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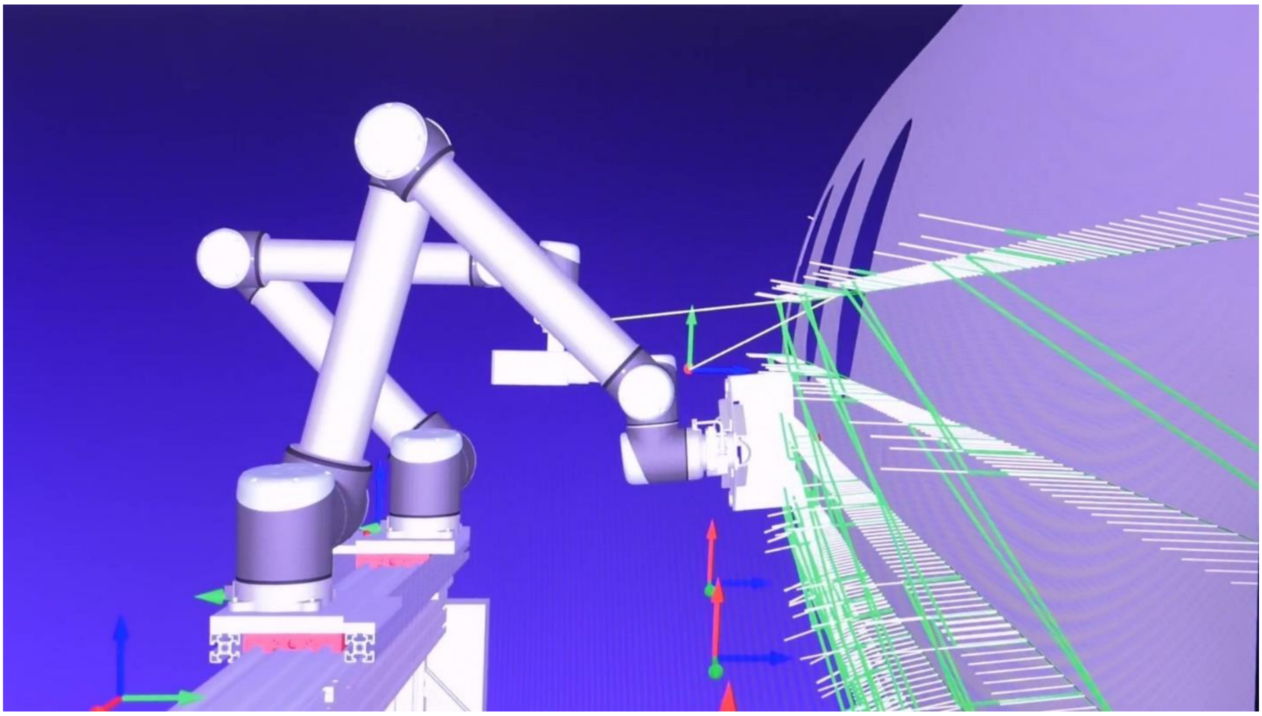
Instruction Manual for Student Lab Exercise:



Simulation of an Industrial Robot

General Notes:

- *The experiment lasts 90 minutes.*
- *Further reworking is not planned in this experiment, so a very thorough preparation is expected!*

Table of contents

You should have these files for this lab, uploaded on the E-learning:

- **This manual.**
- **“201026_EN_v1_R_Versuchsbeschreibung, Robotik_Kuka_corona.pdf“ document.**
- **“KSS_83_END_en.pdf “document.**
- **“Simulation of the kuka robot” video.**
- **“Gripper.robot” file.**
- **“Table.sld” file.**
- **“Robot-base.sld” file.**
- **“Slider.sld” file.**
- **“Left-plate.sld” file.**
- **“Right-plate.sld” file.**
- **“Part.sld” file.**

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1. Preparation:

Designing and testing a robotic cell can be a time consuming and costly process. This can make it hard for beginners to get started in the field of robotics, and it can even slow down the development process for an experienced roboticist.

Therefore, it is important to learn a simulation software, so you can thoroughly test your designs before you commit any resources.

- How NASA Uses RoboDK For Multi-Robot Inspection: https://robodk.com/blog/multi-robot-inspection/

You will need some basic background about the robotics terms used, e. g. If you don't know the term "TCP", please check Appendix 1.

