Installation

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1 Introduction

In this project, the installation and running of different, well-known benchmarks and algorithms are being investigated. The camera that tests are being conducted by that is D435i. ORBSLAM and Kimer are being tested by that.

1.1 Camera D435i

The Intel RealSense Depth Camera D435i extracts 3D information from a scene to let developers add 3D depth to robotics navigation, object recognition, and other applications. It is a USB-powered depth camera and features a pair of depth sensors, an RGB sensor, and an infrared projector. This D435i version includes inertial 6DoF (six degrees of freedom) measurement data for enhanced accuracy. The D435i is an indoor/outdoor solution designed to best fit developers' prototypes. It has a wide field of view and global shutter combination that offers accurate depth perception when an object is moving or a device is in motion, and it covers more area, minimizing blind spots. This camera comes with a mini tripod and a USB Type-C to USB Type-A cable.

1.2 SLAMbench

SLAMBench is a SLAM performance benchmark that combines a framework for quantifying quality-of-result with instrumentation of accuracy, execution time, memory usage and energy consumption. It also include a graphical interface to visualize these information.

1.3 ORBSLAM 2

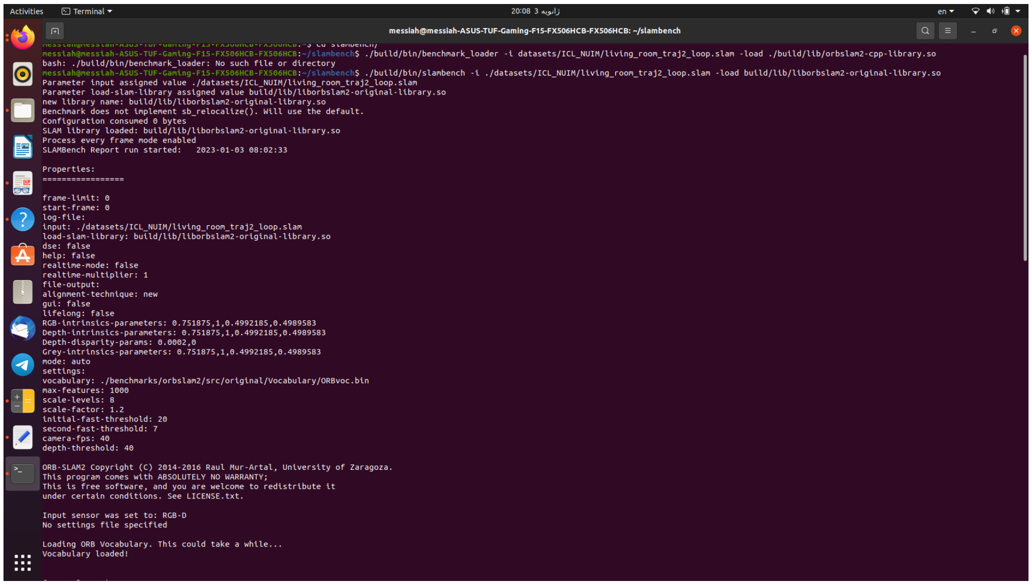
ORB-SLAM2 is a real-time SLAM library for Monocular, Stereo and RGB-D cameras that computes the camera trajectory and a sparse 3D reconstruction (in the stereo and RGB-D case with true scale). It is able to detect loops and relocalize the camera in real time.

1.4 Kimera

Kimera is a C++ library for real-time metric-semantic simultaneous localization and mapping, which uses camera images and inertial data to build a semantically annotated 3D mesh of the environment. Kimera is modular, ROS-enabled, and runs on a CPU.

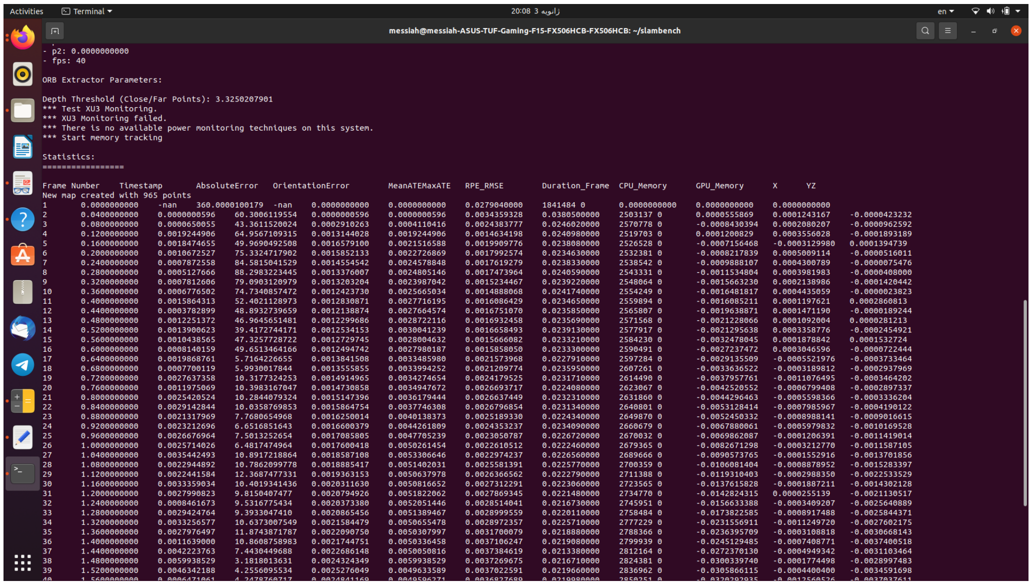
2 SLAMBench installation

In order to install the SLAMBench, this link has been utilized. After cloning that by using the following command: **git clone https://github.com/pamela-project/slambench**
There is a need to compile dependencies by using following command:
make deps
By using the above command, dependencies such as eigen3, flann, g2o, opencv, opengv, pcl, toon, suitesparse would be installed.
However during the installation of dependencies, an error occured regarding to the issue of cloning flann by using ssh from git clone and overloading, that was solved by using the following command:
git config –global url.”https://”.insteadOf git://
After that, the dependencies would be installed correctly. Then the framework must be compiled:
make slambench After that for running and installing ORBSLAM2 the following commands were executed:
make orbslam2
Then there is a need to install a dataset. For that the following command was utilized:
make datasets/ICL _NUIM/living_room _traj2 _loop.slam make slambench APPS=orbslam2
For running the following command was executed:
./build/bin/slambench -i ./datasets/ICL/living_room_traj2_loop.slam -load build/lib/liborbslam2-original-library.so
After running the code the output would be as follow:


Activities
Terminal
20:08 3 ژانویه
en
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/slambench

```
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~$ cd slambench/
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~/slambench$ ./build/bin/benchmark_loader -i datasets/ICL_NUIM/living_room_traj2_loop.slam -load ./build/lib/orbslam2-cpp-library.so
bash: ./build/bin/benchmark_loader: No such file or directory
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~/slambench$ ./build/bin/slambench -i ./datasets/ICL_NUIM/living_room_traj2_loop.slam -load build/lib/liborbslam2-original-library.so
Parameter input assigned value ./datasets/ICL_NUIM/living_room_traj2_loop.slam
Parameter load-slam-library assigned value build/lib/liborbslam2-original-library.so
new library name: build/lib/liborbslam2-original-library.so
Benchmark does not implement sb_relocalize(). Will use the default.
Configuration consumed 0 bytes
SLAM library loaded: build/lib/liborbslam2-original-library.so
Process every frame mode enabled
SLAMBench Report run started:   2023-01-03 08:02:33

Properties:
=================

frame-limit: 0
start-frame: 0
log-file:
input: ./datasets/ICL_NUIM/living_room_traj2_loop.slam
load-slam-library: build/lib/liborbslam2-original-library.so
dse: false
help: false
realtime-mode: false
realtime-multiplier: 1
file-output:
alignment-technique: new
gui: false
lifelong: false
RGB-intrinsics-parameters: 0.751875,1,0.4992185,0.4989583
Depth-intrinsics-parameters: 0.751875,1,0.4992185,0.4989583
Depth-disparity-params: 0.0002,0
Grey-intrinsics-parameters: 0.751875,1,0.4992185,0.4989583
mode: auto
settings:
vocabulary: ./benchmarks/orbslam2/src/original/Vocabulary/ORBvoc.bin
max-features: 1000
scale-levels: 8
scale-factor: 1.2
initial-fast-threshold: 20
second-fast-threshold: 7
camera-fps: 40
depth-threshold: 40

ORB-SLAM2 Copyright (C) 2014-2016 Raul Mur-Artal, University of Zaragoza.
This program comes with ABSOLUTELY NO WARRANTY;
This is free software, and you are welcome to redistribute it
under certain conditions. See LICENSE.txt.

Input sensor was set to: RGB-D
No settings file specified

Loading ORB Vocabulary. This could take a while...
Vocabulary loaded!
```

