Kinematic controller

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Chapter 1

Namespace Index

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gui 11
main 11
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robot_movement 14
test 21

Chapter 2

Hierarchical Index

2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

- Canvas
  - gui.Light 32
- communication.CommunicationProtocol 23
- Exception
  - communication.SerialCommunicationUnknownResponse 25
  - robot_movement.CoordinateSyntaxError 41
  - robot_movement.InvalidTimeIncrease 42
  - robot_movement.JointSyntaxError 43
  - robot_movement.MoveNotPossible 58
  - robot_movement.TakesOnlyTwoCoordinates 63
- gui.GUI 26
- main.Main 34
- robot_controller.RobotControllerSettings 39
- robot_movement.Kinematics 44
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- robot_movement.Robot 58
- robot_movement.RobotMyCobot 60
- robot_movement.RobotMyCobotAndSim 62

Chapter 3

Data Structure Index

3.1 Data Structures

Here are the data structures with brief descriptions:

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communication.SerialCommunicationUnknownResponse 25
gui.GUI 26
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main.Main 34
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File Index

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main.py 69
robot_controller.py 73
robot_movement.py 74
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Chapter 5

Namespace Documentation

5.1 commands Namespace Reference

Variables

- str HOME_GRIPPER = "home -g"
- str CLOSE_GRIPPER = "close"
- str HOME_PRESSER = "home -p"
- str PREPARE_PRESSING = "prepare pressing"
- str PRESS_ALLERGEN = "press -"
- str NEW_TEST = "new test"
- str RESPONSE = "b'Done'"
- str EMPTY = "b''"

5.1.1 Variable Documentation

5.1.1.1 CLOSE_GRIPPER

```
str commands.CLOSE_GRIPPER = "close"
```

Definition at line 2 of file commands.py.

5.1.1.2 EMPTY

```
str commands.EMPTY = "b''"
```

Definition at line 11 of file commands.py.

5.1.1.3 HOME_GRIPPER

```
str commands.HOME_GRIPPER = "home -g"
```

Definition at line 1 of file commands.py.

5.1.1.4 HOME_PRESSER

```
str commands.HOME_PRESSER = "home -p"
```

Definition at line 4 of file commands.py.

5.1.1.5 NEW_TEST

```
str commands.NEW_TEST = "new test"
```

Definition at line 8 of file commands.py.

5.1.1.6 PREPARE_PRESSING

```
str commands.PREPARE_PRESSING = "prepare pressing"
```

Definition at line 5 of file commands.py.

5.1.1.7 PRESS_ALLERGEN

```
str commands.PRESS_ALLERGEN = "press -"
```

Definition at line 6 of file commands.py.

5.1.1.8 RESPONSE

```
str commands.RESPONSE = "b'Done'"
```

Definition at line 10 of file commands.py.

5.2 communication Namespace Reference

Data Structures

- class CommunicationProtocol
- class SerialCommunicationUnknownResponse

Variables

- str SERIAL_COMMUNICATION_UNKNOWN_RESPONSE_ERROR_MSG = "SerialCommunication↩
UnknownResponse: The received serial response was not valid."
- com_test = CommunicationProtocol("COM3", 9600, 0.1)

5.2.1 Variable Documentation

5.2.1.1 com_test

```
communication.com_test = CommunicationProtocol("COM3", 9600, 0.1)
```

Definition at line 40 of file communication.py.

5.2.1.2 SERIAL_COMMUNICATION_UNKNOWN_RESPONSE_ERROR_MSG

```
str communication.SERIAL_COMMUNICATION_UNKNOWN_RESPONSE_ERROR_MSG = "SerialCommunication↩
UnknownResponse:  The received serial response was not valid."
```

Definition at line 6 of file communication.py.

5.3 gui Namespace Reference

Data Structures

- class GUI
- class Light

Variables

- test = GUI()

5.3.1 Variable Documentation

5.3.1.1 test

```
gui.test = GUI()
```

Definition at line 198 of file gui.py.

5.4 main Namespace Reference

Data Structures

- class Main

Functions

- communication_multi_thread (communicator, command)

Variables

- bool BOTH = True
- bool SIMULATING = False
- int Z_OFFSET = 0
- int STORAGE_OFFSET_X = 30
- int SYRINGE_OFFSET_X = -18
- int SYRINGE_MOVEMENT_Z = 25
- int SPEED = 1/0.5
- ALLERGEN_AMOUNT = str(150)
- int END_EFFECTOR_TILT_TAKE = 85
- int END_EFFECTOR_TILT_PLACE = 89
- list PATCH_TEST_CORNER_COORDINATES = [-215, -265, 215]
- list SYRINGE_COORDINATES
- bool performing_command = False
- main = Main()

5.4.1 Function Documentation

5.4.1.1 communication_multi_thread()

```
main.communication_multi_thread (
              communicator,
              command )
```

```
Executes a command on the arduino using multi_threading
:param communicator: instance of the communication class
:param command: command to execute.
```

Definition at line 46 of file main.py.

5.4.2 Variable Documentation

5.4.2.1 ALLERGEN_AMOUNT

```
main.ALLERGEN_AMOUNT = str(150)
```

Definition at line 21 of file main.py.

5.4.2.2 BOTH

```
bool main.BOTH = True
```

Definition at line 14 of file main.py.

5.4.2.3 END_EFFECTOR_TILT_PLACE

```
int main.END_EFFECTOR_TILT_PLACE = 89
```

Definition at line 23 of file main.py.

5.4.2.4 END_EFFECTOR_TILT_TAKE

```
int main.END_EFFECTOR_TILT_TAKE = 85
```

Definition at line 22 of file main.py.

5.4.2.5 main

```
main.main = Main()
```

Definition at line 250 of file main.py.

5.4.2.6 PATCH_TEST_CORNER_COORDINATES

```
list main.PATCH_TEST_CORNER_COORDINATES = [-215, -265, 215]
```

Definition at line 26 of file main.py.

5.4.2.7 performing_command

```
bool main.performing_command = False
```

Definition at line 43 of file main.py.

5.4.2.8 SIMULATING

```
bool main.SIMULATING = False
```

Definition at line 15 of file main.py.

5.4.2.9 SPEED

```
int main.SPEED = 1/0.5
```

Definition at line 20 of file main.py.

5.4.2.10 STORAGE_OFFSET_X

```
int main.STORAGE_OFFSET_X = 30
```

Definition at line 17 of file main.py.

5.4.2.11 SYRINGE_COORDINATES

```
list main.SYRINGE_COORDINATES
```

Initial value:

```
=  [
     [305, 169.5+5, 153.5+5],
     [310, 94.5, 153.5+5],
     [310, 19.5, 153.5+5],
     [310, -65.5, 153.5+5],
     [305, -140.5, 153.5+5],
     [310, 132+5, 78],
     [310, 57, 76],
     [310, -28-5, 76],
     [310, -106-5, 76],
     [310, -184-5, 78]
]
```

Definition at line 29 of file main.py.

5.4.2.12 SYRINGE_MOVEMENT_Z

```
int main.SYRINGE_MOVEMENT_Z = 25
```

Definition at line 19 of file main.py.

5.4.2.13 SYRINGE_OFFSET_X

```
int main.SYRINGE_OFFSET_X = -18
```

Definition at line 18 of file main.py.

5.4.2.14 Z_OFFSET

```
int main.Z_OFFSET = 0
```

Definition at line 16 of file main.py.

5.5 robot_controller Namespace Reference

Data Structures

- class RobotControllerSettings

5.6 robot_movement Namespace Reference

Data Structures

- class CoordinateSyntaxError
- class InvalidTimeIncrease
- class JointSyntaxError
- class Kinematics
- class MoveJ
- class MoveL
- class MoveNotPossible
- class Robot
- class RobotMyCobot
- class RobotMyCobotAndSim
- class TakesOnlyTwoCoordinates

Functions

- joint_matrix (alpha, a, d, theta)
- get_rot_x_matrix (angle)
- get_rot_y_matrix (angle)
- get_rot_z_matrix (angle)
- orientation_degree_to_radians (orientation)
- radians_to_degree (angle)
- radians_to_degree_list (list_radians)
- transform_list_into_range (untransformed_list, min_value, max_value, adjuster)
- best_end_joint (current_joint, joints)

Variables

- int MIN_ANGLE_LINK_1_5 = -165 / 180 ∗ m.pi
- int MAX_ANGLE_LINK_1_5 = 165 / 180 ∗ m.pi
- int MIN_ANGLE_LINK_6 = -175 / 180 ∗ m.pi
- int MAX_ANGLE_LINK_6 = 175 / 180 ∗ m.pi
- str MOVE_NOT_POSSIBLE_ERROR_MSG = "MoveNotPossible: The given movement command can not be executed by the program. Please make sure that it dies not result in a singularity"
- str JOINT_SYNTAX_ERROR_MSG = "JointSyntaxError: The syntax must be [Joint1, joint2, joint3, joint4, joint5, joint6] for a joint"
- str TAKES_ONLY_TWO_COORDINATES_ERROR_MSG = "TakesOnlyTwoCoordinates: This class takes only two coordinates."
- str COORDINATE_SYNTAX_ERROR_MSG = "CoordinateSyntaxError: The syntax must be: [x, y, z, alpha, beta, gamma, time] for a coordinate."
- str INVALID_TIME_INCREASE_ERROR_MSG = "InvalidTimeIncrease: Later coordinates must have a higher time than those before or the robot will not be able to move to the given point."
- list robot_joint_position = [107.38158881112184, 46.157985403753784, 103.3563681945703, 30.↩ 485646401675925, 107.38158881112184, 135.0]
- list robot_cartesian_position = [280, 132, 74, -90, 135, -90]

5.6.1 Function Documentation

5.6.1.1 best_end_joint()

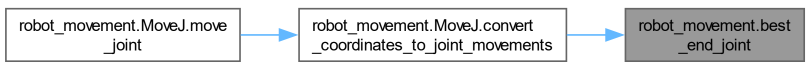
```
robot_movement.best_end_joint (
              current_joint,
              joints )
```

```
Takes the current joint position and a list containing of possible joint positions and returns the closest pos
:param current_joint: The current position of the robots joint.
:param joints: The possible joint positions for a point.
:return: The closest joint position to the current joint position
```

Definition at line 195 of file robot_movement.py.

Referenced by robot_movement.MoveJ.convert_coordinates_to_joint_movements().

Here is the caller graph for this function:


robot_movement.MoveJ.move _joint
robot_movement.MoveJ.convert _coordinates_to_joint_movements
robot_movement.best _end_joint

5.6.1.2 get_rot_x_matrix()

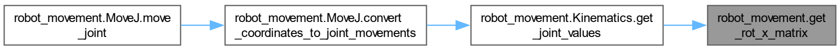
```
robot_movement.get_rot_x_matrix (
              angle )
```

```
Get rotation matrix around x axis.
:param angle: Angle the rotation matrix should rotate an object.
:return: Returns the rotation matrix.
```

Definition at line 91 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.get_rot_x_matrix

5.6.1.3 get_rot_y_matrix()

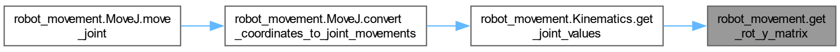
```
robot_movement.get_rot_y_matrix (
              angle )
```

```
Get rotation matrix around y axis.
:param angle: Angle the rotation matrix should rotate an object.
:return: Returns the rotation matrix.
```

Definition at line 105 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.get_rot_y_matrix

5.6.1.4 get_rot_z_matrix()

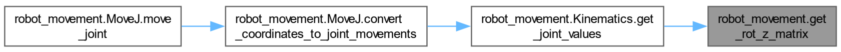
```
robot_movement.get_rot_z_matrix (
              angle )
```

```
Get rotation matrix around z axis.
:param angle: Angle the rotation matrix should rotate an object.
:return: Returns the rotation matrix.
```

Definition at line 119 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.get_rot_z_matrix

5.6.1.5 joint_matrix()

```
robot_movement.joint_matrix (
              alpha,
              a,
              d,
              theta )
```

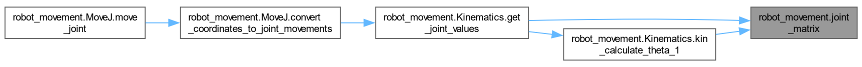
```
Function to create transformation matrix.

:param alpha: alpha value from David Hartenberg parameters.
:param a: a value from David Hartenberg parameters.
:param d: d value from David Hartenberg parameters.
:param theta: theta value from David Hartenberg parameters.
:return: returns a 4x4 matrix containing the transformation matrix for the given parameters.
```

Definition at line 73 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values(), and robot_movement.Kinematics.kin_calculate_theta_1().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.Kinematics.kin_calculate_theta_1
robot_movement.joint_matrix

5.6.1.6 orientation_degree_to_radians()

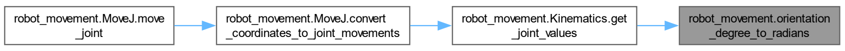
```
robot_movement.orientation_degree_to_radians (
              orientation )
```

```
Converts angle from degree to radians
:param orientation: Angle in degree.
:return: Angle in radians
```

Definition at line 133 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.orientation_degree_to_radians

5.6.1.7 radians_to_degree()

```
robot_movement.radians_to_degree (
              angle )
```

```
Converts angle from radians to degree.
:param angle: Angle in radians.
:return: Angle in degree.
```

Definition at line 145 of file robot_movement.py.

5.6.1.8 radians_to_degree_list()

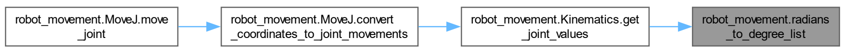
```
robot_movement.radians_to_degree_list (
              list_radians )
```

```
Converts radians in a list to degree
:param list_radians: List containing angles in radians
:return: List containing angles in degrees
```

Definition at line 156 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.radians_to_degree_list

5.6.1.9 transform_list_into_range()

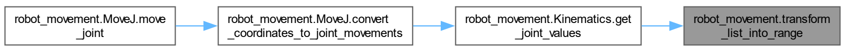
```
robot_movement.transform_list_into_range (
              untransformed_list,
              min_value,
              max_value,
              adjuster )
```

```
Takes a list containing angles and checks if they are in a given range.
:param untransformed_list: List containing angles
:param min_value: Min value in range
:param max_value: Max value in range
:param adjuster: How much the values may be adjusted
:return: Transformed list. Some of the elements may have been changed to False if the given value is not in th
```

Definition at line 170 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.transform_list_into_range

5.6.2 Variable Documentation

5.6.2.1 COORDINATE_SYNTAX_ERROR_MSG

```
str robot_movement.COORDINATE_SYNTAX_ERROR_MSG = "CoordinateSyntaxError:  The syntax must be:
[x, y, z, alpha, beta, gamma, time] for a coordinate."
```

Definition at line 17 of file robot_movement.py.

5.6.2.2 INVALID_TIME_INCREASE_ERROR_MSG

```
str robot_movement.INVALID_TIME_INCREASE_ERROR_MSG = "InvalidTimeIncrease:  Later coordinates
must have a higher time than those before or the robot will not be able to move to the given
point."
```

Definition at line 18 of file robot_movement.py.

5.6.2.3 JOINT_SYNTAX_ERROR_MSG

```
str robot_movement.JOINT_SYNTAX_ERROR_MSG = "JointSyntaxError:  The syntax must be [Joint1,
joint2, joint3, joint4, joint5, joint6] for a joint"
```

Definition at line 15 of file robot_movement.py.

5.6.2.4 MAX_ANGLE_LINK_1_5

```
int robot_movement.MAX_ANGLE_LINK_1_5 = 165 / 180 * m.pi
```

Definition at line 10 of file robot_movement.py.

5.6.2.5 MAX_ANGLE_LINK_6

```
int robot_movement.MAX_ANGLE_LINK_6 = 175 / 180 * m.pi
```

Definition at line 12 of file robot_movement.py.

5.6.2.6 MIN_ANGLE_LINK_1_5

```
int robot_movement.MIN_ANGLE_LINK_1_5 = -165 / 180 * m.pi
```

Definition at line 9 of file robot_movement.py.