The purpose of this lab is to learn:

- How to simulate basic operations of an industrial robot in a robotics simulation software (RoboDK), and
- How to transfer the simulation into the real world by running it on a KUKA industrial robot.

Watch the following video to fully understand the task.

    - Simulation of the kuka robot video.

2. Download and initialize of RoboDK:

Please watch this Video:

https://youtu.be/xZ2_JEbS_E0

After you have watched the video, you should be able to download RoboDK and get familiar with it.

3. Setup the workspace:

Please watch these videos:

https://youtu.be/uxlfxglE2YE

https://youtu.be/gNgCwwpZrWE

After you have watched these videos, you should be able to follow these steps:

- Create a new station.
- Upload the “Table.sld” part and define a reference frame for it, see Figure 2.
- Make a new frame and name it “corner”, then place it on the corner of the table.
- Upload the “Robot-base.sld” part and define a reference frame for it.
- Download the kuka robot (brand: kuka, name: KUKA KR 10 R900 sixx, type: 6 DOF, payload: 10 kg) from the online library.
- Change the kuka base frame to the table frame, and position it.
- Load the “Gripper.robot” file.
- Attach the gripper to the robot flange and delete the gripper frame.
- Add tool (TCP) and position it.
  - Tool center point with respect to the robot flange:
  - X: 00.00 mm, Y: 00.00 mm, Z: 288.00 mm, ROTX: 43.00 deg, ROTY: 00.00 deg, ROTZ: 00.00 deg

- Load all objects with the right frame as in Figure 2 and position it by double-clicking on it. Change the reference frame to corner frame ”Figure 1”, then change the dimensions according to Table 1.

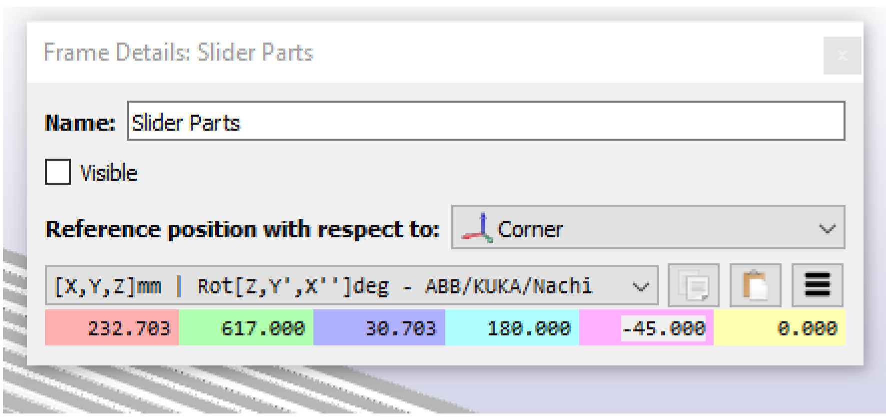

Figure 1: Frame details window used to change the distance of an object with respect to a reference frame.

