USER INTERFACE FOR A SIX DOF MANIPULATOR

TECHNICAL UNIVERSITY OF CLUJ-NAPOCA ROMANIA

MAN DARIUS

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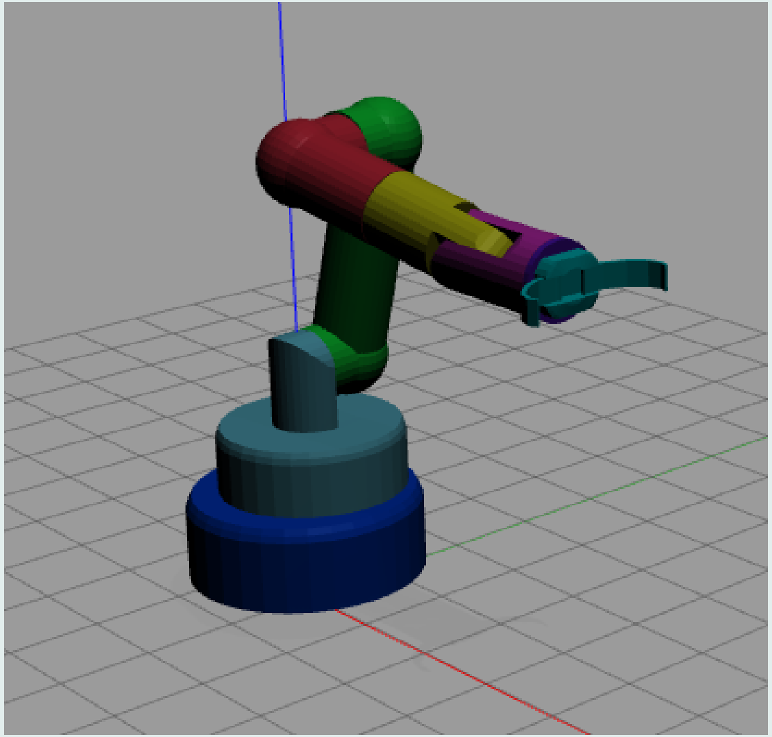
1. CONTEXT

As the title of this presentations implies, what is about to be presented is a simple user interface for a manipulator.

The overall goal is to simplify the creation of trajectories for a six degree of freedom manipulator.

Because the trajectories of the manipulator must be written into a specific code, this converts button presses into that code.

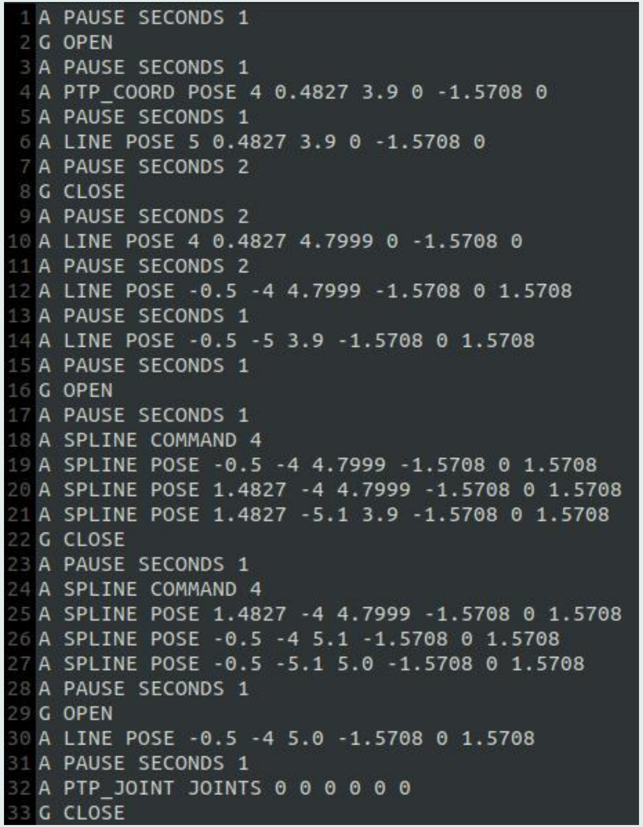


1. CONTEXT

The user interface should provide all the commands that the manipulator can understand.

The trajectories and commands are as follows:

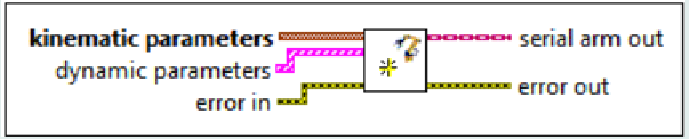
- Line
- Circle
- Spline
- Pause
- Gripper close, open
- Loop



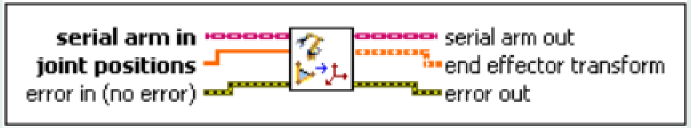
```
A PAUSE SECONDS 1
G OPEN
A PAUSE SECONDS 1
A PTP_COORD POSE 4 0.4827 3.9 0 -1.5708 0
A PAUSE SECONDS 1
A LINE POSE 5 0.4827 3.9 0 -1.5708 0
A PAUSE SECONDS 2
G CLOSE
A PAUSE SECONDS 2
A LINE POSE 4 0.4827 4.7999 0 -1.5708 0
A PAUSE SECONDS 2
A LINE POSE -0.5 -4 4.7999 -1.5708 0 1.5708
A PAUSE SECONDS 1
A LINE POSE -0.5 -5 3.9 -1.5708 0 1.5708
A PAUSE SECONDS 1
G OPEN
A PAUSE SECONDS 1
A SPLINE COMMAND 4
A SPLINE POSE -0.5 -4 4.7999 -1.5708 0 1.5708
A SPLINE POSE 1.4827 -4 4.7999 -1.5708 0 1.5708
A SPLINE POSE 1.4827 -5.1 3.9 -1.5708 0 1.5708
G CLOSE
A PAUSE SECONDS 1
A SPLINE COMMAND 4
A SPLINE POSE 1.4827 -4 4.7999 -1.5708 0 1.5708
A SPLINE POSE -0.5 -4 5.1 -1.5708 0 1.5708
A SPLINE POSE -0.5 -5.1 5.0 -1.5708 0 1.5708
A PAUSE SECONDS 1
G OPEN
A LINE POSE -0.5 -4 5.0 -1.5708 0 1.5708
A PAUSE SECONDS 1
A PTP_JOINT JOINTS 0 0 0 0 0 0
G CLOSE
```

2. ROBOTICS MODULE

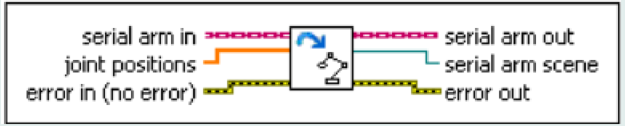
This LabView module provides the necessary tools in order to developed and simulate a robot.



