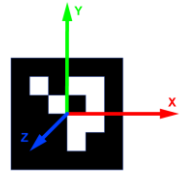


3D Displacement Measurement using ARUCO Marker

User Guide

ROS



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Overview

This is the user manual for the 3D displacement measurement toolkit utilizing GigE cameras and aruco marker.

Requirements

The following are the system's specifications:

1. Desktop Computer System (Intel Core i5, 8GB, 256GB)
2. Gigabit Ethernet GigE Machine Vision Industrial Camera (MS-GE40GC-T 0.4MP 298fps)
3. Quad Network Interface Card (I340-T4 Network Card Intel 1000Mbps)
4. Ubuntu 20.04 LTE with ROS Noetic

Working Instructions

The following describe the working of the system:

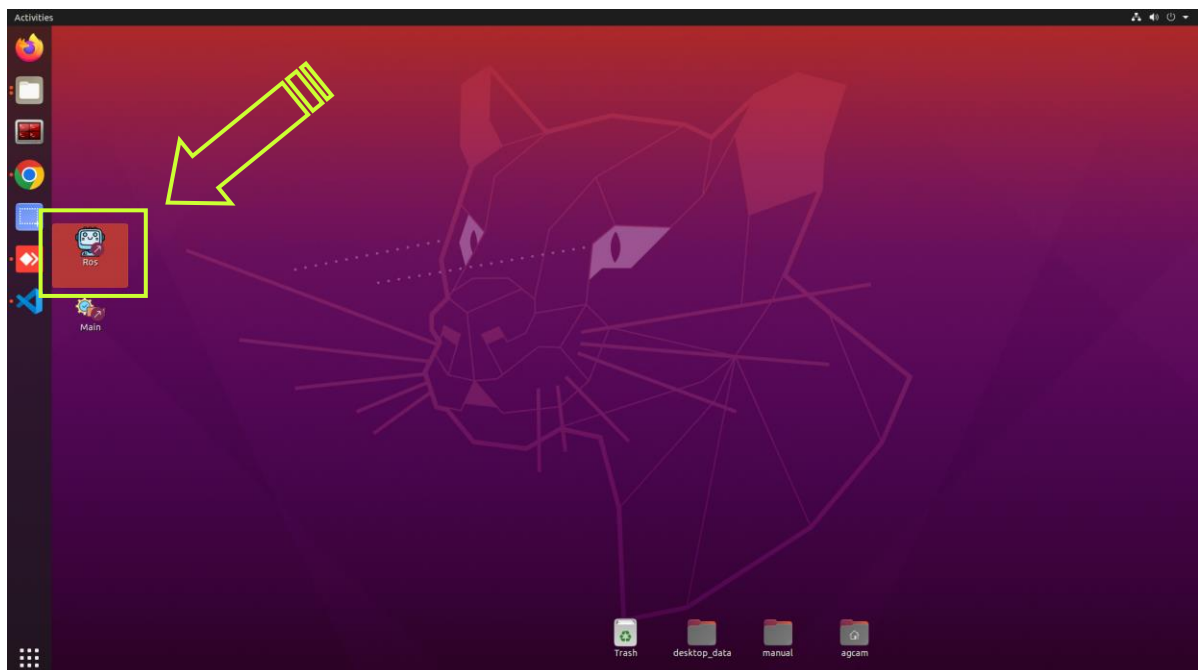
1. Ros Initialization
2. Store camera video stream for post processing
3. Displacement calculation using post processing of stored video stream data.

Following is a comprehensive description of the preceding steps:

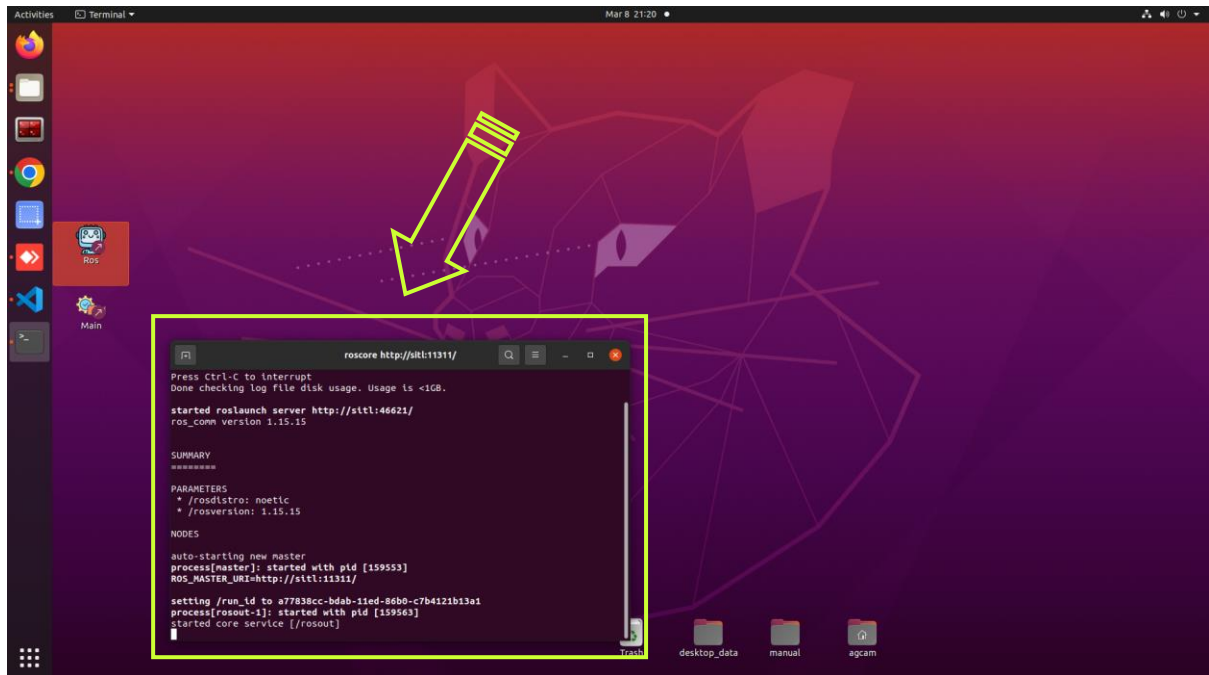
Step No. 01: ROS Initialization

The following steps are required for every ROS-compatible program:

1. Initialize the **ROS node** by pressing the **Ros** desktop icon () as shown in the following figure:




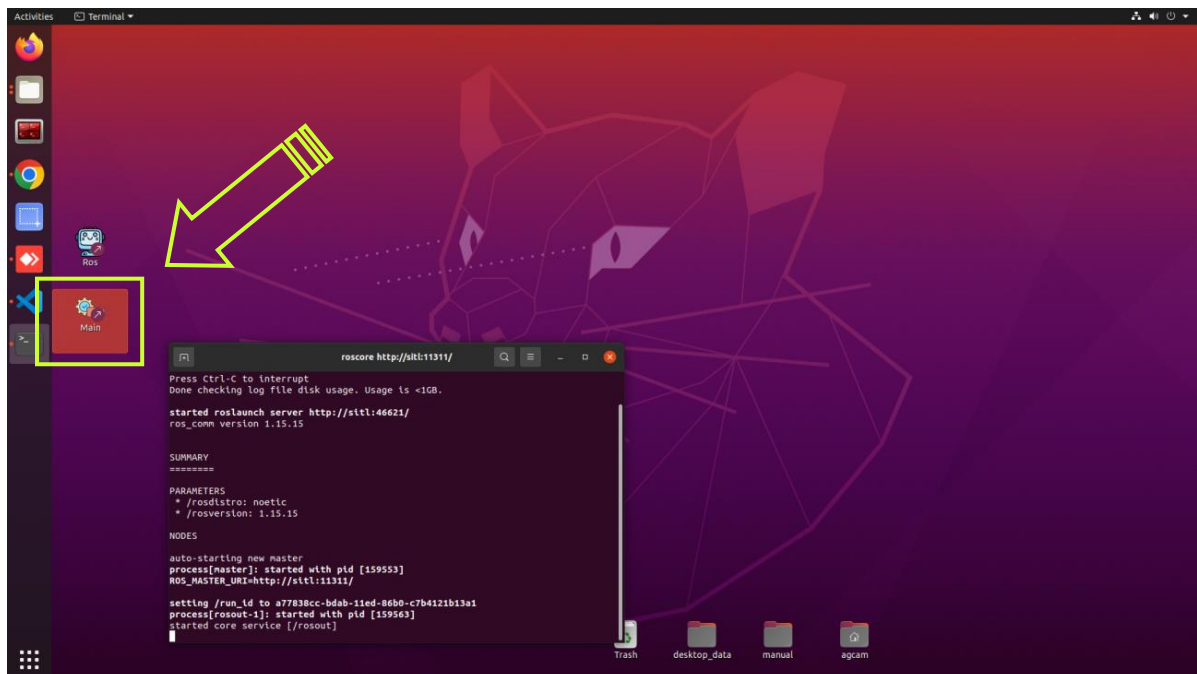
2. The **ROS node** is now operational, as illustrated in the following figure:



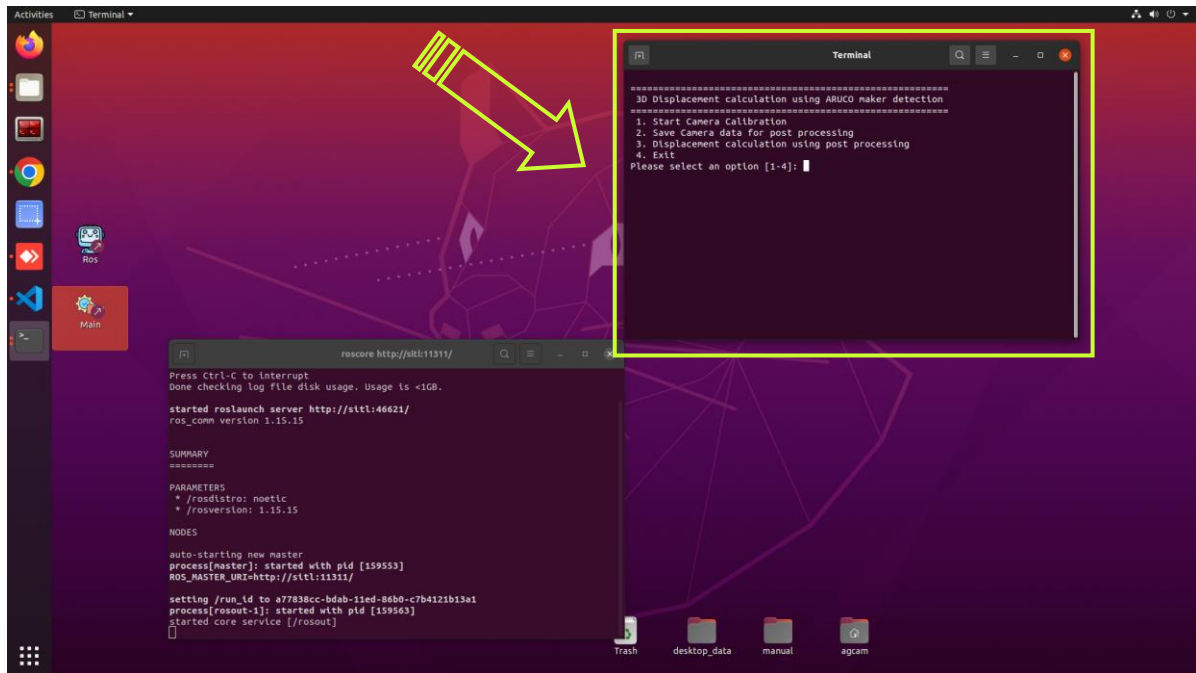
3. Next, we will launch our main program.

