Kinematics lab session

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This tutorial is divided in three parts : Singularity, URDF, and MoveIt. If you have already installed ROS and MoveIt, you can jump directly to sections on URDF and MoveIt.

1 Operating System Virtualization : Singularity

Working with ROS often requires you to have specific software configurations on your computer. Managing multiple such configurations is difficult without specialised software to separate them properly.

An OS virtualization system allows to instantiate other Operating Systems (OS) within your OS. You may have heard of **Docker** or **Virtuozzo**, which are proprietary solutions for this. Open-source solutions exist as well (OpenVZ derived from Virtuozzo, Singularity, etc.). Today we will work with **Singularity**. It will facilitate our work with different versions of ROS and MoveIt. Most of all, it will facilitate the reproducibility of your work.

1.1 Singularity : How does it work ?

Singularity uses (immutable / read-only) images of operating systems (e.g. Ubuntu 22.04). You can download these images from so-called hubs : DockerHub, SingularityHub (archived), etc. Some images are provided with specific software readily installed (e.g. Ubuntu 18.04 with ROS or MoveIt, or Ubuntu 20.04 with Node.js webserver). You can download these (read-only) images, and instantiate them in (writeable) containers. This will create a directory on your disk, which will store the contents of the file-system of your container.

1.2 Singularity : installation

Let's begin by installing Singularity : https://docs.sylabs.io/guides/3.0/user-guide/installation.html.

1.3 Singularity : download images of ROS and MoveIt

1. Create a directory for holding all your singularity images :

```
cd ~mkdir -p ~/singularity_images/
```

2. Pull the images we are interested in. Today we are interested in images with ROS and MoveIt. Luckily, Singularity images exist of Ubuntu with ROS already installed, and (if you're lucky) MoveIt already configured.

   You can explore the list of packages here : https://hub.docker.com/search?q=moveit

   For MoveIt, you will find two repositories : one for MoveIt (ROS v1), and one for MoveIt 2 (ROS v2).

   ROS v2 and MoveIt 2, even though they are released, do not always they their documentation and tutorials up to date. Last time I tried the MoveIt 2 tutorials, I was blocked after the first one. So I suggest to use MoveIt (ROS v1).

   The syntax for pulling (downloading) a singularity image is :

```
singularity pull --dir <targetDirectory> <sourceHub>://<repository>:<tag>
```

   If you do not specify the <tag>, the tag **:latest** will be used.

   Pull the latest image of **MoveIt** of the latest ROS v1 distribution from **DockerHub**.

   Reminder of ROS distributions :

   — ROS v1 distributions list : http://wiki.ros.org/Distributions

   — ROS v2 distributions list : https://docs.ros.org/en/rolling/Releases.html

   It is a good practice to explicitly mention which image to download.

   For MoveIt on ROS v1 Noetic on Ubuntu 20.04 (Focal), run :

```
singularity pull --dir ~/singularity_images/ docker://moveit/moveit:noetic-source
```

For MoveIt2 on ROS v2 Humble on Ubuntu 22.04 (Jammy), run :

```
singularity pull --dir ~/singularity_images/ docker://moveit/moveit2:humble-source
```

This will create a `.sif` file (`moveit2_humble-source.sif`) inside `~/singularity_images`.

1.4 Singularity : working with images and containers

1. Build a container from the Singularity image of (Ubuntu + ROS + MoveIt) that was downloaded :

```
 singularity build  --sandbox ~/singularity_images/moveit_tp_sandbox
~/singularity_images/moveit2_humble-source.sif
```

2. Launch a shell within the **Singularity** container that you just built :

```
singularity shell --writable --fakeroot ~/singularity_images/moveit_tp_sandbox/ -B
~/.Xauthority
```

3. You are now ready to go through the MoveIt tutorials.

2 Unified Robot Description Format (URDF)

Let us start the lab session by defining a robot using the Unified Robot Description Format (URDF).

Open ROS URDF Tutorials : http://wiki.ros.org/urdf/Tutorials, and go through the tutorials of the section **Learning URDF Step by Step**.

3 MoveIt

Let us continue with the MoveIt tutorials.

— For MoveIt on ROS v1 (recommended) see :
https://ros-planning.github.io/moveit_tutorials/
Go through the tutorials from **MoveIt QuickStart in RViz** till **Planning with Approximated Constraing Manifolds**.

— For MoveIt2 on ROS v2 see :
https://moveit.picknik.ai/humble/doc/tutorials/tutorials.html