5.6.2.7 MIN_ANGLE_LINK_6

```
int robot_movement.MIN_ANGLE_LINK_6 = -175 / 180 * m.pi
```

Definition at line 11 of file robot_movement.py.

5.6.2.8 MOVE_NOT_POSSIBLE_ERROR_MSG

```
str robot_movement.MOVE_NOT_POSSIBLE_ERROR_MSG = "MoveNotPossible:  The given movement command
can not be executed by the program.  Please make sure that it dies not result in a singularity"
```

Definition at line 14 of file robot_movement.py.

5.6.2.9 robot_cartesian_position

```
list robot_movement.robot_cartesian_position = [280, 132, 74, -90, 135, -90]
```

Definition at line 22 of file robot_movement.py.

5.6.2.10 robot_joint_position

```
list robot_movement.robot_joint_position = [107.38158881112184, 46.157985403753784, 103.↩
3563681945703, 30.485646401675925, 107.38158881112184, 135.0]
```

Definition at line 21 of file robot_movement.py.

5.6.2.11 TAKES_ONLY_TWO_COORDINATES_ERROR_MSG

```
str robot_movement.TAKES_ONLY_TWO_COORDINATES_ERROR_MSG = "TakesOnlyTwoCoordinates:  This
class takes only two coordinates."
```

Definition at line 16 of file robot_movement.py.

5.7 test Namespace Reference

Functions

- mySqrt (number, guess, step, tol)

Variables

- int testVal = 9

5.7.1 Function Documentation

5.7.1.1 mySqrt()

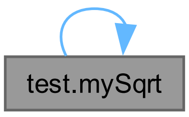
```
test.mySqrt (
              number,
              guess,
              step,
              tol )
```

Definition at line 1 of file test.py.

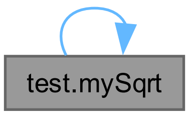
References mySqrt().

Referenced by mySqrt().

Here is the call graph for this function:



Here is the caller graph for this function:



5.7.2 Variable Documentation

5.7.2.1 testVal

```
int test.testVal = 9
```

Definition at line 24 of file test.py.

Chapter 6

Data Structure Documentation

6.1 communication.CommunicationProtocol Class Reference

Public Member Functions

- __init__ (self, com, baudrate, timeout)
- send_command (self, command)

Data Fields

- com
- baudrate
- timeout
- connection

6.1.1 Detailed Description

Definition at line 18 of file communication.py.

6.1.2 Constructor & Destructor Documentation

6.1.2.1 __init__()

```
communication.CommunicationProtocol.__init__ (
              self,
              com,
              baudrate,
              timeout )
```

Definition at line 19 of file communication.py.

6.1.3 Member Function Documentation

6.1.3.1 send_command()

```
communication.CommunicationProtocol.send_command (
              self,
              command )
```

Definition at line 25 of file communication.py.

References communication.CommunicationProtocol.connection.

6.1.4 Field Documentation

6.1.4.1 baudrate

```
communication.CommunicationProtocol.baudrate
```

Definition at line 21 of file communication.py.

6.1.4.2 com

```
communication.CommunicationProtocol.com
```

Definition at line 20 of file communication.py.

6.1.4.3 connection

```
communication.CommunicationProtocol.connection
```

Definition at line 23 of file communication.py.

Referenced by communication.CommunicationProtocol.send_command().

6.1.4.4 timeout

```
communication.CommunicationProtocol.timeout
```

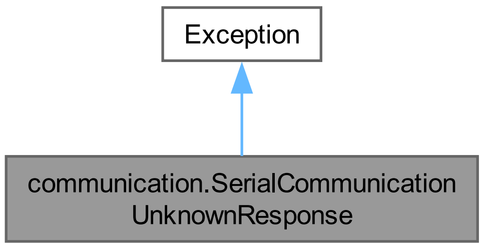
Definition at line 22 of file communication.py.

The documentation for this class was generated from the following file:

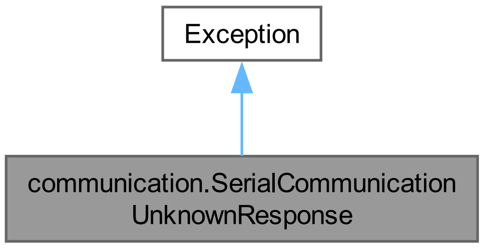
- communication.py

6.2 communication.SerialCommunicationUnknownResponse Class Reference

Inheritance diagram for communication.SerialCommunicationUnknownResponse:



Collaboration diagram for communication.SerialCommunicationUnknownResponse:



6.2.1 Detailed Description

```
Used for error handling. Also the reason for the inheritance of Exception. The following error is described as

SerialCommunicationUnknownResponse: The received serial response was not valid.
```

Definition at line 9 of file communication.py.

The documentation for this class was generated from the following file:

- communication.py

6.3 gui.GUI Class Reference

Public Member Functions

- __init__ (self)
- start_pressed (self)
- stop_pressed_init (self)
- stop_pressed (self)
- robot_pressed (self)
- simulation_pressed (self)
- both_pressed (self)
- run (self)

Data Fields

- root
- pressed_buttons
- mode
- running
- button_START
- button_STOP
- button_SELECT_ROBOT
- button_SELECT_SIMULATION
- button_SELECT_BOTH
- light_SELECT_ROBOT
- light_SELECT_SIMULATION
- light_SELECT_BOTH
- title

6.3.1 Detailed Description

```
Main class for the GUI
```

Definition at line 36 of file gui.py.

6.3.2 Constructor & Destructor Documentation

6.3.2.1 __init__()

```
gui.GUI.__init__ (
                self )
```

```
Initializer for tkinter menu
```

Definition at line 40 of file gui.py.

6.3.3 Member Function Documentation

6.3.3.1 both_pressed()

```
gui.GUI.both_pressed (
              self )
```

```
Button method for when clicking on the 'Execute program on robot and in simulation'
```

Definition at line 174 of file gui.py.

References gui.GUI.button_SELECT_BOTH, gui.GUI.button_SELECT_ROBOT, gui.GUI.button_SELECT_SIMULATION, gui.GUI.button_START, gui.GUI.button_STOP, gui.GUI.light_SELECT_BOTH, gui.GUI.light_SELECT_ROBOT, gui.GUI.light_SELECT_SIMULATION, and gui.GUI.pressed_buttons.

6.3.3.2 robot_pressed()

```
gui.GUI.robot_pressed (
              self )
```

```
Button method for when clicking on the 'Execute program on robot'
```

Definition at line 142 of file gui.py.

References gui.GUI.button_SELECT_BOTH, gui.GUI.button_SELECT_ROBOT, gui.GUI.button_SELECT_SIMULATION, gui.GUI.button_START, gui.GUI.button_STOP, gui.GUI.light_SELECT_BOTH, gui.GUI.light_SELECT_ROBOT, gui.GUI.light_SELECT_SIMULATION, and gui.GUI.pressed_buttons.

6.3.3.3 run()

```
gui.GUI.run (
              self )
```

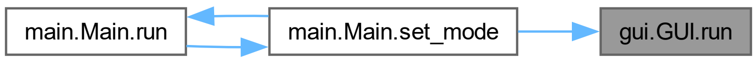
```
Runs the program
```

Definition at line 190 of file gui.py.

References gui.GUI.root.

Referenced by main.Main.set_mode().

Here is the caller graph for this function:



6.3.3.4 simulation_pressed()

```
gui.GUI.simulation_pressed (
              self )
```

```
Button method for when clicking on the 'Execute program in simulation'
```

Definition at line 158 of file gui.py.

References gui.GUI.button_SELECT_BOTH, gui.GUI.button_SELECT_ROBOT, gui.GUI.button_SELECT_SIMULATION, gui.GUI.button_START, gui.GUI.button_STOP, gui.GUI.light_SELECT_BOTH, gui.GUI.light_SELECT_ROBOT, gui.GUI.light_SELECT_SIMULATION, and gui.GUI.pressed_buttons.

6.3.3.5 start_pressed()

```
gui.GUI.start_pressed (
              self )
```

```
Button method for when clicking on the start button
```

Definition at line 79 of file gui.py.

References gui.GUI.button_SELECT_BOTH, gui.GUI.button_SELECT_ROBOT, gui.GUI.button_SELECT_SIMULATION, gui.GUI.button_START, gui.GUI.button_STOP, gui.GUI.light_SELECT_BOTH, gui.GUI.light_SELECT_ROBOT, gui.GUI.light_SELECT_SIMULATION, gui.GUI.mode, gui.GUI.pressed_buttons, and gui.GUI.running.

6.3.3.6 stop_pressed()

```
gui.GUI.stop_pressed (
              self )
```

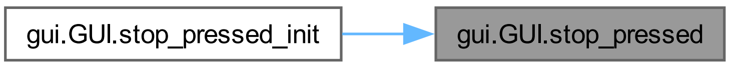
```
Button method for when the program has run the stop command and the buttons should be clickable again.
```

Definition at line 132 of file gui.py.

References gui.GUI.button_SELECT_BOTH, gui.GUI.button_SELECT_ROBOT, gui.GUI.button_SELECT_SIMULATION, gui.GUI.button_START, and gui.GUI.button_STOP.

Referenced by gui.GUI.stop_pressed_init().

Here is the caller graph for this function:



6.3.3.7 stop_pressed_init()

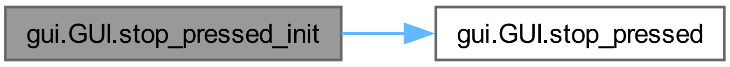
```
gui.GUI.stop_pressed_init (
              self )
```

```
Button method for when clicking on the stop button
```

Definition at line 109 of file gui.py.

References gui.GUI.button_SELECT_BOTH, gui.GUI.button_SELECT_ROBOT, gui.GUI.button_SELECT_SIMULATION, gui.GUI.button_START, gui.GUI.button_STOP, gui.GUI.light_SELECT_BOTH, gui.GUI.light_SELECT_ROBOT, gui.GUI.light_SELECT_SIMULATION, gui.GUI.mode, gui.GUI.pressed_buttons, gui.GUI.running, and gui.GUI.stop_pressed().

Here is the call graph for this function:



6.3.4 Field Documentation

6.3.4.1 button_SELECT_BOTH

```
gui.GUI.button_SELECT_BOTH
```

Definition at line 58 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), gui.GUI.stop_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.2 button_SELECT_ROBOT

```
gui.GUI.button_SELECT_ROBOT
```

Definition at line 54 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), gui.GUI.stop_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.3 button_SELECT_SIMULATION

```
gui.GUI.button_SELECT_SIMULATION
```

Definition at line 56 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), gui.GUI.stop_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.4 button_START

```
gui.GUI.button_START
```

Definition at line 50 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), gui.GUI.stop_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.5 button_STOP

```
gui.GUI.button_STOP
```

Definition at line 52 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), gui.GUI.stop_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.6 light_SELECT_BOTH

```
gui.GUI.light_SELECT_BOTH
```

Definition at line 73 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.7 light_SELECT_ROBOT

```
gui.GUI.light_SELECT_ROBOT
```

Definition at line 67 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.8 light_SELECT_SIMULATION

```
gui.GUI.light_SELECT_SIMULATION
```

Definition at line 70 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.9 mode

```
gui.GUI.mode
```

Definition at line 47 of file gui.py.

Referenced by gui.GUI.start_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.10 pressed_buttons

```
gui.GUI.pressed_buttons
```

Definition at line 45 of file gui.py.

Referenced by gui.GUI.both_pressed(), gui.GUI.robot_pressed(), gui.GUI.simulation_pressed(), gui.GUI.start_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.11 root

```
gui.GUI.root
```

Definition at line 44 of file gui.py.

Referenced by gui.GUI.run().

6.3.4.12 running

```
gui.GUI.running
```

Definition at line 48 of file gui.py.

Referenced by gui.GUI.start_pressed(), and gui.GUI.stop_pressed_init().

6.3.4.13 title

```
gui.GUI.title
```

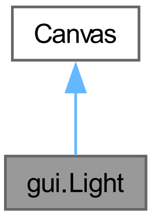
Definition at line 76 of file gui.py.

The documentation for this class was generated from the following file:

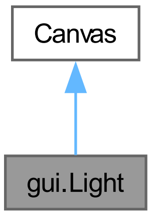
- gui.py

6.4 gui.Light Class Reference

Inheritance diagram for gui.Light:



Collaboration diagram for gui.Light:



Public Member Functions

- __init__ (self, master, ∗∗kwargs)
- turn_on (self)
- turn_off (self)
- turn_ready (self)

Data Fields

- oval_id

6.4.1 Detailed Description

```
Class to construct an oval element in the GUI
```

Definition at line 4 of file gui.py.

6.4.2 Constructor & Destructor Documentation

6.4.2.1 __init__()

```
gui.Light.__init__ (
              self,
              master,
             ** kwargs )
```

```
initializer
:param master: the root of the tkinter menu
:param kwargs: possible arguments for the canvas.
```

Definition at line 8 of file gui.py.

6.4.3 Member Function Documentation

6.4.3.1 turn_off()

```
gui.Light.turn_off (
              self )
```

```
Changes the color of the oval to gray
```

Definition at line 23 of file gui.py.

References gui.Light.oval_id.

6.4.3.2 turn_on()

```
gui.Light.turn_on (
              self )
```

```
Changes the color of the oval to green
```

Definition at line 17 of file gui.py.

References gui.Light.oval_id.

6.4.3.3 turn_ready()

```
gui.Light.turn_ready (
              self )
```

```
Changes the color of the oval to red
```

Definition at line 29 of file gui.py.

References gui.Light.oval_id.

6.4.4 Field Documentation

6.4.4.1 oval_id

```
gui.Light.oval_id
```

Definition at line 15 of file gui.py.

Referenced by gui.Light.turn_off(), gui.Light.turn_on(), and gui.Light.turn_ready().

The documentation for this class was generated from the following file:

- gui.py

6.5 main.Main Class Reference

Public Member Functions

- __init__ (self)
- create_gui (self)
- set_mode (self, mode)
- run (self)
- dispense_allergen (self, index)
- take_allergen (self, index)
- place_allergen (self, index)

Data Fields

- communication
- patch_test_config
- robot
- gui_created
- gui_thread
- gui

6.5.1 Detailed Description

```
Main class containing the whole program.
```

Definition at line 59 of file main.py.

6.5.2 Constructor & Destructor Documentation

6.5.2.1 __init__()

```
main.Main.__init__ (
              self )
```

```
Connecting to ROBODK or MyCobot.
```

Definition at line 63 of file main.py.

6.5.3 Member Function Documentation

6.5.3.1 create_gui()

```
main.Main.create_gui (
              self )
```

```
Creates the GUI
```

Definition at line 90 of file main.py.

6.5.3.2 dispense_allergen()

```
main.Main.dispense_allergen (
              self,
              index )
```

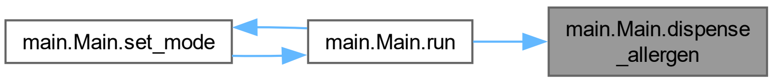
```
Runs the movements needed to dispense allergen onto a patch test
:param index: What index the position on the patch test has
:return: None
```

Definition at line 171 of file main.py.

References main.Main.communication, main.Main.robot, robot_movement.MoveJ.robot, and robot_movement.MoveL.robot.

Referenced by main.Main.run().

Here is the caller graph for this function:



6.5.3.3 place_allergen()

```
main.Main.place_allergen (
              self,
              index )
```

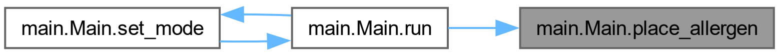
```
Places an allergen in storage
:param index: Index for storage place
:return: None
```

Definition at line 224 of file main.py.

References main.Main.communication, main.Main.robot, robot_movement.MoveJ.robot, and robot_movement.MoveL.robot.

Referenced by main.Main.run().

