

INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH
EVENING LECTURE “ROBOTIC WELDING FOR CONSTRUCTION SITES” ON 23/10/2019



The evening lecture “Robotic Welding for Construction Industry” was convened in 23/10/2019

Automation: way out for labour shortage

The first industrial robot was a welder robot invented in 1950. Over half a century later, although automation has been widely adopted in a broad range of industries, the construction industry still lags the industry average in implementing automation. While the construction industry has not been supported by any maturely developed robot and has remained manual labour dominant and intensive, ageing of the construction workforce starts eroding the long term viability of the industry, and construction welder is hit particularly hard.

A typical construction site in Hong Kong prepares 5,000 to 6,000 pieces of H-pile for piling, while each H-pile has five (5) to six (6) joints to be welded. This amounts to hundreds of construction welders are required for each construction site. However, the supply of construction welders is less likely to meet the demand in the long term.

Among the registered construction welders in Hong Kong, 63 % of them are over 50 years of age and only 5 % of them are 29 years old or below. Besides, it is forecasted that by 2022, the construction industry will short 1,500 construction welders. On the other hand, provided that the construction welders have to bear the harsh working environment, as they need to wear the heavy and thick protective clothing to protect themselves from the welding temperature can be as high as 2,000 C when the ambient temperature and relative humidity are both high, the construction industry is not surprising

to find itself hard to attract young people to join it and become construction welder. In fact, not only is it the phenomenon in Hong Kong, the trend of lacking construction welders is global.

To match the future demand of construction welder, and bringing a green youngster to become a welding master takes long time, automation of construction welding is a way forward.

Automation: agile deployment for construction sites

The long well understood suitable closed and controlled environment for automation and implementing robotic operations is indoor, repetitive, pre-programmed, precise and work on standardised workpieces. Nevertheless, a typical construction site is outdoor and the workpiece geometries are highly diverse. In conjunction with the workpieces are normally prepared at site and do not enjoy high precision, the construction site environment is not suitable for implementing automation in the ordinary manner.

Ordinary industrial welding robots require the input of the three-dimensional (3-D) profile of the workpiece in order to programme the work sequence, while tooling and commissioning demand minimum one (1) week to proceed with mass production. In a construction site, the weld surfaces are often prepared *in-situ* and no prior information about the workpiece profile is available at all, whereas the fast pace nature of the construction industry can only tolerate a weld joint to be welded within hours. Moreover, very often the workpieces to be welded at the construction sites are prepared by flame cutting, resulting in the weld gaps are non-uniform and in poor profile.

A solution for robotic welder possible is using adaptive robotic control (ARC). Instead of inputting the weld joint full 3-D profile in advance, ARC only needs two (2) points of start and finish to define the weld joint, and the weld joint geometry is non-contact 3-D scanned by laser sensing. The scanned data is processed by numerical algorithms to derive the weld path, including compensation weaves in zig-zag, triangular or spring form, which are the outcomes of capturing the know-how of the experienced construction welders, and transforming their techniques and craftsmanship into the algorithm and operation commands. Whenever multi-layer welding requires, ARC, supplements by artificial intelligence, derives the number of pass needed and programmes the beads layout. After the weld gap is well filled with beads, the weld joint is laser scanned once again to determine the top layer profile, and the top layer is welded accordingly. Not only can the adaptive robotic welder weld straight lines, it can also weld non-straight lines and curvature surfaces.

Automation: safety for construction sites

To be agile in deploying in construction sites, safety is of priority concern for the adaptive welding robot. The ordinary industrial robotic welders have no mechanism to halt their motion in case of hit; thus their operating area has to be shielded for the safety of the human workers. Conversely, fencing is not possible for the robotic welders working in construction sites due to the site constraints and the requirement of agile deployment. They need to sense impacts and proactively stop their motion in protection of the workers on impact and in vicinity.

A solution is the adoption of collaborative robots, such as which developed by Universal Robots from Denmark. Collaborative robot should satisfy ISO 10218-1:2011 “Robots and Robotic Devices – safety requirements for industrial robots – part 1: robots”, ISO 10218-2:2011 “Robots and Robotic Devices – safety requirements for industrial robots – robotic systems and integration” ISO 12100:2010 “Safety of Machinery – general principles for design – risk assessment and risk reduction”, ISO 13849 “Safety of Machinery – safety-related parts for control system” and ISO/TS 15006 15066: 2016 “Robots and

Robotic Devices – collaborative robots”. Collaborative robots are available in a range of weight and working radius capacities, from 3 kg at 500 mm to 10 kg at 1,300 mm.

The integration of ARC and weld gun into a collaborative robot forms the highly autonomous, flexible and durable to deploy and operate adaptive robotic welder. Only few workers locate the adaptive robotic welder about one (1) feet from the weld joint using just tape measure and visual level check, and laser scanning and weld path programming take place autonomously. Once installed, which takes about 15 minutes, the adaptive robotic welder then executes the welding programme in six (6) axes and a weld joint is done. Working on the next weld joint, even though the profile is vastly different to the previous one, the adaptive robotic welder tailor-makes the welding regime for it without any need of re-tooling itself.



Certificate of appreciation was presented to Mr. Stanley Ho, Co-founder of Welbot Technology Limited, recognition of his delivery of the evening lecture on 23/10/2019

the construction industry adaptive robotic welders, which procurement for use will enjoy 70 % price subsidy from Construction Innovation and Technology Fund under Construction Industry Council. The solution for construction welding is there.

Institution of Mechanical Engineers Hong Kong Branch (IMechE-HKB) thanks Mr. Stanley Ho, the Welbot Co-founder, for sharing the technologies of adaptive robotic welder in the IMechE-HKB evening lecture on 23/10/2019.

*** END ***

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Encl.
WHT

Should the workpiece be a H-pile, the adaptive robotic welder can be clamped on the H-pile and the robotic arm can travel in one (1) goal to complete welding of all six (6) sides. Apart from tungsten inert gas welding which first pass needs to be done manually, the adaptive robotic welder can perform metal inert gas, metal active gas and flux-cored welding fully autonomously following the existing Welding Procedure Specifications (WPS) developed by manual welding. The development of WPS for adaptive robotic welder are in progress.

Remarks

Adaptive robotic welder is a solution to the shortage of construction welders. Adaptive robotic welder must be simple and easy to deploy, fully autonomous, highly tolerant to precision and able to stop motion upon impact in order to perform in the demanding environment of construction sites safely.

Welbot Technology Limited (Welbot) offers

ROBOTIC CONSTRUCTION

DATE: 18 OCTOBER 2019

VERSION 3.7



VISION

AS A **PIONEER** TO IMPLEMENT
CONSTRUCTION SITES WITH
INTELLIGENCE, HARMLESS, EFFICIENCY AND
COST EFFECTIVE
CONSTRUCTION ROBOTIC SYSTEM

WELBOT COMPANY STRUCTURE

**Welbot Technology
Limited (HK)**

- Welbot Head Office
- HKSTP Incu-Tech



**Welbot Technology
(Shenzhen) Limited**

深圳市威博特科技有限公司

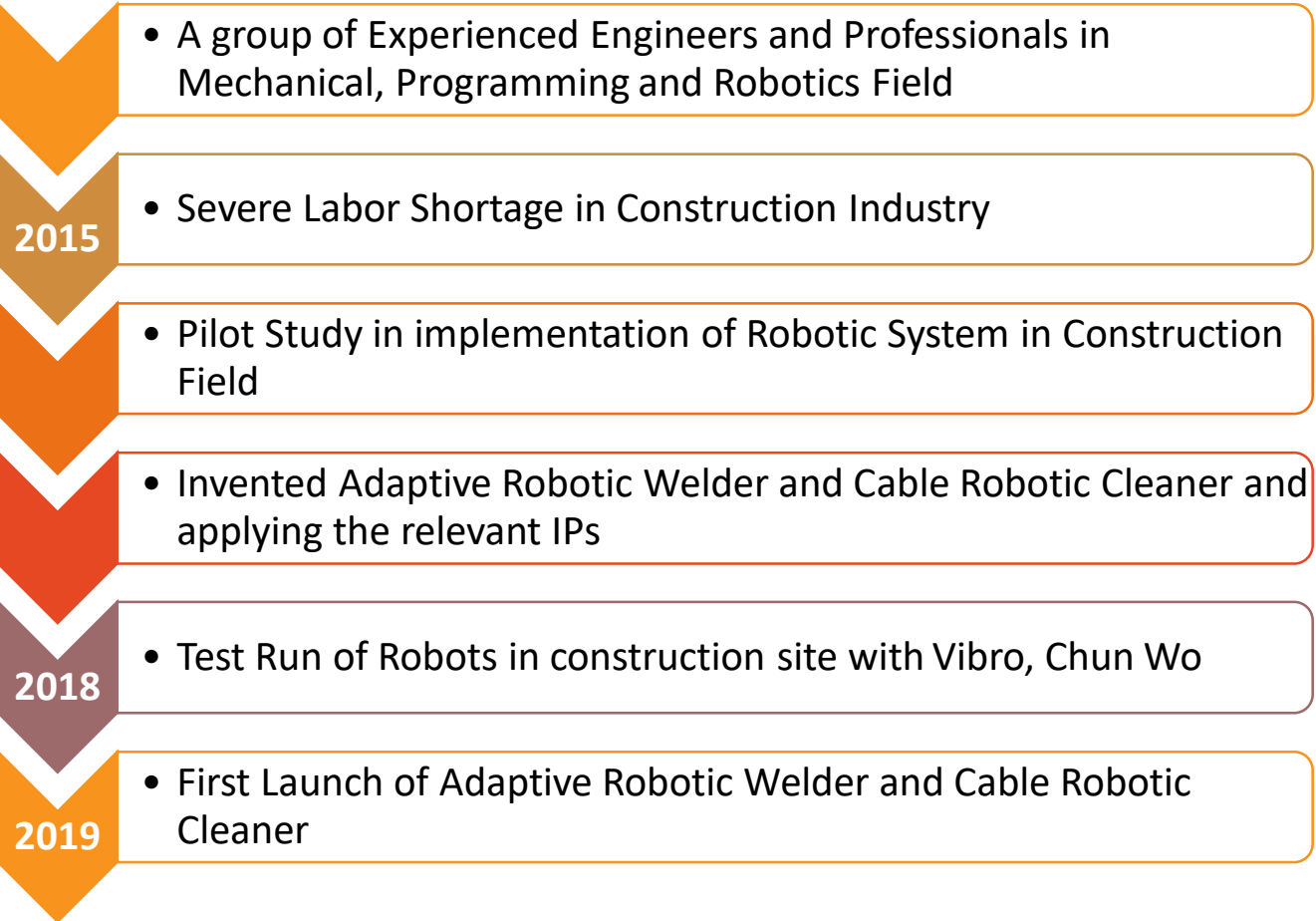
- Welbot SZ Branch Office
- Hold the Patent
 - (Application Code: 201710943375.5)
 - (Application Code: 201910780609.8)

