4- Axis SCARA Robot
For pick and place applications

California State University, Chico
MECA/MECH 440B
Project Members

Tony Gonzalez
Mechanical

Jeremy Heckman
Mechatronic

Hogan Hempy
Mechatronic

Patrick Kelly
Mechanical

Blake Nelson
Mech/Meca

Faculty Advisor:

Nick Repanich

Project Sponsor / Customer:

Micro Vu
Precision Measurement Equipment Since 1959
The Problem

Micro-Vu develops various high precision measuring devices, but they realize that there continues to be a demand for automation. If they can automate the process of loading and unloading of their measuring devices, it could increase the efficiency of their products.
The Need

Micro-Vu needs a reliable autonomous robot to be developed, capable of pick and place applications for their Excel Measuring Centers.
Function of the Device

The device to be built will be a competitive and reliable prototype of a 4-axis SCARA Robot for pick and place applications. It will meet all of the requirements provided by Micro-Vu.
# Problem Definition

<table>
<thead>
<tr>
<th>Must Do</th>
<th>Should Do</th>
<th>Would be Nice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be of a SCARA configuration</td>
<td>Have an accuracy of ±0.2 mm</td>
<td>Have an accuracy of ±0.1 mm</td>
</tr>
<tr>
<td>Operate in at least four axes of motion</td>
<td>Have a repeatability tolerance of ±0.1 mm</td>
<td>Have a repeatability tolerance of ±0.05 mm</td>
</tr>
<tr>
<td>Be able to lift a “sample piece” of 0.5 kg</td>
<td>Be able to lift at least 8 Kilograms</td>
<td>Upgrade to 6 axes of motion</td>
</tr>
<tr>
<td>Be capable of covering a workspace of multiple 650 mm</td>
<td>Operate for 10,000 hrs. without failure</td>
<td>Be aesthetically pleasing</td>
</tr>
<tr>
<td>Micro-Vu Excel measuring stages.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pick and place cycle a “sample part” in less than 1 hour</td>
<td>Pick and place cycle a “sample part” within 10 seconds</td>
<td>Pick and place cycle a “sample part” in less than 1 second</td>
</tr>
<tr>
<td>Be an independent unit, separate from Excel Measuring Center</td>
<td>Be designed for manufacturing 1,000 units per year</td>
<td></td>
</tr>
<tr>
<td>Have an accuracy of ±1 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have a repeatability tolerance of ±0.5 mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Design Solution
Design Solution
End Mechanism
Elbow Joint
Base Joint
Fabrication

**Purchased Parts**
- SHA 25 & 32 motors
- 2x Yaskawa SGMAV motors
- Controller and power supplies
- Gripper module
- Pneumatic solenoid & regulator
- THK ball spline/screw
- Raw machining materials
- Miscellaneous electrical components
- Miscellaneous mechanical fasteners

**Fabricated parts**
- Base and riser
- Base side panels
- Link 1 & 2
- Motor mounts
- Gripper Fingers
- Gripper Mounting Apparatus
CNC Production
High Speed Machining
Repeatability Results

Repeatability Requirements

• Must do: ± 0.5 mm
• Should do: ± 0.1 mm
• Would be nice: ± 0.05 mm
• Test Results: ± 12 µm

Met = ✔ Not met = X
Accuracy Requirements

• Must do: $\pm 1$ mm  X
• Should do: $\pm 0.2$ mm  X
• Would be nice: $\pm 0.1$ mm  X
• Test Results: $\pm 1.3$ mm
Weight/Payload Requirements

- Must do: 0.5 kg ✔
- Should do: 8 kg ✔
- Test Results:
  - 0.5 kg ✔
  - 1.0 kg ✔
  - 2.0 kg ✔
  - 4.0 kg ✔
  - 8.0 kg ✔
  - 11.6 kg ✔
Cycle Time Results

Requirements

• Must Do: < one hour ✔
• Should Do: < 10 seconds ✔
• Would Be Nice: < one second X
• Test Results: 1.2 seconds
## Final Budget Overview

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller</td>
<td>$5,750.39</td>
</tr>
<tr>
<td>Base</td>
<td>$1,095.77</td>
</tr>
<tr>
<td>Links</td>
<td>$3,567.77</td>
</tr>
<tr>
<td>Pneumatics</td>
<td>$1,701.21</td>
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<tr>
<td>Motors and Gearheads</td>
<td>$10,882.00</td>
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<tr>
<td>Misc.</td>
<td>$488.88</td>
</tr>
<tr>
<td>Shipping Costs</td>
<td>$300.00</td>
</tr>
<tr>
<td><strong>Total Component Cost</strong></td>
<td><strong>$23,786.02</strong></td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$121,470.00</td>
</tr>
<tr>
<td>Machining Costs</td>
<td>$900.00</td>
</tr>
<tr>
<td><strong>Total Project Cost</strong></td>
<td><strong>$146,156.02</strong></td>
</tr>
</tbody>
</table>
Reflection

Unique Problems Encountered
1. Extra time needed when using Beta systems (i.e. our controller)
2. Keep in constant contact with suppliers
3. Monitor lead times closely

Solutions Achieved (for above problems)
• Communication
  • Teammates
  • Supervisors
• Suppliers
• Plan ahead for troubleshooting time
Suggestions for Future

- Regulate the air exhaust valve to slow open/close of the gripper
- Evaluation of hard stops for all axes
- Electrical gripper instead of pneumatic
- Proper sized ball spline/screw
- Cast aluminum arms – lighter & stronger
Conclusion

• Product met all but one of the required must do and should do specifications
  • Accuracy requirements not met
  • Error is due to the gripper release mechanism

• Several would be nice specifications were also met

• Is product ready for market?

• A special thanks to:
  • Micro Vu  
    • Jeremy Bardell  
    • Chuck Howard  
  • Nick Repanich
  • Tony Arena
  • Louk Hendricks
  • Support staff at Precise Automation
  • CSU, Chico Tech Shop
Questions?