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DNNP009

Software Add-Ons for uniVision: KUKA Interface SeamTech Tracking

uniVision

Operating Instructions

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1. General

The software add-on permits communication between a uniVision application DNNF012 and a robot for seam tracking applications. In this way, a 2D/3D Profile Sensor can be used with a uniVision application for seam detection and tracking in realtime with a robot.

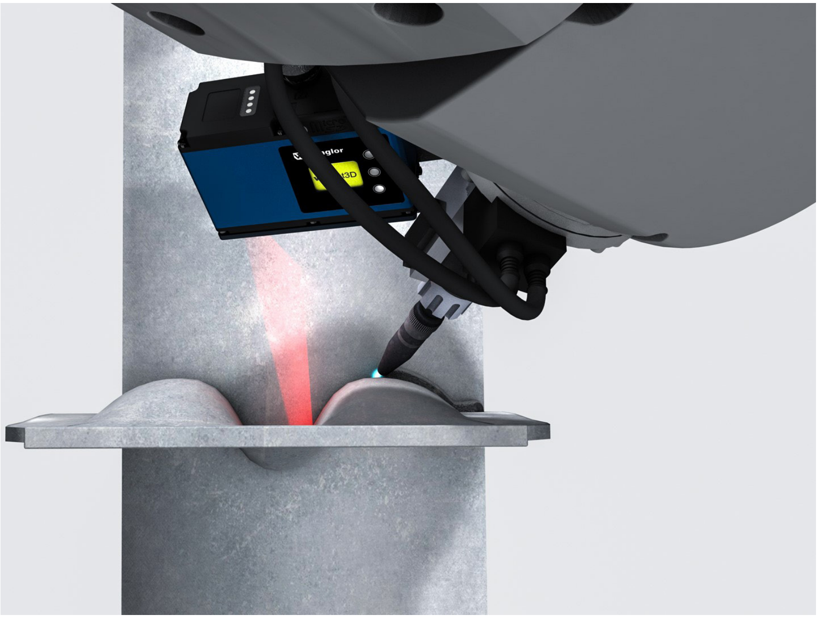


Fig. 1: Seam tracking with 2D/3D Profile Sensor and robot

NOTE!
These instructions are limited to a description of the interface between the uniVision application and the robot controller. Comprehensive information regarding uniVision parameters configuring software and the mode of operation of the 2D/3D Profile Sensors can be found in the operating instructions of the respective products. Details concerning available robot commands can be obtained from the respective robot manufacturer.

2. Connection Overview

Communication between the 2D/3D Profile Sensor's control unit and the robot controller takes place via a TCP/IP interface.

NOTE!
Bridge the network settings at the control unit of the 2D/3D Profile Sensor in order to be able to use a LAN interface for the 2D/3D profile sensor and a LAN interface for connection to the robot controller. Open the properties window for the control unit in the device list and set the "Bridge" parameter to "LAN1 and LAN2" to this end.

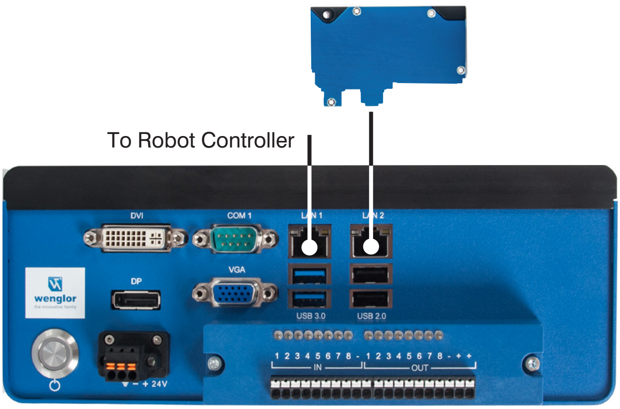


Fig. 2: Connection between Control Unit and robot controller

3. Functions Overview

The "robot interface" software add-on is installed to the control unit of the 2D/3D profile sensor. It controls communication between the uniVision application and the robot controller.

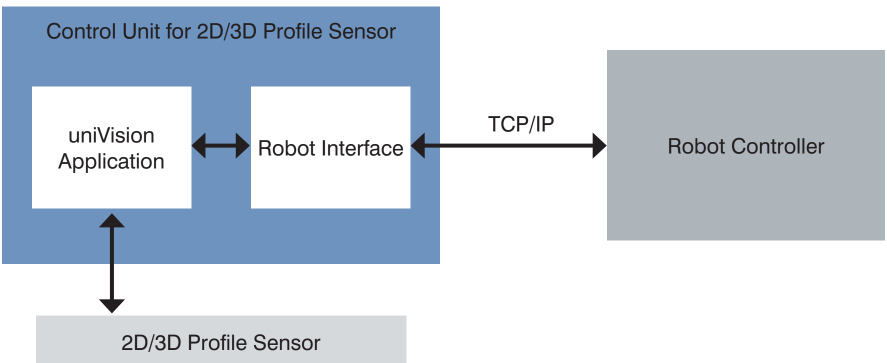


Fig. 3: Function diagram

4. Installing the Interface

Install the software add-on to the control unit of the 2D/3D profile sensor.

1. Download the file and save it to a USB stick.
2. Connect the USB stick to one of the USB ports on the control unit.
3. Select the file and copy it to the /media/card/firmware directory.
4. Restart the control unit.
5. The software add-on is installed and started the next time the system is booted.

5. Interface for SeamTech Tracking in KUKA robots

5.1 Setting up an uniVision Application Project

The user should create at first a uniVision project and configure it to detect the seam. Once the project is created and configured, the user should save the project using a number as project name.

Example:

- Job number on robot side: 1
- Matching name of the uniVision project:1.u_p

A uniVision project for robot interface should mainly consist of three basic modules:
1. Module device weCat3D
2. A module to detect the seam (e.g. module Pointcloud Measure)
3. Module Device TCP

Fig. 4 shows a simple uniVision project for robot interface to find the V joint.

