METALSELF

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COMPREHENSIVE OPERATION MANUAL FOR ROBOTIC SOLDERING STATION

COMPREHENSIVE OPERATIONAL MANUAL: AUTOMATED SOLDERING STATION

1. SECURITY AND SYSTEM INITIATION
Before interacting with the robot, ensure that the area is secure.

1.1 Essential Principles

- **Mandatory PPE: Always don a darkened mask, fire-resistant gloves, and protective attire.**
- **Working Area: Ensure that no individuals are within the robot's operational range.**
- **Emergency: Promptly identify the red emergency button located on the tablet (Teach Pendant) and on the electrical panel.**

1.2 Power-On Procedure

Electric Ignition: Activate the main switch located on the control panel.
2. Unlock: To unlock, press and rotate the emergency button.
3. Login: On the tablet, input the password (Default: 888888).
4. Activation: Press the "Start" or "Turn On" button on the interface to engage the motors and unlock the brakes.

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2. PHYSICAL CONFIGURATION OF THE ROBOT (To be completed prior to initial use or torch replacement)
The robot lacks vision: without information regarding the object it holds, it cannot operate with precision.

2.1 Configuring the TCP (Tool Center Point)

You must specify to the robot the precise location of the welding wire's tip in relation to your wrist.

1. Navigate to Configuration > General > TCP.
2. Employ the calibration procedure (4-point method): position the tip of the wire near a fixed reference point (such as a pin or a (marked point) from four distinct perspectives.
3. Save. The robot is now programmed to rotate around the tip of the wire rather than the wrist.

2.2 Payload Configuration

Navigate to Configuration > General > Load.
2. Please provide the weight of the flashlight (in kg) along with the estimated center of gravity.

the *Note: If you input "0 kg" while the flashlight weighs 2 kg, the robot will trigger a collision alarm as soon as it accelerates.*

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3. WELDING PROCESS CONFIGURATION Logical integration
between the robot's control system and the welding apparatus.

3.1 Welding Machine Setup

1. Navigate to the Welding > Setup menu.
2. Machine Type: Choose the brand (e.g., "AOTAI") and the mode ("Analog").
3. Analog Calibration (Essential): It is necessary to synchronize the robot's values with those of the welder.

oh Establish a minimum value (e.g., Robot 0V = Welder 0A).
oh Establish a maximum value (e.g., Robot 10V = Welder 500A).
oh *Without this step, requesting 100 Amps may result in the welder delivering either 50 or 200.*

3.2 Configuring Input/Output Signals
Associate physical cables with software commands:

- **Arcing (Arc Start): Chooses the digital output (DO) linked to the welder's "Trigger."**
- **Arc Successful (Arco OK): Chooses the digital input (DI) that receives the "Arc on" signal from the welder.**

COMPREHENSIVE OPERATIONAL MANUAL: AUTOMATED SOLDERING STATION

FAMILIARIZING YOURSELF WITH THE CONTROL PANEL (Lateral Buttons)

Before programming, it is essential to understand how to prepare the torch. On the left side of the welding interface, you will find four blue buttons that are crucial for maintenance and preparation.

1.1 Management of Wire and Gas
These commands are utilized to ready the machine without relocating the robot.

- **ARCING (Static Arc Test):**
  - oh **What it does: Attempts to initiate the welding arc from a**
  - oh **stationary position. 8. When to use it: CAUTION. Its usage is infrequent.**
    This is merely to verify whether the welder responds to the start command during maintenance.
  - the Technical note: Enable digital output DO[2]9.

- **GASCARE (Gas Management / Release):**
  - oh **What it does: Activates the gas solenoid valve without**
  - oh **initiating the arc and without allowing the wire to extend. When to utilize it:**
    Before commencing work, ensure that the
    The cylinder is open, and gas is escaping (you will hear a puff).
    2. To "bleed" the pipes of ambient air if the machine is has been halted for an extended period.
  - the **Technical note: Activate digital output DO[1]7.**

- **Tapering (Thread Retraction):**
  - oh **What it does: Reverses the motor to retract the wire into the torch. When to use it:**
  - oh **If the wire protrudes excessively.**
    Before commencing soldering, or if it is necessary to extract the wire from the sheath.
  - th **Technical note: Enable digital output DO[3]5.**
    e

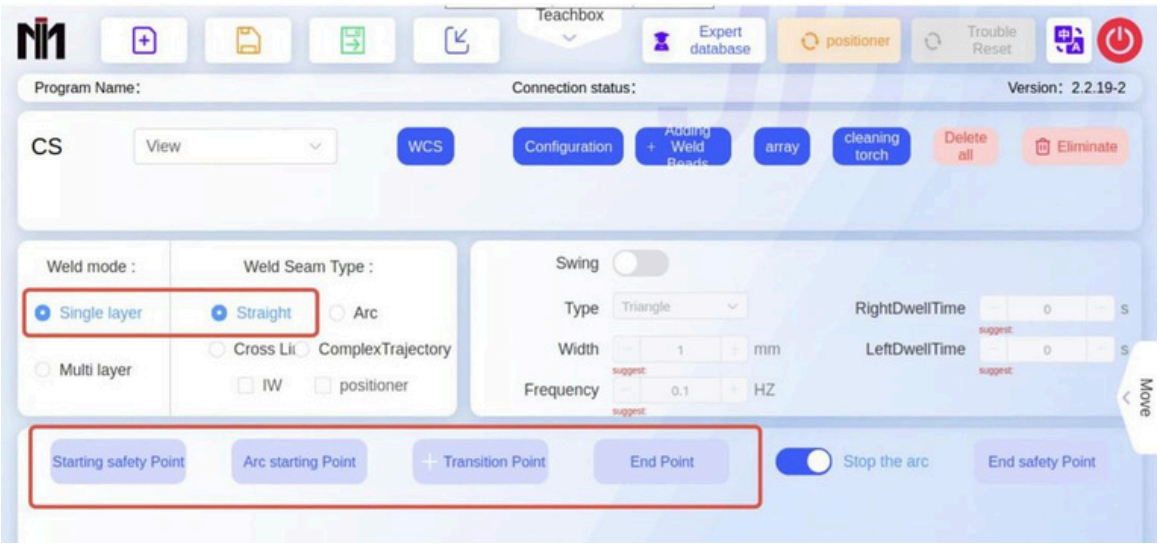
- **WIRE FEEDING:**
  - oh **What it does: Activates the wire feeder motor to advance the wire from the torch.**
  - oh **When to use: When replacing the bobbin or if the thread is too short and requires**
  - oh **feeding. Technical note: Activates digital output DO[0]3.**

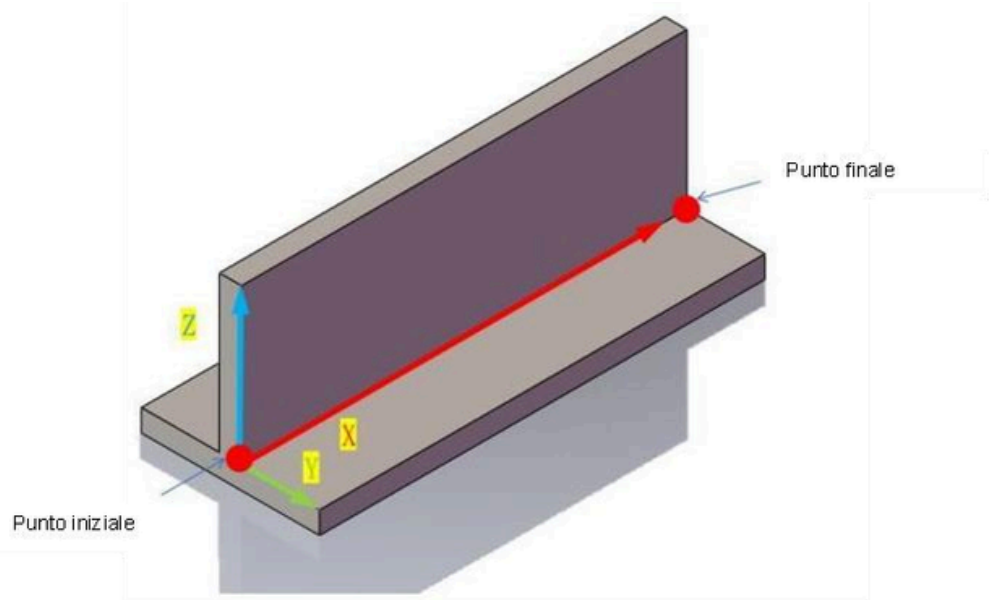
WELDING MODES (Types of Trajectories)

