Midterm Localization Report

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Pipeline

建立類別 icp_localization, 宣告於主程式中，並使用ros::spin()執行緒

1. 初始化
    - 讀map
    - 對map做voxel grid降低取樣
    - 定義publisher, subscriber
    - 利用gps和imu的資訊得到initial guess
2. lidar points callback function
    - 將收到的ros msgs轉成pointcloud資料型態
    - 對pointcloud做座標轉換(從velodyne link到base_link, nuscenes_lidar到car)
    - 使用濾波器(passthrough)，降低運算量，並從x,y,z方向過濾掉不好match的點雲
    - 進行ICP，疊合map和lidar的點雲，計算出world和base_link(car)之間的transformation matrix
    - TF broadcast world和car的座標轉換
    - 根據transformation matrix的結果計算出Odometry
    - 將結果publish(經過icp後的點雲及Odometry)到rostopic上

Contribution

ICP 演算法:

使用PCL函式庫，其特色為求取source pointcloud和target pointcloud的對應點對，利用所求出的座標轉換矩陣，將source pointcloud變換到target pointcloud的座標系下，計算變換後source和target pointcloud的誤差，若誤差值大於threshold值，則持續進行迭代直到滿足給定的誤差要求。ICP演算法採用最小二乘估計計算變換矩陣，但由於使用迭代做

計算，導致計算速度較慢，而且在進行ICP計算時，對initial guess有蠻高的要求，若選擇的initial guess不合理，則會導致icp迭代的點雲沒辦法match到target pointcloud上

在這次期中專題，主要策略是選取適合的initial guess，修改ICP的參數以及修正passthrough的濾波範圍

1. Initial guess

使用gps的資訊得到initial guess的translation, 使用imu的orientation取得yaw並得到initial guess的rotation, 然而利用imu的資訊得到的yaw並不精準，所以最後yaw值的取得方式是透過rviz來調整

```
Eigen::Matrix4f icp_localization::get_initial_guess(){

  sensor_msgs::ImuConstPtr imu;
  imu = ros::topic::waitForMessage<sensor_msgs::Imu>("/imu/data", nh);
  double roll, pitch, yaw;
  tf2::Quaternion q_imu(imu->orientation.w, imu->orientation.x, imu->orientation.y, imu->orientation.z);
  tf2::Matrix3x3 m(q_imu);
  m.getRPY(roll, pitch, yaw);
  // cout << "yaw:" << yaw << endl;
// double yaw = 0.0245;
  if(task==3){
    yaw = -2.21;
  }
  tf2::Quaternion q;
  q.setRPY(0,0,yaw);
  tf2::Matrix3x3 rotation;
  rotation.setRotation(q);
  Eigen::Matrix4f trans = Eigen::Matrix4f::Zero();
  geometry_msgs::PointStampedConstPtr gps;
  gps = ros::topic::waitForMessage<geometry_msgs::PointStamped>("/gps", nh);


  trans << rotation[0][0], rotation[0][1], rotation[0][2],  (*gps).point.x,
           rotation[1][0], rotation[1][1], rotation[1][2],  (*gps).point.y,
                           rotation[2][0], rotation[2][1], rotation[2][2],  (*gps).point.z,
                                0,              0,              0,                      1;

  return trans;
}
```

2. 修改ICP參數

- PCL VoxelGrid downsample:

VoxelGrid是將3D空間畫分成很多小區塊，然後讓處在同一個區塊內的所有pointcloud的中心點作為該區域唯一一個點，如此來降低取樣數目。leafsize越大，表示採樣的幅度範圍越大，輸出結果的點會越少

- setMaximumIterations, setEuclideanFitnessEpsilon:

設定迭代次數的上限，以及收斂條件，當均方誤差小於setEuclideanFitnessEpsilon的值，停止迭代

- setTransformationEpsilon:

前一個座標轉換矩陣和現在的座標轉換矩陣的誤差小於此值時，就判定為收斂

- setMaxCorrespondenceDistance:

設對應點之間的最大距離，我調1m，因為範圍太鬆配對會不精確

3. 修正PassThrough的濾波範圍

在做ICP時，有個很重要的地方是要濾掉不合適的點，因此我對map和lidar point都有做濾波以利ICP配對，尤其二三題的map，z軸方向的點太亂了，必須要先過濾在進行ICP

而x軸和y軸方向，我採取的策略是濾掉lidar points base_link(car)附近的點，只採用兩側的feature做ICP matching，因為我認為只採用兩側的points做ICP matching會比較精確(減少變因)

ex. x limit(5~30, -30~-5)，再將positive和negative的pointcloud做疊加

```
174     tmp_P.reset(new pcl::PointCloud<pcl::PointXYZI>());
175     tmp_N.reset(new pcl::PointCloud<pcl::PointXYZI>());
176     *tmp_P = *pc_input;
177     *tmp_N = *pc_input;
178     // ==========filter============
179
180     pcl::PassThrough<pcl::PointXYZI> pass_x_P;
181     pass_x_P.setInputCloud(tmp_P);
182     pass_x_P.setFilterFieldName ("x");
183     pass_x_P.setFilterLimits (min_x, max_x);
184     pass_x_P.filter (*tmp_P);
185     // cout<<"filter_x: "<<pc_input->points.size()<<endl;
186
187     pcl::PassThrough<pcl::PointXYZI> pass_x_N;
188     pass_x_N.setInputCloud(tmp_N);
189     pass_x_N.setFilterFieldName ("x");
190     pass_x_N.setFilterLimits (-max_x, -min_x);
191     pass_x_N.filter (*tmp_N);
192     // cout<<"filter_x: "<<pc_input->points.size()<<endl;
193     *pc_input = *tmp_P + *tmp_N;
194     cout<<"filter_x: "<<pc_input->points.size()<<endl;
```

Problems and Solutions

1. initial guess:

以gps座標作為x,y,z的出值，imu的orientation得到yaw值，然而imu的data會有誤差導致inital guess不準確，解決方式是用rviz觀察yaw的方向，微調出適合的yaw值

2. 掉frame:

一開始在執行時，會遇到掉frame的問題，最初的作法是將播放rate減慢至0.01，但此時在播完整個bag後仍然會掉一個frame，後來發現應該是掉第一個frame，推測是因為在bag播放時同時建立publisher及subscriber，導致第一個frame沒進入callback function，所以在播rosbag時加上—pause指令，先建立好連結，在開始播放，即可解決這個問題

3. 整個transformation被一部分的點拉走，造成converge score劇增

為了不讓ICP因為要配對某些點而偏掉，會觀察rviz的畫面，找出是哪個軸，哪個範圍的點造成的問題，並用passthrough filter將其過濾掉，例如task3時，一開始在直走時ICP的

matching效果很好，然而到了轉彎的地方localization就跑掉了，我就是透過調整setFilterLimits的參數來解決這個問題

Others Discussion or Findings

程式執行:

- task1: roslaunch localization task1.launch
- task2: roslaunch localization task2.launch
- task3: roslaunch localization task3.launch

