

D3.3 Software Installation Manual

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PU	Public	PU
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RE	Restricted to a group specified by the consortium (including Afretec Administration)	
CO	Confidential, only for members of the consortium (including Afretec Administration)	

Executive Summary

Deliverable D3.3 serves as a comprehensive installation manual for the Culturally Sensitive Social Robotics for Africa (CSSR4Africa) project. The manual will be continually updated as a living document to ensure it reflects the current capabilities of the system. The objective of this task is to document the process of installing and executing the required software components to instantiate the CSSR4Africa system. It provides step-by-step instructions for setting up the development environment and controlling the Pepper robot in both physical and simulated environments.

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1 Introduction

Software Installation Manual(D3.3) outlines the detailed steps necessary for installing and executing the software critical for deploying parts or the entirety of the CSSR4Africa system, as well as conducting the requisite unit, integration, and system tests. It is designed for systems running a native Ubuntu 20.04 OS and equipped with ROS Noetic. The manual also specifies the NAOqi OS version for the robot as 2.5.10.7.

The manual is divided into several key sections. The initial section, referred to as “Setting up Pepper Robot, delineates the preliminary configurations required for the Pepper robot before any software installations. Following this, the “Setting up the Development Environment” section provides comprehensive instructions for preparing the development environments tailored for both the physical robot and the Gazebo simulator. This includes a walkthrough of the prerequisite setup common to both environments, followed by specific installation procedures. Lastly, the “Installing and Running the CSSR4Africa Software” section discusses installing and initiating the CSSR4Africa software, ensuring a smooth deployment.

2 Setting up Pepper robot

To configure the Pepper robot for the first time, reference the Pepper Robot Pocket Guide included with your robot when shipped. This guide provides detailed instructions for unboxing and setting up your robot. For additional support, access the online configuration guide at [Pepper User Guide](#). We are utilizing version 1.8 of the Pepper robot. For comprehensive technical details, including its sensor and actuator capabilities, please refer to the [Pepper Technical Detail](#) [1]. This resource offers a thorough overview of the robot's technical specifications

Next, establish a Wi-Fi connection between the robot and the user's computer. It's advisable to use a dedicated Wi-Fi router for this purpose, rather than relying on a campus wireless network (CMU), to avoid the complications of logging in with a school ID (Andrew ID). To achieve this, connect a router to the campus's network via an Ethernet cable. Upon powering your laptop, instructions on the tablet will guide you to connect to this router. Once connected, the Pepper robot will vocalize its IP address when you press the power button once. This IP address is crucial, as it will be used to establish a connection through ROS (Robot Operating System), enabling communication and control of the robot from your computer. Furthermore, we set up the router for the robot to have a static IP address using the robot's MAC address.

The MAC address can be found when accessing the Pepper web page as shown in Figure 1 by opening a web browser and entering the IP address. Then log in by setting the username and password you configured when setting up the robot. Then using the Wi-Fi MAC address configure the router to have the pepper robot IP address permanent. This can be done by looking in the DHCP or static IP Assignment. Then assign a static IP address by adding a new reservation, enter the MAC address, and save the setting. Restart the robot and the router for the changes to take effect.