11 Number of R&D staff of robotic welding

2 Number of PhD

3 Number of Master

WELBOT BUSINESS



Cable Robotic Cleaner



Adaptive Robotic Welder

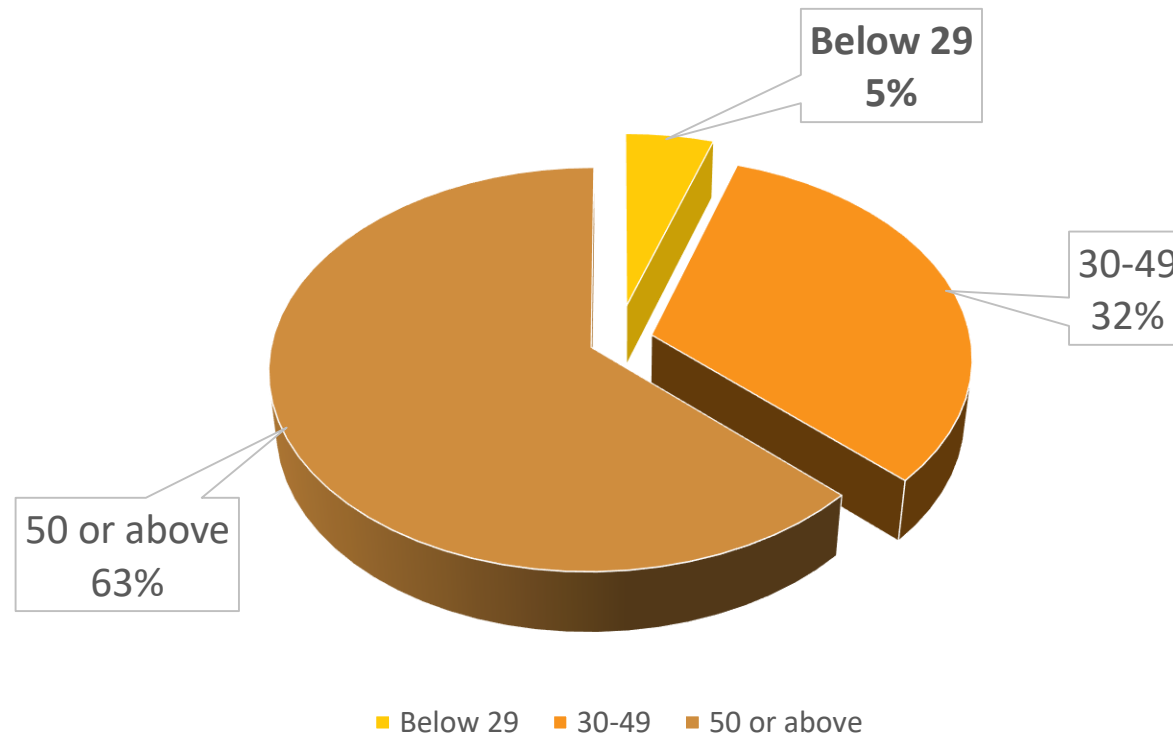
ADAPTIVE ROBOTIC WELDER



ON SITE WELDING CHALLENGES

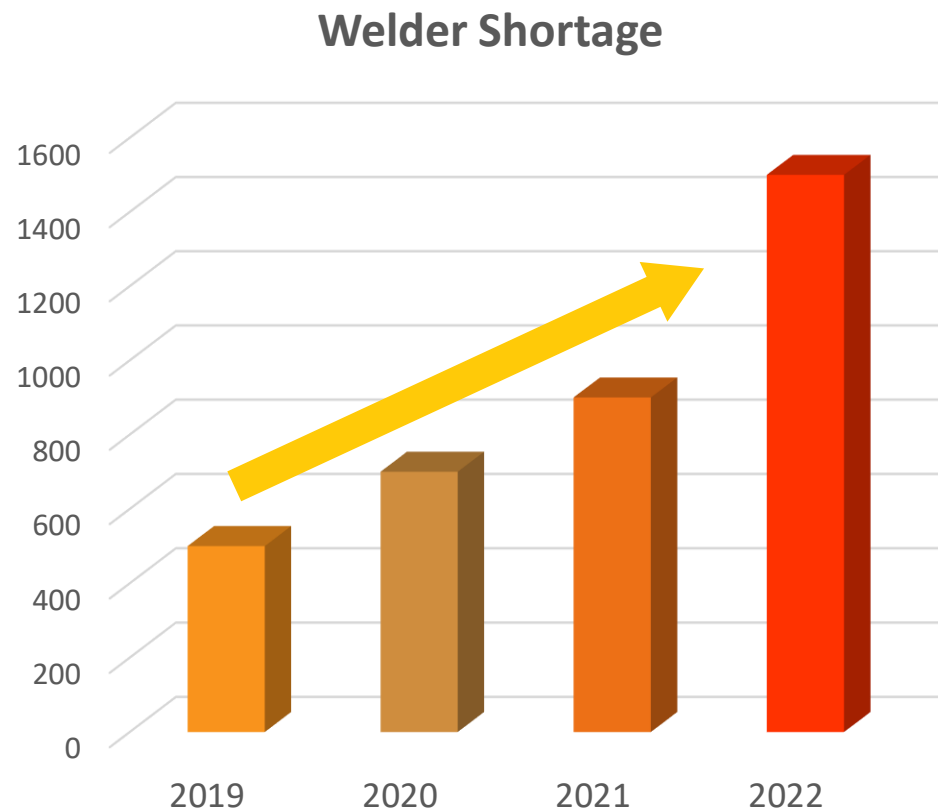
1. SHORTAGE OF SKILLED WELDERS

Demographic of Registered Welders



ON SITE WELDING CHALLENGES

1. SHORTAGE OF SKILLED WELDERS



[From Construction Industrial Council Report of CIC Manpower Forecasting Model 2018 \(Skilled Construction Workers\) \(May 2019\)](#)

ON SITE WELDING CHALLENGES

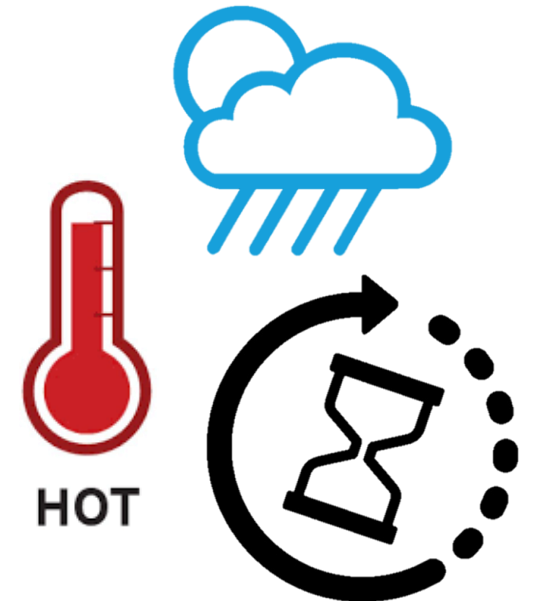
2. LIMITATION IN APPLYING INDUSTRIAL WELDING ROBOTS

Experienced Robotic Engineers required

- Long Set up time consumed

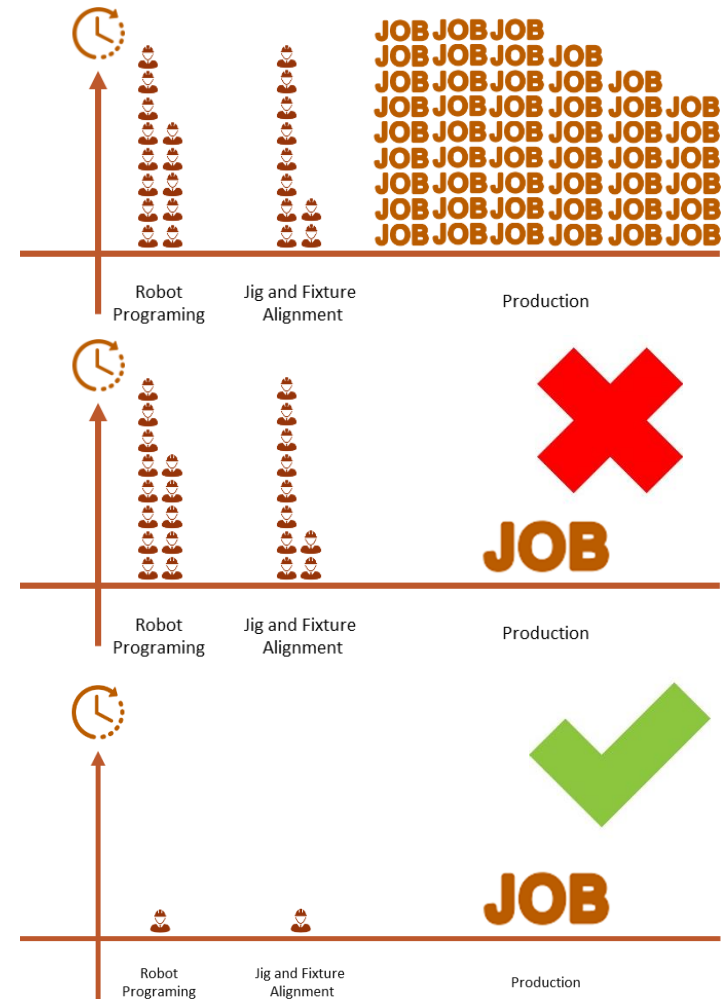
At least 6-8 hours for programming industrial welding robots on site due to

- Harsh Construction Site Environment
- Precise Alignment required



KEY FACTOR OF CONSTRUCTION AUTOMATION

- **Traditional Manufacturing Automation**
it spend 1 week to prepare the Mass Production
- **But it do not accept by Construction industry to spend the same time to complete ONE JOB**
- **Successful Construction Automation**
solution Should be minimum the Time of pre-programing, and fulfil the task Flexibility



OUR SOLUTION

ADAPTIVE ROBOTIC WELDER

Leading Core Technology
Adaptive Robotic Control (ARC)

Construction
Site Ready

High
Efficiency,
Less
Wastage

User
Friendly
Operation

More Safety,
Less
Casualty

The FIRST
and ONLY
robot
technology

Prefect
Welding,
Consistent
Quality



H-PILE WELDING IN FOUNDATION

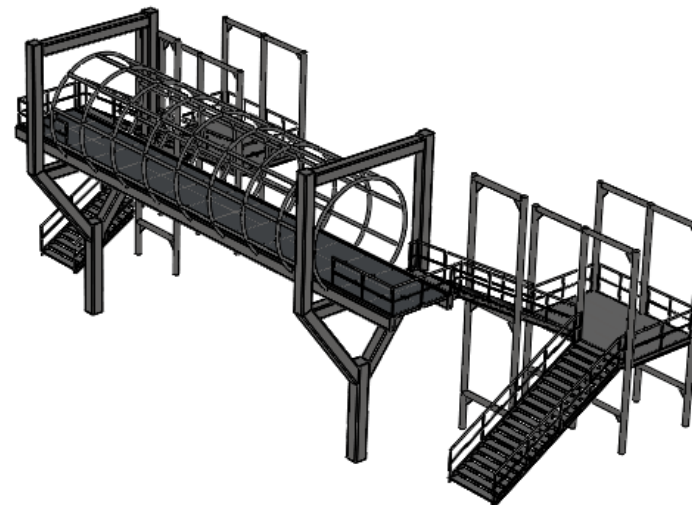
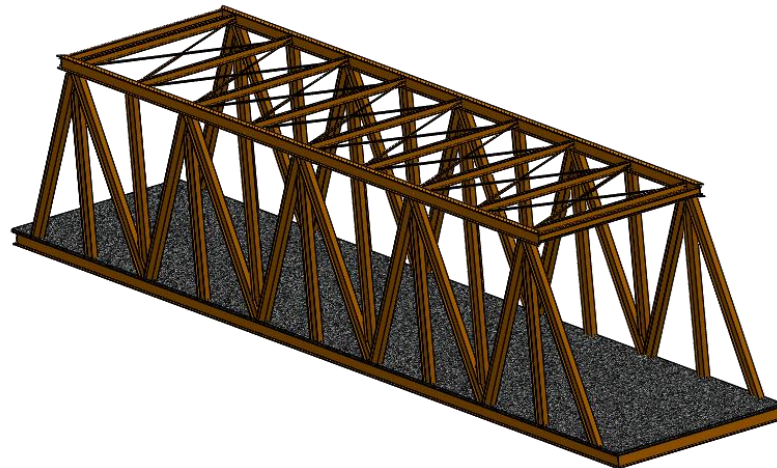
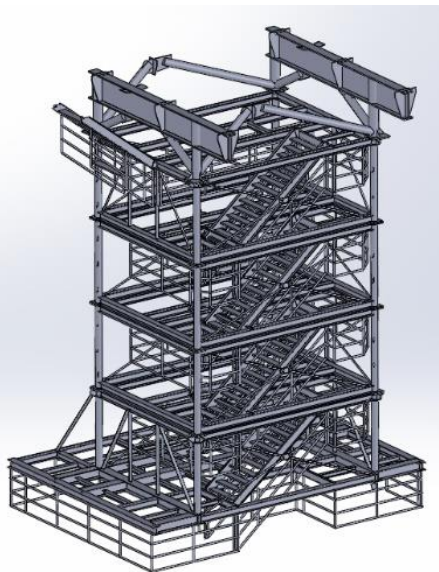


ELS WELDING IN FOUNDATION



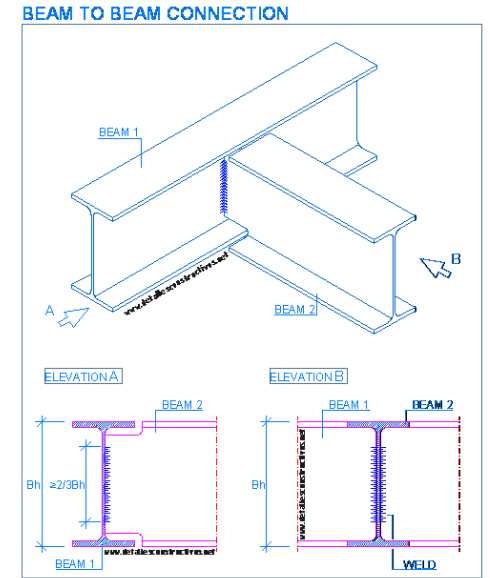
STRUCTURE WELDING

- Large-scale Construction projects continuous implement globally



ROBOT WELDER TARGET SECTOR

- Construction Site Welding (H-beam, Bore Pile...etc)
- Outdoor Oil Pipe connection Welding
- One-Off Structure Pre-workpiece Welding
- On-site Maintenance Welding
- Ship building



ADAPTIVE ROBOTIC CONTROL



OUR SOLUTION

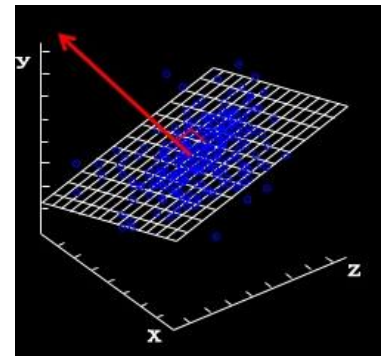
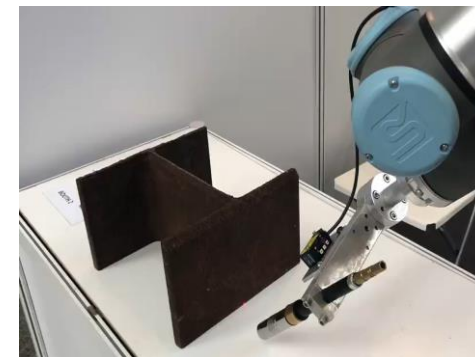
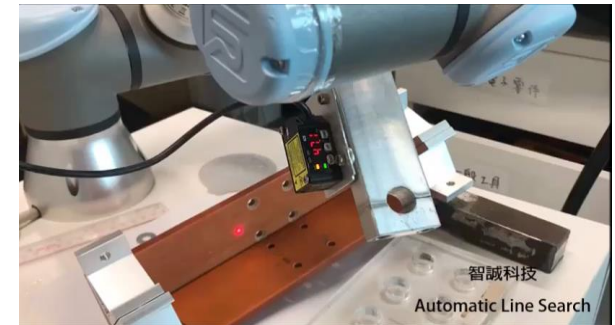
ADAPTIVE ROBOTIC CONTROL -COMPRESS ROBOTIC PROGRAMMING

Data Collected by Laser Sensor

- Contactless collection
- Precise measurement
- Instant modelling

Numerical Algorithm

- Normal fitting
- Curve fitting
- AI noise filtering

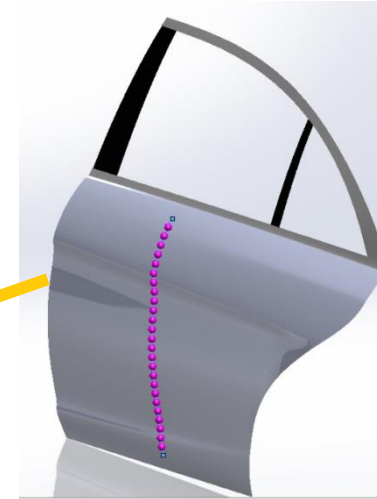
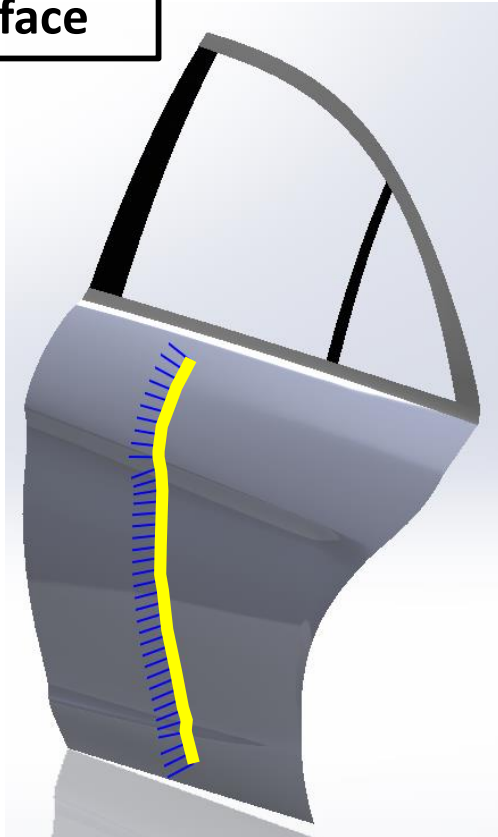