Figure 1: Sample output of running the Benchmark


Activities
Terminal
20:08 3 ژانویه
en
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/slambench

```
- p2: 0.0000000000
- fps: 40

ORB Extractor Parameters:

Depth Threshold (Close/Far Points): 3.3250207901
*** Test XU3 Monitoring.
*** XU3 Monitoring failed.
*** There is no available power monitoring techniques on this system.
*** Start memory tracking

Statistics:
=================

Frame Number    Timestamp       AbsoluteError   OrientationError        MeanATEMaxATE   RPE_RMSE        Duration_Frame  CPU_Memory      GPU_Memory      X       YZ
New map created with 965 points
1       0.0000000000    -nan    360.0000100179  -nan    0.0000000000    0.0000000000    0.0279040000    1841484 0       0.0000000000    0.0000000000    0.0000000000
2       0.0400000000    0.0000000596    60.3006119554   0.0000000596    0.0000000596    0.0034359328    0.0380500000    2503137 0       0.0000555869    0.0001243167    -0.0000423232
3       0.0800000000    0.0000650055    43.3611520024   0.0002910263    0.0004110416    0.0024383777    0.0246020000    2570778 0       -0.0008430394   0.0002080207    -0.0000962592
4       0.1200000000    0.0019244906    64.9567109315   0.0013144028    0.0019244906    0.0014634198    0.0240980000    2519703 0       0.0001200829    0.0003556028    -0.0001893189
5       0.1600000000    0.0018474655    49.9690492508   0.0016579100    0.0021516588    0.0019909776    0.0238080000    2526528 0       -0.0007156468   -0.0003129980   0.0001394739
6       0.2000000000    0.0010672527    75.3324717902   0.0015852133    0.0022726869    0.0017992574    0.0234630000    2532381 0       -0.0008217839   0.0005009114    -0.0000516011
7       0.2400000000    0.0007872558    84.5815041529   0.0014554542    0.0024578848    0.0017619279    0.0238330000    2538542 0       -0.0009888107   0.0004300789    -0.0000075476
8       0.2800000000    0.0005127666    88.2983223445   0.0013376007    0.0024805146    0.0017473964    0.0240590000    2543331 0       -0.0011534804   0.0003981983    -0.0000408000
9       0.3200000000    0.0007812606    79.0903120979   0.0013203204    0.0023987042    0.0015234467    0.0239220000    2548064 0       -0.0015663230   0.0002138986    -0.0001420442
10      0.3600000000    0.0006776502    74.7340857472   0.0012423730    0.0025665034    0.0014888068    0.0241740000    2554249 0       -0.0016481817   0.0004435059    -0.0000023823
11      0.4000000000    0.0015864313    52.4021128973   0.0012830871    0.0027716195    0.0016086429    0.0234650000    2559894 0       -0.0016085211   0.0001197621    0.0002860813
12      0.4400000000    0.0003782899    48.8932739659   0.0012138874    0.0027664574    0.0016751070    0.0235850000    2565807 0       -0.0019638871   0.0001471190    -0.0000189244
13      0.4800000000    0.0012251372    46.9645651481   0.0012299686    0.0028722116    0.0016932458    0.0235690000    2571568 0       -0.0021228066   0.0001092004    0.0000281213
14      0.5200000000    0.0013900623    39.4172744171   0.0012534153    0.0030041239    0.0016658493    0.0239130000    2577917 0       -0.0021295638   0.0003358776    -0.0002454921
15      0.5600000000    0.0010438565    47.3257728722   0.0012729745    0.0028004632    0.0015666082    0.0233210000    2584230 0       -0.0032478045   0.0001878842    0.0001532724
16      0.6000000000    0.0008140159    49.6513464166   0.0012494742    0.0027980187    0.0015858050    0.0233300000    2590491 0       -0.0027237472   0.0003046596    -0.0000722444
17      0.6400000000    0.0019868761    5.7164226655    0.0013841508    0.0033485980    0.0021573968    0.0227910000    2597284 0       -0.0029135509   -0.0005521976   -0.0003733464
18      0.6800000000    0.0007700119    5.9930017844    0.0013555855    0.0033994252    0.0021209774    0.0235950000    2607261 0       -0.0033636522   -0.0003189812   -0.0002937969
19      0.7200000000    0.0027637358    10.3177324253   0.0014914965    0.0034274654    0.0024179525    0.0231710000    2614490 0       -0.0037957761   -0.0011076495   -0.0003464202
20      0.7600000000    0.0011975069    10.3983167047   0.0014730858    0.0034947672    0.0026693717    0.0224080000    2623067 0       -0.0042520552   -0.0006799408   -0.0002897337
21      0.8000000000    0.0025420524    10.2844079324   0.0015147396    0.0036179444    0.0026637449    0.0232310000    2631860 0       -0.0044296463   -0.0005598366   -0.0003336204
22      0.8400000000    0.0029142844    10.0358769853   0.0015864754    0.0037746308    0.0026796854    0.0231340000    2640801 0       -0.0053128414   -0.0007985967   -0.0004190122
23      0.8800000000    0.0021317969    7.7680654968    0.0016250014    0.0040138373    0.0025189330    0.0224340000    2649870 0       -0.0052450332   -0.0008988141   -0.0009016615
24      0.9200000000    0.0023212696    6.6516851643    0.0016600379    0.0044261809    0.0024353237    0.0234090000    2660679 0       -0.0067880061   -0.0005979832   -0.0010169528
25      0.9600000000    0.0026676964    7.5013252654    0.0017085805    0.0047705239    0.0023050787    0.0226720000    2670032 0       -0.0069862087   -0.0001206391   -0.0011419014
26      1.0000000000    0.0025714026    6.4817474964    0.0017600418    0.0050261454    0.0022610512    0.0222460000    2679365 0       -0.0082671298   -0.0003212770   -0.0011587105
27      1.0400000000    0.0035442493    10.8917218864   0.0018587108    0.0053306646    0.0022974237    0.0226560000    2689666 0       -0.0090573765   -0.0001552916   -0.0013701856
28      1.0800000000    0.0022944892    10.7862099778   0.0018885417    0.0051402031    0.0025581391    0.0225770000    2700359 0       -0.0106081404   -0.0008878952   -0.0015283397
29      1.1200000000    0.0022441584    12.3687477331   0.0019363153    0.0050637978    0.0026366562    0.0222790000    2711388 0       -0.0119310403   -0.0002988350   -0.0022533529
30      1.1600000000    0.0033359034    10.4019341436   0.0020311630    0.0050816652    0.0027312291    0.0223060000    2723565 0       -0.0137615828   -0.0001887211   -0.0014302128
31      1.2000000000    0.0027990823    9.8150407477    0.0020794926    0.0051822062    0.0027869345    0.0221480000    2734770 0       -0.0142824315   0.0000255139    -0.0021130517
32      1.2400000000    0.0008461673    9.5316775434    0.0020373380    0.0052051446    0.0028514041    0.0216730000    2745951 0       -0.0156633388   -0.0003409207   -0.0025640889
33      1.2800000000    0.0029424764    9.3933047410    0.0020865456    0.0051389467    0.0028999559    0.0220110000    2758484 0       -0.0173822585   -0.0008917488   -0.0025844371
34      1.3200000000    0.0033256577    10.6373007549   0.0021584479    0.0050655478    0.0028972357    0.0225710000    2777229 0       -0.0231556911   -0.0011249720   -0.0027602175
35      1.3600000000    0.0027976497    11.8743871787   0.0022090750    0.0050307997    0.0031700079    0.0218880000    2788366 0       -0.0236395709   -0.0003108818   -0.0030668143
36      1.4000000000    0.0011639000    10.8608758983   0.0021744751    0.0050336458    0.0037106247    0.0219080000    2799939 0       -0.0245129485   -0.0007408771   -0.0037400518
37      1.4400000000    0.0042223763    7.4430449688    0.0022686148    0.0050050816    0.0037384619    0.0213380000    2812164 0       -0.0272370130   -0.0004949342   -0.0031103464
38      1.4800000000    0.0059938529    3.1818013631    0.0024324349    0.0059938529    0.0037269675    0.0216710000    2824381 0       -0.0300339740   -0.0001774498   -0.0028997483
39      1.5200000000    0.0046342188    4.2556095534    0.0025276049    0.0049633589    0.0037022591    0.0219660000    2836962 0       -0.0305866115   -0.0004400400   -0.0034591698
40      1.5600000000    0.0006471061    4.2478760717    0.0024841169    0.0049596271    0.0036827689    0.0219980000    2850251 0       -0.0320292935   -0.0012560526   -0.0037037611
```

Figure 2: Sample output of running the Benchmark

Its output is composed of two main parts, the Properties section, and the

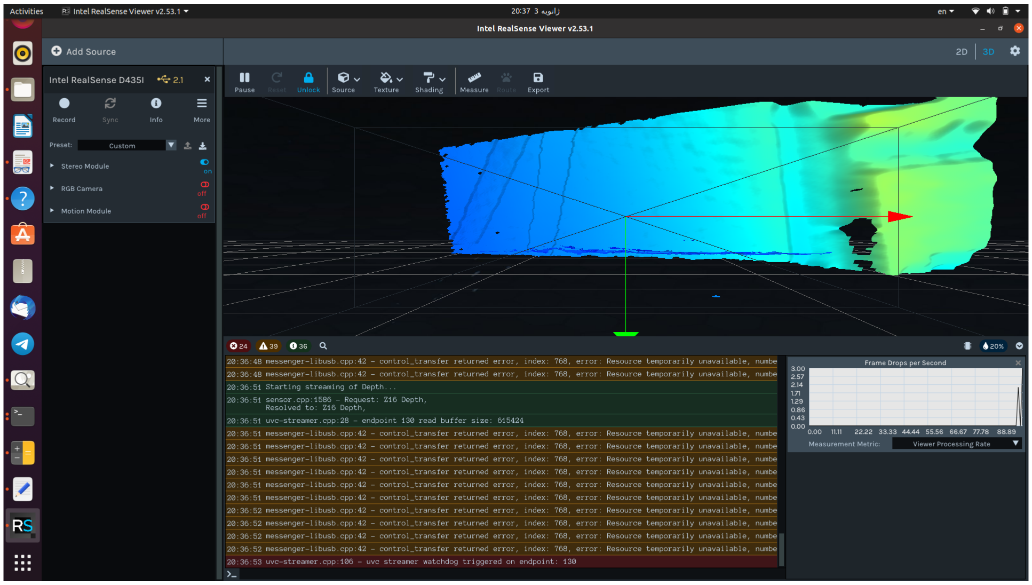
Statistics section. the properties section details all the parameters used for the experiment (could been changed or not via the command line). the statistics section report all the outputs and metrics selection for output in the benchmark loader.

