



Práctica 3:

Sistemas hápticos y teleoperación con PHANTOM Omni

GUÍA PRÁCTICA PARA LA TELEOPERACIÓN EN ROS
CON DOCKER

Objetivos

- ❑ Familiarizarse con el sensor háptico PHANTOM Omni.
- ❑ Implementar el uso de Docker para ROS.
- ❑ Desarrollar una aplicación de 'pozo de gravedad'.

Sensor háptico PHANTOM Omni



- Interacción háptica
- Retroalimentación de fuerza
- Ampliamente utilizado en aplicaciones de teleoperación
- Tiene un brazo con **6 grados de libertad** que detecta tanto la **posición** como la **orientación**, y proporciona **fuerzas en tres ejes**

Materiales

- Ordenador con Ubuntu.
- Sensor háptico PHANTOM Omni.
- Archivos proporcionados (carpeta Phantom y Dockerfile).



kinova-phantom_docker.zip

Nombre	Tamaño del archi...
kinova-phantom_docker	52 MB

Instalación de Docker

Install using the `apt` repository

Before you install Docker Engine for the first time on a new host machine, you need to set up the Docker repository. Afterward, you can install and update Docker from the repository.

1. Set up Docker's `apt` repository.

```
# Add Docker's official GPG key:
sudo apt-get update
sudo apt-get install ca-certificates curl
sudo install -m 0755 -d /etc/apt/keyrings
sudo curl -fsSL https://download.docker.com/linux/ubuntu/gpg -o /etc/apt/keyrings/docker.asc
sudo chmod a+r /etc/apt/keyrings/docker.asc

# Add the repository to Apt sources:
echo \
  "deb [arch=$(dpkg --print-architecture) signed-by=/etc/apt/keyrings/docker.asc] https://download.docker.com/linux/ubuntu $(. /etc/os-release && echo "$VERSION_CODENAME") stable" | \
  sudo tee /etc/apt/sources.list.d/docker.list > /dev/null
sudo apt-get update
```

2. Install the Docker packages.

Latest Specific version

To install the latest version, run:

```
$ sudo apt-get install docker-ce docker-ce-cli containerd.io docker-buildx-p
```

3. Verify that the Docker Engine installation is successful by running the `hello-world` image.

```
$ sudo docker run hello-world
```

Estos pasos lo harán cada alumno en su ordenador para tener Docker instalado. (Seguir los 3 pasos de la página).

Nota: Los alumnos únicamente tienen Docker, aún no se les ha entregado la imagen que tiene el contenedor para la práctica. Esto se verá el día de introducción a la práctica.

<https://docs.docker.com/engine/install/ubuntu/>

Construcción del Contenedor Docker

- Comando para construir el contenedor.

```
sudo docker build -t kinova-phantom .
```

- Tamaño aproximado (5.51 GB).

```
epvs@asus-pc2:~/docker_ws/kinova-phantom_docker$ sudo docker build -t kinova-phantom .
[sudo] contraseña para epvs:
[+] Building 1.4s (58/58) FINISHED                                docker:default
=> [internal] load build definition from Dockerfile              0.0s
=> => transferring dockerfile: 4.58kB                             0.0s
=> [internal] load metadata for docker.io/osrf/ros:noetic-desktop-focal 1.0s
=> [internal] load .dockerignore                                0.0s
=> => transferring context: 2B                                       0.0s
=> [internal] load build context                                0.0s
=> => transferring context: 84.16kB                                  0.0s
=> [ 1/53] FROM docker.io/osrf/ros:noetic-desktop-focal@sha256:3a0e6e9f937b9a734732f653271952772e7945f5f3cf9ad01b50043 0.0s
=> => resolve docker.io/osrf/ros:noetic-desktop-focal@sha256:3a0e6e9f937b9a734732f653271952772e7945f5f3cf9ad01b5004358 0.0s
=> CACHED [ 2/53] RUN apt-get update && apt-get install -y --no-install-recommends ros-noetic-desktop-full=1.5.0-1 0.0s
=> CACHED [ 3/53] RUN apt-get update && apt-get install -y libgl1-mesa-glx libgl1-mesa-dri libglu1-mesa 0.0s
=> CACHED [ 4/53] RUN apt-get update && apt-get install -y apt-utils curl wget git bash-completion build-essential sud 0.0s
=> CACHED [ 5/53] RUN addgroup --gid 1000 kinova-phantom          0.0s
=> CACHED [ 6/53] RUN adduser --gecos "ROS User" --disabled-password --uid 1000 --gid 1000 kinova-phantom 0.0s
=> CACHED [ 7/53] RUN usermod -a -G dialout kinova-phantom       0.0s
=> CACHED [ 8/53] RUN mkdir config && echo "kinova-phantom ALL=(ALL) NOPASSWD: ALL" > config/99_aptget 0.0s
=> CACHED [ 9/53] RUN cp config/99_aptget /etc/sudoers.d/99_aptget 0.0s
=> CACHED [10/53] RUN chmod 0440 /etc/sudoers.d/99_aptget && chown root:root /etc/sudoers.d/99_aptget 0.0s
=> CACHED [11/53] RUN apt-get update && apt-get install -y apt-utils curl wget git bash-completion build-essential sud 0.0s
```