Step No. 02: Main Program Initialization

1. Initialize the **Main program** node by pressing the **Main** desktop icon () as shown in the following figure:



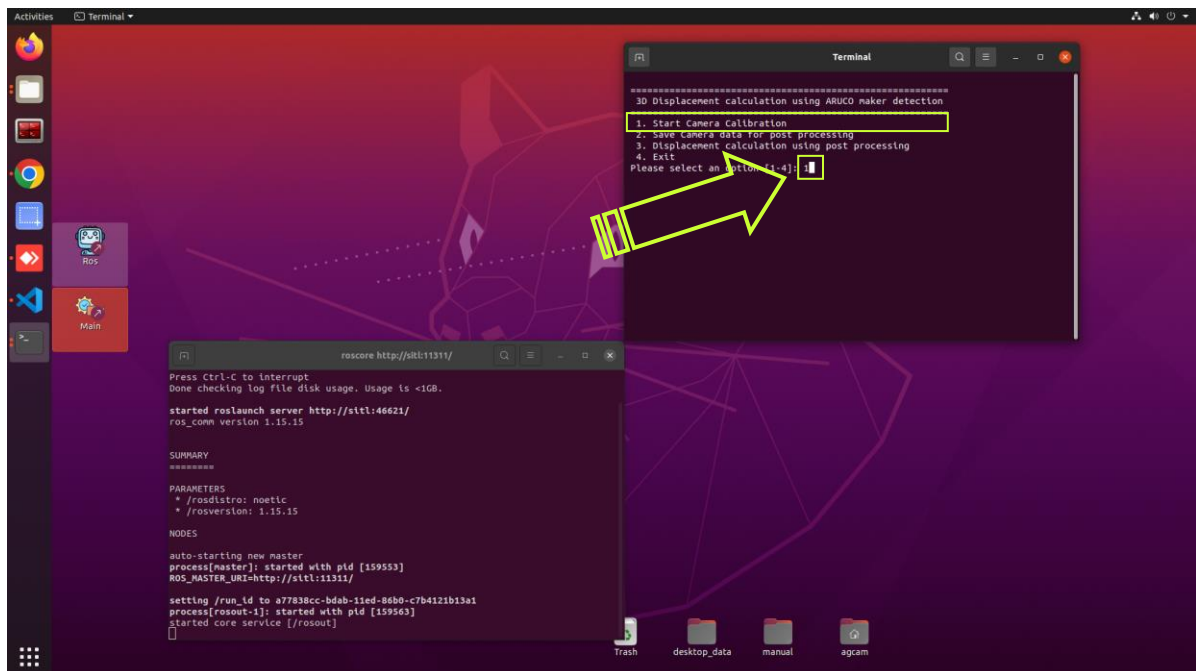
2. Now the **Main program** node is running, as showing in the following figure:



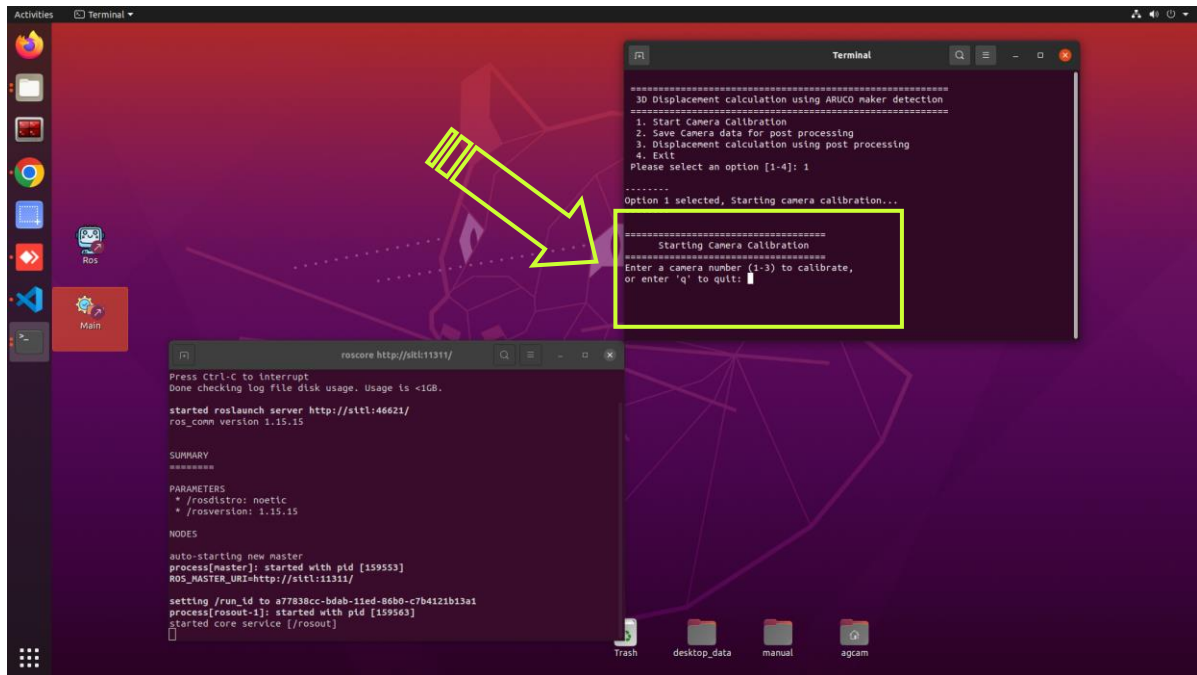
3. Now we may proceed to the next steps.

Step No. 03: Camera Calibration

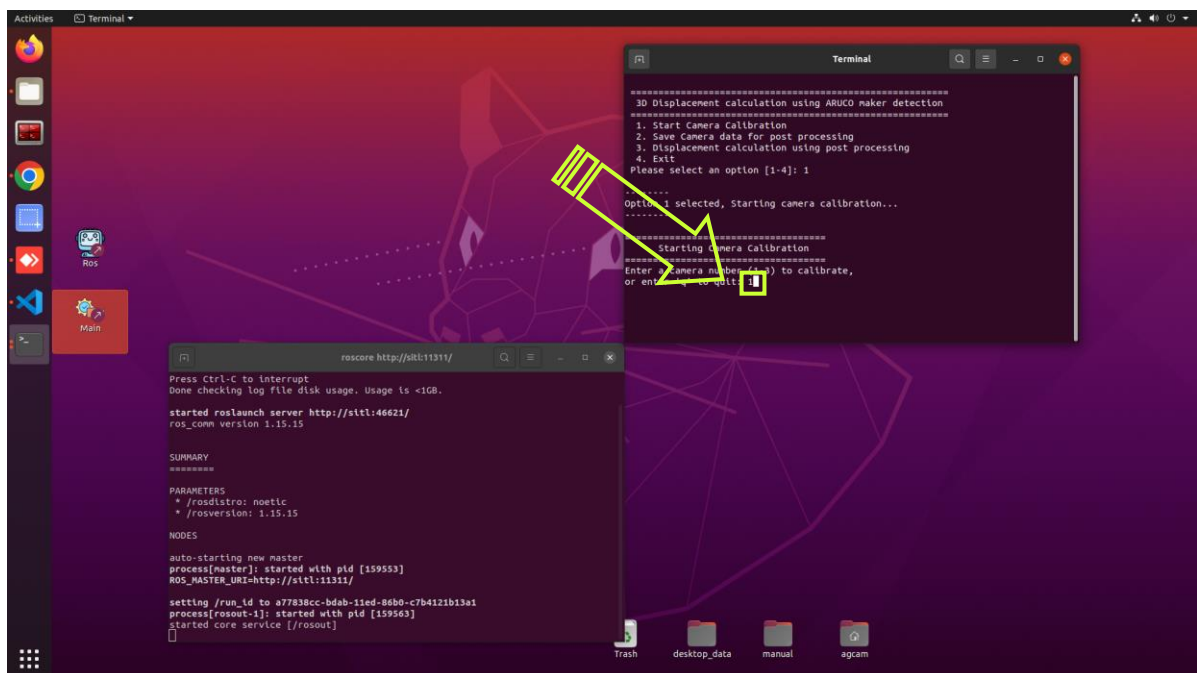
1. Please select option “1” to begin **Camera Calibration**, as depicted in the figure below:



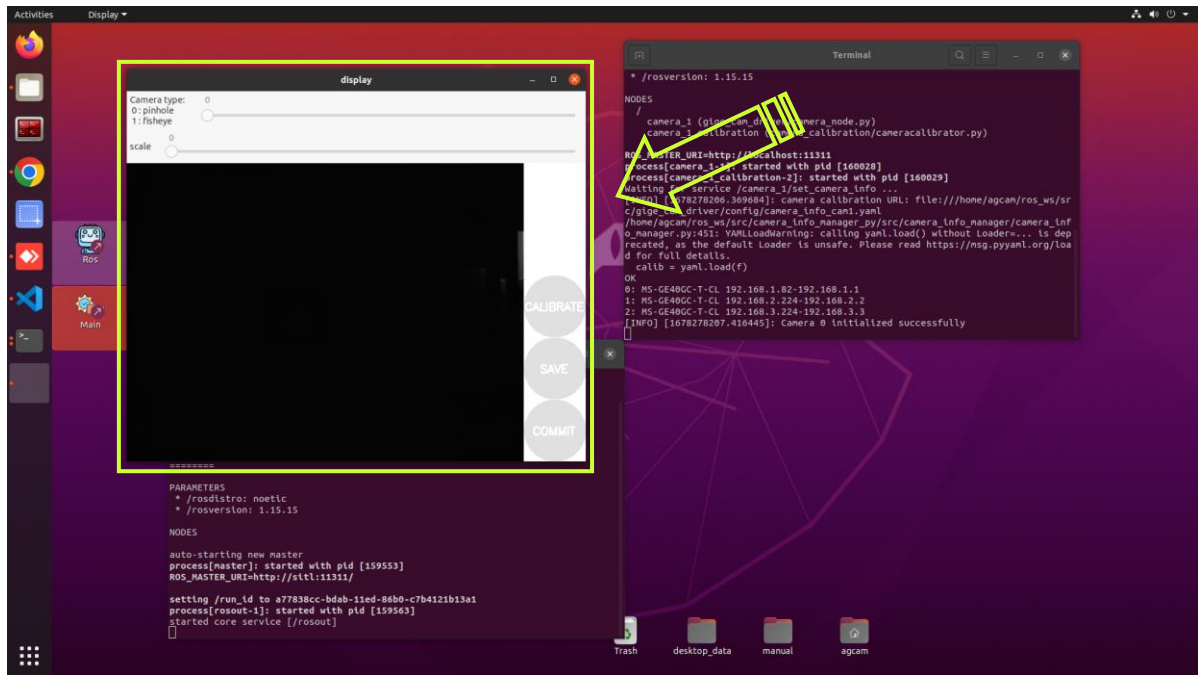
2. The **Camera Calibration** process has started as depicted in the figure:



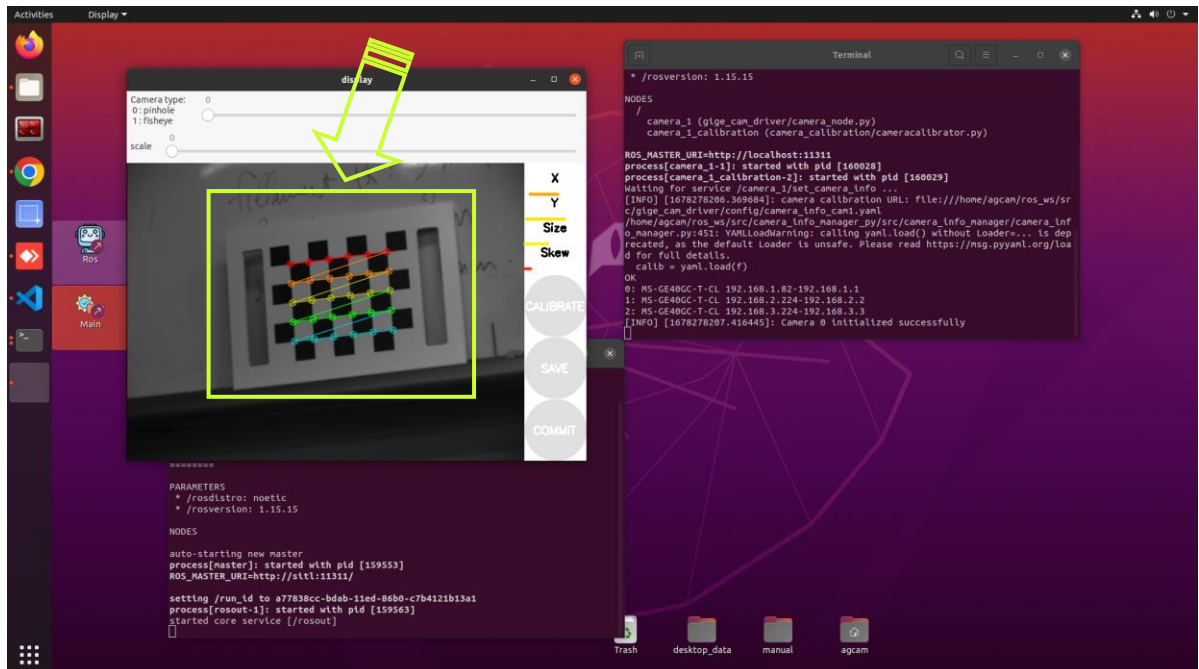
3. Please select “1” to calibrate **Camera 1**, as depicted in the figure below:



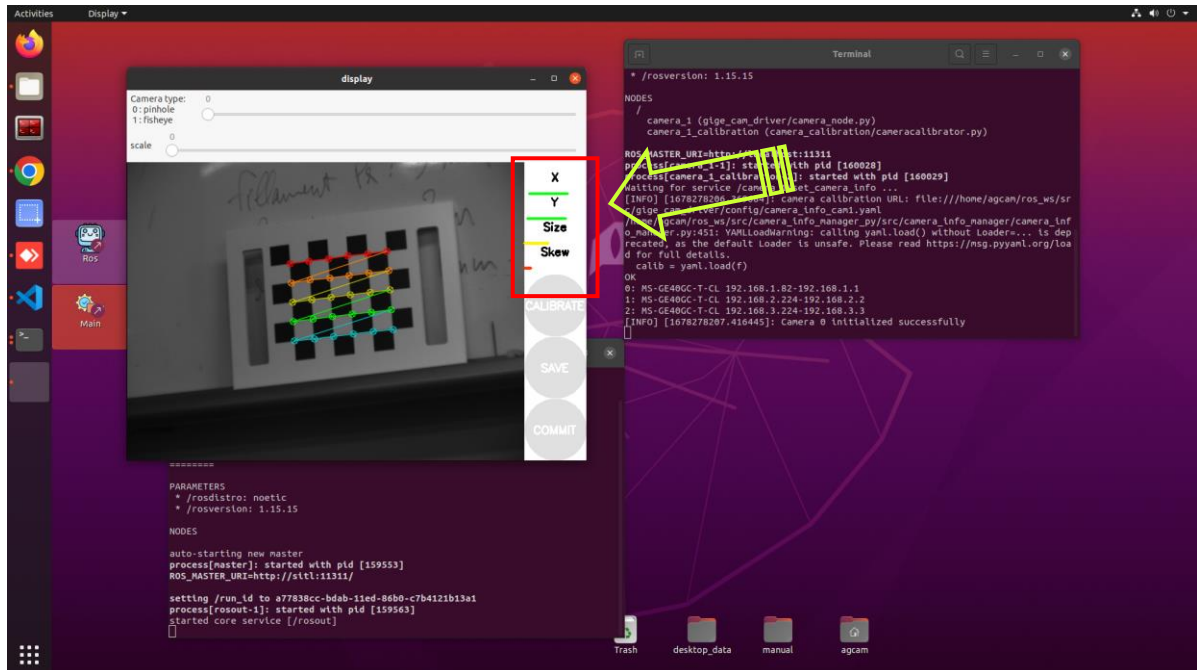
4. The **Camera Calibration** window will launch as depicted in the following figure:



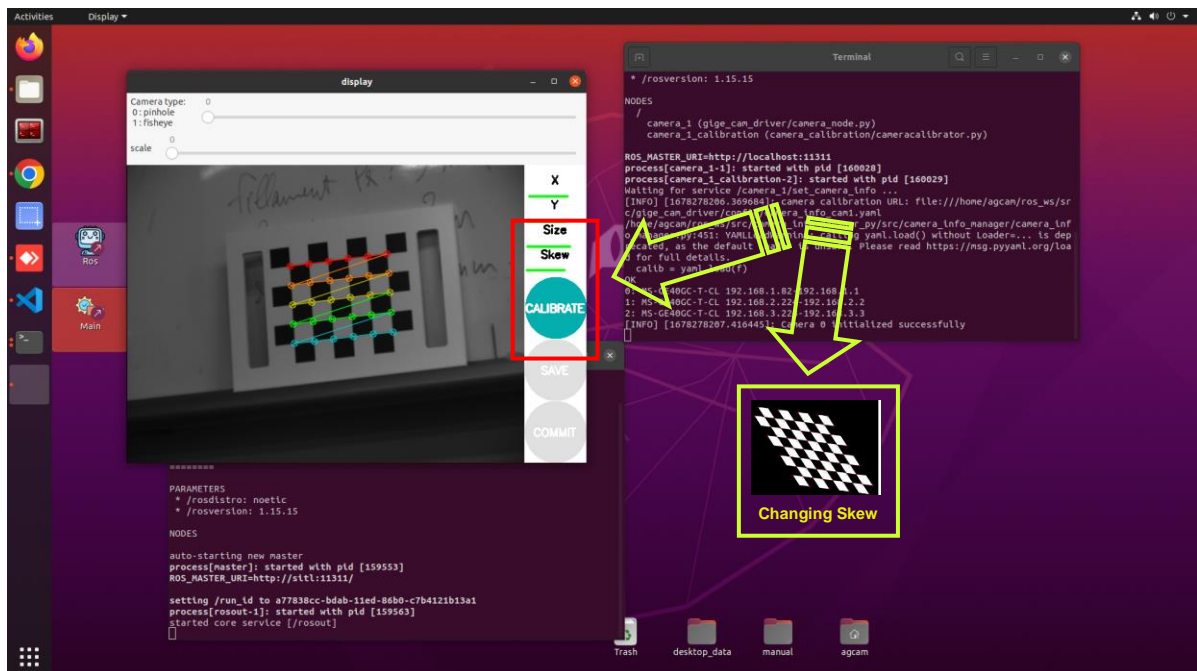
5. Place a **6x4 Checkerboard** in front of the **Camera 1** to initiate the **Calibration** process. As depicted in the figure below, if the checkerboard is identified, a **colorful pattern** will appear:



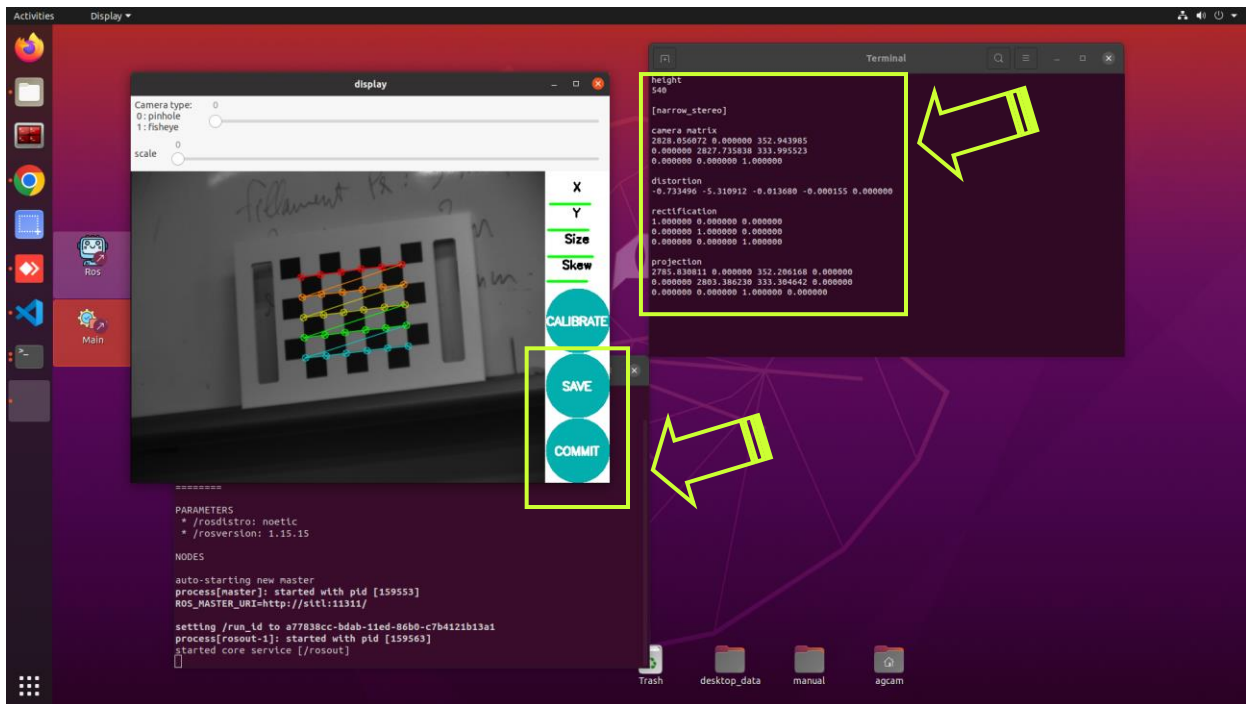
- Move the **Checkerboard** in horizontal and vertical directions until the bars below **X** and **Y** turn **Green**, as depicted in the figure below:



- Move the **Checkerboard** towards and away from the camera for **Size** adjustment, and turn diagonally (changing roll, pitch, and yaw axis) for **Skew** adjustment, until the bars below **Size** and **Skew** turn **Green** and the **CALIBRATE** button also turns **Green**, as shown in the figure below:




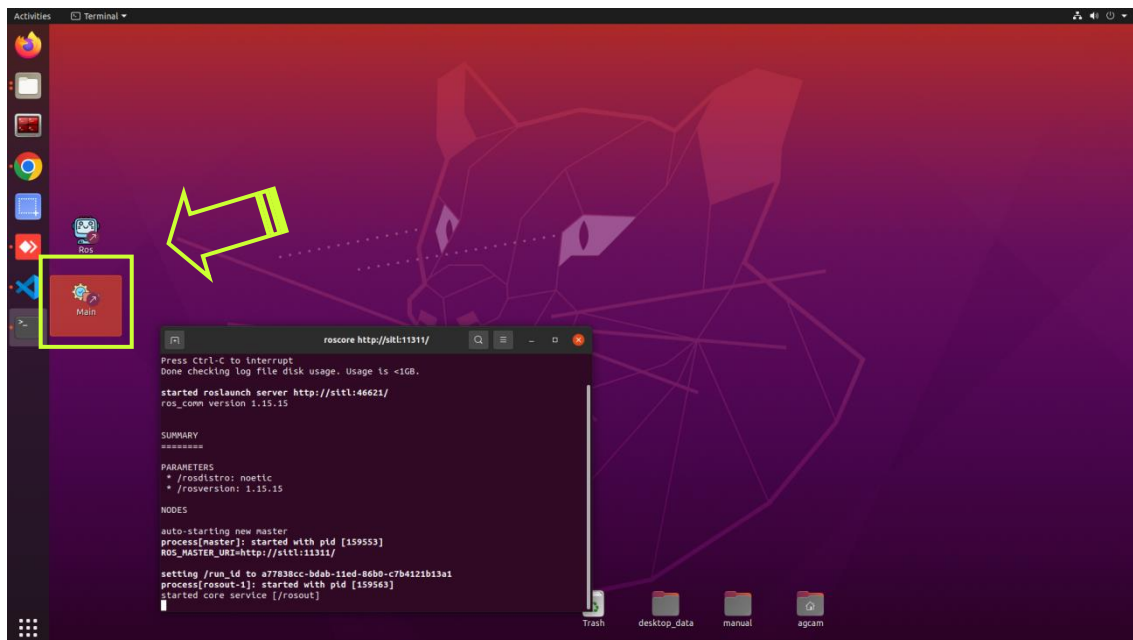
- Press the **SAVE** button to save the camera parameters and calibration images, then press the **COMMIT** button to conclude the **Camera Calibrating** procedure. The terminal screen will display the camera's parameters as shown below:



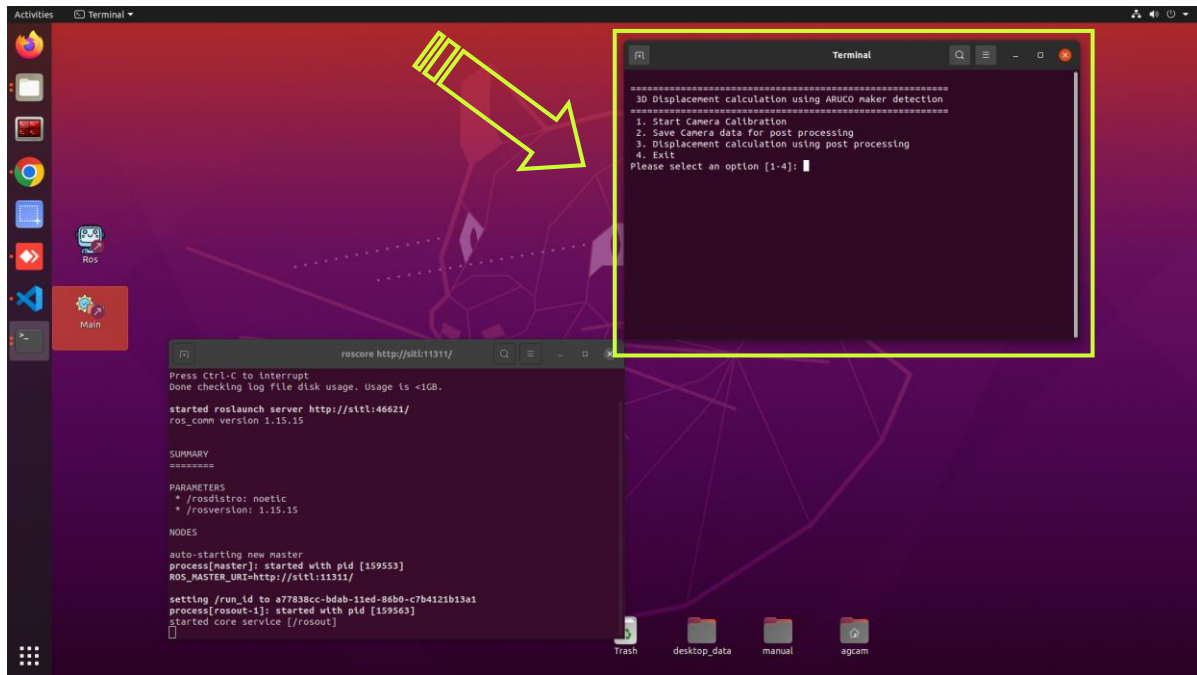
- Camera Calibration has completed successfully, close the terminal window and now we may proceed to the next steps.

Step No. 04: Storing Camera Data for Post Processing

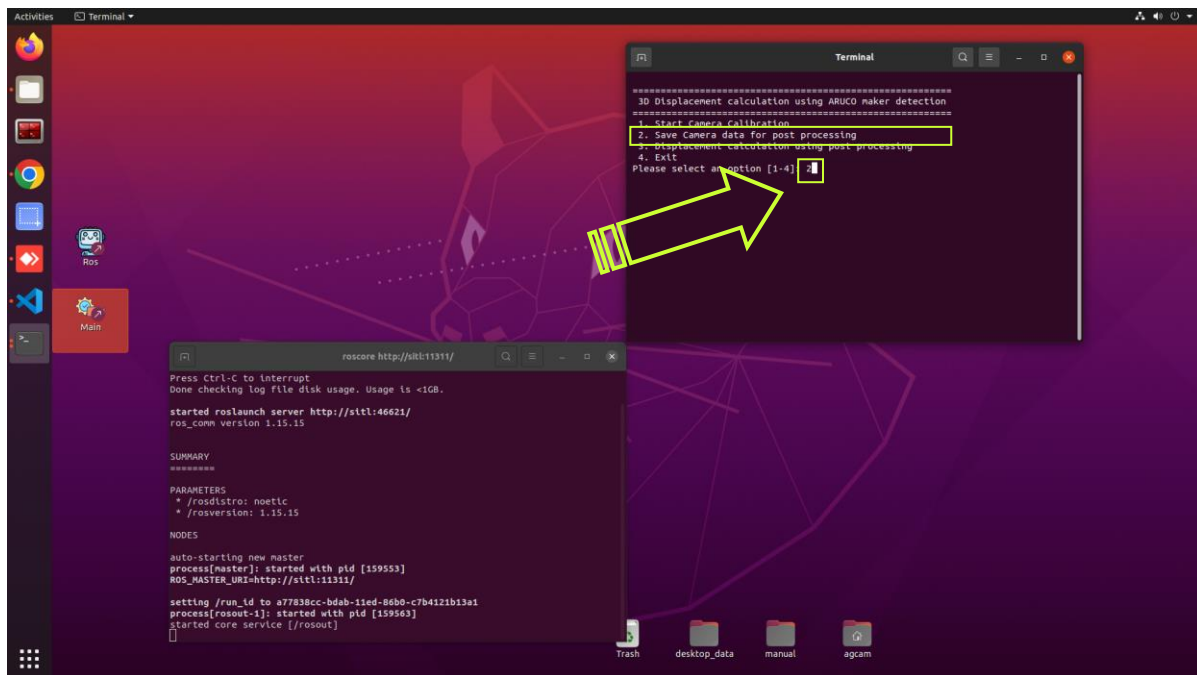
- Initialize the **Main program** node by pressing the **Main** desktop icon () as shown in the following figure:



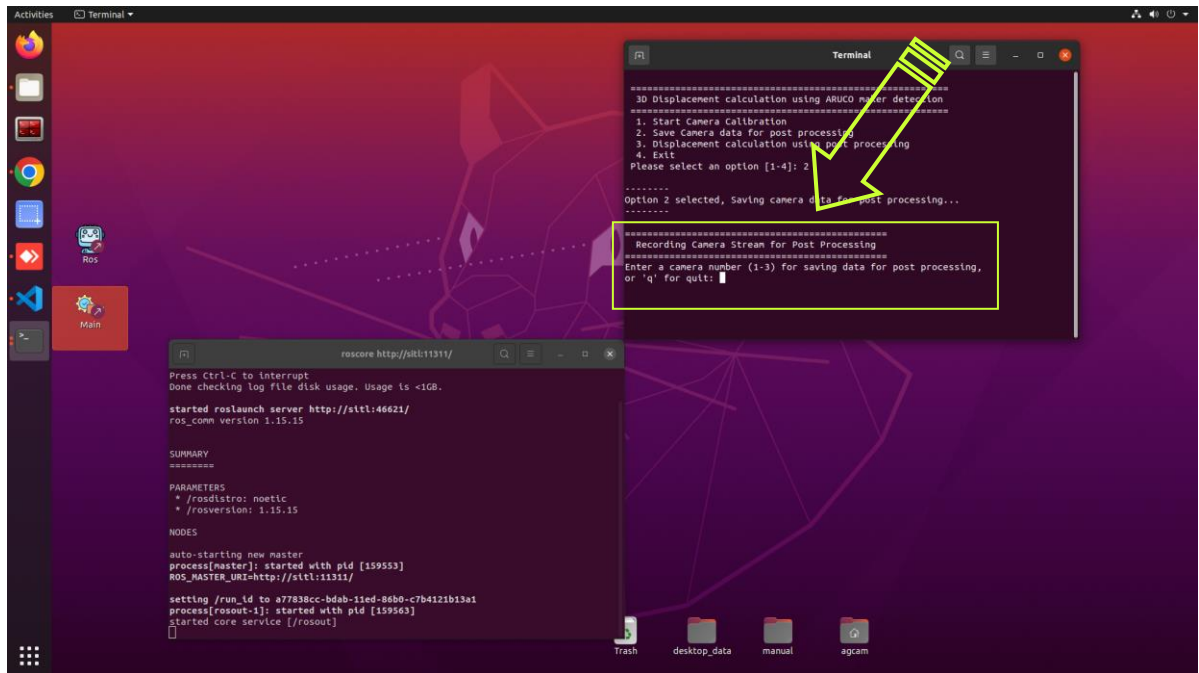
2. Now the **Main program** node is running, as showing in the following figure:



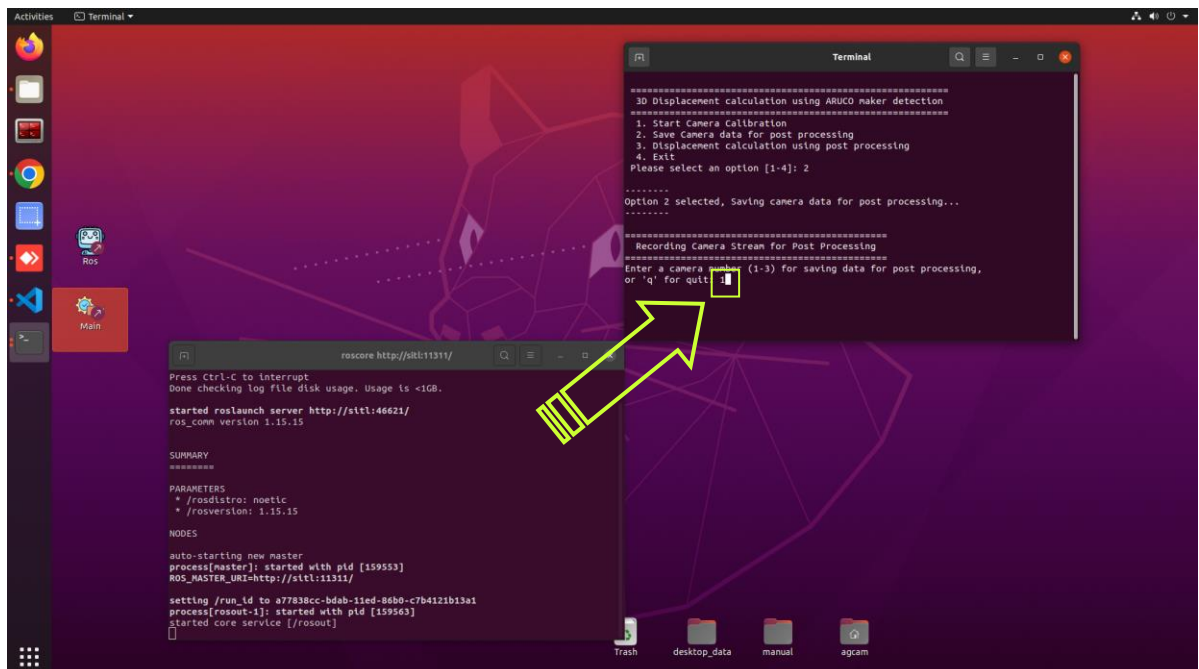
3. Now select option “2” to **store** camera data for **Post Processing**, as depicted in the figure below:



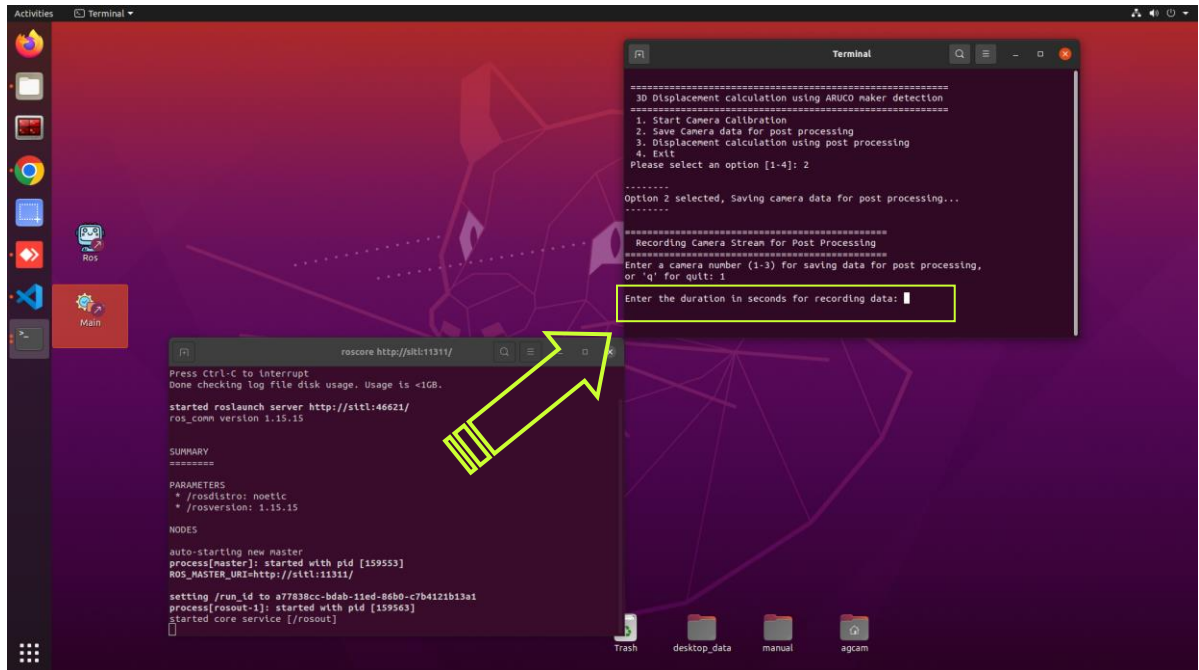
4. The **Storing Camera Data** process has started as depicted in the figure:



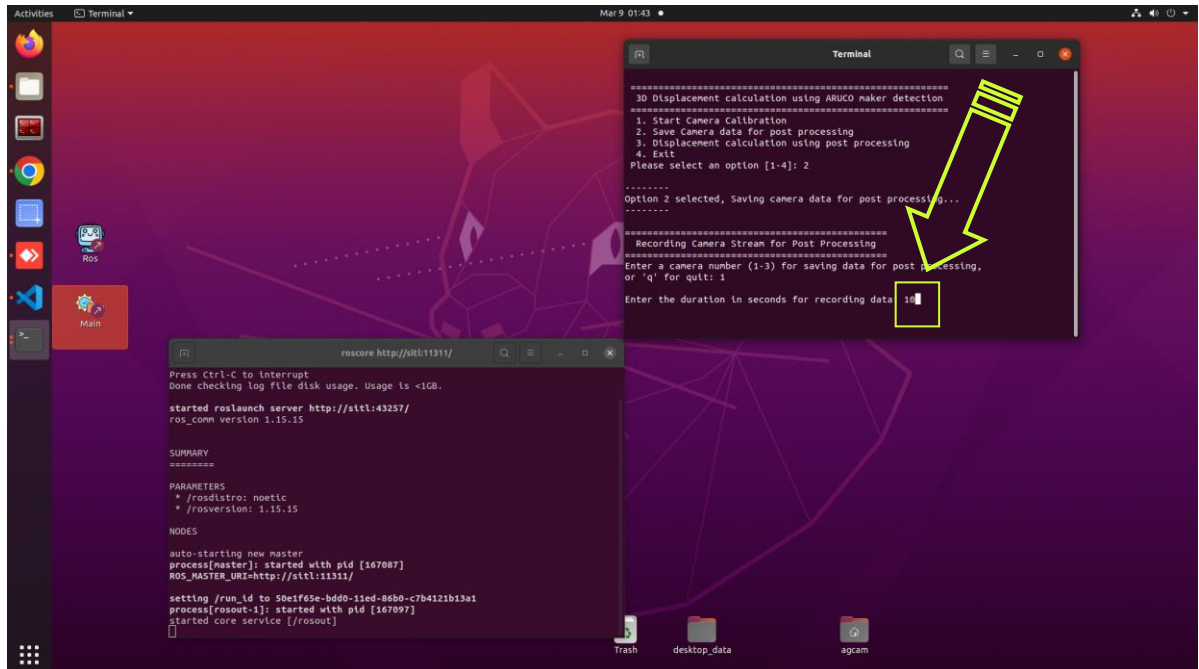
5. Please enter "1" to record the camera stream from **Camera 1** for post-processing, as shown in the figure below:



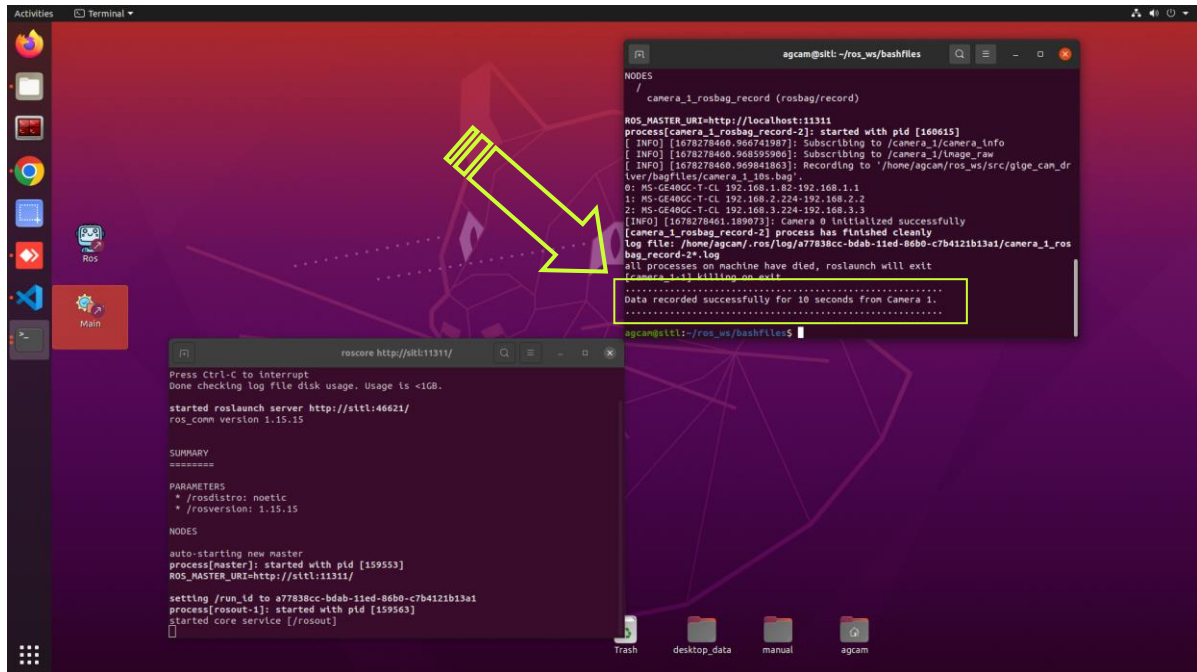
- Enter the duration for which the camera data should be recorded for post-processing from Camera 1.



- Please enter "10" to capture 10 seconds of video stream from **Camera 1** for post-processing, as depicted in the figure below:




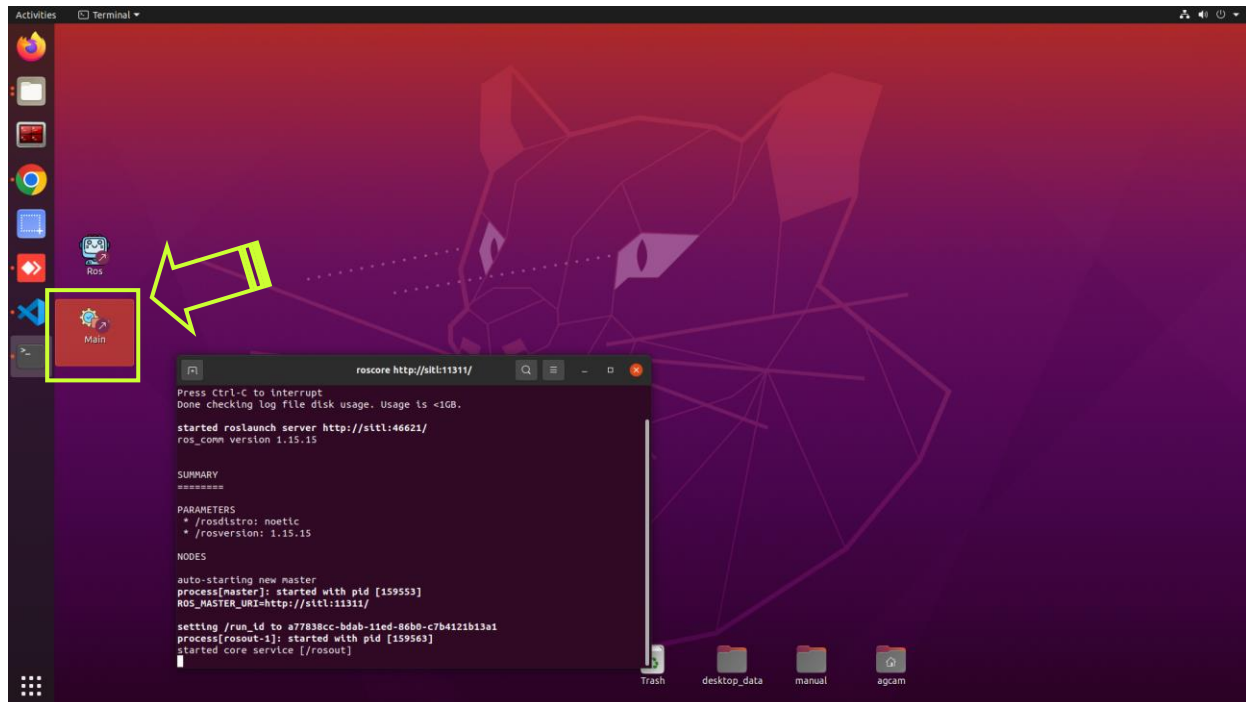
8. Now a 10 seconds of video stream from **Camera 1** for post-processing has been successfully saved as shown in the following figure:



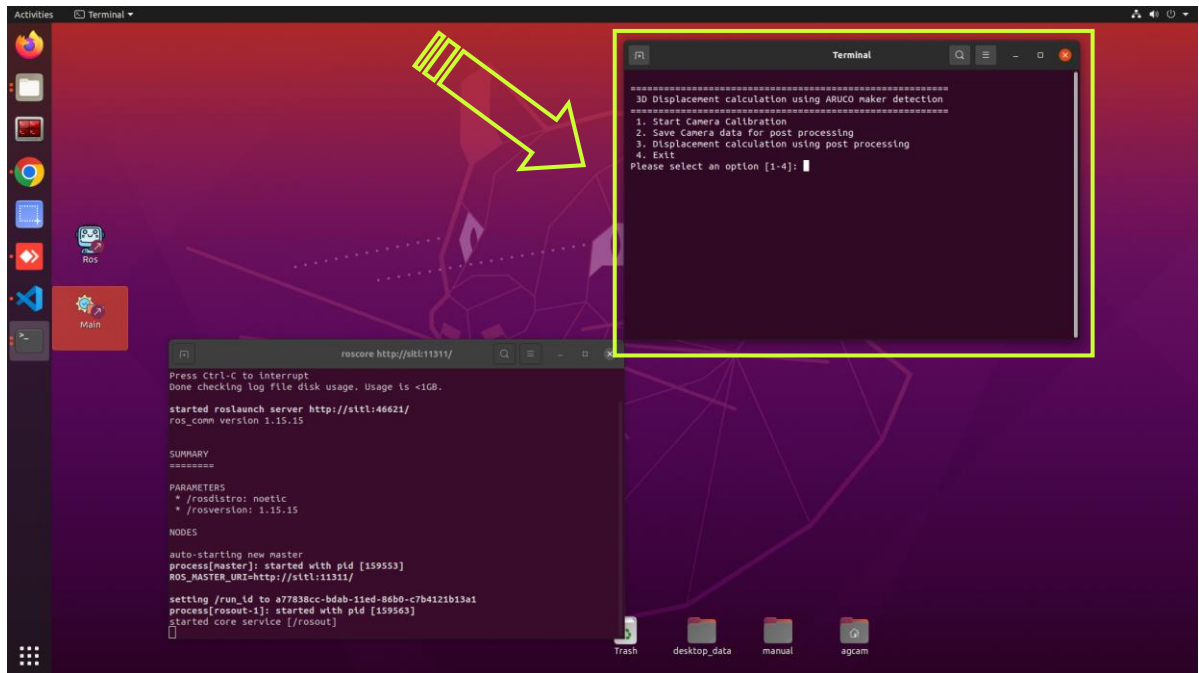
9. Now you may close the terminal window and proceed to the next step.