The user can use the point cloud measuring module together with the find line or find line segment tool, to detect the seam. The start and end points of the detected lines are determined and can be used as points for tracking.

NOTE!
uniVision 2.1.0 or higher provides ready to use templates to find different sets of simple joints. The user is free to modify a template to match his own needs.

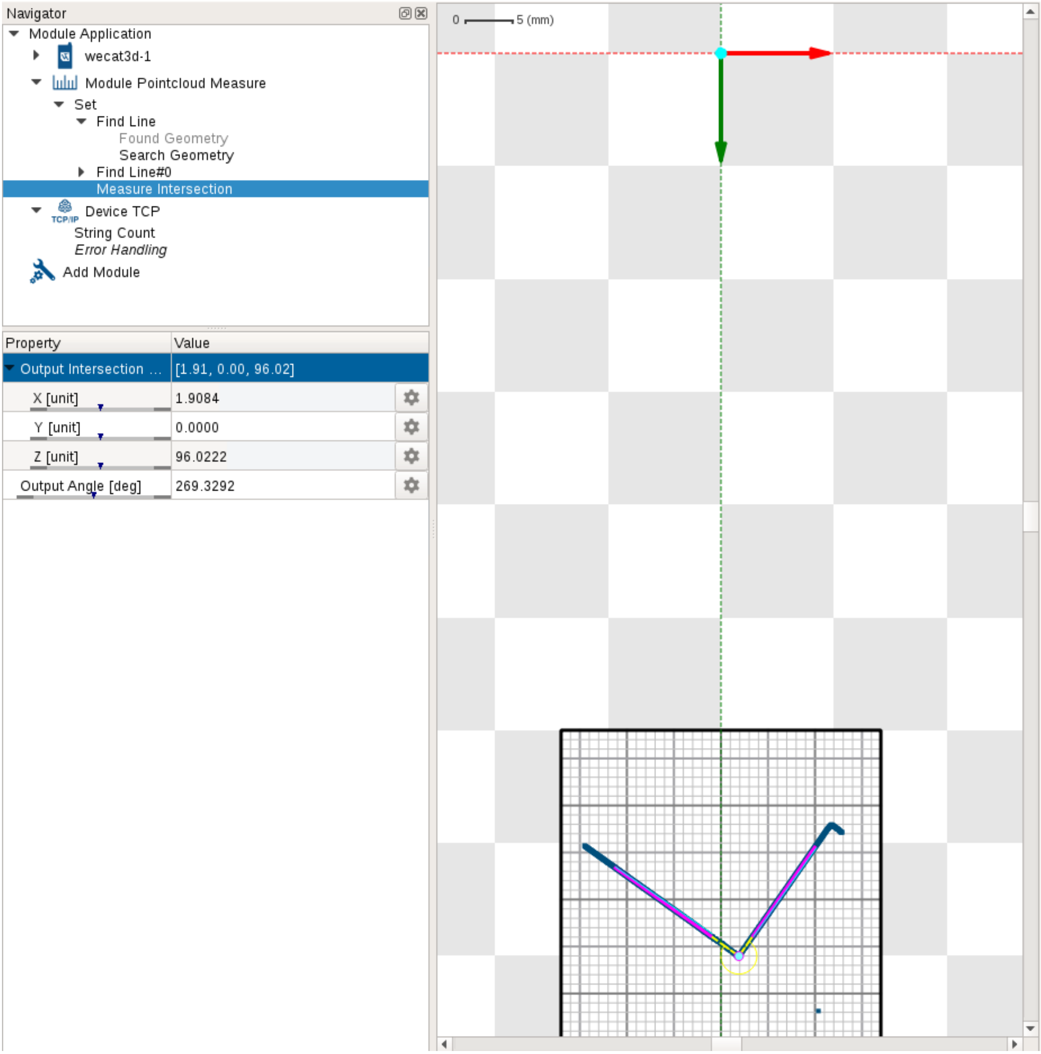
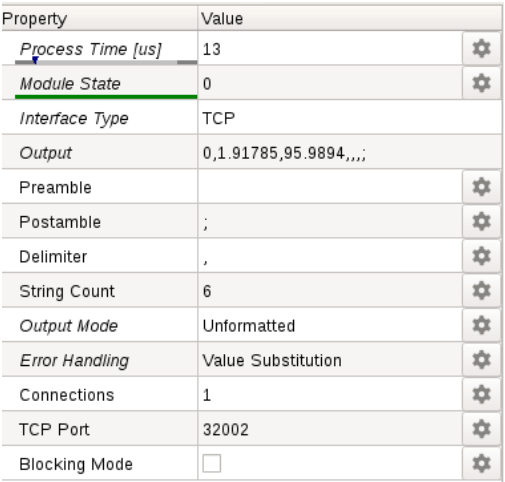


Fig. 4: Basic uniVision project to detect V joint

Device TCP module should be configured as follows:

Postamble: ; (semicolon)
Delimiter: , (comma)
Number of characters: 6



Property	Value
Process Time [us]	13
Module State	0
Interface Type	TCP
Output	0,1.91785,95.9894,,,;
Preamble	
Postamble	;
Delimiter	,
String Count	6
Output Mode	Unformatted
Error Handling	Value Substitution
Connections	1
TCP Port	32002
Blocking Mode	

Fig. 5: Device TCP module configuration for robot interface

1. Link the values for the character strings using the “number of characters” submodule:

<table>
<tr><th>Character String Number</th><th>Linked Value</th></tr>
<tr><td>Character string #1</td><td>Link with a value which provides information concerning the validity of the measured value (e.g. module status of module pointcloud measure).

