Intelligent Welding

SCITECH PATENT ART SERVICES PVT LTD

CONTENTS

INTRODUCTION

- The shortage of skilled welders is forcing big companies to do more with less number of workers. Intelligent welding is an emerging alternative which reduces manpower and improves productivity.
- Intelligent welding system is a real-time based optimization system and is derived from a combination of hardware and software components. Hardware components (pressure sensor, image acquisition unit, data acquisition unit, light detection unit etc.) work in combination with software (programs based on Visual Studio etc.,) **to enable appropriate control** of multiple nonlinear variables effecting the process.
- Intelligent welding is thus a combination of advanced sensing and monitoring systems with proper control of the welding system through AI which results in quality welds. The technology aims at **controlling microstructural properties** to produce high quality welds which improves not only the performance of welded parts but also overall productivity.
- Welding robots and artificial intelligence have become part of the advancements in technology wherein the robot is fully capable of self-adjustment of its functions and operations.
- Increasing use of welding in every industry coupled with the shortage of skilled labor has led to major welding companies relying on intelligent welding (welding 4.0, robot welding, virtual welding, etc.). An intelligent welding system will monitor and control operations at the station, system, and system-of-systems (SoS) levels to achieve various system goals.
- Major welding companies such as ITW Miller, Lincoln Electric, Daihen, EWM have launched various automated welding tools such as welding robots, mobile weld equipment, wire feeders, etc. There are also companies that serve the industry by providing software to the manufacturers in order to automate the process such as Delfoi Oy, Visual Components Oy, Octopuz Inc, etc.

SCITECH PATENT ART

INTRODUCTION CONTINUED

- Various artificial intelligence models such as ANN, Genetic Algorithm, Convolutional neural network (CNN), Restricted Boltzmann Machine (RBM), Recurrent Neural Network (RNN) have been used to handle uncertainties in weld process system. In recent years, machine learning (ML) has been applied to tackle these challenges, and many methods, tools, and techniques have been developed and implemented in a variety of applications.
- ML applications include model prediction and parameter optimization, path planning and welding sequence, process control and quality monitoring, defect recognition, and classification. The algorithms can be widely used, independently (standard or customized algorithms) or in combination to make use of their strengths while mitigating their weaknesses.
- An interesting area of intelligent welding system is the development of autonomous welding systems that combine welding robots with welding tools and power sources. Better integration of welding simulation models and machine-readable expert knowledge into the process control systems will improve the ability to react autonomously to changes in process conditions.
- As product design is moving toward mass customization and personalization, so must welding services in the future. Personalized/smart welding products and services based on platform technologies including CPS, IoT, and cloud manufacturing can help realize green, efficient, and humanized IWS in the context of Industry 4.0.

SUMMARY – KEY RESEARCH FOCUS AREAS BY COMPANY

LINCOLN ELECTRIC

- A welding system having a controller in co-ordination with a sensor and a waveform generator, in which the output is used to control the stick-out distance of the electrode by adjusting the DC offset and the duty cycle of the welding waveform. This way, the welding parameters can be tuned.
- Quality of welding is determined with the help of a reference signature weld. Image of the weld signature is compared with the reference weld signature in terms of upper boundary and lower boundary. Weld fault condition is determined to exist when either the weld signature shape difference exceeds a predefined limit or when a portion of the weld signature exceeds the upper or the lower boundary.
- A robot with an arm whose movement is controlled by a robot control in multiple degrees of freedom. The movement of the arm is based on the motion parameters defined by the controller. Power source controller is also integrated which can communicate with the robot controller allowing path planner that generates motion parameters to avoid robot collisions.
- Lincoln Electric Automation Division is thus integrating robotic arc welding equipment and automated welding systems to help decrease manufacturing costs, increase weld quality, improve welding productivity and enhance the working environment. The company is also capable of welding metal additive parts that are measured in feet or meters instead of inches.

DAIHEN

- Welding current waveform that is adjusted using a device capable of calculating the adjustment amount data. The moving image data from video acquisition device at the welding location is inputted to the device which then calculates the adjustment data using a learned neural network and outputs the adjustment amount where the droplet transfers in the form of 1 pulse 1 drop from welding wire.
- An arc end adjustment device that adjusts the arc end based on the data from the acquisition unit indicating the result of anti-stick processing and a welding state. Based on the acquired data, arc end is adjusted so that the cycle time of the welding process is shortened.
- Reduction of consumables using an adjustment device, based on the data from the acquisition unit which acquires welding data indicating a welding state during or after the welding process. A learned neural network takes the judgement on the quality of the weld and takes action on the consumption of the consumable in an appropriate manner.
- Daihen Corp. with its capability of joining dissimilar metals, produces seams of the strength required by the automotive industry along with high-quality.

SUMMARY CONTINUED

EWM (WE ARE WELDING)

- A welding device is controlled by correcting the values to the setpoint data of the parameter and is connected to the server from which the device receives the instructions
- A control device that provides a communication connection between the torch button interface and data interface of welding torch. The control unit enables control of multiple welding parameters within a single device.
- Detection of short circuits using a detection means and display when the number of short circuits precedes a specified value. This warning gives the operator an opportunity to react to the occurrence of short circuit which is one of the reasons for emission of harmful fumes during welding.
- EWM has thus incorporated sustainability by reducing emission of fumes which help environment as well as health of the welders

ITW

- A controller is coupled to the sensor and adapted to receive the acquired data from the sensor. This data is indicative of a welding defect. When a defect is observed, the controller alerts the operator and logs the error in the associated memory.
- ITW-Miller has a fully integrated monitoring capability right within the power source. This has the ability to govern the fabrication of each part on a weld-by-weld basis. This helps in easy detection of missed welds, under-welding, over-welding, differences with respect to preset parameters and more. Such monitoring yields in enhanced productivity and quality leading to lower overall fabrication costs.

SIEMENS

- Welding operation is simulated by a weld analysis system. Welding defects are detected and predicted based on simulated welding operation and the analysis of the physical weld. Root cause analysis is performed based on the detected and predicted welding defects to produce corrective action to eliminate defects from subsequent physical welds

ABB

- Welding path of workpieces is compiled in a log file. The log file is processed to form a geometrical visualization so that the welding parameters are paired with geometrical positions of the weld. The geometrical visualization of the log file makes the variation of the welding parameters along the welding path comprehensive to the user and enables easy adjustments at certain positions.

