Part II. Autoware Install / Build / Run (2 hours)

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Outline

- Installation overview
- Docker-based installation
- Docker image build
- Installation from scratch (can be skipped if CUDA is not used)
- Source build (can be skipped since it is part of docker image build)
- Simulation in Autoware
- rosbag play

Software Stack

docker image: lab_kinetic_cuda.tar.gz
or lab_kinetic.tar.gz

Application:	Autoware 1.12	CUDA runtime 10
Middleware:	ROS kinetic	
System Libraries:	Ubuntu 16.04	
Virtualization:	Docker	NVIDIA runtime
Host OS:	Ubuntu 16.04	CUDA driver 10

Installation Overview

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Installation

- Autoware 설치 방법
  - host 환경에 설치하는 방법
    - 하나의 ROS 버전과 Autoware 버전을 사용하는 경우에 추천함
    - 변경 사항들이 스토리지에 바로 저장됨
  - **docker 환경에 설치하는 방법 ← 이번 실습에서 사용하는 방법**
    - 여러 ROS 버전과 Autoware 버전을 사용하는 경우에 추천함
      - Autoware 실행 이미지를 여러 개 관리할 때 필수적으로 사용함
    - 변경 사항들이 docker image에 저장되지 않음!
      - docker container는 하나의 filesystem image 상에서 실행되며, container 안에서 변경된 파일들은 container 종료시 image에 저장되지 않음
      - 따라서 변경된 파일들을 유지하기 위해서는 container를 종료하기 전에 docker image를 새로 생성(commit)해야 함
    - host의 cuda driver와 cuda runtime toolkit을 모두 사용할 수 있음
    - host와 container 사이에 /home/autoware/shared_dir 폴더를 공유하여 두 시스템 사이에 파일 공유가 가능함

Source Build Requirements

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Source-Build

❖ 실습 목표: ubuntu 16.04 & ros kinetic & docker & autoware 1.12

Autoware Version	Ubuntu 14.04	Ubuntu 16.04	Ubuntu 18.04
v1.12.0		X	X
v1.11.1		X	
v1.11.0		X	
v1.10.0		X	
v1.9.1	X	X	
v1.9.0	X	X	

Product	Ubuntu 14.04	Ubuntu 16.04	Ubuntu 18.04
ROS	Indigo	Kinetic	Melodic
Qt	4.8.6 or higher	5.2.1 or higher	5.9.5 or higher
CUDA (optional)	8.0GA(?)	9.0	10.0

Note: autoware 1.12를 cuda와 함께 빌드하기 위해서는 반드시 cuda v10.0 을 사용해야 함. cuda v10.1을 사용하면 빌드 실패함

Computer Spec Recommendation

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Docker

❖ Generic amd64(64-bit x86) ● Ubuntu 16.04 / 18.04 ● CPU ❖ Intel Core i7 (preferred) ❖ Intel Core i5 ❖ AMD Ryzen 7 (preferred) ❖ AMD Ryzen 5 ● 16GB ~ 32GB of RAM ● > 30GB of Storage (SSD preferred) ● NVIDIA GTX GeForce GPU (>= 980M) ❖ NVIDIA Drive ● Drive PX2, Drive Xavier ● > 30 GB SSD	**이번 실습에서 사용하는 랩탑 사양** ❖ Generic amd64 (64-bit x86) ● Ubuntu 16.04 LTS ● CPU ❖ Intel Core i7-4700HQ @ 2.4GHz (quadcore) ● 16GB RAM ● 250GB SSD ● no NVIDIA GTX GeForce GPU **→ GPU 없이, 즉 cuda 없이 autoware 빌드!**

Docker-based Installation

Docker-based Installation Steps

Note 1: 이번 실습에서는 ros kinetic & autoware source files & prebuilt autoware binaries를 담고 있는 docker image를 제공받아 사용함

Note 2: 이번 실습에서 사용하는 docker image는 cuda를 사용하지 않으므로 step 3은 필요 없음. 또한 step 4에서 run.sh 에서 CUDA="off"하고 docker image를 download해야 함

- [host] step 1: create a user named 'autoware'
- [host] step 2: install Docker CE
- [host] step 3: install NVIDIA Docker Runtime
- [host] step 4: run an Autoware Docker image

Step 1: Create a user named 'autoware'

- create a user named 'autoware'
  - $ sudo adduser autoware
    - host에서 실행하는 위 명령이 UID = 1000 이라는 것을 보장하지는 않음 (docker container 안에서 autoware UID = 1000 임)
    - 만약 user rubicom이 UID = 1000이고, user autoware가 UID = 1001이라면 , 아래 결과를 얻도록 관련 파일들을 편집할 것
- edit /etc/passwd
  - rubicom:x:1001:1001:Rubicom,,,:/home/rubicom:/bin/bash
  - autoware:x:1000:1000:Autoware,,,:/home/autoware:/bin/bash
- edit /etc/group
  - sudo:x:27:autoware # add 'autoware' into group 'sudo'
  - rubicom:x:1001 # previously 1000
  - autoware:x:1000 # previously 1001
- change the ownership of files owned by 'autoware'
  - $ sudo chown –R 1000:1000 /home/autoware
  - $ sudo chown –R 1001:1001 /home/rubicom
- edit /etc/gdm3/custom.conf
  - AutomaticLogin=autoware

Step 2: Install Docker CE

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/docker-installation

- Old Docker Cleanup
  - $ sudo apt-get remove docker docker-engine docker.io
- Docker CE Installation
  - $ sudo apt-get update # update package lists
  - $ sudo apt-get install apt-transport-https ca-certificates curl software-properties-common # permit apt-get to access the repository, which uses HTTPS
  - $ curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add - # add Docker's official GPG key
  - $ sudo apt-key fingerprint 0EBFCD88 # validate the key

```
pub 4096R/0EBFCD88 2017-02-22
Key fingerprint = 9DC8 5822 9FC7 DD38 854A E2D8 8D81 803C 0EBF CD88
uid Docker Release (CE deb)
sub 4096R/F273FCD8 2017-02-22
```

  - $ sudo add-apt-repository "deb [arch=amd64] https://download.docker.com/linux/ubuntu $(lsb_release -cs) stable" # add the repository to your system

Step 2: Install Docker CE

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/docker-installation

- Docker CE Installation (cont'd)
  - $ sudo apt-get update # update package lists with the new repository
  - $ sudo apt-get install docker-ce # install the latest version of Docker CE
  - $ sudo docker run hello-world # validate the installation succeeded

Step 3: Install NVIDIA Docker Runtime (GPU 사용시)

https://github.com/NVIDIA/nvidia-docker/wiki/Installation-(version-2.0)

- Prerequisites for running nvidia-docker 2.0
  - GNU/Linux x86_64 with kernel version > 3.10
  - Docker >= 1.12
  - NVIDIA GPU with Architecture > Fermi (2.1)
  - NVIDIA drivers ~= 361.93 (untested on older versions)

- Remove nvidia-docker 1.0
  - $ docker volume ls -q -f driver=nvidia-docker | xargs -r -I{} -n1 docker ps -q -a -f volume={} | xargs -r docker rm -f
  - $ sudo apt-get purge nvidia-docker

Step 3: Install NVIDIA Docker Runtime (GPU 사용시)

https://github.com/NVIDIA/nvidia-docker/wiki/Installation-(version-2.0)

- Set up the repository configuration (assuming Debian-based distributions)
  - $ curl -s -L https://nvidia.github.io/nvidia-docker/gpgkey | sudo apt-key add -
  - $ distribution=$(. /etc/os-release;echo IDVERSION_ID)
  - $ curl -s -L https://nvidia.github.io/nvidia-docker/$distribution/nvidia-docker.list | sudo tee /etc/apt/sources.list.d/nvidia-docker.list
  - $ sudo apt-get update
- Updating repository keys
  - $ curl -s -L https://nvidia.github.io/nvidia-docker/gpgkey | sudo apt-key add -
- Install the nvidia-docker2 package and reload the Docker daemon configuration:
  - $ sudo apt-get install nvidia-docker2
  - $ sudo pkill -SIGHUP dockerd
- Basic usage
  - $ docker run --runtime=nvidia --rm nvidia/cuda nvidia-smi

Step 4: Run an Autoware Docker Image

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Generic-x86-Docker

Note on file permissions (both in host or in container)

- $ cp –r *target_dir* ~/shared_dir
- $ cd ~/shared_dir && sudo chown -R $(id -u):$(id -g) *

Using Pre-built Autoware Docker Images

- docker image 안에 Autoware release를 build하는데 필요한 모든 요구사항들이 이미 image 안에 설치되어 있으며, 해당 release도 이미 build된 상태로 제공됨 → /home/autoware/Autoware
  - $ git clone https://gitlab.com/autowarefoundation/autoware.ai/docker.git
  - $ cd docker/generic
  - $ sudo ./run.sh -r kinetic -s # autoware/autoware:latest-kinetic-cuda 설치

```
autoware@rubicom-MS-7B09:~/docker/generic$ sudo docker images
REPOSITORY           TAG                             IMAGE ID       CREATED         SIZE
autoware/autoware    local-melodic-cuda              9461c01555ed   4 hours ago     8.46GB
autoware/autoware    local-melodic-base-cuda         205560ac8d8c   4 hours ago     5.4GB
autoware/autoware    local-melodic-base              a7defe6bfad0   5 hours ago     3.17GB
ros                  melodic                         8c7e1b93c802   2 days ago      1.25GB
autoware/autoware    latest-melodic-cuda             3ff5da2f0f72   2 weeks ago     8.45GB
autoware/autoware    latest-kinetic-cuda             22a5ed3276d6   2 weeks ago     8.07GB
nvidia/cuda          latest                          010a71dc59db   4 weeks ago     2.81GB
ubuntu               latest                          4c108a37151f   6 weeks ago     64.2MB
nvidia/opengl        1.0-glvnd-runtime-ubuntu18.04   f7d2b59439b6   2 months ago    315MB
autoware/autoware    1.10.0-kinetic-cuda             7926d37a198a   6 months ago    7.98GB
hello-world          latest                          fce289e99eb9   7 months ago    1.84kB
```

Step 4: Run an Autoware Docker Image

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Generic-x86-Docker

```
#!/bin/bash
# Default settings
CUDA="on"
IMAGE_NAME="autoware/autoware"
TAG_PREFIX="latest"
ROS_DISTRO="kinetic"
BASE_ONLY="false"
PRE_RELEASE="off"
AUTOWARE_HOST_DIR=""
USER_ID="$(id -u)"
...
RUNTIME="--runtime=nvidia"
SUFFIX="-cuda"
...
IMAGE=$IMAGE_NAME:$TAG_PREFIX-$ROS_DISTRO$SUFFIX
docker run -it --rm  $VOLUMES ₩
    --env="XAUTHORITY=${XAUTH}" ₩
    --env="DISPLAY=${DISPLAY}" ₩
    --env="USER_ID=$USER_ID" ₩
    --privileged ₩
    --net=host ₩
    $RUNTIME ₩
    $IMAGE
```

사용자가 원하는대로 편집할 것

Docker Image Build
(covering 'Installation from Scratch' and 'Source Build')

One shot one kill : build.sh

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Generic-x86-Docker

Creating a Custom Autoware Docker Image

- image build 전에 build.sh 파일을 원하는대로 편집함 → 다음 페이지 참조
  - $ git clone https://gitlab.com/autowarefoundation/autoware.ai/docker.git
  - $ cd docker/generic
  - $ sudo ./build.sh # 'local-' prefix로 시작하는 docker image 생성함
  - $ sudo docker images
    - 최종 이미지 이름은 autoware/autoware:local-kinetic-cuda 임

One shot one kill : build.sh

```
#!/bin/bash
# Default settings
CUDA="on"
IMAGE_NAME="autoware/autoware"
TAG_PREFIX="local"
ROS_DISTRO="kinetic"
BASE_ONLY="false"
VERSION="master"
...
BASE=$IMAGE_NAME:$TAG_PREFIX-$ROS_DISTRO-base
CUDA_SUFFIX="-cuda"
DOCKERFILE="Dockerfile"
...
docker build ₩
    --rm ₩
    --tag $IMAGE_NAME:$TAG_PREFIX-$ROS_DISTRO$CUDA_SUFFIX ₩
    --build-arg FROM_ARG=$BASE$CUDA_SUFFIX ₩
    --build-arg ROS_DISTRO=$ROS_DISTRO ₩
    --build-arg VERSION=$VERSION ₩
    --file $DOCKERFILE .
```

→ 사용자가 원하는대로 편집할 것

Installation from Scratch

Installation Steps from Scratch

Note 1: 이번 실습에서는 ros kinetic & autoware source files & prebuilt autoware binaries를 담고 있는 docker image를 제공받아 사용함

Note 2: 다음 절차는 host 또는 docker 환경에서 autoware build & run 환경을 새로 구성하려는 경우에 필요함

Note 3: cuda driver는 host 환경에서 설치되어야 하며, cuda runtime는 autoware 실행 환경과 동일한 환경(host 또는 docker 환경)에서 설치되어야 함 → 즉 step 3 중 cuda driver 설치 과정은 docker 환경에서 필요 없음

- step 1: install ROS Kinetic
- step 2: install system dependencies for Ubuntu 16.04 / Kinetic
- step 3: install CUDA 10.0 (GPU 사용시)
    - cuda driver는 반드시 host 환경에서 설치되어야 함

Step 1: Install ROS Kinetic

http://wiki.ros.org/kinetic/Installation/Ubuntu

- Set up your sources.list
  - $ sudo sh -c 'echo "deb http://packages.ros.org/ros/ubuntu $(lsb_release -sc) main" > /etc/apt/sources.list.d/ros-latest.list'
- Set up your keys
  - $ sudo apt-key adv --keyserver 'hkp://keyserver.ubuntu.com:80' --recv-key C1CF6E31E6BADE8868B172B4F42ED6FBAB17C654
- Install
  - $ sudo apt update;   sudo apt install ros-kinetic-desktop-full
- Initialize rosdep
  - $ sudo rosdep init;   rosdep update
- Set up environment
  - $ echo "source /opt/ros/kinetic/setup.bash" >> ~/.bashrc; source ~/.bashrc
    - Note: docker container 안에서는 /etc/profile.d/ros.sh 가 /opt/ros/kinetic/setup.bash 을 자동으로 실행시킴
- Set up tools for building packages
  - $ sudo apt install python-rosinstall python-rosinstall-generator python-wstool build-essential

Step 2: Install system dependencies for Ubuntu 16.04 / Kinetic

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Source-Build

- $ sudo apt-get update
- $ sudo apt-get install -y python-catkin-pkg python-rosdep ros-kinetic-catkin gksu
- $ sudo apt-get install -y python3-pip python3-colcon-common-extensions python3-setuptools python3-vcstool
- $ pip3 install -U setuptools

Step 3: Install CUDA 10.0 (GPU 사용시)

https://docs.nvidia.com/cuda/archive/10.0/cuda-installation-guide-linux/index.html