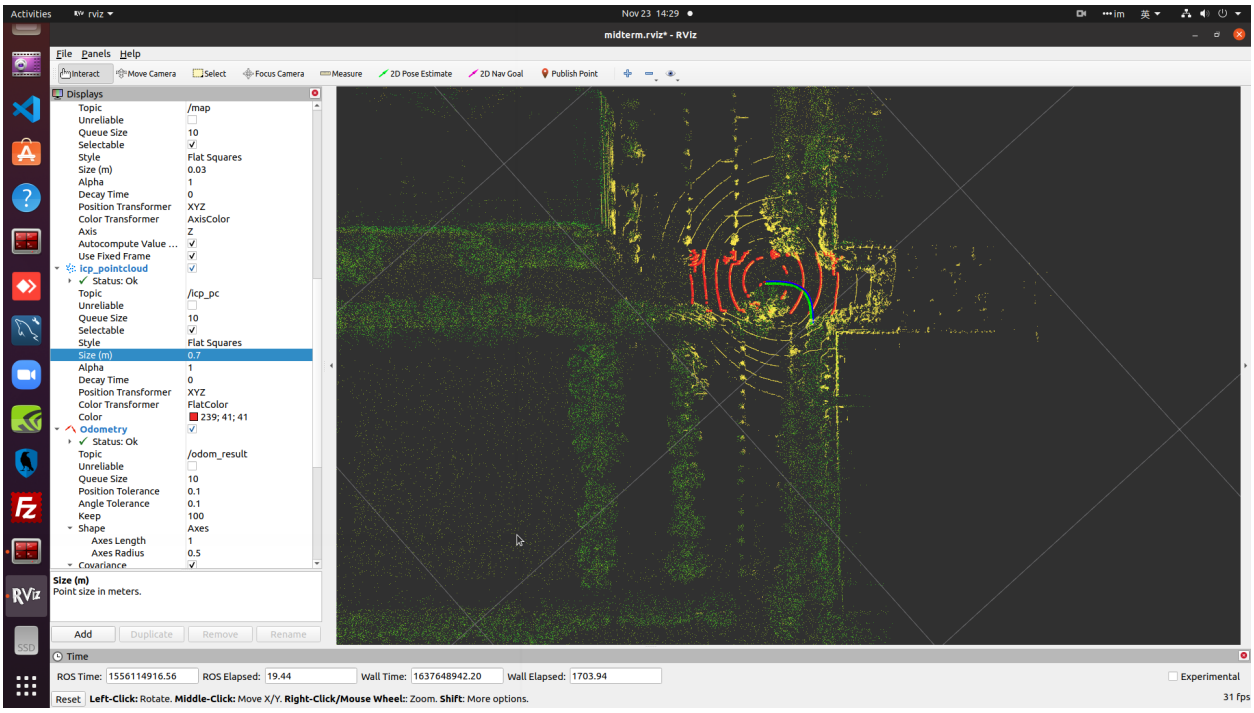
播rosbag

- task1: rosbag play sdc_localization_1.bag --clock -r 0.02 --pause
- task2: rosbag play sdc_localization_2_lite.bag --clock -r 0.02 --pause
- task3: rosbag play sdc_localization_3_lite.bag --clock -r 0.02 --pause