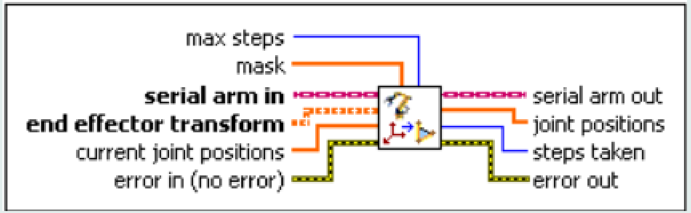
Generates an object that contains different information about the manipulator model



Direct kinematics computation



Return a scene with the manipulator using the joint position



Inverse kinematics of a manipulator

2. ROBOTICS MODULE

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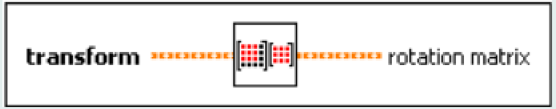
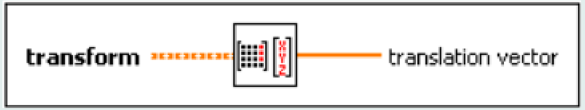


Returns the rotation matrix from the homogenous matrix



Returns the translation from the homogenous matrix

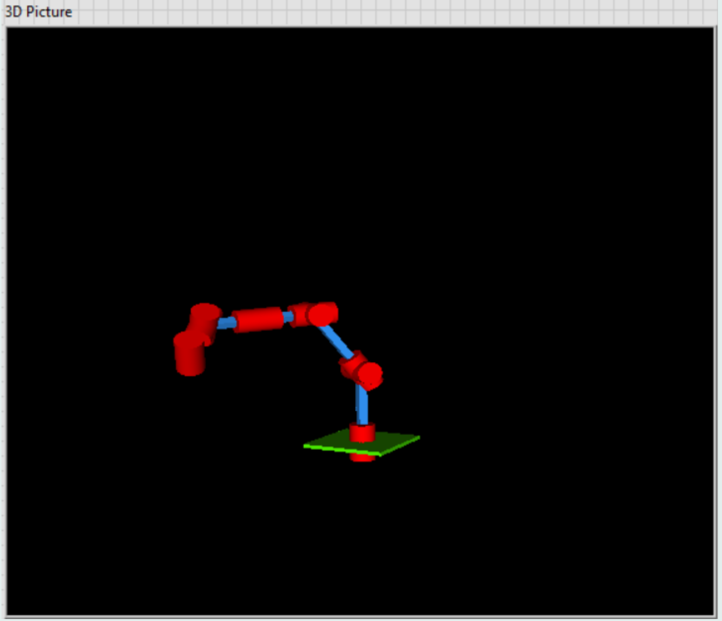
Robotics module also provides a simple model editor and a world simulation in which the robot can be placed in.

3. FRONT PANNEL

The front pannel si composed of three sections:

- **Manipulator preview**
- Joint configuration
- Command

Each section will be presented in the following slides.



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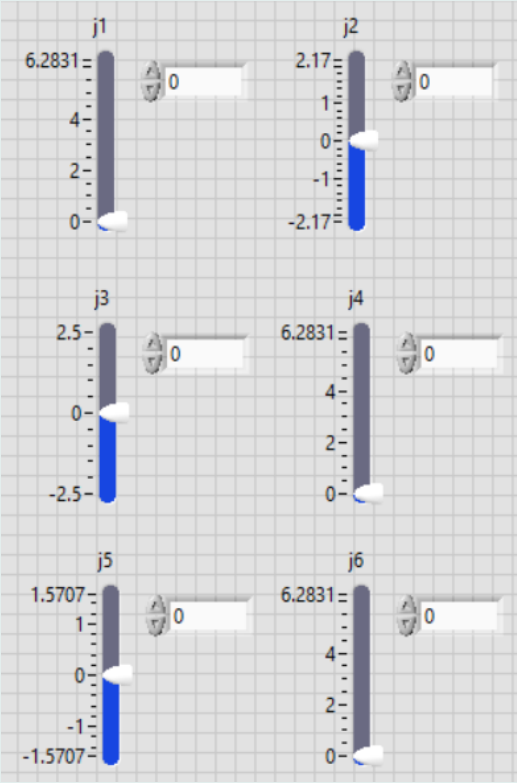

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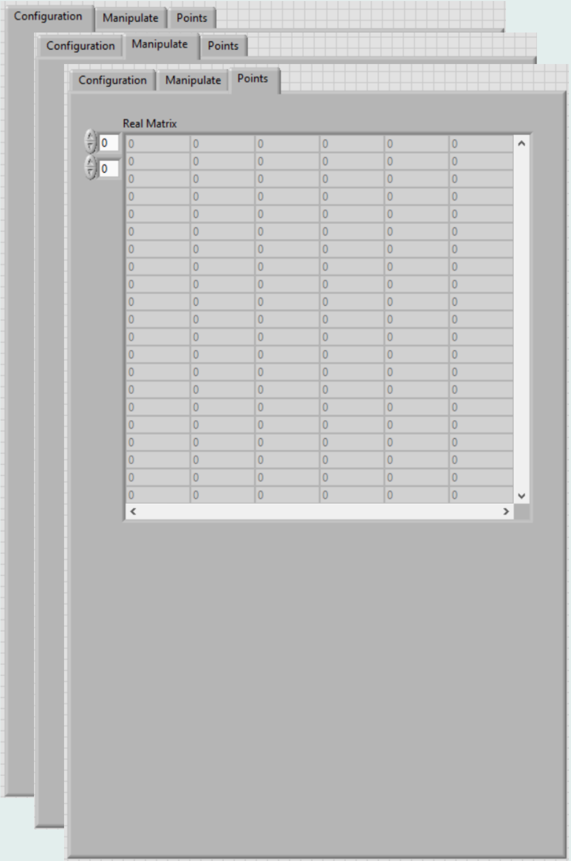