- Verify you have a cuda-capable gpu
  - $ lspci | grep -i nvidia
- Install the kernel headers
  - $ sudo apt-get install linux-headers-$(uname -r)
- Download cuda-10.0 package from https://developer.nvidia.com/cuda-10.0-download-archive # 상기 URL에는 없는 절차임
- Install the package using Package Manager
  - $ sudo dpkg -i cuda-repo-ubuntu1804-10-0-local-10.0.130-410.48_1.0-1_amd64.deb
  - $ sudo apt-key add /var/cuda-repo-10-0-local-10.0.130-410.48/7fa2af80.pub
  - $ sudo apt-get update
  - $ sudo apt-get install cuda-10-0 # 반드시 cuda-10-0이라고 명시할 것! 상기 URL을 따라 'sudo apt-get install cuda' 명령을 실행하면 cuda-10-1이 설치됨
- Set up environment variables in ~/.bashrc
  - $ echo "export PATH=/usr/local/cuda-10.0/bin:${PATH}" >> ~/.bashrc
  - $ echo "export LD_LIBRARY_PATH=/usr/local/cuda-10.0/lib64:${LD_LIBRARY_PATH}" >> ~/.bashrc
  - $ source ~/.bashrc

Step 3: Install CUDA 10.0 (GPU 사용시)

- cuda driver 설치 확인: nvidia-smi
- cuda runtime 설치 확인: deviceQuery

```
autoware@rubicom-MS-7B09:~/docker/generic$ /usr/local/cuda/extras/demo_suite/deviceQuery
/usr/local/cuda/extras/demo_suite/deviceQuery Starting...

 CUDA Device Query (Runtime API) version (CUDART static linking)

Detected 1 CUDA Capable device(s)

Device 0: "GeForce GTX 1080 Ti"
  CUDA Driver Version / Runtime Version          10.1 / 10.0
  CUDA Capability Major/Minor version number:    6.1
  Total amount of global memory:                 11175 MBytes (11718230016 bytes)
  (28) Multiprocessors, (128) CUDA Cores/MP:     3584 CUDA Cores
  GPU Max Clock rate:                            1683 MHz (1.68 GHz)
  Memory Clock rate:                             5505 Mhz
  Memory Bus Width:                              352-bit
  L2 Cache Size:                                 2883584 bytes
  Maximum Texture Dimension Size (x,y,z)         1D=(131072), 2D=(131072, 65536), 3D=(16384, 16384, 16384)
  Maximum Layered 1D Texture Size, (num) layers  1D=(32768), 2048 layers
  Maximum Layered 2D Texture Size, (num) layers  2D=(32768, 32768), 2048 layers
  Total amount of constant memory:               65536 bytes
  Total amount of shared memory per block:       49152 bytes
  Total number of registers available per block: 65536
  Warp size:                                     32
  Maximum number of threads per multiprocessor:  2048
  Maximum number of threads per block:           1024
  Max dimension size of a thread block (x,y,z): (1024, 1024, 64)
  Max dimension size of a grid size    (x,y,z): (2147483647, 65535, 65535)
  Maximum memory pitch:                          2147483647 bytes
  Texture alignment:                             512 bytes
  Concurrent copy and kernel execution:          Yes with 2 copy engine(s)
  Run time limit on kernels:                     Yes
  Integrated GPU sharing Host Memory:            No
  Support host page-locked memory mapping:       Yes
  Alignment requirement for Surfaces:            Yes
  Device has ECC support:                        Disabled
  Device supports Unified Addressing (UVA):      Yes
  Device supports Compute Preemption:            Yes
  Supports Cooperative Kernel Launch:            Yes
  Supports MultiDevice Co-op Kernel Launch:      Yes
  Device PCI Domain ID / Bus ID / location ID:   0 / 65 / 0
  Compute Mode:
     < Default (multiple host threads can use ::cudaSetDevice() with device simultaneously) >

deviceQuery, CUDA Driver = CUDART, CUDA Driver Version = 10.1, CUDA Runtime Version = 10.0, NumDevs = 1, Device0 = GeForce GTX 1080 Ti
Result = PASS
```

cuda driver version 10.1이더라도 cuda runtime version 10.0 이면 autoware 1.12를 빌드하는데 문제 없음

Source Build

Source Build Steps

Note 1: 이번 실습에서는 ros kinetic & autoware source files & prebuilt autoware binaries를 담고 있는 docker image를 제공받아 사용함

Note 2: 다음 절차는 host 또는 docker 환경에서 autoware build & run 하려는 경우에 필요함

- step 1: Create a workspace
- step 2: Download the workspace configuration for autoware.ai
- step 3: Download the source files into the workspace
- step 4: Install dependencies using rosdep
- step 5: Compile the workspace

Source Build Steps

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Source-Build

- step 1: Create a workspace
  - $ mkdir -p Autoware/src && cd Autoware
    - docker image 안에서는 autoware.ai 아닌 Autoware라는 폴더명을 사용할 것. 왜냐하면 /home/autoware/.bashrc가 /home/autoware/Autoware/install/local_setup.bash 스크립트를 찾기 때문임
- step 2: Download the workspace configuration for autoware.ai
  - $ wget -O autoware.ai.repos "https://gitlab.com/autowarefoundation/autoware.ai/autoware/raw/1.12.0/autoware.ai.repos?inline=false" # for the 1.12.0 release
  - $ wget -O autoware.ai.repos "https://gitlab.com/autowarefoundation/autoware.ai/autoware/raw/master/autoware.ai.repos?inline=false" # for the bleeding edge version

Source Build Steps

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Source-Build

- step 3: Download the source files into the workspace
  - $ vcs import src < autoware.ai.repos
- step 4: Install dependencies using rosdep
  - $ rosdep update
  - $ rosdep install -y --from-paths src --ignore-src --rosdistro kinetic
- step 5: Compile the workspace
  - $ AUTOWARE_COMPILE_WITH_CUDA=1 colcon build --cmake-args -DCMAKE_BUILD_TYPE=Release # with cuda support
  - $ colcon build --cmake-args -DCMAKE_BUILD_TYPE=Release
    # without cuda support

Note : SSD (single shot detection)와 같은 DNN 기반 노드들은 자동적으로 빌드되지 않음. 해당 노드의 README 파일을 참조할 것

Source Build Steps

https://gitlab.com/autowarefoundation/autoware.ai/autoware/wikis/Source-Build

- build success screenshot

```
Finished <<< waypoint_planner [44.0s]
Starting >>> lattice_planner
Finished <<< lane_planner [52.3s]
Starting >>> waypoint_maker
Finished <<< dp_planner [53.0s]
Finished <<< lidar_localizer [3min 2s]
Finished <<< op_global_planner [37.0s]
Finished <<< op_utilities [37.8s]
Finished <<< lidar_kf_contour_track [39.3s]
Finished <<< op_local_planner [40.4s]
Finished <<< lattice_planner [32.1s]
Finished <<< waypoint_maker [26.8s]
Finished <<< op_simulation_package [56.2s]
Summary: 141 packages finished [5min 25s]
  47 packages had stderr output: adi_driver astar_search autoware_camera_lidar_calibrator autoware
_connector autoware_driveworks_gmsl_interface autoware_driveworks_interface autoware_pointgrey_dri
vers citysim data_preprocessor decision_maker dp_planner glviewer kitti_player kvaser lidar_apollo
_cnn_seg_detect lidar_euclidean_cluster_detect lidar_localizer lidar_point_pillars lidar_shape_est
imation map_file microstrain_driver mqtt_socket ndt_cpu ndt_gpu object_map op_ros_helpers op_simul
ation_package op_utilities pcl_omp_registration pixel_cloud_fusion points_downsampler points_prepr
ocessor qpoases_vendor range_vision_fusion road_occupancy_processor sick_ldmrs_tools sick_lms5xx t
rafficlight_recognizer vector_map_server vision_darknet_detect vision_segment_enet_detect vision_s
sd_detect vlg22c_cam way_planner waypoint_follower waypoint_maker waypoint_planner
```

build success!!

Simulation in Autoware

Step 1: Prepare shared_dir

- 제공된 USB DISK를 usb slot에 꽂은 후에 다음 절차를 진행함
  - $ cp /media/autoware/AUTOWARE/shared_dir.tar.gz ~/
  - $ cd # change to home directory
  - $ tar xvzf shared_dir.tar.gz # unpack files into ~/shared_dir folder
  - $ cd shared_dir
  - $ ls –al # only files in blue are used in this simulation
    - default.rviz # rviz default configuration file
    - EgoCar.csv # open_planner's saved initialpose and goalpose
    - kcity_map/ # contains map files for kcity
      - tf.launch # initial transform to make the map visible in rviz
      - kcity_20190629_0.2_update.pcd # point map (pcd format)
      - kcity_avc2019_final/[1-9]/*.csv # vector map (csv format)
    - rosbag_demo/ # contains rosbag & launch files for rosbag play
    - src/ # contains modified autoware source files for this demo

Step 2: Run ‘local-kinetic’ container

- [host] $ cd ~/docker/generic
- [host] $ sudo ./run.sh –s

    # ‘local-kinetic’ or ‘local-kinetic-cuda’ 이미지 기반 container 실행

Step 3: Prepare runtime_manager

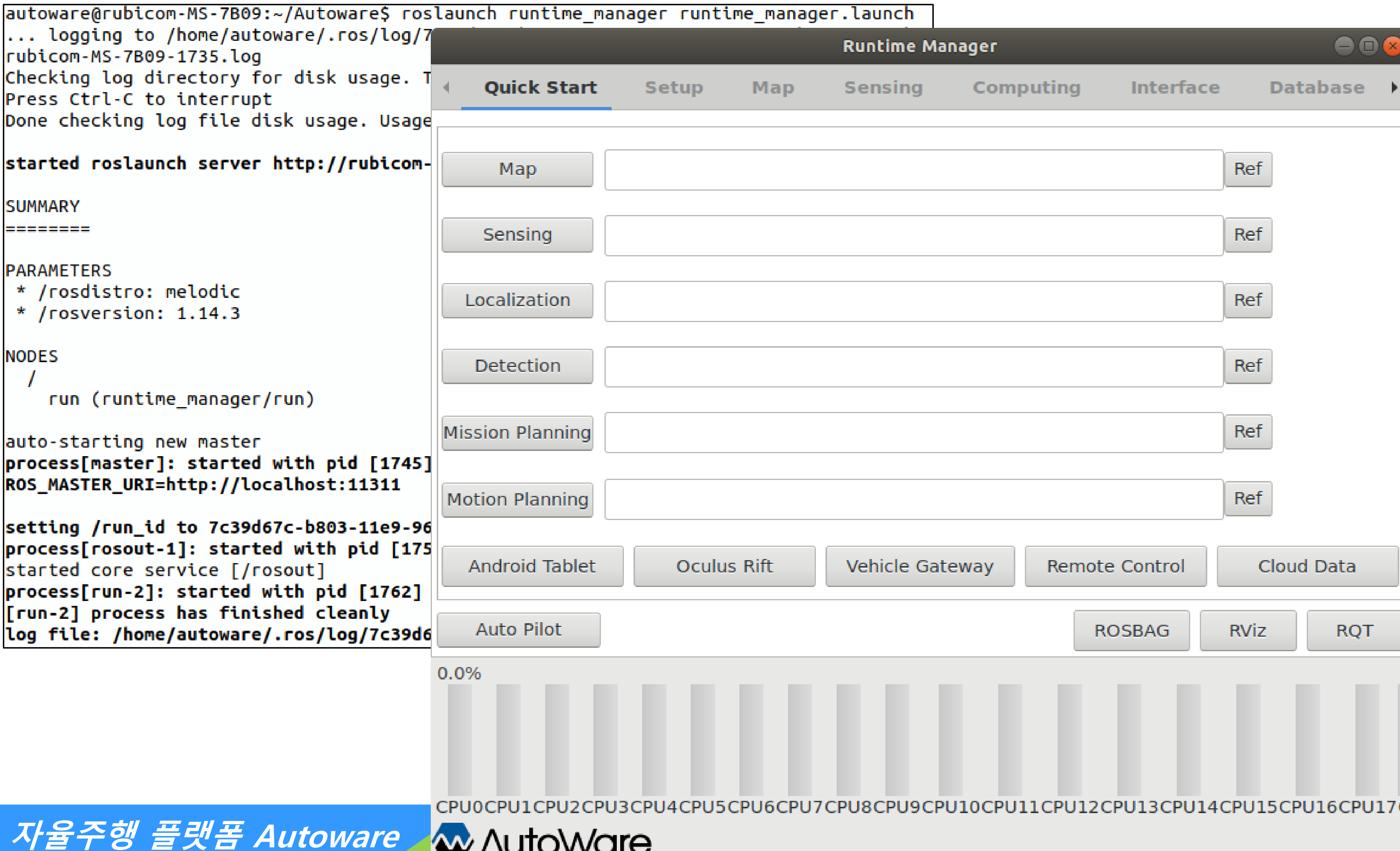
- [container] $ cd Autoware
- [container] $ find . –name run –print
  - ./src/autoware/utilities/runtime_manager/scripts/run
  - ./install/runtime_manager/share/runtime_manager/scripts/run
- [container] $ edit the above two files as follows
  - add the following command “cp ~/shared_dir/default.rviz ~/.rviz/” right before “rosrun runtime_manager runtime_manager_dialog.py”

```
# boot runtime_manager
${TERMINAL} ${RUNMGR_DISPLAY_OPTION} ${OPTION_WORKING_DIR}=${MY_PATH} ${OPTION_C
OMMAND}="bash -c 'source ./../../../setup.bash; mkdir ~/.rviz; cp `rospack find
autoware_quickstart_examples`/launch/rosbag_demo/default.rviz ~/.rviz/; cp ~/sha
red_dir/default.rviz ~/.rviz/; rosrun runtime_manager runtime_manager_dialog.py'
"
```

Note: run script 편집 후에 현재 container 의 변경 사항들을 저장하는 docker image를 docker commit 명령으로 생성할 것을 권장함