INTELLIGENT WELDING – MAJOR CHALLENGES ADDRESSED BY COMPANIES

01

Tuning welding parameters

Adjustment in one parameter affects another parameter (non-linear relationship between the parameters) makes the job tough in controlling the welding to attain quality weld

02

Defect detection

Defects are inevitable in welding due to several factors including environmental conditions. Early detection becomes the check point in assuring the quality of the weld

03

Path planning

Rational weld joint sequence plays an important role in improving the productivity. Path length and energy consumption are the primary parameters considered for optimization

04

Use of welding consumables

Extra consumables used not only lead to the wastage of consumables but also lead to the warpage and damage of the weld as the extra heat is added to the joint

THE FOLLOWING SLIDES COVER HOW VARIOUS COMPANIES ARE ADDRESSING THESE CHALLENGES

COMPANIES COVERED IN THIS REPORT INCLUDE:

- LINCOLN ELECTRIC
- DAIHEN CORP.
- EWM
- ILLINOIS TOOL WORKS INC
- SIEMENS CORP.
- ABB TECHNOLOGY
- SHENZHEN WEIAI INTELLIGENT TECH LTD
- SHANGHAI ELECTRIC NUCLEAR POWER EQUIPMENT CO LTD

LINCOLN ELECTRIC

01. Tuning welding parameters

US20180264577A1 (Publication date: 2018-09-20)

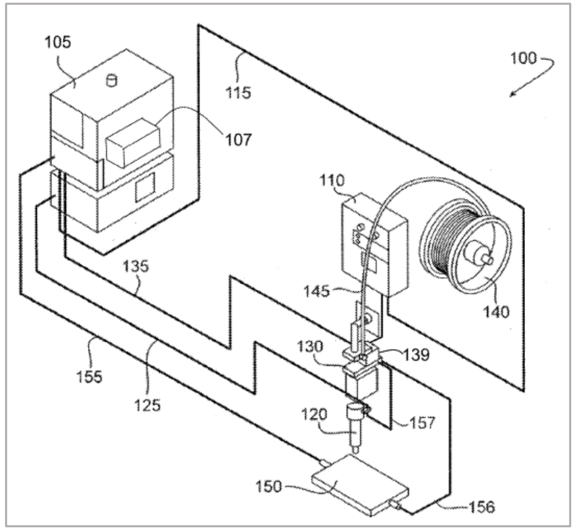
ADAPTIVE CONTROL OF AN AC WELDING WAVEFORM

The welding system has a controller in co-ordination with a sensor and a waveform generator. The parameter value from the sensor is compared with the pre-defined value and the output is used to control the stick-out distance of the electrode by adjusting the DC offset and the duty cycle of the welding waveform by the controller.

A **method of controlling a stick-out distance of an electrode** during a welding operation by generating a welding waveform with adjustable polarity amplitudes and an adjustable balance, wherein the **welding waveform includes a pre-defined voltage and current; sensing a welding parameter at a welding electrode; comparing the welding parameter to a pre-defined parameter**; and **adjusting the polarity amplitudes and the balance of the welding waveform to control an arc length** between the electrode and a workpiece while a wire feed speed of the electrode, the pre-defined voltage, and the pre-defined current of the welding waveform are held more or less constant.

The wire feeder (130) of the welding system (100) includes **a sensor (139) (e.g., a voltage sensor)** configured to sense a welding parameter (e.g., a voltage) at the welding electrode (145) during a welding operation. A work sense lead (156) may be operationally connected between the workpiece (150) and the wire feeder (130). Similarly, an electrode sense lead (157) may be connected between the welding head and nozzle (120) and the wire feeder (130). **The sense leads (156 and 157) allow the sensor (139) to sense the welding parameter**. **The sensor (139) is connected to the controller (110) to feedback the sensed welding parameter to the controller (110). The sensed welding parameter may be used by the controller 110 to control the welding waveform produced by the waveform generator 107.**

The waveform generator 107 of the welding power source 105 is configured to generate a welding waveform with an adjustable DC offset and an adjustable duty cycle. **The welding waveform includes a pre-defined voltage and a pre-defined current (e.g., a RMS voltage and a RMS current)**. The term DC offset refers to a displacement of the mean amplitude of an AC welding waveform from a baseline of zero (zero voltage or current). The term duty cycle refers to the fraction of one period of an AC welding waveform in which the waveform is positive (above zero voltage or current). **As an example, a voltage welding waveform 200 (FIG. 2A) being an 80 volt peak-to-peak symmetrical square wave centered at zero volts may be adjusted to having a 25% duty cycle and a +10 volts DC offset. The result is an adjusted waveform 210 (FIG. 2B) being at +50 volts for 25% of each cycle and at -30 volts for 75% of each cycle.**



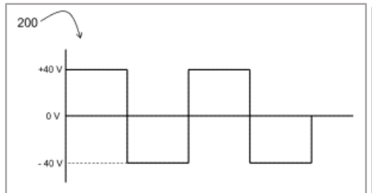


FIG. 2A

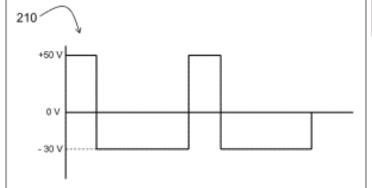
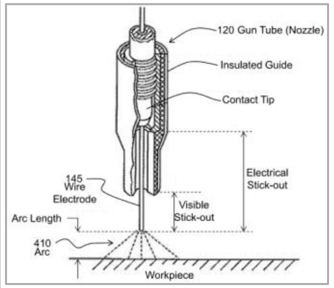


FIG. 2B



LINCOLN ELECTRIC

02. Defect detection

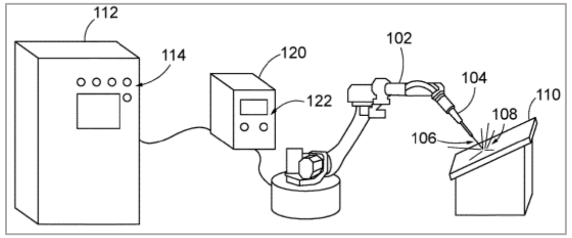
US20190291200A1 (Publication date: 2019-09-26)

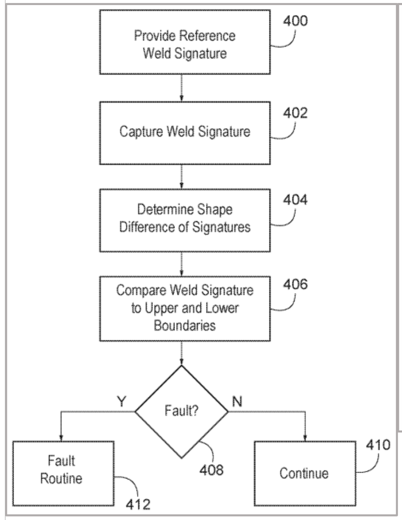
WELD SIGNATURE ANALSYS FOR WELD QUALITY DETERMINATION

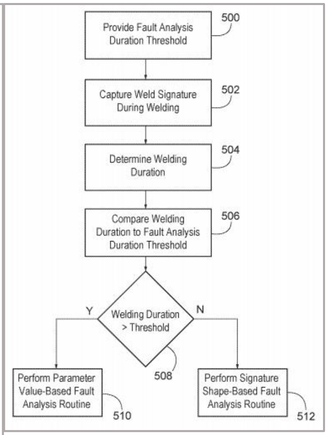
Quality of welding is determined with the help of a reference signature weld. Image of the weld signature is compared with the reference weld signature in terms of upper boundary and lower boundary. weld fault condition is determined to exist when either the weld signature shape difference exceeds a predefined limit or when a portion of the weld signature exceeds the upper boundary or the lower boundary

A **method of determining weld quality by providing a fault analysis duration threshold**; **obtaining a weld signature of a weld bead**, wherein the weld signature has a shape; **determining a welding duration of the weld bead**; **comparing the welding duration of the weld bead to the fault analysis duration threshold**; when the welding duration is greater than the fault analysis duration threshold, performing a parameter value-based fault analysis routine including comparing one welding parameter value to a predetermined limit value; and when the welding duration is less than the fault analysis duration threshold, performing a signature shape-based fault analysis routine including comparing the shape of the weld signature to a reference weld signature shape.