FUNDAMENTAL TECHNOLOGY

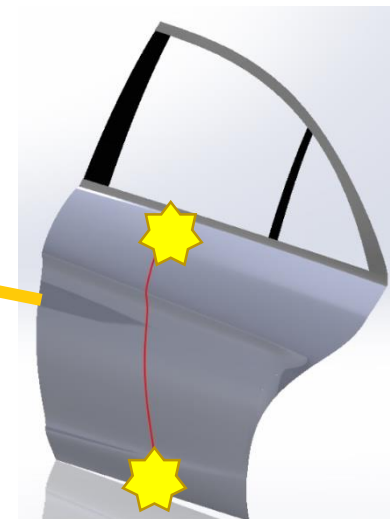
ADAPTIVE ROBOTIC CONTROL

Robot Path Task for
normal to surface

Robotic path required
to drive the tool



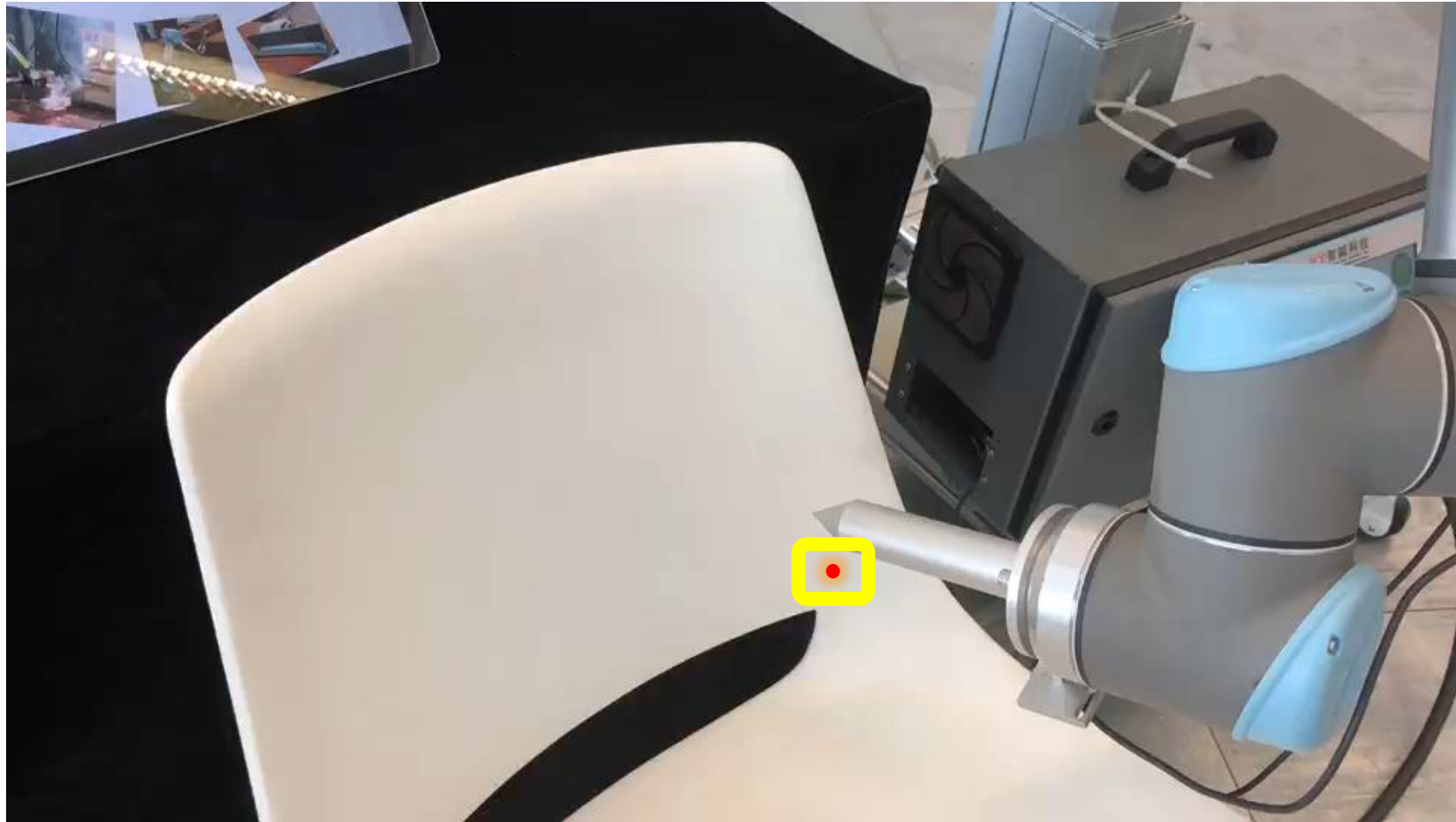
Traditional method
Need 3D CAD
Model and Robot
Simulator



**Robotic Adaptive
Control**
Only 2 points are
needed for

FUNDAMENTAL TECHNOLOGY

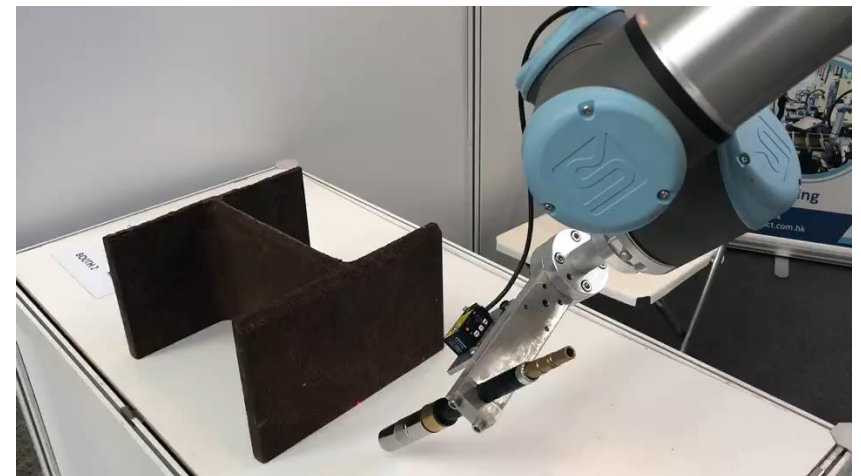
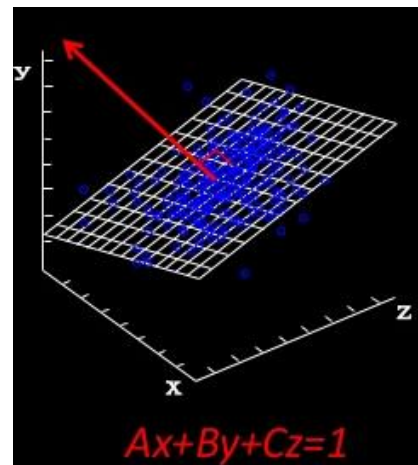
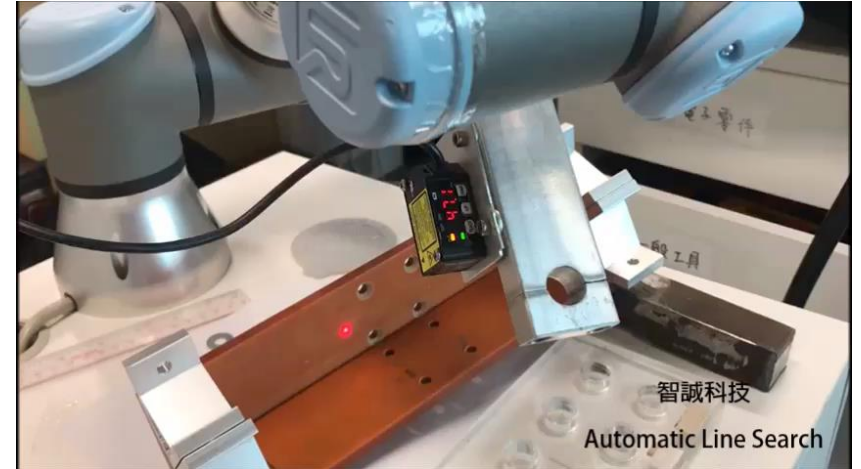
ADAPTIVE ROBOTIC CONTROL



Robotic path Auto Generation by ARC

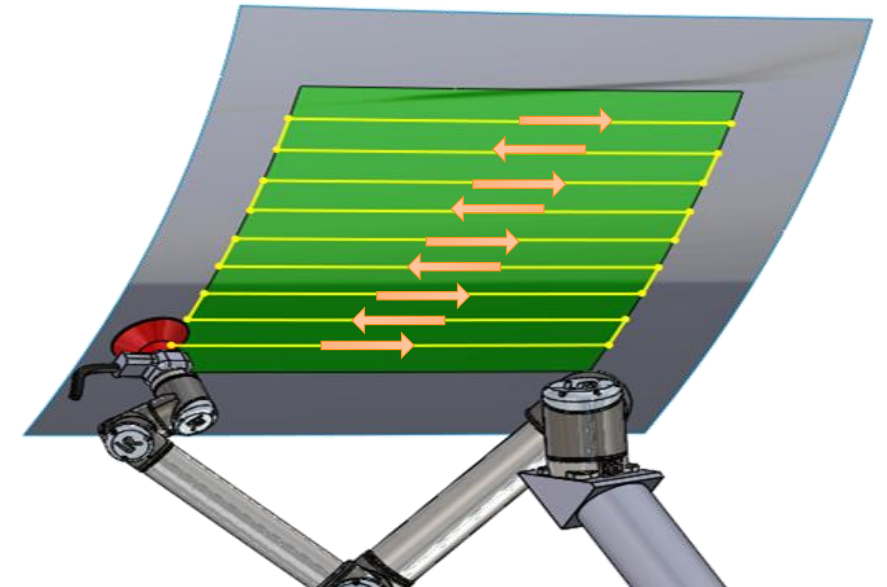
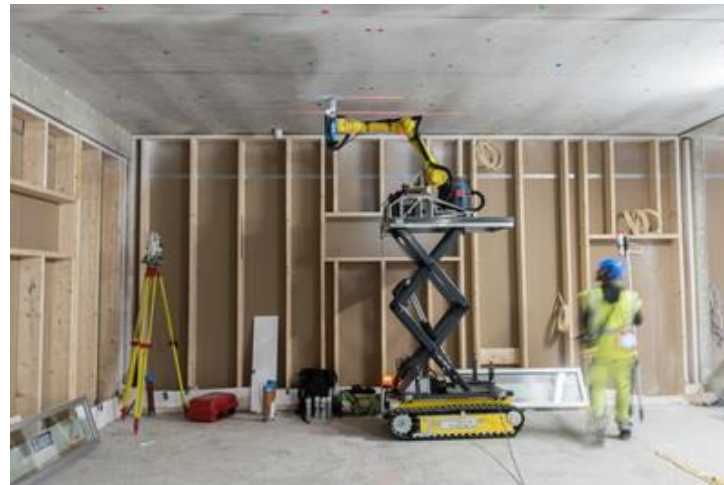
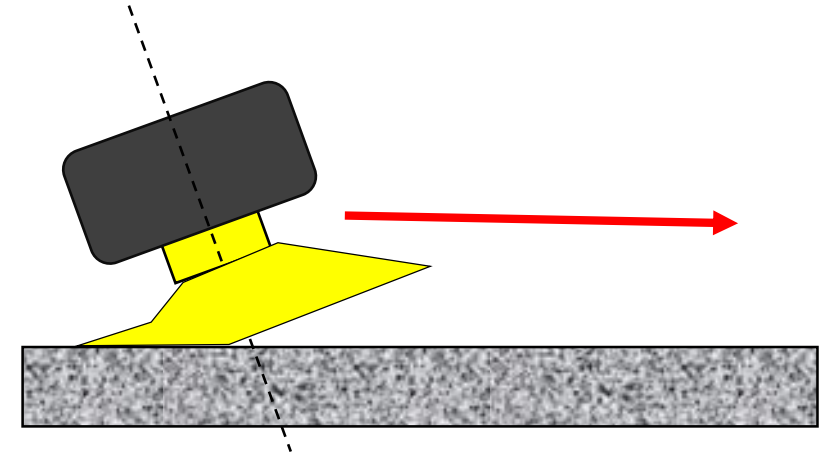
ADAPTIVE ROBOTIC CONTROL

- Compress robotic programming task
- Use laser sensor and numeric method to extract data
- Non-contact Scanning
 - 3D Point
 - Work normal by numerical method
 - Line by numerical method
 - Free form workpiece