When developing a program, it is essential to instruct the robot on how to navigate along the joint. In the central "Weld Seam Type" panel, the following options are available:

2.1 STRAIGHT (Linear Welding)

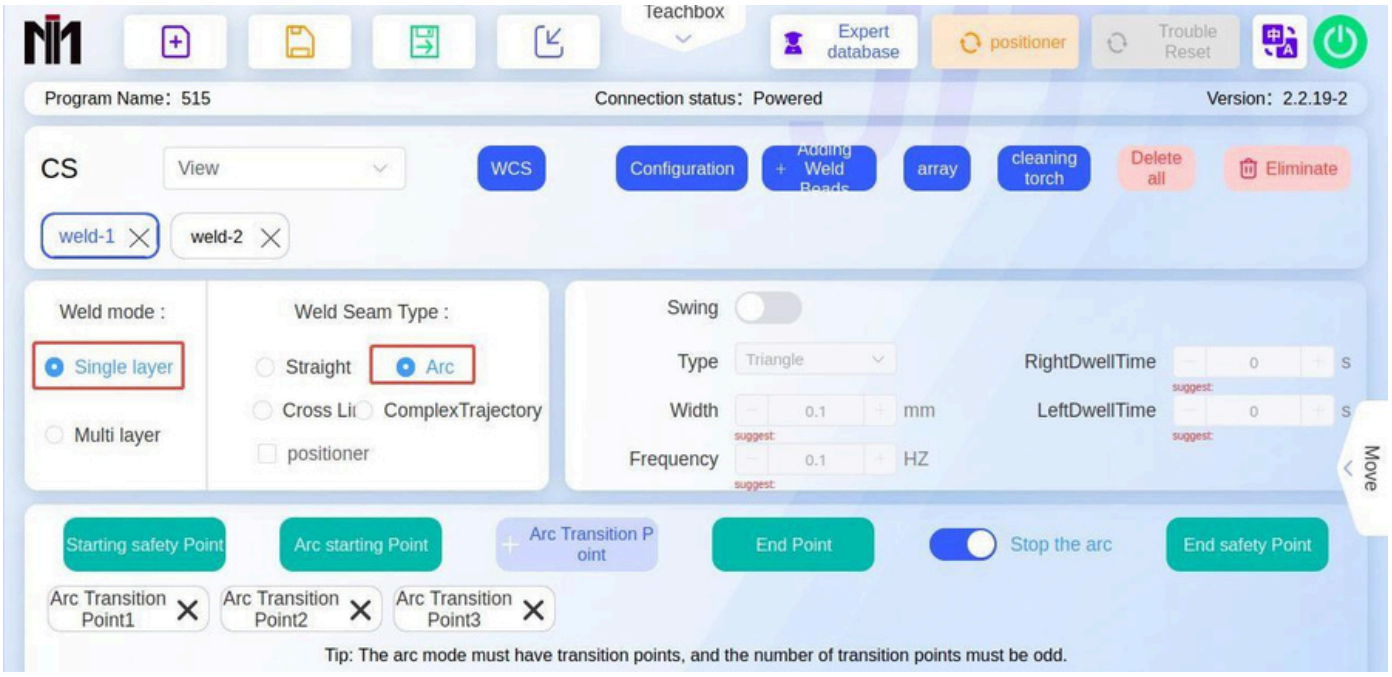
- **What it is: The most basic weld. A direct line from point A to point B.** [11]
- **Required points: 2 points.**
    1. Starting Point: The location where the cord originates.
    2. Termination Point: Where it concludes.
    3. Application: Suitable for the majority of welding tasks involving flat plates, beams, or square profiles.