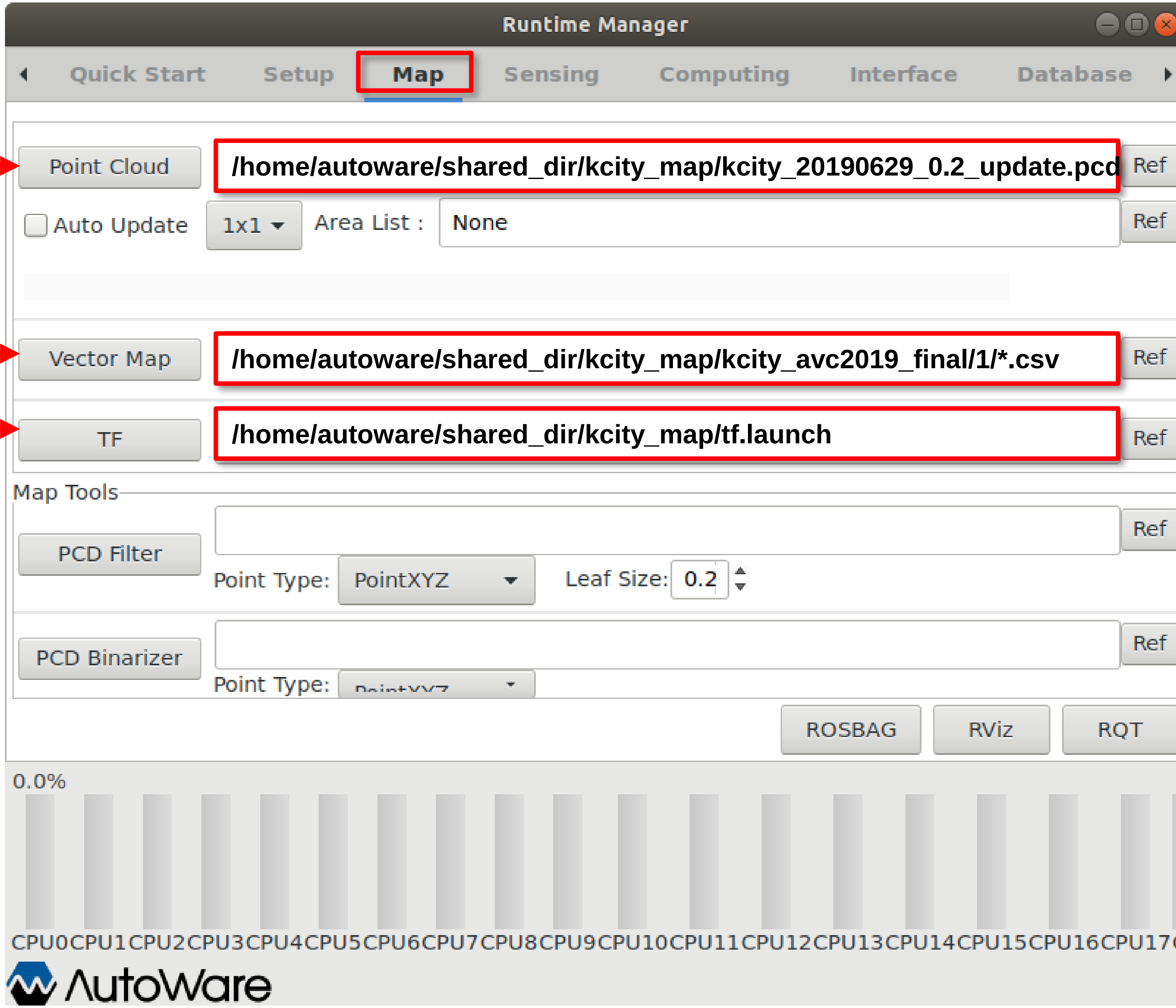
Step 4: Launch runtime_manager

- [container] $ cd Autoware
- [container] $ roslaunch runtime_manager runtime_manager.launch



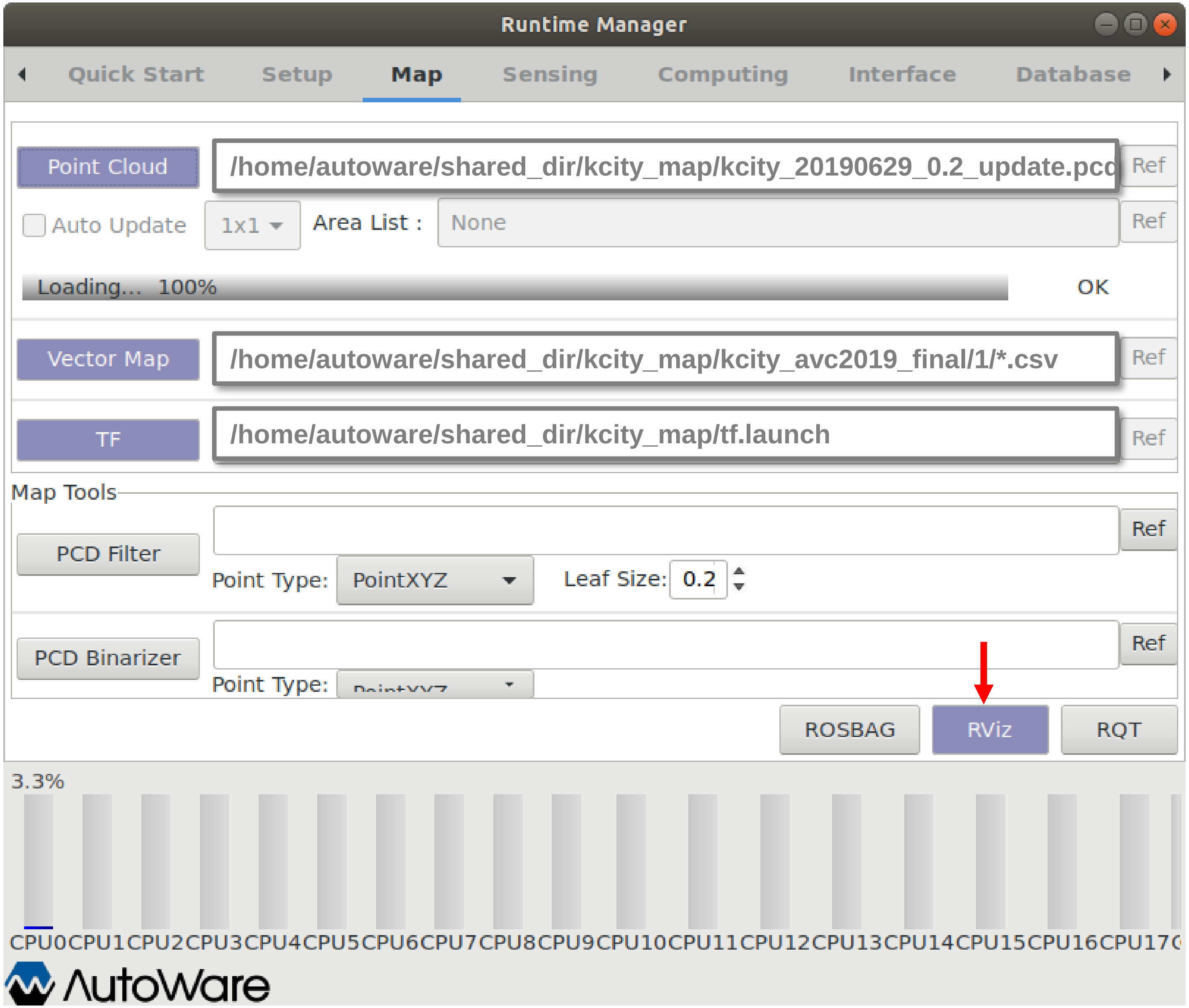
Step 4-1: Load map and tf files

(4) (5) (6)

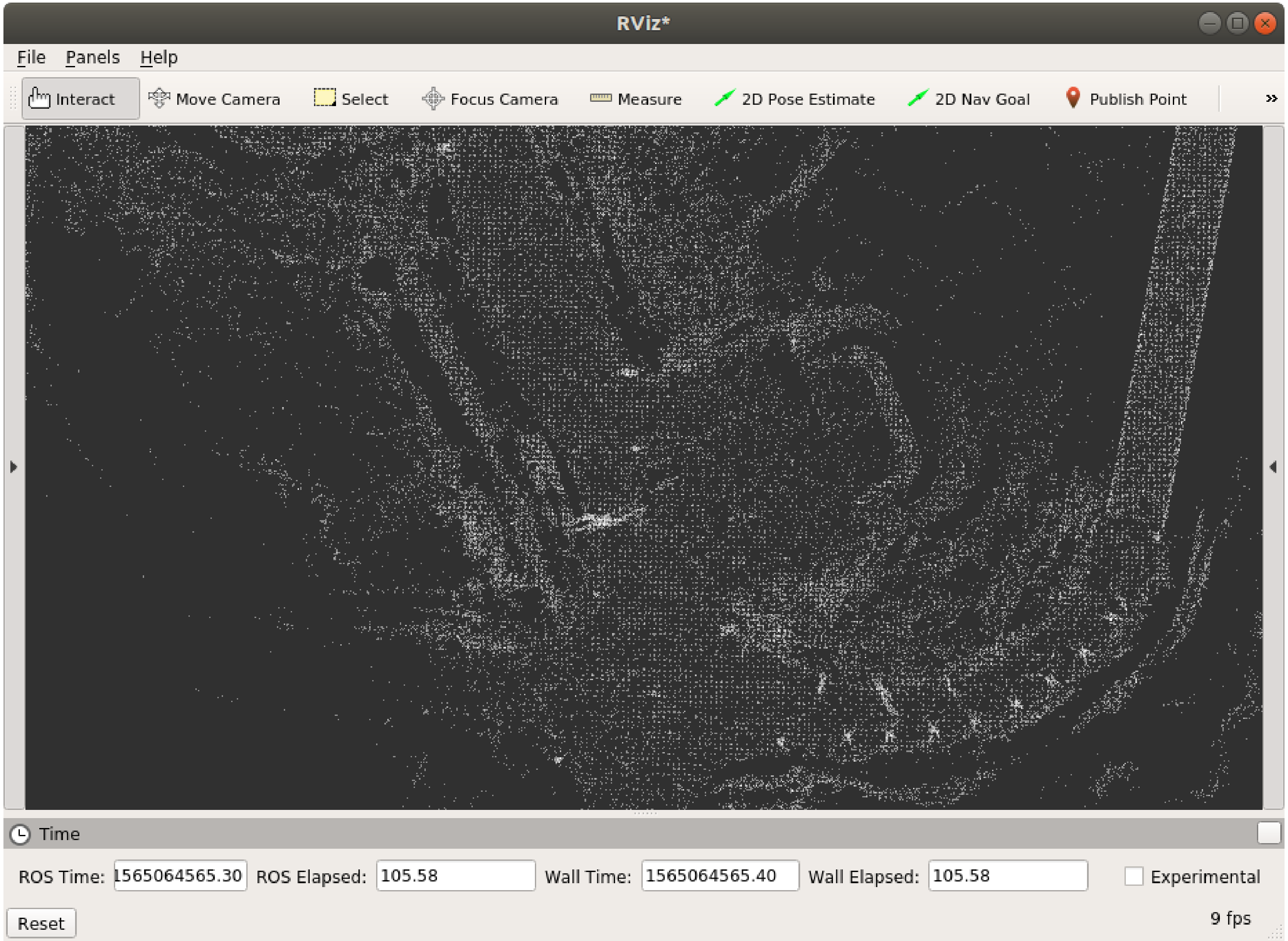


(1) (2) (3)