NOTE!
The linked value is interpreted as follows:<table><tr><th>Linked Value</th><th>Meaning</th></tr><tr><td>0 or false</td><td>The ascertained value is valid.</td></tr><tr><td>Value not equal to 0 or false</td><td>The ascertained value is invalid. The robot ignores the measured value.</td></tr></table></td></tr>
<tr><td>Character string #2</td><td>Link to the X-coordinate of the tracking point
(e.g. the X-coordinate of the detected endpoint of a line).</td></tr>
<tr><td>Character string #3</td><td>Link to the Z-coordinate of the tracking point
(e.g. the Z-coordinate of the detected endpoint of a line).</td></tr>
<tr><td>Character string #4</td><td>Link to a value which represents information concerning the width of a gap (e.g. the X-value difference at a gap).</td></tr>
<tr><td>Character string #5</td><td>Link to a height difference (e.g. the Z-value difference at an edge).</td></tr>
<tr><td>Character string #6</td><td>Link to a surface (e.g. a detected surface from the point cloud region module).</td></tr>
</table>

NOTE!
Character strings 1 through 3 must be linked, but linking of character strings 4, 5 and 6 is optional.

NOTE!
It is fine to add more than 6 strings in the module Device TCP and link them to different values. The robot interface reads only the first 6 strings and ignores the rest.

5.2 Configuring the Robot Interface

The robot interface includes various setting options and results displays.

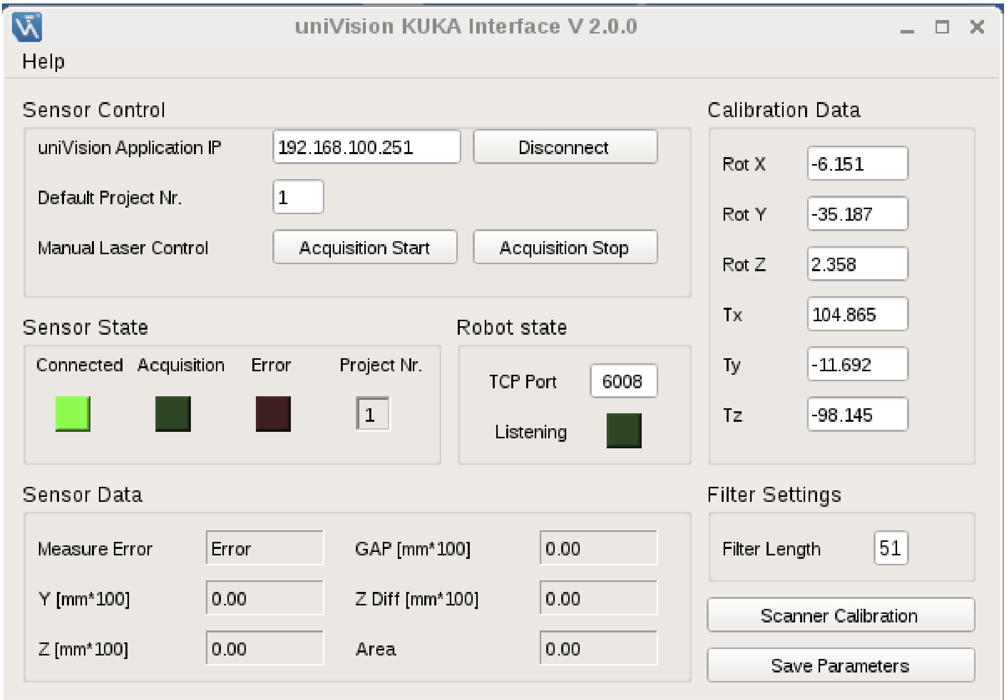


Fig. 6: uniVision KUKA interface

5.2.1 Sensor Control

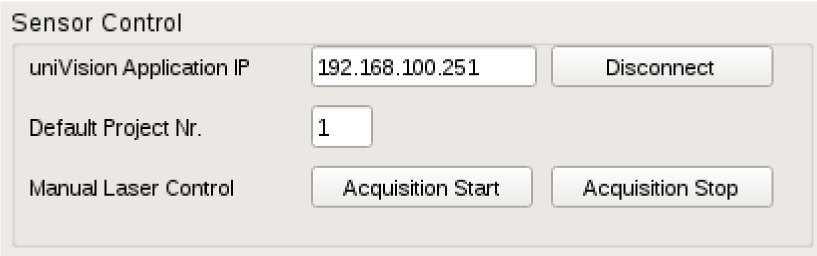


Fig. 7: Sensor control

The robot interface automatically connects to the uniVision project through the given IP. For safety reasons the laser of the 2D/3D Profile Sensor will be automatically deactivated after establishing a connection. You can manually control the laser of the 2D/3D Profile Sensor from the robot interface through the buttons “Acquisition Start” and “Acquisition Stop”.
The robot interface communicates with the uniVision application via a TCP/IP connection.

NOTE!
The IP address of the uniVision application is visible in the device list of the uniVision software. The default IP address is **192.168.100.251**.

NOTE!
In case of an open connection between the robot interface and the uniVision project, the uniVision project can be used in live mode. Changing to edit mode is only possible if the connection from the robot interface to the uniVision project is closed before.

5.2.2 Sensor State

Fig. 8: Sensor state

The table below describes the state of each LED in sensor state.

<table>
<tr><th>Status Value</th><th colspan="2">Meaning</th></tr>
<tr><td rowspan="4">Connected</td><td colspan="2">Connection status, robot interface to uniVision project:</td></tr>
<tr><td>Orange</td><td>Not connected

Possible causes:
• The IP address of the uniVision application is incorrect.
• The uniVision project is in edit mode.