3 RealSense SDK 2.0

For installing the RealSense SDK 2.0 on ubuntu following commands must be executed:

```
sudo apt install libglfw3-dev libgl1-mesa-dev libglu1-mesa-dev libusb-1.0-0-dev
mkdir -p  /repos  cd  /repos
git clone https://github.com/IntelRealSense/librealsense
mkdir -p librealsense/build  cd librealsense/build
make -j(nproc)
```

After that the installation can be tested as follow by running **librealsense-viewer** the software would appear, by using that the camera can be tested:



Preset: Custom

Measurement Metric: Viewer Processing Rate

```
20:36:48 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:48 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:51 Starting streaming of Depth...
20:36:51 sensor.cpp:1586 - Request: Z16 Depth,
         Resolved to: Z16 Depth,
20:36:51 uvc-streamer.cpp:28 - endpoint 130 read buffer size: 615424
20:36:51 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:51 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:51 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:51 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:51 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:51 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:52 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:52 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:52 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:52 messenger-libusb.cpp:42 - control_transfer returned error, index: 768, error: Resource temporarily unavailable, numbe
20:36:53 uvc-streamer.cpp:106 - uvc streamer watchdog triggered on endpoint: 130
>_
```

Figure 3: Sample output of the Realsense software after connecting the camera

After installing the SDK library, it is the time to compile and run ORB-SLAM2 and Kimera. For running codes on D435i camera Ros Noetic must be installed.

4 ROS Noetic

In order to install Ros Noetic the following steps, must be performed. The computer sources and keys must be updated by following commands:

```
sudo sh -c ’echo ”deb http://packages.ros.org/ros/ubuntu $ (lsb_release -sc) main” > /etc/apt/sources.list.d/ros-latest.list’
sudo apt install curl
curl -s https://raw.githubusercontent.com/ros/rosdistro/master/ros.asc — sudo apt-key add -
```

Then by utilizing the following command the ros Noetic would be installed:

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

For building packages, some dependencies must be installed:

```
sudo apt install python3-rosdep python3-rosinstall python3-rosinstall-generator python3-wstool build-essential
sudo apt install python3-rosdep
sudo rosdep init
rosdep update
```

5 ORBSLAM2

To build the project the following steps must be conducted:

```
git clone https://github.com/RAFALAMAO/ORB_SLAM2_NOETIC
```

In order to build the project, At first we should enter the Pangolin directory and build that by utilizing the following commands:

```
cd ORB_SLAM2_NOETIC/Pangolin
mkdir build
cd build
cmake ..
make -j
```

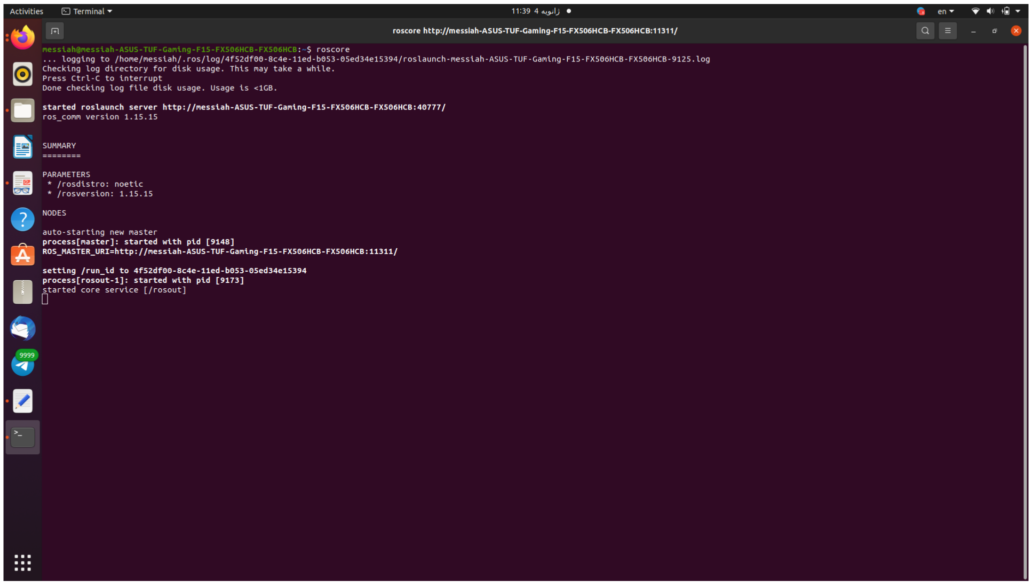
For building the ORBSALM2 library the following command must be executed:

```
./build.sh
```

In order to run the algorithm on the camera the following command must be executed:

```
roscore
```

roscore is a collection of nodes and programs that are pre-requisites of a ROS-based system. You must have a roscore running in order for ROS nodes to communicate. It is launched using the roscore command. The output of the above command, is shown below:

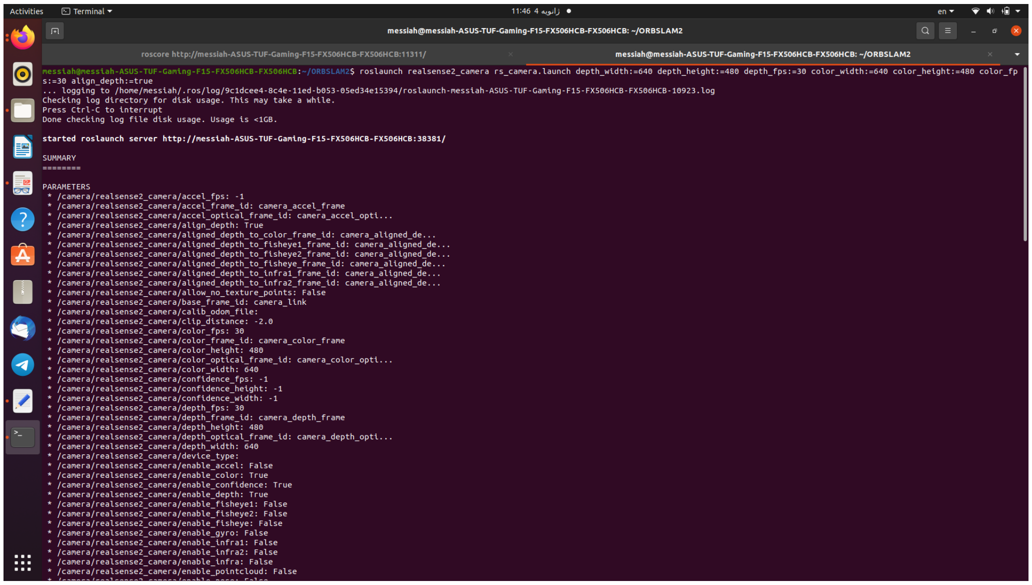


Activities
Terminal
11:39 4 ژانویه
en
roscore http://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:11311/
9999

```
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~$ roscore
... logging to /home/messiah/.ros/log/4f52df00-8c4e-11ed-b053-05ed34e15394/roslaunch-messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB-9125.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://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:40777/
ros_comm version 1.15.15


SUMMARY
========

PARAMETERS
 * /rosdistro: noetic
 * /rosversion: 1.15.15

NODES

auto-starting new master
process[master]: started with pid [9148]
ROS_MASTER_URI=http://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:11311/

setting /run_id to 4f52df00-8c4e-11ed-b053-05ed34e15394
process[rosout-1]: started with pid [9173]
started core service [/rosout]
```

Figure 4: The result of execution roscore

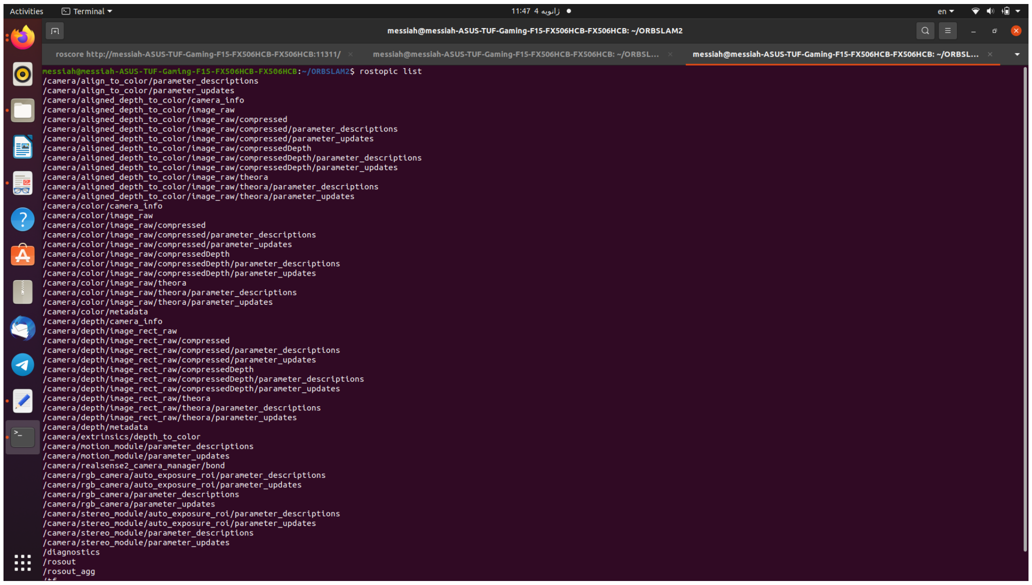
The camera can be run on ROS by utilizing the following command: **roslaunch realsense2_camera rs _camera.launch depth_width:=640 depth _height:=480 depth_fps:=30 color_width:=640 color _height:=480 color _fps:=30 align _depth:=true** The output of the above command is shown below:


Activities
Terminal
11:46 4 ژانویه
en
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/ORBSLAM2
roscore http://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:11311/
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/ORBSLAM2

```
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~/ORBSLAM2$ roslaunch realsense2_camera rs_camera.launch depth_width:=640 depth_height:=480 depth_fps:=30 color_width:=640 color_height:=480 color_fp
s:=30 align_depth:=true
... logging to /home/messiah/.ros/log/9c1dcee4-8c4e-11ed-b053-05ed34e15394/roslaunch-messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB-10923.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://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:38381/

SUMMARY
========

PARAMETERS
 * /camera/realsense2_camera/accel_fps: -1
 * /camera/realsense2_camera/accel_frame_id: camera_accel_frame
 * /camera/realsense2_camera/accel_optical_frame_id: camera_accel_opti...
 * /camera/realsense2_camera/align_depth: True
 * /camera/realsense2_camera/aligned_depth_to_color_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_fisheye1_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_fisheye2_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_fisheye_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_infra1_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_infra2_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/allow_no_texture_points: False
 * /camera/realsense2_camera/base_frame_id: camera_link
 * /camera/realsense2_camera/calib_odom_file:
 * /camera/realsense2_camera/clip_distance: -2.0
 * /camera/realsense2_camera/color_fps: 30
 * /camera/realsense2_camera/color_frame_id: camera_color_frame
 * /camera/realsense2_camera/color_height: 480
 * /camera/realsense2_camera/color_optical_frame_id: camera_color_opti...
 * /camera/realsense2_camera/color_width: 640
 * /camera/realsense2_camera/confidence_fps: -1
 * /camera/realsense2_camera/confidence_height: -1
 * /camera/realsense2_camera/confidence_width: -1
 * /camera/realsense2_camera/depth_fps: 30
 * /camera/realsense2_camera/depth_frame_id: camera_depth_frame
 * /camera/realsense2_camera/depth_height: 480
 * /camera/realsense2_camera/depth_optical_frame_id: camera_depth_opti...
 * /camera/realsense2_camera/depth_width: 640
 * /camera/realsense2_camera/device_type:
 * /camera/realsense2_camera/enable_accel: False
 * /camera/realsense2_camera/enable_color: True
 * /camera/realsense2_camera/enable_confidence: True
 * /camera/realsense2_camera/enable_depth: True
 * /camera/realsense2_camera/enable_fisheye1: False
 * /camera/realsense2_camera/enable_fisheye2: False
 * /camera/realsense2_camera/enable_fisheye: False
 * /camera/realsense2_camera/enable_gyro: False
 * /camera/realsense2_camera/enable_infra1: False
 * /camera/realsense2_camera/enable_infra2: False
 * /camera/realsense2_camera/enable_infra: False
 * /camera/realsense2_camera/enable_pointcloud: False
 * /camera/realsense2_camera/enable_pose: False
```

Figure 5: The rsult of running camera on a node

By using the **rostopic list** the sensors information that can be published are visualized:


Activities
Terminal
11:47 4 ژانویه
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/ORBSLAM2
roscore http://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:11311/
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/ORBSL...
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB: ~/ORBSL...
en

```
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~/ORBSLAM2$ rostopic list
/camera/align_to_color/parameter_descriptions
/camera/align_to_color/parameter_updates
/camera/aligned_depth_to_color/camera_info
/camera/aligned_depth_to_color/image_raw
/camera/aligned_depth_to_color/image_raw/compressed
/camera/aligned_depth_to_color/image_raw/compressed/parameter_descriptions
/camera/aligned_depth_to_color/image_raw/compressed/parameter_updates
/camera/aligned_depth_to_color/image_raw/compressedDepth
/camera/aligned_depth_to_color/image_raw/compressedDepth/parameter_descriptions
/camera/aligned_depth_to_color/image_raw/compressedDepth/parameter_updates
/camera/aligned_depth_to_color/image_raw/theora
/camera/aligned_depth_to_color/image_raw/theora/parameter_descriptions
/camera/aligned_depth_to_color/image_raw/theora/parameter_updates
/camera/color/camera_info
/camera/color/image_raw
/camera/color/image_raw/compressed
/camera/color/image_raw/compressed/parameter_descriptions
/camera/color/image_raw/compressed/parameter_updates
/camera/color/image_raw/compressedDepth
/camera/color/image_raw/compressedDepth/parameter_descriptions
/camera/color/image_raw/compressedDepth/parameter_updates
/camera/color/image_raw/theora
/camera/color/image_raw/theora/parameter_descriptions
/camera/color/image_raw/theora/parameter_updates
/camera/color/metadata
/camera/depth/camera_info
/camera/depth/image_rect_raw
/camera/depth/image_rect_raw/compressed
/camera/depth/image_rect_raw/compressed/parameter_descriptions
/camera/depth/image_rect_raw/compressed/parameter_updates
/camera/depth/image_rect_raw/compressedDepth
/camera/depth/image_rect_raw/compressedDepth/parameter_descriptions
/camera/depth/image_rect_raw/compressedDepth/parameter_updates
/camera/depth/image_rect_raw/theora
/camera/depth/image_rect_raw/theora/parameter_descriptions
/camera/depth/image_rect_raw/theora/parameter_updates
/camera/depth/metadata
/camera/extrinsics/depth_to_color
/camera/motion_module/parameter_descriptions
/camera/motion_module/parameter_updates
/camera/realsense2_camera_manager/bond
/camera/rgb_camera/auto_exposure_roi/parameter_descriptions
/camera/rgb_camera/auto_exposure_roi/parameter_updates
/camera/rgb_camera/parameter_descriptions
/camera/rgb_camera/parameter_updates
/camera/stereo_module/auto_exposure_roi/parameter_descriptions
/camera/stereo_module/auto_exposure_roi/parameter_updates
/camera/stereo_module/parameter_descriptions
/camera/stereo_module/parameter_updates
/diagnostics
/rosout
/rosout_agg
```

Figure 6: The result of execution rostopic list

The rostopic command-line tool displays information about ROS topics. Currently, it can display a list of active topics, the publishers and subscribers of a specific topic, the publishing rate of a topic, the bandwidth of a topic, and messages published to a topic. The display of messages is configurable to output in a plotting-friendly format. The algorithm can be run on the camera by using the following command:
rosrun ORB_SLAM2 RGBD /home/messiah/ORBSLAM2/ORB_SLAM2_NOETIC/Vocabulary/ORBvoc.txt /home/messiah/1/2/ORB_SLAM3/Examples_old/RGB-D/RealSense_D435i.yaml /camera/rgb/image_raw:=/camera/color/image_raw camera/depth_registered/image_raw:=/camera/aligned_depth_to_color/image_raw

6 Kimera

In order to install Kimera on catkin, at firs the following must be executed:
sudo apt-get install python3-rosinstall python3-rosinstall-generator python3-wstool build-essential python3-catkin-tools
Then some dependencies must be installed, by using the following command:
sudo apt-get install -y –no-install-recommends apt-utils
sudo apt-get install -y cmake build-essential unzip pkg-config autoconf libboost-all-dev libjpeg-dev libpng-dev libtiff-dev libvtk6-dev libgtk-3-dev libatlas-base-dev gfortran libparmetis-dev python-wstool python-catkin-tools
By utilizing the following commands, the catkin workspace would be setup:

```
mkdir -p /catkin _ws/src
cd /catkin_ws/
catkin init
catkin config –cmake-args -DCMAKE_BUILD_TYPE=Release -DGTSAM
_TANGENT_PREINTEGRATION=OFF
```

The catkin config will be set using the following command:

```
catkin config –merge-devel
```

The workspace would be added to bashrc file for automatic sourcing of workspace:

```
echo ’source /catkin_ws/devel/setup.bash’ >> /.bashr
```

Dependencies would be installed as follow:

```
cd /catkin_ws/src
git clone git@github.com:MIT-SPARK/Kimera-VIO-ROS.git
```

Dependencies from rosinstall file can be installed and updated using wstool:

```
wstool init
wstool update
```

After that running **catkin build** will result in errors, for handling them the following things must be accomplished:
need to apply ubuntu 20.04 patch commits available in https://github.com/MIT-SPARK/mesh_rviz_plugins:

```
cd mesh_rviz_plugins
- (change the remote url to valid one ) git remote set-url origin
https://github.com/MIT-SPARK/mesh_rviz_plugins - git pull origin
master - git apply ubuntu_focal.patch
```

In addition to that, there is a need to use GTSAM 4.1.1. for using that, the following steps must be accoompolished:

```
cd gtsam
git checkout 4.1.1
```

