User Guide

KINOVAFSWare development kit
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Overview

The KINOVA® Software Development Kit is a complete set of interface, documentation, examples and software tools that help the developer interact with the KINOVA® Gen2 Ultra lightweight robot. It is available under Ubuntu (14.04 and 16.04) and Windows (7, 8.1, and 10) systems.

Contents of SDK

- Development Center application
- Torque Console application
- A set of project examples
- User guide
- HTML documentation on all APIs
- Tools to configure your product
Installation

Windows 7 / 8.1 / 10

New Windows Installation

If you have any Kinova products already installed on your computer, please refer to the “Update from existing Windows installation” section. If it is your first installation of a Kinova product, follow the procedure below. The files needed for the installation are contained in the SDK package.

1. Install the Microsoft Visual C++ Redistributable(x86) named vc_redist_x86.exe
2. Execute the Kinova USB driver installer named Kinova-Jaco-Usb-Device-(usbLib)-Installer.exe
   This will install the Kinova USB driver to allow the computer to communicate with the robot over USB.
3. Execute the SDK installer named SDK_GEN2_1_5_1_x86.exe
   This will install the SDK and related software tools.
4. Connect the robot to your computer via USB.
5. Power on the robot.
6. In the Windows Control Panel, open the device manager and confirm that the computer detects the robot as a Universal Serial Bus device.

You will now be able to use the computer to communicate with and control the robot via the API and use the Development Center and Torque Console development tools.
Update from existing Windows installation

This section explains how to install the SDK if you have any Kinova products already installed on your computer. This is advised because the SDK uses a new driver which is different from the driver used in previous versions of the SDK and from the driver used by previous Kinova software products such as Jacosoft.

Note that it is possible to have different driver versions on different USB ports. As an example, you could install the previous USB driver on USB port A and when the robot is connected to that port, Jacosoft is available. At the same time, you could install the new driver on USB port B and when your robot is connected to that port, the new Development Center is available.

The procedure below explains how to completely uninstall a driver before installing the new SDK.

1. Connect the robot to your computer via USB.
2. Power on the robot.
3. In Windows Control Panel, open the Device Manager and look for a Universal Serial Bus Device called Jaco Robotical Arm.
4. Right click on it and choose Uninstall Device
5. Check the option Delete the driver software for this device and click OK.
6. Stay in the device manager and right click on your computer. Choose Scan for hardware changes.
7. From here, you can follow the procedure in the section “New Windows Installation.”
Ubuntu 14.04/16.04 installation

1. Using sudo, execute the bash script named `installSDK32.sh` if your computer’s architecture is 32 bits or `installSDK64.sh` if your computer's architecture is 64 bits.
2. The script will ask for root permission to install a package named kinova-api.
3. The Kinova SDK Installer Setup window will appear to install the remainder of the Development Center.
4. Choose an installation folder (default: /opt/JACO-SDK)

5. Choose which components you need to install.

6. Click on the next button until the installation is completed.
7. The Development Center is now installed. To launch the Development Center, execute [installation folder]/GUI/DevelopmentCenter.sh
Development Center

Overview

The Development Center application is a tool provided with the Software development kit which allows for several useful functionalities:

- Configuring retract positions for the robot
- Updating robot firmware
- Configuring robot Ethernet communications
- Advanced robot control settings
- Monitoring of robot status
- Control of robot via virtual joysticks
- Trajectory planning
- Access to support resources
- Code examples

The Development Center UI is divided into sections:

- Settings and Configuration
  - General Settings
  - Advanced Settings
- Tools
  - Monitoring
  - Virtual Joystick
  - Trajectory Planner
- Resources
  - ROS
  - Support
  - Documentation
- Examples

The sections that follow give an overview of the main pages of the Development Center.
General settings

Settings tab

1. **Advanced HOME / RETRACTED position**

   - **Activate**: Check to enable the advanced HOME / RETRACTED feature.

   - **List of positions**: Contains the list of positions (angular or Cartesian) that represents the new path that the robot will follow between the HOME and the RETRACTED position.

   - **Add**: Click to add the current robot's position at the end of the positions list.

