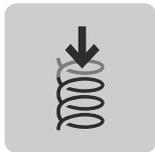


## Available Research Apps



'Repeat' allows you to repeatedly execute a sequence of Apps. Select the number of repetitions and the action to be carried out at the end of each cycle. You can choose from three actions: Wait: the system pauses for the set amount of time between each iteration. User: the system waits for the user to confirm with a haptic gesture from above before continuing Repeat: simply starts again from the beginning

### Repeat



'Set Cartesian Compliance' allows you to set the impedance of the Arm in all Cartesian axes. The axes to be set are defined by the settings in the transformation matrix of the flange to the end effector because impedance is defined in the coordinate system for the end effector. The lower a value for an axis, the higher the impedance of the arm in this axis. The values set here are maintained for all subsequent Apps.

### Set Cartesian Compliance



'Set Joint Compliance' allows you to set the impedance of the Arm on joint level. The stiffness for each joint can be defined here. The lower the value, the softer and more compliant the Arm is in the corresponding axis. The values set here are maintained for subsequent Apps and can negatively influence the behavior of Panda when following paths. They can, however, also be used to implement guiding of the Arm within the environment.

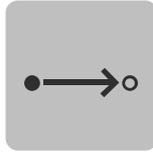
### Set Joint Compliance



'Set Collision Thresholds' allows you to define collision thresholds. Because Panda is equipped with an external force and torque estimation based on internal sensors, the Arm can stop its current activity when exceeding a certain force or torque limit. The limits should always be chosen with regard to the Task to be carried out. The values set are valid for all subsequent Apps. In a first step the App allows you to set the force limits. For each Cartesian direction, an individual limit can be defined. This facilitates exact adaptation of the limits to the specific Task. In the next step the torque limits for each joint can be set. If a defined torque or force limit is exceeded, the current action is interrupted and can be continued with after rectifying the error.

### Set Collision Thresholds

## Cartesian Motion



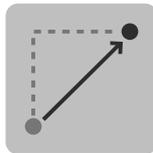
'Cartesian Motion' lets the Arm move in the Cartesian space within the points taught by the user. The Arm moves on a straight line between two points, the actual points are only struck and do not need to be reached. For execution of this App, the impedance values set under a 'Joint Compliance' App are used. The first step of the configuration is teaching the points between which the Arm should move. Then the speed and acceleration for the movement are defined and set in percent of the maximum speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed.

## Joint Motion

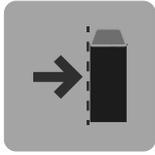


'Joint Motion' allows the Arm to move in the joint space between the points taught by the user. Panda moves all joints synchronized to reach the next point. For execution of this App, the impedance values set in a 'Joint Compliance' app are used. The first step of the configuration is to teach the desired points. Then the speed and acceleration for the movement are defined and set in percent of the maximum speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed.

## Relative Motion



The App "Relative Motion" moves the Arm relative to its current position along a configured vector. The motion is in Cartesian space similar to the App "Cartesian Motion". The motion can be configured to be executed in the end-effector frame or in the coordinate system of the base.



'Move Contact' allows the tracing of a taught sequence of points within the Cartesian space. The difference to 'Cartesian Motion' is the different reaction to collision within a strictly defined area. The app offers the additional possibility of recognizing a contact within a strictly defined area as having reached the target position. This can be used for implementing stacking for example. For execution of this App, the impedance values set in a 'Joint Compliance' App are used. The first step of the configuration is to teach the trajectory and configure the speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed. In addition, the radius around the last point can be defined, in which contact will be considered as a successful end to the movement.

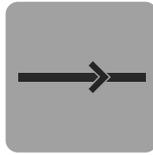
## Move Contact



'Apply Force' enables Panda to apply a defined force within a time frame set by the user. The force is applied in the current position of the Arm. Nonconfigured end effectors or other weights impeding the external force estimation of the Arm will also negatively influence the precision of the applied force. For execution of this App, the impedance values set in a 'Set Cartesian Compliance' App are used. The first step of the configuration is setting the desired time frame in which the force shall be applied. Then the desired forces are set for the different direction in the coordinate system of the end effector. Setting the force to 0 means that no force is applied. In addition, the maximum distance that the Arm may cover during execution of the App needs to be entered. For this purpose, different limits are defined for deviation in X, Y and Z, and an additional limit for the permissible change of orientation.