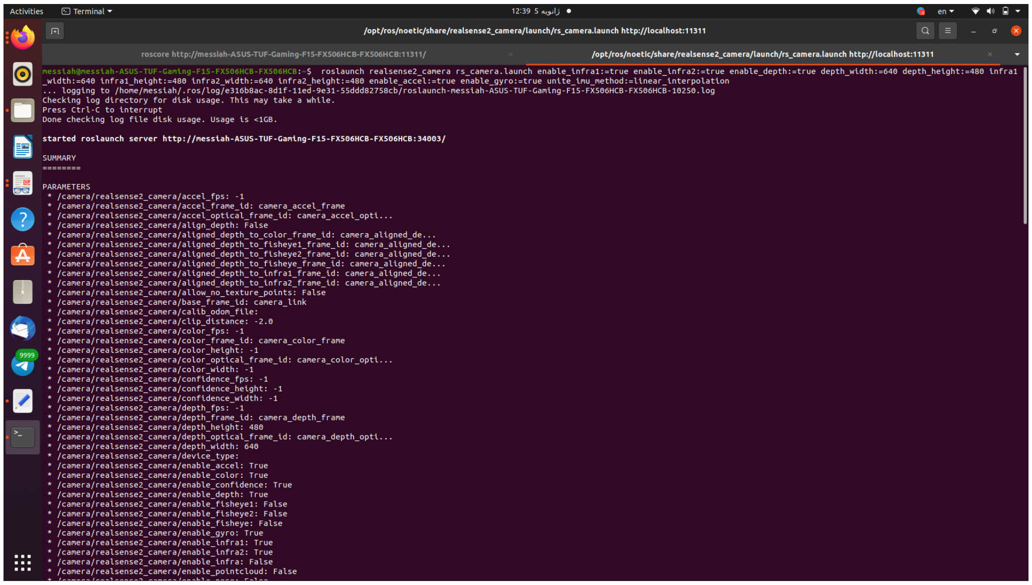
There is stil some conflicts with opencv version, to handle that the following steps must be performed:

- Remove opencv3_catkin from src directory
- Replace all opencv3 with opencv4
- build dbow2 _src and delete everything in the build folder except that.
- In Cmakelists change ON to OFF in option(KIMERA_BUILD _TESTS ”Build tests” OFF)

At first again the **roscore** command must be executed. In order to run the algorithm on D435i, At first the camera must become executed by following command:

```
roslaunch realsense2_camera rs_camera.launch enable_infra1:=true en-
able_infra2:=true enable_depth:=true depth_width:=640 depth_height:=480
infra1_width:=640 infra1 _height:=480 infra2 _width:=640 infra2_height:=480
enable _accel:=true enable _gyro:=true unite_imu_method:=linear_interpolation
```

The output is shown in figure below:

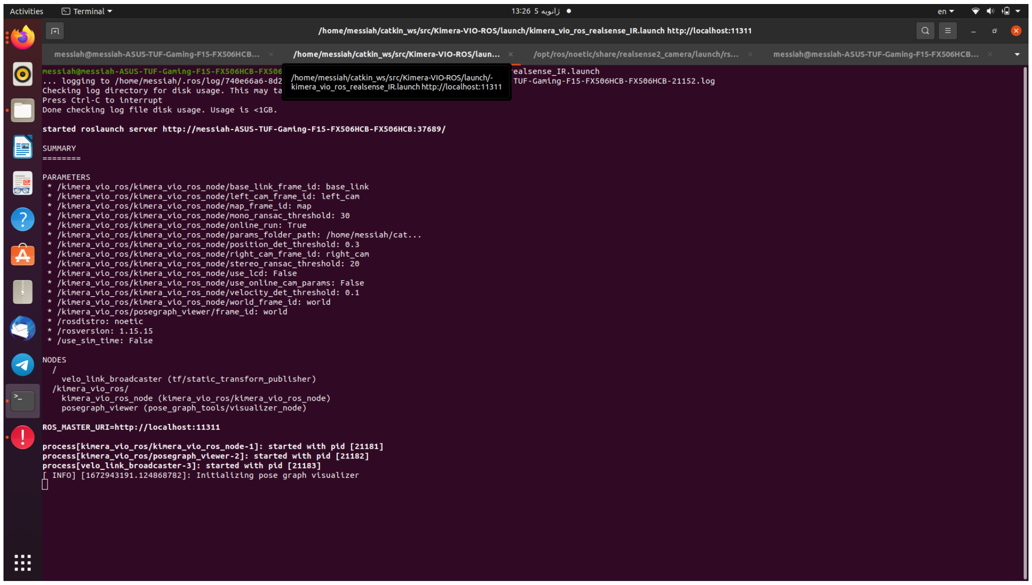


Activities
Terminal
12:39 5 ژانویه
en
/opt/ros/noetic/share/realsense2_camera/launch/rs_camera.launch http://localhost:11311
roscore http://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:11311/
/opt/ros/noetic/share/realsense2_camera/launch/rs_camera.launch http://localhost:11311
9999

```
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:~$  roslaunch realsense2_camera rs_camera.launch enable_infra1:=true enable_infra2:=true enable_depth:=true depth_width:=640 depth_height:=480 infra1
_width:=640 infra1_height:=480 infra2_width:=640 infra2_height:=480 enable_accel:=true enable_gyro:=true unite_imu_method:=linear_interpolation
... logging to /home/messiah/.ros/log/e316b8ac-8d1f-11ed-9e31-55ddd82758cb/roslaunch-messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB-10250.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://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:34003/

SUMMARY
========

PARAMETERS
 * /camera/realsense2_camera/accel_fps: -1
 * /camera/realsense2_camera/accel_frame_id: camera_accel_frame
 * /camera/realsense2_camera/accel_optical_frame_id: camera_accel_opti...
 * /camera/realsense2_camera/align_depth: False
 * /camera/realsense2_camera/aligned_depth_to_color_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_fisheye1_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_fisheye2_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_fisheye_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_infra1_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/aligned_depth_to_infra2_frame_id: camera_aligned_de...
 * /camera/realsense2_camera/allow_no_texture_points: False
 * /camera/realsense2_camera/base_frame_id: camera_link
 * /camera/realsense2_camera/calib_odom_file:
 * /camera/realsense2_camera/clip_distance: -2.0
 * /camera/realsense2_camera/color_fps: -1
 * /camera/realsense2_camera/color_frame_id: camera_color_frame
 * /camera/realsense2_camera/color_height: -1
 * /camera/realsense2_camera/color_optical_frame_id: camera_color_opti...
 * /camera/realsense2_camera/color_width: -1
 * /camera/realsense2_camera/confidence_fps: -1
 * /camera/realsense2_camera/confidence_height: -1
 * /camera/realsense2_camera/confidence_width: -1
 * /camera/realsense2_camera/depth_fps: -1
 * /camera/realsense2_camera/depth_frame_id: camera_depth_frame
 * /camera/realsense2_camera/depth_height: 480
 * /camera/realsense2_camera/depth_optical_frame_id: camera_depth_opti...
 * /camera/realsense2_camera/depth_width: 640
 * /camera/realsense2_camera/device_type:
 * /camera/realsense2_camera/enable_accel: True
 * /camera/realsense2_camera/enable_color: True
 * /camera/realsense2_camera/enable_confidence: True
 * /camera/realsense2_camera/enable_depth: True
 * /camera/realsense2_camera/enable_fisheye1: False
 * /camera/realsense2_camera/enable_fisheye2: False
 * /camera/realsense2_camera/enable_fisheye: False
 * /camera/realsense2_camera/enable_gyro: True
 * /camera/realsense2_camera/enable_infra1: True
 * /camera/realsense2_camera/enable_infra2: True
 * /camera/realsense2_camera/enable_infra: False
 * /camera/realsense2_camera/enable_pointcloud: False
 * /camera/realsense2_camera/enable_pose: False
```

