AUE-8200-Perception and Intelligence

Homework-2

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1. For NuScene dataset access, you may need to register on that website. To save time, you can download only the Full dataset/Mini set.

Mini

Subset of trainval, 10 scenes, used to explore the data without downloading the whole dataset.

Metadata and sensor file blobs [US, Asia] 3.88 GB (4167696325 Bytes) md5: 791dd9ced556cfa1b425682f177b5d9b

➢ I download Full NuScene dataset/Mini set from the " NuScene" website into my documents and created a separate folder for all NuScene datasets.

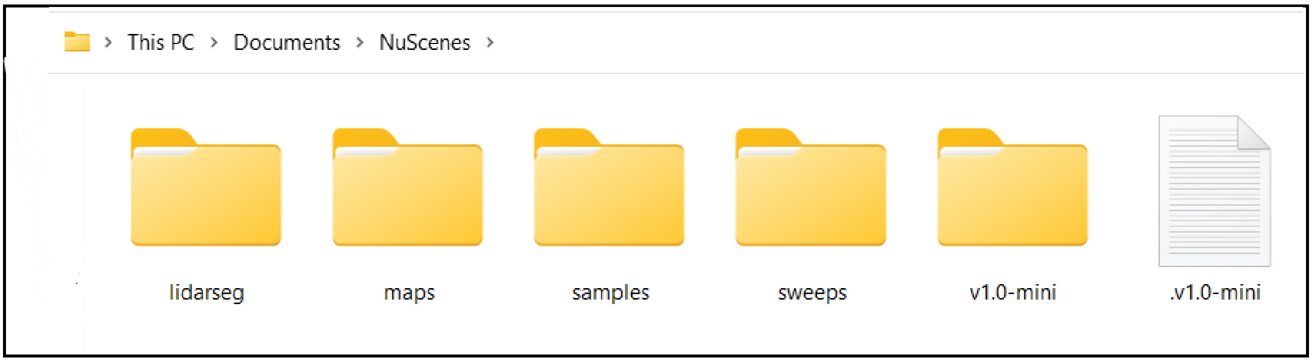


Figure 1

Path-Link: C:\Users\siddh\OneDrive\Pictures\Screenshots\Documents\NuScenes

2. If you use Python, set up the NuScene develop kit locally, you may need to install Anaconda and Jupyter notebook; If you use Matlab, setup your Matlab for this data process.

➢ I installed Anaconda and jupyter Notebook in my laptop to setup the NuScene develop kit locally.