Step No. 05: Post Processing from Saved Camera Data

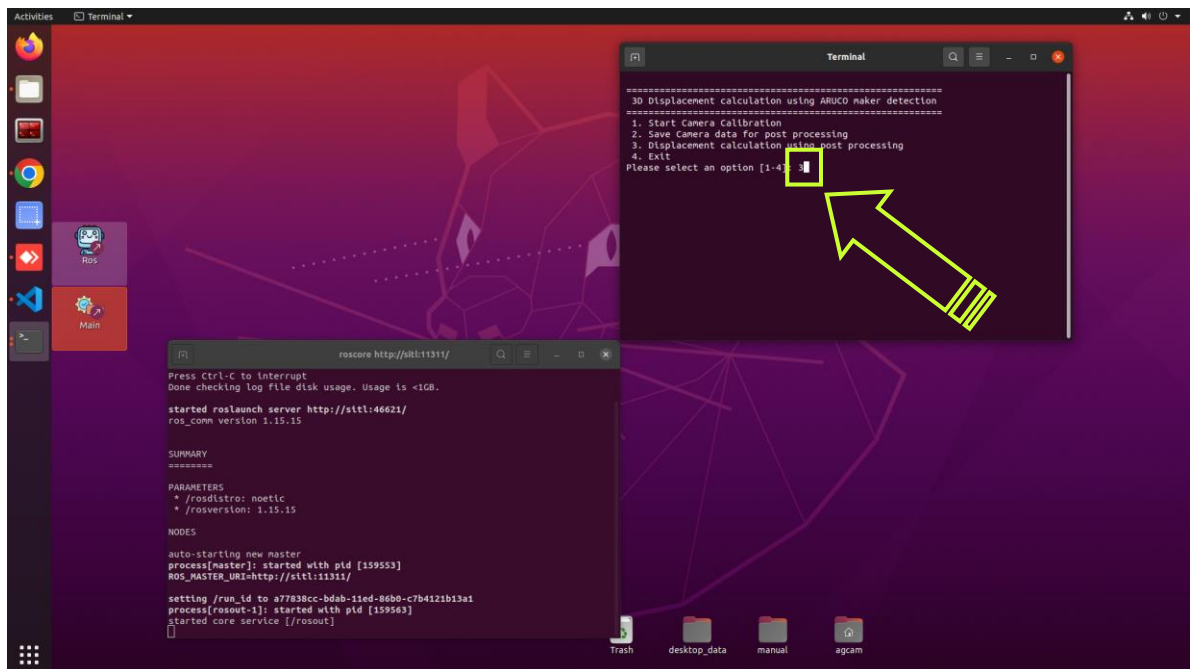
1. Initialize the **Main program** node by pressing the **Main** desktop icon () as shown in the following figure:



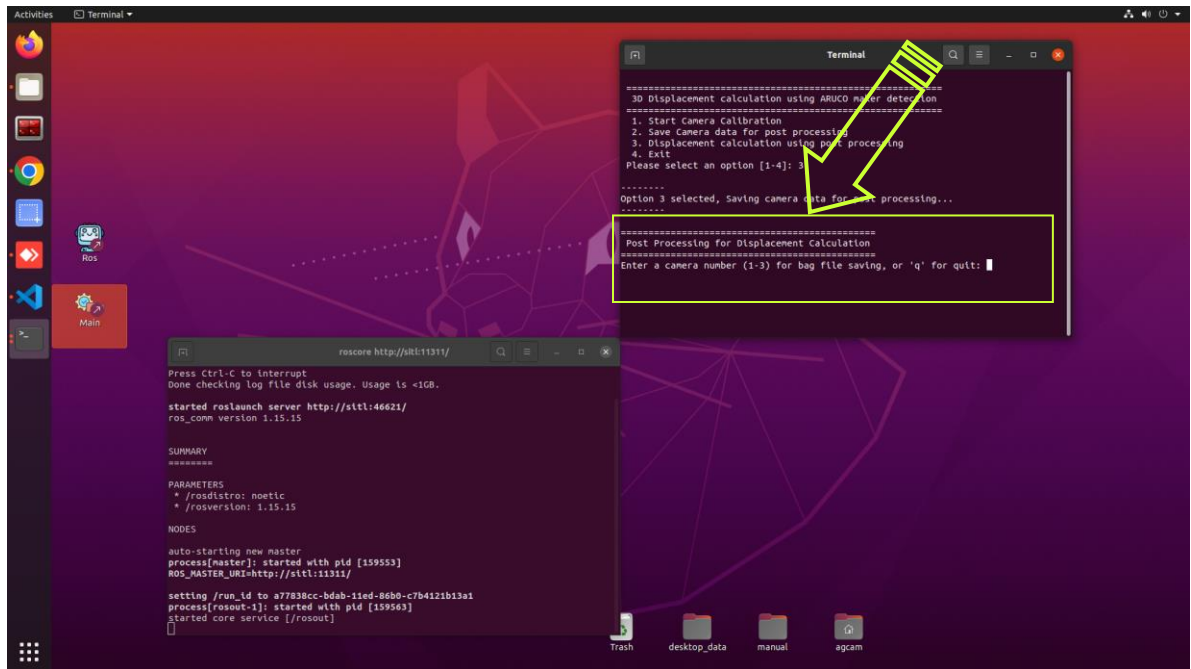
2. Now the **Main program** node is running, as showing in the following figure:



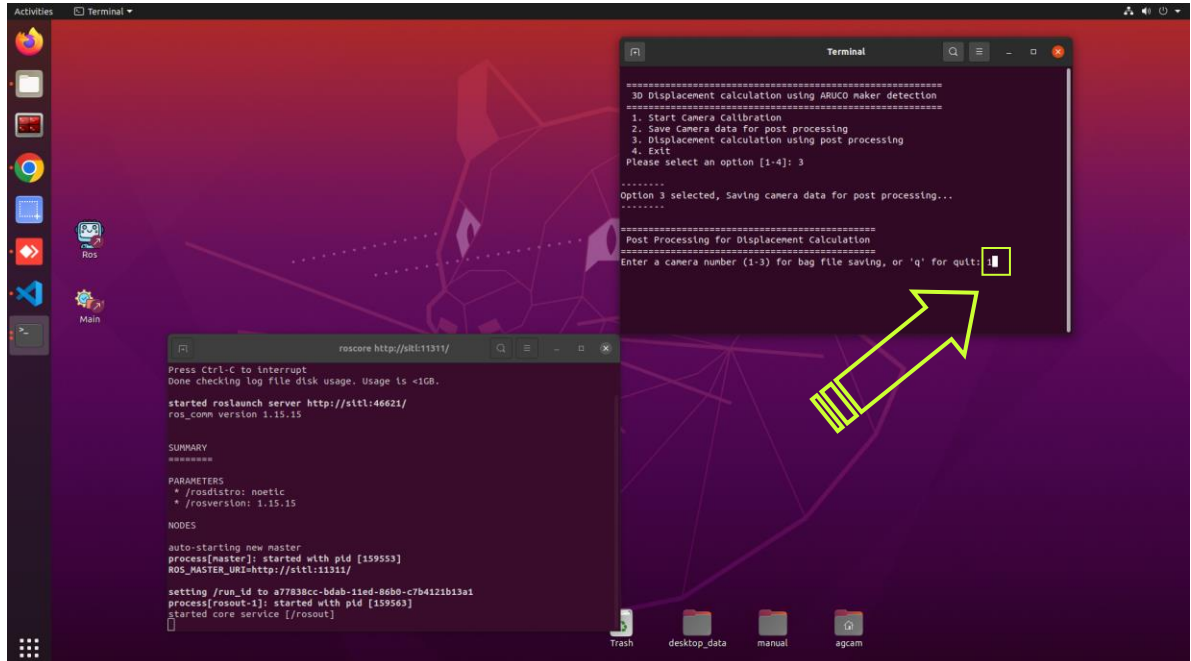
3. Now select option “3” to start **Displacement Calculation** from camera data, as depicted in the figure below:



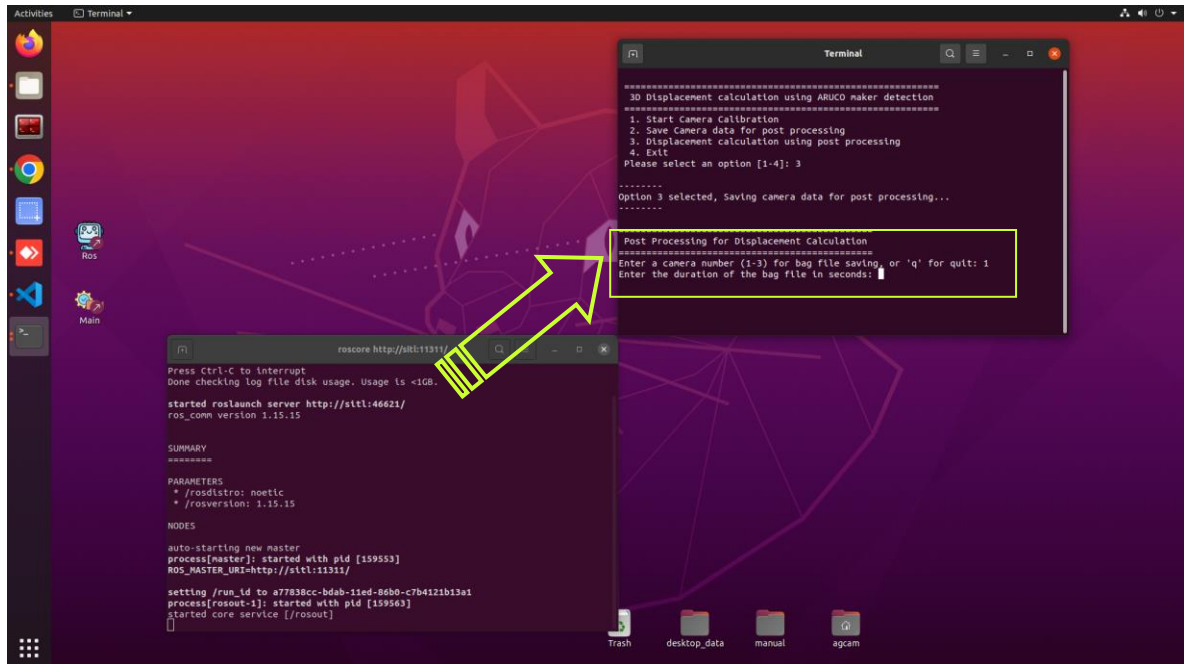
4. The **Displacement Calculation** process has started as depicted in the figure:



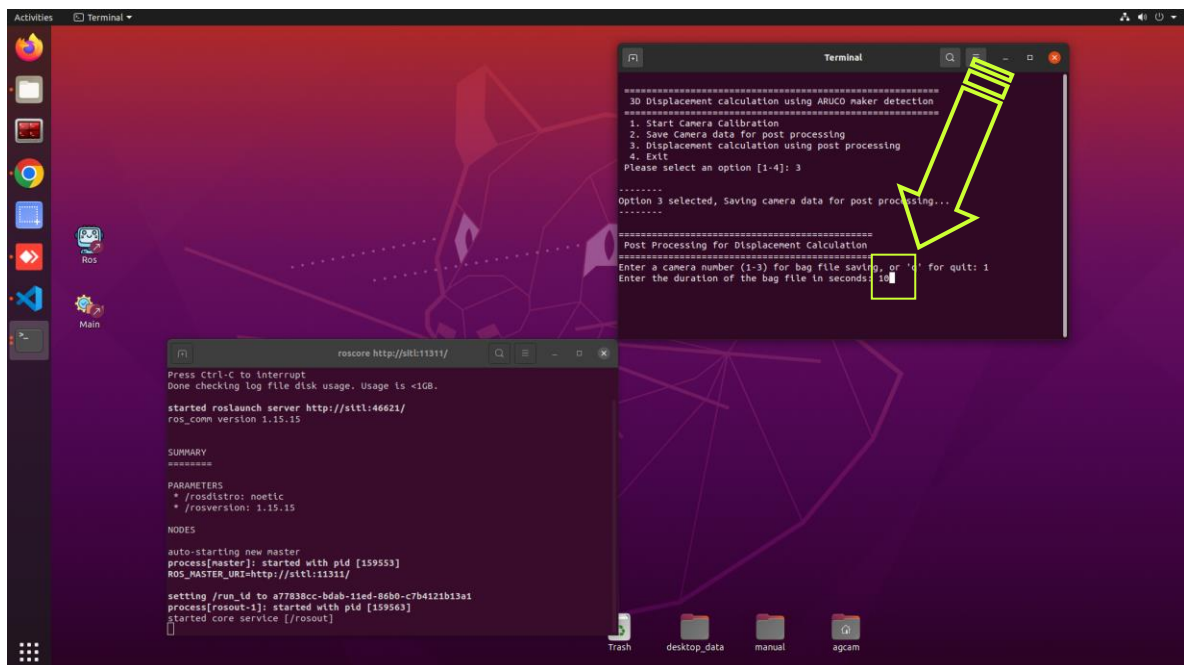
5. Please enter "1" to use the **Camera 1** recorded stream for post-processing, as shown in the figure below:



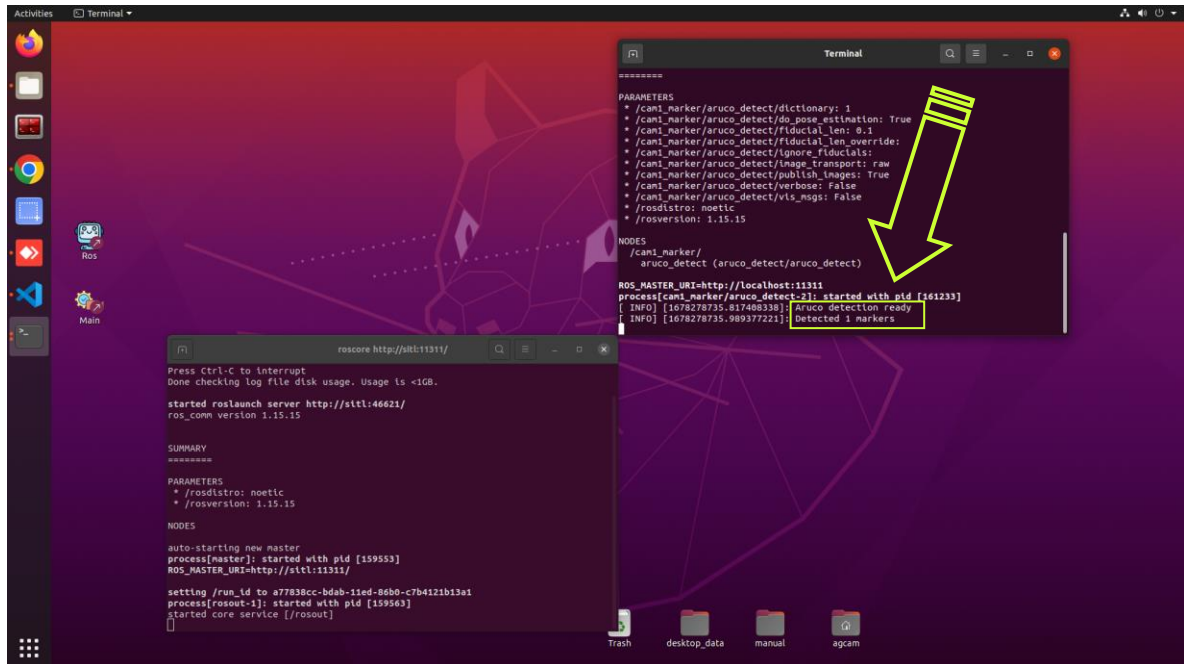
6. Enter the duration of the stored video stream from **Camera 1** to be used for post-processing, as depicted in the figure below:



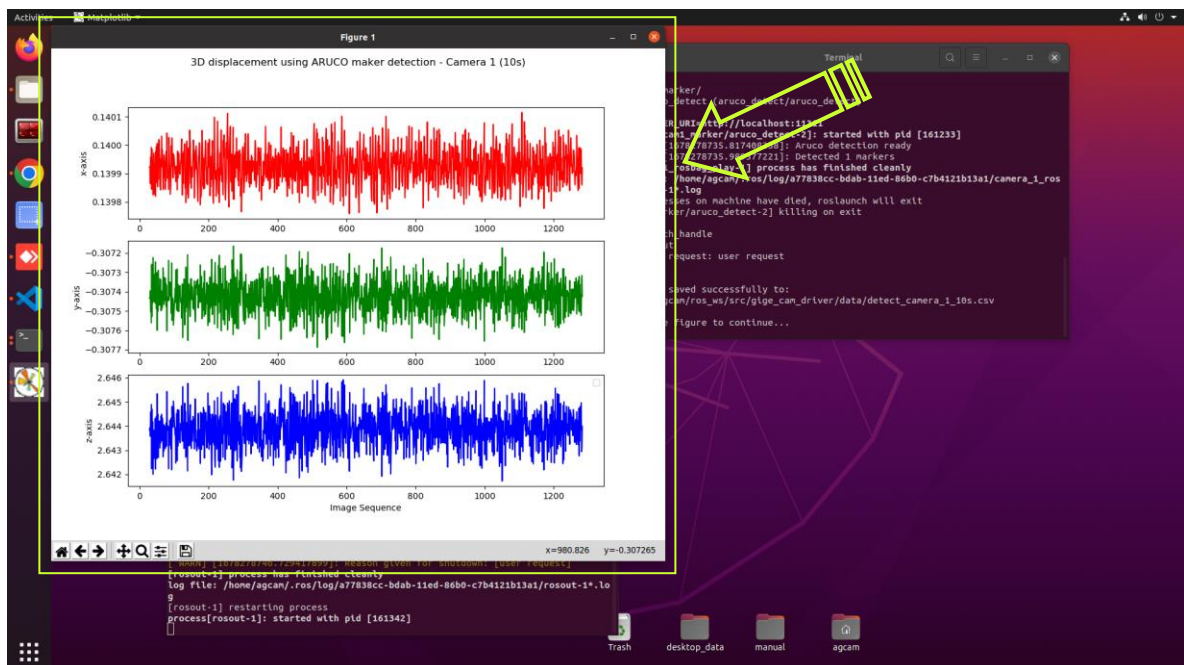
7. Please enter "10" to use 10 seconds video stream stored from **Camera 1** for post-processing, as depicted in the figure below:



8. The following figure demonstrates that the **ARUCO** marker is **detected** in the video captured by **Camera 1**:

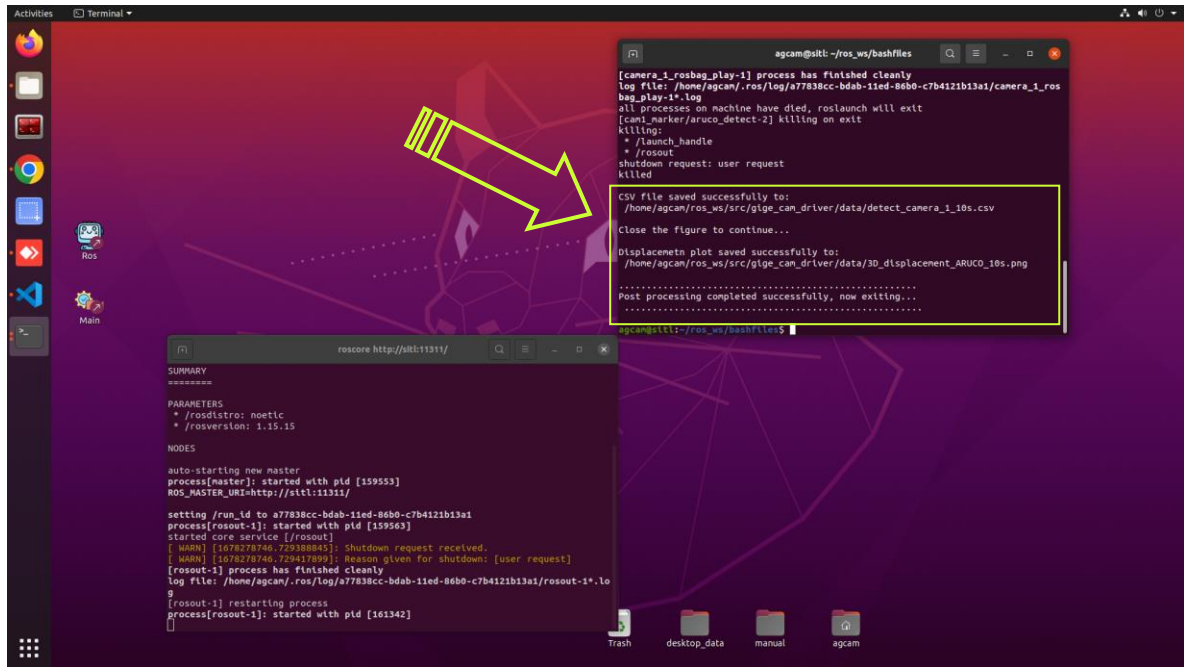


9. The **three-dimensional displacement** plots are then displayed as shown in the subsequent figure:

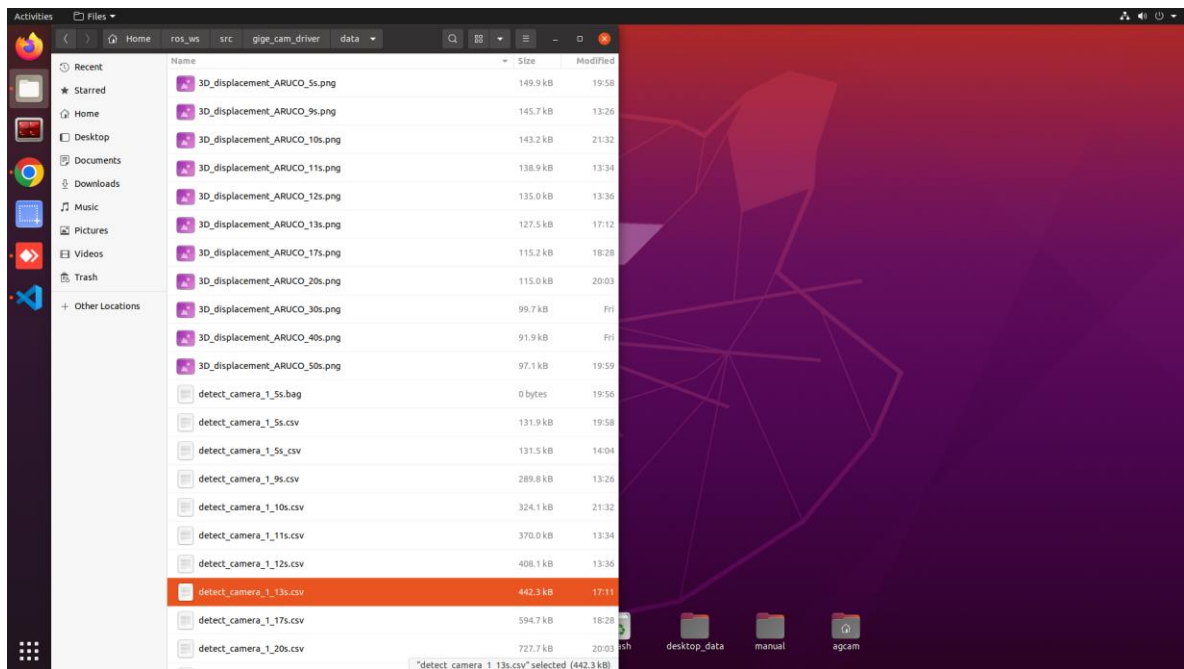


10. To proceed, please close the **Figure** window.

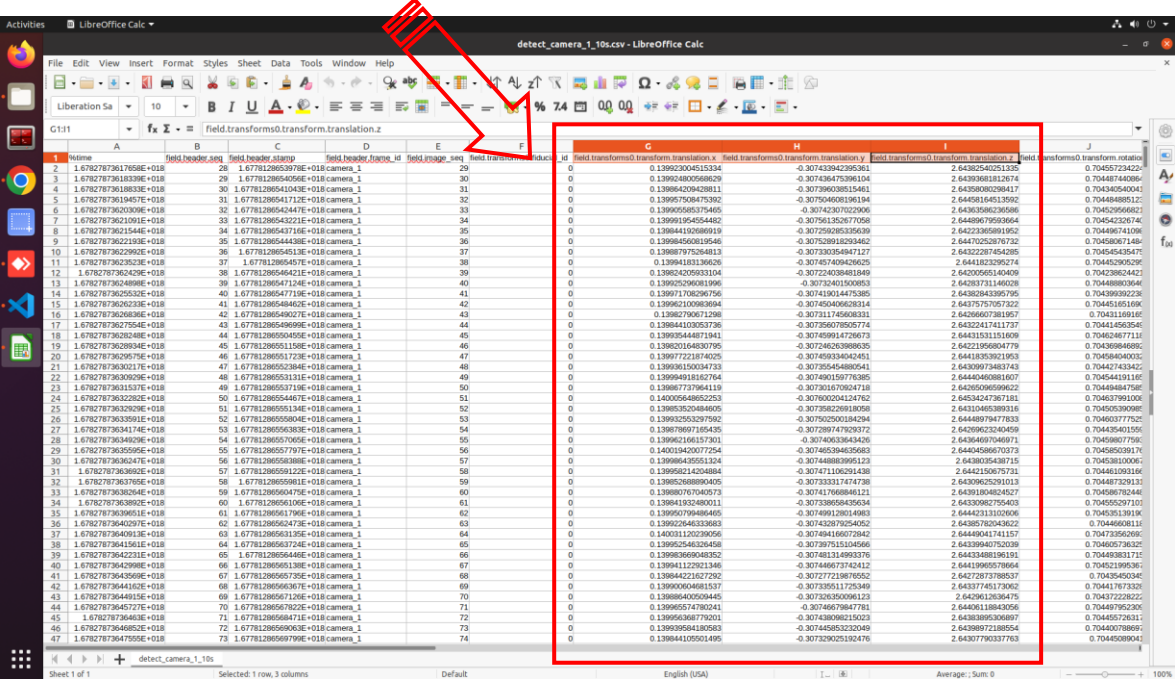
11. The post-processing procedure was completed successfully, displaying the csv file and plot file storage paths as shown in the figure below:



12. The three-dimensional displacement data stored as the.csv files as well as the plot images are stored under the directory /home/agcam/ros_ws/src/gige_cam_driver/data/, as shown below:



13. The following illustration depicts the contents of a CSV file featuring three-dimensional displacement data:



	A	B	C	D	E	F	G	H	I	J
	time	field.transform.translation.x	field.transform.translation.y	field.transform.translation.z	field.transform.rotation.x	field.transform.rotation.y	field.transform.rotation.z	field.transform.rotation.x	field.transform.rotation.y	field.transform.rotation.z
1	1.67827873617659E+018	29	1.6778128653978E+018	camera_1	29	0	0.139923004515334	-0.307433942295361	2.64382542511354	0.70457274421
2	1.67827873618339E+018	29	1.6778128654056E+018	camera_1	30	0	0.139924800566629	-0.307433942295361	2.64393681812674	0.7047474066
3	1.67827873618833E+018	30	1.67781286541043E+018	camera_1	31	0	0.139884208428811	-0.307396038515481	2.64398080288417	0.704349540041
4	1.67827873619407E+018	31	1.67781286541123E+018	camera_1	32	0	0.139957508473392	-0.30750448318184	2.64405164813392	0.70448489123
5	1.67827873620009E+018	32	1.67781286542447E+018	camera_1	33	0	0.139955585375465	-0.30742307022906	2.64363586235586	0.70452956621
6	1.67827873621091E+018	33	1.67781286543221E+018	camera_1	34	0	0.139991954554482	-0.307561352677058	2.64489679593664	0.70454232674
7	1.67827873621544E+018	34	1.67781286543116E+018	camera_1	35	0	0.139844150968919	-0.30729263335639	2.6422236581952	0.7048671108
8	1.67827873622193E+018	35	1.67781286544438E+018	camera_1	36	0	0.13998456819546	-0.307528918293462	2.64470252876732	0.70458071489
9	1.67827873622992E+018	36	1.6778128654513E+018	camera_1	37	0	0.139887875264813	-0.307330254947127	2.64322287454295	0.7045454547
10	1.67827873623529E+018	37	1.6778128654617E+018	camera_1	38	0	0.13994183138628	-0.307467409426625	2.6441323295214	0.70443295295
11	1.6782787362429E+018	38	1.67781286546421E+018	camera_1	39	0	0.139824203848189	-0.30722403848189	2.6420056514049	0.70423862421
12	1.6782787362489E+018	39	1.67781286547124E+018	camera_1	40	0	0.13995296081996	-0.30732401500593	2.6428371146028	0.7048888364
13	1.67827873625523E+018	40	1.67781286547118E+018	camera_1	41	0	0.139971706296756	-0.307418014473885	2.6438243295795	0.70499392238
14	1.67827873626233E+018	41	1.67781286548462E+018	camera_1	42	0	0.139962100883684	-0.307450406628314	2.6437575757322	0.70451651698
15	1.67827873626936E+018	42	1.67781286549027E+018	camera_1	43	0	0.13982790871298	-0.30731114568331	2.64266697811857	0.7041116916
16	1.6782787362754E+018	43	1.67781286549696E+018	camera_1	44	0	0.13984103053738	-0.3075607868774	2.64322147117137	0.7041450364
17	1.67827873628248E+018	44	1.67781286550455E+018	camera_1	45	0	0.13993544871941	-0.307499914726673	2.64431531151609	0.7042467711
18	1.67827873628934E+018	45	1.67781286551158E+018	camera_1	46	0	0.139920148303795	-0.307246253969635	2.6422195684779	0.7046984686
19	1.67827873629597E+018	46	1.67781286551723E+018	camera_1	47	0	0.13997273674025	-0.307493934042451	2.6441353821953	0.70480440035
20	1.67827873630217E+018	47	1.67781286552384E+018	camera_1	48	0	0.139936150034733	-0.307355454880541	2.64309973483743	0.7047473422
21	1.67827873630829E+018	48	1.67781286553131E+018	camera_1	49	0	0.139994918162764	-0.307492159770385	2.6444440881857	0.70454191148
22	1.67827873631537E+018	49	1.67781286553719E+018	camera_1	50	0	0.139987379674118	-0.307301670924718	2.6426500959622	0.7044848758
23	1.67827873632202E+018	50	1.67781286554467E+018	camera_1	51	0	0.14005648652253	-0.3078000204124782	2.6453424787181	0.70483799100
24	1.67827873632829E+018	51	1.67781286555134E+018	camera_1	52	0	0.13995352048405	-0.3075922918058	2.64313485389316	0.70450539098
25	1.67827873633591E+018	52	1.67781286555804E+018	camera_1	53	0	0.139953253297582	-0.30750250134294	2.64448978477833	0.7046377522
26	1.67827873634174E+018	53	1.67781286556383E+018	camera_1	54	0	0.139878697185435	-0.307289747929372	2.64269623240459	0.70435401595
27	1.67827873634829E+018	54	1.67781286557065E+018	camera_1	55	0	0.13996165157351	-0.30748533843426	2.64384697949571	0.7045807759
28	1.67827873635595E+018	55	1.67781286557797E+018	camera_1	56	0	0.140019420077254	-0.30748533843426	2.64404586670373	0.7045805917
29	1.67827873636247E+018	56	1.67781286558388E+018	camera_1	57	0	0.13986435551324	-0.307488839951123	2.6430435438715	0.70458100067
30	1.67827873636902E+018	57	1.67781286559122E+018	camera_1	58	0	0.139958214248884	-0.307471106231438	2.6442155875731	0.70461081316
31	1.6782787363765E+018	58	1.67781286559811E+018	camera_1	59	0	0.13985268889405	-0.307333317474738	2.6430625291013	0.70478729131
32	1.67827873638324E+018	59	1.67781286560479E+018	camera_1	60	0	0.13988070740573	-0.307417688461121	2.64391804824527	0.7048678244
33	1.67827873639002E+018	60	1.67781286561106E+018	camera_1	61	0	0.139841932480111	-0.307338658459504	2.6433082750403	0.70495297101
34	1.67827873639651E+018	61	1.67781286561796E+018	camera_1	62	0	0.13995799486465	-0.307499128614983	2.64442131320606	0.70453519191
35	1.67827873640297E+018	62	1.67781286562473E+018	camera_1	63	0	0.139952646333683	-0.307432970254052	2.64385762043622	0.7044689111
36	1.67827873641001E+018	63	1.67781286563125E+018	camera_1	64	0	0.140031150278956	-0.3078416672842	2.644484041741157	0.7047356266
37	1.67827873641641E+018	64	1.67781286563724E+018	camera_1	65	0	0.139952546326458	-0.307397515514566	2.64339940732039	0.7046573632
38	1.67827873642311E+018	65	1.6778128656448E+018	camera_1	66	0	0.13996369048352	-0.307481314983376	2.64432488196391	0.70483881712
39	1.6782787364298E+018	66	1.67781286565138E+018	camera_1	67	0	0.139941123211346	-0.307446673742412	2.6441986578664	0.70482199361
40	1.6782787364369E+018	67	1.67781286565735E+018	camera_1	68	0	0.139844221627282	-0.30727219876552	2.64272873788537	0.7045450342
41	1.67827873644432E+018	68	1.67781286566307E+018	camera_1	69	0	0.13996004681537	-0.30735511725349	2.64337745173982	0.70417873329
42	1.6782787364513E+018	69	1.67781286567126E+018	camera_1	70	0	0.13986402504455	-0.307326500661123	2.6426812536475	0.7047223822
43	1.67827873645827E+018	70	1.67781286567822E+018	camera_1	71	0	0.13996557480241	-0.3074667847781	2.64406118843056	0.7048795230
44	1.6782787364653E+018	71	1.67781286568517E+018	camera_1	72	0	0.139958958777021	-0.30743009215023	2.64383895958987	0.70455726311
45	1.6782787364722E+018	72	1.67781286569063E+018	camera_1	73	0	0.1399539584180583	-0.30745853210249	2.64398972188554	0.704073865
46	1.67827873647955E+018	73	1.67781286569799E+018	camera_1	74	0	0.139844105501495	-0.307329025192476	2.64307790337763	0.7045089043

14. The post-processing has completed effectively.