PhanTorque 3Dof and 6Dof Libraries

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The PhanTorque libraries are designed to facilitate the implementation of control algorithms from Simulink® to the Sensable® haptic devices. In particular, the PhantTorque 6Dof library (Figure 1) is designed to be used with the PHANTOM Premiums 1.5® and the PhanTorque 3Dof library (Figure 4) with the PHANTOM Omni® and PHANTOM Desktop®. These libraries follow the same idea of the Phansim library [1]. They use C/C++ S-functions and the OpenHaptics libraries [2] to make the interface between the haptics and Simulink. The main differences of the PhanTorque 6Dof library (versus Phansim) are that it allows to set the torques of the six DoF in the PHANTOM Premiums 1.5 and it gives the transformation matrix of the robot's end-effector and the linear and angular velocities.

1 PhanTorque 6Dof Library

In the Figure 1 can be observed the blocks that compose the PhanTorque 6Dof library. The masks of the two principal blocks, *PhanTorque_6Dof* and *PhanTorque_6Dof_vels*, are detailed in the Figure 2 and Figure 3, respectively. The Jacobian derived in [3] was used to program the blocks *Phantom 1.5/6DOF Jacobian* and *Phantom 1.5/6DOF Jacobian Transpose*. The *Clock Generator* block is the same of [1]. The *Homogeneus Matrix* block changes the vector $h \in \mathbb{R}^{16}$ to a matrix $H \in \mathbb{R}^{4\times4}$ and the *Rotation Matrix* block extracts the rotation matrix data from h.

2 PhanTorque 3Dof Library

The blocks that compose the PhanTorque 3Dof library are shown in the Figure 4 . In the Figure 5 and Figure 7 are detailed the masks of the two principal blocks of the library. The Jacobian derived in [4] was used to program the blocks *Omni Jacobian* and *Omni Jacobian Transpose*. The rest of the blocks are the same as those described in the las section. All the blocks of this library, except Omni Jacobian and Omni Jacobian Transpose, work with the Phantom Desktop.

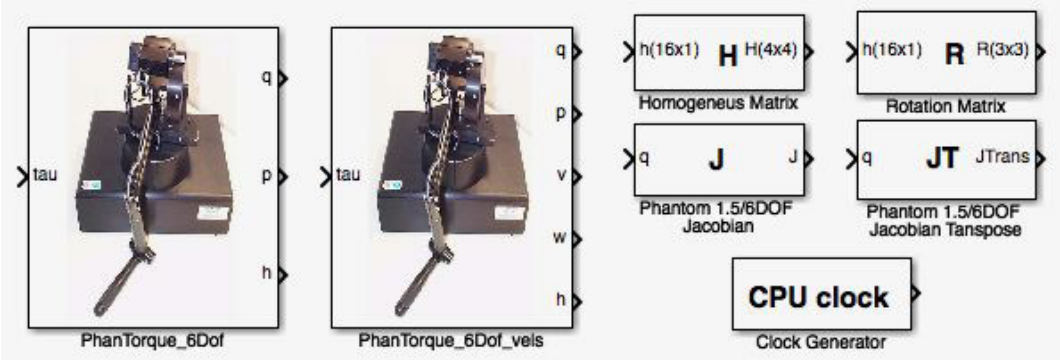

Figure 1: PhanTorque 6Dof library.

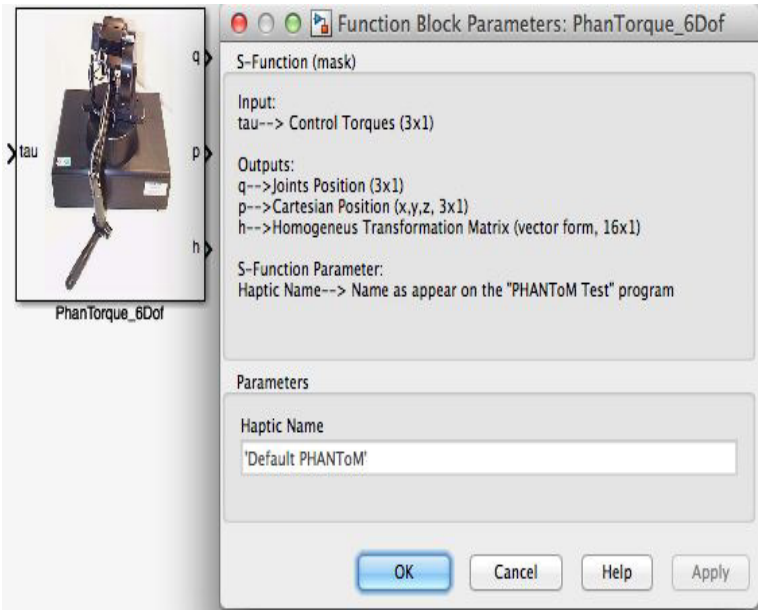

Figure 2: PhanTorque_6Dof block.