In Figs. 4 and 5, methodologies are described in connection with the illustrated flow diagrams. The methodologies described can be performed by the computing device 112, or the power supply 120. FIG. 4, is a flow diagram of a method for determining weld quality. **At 400, a reference weld signature is provided, such as retrieved from a memory device**. **At 402, a weld signature of a welding parameter is captured. At 404, the shape of the reference weld signature is compared to the shape of the captured weld signature, and one or more shape differences between the reference weld signature and the shape of the captured weld signature is determined. At 406, the captured weld signature is compared to upper and lower boundaries**. At 408 a determination is made as to whether or not a fault weld has occurred. The determination can be based on one or more shape differences between the reference weld signature and the shape of the captured weld signature, and/or based on comparing the captured weld signature to the upper and lower boundaries. If no weld fault condition has occurred, the welding operation moves to 'Continue 410' which means it is working normally. If a weld fault condition has occurred, then 'Fault routine 412' will be initiated. **The fault routine can include flagging the weld bead as faulty, generating an alarm, sending a message to a predetermined person or device, stopping the welding process, etc**. Similarly, in Fig. 5, when welding duration exceeds a threshold value, the welding operation moves to 'Perform Parameter Value-Based Fault Analysis Routine 512' and when the duration is less than threshold value, the welding operation moves to 'Perform Signature Shape-Based Fault Analysis Routine 510'







LINCOLN ELECTRIC

03. Path planning

US20190291200A1 (Publication date: 2019-09-26)

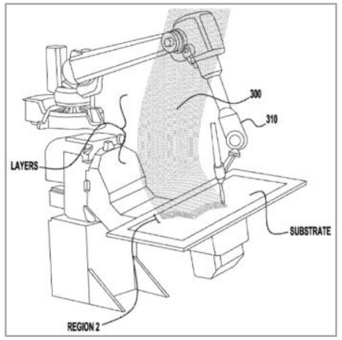
SYSTEM AND METHOD FOR MANUFACTURING AND CONTROL THEREOF

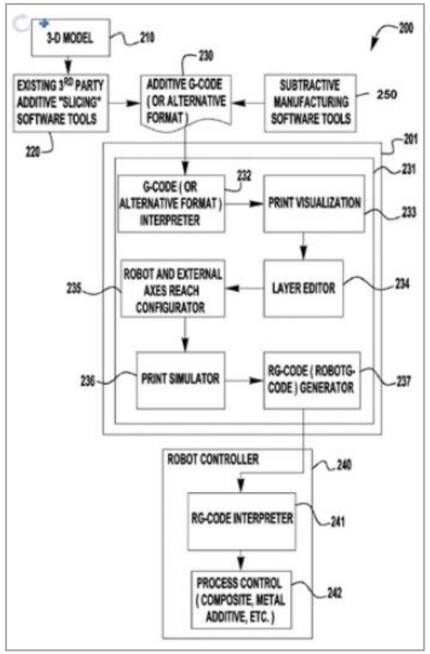
A robot with an arm whose movement is controlled by a robot control in multiple degrees of freedom. The movement of the arm is based on the motion parameters defined by the controller. Power source controller can communicate with the robot controller allowing path planner that generates motion parameters to avoid robot collisions.

The **robot controller and the power source controller are configured to communicate the information between each other to negotiate the combination of the motion parameters for the robot and the electrical input parameters for the power source. This results in collision avoidance** and **welds, depositions**, and **cuts** via the tool as part of the manufacture process on the workpiece.

The **path planner component includes a reach configuration component including data related to physical attributes, motion attributes, kinematics, and limitations of the robot**.

A system that includes a tool configured to be used in a manufacturing process on a workpiece is provided. The manufacturing process may be a welding process, an additive manufacturing process, or a plasma cutting process. **The system includes a robot having an arm with an attachment point.** The **arm is configured to move the tool**, when attached to the attachment point, **in multiple degrees of freedom** during the manufacturing process. The robot also includes a **robot controller configured to control movement of the arm** based on motion parameters to perform the manufacturing process via the tool. The system includes a power source having power electronics. The power electronics are configured to generate electrical output power, based on electrical input parameters, which are provided to the tool during the manufacturing process. The power source also includes a **power source controller configured to receive the motion parameters from the robot controller and adjust the electrical input parameters based on the motion parameters** to allow generation of adjusted electrical output power. The power source controller is configured to adjust the motion parameters based on the electrical input parameters to generate adjusted motion parameters and provide the same to the robot controller. The **power source controller is also configured to adjust, based on the motion parameters, to generate an adjusted wire feed speed of a consumable electrode** used by the tool during the manufacturing process. The **robot controller includes a processor and a non-transitory computer-readable medium storing a path planner component**. The **path planner component includes instructions that when executed by the processor causes the robot controller to generate the motion parameters while avoiding robot collision conflicts**. The power source controller includes the path planner component consisting of **a reach configuration** component that includes data related to physical attributes, motion attributes, kinematics, and limitations of the robot. The **path planner component also includes a collision avoidance evaluator** configured to determine if an anticipated robot path results in any robot collision conflicts. A **user can modify the robot path and/or the manufacturing process to avoid the robot collision conflicts with the aid of the collision avoidance evaluator**.





LINCOLN ELECTRIC – RECENT PRODUCTS ADDRESSING THE CHALLENGES

FAB-PAK® COBOT

THE FAB-PAK® COBOT ROBOTIC WELDING SYSTEM

- Extra safety features – Power and force limiting sensors, speed and separation monitoring with soft impact design and sensing technology
- Easy to program – Minimal tech-savviness requirement makes training and learning simple and straightforward
- Adaptable – Easy to re-deploy anywhere on high-mix, low-volumes of dedicated parts saving valuable floor space

Capabilities/Configurations Include:

- MIG welding on steel and aluminum
- Twin-wire, heavy deposition welding
- Weaving and seam-tracking
- Touch-sense technology

TOPTIG® Fab-Pak®

Designed to revolutionize robotic TIG welding, delivers TIG quality welds while automating the welding process.