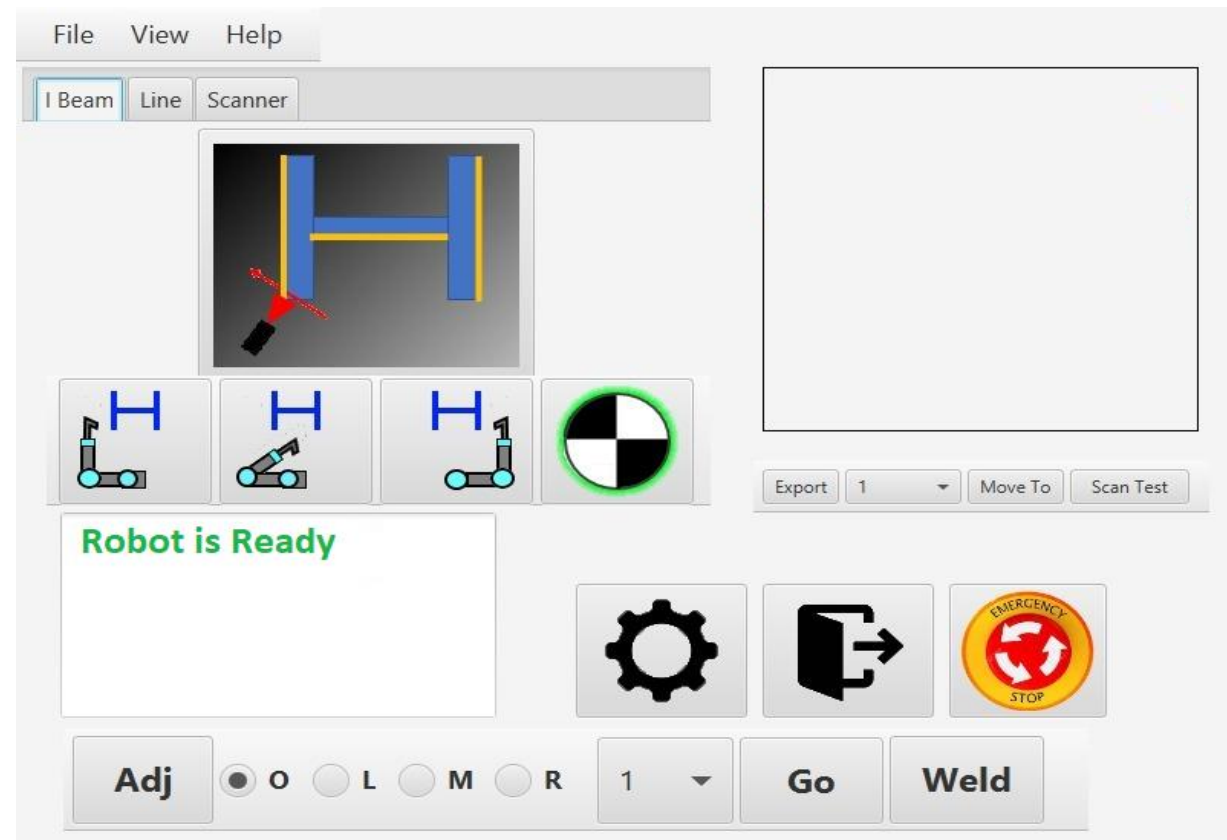
ARC – OTHER APPLICATION

- Welding
- Polishing
- Wall finishing
- Drilling
- Inspection
- Painting



ADAPTIVE ROBOTIC WELDER ON SITE WELDING

- ① Worker install on approximately position and start scan



OUR SOLUTION

ADAPTIVE ROBOTIC WELDER ON SITE WELDING

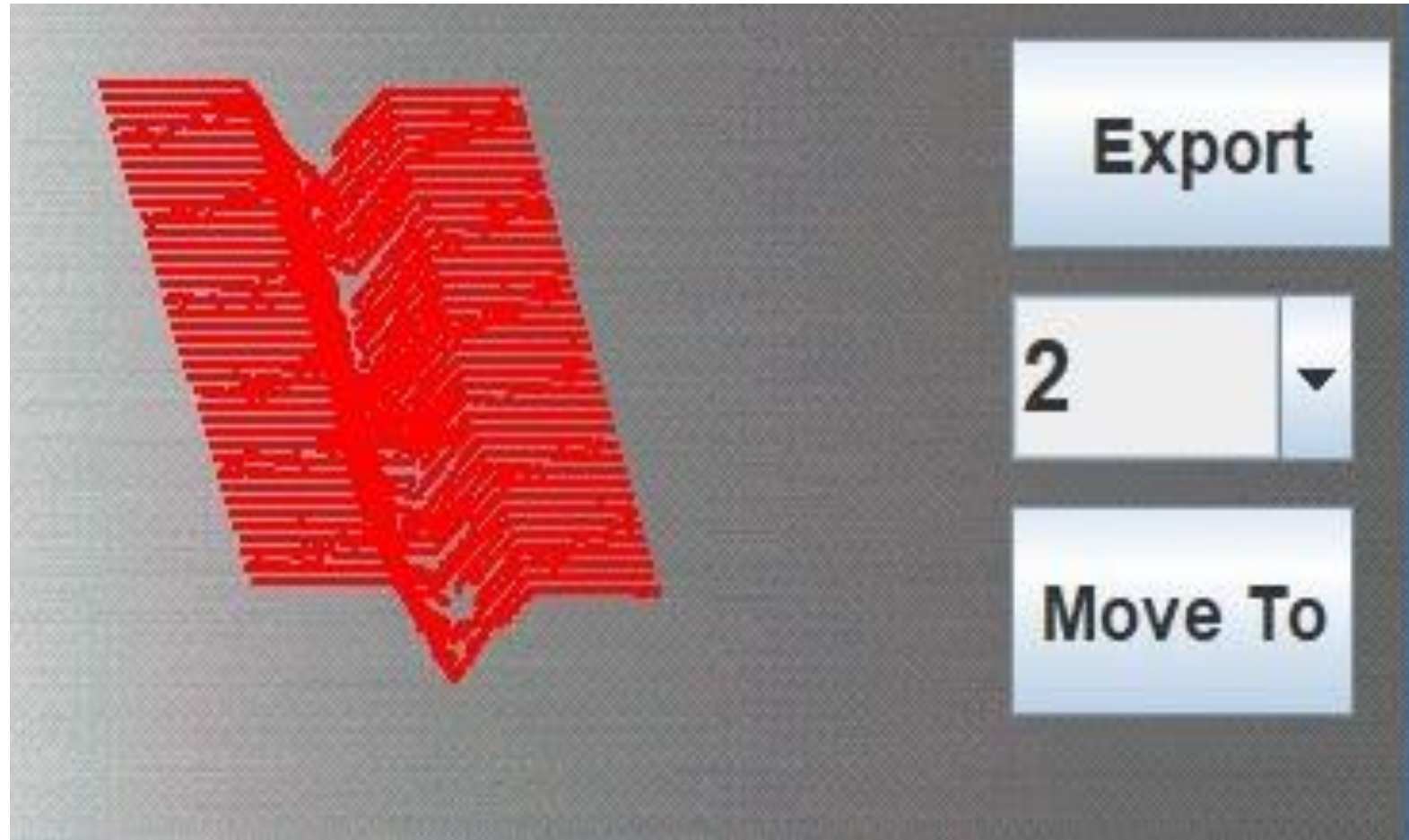
② Scan Workpieces



OUR SOLUTION

ADAPTIVE ROBOTIC WELDER ON SITE WELDING

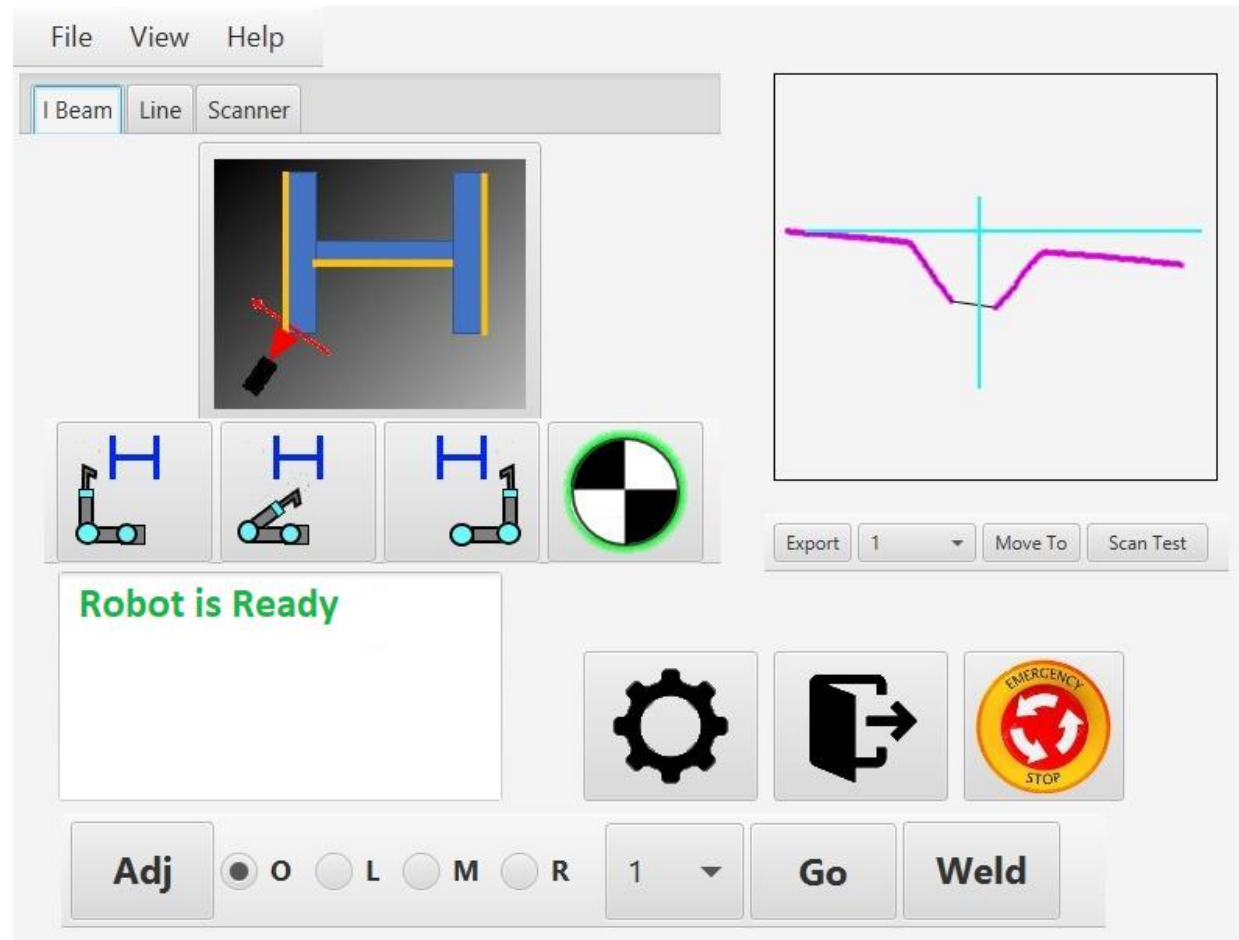
③ Auto Weld Path



OUR SOLUTION

ADAPTIVE ROBOTIC WELDER ON SITE WELDING

④ Worker confirm and start



OUR SOLUTION

ADAPTIVE ROBOTIC WELDER ON SITE WELDING

- ⑤ Live data to preform accurate welding



OUR SOLUTION

ADAPTIVE ROBOTIC WELDER ON SITE WELDING

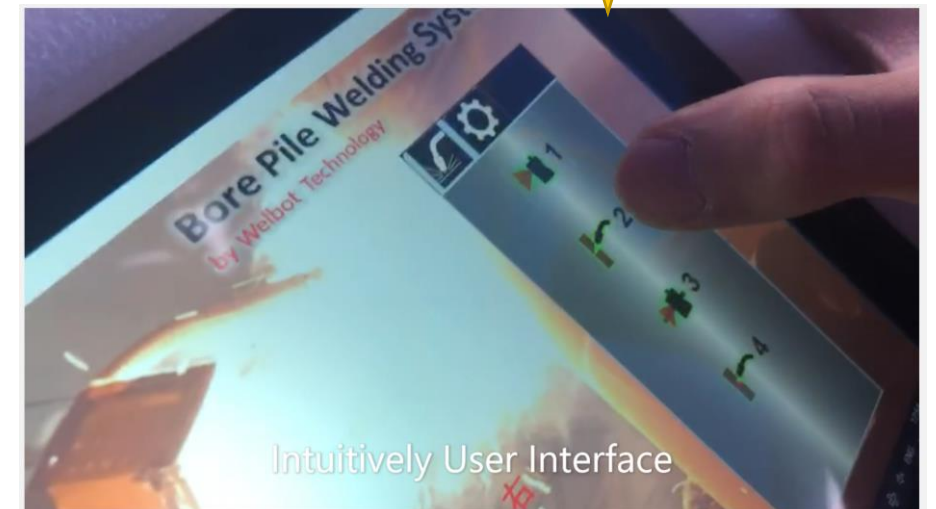
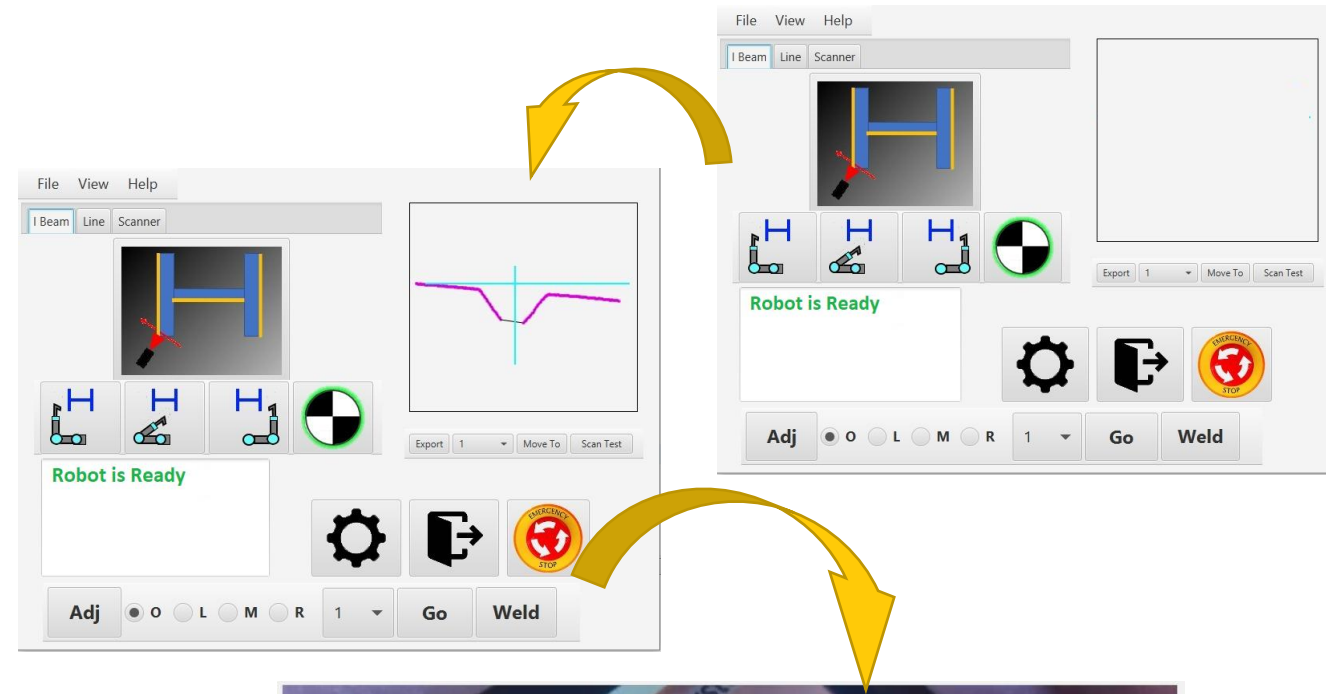
⑥ Auto – AI Multilayer



