Advancements in Autonomous Mobile Manipulation

Norm Williams, Director of Robotics
Omron - Americas
Agenda - Advancements in Autonomous Mobile Manipulation

• What Is Driving The Demand
• Manufacturing and Retail Challenges
• The Technology, Components & Integration
• Real World Applications
What is Driving the Demand for Mobile Manipulators

• According to a study by Deloitte and the Manufacturing Institute, the skills gap may leave an estimated 2.4 million positions unfilled between 2018 and 2028.

• The Society of Manufacturing Engineers (SME) reports that 89% of manufacturers are having difficulty finding skilled workers, which is partially due to an aging, retiring workforce and lack of desire among younger workers to enter the manufacturing field.

• Research by Korn Ferry Institute estimates that the labor shortage in the global manufacturing industry could result in more than $607 billion in lost revenue by 2030, with the U.S. representing more than 10% of the global deficit at a total of $73 billion in unrealized output.
Manufacturing Challenges

Mobile Manipulation in Manufacturing

i-Automation!

Robotic Automation Line & Autonomous Transportation

- Integrated
- Intelligent
- Interactive

Customer Needs
- Flexible Manufacturing
- Small Lot Sizes
- Quick Change Over
- Increased throughput

Applications
- Machine Tending
- Line Replenishment
- Pick and Place Operations
- Material Transport
- Automated Inspection

Continuous Improvement & Zero Downtime
Logistic and Operational Challenges

Mobile Manipulation in Logistics

- Pressure to reduce redundant inventory across the supply chain
- High Training and recruiting cost
- Change in demand from batch picking to each picking
- Labor intense Product Transport
Retail Challenges

Mobile Manipulation in Retail

- Inbound Product Delivery
- Shelf Stocking & Picking
- Inventory Management
- Outbound Product Delivery
Technology Advancements Enabling Autonomous Mobile Manipulators

ERP/MES/WMS

Robot Fleet Management System
- Facility Mapping
- Robot Coordination
- Job Dispatch

User Interfaces

Worker

Facility

Manipulator Device

Safety Devices
- Safety Laser
- Area Scanners
- Safety PLC'S

Manipulator Devices
- Collaborative Arms
- Vision Systems
- Gripping Devices

Autonomous Mobile Robot
- Lasers and Sensors
- Vision
- Batteries
- Safety

Mobile Robot

Worker
Enhancements in Controls Systems

ERP/MES/WMS

Robot Fleet Management System
- Facility Mapping
- Robot Coordination
- Job Dispatch

User Interfaces

Performance

Control

Detect and resolve conflicts.
Sequence the arrivals to avoid traffic jams

Improvements

Data Services
- Fleet Simulation
- Fleet Performance
- Business Intelligence
- Throughput Optimization
- Predictive Maintenance
Continuous value generation by data from AMRs and AGVs for diverse needs

<table>
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<tr>
<th>Essential needs</th>
<th>Customer’s Needs</th>
<th>Software Solution</th>
<th>Strength &amp; How Innovative</th>
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<td>A Product flow control</td>
<td>Fleet Management</td>
<td>- Optimized AMRs as a Fleet</td>
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<td>B Zero downtime</td>
<td>Data services</td>
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<td>C Continuous improvement</td>
<td>Business Intelligence</td>
<td>- Getting better year over year</td>
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<td>Variety of demand</td>
<td>D MES &amp; ERP access</td>
<td>Business Acceleration</td>
<td>- Health status &amp; maintenance prediction</td>
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<td>E Cover diverse physical requirements</td>
<td>3rd Party (Kits) AMRs</td>
<td>- Fast fix support</td>
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<td>- Layout Improvement</td>
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<td>- Throughput Improvement</td>
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<td>- Connectivity with various MES/ERP system</td>
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<td>- Safe and intelligent navigation</td>
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<td>- Multiple vehicle sizes</td>
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<td>- Manage AGVs also intelligently</td>
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Enhancements in Mobile Robots

Sensor Options
- Dynamic Environment Localization Camera
- Navigation / Mapping /Localization
  - Safety Laser LIDAR
- Additional Obstacle detection
  - Laser, Time of Flight, Contact switches

Payload and Attachment Options
- Payloads up 60 - 1500KG
- Forklift & Pallet Truck retrofits
- AMR Attachments – Carts - Tuggers

Battery Improvements
- 6-15 hours of continuous operation
- Quick charging options
- Wireless charging
The increase in the number of mobile robot shipments is driving new sensor development and lowering the cost of the sensing technology.

Advanced light fixture sensing improves localization of robots.
Manipulator Improvements

Adoption of Collaborative Technology

Advancements in Gripping and sensing Technology

Investments are Driving Innovation and Competition

Plug & Play devices for easier deployment

Camera Integration
Vision Integration

3D Calibration

- The cobot’s camera and can provide 3D position calibration on the fly in operation.
- 3D Calibration eliminates precision robot mounting, work surfaces, machines, and material handing tooling.
- Applications are easily mobile while improving accuracy
- Flexible tool and product changes
- Enables advanced multi robot arm coordinated assembly

Standard Features and Easy Deployment
Mobile Manipulator
Line Side Bin
Replenishment

- Autonomously drive to a fixed inventory rack
- Transfer Up to 4 various bins from inventory rack to mobile robot platform
- Autonomously navigate to specified workstation and automatically unload the bins to the workstation without human intervention
Concept and Key Functions

- Mechanical design for stability
- Utilize built in camera and Landmark calibration feature for robot positioning, rack location and workstation location
- Incorporate Safety PLC for safety interlocks
- Incorporate size lasers for additional obstacle detection
The Solution
Mobile Manipulator Examples