Conexión del Sensor

□ Dos tipos de conexión (USB y Ethernet).

➤ USB (verificar el puerto)

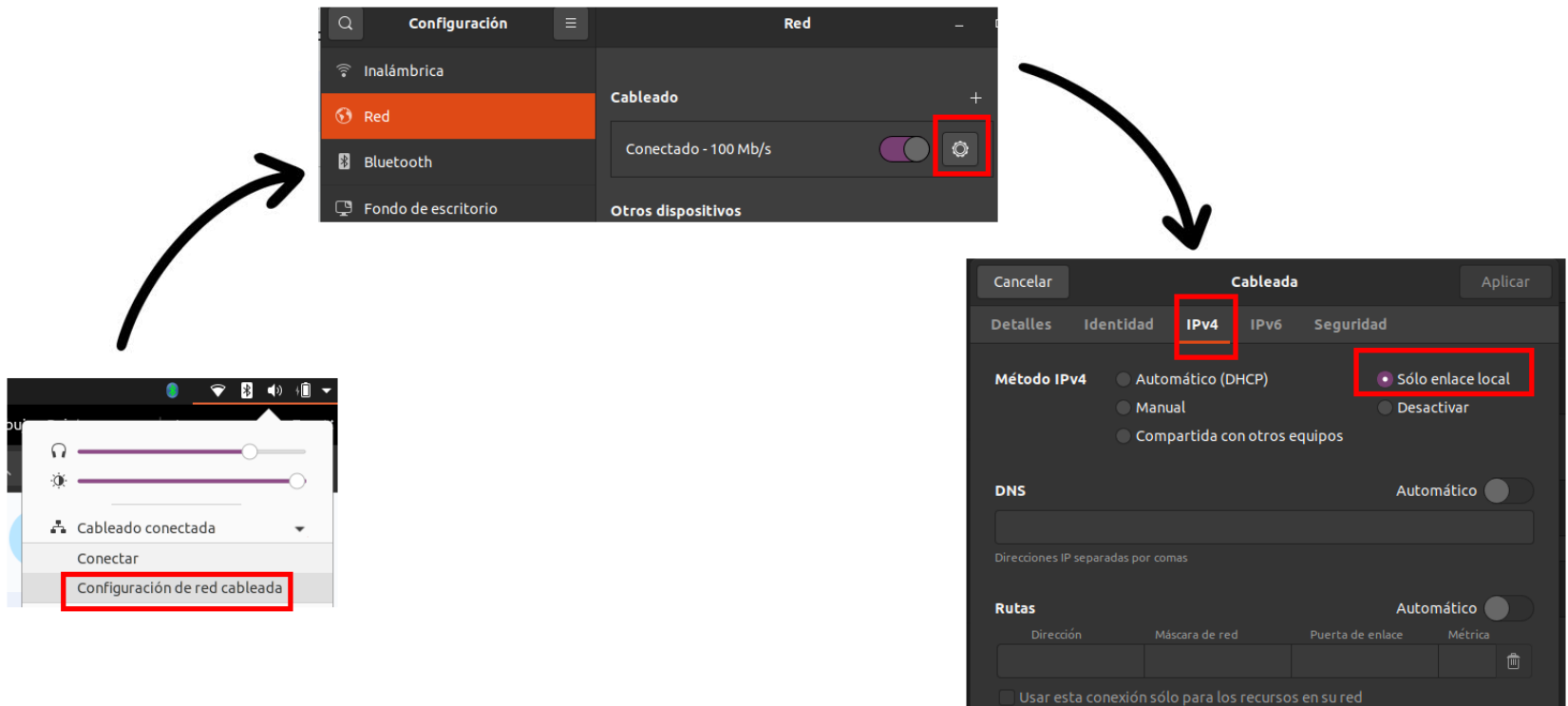
```
ls -l /dev/ttyACM*
```

```
epvs@asus-pc2:~$ ls -s /dev/ttyACM*  
0 /dev/ttyACM0
```