Here is the caller graph for this function:



6.5.3.4 run()

```
main.Main.run (
              self )
```

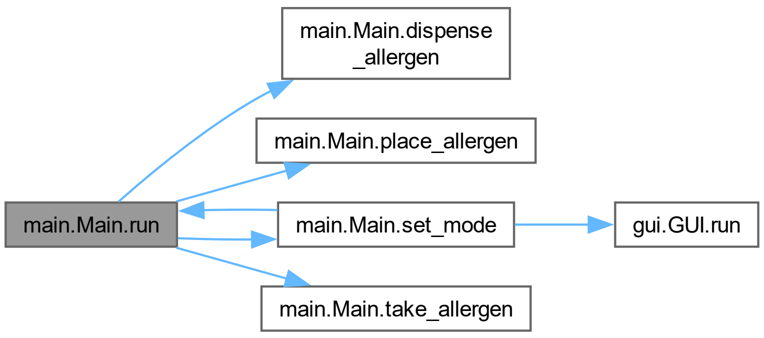
```
Runs the whole program sequence
```

Definition at line 131 of file main.py.

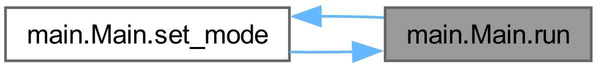
References main.Main.communication, main.Main.dispense_allergen(), main.Main.gui, main.Main.patch_test_config, main.Main.place_allergen(), main.Main.robot, robot_movement.MoveJ.robot, robot_movement.MoveL.robot, main.Main.set_mode(), and main.Main.take_allergen().

Referenced by main.Main.set_mode().

Here is the call graph for this function:



Here is the caller graph for this function:



6.5.3.5 set_mode()

```
main.Main.set_mode (
              self,
              mode )
```

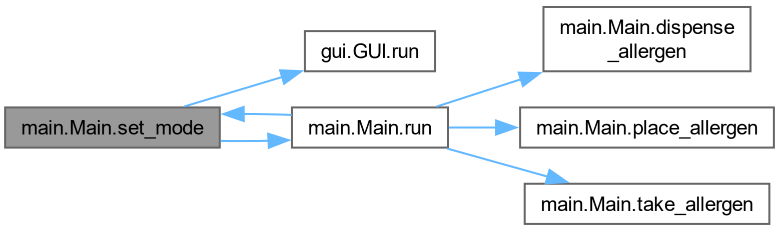
```
Sets the mode for how the robot should run
:param mode: either "both", "simulation", "robot".
```

Definition at line 100 of file main.py.

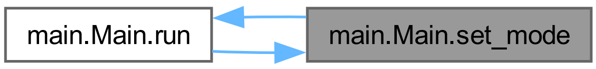
References main.Main.robot, robot_movement.MoveJ.robot, robot_movement.MoveL.robot, gui.GUI.run(), and main.Main.run().

Referenced by main.Main.run().

Here is the call graph for this function:



Here is the caller graph for this function:



6.5.3.6 take_allergen()

```
main.Main.take_allergen (
              self,
              index )
```

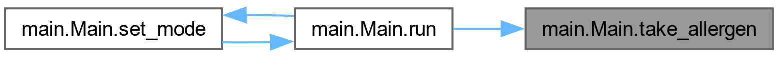
```
Takes an allergen from the storage
:param index: Index for the allergen in the storage system
:return: None
```

Definition at line 195 of file main.py.

References main.Main.communication, main.Main.robot, robot_movement.MoveJ.robot, and robot_movement.MoveL.robot.

Referenced by main.Main.run().

Here is the caller graph for this function:



6.5.4 Field Documentation

6.5.4.1 communication

`main.Main.communication`

Definition at line 67 of file main.py.

Referenced by main.Main.dispense_allergen(), main.Main.place_allergen(), main.Main.run(), and main.Main.take_allergen().

6.5.4.2 gui

`main.Main.gui`

Definition at line 94 of file main.py.

Referenced by main.Main.run().

6.5.4.3 gui_created

`main.Main.gui_created`

Definition at line 78 of file main.py.

6.5.4.4 gui_thread

```
main.Main.gui_thread
```

Definition at line 79 of file main.py.

6.5.4.5 patch_test_config

```
main.Main.patch_test_config
```

Definition at line 70 of file main.py.

Referenced by main.Main.run().

6.5.4.6 robot

```
main.Main.robot
```

Definition at line 76 of file main.py.

Referenced by main.Main.dispense_allergen(), robot_movement.MoveJ.move_joint(), main.Main.place_allergen(), main.Main.run(), main.Main.set_mode(), and main.Main.take_allergen().

The documentation for this class was generated from the following file:

- main.py

6.6 robot_controller.RobotControllerSettings Class Reference

Public Member Functions

- __init__ (self)

Data Fields

- update_frequency
- linear_frequency
- dh_values

6.6.1 Detailed Description

```
Robot controller settings class
```

Definition at line 4 of file robot_controller.py.

6.6.2 Constructor & Destructor Documentation

6.6.2.1 __init__()

```
robot_controller.RobotControllerSettings.__init__ (
              self )
```

```
Settings for the robot controller
```

Definition at line 8 of file robot_controller.py.

6.6.3 Field Documentation

6.6.3.1 dh_values

```
robot_controller.RobotControllerSettings.dh_values
```

Definition at line 15 of file robot_controller.py.

6.6.3.2 linear_frequency

```
robot_controller.RobotControllerSettings.linear_frequency
```

Definition at line 13 of file robot_controller.py.

6.6.3.3 update_frequency

```
robot_controller.RobotControllerSettings.update_frequency
```

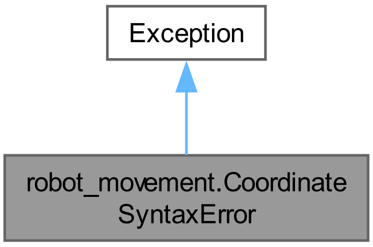
Definition at line 12 of file robot_controller.py.

The documentation for this class was generated from the following file:

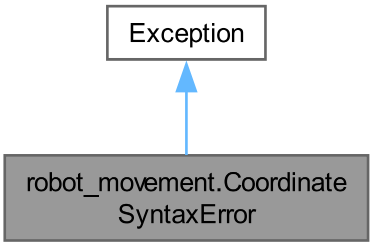
- robot_controller.py

6.7 robot_movement.CoordinateSyntaxError Class Reference

Inheritance diagram for robot_movement.CoordinateSyntaxError:



Collaboration diagram for robot_movement.CoordinateSyntaxError:



6.7.1 Detailed Description

```
Used for error handling. Also the reason for the inheritance of Exception. The following error is described as

CoordinateSyntaxError: The syntax must be: [x, y, z, alpha, beta, gamma, time] for a coordinate.
```

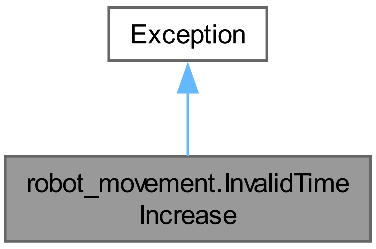
Definition at line 52 of file robot_movement.py.

The documentation for this class was generated from the following file:

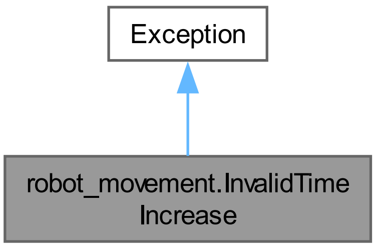
- robot_movement.py

6.8 robot_movement.InvalidTimeIncrease Class Reference

Inheritance diagram for robot_movement.InvalidTimeIncrease:



Collaboration diagram for robot_movement.InvalidTimeIncrease:



Static Public Attributes

- suppress

6.8.1 Detailed Description

```
Used for error handling. Also the reason for the inheritance of Exception. The following error is described as
InvalidTimeIncrease: Later coordinates must have a higher time than those before or the robot will not be able
```

Definition at line 61 of file robot_movement.py.

6.8.2 Field Documentation

6.8.2.1 suppress

```
robot_movement.InvalidTimeIncrease.suppress  [static]
```

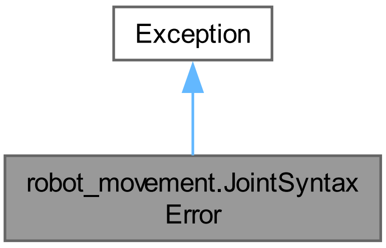
Definition at line 70 of file robot_movement.py.

The documentation for this class was generated from the following file:

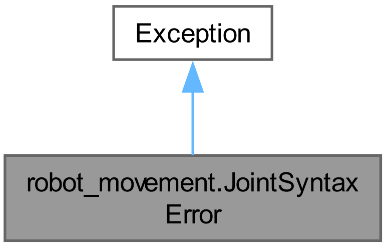
- robot_movement.py

6.9 robot_movement.JointSyntaxError Class Reference

Inheritance diagram for robot_movement.JointSyntaxError:



Collaboration diagram for robot_movement.JointSyntaxError:



6.9.1 Detailed Description

```
Used for error handling. Also the reason for the inheritance of Exception. The following error is described as

JointSyntaxError: The syntax must be [Joint1, joint2, joint3, joint4, joint5, joint6] for a joint
```

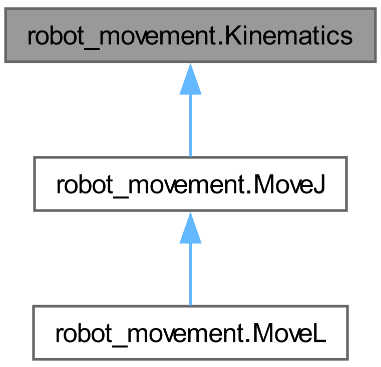
Definition at line 34 of file robot_movement.py.

The documentation for this class was generated from the following file:

- robot_movement.py

6.10 robot_movement.Kinematics Class Reference

Inheritance diagram for robot_movement.Kinematics:



Public Member Functions

- __init__ (self)
- get_joint_values (self, coordinate, orientation)
- kin_calculate_theta_1 (self, T_link0_link6)
- kin_calculate_theta_2_3 (self, T_link2_link3)
- kin_calculate_theta_4 (self, rot_matrix, theta_5)
- kin_calculate_theta_5 (self, rot_matrix)
- kin_calculate_theta_6 (self, rot_matrix, theta_5)

Data Fields

- robot_controller_settings
- dh_value_alpha
- dh_value_a
- dh_value_d
- dh_value_theta

6.10.1 Detailed Description

```
Class to compute the inverse kinematics.
```

Definition at line 221 of file robot_movement.py.

6.10.2 Constructor & Destructor Documentation

6.10.2.1 __init__()

```
robot_movement.Kinematics.__init__ (
              self )
```

```
Constructor for class
```

Reimplemented in robot_movement.MoveJ, and robot_movement.MoveL.

Definition at line 225 of file robot_movement.py.

6.10.3 Member Function Documentation

6.10.3.1 get_joint_values()

```
robot_movement.Kinematics.get_joint_values (
              self,
              coordinate,
              orientation )
```

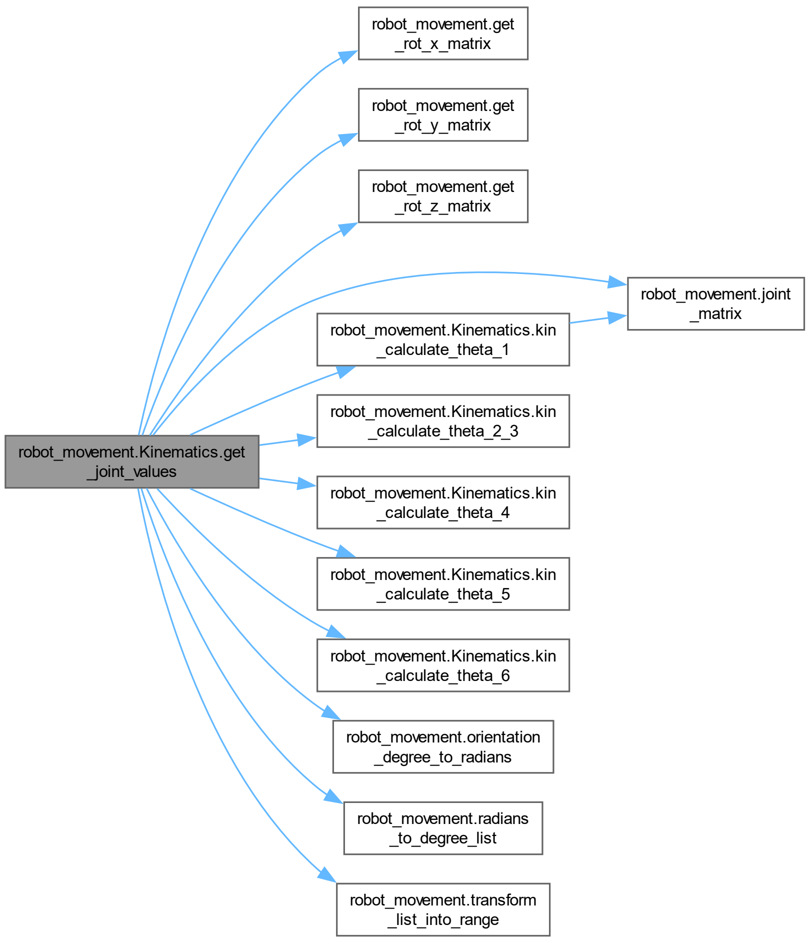
```
Method for getting the joint values from a coordinate and orientation.
:param coordinate: Coordinate in the format [x, y, z].
:param orientation: Orientation in the format [roll, pitch, yaw].
:return: Returns a list containing all possible joint configurations for the robot.
```

Definition at line 235 of file robot_movement.py.

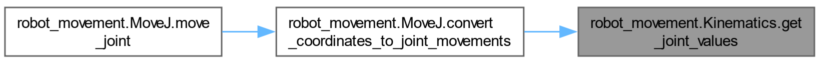
References robot_movement.Kinematics.dh_value_a, robot_movement.Kinematics.dh_value_alpha, robot_movement.Kinematics.dh_
robot_movement.Kinematics.dh_value_theta, robot_movement.get_rot_x_matrix(), robot_movement.get_rot_y_matrix(), robot_movement.get_rot_z_matrix(), robot_movement.joint_matrix(), robot_movement.Kinematics.kin_calculate_theta_1(), robot_movement.Kinematics.kin_calculate_theta_2_3(), robot_movement.Kinematics.kin_calculate_theta_4(), robot_movement.Kinematics.kin_calculate_theta_5(), robot_movement.Kinematics.kin_calculate_theta_6(), robot_movement.orientation_degree_to_radians(), robot_movement.radians_to_degree_list(), and robot_movement.transform_list_in

Referenced by robot_movement.MoveJ.convert_coordinates_to_joint_movements().

Here is the call graph for this function:


robot_movement.get_rot_x_matrix
robot_movement.get_rot_y_matrix
robot_movement.get_rot_z_matrix
robot_movement.joint_matrix
robot_movement.Kinematics.kin_calculate_theta_1
robot_movement.Kinematics.get_joint_values
robot_movement.Kinematics.kin_calculate_theta_2_3
robot_movement.Kinematics.kin_calculate_theta_4
robot_movement.Kinematics.kin_calculate_theta_5
robot_movement.Kinematics.kin_calculate_theta_6
robot_movement.orientation_degree_to_radians
robot_movement.radians_to_degree_list
robot_movement.transform_list_into_range

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values

6.10.3.2 kin_calculate_theta_1()

```
robot_movement.Kinematics.kin_calculate_theta_1 (
              self,
              T_link0_link6 )
```

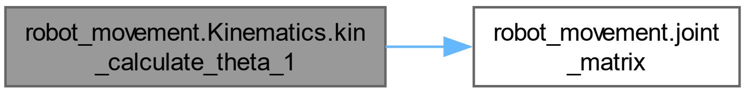
```
Calculates theta 1
:param T_link0_link6: Transformation matrix from link 1 to link 6.
:return: Returns the two possible values for theta 1
```

Definition at line 369 of file robot_movement.py.

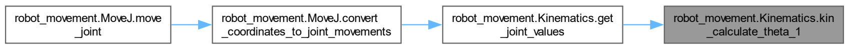
References robot_movement.Kinematics.dh_value_d, and robot_movement.joint_matrix().