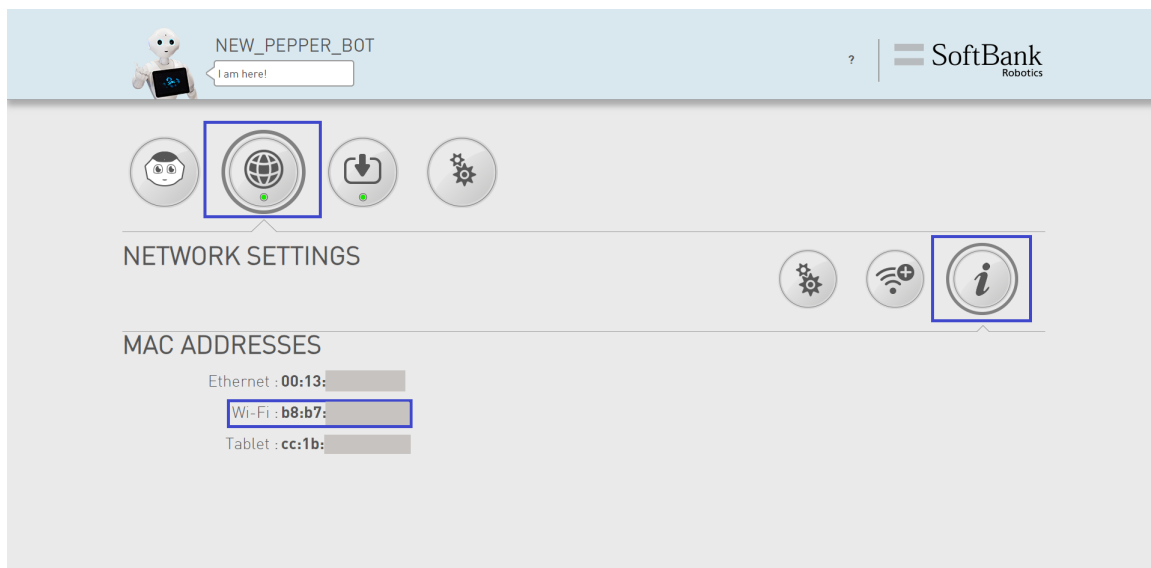


Figure 1: Pepper Web Page

3 Setting up the Development Environment

This section provides step-by-step instructions for installing a set of software packages required to control the physical Pepper robot and the robot in the Gazebo simulator. Open a new terminal (*ctrl + shift + t*) and type the following commands carefully.

3.1 Prerequisite

The prerequisite for setting up the development environment for the physical robot and the simulator is installing ROS-Noetic. The following instructions are followed to install ROS-Noetic.

1. Setup the computer to accept software from packages.ros.org.

```
sudo sh -c 'echo "deb http://packages.ros.org/ros/ubuntu \
$(lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'
```

2. Install curl.

```
sudo apt install curl
```

3. Setup your keys.

```
curl -s https://raw.githubusercontent.com/ros/rosdistro/\
master/ros.asc | sudo apt-key add -
```

4. Update Debian package index.

```
sudo apt update
```

5. Install ROS Noetic with the default configurations.

```
sudo apt install ros-noetic-desktop-full
```

6. Make ROS environment variables automatically added every time a new shell is launched.

```
echo "source /opt/ros/noetic/setup.bash" >> $HOME/.bashrc
source $HOME/.bashrc
```