Conexión del Sensor

❑ Dos tipos de conexión (USB y Ethernet).

➤ LAN (Configuración de red cableada)



Ejecución del Contenedor

- Comando **docker run**.

```
sudo docker run \  
--shm-size=1g \  
--privileged \  
--ulimit memlock=-1 \  
--ulimit stack=67108864 \  
--rm -it --net=host \  
-e DISPLAY=:0 \  
--user=root \  
-v /tmp/.X11-unix:/tmp/.X11-unix:rw \  
--device=/dev/ttyACM0:/dev/ttyACM0 \  
--name kinova-phanthom_container \  
--gpus all \  
--cpuset-cpus=0-3 \  
-v /home/epvs:/home/kinova-phanthom/catkin_ws/epvelasco \  
kinova-phanthom
```

Ejecución del Contenedor

- Comando **docker run**.

```
sudo docker run \  
--shm-size=1g \  
--privileged \  
--ulimit memlock=-1 \  
--ulimit stack=67108864 \  
--rm -it --net=host \  
-e DISPLAY=:0 \  
--user=root \  
-v /tmp/.X11-unix:/tmp/.X11-unix:rw \  
--device=/dev/ttyACM0:/dev/ttyACM0 \  
--name kinova-phantom_container \  
--gpu all \  
--cpuset-cpus=0-3 \  
-v /home/epvs/:/home/kinova-phantom/catkin_ws/epvelasco \  
kinova-phantom
```

Ejecución del Contenedor

- Comando **docker run**.

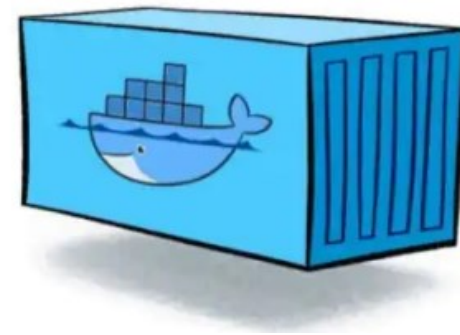
```
epvs@asus-pc2:~/docker_ws/kinova-phantom_docker$ sudo docker run \  
> --shm-size=1g \  
> --privileged \  
> --ulimit memlock=-1 \  
> --ulimit stack=67108864 \  
> --rm \  
> -it \  
> --net=host \  
> -e DISPLAY=:1 \  
> --user=root \  
> -v /tmp/.X11-unix:/tmp/.X11-unix:rw \  
> --device=/dev/ttyACM0:/dev/ttyACM0 \  
> --name kinova-phantom_container \  
> --gpus all \  
> --cpuset-cpus=0-10 \  
> -v /home/epvs/:/epvelasco \  
> kinova-phantom  
root@asus-pc2:~/catkin_ws/phantom$
```

Compartiendo rutas

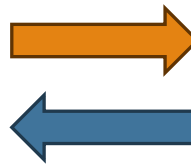
`/home/miOrdenador/practica:/home/kinova-phantom/catkin_ws/practica`



`/home/miOrdenador/practica`



`/home/kinova-phantom/catkin_ws/practica`



¿Más terminales con el contenedor?

```
sudo docker exec -it kinova-phantom_container /bin/bash
```

```
epvs@asus-pc2:~$ sudo docker exec -it kinova-phantom_container /bin/bash  
root@asus-pc2:~/catkin_ws/phantom$
```

