ROS-Industrial Asia Pacific Updates and ARTC Application Highlights

Erik Unemyr, A*STAR ARTC
Introduction to A*STAR ARTC
**Agency for Science, Technology and Research (A*STAR)**

**VISION**
A global leader in science, technology and open innovation

**MISSION**
We advance science and develop innovative technology to further economic growth and improve lives

### Biomedical Research Council (BMRC)
- 11 Research Entities
- >5,200 Staff

### Science & Engineering Research Council (SERC)
- 9 Research Entities
- >4,100 Researchers, Engineers and Technical Support Staff

### A*ccelerate
- Commercialisation
- ~40% from >60 countries

### A*STAR Graduate Academy
- Scholarships
The Advanced Remanufacturing and Technology Centre

Leading Public-Private Partnership Research Centre in Asia

- Bridging the gap between Research and Industry
- Focus in Developing Advanced Manufacturing and Remanufacturing Capabilities
- Co-Create and Value Capture with Industry through the Implementation of Solutions
Bridging the Technological Valley of Death

ARTC was created for a step change model to drive in Public Private Partnership for translational R&D with industry

- ROI
- Productivity
- Value Creation
- Market Demand
- New Discoveries
- Fundamental Research
- Process Validation & Optimisation
- Conceptualisation of Technologies
- Addressing Industry Core Problems

Technology Readiness Level (TRL) is a scale for determining the maturity of a technology.
Our Achievements

1 of the leading Public Private Partnership Research Centres in Asia

>75 Industry Members with Global Presence

>285 Core Staff

>55 PhD students and Interns

6 Core Technology Themes
- Additive Manufacturing Industrialisation
- Advanced Remanufacturing
- Advanced Robotics Applications
- Data-Driven Surface Enhancement
- Intelligent Product Verification
- Smart Manufacturing

5 Industrial Flagship Programmes
- A*STAR Model Factory at ARTC
- Industrial Additive Manufacturing Facility (IAMF)
- ROS- Industrial Consortium
- A*STAR – Rolls-Royce – SAESL Smart Manufacturing Joint Lab
- Hyper-Personalisation Line

>430 Industrial projects successfully delivered
ROS-Industrial Asia Pacific Updates
ROS Growth Trend

Unique Monthly Downloads

- Jul 2016: 105,000 downloads (+105%)
- Jul 2017: 220,000 downloads (+41%)
- Jul 2018: 350,000 downloads (+33%)
- Jul 2019: 470,000 downloads (+33%)

Download statistics excludes mirrors so actual usage is higher!

Reaching towards 0.5 million unique downloads per month

Source: Open Robotics ROS Metrics Reports 2016-2019
**ROS Growth Trend**

**Unique monthly Wiki visitors Jul 2018 → Jul 2019**

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- 8 APAC countries in top 20
- APAC user base grew 12% YoY
- China now number #1 ROS user
- China user base grew 29% YoY
- Japan user base grew 27% YoY

Source: Open Robotics ROS Metrics Reports 2018-2019
Asia Pacific Membership

• 16 members in Asia Pacific (since Jul 2017) – 6 new members in 2019!
Highlights - Training

• We continue to support the industry with ROS training on regular basis:
  – May 21-24\textsuperscript{th} - Developer’s Training – First training on Melodic
  – Sep 21-24\textsuperscript{th} - Developer’s Training
  – Dec 10-13\textsuperscript{th} - Developer’s Training – As we speak!