7. Install Git

```
sudo apt install git
```

8. Install python3-pip.

```
sudo apt install python3-pip
```

3.2 Setting up the Development Environment for the Physical Robot

3.2.1 Installing NAOqi Driver and ROS Packages

The NAOqi driver is a module that provides bridge capabilities. It publishes sensory data and the pepper position, enabling ROS to call part of the NAOqi API. The driver is dependent on `naoqi_libqi`, `naoqi_libqicore`, and `naoqi_bridge_msgs` packages. Those packages could be installed using `apt-get`. The rest of the packages are installed from the source by cloning them from GitHub. The three packages `naoqi_dcm_driver`, `naoqi_driver`, and `pepper_dcm_robot` have been modified compared to the official repository on GitHub. Hence, these updated packages are under the CSSR4Africa repository.

```
# Install the NAOqi driver
sudo apt-get install ros-.*-naoqi-driver

# Create ROS workspace
mkdir -p $HOME/workspace/pepper_rob_ws/src

# Move to the workspace directory
cd $HOME/workspace/pepper_rob_ws/src

# Clone NAOqi DCM driver repository
git clone https://github.com/cssr4Africa/naoqi_dcm_driver.git

# Clone NAOqi driver repository
git clone https://github.com/cssr4Africa/naoqi_driver.git

# Clone Pepper DCM driver repository
git clone https://github.com/cssr4Africa/pepper_dcm_robot.git

# Clone Pepper virtual repository
git clone https://github.com/ros-naoqi/pepper_virtual.git

# Clone Pepper robot repository
git clone https://github.com/ros-naoqi/pepper_robot.git

# Clone Pepper moveit config repository
git clone https://github.com/ros-naoqi/pepper_moveit_config.git

# Build the repository
cd .. && catkin_make
# Add the workspace to your ROS environment by sourcing the setup file in
  devel folder
source devel/setup.bash

# Add the setup to your .bashrc file so that you don't have to do this
  every time you open a new terminal
echo "source $HOME/workspace/pepper_rob_ws/devel/setup.bash" >> \
$HOME/.bashrc
# Install additional packages
sudo apt-get install ros-noetic-joint-trajectory-controller

sudo apt-get install ros-noetic-ros-controllers
```

```
sudo apt-get install ros-noetic-pepper-meshes
# When the configuring window opens up, you may agree to the license
  terms using the right/left arrow key select <ok> hit enter, and then
  select <Yes> to accept the terms and press enter

# Install rosdep
sudo pip install -U rosdep
sudo rosdep init
rosdep update

rosdep install --from-paths src --ignore-src -r -y
```

3.2.2 Installing and Configuring the Python NAOqi SDK

The NAOqi Framework, a cross-language programming framework for programming Pepper, supports both C++ and Python. The Python NAOqi SDK was used when the microphone sensor failed to function with the `naoqi_driver`, the Python SDK was employed to access the microphone sensors' API. This method allowed the modified `naoqi_driver` to publish the captured audio data successfully. Furthermore, since the tablet was not supported by the ROS-NAOqi drivers, the Python SDK was used to provide an interface through ROS.

`rospy` (a python client library for ROS(Robot Operating System) which enables the development of ROS-based applications was used mainly to define publishers, subscribers, and services. However, one of the limitations of Python SDK is that it runs on Python 2 whereas `rospy` uses Python 3 (ROS-Noetic). To overcome this problem, a UDP socket was used that will send the data from Python 2 to the `python3` script that receives data and then publishes or provides a ros service using the `rospy`.

1. Change directory to home

```
cd $HOME
```

2. Installing Python 2.7

```
sudo apt install python2

# check the version of the Python
python2 --version
```

3. Installing Pip2

```
curl https://bootstrap.pypa.io/pip/2.7/get-pip.py --output get-pip.py
```

4. Installing the necessary packages

```
sudo apt-get install libpython2.7
sudo apt-get install libatlas3-base
sudo python2 get-pip.py
```

5. Checking the pip2 version

```
pip2 --version
```

6. Installing NumPy


```
pip2 install numpy
```

7. Download the Python SDK by using the following command.

```
wget -S -L https://community-static.aldebaran.com/resources/2.5.5/\
sdk-python/pynaoqi-python2.7-2.5.5.5-linux64.tar.gz
```

8. Extract the SDK

```
tar -xvf pynaoqi-python2.7-2.5.5.5-linux64.tar.gz
```

9. To ensure that the PYTHONPATH environment variable is automatically set every time a new shell session starts.

```
# If you extracted it in another directory you can set it up by
  putting the correct path here.
```

Put the correct path by replacing the one written in red.
In addition, Write the entire code in one line (avoid using two lines)

```
echo "export PYTHONPATH=${PYTHONPATH}:/path/to/python-sdk/lib/
python2.7/site-packages" >> $HOME/.bashrc
```

To apply the changes immediately, you can source your

```
source $HOME/.bashrc
```

3.2.3 Package installation for pepper tablet

3.2.4 Bring up Pepper

To establish communication between the computer device and the Pepper robot, the IP address of the computer device, its network interface name, and the IP address of the Pepper robot are needed. Below are the steps to find this information. First, make sure the Pepper robot and computer device are on the same network.