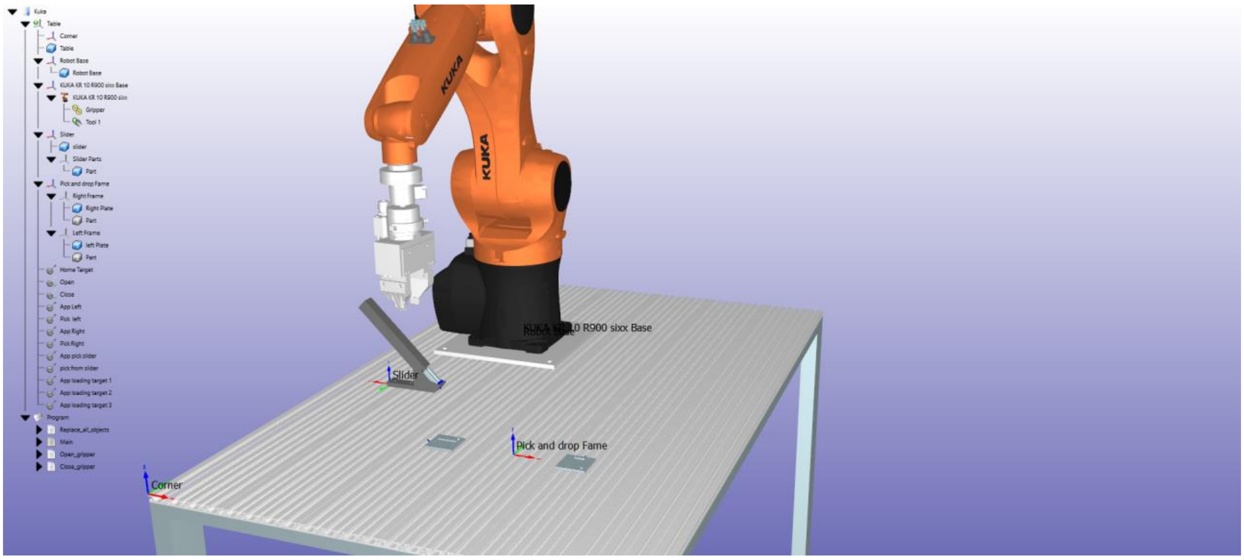

Figure 2: How your workspace should look like.

Part Name:	Translation in (mm):			Rotation around (deg):		
	X – axis	Y – axis	Z –axis	X – axis	Y –axis	Z – axis
Robot Base	280.0	990.0	0.0	0.0	0.000	-90.0
Kuka Robot	280.0	990.0	10.0	0.0	0.0	0.0
Tool	0.0	0.0	148.0	0.0	0.0	0.0
Slider Frame	125.0	617.0	0.0	180.0	0.0	180.0
Slider	125.0	617.0	0.0	0.0	0.0	180.0
Slider parts Frame	232.7	617.0	30.7	180.0	-45.0	0.0
Pick and drop Fame	550.0	370.0	0.0	0.0	0.0	0.0
Right Frame	680.0	370.0	0.0	-90.0	0.0	0.0
Right plate	680.0	370.0	0.0	0.0	0.0	-90.0
Left Frame	400.0	370.0	0.0	0.0	0.0	0.0
Left Plate	400.0	370.0	0.0	0.0	0.0	0.0

Table 1: Dimensions needed to build the workspace.

After you have finished, it is very important to make a program that saves the objects positions. This enables you to return everything to its original place, you just run this program.

Please follow these steps:

- Right-click on the station bar and choose: Add folder.
- Name the folder as "Programs".
- Select Add program.

Figure 3: Add program icon.

- Name the program "Replace_all_objects"
- Right click on the program, and then click on: Add instruction -> Simulation event instruction.
- From the dropdown menu choose: set object position (relative).
- Select all objects (CTRL + a).
- Press ok.

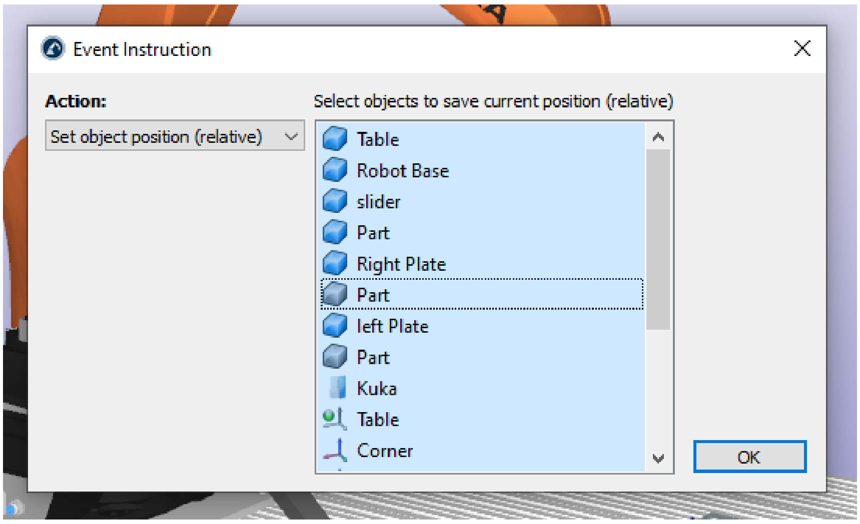

Figure 4: Event instruction window.

4. Create the Robot Targets:

Please watch these videos. You will learn how to move the robot and understand the concept of a "target":

https://youtu.be/ilmJSD-a9bs

https://youtu.be/ylKTq03-b_A

The example below shows how to create a target for picking a part from the slider.

