National Workshop on Challenges to Innovation in Advanced Manufacturing: Industry Drivers and R&D Needs

Ushering in the Next Generation of Factory Robotics & Automation

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Traditional Manufacturing
Robotics

$T = $R + ($R \times 10)$
Next Generation R&A Needs

- Develop technical expertise and manufacturing capability to preserve and develop U.S. industries through the use of cost effective R&A
- Reduce the reliance on fixturing, mechanized structuring, and conventional sense-plan-act programming via flexible perception & learning
- Agree on industry-wide system specifications, capability levels, standards of performance and test methods
- Require overall system performance assessments beyond mechanical & electrical characteristics
Flexible Perception & Autonomy Inspiration

2007 Darpa Urban Challenge Winner

Enabling Autonomous Driving Assembly
Autonomous Assembly Roadmap

1. Geometric reasoning to plan an assembly
2. Plan detailed motions
3. Sense to locate incoming parts and tools
4. Bring parts into contact and alignment using dexterity
5. Monitor progress re-planning sequence and motion
6. Indicate success or failure
7. Learn to perform more efficiently with practice
8. Generalize the geometric reasoning and learned behaviors on one task to help in executing other similar tasks

A path to Autonomous Assembly

1. Spatiotemporal Reasoning With Uncertainty
2. Motion Planning
3. Dexterous Behavior Classification & Needs Analysis
4. Sensing For Fine Motion Dexterity
5. Human Detection & Tracking
6. Advanced Robotic Mechanisms
7. 3D Vision
8. Sensing For Verification Of Task Completion

High Level Task Description Language

Formal Language That Could Be Readily Interpreted

Motion Planning

Probabilistic Roadmap Translates The Task Plan Into Detailed Robot Motions

Dexterous Behavior Classification & Needs Analysis

A List Of Basic Operations That Would Cover The Requirements Of Assembly Work

Sensing For Fine Motion Dexterity

Touch Sensing With Wrist Force/Torque Sensing To Complete Insertions for Compliant Manipulation

Human Detection & Tracking

Vision Techniques To Detect The Presence Of Humans

Advanced Robotic Mechanisms

Design Robot Mechanism To Optimize Assembly Process

3D Vision

Finding Parts To Pick Up, Finding Target Features To Guide The Assembly Process, And Detecting Obstacles To Avoid

General Motors R&D
Why Robots with Human-Like Capability?

- Enhance and complement the role of humans on the assembly line
- Reduce or eliminate worker time spent on routine, non-critical, dangerous, and/or repetitive functions
- Compensate for human physical, environmental, and cognitive limitations
- Take advantage of manual processes existing infrastructure
- Allow planning of operations to maximize the capabilities and efficiency of humans
Next Generation R&A Drivers

- High-level flexible perception
- Highly flexible & dexterous robots/end-effectors
- Safe integration & harmony with people who are also performing tasks in the assembly process
- Pervasive use of intelligent R&A that can be as flexible and as easily “trained” as people
- Rapid “reassignment” of automation resources via social interaction rather than programming
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Questions?

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