- Low system complexity – All-in-one palletized robotic welding system
- Operational efficiency – Greater part repeatability and weld consistency
- Maximum productivity – Increased deposition rates compared to conventional TIG process
- Includes: » TopTIG® Advanced Robotic Solution » Power Wave® power source » Power Wave® Advanced Module » Cool Wave® 20S Water Cooler » Headstock/tailstock positioner » FANUC® welding robot with TIG software » Solid metal panel walls » Advanced touch screen control panel » Robotic training (5 days)

K1780-3

Automation Wire Feeders - POWER FEED® 10R WIRE DRIVE SYSTEM

- Specifically designed to mount to a robot arm used in hard automation applications
- Fast Braking
- Two Speed Settings
- Split Wire Guides
- Designed to "nest" in the upper arm of the FANUC® Robotics ARC Mate® iC family of arms
- Tachometer Feedback
- Self-loading Wire Capability

FERRIS WHEEL ROBOTIC POSITIONER

- Degrees of Freedom: 2 (per head/tail stock)
- Horizontal-axis rotational positioner with dual horizontal-rotating head/tail stocks for increased weight capacity, versatility and productivity. Enables downtime-free part installation and removal when integrated flash screen is included with the positioner assembly.

Z-AXIS SKYHOOK

- Degrees of Freedom: 3
- Horizontal-axis rotational positioner with cantilevered rotating secondary-axis and height adjustment for complex components or applications requiring compound degrees of freedom.

DAIHEN CORP

01. Tuning welding parameters

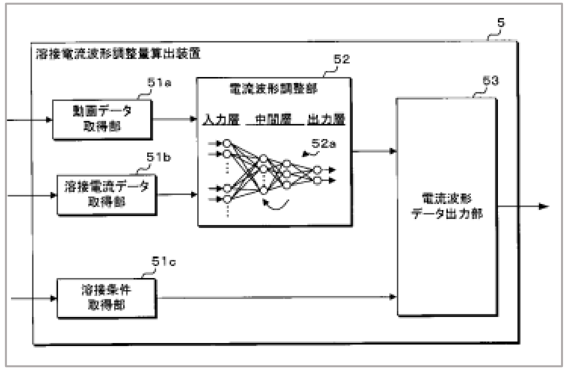
JP2020049509A (Publication date: 2020-04-02)

WELDING CURRENT WAVEFORM ADJUSTMENT AMOUNT CALCULATION DEVICE AND LEARNING METHOD

Welding current waveform is adjusted using a device capable of calculating the adjustment amount data. The moving image data from video acquisition device at the welding location is the input for the device. The device then calculates the adjustment data using a learned neural network and outputs the adjustment amount where the droplet transfers in the form of 1 pulse 1 drop from welding wire.

The **device calculates adjustment amount data for a welding current waveform of pulse welding using a welding wire. If the moving image of the welding wire is input during the welding process then the droplet transfer form of the welding wire should be 1 pulse 1 drop.** A learned neural network has been trained to calculate and output adjustment amount data for adjusting the welding current waveform. A moving image data acquisition unit acquires moving image data obtained by imaging the welding location during the welding process. **The learned neural network is input with the moving image data acquired by the moving image data acquisition unit, and outputs adjustment amount data according to the input moving image data.**

In the welding current waveform adjustment amount calculation device, the welding current waveform is a pulse waveform in which the **welding current increases and decreases exponentially, and the adjustment amount data is used to determine the rising aspect of the welding current**. It includes the constant increase/decrease in amount, the peak current value increase/decrease amount of the welding current, the peak current time increase/decrease, and the time constant increase/decrease amount that determines the falling mode of the welding current.



WO2019208317A1 (Publication date: 2019-10-31)

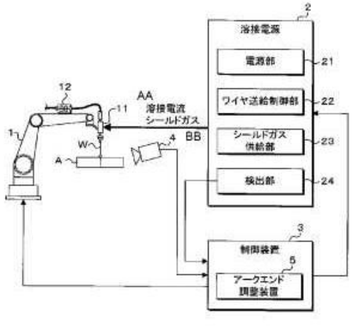
ARC END ADJUSTMENT DEVICE, WELDING SYSTEM, ARC END ADJUSTMENT METHOD, AND COMPUTER PROGRAM

An arc end adjustment device is provided that adjusts the arc end based on the data from the acquisition unit indicating the result of anti-stick processing and a welding state. Based on the acquired data, arc end is adjusted so that the cycle time of the welding process is shortened.

The **arc end adjusting apparatus ~~that~~ adjusts an arc end procedure in a welding process that is repeatedly performed. The welding data indicates the result of anti-stick processing** and a welding state related to the next welding process. A **procedure adjusting section adjusts the arc end procedure based on the welding data acquired** by the acquiring section **so that the cycle time of the welding process is shortened**.

In the arc end adjusting apparatus, when the **welding data indicating the welding state of the next welding process is input, the quality determination unit is configured to perform welding**. ~~A~~ quality determination **neural network that has learned the neural network is provided so as to output data indicating the quality of the result**. In the arc end adjusting apparatus, **when the welding data is input,** the procedure adjusting unit **is capable of shortening the cycle time of the welding process** and displays data indicating a change content of the arc end procedure. A procedure adjustment neural network is provided in which the neural network is trained according to required output.

The procedure adjustment neural network is, for example, a learned deep neural network, and can appropriately adjust the arc end procedure**. The type of the neural network is not particularly limited. CNN, RNN, LSTM, etc. may be appropriately selected according to the characteristics of the welding data**.



2 Welding power source
3 Control device
5 Arc end adjustment device
21 Power source unit
22 Wire feed control unit
23 Shielding gas supply unit
24 Detection unit
AA Welding current
BB Shielding gas

04. Use of welding consumables

JP2019101497A (Publication date: 2019-06-24)

CONSUMPTION AMOUNT ADJUSTMENT DEVICE, WELDING SYSTEM, CONSUMPTION AMOUNT ADJUSTMENT METHOD AND COMPUTER PROGRAM

Use of consumables is reduced by the adjustment device based on the data from the acquisition unit which acquires welding data indicating a welding state during or after the welding process. A learned neural network takes the judgement on the quality of the weld and takes action on the consumption of the consumable in an appropriate manner.

A **consumption adjusting device adjusts the consumption of consumables** in the welding process, and an **acquisition unit acquires welding data** indicating the welding state during or after the welding process. A consumption adjustment device **adjusts the consumption so that the consumption of the consumable item is reduced based on the data** .