## Apply Force

## Line

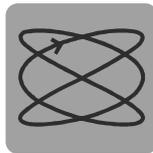


'Line' lets the Arm move with a defined speed along a line. The App also allows the application of force during a movement. For executing this App, the impedance values set in a 'Set Joint Compliance' app are used. Should the option 'Apply Force' have been selected, the values from the 'Set Cartesian Compliance' App are used.

Parametrization of the App is done as follows:

At first, two points are taught to define the direction the Arm shall follow. Then the time duration is set, for which Panda shall follow the line, and the speed with which it shall trace the line. In addition, the maximum distance for all Cartesian directions needs to be defined, for which the Arm is allowed to distance itself from the starting point. If the Arm is to apply force in addition to the movement, the force needs to be defined. This is done as described for the 'Apply Force' App.

## Lissajous Figures



'Lissajous Figures' allows Panda to trace different Lissajous figures. In addition, force can be applied during the movement. For executing this App, the impedance values set in a 'Set Joint Compliance' App are used. Should the option 'Apply Force' have been selected, the values from the 'Set Cartesian Compliance' App are used.

For parametrization, first the duration of the movement needs to be defined. Then the movement can be configured more precisely. For this purpose, the number of movements in both directions and the amplitude of them ovement in both directions is configured. Finally, the level on which the movement is to be executed is defined. If the Arm is to apply force in addition to the movement, the force needs to be defined. This is done as described for the 'Apply Force' App.

## Spiral



'Spiral' is used for executing a spiral mvement with the Arm. In addition, force can be applied uring the movement. For executing this App, the impedance values set in a 'Set Joint Compliance' App. Should the option 'Apply Force' have been selected, the values from the 'Set Cartesian Compliance' App are used.

For parametrization, first the duration of the movement needs to be set. In the following steps the spiral is defined more precisely by setting the ascent, width and direction of rotation of the spiral. Then the level on which the movement is to be carried out can be selected. Should the option 'Apply Force' have been selected, the values from the 'Apply Force' App are used.



'User Interaction' enables Panda to wait for a haptic confirmation by the user. After successfully triggering a haptic gesture in one of the configured directions, the App is closed and the following App will be executed.

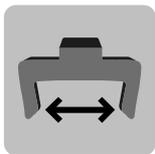
At first, the force limit, which needs to be exceeded for triggering the gesture, needs to be defined. In the next step all directions from which contact is to be recognized need to be defined.

## User Interaction



'Wait' provides the option to pause execution for a certain time period. The desired waiting period can be configured in seconds.

## Wait



'Change Gripper Width' allows the user to change the gripper width during the execution of a Task, for example to open the Hand before gripping an object.

The desired gripper width and the speed with which the gripper shall move can be set on the Arm or using the slider.

## Change Gripper Width

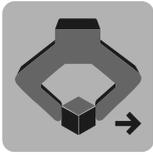


'Grasp' allows Panda to grasp objects.

The configuration is done similarly to the configuration in the 'Change Gripper Width' App. The grasping force and the mass of the object to be grasped can be configured additionally.

This should be done very precisely in order to avoid negative effects on the performance of force application or subsequent movements.

## Grasp



'Transport Motion' allows the tracing of a taught sequence of points in the Cartesian space. In contrast to the 'Cartesian Motion' App, here the system checks whether a gripped object is lost during the movement, which terminate the movement. For executing this App, the impedance values set in a 'Set Joint Compliance App.

The configuration is done similarly to the 'Cartesian Motion' App, by teaching a trajectory and configuring speed and acceleration. The maximum values can vary depending on the configuration, the weight of the end effector and the defined maximum speed.

## Transport Motion



'Modbus Wait' will wait for the configured Modbus input to accept the expected value. Once this has happened, the App is closed and the subsequent App is executed.

For configuring this App, the corresponding Modbus input needs to be selected, meaning that the module, the card and the input of the value to be expected need to be configured.

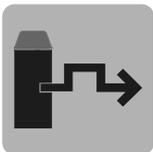
## Modbus Wait



'Modbus Out' sets the configured Modbus output to the configured value.

For configuring this App, the corresponding Modbus output needs to be selected, meaning that the module, the card and the input of the value to be expected need to be configured.

## Modbus Out



'Modbus Pulse' sets the configured modbus output tot he configured value. After the defined waiting period has passed, the output is reset again.

For configuring this App, the corresponding Modbus output needs to be selected, meaning that the module, the card and the input of the value to be expected need to be configured. In the next step, the waiting period can be defined.

## Modbus Pulse