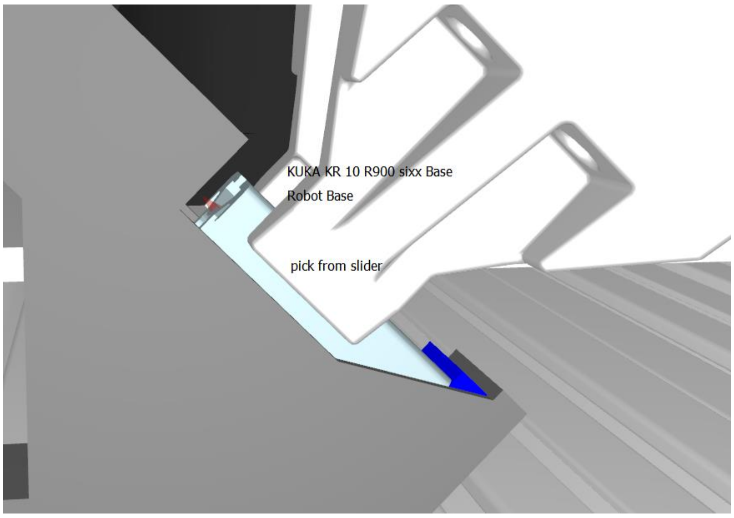

Figure 5: You should pick this part in this way.

- To match the TCP point with the part, do the following:

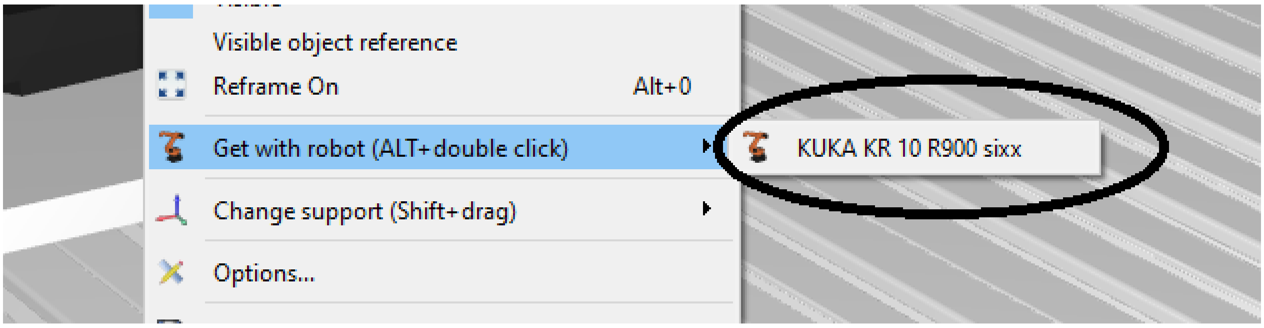

Figure 6: Illustration of where to click to match the TCP point with the part.

- As shown in the video, you can rotate the robot wrist to logically pick the part. (See Figure 7, step 1)
- Choose the frame: slider parts. (See Figure 7, step 2)

- Press "Align", and the program will precisely adjust the position for you. (See Figure 7, step 3)
- If the robot configuration is not suitable, you can change it (See the picture below, step 4).
  If you are familiar with robotics terms, you will be able to choose
  - (Lefty/Righty = Front/Rear on RoboDK)
  - (Elbow up / down)
  - (Flip / non-Flip)