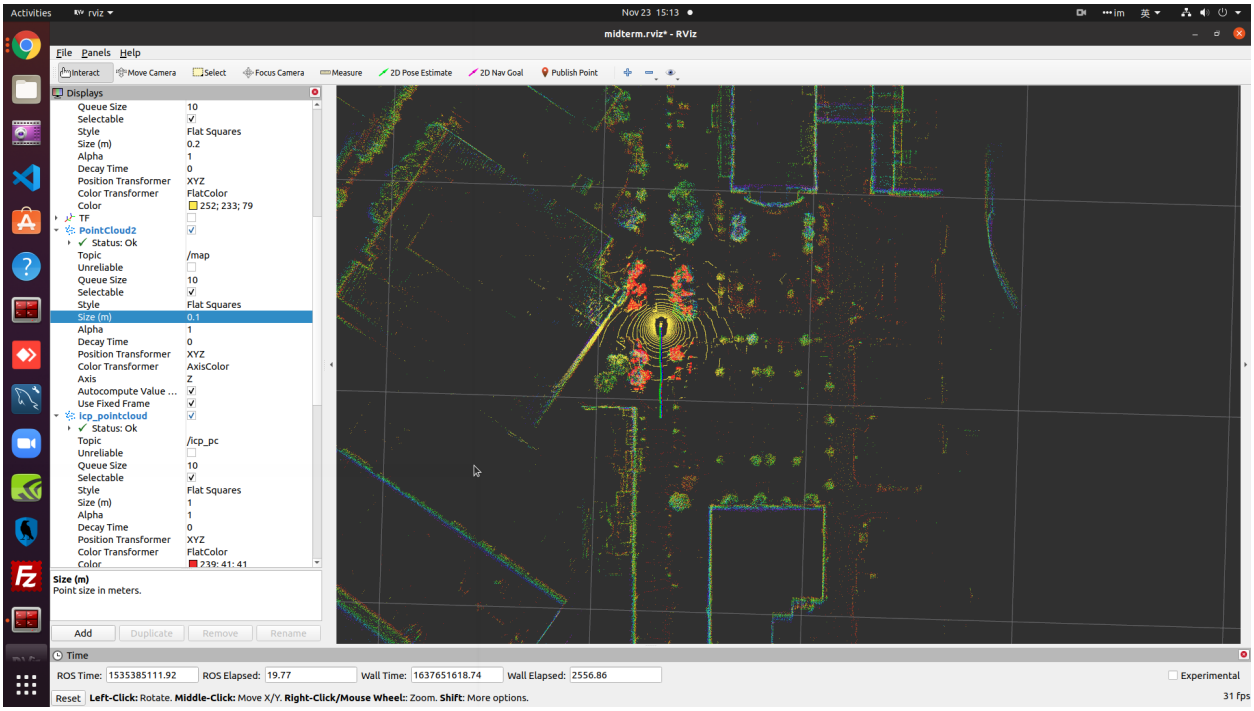
Rviz 畫面截圖

- 黃色為lidar點雲
- 紅色為經過ICP matching的點雲
- 彩色為map(ground thruth)
- 座標系曲線為Odometry

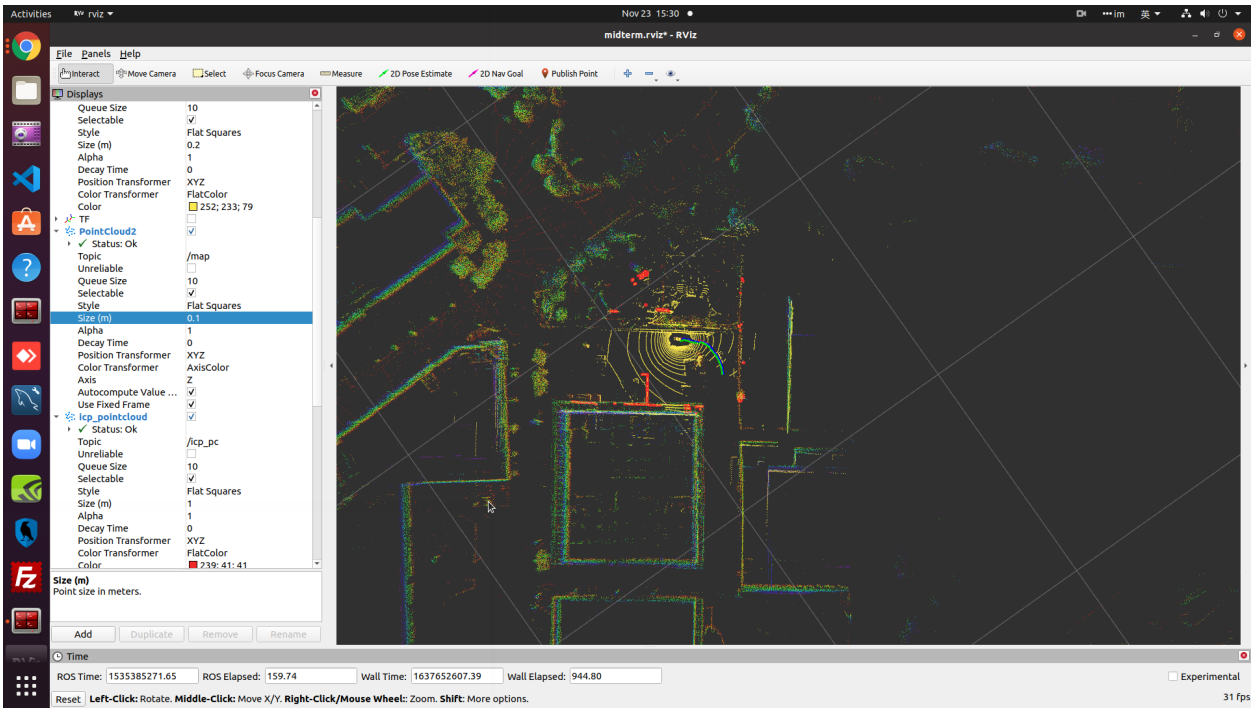
Task1:


Activities
rviz
Nov 23 14:29
midterm.rviz* - RViz
File Panels Help
Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point
Displays
Topic /map
Unreliable
Queue Size 10
Selectable
Style Flat Squares
Size (m) 0.03
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer AxisColor
Axis Z
Autocompute Value ...
Use Fixed Frame
icp_pointcloud
Status: Ok
Topic /icp_pc
Unreliable
Queue Size 10
Selectable
Style Flat Squares
Size (m) 0.7
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer FlatColor
Color 239; 41; 41
Odometry
Status: Ok
Topic /odom_result
Unreliable
Queue Size 10
Position Tolerance 0.1
Angle Tolerance 0.1
Keep 100
Shape Axes
Axes Length 1
Axes Radius 0.5
Covariance
Size (m)
Point size in meters.
Add Duplicate Remove Rename
Time
ROS Time: 1556114916.56 ROS Elapsed: 19.44 Wall Time: 1637648942.20 Wall Elapsed: 1703.94
Experimental
Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps

Task2:


Activities
rviz
Nov 23 15:13
midterm.rviz* - RViz
File Panels Help
Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point
Displays
Queue Size 10
Selectable
Style Flat Squares
Size (m) 0.2
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer FlatColor
Color 252; 233; 79
TF
PointCloud2
Status: Ok
Topic /map
Unreliable
Queue Size 10
Selectable
Style Flat Squares
Size (m) 0.1
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer AxisColor
Axis Z
Autocompute Value ...
Use Fixed Frame
icp_pointcloud
Status: Ok
Topic /icp_pc
Unreliable
Queue Size 10
Selectable
Style Flat Squares
Size (m) 1
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer FlatColor
Color 239; 41; 41
Size (m)
Point size in meters.
Add Duplicate Remove Rename
Time
ROS Time: 1535385111.92 ROS Elapsed: 19.77 Wall Time: 1637651618.74 Wall Elapsed: 2556.86
Experimental
Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps

Task3:


Activities
rviz
Nov 23 15:30
midterm.rviz* - RViz
File Panels Help
Interact Move Camera Select Focus Camera Measure 2D Pose Estimate 2D Nav Goal Publish Point
Displays
Queue Size 10
Selectable
Style Flat Squares
Size (m) 0.2
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer FlatColor
Color 252; 233; 79
TF
PointCloud2
Status: Ok
Topic /map
Unreliable
Queue Size 10
Selectable
Style Flat Squares
Size (m) 0.1
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer AxisColor
Axis Z
Autocompute Value ...
Use Fixed Frame
icp_pointcloud
Status: Ok
Topic /icp_pc
Unreliable
Queue Size 10
Selectable
Style Flat Squares
Size (m) 1
Alpha 1
Decay Time 0
Position Transformer XYZ
Color Transformer FlatColor
Color 239; 41; 41
Size (m)
Point size in meters.
Add Duplicate Remove Rename
Time
ROS Time: 1535385271.65 ROS Elapsed: 159.74 Wall Time: 1637652607.39 Wall Elapsed: 944.80
Experimental
Reset Left-Click: Rotate. Middle-Click: Move X/Y. Right-Click/Mouse Wheel:: Zoom. Shift: More options.
31 fps