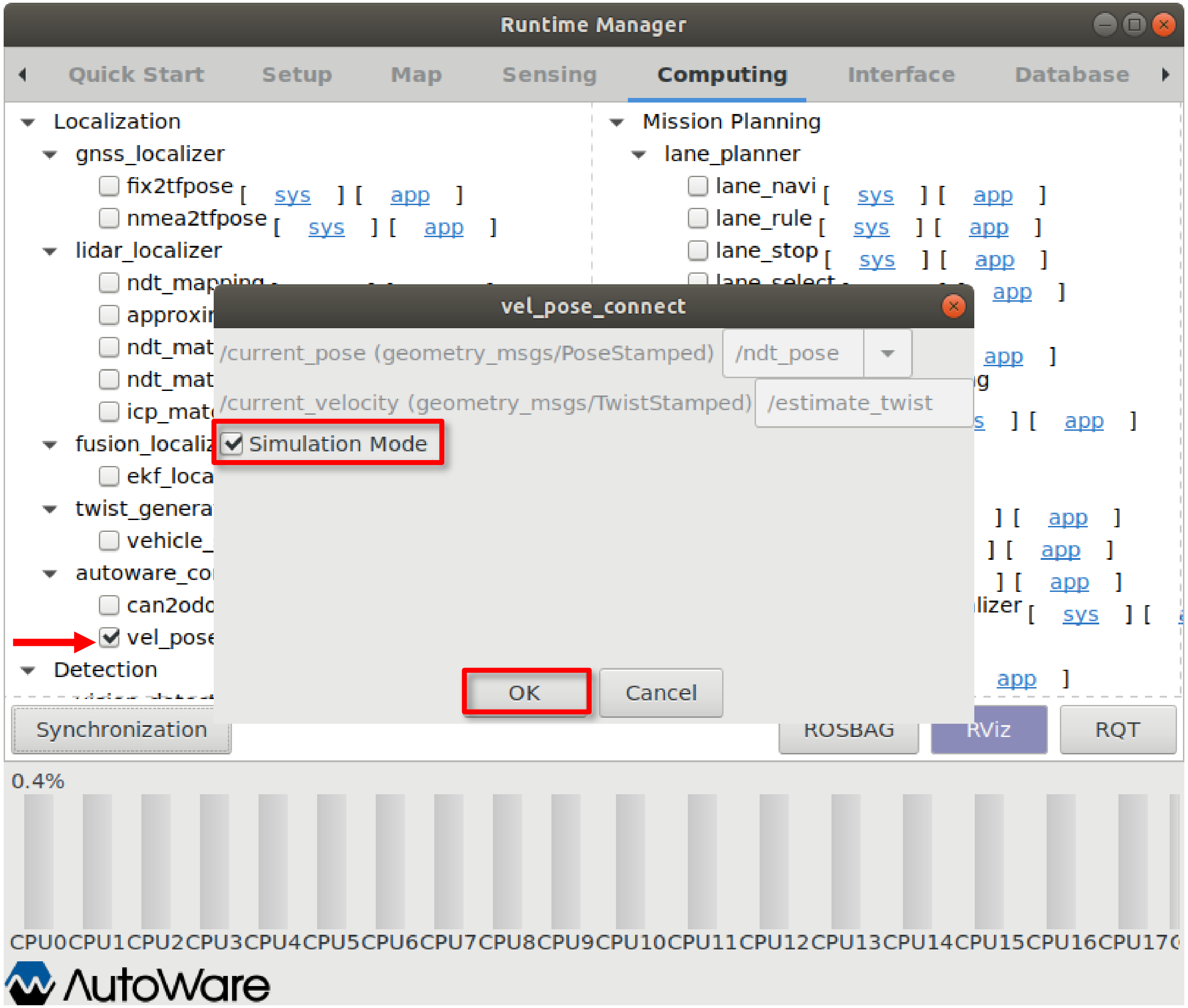
Step 4-2: Launch rviz



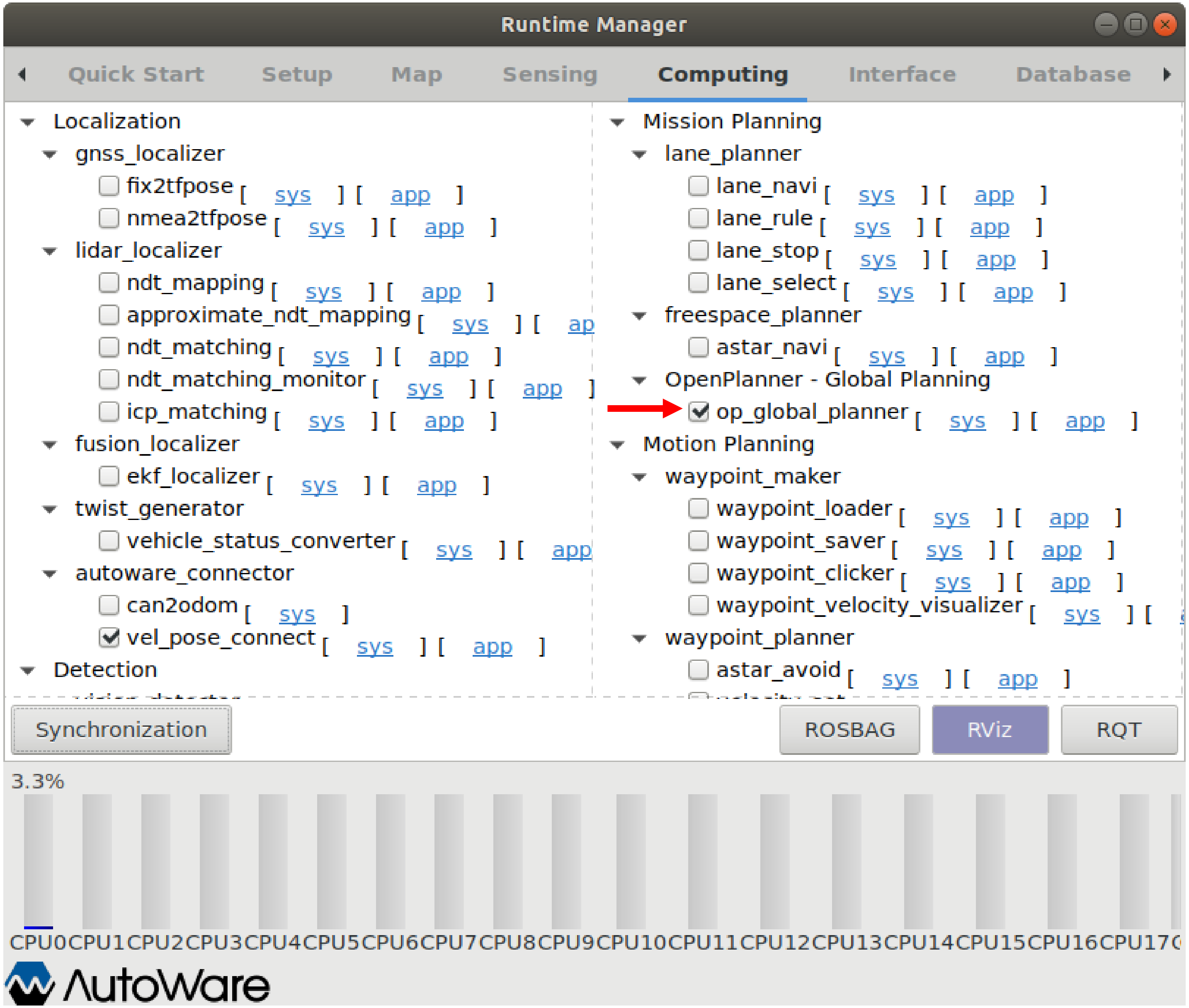
Step 4-2: Launch rviz



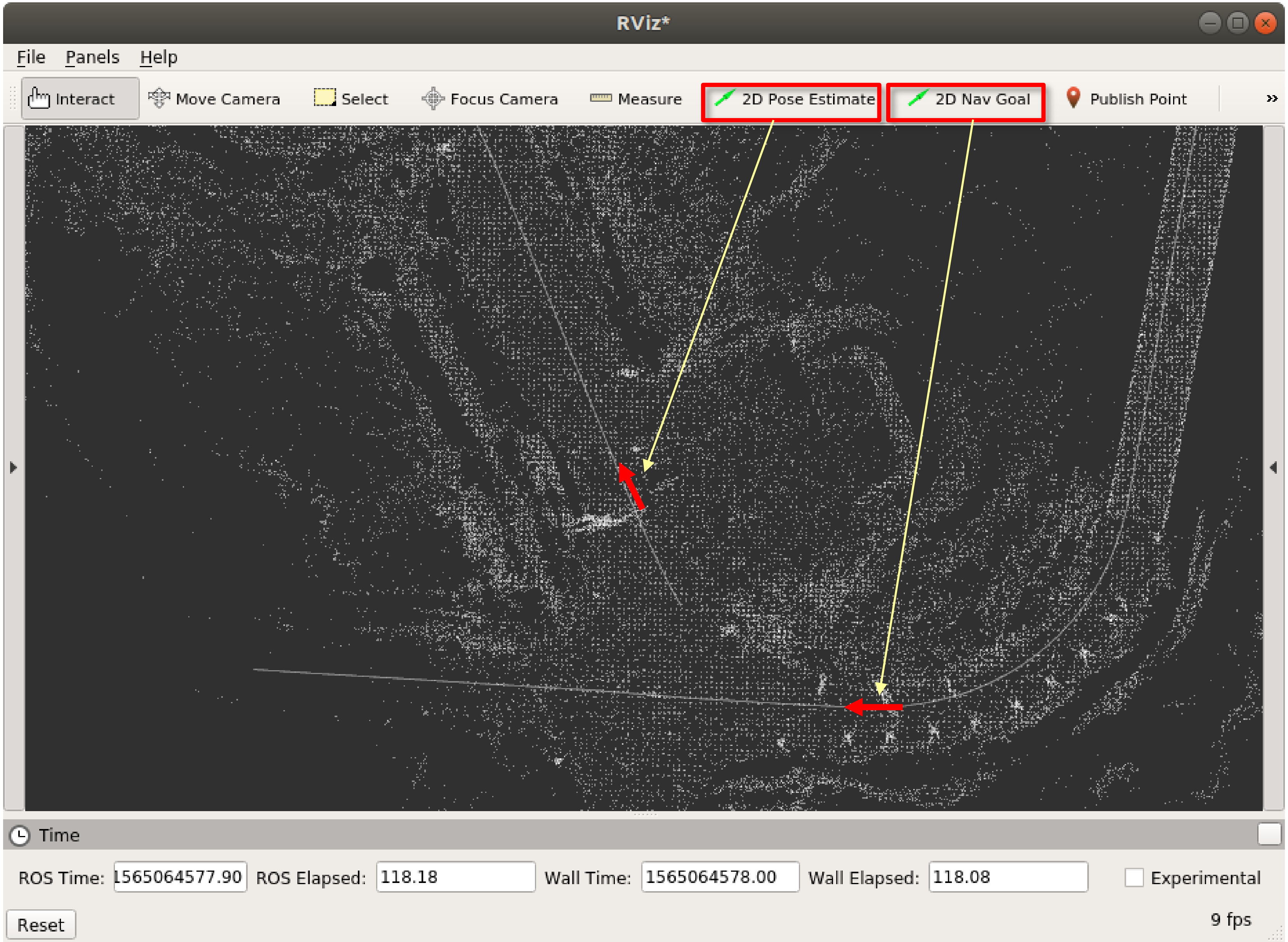
Step 4-3: Launch vel_pose_connect



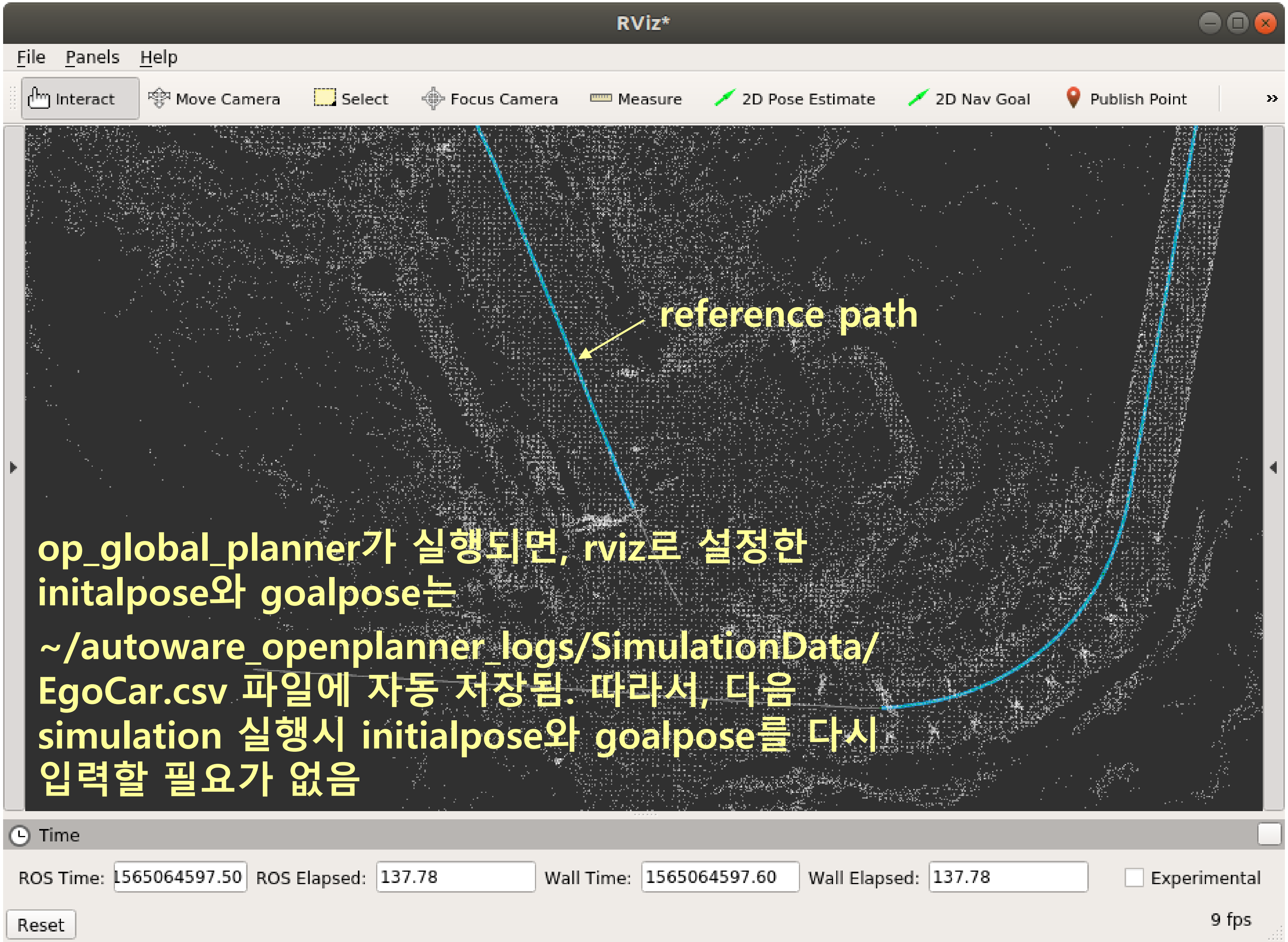