1. **IP address identification of the computer** To find the IP address of the computer device, open a new terminal and execute the following commands.

- (a) Install network tool.

```
sudo apt install net-tools
```

- (b) Identify network IP and interface name.

```
ifconfig
```

```
10:19:58 yohanneh@CSSR4A-Robotics-Lab:~$ ifconfig
docker0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
inet 172.17.0.1 netmask 255.255.0.0 broadcast 172.17.255.255
inet6 fe80::42:63ff:fe97:aef4 prefixlen 64 scopeid 0x20<link>
ether 02:42:63:97:ae:f4 txqueuelen 0 (Ethernet)
RX packets 14799 bytes 890282 (890.2 KB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 23466 bytes 46389487 (46.3 MB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

ens160 flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
inet 172.29.111.229 netmask 255.255.255.0 broadcast 172.29.111.255
inet6 fe80::250:56ff:fe8b:50b0 prefixlen 64 scopeid 0x20<link>
ether 00:50:56:8b:50:b0 txqueuelen 1000 (Ethernet)
RX packets 11544145 bytes 5387799739 (5.3 GB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 7859783 bytes 19733006740 (19.7 GB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 2204209 bytes 304665921 (304.6 MB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 2204209 bytes 304665921 (304.6 MB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0

10:20:01 yohanneh@CSSR4A-Robotics-Lab:~$
```

Figure 2: `ifconfig` command output: Network interface name and IP address.

Upon executing the `ifconfig` command, the output will display information similar to the illustration shown in Figure 2. Please take note of the network interface name and its corresponding IP address as shown in the output. This IP address will be passed as a value for the `roscore_ip` argument. Similarly, the network interface must be passed as a value for the `network_interface` argument.

2. **IP address identification of the Pepper robot** To find the IP address of the Pepper Robot, ensure the robot is powered on and connected to the network. Usually when the Pepper Robot is booting it says, “Hello, I’m Pepper, my internet address is < `robot_ip` > (for example, 172.29.111.230)”. If you missed it, press the chest button once and take note of that IP address. This IP address will be passed as a value for the `robot_ip` argument.

Using the above IP address of the robot, the IP address, and the network interface name of the computer device, the following instruction will bring Pepper up over ROS, and the NAOqi driver will be launched. Below are the instructions to follow for the sample shown above:

1. Open a new terminal and bring up the Pepper robot (assuming the robot is turned on).

```
roslaunch pepper_dcm_bringup pepper_bringup.launch \
robot_ip:=172.29.111.230 roscore_ip:=172.29.111.229 \
network_interface:=ens160
```

2. Open a new terminal and launch the NAOqi driver.

```
roslaunch naoqi_driver naoqi_driver.launch nao_ip:=172.29.111.230 \
roscore_ip:=172.29.111.229 network_interface:=ens160
```

3.3 Setting up the Development Environment for the Gazebo Simulator

Section 3.2 assumes access to a physical Pepper robot. However, circumstances may arise where testing software without the physical robot becomes necessary. In such cases, a simulator can serve as an alternative. This section explains how to control the Pepper robot within a Gazebo simulator. The simulation is based on an open-source Pepper ROS environment developed by Sam Pfeiffer.¹ The installation of the Gazebo simulator is presented below.

3.3.1 Installation of the Gazebo Simulator

To install the Gazebo simulator, follow the instructions below.

