作业说明

一、作业内容

1. 利用老师课堂提供的 C++代码和 pybind11 实现了在 python 中调用 PCL 的特征描述子提取函数。

* 按照老师提供的 github 中的 readme 安装，CMake 会自动链接到 python2.7，运行 python3 会报错。利用源码安装 PCL1.11 后问题解决。

* 由于一开始没有发现上面这个解决方案，我自己编译了工程，生成.so 文件后，import 该文件。我代码中 import libPCLKeypoints 而不是 PCLKeypoints，是因为我把 CMake 中的 project name 改了。

2. 自己实现了 fpfh，与 PCL 库进行了对比。其中，test.py 文件中是对比不同特征描述子提取方法的代码。fpfh.py 中是我自己实现的特征描述子提取方法。

二、作业结果

1. 我选择了 stool_0091.txt 文件中的点云，选择了一个角点作为参考点，同时又选择了 3 个与参考点非常相似的角点和 9 个与参考点差异较大的角点。

* 图 1-3 是相似点

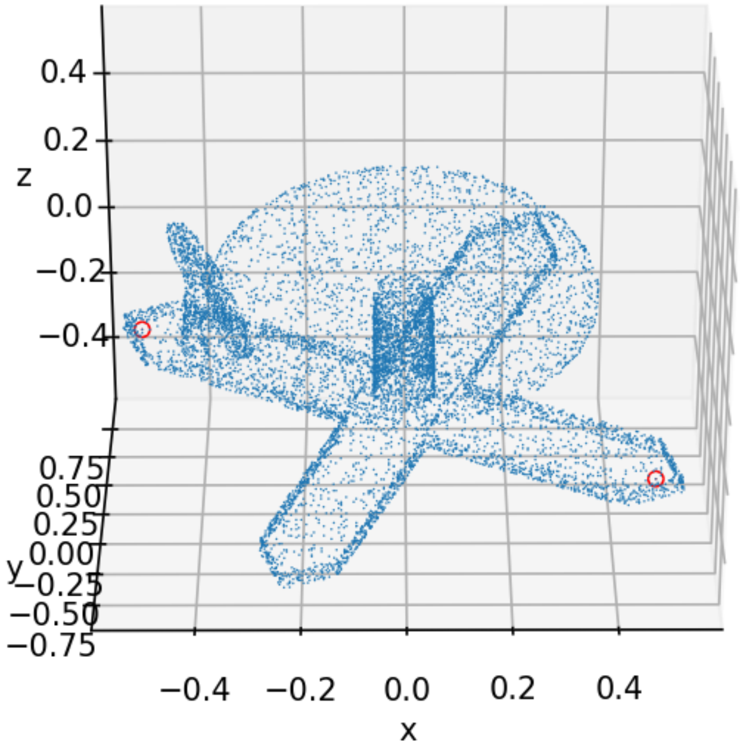