Tab 0 roscore http://asus-pc2:11311/ 60x29	epvs@asus-pc2: ~ epvs@asus-pc2: ~ 60x29	epvs@asus-pc2: ~ 61x29
<pre>root@asus-pc2:~/catkin_ws/phantom\$ roscore ... logging to /home/kinova-phantom/.ros/log/8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e/roslaunch-asus-pc2-265.log Checking log directory for disk usage. This may take a while . Press Ctrl-C to interrupt Done checking log file disk usage. Usage is <1GB. started roslaunch server http://asus-pc2:42611/ ros_comm version 1.16.0 SUMMARY ===== PARAMETERS * /rostdistro: noetic * /rosversion: 1.16.0 NODES auto-starting new master process[master]: started with pid [273] ROS_MASTER_URI=http://asus-pc2:11311/ setting /run_id to 8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e process[rosout-1]: started with pid [283] started core service [/rosout] </pre>	<pre>root@asus-pc2:~/catkin_ws/phantom\$</pre>	<pre>root@asus-pc2:~/catkin_ws/phantom\$</pre>
<pre>epvs@asus-pc2: ~ 60x24 root@asus-pc2:~/catkin_ws/phantom\$</pre>	<pre>epvs@asus-pc2: ~ 60x24 root@asus-pc2:~/catkin_ws/phantom\$</pre>	<pre>epvs@asus-pc2: ~ 61x24 root@asus-pc2:~/catkin_ws/phantom\$</pre>

Ejecutando los nodos del sensor Háptico.


Para el sensor háptico por USB:

```
cd ~/catkin_ws/phanthom/  
./start_omni_USB.sh
```


Para el sensor háptico por LAN:

```
cd ~/catkin_ws/phanthom/  
./start_omni_LAN.sh
```


Touch Setup



Hardware



Reset Angle



About

Device Name:


Device Model:

Interface:


Device Serial Num:

Device List:


Firmware Version:




Hardware



Reset Angle



LAN Settings



About

Device Name:

Device Model:

Interface:

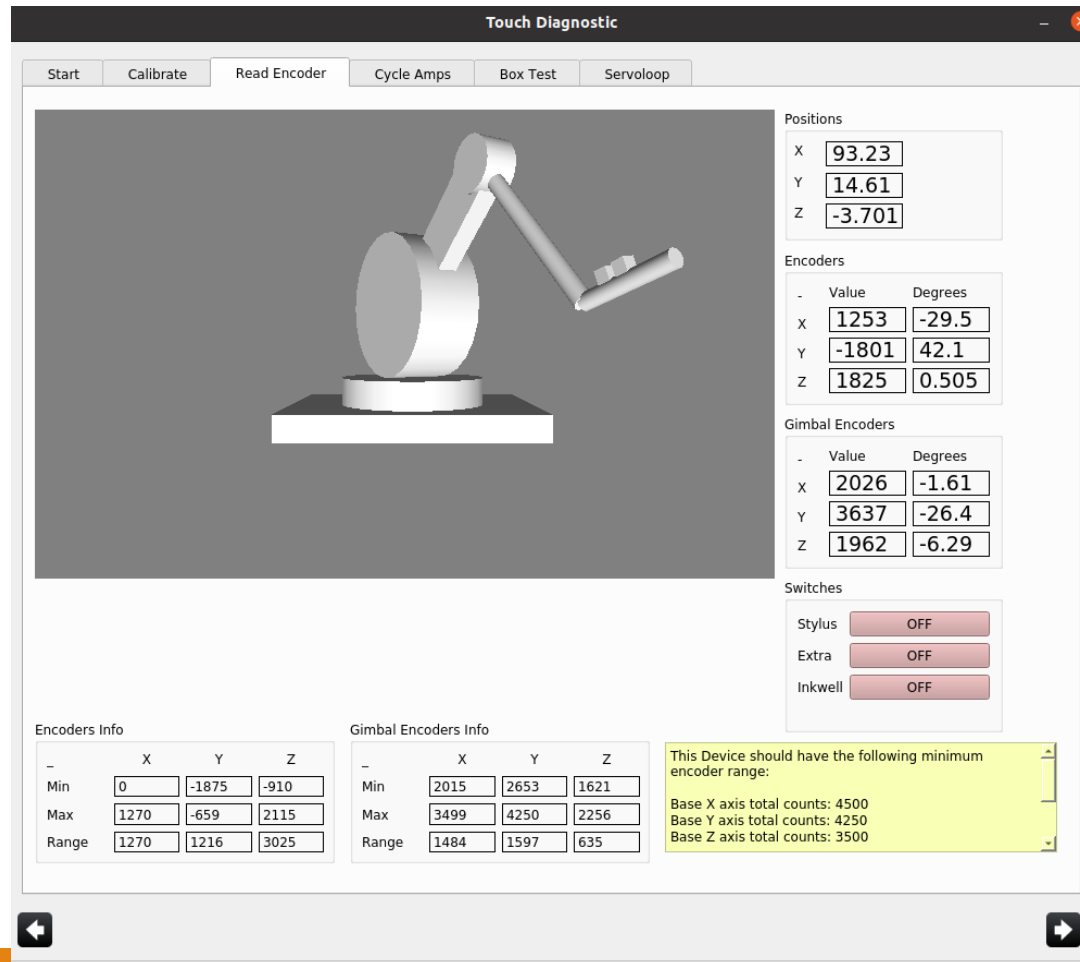
Device Paired:

Device List:

Rescan for Devices

Touch Diagnostic

```
cd ~/catkin_ws/phantom/ && ./Touch_Diagnostic
```



The screenshot displays the 'Touch Diagnostic' application window. It features a central 3D visualization of a robotic arm. To the right of the 3D model are three panels: 'Positions' showing X (93.23), Y (14.61), and Z (-3.701) coordinates; 'Encoders' showing raw values and degrees for X, Y, and Z; and 'Gimbal Encoders' showing raw values and degrees for X, Y, and Z. Below these are 'Switches' for Stylus, Extra, and Inkwell, all currently set to 'OFF'. At the bottom, there are two tables for 'Encoders Info' and 'Gimbal Encoders Info', and a yellow box with a warning message about minimum encoder ranges and total counts.

Positions

X	93.23
Y	14.61
Z	-3.701

Encoders

	Value	Degrees
X	1253	-29.5
Y	-1801	42.1
Z	1825	0.505

Gimbal Encoders

	Value	Degrees
X	2026	-1.61
Y	3637	-26.4
Z	1962	-6.29

Switches

- Stylus: OFF
- Extra: OFF
- Inkwell: OFF

Encoders Info

	X	Y	Z
Min	0	-1875	-910
Max	1270	-659	2115
Range	1270	1216	3025

Gimbal Encoders Info

	X	Y	Z
Min	2015	2653	1621
Max	3499	4250	2256
Range	1484	1597	635

Warning: This Device should have the following minimum encoder range:

- Base X axis total counts: 4500
- Base Y axis total counts: 4250
- Base Z axis total counts: 3500

Ejecutando ROS con el sensor háptico

```
Tab 0      roscore http://asus-pc2:11311/60x29      epvs@asus-pc2: ~      epvs@asus-pc2: ~ 61x29
root@asus-pc2:~/catkin_ws/phantom$ roscore
... Logging to /home/kinova-phantom/.ros/log/8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e/roslaunch-asus-pc2-265.log
Checking log directory for disk usage. This may take a while
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://asus-pc2:42611/
ros_comm version 1.16.0

SUMMARY
=====
PARAMETERS
* /rostdistro: noetic
* /rosversion: 1.16.0

NODES

auto-starting new master
process[master]: started with pid [273]
ROS_MASTER_URI=http://asus-pc2:11311/

setting /run_id to 8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e
process[rosout-1]: started with pid [283]
started core service [/rosout]
^C

epvs@asus-pc2: ~ 60x24      epvs@asus-pc2: ~ 60x24      epvs@asus-pc2: ~ 61x24
root@asus-pc2:~/catkin_ws/phantom$      root@asus-pc2:~/catkin_ws/phantom$      root@asus-pc2:~/catkin_ws/phantom$
```



```
Tab 0      roscore http://asus-pc2:11311/ 60x29
root@asus-pc2:~/catkin_ws/phantom$ roscore
... logging to /home/kinova-phantom/.ros/log/8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e/roslaunch-asus-pc2-265.log
Checking log directory for disk usage. This may take a while
.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

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ros_comm version 1.16.0

SUMMARY
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PARAMETERS
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NODES

auto-starting new master
process[master]: started with pid [273]
ROS_MASTER_URI=http://asus-pc2:11311/

setting /run_id to 8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e
process[rosout-1]: started with pid [283]
started core service [/rosout]
^

epvs@asus-pc2: ~ 60x29
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 61x29
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 60x24
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 60x24
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 61x24
root@asus-pc2:~/catkin_ws/phantom$
```