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the call graph for this function:



Here is the caller graph for this function:


robot_movement.MoveJ.move
_joint
robot_movement.MoveJ.convert
_coordinates_to_joint_movements
robot_movement.Kinematics.get
_joint_values
robot_movement.Kinematics.kin
_calculate_theta_1

6.10.3.3 kin_calculate_theta_2_3()

```
robot_movement.Kinematics.kin_calculate_theta_2_3 (
              self,
              T_link2_link3 )
```

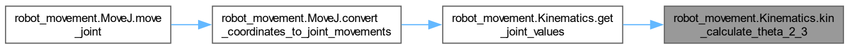
```
Calculates theta 2 and 3
:param T_link2_link3: Transformation matrix from link 2 to link 3
:return: Returns the possible configurations for theta 2 and theta 3.
```

Definition at line 387 of file robot_movement.py.

References robot_movement.Kinematics.dh_value_a.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move
_joint
robot_movement.MoveJ.convert
_coordinates_to_joint_movements
robot_movement.Kinematics.get
_joint_values
robot_movement.Kinematics.kin
_calculate_theta_2_3

6.10.3.4 kin_calculate_theta_4()

```
robot_movement.Kinematics.kin_calculate_theta_4 (
              self,
              rot_matrix,
              theta_5 )
```

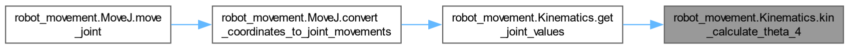
```
Calculates theta 4
:param rot_matrix: Rotation matrix describing rotation from link 4 to link 6.
:param theta_5: Value for theta 5
:return: Returns the value for theta 4
```

Definition at line 419 of file robot_movement.py.

References robot_movement.Kinematics.dh_value_theta.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.Kinematics.kin_calculate_theta_4

6.10.3.5 kin_calculate_theta_5()

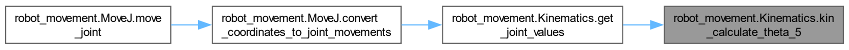
```
robot_movement.Kinematics.kin_calculate_theta_5 (
              self,
              rot_matrix )
```

```
Calculates theta 5
:param rot_matrix: Rotation matrix describing rotation from link 4 to link 6.
:return: Returns the two values for theta 5
```

Definition at line 432 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.Kinematics.kin_calculate_theta_5

6.10.3.6 kin_calculate_theta_6()

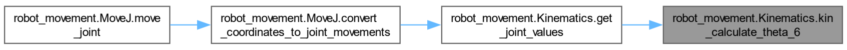
```
robot_movement.Kinematics.kin_calculate_theta_6 (
              self,
              rot_matrix,
              theta_5 )
```

```
 Calculates theta 6
 :param rot_matrix: Rotation matrix describing rotation from link 4 to link 6.
 :param theta_5: Value for theta 5
 :return: Returns the value for theta 6
```

Definition at line 444 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

Here is the caller graph for this function:


robot_movement.MoveJ.move_joint
robot_movement.MoveJ.convert_coordinates_to_joint_movements
robot_movement.Kinematics.get_joint_values
robot_movement.Kinematics.kin_calculate_theta_6

6.10.4 Field Documentation

6.10.4.1 dh_value_a

```
robot_movement.Kinematics.dh_value_a
```

Definition at line 231 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values(), and robot_movement.Kinematics.kin_calculate_theta_2_3().

6.10.4.2 dh_value_alpha

```
robot_movement.Kinematics.dh_value_alpha
```

Definition at line 230 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values().

6.10.4.3 dh_value_d

```
robot_movement.Kinematics.dh_value_d
```

Definition at line 232 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values(), and robot_movement.Kinematics.kin_calculate_theta_1().

6.10.4.4 dh_value_theta

```
robot_movement.Kinematics.dh_value_theta
```

Definition at line 233 of file robot_movement.py.

Referenced by robot_movement.Kinematics.get_joint_values(), and robot_movement.Kinematics.kin_calculate_theta_4().

6.10.4.5 robot_controller_settings

```
robot_movement.Kinematics.robot_controller_settings
```

Definition at line 229 of file robot_movement.py.

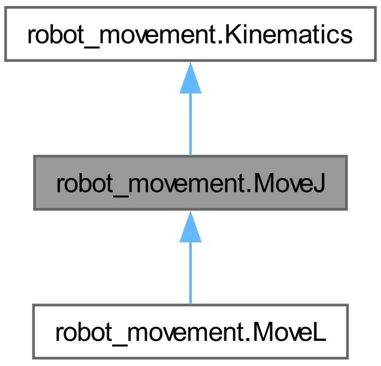
Referenced by robot_movement.MoveL.get_linear_via_points(), and robot_movement.MoveJ.move_joint().

The documentation for this class was generated from the following file:

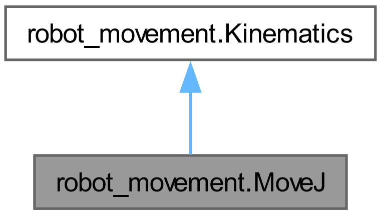
- robot_movement.py

6.11 robot_movement.MoveJ Class Reference

Inheritance diagram for robot_movement.MoveJ:



Collaboration diagram for robot_movement.MoveJ:



Public Member Functions

- __init__ (self, robot_pointer, positions_with_time)
- convert_coordinates_to_joint_movements (self)
- move_joint (self)

Public Member Functions inherited from robot_movement.Kinematics

- get_joint_values (self, coordinate, orientation)
- kin_calculate_theta_1 (self, T_link0_link6)
- kin_calculate_theta_2_3 (self, T_link2_link3)
- kin_calculate_theta_4 (self, rot_matrix, theta_5)
- kin_calculate_theta_5 (self, rot_matrix)
- kin_calculate_theta_6 (self, rot_matrix, theta_5)

Data Fields

- robot
- pos_w_time
- start_joint_values
- joint_matrix

Data Fields inherited from robot_movement.Kinematics

- robot_controller_settings
- dh_value_alpha
- dh_value_a
- dh_value_d
- dh_value_theta

6.11.1 Detailed Description

```
Class for moving in joint space
```

Definition at line 456 of file robot_movement.py.

6.11.2 Constructor & Destructor Documentation

6.11.2.1 __init__()

```
robot_movement.MoveJ.__init__ (
              self,
              robot_pointer,
              positions_with_time )
```

```
Constructor for the MoveJ class. Takes the robot and position.
:param robot_pointer: A pointer to the robot class for the robot
:param positions_with_time: The position with time.
```

Reimplemented from robot_movement.Kinematics.

Reimplemented in robot_movement.MoveL.

Definition at line 460 of file robot_movement.py.

6.11.3 Member Function Documentation

6.11.3.1 convert_coordinates_to_joint_movements()

```
robot_movement.MoveJ.convert_coordinates_to_joint_movements (
              self )
```

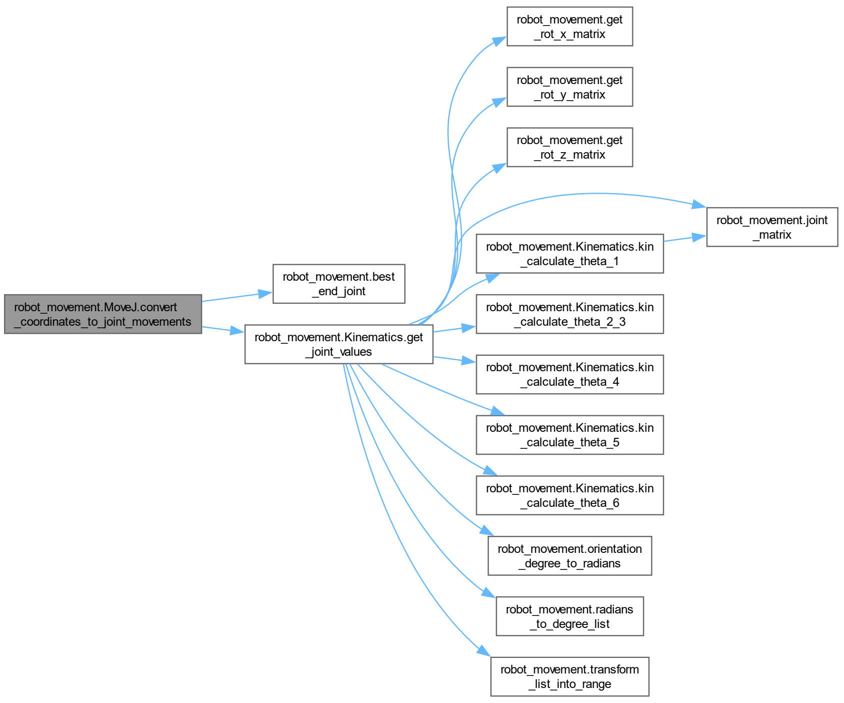
```
Method that converts the coordinates into joint degrees for each via point and end position.
:return: Returns the transformed matrix.
```

Definition at line 488 of file robot_movement.py.

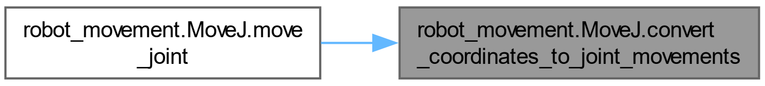
References robot_movement.best_end_joint(), robot_movement.Kinematics.get_joint_values(), robot_movement.MoveJ.pos_w_time, robot_movement.MoveL.pos_w_time, and robot_movement.MoveJ.start_joint_values.

Referenced by robot_movement.MoveJ.move_joint().

Here is the call graph for this function:



Here is the caller graph for this function:


robot_movement.MoveJ.move
_joint
robot_movement.MoveJ.convert
_coordinates_to_joint_movements

6.11.3.2 move_joint()

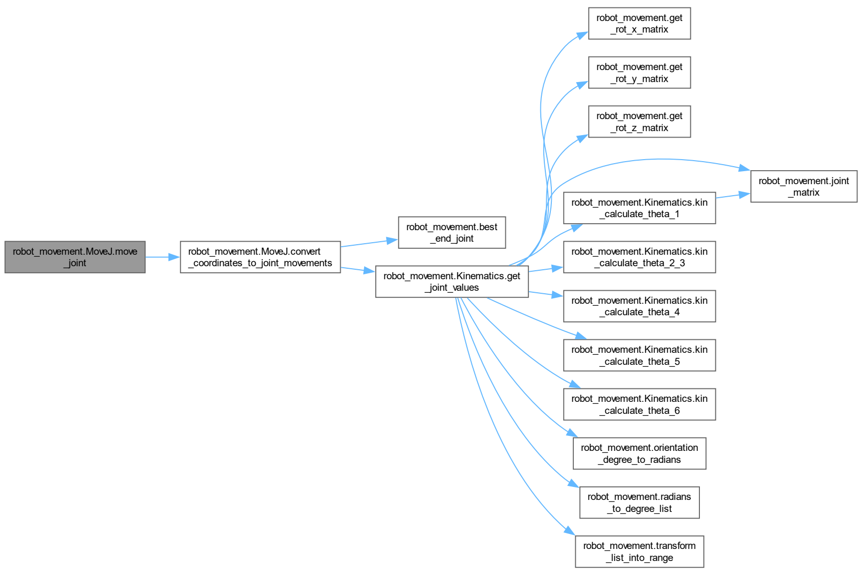
```
robot_movement.MoveJ.move_joint (
              self )
```

```
Method for moving the robot in the joint space thrugh the different via points.
```

Definition at line 517 of file robot_movement.py.

References robot_movement.MoveJ.convert_coordinates_to_joint_movements(), robot_movement.MoveJ.joint_matrix, robot_movement.MoveJ.pos_w_time, robot_movement.MoveL.pos_w_time, main.Main.robot, robot_movement.MoveJ.robot, robot_movement.MoveL.robot, and robot_movement.Kinematics.robot_controller_settings.

Here is the call graph for this function:


robot_movement.MoveJ.move _joint
robot_movement.MoveJ.convert _coordinates_to_joint_movements
robot_movement.best _end_joint
robot_movement.Kinematics.get _joint_values
robot_movement.get _rot_x_matrix
robot_movement.get _rot_y_matrix
robot_movement.get _rot_z_matrix
robot_movement.joint _matrix
robot_movement.Kinematics.kin _calculate_theta_1
robot_movement.Kinematics.kin _calculate_theta_2_3
robot_movement.Kinematics.kin _calculate_theta_4
robot_movement.Kinematics.kin _calculate_theta_5
robot_movement.Kinematics.kin _calculate_theta_6
robot_movement.orientation _degree_to_radians
robot_movement.radians _to_degree_list
robot_movement.transform _list_into_range

6.11.4 Field Documentation

6.11.4.1 joint_matrix

```
robot_movement.MoveJ.joint_matrix
```

Definition at line 486 of file robot_movement.py.

Referenced by robot_movement.MoveJ.move_joint().

6.11.4.2 pos_w_time

```
robot_movement.MoveJ.pos_w_time
```

Definition at line 467 of file robot_movement.py.

Referenced by robot_movement.MoveJ.convert_coordinates_to_joint_movements(), and robot_movement.MoveJ.move_joint().

6.11.4.3 robot

```
robot_movement.MoveJ.robot
```

Definition at line 466 of file robot_movement.py.

Referenced by main.Main.dispense_allergen(), robot_movement.MoveJ.move_joint(), main.Main.place_allergen(), main.Main.run(), main.Main.set_mode(), and main.Main.take_allergen().

6.11.4.4 start_joint_values

```
robot_movement.MoveJ.start_joint_values
```

Definition at line 468 of file robot_movement.py.

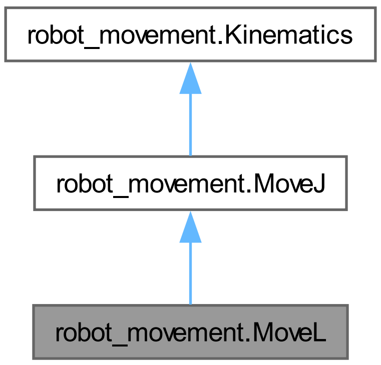
Referenced by robot_movement.MoveJ.convert_coordinates_to_joint_movements().

The documentation for this class was generated from the following file:

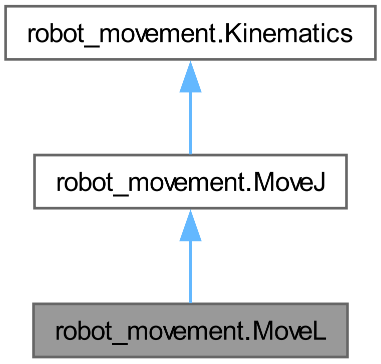
- robot_movement.py

6.12 robot_movement.MoveL Class Reference

Inheritance diagram for robot_movement.MoveL:



Collaboration diagram for robot_movement.MoveL:



Public Member Functions

- __init__ (self, robot_pointer, positions_with_time)
- get_linear_via_points (self)

Public Member Functions inherited from robot_movement.MoveJ

- convert_coordinates_to_joint_movements (self)
- move_joint (self)

Public Member Functions inherited from robot_movement.Kinematics

- get_joint_values (self, coordinate, orientation)
- kin_calculate_theta_1 (self, T_link0_link6)
- kin_calculate_theta_2_3 (self, T_link2_link3)
- kin_calculate_theta_4 (self, rot_matrix, theta_5)
- kin_calculate_theta_5 (self, rot_matrix)
- kin_calculate_theta_6 (self, rot_matrix, theta_5)

Data Fields

- robot
- pos_w_time_linear
- move_time
- start_pos_cartesian
- pos_w_time

Data Fields inherited from robot_movement.MoveJ

- robot
- pos_w_time
- start_joint_values
- joint_matrix

Data Fields inherited from robot_movement.Kinematics

- robot_controller_settings
- dh_value_alpha
- dh_value_a
- dh_value_d
- dh_value_theta

6.12.1 Detailed Description

```
Class for moving in cartesian space.
```

Definition at line 583 of file robot_movement.py.

6.12.2 Constructor & Destructor Documentation

6.12.2.1 __init__()

```
robot_movement.MoveL.__init__ (
              self,
              robot_pointer,
              positions_with_time )
```

```
Constructor for MoveL class
:param robot_pointer: Pointer to robot controller
:param positions_with_time: Position for where the robot should move to.
```

Reimplemented from robot_movement.MoveJ.

Definition at line 587 of file robot_movement.py.