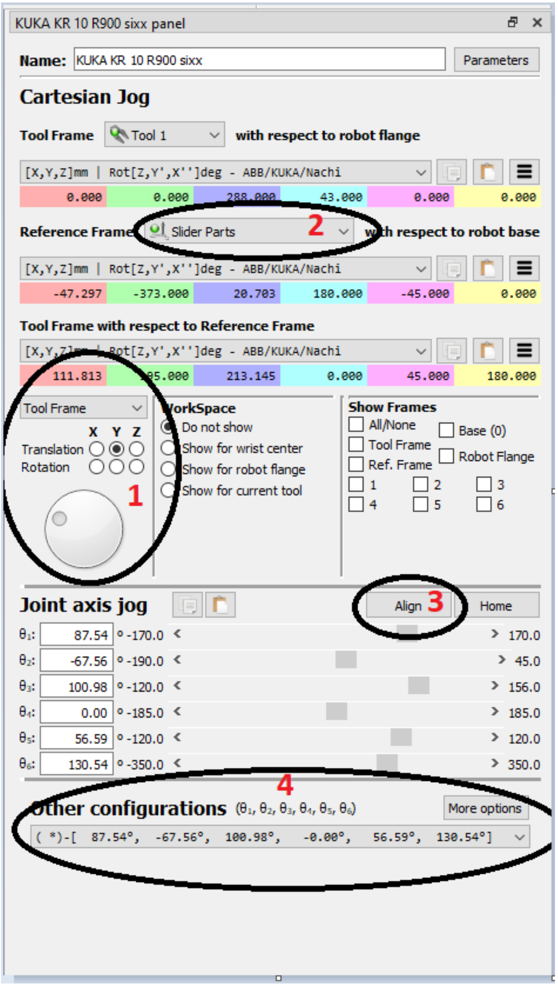

Figure 7: Panel window to move the robot.

- If you are not familiar with these terms, just try different configurations.

- After you have adjusted the robot configuration, make a new target (CTRL + t). Please read the RoboDK documentation (press F1) to learn the difference between a Joint target and a Cartesian target. For this lab, use Joint targets for gripper targets and Cartesian targets for all other targets.

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- For our task we should have the following targets:

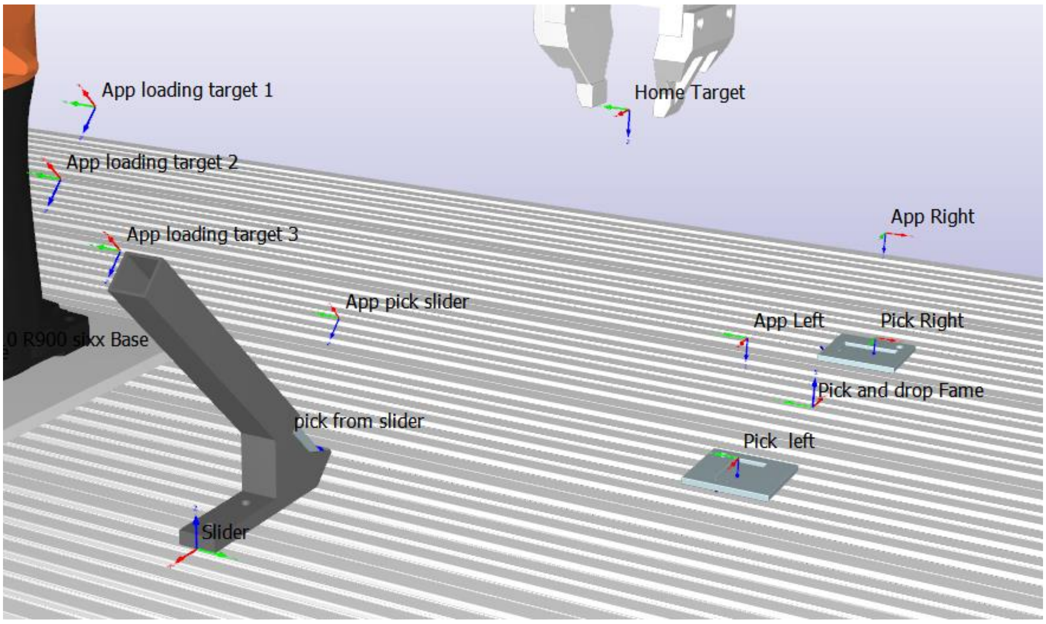

Figure 8: Target places.

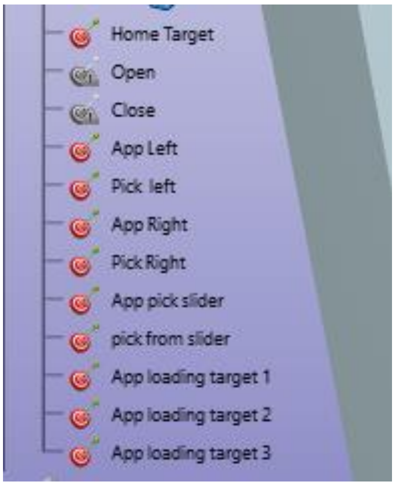

Figure 9: Target names in the station tree.

