

BifCo Panel Repair

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Abstract

BifCo repairs two-dimensional structural panels. Mr. Bif has hired you to design the motion control for his proprietary repair process. A robotic arm assembly performs the repairs in an environmental chamber. The repairs can be done without totally disassembling the panel. So in addition to defining the section to be repaired, exclusion zones must be observed for features that protrude from the assembled portion of the panel. Further, the robotic arms must stay within the walls of the repair chamber. You must design a system that supports all robotic motion: “Manual” moves commanded by the operator, and automatic motion that moves the tool back and forth across the repair zone a segment at a time, from the starting edge to the end of the repair zone. Your design must support a graphical display that shows the zones of work, exclusion zones, the real-time position of the robot’s arms, as well as the end position for each move of the robot’s arms.

BifCo Overview

Typical Operation

Initially the traverse is stowed in its home position so it is out of the way. Workers transport and attach the panel to be repaired to a fixture in the chamber.

The machinist then powers up the repair robot and begins the job setup. The machinist uses a remote control to digitize, or outline, the defective section, an irregular polygon that may contain voids, and also digitizes any exclusion zones that are in the path of motion from the tool magazine to the repair site. The zones may also be built and edited with the mouse.

After defining the zones of work and motion exclusion the repair process begins. The machinist’s display graphically shows zones of work and exclusion. The display also shows the tool holder’s current position and the positions of the robot’s arms (important for radial/radial case).

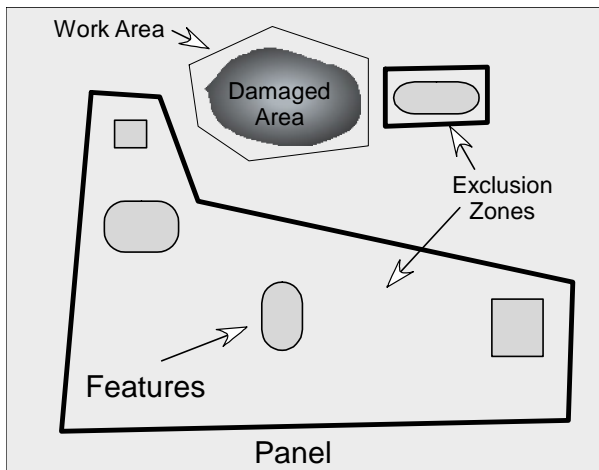
Using a series of mouse drags, the machinist positions the robot’s tool holder to a starting point just inside an edge of the repair zone and then initiates the multi-step repair process.

Your code moves the tool back and forth across the repair zone a segment at a time, from the starting edge to the end of the repair zone. Automatic motion is not permitted if positioned outside of a repair zone. The graphical display shows the real-time position and end position during each move of the robots arms.

In the case of the X/Y traverse, the motion is linear. In the case of the rotary/rotary the repair motion is a series of arcs. Straight-line motion is not expected or required in the rotary case.

Your software is not expected to solve for an optimal or full coverage path. The machinist may have to set the position for several start points to complete the repairs. Automating this is considered phase 2 work.

Below is an example of how work and exclusion zones could be shaped and positioned on a panel. Note: the real-time display does not show the features or damage, just the zones.



Traverse Alignment

Alignment defines the traverse's position in space. The motion controllers do not know where the traverse is positioned until it is aligned. If alignment of the traverse is lost, it must be realigned before any work. The only way to move an unaligned traverse is with the remote control. The real-time display should indicate that alignment is not complete. Alignment is lost by reset of the controllers, or is assumed lost if an electrical limit switch is hit. To realign the traverse it must be driven near the home switch positions with the remote control and then told to find home.