   - **Remove**: Click to remove the selected position from the position list.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insert below</td>
<td>Click to add the current robot's position below the selected position in the positions list.</td>
</tr>
<tr>
<td>Insert above</td>
<td>Click to add the current robot's position above the selected position in the positions list.</td>
</tr>
<tr>
<td>Clear all</td>
<td>Click to clear the entire positions list.</td>
</tr>
</tbody>
</table>

2. Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retracted angle</td>
<td>The angle of the default RETRACTED position shown by the image aside.</td>
</tr>
<tr>
<td>Handedness</td>
<td>Select the radio button to set the robot in right handed mode or in left handed mode.</td>
</tr>
<tr>
<td>Invert fingers</td>
<td>Check to invert the closing finger when a 3 fingers robot is closing only 2 fingers. This mode is mainly used with a left handed configuration.</td>
</tr>
<tr>
<td>Control mode</td>
<td>Displays the current control mode. It can be either Angular or Cartesian.</td>
</tr>
<tr>
<td>Switch button</td>
<td>Select to toggle between the Angular control mode and the Cartesian control mode. Note that if the robot's position cannot switch to Cartesian mode because of a singularity, the robot will stay in Angular mode.</td>
</tr>
<tr>
<td>Velocity</td>
<td>Select the maximum Cartesian velocity of the robot.</td>
</tr>
</tbody>
</table>
Activate offset

Check to apply a position offset on the end effector. The offset is described by the text fields X, Y and Z.

Save

Press to send the modification to the robot. If you perform a modification in the Option panel nothing will be applied unless the save button is pressed. The exception is the velocity which is applied directly when modified.

Update tab

Firmware update

Displays the complete path to the .hex file that will be uploaded to the robot when the button update is pressed.
Browse  Press to choose a HEX file on your disk that contains a firmware update.

Update  Press to update your robot with the chosen HEX file.

Restore factory settings  Restore the robot with its factory settings.

## Versions

- **Main firmware**  Displays the main firmware’s code version.
- **Arm type**  Displays the model of the connected robot.
- **Actuator X**  Displays the code’s version of the actuator X where X is a number greater than 0.
- **Finger X**  Displays the code’s version of the finger X where X is a number greater than 0.

## Ethernet tab

### Ethernet Default Configuration

The KINOVA® Gen2 Ultra lightweight robot ships with a default Ethernet configuration. In other words, the robot already has a default IP address, subnet mask, port number and MAC address. These default parameters can be seen in the Development Center’s General settings > Ethernet window with any given connected arm provided it supports Ethernet.

For a quick and easy setup, we advise not to change these default parameters and to adapt your IP address to the arm’s pre-configured Ethernet settings. The easiest way to achieve this is to use a separate Ethernet network card that will be dedicated to communicating with the robot. A USB to Ethernet adapter can also be used.

The only requirement for the user is to set a static IPv4 address and a subnet mask for the dedicated network card (or adapter). This can be done by changing the adapter settings in the Network and sharing center.
Keep in mind that it is important for the user's static IP address to have the same subnet as the robot (we advise to use a subnet mask of 255.255.255.0). You do not need to set a default gateway. Below is an example.

If the user wishes to modify his PC's dedicated static IP address and/or subnet mask to one of his choosing, the robot's Ethernet settings will need to be configured accordingly. What follows is a step by step guide to modifying the Ethernet parameters (user's PC and robot) to parameters different from the default configuration.
Ethernet Setup on PC

The following steps describe how to set up a static IP address on your computer. This IP address will then be used to communicate with the robot.

1. Navigate to **Control Panel > Network and Sharing Center**.

2. Click on **Change adapter settings** situated in the left column.
3. Right click on the desired connection and click on **Properties** from the drop down menu.

4. Select **Internet Protocol Version 4 (TCP/IPv4)** and click on **Properties**.
5. Select **Use the following IP address** and fill out the pertinent information.
   a. The IP address should be the IP address you want to use to communicate with the robot. Make sure it is not already in use.
   b. The Subnet mask must be 255.255.255.0
   c. You don’t need to set a Default gateway.

6. Click on **OK** and close the Control Panel. You have now set up a static IP address that will be used to communicate with the robot.
Ethernet Setup

The following steps describe how to set up the Ethernet configuration for the robot.

1. Make sure the robot is connected via USB and Ethernet cable simultaneously (this is required only for the first set-up).
2. Launch the Development Center.
3. Once the Development Center establishes a connection via the USB (serial number should appear next to the USB Enable tab), click on the serial number, click on General settings under the SETTINGS & CONFIGURATION tab and then click on Ethernet.
4. Under the Robot Ethernet Configuration tab, fill out the required information (IP address, Subnet Mask, Port #, Gateway and MAC)
   a. The IP address should have the same subnet as your PC’s static IP address.
   b. The subnet mask must be 255.255.255.0
   c. The port number can be any given port number (as long as it’s not already in use).
   d. The Gateway must be 0.0.0.0
   e. The MAC address should be the one that has been provided.
5. Under the **SDK Application Ethernet Setting** tab, fill out the required information (IP address, Command Port #, Discover Port #, Robot Port #)

   a. The IP address should be the connection with the static IP address you have configured on your PC.
   b. The Command Port number and Discover Port number can be any given port number (as long as it isn’t already in use).
   c. The Robot Port # must be the same as the Port # from the Robot Ethernet Configuration.