Terminal para:
nodo sensable_phantom

```
Tab 0      roscore http://asus-pc2:11311/ 60x29
root@asus-pc2:~/catkin_ws/phantom$ roscore
... logging to /home/kinova-phantom/.ros/log/8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e/roslaunch-asus-pc2-265.log
Checking log directory for disk usage. This may take a while
.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://asus-pc2:42611/
ros_comm version 1.16.0

SUMMARY
=====

PARAMETERS
 * /rostdistro: noetic
 * /rosversion: 1.16.0

NODES

auto-starting new master
process[master]: started with pid [273]
ROS_MASTER_URI=http://asus-pc2:11311/

setting /run_id to 8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e
process[rosout-1]: started with pid [283]
started core service [/rosout]
^

epvs@asus-pc2: ~ 60x29
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 61x29
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 60x24
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 60x24
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 61x24
root@asus-pc2:~/catkin_ws/phantom$
```

Terminal para
rviz.launch

```
Tab 0      roscore http://asus-pc2:11311/ 60x29
root@asus-pc2:~/catkin_ws/phantom$ roscore
... logging to /home/kinova-phantom/.ros/log/8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e/roslaunch-asus-pc2-265.log
Checking log directory for disk usage. This may take a while
.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://asus-pc2:42611/
ros_comm version 1.16.0

SUMMARY
=====

PARAMETERS
 * /rostdistro: noetic
 * /rosversion: 1.16.0

NODES

auto-starting new master
process[master]: started with pid [273]
ROS_MASTER_URI=http://asus-pc2:11311/

setting /run_id to 8568ad6e-49bb-11ef-a9ee-08bfb8d3b50e
process[rosout-1]: started with pid [283]
started core service [/rosout]
^

epvs@asus-pc2: ~ 60x29
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 61x29
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 60x24
root@asus-pc2:~/catkin_ws/phantom$

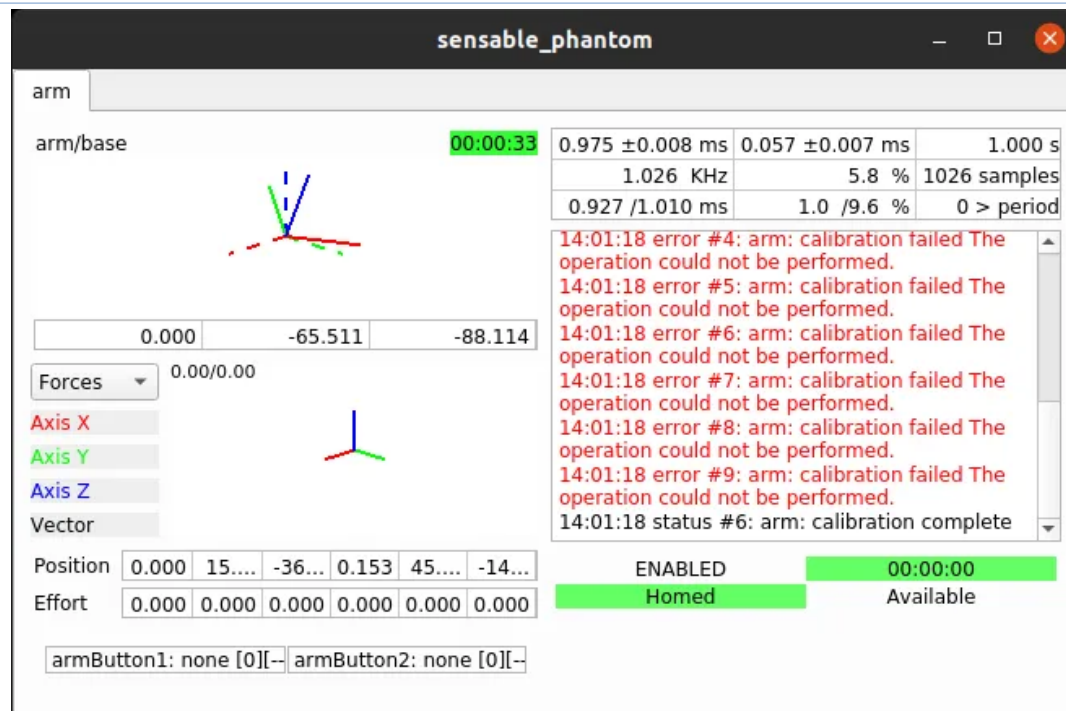
epvs@asus-pc2: ~ 60x24
root@asus-pc2:~/catkin_ws/phantom$

epvs@asus-pc2: ~ 61x24
root@asus-pc2:~/catkin_ws/phantom$
```