Real Matrix

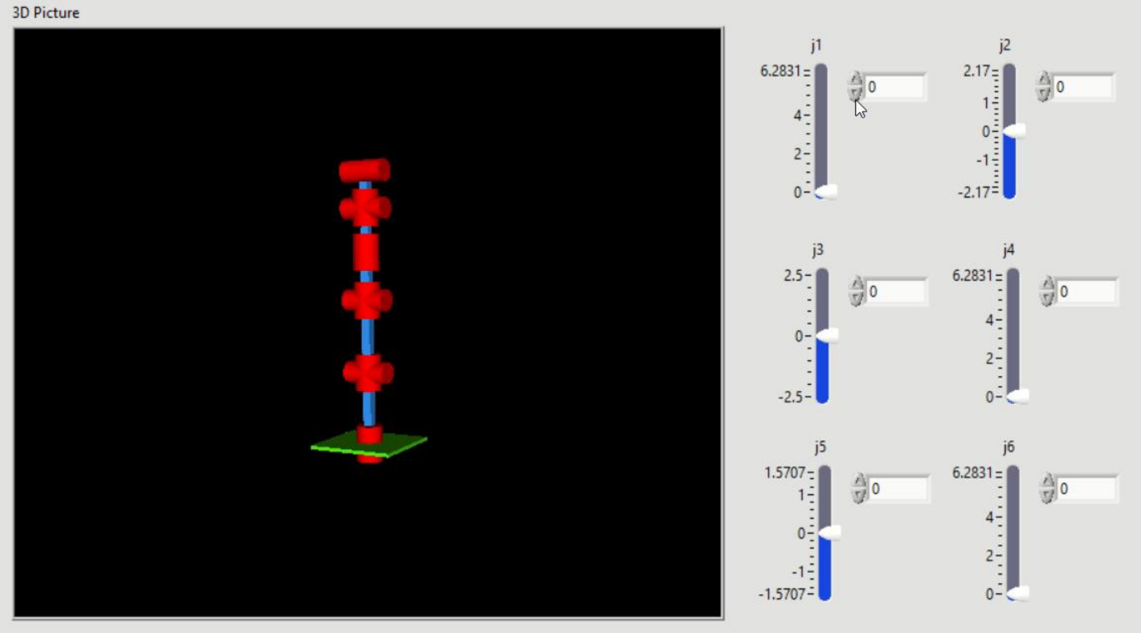
0
0

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

3. FRONT PANNEL

The manipulator preview has the role of displaying the manipulator, and it is linked with the joint configuration section.

Any change in the sliders will be seen in the 3D preview.

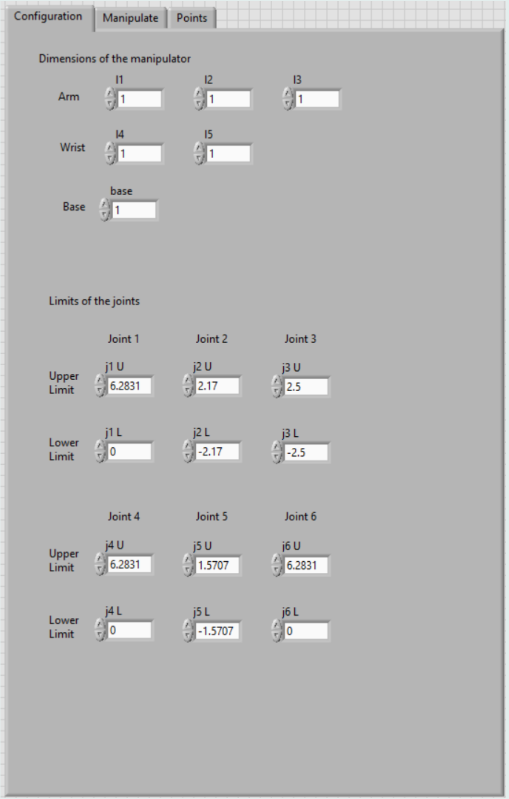


manipulator_preview.mp4

3. FRONT PANNEL

All the limits for the sliders can be change using the Configuration tab.

The dimensions of the arm can be also changed, but they will not be seen in the preview. They are only taken into consideration when computing the position of the end-effector.



Dimensions of the manipulator

Arm: l1 = 1, l2 = 1, l3 = 1

Wrist: l4 = 1, l5 = 1

Base: base = 1

Limits of the joints

	Joint 1	Joint 2	Joint 3
Upper Limit	j1 U: 6.2831	j2 U: 2.17	j3 U: 2.5
Lower Limit	j1 L: 0	j2 L: -2.17	j3 L: -2.5

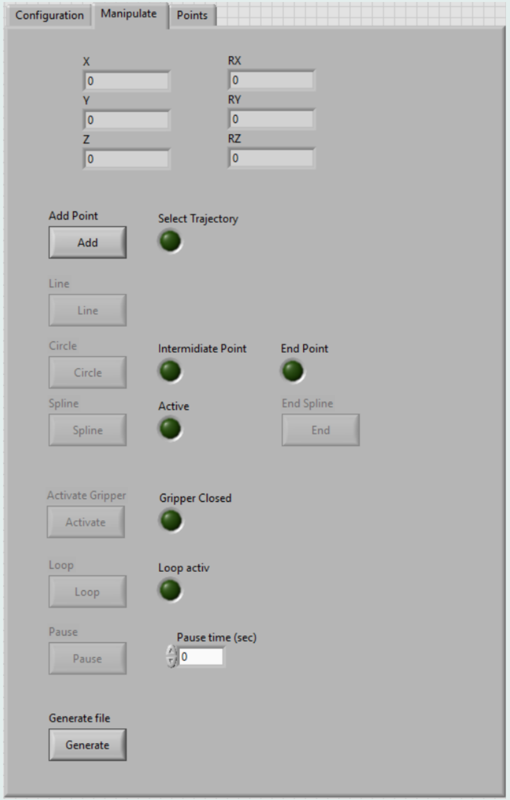
	Joint 4	Joint 5	Joint 6
Upper Limit	j4 U: 6.2831	j5 U: 1.5707	j6 U: 6.2831
Lower Limit	j4 L: 0	j5 L: -1.5707	j6 L: 0

3. FRONT PANNEL

The definition of the trajectories and other commands are in the Manipulate tab.

At the top of the tab there can be seen the position of the manipulator in its local frame along with the orientation of the end-effector.

When ever the joint configuration is changed the position and orientation is also updated.



X: 0
Y: 0
Z: 0
RX: 0
RY: 0
RZ: 0

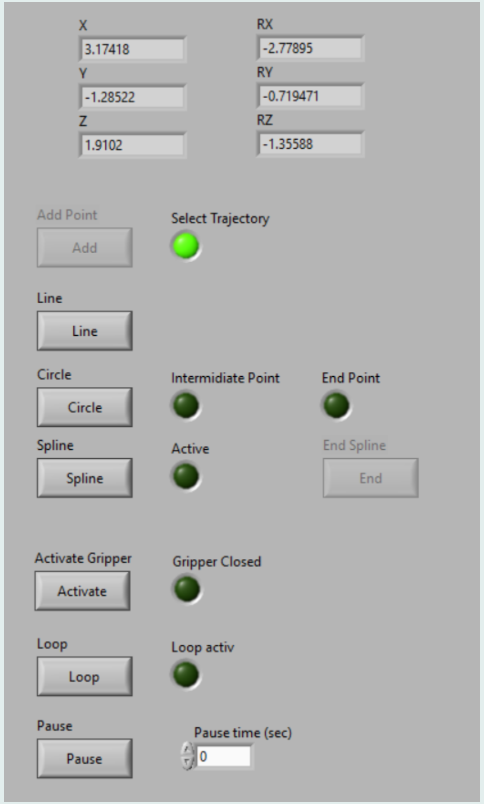
Pause time (sec): 0

3. FRONT PANNEL

When the VI is started the user will select a text file where the commands will be generated.

The user will select a starting position using the sliders and click the “Add” button, after the manipulator is moved in another position, the “Add” button is pressed again.

When the “Add” button is pressed a second time the “Select trajectory” light will turn-on, and the user needs to select a trajectory or command.