• Future plans:
  – We are reviewing and improving training content
  – Planning for ROS 2.0 based training
  – Exploring more specialized ROS topics as additional courses and scaling up training
Highlights – Community and Student Engagement

• In March, organized together with new member Singapore Polytechnic a one week ROS Turtlebot hands on learning and coding challenge with participating Polytechnic students to spur further interest in ROS and robotics in our youth

• World ROS-I Day – 2nd July

• World MoveIt Day – 20th November

Future robotics engineers in the making!?!
Highlights – Asia Pacific Workshop

• The 2019 edition of the Asia Pacific Workshop held 18-19th June hosted over 100 attendees (from more than 25 countries) and included industry talks, demonstrations and group activities.
Highlights – Exhibitions

• The team exhibited at Industrial Transformation Asia Pacific (Singapore) 22-24 Oct and ROSCON (Macau) 31 Oct – 1 Nov, showcasing technology demos on ROS 2.0, Augmented Reality Robotics, Sensors Integration et c
Highlights - Packages to be Open Sourced

• **PackML2**
  - Solution that enables control of a PackML state machine that communicate between PLCs and ROS
  - Has been upgraded from original ROS 1.0 support to ROS 2.0 (tested on Dashing)

• **Robotic Vision Integration Pipeline (RVIP)**
  - Skeleton project that implements a complete pipeline for object detection, accurate object positioning using ML models, and pose estimation

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PackML (Packing Machine Language) state machine is commonly used by PLCs in packaging

RVIP architectural overview
2020 Key Focus

• **Membership** – ROS-Industrial Asia Pacific is continuing to grow its membership base with companies embracing open collaboration as well as equipment providers to grow the ROS ecosystem

• **ROS 2.0** – core development started are now based on ROS 2.0

• **Technology** – developing enabling features for the industry on top of ROS 2.0 that will help to *reduce barriers for adoption*. Technology areas include:

  - Advanced Perception
  - Intelligent Navigation
  - Smart Manipulation
  - Unified Communication with Robots (Interoperability)
Welcome to next year’s ROS-Industrial Asia Pacific Workshop!

**When:** 20-21\textsuperscript{st} May 2020

**Where:** Advanced Remanufacturing and Technology Centre, Singapore

QR Link for Online Registration and Info

Early Bird Promotion now Applicable!
Advanced Remanufacturing and Technology Centre – Application Highlights
Topic 1 – Simplified Robotics

Moving the needle for adoption by reducing the technology barrier from Engineer to Operator
Model-based Teaching of Robotics - Introduction

• **Problem Statement/Objectives**
  - A cobot is used in a gearbox assembly line to reduce human intervention in heavy and dangerous tasks. However, the objects to-be-picked currently have to be in precise predefined positions which is sometimes not feasible in an agile shopfloor environment
  - To automate cobot movement generation based on 2D/3D computer vision, allowing personalised order without re-programming the cobot

• **Benefits**
  - 3D computer vision based system is used to detect the gearbox parts placed anywhere on the tray. Optimal, collision-free robot motion are generated automatically based on this visual input
  - Process sequence is modeled as a state-machine that invokes the different devices and software modules

• **Using ROS**
  - MoveIt for motion control
  - Kuka robot driver control

• **Architectural Overview**

Courtesy of ARTC Advanced Robotics Applications Team
Model-based Teaching of Robotics - Showcase

1) Cobot station for gearbox assembly

2) Detection of gearbox parts on a tray

3) Modular programming GUI

4) Collision-free motion planning

Courtesy of ARTC Advanced Robotics Applications Team
Model-based Teaching of Robotics - Showcase

Select task *(Place)*

Managed by ARTC

Courtesy of ARTC Advanced Robotics Applications Team
Augmented Reality Teaching - Introduction

- **Problem Statement/Objectives**
  - Scalability of robotics solutions are hampered by the need of skilled engineers/technicians to program robots
  - Human robot collaboration requires improved safety visualization

- **Benefits**
  - Provides an operator with a simple user interface that can be used to program instructions for the robot directly in its deployment environment interacting with both static and dynamic objects in the robot’s work cell

- **Using ROS**
  - Developed a ROS module that can communicate with a Microsoft Hololens application
  - MoveIt for motion control
  - UR robot driver control
Augmented Reality Teaching - Showcase
Topic 2 – Process Applications

Providing flexibility to provide more automation in high-mix applications
Automatic Toolpath Generation - Introduction

• **Problem Statement/Objectives**
  - Machining industry demands robotic surface finishing capability for material removal process in order to achieve higher efficiency. Conventional robotic surface processing relies on CAD files and very skilled technicians, which could be time consuming especially for high-mix-low-volume production.