Terminal para :
**El programa de la
práctica**

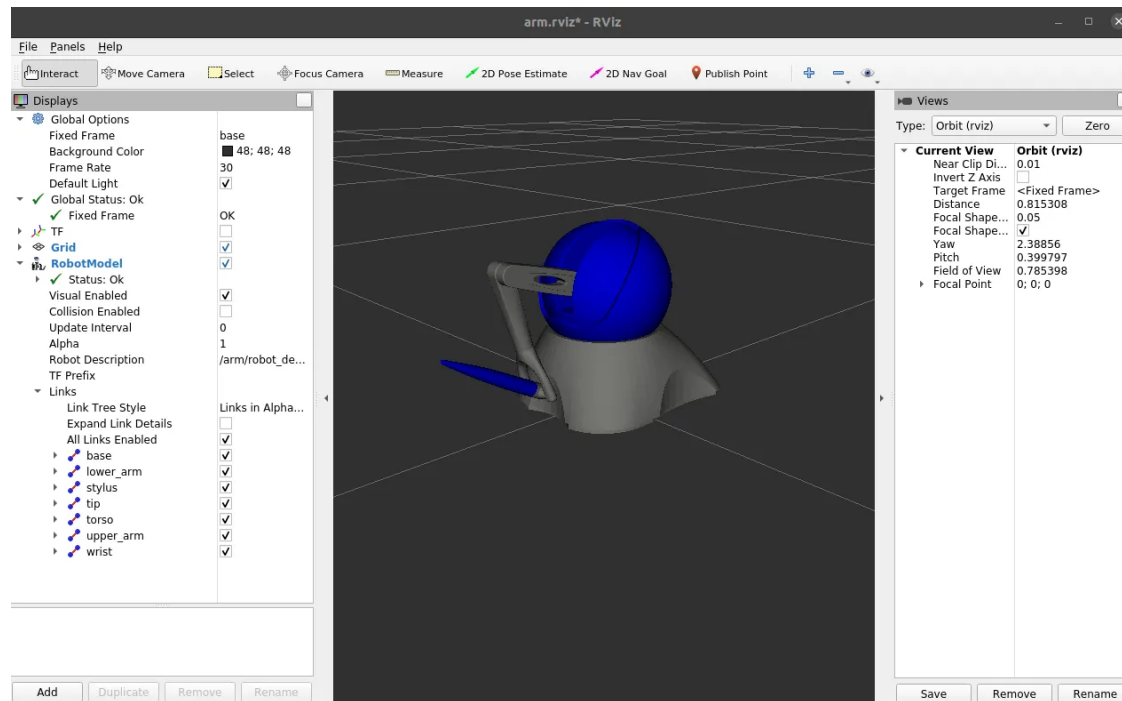
Ejecutando el ROS con el sensor háptico

```
cd ~/catkin_ws/phanthom/ &&\nsource devel/setup.bash &&\nroslaunch sensable_phantom_ros sensable_phantom
```



Ejecutando el ROS con el sensor háptico

```
source devel/setup.bash &&\nroslaunch sensable_phantom_ros rviz.launch
```