SMARTWELD FEATURE

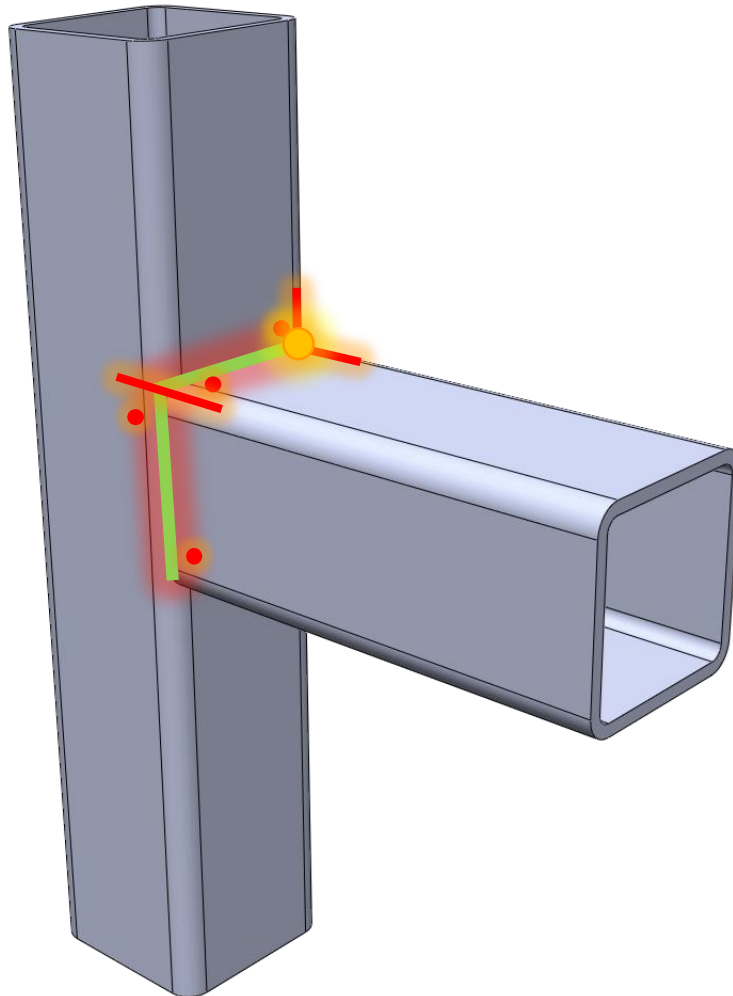
Feature

- Intuitive User interface
- Auto-WeldPath Generation
- 3D Welding Weave
- Complex Welding Path
 - Non-Straight Welding
 - Curvature surface welding
- Gap compensation
- Multi-Layer Auto Weld



SMARTWELD FEATURE

AUTO-WELDPATH GENERATION



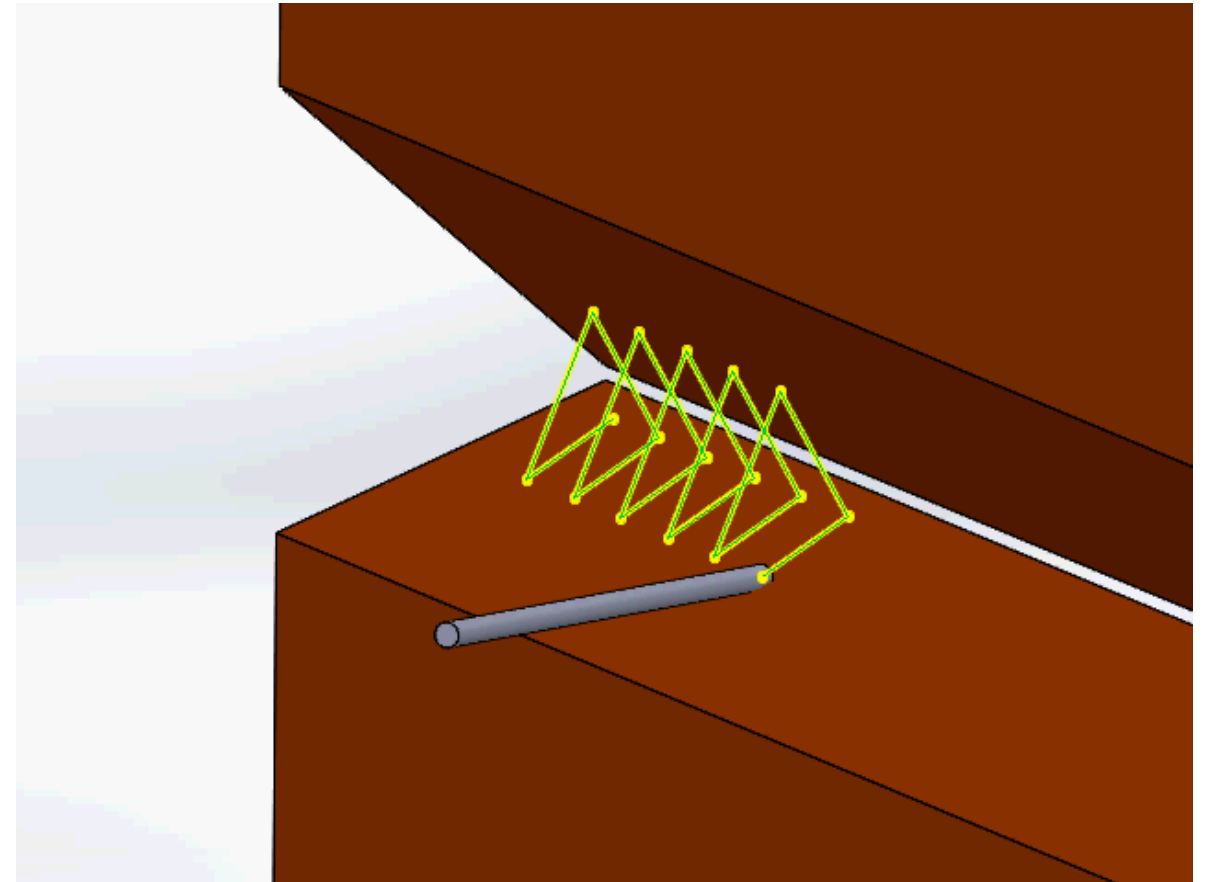
- Welding Target
- Approximate point out the welding location (by Worker)
- SMARTScan the welding Profit
- Auto-Weld path generated

SMARTWELD FEATURE

3D WELDING SWING WEAVE

To Fulfil Complex requirement

- Zigzags Welding Weave
- 3D Welding Weave
 - Spring
 - Triangle



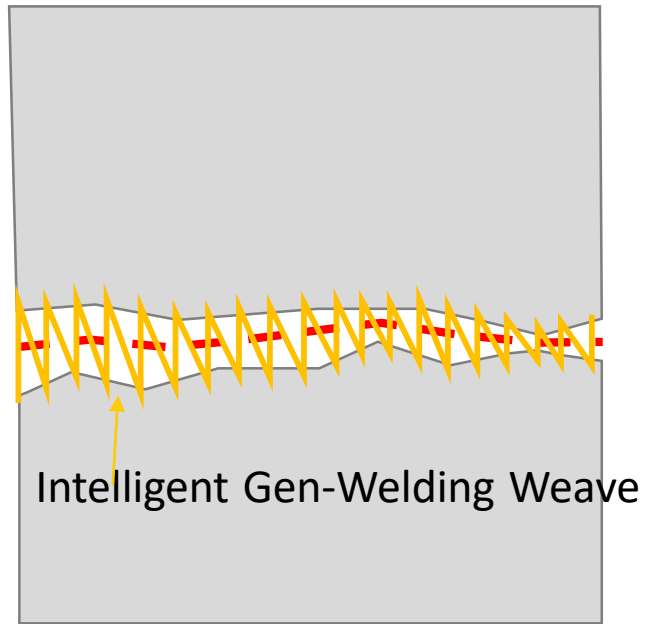
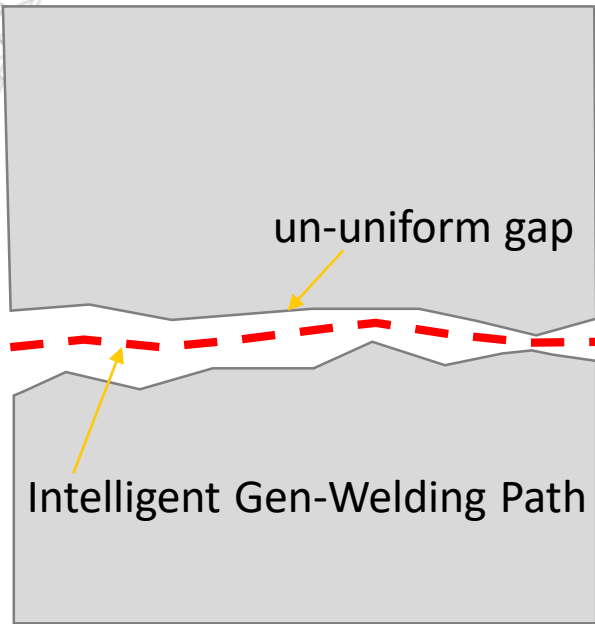
SMARTWELD FEATURE COMPLEX WELDING PATH

- Non-Straight Welding
- Curvature surface welding



(Advance Option)

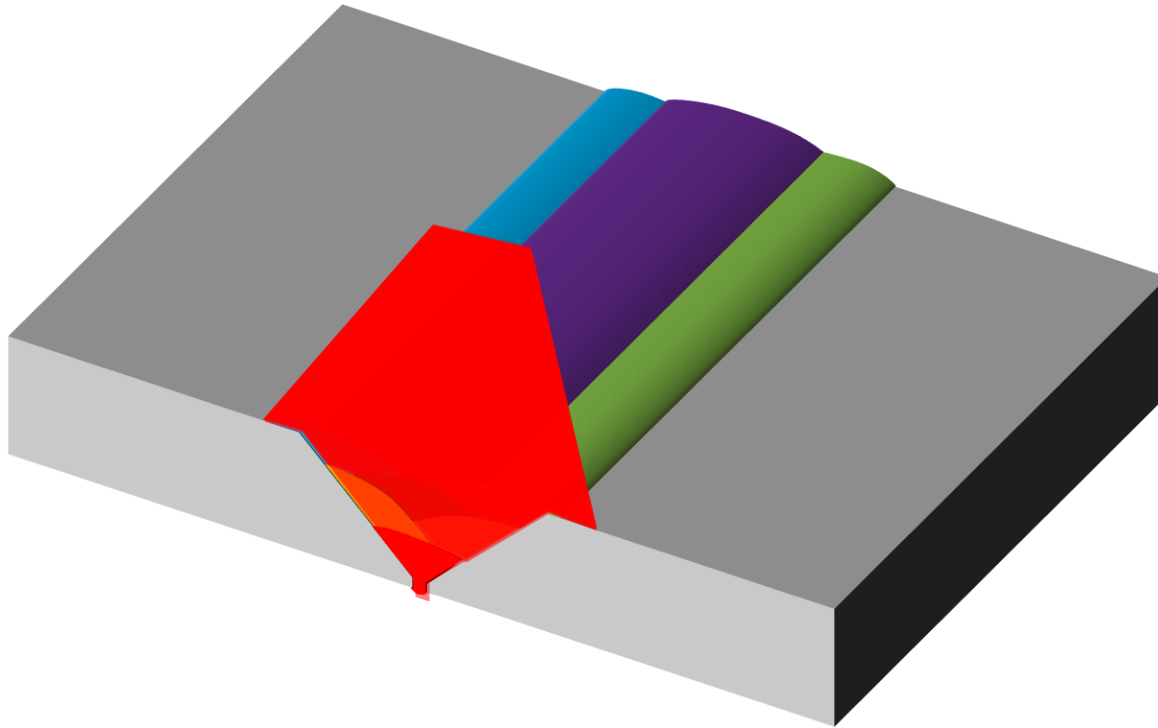
FEATURE GAP COMPENSATION



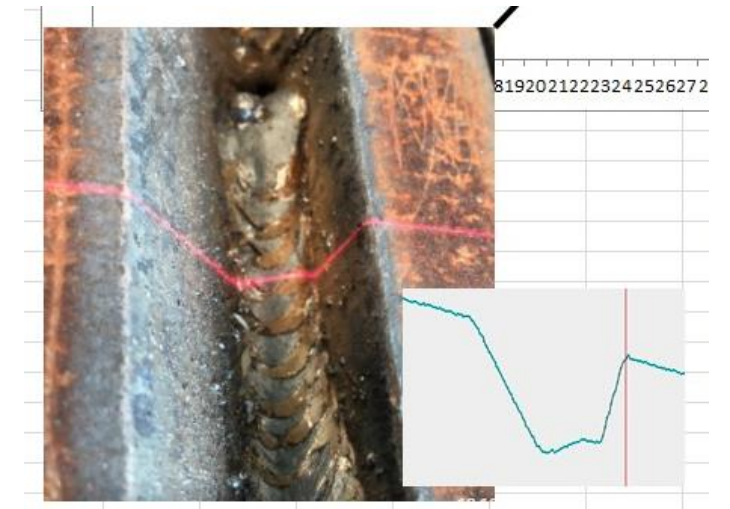
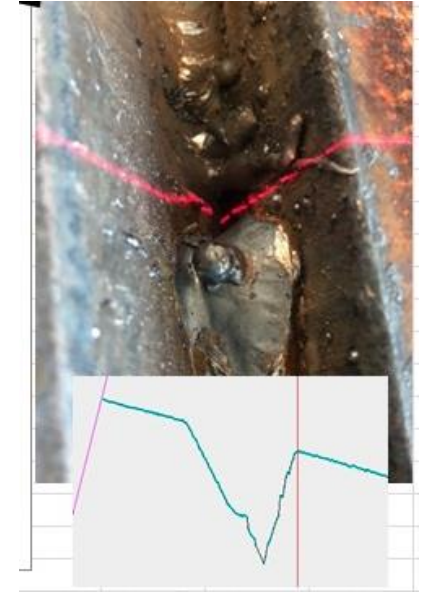
Intelligent compensation Weave