- For gripper:
    - A joint target to open the gripper.
    - A joint target to close the gripper.
- To do so, double-click on the gripper:

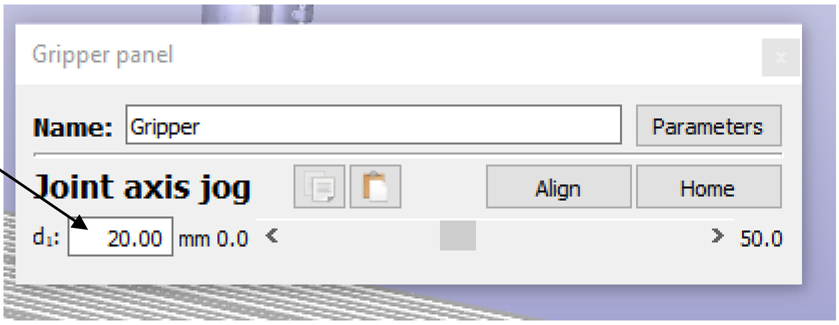

Figure 10: Where you can change the distance between the gripper's fingers.

- Create a Joint target, name it close_gripper, and link it to the gripper :

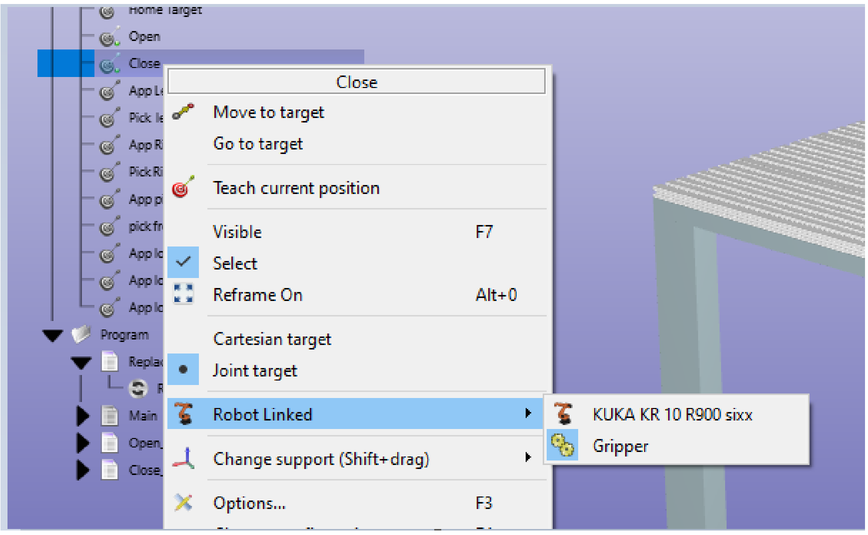

Figure 11: To link the joint targets to the gripper.

- Create the open_gripper target with higher d.
- Create two programs to open and close the gripper using joint movements to the close and open targets.
- Link the programs to the gripper.

5. Robot Program:

Please watch this video (only as an example):
https://youtu.be/38Yzhsom54E

- As shown in the simulation of the kuka robot video and the previous example, you should be able to create a single program using the previously created targets. The program should simulate the complete motion of the robot.
- **Tip**: To return the part to the original place call the program "Replace_all_objects" in your main program.
- Finally, Generate the robot program:

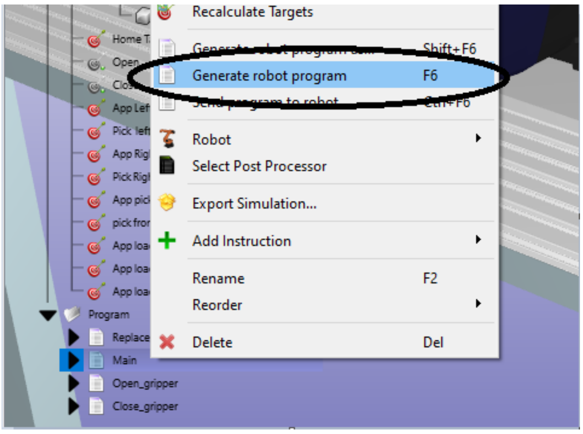

Figure 12: Generate robot program tool.

- **Optional**: Watch this video to learn more about pick-and-place application in RoboDK.
https://youtu.be/P0rEwpmAHq4

6. In the Lab:

You need to bring the following to the lab session:

- RoboDK model file and the generated program on a USB stick.
- Your laptop with RoboDK installed and a working simulation (steps 1-5 from above).