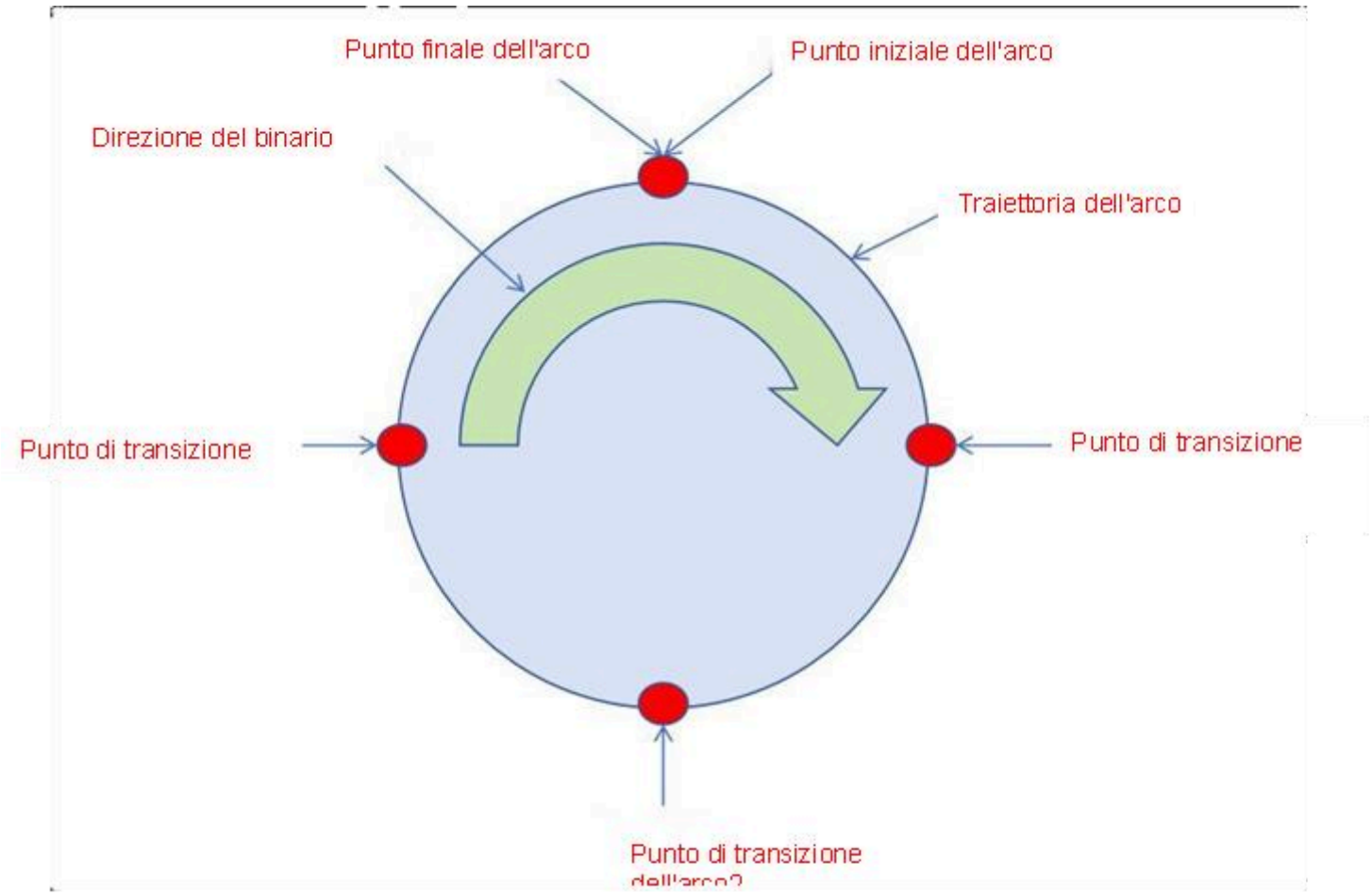




2.2 ARC (Circular/Curved Welding)

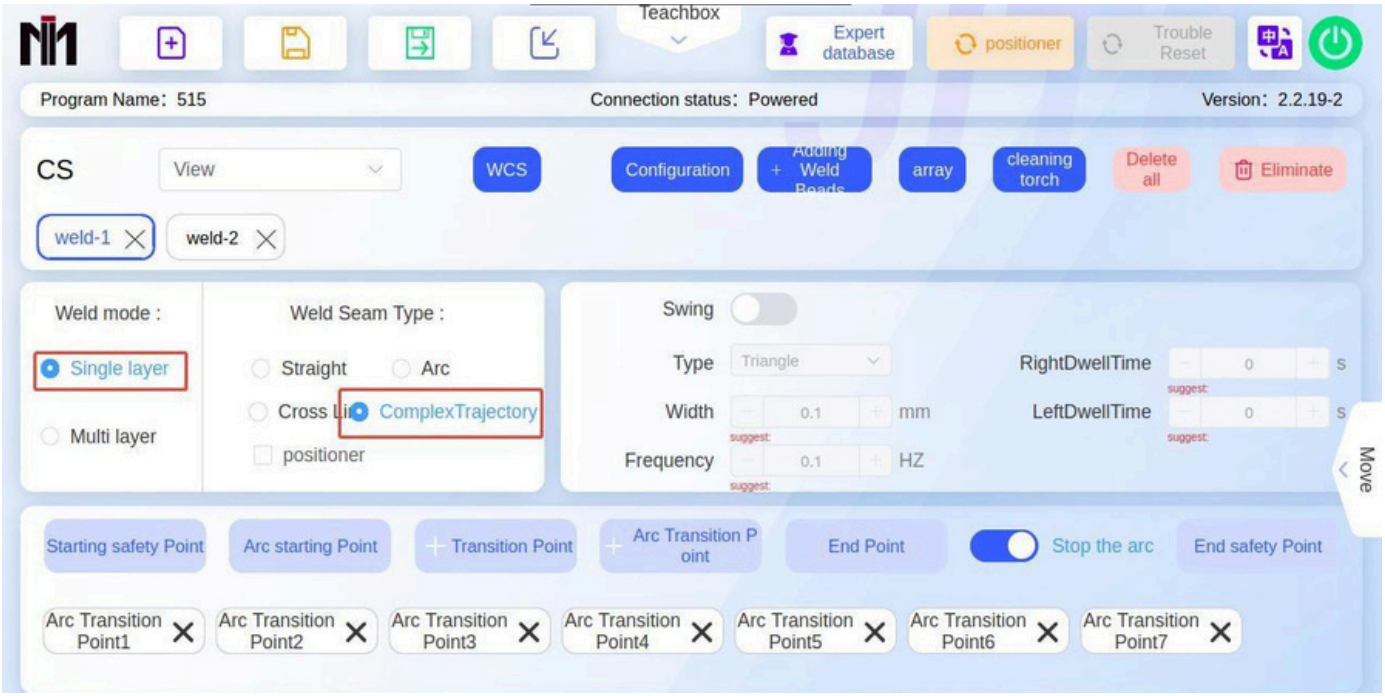
- **What it is: It is utilized for welding along a curve or a perfect** [12].
- **circle. Required points: A minimum of 3 points.**
    1. **Starting Point: Commencement of the curve.**
    2. Transition Point: A midpoint along the curve that assists the robot in comprehending the radius.
    3. **End Point: Conclusion of the curve.**
- **Important rule: To complete a full circle (360°), it is essential to utilize an odd number of transition points (e.g., Start + 3 transition points + End that coincides with Start)13.**

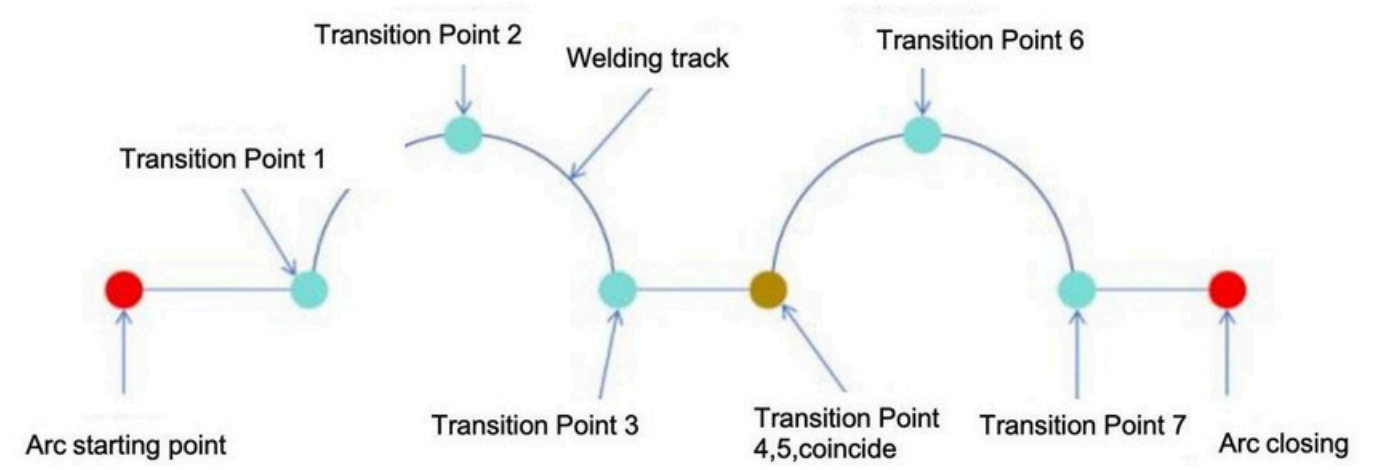




2.3 COMPLEX TRAJECTORY (Complex Trajectories/Splines)

- **What it is: For irregular trajectories that are neither perfectly straight nor perfectly circular. How it works: It**
- **involves a combination of lines and curves. You must document numerous transition points sequentially to "render" the shape.**
- **Utilize: Formed components, automotive chassis, or artistic silhouettes.**





2.4 CROSS LINE / INTERSECTING LINE (Welding at Intersections)

- **What it is: A specialized technique for welding intersecting pipes (e.g., a round pipe joined to another pipe, forming a "saddle" shape)15.**
- **How it works: The software autonomously computes the intricate intersection curve using several key points defined on the surface.**
- **Utilization: Tubular carpentry, bicycle frames, industrial piping.**

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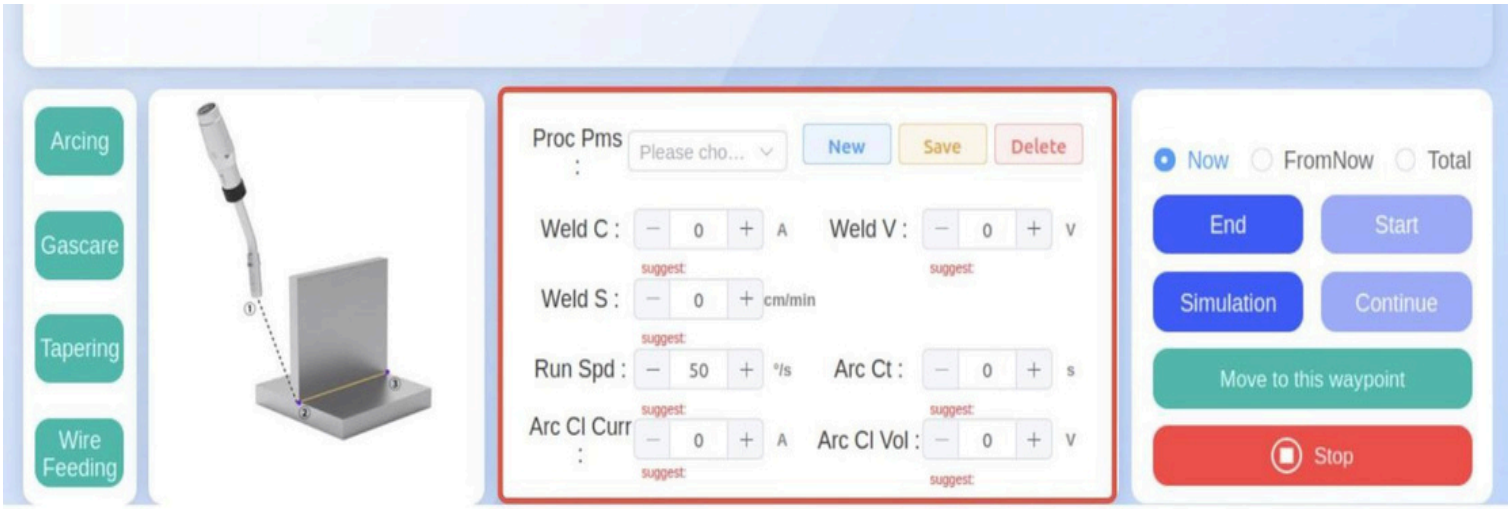
3. CONFIGURATION OF PROCESS PARAMETERS

Once you have determined the trajectory, you must also establish the speed and power. This can be accomplished in the "Proc Pms" (Process Parameters) box.