6. Once all the information is filled out, first click on **Apply** and then on **Update**. Close the Development Center and reboot your robot.

7. Open the Development Center once again. Once the robot’s serial number appears on the top right corner, click on **Ethernet enable**. At this point, the serial number will have disappeared from the top right corner and the Development Center will try and establish the connection via Ethernet.

8. Once the serial number appears once more in the top right corner, this signifies that an Ethernet connection has been established.

9. You can now unplug the USB cable from the robot and control it via Ethernet. All subsequent connections to the robot via the Development Center can be done directly with the Ethernet cable.
## Advanced settings

### PID (Proportional, Integral and derivative)

**P**

The proportional part of the controller. (Suggested range $[0, 2]$)
I

The integral part of the controller.

D

The derivative part of the Controller. (Suggested range [0, 0.1])

Command filter

Filters the commands sent to the actuator. The filter is of first order and the parameter value is a frequency in rad/s. The suggested range is [0, 500].

Derivative filter

Filters the error derivative signal (derivative of (desired position - measured position)). The filter is of first order and the parameter value is a frequency in rad/s. The suggested range is [0, 500].

Error filter

Filters the error signal (desired position - measured position). The filter is of first order and the parameter value is a frequency in rad/s. The suggested range is [0, 500].

Address

The address of the actuator to modify.

⚠️ Setting these parameters out of the suggested range can severely damage the robot and is not covered by the warranty.

2 Zero position

Address

The address of the actuator to modify.

Apply

Apply the zero position. The actual position of the targeted actuator will now be 180°.

Apply to all

Apply the zero position to every actuator of the robot.
Setting these parameters incorrectly can severely damage the robot and is not covered by the warranty.

3 Address

Current
The current address of the actuator.

New
The new address to assign.

Apply
Apply the new address on the actuator.

Setting these parameters incorrectly can severely damage the robot and is not covered by the warranty.

4 Torque zero

Address
The address of the actuator on which the torque zero will be applied.

Apply
Apply the torque zero. The actual torque of the targeted actuator will now be considered as 0

Apply to all
Apply the zero torque on every actuator of the robot.

Setting these parameters incorrectly can severely damage the robot and is not covered by the warranty.
Reference frame

**Fixed frame**
Set the robot to fixed frame. When a translation is performed, the orientation stays the same.

**Rotating frame**
Set to rotating. When a translation is performed, the orientation follows the first actuator (rotation in the XY plane).

Reactive force control

**Activated**
Select to activate the reactive force control (admittance mode).

**Not activated**
Select to deactivate the reactive force control (admittance mode).

Current limitation

**Activated**
Select it to activate the current limitation.

**Not activated**
Select it to deactivate the current limitation.

⚠️ Setting these parameters incorrectly can severely damage the robot and is not covered by the warranty.
Monitoring

General tab

1. System
   - Displays general information stored in the robot.

2. Peripheral list
   - Lists all peripherals detected on the robot's communication bus. Each peripheral can be expanded to display its type, address, port and code version.
Angular tab

<table>
<thead>
<tr>
<th>Actuator</th>
<th>Current (A)</th>
<th>Torque (N·m)</th>
<th>Command (°)</th>
<th>Position (°)</th>
<th>Temp (°C)</th>
<th>Velocity (°/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>2</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>3</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>5</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>6</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>7</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Finger 1</td>
<td>0.000</td>
<td>N/A</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>0.000</td>
<td>N/A</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>0.000</td>
<td>N/A</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Angular tab displays all the information on every actuator. It includes the current, torque, command, position, encoder value, temperature, velocity, acceleration along the X axis, acceleration along the Y axis, and acceleration along the Z axis.
## Cartesian tab

Displays all the information on the end effector’s motion. It includes the force (gravity free), Cartesian command, Cartesian position and Cartesian velocity. Note that the Command’s X, Y and Z fields and Position’s X, Y and Z fields are expressed in the base reference frame. The Command’s Theta X, Theta Y and Theta Z fields and Position’s Theta X, Theta Y and Theta Z are Euler angles (XYZ convention) with respect to the base reference frame. The Velocity’s X, Y and Z fields represent the end effector’s translation velocities in the base reference frame. The Velocity’s Theta X, Theta Y and Theta Z fields represent the end effector’s rotation velocities in the effector reference frame.
Virtual joystick

Angular tab

1. Angular control

   Actuator X +  Press and hold to move the actuator X counter clockwise where X is a number greater than 0.