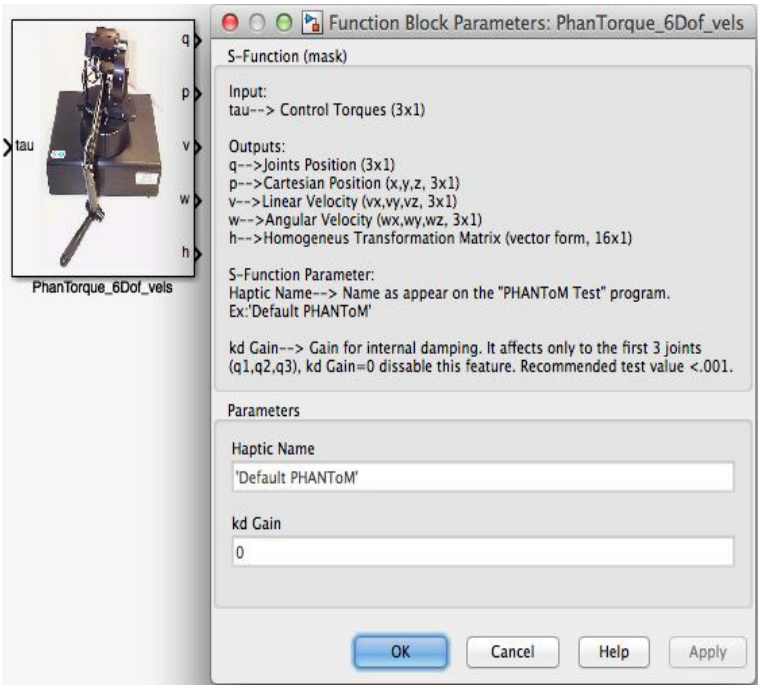

Figure 3: PhanTorque_6Dof_vels block.

Figure 4: PhanTorque_3Dof library.

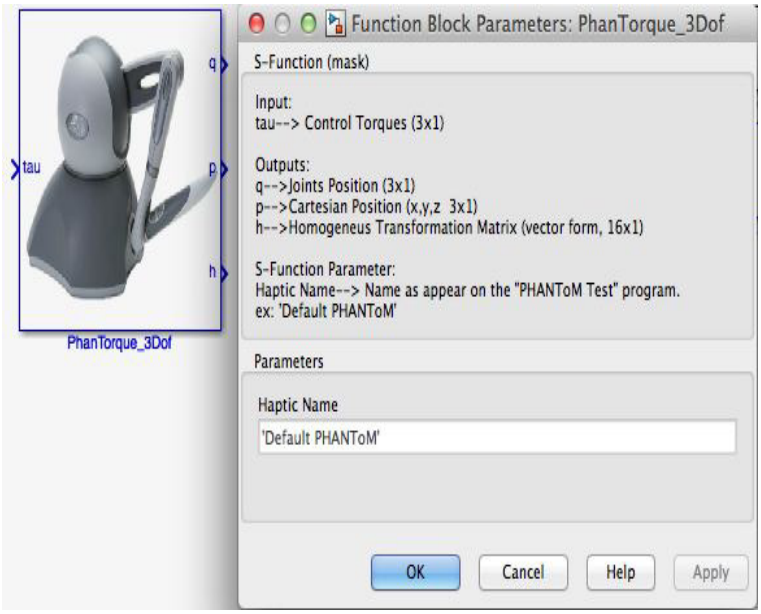

Figure 5: PhanTorque_3Dof block.