In the lab, the task is to port the application from the simulation to the real robot, and with a little adjustments using the teach pendant (smartPAD) you will be able to perform the task.

If you are interested to know more about the teach pendant, see manual" KSS_83_END_en.pdf / chapter 4.1".

Appendix 1:

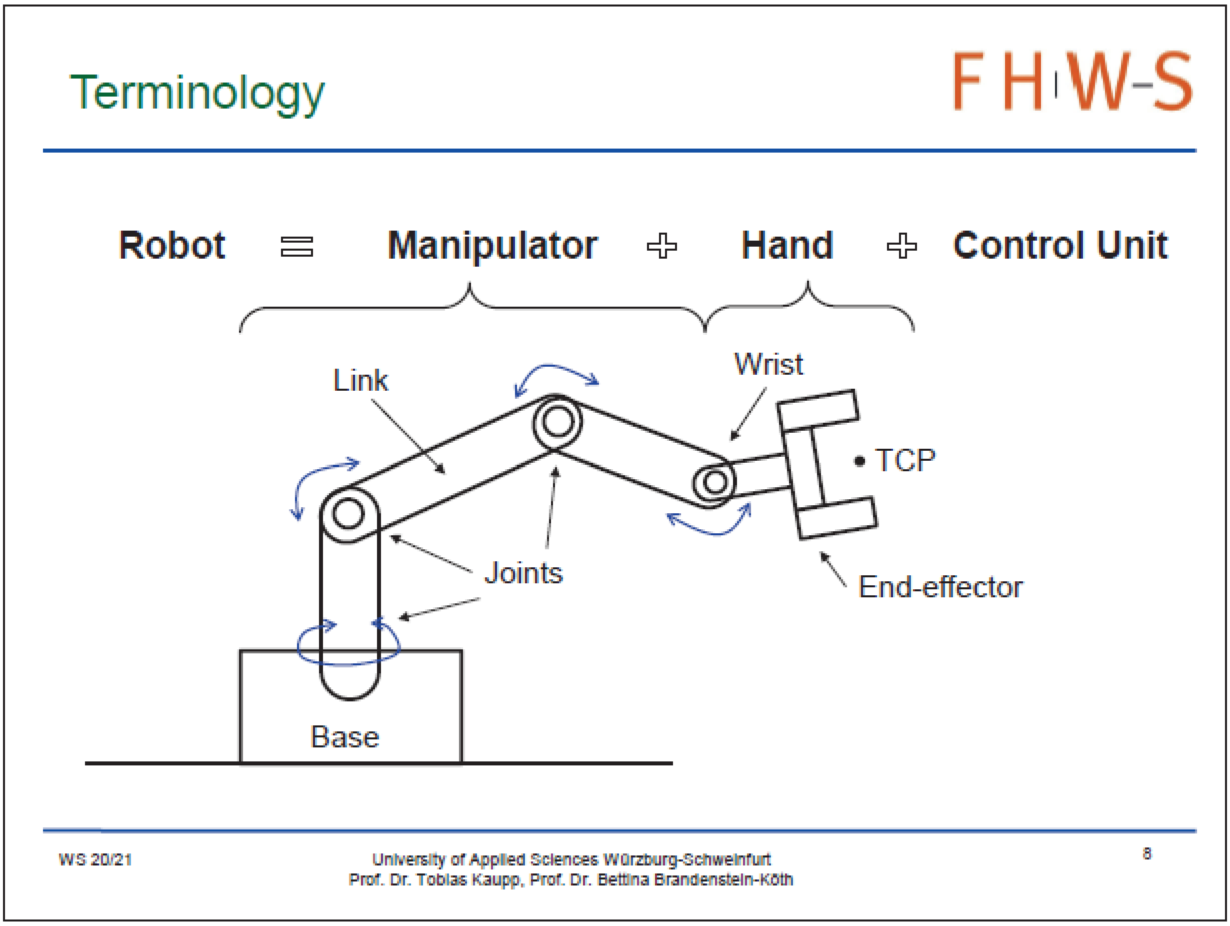

Figure 13: Terminology of an industrial robot.

If you need to know more, see manual “201026_EN_v1_R_Versuchsbeschreibung, Robotik_Kuka_corona.pdf/ chapter 3”.