(Advance Option)

SMARTWELD FEATURE MULTI-LAYER AUTO WELD

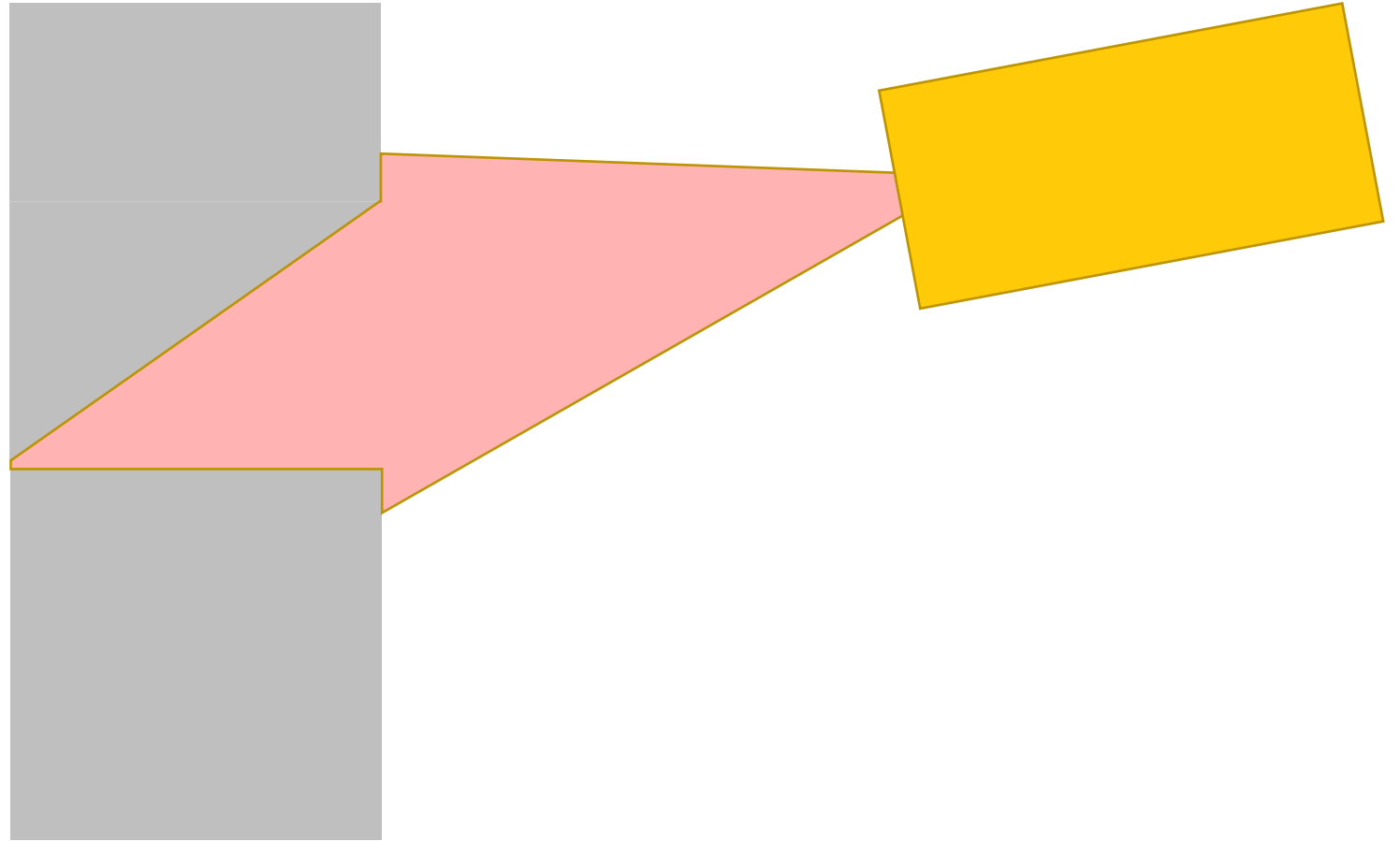


Re-Scanning after last layer welded
And Generate the next layer's Welding path



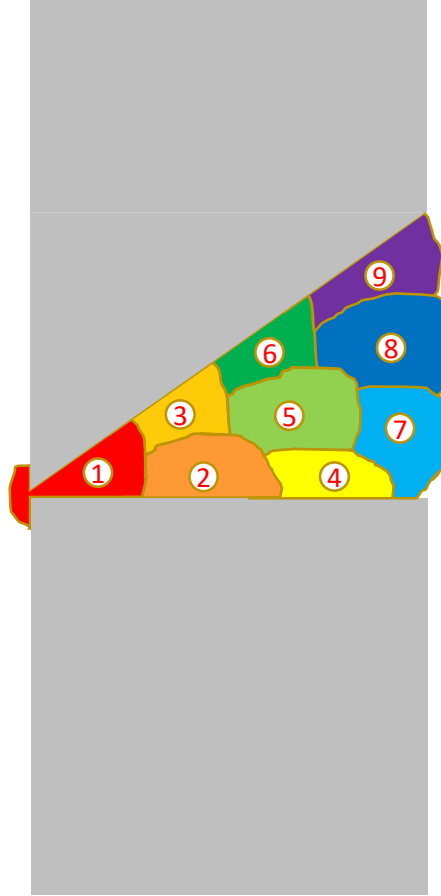
(Advance Option)

SMARTWELD FEATURE MULTI-LAYER AUTO WELD

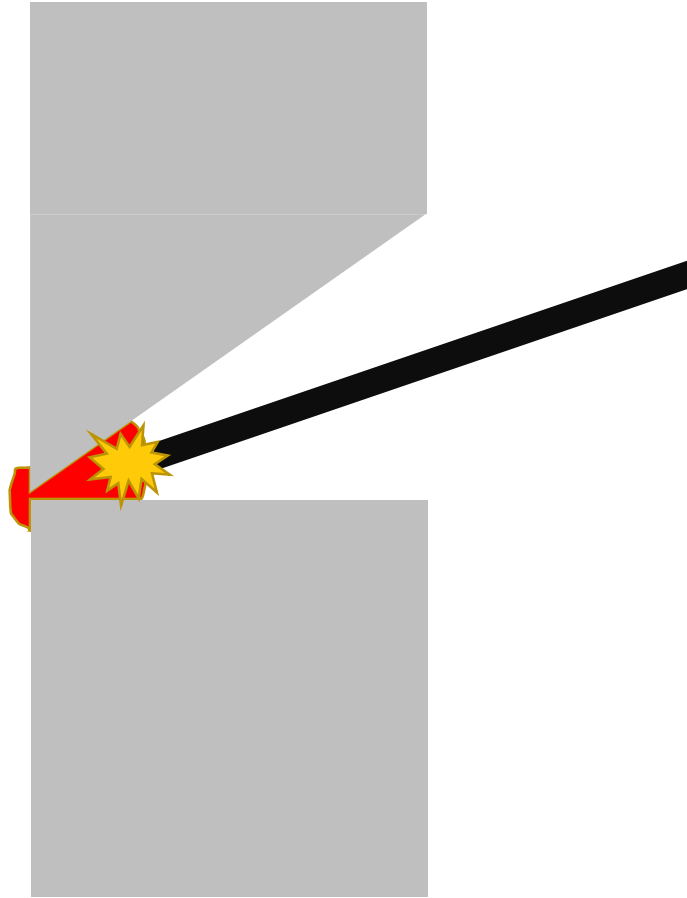


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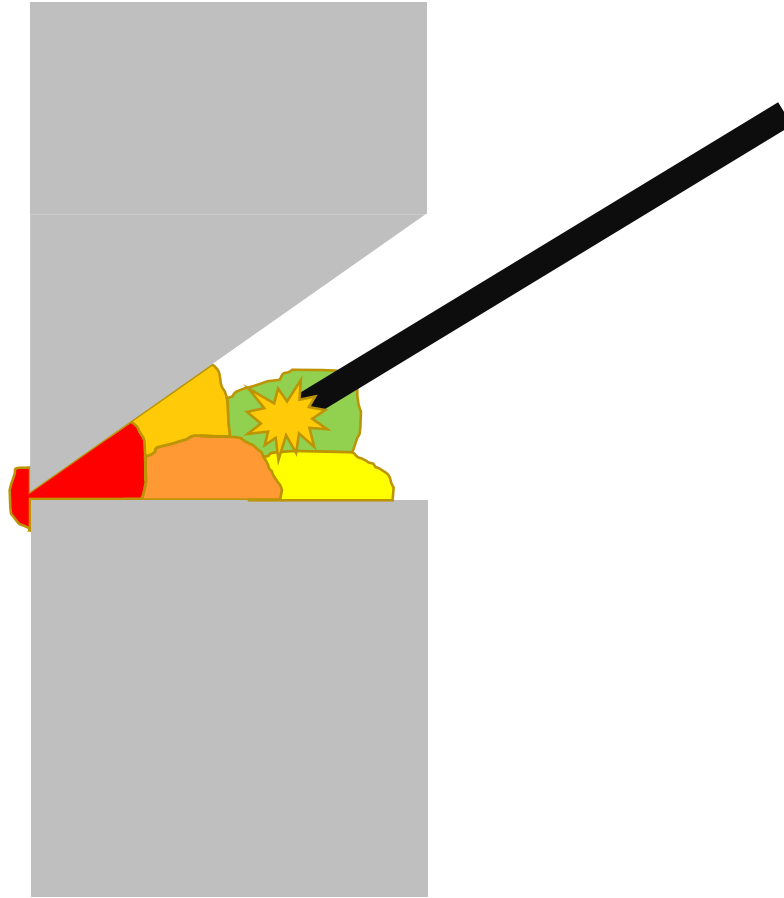
MULTI-LAYER AUTO WELD