   Actuator X -  Press and hold to move the actuator X clockwise where X is a number greater than 0.
2 Gripper

Open 3 fingers Press and hold to open the gripper’s three fingers (only available on the 3 finger gripper)

Close 3 fingers Press and hold to close the gripper’s three fingers (only available on the 3-finger gripper)

Open 2 fingers Press and hold to open the gripper’s thumb and index fingers.

Close 2 fingers Press and hold to close the gripper’s thumb and index fingers.

3 Angular velocity

Text field Set the velocity of a specific actuator.

Save Send the new velocity configuration to the robot.
Cartesian tab

**Virtual Joystick**

1. **Translation**
   - **Button +** Press and hold to move the end effector along the positive axis described by the button.
   - **Button -** Press and hold to move the end effector along the negative axis described by the button.

2. **Orientation**
   - **Button +** Press and hold to move the end effector counter clockwise around the axis described by the button.
Button - Press and hold to move the end effector clockwise around the axis described by the button.

3 Gripper

Open 3 fingers Press and hold to open the gripper’s three fingers (only available on the 3-finger gripper).

Close 3 fingers Press and hold to close the gripper’s three fingers (only available on the 3-finger gripper).

Open 2 fingers Press and hold to open the gripper’s thumb and index fingers.

Close 2 fingers Press and hold to close the gripper’s thumb and index fingers.

4 Cartesian velocity

Translation velocity Set the translation velocity of the end effector.

Orientation velocity Set the orientation velocity of the end effector.
Keyboard tab

1. Control (Angular or Cartesian)
   
   **Combo box**  
   Select a key that will be mapped with the specified movement. Note that this panel can be changed by pressing the angular or Cartesian button.

2. Gripper
   
   **Combo box**  
   Select a key that will be mapped with the specified gripper movement.
### Others

**Move HOME**  Select a key that will be mapped with the Move HOME functionality.

**Activate keyboard**  Check to activate the keyboard control with the robot. Note that the robot’s joystick will always have a higher control priority than the keyboard.

**Cartesian**  Press to switch the control panel to Cartesian.

**Angular**  Press to switch the control panel to Angular.

### Trajectory Planner

**Trajectory tab**

![Trajectory Planner](image-url)

- **Position**
  - Actuator 1: 0 deg
  - Actuator 2: 0 deg
  - Actuator 3: 0 deg
  - Actuator 4: 0 deg
  - Actuator 5: 0 deg
  - Actuator 6: 0 deg
  - Actuator 7: 0 deg
  - Finger 1: 0
  - Finger 2: 0
  - Finger 3: 0

- **Options**
  - Control mode: Angular
  - Enable limitations
  - Enable fingers
  - Delay (sec): 0

- **Trajectory**
  - Import
  - Export

- **Add**
  - Update
  - Reach
  - Clear all

- **Launch**
  - STOP
  - LAUNCH
Position (Angular or Cartesian)

Left section  Displays the current position or the position of a selected trajectory point.

Right section  Displays the max velocity of the robot for the selected trajectory point.

Trajectory

Import  Press to import a trajectory. The trajectory can be saved in a KTJ file on disk.

Export  Press to export a trajectory on disk in a KTJ file.

Position list  Displays the list of positions contained in the trajectory. Each point can be selected and their data will be displayed on the position panel.

Get  Press to display the current robot’s position on the position panel.

Add  Press to add a point in the list based on the information on the position panel.

Quick add  Press to execute a combination of a Get and Add.

Update  Press to update the selected point in the list with the information from the position panel.