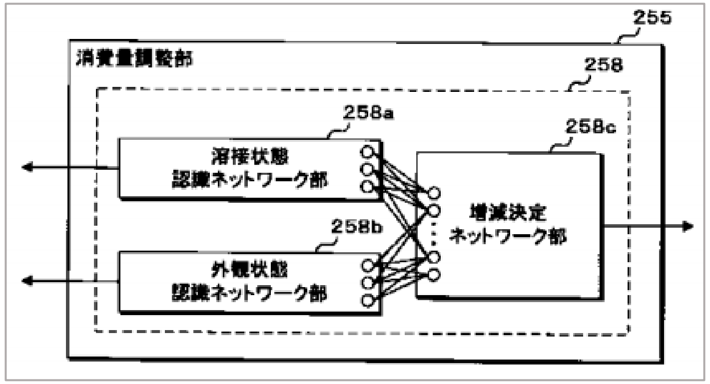
A consumption adjusting device includes a **pass/fail determining unit that determines pass/fail of a welding result based on the welding data acquired by the acquisition unit** When it is determined that the consumption amount is good, the consumption amount is reduced, and when the quality determination unit determines that the consumption amount is not good, the consumption amount is increased or decreased

The consumption adjustment neural network is, for example, a learned deep neural network, and can appropriately increase or decrease the consumable item. The type of the neural network is not particularly limited. CNN, RNN, LSTM, etc. may be appropriately selected according to the characteristics of the welding data.

The consumption adjustment device includes a welding condition data acquisition unit, which acquires welding condition data. The welding condition data includes, for example, information such as the material of the base material A, the groove shape, the welding current setting value, the voltage setting value, the speed setting value, and the frequency setting value when periodically changing the welding current.

The consumption amount adjusting unit can reduce the consumption amount of consumables without deteriorating the welding result, based on the input data on welding monitor and image, and the welding condition. A learned consumption adjustment NN that outputs the indicated data is provided. It can further learn by using the same pass/fail comprehensive determination unit and the learning processing unit.

According to the consumption adjusting device, the welding system, the consumption adjusting method, and the computer program, the consumption is adjusted in consideration of welding conditions, so that the consumption is more effective. It is possible to control the increase and decrease of the product.

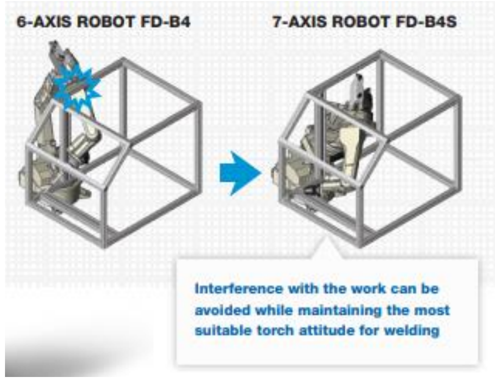


DAIHEN CORP – RECENT PRODUCTS ADDRESSING THE CHALLENGES

7-AXIS WELDING ROBOTS

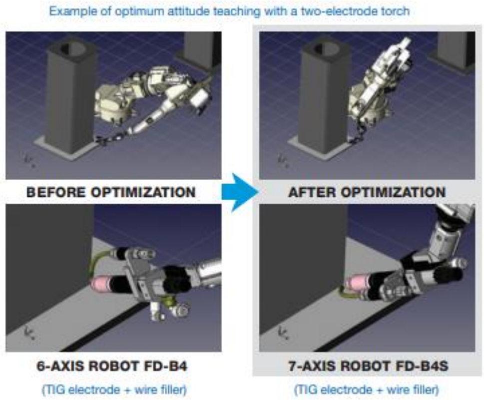
PROVIDES UNMATCHED FREEDOM OF MOVEMENT

AVOIDS INTERFERENCE - Interference with tooling and/or work is easily avoided.



OPTIMUM TEACHING

Easy teaching, even for a two-electrode torch



FD-B4S

FD-V6S

FD-B4LS

FD-V6LS

FD-V20S

FD-SFH LASER SEARCH SENSOR - EXTREMELY FAST AND ACCURATE, STABLE DEVIATION DETECTOR VIA LASER BEAM

Real-Time Tracking)	NO (use with FD-AR)
Material	Mild Steel, Stainless, Aluminum (Other materials available)
Applicable Range	Lap Joints, (1mm or more), Fillet Joint, Corner Joint and many more. *Not applicable for mirrored surfaces.
Accuracy	±0.2mm (0.008”)
Welding Machine	All OTC Machines
Welding Torch	350A Air Cooled MAG Torch (Other torches are available by special order)
Basic Functions	Laser Probe, Groove Data Acquisitions
Combination	FD-AR (for Tracking)

- Joint detection as low as .5 sec, reducing cycle time compared to the FD-QD; Adaptive technology with gap recognition; Mounting position leaves much room for torch accessibility in the production environment

FD-AR ARC SENSOR - REAL-TIME SEAM TRACKING SENSOR USING THROUGH-ARC TRACKING

Deviation Detection	NO (use with FD-WD / FD-QD / FD-SFH)
Material	Mild Steel, Stainless (Solid or Cored Wire)
Applicable Range	Fillet Joints, Lap Joints (3mm or more), V-groove (First path)
Welding Methods	CO_2, MAG, MAG Pulse
Welding Machine	DM350, DP400, DP500
Welding Torch	DAIHEN CO_2 / MAG Torch (Air Cooled / Water Cooled)
Accuracy	±1mm (0.04”)
Remarks	Weaving motion is required.

- Ideal for mid to thick plate Mild Steel and Stainless applications; Settings and controls in the teaching pendant are in a dedicated, user-friendly menu; Easy to understand & easy to use.

FD-LT LASER TRACKING - HIGH-END LASER WITH REAL-TIME SEAM TRACKING SENSOR

Deviation Detection	Under Development (Ask for details)
Material	Mild Steel, Stainless, Aluminum (Other materials available)
Applicable Range	Lap Joints, (1mm or more), Fillet Joint, Corner Joint and many more. *Not applicable for mirrored surfaces.
Accuracy	±0.5mm (0.02”)
Welding Machine	All OTC Machines
Welding Torch	350A Air Cooled MAG Torch (Other torches are available by special order)
Basic Functions	Start, End Point Search 3D Seam Tracking
Combination	FD-AR (for Tracking)

- Dedicated menu can provide user-friendly and easy to use operation; Advanced 3D tracking technologies can provide stable and accurate tracking results; Full support of equipment (Robot, Welder and sensor) from one company.

EWM

01. Tuning welding parameters

EP3296051A2 (Publication date: 2018-03-21)

METHOD OF CONTROLLING A WELDING DEVICE, SYSTEM COMPRISING A WELDING DEVICE AND COMPUTER PROGRAM

Welding device is controlled by correcting the values to the setpoint data of the parameter. The welding device has a controller ~~or~~ connected to the server from which the device receives the instructions

A **method for controlling a welding device**,

- in which **a component data set (46) assigned to a specific component (42) is obtained, the welding parameter setpoints for one of the Component (42) specifies the welding process to be carried out**, and

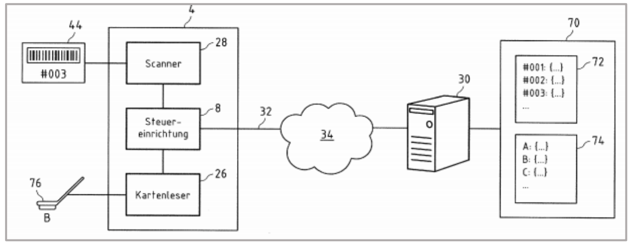
the welding device (4) is **automatically set according to the predetermined welding parameter setpoints** for the welding process.

