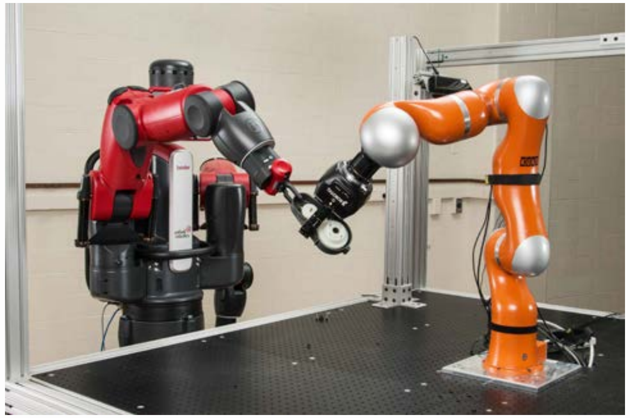
Robotic Systems for Smart Manufacturing



Elena Messina, Program Manager
Leader, Manipulation & Mobility Systems
Intelligent Systems Division
Engineering Laboratory

https://www.nist.gov/programs-projects/robotic-systems-smart-manufacturing-program

Overview

- Laboratory Research Program
  - Robotic Systems for Smart Manufacturing
- Collaboration with Manufacturing Extension Partnership
- Collaboration with Manufacturing USA
  - Advanced Robotics for Manufacturing Institute

Current State of Robotics in Manufacturing

- Strong, fast, repeatable, tireless
- Ad hoc, expensive custom solutions for installation, fixturing, tooling, integration
- Static: work comes to the robot
- Lengthy programming & tweaking for each new task
- Limited or no ability to deal with variations or errors
- Separated from humans for safety; cannot collaborate/assist

Vision for Robotics in Manufacturing

In other words,
robots that are cost effective to use

- ➢ in dynamic, unstructured shop floors
- ➢ by non-specialist operators to
  - ✓ increase productivity
  - ✓ improve quality
  - ✓ reduce ergonomic and safety concerns.

Robots that are sensing- and knowledge-enabled to:

- Execute tasks with minimal upfront programming, without expensive end-of-arm tooling
- Adapt to variations in part position, size and other changes in their workspace, reducing the need for custom fixturing
- Intelligently navigate around the factory; go to where the work is
- Assist humans by working safely and collaboratively
- Be easily installed and integrated with subsystems and rest of enterprise

What is Needed to Achieve the Future Vision?

Robots that are

- Easy to install and integrate into enterprise
  - Plug and play
  - Streamlined calibration and registration
- Reconfigurable
  - Mobile solutions: go to where the work is
  - Can handle a broader range of parts with general-purpose end-of-arm tool ("hand")
- Adaptable and agile
  - Easy to program and re-task
  - Able to use on-board sensors to perform task, recognize failures, and re-plan
- Partners with humans to amplify productivity and quality
  - Intrinsically safe working next to and in collaboration with humans
  - Intuitive interfaces for collaborating with humans

Enabling Technologies

Integration & Interoperability

Autonomous Mobility

Mobile Manipulation

Dexterous Advanced Grasping

Planning Agility

Robust Perception

Safety Assurance

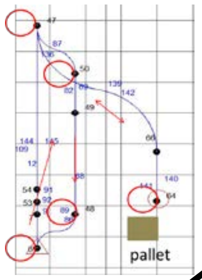
Collaborative Robot Systems

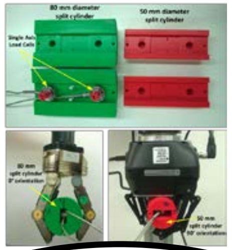
Robotic Systems for Smart Manufacturing Project Structure

Reducing risks in adopting new technology and helping spur innovation

Performance Assessment Framework for Robotic Systems

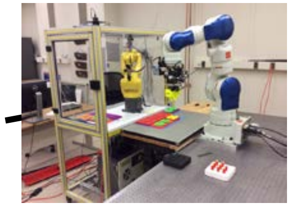
Assess and assure robot elemental & task performance





