Mobile Robotics

ASSIGNMENT 2 - REPORT

TEAM 1 - curiosity
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OUTPUTS:

- https://iiitaphyd-my.sharepoint.com/:f:/g/personal/gowri_lekshmy_research_iiit_ac_in/Et4DZzci3tZPtgqzg2DS5aUBW91no-cT-3ex07CcDuQhAg?e=Zniebn

POINT CLOUD REGISTRATION

PART - 2.1

Input Data Format:

- The input LIDAR data of the first 77 bin files of KITTI odometry evaluation dataset was used.
- Each of the bin files contains the 3d point cloud captured by the LIDAR (format x,y,z, reflectance) at a particular time step.
- **We ignored the 4th value of reflectance for creating the point cloud.**
- We used the corresponding ground truth pose (Nx12) from the file 0.1 txt for each of the 77 bins.

Transformation Procedure of LIDAR data:

- The LIDAR data was first transformed into the ***camera frame***, then later transformed with the ground truth ***poses***. This was done for each of the 77 bins by rotation and translation and finally, all the points clouds were appended and visualized.
- To transform the LIDAR data into the camera frame, we first found the rotation matrix with the Euler angles 'ZYX' as **(0,-90,90).** The final rotation matrix was made into a 4x4 matrix by appending.

$$R_Z R_Y R_X = \begin{pmatrix} \cos C & -\sin C & 0 \\ \sin C & \cos C & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos B & 0 & \sin B \\ 0 & 1 & 0 \\ -\sin B & 0 & \cos B \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos A & -\sin A \\ 0 & \sin A & \cos A \end{pmatrix}$$

$$R = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

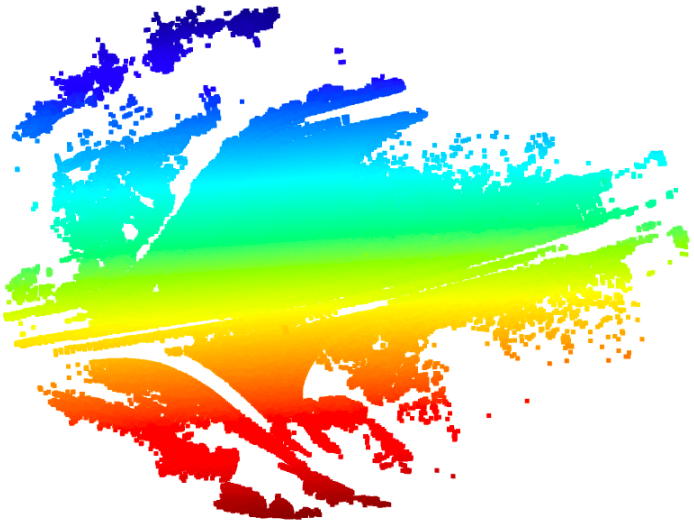
$$M = \text{pose\_i x R}$$

$$pcd_i = (\text{M x } Lidar_i.\text{T}).\text{T}$$

$$R = 4\text{x}4 \quad pose_i = 3\text{x}4 \quad M = 3\text{x}4 \quad Lidar_i = \text{nx}4 \quad pcd_i = \text{nx}3$$

- The corresponding pose was made into 3x4 matrix and multiplied with the rotation matrix. This is the total transformation matrix.
- The LIDAR data is made (nx4) by appending a column of 1s to it.
- Then the point cloud (pcd_i) for each bin is found by multiplying the total transformation matrix to the LIDAR points
- All the 77 point clouds are appended together and the final point cloud is visualized.