- **Weld C (Current) / Weld V (Voltage): In this section, you can configure the Amperes and Volts. If your welder is synergic, you need only adjust the wire speed, and the Volts will automatically calibrate.**
- **Weld Speed (Welding Speed): This refers to the rate (in cm/min or mm/s) at which the torch progresses during the welding process.**
  - *Too rapid: Slim bead, inadequate penetration. Too*
  - *sluggish: Thick bead, potential for puncture.*
- **Run Spd (No-load Speed): The velocity at which the robot traverses the air to transition from the safety point to the commencement of the line18.**
- **Arc Closure (Crater Fill):**
  - **Arc Ct (Time): Duration of stillness at the conclusion (e.g., 0.5 seconds).**
  - **Arc Cl Curr/Vol: Reduce current and voltage to address the final "gap" created when the arc extinguishes.**



4. STEP-BY-STEP GUIDE: WELDING STEP 1:

Preparation

1. Utilize personal protective equipment.
2. Activate the robot and sign in.
3. Press GASCARE to verify that the gas is being released.
4. Press WIRE FEEDING or TAPERING to modify the length of the wire (10-15 mm extending from the nozzle) 20.

PHASE 2: Development of the Program

1. Launch a "New" program and assign it a name.
2. Choose the "Straight" template (to begin with simplicity).

PHASE 3: Instruction on the Concepts

1. Grasp the robot by pressing and holding the button on the flange (Drag-to-Teach).
2. Bring it to the forefront of the piece.
   - oh *Distance: 15 mm.*
   - oh *Angle: 90° lateral, 15° anterior.*
3. On the tablet, select "Arc Starting Point" followed by "Set Point" (Record). 4. Position the robot at the end of the piece while maintaining the same angles.
5. On the tablet, select "End Point" -> "Set Point" (Register)21.

STEP 4: Configuring Texture (Optional)

If you need to perform a vertical or wide weld, activate SWING (Weaving) 22:

- **Type: Select "Triangle" or "Sine".**
- **Frequency: Low (0.5 - 1.5 Hz) for regulation.**
- **Width: The measurement of the bead's width (e.g., 5 mm).**
- **Dwell Time: Configure 0.3s on the Left and Right to halt at the edges and prevent dripping to the center.**

PHASE 5: Validation and Commissioning

1. Activate the "Simulation" switch.
2. Press Start. The robot will execute the movement without welding. Ensure that it does not collide and that the torch is correctly positioned. 3. If all is satisfactory, deactivate Simulation.
4. Press Start. The robot will activate the DO[2] (Arcing) output, await the DI[4] (Arc OK) input, and commence movement.

5. SPECIALIZED FUNCTIONS

5.1 Multi-layer Welding

If the cord must be particularly thick, avoid completing it in a single attempt.

1. Document the initial pass as "Straight" or "Arc."
2. Enable "Multi layer" 25.
3. For subsequent passes, refrain from moving the robot. Input only the offset numbers:
   - oh **ΔZ: Elevate the torch (e.g., +2mm for the second pass).**
   - oh **ΔY: Shift laterally (e.g., +2mm to overlap the beads).**

5.2 Sanitation Station

If you possess an automatic station, it is essential to instruct the robot on its location. There are ten fixed points that need to be documented only once.[26]:

1. Wire Cutting (Points 2-3-4): Above the shear -> Within the shear -> Away from the shear.
2. Nozzle Cleaning (Points 5-6-7): Above the reamer -> Interlocking descent -> Ascending.
3. Liquid Spray (Points 8-9-10): Position the spray nozzle -> Activate spray -> Conclusion.

This sequence must be integrated into the main program after a specified number of welds (e.g., through a counter).

4. GOLDEN RULES: TORCH PLACEMENT

The robot performs precisely as instructed. Adhere to these physical principles when documenting points.

4.1 The "Drag-to-Teach" technique (Manual Teaching) for robot movement:

1. Press and hold the blue button located on the flange (adjacent to the flashlight). 2. The robot transitions into "Zero Gravity" (becomes weightless).
3. Adjust it manually to the preferred location.
4. Release the button to secure it.

4.2 Distance and Angles (Stick-out and Tilt) When recording points, orient the flashlight in the following manner:

Parameter	Operational Guideline
Distance (Stick-out) The	**nozzle tip must be positioned 10-15 mm from the workpiece.**
Flat Welding	90° to the sheet metal (straight sideways). 15° inclined forward (direction of travel, push technique).
Vertical Upward	Precisely 45° between the two walls (0° tilt to the bisector). 15° inclined forward in the direction of travel.
Fillet Weld	90° to the wall. 10-15° angled upwards (elevating).

The Fundamental Principles of Positioning (How to Position the Flashlight)

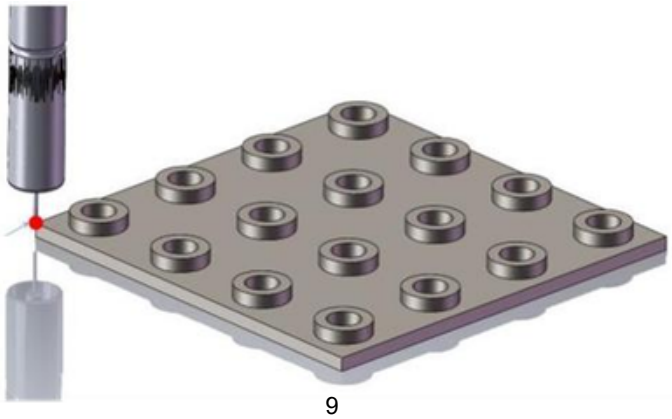
The robot lacks the ability to weld independently; it merely replicates your actions. When documenting the points (Start and End), it is essential to adhere to these physical principles:

- **Distance (Stick-out): Position the nozzle approximately 10-15 mm from the workpiece. Avoid contact, but do not stand too far away. The robot will register this height.**

Flat Welding:

- oh **Sideways: Position the torch vertically (90° to the workpiece).**
- oh **Direction of travel: Tilt it forward approximately 15° (push technique).**

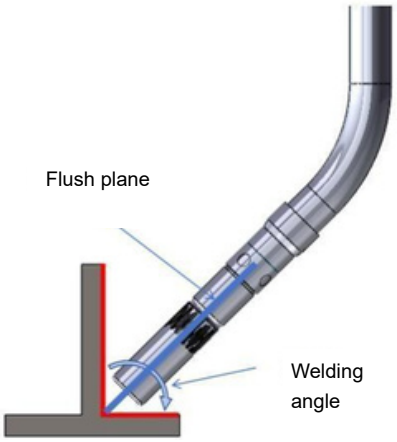
- **Note: If you document the starting point at these angles and the endpoint at the same angles, the robot will maintain the flashlight in that optimal position throughout the entire journey.**



Fillet Weld (L-joint or T-joint)
This represents the quintessential scenario in which two perpendicular plates must be joined at a 90° angle to one another.

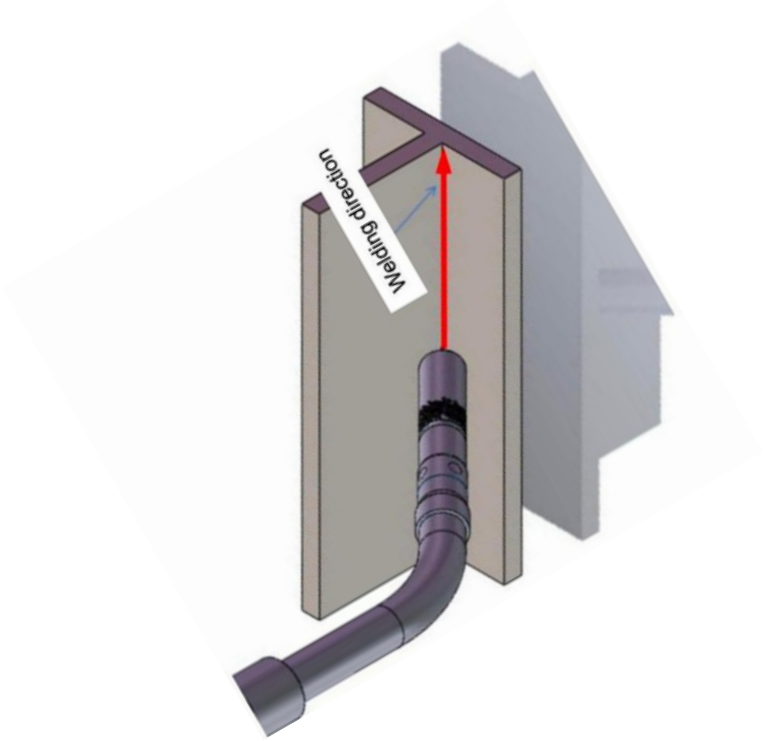
- **Lateral Angle (Tilt): 45°**
  - The torch must bisect the angle formed by the two pieces.
  - **In robotic terminology: The manual stipulates that the Tilt Angle must be maintained at 0° from the bisector. In layman's terms: Avoid tilting the flashlight excessively toward the wall or the floor; ensure it remains perfectly centered. Direction of movement: Tilt it approximately 15° forward (the "push" technique).**

Practical "Teaching" Tip: When positioning the robot at the starting point using the blue button, envision a laser beam emanating from the flashlight's tip, which must precisely intersect the corner line while maintaining a 45° angle to the walls and a 15° forward tilt.