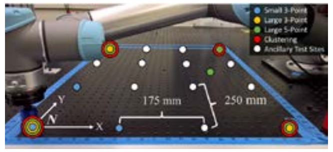
Agility Performance of Robotic Systems

Easily and rapidly reconfigure and re-task robots



Performance of Collaborative Robot Systems

Ensure robots working collaboratively meet performance objectives



Robotic Systems Interoperability and Integration

Easily and rapidly put together robotic systems

Tools for Collaborative Robots Within SME Workcells

Reduce the technical barriers to adopting robots

Robotic Systems for Smart Manufacturing

- Objective: To develop and deploy advances in measurement science that enhance U. S. innovation and industrial competitiveness by improving robotic system performance, collaboration, agility, and ease of integration into the enterprise to achieve dynamic production for assembly-centric manufacturing.
- Examples of our work
  - Safety standards: Collaborative robots (RIA, ISO); industrial vehicles (ANSI ITSDF)
  - Creation and leadership of new ASTM F45 Committee on A-UGV performance; 5 standards approved thus far
  - Definition of robot “agility” (adaptability) measures; inspire community via Agile Robots in Industrial Applications Competition (ARIAC)
  - Definition of metrics, prototyping of artifacts and test methods for robotic hands and assembly tasks
  - Development of evaluation methodologies for next-generation robot interfaces (Augmented, Virtual Reality)

Examples of RSSM Contributions

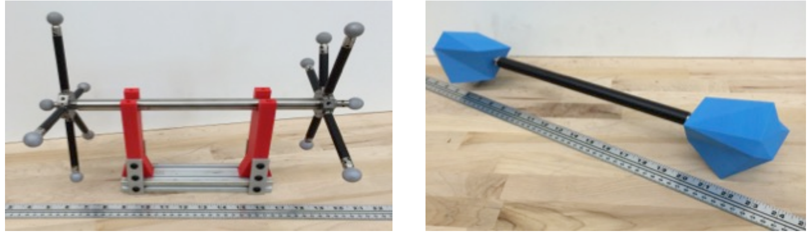
Metrics, Test Methods

Elemental Grasp Metrics

Mobile Manipulator Localization Relative to Workpiece

Ground Truth, Artifacts

Instrumented Metrology Bar for Robot Coordinated Motion Evaluation

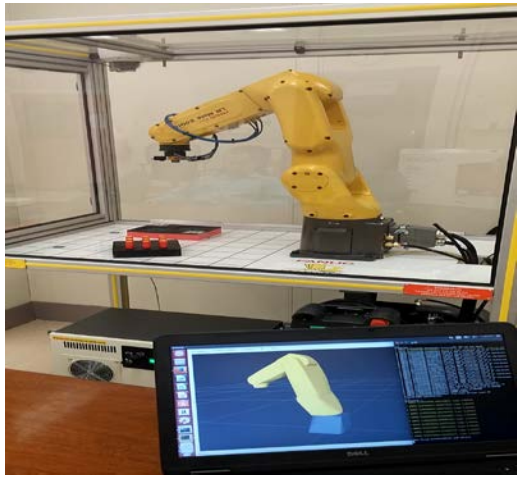


Artifacts for Dynamic 6DOF Pose Evaluation (ASTM E57)

Datasets

3D Data for the Evaluation of Point-Based, Rigid Body Registration Error

Interface Languages



Canonical Robot Command Language

Software Tools

Performance Data Analytics

Performance Data Analytics

Attribute and Ordinal Data:

Algorithms:

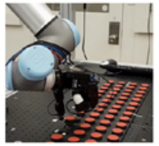
Probability of Success (PS) - a PS is calculated from a confidence level, number of samples, and number of successes.

Kolmogorov-Conover – this algorithm determines whether two sets of 1D ordinal data (ranked, numerical data) belong to the same population. This applies to pass-fail data as well.

Implementations:

KC Download (compiled C++) – this console program implements the KC algorithm, and additionally calculates the probability of success (PS) for achieving each rank of the data. *See Readme within archive for more details.

KC (LabView) – this program implements the KC algorithm with an associated LabView GUI.