6.12.3 Member Function Documentation

6.12.3.1 get_linear_via_points()

```
robot_movement.MoveL.get_linear_via_points (
              self )
```

```
Method for getting all via points on the path, the robot moves on.
:return: Returns the coordinates which will be used as via points in the joint movement.
```

Definition at line 618 of file robot_movement.py.

References robot_movement.MoveL.move_time, robot_movement.MoveL.pos_w_time_linear, robot_movement.Kinematics.robot_cor
and robot_movement.MoveL.start_pos_cartesian.

6.12.4 Field Documentation

6.12.4.1 move_time

```
robot_movement.MoveL.move_time
```

Definition at line 595 of file robot_movement.py.

Referenced by robot_movement.MoveL.get_linear_via_points().

6.12.4.2 pos_w_time

```
robot_movement.MoveL.pos_w_time
```

Definition at line 616 of file robot_movement.py.

Referenced by robot_movement.MoveJ.convert_coordinates_to_joint_movements(), and robot_movement.MoveJ.move_joint().

6.12.4.3 pos_w_time_linear

```
robot_movement.MoveL.pos_w_time_linear
```

Definition at line 594 of file robot_movement.py.

Referenced by robot_movement.MoveL.get_linear_via_points().

6.12.4.4 robot

```
robot_movement.MoveL.robot
```

Definition at line 593 of file robot_movement.py.

Referenced by main.Main.dispense_allergen(), robot_movement.MoveJ.move_joint(), main.Main.place_allergen(), main.Main.run(), main.Main.set_mode(), and main.Main.take_allergen().

6.12.4.5 start_pos_cartesian

```
robot_movement.MoveL.start_pos_cartesian
```

Definition at line 613 of file robot_movement.py.

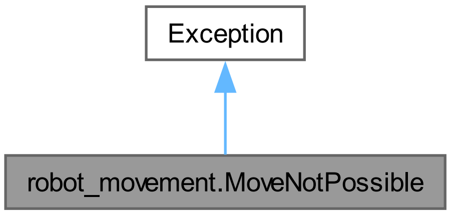
Referenced by robot_movement.MoveL.get_linear_via_points().

The documentation for this class was generated from the following file:

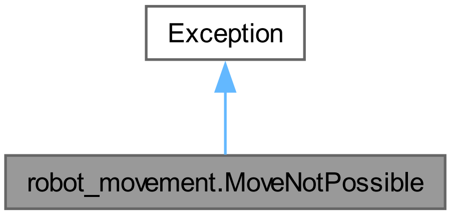
- robot_movement.py

6.13 robot_movement.MoveNotPossible Class Reference

Inheritance diagram for robot_movement.MoveNotPossible:



Collaboration diagram for robot_movement.MoveNotPossible:



6.13.1 Detailed Description

```
Used for error handling. Also the reason for the inheritance of Exception. The following error is described as

MoveNotPossible: The given movement command can not be executed by the program. Please make sure that it dies
```

Definition at line 25 of file robot_movement.py.

The documentation for this class was generated from the following file:

- robot_movement.py

6.14 robot_movement.Robot Class Reference

Public Member Functions

- __init__ (self, rdk_link)
- set_joints (self, position, robot_speed=100)

Data Fields

- robot_settings
- rdk_link
- prev_position
- time_between_move
- max_joint_speed

6.14.1 Detailed Description

```
Robot class used to talk with RoboDK and the correct robot
```

Definition at line 651 of file robot_movement.py.

6.14.2 Constructor & Destructor Documentation

6.14.2.1 __init__()

```
robot_movement.Robot.__init__ (
              self,
              rdk_link )
```

```
Constructor for class
```

Definition at line 655 of file robot_movement.py.

6.14.3 Member Function Documentation

6.14.3.1 set_joints()

```
robot_movement.Robot.set_joints (
              self,
              position,
              robot_speed = 100 )
```

```
Sets the joint values for the robot
:param position: Position in joint space.
:param robot_speed: Not used due to it not being neccessary, but has to be there in order to use the class tog
```

Definition at line 666 of file robot_movement.py.

References robot_movement.Robot.max_joint_speed, robot_movement.Robot.prev_position, robot_movement.Robot.rdk_link, robot_movement.RobotMyCobotAndSim.rdk_link, and robot_movement.Robot.time_between_move.

6.14.4 Field Documentation

6.14.4.1 max_joint_speed

`robot_movement.Robot.max_joint_speed`

Definition at line 664 of file robot_movement.py.

Referenced by robot_movement.Robot.set_joints().

6.14.4.2 prev_position

`robot_movement.Robot.prev_position`

Definition at line 662 of file robot_movement.py.

Referenced by robot_movement.Robot.set_joints().

6.14.4.3 rdk_link

`robot_movement.Robot.rdk_link`

Definition at line 661 of file robot_movement.py.

Referenced by robot_movement.Robot.set_joints(), and robot_movement.RobotMyCobotAndSim.set_joints().

6.14.4.4 robot_settings

`robot_movement.Robot.robot_settings`

Definition at line 659 of file robot_movement.py.

6.14.4.5 time_between_move

`robot_movement.Robot.time_between_move`

Definition at line 663 of file robot_movement.py.

Referenced by robot_movement.Robot.set_joints().

The documentation for this class was generated from the following file:

- robot_movement.py

6.15 robot_movement.RobotMyCobot Class Reference

Public Member Functions

- __init__ (self, robo_link)
- set_joints (self, position, robot_speed=100)

Data Fields

- robo_link

6.15.1 Detailed Description

```
Robot class used to talk with MyCobot 320 PI
```

Definition at line 684 of file robot_movement.py.

6.15.2 Constructor & Destructor Documentation

6.15.2.1 __init__()

```
robot_movement.RobotMyCobot.__init__ (
              self,
              robo_link )
```

```
Constructor for class
```

Definition at line 688 of file robot_movement.py.

6.15.3 Member Function Documentation

6.15.3.1 set_joints()

```
robot_movement.RobotMyCobot.set_joints (
              self,
              position,
              robot_speed = 100 )
```

```
Sets the joint values for the robot
:param position: Position in joint space.
:param robot_speed: Value between 0-100 setting the robot's speed.
```

Definition at line 694 of file robot_movement.py.

References robot_movement.RobotMyCobot.robo_link, and robot_movement.RobotMyCobotAndSim.robo_link.

6.15.4 Field Documentation

6.15.4.1 robo_link

```
robot_movement.RobotMyCobot.robo_link
```

Definition at line 692 of file robot_movement.py.

Referenced by robot_movement.RobotMyCobot.set_joints(), and robot_movement.RobotMyCobotAndSim.set_joints().

The documentation for this class was generated from the following file:

- robot_movement.py

6.16 robot_movement.RobotMyCobotAndSim Class Reference

Public Member Functions

- __init__ (self, robo_link, rdk_link)
- set_joints (self, position, robot_speed=100)

Data Fields

- rdk_link
- robo_link

6.16.1 Detailed Description

```
Robot class used to talk with MyCobot 320 PI and RoboDK
```

Definition at line 709 of file robot_movement.py.

6.16.2 Constructor & Destructor Documentation

6.16.2.1 __init__()

```
robot_movement.RobotMyCobotAndSim.__init__ (
                self,
                robo_link,
                rdk_link )
```

```
Constructor for class
```

Definition at line 713 of file robot_movement.py.

6.16.3 Member Function Documentation

6.16.3.1 set_joints()

```
robot_movement.RobotMyCobotAndSim.set_joints (
                self,
                position,
                robot_speed = 100 )
```

```
Sets the joint values for the robot
:param position: Position in joint space.
:param robot_speed: Value between 0-100 setting the robot's speed.
```

Definition at line 720 of file robot_movement.py.

References robot_movement.Robot.rdk_link, robot_movement.RobotMyCobotAndSim.rdk_link, robot_movement.RobotMyCobot.robo
and robot_movement.RobotMyCobotAndSim.robo_link.

6.16.4 Field Documentation

6.16.4.1 rdk_link

```
robot_movement.RobotMyCobotAndSim.rdk_link
```

Definition at line 717 of file robot_movement.py.

Referenced by robot_movement.Robot.set_joints(), and robot_movement.RobotMyCobotAndSim.set_joints().

6.16.4.2 robo_link

```
robot_movement.RobotMyCobotAndSim.robo_link
```

Definition at line 718 of file robot_movement.py.

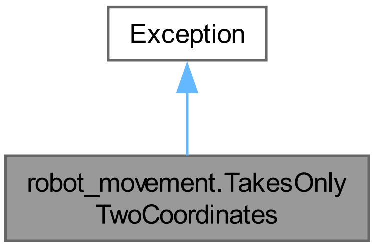
Referenced by robot_movement.RobotMyCobot.set_joints(), and robot_movement.RobotMyCobotAndSim.set_joints().

The documentation for this class was generated from the following file:

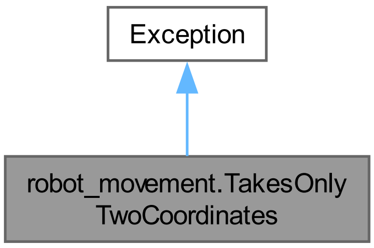
- robot_movement.py

6.17 robot_movement.TakesOnlyTwoCoordinates Class Reference

Inheritance diagram for robot_movement.TakesOnlyTwoCoordinates:



Collaboration diagram for robot_movement.TakesOnlyTwoCoordinates:



6.17.1 Detailed Description

```
Used for error handling. Also the reason for the inheritance of Exception. The following error is described as

TakesOnlyTwoCoordinates: This class takes only two coordinates.
```

Definition at line 43 of file robot_movement.py.

The documentation for this class was generated from the following file:

- robot_movement.py

Chapter 7

File Documentation

7.1 commands.py File Reference

Namespaces

- namespace commands

Variables

- str commands.HOME_GRIPPER = "home -g"
- str commands.CLOSE_GRIPPER = "close"
- str commands.HOME_PRESSER = "home -p"
- str commands.PREPARE_PRESSING = "prepare pressing"
- str commands.PRESS_ALLERGEN = "press -"
- str commands.NEW_TEST = "new test"
- str commands.RESPONSE = "b'Done'"
- str commands.EMPTY = "b''"

7.2 commands.py

Go to the documentation of this file.

```
HOME_GRIPPER = "home -g"
CLOSE_GRIPPER = "close"

HOME_PRESSER = "home -p"
PREPARE_PRESSING = "prepare pressing"
PRESS_ALLERGEN = "press -"

NEW_TEST = "new test"

RESPONSE = "b'Done'"
EMPTY = "b''"
```

7.3 communication.py File Reference

Data Structures

- class communication.SerialCommunicationUnknownResponse
- class communication.CommunicationProtocol

Namespaces

- namespace communication

Variables

- str communication.SERIAL_COMMUNICATION_UNKNOWN_RESPONSE_ERROR_MSG = "Serial↩ CommunicationUnknownResponse: The received serial response was not valid."
- communication.com_test = CommunicationProtocol("COM3", 9600, 0.1)

7.4 communication.py

Go to the documentation of this file.

```
import serial
import commands as cmd
import time as t


SERIAL_COMMUNICATION_UNKNOWN_RESPONSE_ERROR_MSG = "SerialCommunicationUnknownResponse: The received
serial response was not valid."


class SerialCommunicationUnknownResponse(Exception):
    """
    Used for error handling. Also the reason for the inheritance of Exception. The following error is
described as the following:

    SerialCommunicationUnknownResponse: The received serial response was not valid.
    """
    pass


class CommunicationProtocol:
    def __init__(self, com, baudrate, timeout):
        self.com = com
        self.baudrate = baudrate
        self.timeout = timeout
        self.connection = serial.Serial(port=self.com, baudrate=self.baudrate, timeout=self.timeout)

    def send_command(self, command):
        self.connection.write(bytes(command, 'utf-8'))

        while True:
            resp = str(self.connection.readline())
            print(resp)

            if resp == cmd.RESPONSE:
                break

            if resp != cmd.EMPTY:
                raise
SerialCommunicationUnknownResponse(SERIAL_COMMUNICATION_UNKNOWN_RESPONSE_ERROR_MSG)


if __name__ == "__main__":
    com_test = CommunicationProtocol("COM3", 9600, 0.1)
    t.sleep(5)
    com_test.send_command(cmd.HOME_PRESSER)
    com_test.send_command(cmd.HOME_GRIPPER)
    com_test.send_command(cmd.CLOSE_GRIPPER)
    t.sleep(5)
    com_test.send_command(cmd.PREPARE_PRESSING)
    com_test.send_command(cmd.PRESS_ALLERGEN + "2500")

```

7.5 gui.py File Reference

Data Structures

- class gui.Light
- class gui.GUI

Namespaces

- namespace gui

Variables

- gui.test = GUI()

7.6 gui.py

Go to the documentation of this file.

```
from tkinter import *


class Light(Canvas):
    """
    Class to construct an oval element in the GUI
    """
    def __init__(self, master, **kwargs):
        """
        initializer
        :param master: the root of the tkinter menu
        :param kwargs: possible arguments for the canvas.
        """
        Canvas.__init__(self, master, width=50, height=50, **kwargs)
        self.oval_id = self.create_oval(2, 2, 50, 50, fill='gray')

    def turn_on(self):
        """
        Changes the color of the oval to green
        """
        self.itemconfig(self.oval_id, fill='green')

    def turn_off(self):
        """
        Changes the color of the oval to gray
        """
        self.itemconfig(self.oval_id, fill='gray')

    def turn_ready(self):
        """
        Changes the color of the oval to red
        """
        self.itemconfig(self.oval_id, fill='yellow')


class GUI:
    """
    Main class for the GUI
    """
    def __init__(self):
        """
        Initializer for tkinter menu
        """
        self.root = Tk()
        self.pressed_buttons = set()

        self.mode = None
        self.running = False

        self.button_START = Button(self.root, text="START", padx=150, pady=50, state=DISABLED,
command=self.start_pressed, fg="black",
                                   bg="green")
        self.button_STOP = Button(self.root, text="STOP", padx=140, pady=50, state=NORMAL,
command=self.stop_pressed_init, fg="black",
                                   bg="red")
        self.button_SELECT_ROBOT = Button(self.root, text="Execute program on robot", padx=150,
pady=50, state=NORMAL, command=self.robot_pressed, fg="white",
                                   bg="black")
        self.button_SELECT_SIMULATION = Button(self.root, text="Execute program in simulation",
padx=150, pady=50, state=NORMAL, command=self.simulation_pressed,
                                   fg="white", bg="black")
        self.button_SELECT_BOTH = Button(self.root, text="Execute program on robot and in simulation",
padx=100, pady=50, state=NORMAL, command=self.both_pressed,
                                   fg="white", bg="black")

        self.button_START.grid(row=0, column=0, padx=10, pady=10)
        self.button_STOP.grid(row=0, column=2, padx=10, pady=10)
        self.button_SELECT_ROBOT.grid(row=1, column=0, padx=10, pady=10)
        self.button_SELECT_SIMULATION.grid(row=1, column=1, padx=10, pady=10)
        self.button_SELECT_BOTH.grid(row=1, column=2, padx=10, pady=10)

        self.light_SELECT_ROBOT = Light(self.root)
        self.light_SELECT_ROBOT.grid(row=2, column=0, padx=10, pady=10)

        self.light_SELECT_SIMULATION = Light(self.root)
        self.light_SELECT_SIMULATION.grid(row=2, column=1, padx=10, pady=10)

        self.light_SELECT_BOTH = Light(self.root)
        self.light_SELECT_BOTH.grid(row=2, column=2, padx=10, pady=10)

        self.title = Label(self.root, text="Patch test preparer")
        self.title.grid(row=0, column=1)

    def start_pressed(self):
        """
        Button method for when clicking on the start button
        """
        self.button_START["state"] = NORMAL
        self.button_STOP["state"] = NORMAL
        self.button_SELECT_ROBOT["state"] = DISABLED
        self.button_SELECT_SIMULATION["state"] = DISABLED
        self.button_SELECT_BOTH["state"] = DISABLED

        if "Robot" in self.pressed_buttons:
            self.light_SELECT_ROBOT.turn_on()
            self.mode = "robot"
        else:
            self.light_SELECT_ROBOT.turn_off()

        if "Simulation" in self.pressed_buttons:
            self.light_SELECT_SIMULATION.turn_on()
            self.mode = "simulation"
        else:
            self.light_SELECT_SIMULATION.turn_off()

        if "Robot and Simulation" in self.pressed_buttons:
            self.light_SELECT_BOTH.turn_on()
            self.mode = "both"
        else:
            self.light_SELECT_BOTH.turn_off()

        self.running = True

    def stop_pressed_init(self):
        """
        Button method for when clicking on the stop button
        """
        self.mode = None

        self.button_START["state"] = DISABLED
        self.button_STOP["state"] = DISABLED
        self.button_SELECT_ROBOT["state"] = DISABLED
        self.button_SELECT_SIMULATION["state"] = DISABLED
        self.button_SELECT_BOTH["state"] = DISABLED

        self.light_SELECT_ROBOT.turn_off()
        self.light_SELECT_SIMULATION.turn_off()
        self.light_SELECT_BOTH.turn_off()

        self.pressed_buttons.clear()

        if self.running:
            self.running = False
        else:
            self.stop_pressed()

    def stop_pressed(self):
        """
        Button method for when the program has run the stop command and the buttons should be clickable again.
        """
        self.button_START["state"] = DISABLED
        self.button_STOP["state"] = NORMAL
        self.button_SELECT_ROBOT["state"] = NORMAL
        self.button_SELECT_SIMULATION["state"] = NORMAL
        self.button_SELECT_BOTH["state"] = NORMAL

    def robot_pressed(self):
        """
        Button method for when clicking on the 'Execute program on robot'
        """
        self.pressed_buttons.add("Robot")

        self.button_START["state"] = NORMAL
        self.button_STOP["state"] = NORMAL
        self.button_SELECT_ROBOT["state"] = NORMAL
        self.button_SELECT_SIMULATION["state"] = DISABLED
        self.button_SELECT_BOTH["state"] = DISABLED

        self.light_SELECT_ROBOT.turn_ready()
        self.light_SELECT_SIMULATION.turn_off()
        self.light_SELECT_BOTH.turn_off()

    def simulation_pressed(self):
        """
        Button method for when clicking on the 'Execute program in simulation'
        """
        self.pressed_buttons.add("Simulation")

        self.button_START["state"] = NORMAL
        self.button_STOP["state"] = NORMAL
        self.button_SELECT_ROBOT["state"] = DISABLED
        self.button_SELECT_SIMULATION["state"] = NORMAL
        self.button_SELECT_BOTH["state"] = DISABLED

        self.light_SELECT_ROBOT.turn_off()
        self.light_SELECT_SIMULATION.turn_ready()
        self.light_SELECT_BOTH.turn_off()

    def both_pressed(self):
        """
        Button method for when clicking on the 'Execute program on robot and in simulation'
        """
        self.pressed_buttons.add("Robot and Simulation")

        self.button_START["state"] = NORMAL
        self.button_STOP["state"] = NORMAL
        self.button_SELECT_ROBOT["state"] = DISABLED
        self.button_SELECT_SIMULATION["state"] = DISABLED
        self.button_SELECT_BOTH["state"] = NORMAL

        self.light_SELECT_ROBOT.turn_off()
        self.light_SELECT_SIMULATION.turn_off()
        self.light_SELECT_BOTH.turn_ready()

    def run(self):
        """
        Runs the program
        """
        self.root.mainloop()


if __name__ == "__main__":
    test = GUI()
    test.run()
```