X	3.17418
Y	-1.28522
Z	1.9102
RX	-2.77895
RY	-0.719471
RZ	-1.35588
Pause time (sec)	0

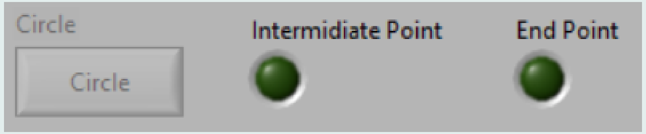
3. FRONT PANNEL

After a trajectory is selected the user can move the manipulator in a new position and click the “Add” button again.

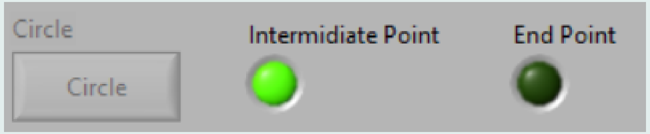
Some trajectories need more points in order to generate the full command. In this case there is the Circle and Spine trajectories.

When the “Circle” button is pressed the “Intermediary Point” light will turn-on which means that the intermediary point has been added. Finally, when the end point has been selected the ”End point” light will also turn-on.

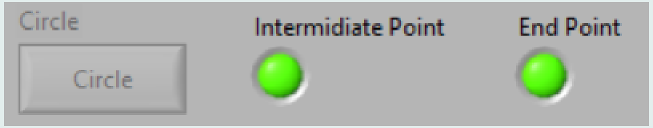
Default



First click



Second click

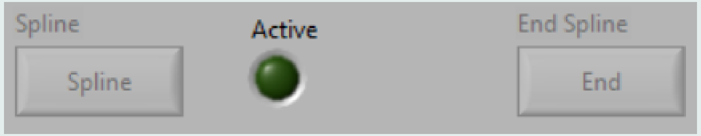


3. FRONT PANNEL

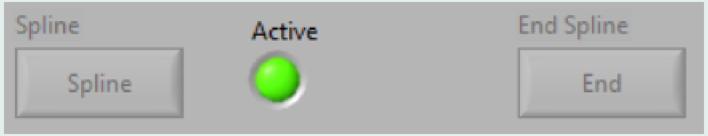
The same procedure applies when the "Spline" button is clicked. A minimum of three points must be added before the trajectory can end. More points can be added, and when the user is satisfied the "End" button can be pressed.

The "Active" light indicates that the "Spline" trajectory has been started.

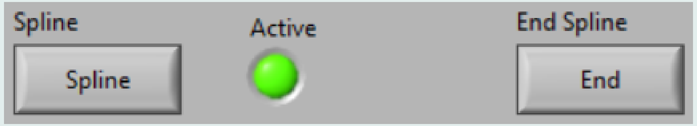
Default



First click



Third click



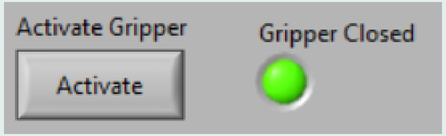
3. FRONT PANNEL

All the other command buttons can be selected between trajectory segments.

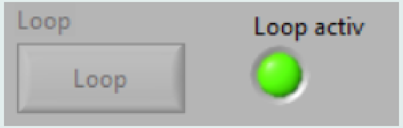
The “Activate” button will close the gripper. By default, the gripper will be opened. The gripper will be closed until the button is clicked again. “Gripper Closed” light indicates when the gripper is closed.

The “Loop” button indicates if and where a sequence of commands should repeat. All the commands from the activation of the loop will be in a cyclical pattern.

Gripper is closed

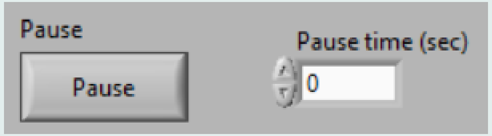


Loop has been started



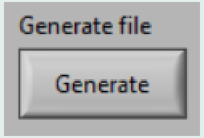
3. FRONT PANNEL

If the user wants to stop the execution of the manipulator the “Pause” button can be pressed, after introducing the number of seconds of the pause.



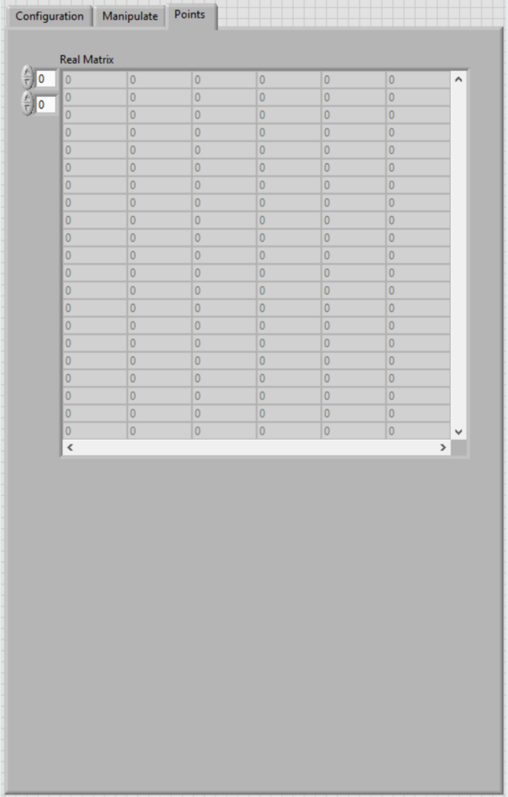
Pause time (sec) 0

When the user finished the trajectory, the generate button can be pressed and the commands will be written in the selected file at the start of the execution.



3. FRONT PANNEL

Lastly a “Points” tab is provided in which the points that were recorded will be showed.



Real Matrix

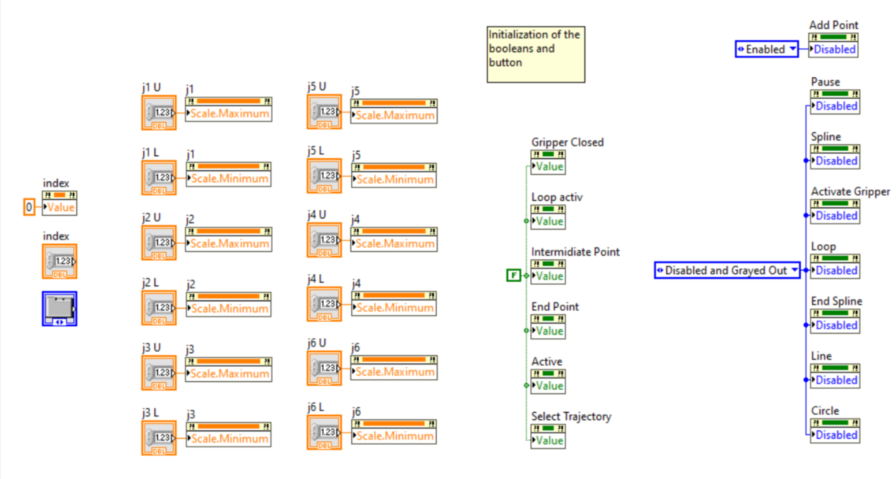
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

4. BLOCK DIAGRAM

The block diagram is rather large and will be spited, as well, into four sections.
There sections are as follows:

- **Initialization**
- Preview update
- Direct kinematics
- Value change

Each section will be detailed in the following slides.