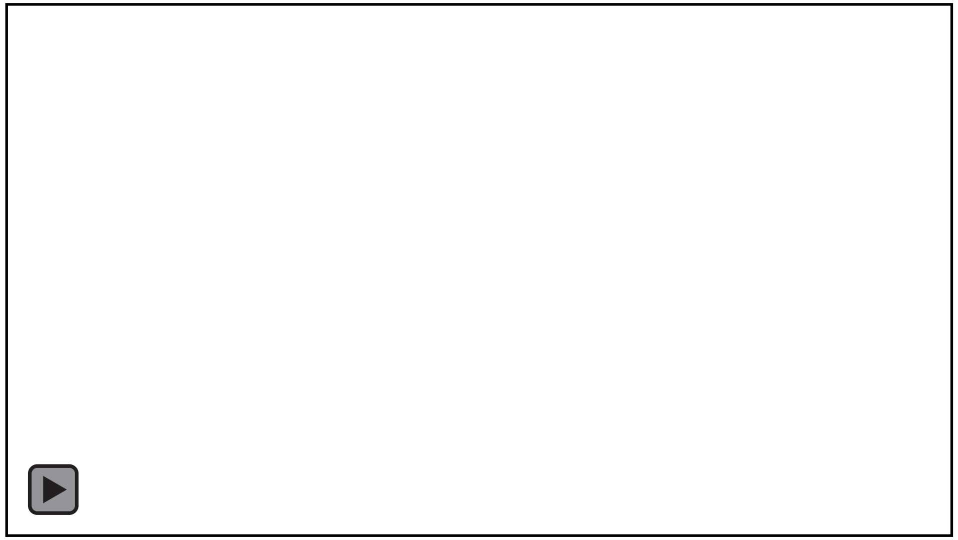


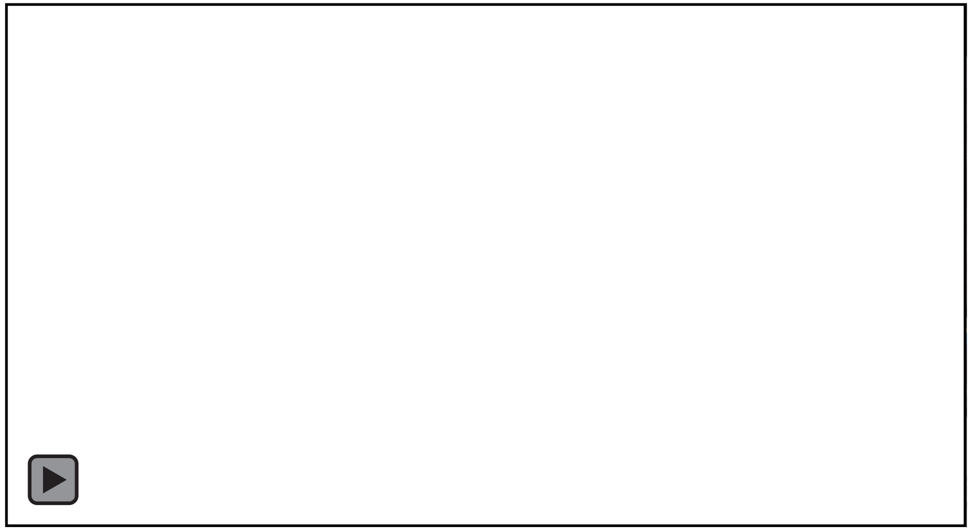
Contact

Karl Van Wyk
301 975 3424 Telephone
301 990 9688 Fax
100 Bureau Drive, M/S 8230
Gaithersburg, MD
20899-8230