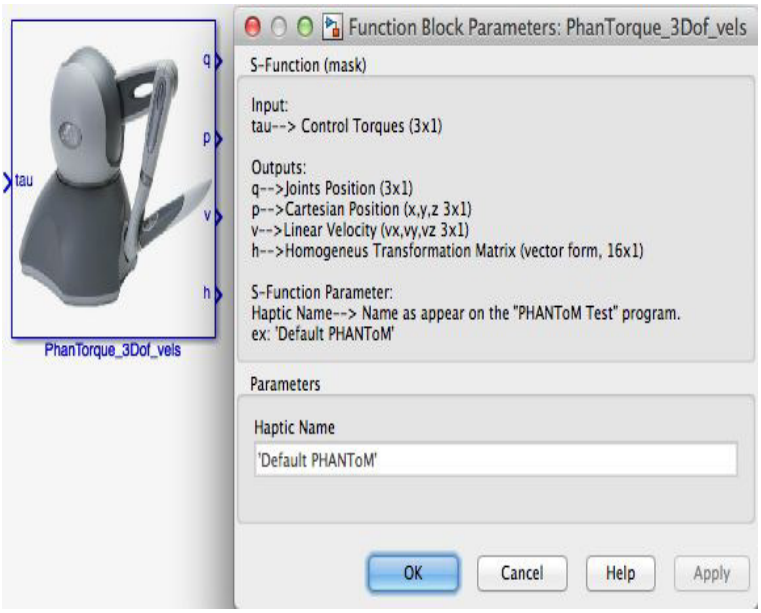

Figure 6: PhanTorque_3Dof_vels block.

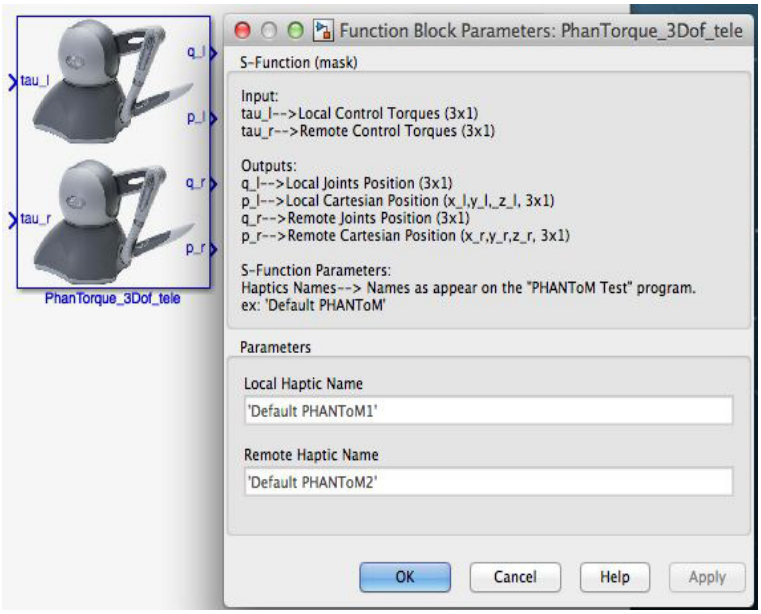

Figure 7: PhanTorque_3Dof_tele block.

3 Libraries Installation

1. Unzip the file (PhanTorque_6Dof Library **Bits.zip or PhanTorque_3Dof Library **Bits.zip).
2. Place the folder in the Matlab directory.
3. Add the path to this folder to Matlab (Set path option in Matlab).
4. Compile the S-functions: The codes of the S-functions are inside of the library folder, from Matlab compile the .c files with the next command:

   mex PhanTorque_*Dof_*.c hd.lib hdu.lib

   For example, the command to compile *PhanTorque_6Dof_damp_vels.c* is:

   mex PhanTorque_6Dof_damp_vels.c hd.lib hdu.lib

   IMPORTANT: The Matlab's file, *mexopts.bat,* has to be edited to include the path to the headers (.h) and libraries (.lib) of the OpenHaptics libraries.

IMPORTANT: The OpenHaptics libraries are NOT included in the zip files. The people interested on getting them please visit [2].

4 Acknowledgment

The author would like to thank Alireza Mohammadi and Tadej Petric for sharing their libraries.

References

[1] A Mohammadi, M Tavakoli, and A Jazayeri. Phansim : A Simulink Toolkit for the Phantom Haptic Devices. Proc. of 23rd Canadian Congress of Applied Mechanics, pages 787-790.

[2] http://geomagic.com/en/products/open-haptics/overview.

[3] A. Rodríguez and L. Basañez. Modelo cinemático de la interfase háptica PHANToM 1.5/6DOF. Technical report, Institute of Industrial and Control Engineering, Technical University of Catalonia, 2005. (http://upcommons.upc.edu/pfc/handle/2099.1/14587).

[4] E. Nuño, I. Sarras, E. Panteley, and L. Basañez. Consensus in networks of nonidentical Euler-Lagrange systems with variable time-delays. In 51st IEEE Conference on Decision and Control, pages 4721-4726, Maui, Hawaii, USA, Dec. 2012.