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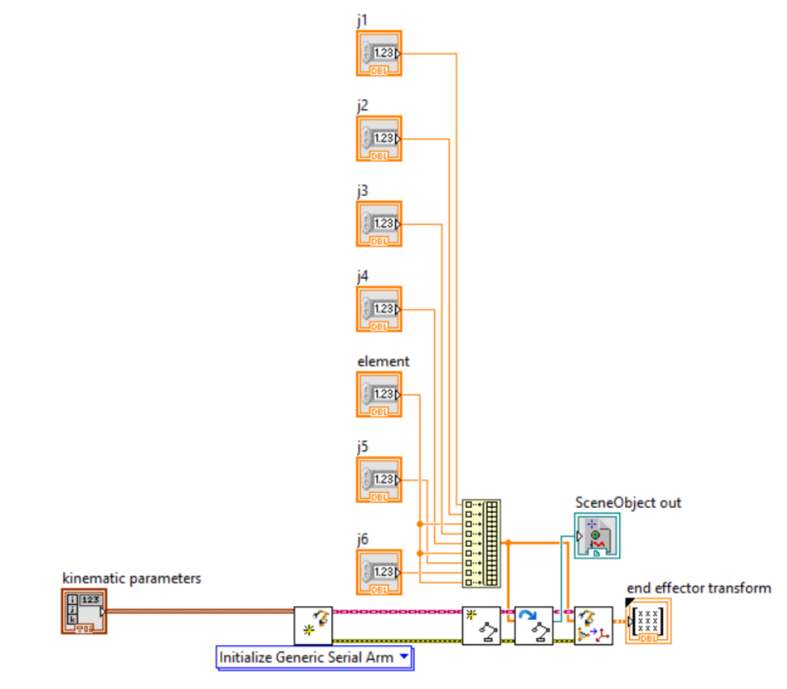

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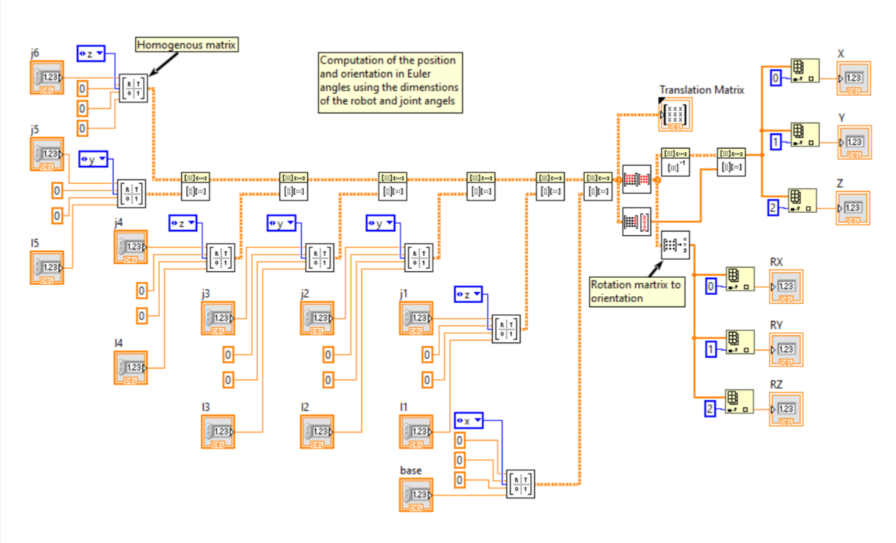

Homogenous matrix

Computation of the position and orientation in Euler angles using the dimenstions of the robot and joint angels

Translation Matrix

Rotation martrix to orientation

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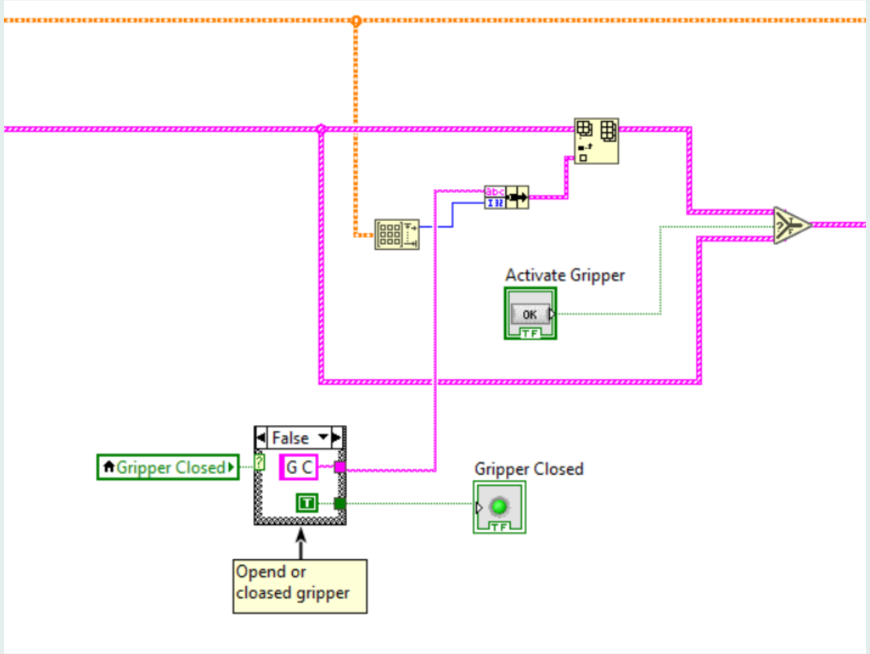
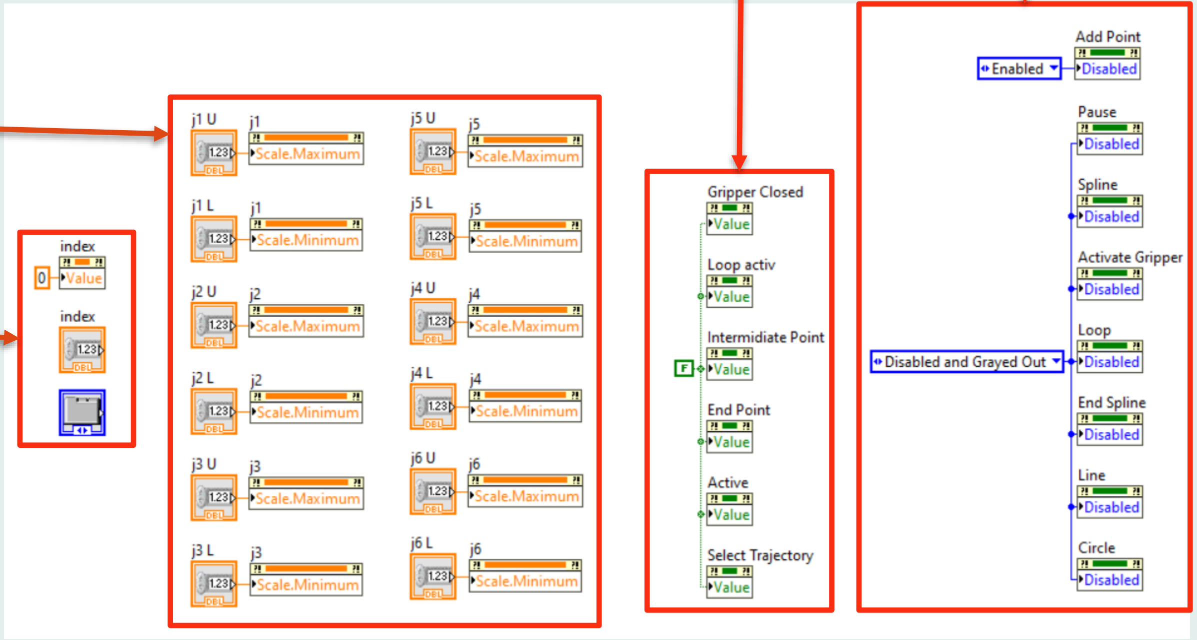