Output Point Cloud obtained:



OCCUPANCY GRID CONSTRUCTION

PART - 2.2

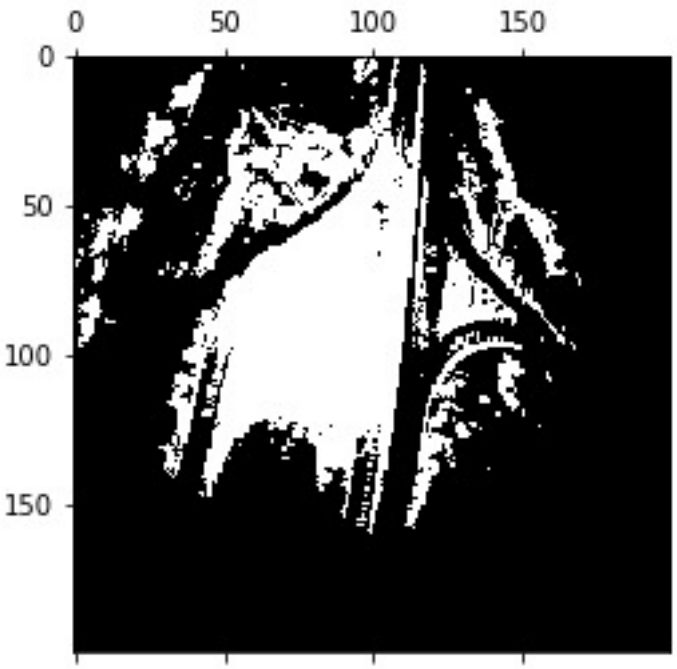
Occupancy Grid Map

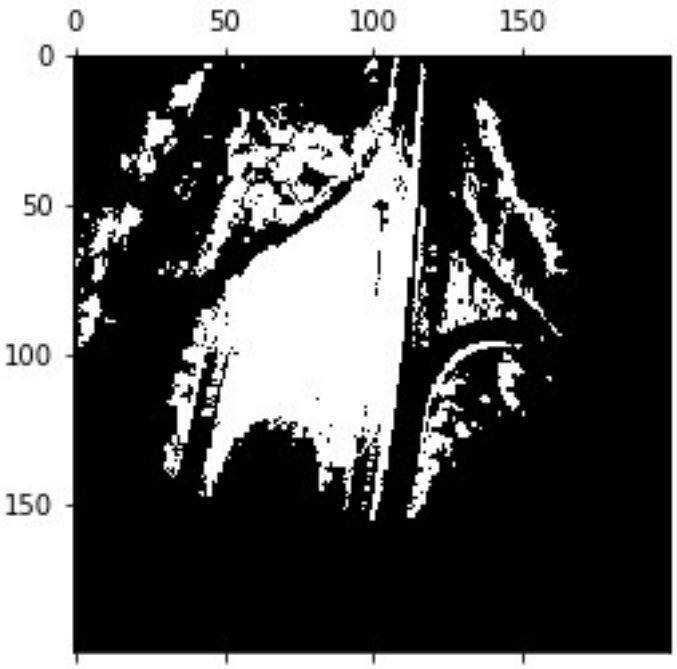
Procedure:

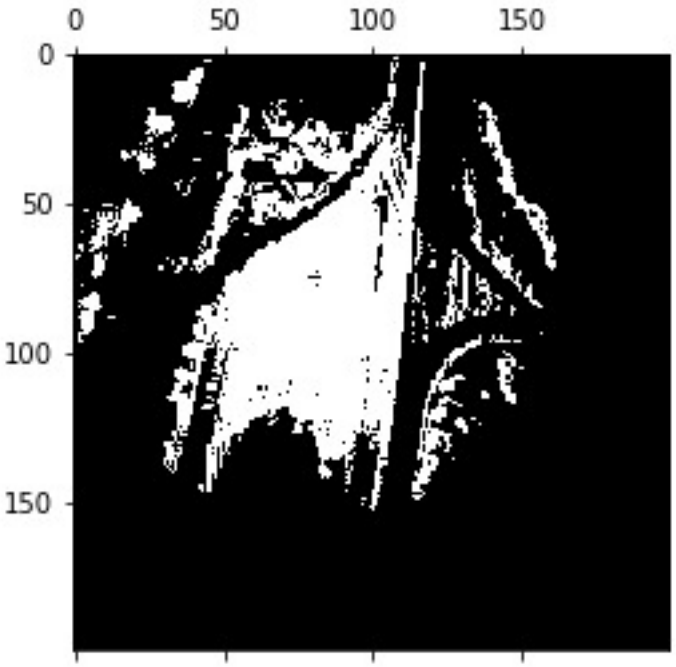
- After getting the transformed point cloud as done in 2.1, we try to create an occupancy grid map for each LIDAR scan.
- We see that the variance of y is the least. Therefore, we marked a cell as occupied based on a threshold of how many different y values are there for a particular (x,z) cell.
- All the (x,y,z) transformed points are rounded in their x-coordinate and z-coordinate to their closest integer values so that we can map each of these co-ordinates to a grid. Other un-mapped points in the grid are considered free.
- We created a grid of zeros initially and shifted all the points in the point_cloud (which is being mapped to an Occupancy Grid Map) so that all points get mapped between (0,0) and (length, width) and fit in the 2D co-ordinate system.
- Each grid is of size 1*1 units. The Occupancy Grid Map is of size (200, 200). We simply added some buffer to the co-ordinates of the point with maximum x and z values (i.e, 160 + 40).
- We took the pcd (registered and transformed point cloud) of each lidar scan and generated the occupany map for each of it. Therefore, we have 77 single-bin outputs in the folder ‘./data/outputs/77_outputs’.
- Similarly, we took first 5, then 10, then 15 LIDAR scans by concatenating them which gave pcds of the point_clouds of respective lengths
- We varied our threshold value from 1 to 10 and checked how the occupancy map was changing. On an average, from the results, we took threshold as 3.
- We fix (x,z) pairs and check for y values. That is, we obviously have points with same x,z values but different y values. We counted that frequency and checked if it is greater or less than the threshold.
- Therefore, we were able to find the number of times each point has occurred, then those which have occurred more than the threshold value are considered as occupied while others are considered as free in the occupancy map.
- The occupied points are considered as white and the empty ones are black.

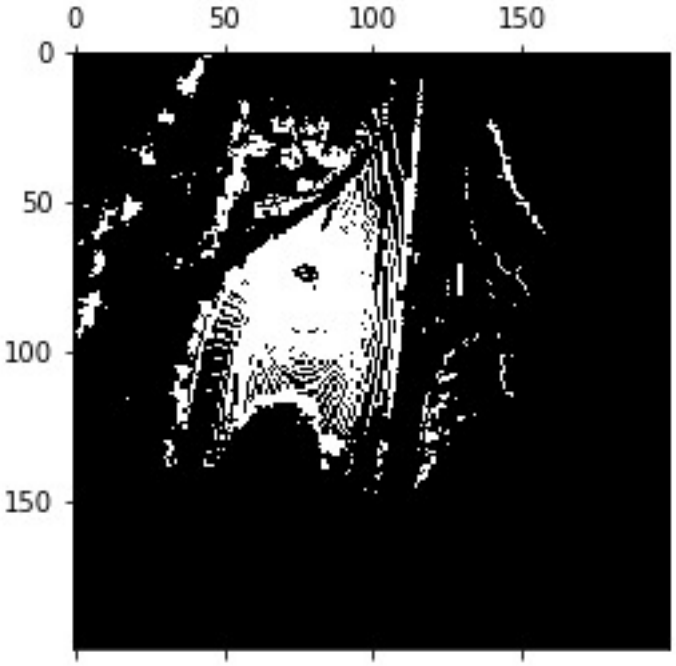
Output Occupancy Grid Map obtained:

- The following are the images for first 5 scans, first 10, first 15 and then first Lidar scan(first bin) respectively.






0
50
100
150
0
50
100
150


0
50
100
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0
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150

Contribution:

Both members have contributed equally to both the questions. Gowri focussed on 2.1 while Shivani focussed more on 2.2.

OUTPUTS:

- https://iiitaphyd-my.sharepoint.com/:f:/g/personal/gowri_lekshmy_research_iiit_ac_in/Et4DZzci3tZPtgqzg2DS5aUBW91no-cT-3ex07CcDuQhAg?e=Zniebn