A computer program comprising **program instructions which cause the processor to execute and / or control the method. The component data record assigned to the specific component is obtained in that a component identifier assigned to the specific component** is received and a component data record assigned to the component identifier is retrieved. The **component identifier can be, for example, a component number that is assigned to the relevant component**. The component identifier can be received, for example, by a user input at a user input device provided for this purpose. In this way, **the user only has to read a component number noted on the component itself,** for example, and enter it into the user input device so that the welding device is set with the appropriate welding parameter setpoints for the welding process to be carried out on this component.

The **user input device is integrated into the welding device or connected to it**. In this way, the welder can enter the component identifier directly on the welding device or have it read in, which simplifies operation.

With the component identifier, the correspondingly assigned component data record of the associated component is then retrieved. The **component data record can be called up from a memory of the welding device or also from an external device, for example from a server connected to the welding device via a communication link**. For this purpose, the welding device and / or a server connected to it can have a memory on which a list is stored which assigns component data records belonging to various component identifiers. **With the received component ID, the associated component data record can then be selected from the list.**

The component dataset specifies a welding sequence plan for the component, and for several welding processes to be carried out one after another on the component, **as well as welding parameter setpoints for the individual welding processes.** The welding device is automatically set in the specified sequence according to the welding parameter setpoints for the individual welding processes. In this way, **even if several welding processes are to be carried out on a component, it can be ensured that the welding parameter setpoints specified for the individual welding processes are set automatically and in the correct sequence on the welding machine**.



01. Tuning welding parameters

DE202011110810U1 (Publication date: 2016-07-14)

CONTROL UNIT FOR A WELDING MACHINE

Control device provides a communication connection between the torch button interface and data interface of welding torch. The control unit enables control of multiple welding parameters within a single device.

The **communication means is set up to superimpose information signals to be sent via the control unit on a voltage or a current provided by the energy supply means.**

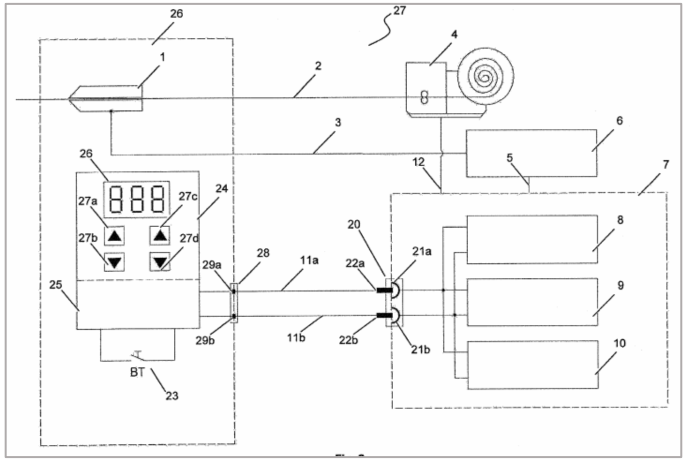
Additional conductor connections in the interface of the control unit and in the torch button or data interfaces to be connected therewith for the power transmission - and additional conductors for the connection - may be unnecessary. The **same conductors can be used for information and energy transmission. Because of the overlay, this can happen simultaneously. This means that information can be transmitted without interrupting the energy supply.**

The superposition can take place, for example, by adding a supply voltage provided by the energy supply means and the voltage of an information signal. **The superimposition can also take place by adding a supply current provided by the energy supply means and the current strength of an information signal.**

The superposition is carried out in such a way that the amount of the voltage or current is always greater than or equal to the amount of the supply voltage or supply current. **In particular, the sign of the superimposed voltage or superimposed current can be selected accordingly for this purpose**. **In this way it can be ensured that even with a superimposed information signal, the amount of the supply voltage or supply current is never undershot and a sufficient energy supply is guaranteed.**

In a welding torch with a data interface that can be connected to the interface of a control unit, the data interface has a special design. Since the control unit interface can alternatively be connected both to a torch button interface and to a data interface of a welding torch, the data interface has a special design adapted to the control unit interface.

The control unit interface can be connected to a conventional torch button interface. In particular, the control unit interface can be designed externally like a conventional control unit interface configured for connection to a conventional torch button interface so that the data interface can also be connected to the control unit interface. The data interface can be designed like a conventional torch trigger interface.



02. Defect detection

EP2669037B1 (Publication date: 2019-09-11)

WELDING FUMES REDUCTION

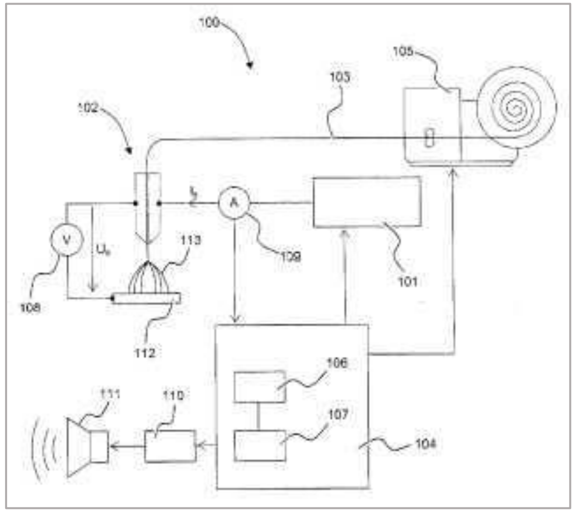
Short-circuits are detected using a detection means and are displayed when the number of short circuits precedes a specified value. This warning gives the operator an opportunity to react to the occurrence of short circuit which is one of the reasons for emission of harmful fumes during welding.