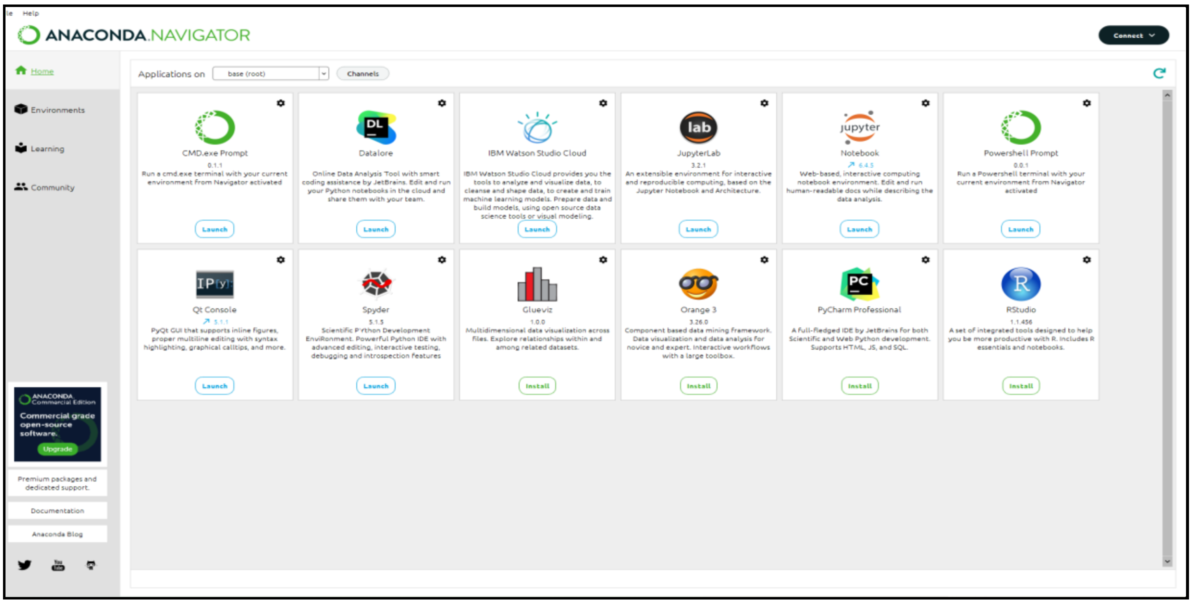


Figure 2

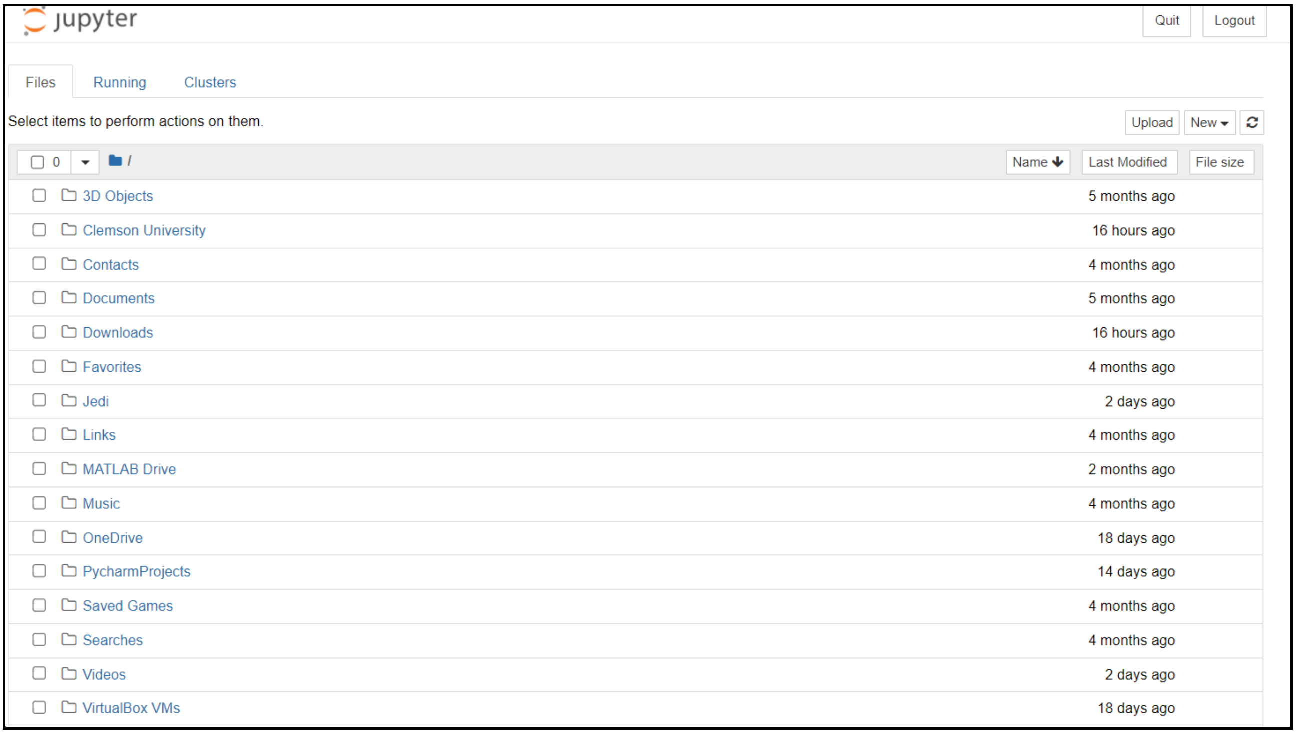


Figure 3

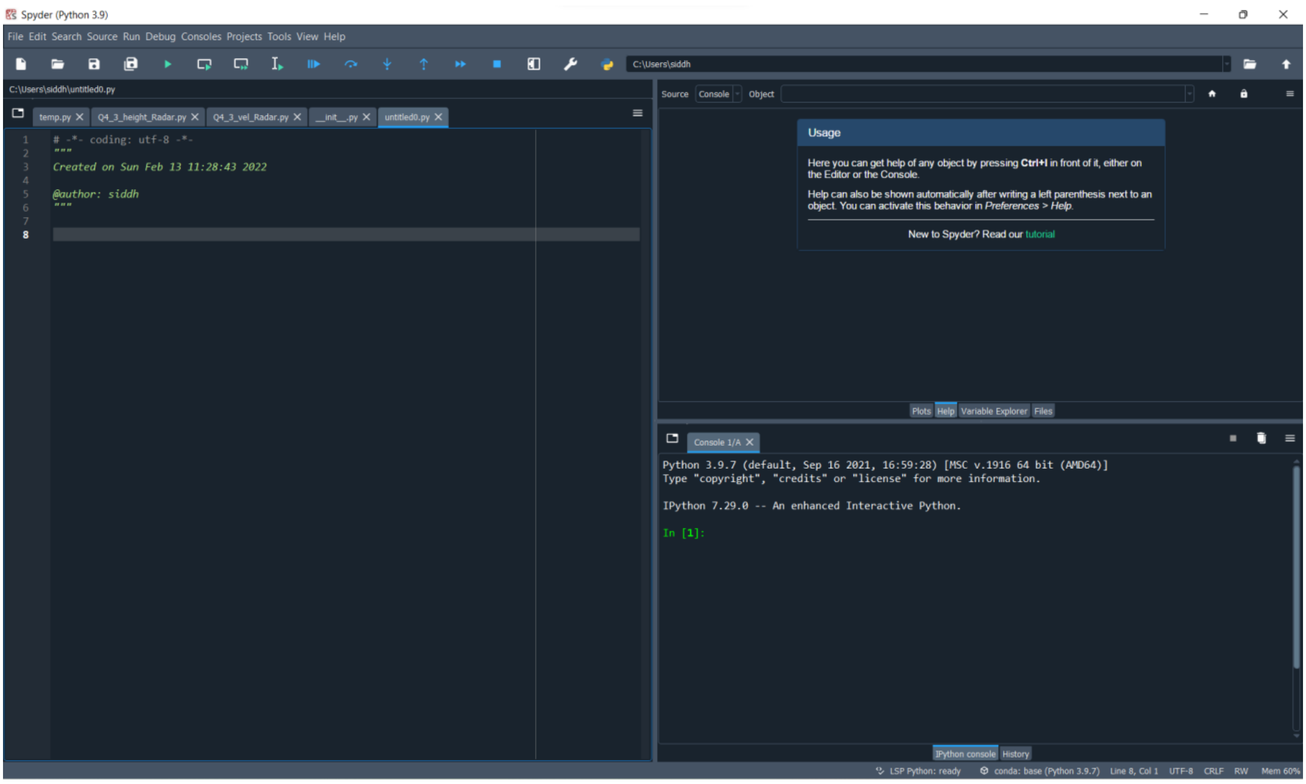
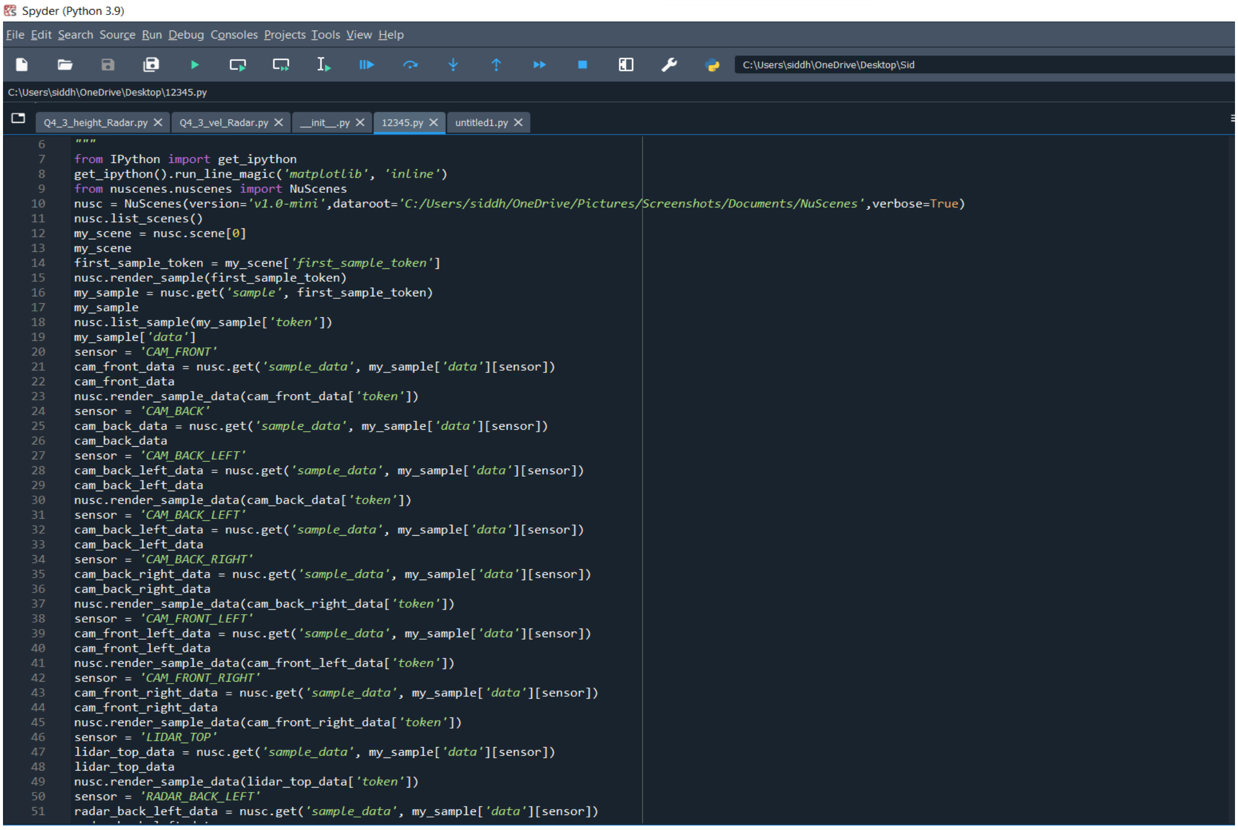


Figure 4

3. Pickup a set of data, including Image, Lidar, and Radar data. Visualize them respectively. If you use Python, you can refer to NuScene dev-kit tutorial.

➢ I have selected a set of data which includes Image, Lidar, and Radar data from the NuScenes dataset and visualized using Anaconda-Spyder

Program:



Visualization Plots:

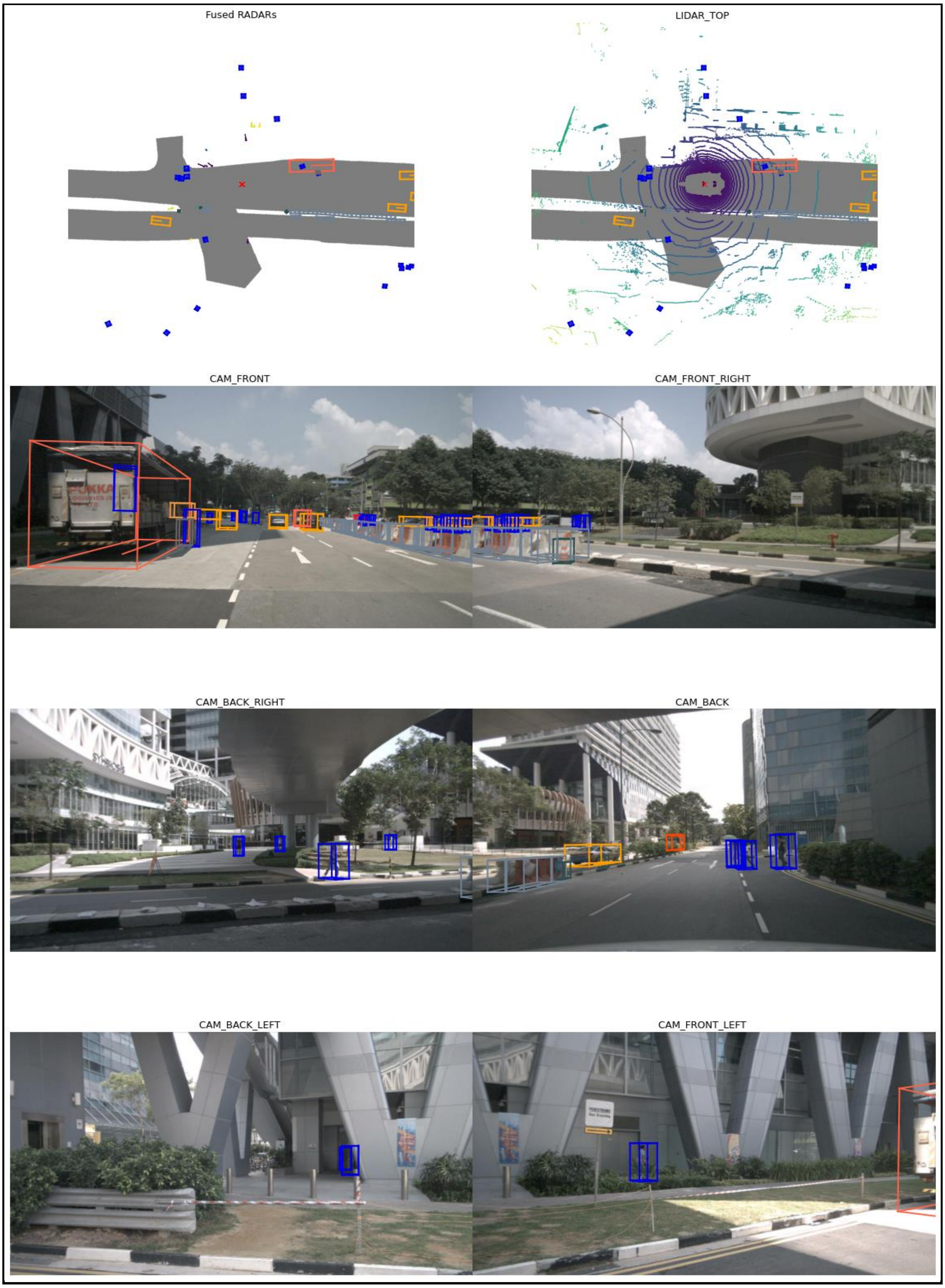


Figure 5

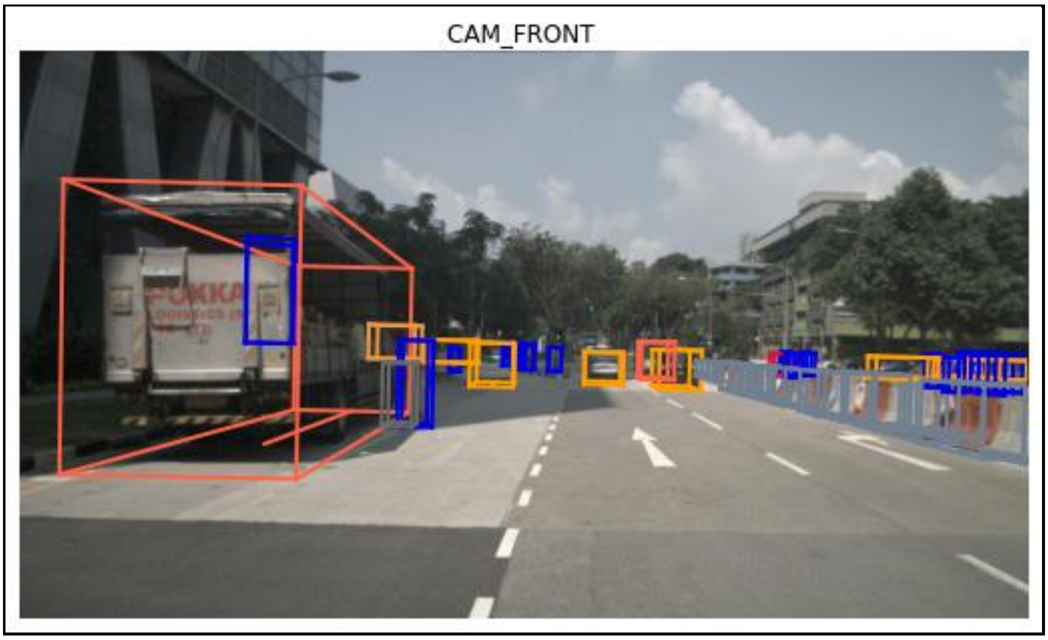


Figure 6

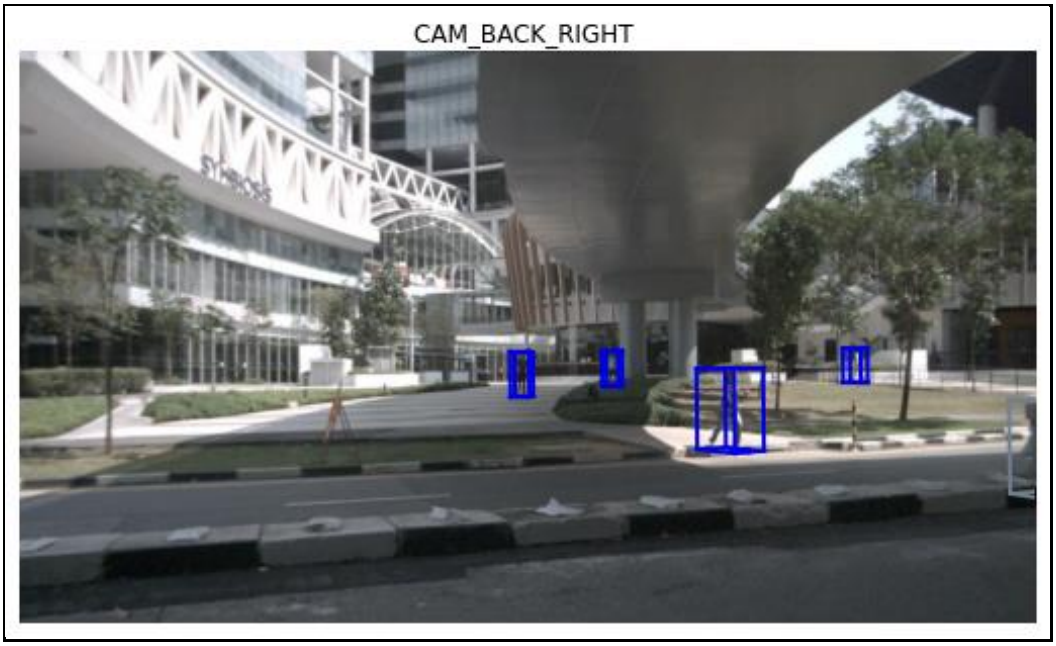


Figure 7

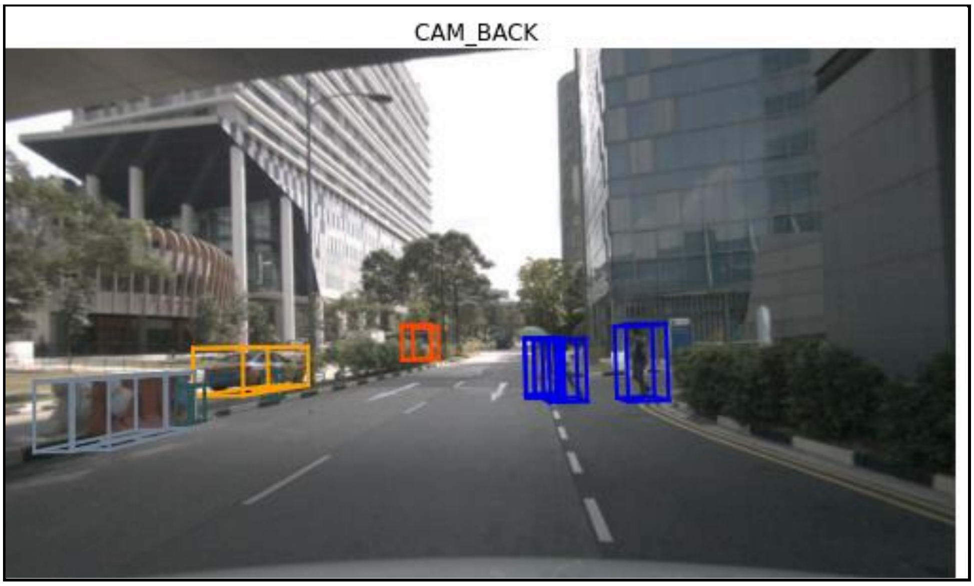


Figure 8

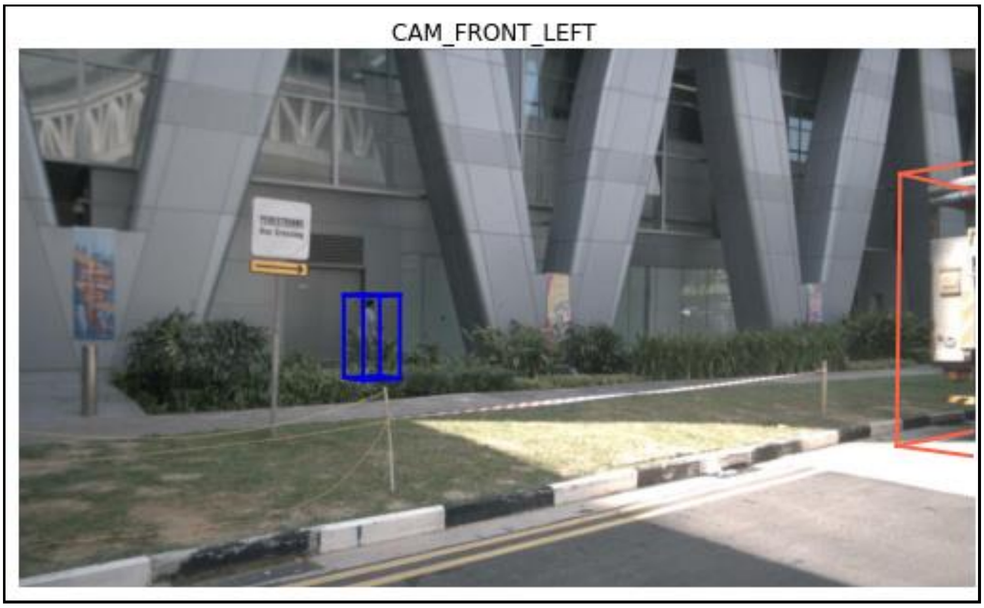


Figure 9

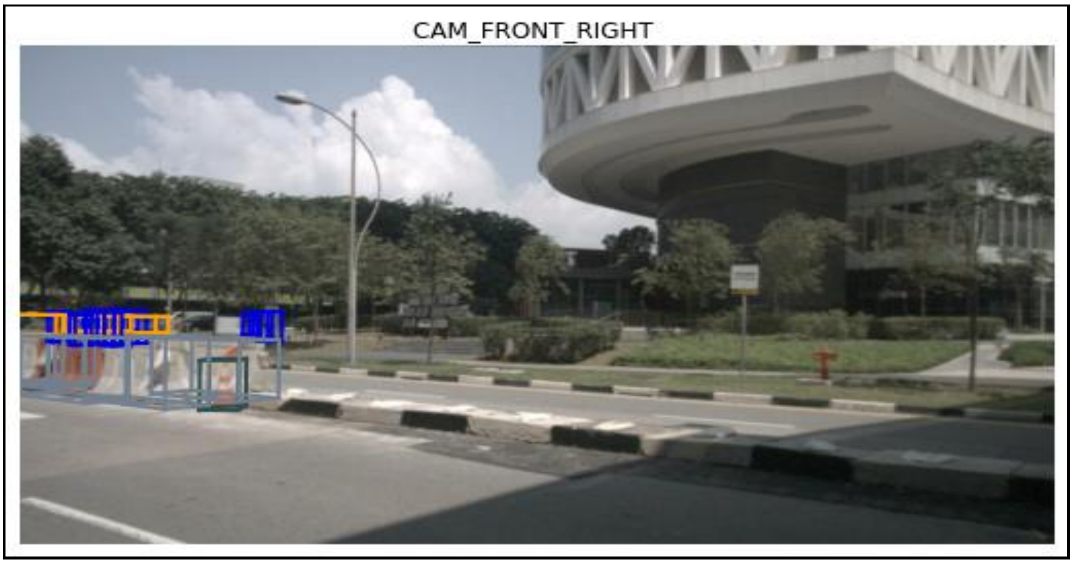


Figure 10

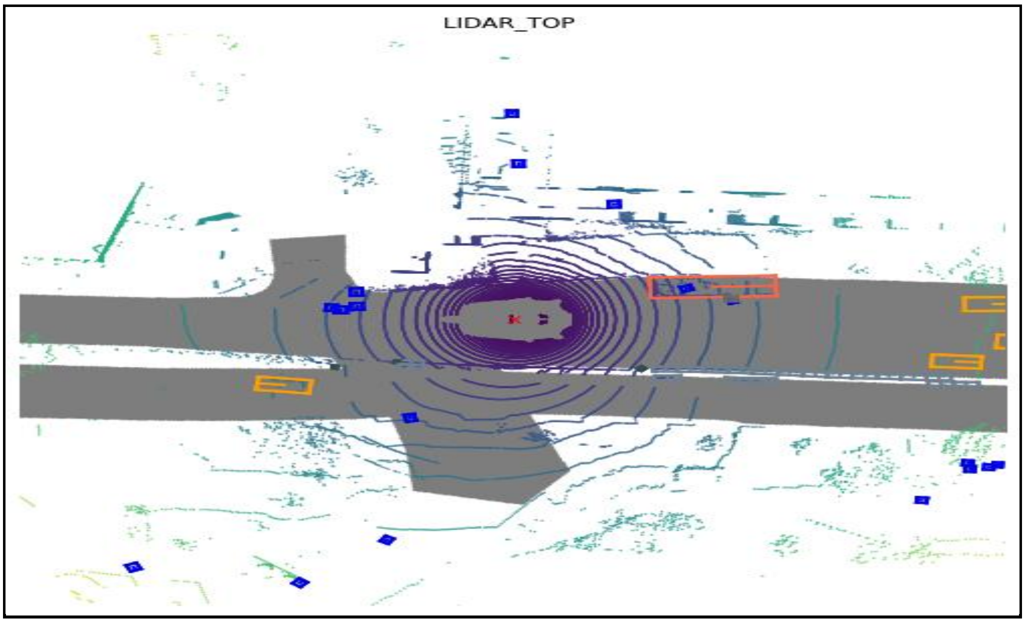


Figure 11

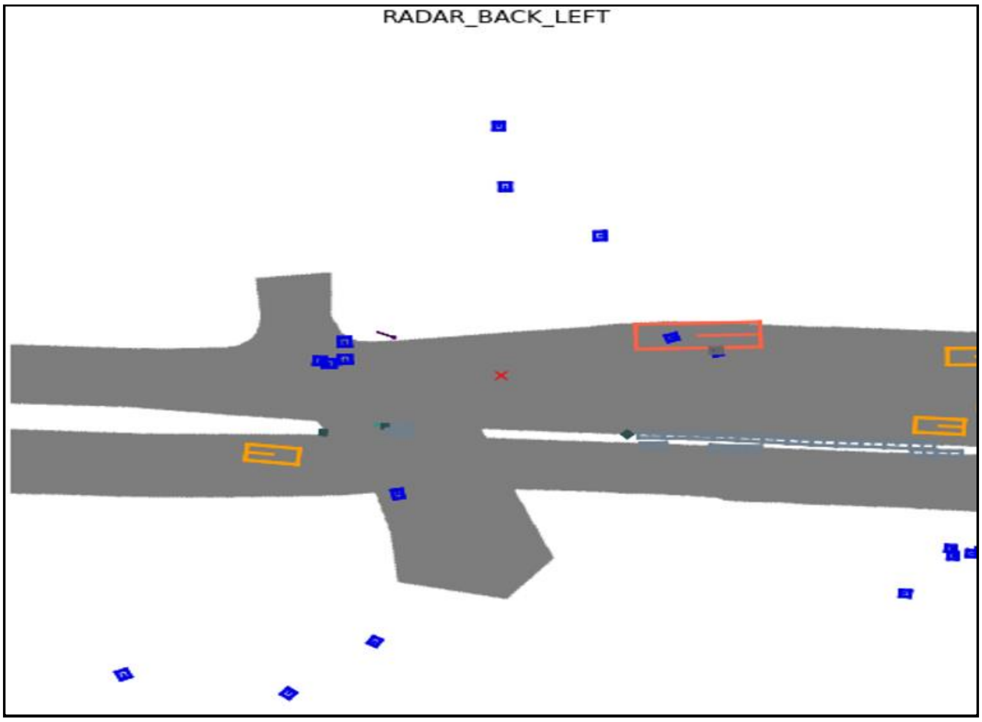


Figure 12

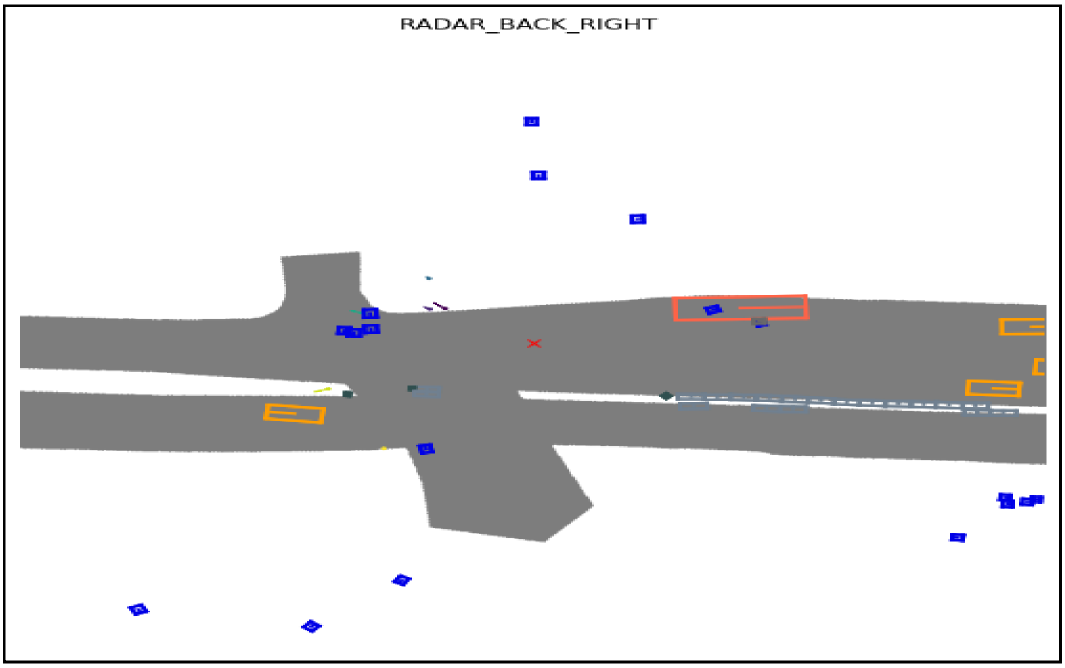


Figure 13

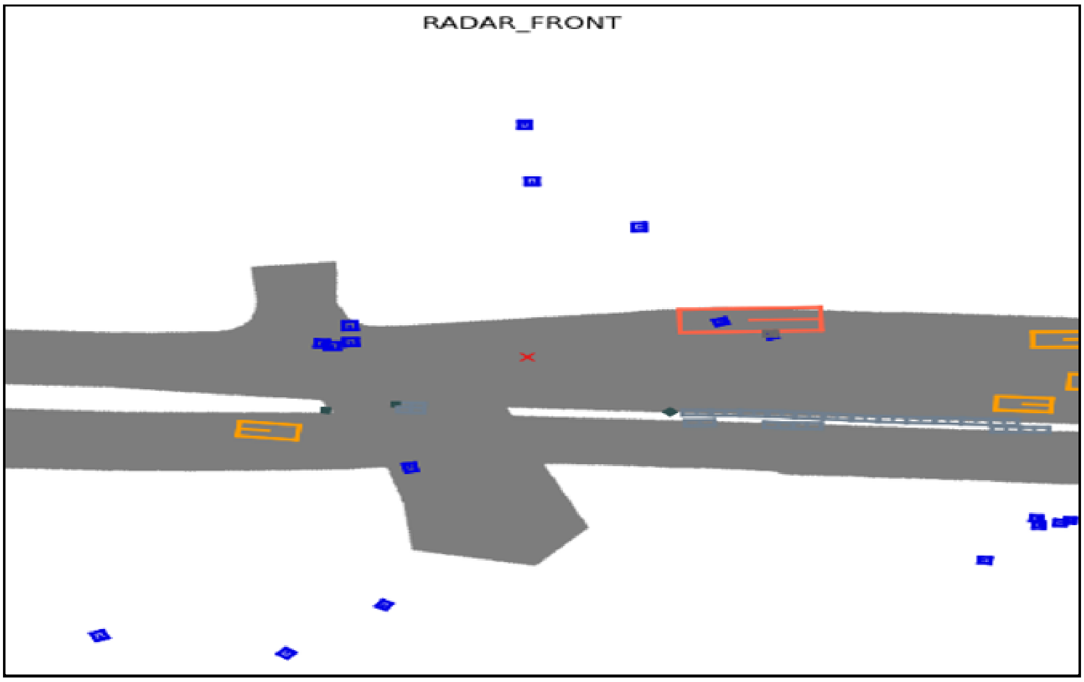


Figure 14

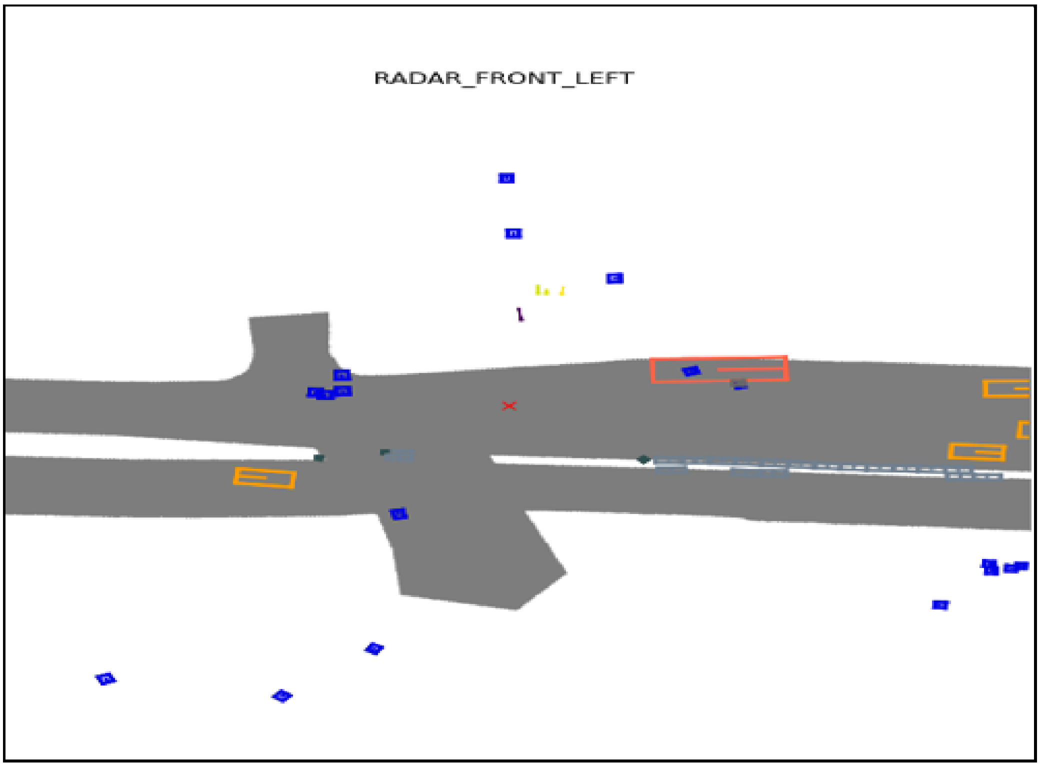


Figure 15

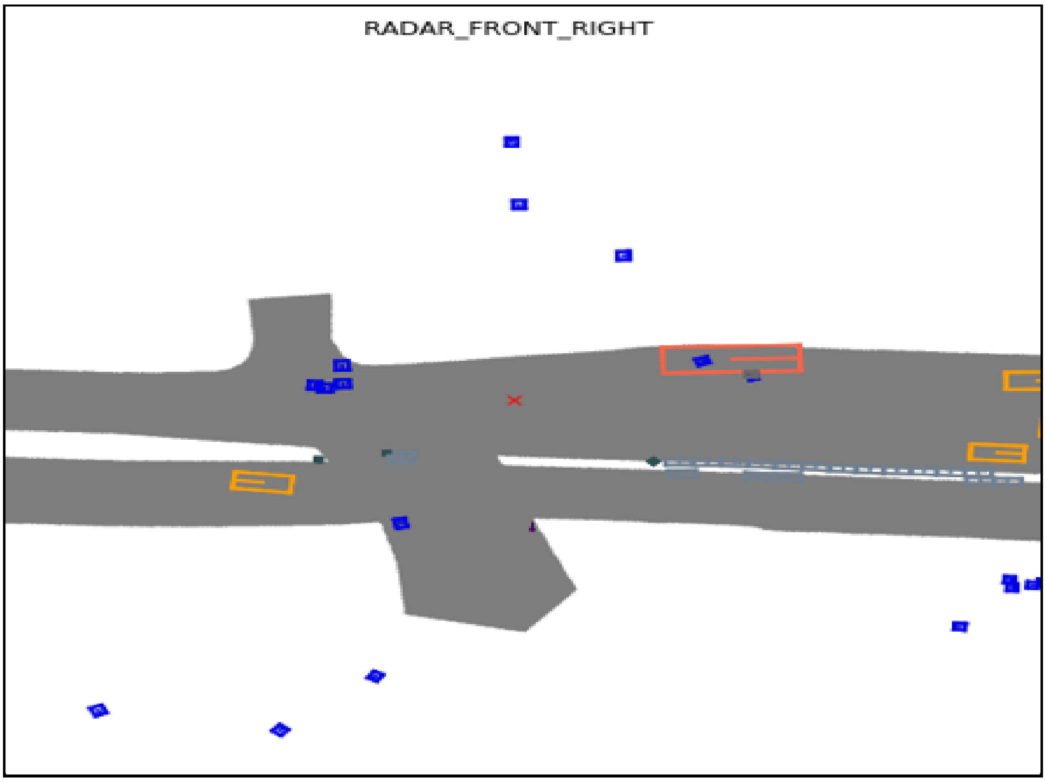


Figure 16

4. Rather than using NuScene dev-kit, implement below by yourself:
   (1) Visualize images (you can use library OpenCV or others.
   (2) Visualize Lidar point cloud data
      a. You can refer to this sample code.
      b. Colorize points by height, intensity, and semantic label respectively.
         i. Height is the Z value for a point.
         ii. You can get intensity referring the code here.