Step 4-4: Launch op_global_planner



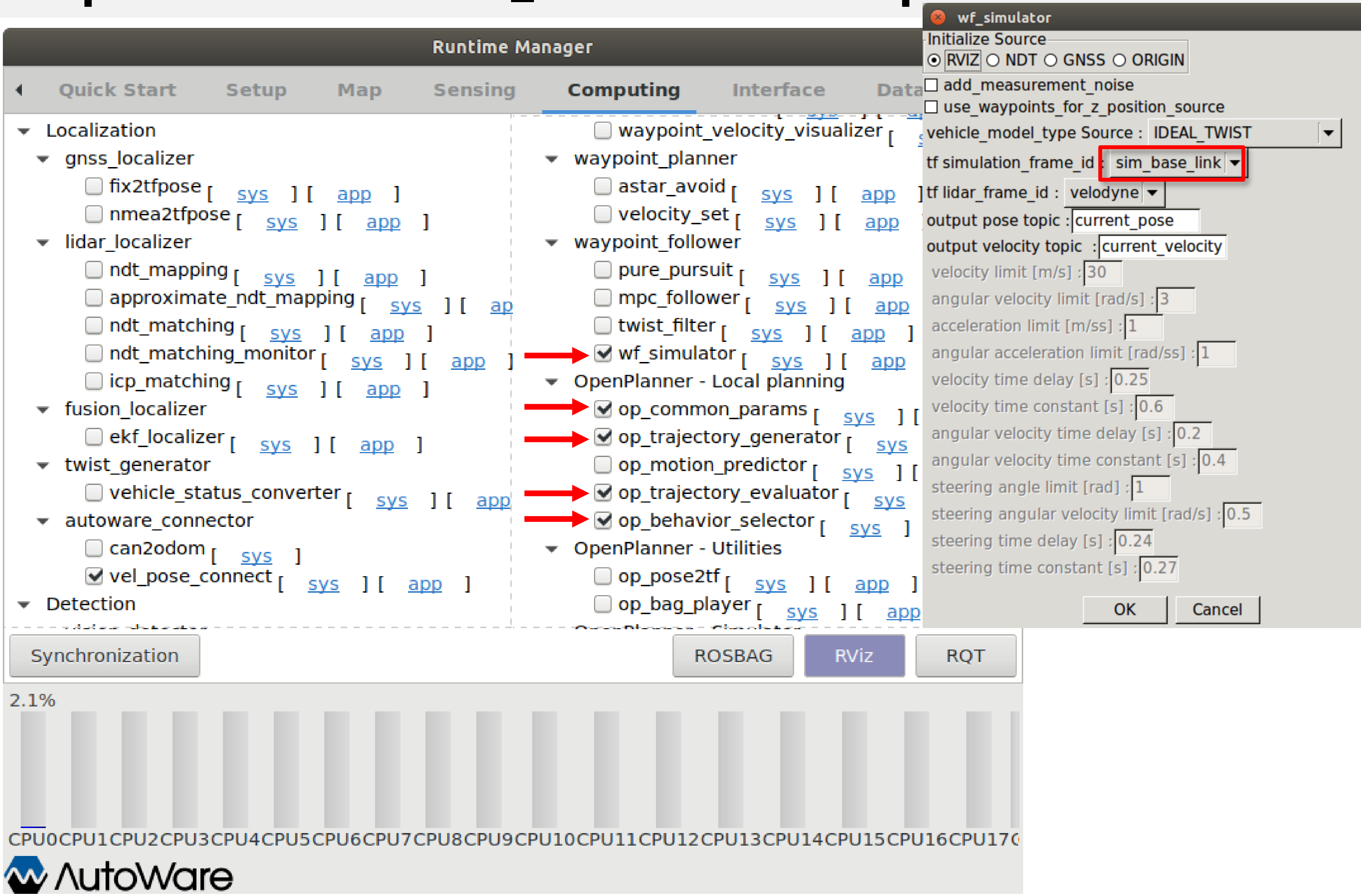
Step 4-5: Set start and goal poses



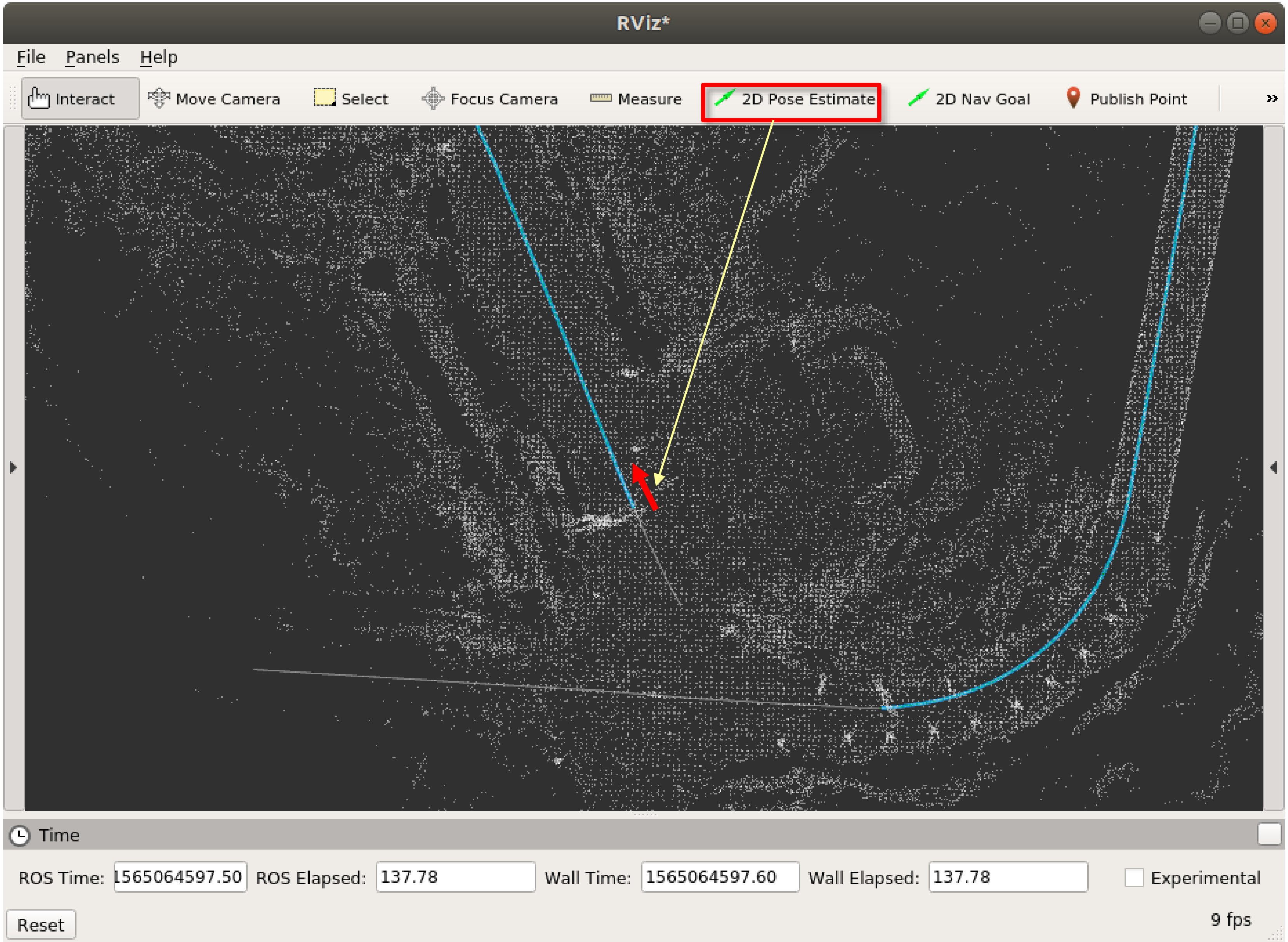
Step 4-5: Set start and goal poses



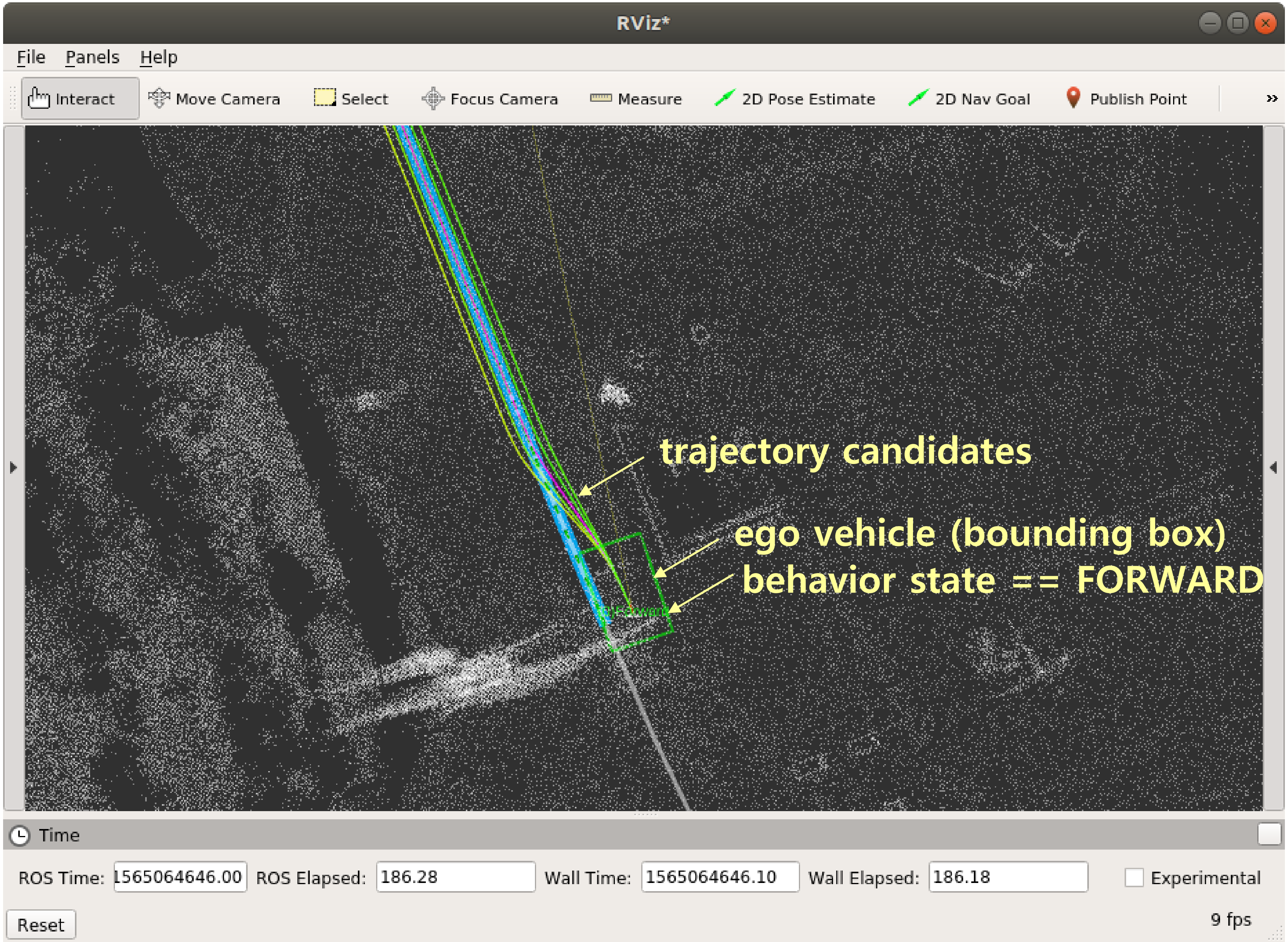
Step 4-6: Launch wf_simulator & OpenPlanner



