Collaborative and Industrial Robotics In Advanced Applications

Scott Beute & Tyler McCoy
JR Automation Technologies, LLC

AUTOMATE • 2017
Presenter Background

- **Annual Sales**: $300MM+
  - 30% CAGR Since 2009

- **Cross Industry Experience**:
  - Fully-staffed R&D and Software Eng

- **ISO**
  - RIA Certified Integrator
  - FANUC, ABB, Kuka, etc.

- **Certifications**:
  - ISO 9001:2008

- **Facilities**:
  - 625,000+ sq. ft.
  - 9 bldg. across the U.S.

- **Employees**:
  - 850+
  - 30% Degreed Engineers
What Is A Collaborative Robot?

• ISO 10218 defines four types of robot collaboration
  • Safety Rated Monitored Stop
  • Hand-Guided
  • Speed & Separation Monitoring
  • Power & Force Limited
Types Of Collaboration

• Safety Rated Monitored Stop
  • Safe stop of the robot without removal of power (Fanuc DCS, ABB Safemove, Nachi RMU)
Types Of Collaboration

• Hand Guidance
  • Allows robot to be manually controlled via force feedback
Types Of Collaboration

• Speed & Separation Monitoring (Fenceless)
  • Limits robot speed proportional to the distance between the robot and the human
Types Of Collaboration

• Power and Force Limited
  ▪ Robot system speed and torque limited such that impact will not injure human

• Commonly called “Collaborative Robots”
Collaborative Robot Assumptions

1. Faster and Easier to Teach

2. Simplify System Integration

3. Simplify Safety Integration
Collaborative Robot Assumptions

1. Faster and Easier to Teach
**Major Differentiator**

- Lead through teach (hand guiding)

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<th>YuMi</th>
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Faster And Easier To Teach

• Lead through teach is intuitive and an advantage for simple tasks. We have found this utility to vary greatly from manufacturer to manufacturer. This may be an advantage for simple systems, but diminishes for larger, more complex systems.
Collaborative Robot Assumption

2. Simplify System Integration
Point Programming Is A Small Piece Of The Picture

- System Integration
- Error Recovery
- Vision Integration
- Point Programming
Typical System Integration

Incoming Parts → Presence, Control → Data → Tester → Pass/Fail, Start/Stop, Presence

PASS
FAIL
Typical System Integration

- **Goal**: Create vision-based pick and place application with a UR
  - Design hardware (camera, gripper, sensors)
  - Perform system risk assessment
    - Determine if additional safety devices are required
  - Write modbus interface between camera/robot
  - Wire
    - Camera system
    - Part Sensors
    - Tester IO
  - Calibrate camera to robot frame
  - Train vision pick
  - Add integration logic
    - Incoming parts, tester triggers, outgoing conveyors
  - Provide system feedback on alarms to user
Non-traditional Integration Design
Collaborative Robot Assumptions

3 Simplify Safety Integration
Cobot Safety (TS 15066)

- Power and force limited robots are not inherently safe
- Collaborative cells are defined by **applications not robots**
- Injury/pain/force **thresholds** make a huge difference in risk assessment
- Much more emphasis in a cell’s engineering will need to take place
Identify Each Hazard

1. EOAT Design
2. Grabbing Parts (open/close pinch)
3. Regulating pneumatic pressure
4. Sharp edges

1. Full body contact in free space
2. Full body contact against wall
3. Dropping parts
4. Minimize hitting sensitive extremities

Tester

Pinch & Shear

PASS

FAIL
Identify Each Hazard

Tester

PASS

FAIL
Identify Each Hazard

1. EOAT Design
2. Grabbing Parts (open/close, pinch)
3. Regulating pneumatic pressure
4. Sharp edges

Pass

FAIL

1. Full body contact in free space
2. Full body contact against wall
3. Dropping parts
4. Minimize hitting sensitive extremities
**Quantify Each Hazard**

**ISO TS/15066 Specification**

<table>
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<tr>
<th>Body Region</th>
<th>Specific Body Area</th>
<th>Quadratic Contact</th>
<th>Transient Contact</th>
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<td>Maximum permissible pressure (p)</td>
<td>Maximum permissible force (P)</td>
<td>Maximum permissible pressure multiplier (β)</td>
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<tr>
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<td>Lower extremities</td>
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<td>Sciatic nerve</td>
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Free Transient Contact: Speed limits vs. Effective Robot Mass converted from Peak Pressure Limit Values.
Determine If Additional Safeguards Are Required

- Remove pinch points
- Additional guarding to shield pinch points
- Combining the use of scanners and other safety products to reduce speed while human is in restricted space
Verdict

• Power and force limited robots are only one tool to create a safe workcell

• When choosing between a collaborative robot and standard robot, the entire application must be considered

• Misconceptions about the intrinsic safety of a collaborative robot can lead to risky end uses
Advanced Applications

• Utilizing Power and Force Limited Robots as an enabling technology
Mobility

• Enabling robots to autonomously move between different tasks
  • **Robot/Vehicle Integration** - Turning the “world” into a single accurate coordinate system
  • **Automatic Calibration** – Enabling the robot to get near a position and further localize itself
  • **Movement-on-the-fly** – Allowing the robot to move while the cart is moving
Path Recording & Transformation
Built In Force Sensing
Conclusions

• In the correct application, the capabilities of a Power and Force Limit Robots can be a real benefit
• A thorough risk assessment of the entire application is key
• Enabling technology for future solutions
JR Automation Technologies, LLC
13365 Tyler Street
Holland, MI 49424
USA

www.JRAUTO.com