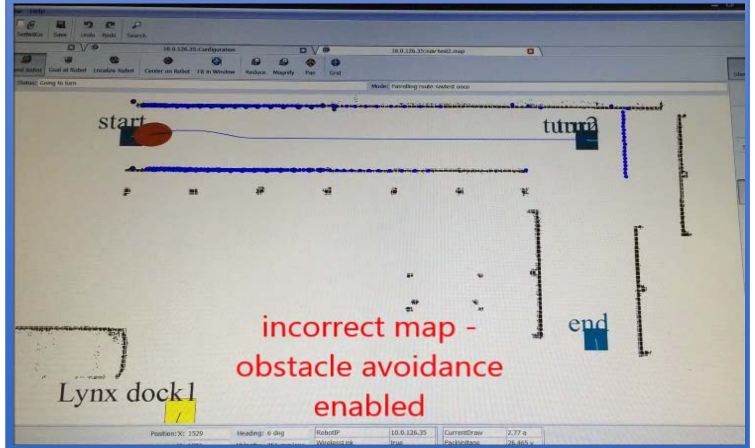
Examples of RSSM Contributions

Competitions to Disseminate Metrics & Benchmarks





Technical Inputs to Standards



Visualization of Vehicle Path for ASTM F3244 Navigation in Defined Spaces

Draft Exoskeleton Tests at WearaCon

MEP Collaborations

- MEP-Assisted Technology and Technical Resource (MATTR) program fosters interactions between Robotics staff and MEP centers and their clients.
- Examples:
  - Technical advice on integration of robotic arm onto mobile platform to South Dakota MEP center for a client
  - Tours and demonstrations to MEP center representatives to educate them on collaborative robotics and industrial vehicles
  - Investigating technical exchanges with the MEP embeds in the Advanced Robotics for Manufacturing Institute

MEP Collaborations

- Joint Workshop on Collaborative Robotics


MANUFACTURING EXTENSION PARTNERSHIP National Network

NIST National Institute of Standards and Technology U.S. Department of Commerce

engineering laboratory

Small Manufacturer Robotics Workshop 2015

Information | Contact Us

Summary | Agenda | Location | Contact Us

Small Manufacturers Robotics Workshop 2015

The National Institute of Standards and Technology (NIST) wants to reduce the barriers that small- and medium-sized enterprises (SMEs) encounter today in the adoption of robots within their manufacturing facilities. Robots have the ability to help SMEs decrease part cycle times, improve part quality, improve workflow, as well as to perform dangerous and dirty tasks. Rather than have an academic discussion NIST wants to hear from the robotic end-users themselves on what challenges/barriers they encounter when integrating and using robots in their factories.

SMEs who participate in the workshop will:

- Gain insights into trends, cutting edge tools and emerging robot technologies.
- Learn how some organizations have been able to address and overcome the challenges of integrating robots into existing manufacturing processes.
- Tour state-of-the-art NIST robotics research facilities. (if interested)
- Have the opportunity to influence NIST research by ensuring that their company's technical interests are considered.
- Potentially gain future access to NIST's robotics testbeds in areas such as state-of-the-art technologies, advanced sensor systems, and cutting edge manufacturing application research.


NIST National Institute of Standards and Technology U.S. Department of Commerce

PUBLIC SUMMARY
OF
WORKSHOP FINDINGS AND RECOMMENDATIONS

Collaborative Robotics Workshop 2015

Advantages and Challenges for Small Manufacturers

Held October 7, 2015

engineering laboratory

MEP • MANUFACTURING EXTENSION PARTNERSHIP

Prepared by NIST MEP for NIST EL
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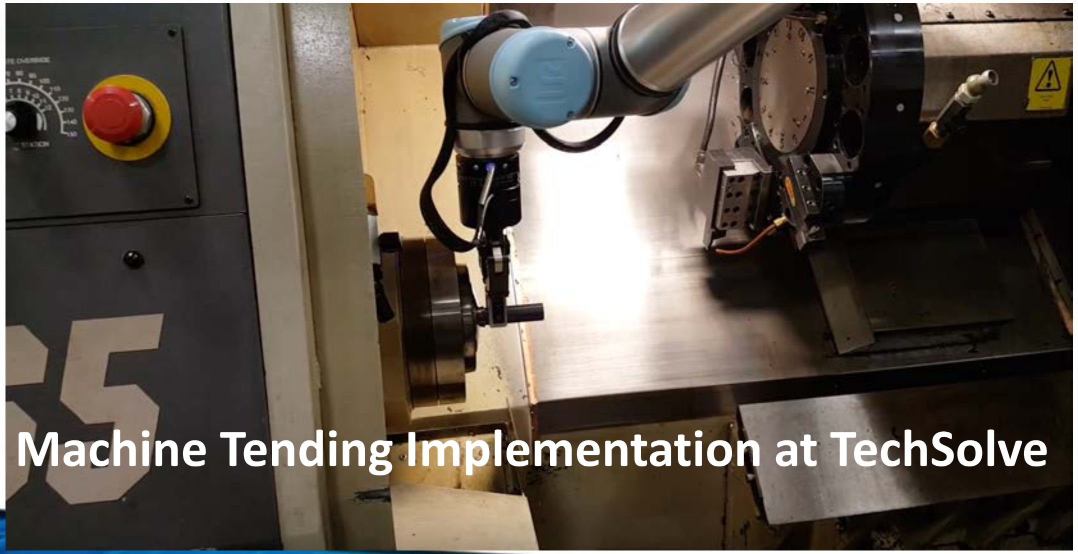
Cooperative Agreement with Ohio MEP Affiliate