Fig 1. 参考点和相似点 1

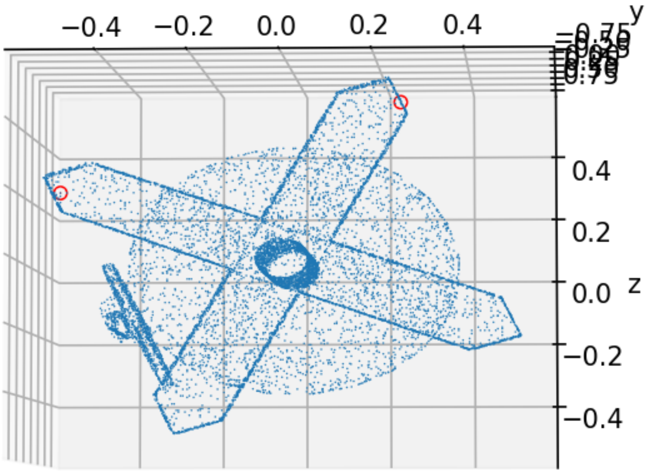


Fig 2. 参考点和相似点 2

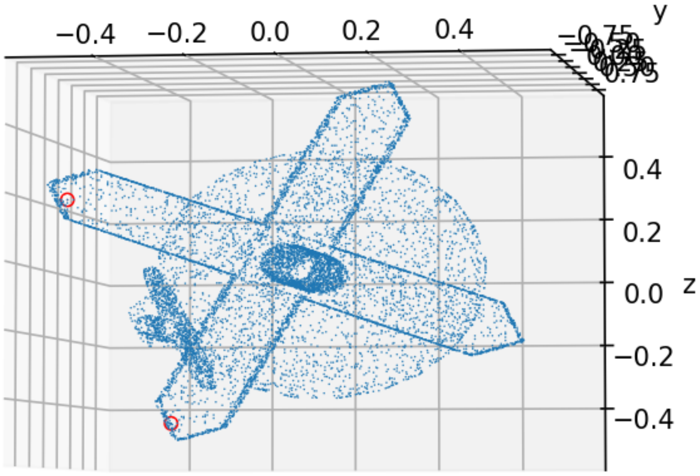


Fig 3. 参考点和相似点 3

* 图 4-6 是差异较大点

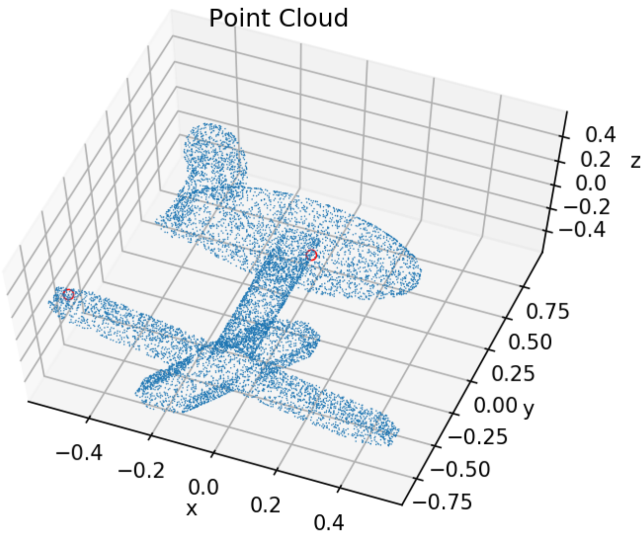


Fig 4. 参考点和差异点 1

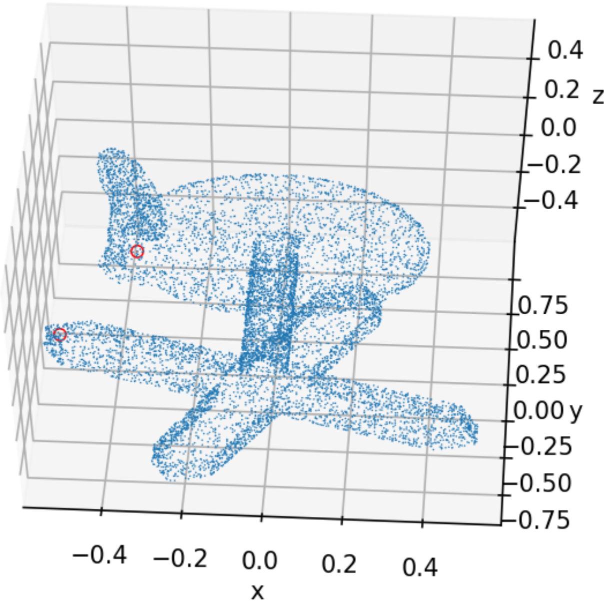


Fig 5. 参考点和差异点 2

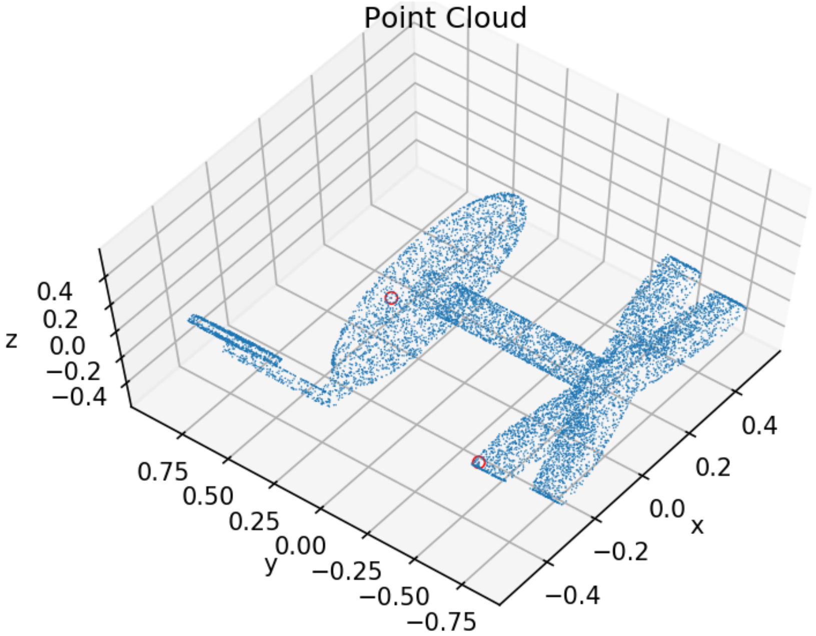


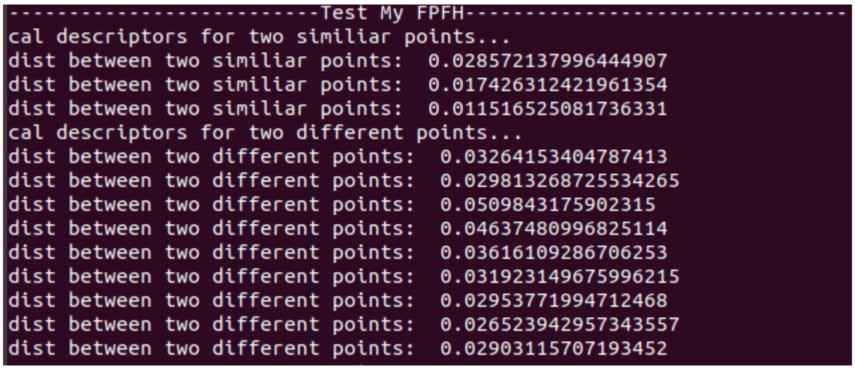
Fig 6. 参考点和差异点 3

2. 我借鉴汉明距离的思想设计了一个衡量两个描述子之间差异的距离函数。即 description 中相同 index 处的值做差取绝对值，然后再将所有的差取平均。函数返回值越大，两个 description 差异越大。距离的绝对值没有意义，要相对着比较。