1. Install the Pepper Gazebo Simulator

- (a) Make a separate workspace for the simulator installation.

```
mkdir -p $HOME/workspace/pepper_sim_ws/src
cd $HOME/workspace/pepper_sim_ws/src
```

- (b) Clone the necessary packages from the GitHub repository.

```
git clone -b correct_chain_model_and_gazebo_enabled \
https://github.com/awesomebytes/pepper_robot
```

```
git clone -b simulation_that_works \
https://github.com/awesomebytes/pepper_virtual
```

```
git clone https://github.com/cssr4africa/\
gazebo_model_velocity_plugin
```

- (c) Install additional libraries.

```
sudo apt-get install ros-noetic-tf2-sensor-msgs \
ros-noetic-ros-control ros-noetic-ros-controllers \
ros-noetic-gazebo-ros ros-noetic-gazebo-ros-control \
ros-noetic-gazebo-plugins ros-noetic-controller-manager \
ros-noetic-ddynamic-reconfigure-python
```

- (d) Install pepper mesh.

```
sudo apt-get install ros-noetic-pepper-meshes
# When the configuring window opens up, you may agree to the
# license terms using the right/left arrow key and select <ok>
# and press enter, and then select <Yes> to accept the terms
# and press enter
```

- (e) Build the packages in the workspace.

```
cd .. && catkin_make
```

¹The Pepper ROS simulator is available on the following links: https://github.com/awesomebytes/pepper_virtual

Note:

After setting up the physical robot's environment, following step f to modify the `.bashrc` will result in the simulator environment being sourced last, overriding the physical robot's settings. If your main work is with the physical robot, consider skipping this step. You can manually `source devel/setup.bash` when necessary for simulator tasks to maintain the correct environment setup

- (f) Make ROS environment variables automatically added every time a new shell is launched.

```
echo "source $HOME/workspace/pepper_sim_ws/devel/setup.bash" >> \
$HOME/.bashrc
```

```
source $HOME/.bashrc
```

2. Run the Pepper Gazebo Simulator

- (a) Start the Gazebo simulation.

```
roslaunch pepper_gazebo_plugin \
pepper_gazebo_plugin_in_office_CPU.launch
```

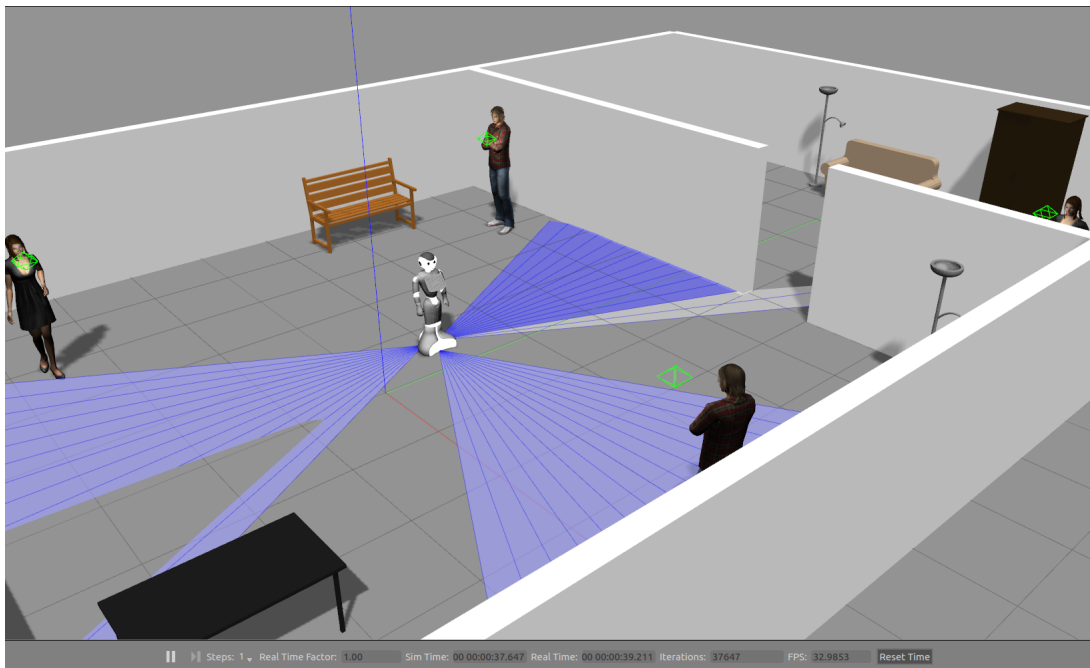


Figure 3: Pepper Gazebo simulation environment.

