Touch Sensing for Robotic Welding
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Problem
Implementing touch sensing functionality of a robotic welding arm. The result must be able to:

- Successfully reproduce a programmed travel path with an imperfect fixturing/positioning of a test piece
- Avoid collisions between robot and test piece
- Adjust for variations in both the x and y axes

Background
Robotics have seen more applied use in industry at large for their ability to complete repetitive tasks efficiently, continuously, and precisely. These capabilities offer benefits in the form of higher production, improved reliability, and reduced waste. Figure 1 shows some examples of robotic applications in the welding industry.

One of the greatest challenges for automation in welding from an implementation standpoint is consistency in the fixturing and fit up of a component. Small variations in thickness, gap, and circularity have major effects on the welding process. Touch sensing addresses some of these issues.

Touch sensing is a low cost, software based, joint locating system. Contact touch sensing (as used in this work) uses the electrode to make electrical contact with the piece. The robot stores the position data then automatically makes adjustments to the programmed path, which can automatically compensate for errors in fit-up, geometry, or placement of the piece.

Approach
To learn how to implement touch sensing, we reproduced the demo for the touch sensing feature done by Fanuc shown in Figure 2. In the demo, the piece is placed on a table in the position that the substrate was in when the program was created, then the substrate is bumped out of position. The program is successfully reproduced in the new position automatically.

Results

<table>
<thead>
<tr>
<th>Targets:</th>
<th>Equipment</th>
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</thead>
<tbody>
<tr>
<td>- Consistent original program</td>
<td>Fanuc Arcmate 100iC Robotic Welding Arm:</td>
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<tr>
<td>- Successfully inputted search path for x and y axes</td>
<td>Test Piece:</td>
</tr>
<tr>
<td>- Piece successfully found in new position</td>
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Search Path
This series of photos shows the substrate in its original position while running the program. The path traces the top surface of the piece then outlines the vertical plates creating the “i” symbol. Figure 4 shows the sequence of the travel path.

The search path is split two parts: a search in Y axis and a search in the X axis. The robot starts at a safe distance away from the part with the torch head perpendicular to the surface with the wire sticking out at approximately the CTWD. This is shown in Figure 5. The torch slowly moves until contact is made and a small spark (voltage signal) identifies the substrate location.

Program in Off Position
The substrate has been bumped so that it is in a different position than it was when the path was originally programmed. Figure 7 shows the robot successfully tracing points in the original program in the modified position automatically.

Discussion
Touch sensing was successfully implemented in the CCWJ facilities. A test path was automatically corrected to compenrate for a change in position simulating incorrect placement of a part on a table fixture prior to welding. The largest difficulty with this technology was oxide formation on the test piece, which inhibited the robot’s ability to generate the voltage signal (spark) occasionally resulting in a crash during the search. Grinding of the test locations in the search corrected for this issue but is still a limitation of contact-type sensing. Future work will incorporate welding the joint also.

Conclusions
Understanding the use and applications of robotic welding is important to an industry that is driven by productivity and efficiency advancements through technology. Touch sensing is a promising improvement to automation to make corrections to imperfect scenarios often encountered in the welding environment, which were demonstrated in this research project.