to utilise A*STAR's intellectual property to resolve the problem statement and give due consideration to license, post-challenge.

CONTEXT

Currently, the Challenge Owner's disassembly process is highly manual and labour-intensive. To address this, the company has investigated technologies focusing on automated systems or static robotic systems, which require a large, fenced-off working environment that reduces the available workspace. Due to safety concerns, human operators are not allowed within these areas. This approach, while effective in task completion, limits flexibility and adaptability in cases which may require human intervention or human-robot collaboration.

The challenges faced when using the static manipulators include:

- Inflexible and inefficient. Robotics engineers are needed to pre-programme robots for specific manufacturing processes (e.g. disassembly) and any changes requires reprogramming and retesting. The entire process is time-consuming and inflexible, requiring advanced planning and precise definitions of movements and operations based on detailed task requirements. This is to ensure accuracy, optimise performance, and mitigate potential errors before the robots are deployed in actual production environments.
- Optimising sensitivity**.** If the sensors detect an impending collision, the robot takes preventive action by slowing down or stopping. A high sensitivity setting may lead to frequent interruptions and reduced productivity, while a low sensitivity setting may compromise safety. An appropriate trade-off between safety and productivity needs to be considered.
- Availability of safety-certified precision devices. Perception systems utilise cameras and LiDAR sensors to constantly scan the workspace for human and object presence. These systems require high precision and reliability to accurately detect human presence. Designing a safe architecture, using e. g. vision-based approach, can be challenging to provide sufficient safety guarantee (Performance Level or Safety Integrity Level) based on existing industrial safety standards.

The Challenge Owner is therefore looking for a solution that interfaces with mobile manipulators and enhances human-robot interaction while taking into account safety. AI-supported contextualisation of environments and instructions would allow the mobile manipulator to efficiently adapt to dynamic scenarios without the need for extensive pre-programming or manual operation. This solution would transform human-robot interaction from mere coexistence to productive collaboration which aims to improve the efficiency of manufacturing processes while maintaining high safety standards.

PROBLEM STATEMENT

How might we enhance human-robot interaction for mobile manipulators in dynamic environments while maintaining the safety of human operators?

WHAT ARE WE LOOKING FOR?

This challenge will explore the use case for robot mobile manipulators in the automotive sector. The disassembly of electric vehicle (EV) batteries is a new and highly manual process for which the Challenge Owner aims to develop a semi-automated process. The Challenge Owner is looking for the integration and use of Large Language/Vision Language Models with mobile manipulators, reducing the complexity of robot operations, and enhancing human-robot collaboration.

The solution should meet the following criteria:

- Natural commands and intuitive operations. The robot is able to complete tasks via verbal commands delivered through natural conversation (in English), ensuring ease of use.
- Collision avoidance. The robot must reliably detect and avoid human operators within its workspace to prevent collisions and potential injuries by planning collision-free trajectories.
- Compliance with industry safety regulations. While regulatory clearance and comprehensive risk assessmentare not a priority at the prototype stage, related safety standards (e.g. ISO 12100, ISO 10218) should be considered.
- Efficiency in dynamic environments. The robot is able to operate in a fenceless environment alongside human operators and is able to adapt its movements and manipulation strategies to unexpected changes in the environment, especially human presence, to maintain safety. This allows humans to work in close spatial proximity and in concurrent workflows such that the efficiency of human-robot collaboration is optimised.

This solution will be supported by ARTC in the development of backend dynamic planning and decision- making models. ARTC will also be able to provide hardware support, potentially contributing mobile bases, robotic arms, mobile manipulators, etc. Solution partners will focus on the frontend of human-robot interaction, providing speech/gesture recognition technology and integrating Large Language Models into mobile manipulators.

OVERALL PERFORMANCE REQUIREMENTS

- Process efficiency. The solution makes flexible, efficient decisions with an understanding of its operating context and environmental conditions.
- Safety. The solution prioritises the safety of human operators.
- Ease of use. The solution is user-friendly and does not require deep technical expertise to use.

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 utilise 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:

- Increased productivity. 10% to 30% reduction in time taken to disassemble an EV battery. Reduction in engineering time required to pre-programme the robot for each task. It currently takes around 1 day to disassemble an EV battery and around half a day to pre-programme a task (only a rough estimation for the purpose of this startup challenge without considering the exact level of automation).
- Manpower savings. 10 to 30% savings in manpower required. The current disassembly of EV batteries is fully manual or automated only for certain limited steps.

POSSIBLE USE CASES

1. Semi-automated disassembly of EV batteries. Henry is an operator who works on the disassembly of EV batteries which is an entirely manual process that takes up to one man-day to complete. The new solution enables rapid and precise disassembly which significantly reduces the time taken by him to complete his task. He is able to work on disassembling certain areas of the EV battery while giving verbal commands to the solution, which concurrently works on disassembling another part of the EV battery. With both human and robot working together, the disassembly process can now be completed in less than 1 day.

2. Simplification of programming tasks in robot operations. Jarod is a specialised robotics engineer who programmes static robots for specific manufacturing tasks. He typically takes half a day to programme a task. If there is any change in the configuration or product type, he will need to re-programme the task and disassembly will not be able to commence until he has finished re-programming. With natural language commands and AI-training models, Jarod is able to ensure that the robot is able to be deployed to the disassembly line quickly, thus reducing the overall resources required.

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 a SGD20,000 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.