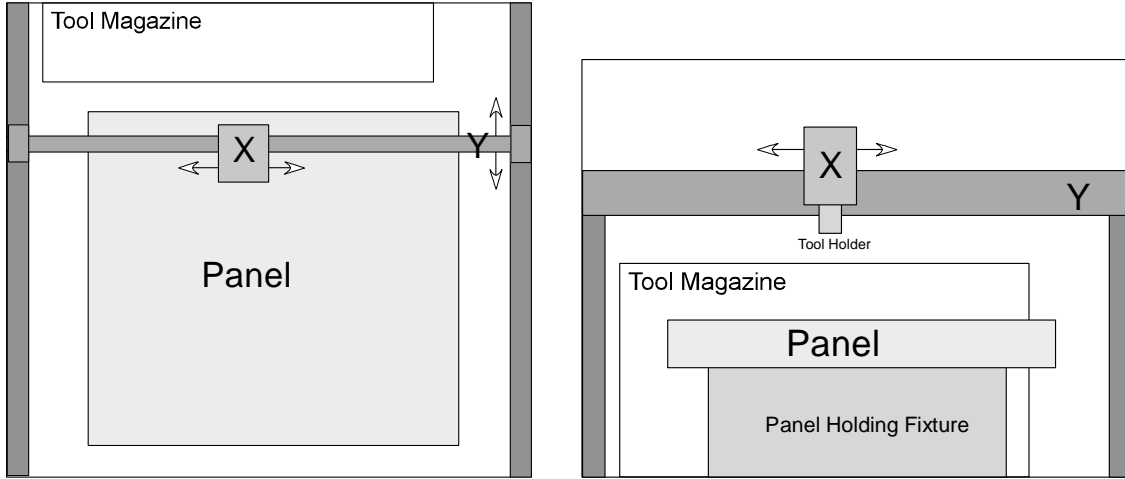
System Components

Robot Assembly

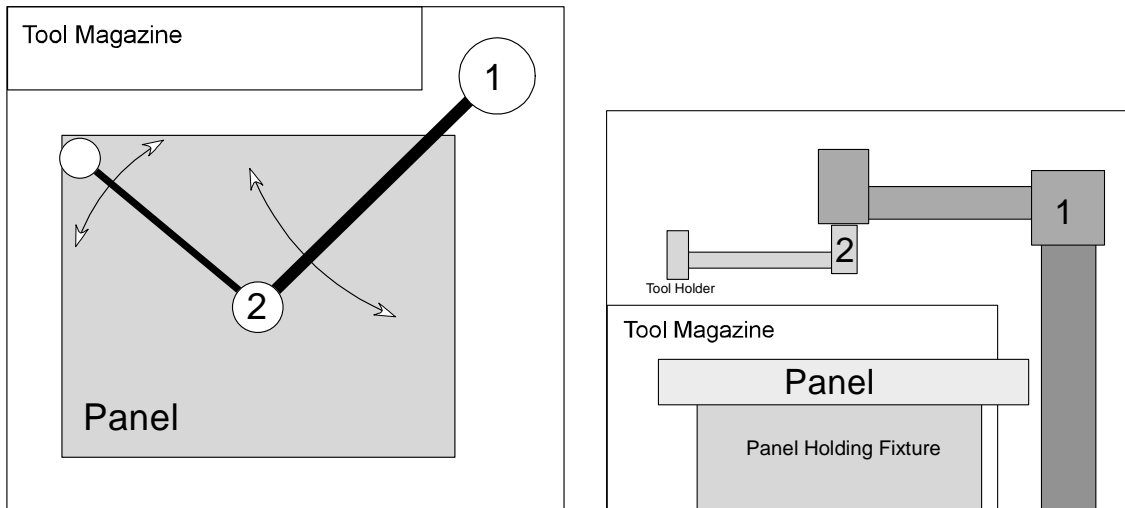
Currently BifCo uses two types of robots in their repair chambers, a simple X/Y traverse and a radial/radial form. Mr. Bif would like your design to be extensible to other combinations of traverses. For instance, a linear and rotary could be combined.

Below are examples of the repair chambers currently in use.

Linear/Linear Axis Top and Front Views



Radial/Radial Axis Top and Front Views



The radial/radial assembly's axes of rotation are parallel to each other and perpendicular to the plane of the panel.

The working head of the robot has two positions, engaged and retracted. This will be controlled by the tool software (outside of the problem domain).

Remote Controller

A remote control pendant for moving the traverse is attached to the computer. The remote control software will use methods in the motion control software to move the traverse axis. Remote control moves are done in velocity mode: move at a speed X until told by the remote to stop. The remote control moves the traverse like a mouse moves a mouse

pointer. It is also used to digitize vertices of the work and exclusion zones. Digitization records the position of the traverse. Your motion control software will receive these positions to define the zones.

Motion Controllers

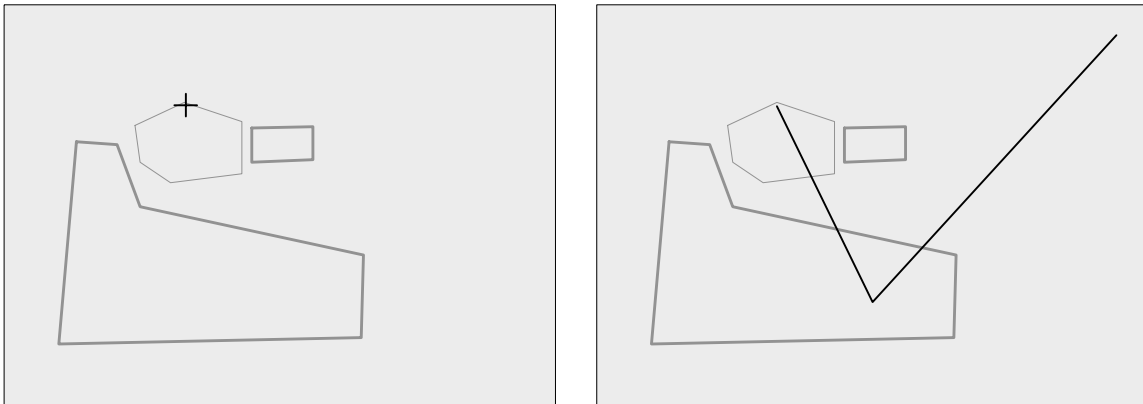
Currently BifCo uses BrandX and BrandY motion control cards in the computers, but we are thinking of updating to the SuperDuper (this must be better). Your design must support multiple motion controllers. The controllers are multi-axis, and only one type is used in a repair station.