         iii. You can get semantic label from the sample above code.
   (3) Visualize Radar data
      c. Use any other library (e.g., Open3D, PCL, etcl) or modify the previous sample code to visualize the Radar data which you chosen.
      d. Colorize points by below two variable aspects respectively.
         i. For height (if it's all zero, you can colorize the points by distance).
         ii. For velocity, you can find some velocity information from here.

(1) Visualize images (you can use library OpenCV or others:

Program:

```python
#4.
#(1)
import cv2

# Load an color image
img = cv2.imread('C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes/image.jpg')

# Show image
cv2.imshow('C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes/image.jpg',img)
cv2.waitKey(0)
cv2.destroyAllWindows()

#(2)
import numpy as np
import open3d as o3d
import cv2, random,os
```

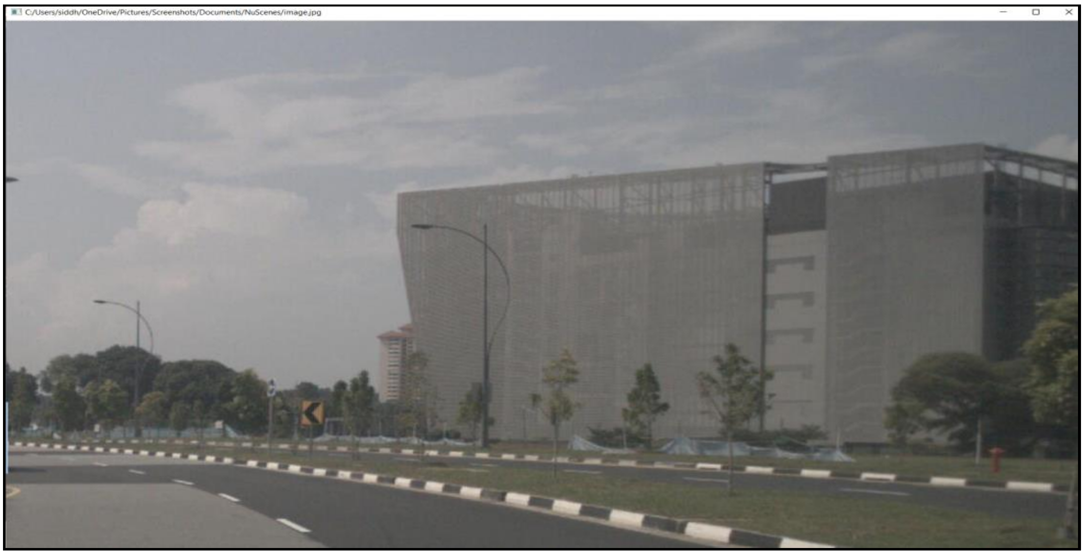


Figure 17

(2) Visualize Lidar point cloud data:

e. You can refer to this [sample code](#).
f. Colorize points by height, intensity, and semantic label respectively.
   i. Height is the Z value for a point.
   ii. You can get intensity referring the code [here](#).
   iii. You can get semantic label from the sample above code.

e. Program:

```python
@author: siddh
"""

import open3d as o3d
import numpy as np

seg_name="C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes/lidarseg/v1.0-mini/0ab9ec2730894df2b48df70d0d2e84a9_lidarseg.bin"
seg=np.fromfile(seg_name, dtype=np.uint8)

color = np.zeros([len(seg), 3])
color[:, 0] = seg/32
color[:, 1] = seg/32
color[:, 2] = seg/32

pcd_name="C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes/samples/LIDAR_TOP/n008-2018-08-01-15-16-36-0400__LIDAR_TOP__1533151613398020.pcd.bin"
scan=np.fromfile(pcd_name, dtype=np.float32)
points = scan.reshape((-1, 5))[:, :4]

pcd = o3d.geometry.PointCloud()
pcd.points = o3d.utility.Vector3dVector(points[:, :3])
pcd.colors = o3d.utility.Vector3dVector(color)

o3d.visualization.draw_geometries([pcd])
```

Visualization of Lidar Image:

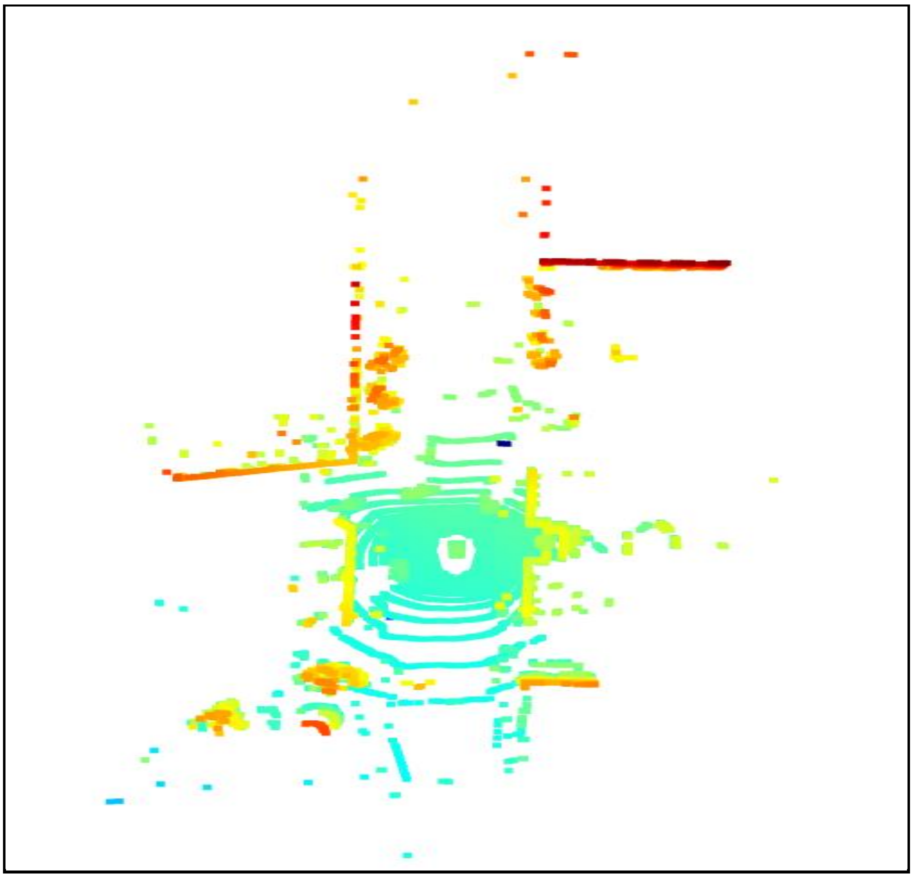


Figure 18

f. Program:

```python

#---------------------------------------Q.4.2

#Define PCD Path
input_path= r"C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes/samples/LIDAR_TOP"

#Picking Random file
dataname = random.choice([
    x for x in os.listdir(input_path)
    if os.path.isfile(os.path.join(input_path, x))
])
Filename_rand= (os.path.join(input_path, dataname))
print('Displayed image is ',Filename_rand)

#Converting PCD to points
pcd_data=Filename_rand
data=np.fromfile(pcd_data, dtype=np.float32)
pointsdata = data.reshape((-1, 5))[:, :4]
print(pointsdata)

#Value of Z
Z=pointsdata[:,2]
print('The value of Z is ',Z)

#Value of Intensity
intensity=pointsdata[:,3]
print('The value of intensity is ',intensity)

#For height
color = np.zeros([len(Z), 3])
color[:, 0] = Z[1]/10
color[:, 1] = 0.5
color[:, 2] = 0.5


pcdimage = o3d.geometry.PointCloud()
pcdimage.points = o3d.utility.Vector3dVector(pointsdata[:, :3])
pcdimage.colors = o3d.utility.Vector3dVector(color)
o3d.visualization.draw_geometries([pcdimage])

#For Intensity
color = np.zeros([len(intensity), 3])
color[:, 0] = intensity[1]/10
color[:, 1] = 0.5
color[:, 2] = 0.5


pcdimage = o3d.geometry.PointCloud()
pcdimage.points = o3d.utility.Vector3dVector(pointsdata[:, :3])
pcdimage.colors = o3d.utility.Vector3dVector(color)
o3d.visualization.draw_geometries([pcdimage])

#Visualize by Segement
sem=np.fromfile(Filename_rand, dtype=np.uint8)


color = np.zeros([len(sem), 3])
color[:, 0] = sem/20
color[:, 1] = 0.5
color[:, 2] = 0.5
pcdimage = o3d.geometry.PointCloud()
pcdimage.points = o3d.utility.Vector3dVector(pointsdata[:, :3])
pcdimage.colors = o3d.utility.Vector3dVector(color)
o3d.visualization.draw_geometries([pcdimage])

```

Visualizations of h\Height, Intensity, Segmantic label:

a. Height:

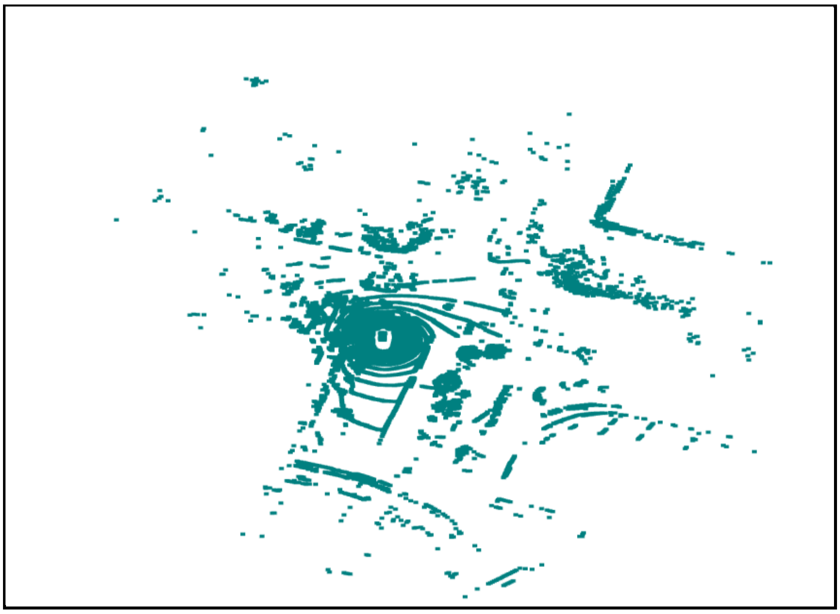


Figure 19

b. Intensity:

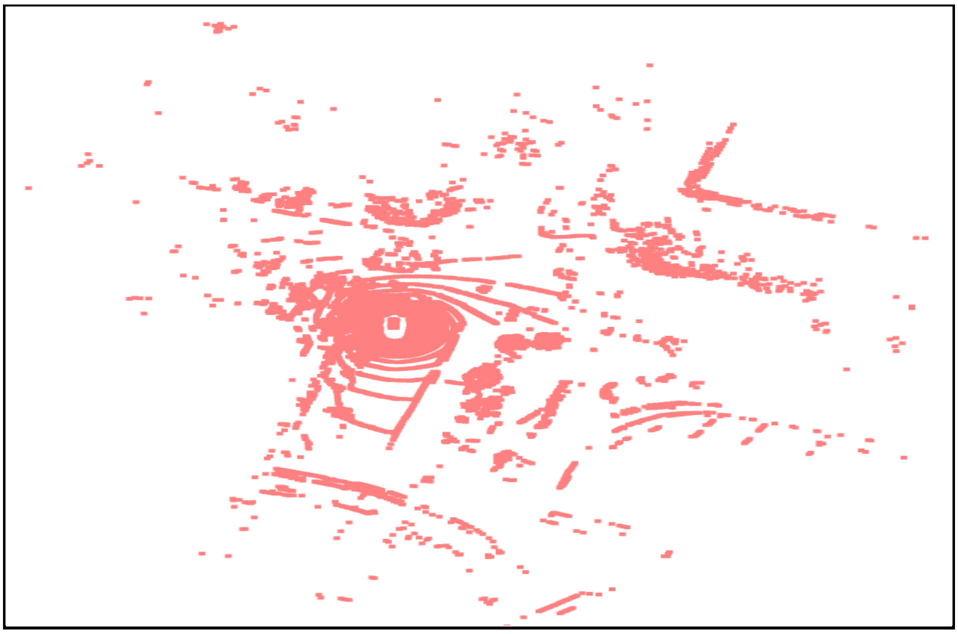


Figure 20

c. Segmantic label:

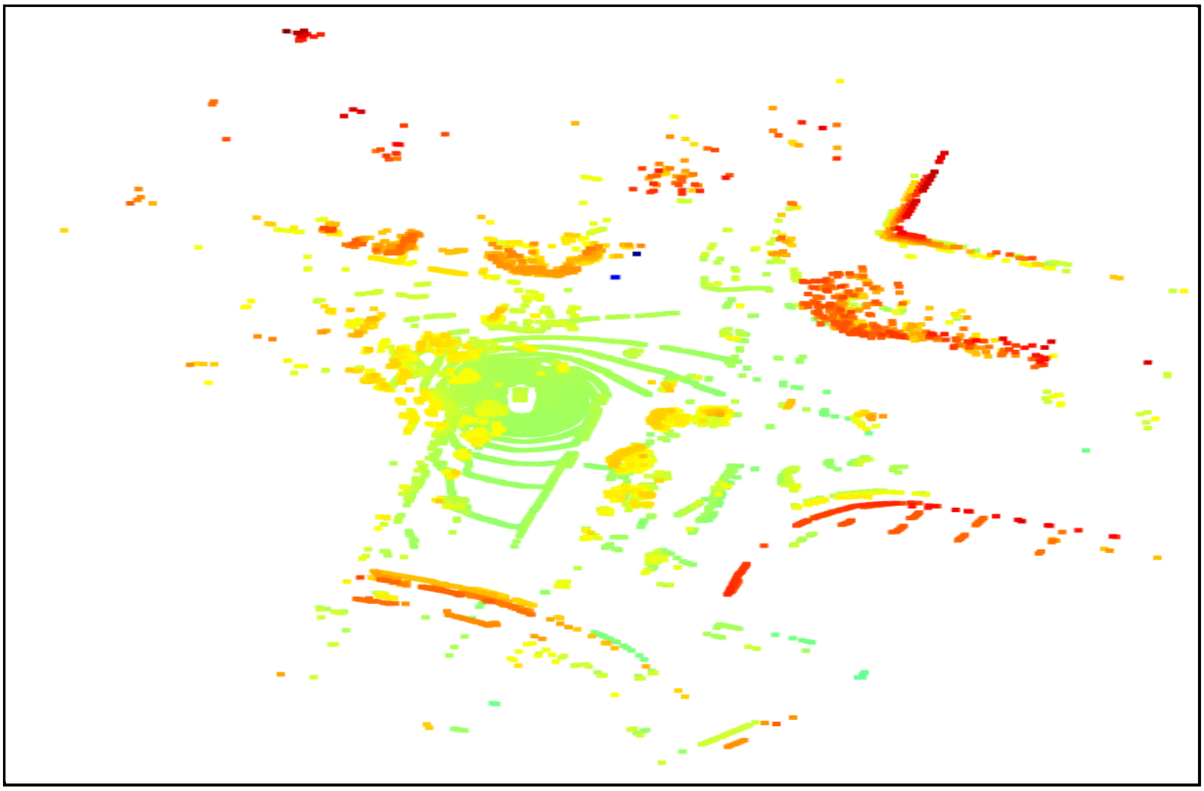


Figure 21

(4) Visualize Radar data

g. Use any other library (e.g., Open3D, PCL, etcl) or modify the previous sample code to visualize the Radar data which you chosen.

h. Colorize points by below two variable aspects respectively.

i. For height (if it's all zero, you can colorize the points by distance).

ii. For velocity, you can find some velocity information from [here](#).

g. Use any other library (e.g., Open3D, PCL, etcl) or modify the previous sample code to visualize the Radar data which you chosen.