Vertical Welding (On vertical surface) Vertical Ascending (From bottom to top)
It is the most prevalent choice for medium to large thicknesses, as it ensures a reliable seal.

- **Laterally: 90° (Perpendicular)**
  - Hold the torch perpendicular to the plate, ensuring it is not tilted to the right or left.
- **Direction of travel (Vertical): 10° - 15° upward**
  - The torch should be angled slightly upward (in the direction of travel). This positioning assists the gas in shielding the weld pool and effectively "pushing" the solder upward.



Caution: In vertical-up welding, the oscillation setting—referred to as "Swing" or "Weave" in the robot software—is essential. Without this adjustment, gravity will cause the weld pool to drip downward, resulting in the classic "drip."

Here is a straightforward and intuitive method for configuring the parameters on the robot's tablet to "combat" gravity:

1. Select the Movement Type ("Type")
In the welding menu, under Swing (or Weaving), you must select the movement shape:

- **Recommended: Crescent or Triangular.**
- **Reason: These shapes enable the formation of a "shelf" or step upon which the molten metal rests as you ascend, thereby preventing central sagging.**

2. The Essential Metrics ("The Figures")
Here is the procedure for modifying the numeric values in the "Swing" panel:

- **Frequency: Low (0.5 - 1.5 Hz)**
  - The robot should not "vibrate"; it should "illustrate" the movement. If it operates too quickly, it will merely
  - disturb the bath and cause dripping. Conversely, if it moves too slowly, overheating will occur.
    Envision: A "one-two, one-two" cadence.

- **Dwell Time: The "Key"**
  - In the menu, you will find Left Dwell Time and Right Dwell Time.
    Setting: Establish a value ranging from 0.2 seconds to 0.5 seconds.
  - **Why: It is essential to pause briefly at the sides to effectively fuse the walls of the joint and adequately fill the incision (the "mso"). In the center: The transition to the center must be swift (without a central pause); otherwise, the cord may swell excessively and leak.**

- **Width: Average**
  - Determine the desired width of the bead (e.g., 3mm - 6mm, depending on the thickness).
  - *Rule of thumb: Avoid swinging excessively to make contact with both walls of the joint.*

Robot Strategy Overview
When configuring the Swing screen for vertical ascent, the underlying logic is as follows:

1. Side: Dwell (0.3s) -> Integrates with the wall, occupies the side.
2. **Center: Accelerate swiftly -> Avert the descent of the**
3. Opposite Side: Halt (Dwell 0.3s) -> Causes the adjacent wall to melt. 4. Climb: The robot ascends while executing this zigzag motion.

Operational Tip: During the test (or the initial beads), examine the sides. If you observe "holes" or nicks along the edges of the weld, extend the dwell time. If the center exhibits dripping, increase the oscillation speed or decrease the current.

Important Note: When recording points (Start Point and End Point) using the Drag-to-Teach button, ensure that these angles remain constant at both the start and end. Altering the angle between the start and end will cause the robot to rotate its wrist during the process.
the welding, jeopardizing the integrity of the bead.

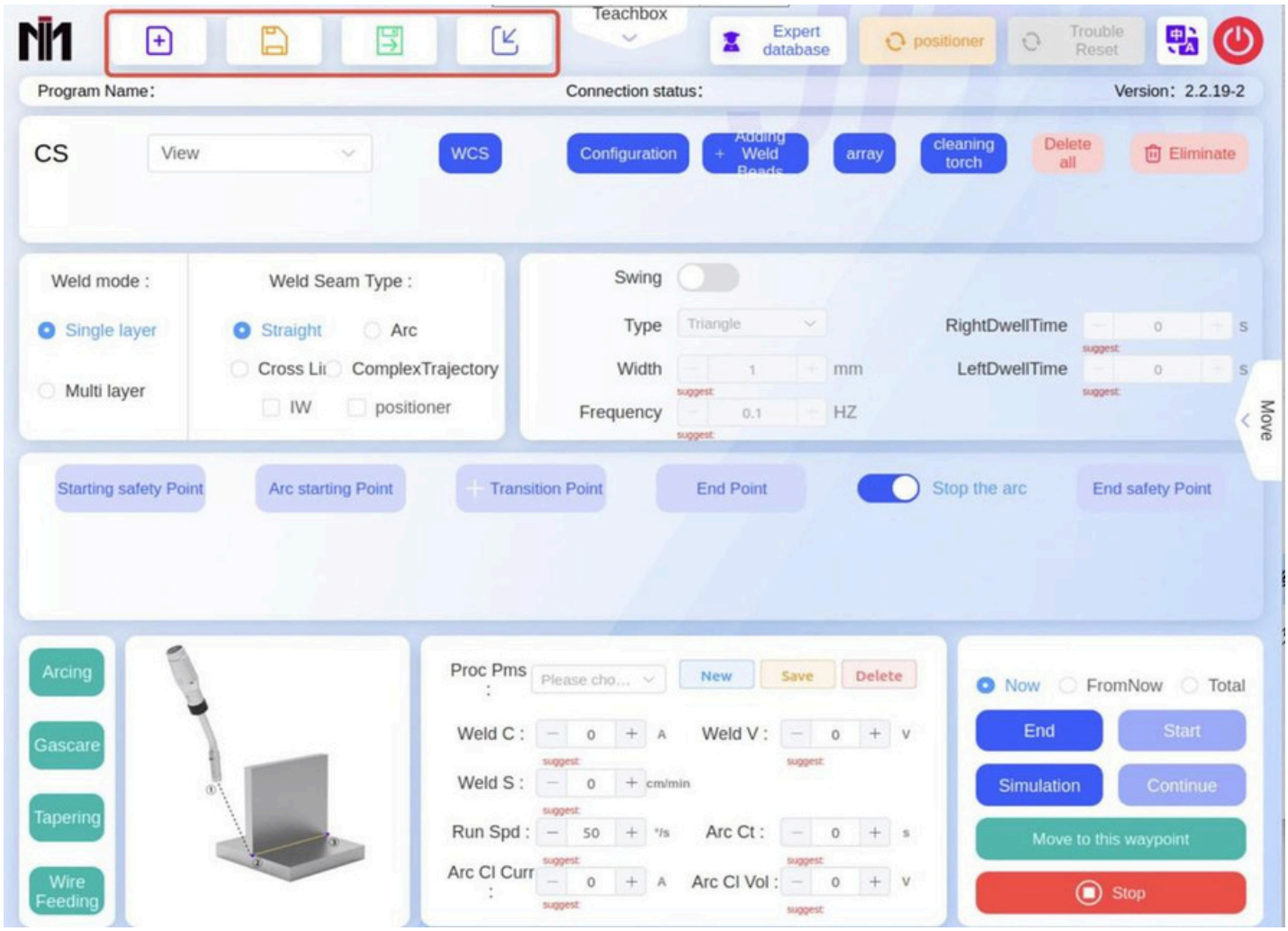
5. DEVELOPING A WELDING PROGRAM (Step-by-Step) 5.1 File Development

1. Main Menu: New Program.
2. Save as (e.g., "Welding_Bracket_01").

5.2 Utilizing the Welding Template

Refrain from writing code; instead, employ pre-existing blocks.

1. Navigate to Blocks > Template > Scene.
2. Select the welding type: Straight or Arc.



5.3 Instructional Points The software will prompt you to complete the blank fields:

1. Initial Point (Arc Initial Point):
   - oh oh Position the robot at the beginning of the joint (ensuring the angles and a 15 mm distance are maintained). Select "Register Point."
2. Terminal Point (Arc Terminal Point):
   - oh oh Position the robot at the end of the joint. Select "Record Point."
3. Safety Considerations (Optional but advisable):
   - th e Establish an approach point in the air prior to the commencement and a departure point following the conclusion to prevent the robot from colliding with the component during movement.