Position Sensing

Position is sensed by encoders attached to the output of the gearboxes. These are quadrature encoders, not absolute. These encoders feed back to the motion controllers. This feedback is required for closed loop control and to update the real-time display. Each axis has a home switch and two limit switches at each end of travel. These limit switches are set outside of the software limits. If a limit switch is closed, the traverse is stopped and the tool head is retracted.

Real-time Display

A real-time display shows the current position of the traverse and tool head at all times. Below are examples of the real time display with the traverse position shown for linear and rotary cases.



You must provide methods to configure the origin, scale factor, drawing colors for the display window. The real time display will call into your code to update the positions at least 10 times per second.

For each motion, your code must calculate and display the traverse's end position on the real-time display before the motion is started. This allows the machinist to abort the operation in case a software bug or setup error sends the tool holder to the wrong place.

Methods must also support mouse drag initiated moves that show the trajectory the tool head will take. You are not expected to support this for dual axes moves because of the complexity added when considering motor accelerations.

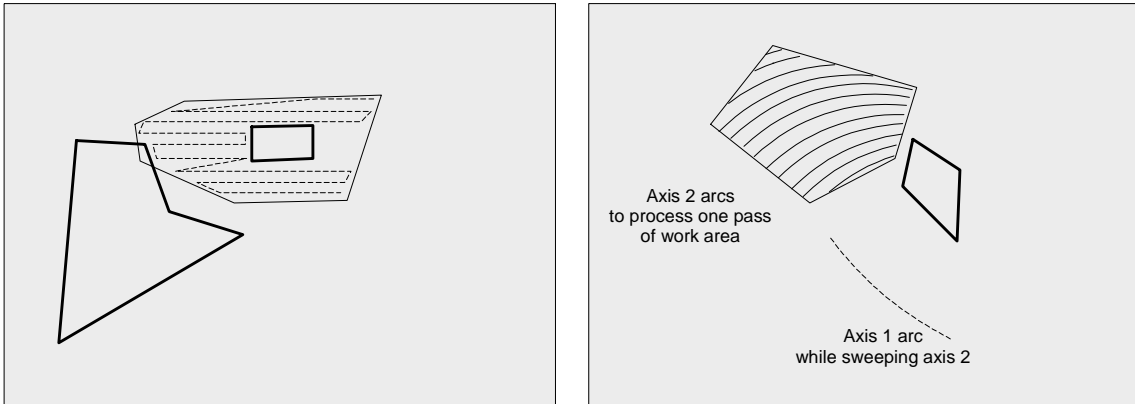
System Behavior

Motion Types

Methods are required for two kinds of motion: absolute moves to a position and velocity moves when using the remote control. Methods are also required to set the speed for absolute moves.

Exclusion and Work Zones

During automatic motion throughout the repair process, exclusion zones must be avoided and the work zones boundaries must be observed.



During mouse drag moves, exclusion zones must also be avoided. Allow motion up to the edge of the exclusion zone or software limit, but not entry into the zone or motion past the limit.

In the rotary case an exclusion zone protecting the chamber walls will always be in effect.

Exclusion zones must be observed for fixed angle or distance moves. For instance, if a request to move the X position +10 inches would run into an exclusion zone or software limit 8 inches away, an error message must indicate that the maximum allowed would be +8 inches.

Motion Completion

Methods are required to test for motion completion during remote control moves, absolute moves, and end of segment moves during automatic processing. Note that during the processing, the automatic motion is a step-by-step process so the tool can be

commanded for the two types of moves: a processing segment, and moving to the next segment start point.

Other Issues

Negotiating the interface BifCo will use to call the code.

Configuration

Other configuration information must be accessible:

- Changing the axis lengths.
- Encoder counts per unit of travel.
- Limit of motion – software limits set inside the hardware limit switches.
- Changing motion speeds when processing, moving, and digitizing.
- Step size during processing – the distance between each sweep of an automatic move.