Program:

```
# 4.(3d(i))
import os.path as osp
import random
import numpy as np
import open3d as o3d
from nuscenes.nuscenes import NuScenes
from nuscenes.utils.data_classes import RadarPointCloud
```

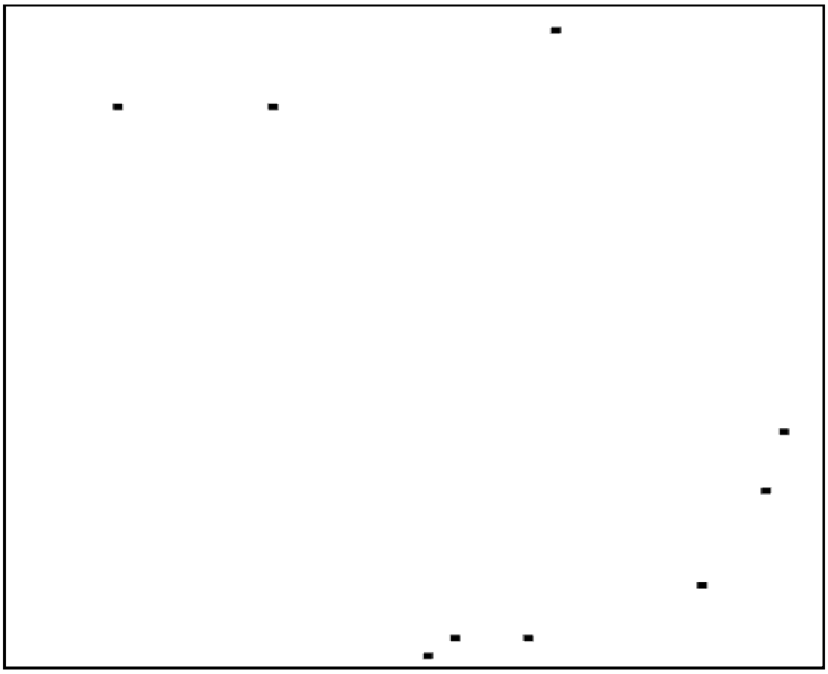


Figure 22

h. Colorize points by below two variable aspects respectively:

iii. For height (if it's all zero, you can colorize the points by distance).

iv. For velocity, you can find some velocity information from here.

Program:

```
import os.path as osp
import random
import numpy as np
import open3d as o3d
from nuscenes.nuscenes import NuScenes
from nuscenes.utils.data_classes import RadarPointCloud

nusc = NuScenes(version='v1.0-mini', dataroot='C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes', verbose=True)
random_number=random.randint(0,100)
my_sample = nusc.sample[random_number]

pointsensor_token = my_sample['data']['RADAR_FRONT']
pointsensor = nusc.get('sample_data', pointsensor_token)
pcl_path = osp.join(nusc.dataroot, pointsensor['filename'])
#Radar plot

pc = RadarPointCloud.from_file(pcl_path)
data=np.asarray(pc.points.astype(dtype=np.float32()))

pointsdata = data.reshape((-1, 18))[:, :17]
print(pointsdata)

#Height
Z=data[2]


#Velocity
vx=data[6]
vy=data[7]

#For height
color = np.zeros([len(Z), 3])
color[:, 0] = Z/10
color[:, 1] = 0.5
color[:, 2] = 0.5


pcdimage = o3d.geometry.PointCloud()
pcdimage.points = o3d.utility.Vector3dVector(pointsdata[:, :3])
pcdimage.colors = o3d.utility.Vector3dVector(color)
o3d.visualization.draw_geometries([pcdimage])
```

Visualization of height:

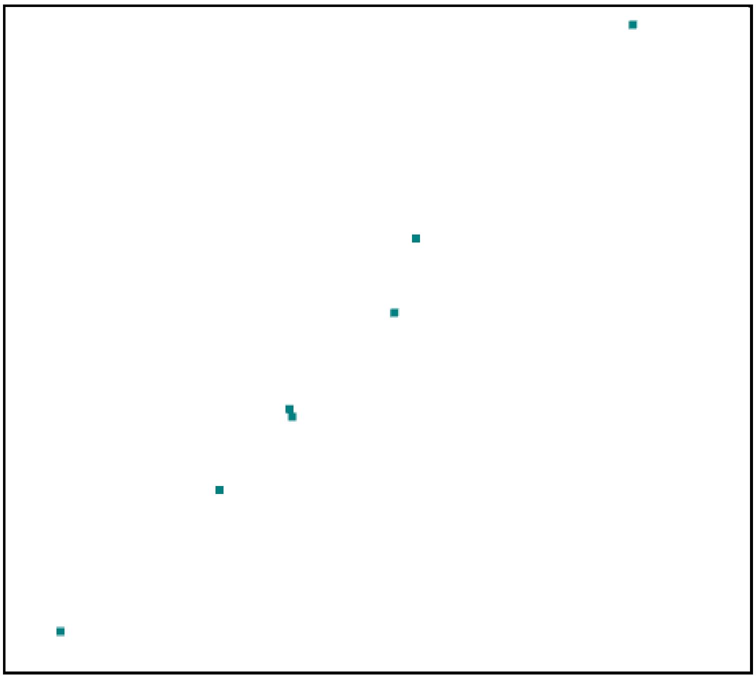


Figure 23

Program:

```python
# 4.(3d(ii))
import os.path as osp
import random
import numpy as np
import open3d as o3d
from nuscenes.nuscenes import NuScenes
#from data_classes import RadarPointCloud
from nuscenes.utils.data_classes import RadarPointCloud

nusc = NuScenes(version='v1.0-mini', dataroot='C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes', verbose=True)
random_number=random.randint(0,100)
my_sample = nusc.sample[random_number]

pointsensor_token = my_sample['data']['RADAR_FRONT']
pointsensor = nusc.get('sample_data', pointsensor_token)
pcl_path = osp.join(nusc.dataroot, pointsensor['filename'])
#Radar plot

pc = RadarPointCloud.from_file(pcl_path)
#data=np.asarray(pc.points.astype(dtype=np.float32()))

data = pc.points.T

pointsdata = data.reshape((-1, 18))[:, :17]
print(pointsdata)

#Height
#Z=data[2]


#Velocity
vx=data[:,8]
vy=data[:,9]

#For height
color = np.zeros([len(vx), 3])
color[:, 0] = vx/10
color[:, 1] = vy/10
color[:, 2] = 0.5

pcdimage = o3d.geometry.PointCloud()
pcdimage.points = o3d.utility.Vector3dVector(pointsdata[:, :3])
pcdimage.colors = o3d.utility.Vector3dVector(color)
o3d.visualization.draw_geometries([pcdimage])
print('done')
```

Visualization of velocity:

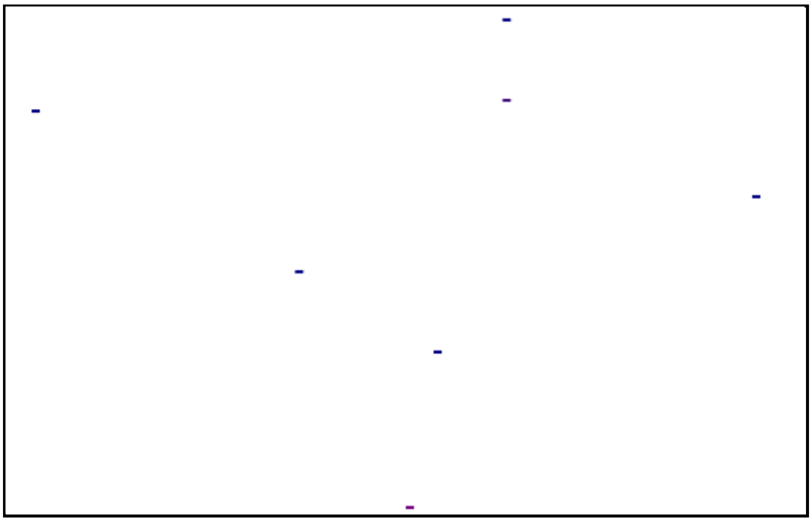


Figure 24

5. Using NuScene dev-kit for the set of data which you picked up:
   (1) Visualize Radar data projection on image
      a. Print calibration info (between Radar and Camera sensors) by referring code here.
      b. Explain the above calibration info, and pipeline of First~Fifth steps in the code.
      c. Visualize Radar data projection on image based on calibration info.

a.