• **Benefits**
  - The system is dynamic and particularly suitable for high-mix-low-volume production, and applicable for those jobs that do not have CAD files or 3D models available.
  - Outline support
  - This system can be applied to various surface finishing processes: such as polishing, deburring, laser peening etc.

• **Using ROS**
  - MoveIt for motion control
  - Descartes for Cartesian path planning

Courtesy of ARTC Advanced Robotics Applications Team
Automatic Toolpath Generation - Showcase

Zig-Zag Fill Toolpath

Courtesy of ARTC Advanced Robotics Applications Team
Singapore Key ROS Initiatives
Industrial Robots Control

ROS-Industrial Capabilities
ROS-Industrial Capabilities

Collaborative Robots Control
ROS-Industrial Capabilities

Mobile Robots Control
Integration of Robotic Systems

Integration with Industrial Systems
Robotics Middleware Framework (RMF) for Healthcare

• **Project Overview**

  - Formally announced at ROSCON 2019 Macau
  
  - Government sponsored project to allow for large scale adoption of robots for Singapore healthcare sector
  
  - **ROS 2.0 middleware** allowing:
    
    - **Connectivity** to Hospital IT systems
    - **Interoperability** between robots as well as edge devices (including building infrastructure)
    - **Task and fleet scheduling**
    
    - Significant portions of project will be **Open Sourced**

• **Sponsor**

  - **National Robotics Programme (NRP)**

• **Participating Organizations**

  ![Participating Organizations Logos]
Current Situation

Challenges
- Prolonged deployment timelines
- Duplication in integration efforts
- Open loop in health IT systems
- Lack of ability for resource optimisation

Courtesy of Open Robotics (Singapore)
Challenges in Multi-fleet Deployment

Lack of Interoperability
- Lack of communication and integration between robots, medical devices, building infrastructure and health IT systems

Infrastructure Constraints
- Need to interface with lifts and doors
- Dedicated routes and lifts for robot

Lack of Realistic Test Environment
- Challenging and expensive to test effectiveness of large scale deployment of robotic solutions

Dynamic Environments
- Dynamic human traffic and crowds
- Direct contact with high volume of untrained personnel and visitors

Cybersecurity Concerns
- Increased reliance on network for data transmission

Courtesy of Open Robotics (Singapore)
Architectural Overview

Connecting Heterogeneous Fleets

- Submit spatio-temporal updates of robots in fleet
  - in standardized measurement frames
  - at regular intervals
- Receive job requests from Dispatch Planner and submit plan to Scheduler
  - conflict free
  - time optimal
- Submit requests to other building/automation systems
  - open doors, operate lifts
  - other robotic workcells
- Interface through common UI platforms
  - using hospital protocols

http://github.com/osrf/rmf_core
https://github.com/osrf/traffic-editor
https://github.com/osrf/soss

Cautionary note: Packages are works-in-progress and not yet well documented
Example – Coffee Delivery Task to Hospital Ward

Asset Generation and Large-Scale Operations Simulation Testing

Courtesy of Open Robotics (Singapore)
• Project Overview

  – ROS-Industrial Consortium and Open Robotics will collaborate to develop enhancements required to adopt RMF for commercial and industry sectors

  – ROS 2.0 middleware allowing:
    • Connectivity to brownfield systems
    • Interoperability between robots as well as edge devices (including building infrastructure)
    • Task and fleet scheduling

  – Significant portions of project will be Open Sourced

• Sponsor

  – National Robotics Programme (NRP)

• Participating Organizations

Robotics Interoperability – Allowing for Large Scale Deployments
Thank You
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Advanced Remanufacturing and Technology Centre

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