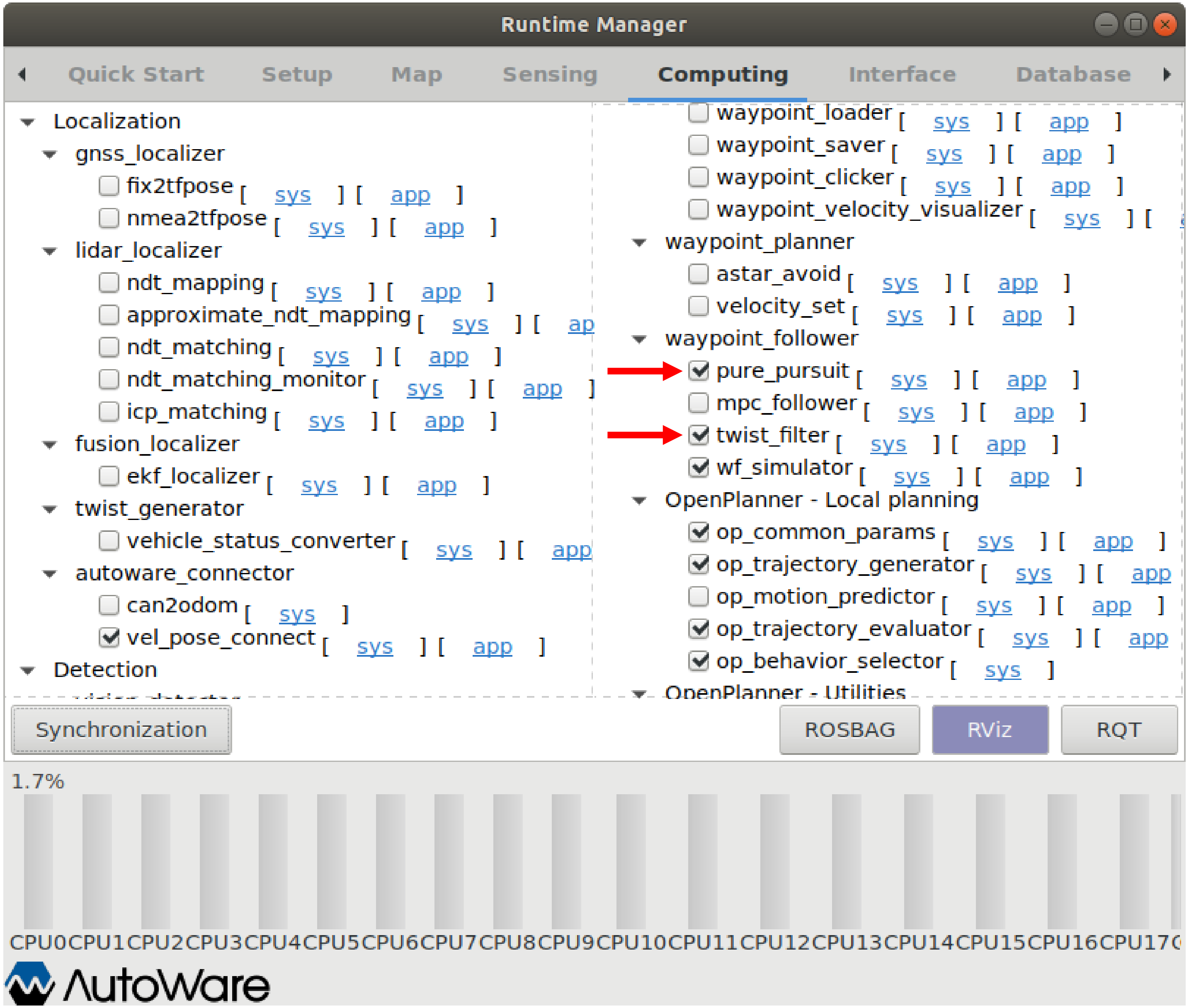
Step 4-7: Set start pose once again



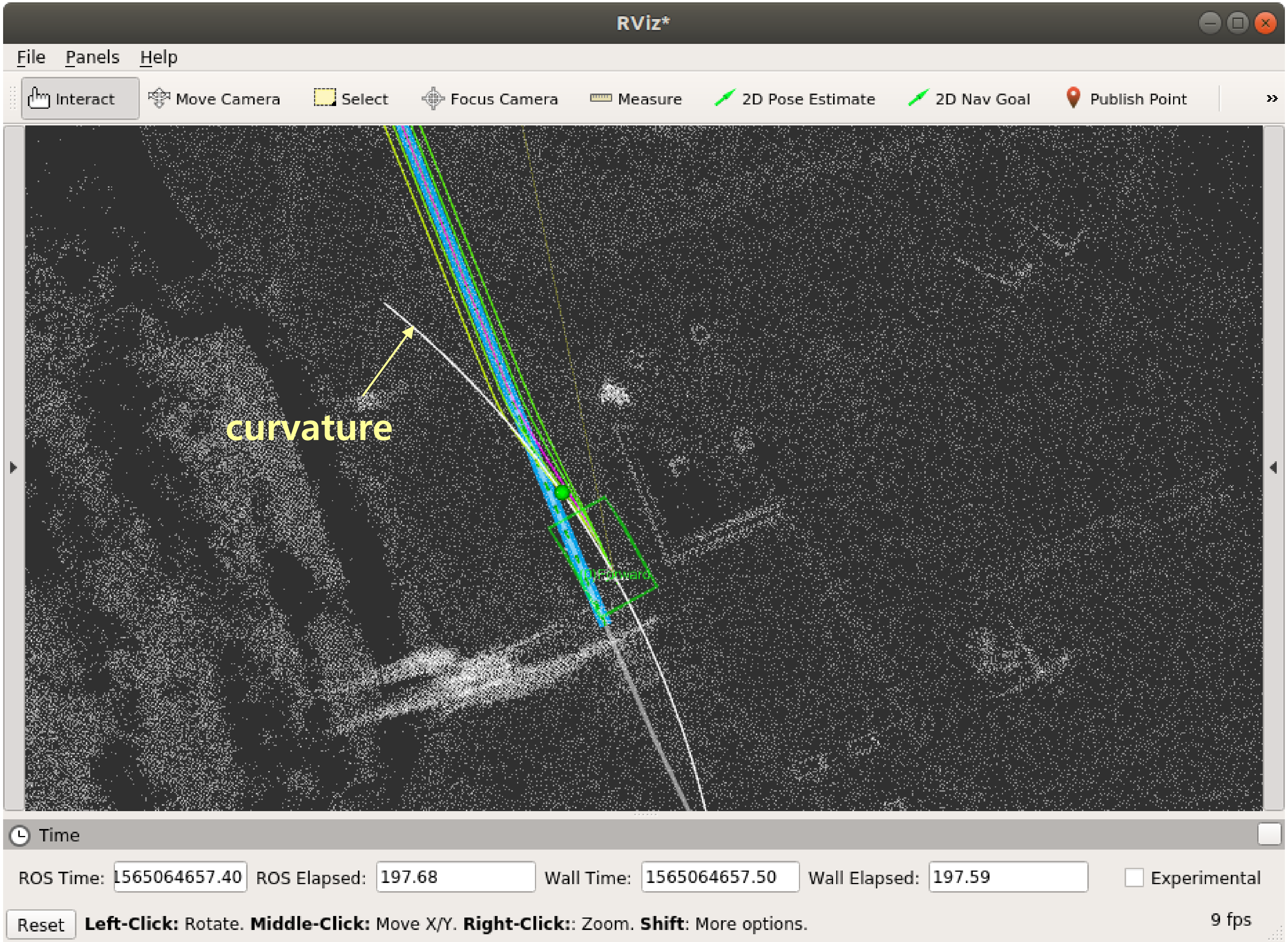
Step 4-7: Set start pose once again



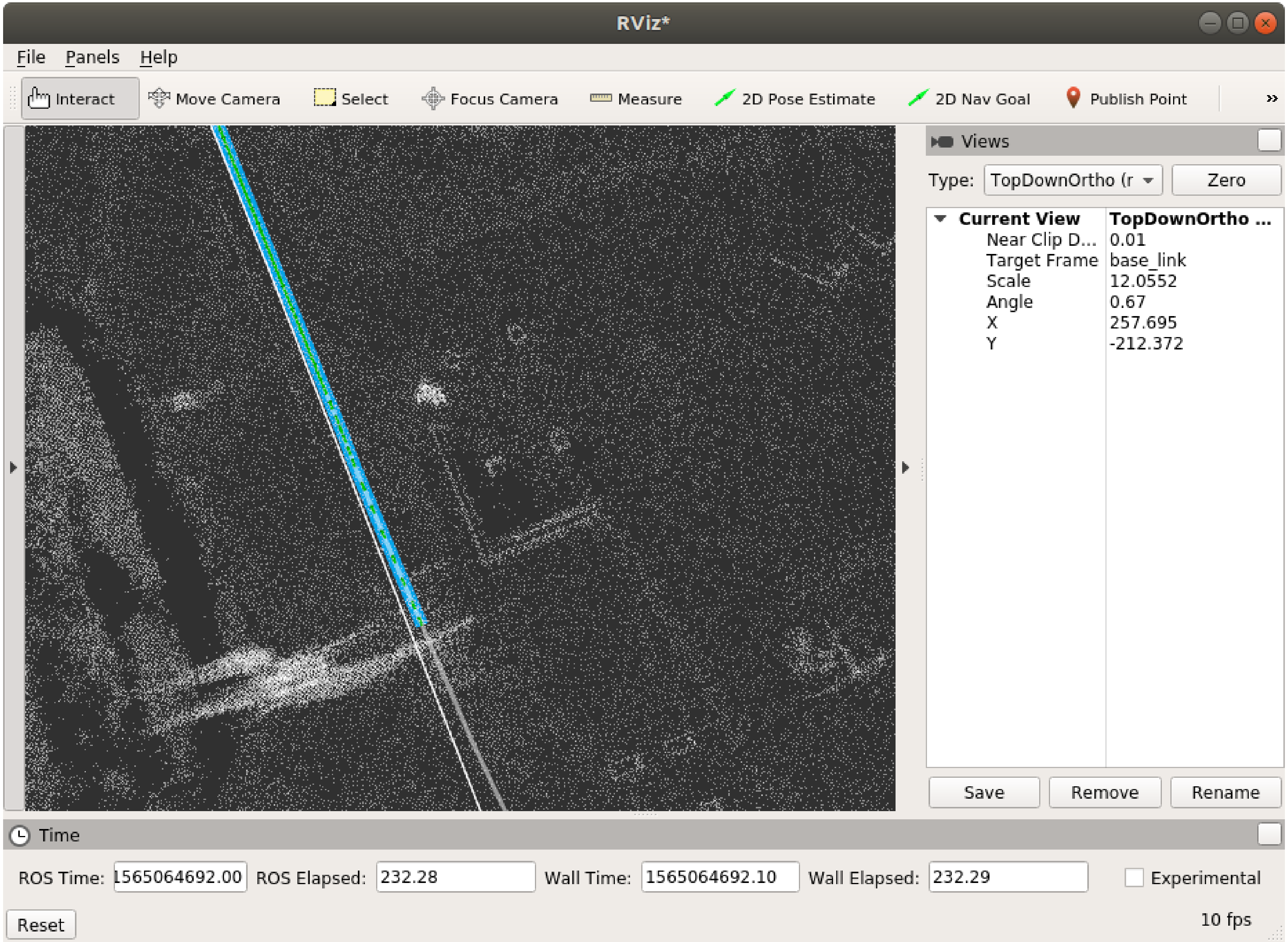
Step 4-8: Launch pure_pursuit & twist_filter



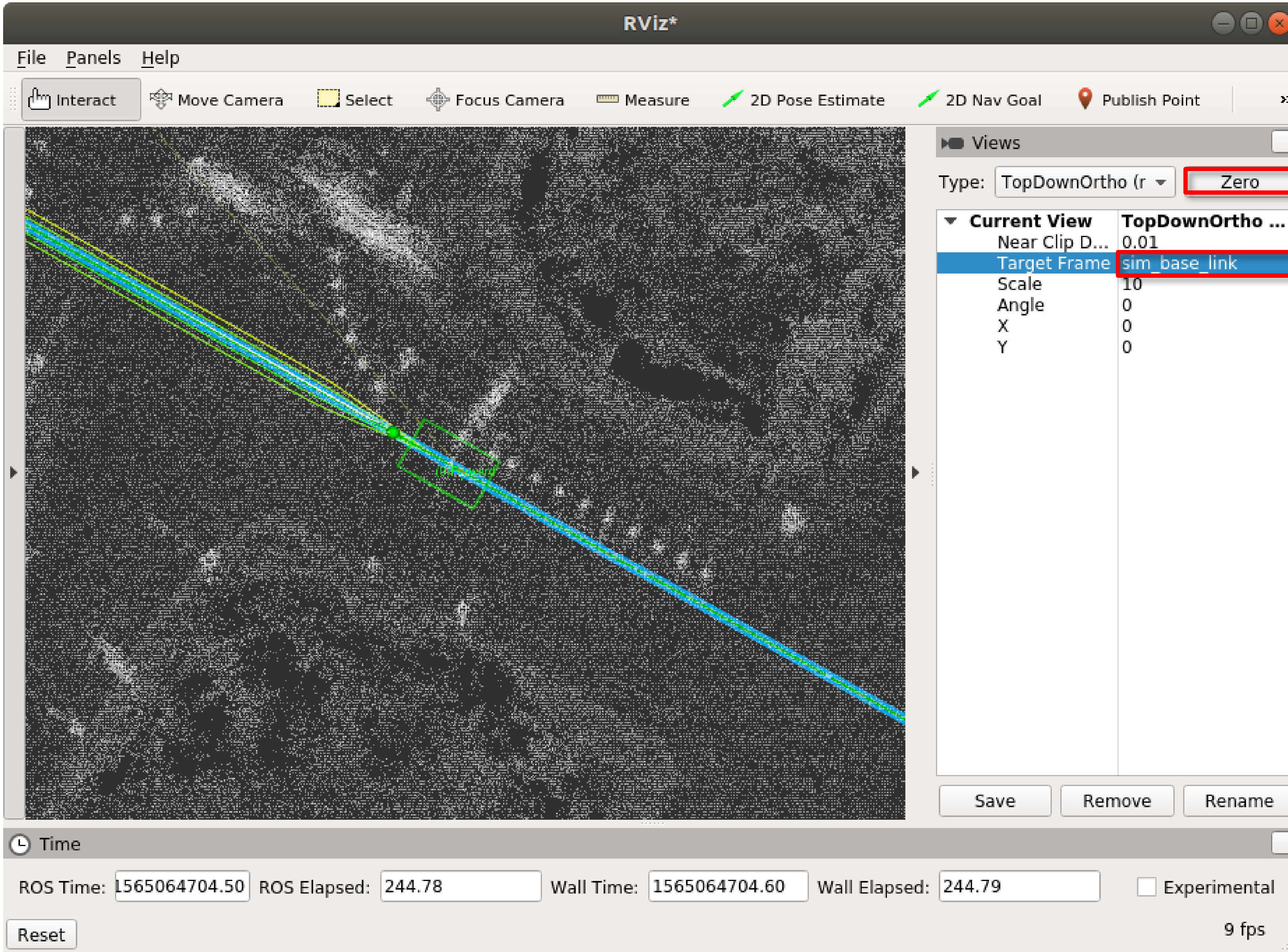
Step 4-8: Launch pure_pursuit & twist_filter



Step 4-8: Vehicle is gone!



Step 4-9: Change Target Frame



Step 4-10: Quit

- kill rviz by clicking x button
- kill runtime_manager by clicking x buttion
- enter ^C on the controlling terminal

```
started roslaunch server http://rubicom-MS-7B09:40243/

SUMMARY
========

PARAMETERS
 * /rosdistro: melodic
 * /rosversion: 1.14.3

NODES
  /
    run (runtime_manager/run)

auto-starting new master
process[master]: started with pid [1745]
ROS_MASTER_URI=http://localhost:11311

setting /run_id to 7c39d67c-b803-11e9-96f9-00e06333e8fb
process[rosout-1]: started with pid [1756]
started core service [/rosout]
process[run-2]: started with pid [1762]
[run-2] process has finished cleanly
log file: /home/autoware/.ros/log/7c39d67c-b803-11e9-96f9-00e06333e8fb/run-2*.log
^C[rosout-1] killing on exit
[master] killing on exit
shutting down processing monitor...
... shutting down processing monitor complete
done
autoware@rubicom-MS-7B09:~/Autoware$
```

rosbag Play

Step 1: Run 'local-kinetic' container

"Simulation in Autoware"의 step 1을 먼저 수행함

- [host] $ cd ~/docker/generic
- [host] $ sudo ./run.sh –s

  # 'local-kinetic' or 'local-kinetic-cuda' 이미지 기반 container 실행
- 또는 [host] $ sudo ./run_aw.sh local-kinetic

  # run_aw.sh 파일 안에 '—runtime=nvidia' 라인을 comment out 처리

또는 제공된 USB Disk 안에 prebuilt docker image를 복사해서 사용함

- [host] $ cp /media/autoware/AUTOWARE/lab-kinetic.tar.gz ~/docker/generic
- [host] $ cd ~/docker/generic
- [host] $ sudo docker load < lab-kinetic.tar.gz
- [host] $ sudo docker images

  → 'autoware/autoware:lab-kinetic' 라는 이미지가 생성됨.
  이 이미지는 다음 step 2와 step 3 실행 결과가 이미 반영되었음.
  따라서 이 이미지를 사용하면 step 4로 점프할 것.
- [host] $ sudo ./run_aw.sh lab-kinetic

Step 2: Rebuild and install Autoware packages

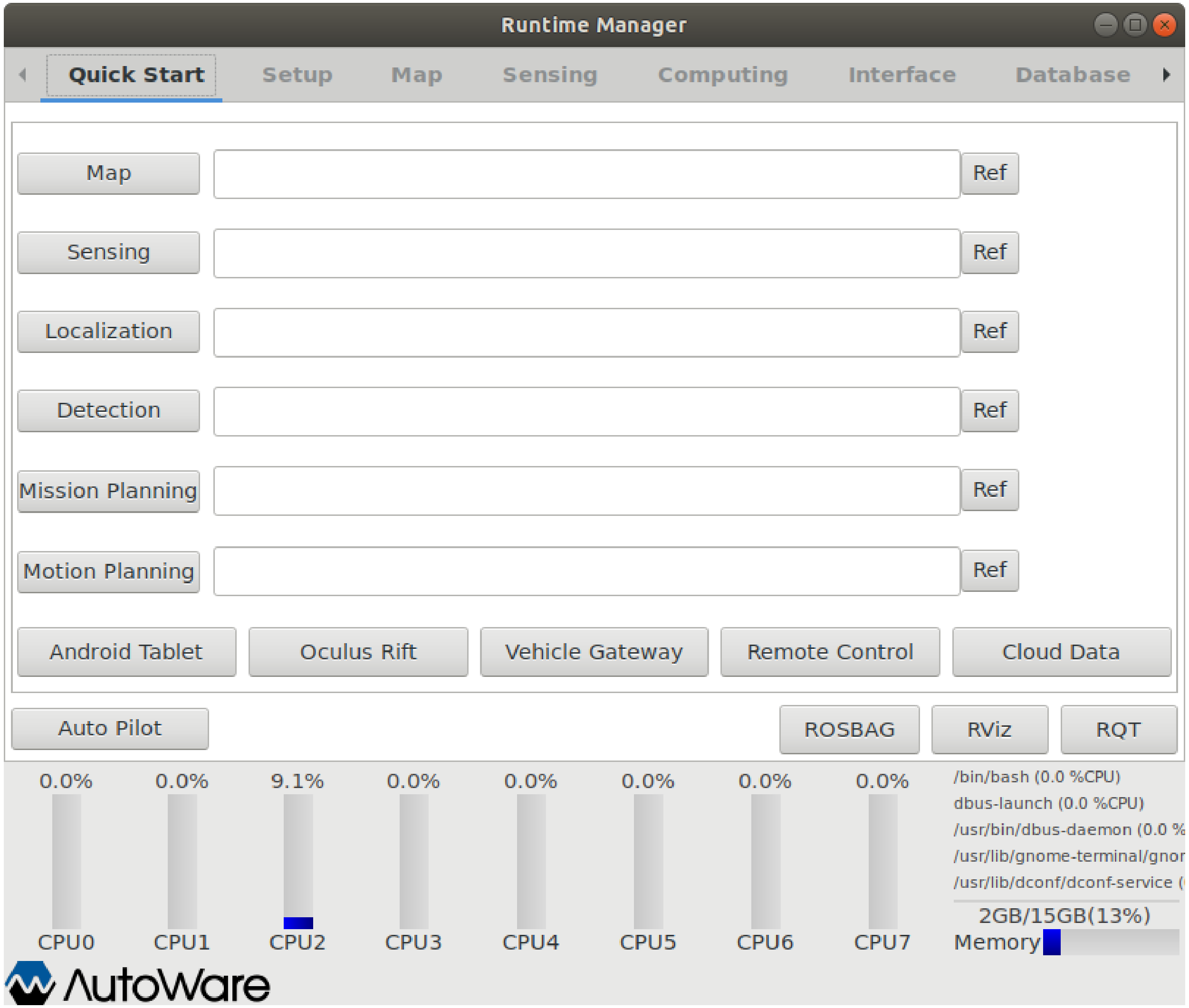
- $ cd # change to home directory
- $ cp shared_dir/src/autoware/utilities/runtime_manager/scripts/run Autoware/src/autoware/utilities/runtime_manager/scripts/run
- $ cd Autoware/build/**runtime_manager**
- $ make install # install 'run' file → "Simulation in Autoware"의 step 3와 동일
- $ cd # change to home directory
- $ cp shared_dir/src/autoware/core_perception/lidar_localizer/launch/ndt_matching.launch Autoware/src/autoware/core_perception/lidar_localizer/launch/ndt_matching.launch
- $ cd Autoware/build/**lidar_localizer**
- $ make install # rebuild and install ndt_matching
- $ cd # change to home directory
- $ cp shared_dir/src/autoware/core_perception/lidar_euclidean_cluster_detect/launch/lidar_euclidean_cluster_detect.launch Autoware/src/autoware/core_perception/lidar_euclidean_cluster_detect/launch/lidar_euclidean_cluster_detect.launch
- $ cd Autoware/build/**lidar_euclidean_cluster_detect**
- $ make install # install 'lidar_euclidean_cluster_detect.launch' file