5.4 Establishing Process Parameters

In the right panel, input the figures for the welding:

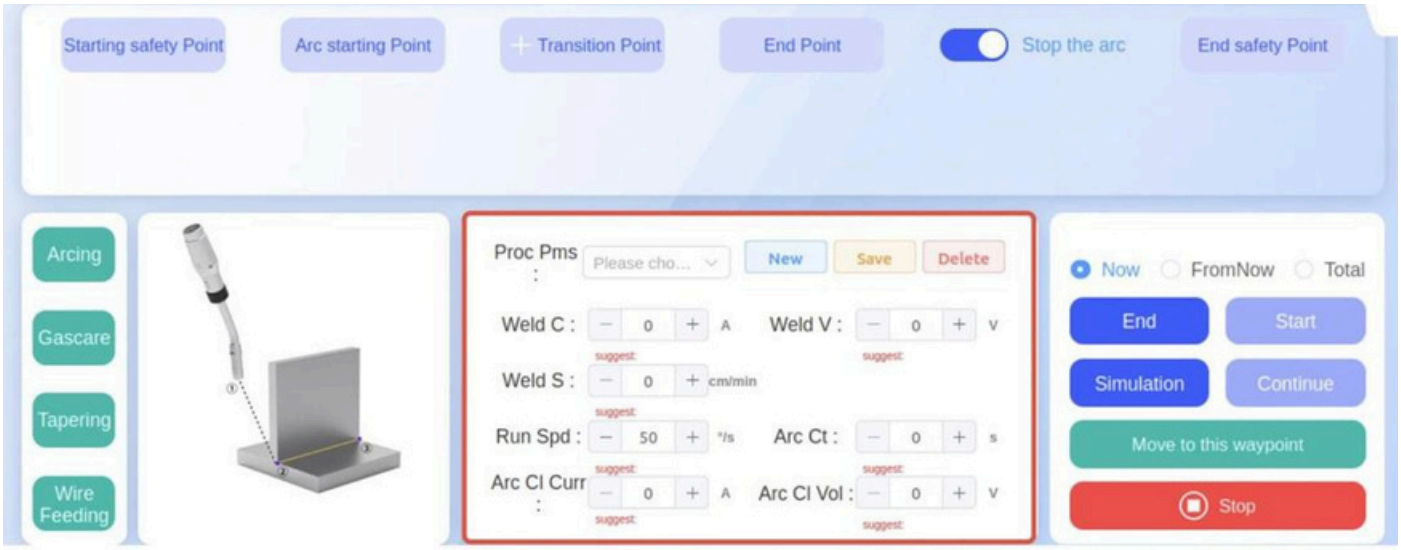
- **Weld Speed (Velocity): Feed rate measured in cm/min or mm/s (e.g., 50 cm/min).**
- **Current/Voltage: Specify the required Amperes and Volts.**
- **Crater Fill (Arc Closure): Specify a duration (e.g., 0.5 seconds) and a reduced current to fill the final crater upon the extinguishing of the arc.**

5.5 Verifica

Set the selector to "Simulation."

2. Press Play. The robot will navigate the course without activating the arc.

3. Conduct a visual inspection to ensure that the distance (10-15mm) and torch angle are maintained consistently. 4. If all parameters are satisfactory, deselect Simulation and continue with the welding process.

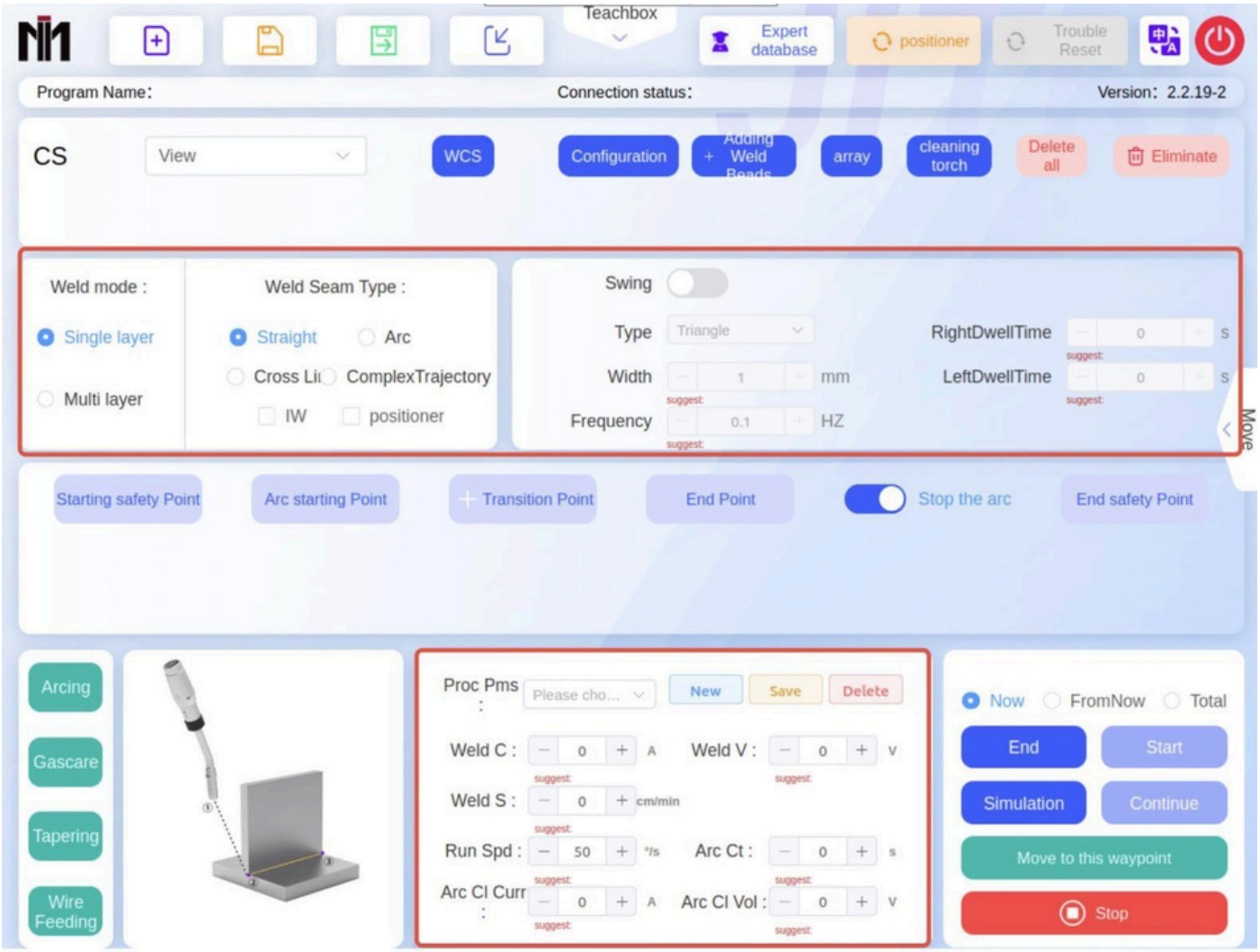


6. ENHANCED FUNCTIONS

6.1 Weaving

Designed for wide beads or vertical upward welding.

In the welding menu, enable the "Swing" toggle.
2. Type: Select "Triangle" or "Crescent" (recommended for vertical orientation).
3. Frequency: Low for vertical (0.5 - 1.5 Hz).
4. Width: The measurement of the bead's width (e.g., 4mm).
5. Dwell Time: Configure to 0.2s - 0.5s on the Left and Right to effectively "bite" the walls without causing drips in the center.



6.2 Multi-Layer Welding

To fill deep joints without reconfiguring everything.

Instruct on the initial chord (root) as previously described.
2. Choose the "Multi-layer" mode.
3. For subsequent passes, refrain from recording new points. Only input the offset:
   - oh oh ΔZ: Increases the twist (i.e., +2mm). ΔY: Displaces the twist laterally.