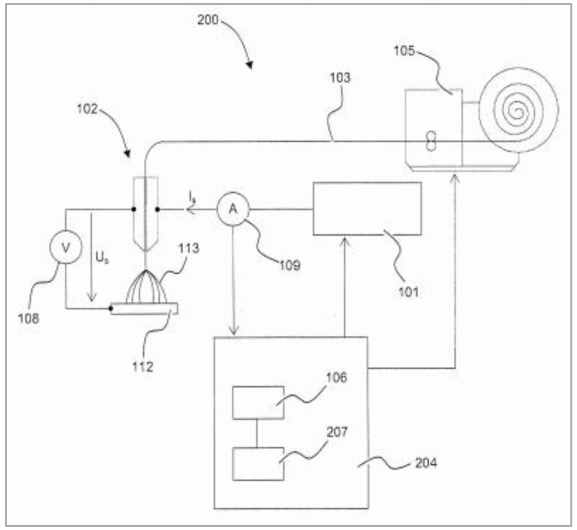
Arc welding device (100) having a melting electrode (103), comprises short circuit detection means (108) and is configured to carry out a pulsed arc welding process, consisting of **indication means (110, 111) that are configured to indicate a short circuit detected by the detection means (108), if a set number of detected short circuits has preceded the detected short circuit during the welding process while being executed.**

Electric arc process control unit (204) for an arc welding device (200) having a melting electrode (103), wherein the unit (204) is configured to control the arc amperage (Is) so that a pulsed arc welding process is executed. The **short circuit detection means (108) are assigned to the electric arc process control unit** (204) wherein the **unit (204) is configured to cause a short circuit prevention on detection of a short circuit by the detection means (108). This is done by influencing a welding process parameter** (Us, Is), **if a set number of detected short circuits has preceded the detected** short circuit during the pulsed-arc welding process.

The arc process control unit is set up wherein **when a short circuit is detected by the detection means, by influencing a welding process parameter, only to effect a short circuit avoidance if it is detected during the welding process; and has a fixed number of detected short circuits in a specified period has exceeded**. With pulse welding, the duration can be specified in the form of a number of pulses. In this way, **the influencing of a welding process parameter can be related to the duration of the welding process and thus an improved criterion for influencing a welding process parameter can be obtained**

Influencing a welding process parameter includes increasing the arc voltage and / or the arc current intensity. In particular, it can consist of an increase in the arc voltage and / or the arc current intensity. The **energy input into the melting electrode can be increased by increasing the arc voltage and / or the arc current intensity. The arc length can thus increase, so that a short circuit can be avoided.**





EWM – RECENT PRODUCTS ADDRESSING THE CHALLENGES

WELDING 4.0 – WELDING MANAGEMENT SYSTEM

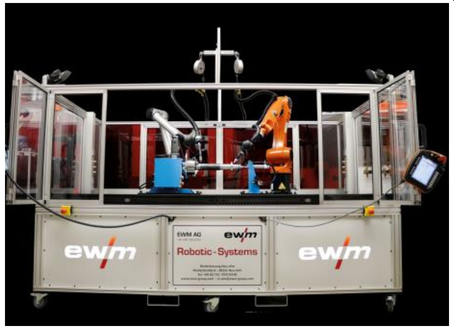
Intelligent and productivity-boosting networking of man and machine for an automatic flow of data within the production chain

- Platform-independent – Browser-based for all end devices
- Any number of welding machines can be added at a later date using drag & drop
- LAN/WiFi control connection – Wireless network; Connect portable power sources, automated systems or robot systems
- Offline data recording even in 24-hour three-shift operation can be saved for up to 28 days
- Manage components (with image, drawing etc.,), create welding sequence plans
- WPS linked to component, on-time monitoring of parameters directly on the welding machine; Transferring of welding parameters to the machine

Welding 4.0 – ewm Xnet welding management system

Flexible complete system for robotic welding

- Ready-to-weld robot cell
- Modular construction in the size desired
- Station that can be equipped with robots from Fanuc, Kuka, Universal Robots or Yaskawa
- Integrated cross arm
- Built-in power source (MIG/MAG and/or TIG, Wire feeder on lift)
- Included safety devices (Emergency stop switch, Door switch, Eye protection)
- Easy to change the welding torch



URL

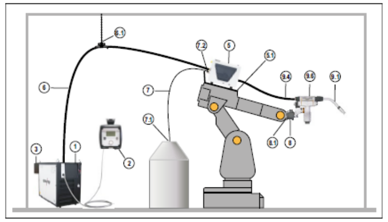
MULTIMATRIX®

Complete system of power source, wire feeder and welding torch, guaranteeing smooth processes and flawless results. Now and in the future.

- Direct access to expert knowledge – combined and displayed in the Expert 2.0 control unit.
- All the important parameters at a glance for every welding task – and full control of complete welding process

MIG/MAG automation - Sample application

- Alpha Q, gas cooled
- Pulse: forceArc, coldArc, pipeSolution
- Handling/welding robot system alpha Q 352 RC as frontDrive system



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MIG/MAG automation - Wire feeder

M drive 4 Rob 2X ZT

- Additional drive unit for robot power source
- wire feeder when there are large distances between spool/drum and welding torch

URL

MIG/MAG automation - Welding torches

Robot welding torches for hollow wrist robots, gas-cooled

- Duty cycle CO2: 500 A / 100 %
- Duty cycle M21: 400 A / 100 %
- Ø wire: 0.8 mm - 1.6 mm

URL

OTHER CHALLENGES ADDRESSED BY MAJOR COMPANIES

Company	Challenge	Solution
ITW US20190217418A1	Penetration cannot be adequately controlled when there are gaps in the weld which need advanced solutions	A controller is communicatively coupled to the sensor and adapted to receive the acquired data from the sensor. This data is indicative of a welding defect. When a defect is observed, the controller alerts the operator and logs the error in the associated memory
Shenzhen Weiai Intelligent Tech Ltd WO2020077694A1	Training robots on multiple scenarios (Input parameters and output parameters)	Robots are trained with the help of neural network. A neural network is established and the number of neurons in the input layer, hidden layers, and output layer of the neural network are determined. A back propagation algorithm is used to determine the weight value and bias value of the neural network, and train the neural network
SIEMENS WO2019103772A1	Delay in defect detection resulting in multiple defects	Welding operation is simulated by a weld analysis system. Welding defects are detected and predicted based on simulated welding operation and the analysis of the physical weld. Root cause analysis is performed based on the detected and predicted welding defects to produce corrective action to eliminate defects from subsequent physical welds
上海电气 SHANGHAI ELECTRIC WO2017079995A1	Welding position recognition and guidance, path planning are difficult in robotic welding	Robot welding system is provided with a path planning and offline programming module that is signal-connected and controlled by the central control module; it performs anti-collision planning of welding paths for multiple industrial robots, and performs offline programming of the planned solutions.
ABB EP3241083B1	Welding parameters are often different at different locations on the welding path. Large number of test runs are needed before setting an appropriate parameters	Welding path of one or more workpieces is compiled in a log file. The log file is processed to form a geometrical visualization so that the welding parameters are paired with geometrical positions of the weld. The geometrical visualization of the log file makes the variation of the welding parameters along the welding path comprehensive to the user and enables easy adjustments at certain positions.

APPROACHES FROM UNVERSITIES TO ADDRESS THE CHALLENGES

1. LUT University: Artificial Neural Network Controlled GMAW System: Penetration and Quality Assurance in a Multi-Pass Butt Weld Application

Artificial neural network (ANN) decision-making software and a machine vision system are combined to develop an adaptive artificial intelligence (AI)-based gas metal arc welding (GMAW) parameter control system. Seam profile data is further processed and welding parameters are optimized by the decision-making system. Different sensors such as laser sensors, thermal sensors, arc imaging, and acoustic sensors etc., are used to check the quality of the weld, of which laser sensor is observed to be the suitable tool for the detection and measurement of the root gap and root face of the weld seam for welding process control purposes.