Remedy:
• Enter the correct IP address.
• Switch the uniVision project to run mode.</td></tr>
<tr><td>Dark green</td><td>The connection to the uniVision application is active and the uniVision application project is being loaded.</td></tr>
<tr><td>Bright green</td><td>The connection to the uniVision project is active and the 2D/3D Profile Sensor is ready.</td></tr>
<tr><td rowspan="2">Acquisition</td><td>Dark green</td><td>The 2D/3D Profile Sensor’s laser is off.</td></tr>
<tr><td>Bright green</td><td>The 2D/3D Profile Sensor’s laser is on.</td></tr>
<tr><td rowspan="2">Error</td><td>Dark red</td><td>No errors</td></tr>
<tr><td>Bright red</td><td>Problem in communication with the uniVision project</td></tr>
<tr><td>Project number</td><td colspan="2">Number (name) of the project which is currently loaded in the uniVision application</td></tr>
</table>

5.2.3 Robot State

Fig. 9: Robot state

The TCP port edit line defines the port number. The port number in robot interface should match the port number in sensor configuration in robot control. Please refer to section 5.4 for more details.

The table below describes the state LED in robot state.

Status Value	Color	Status of connection between controller and robot interface
Robot status	Orange	The robot interface software is not licensed. Please refer to section 5.3 to learn more about licensing the robot interface
	Dark green	Waiting for a connection from the robot controller
	Bright green	Connected

5.2.4 Sensor Data

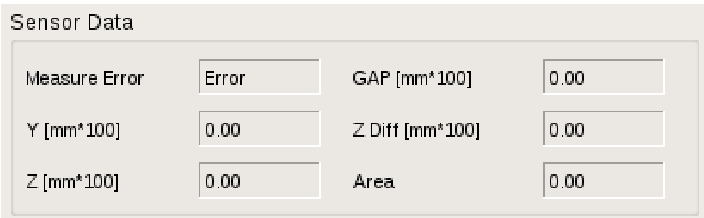


Fig. 10: Sensor data

Sensor data shows the linked data in Device TCP module in the loaded uniVision project. If the laser of the 2D/3D Profile Sensor is deactivated or the uniVision project could not compute the tracking point, the measure error label will show “Error” and the data will not be updated.

5.2.5 Robot Interface Calibration Data and Filter Settings

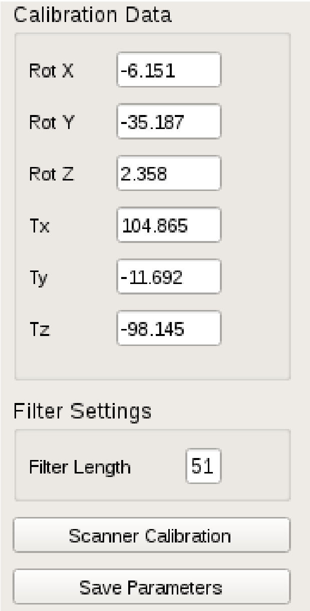


Fig. 11: Sensor calibration data and filter settings

The KUKA robot interface offers also more settings compared to other robot interfaces. Those settings are related to the sensor calibration data and filter settings. Calibration data can be either computed by the user, or it can be automatically computed by the robot interface (recommended). Please refer to section 5.5 to learn more about the topic.
Filter length in the filter settings defines the size of the smoothing window. It is recommended to use a filter size of 51.
"Sensor calibration" button will open a new window to start the calibration process. Refer to section 5.5 to learn more about the calibration process.
"Save Parameters" saves the calibration and filter settings into a log file.
The KUKA roto interface loads the settings from the log file when it starts.

5.3 RobotInterface Licensing

The robot interface needs to be licensed in order to accept a connection from the robot controller.

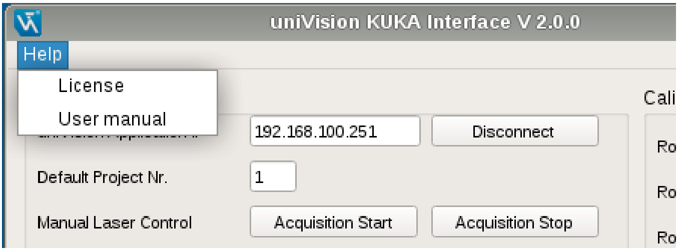


Fig. 12: Robot interface licensing

In the Help menu in the menu tool click on license to open the license dialog window.
In the “License Request” tab enter your data to the lines provided for this purpose and activate the checkbox next to the desired module (see Fig. 13). Click “Generate request”, save the displayed license request key on the desktop and send it by e-mail to **order@wenglor.com**.

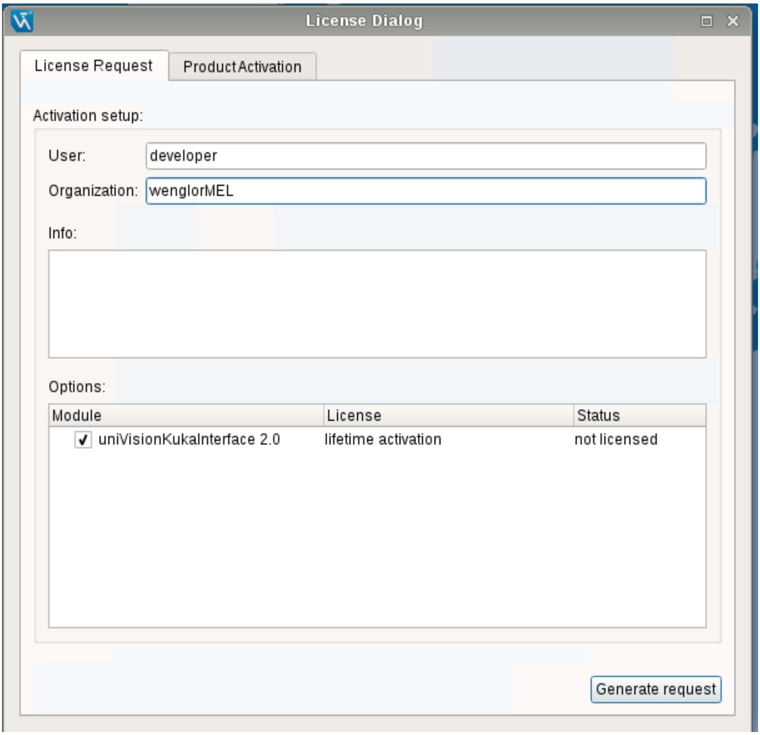


Fig. 13: License window

NOTE!
Please make sure that the licensing process is executed on the control unit which will actually be used in the application. The license is restricted to the respective control unit.