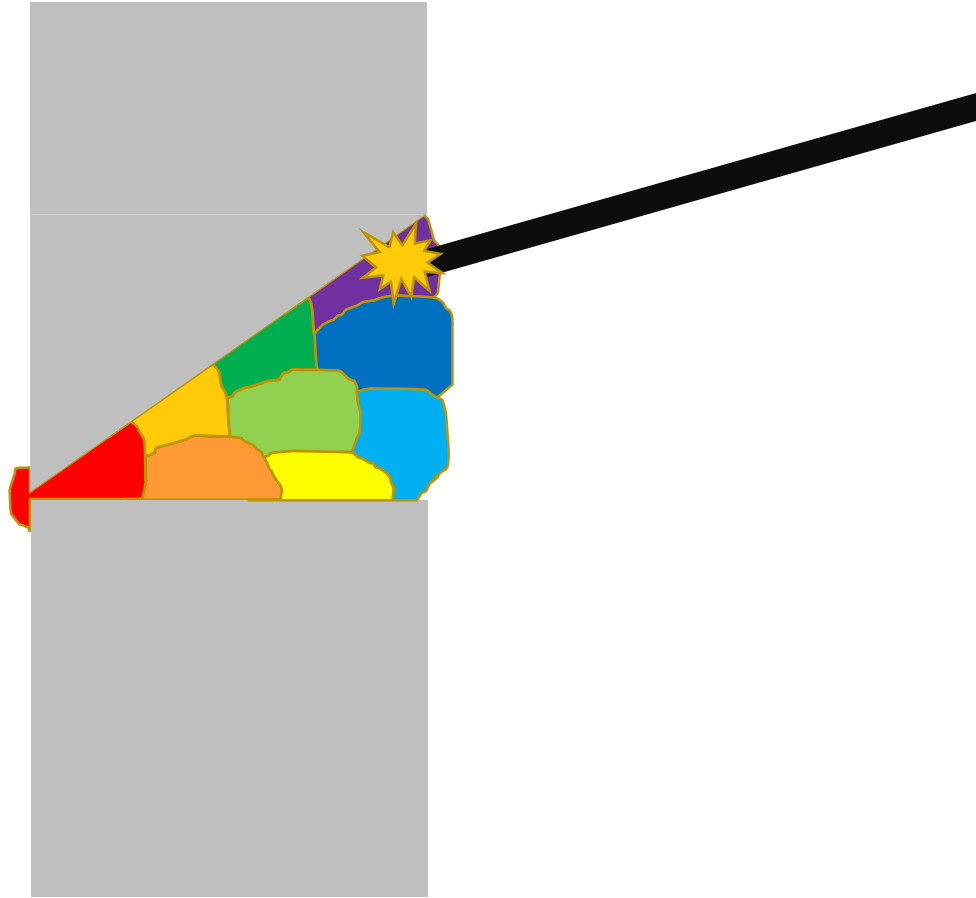
SMARTWELD FEATURE MULTI-LAYER AUTO WELD



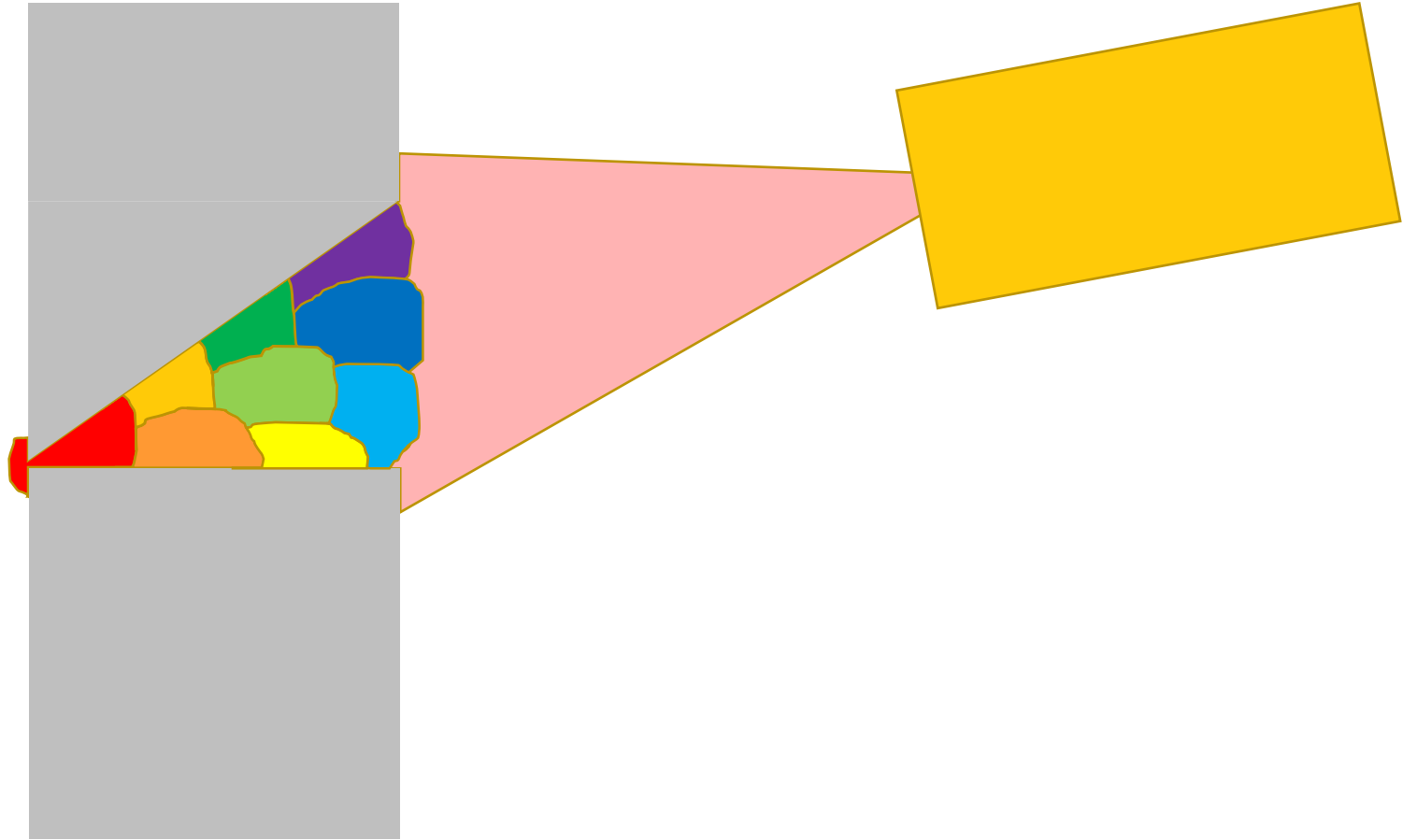
SMARTWELD FEATURE MULTI-LAYER AUTO WELD



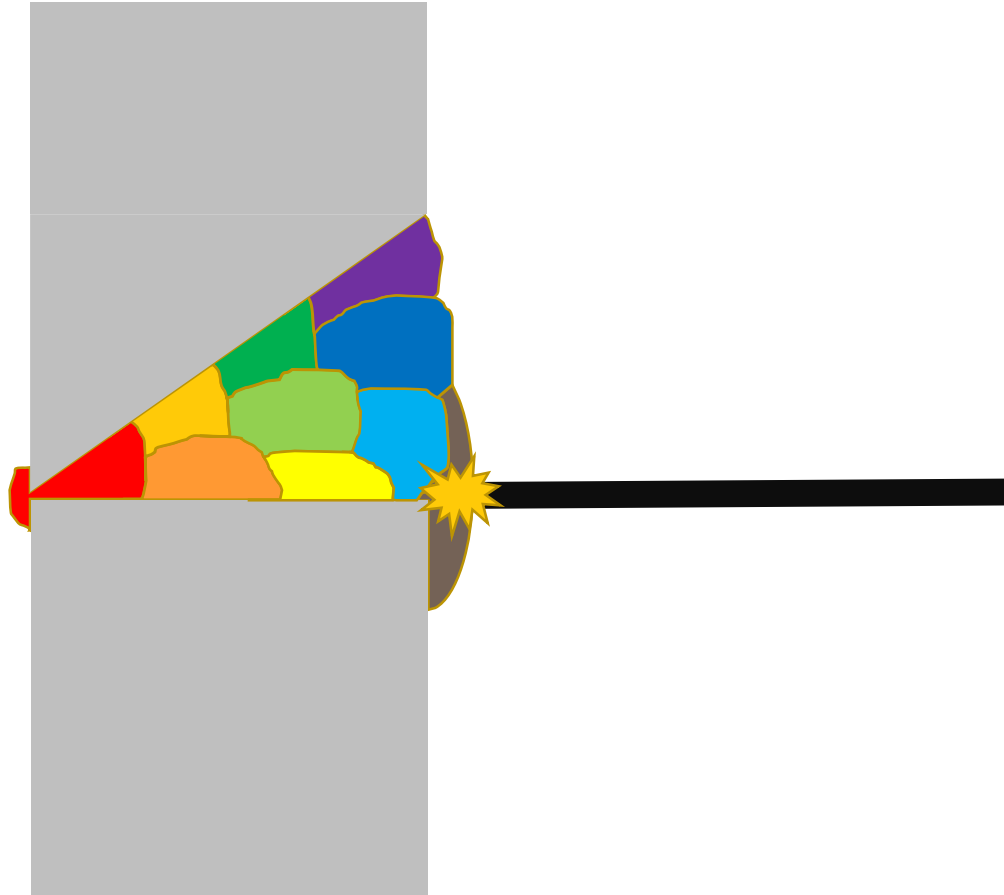
SMARTWELD FEATURE MULTI-LAYER AUTO WELD



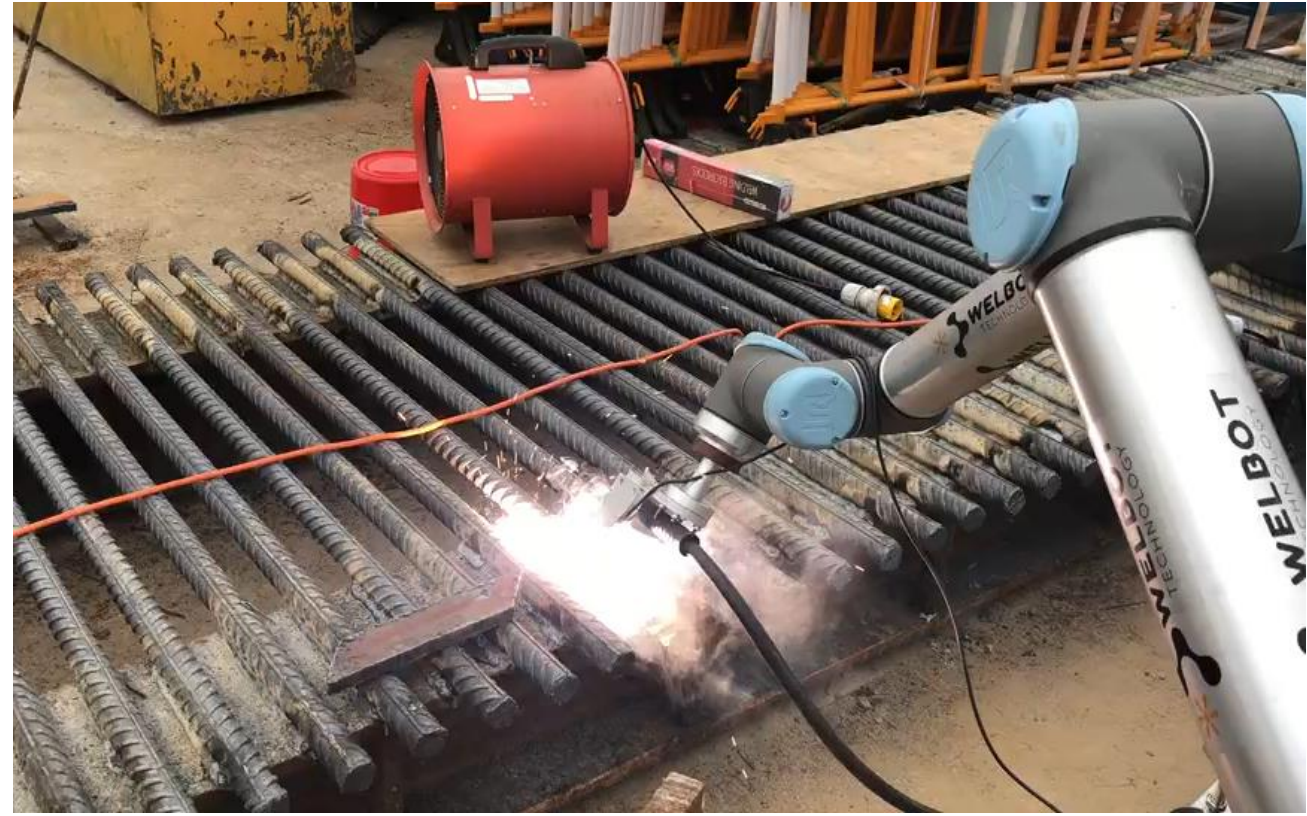
SMARTWELD FEATURE MULTI-LAYER AUTO WELD



SMARTWELD FEATURE MULTI-LAYER AUTO WELD



CASE REFERENCE- OUTDOOR WELDING






CASE REFERENCE- OUTDOOR WELDING



COMPETITIVE ANALYSIS

ADAPTIVE ROBOTIC WELDER VS MARKET WELDERS

	Adaptive Robotic Welder	Industrial Robotic Welder	Auto Guided Machine
			
Construction Site	Yes	No	Yes
Machine	6 axis Robot Arm (Cobot)	6 axis Robot Arm	Guided rail
Weight of System	30Kg	200Kg+	30Kg
Allowed Workpieces Tolerance	High	Low	Low
Installation	15 mins	1 day+	2 Hour +
Programable welding Path	Yes	Yes	No
Programming Time	2-5 mins	2hour +	Nil
Multi-Pass welding	Yes	No	Yes
Safety	Robot Collaboration EN ISO 13849:2008 PL d	Industrial Robot needs extra safety shield	No Safety

SAFETY



COLLABORATIVE AND SAFE

- The safety system is approved and certified by TÜV (The German Technical Inspection Association)
- Achieved ISO/TS 15066 standard for collaborative robot
- Replace human operators in dirty, dangerous and dull jobs to reduce repetitive strain and accidental injuries



UR ROBOTS MEET THE BELOW INTERNATIONAL STANDARDS:

- German Technical Inspection Association Certificate



International
Organization for
Standardization

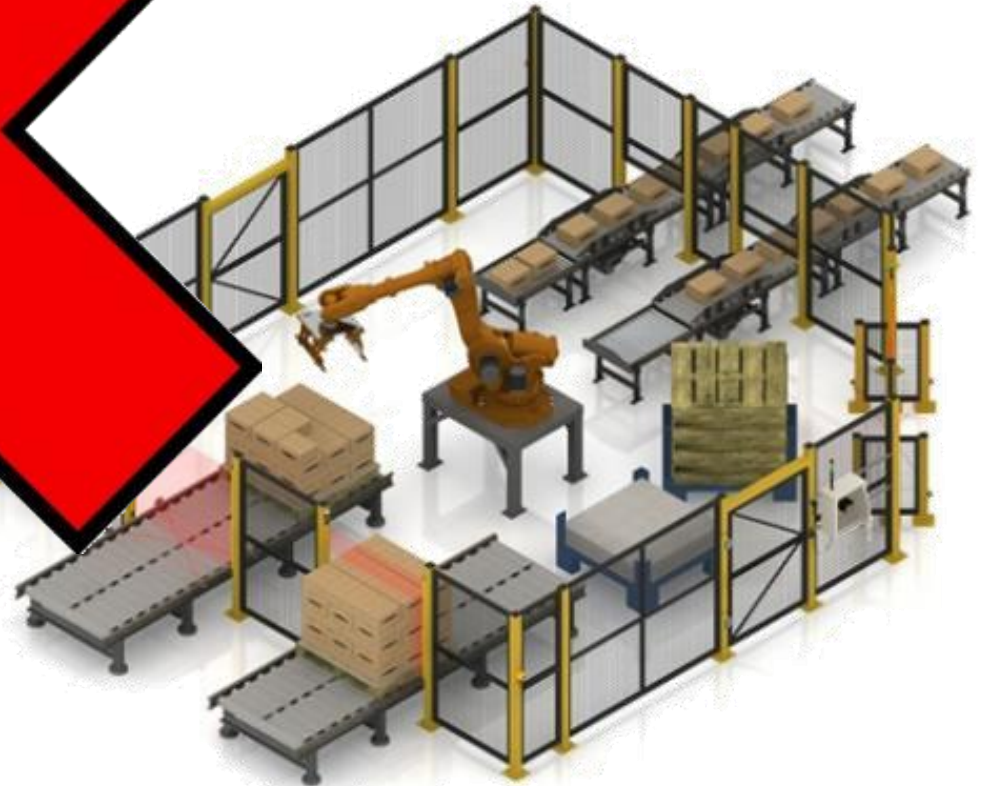
ISO 10218-1,2

ISO 12100

ISO 13849

ISO TS 15066

NO SAFETY FENCE



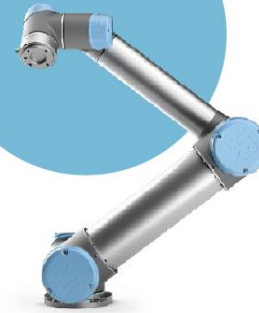
ROBOT SERIES

PICK THE RIGHT
COBOT FOR YOUR
AUTOMATION

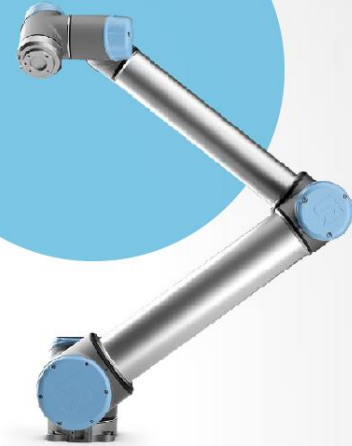
UR3



UR5



UR10



Automate tasks up to:

3Kg

5Kg

10Kg

Working radius:

500mm

*(Best deployed in tight
spaces or on table tops)*

850mm

1300mm

*(For tasks across
large areas)*

WELBOT BACKGROUND



WELBOT COMPANY STRUCTURE

**Welbot Technology
Limited (HK)**

- Welbot Head Office
- HKSTP Incu-Tech



**Welbot Technology
(Shenzhen) Limited**

深圳市威博特科技有限公司

- Welbot SZ Branch Office
- Hold the Patent
 - (Application Code: 201710943375.5)
 - (Application Code: 201910780609.8)

11 Number of R&D staff of robotic welding

2 Number of PhD

3 Number of Master




CONSTRUCTION
INDUSTRY COUNCIL
建造業議會











CITF 建造業
創科基金

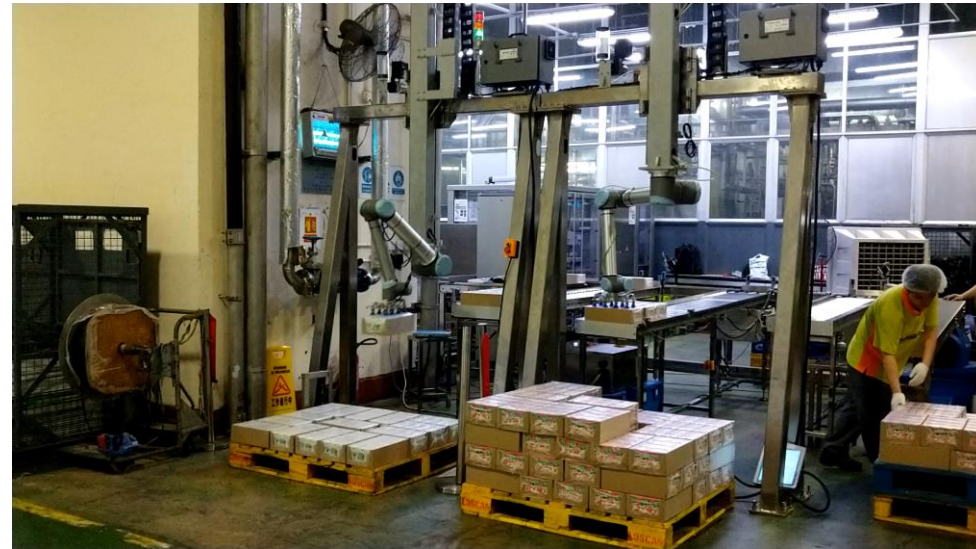
CITF Pre-approved Product

PA19-001	Automation and Robotics 自動化及機械	Enhance productivity, built quality and site safety 提高生產力、提升建造質素及改善工地安全	xxviii)	Welbot Technology Ltd. Welbot Welding Robot (On-site Mobile Welding Robot)	<p>The welding robotic control software could auto generate the weldpath, perform 3D welding weave, complex, non-straight welding path. It can set up the robot task within 2 minutes. The robot can provide standard welding quality to improve the productivity by replacing experienced welder on site.</p> <p>The weight of six-axis robot arm is light (11-28kg) with (0.5-1.3m) reach radius provide flexible mobility requirement for construction industry.</p> <p>此自動焊接機械人能配合軟件，自動產生各種複雜的三維焊接路徑。機械人能以快至2分鐘完成設定開始工作。同時，機械人所產生的焊接質素穩定，從而提高建造質素並可取代焊接工。</p> <p>此六軸機械人輕便(11-28kg)、操作範圍廣(0.5-1.3m)，能於建築工地流動使用。</p>	
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PROJECT REFERENCE

	Adaptive Polishing Robot		Robot Soft Drink Automation line
	Robotic Bar Tender		Inspection Production-line
	Collaborative Robot		Robot Motor Assemble line
	Milk Tea Robot		Welding Robot

PROJECT REFERENCE



THANKS



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AUTOMATION REVOLUTIONARY

**ON-SITE ROBOT WELDING
EXTERNAL WALL-ROBOTIC
ROBOTIC AUTOMATION**



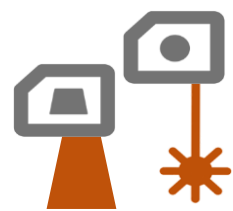
www.welbot-tech.com



We believe in the nearly future, robot operating should be extremely easy and could be done by anyone, whatever the age, education or else. Our team focused on making it becomes a reality in construction automation using our core patent pending technology **“Adaptive Robotic Control” (ARC)**. **ANYONE** can easily and intuitively set up the industrial Robot task within **2 MINS**. It is a breakthrough in construction automation area and revolutionary in Automated Welding Solution.

Welbot Robot Welder (Listed in CITF Pre-approved List item: PA19-001)

Welbot devoted to bringing safe, flexible, and easy-to-use collaborative robots for Construction Welding Automation. World Supreme light weight (18-28kg) of Six-axis Robot arm with (0.85-1.3m) reach radius provide a flexible mobility requirement for construction industry. With this approach, we help construction company assign their operators to more enjoyable Intuitively functions – thereby helping provide them with new challenges and add value to the company.



Adaptive Robotic Control (ARC)

Use precision laser sensor tracking welding path form large variation (Position/Tol.) workpieces on Construction-site. Intuitive UI allow anyone setup in **2 MINS**



Support manual weld gun

Welbot Welder design under construction environment, common manual weld gun and laser sensor can be mounted on fixture. (Support Robot Weld gun)



FEATURE

- Intuitive User interface
- Gesture Control
- Auto-WeldPath Generation
- Complex Welding Path
 - Non-Straight Welding
 - Curvature surface welding
- 3D Welding Weave
- Gap compensation (Advance)
- Multi-Layer Auto Weld (Advance)
- Zero Program Intelligent Welding (H-Pile, Standard Structure)



Wide range welding machine

Welbot Welder support GAS protection ARC welding and Flux cored ARC welding, which is common used in construction industry. (Support MIG MAG)



Moving platform

Welbot Welder can be installed on remote control tracked vehicle, its advantage allow Robot move on harsh environment such as construction site.



Specific task platform

Welbot Welder can be installed on specific fixture and operate with **ARC** dedicate module (Zero Program Intelligent Welding such as H-Pile welding).

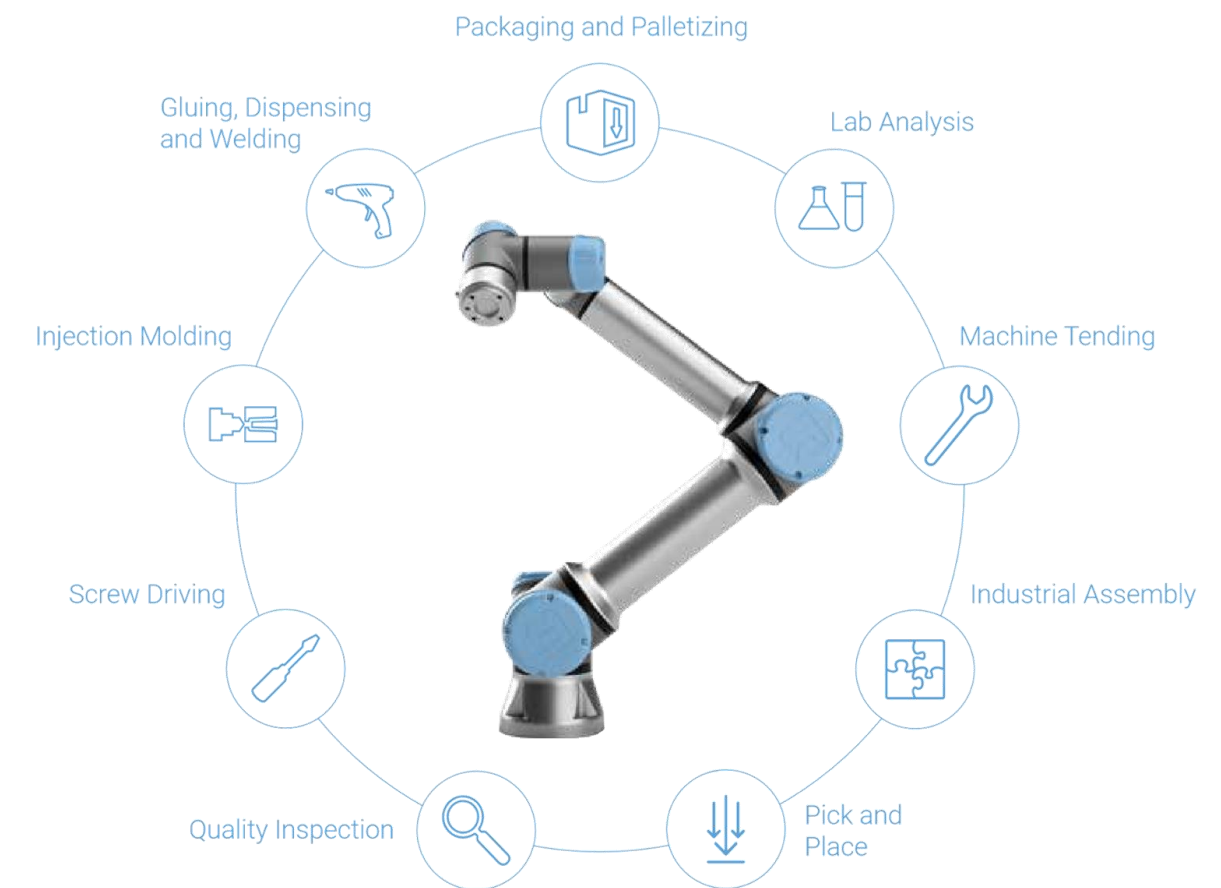


Vertical Robotic Solution

Welbot Technology is well-versed in Robotic Integration Solutions. Our team include professional development programmer, Mechanical Engineer and Electrical Engineer. We have an assembly workshop located in Hong Kong and Shenzhen to support our clients covered in Asia.

Benefit of Welbot

Welbot has timely and complete after-sales service
Strong ability of independent development.
Fully Customization by customer requirements.



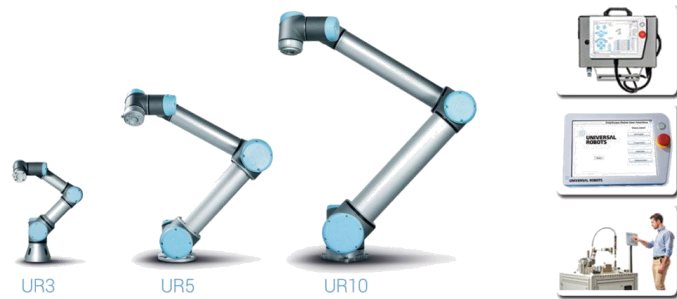
Welbot Technology

We provide a full range robot product for professional automation solution to our client, such as Industrial Robot, Collaborative Robot (Cobot), Robot Accessories and Robotic Simulator.



Collaborative Robot

Collaborative robots (Cobot) Cost-effective, flexible, safe, and easy-to-use.



KUKA offers a wide range of various payload capacities and reaches.

Stäubli Robotics recognized for their efficiency and reliability.



Robot Accessories



One stop for END-OF-ARM Tooling.



Machine Learning AI 3D Vision.



Robotic Simulator



Program any Industrial Robot with One Simulation Environment.

Welbot Robot Welder Spec	Universal Welder	Zero Program Welder
Software	Welbot ARC	Welbot ARC - Intelligent
Support Robot	UR5 / UR5e / UR10 / UR10e	
Intuitive User interface	Yes	Yes
Gesture Control (Option)	Yes	Yes
Complex Welding Path (Curve)	No	Yes
3D Welding Weave	Yes	Yes
Gap compensation	No	Yes
Multi-Layer	Manual define start point	Auto-Scan
Zero Program	No	Yes require Specific Mount
Laser Sensor	Precision Point Laser	Precision Line Laser
Laser Sensor Protector	Manual / Auto (Option)	
Weld Gun	Robotic Weld Gun / Manual Weld Gun	
Welding Machine	MIG / MAG / Flux Cored	
Mounting Platform (Option)	Quick Mount / Specific Module Mount	
Moveing Platform (Option)	Remote Control Tracked Vehicle (Option)	

UNIVERSAL ROBOTS Spec	UR3	UR5	UR10
Repeatability	0.1 mm	0.1 mm	0.1 mm
Ambient temperature range	0-50° C	0-50° C	0-50° C
Power consumption	Typical 125W	Typical 150W	Typical 250W
Safety Collaboration	15 advanced adjustable safety functions. TüV NORD Approved Safety Function Tested in accordance with:EN ISO 13849:2008 PL d		
Payload	3 kg	5 kg	10 kg
Reach	500mm	850 mm	1300 mm
Degrees of freedom	6 rotating joints	6 rotating joints	6 rotating joints
Working range - All Joint	± 360°	± 360°	± 360°
Working range - End of Tooling	Infinite	± 360°	± 360°
Maximum speed	1 m/Sec.	1 m/Sec.	1 m/Sec.
IP classification	IP64	IP54	IP54
ISO Class Cleanroom	5	6	6
End Tool I/O port / Power	DI 2 / DO 2 / AI 2 / 12V/24V 600mA		
Control Box I/O port / Power	DI 16 / DO 16 / AI 2 / AO 2 / 24V 2A		
Communication	TCP/IP 100Mbit, Modbus TCP, Profinet, EthernetIP		
Power	100-240 VAC, 50-60 Hz		
Weight	11 kg	18.4 kg	28.9 kg
Additional Spec for e-Series	UR3e	UR5e	UR10e
Additional Safety Collaboration	+2, incl. elbow monitoring certified to Cat.3, PL d.Remote Control according to ISO 10218		
Repeatability	0.03 mm	0.03 mm	0.05 mm
F/T Sensor - Force/Torque, x-y-z			
Range	30N / 10Nm	50N / 10Nm	100N / 10Nm
Resolution	1.0N / 0.02Nm	2.5N / 0.04Nm	2.0N / 0.02Nm
Accuracy	3.5N / 0.10Nm	4.0N / 0.30Nm	5.5N / 0.60Nm
IP classification	IP54	IP54	IP54
End Tool I/O port / Power	DI 2 / DO 2 / AI 2 /RS-485 / 12V/24V 600mA continuous, 2A peak		
Control Box I/O speed	500 Hz control, 4 separated / high speed quadrature digital inputs		
Weight	11.2 kg	20.6 kg	33.5 kg