- TechSolve Inc: *Collaborative Robot (CR) Technology Requirements and Performance Metrics for Small and Midsize Manufacturers (SMMs)*
  - Gather and summarize available information and data regarding CR technology and its perceptions and uses by SMMs;
  - Develop a CR demonstration environment;
  - Employ direct contact with SMMs and to identify, quantify, and articulate requirements and opportunities for effective application of this technology; and
  - Help define performance metrics for collaborative robots that are meaningful to SMMs as input to NIST Robotic Systems for Smart Manufacturing Program



Machine Tending Implementation at TechSolve

Manufacturing USA Collaborations

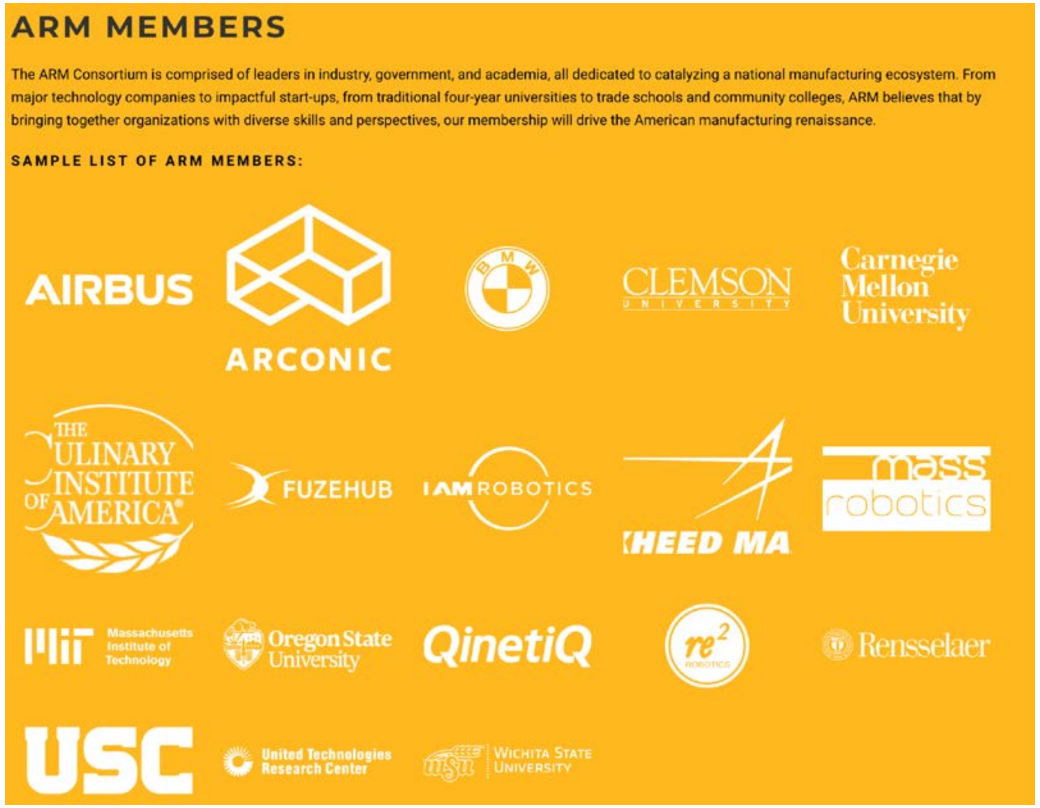
From their website:

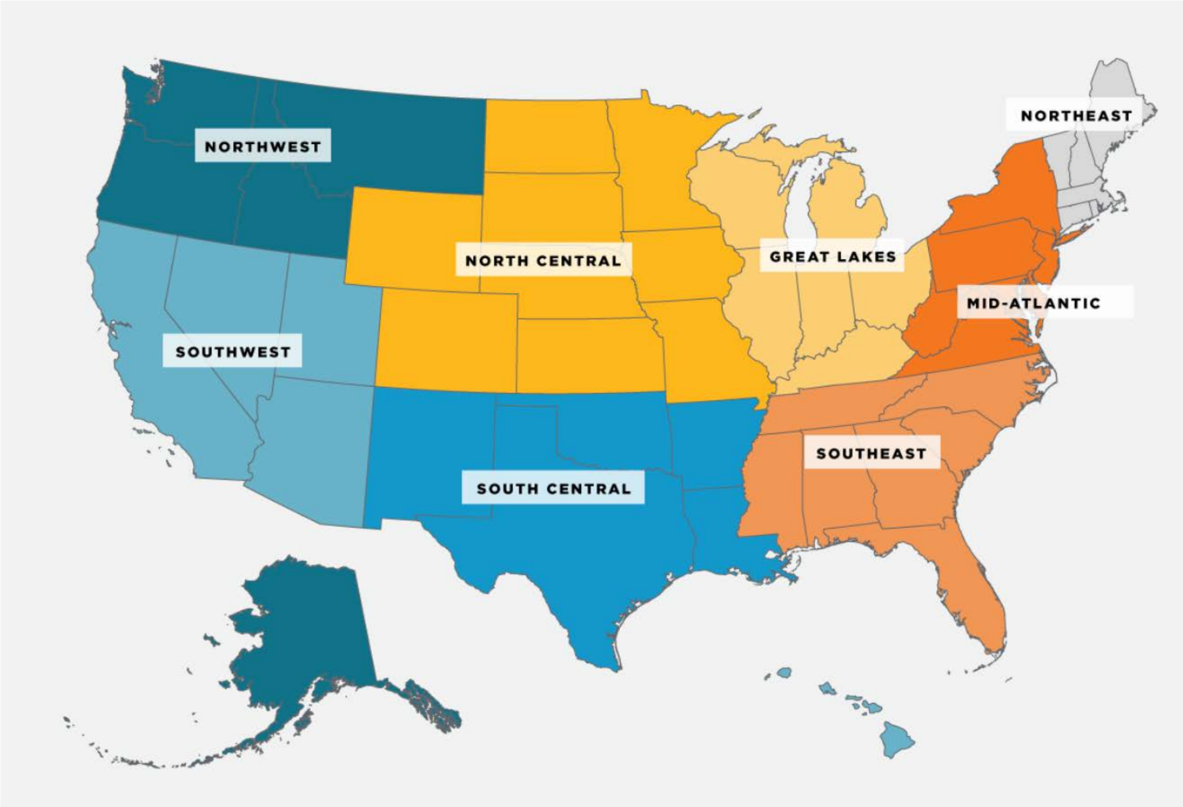
- Advanced Robotics for Manufacturing (ARM) is the nation's leading collaborative in robotics and workforce innovation. Structured as a public-private partnership, we accelerate the advancement of transformative robotic technologies and education to increase U.S. global manufacturing competitiveness.
- ARM is building:
  - A repository of innovative robotics technology and workforce solutions.
  - A world-class knowledge center that showcases what's new and next in robotics.
  - A trusted national standard for certifying top-tier robotics curricula and credentials.
  - A nationwide robotics ecosystem that scales high-potential businesses and workforce initiatives.
  - A world-class staging facility that transitions innovative technologies to production plants.

ARM
ADVANCED ROBOTICS
FOR MANUFACTURING

Big Picture of the Institute

- 150+ members
- Regional Collaboratives





NIST Roles

- Provided input on manufacturing robotics to DOD sponsors prior to their call for proposals for new institute
- Served as Subject Matter Experts during institute proposal reviews
- After ARM's selection as institute, ongoing contributions by NIST staff:
  - Co-chair of Metrics Working Group, advising and educating members about project and component performance evaluations and characterization
  - Member of Technical Advisory Committee (TAC)
  - Participate in Software Working Group, helping define common infrastructure and guidelines to encourage reuse/sharing
  - Informal advisor/team member for one of the initially-funded projects on Assembly of Composite Panels
  - Exploring further collaborations that leverage NIST expertise in measurement science for manufacturing robotics

Thank You!