4. BLOCK DIAGRAM

The initialization section will set the default state of the UI and updates the values of the slider limits.



Setting the limits of the joint sliders

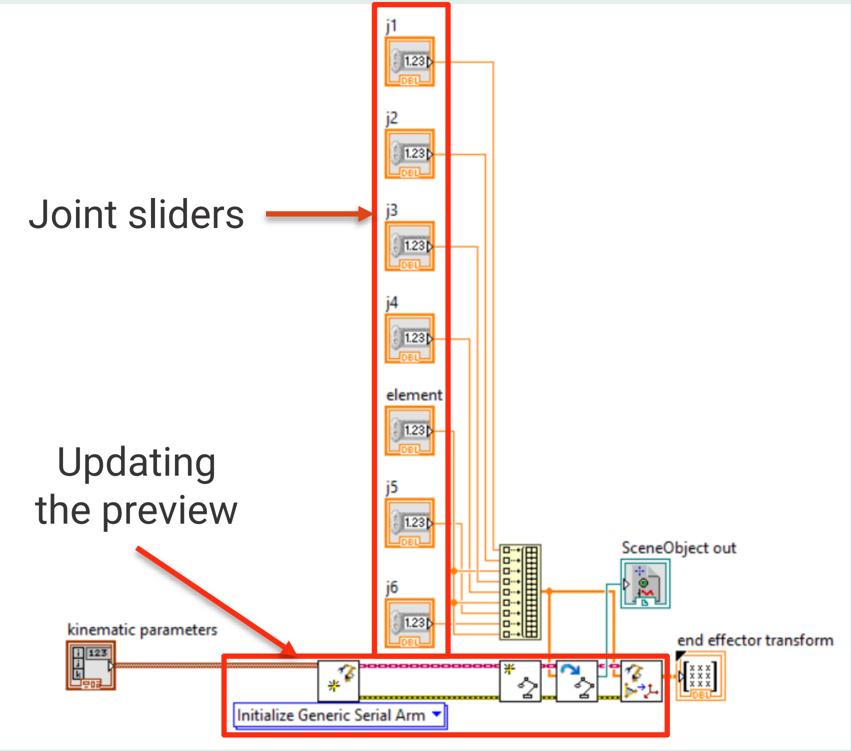
Auxiliary variables

Initial state of the lights

Initial state of the buttons

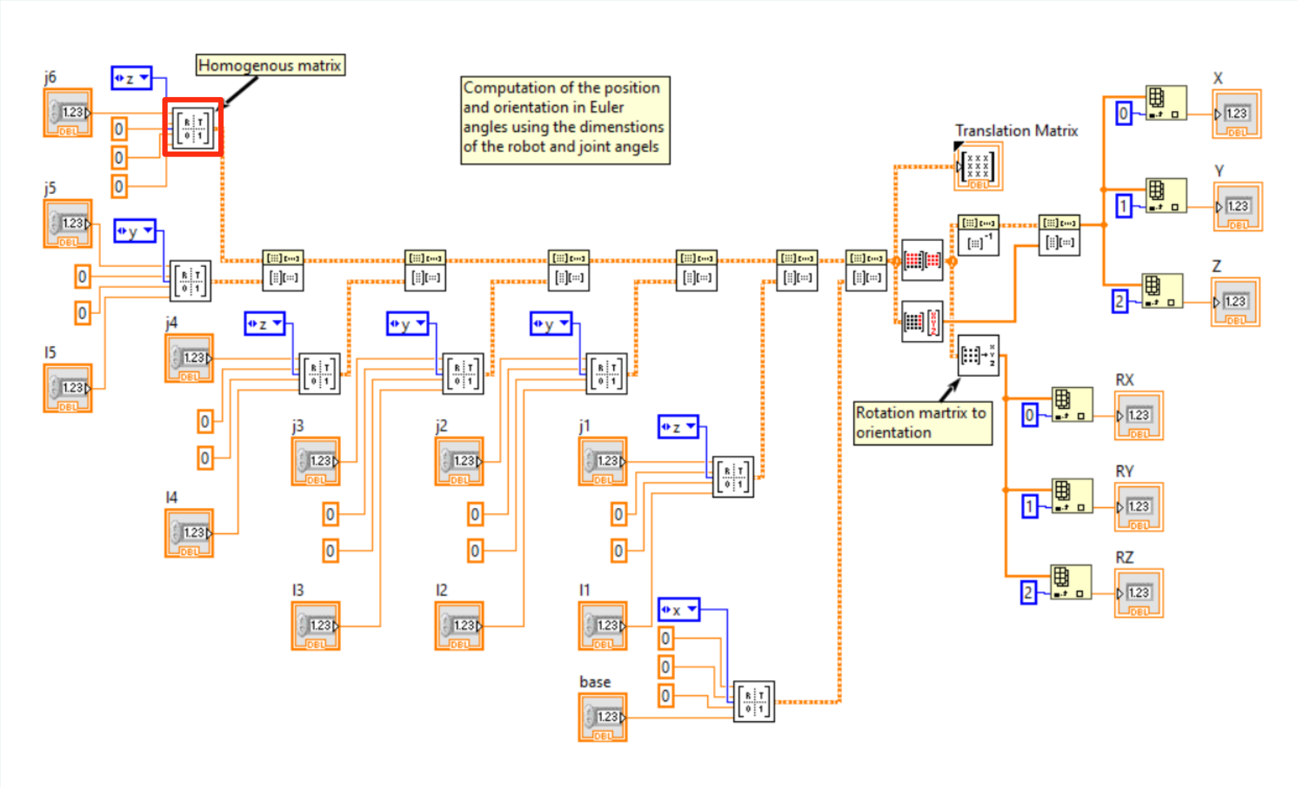
4. BLOCK DIAGRAM

The preview update section takes the joint values from the sliders and updates the 3D Picture using the provided VI from the Robotics Module.