Once you've successfully launched the simulator, your simulation environment should be similar to Figure 3. To visualize the simulation on `rviz`, open a new terminal and type the below command.

```
roslaunch rviz rviz -d `rospack find \
pepper_gazebo_plugin`/config/pepper_sensors.rviz
```

The visualization that appears on rviz after launching will have a similar appearance to Figure 4.

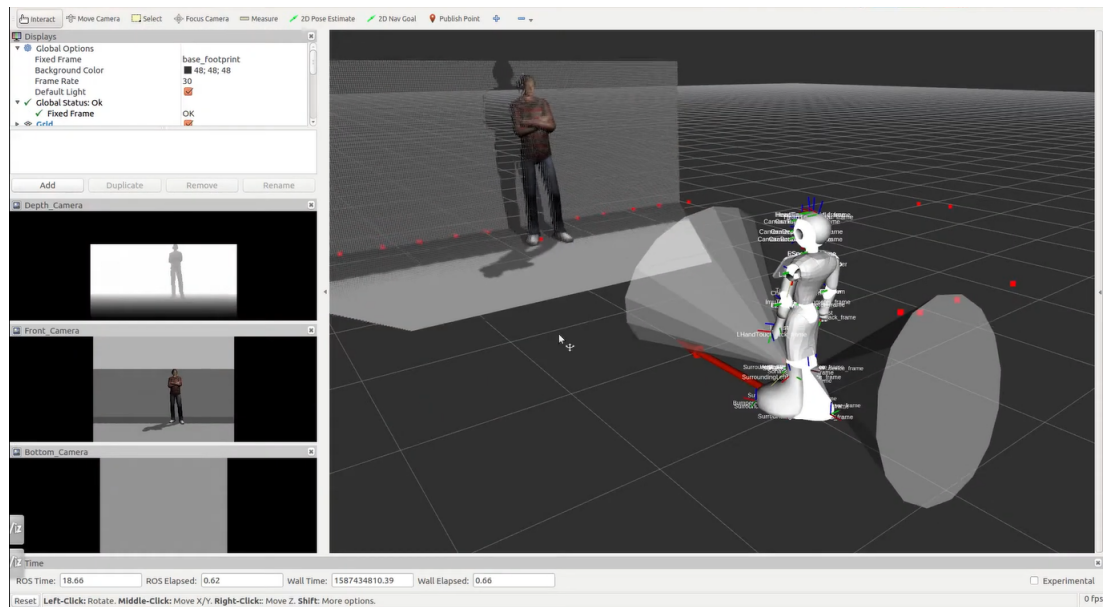


Figure 4: Visualization of the simulation on rviz.

4 Installing and Running the CSSR4Africa Software

4.1 Installing the CSSR4Africa Software

This section will guide you through the installation process of the CSSR4Africa software in the source directory of the workspace. The installation of the software for the physical and simulator environment will be discussed below.

4.1.1 Installing the CSSR4Africa Software for the Physical Robot

The outlined steps for installing the CSSR4Africa software for the physical robot are as follows:

```
# Move to the source directory of the workspace
cd $HOME/workspace/pepper_rob_ws/src

# Clone the CSSR4Africa software from the GitHub repository
git clone https://github.com/cssr4africa/cssr4africa.git

# Build the source files
cd .. && catkin_make
```

Upon completing the installation above, the `src` folder within the development environment's workspace will contain the CSS4Africa software meta-package and all the necessary packages for the project. Below is the directory structure of the workspace for reference.

