Introducing Your Presenters

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Advancing Open-Source for Industry
Industrial Robotics – Silos & Stagnation

Stagnated Due to Reliance on Large-scale Manufacturers that Leverage Sheer Volume to Offset Cost and Limitations

Industrial Robot Sales in North America 1993–2017

Typical Large Auto OEM

Custom SwRI Solution
A Disruption in Software for Automation

Enter ROS – Robot Operating System

- Open Source
- Established to prevent re-inventing the wheel
- Maintained by Open Robotics
- Reusable Software Components
- >1,000,000 user downloads/mo
ROS Releases and Journey to Industry

2008
• PR2 and ROS start at a research platform for universities and research institutes

Jan 2010
• ROS 1.0 is released with tutorials
• 12 releases between 2010-2018

Dec 2017
• First Beta release of ROS 2.0 for general use

Dec 2018
• Actions support
• Navigation package

May 2019
• Multi-axis robot motion planning

Jun 2020
• Latest release

Source: Open Robotics Presentation at ROSCON 2018 (Updated)
Goals for ROS 2.0

**product-ready**
- Use **industry-standard middleware** (e.g., DDS)
- Build in **security** from the beginning
- Support **Linux**, macOS, and **Windows**

**mission-critical**
- Support **real-time control**
- **Static analysis** (e.g., MISRA)
- Document design choices
- **Support safety certification**

**...but also familiar**
- Keep the core concepts from ROS 1
- Distributed systems
- Federated development
- Permissive open source license – allows for commercial hybrid model

**Important for mass-scale industry adoption**

Source: Open Robotics Presentation at ROSCON 2018 (Updated)
What is ROS-Industrial?
ROS-Industrial Timeline

2010
SwRI Adopts ROS

2011
ROS-I Inception

2012
ROS-I Launch

2013-2016
ROS-I Consortium

SwRI Unmanned Ground Systems

Robotics Coating Removal System

Robotic Workcell Visualization

Hardware Interfaces
Human Interfaces
Developer Tools
Reliable Code

MR ROAM Mobile Robot

Enable Global Leverage of Regional Development
Introduction to ROS-Industrial Consortium

- A Global Consortium with regional presence:
  - Southwest Research Institute, Texas
  - Fraunhofer IPA, Germany
  - Advanced Remanufacturing and Technology Centre, Singapore
Tech Vision Supported by Industry

- **ROS-Industrial Consortium** acts as an ecosystem where different players – end-users, equipment providers, system integrators, institutes of research and training partners **come together to advance and proliferate Open Source robotics**
Strategy for Capability Development

- Environment Layer (MoveIt, Tesseract, Dart, etc.)
- ROS 1 / ROS 2 / Middleware Layer
  - Messages, Topics
  - Collision Detection
  - Motion Planners
  - Kinematic Solvers
  - Connectivity Structure
  - Independent of ROS

Build ROS1 or ROS2, these are independent

Continue to support deployed end-user ROS1 systems with new capabilities as they are developed even if for a ROS2 solution
What Can ROS-I Do?
Industry Quality and Commercial Adoption

Robot Operating System packages adopts business friendly software licensing that do not taint Intellectual Property (allows for hybrid Open Source and proprietary solutions)

Industrial Quality

ROS-Industrial supports development of formal software development processes, and provides standardized automation tools for quality assurance for ROS modules

Business Friendly Open Source Software

Industrial Adoption
Collaboration

On-site at BMW Regensburg

Pre-competitive Focused Technical Projects between Industry Members (https://youtu.be/PWCpehyKnTY)

NIST-MTConnect-ROS Interoperability - Follow on MTConnect-OPC-UA-DDDS

Training Co-Development
Joint Industry & Collaboration Projects

Tech Demonstration of Robotic Blending Milestone 4
Caterpillar, 3M, GKN Aerospace, Wolf Robotics
https://youtu.be/PWCpehyKnTY

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

PackML FTP now available in ROS2 – Collaboration across regions and industry members
https://vimeo.com/378683073
Augmented Reality Teaching

• 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

1) Operator utilizes an Augmented Reality headset (Microsoft Hololens) – ARTC developed an interface between ROS and Hololens/Unity