4. BLOCK DIAGRAM

The direct kinematics section computes the DK of the manipulator



Homogenous matrix

Computation of the position and orientation in Euler angles using the dimenstions of the robot and joint angels

Translation Matrix

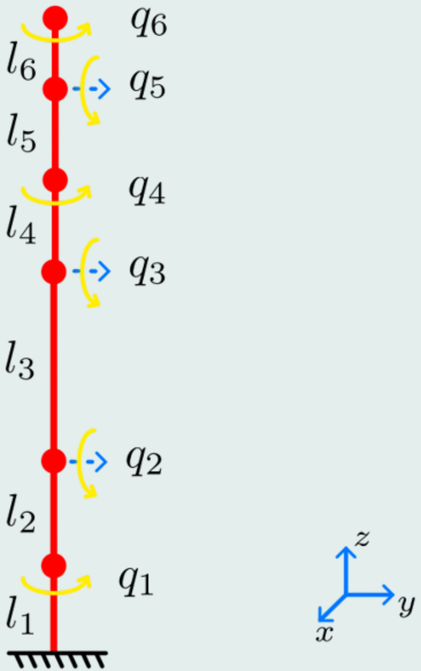
Rotation martrix to orientation

4. BLOCK DIAGRAM

Direct Kinematics is a process of obtaining the pose of the end-effector from the angle of the joints.

$$H = H_{6-E} \cdot H_{5-6} \cdot H_{4-5} \cdot H_{3-4} \cdot H_{2-3} \cdot H_{1-2} \cdot H_{B-1}$$

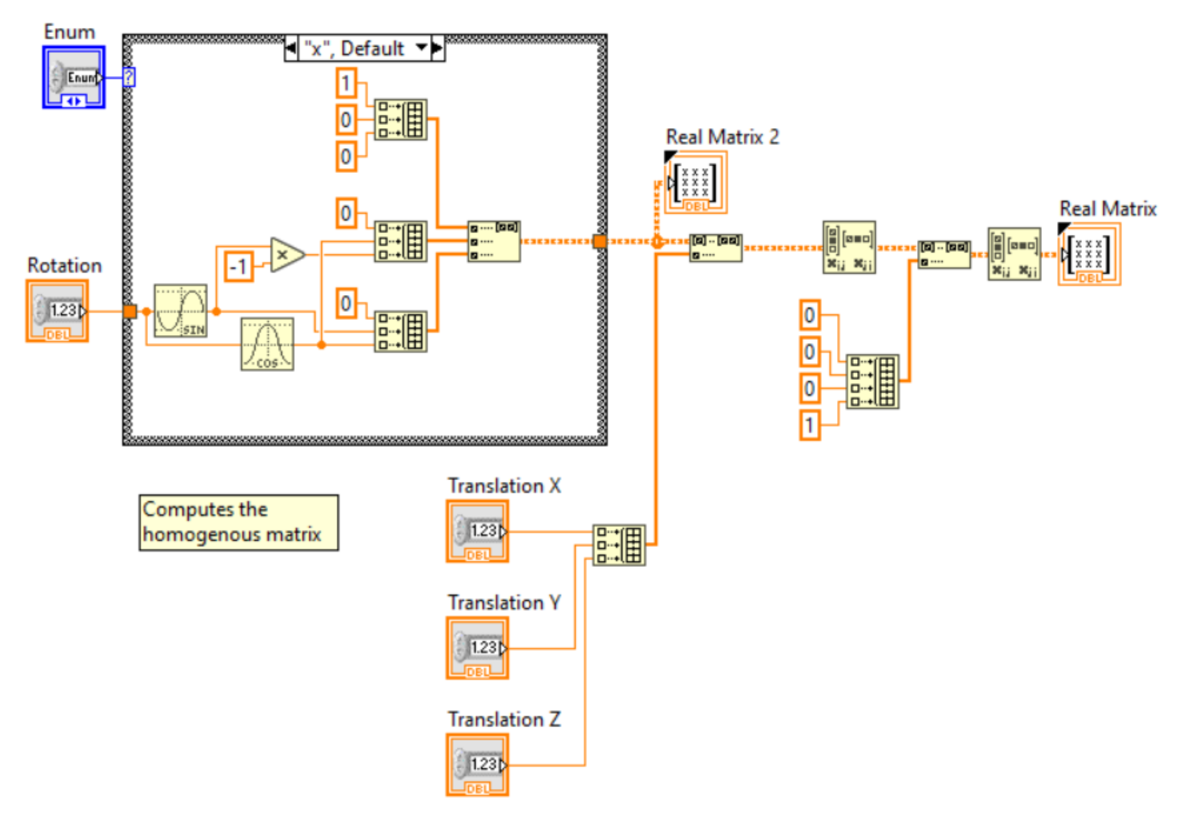
$$H = \begin{matrix} R & T \\ 0 & 1 \end{matrix} \qquad R = \begin{matrix} 1 & 0 & 0 \\ 0 & cos\alpha & -sin\alpha \\ 0 & sin\alpha & cos\alpha \end{matrix} \qquad T = \begin{matrix} x \\ y \\ z \end{matrix}$$