7.7 main.py File Reference

Data Structures

- class main.Main

Namespaces

- namespace main

Functions

- main.communication_multi_thread (communicator, command)

Variables

- bool main.BOTH = True
- bool main.SIMULATING = False
- int main.Z_OFFSET = 0
- int main.STORAGE_OFFSET_X = 30
- int main.SYRINGE_OFFSET_X = -18
- int main.SYRINGE_MOVEMENT_Z = 25
- int main.SPEED = 1/0.5
- main.ALLERGEN_AMOUNT = str(150)
- int main.END_EFFECTOR_TILT_TAKE = 85
- int main.END_EFFECTOR_TILT_PLACE = 89
- list main.PATCH_TEST_CORNER_COORDINATES = [-215, -265, 215]
- list main.SYRINGE_COORDINATES
- bool main.performing_command = False
- main.main = Main()

7.8 main.py

Go to the documentation of this file.

```
from robot_movement import MoveJ, MoveL, Robot, Kinematics, RobotMyCobot, RobotMyCobotAndSim
from gui import GUI
from robodk.robolink import *
from pymycobot.mycobot import MyCobot
from communication import CommunicationProtocol


import threading
import commands as cmd
import time as t
import math as m


BOTH = True
SIMULATING = False
Z_OFFSET = 0
STORAGE_OFFSET_X = 30
SYRINGE_OFFSET_X = -18
SYRINGE_MOVEMENT_Z = 25
SPEED = 1/0.5
ALLERGEN_AMOUNT = str(150)
END_EFFECTOR_TILT_TAKE = 85
END_EFFECTOR_TILT_PLACE = 89


PATCH_TEST_CORNER_COORDINATES = [-215, -265, 215]


SYRINGE_COORDINATES = [
    [305, 169.5+5, 153.5+5],
    [310, 94.5, 153.5+5],
    [310, 19.5, 153.5+5],
    [310, -65.5, 153.5+5],
    [305, -140.5, 153.5+5],
    [310, 132+5, 78],
    [310, 57, 76],
    [310, -28-5, 76],
    [310, -106-5, 76],
    [310, -184-5, 78]
]


performing_command = False


def communication_multi_thread(communicator, command):
    """
    Executes a command on the arduino using multi_threading
    :param communicator: instance of the communication class
    :param command: command to execute.
    """
    global performing_command

    performing_command = True
    communicator.send_command(command)
    performing_command = False


class Main:
    """
    Main class containing the whole program.
    """
    def __init__(self):
        """
        Connecting to ROBODK or MyCobot.
        """
        self.communication = CommunicationProtocol("COM3", 9600, 0.1)
        t.sleep(5)

        self.patch_test_config = [0, 1,
                                  2, 3,
                                  4, 5,
                                  6, 7,
                                  8, 9]

        self.robot = None

        self.gui_created = False
        self.gui_thread = threading.Thread(target=self.create_gui)
        self.gui_thread.start()

        while not self.gui_created:
            continue

        while not self.gui.running:
            continue

        self.set_mode(self.gui.mode)

    def create_gui(self):
        """
        Creates the GUI
        """
        self.gui = GUI()

        self.gui_created = True

        self.gui.run()

    def set_mode(self, mode):
        """
        Sets the mode for how the robot should run
        :param mode: either "both", "simulation", "robot".
        """
        if mode == "both":
            RDK = Robolink()
            rdk_link = RDK.Item('My Mechanism')
            my_cobot = MyCobot('COM4', 115200)

            self.robot = RobotMyCobotAndSim(my_cobot, rdk_link)
            self.robot.set_joints([0, 0, 0, 0, 0, 0], robot_speed=20)
            #self.communication.send_command(cmd.HOME_PRESSER)
            #self.communication.send_command(cmd.PREPARE_PRESSING)
            #self.communication.send_command(cmd.HOME_GRIPPER)
            #self.communication.send_command(cmd.CLOSE_GRIPPER)

        elif mode == "simulation":
            RDK = Robolink()
            rdk_link = RDK.Item('My Mechanism')
            self.robot = Robot(rdk_link)

        elif mode == "robot":
            my_cobot = MyCobot('COM4', 115200)

            my_cobot.set_free_mode(0)
            self.robot = RobotMyCobot(my_cobot)
            self.robot.set_joints([0, 0, 0, 0, 0, 0], robot_speed=20)

        self.run()

    def run(self):
        """
        Runs the whole program sequence
        """
        # Homing sekvens

        self.communication.send_command(cmd.HOME_PRESSER)
        self.communication.send_command(cmd.HOME_GRIPPER)

        self.communication.send_command(cmd.NEW_TEST)

        self.robot.set_joints([107.38158881112184, 46.157985403753784, 103.3563681945703, 30.485646401675925, 107.38158881112184, 135.0], robot_speed=20)

        t.sleep(5)

        for patch_text_index_number in range(len(self.patch_test_config)):

            self.take_allergen(self.patch_test_config[patch_text_index_number])

            MoveL(self.robot, [[260, -132-37.5, 153.5-Z_OFFSET, -90, 90, -90, 1.75 * SPEED]]).move_joint()
            MoveJ(self.robot, [[0, -350, PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET, -90, 90, 135+45, 0.5 * SPEED], [PATCH_TEST_CORNER_COORDINATES[0], PATCH_TEST_CORNER_COORDINATES[1], PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET, -90, 90, 135, 1 * SPEED]]).move_joint()

            self.dispense_allergen(patch_text_index_number)

            MoveJ(self.robot, [[0, -350, PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET, -90, 90, 135+45, 0.5 * SPEED], [260, -132-37.5, 153.5-Z_OFFSET, -90, 90, -90, 1 * SPEED]]).move_joint()

            self.place_allergen(self.patch_test_config[patch_text_index_number])

            if not self.gui.running:
                break

        self.gui.running = False
        self.gui.stop_pressed()

        # Waiting on a new start
        while not self.gui.running:
            continue

        self.set_mode(self.gui.mode)

    def dispense_allergen(self, index):
        """
        Runs the movements needed to dispense allergen onto a patch test
        :param index: What index the position on the patch test has
        :return: None
        """
        x_offset = (index % 2) * 20.5
        y_offset = m.floor(index / 2) * 20.5

        MoveL(self.robot, [[PATCH_TEST_CORNER_COORDINATES[0] - x_offset, PATCH_TEST_CORNER_COORDINATES[1] + y_offset, PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET, -90, 90, 135, 1 * SPEED]]).move_joint()
        MoveL(self.robot, [[PATCH_TEST_CORNER_COORDINATES[0] - x_offset, PATCH_TEST_CORNER_COORDINATES[1] + y_offset, PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET-10, -90, 90, 135, 0.5 * SPEED]]).move_joint()

        while performing_command:
            continue

        self.communication.send_command(cmd.PRESS_ALLERGEN + ALLERGEN_AMOUNT)

        MoveL(self.robot, [[PATCH_TEST_CORNER_COORDINATES[0] - x_offset, PATCH_TEST_CORNER_COORDINATES[1] + y_offset, PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET, -90, 90, 135, 0.5 * SPEED]]).move_joint()

        thread = threading.Thread(target=communication_multi_thread, args=(self.communication, cmd.HOME_PRESSER))
        thread.start()

        MoveL(self.robot, [[PATCH_TEST_CORNER_COORDINATES[0], PATCH_TEST_CORNER_COORDINATES[1], PATCH_TEST_CORNER_COORDINATES[2]-Z_OFFSET, -90, 90, 135, 1 * SPEED]]).move_joint()

    def take_allergen(self, index):
        """
        Takes an allergen from the storage
        :param index: Index for the allergen in the storage system
        :return: None
        """

        x = SYRINGE_COORDINATES[index][0]
        y = SYRINGE_COORDINATES[index][1]
        z = SYRINGE_COORDINATES[index][2]

        MoveL(self.robot, [[x + SYRINGE_OFFSET_X - STORAGE_OFFSET_X, y, z - Z_OFFSET, 0, END_EFFECTOR_TILT_TAKE, 0,
                            1.75 * SPEED]]).move_joint()

        MoveL(self.robot, [[x + SYRINGE_OFFSET_X, y, z - Z_OFFSET, 0, END_EFFECTOR_TILT_TAKE, 0,
                            0.75 * SPEED]]).move_joint()

        self.communication.send_command(cmd.CLOSE_GRIPPER)

        thread = threading.Thread(target=communication_multi_thread, args=(self.communication,
cmd.PREPARE_PRESSING))
        thread.start()

        MoveL(self.robot, [
            [x + SYRINGE_OFFSET_X, y, z + SYRINGE_MOVEMENT_Z - Z_OFFSET, 0, END_EFFECTOR_TILT_TAKE, 0,
             0.75 * SPEED]]).move_joint()
        MoveL(self.robot, [
            [x + SYRINGE_OFFSET_X - STORAGE_OFFSET_X, y, z + SYRINGE_MOVEMENT_Z - Z_OFFSET, 0,
END_EFFECTOR_TILT_TAKE, 0,
             0.75 * SPEED]]).move_joint()

    def place_allergen(self, index):
        """
        Places an allergen in storage
        :param index: Index for storage place
        :return: None
        """

        x = SYRINGE_COORDINATES[index][0]
        y = SYRINGE_COORDINATES[index][1]
        z = SYRINGE_COORDINATES[index][2]

        MoveL(self.robot, [[x + SYRINGE_OFFSET_X - STORAGE_OFFSET_X, y, z + SYRINGE_MOVEMENT_Z -
Z_OFFSET, 0, END_EFFECTOR_TILT_PLACE, 0, 1.75 * SPEED]]).move_joint()
        MoveL(self.robot, [[x + SYRINGE_OFFSET_X, y, z + SYRINGE_MOVEMENT_Z - Z_OFFSET, 0,
END_EFFECTOR_TILT_PLACE, 0, 0.75 * SPEED]]).move_joint()
        MoveL(self.robot, [[x + SYRINGE_OFFSET_X, y, z - Z_OFFSET, 0, END_EFFECTOR_TILT_PLACE, 0, 0.75
* SPEED]]).move_joint()

        while performing_command:
            continue

        self.communication.send_command(cmd.HOME_GRIPPER)

        MoveL(self.robot, [[x + SYRINGE_OFFSET_X - STORAGE_OFFSET_X, y, z - Z_OFFSET, 0,
END_EFFECTOR_TILT_PLACE, 0, 0.75 * SPEED]]).move_joint()


if __name__ == "__main__":
    t.sleep(2)

    main = Main()

```

7.9 robot_controller.py File Reference

Data Structures

- class robot_controller.RobotControllerSettings

Namespaces

- namespace robot_controller

7.10 robot_controller.py

Go to the documentation of this file.

```
import math as m


class RobotControllerSettings:
    """
    Robot controller settings class
    """
    def __init__(self):
        """
        Settings for the robot controller
        """
        self.update_frequency = 30 # hz
        self.linear_frequency = 10 # hz

        self.dh_values = {
            "alpha": [0, m.pi / 2, 0, 0, -m.pi / 2, m.pi / 2],
            "a": [0, 0, 135, 120, 0, 0],
            "d": [173.900, 0, 0, 88.78, 95, 65.5],
            "theta": [m.pi / 2, m.pi / 2, 0, -m.pi / 2, 0, 0]
        }


```

7.11 robot_movement.py File Reference

Data Structures

- class robot_movement.MoveNotPossible
- class robot_movement.JointSyntaxError
- class robot_movement.TakesOnlyTwoCoordinates
- class robot_movement.CoordinateSyntaxError
- class robot_movement.InvalidTimeIncrease
- class robot_movement.Kinematics
- class robot_movement.MoveJ
- class robot_movement.MoveL
- class robot_movement.Robot
- class robot_movement.RobotMyCobot
- class robot_movement.RobotMyCobotAndSim

Namespaces

- namespace robot_movement

Functions

- robot_movement.joint_matrix (alpha, a, d, theta)
- robot_movement.get_rot_x_matrix (angle)
- robot_movement.get_rot_y_matrix (angle)
- robot_movement.get_rot_z_matrix (angle)
- robot_movement.orientation_degree_to_radians (orientation)
- robot_movement.radians_to_degree (angle)
- robot_movement.radians_to_degree_list (list_radians)
- robot_movement.transform_list_into_range (untransformed_list, min_value, max_value, adjuster)
- robot_movement.best_end_joint (current_joint, joints)

