Confluence of robotics and automation for manufacturing

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Background

• Analysis of business needs across a variety of areas
  • Big Manufacturing - GM, PSA, BMW, Boeing,
  • Small Manufacturing - Marlin Wire, Printed Circuits Corporation, ...
  • Logistics Companies - C&S WholeSale, UPS,
• Where are the gaps? challenges?
• How can we address the gaps?
• What technologies are emerging?
Outlines

• Where are the business needs / drivers?
• What are the gaps we need to address?
• What R&D do we need to conduct to close the gaps?

• We need to increase the number of jobs and grow the economy!
• Educate the future workforce
Robot Shipping

Robot Units Shipped Per Region (Source: IFR/VDMA)

Green = Asia
Red = Europe
Blue = Americas

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Co-X Robotics

- Co-Worker
  Next Generation Manufacturing/Hospitals

- Co-Inhabitants
  Assistance to People in Daily Lives

- Co-Protectors
  Support for core industries
Manufacturing

• US is competing with China to be the biggest manufacturer in the world

• Manufacturing generates more associated jobs than any other sector

• 94% of all manufacturing jobs are in Small and Medium Enterprises (SMEs)

• The SMEs are responsible for 60% of all US manufacturing export
Some of the big challenges/issues

• Bringing home/retaining manufacturing

• Empowering small and medium sized companies

• Automating the supply chain
Salary comparison

Unit labour costs in manufacturing in US$

Source: Oxford Economics/Haver Analytics

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Co-Workers

- See tremendous growth in use of robots (40.8%)
- Re-shoring of jobs for Apple, Lenovo, Tesla, Foxconn, ...
- Urgent need for flexibility in manufacturing - Boeing, ...
- Pushing logistics for delivery, food, ...

Needs
  - Higher Flexibility
  - Faster Deployment and Programming
  - Integrated process from CAD to factory floor
Business drivers

- Reduced cost of a system solution
- Agile changes to accommodate product variations
- Higher precision / robustness / speed
- In process inspection
- Simplified programming / deployment
- A connected infrastructure (“industrial internet”)
Big Manufacturing Challenges

- Cost
- Robots as a replacement for machine centers (taking out the monuments)
- In-process inspection
- Agility
- Process Speed

Source: Indradi Soemardjan

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Small and Medium Sized Manufacturing Challenges

• Cost
• Setup time and maintenance
• Flexibility and multi-tasking
Logistics / Warehousing

- Cost
- Increase volume / speed
- Increase density
- Reduce manpower for sorting
- A bold vision: Autonomous Trucks / Autonomous Fight
Manufacturing vs E-Commerce

Growth in Manufacturing vs E-commerce (Source: US Census)
Gaps to move forward

- Flexible / human-safe manipulators / platforms
- Robust (easy to use) Perception
- Plug-n-Play Systems Integration
- Flexible Programming/Minimum Set-up Time
Co-Worker Roadmap

R&D Drivers
- Human-Robot Interaction
- Model Based Programming
- Large-Scale Vision
- 3D Modeling
- Open Software Interfaces
- Fleet Management
- Multi-Objective Planning
- Flexible Grippers
- Learning By Demonstration
- Hybrid Control Systems

GAPS
- Robot-Cooperation
- Feedback Control
- Plug-n-Play Integration
- Flexible Programming
- Flexible End-Effectors
- High-performance Manipulators
- High Speed Mobile Platforms

$GAPSR&D Drivers
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Big Enterprises
- Logistics & Warehousing
- Cost
- Quality
- Speed
- In-process Inspection
- Human-Robot

Small and Medium Enterprises
- Multi-Objective Planning
- Multi-Purpose
- Human-Augmentation
- Cost
- Agility
- Density
- Speed
- Agility
Opportunities

• Cost breakdown
  • Basic robot system 20-30% of cost
  • Auxiliary hardware 20-30% of cost
  • Software 40-60% of the cost
• Utilizing technologies from related fields
• Integrating humans and robots
Robots

• Encouraging development with cheaper and lighter robot systems
• Rethink Robotics - Baxter 22k for a two-arm system
• Universal Robots
• New mobile platforms

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Baxter & Universal Robots

Source: Rethink Robotics

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Programming Objective
Modeling Framework

- **Systems Modeling Language**

  - UML 2.0
  - SysML 1.0

  Not Required by SysML
  Reused by SysML
  SysML Extensions
Combined taxonomy for assembly actions
Model Airplane?
Model for “aircraft” assembly
Comprehensive model for “toy system”
Auxiliary Hardware

• Fences, Conveyers, PLCs for Cell Control
• New Types of Sensors
  • PrimeSense, Kinect Sensor, IMUs, …

Source: NYTimes
Robust Perception

- Sensory Fusion for real-world complexity
- Recognition at the 99.9% level
- Realistic perception/action laws
- Context driven perception
- Recognition at the $10^6$ level of objects
- Action interpretation
- Affordance perception/interpretation
Component Based Industries

- The use of standardized components open up for new opportunities
  - Integrated Quality Control
  - Grasp Planning / Bin Picking
  - Gripper Technology
  - Navigation Solutions
  - New Types of User Interfaces
First person games

Estimated time spent* playing video games in the U.S. from 2002 to 2012** (hours per person per year)

Source: Veronis Suhler Stevenson; 2002 to 2008
Next generation workers are experts on
Utilizing the Cloud

- Cloud Based Recognition
- Utilizing cloud resources - models
- Tying in with the “Industrial Internet”
Industrial Internet

Source: General Electric
ROS-Industrial

- We are seeing an emergence of an open middleware platform for robotics
- 20-25% of cost is robot
- 20-25% of cost is aux hardware
- 50-60% of cost is software
- ROS-I would reduce cost by 30-40%
- The big players are not excited about this.
Summary

- Robotics in a broader sense could be the next “wave” when we network machines, things and services to provide the physical interface to the network
  - In Europe termed Industry 4.0
- Manufacturing is seeing major growth after 2009
  - Reshoring, re-evaluating metric - total cost of ownership
- Service such as logistics are seeing major changes with e-commerce
- Significant progress on
  - Perception
  - Effective interfaces
  - Significant speed-up in programming