You will receive your license activation key. Save it on your desktop. Select the “Product Activation” tab in the license dialog box and open the corresponding file. Click “Activate License” in order to enable the software.

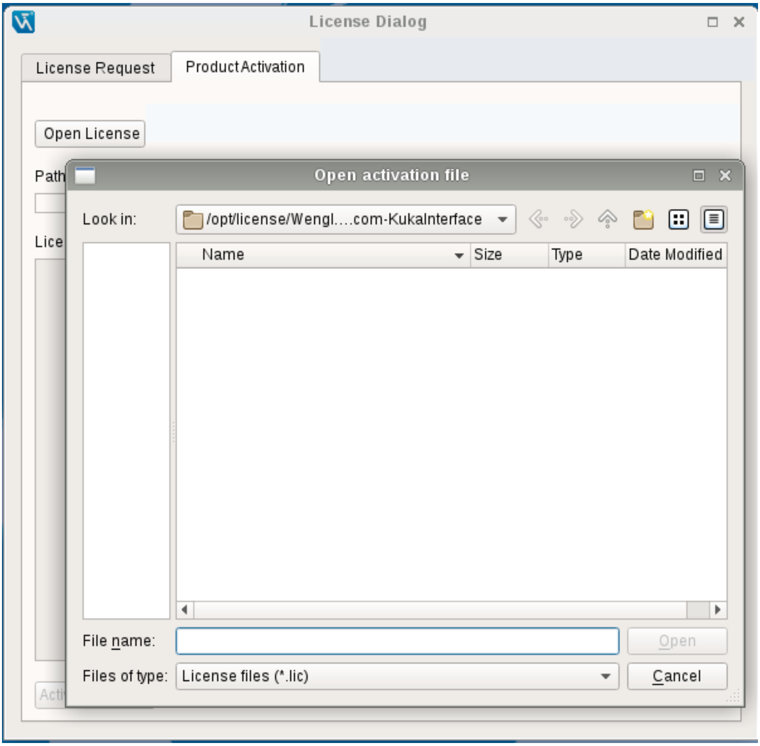


Fig. 14: License activation window

5.4 Configuring the SeamTech Tracking in KUKA Robot

The robot controller should be configured to build a connection to the robot interface.

NOTE!
Make sure the software package SeamTechTracking is already installed on the robot controller. Please contact your KUKA support to learn more about the topic.

In the related project in WorkVisual software from KUKA select the Meta sensor from the SeamTeck tracking option in the project catalogue.

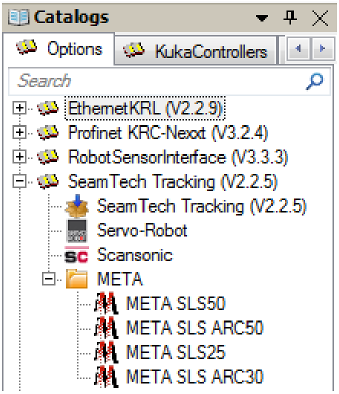


Fig. 15: SeamTech Tracking options

In general tab in the sensor settings type in the IP address and the port number. The IP address should match the IP address of the PC (default is **192.168.100.252**). The port number should match the port number of the KUKA robot interface, refer to section 5.2.3 (default is 6008).

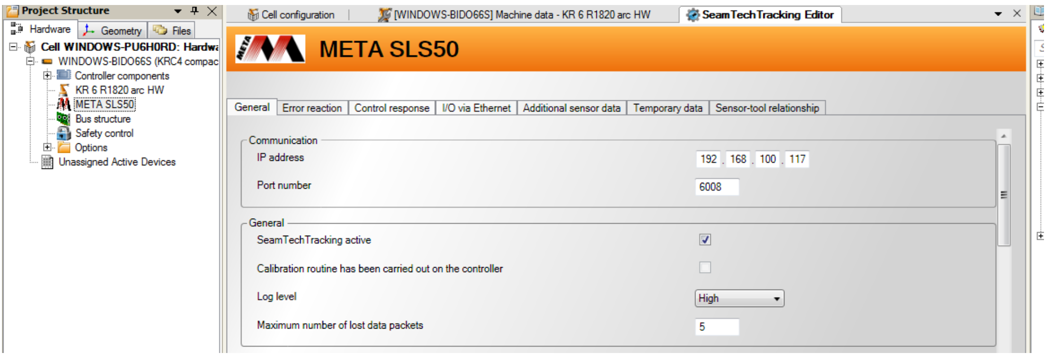


Fig. 16: Sensor configuration in SeamTech Tracking

5.5 2D/3D Profile Sensor Calibration for KUKA Robots

Seam Tech Tracking software in KUKA robots does not provide calibration algorithm to compute the 2D/3D Profile Sensor frame with respect to the robot tool frame. Calibrating the 2D/3D Profile Sensor is important to convert the detected seam from the sensor coordinate system into robot coordinate system.
The uniVisionKukaInterface provides the user an easy way to calibrate the 2D/3D Profile Sensor.

NOTE!
The results of the 2D/3D Profile Sensor calibration process and hence the result of the seam tracking depends on the accuracy of the computed robot tool frame. Make sure that the computed robot tool frame is accurate.

The computed sensor frame (calibration parameters) is valid as long as the mechanical connection between 2D/3D Profile Sensor and the robot TCP does not change.
The uniVisionKukaInterface calibration algorithm does not need any special calibration plate. The user can use any simple lap joint to calibrate the sensor.