2. University of Birmingham: Automated defect classification of Aluminium 5083 TIG welding using HDR camera and neural networks

Tungsten inert gas (TIG) welding is assessed using a high dynamic range (HDR) camera and artificial neural networks (ANN) for image processing.

3. Rzeszow University of Technology: Diagnostics of welding process based on thermovision images using convolutional neural network

Convolutional neural network in combination with infrared image recording using two thermovision cameras is observed to produce welds with an accuracy of above 98% for stainless steel materials of various thicknesses

4. Purdue University: Deep-learning-based porosity monitoring of laser welding process

A convolutional neural network (CNN) model with compact architecture was designed to learn weld-pool patterns to predict porosity. Data is sensed with a coaxial high-speed camera. CNN model could detect the porosity occurrence. It was also found that for a pore to be detectable, it must produce sufficient impact on the weld pool that can be captured by the camera.

5. Beijing Institute of Technology: Discrete Fireworks Algorithm for Welding Robot Path Planning

Shortest possible route calculation along with efficient weld is proposed. The discrete fireworks algorithm (DFWA) combines 2-opt local search and operators in GA to discretize the searching process of the FWA. It is very effective for welding robot path planning, and it can be applied to more discrete optimization problems.

SOFTWARE DEVELOPERS WORKING IN INTELLIGENT WELDING SYSTEMS

DELFOI

Delfoi ARC

Creates accurate, error-free, homogeneous and high-quality welding programs regardless of the robot brand

- **Fast and easy:** semi-automatic programming with user friendly user interface
- **Multi-Robot System:** supports programming of multiple synchronously co-working robots
- **Jigless welding:** a robot as the part positioner while another robot is welding
- **High quality programs:** integrated quality control and WPS (Welding Procedure Specification)
- **Accurate tool paths:** advanced calibration tools and trajectory management
- **Generic:** supports ABB, Fanuc, KUKA, Yaskawa, Motoman, Kawasaki, Panasonic, IGM, CLOOS, Reis etc
- Automatic detection of collisions and "near-miss" incidents with visual feedback
- Cell layout planning and fast positioning of components within a cell
- Robust and tested postprocessors including downloading to a robot controller and uploading from a robot controller for all major robot brands, like ABB, KUKA, Yaskawa, Motoman, Reis, CLOOS, IGM, Kawasaki, Fanuc, OTC, Deihen, Nachi, Staübli and Hyundai
- Command of external I/O devices, e.g. using PLC logic, is also easy to implement

OCTOPUZ®

OCTOPUZ 3.0

The PathPlanner suite of tools, an enhanced programming experience for creating, modifying, and transforming path and search statements

- **PathPlanner Create -** New, intuitive tools for creating path and search statements in OCTOPUZ. With multiple path and search selection methods, along with real-time path previews, integrated automatic collision avoidance, and simple configuration options, creating statements etc..
- **PathPlanner Modify** - Sometimes, modifications to previously created path and search statements are needed. In OCTOPUZ, there is a collection of modification tools to help.
- **PathPlanner Transform** - If there is similar geometry along the physical programmed part, one might want to take the exact path or search statement in the robot program and place in a different location or in multiple different locations in a 3D environment. For these cases, there are transform tools available in OCTOPUZ.
- **Point Editor** - The Point Editor panel brings an entirely redesigned point editing experience to OCTOPUZ, through a unified look that focuses on providing easy-access tools which affect specific points of a path or search statement.

VISUAL COMPONENTS

Visual Components 4.2 - Premium

Virtualizes factory with Visual Components Premium. It includes everything in Essentials and Professional, plus more features for advanced robotics applications

- **Create Path Statement -** Quickly teach and simulate paths of positions with robots. Edge and curve selection tools help pick and edit robot paths with practical applications for robot welding, machine tending, paint, and water jet operations, sealing, and cutting.
- **VRC connectivity for UR and Stäubli** - The Universal Robot connectivity plugin enables connecting to a Universal Robot controller and running a simulated robot with realistic movements. The Stäubli robot connection add-on supports creating/editing robot program positions and running them with a Stäubli CS8 controller to verify program operation and cycle times. It also supports positional data transfer between a simulated and real controller.
- **Siemens S7 PLC Connectivity** - Supports native connectivity to most physical and simulated Siemens PLCs, including older models. This native connection provides faster communication speeds with physical S7-1200 controllers and supports connection to S7-PLCSIM.
- **Interactive VR –** It is possible to create a streaming connection to visual components experience, allowing users to interact with the VR environment.

START-UPS WORKING IN INTELLIGENT WELDING SYSTEMS

MINYUE TECH

- Developed a 3D laser optical-angle sensor SmartEye that equips robots with “eyes and brains”.
- Using vision and artificial intelligence technology, SmartEye can accurately track robot's motions in real time through the visual feedback.
- Developed *RobotSmart*, an offline programming software that allows rapid programming of industrial robots

LIVNSENSE TECHNOLOGIES

- Focusing on next-generation digital solutions in various domains, LivNSense Technologies has launched a smart welding platform called *WELDSENSE™* for improving efficiency, reliability and safety of weld process.
- Offers real-time monitoring of weld data using multiple connectivity technologies that can sustain the adverse RF environment in manufacturing.

PATH ROBOTICS, INC

- Transformative robotic welder system that sees, understands, autonomously generates motion, and delivers perfect welds with zero programming and zero custom fixtures.
- The robots can understand where to weld in the system and autonomously generate motion

SENSIGMA LLC

- Dedicated to Sensory and Quality Control innovation
- Developed a reliable, low cost sensing and feedback system to maintain high quality, very low to no defect weld in various manufacturing processes.
- Developed Smart Optical Monitoring Systems (SOMS), which detect the defects, elements and quality of each weld by analyzing the wavelengths of light emitted by laser-induced plasmas in real-time, during the welding process.

RECENT COLLABORATIONS IN INTELLIGENT WELDING SYSTEMS

2019

Toshiba |Gestamp

Toshiba Digital & Consulting Corporation (TDX) and Spain's *Gestamp*, manufacturer of metal components for automobiles, are collaborating to leverage IoT and AI, and utilizing data from camera images and acoustic emission sensors to bring advanced monitoring and analysis to the welding of vehicle chassis parts. The partnership aims to improve vehicle safety by securing very high-precision detection of weld seam quality.

2020

Baoneng Motor | Midea Group

Chinese based *Baoneng Motor* and *Midea Group* have recently entered into a partnership to develop an intelligent manufacturing and retail ecosystem, with a focus on high-end intelligent manufacturing under which Baoneng will introduce the welding robot and welding wire.