ARRAY FUNCTION MANUAL (Matrix Welding)

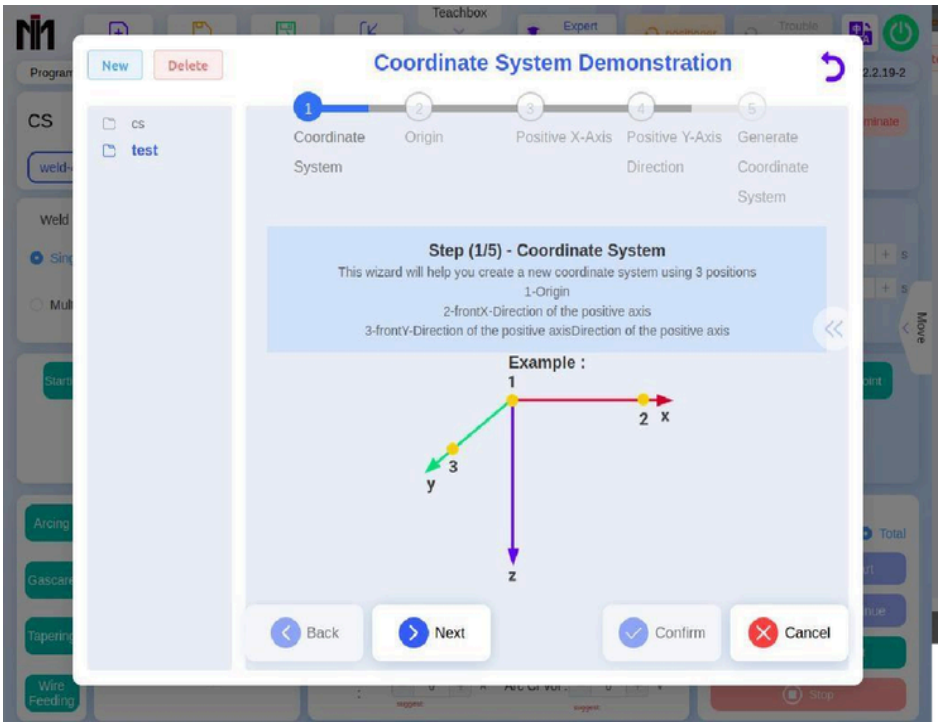
What is its purpose?
The Array function is employed when multiple identical components are systematically organized on a workbench (in rows and columns). Rather than instructing the robot on the location of each individual part (which would be time-consuming), you only need to teach it the position of the first part to be welded and inform the robot, "There are 4 additional parts to the right, spaced 50mm apart, and 3 more forward, also 50mm apart."

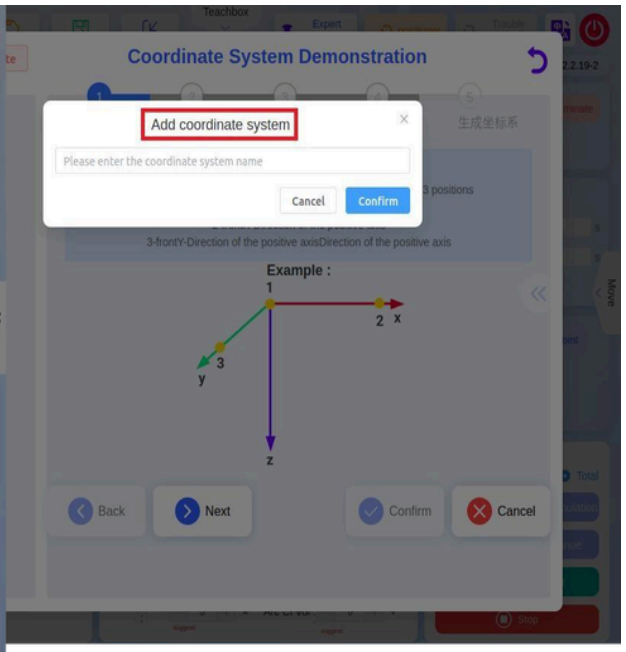
Advantages:

- **Time efficiency: Program a single time.**
- **Accuracy: If the initial one is flawless, the subsequent ones will be as well.**
- **Effortless editing: Should you need to modify a parameter (e.g., speed), simply adjust it on the first instance, and it will automatically update across all of them.**

PHASE 1: The essential prerequisite (Coordinate System)
The robot lacks knowledge of the table's location and the orientation of the components. Prior to generating the array, it is essential to establish a Workpiece Coordinate System (WCS). This system instructs the robot, "This is the origin (0,0), this is the X direction, and this is the Y direction of my tray of components."
How to Establish the Coordinate System (Three-Step Process):

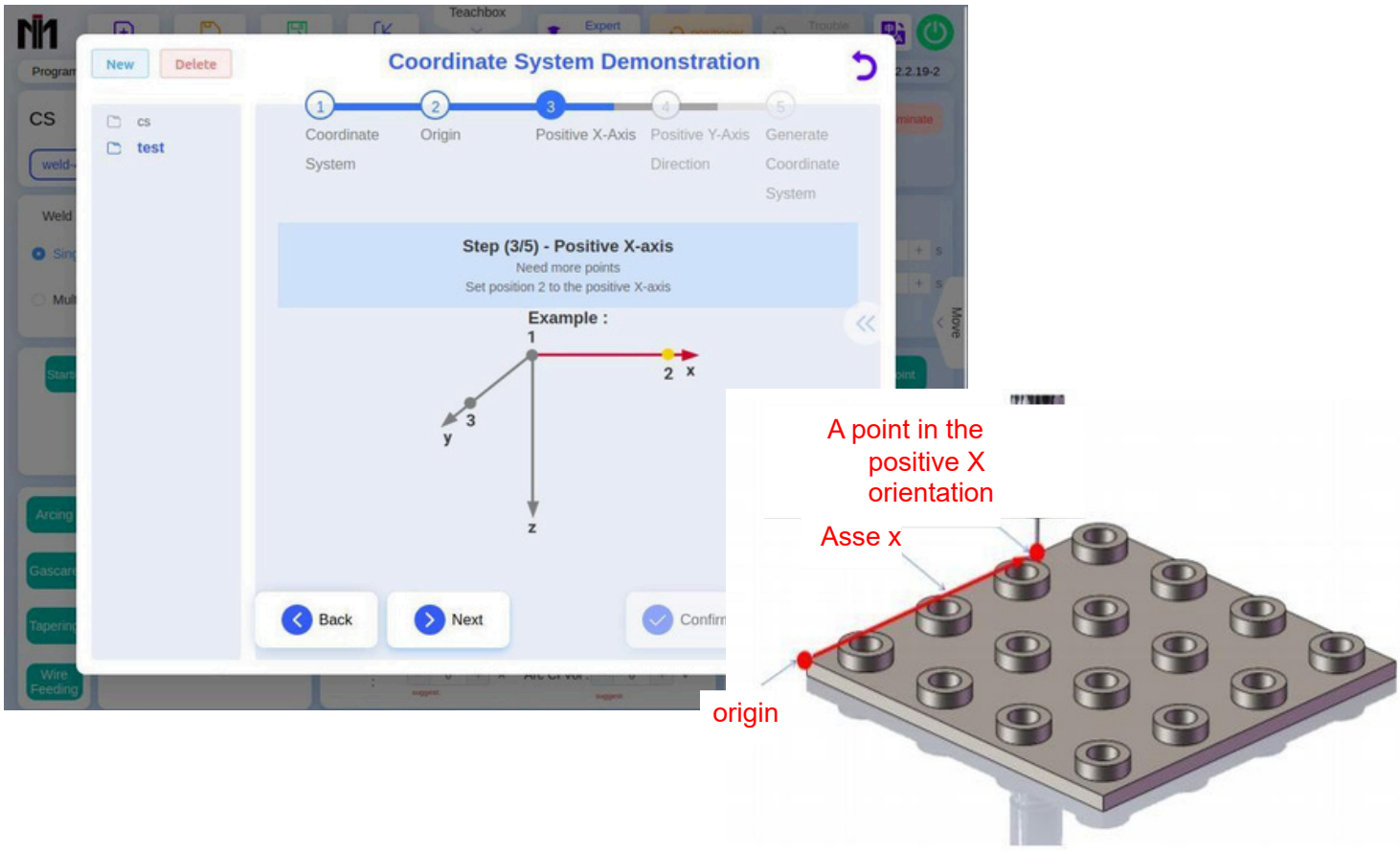
1. Navigate to Configuration > General > TCP > Coordinate Systems. 2. Select New and proceed through the wizard.