Reach  Press to move the robot to the selected point in the list.
<table>
<thead>
<tr>
<th>Action</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delete</td>
<td>Press to delete the selected point in the list.</td>
</tr>
<tr>
<td>Clear all</td>
<td>Press to clear all the positions in the list.</td>
</tr>
<tr>
<td>Stop</td>
<td>Press to stop the robot’s movement. It will also cancel any trajectory loops.</td>
</tr>
<tr>
<td>Launch</td>
<td>Press to execute the trajectory. If the Loop Trajectory check box is checked, the robot will repeat the trajectory until the stop button is pressed.</td>
</tr>
<tr>
<td>Options</td>
<td></td>
</tr>
<tr>
<td>Control mode</td>
<td>Toggle to switch between Cartesian and Angular trajectory control.</td>
</tr>
<tr>
<td>Enable limits</td>
<td>Check to enable maximum velocities limitations.</td>
</tr>
<tr>
<td>Enable finger</td>
<td>Check to enable finger motion during trajectory (note: even if the fingers are enabled, they will not move if they weren’t initialized. Fingers are initialized by opening them at their maximum range once).</td>
</tr>
<tr>
<td>Loop trajectory</td>
<td>Check to execute trajectory in a loop once the Launch button is pressed</td>
</tr>
<tr>
<td>Delay</td>
<td>Adds a delay before the robot starts moving to a given trajectory point.</td>
</tr>
</tbody>
</table>
Resources

These are shortcuts to support elements found on Kinova’s website.

Examples

Source tab

Code Displays the code that reflects the example.
**Console tab**

The Console tab displays the output of the example’s execution in a console-like window.

**Console**

**Output**
Displays the output of the example’s execution in a console-like window.
Switch Torque and Trajectory

**Switch Torque Control**

Click to switch to direct torque control. When the robot is in torque control mode, you will be able to move it by hand with very little resistance. The robot also becomes unresponsive to joystick commands. Note that the robot might 'refuse' the switch to torque control. This means that the measured torques and the computed gravity torques are too different. Insure that the torque sensors are well calibrated (do a zero
torque if needed), that the payload (when required) is appropriate, that the gravity vector is appropriate and that nothing is touching the robot. Generally, the robot’s Home position is a good position to switch the control to torque mode.

- **Switch Trajectory Control**
  
  Click to switch to kinematics (position) control. When the robot is in kinematics control mode, you are not able to move it by hand and it is reactive to joystick inputs. Note that the robot should always be able to switch from torque mode to trajectory mode (it can have more trouble switching from trajectory mode to torque mode for the reasons given above). Also note that when the robot is switched from torque mode to trajectory mode, it automatically falls in Angular Kinematics control.

- **Safety factor**
  
  Slide the value from 0 (maximum safety: the robot switches from torque mode to trajectory mode as soon as the actuators’ velocity is above a very low threshold) to 1 (minimal/no safety: the robot never switches)

  Do not set Safety Factor to 1 unless you are sure the robot is in a collision-free environment. Ideally, validate the torques readings and the gravity-free torques before setting Safety Factor to 1, or else the robot could start moving very fast without being stopped.

- **Vibration controller**
  
  Slide the value from 0 (no vibration controller) to 1 (maximum vibration controller). When vibration controller is activated, you should feel the vibration damped.

- **Actuator damping**
### Actuator damping
Slide the value from 0 (no damping) to 2 (max damping). When the damping is activated, you should feel more resistance moving the robot.

### Gravity

**Gravity vector**
Enter the gravity vector orientation with respect to Kinova robot's base reference frame.

### Payload

**m**
Enter the payload's mass

**rx, ry, rz**
Enter the payload's center of mass with respect to Kinova robot's effector reference frame.

### Torque command

**Actuator X**
Specify a direct torque command on actuator X, where X is a number greater than 0. This command will be executed in torque mode as long as the button SEND (Hold) is held.

**SEND (Hold)**
Hold this button to send a direct torque command

### Force command

**X, Y, Z**
Specify a force command to be applied at the end-effector. The force direction follows the base reference frame X, Y and Z axes direction. The force command will be executed in torque mode as long as the button SEND (Hold) is held.

**RX, RY, RZ**
Specify a torque command to be applied at the end-effector. The three torques are expressed with respect to the effector
reference frame. The torque command will be executed in torque mode as long as the button SEND (Hold) is held.

**SEND (Hold)** Hold this button to send a direct force command
Contacting Support

If you need help or have any questions about this product, this guide, or the information detailed in it, please contact a Kinova representative through the Kinova website support page at:

kinovarobotics.com/support

We value your comments!

To help us assist you more effectively with problem reports, the following information is required when contacting Kinova or your distributor support:

- Product serial number
- Date/Time of the problem
- Environment where the problem occurred (per example 30° Celsius, raining, ...)
- Actions performed immediately before the problem occurred
There is no need too small.
No task too great.

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