Variables

- int robot_movement.MIN_ANGLE_LINK_1_5 = -165 / 180 ∗ m.pi
- int robot_movement.MAX_ANGLE_LINK_1_5 = 165 / 180 ∗ m.pi
- int robot_movement.MIN_ANGLE_LINK_6 = -175 / 180 ∗ m.pi
- int robot_movement.MAX_ANGLE_LINK_6 = 175 / 180 ∗ m.pi
- str robot_movement.MOVE_NOT_POSSIBLE_ERROR_MSG = "MoveNotPossible: The given movement command can not be executed by the program. Please make sure that it dies not result in a singularity"
- str robot_movement.JOINT_SYNTAX_ERROR_MSG = "JointSyntaxError: The syntax must be [Joint1, joint2, joint3, joint4, joint5, joint6] for a joint"
- str robot_movement.TAKES_ONLY_TWO_COORDINATES_ERROR_MSG = "TakesOnlyTwoCoordinates↩ : This class takes only two coordinates."
- str robot_movement.COORDINATE_SYNTAX_ERROR_MSG = "CoordinateSyntaxError: The syntax must be: [x, y, z, alpha, beta, gamma, time] for a coordinate."
- str robot_movement.INVALID_TIME_INCREASE_ERROR_MSG = "InvalidTimeIncrease: Later coordinates must have a higher time than those before or the robot will not be able to move to the given point."
- list robot_movement.robot_joint_position = [107.38158881112184, 46.157985403753784, 103.↩ 3563681945703, 30.485646401675925, 107.38158881112184, 135.0]
- list robot_movement.robot_cartesian_position = [280, 132, 74, -90, 135, -90]

7.12 robot_movement.py

Go to the documentation of this file.

```
import math as m
import time as t
import numpy as np
import random as r

from robot_controller import RobotControllerSettings
from numpy.linalg import inv

MIN_ANGLE_LINK_1_5 = -165 / 180 * m.pi
MAX_ANGLE_LINK_1_5 = 165 / 180 * m.pi
MIN_ANGLE_LINK_6 = -175 / 180 * m.pi
MAX_ANGLE_LINK_6 = 175 / 180 * m.pi

MOVE_NOT_POSSIBLE_ERROR_MSG = "MoveNotPossible: The given movement command can not be executed by the
program. Please make sure that it dies not result in a singularity"
JOINT_SYNTAX_ERROR_MSG = "JointSyntaxError: The syntax must be [Joint1, joint2, joint3, joint4,
joint5, joint6] for a joint"
TAKES_ONLY_TWO_COORDINATES_ERROR_MSG = "TakesOnlyTwoCoordinates: This class takes only two
coordinates."
COORDINATE_SYNTAX_ERROR_MSG = "CoordinateSyntaxError: The syntax must be: [x, y, z, alpha, beta,
gamma, time] for a coordinate."
INVALID_TIME_INCREASE_ERROR_MSG = "InvalidTimeIncrease: Later coordinates must have a higher time than
those before or the robot will not be able to move to the given point."


robot_joint_position = [107.38158881112184, 46.157985403753784, 103.3563681945703, 30.485646401675925,
107.38158881112184, 135.0]
robot_cartesian_position = [280, 132, 74, -90, 135, -90]


class MoveNotPossible(Exception):
    """
    Used for error handling. Also the reason for the inheritance of Exception. The following error is
described as the following:

    MoveNotPossible: The given movement command can not be executed by the program. Please make sure
that it dies not result in a singularity
    """
    pass


class JointSyntaxError(Exception):
    """
    Used for error handling. Also the reason for the inheritance of Exception. The following error is
described as the following:

    JointSyntaxError: The syntax must be [Joint1, joint2, joint3, joint4, joint5, joint6] for a joint
    """
    pass


class TakesOnlyTwoCoordinates(Exception):
    """
    Used for error handling. Also the reason for the inheritance of Exception. The following error is described as the following:

    TakesOnlyTwoCoordinates: This class takes only two coordinates.
    """
    pass


class CoordinateSyntaxError(Exception):
    """
    Used for error handling. Also the reason for the inheritance of Exception. The following error is described as the following:

    CoordinateSyntaxError: The syntax must be: [x, y, z, alpha, beta, gamma, time] for a coordinate.
    """
    pass


class InvalidTimeIncrease(Exception):
    """
    Used for error handling. Also the reason for the inheritance of Exception. The following error is described as the following:

    InvalidTimeIncrease: Later coordinates must have a higher time than those before or the robot will not be able to move to the given point.
    """
    pass


np.set_printoptions(suppress=True)


def joint_matrix(alpha, a, d, theta):
    """
    Function to create transformation matrix.

    :param alpha: alpha value from David Hartenberg parameters.
    :param a: a value from David Hartenberg parameters.
    :param d: d value from David Hartenberg parameters.
    :param theta: theta value from David Hartenberg parameters.
    :return: returns a 4x4 matrix containing the transformation matrix for the given parameters.
    """
    matrix = np.matrix([[m.cos(theta), -m.sin(theta), 0, a],
                        [m.sin(theta) * m.cos(alpha), m.cos(theta) * m.cos(alpha), -m.sin(alpha), -m.sin(alpha) * d],
                        [m.sin(theta) * m.sin(alpha), m.cos(theta) * m.sin(alpha), m.cos(alpha), m.cos(alpha) * d],
                        [0, 0, 0, 1]])

    return matrix


def get_rot_x_matrix(angle):
    """
    Get rotation matrix around x axis.
    :param angle: Angle the rotation matrix should rotate an object.
    :return: Returns the rotation matrix.
    """
    rot_x_matrix = np.matrix([[1, 0, 0, 0],
                              [0, m.cos(angle), -m.sin(angle), 0],
                              [0, m.sin(angle), m.cos(angle), 0],
                              [0, 0, 0, 1]])

    return rot_x_matrix


def get_rot_y_matrix(angle):
    """
    Get rotation matrix around y axis.
    :param angle: Angle the rotation matrix should rotate an object.
    :return: Returns the rotation matrix.
    """
    rot_y_matrix = np.matrix([[m.cos(angle), 0, m.sin(angle), 0],
                              [0, 1, 0, 0],
                              [-m.sin(angle), 0, m.cos(angle), 0],
                              [0, 0, 0, 1]])

    return rot_y_matrix


def get_rot_z_matrix(angle):
    """
    Get rotation matrix around z axis.
    :param angle: Angle the rotation matrix should rotate an object.
    :return: Returns the rotation matrix.
    """
    rot_z_matrix = np.matrix([[m.cos(angle), -m.sin(angle), 0, 0],
                              [m.sin(angle), m.cos(angle), 0, 0],
                              [0, 0, 1, 0],
                              [0, 0, 0, 1]])

    return rot_z_matrix


def orientation_degree_to_radians(orientation):
    """
    Converts angle from degree to radians
    :param orientation: Angle in degree.
    :return: Angle in radians
    """
    for angle_index in range(len(orientation)):
        orientation[angle_index] = orientation[angle_index] / 180 * m.pi

    return orientation


def radians_to_degree(angle):
    """
    Converts angle from radians to degree.
    :param angle: Angle in radians.
    :return: Angle in degree.
    """
    angle = angle / m.pi * 180

    return angle


def radians_to_degree_list(list_radians):
    """
    Converts radians in a list to degree
    :param list_radians: List containing angles in radians
    :return: List containing angles in degrees
    """
    response = []

    for angle in list_radians:
        response.append(angle / m.pi * 180)

    return response


def transform_list_into_range(untransformed_list, min_value, max_value, adjuster):
    """
    Takes a list containing angles and checks if they are in a given range.
    :param untransformed_list: List containing angles
    :param min_value: Min value in range
    :param max_value: Max value in range
    :param adjuster: How much the values may be adjusted
    :return: Transformed list. Some of the elements may have been changed to False if the given value is not in the range.
    """
    for element_index in range(len(untransformed_list)):
        if not untransformed_list[element_index]:
            continue

        while untransformed_list[element_index] < min_value:
            untransformed_list[element_index] += adjuster
            if untransformed_list[element_index] > max_value:
                untransformed_list[element_index] = False

        while untransformed_list[element_index] > max_value:
            untransformed_list[element_index] -= adjuster
            if untransformed_list[element_index] < min_value:
                untransformed_list[element_index] = False
    return untransformed_list


def best_end_joint(current_joint, joints):
    """
    Takes the current joint position and a list containing of possible joint positions and returns the closest possible joint position.
    :param current_joint: The current position of the robots joint.
    :param joints: The possible joint positions for a point.
    :return: The closest joint position to the current joint position
    """
    lowest_score_joint = []
    lowest_score_value = -1

    if len(joints) == 0:
        raise MoveNotPossible(MOVE_NOT_POSSIBLE_ERROR_MSG)

    for joint in joints:
        angle_difference = 0

        for angle_index in range(len(joint)):
            angle_difference += abs(current_joint[angle_index] - joint[angle_index])

        if angle_difference < lowest_score_value or lowest_score_value < 0:
            lowest_score_value = angle_difference
            lowest_score_joint = joint

    return lowest_score_joint


class Kinematics:
    """
    Class to compute the inverse kinematics.
    """
    def __init__(self):
        """
        Constructor for class
        """
        self.robot_controller_settings = RobotControllerSettings()
        self.dh_value_alpha = self.robot_controller_settings.dh_values["alpha"]
        self.dh_value_a = self.robot_controller_settings.dh_values["a"]
        self.dh_value_d = self.robot_controller_settings.dh_values["d"]
        self.dh_value_theta = self.robot_controller_settings.dh_values["theta"]

    def get_joint_values(self, coordinate, orientation):
        """
        Method for getting the joint values from a coordinate and orientation.
        :param coordinate: Coordinate in the format [x, y, z].
        :param orientation: Orientation in the format [roll, pitch, yaw].
        :return: Returns a list containing all possible joint configurations for the robot.
        """
        orientation = orientation_degree_to_radians(orientation)

        rot_x_matrix = get_rot_x_matrix(orientation[0])
        rot_y_matrix = get_rot_y_matrix(orientation[1])
        rot_z_matrix = get_rot_z_matrix(orientation[2])

        wrist_rot_x_matrix = get_rot_x_matrix(0)
        wrist_rot_y_matrix = get_rot_y_matrix(0)
        wrist_rot_z_matrix = get_rot_z_matrix(0)

        wrist = wrist_rot_z_matrix * wrist_rot_y_matrix * wrist_rot_x_matrix

        wrist[0, 3] = 0
        wrist[1, 3] = 0
        wrist[2, 3] = 66

        T_link0_wrist = rot_z_matrix * rot_y_matrix * rot_x_matrix
        T_link0_wrist[0, 3] = coordinate[0]
        T_link0_wrist[1, 3] = coordinate[1]
        T_link0_wrist[2, 3] = coordinate[2]

        T_link0_link6 = T_link0_wrist * inv(wrist)

        theta_1 = self.kin_calculate_theta_1(T_link0_link6)  # Contains two angles

        # For calculating theta_4, theta_5 and theta_6 a rotation matrix consisting of theta_1 and the
other angles is needed. This is created:
        rot_z_matrix_theta_1_1 = get_rot_z_matrix(theta_1[0] + self.dh_value_theta[0])
        rot_z_matrix_theta_1_2 = get_rot_z_matrix(theta_1[1] + self.dh_value_theta[0])

        rot_matrix_alpha_link_1 = get_rot_x_matrix(self.dh_value_alpha[0])
        rot_matrix_alpha_link_2 = get_rot_x_matrix(self.dh_value_alpha[1])
        rot_matrix_alpha_link_3 = get_rot_x_matrix(self.dh_value_alpha[2])

        rot_matrix_theta_link_2 = get_rot_z_matrix(self.dh_value_theta[1])
        rot_matrix_theta_link_3 = get_rot_z_matrix(self.dh_value_theta[2])

        rot_matrix_link_1_theta_1_1_inv = inv(rot_matrix_alpha_link_1 * rot_z_matrix_theta_1_1)
        rot_matrix_link_1_theta_1_2_inv = inv(rot_matrix_alpha_link_1 * rot_z_matrix_theta_1_2)
        rot_matrix_link_2_inv = inv(rot_matrix_alpha_link_2 * rot_matrix_theta_link_2)
        rot_matrix_link_3_inv = inv(rot_matrix_alpha_link_3 * rot_matrix_theta_link_3)

        rot_matrix_link_1_to_link_3_theta_1_1_inv = rot_matrix_link_3_inv * rot_matrix_link_2_inv *
rot_matrix_link_1_theta_1_1_inv
        rot_matrix_link_1_to_link_3_theta_1_2_inv = rot_matrix_link_3_inv * rot_matrix_link_2_inv *
rot_matrix_link_1_theta_1_2_inv

        rot_matrix_theta_1_1 = rot_matrix_link_1_to_link_3_theta_1_1_inv * rot_z_matrix * rot_y_matrix
* rot_x_matrix
        rot_matrix_theta_1_2 = rot_matrix_link_1_to_link_3_theta_1_2_inv * rot_z_matrix * rot_y_matrix
* rot_x_matrix
```

```

        # Based on the rotational matrix, it is possible to get the angle theta5 using the inverse cosinus to field
        # (3,3) in the matrix. However due to the nature of cosinus to a point, it will not be possible to estimate if
        # the angle is positive or negative.

        theta_5 = self.kin_calculate_theta_5(rot_matrix_theta_1_1) + self.kin_calculate_theta_5(rot_matrix_theta_1_2)

        theta_6_theta_1_1 = [self.kin_calculate_theta_6(rot_matrix_theta_1_1, theta_5[0]),
                             self.kin_calculate_theta_6(rot_matrix_theta_1_1, theta_5[1])]
        theta_6_theta_1_2 = [self.kin_calculate_theta_6(rot_matrix_theta_1_2, theta_5[2]),
                             self.kin_calculate_theta_6(rot_matrix_theta_1_2, theta_5[3])]
        theta_6 = theta_6_theta_1_1 + theta_6_theta_1_2

        # Moving the

        pre_theta_4_theta_1_1 = [self.kin_calculate_theta_4(rot_matrix_theta_1_1, theta_5[0]),
                                 self.kin_calculate_theta_4(rot_matrix_theta_1_1, theta_5[1])]
        pre_theta_4_theta_1_2 = [self.kin_calculate_theta_4(rot_matrix_theta_1_2, theta_5[2]),
                                 self.kin_calculate_theta_4(rot_matrix_theta_1_2, theta_5[3])]
        pre_theta_4 = pre_theta_4_theta_1_1 + pre_theta_4_theta_1_2

        # Currently theta5 and theta6 consists of 4 different angles whereas theta1 consists of 2 angles.
        # To get each angle to match in the angle, theta1 will be defined as:

        theta_1 = [theta_1[0], theta_1[0], theta_1[1], theta_1[1]]

        # This gives the possibility to make a loop of 4 as each array will consist of this:

        inverse_kinematics_list = []
        theta_1 = transform_list_into_range(theta_1, MIN_ANGLE_LINK_1_5, MAX_ANGLE_LINK_1_5, 2 * m.pi)
        theta_5 = transform_list_into_range(theta_5, MIN_ANGLE_LINK_1_5, MAX_ANGLE_LINK_1_5, 2 * m.pi)
        theta_6 = transform_list_into_range(theta_6, MIN_ANGLE_LINK_6, MAX_ANGLE_LINK_6, 2 * m.pi)

        for i in range(4):
            # Checking if any of them are out of range (Joint space more specifically).
            if not theta_1[i] or not theta_5[i] or not theta_6[i]:
                continue

            T_link0_link1_rotation = joint_matrix(self.dh_value_alpha[0], self.dh_value_a[0], self.dh_value_d[0],
                                                  self.dh_value_theta[0] + theta_1[i])
            T_link4_rotation_link4 = joint_matrix(0, 0, self.dh_value_d[3], 0)
            T_link4_link5 = joint_matrix(self.dh_value_alpha[4], self.dh_value_a[4], self.dh_value_d[4],
                                         self.dh_value_theta[4] + theta_5[i])
            T_link5_link6 = joint_matrix(self.dh_value_alpha[5], self.dh_value_a[5], self.dh_value_d[5],
                                         self.dh_value_theta[5] + theta_6[i])

            T_link1_link3 = inv(T_link0_link1_rotation) * T_link0_link6 * inv(T_link5_link6) * inv(T_link4_link5) * inv(
                T_link4_rotation_link4)

            # Sorting points which are further away than the robot can reach.
            if m.sqrt(T_link1_link3[0, 3] ** 2 + T_link1_link3[2, 3] ** 2) > self.dh_value_a[2] + self.dh_value_a[3]:
                continue

            theta_2_theta_3 = self.kin_calculate_theta_2_3(T_link1_link3)

            theta_2_untransformed = theta_2_theta_3[0]
            theta_3_untransformed = theta_2_theta_3[1]

            theta_2 = transform_list_into_range(theta_2_untransformed, MIN_ANGLE_LINK_1_5, MAX_ANGLE_LINK_1_5, 2 * m.pi)
            theta_3 = transform_list_into_range(theta_3_untransformed, MIN_ANGLE_LINK_1_5, MAX_ANGLE_LINK_1_5, 2 * m.pi)

            theta_4_untransformed = [False, False]

            for angle_index in range(2):
                if theta_2[angle_index] and theta_3[angle_index]:
                    theta_4_untransformed[angle_index] = pre_theta_4[i] - theta_2[angle_index] - theta_3[angle_index]

            theta_4 = transform_list_into_range(theta_4_untransformed, MIN_ANGLE_LINK_1_5, MAX_ANGLE_LINK_1_5, 2 * m.pi)

            # Creates the list.
            for j in range(2):
                # Checking if any of them are out of range (Joint space more specifically).
                if not theta_2[j] or not theta_3[j] or not theta_4[j]:
                    continue

                inverse_kinematics_list.append(
                    radians_to_degree_list([theta_1[i], theta_2[j], theta_3[j], theta_4[j], theta_5[i], theta_6[i]]))

        return inverse_kinematics_list

    # Returns two angles.
    def kin_calculate_theta_1(self, T_link0_link6):
        """
        Calculates theta 1
        :param T_link0_link6: Transformation matrix from link 1 to link 6.
        :return: Returns the two possible values for theta 1
        """
        T_link6_rotation_link6 = joint_matrix(0, 0, self.dh_value_d[5], 0)

        T_link0_link6_rotation = T_link0_link6 * inv(T_link6_rotation_link6)

        x_6 = T_link0_link6_rotation[0, 3]
        y_6 = T_link0_link6_rotation[1, 3]

        theta_1_1 = (m.acos(self.dh_value_d[3] / ((x_6 ** 2 + y_6 ** 2) ** 0.5)) + m.atan2(y_6, x_6))
        theta_1_2 = (-m.acos(self.dh_value_d[3] / ((x_6 ** 2 + y_6 ** 2) ** 0.5)) + m.atan2(y_6, x_6))

        return [theta_1_1, theta_1_2]

    def kin_calculate_theta_2_3(self, T_link2_link3):
        """
        Calculates theta 2 and 3
        :param T_link2_link3: Transformation matrix from link 2 to link 3
        :return: Returns the possible configurations for theta 2 and theta 3.
        """
        x = abs(T_link2_link3.item((0, 3)))
        z = T_link2_link3.item((2, 3))

        mirror_angle_length = m.sqrt(x ** 2 + z ** 2)

        direction = -1 * abs(T_link2_link3.item((0, 3))) / T_link2_link3.item((0, 3))

        theta_2_1 = direction * (m.acos(z / mirror_angle_length) + m.acos(
            (self.dh_value_a[3] ** 2 - self.dh_value_a[2] ** 2 - mirror_angle_length ** 2) / (
                    2 * self.dh_value_a[2] * mirror_angle_length)) + m.pi)
        theta_3_1 = direction * (
            m.acos((mirror_angle_length ** 2 - self.dh_value_a[3] ** 2 - self.dh_value_a[2] ** 2) / (
                    2 * self.dh_value_a[2] * self.dh_value_a[3])))

        theta_2_2 = direction * (m.acos(z / mirror_angle_length) - m.acos(
            (self.dh_value_a[3] ** 2 - self.dh_value_a[2] ** 2 - mirror_angle_length ** 2) / (
                    2 * self.dh_value_a[2] * mirror_angle_length)) - m.pi)
        theta_3_2 = -1 * direction * (
            m.acos((mirror_angle_length ** 2 - self.dh_value_a[3] ** 2 - self.dh_value_a[2] ** 2) / (
                    2 * self.dh_value_a[2] * self.dh_value_a[3])))

        theta_2 = [theta_2_1, theta_2_2]
        theta_3 = [theta_3_1, theta_3_2]

        return theta_2, theta_3

    def kin_calculate_theta_4(self, rot_matrix, theta_5):
        """
        Calculates theta 4
        :param rot_matrix: Rotation matrix describing rotation from link 4 to link 6.
        :param theta_5: Value for theta 5
        :return: Returns the value for theta 4
        """
        # -self.dh_value_theta[3] is subtracted due to the calculated angle is based on theta2+theta3+theta4+self.dh_value_theta4 = calculated angle.
        theta_4 = m.atan2(rot_matrix.item((1, 2)) * m.sin(theta_5), rot_matrix.item((0, 2)) * m.sin(theta_5)) - \
                  self.dh_value_theta[3]

        return theta_4

    def kin_calculate_theta_5(self, rot_matrix):
        """
        Calculates theta 5
        :param rot_matrix: Rotation matrix describing rotation from link 4 to link 6.
        :return: Returns the two values for theta 5
        """
        theta_5_unsigned = m.acos(rot_matrix.item((2, 2)))

        theta_5 = [theta_5_unsigned, -theta_5_unsigned]

        return theta_5

    def kin_calculate_theta_6(self, rot_matrix, theta_5):
        """
```

```
         Calculates theta 6
         :param rot_matrix: Rotation matrix describing rotation from link 4 to link 6.
         :param theta_5: Value for theta 5
         :return: Returns the value for theta 6
         """
        theta_6 = m.atan2(rot_matrix.item((2, 1)) * m.sin(theta_5), -1 * rot_matrix.item((2, 0)) *
m.sin(theta_5))

        return theta_6


class MoveJ(Kinematics):
    """
    Class for moving in joint space
    """
    def __init__(self, robot_pointer, positions_with_time):
        """
        Constructor for the MoveJ class. Takes the robot and position.
        :param robot_pointer: A pointer to the robot class for the robot
        :param positions_with_time: The position with time.
        """
        self.robot = robot_pointer
        self.pos_w_time = positions_with_time
        self.start_joint_values = robot_joint_position

        start_time = 0

        if not len(self.start_joint_values) == 6:
            raise JointSyntaxError(JOINT_SYNTAX_ERROR_MSG)

        for coordinate in self.pos_w_time:
            if not len(coordinate) == 7:
                raise CoordinateSyntaxError(COORDINATE_SYNTAX_ERROR_MSG)

            if coordinate[6] <= start_time:
                raise InvalidTimeIncrease(INVALID_TIME_INCREASE_ERROR_MSG)

            start_time = coordinate[6]

        super().__init__()

        self.joint_matrix = self.convert_coordinates_to_joint_movements()

    def convert_coordinates_to_joint_movements(self):
        """
        Method that converts the coordinates into joint degrees for each via point and end position.
        :return: Returns the transformed matrix.
        """
        start_joint = self.start_joint_values
        joint_values = []

        for position_index in range(len(self.pos_w_time)):
            position = self.pos_w_time[position_index]

            coordinate = position[0:3]
            orientation = position[3:6]
            time_val = position[6]

            joints = self.get_joint_values(coordinate, orientation)

            if position_index == 0:
                joint_values.append([start_joint, 0])

                start_joint = best_end_joint(start_joint, joints)
                joint_values.append([start_joint, time_val])

            else:
                start_joint = best_end_joint(start_joint, joints)
                joint_values.append([start_joint, time_val])

        return joint_values

    def move_joint(self):
        """
        Method for moving the robot in the joint space thrugh the different via points.
        """
        global robot_joint_position, robot_cartesian_position

        self.joint_matrix = self.convert_coordinates_to_joint_movements()

        end_joint_position = []

        for move_index in range(
                len(self.joint_matrix) - 1):  # The reason for -1 is because the function is indexing
1 ahead.
            time_val = self.joint_matrix[move_index][1]
            time_val_plus_1 = self.joint_matrix[move_index + 1][1]

            joint_movement_time = time_val_plus_1 - time_val

            joint_function_values = []

            for joint_index in range(len(self.joint_matrix[move_index][0])):
                v_start = 0
                v_end = 0

                joint_val = self.joint_matrix[move_index][0][joint_index]
                joint_val_plus_1 = self.joint_matrix[move_index + 1][0][joint_index]

                if not move_index == 0:
                    joint_val_minus_1 = self.joint_matrix[move_index - 1][0][joint_index]
                    time_val_minus_1 = self.joint_matrix[move_index - 1][1]

                    v_start = ((joint_val - joint_val_minus_1) / (time_val - time_val_minus_1) + (
                                (joint_val_plus_1 - joint_val) / (time_val_plus_1 - time_val))) / 2

                if not move_index == len(self.joint_matrix) - 2:
                    joint_val_plus_2 = self.joint_matrix[move_index + 2][0][joint_index]
                    time_val_plus_2 = self.joint_matrix[move_index + 2][1]

                    v_end = ((joint_val_plus_1 - joint_val) / (time_val_plus_1 - time_val) + (
                                (joint_val_plus_2 - joint_val_plus_1) / (time_val_plus_2 - time_val_plus_1))) / 2

                a_0 = joint_val
                a_1 = v_start
                a_2 = 3 / (joint_movement_time ** 2) * (
                            joint_val_plus_1 - joint_val) - 2 / joint_movement_time * v_start - 1 / joint_movement_time * v_end
                a_3 = (-2) / (joint_movement_time ** 3) * (joint_val_plus_1 - joint_val) + 1 / (
                            joint_movement_time ** 2) * (v_end + v_start)

                joint_function_values.append([a_0, a_1, a_2, a_3])

            for freq in range(round(joint_movement_time * self.robot_controller_settings.update_frequency)):
                joints_value = []
                for fp in joint_function_values:  # fp: function parameters
                    x = freq / self.robot_controller_settings.update_frequency

                    function_value = fp[0] + fp[1] * x + fp[2] * x ** 2 + fp[3] * x ** 3
                    joints_value.append(function_value)

                self.robot.set_joints(joints_value)
                end_joint_position = joints_value
                t.sleep(1 / self.robot_controller_settings.update_frequency)

        robot_joint_position = end_joint_position
        robot_cartesian_position = self.pos_w_time[-1][:6]


# IKKE OPDATERET UD FRA NYESTE EXCEPTIONS!
class MoveL(MoveJ):
    """
    Class for moving in cartesian space.
    """
    def __init__(self, robot_pointer, positions_with_time):
        """
        Constructor for MoveL class
        :param robot_pointer: Pointer to robot controller
        :param positions_with_time: Position for where the robot should move to.
        """
        self.robotrobot = robot_pointer
        self.pos_w_time_linear = positions_with_time
        self.move_time = self.pos_w_time_linear[0][6]

        super().__init__(self.robotrobot, self.pos_w_time_linear)

        if not len(positions_with_time) == 1:
            raise TakesOnlyTwoCoordinates(TAKES_ONLY_TWO_COORDINATES_ERROR_MSG)

        start_time = 0

        for coordinate in self.pos_w_time_linear:
            if not len(coordinate) == 7:
                raise CoordinateSyntaxError(COORDINATE_SYNTAX_ERROR_MSG)

            if coordinate[6] <= start_time:
                raise InvalidTimeIncrease(INVALID_TIME_INCREASE_ERROR_MSG)

            start_time = coordinate[6]

        self.start_pos_cartesian = robot_cartesian_position