NOTE!
The length of the lap joint should be larger than the distance between the laser line of the 2D/3D Profile Sensor and the robot TCP.

System requirements to calibrate the 2D/3D Profile Sensor:

1. The robot tool is calibrated (please refer to KUKA user manual to learn more about tool calibration).

2. The software option SeamTech Tracking is already installed on the KUKA robot controller (please contact your KUKA support to learn more about SeamTech Tracking).

3. The tool coordinate system and the base coordinate system are defined as in Fig. 17:

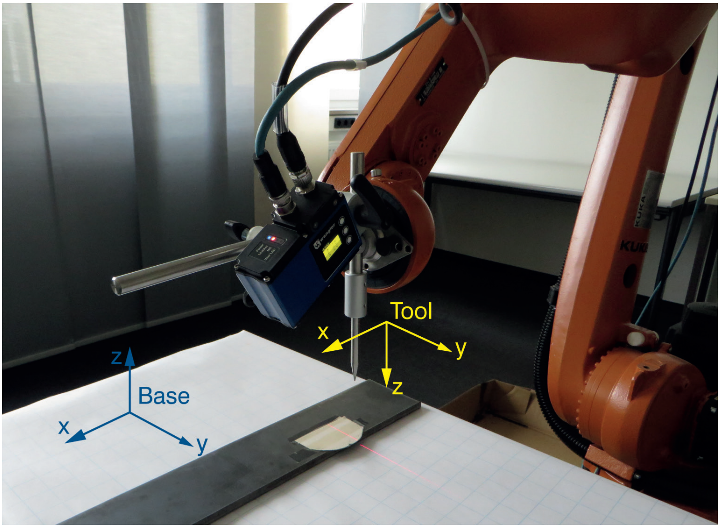


Fig. 17: Base coordinate system and tool coordinates for running the calibration algorithm

4. The sensor is mounted in front of the tool (in the +X-direction of the tool) using a mechanical tool as illustrated in Fig. 17.

5. The KUKA robot controller is configured to connect to the uniVisionKukaInterface (see section 5.4)

How to calibrate:

1. Create a new uniVision project, give it a special name (e.g. 0000.u_p) and configure it to detect the seam from a lap joint (see section 5.1).

2. Write a simple calibration program in the robot controller as demonstrated in the screenshot in Fig. 18 where Pref, P1, P2, P3 and P4 are the points to be taught as described below. Tool[1] and Base[1] are the tool coordinate system and base coordinate system as illustrated in figure Fig. 17.

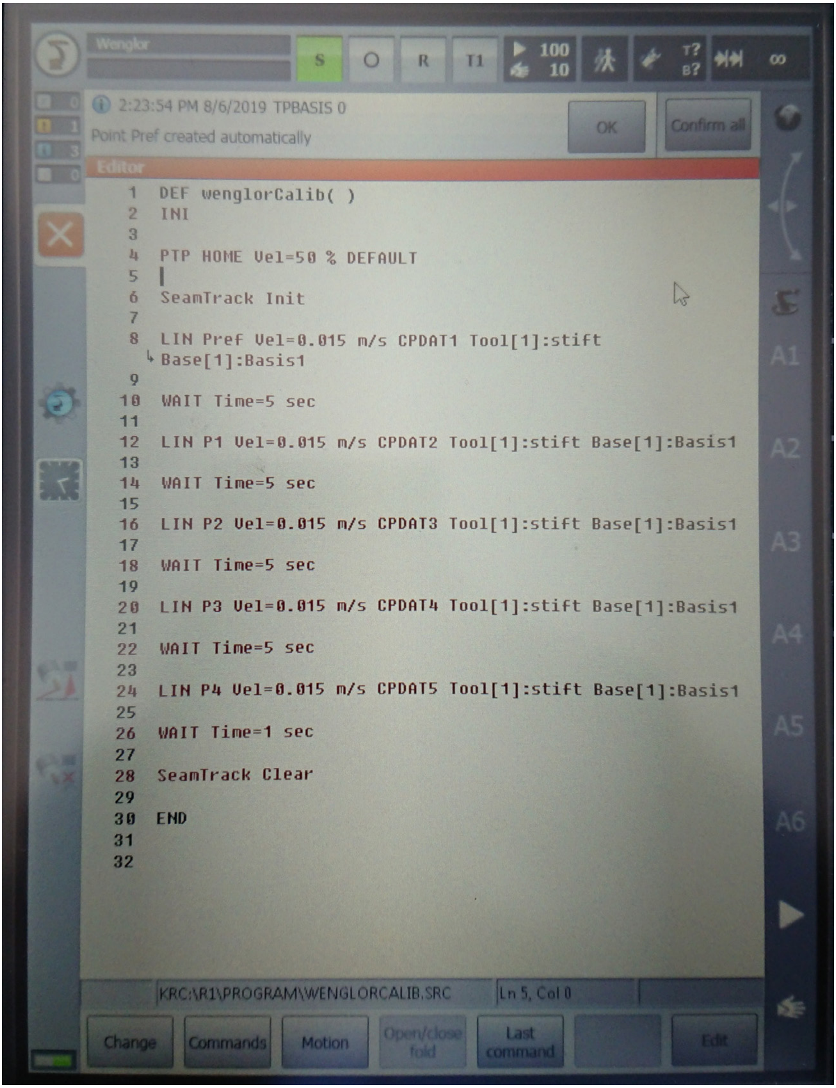


Fig. 18: Calibration program example in KUKA controller

3. Mark any point on the lap joint using a marker pen. Jog the robot tool to this point and teach the position of the tool as Pref in the calibration program in the robot controller.