Program:

```
5(1a.)
5(1a).
# To print calibration info (between Radar and Camera sensors) by referring code:
 Step-1: Transportation of data points from Radar Sensor to the ego vehicle frame
ensor = 'RADAR_BACK_LEFT'
_r_s = nusc.get('sample_data', my_sample['data'][sensor])
_r_s = nusc.get('calibrated_sensor', t_r_s["calibrated_sensor_token"])
rint("RADAR_BACK_LEFT translation_values is: ",c_r_s["translation"])
rint("RADAR_BACK_LEFT rotation_values is: ",c_r_s["rotation"],"\n")
 Step-2: Transfomation of data points from ego vehicle frame to global frame
_r_s = nusc.get('sample_data', my_sample['data'][sensor])
_r_s = nusc.get('ego_pose',t_r_s["ego_pose_token"])
rint("e_translation_values is: ",e_r_s["translation"])
rint("e_rotation_values is: ",e_r_s["rotation"],"\n")
 Step-3: Transformation of data points from global frame to ego vehicle frame
ensor = 'CAM_BACK_LEFT'
_c_s = nusc.get('sample_data', my_sample['data'][sensor])
_c_s = nusc.get('calibrated_sensor', t_c_s["calibrated_sensor_token"])
rint("CAM_BACK_LEFT translation_values is: ",c_c_s["translation"])
rint("CAM_BACK_LEFT rotation_values is: ",c_c_s["rotation"],"\n")
 Step-4: Transformation of data points from ego vehicle frame to camera
_s = nusc.get('sample_data', my_sample['data'][sensor])
_c_s = nusc.get('ego_pose',t_c_s["ego_pose_token"])
rint("e_translation_values is: ",e_c_s["translation"])
rint("e_rotation_values is: ",e_c_s["rotation"],"\n")
 Step-5:  Finally, the radar data points are present in camera.
```

```
[[ 5.59999990e+00  8.50000000e+00  0.00000000e+00  1.00000000e+00
   1.00000000e+00  5.00000000e-01 -4.75000000e+00  0.00000000e+00
   7.58259892e-02  1.15093023e-01  1.00000000e+00  3.00000000e+00
   1.90000000e+01  1.90000000e+01  0.00000000e+00  1.00000000e+00
   1.80000000e+01]
 [ 8.19999981e+00 -7.50000000e+00  0.00000000e+00  1.00000000e+00
   2.00000000e+00 -4.00000000e+00 -5.00000000e+00  0.00000000e+00
   2.29304805e-02 -2.09730007e-02  1.00000000e+00  3.00000000e+00
   1.90000000e+01  1.90000000e+01  0.00000000e+00  1.00000000e+00
   1.70000000e+01]
 [ 1.00000000e+01 -7.30000019e+00  0.00000000e+00  1.00000000e+00
   4.00000000e+00  6.00000000e+00 -5.00000000e+00  0.00000000e+00
   2.54133120e-02 -1.85517203e-02  1.00000000e+00  3.00000000e+00
   1.90000000e+01  1.90000000e+01  0.00000000e+00  1.00000000e+00
   1.70000000e+01]
 [ 1.00000000e+01 -7.69999981e+00  0.00000000e+00  1.00000000e+00
   5.00000000e+00  4.00000000e+00 -5.00000000e+00  0.00000000e+00
   2.48855427e-02 -1.91618670e-02  1.00000000e+00  3.00000000e+00
   1.90000000e+01  1.90000000e+01  0.00000000e+00  1.00000000e+00
   1.70000000e+01]
 [ 8.80000019e+00 -1.01000004e+01  0.00000000e+00  1.00000000e+00
   6.00000000e+00  3.50000000e+00 -5.00000000e+00  0.00000000e+00
   1.98937263e-02 -2.28325725e-02  1.00000000e+00  3.00000000e+00
   1.90000000e+01  1.90000000e+01  0.00000000e+00  1.00000000e+00
   1.80000000e+01]
 [ 1.18000002e+01 -7.50000000e+00  0.00000000e+00  1.00000000e+00
   7.00000000e+00 -1.50000000e+00 -5.00000000e+00  0.00000000e+00
   2.65974645e-02 -1.69051699e-02  1.00000000e+00  3.00000000e+00
   1.90000000e+01  1.90000000e+01  0.00000000e+00  1.00000000e+00
   1.70000000e+01]]
done
RADAR_BACK_LEFT translation_values is:  [-0.562, 0.628, 0.53]
RADAR_BACK_LEFT rotation_values is:  [0.0458860416542946, 0.0, 0.0, 0.9989466808500344]

e_translation_values is:  [656.4798091994182, 1603.971345141823, 0.0]
e_rotation_values is:  [-0.9397410032054776, -0.009941445191752165, 0.009816534042556625, 0.34160159575337645]

CAM_BACK_LEFT translation_values is:  [1.04852047718, 0.483058131052, 1.56210154484]
CAM_BACK_LEFT rotation_values is:  [0.7048620297871717, -0.6907306801461466, -0.11209091960167808, 0.11617345743327073]

e_translation_values is:  [656.4246963278883, 1604.0179020923947, 0.0]
e_rotation_values is:  [-0.9397483329333906, -0.009977299221811859, 0.009906389280725406, 0.34157779157985546]
```

1b. Explain the above calibration info, and pipeline of First~Fifth steps in the code

- Firstly, the data points are transferred from the Radar sensor to ego vehicle frame by using (translation and rotation) calibration data.
- Secondly, the data points are transferred from ego vehicle frame to global frame by using ego pose in calibration data (translation and rotation).
- Thirdly, the data points are now transformed from global frame to ego vehicle frame by using calibration data (translation and rotating).
- Next, the data points are transformed from ego vehicle frame to the camera frame.
- Finally, the radar data points are present in the Camera.

1c. Visualize Radar data projection on image based on calibration info.

```python
import random
from nuscenes.nuscenes import NuScenes
from Nusc_file import NuScenesExplorer


nusc = NuScenes(version='v1.0-mini', dataroot='C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes', verbose=True)
random_number=random.randint(0,100)
my_sample = nusc.sample[random_number]


#Radar plot
nusc.render_pointcloud_in_image(my_sample['token'], pointsensor_channel='RADAR_FRONT')
NuScenesExplorer(nusc).map_pointcloud_to_image(my_sample['data']['RADAR_FRONT'],my_sample['data']['CAM_FRONT'])
```

Figure 25

- If we observe keenly, we can see that they are blue and red colour-based distance values where Red is the maximum and Blue is the minimum.

(2) Visualize LiDAR data projection on image

c. Print and explain the calibration info (between LiDAR and Camera sensors) by referring [here](#).

e. Visualize LiDAR data projection on image based on calibration info.

2c. Print and explain the calibration info (between LiDAR and Camera sensors:

Program:

```
# To print calibration info (between Radar and Camera sensors) by referring code:
# Step-1: Transportation of data points from  Radar Sensor to the ego vehicle frame
sensor = 'LIDAR_TOP'
t_l_s = nusc.get('sample_data', my_sample['data'][sensor])
c_l_s = nusc.get('calibrated_sensor', t_l_s["calibrated_sensor_token"])
print("LIDAR_TOP translation_values is: ",c_l_s["translation"])
print("LIDAR_TOP rotation_values is: ",c_l_s["rotation"],"\n")
# Step-2: Transfomation ofdata points frpom ego vehicle frame to global frame
t_l_s = nusc.get('sample_data', my_sample['data'][sensor])
e_l_s = nusc.get('ego_pose',t_l_s["ego_pose_token"])
print("e_translation_values is: ",e_l_s["translation"])
print("e_rotation_values is: ",e_l_s["rotation"],"\n")
# Step-3: Transformation of data points from global frame to ego vehicle frame
sensor = 'CAM_BACK_LEFT'
t_c_s = nusc.get('sample_data', my_sample['data'][sensor])
c_c_s = nusc.get('calibrated_sensor', t_c_s["calibrated_sensor_token"])
print("CAM_BACK_LEFT translation_values is: ",c_c_s["translation"])
print("CAM_BACK_LEFT rotation_values is: ",c_c_s["rotation"],"\n")
# Step-4: Transformation ofdata points from ego vehicle frame to camera
t_s = nusc.get('sample_data', my_sample['data'][sensor])
e_c_s = nusc.get('ego_pose',t_c_s["ego_pose_token"])
print("e_translation_values is: ",e_c_s["translation"])
print("e_rotation_values is: ",e_c_s["rotation"],"\n")
# Step-5:  Finally, the radar data points is present in camera.
```

c. Explanation of above calibration info:

- Firstly, the data points are transferred from the Radar sensor to ego vehicle frame by using (translation and rotation) calibration data.
- Secondly, the data points are transferred from ego vehicle frame to global frame by using ego pose in calibration data (translation and rotation).
- Thirdly, the data points are now transformed from global frame to ego vehicle frame by using calibration data (translation and rotating).
- Next, the data points are transformed from ego vehicle frame to the camera frame.
- Finally, the radar data points are present in the Camera.

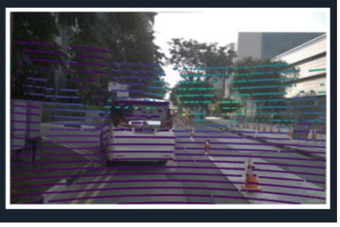
e. Visualize LiDAR data projection on image based on calibration info.

Program:

```python
import random
from nuscenes.nuscenes import NuScenes
from Nusc_file import NuScenesExplorer


nusc = NuScenes(version='v1.0-mini', dataroot='C:/Users/siddh/OneDrive/Pictures/Screenshots/Documents/NuScenes', verbose=True)
random_number=random.randint(0,100)
my_sample = nusc.sample[random_number]

#lidar plot
nusc.render_pointcloud_in_image(my_sample['token'], pointsensor_channel='LIDAR_TOP', render_intensity=False)
NuScenesExplorer(nusc).map_pointcloud_to_image(my_sample['data']['LIDAR_TOP'],my_sample['data']['CAM_FRONT'])
```



Visualization of LiDAR data projection on image based on calibration info:

Figure 26