Step 3: Prepare EgoCar.csv

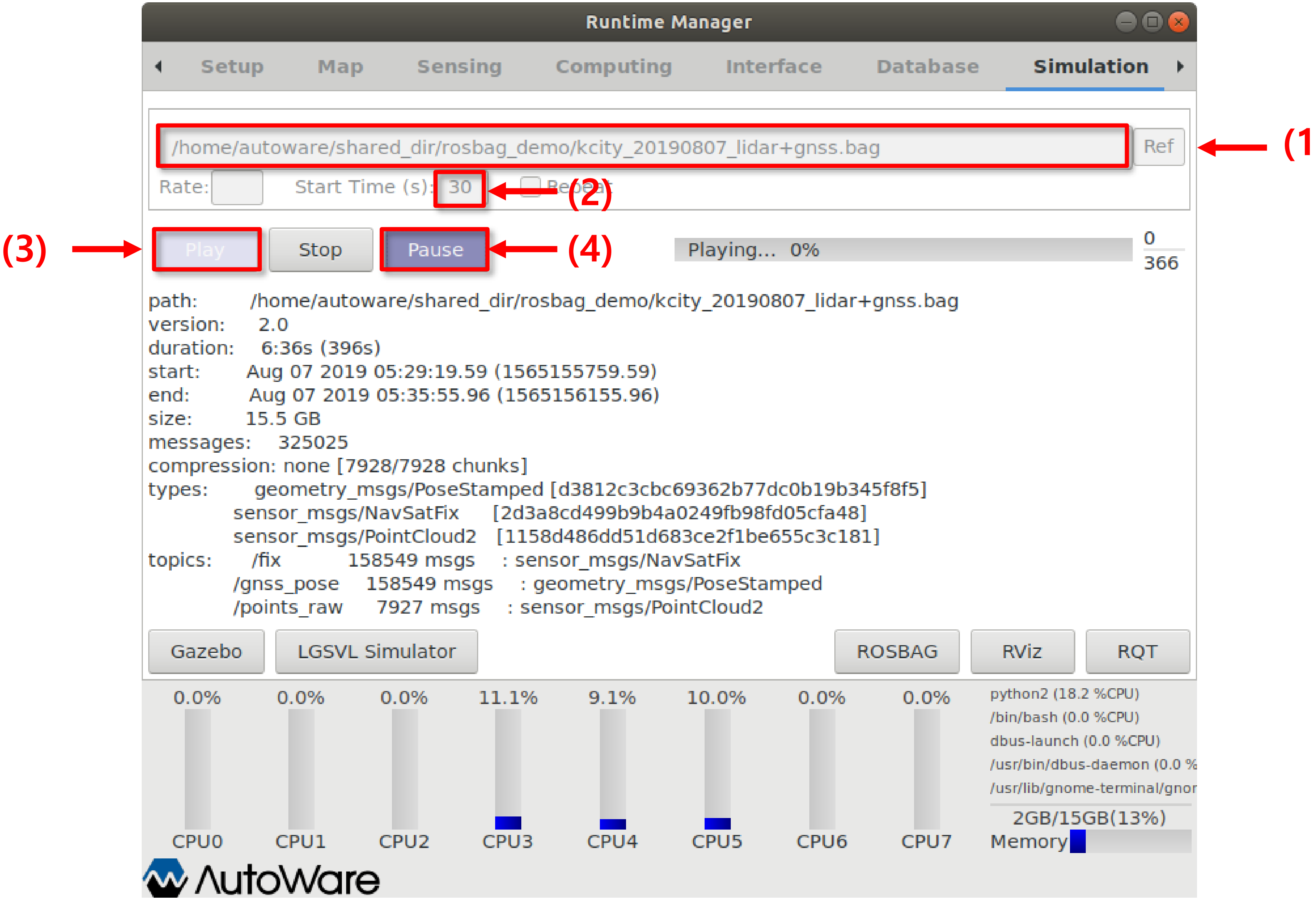
- $ cd
- $ mkdir –p autoware_openplanner_logs/SimulationData
- $ cp shared_dir/autoware_openplanner_logs/SimulationData/EgoCar.csv autoware_openplanner_logs/SimulationData/

Step 4: Launch runtime_manager

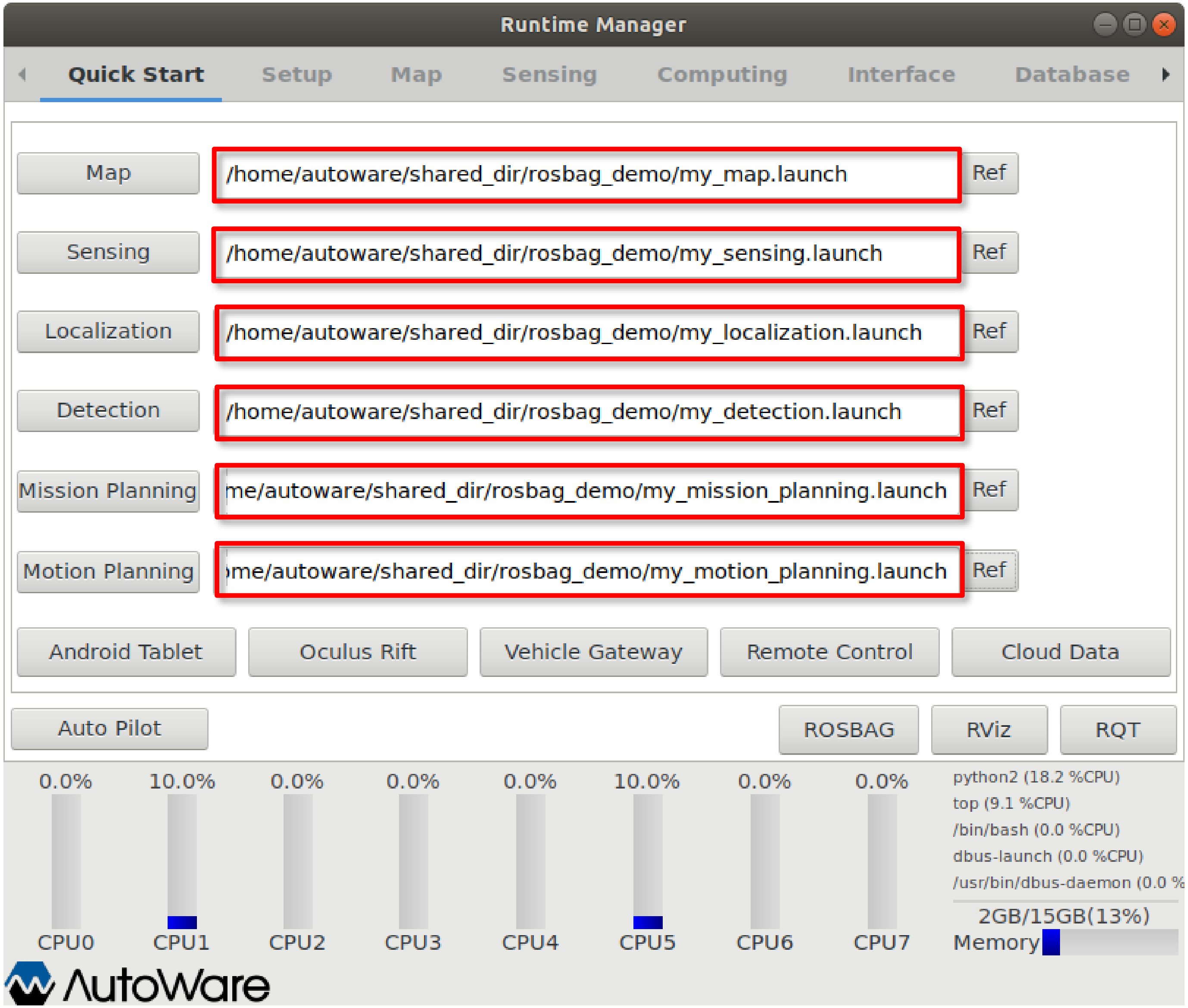
- $ cd Autoware
- $ roslaunch runtime_manager runtime_manager.launch



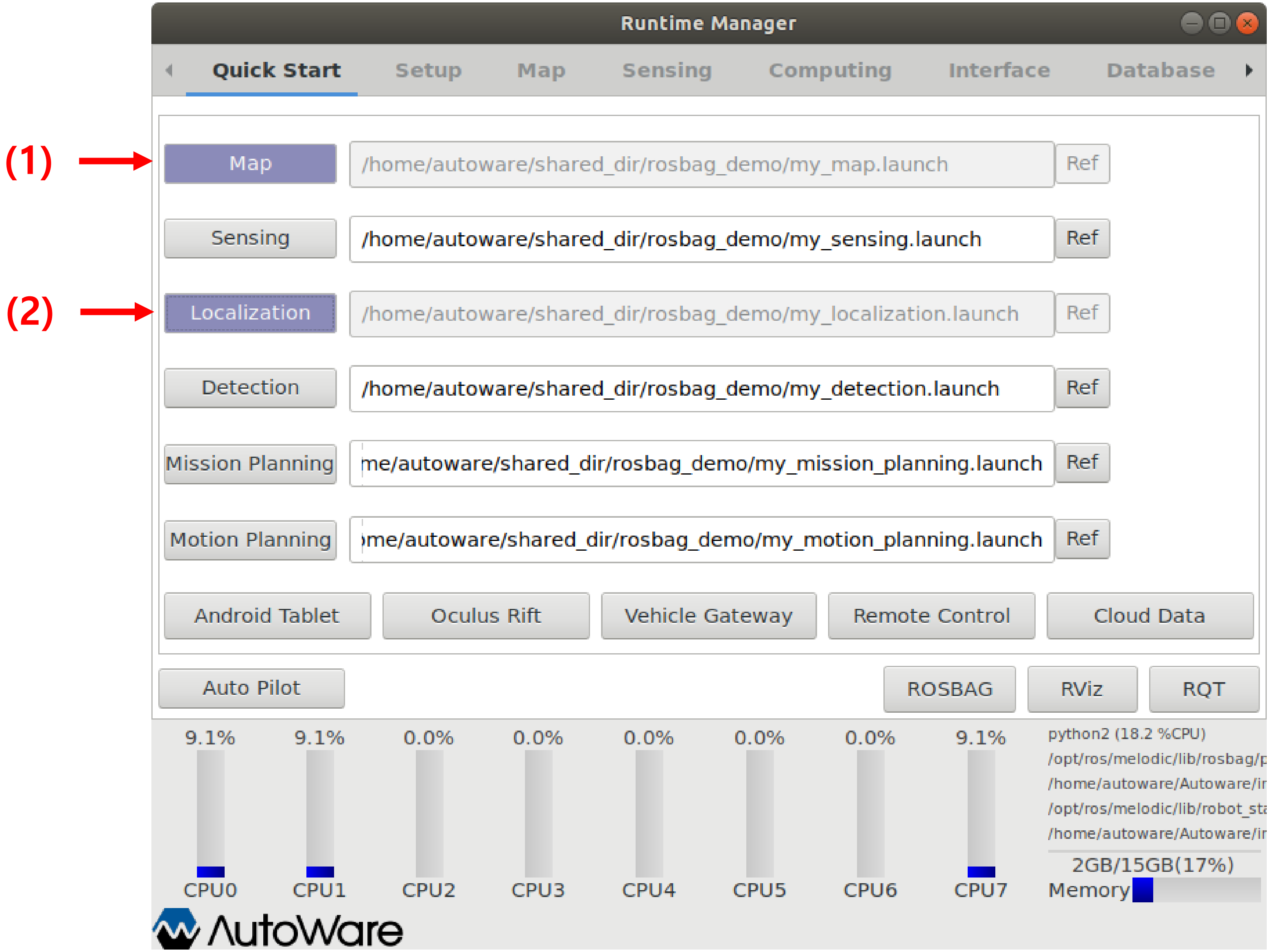
Step 4-1: Load, Play, and Pause rosbag



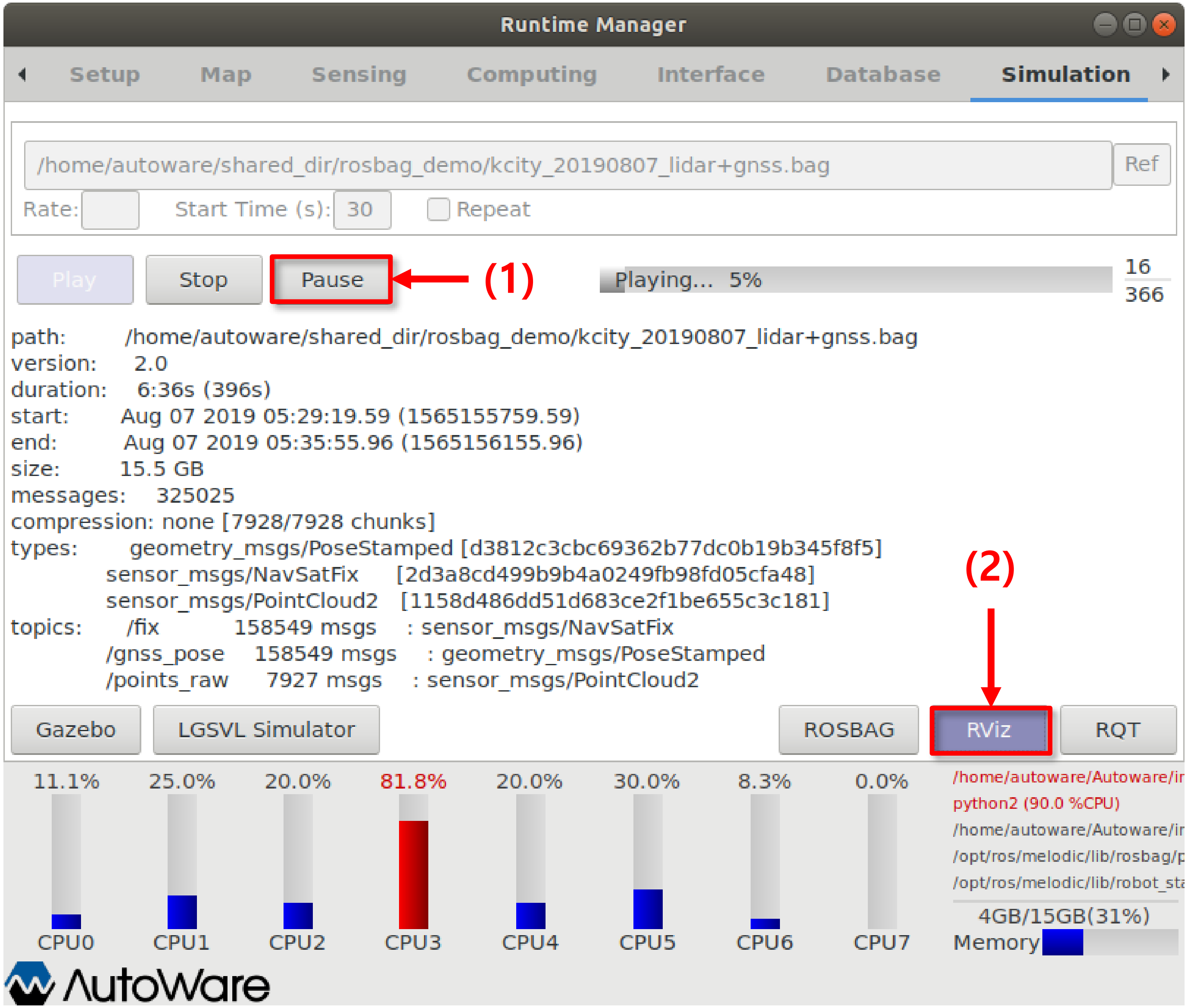
Step 4-2: Select Launch Files for Quick Start