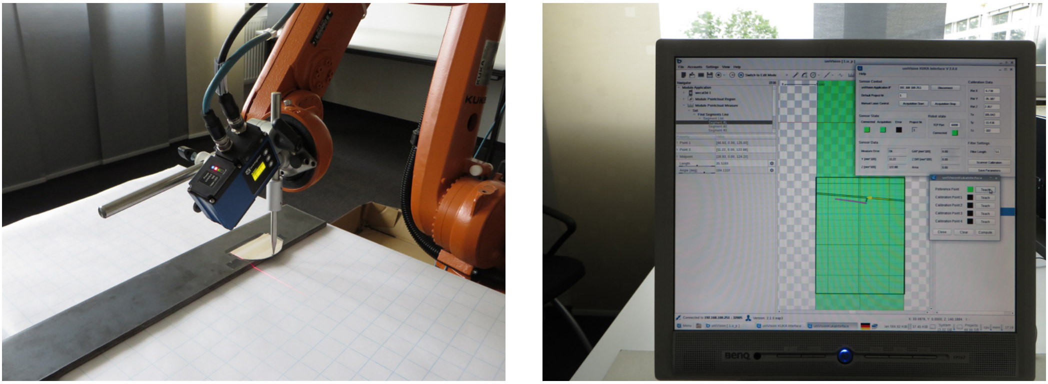


Fig. 19: Calibration point Pref, correspondent screenshot (on the right)

4. Jog the robot tool in the direction –X in base coordinate system (without changing the tool's 3D orientation) until the laser line is located exactly on the marked reference point. Make sure that the uniVision calibration project is able to detect the seam. Teach the position of the tool as P1 in the calibration program in the robot controller.

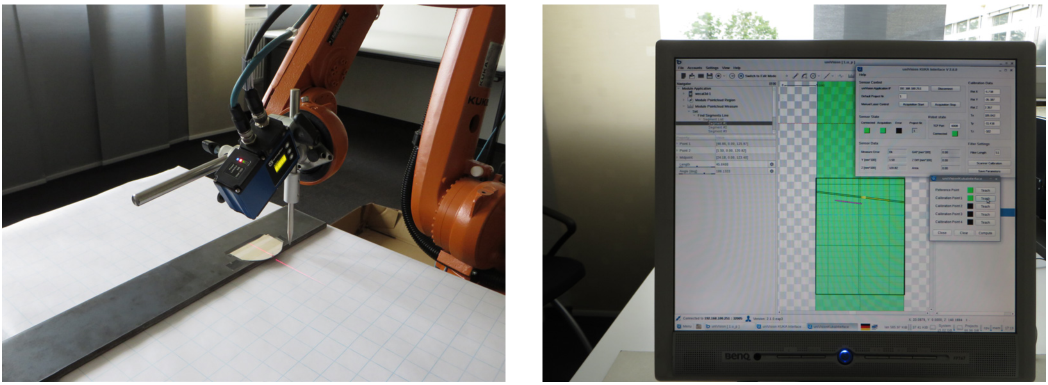


Fig. 20: Calibration point P1, correspondent screenshot (on the right)

5. Jog the robot tool in the direction +Z in base coordinate system for few centimeters (from 5 to 15 cm, depends on the working range of the sensor). Jog the robot tool forward or backward (in X direction base coordinate system) until the laser line matched the reference point on the lap joint. Teach the position of the tool as P2 in the calibration project in the robot controller.

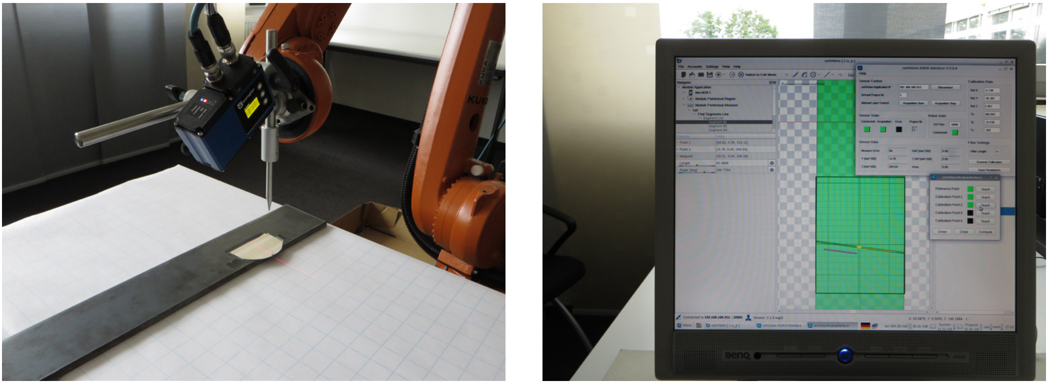


Fig. 21: Calibration point P2, correspondent screenshot (on the right)

6. Jog the robot in the direction +Y few centimeters (depending on the scanner working range in X). Jog again the robot backward and forward (in X direction base coordinate system) until the laser line matches the reference point on the lap joint. Make sure that the uniVision project detects the seam correctly. Teach the current point as P3 in the robot calibration program

Fig. 22: Calibration point P3, correspondent screenshot (on the right)

7. Jog the robot position in the –Y direction base coordinate system. Jog again the robot TCP tool forward and backward (in X direction base coordinate system) until the laser line matches the reference point on the calibration object. Make sure that the uniVision project detects the reference point correctly. Save the current position as P4 in the robot calibration program.