2) Through the headset UI, the operator can instruct the robot to perform tasks through simple hand gestures

3) Robot has now “learned” the task and could replicate it autonomously
Augmented Reality Teaching
Model-based Teaching of Robotics

• **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.
Model-based Teaching of Robotics
High Mix Dynamic Toolpath Generation – Masking Application
Interoperable Large Scale Deployment of Robots - Robotics Middleware Framework (RMF)

- **Challenges in Multi-fleet Deployments**
- **Robotics Middleware Framework provide**
  - Connectivity to enterprise systems and peripherals through open interfaces
  - Interoperability between mobile and fixed robots as well as edge devices
  - Integration with building infrastructure (lifts, doors)
  - Task and fleet scheduling, traffic control
  - Simulation capabilities

- **Developed in Singapore for Healthcare sector by:**

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Advanced Remanufacturing and Technology Centre
RMF Beyond – Warehousing, Manufacturing, Facilities...

Collaborators:

- Advanced Remanufacturing and Technology Centre (ARTC)
- openrobotics

Video Link: https://vimeo.com/osrfoundation/review/405803151/c43403489d
ROSIN – EU support for ROS

Pitch to the funding agency (EC):

– “sweat equity” of OSS: those who put the work have a say
– instead of funding yet another framework, foster EU’s role in ROS with public €

4-years, ~8 million EUR H2020 project (1.2017-12.2020)

– Builds upon what exists; sustainable results after its completion
– Key actions to make ROS better, business friendlier, more accessible
– (Extra goal:) cluster other EU-based publicly funded activities using ROS
ROSIN – EU support for ROS

better

Software Quality

ROS-I best practices and tools: continuous integration, unit testing, code reviews

ROSIN further improves on them with code scanning, automated test generation, model-in-the-loop testing

rosin-project.eu/software-quality-assurance

business friendlier

New components

ROSIN FTPs: 3.5 Million € to third parties for ROS-Industrial development. Develop missing components or improve existing ones.

Commercial release template (licensing, etc)

rosin-project.eu/ftps

more accessible

Education

ROSIN summer schools: Educate students

ROS-I academy: Educate professionals

Education projects: Fund your ROS education initiative

rosin-project.eu/education
ROSIN – EU support for ROS
Industrialization in EU: piTasc + Drag & Bot

- Easy robot programming for industrial robots
  - Everyone can program a robot
  - Simple graphical user interface
  - Control any industrial robot
  - Advanced force controlled assembly processes

- Start-up company Drag & Bot

- Systems in deployed in industrial operation
Industrialization in EU: UR & Pilz & ABB

Robot OEMs start adopting ROS and see the value

- **Pilz:**
  - Drivers for PRBT robot
  - Drivers for Sensors
  - Further packages i.e. industrial trajectory generation
  - Safety certification of ROS based control under way

- **UR:**
  - Drivers for UR robots

- **ABB:**
  - Support of the community effort & part of ROSIN project
ROS-Industrial Integrator Deployment

Intuitive Process Application – Registration, Multi-Process Planning
A5 – Agility in Aerospace Applications
ROS2 System Implementation

- In collaboration with Spirit AeroSystems and Wichita State University with funding provided via the ARM Institute
- Development of a Human-in-the-Loop collaborative composite sanding first article solution for aerospace components
- Full ROS2, with off-line path planning leveraging automatic path planning
- Trajectory optimization for motion execution
- Visual feedback on reach availability
- Velocity controlled trajectory execution
- Dynamic path planning based on human markings on the part

https://arminstitute.org/projects/collaborative-robotic-sanding-of-aircraft-panels/
https://github.com/swri-robotics/collaborative-robotic-sanding
Resources

ROS-Industrial
Home: rosinustrial.org
Documentation: wiki.ros.org/industrial
Training: http://ros-industrial.github.io/industrial_training/
Upcoming Events: https://rosindustrial.org/events-summary/
ROSin: http://rosin-project.eu/

SwRI Robotics: https://www.swri.org/industries/industrial-robotics-automation
ARTC: https://www.a-star.edu.sg/artc
Fraunhofer IPA: https://www.ipa.fraunhofer.de/en.html