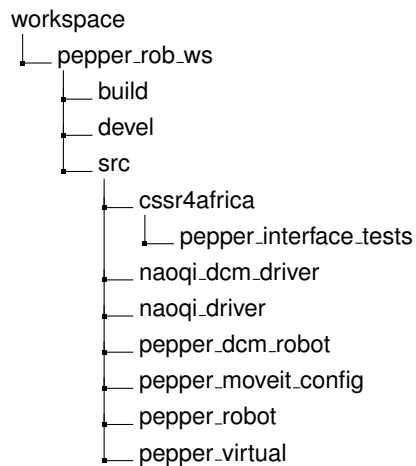


Figure 5: Directory structure for the CSSR4Africa software repository.

4.1.2 Installing the CSSR4Africa Software for the Simulator Robot

The steps for installing the CSSR4Africa software for the simulated environment will be presented as follows:

```
# Move to the source directory of the workspace
cd $HOME/workspace/pepper_sim_ws/src

# Clone the CSSR4Africa software from the GitHub repository
git clone https://github.com/cssr4africa/cssr4africa.git
```

```
# Build the source files
cd .. && catkin_make
```

4.2 Running the CSSR4Africa Software

In this section, the execution of the unit, integration, and system tests of the CSSR4Africa software packages will be presented.

4.2.1 The Pepper Interface Tests Package

The `pepper_interface_test` package contains the node files that have been written to perform the unit tests to evaluate the functionality and performance of sensors and actuators on the physical robot and the robot simulator. The directory structure of the `pepper_interface_test` is as follows:

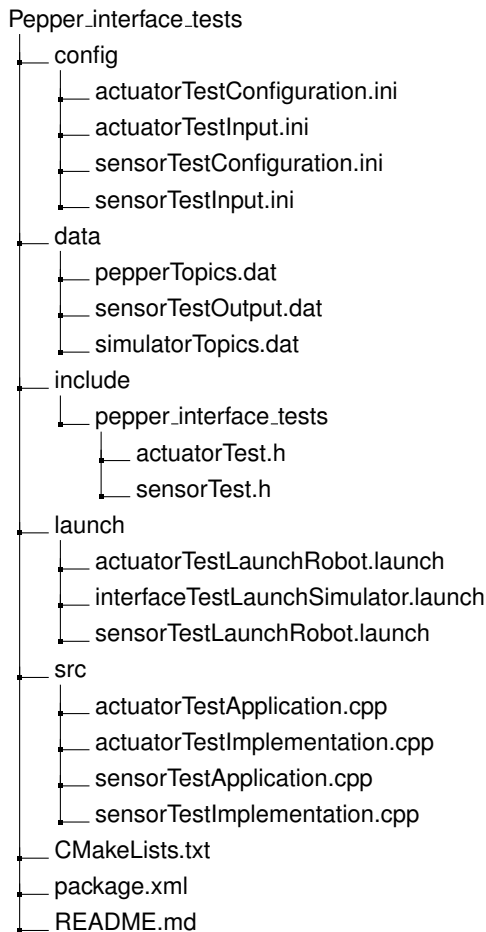


Figure 6: Directory structure for the `pepper_interface_tests` package. There are two nodes: `actuatorTest` and `sensorTest`.

The actuator test includes testing the head, hand, arm, leg, and wheels. The sensor test comprehensively assesses multiple sensors: front and back sonar, front and bottom cameras, stereo and depth cameras, laser sensor, microphone, odometry, and joint states.

To run the test on the physical robot, change the first line of the `actuatorTestConfiguration.ini` and `sensorTestConfiguration.ini` file to `platform robot`. On the other hand, to run the test on the simulator platform, change the first line of the `actuatorTestConfiguration.ini` and `sensorTestConfiguration.ini` file to `platform simulator`.

Before starting the test on the physical robot, run the launch file of the `pepper_interface_tests` package and NAOqi driver on two different terminals. Please replace the variables `robot_ip`, `roscore_ip`, and `network_interface_name` with the values obtained from the section 3.2.4. Then proceed to run the actuator and simulator test.

```
cd $HOME/workspace/pepper_rob_ws
source devel/setup.bash
```

Before starting the test on the robot, open a new terminal and launch either the sensor launch file or the actuator launch file.