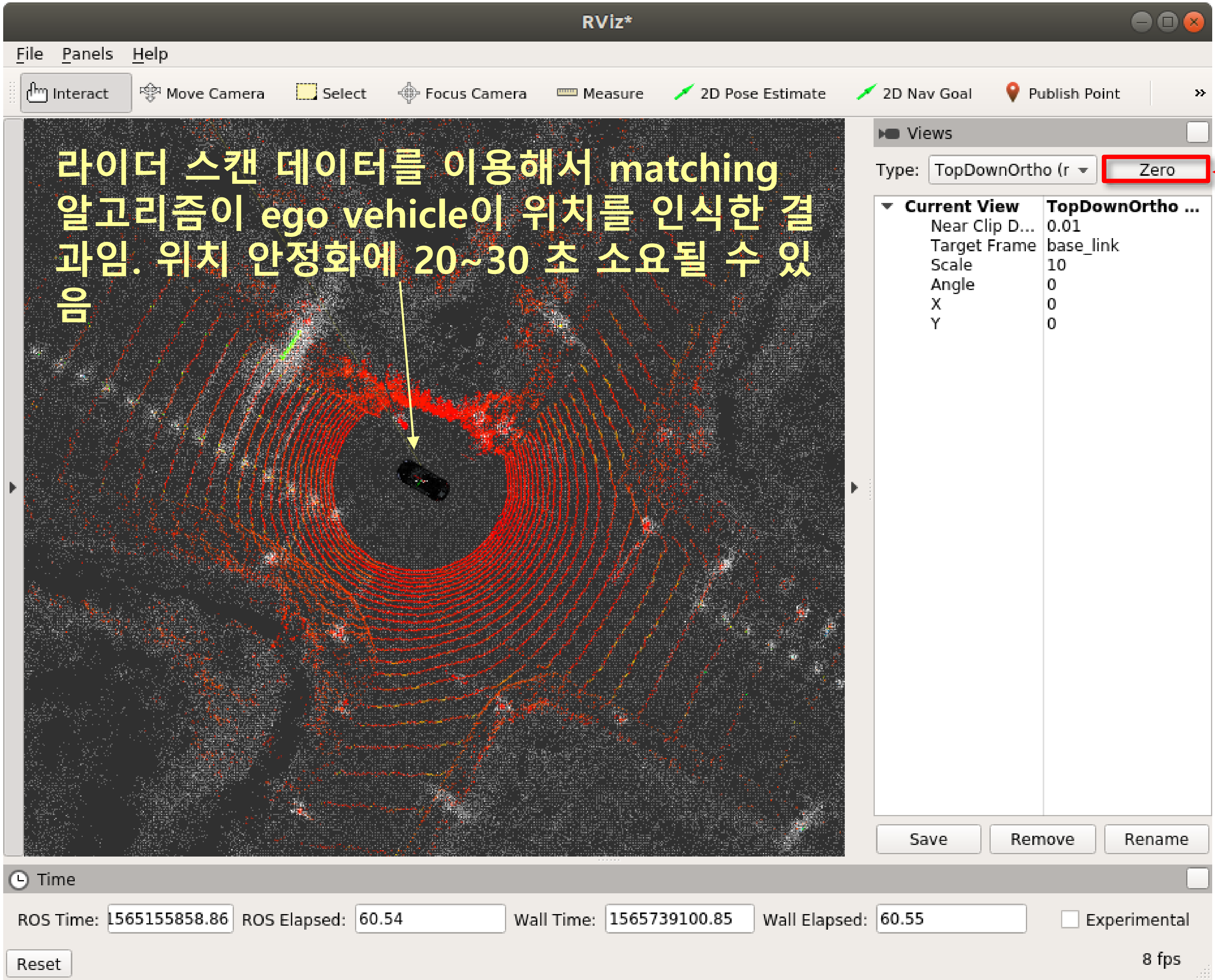
Step 4-3: Launch Map and Localization



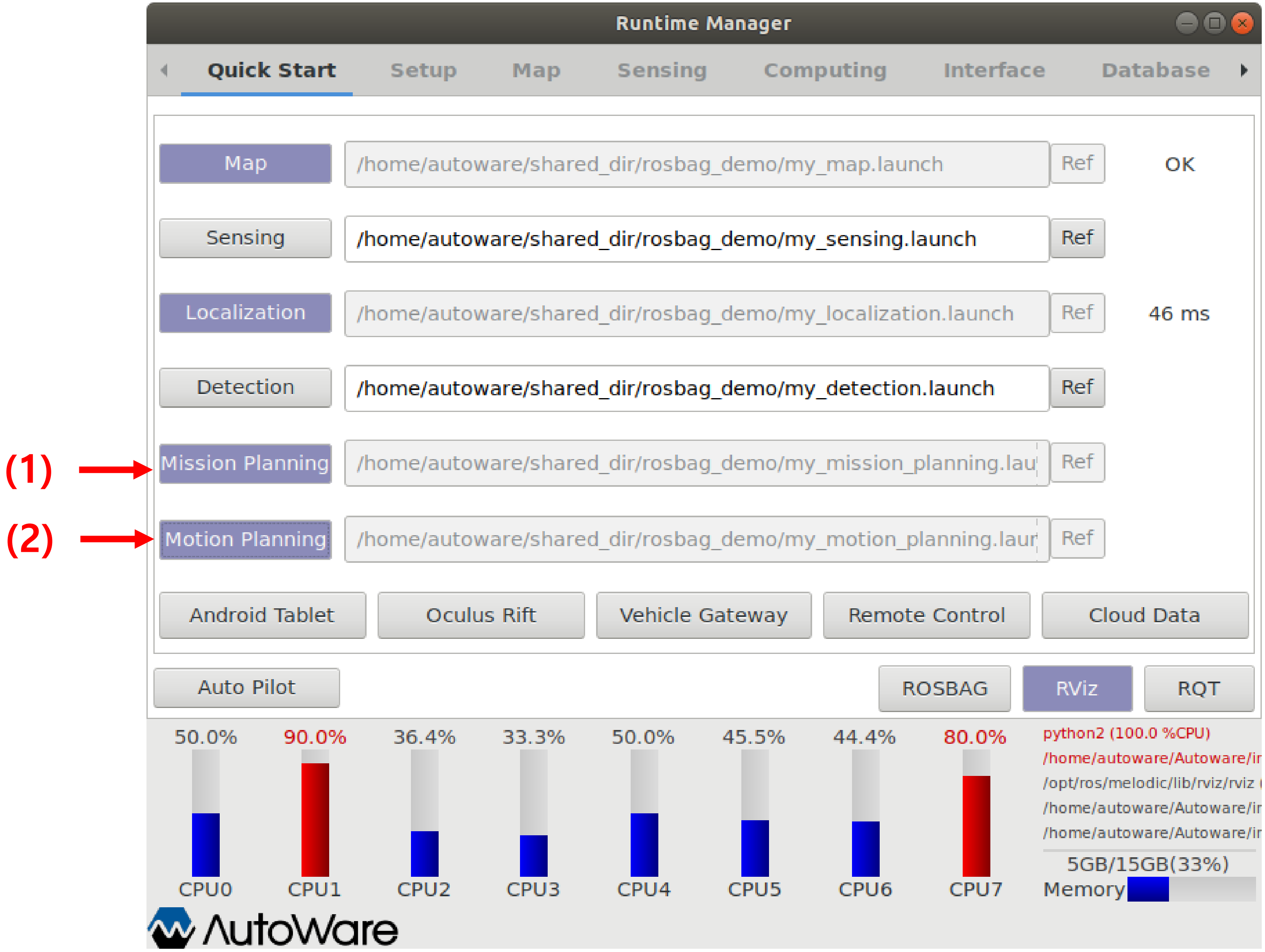
Step 4-4: Unpause rosbag and Launch rviz



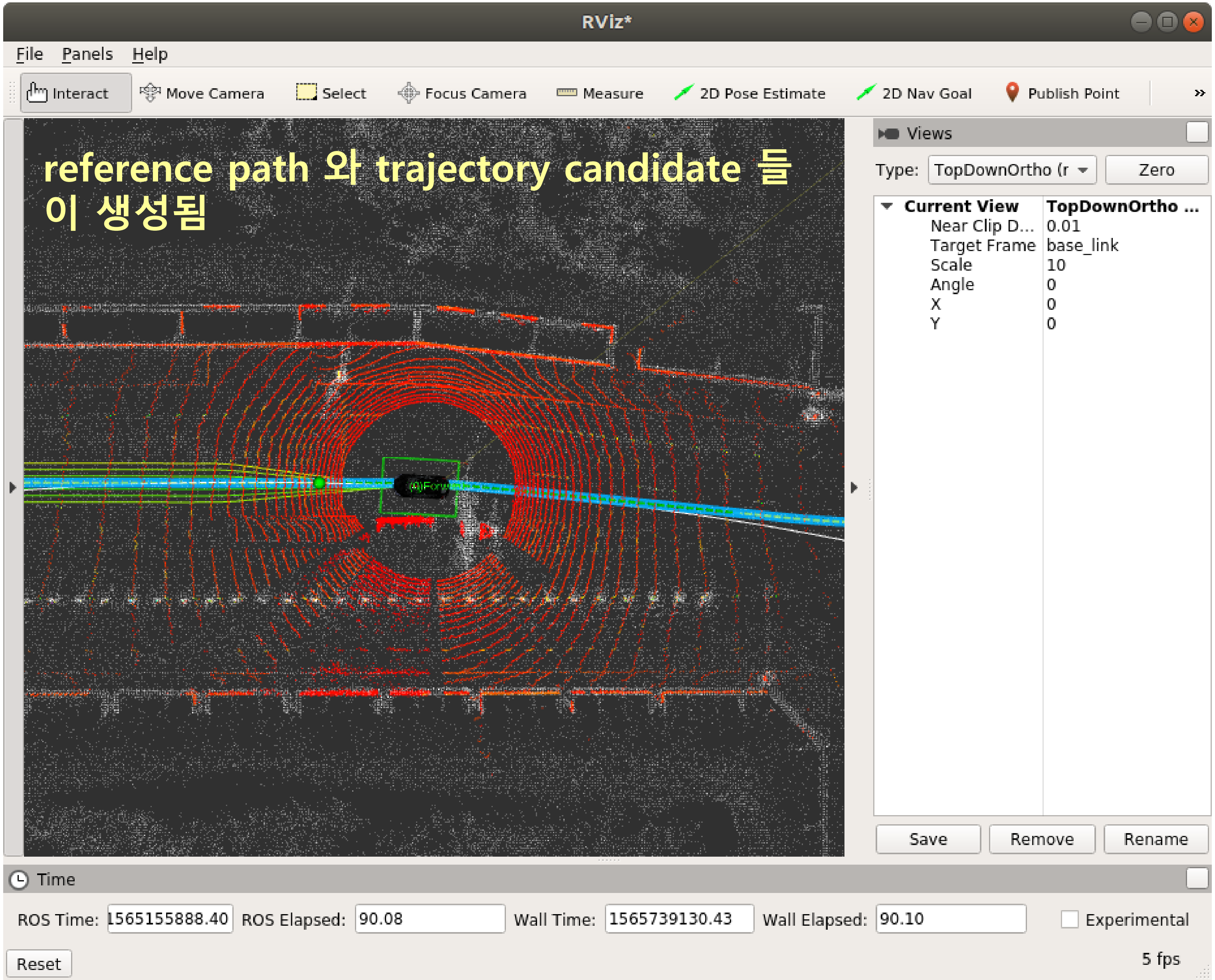
Step 4-4: Unpause rosbag and Launch rviz



Step 4-5: Launch Global and Local Planner



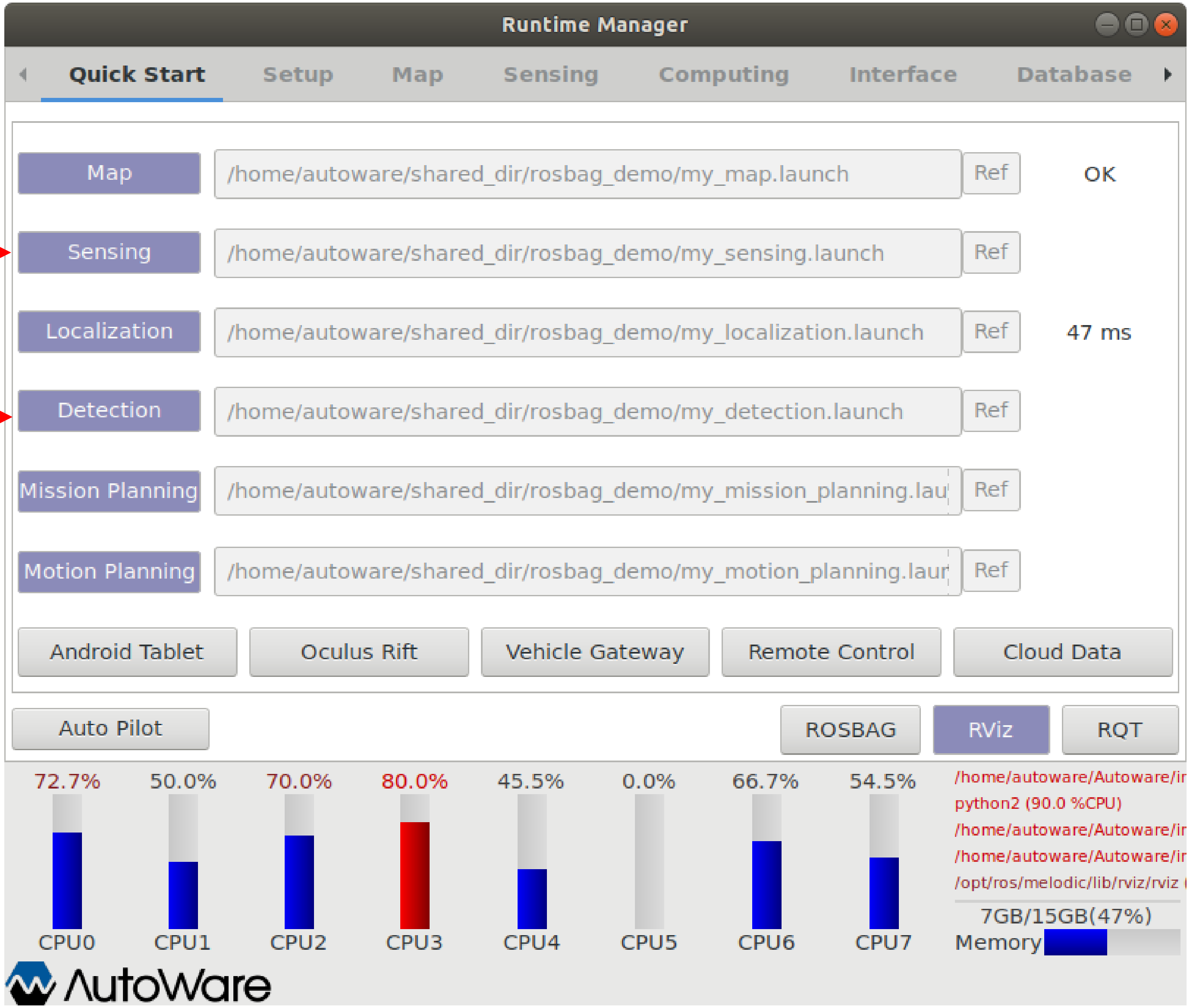
Step 4-5: Launch Global and Local Planner



Step 4-6: Launch Sensing and Detection

(1)

(2)



Step 4-6: Launch Sensing and Detection