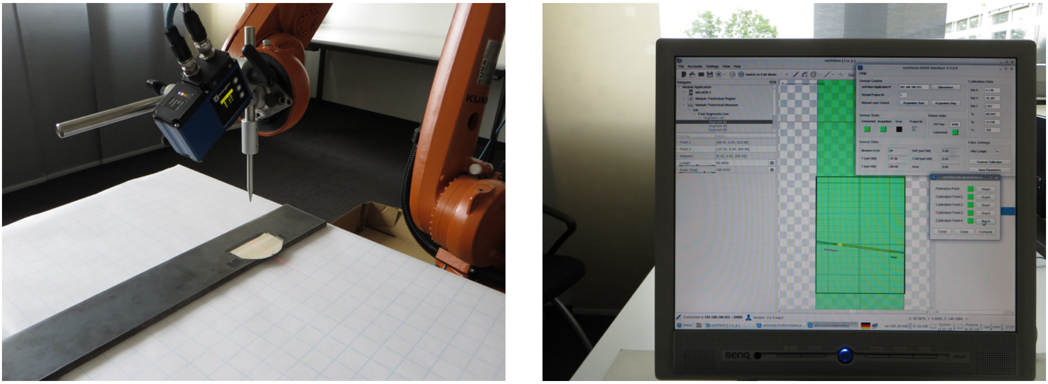


Fig. 23: Calibration point P4, correspondent screenshot (on the right)

8. After teaching the Points Pref, P1, P2, P3 and P4 in the robot calibration program, press the button “cali-brate scanner” in the uniVisionKukaInterface. This will open the calibration window.

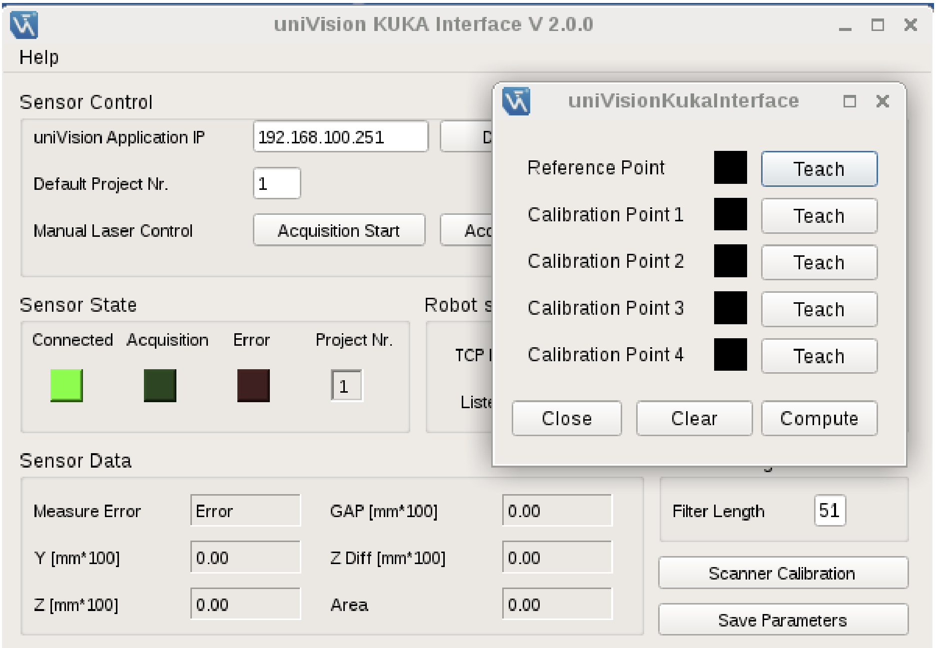


Fig. 24:Calibration window

9. Run the calibration program from robot controller. The robot at first will build a connection to the uniVisionKukaInterface and switch on the laser in the 2D/3D Profile Sensor. Then the robot will travel to the positions Pref, P1, P2, P3 and P4. Each time the robot reaches a saved point, click on teach button related to each point in the calibration window in uniVisionKukaInterface (see Fig. 19 ... Fig. 23).

10. After teaching all points in the calibration window in uniVisionKukaInterface click on „Compute" to compute the calibration parameters. A new window will pop up showing the accuracy of the computed calibration data.

NOTE!
The accuracy should be near zero (like 0.3...0.5 mm).

11. Close the calibration window and click on „Save Parameters" button, see section 5.2.5.

6. Troubleshooting

6.1 The robot is not able to track the seam

Possible reasons:

- The uniVision project is not able to detect the seam.
- The welding direction is in Z axis base coordinate system.

Solutions:

- Make sure, that the uniVision project is able to detect correctly the seam to be tracked.
- Change the base coordinate system in the robot controller so that the welding direction is defined in X-Y plane base coordinate system (see Fig. 17).

NOTE!
The uniVisionKukaInterface supports only seam tracking in X-Y plane base coordinate system.

6.2 The KUKA robot shows SeamLost error

In this case the uniVisionKukaInterface has failed to compute the robot correction at current position where the robot tool is located.

Possible reasons:

- High degree of noise during welding
- The sensor went over a joint point

Solutions:

- In case of high degree of noise: Please use a 2D/3D Profile Sensor with a higher laser power (e.g. MLSL143) and use a shorter exposure time value.
- In case of the sensor moving over a joint point: Make sure that the uniVision project is able to detect and ignore the joint points (like using the statistics module or the dynamic coordinate system module, ask your uniVision support team to learn more about this topic).

NOTE!
Always remember that string#1 in TCP device module should be linked to a value that describes if the detected seam is valid.

Once the uniVision project is configured to detect and ignore the joint points, go to the config.ini file located in /opt/WenglorMEL.com-KukaInterface/bin and change the value of the variable SeamLostLimit (mm). Default value is 2.0 mm, meaning the uniVisionKukaInterface will send SeamLost error to the robot if it cannot find a valid seam for 2 mm.

6.3 Activating the Debug Ouput Log

The debug output log saves the communication between the robot controller and the uniVision application.
The debug output log helps the support team understanding the issue and find an appropriate solution.
To activate the debug output log go to the config.ini file located in /opt/WenglorMEL.com-KukaInterface/bin and change the value of the variable DebugLog to 1 (default is 0).
The robot interface will create a new file DebugLog.txt.
After doing the tests, disconnect the robot controller from the robot interface, copy the file and send it to your support team for further analysis.

NOTE!
Please deactivate the debug output log at the end of the test.