```

```python
        self.pos_w_time_linear = self.get_linear_via_points()
        self.pos_w_timepos_w_time = self.pos_w_time_linear

    def get_linear_via_points(self):
        """
        Method for getting all via points on the path, the robot moves on.
        :return: Returns the coordinates which will be used as via points in the joint movement.
        """
        linear_movement_coords_w_time = []

        function_values = []

        for i in range(6):
            a_0 = self.start_pos_cartesian[i]
            a_1 = 0
            a_2 = 3 / (self.move_time ** 2) * (self.pos_w_time_linear[0][i] - self.start_pos_cartesian[i])
            a_3 = (-2) / (self.move_time ** 3) * (self.pos_w_time_linear[0][i] - self.start_pos_cartesian[i])

            function_values.append([a_0, a_1, a_2, a_3])

        for i in range(1, round(self.move_time * self.robot_controller_settings.linear_frequency + 1)):

            coordinate = []

            x = i / self.robot_controller_settings.linear_frequency

            for j in range(6):
                coordinate.append(function_values[j][0] + function_values[j][1] * x + function_values[j][2] * x ** 2 + function_values[j][3] * x ** 3)

            coordinate.append(x)

            linear_movement_coords_w_time.append(coordinate)

        return linear_movement_coords_w_time


class Robot:
    """
    Robot class used to talk with RoboDK and the correct robot
    """
    def __init__(self, rdk_link):
        """
        Constructor for class
        """
        self.robot_settings = RobotControllerSettings()

        self.rdk_link = rdk_link
        self.prev_position = [0, 0, 0, 0, 0, 0]
        self.time_between_move = 1 / self.robot_settings.update_frequency
        self.max_joint_speed = 180

    def set_joints(self, position, robot_speed=100):
        """
        Sets the joint values for the robot
        :param position: Position in joint space.
        :param robot_speed: Not used due to it not being neccessary, but has to be there in order to use the class together with other classes.'
        """

        # Prints if one of the joins exceed maximum speed.
        for index in range(6):
            speed = abs((position[index] - self.prev_position[index]) / self.time_between_move)
            if speed > self.max_joint_speed:
                print(f"Joint {index+1} exceeded max speed in simulation at {position}")

        self.prev_position = position

        self.rdk_link.setJoints(position)


class RobotMyCobot:
    """
    Robot class used to talk with MyCobot 320 PI
    """
    def __init__(self, robo_link):
        """
        Constructor for class
        """
        self.robo_link = robo_link

    def set_joints(self, position, robot_speed=100):
        """
        Sets the joint values for the robot
        :param position: Position in joint space.
        :param robot_speed: Value between 0-100 setting the robot's speed.
        """
        encoder_val = []
        encoder_dir = [1, 1, -1, 1, 1, 1]

        for joint_val_index in range(len(position)):
            encoder_val.append(round(2048 - position[joint_val_index] / 90 * 1024 *
encoder_dir[joint_val_index]))

        self.robo_link.set_encoders(encoder_val, robot_speed)


class RobotMyCobotAndSim:
    """
    Robot class used to talk with MyCobot 320 PI and RoboDK
    """
    def __init__(self, robo_link, rdk_link):
        """
        Constructor for class
        """
        self.rdk_link = rdk_link
        self.robo_link = robo_link

    def set_joints(self, position, robot_speed=100):
        """
        Sets the joint values for the robot
        :param position: Position in joint space.
        :param robot_speed: Value between 0-100 setting the robot's speed.
        """
        encoder_val = []
        encoder_dir = [1, 1, -1, 1, 1, 1]

        for joint_val_index in range(len(position)):
            encoder_val.append(round(2048 - position[joint_val_index] / 90 * 1024 *
encoder_dir[joint_val_index]))

        self.robo_link.set_encoders(encoder_val, robot_speed)

        self.rdk_link.setJoints(position)

```

7.13 test.py File Reference

Namespaces

- namespace test

Functions

- test.mySqrt (number, guess, step, tol)

Variables

- int test.testVal = 9

7.14 test.py

Go to the documentation of this file.

```
def mySqrt(number, guess, step, tol):
    # We need to take out negative numbers...
    if (number < 0):
        print('Error - we do not work with complex numbers here...')
        return float("NaN")

    # If we set guess to zero, we have to provide a number - we assume this is the initial call
    if (guess == 0):
        if (number > 1):  # If we have numbers larger than one, we can safely guess half as the sqrt
            guess = 0.5 * number
        else:
            guess = number * 2  # If we have numbers smaller than one, we need to double our guess

    tmp = guess * guess  # Now compute the square of our guess
    if ((tmp - number) < tol):  # Check if the (guess^2 - number) is lower than our tolerance level
        return guess
    else:
        if (tmp > number):  # If our guess was too high, then iterate by calling ourselves again with a slightly lower guess
            return mySqrt(number, (1 - step) * guess, step, tol)
        else:  # Else, our guess was too small, we need to increase the guess for our next call
            return mySqrt(number, (1 + step) * guess, step, tol)


testVal = 9
print(’Squareroot of ’ + str(testVal) + ’ is ’)
print(mySqrt(testVal, 0, 0.001, 0.001))
```

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