Figure 7: The result of execution Realsense launch

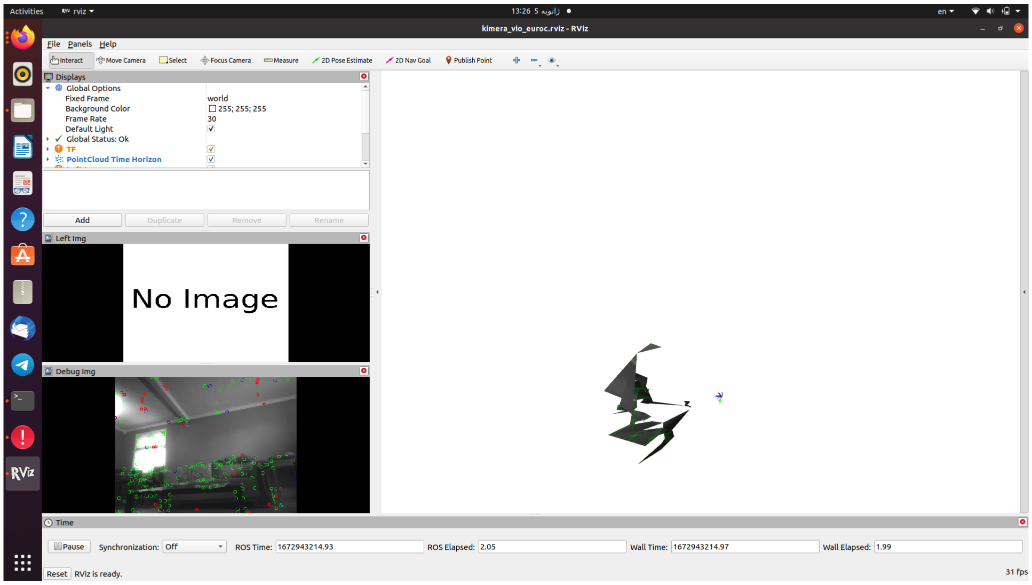
Now it is time for the Kimera to be executed, it can be executed by following command:
roslaunch kimera_vio _ros kimera_vio _ros_realsense_IR.launch
The output is shown in figure below:


Activities
Terminal
13:26 5 ژانویه
en
/home/messiah/catkin_ws/src/Kimera-VIO-ROS/launch/kimera_vio_ros_realsense_IR.launch http://localhost:11311
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB...
/home/messiah/catkin_ws/src/Kimera-VIO-ROS/laun...
/opt/ros/noetic/share/realsense2_camera/launch/rs...
messiah@messiah-ASUS-TUF-Gaming-F15-FX506HCB...
/home/messiah/catkin_ws/src/Kimera-VIO-ROS/launch/-
kimera_vio_ros_realsense_IR.launch http://localhost:11311

```
messiah@messiah-ASUS-TUF-Gaming-F15-FX506                                           ealsense_IR.launch
... logging to /home/messiah/.ros/log/740e66a6-8d2                                  TUF-Gaming-F15-FX506HCB-FX506HCB-21152.log
Checking log directory for disk usage. This may ta
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://messiah-ASUS-TUF-Gaming-F15-FX506HCB-FX506HCB:37689/

SUMMARY
========

PARAMETERS
 * /kimera_vio_ros/kimera_vio_ros_node/base_link_frame_id: base_link
 * /kimera_vio_ros/kimera_vio_ros_node/left_cam_frame_id: left_cam
 * /kimera_vio_ros/kimera_vio_ros_node/map_frame_id: map
 * /kimera_vio_ros/kimera_vio_ros_node/mono_ransac_threshold: 30
 * /kimera_vio_ros/kimera_vio_ros_node/online_run: True
 * /kimera_vio_ros/kimera_vio_ros_node/params_folder_path: /home/messiah/cat...
 * /kimera_vio_ros/kimera_vio_ros_node/position_det_threshold: 0.3
 * /kimera_vio_ros/kimera_vio_ros_node/right_cam_frame_id: right_cam
 * /kimera_vio_ros/kimera_vio_ros_node/stereo_ransac_threshold: 20
 * /kimera_vio_ros/kimera_vio_ros_node/use_lcd: False
 * /kimera_vio_ros/kimera_vio_ros_node/use_online_cam_params: False
 * /kimera_vio_ros/kimera_vio_ros_node/velocity_det_threshold: 0.1
 * /kimera_vio_ros/kimera_vio_ros_node/world_frame_id: world
 * /kimera_vio_ros/posegraph_viewer/frame_id: world
 * /rosdistro: noetic
 * /rosversion: 1.15.15
 * /use_sim_time: False

NODES
  /
    velo_link_broadcaster (tf/static_transform_publisher)
  /kimera_vio_ros/
    kimera_vio_ros_node (kimera_vio_ros/kimera_vio_ros_node)
    posegraph_viewer (pose_graph_tools/visualizer_node)

ROS_MASTER_URI=http://localhost:11311

process[kimera_vio_ros/kimera_vio_ros_node-1]: started with pid [21181]
process[kimera_vio_ros/posegraph_viewer-2]: started with pid [21182]
process[velo_link_broadcaster-3]: started with pid [21183]
[ INFO] [1672943191.124868782]: Initializing pose graph visualizer
```

Figure 8: The result of execution Realsense launch

The result can be visualized by following command:
rviz -d $(rospack find kimera _vio _ros)/rviz/kimera _vio_euroc.rviz
The output is shown in figure below:



Global Options
Fixed Frame world
Background Color □ 255; 255; 255
Frame Rate 30
Default Light ✓
✓ Global Status: Ok
TF ✓
PointCloud Time Horizon ✓

Synchronization: Off ROS Time: 1672943214.93 ROS Elapsed: 2.05 Wall Time: 1672943214.97 Wall Elapsed: 1.99

RViz is ready. 31 fps

Figure 9: The result of execution Realsense launch

By default the resolution is 848x480 in order to run smoothly the realsense launcher was modified to run smoothly.