Note:

If you are switching to a new ROS workspace. Activate the workspace environment by sourcing the `devel/setup.bash`. This process ensures that your terminal session is configured to use the ROS packages and environment settings of the current workspace.

```
roslaunch pepper_interface_tests actuatorTestLaunchRobot.launch \
robot_ip:=<robot_ip> roscore_ip:=<roscore_ip> \
network_interface:=<network_interface_name>
```

```
roslaunch pepper_interface_tests sensorTestLaunchRobot.launch \
robot_ip:=<robot_ip> roscore_ip:=<roscore_ip> \
network_interface:=<network_interface_name>
```

Note:

The launch file can be updated to incorporate default values for each parameter, simplifying the initiation process for the physical robot. To achieve this, navigate to either the `sensorTestLaunchRobot.launch` or `actuatorTestLaunchRobot.launch` file and modify the default parameter values to reflect those currently in use.

If you are running the test for the simulator, start by sourcing the simulator workspace

```
cd $HOME/workspace/pepper_sim_ws
source devel/setup.bash
```

```
roslaunch pepper_interface_tests interfaceTestLaunchSimulator.launch
```

To begin the tests open a new terminal and run the following node.

1. Test the sensors

```
roslaunch pepper_interface_tests sensorTest
```

During each sensor test, the sensor's numerical output data will be logged to a "sensorTestOutput.dat" file. Additionally, real-time sensor values will be displayed in the terminal for a 10-second duration. Meanwhile, sensor data images will be showcased in a separate window for a

10-second interval.

Please go through deliverables to [Deliverable D4.1](#) for a detailed report for the sensor Test task.

2. Test the actuator

```
roslaunch pepper_interface_tests actuatorTest
```

The acutator test is designed to unit test each joint by moving the joint to its minimum, maximum, and mid-range position at a selected angular velocity. The progress for testing each joint will be displayed in the terminal.

Please go through deliverables to [Deliverable 5.1](#) for a detailed report for the actuator Test task.

References

- [1] Pepper technical specifications. http://doc.aldebaran.com/2-5/family/pepper_technical/index_peg.html.

Principal Contributors

The main authors of this deliverable are as follows (in alphabetical order).

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Document History

Version 1.0

First draft.
CSSR4Africa Team.
26 July 2023.

Version 1.1

Fixed several typographical errors.
Updated the Pepper diagnostic routines test on the physical robot to include the expected output of the tests.
Added a new test for the wheels and removed the previous test.
CSSR4Africa Team.
31 July 2023.

Version 1.2

Added the Pepper diagnostic routine test for the robot simulator.
Added non-containerized installation of Pepper Gazebo simulator.
Split the containerized Pepper Gazebo simulator installation into installing and running sections.
Incorporated the updated software's tests into the Pepper diagnostic routine tests.
CSSR4Africa Team.
10 August 2023.

Version 1.3

Changed the test from Pepper diagnostic routines to Pepper interface tests.
Removed containerized docker installation.
Grouped the test section to sensorTest and actuatorTest.
Changed the extension of the configuration files from .txt to .ini. Changed the extension of data files from .txt to .dat.
Added appendix section for server specification and accessibility.
Yohannes Haile and Mihiretab Hordofa.
7 September 2023.

Version 1.4

Setting up Pepper Robot section added.
Changed the ROS-Version from ROS-Melodic to ROS-Noetic.
Removed Installation C++ NAOqi SDK.
Added Installation of Python NAOqi SDK.
Moved the NAOqi DCM driver, Pepper DCM, and NAOqi driver repository to CSSR4Africa due to modification of the code.
Fixed the Audio Service issue.
Modified the directory structure.
Changed the launch file for the pepper_interface_test for the physical and simulator.
Yohannes Haile .
10 February 2023.