Cerrar Contenedor

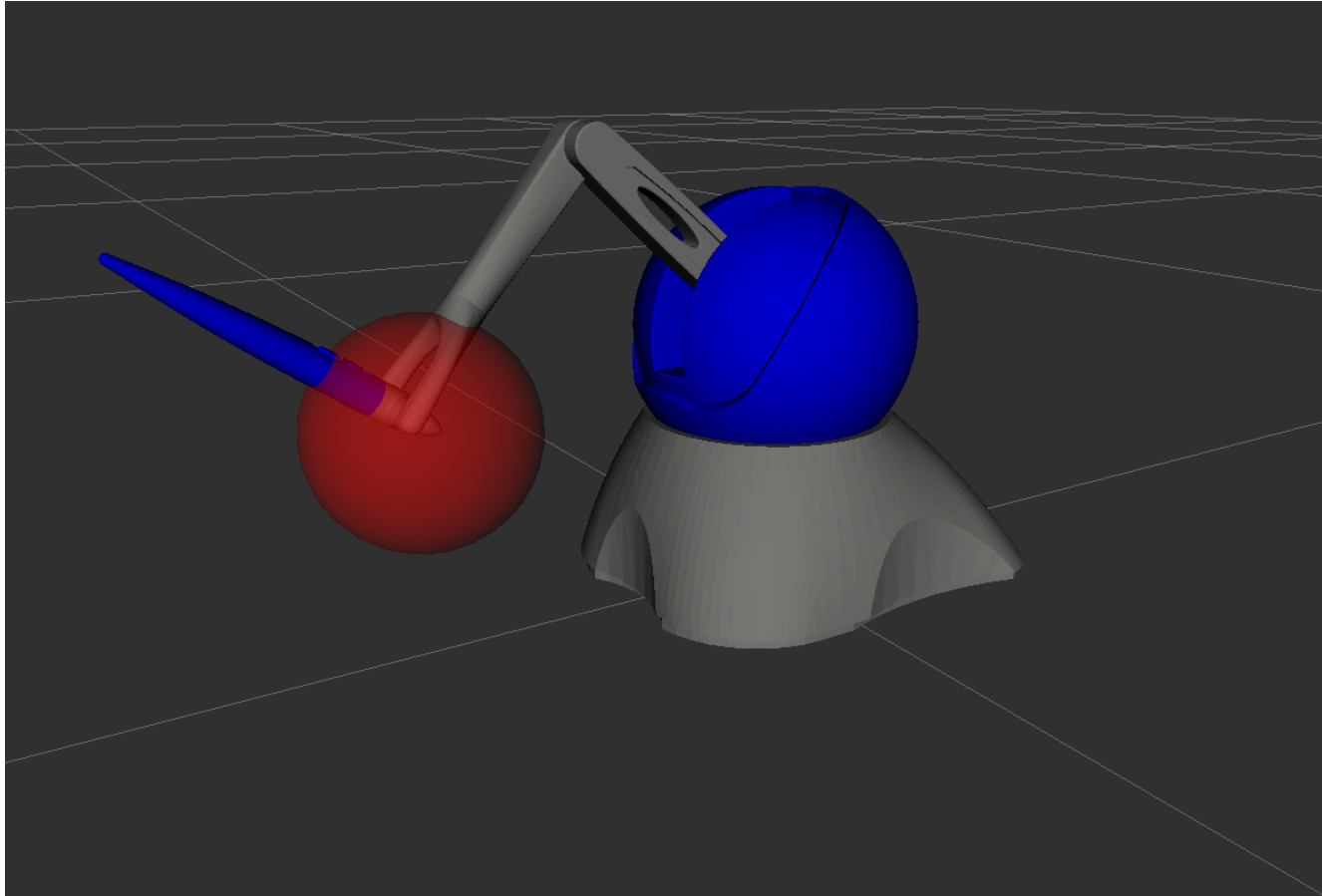
exit

```
root@msi:~/catkin_ws/phantom$ exit  
exit  
epvs@msi:~$
```

NOTA: Recordar que al **salir del contenedor** todos los **archivos** y configuraciones dentro del contenedor se **eliminarán**

Es por ello por lo que se debe **compartir** de manera adecuada las rutas del **ordenador** con la ruta dentro del **contenedor**

Implementación del Pozo de Gravedad





Programa comentado
y un **vídeo** demostrativo



Un **documento** detallado que
explique el sistema desarrollado
durante la práctica.

Entregables