4. BLOCK DIAGRAM

Homogenous
matrix computation

$$R_x(\theta) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{pmatrix}$$

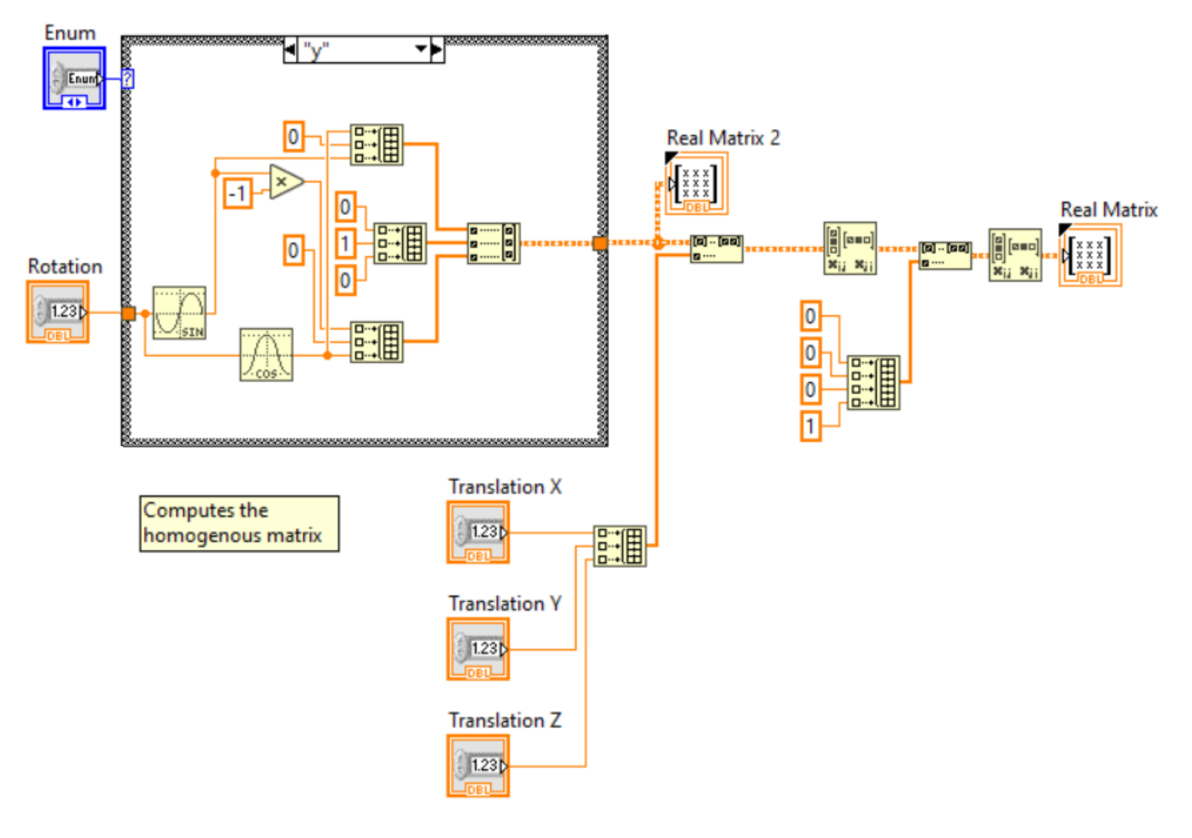


Computes the
homogenous matrix

4. BLOCK DIAGRAM

Homogenous matrix computation

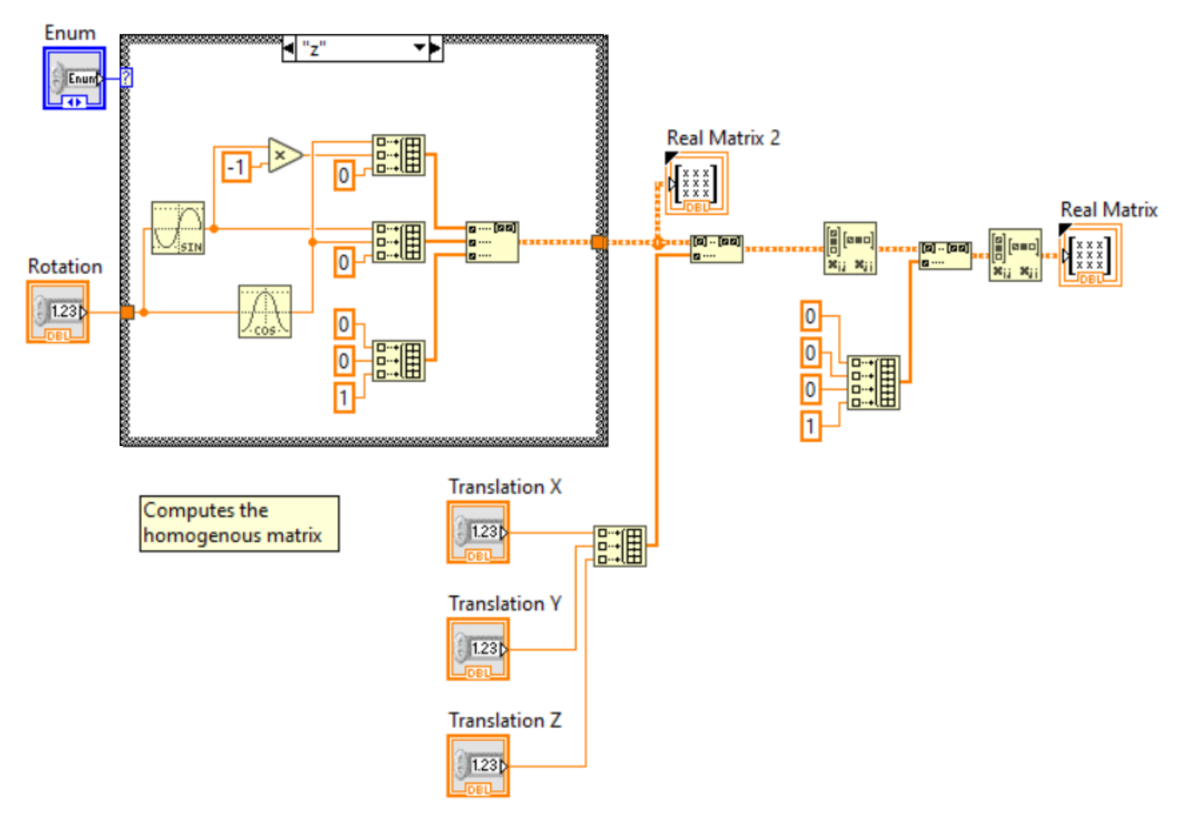
$$R_y(\theta) = \begin{pmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{pmatrix}$$



4. BLOCK DIAGRAM

Homogenous
matrix computation

$$R_z(\theta) = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$



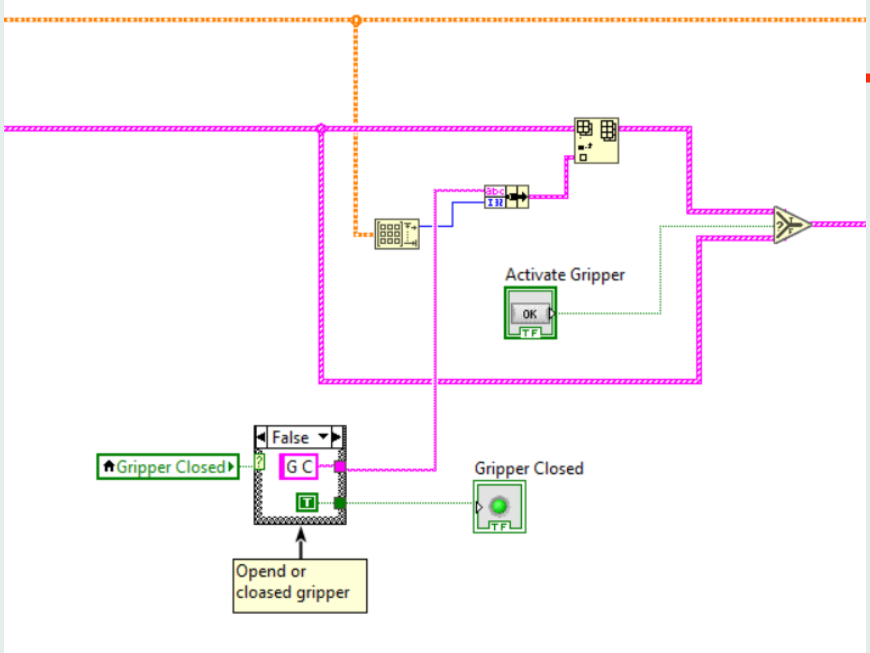
Computes the
homogenous matrix

4. BLOCK DIAGRAM

To handle the change of state for the buttons the “Event Structure” is used.

Each button will have an event case in which the logic of that button takes place.

In the image the event case of the “Activate gripper” button can be seen.



ANY QUESTIONS?

THANKS!

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Measurements and Data Acquisition

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