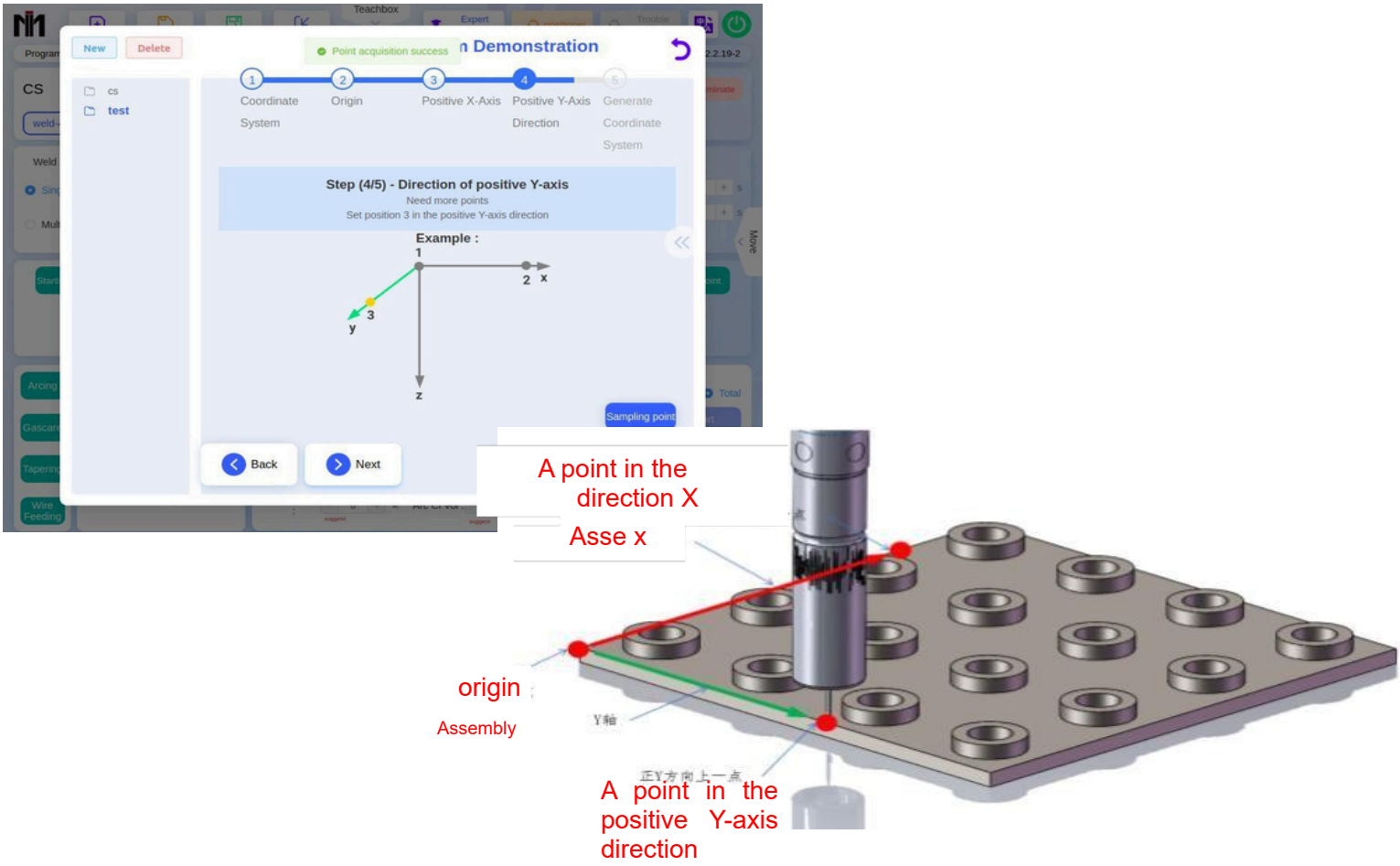


3. **Point 1 (Origin): Position the tip of the torch at the edge of the first piece (or jig). Document the point.**

4. **Point 2 (X Direction): Position the flashlight along the horizontal array of components. The distance is irrelevant; only the linear direction is important. Document the point.**



5. **Point 3 (Y Direction): Position the torch along the vertical axis of the components. Document the location.**



6. **Save: Assign a name to the system (e.g., "Grid_Pieces") and proceed to save.**

PHASE 2: Programming the Initial Component (The "Master")

You must now develop the welding program for the initial piece of the grid, adhering to one essential principle: the system must be utilized **of coordinates recently established.**

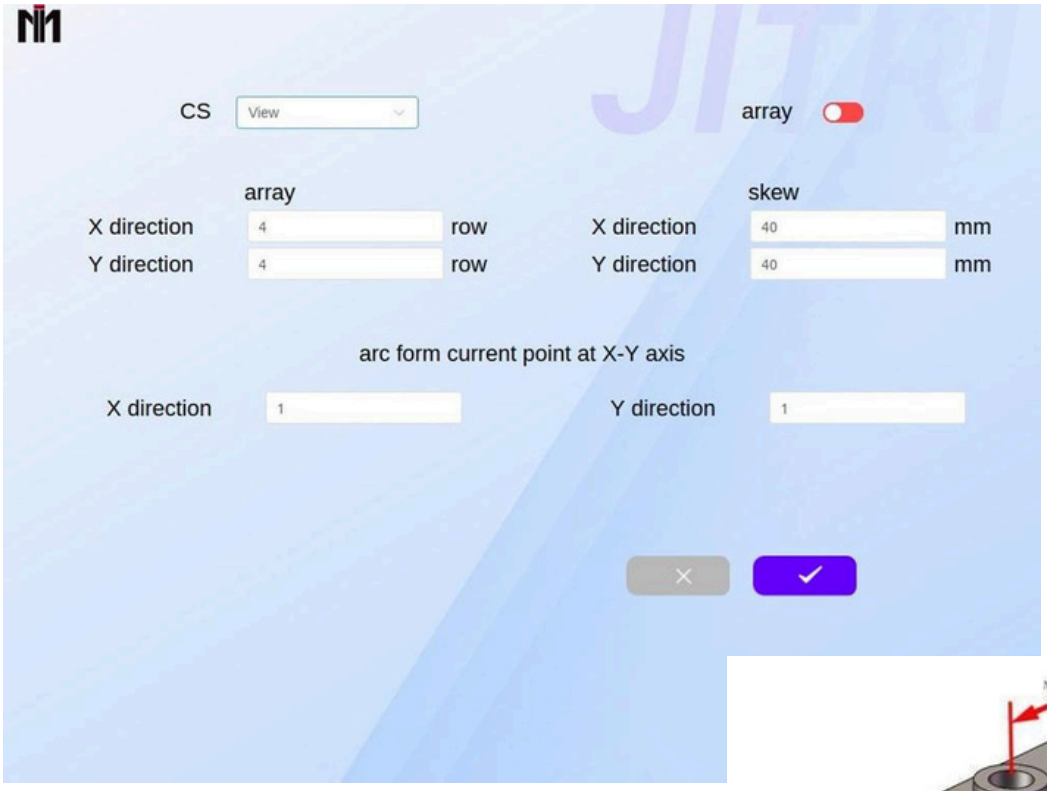
1. Open a new application or utilize the welding interface.
2. In the top menu, where you select the WCS (Workpiece Coordinate System), choose the name of the system you have just created (e.g., "Workpiece_Grid").
3. Document the welding points (Start Point, End Point) of the initial piece (the one situated at or near the origin).
4. Configure the welding parameters (speed, current) as you would for an individual piece.

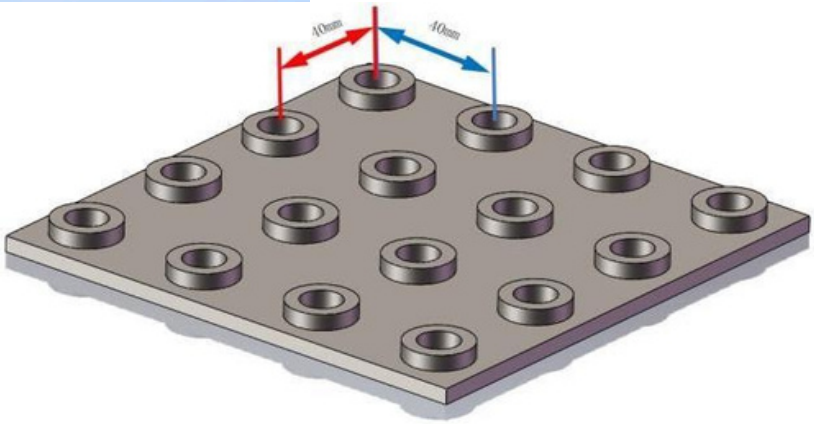
STEP 3: Configuration of the Array

Now that the robot has mastered welding the initial piece and understands the table's orientation, you may proceed to activate the Array.

1. Select the "Array" button located on the top bar of the interface.

   A window will appear prompting you to input the geometric data of your grid:





"Weld from selected X and Y directions" indicates that the robotic arm has the option to initiate welding from either the first row in the X direction and the first row in the Y direction, or from the second row in the X direction and the first row in the Y direction. In this scenario, the robotic arm does not perform welding on the welds located in the first row of the X direction and the first row of the Y direction.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