最终结果如图 7-9 所示。

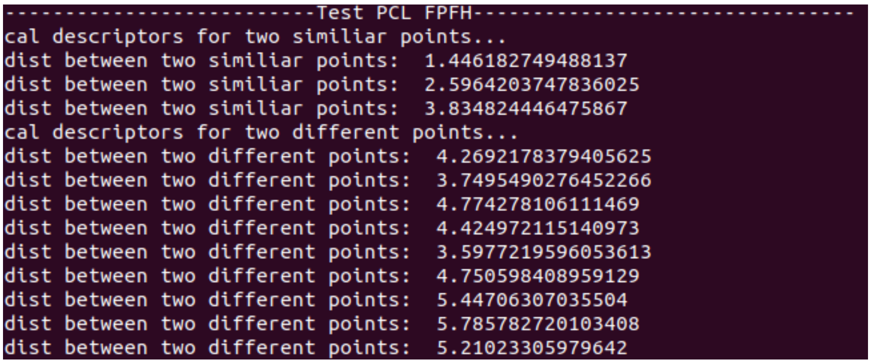
自己实现的 fpfh 和 pcl 的 fpfh 效果差不多，能看出相似点比差异点的距离小一点。但总存在判别效果不好的 case（都存在相似点的描述子距离比差异点还大的情况）。fpfh 效果不行可能是 feature radius 设置的有问题，我尝试调整了几次 feature radius，对结果的影响比较大。

由于 fpfh 随着 feature radius 的增大，耗时陡然上升，就没有测太多。



```
--------------------------Test My FPFH--------------------------------
cal descriptors for two similiar points...
dist between two similiar points:  0.02857213799644907
dist between two similiar points:  0.017426312421961354
dist between two similiar points:  0.011516525081736331
cal descriptors for two different points...
dist between two different points:  0.03264153404787413
dist between two different points:  0.029813268725534265
dist between two different points:  0.0509843175902315
dist between two different points:  0.04637480996825114
dist between two different points:  0.03616109286706253
dist between two different points:  0.031923149675996215
dist between two different points:  0.02953771994712468
dist between two different points:  0.026523942957343557
dist between two different points:  0.02903115707193452
```

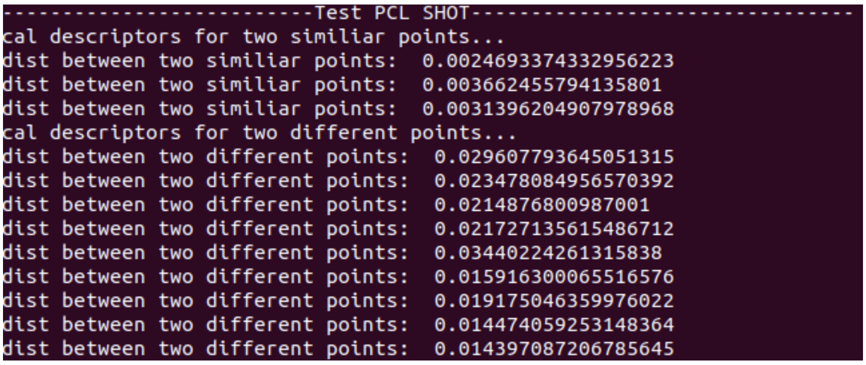
Fig 7. 自己实现的 fpfh 实验结果



```
--------------------------Test PCL FPFH--------------------------------
cal descriptors for two similiar points...
dist between two similiar points:  1.446182749488137
dist between two similiar points:  2.5964203747836025
dist between two similiar points:  3.834824446475867
cal descriptors for two different points...
dist between two different points:  4.2692178379405625
dist between two different points:  3.7495490276452266
dist between two different points:  4.774278106111469
dist between two different points:  4.424972115140973
dist between two different points:  3.5977219596053613
dist between two different points:  4.750598408959129
dist between two different points:  5.44706307035504
dist between two different points:  5.785782720103408
dist between two different points:  5.21023305979642
```

Fig 8. pcl 的 fpfh 实验结果

pcl 的 shot 非常明显地区分开了相似点和差异点（距离差了一个数量级）。



```
--------------------------Test PCL SHOT--------------------------------
cal descriptors for two similiar points...
dist between two similiar points:  0.0024693374332956223
dist between two similiar points:  0.003662455794135801
dist between two similiar points:  0.0031396204907978968
cal descriptors for two different points...
dist between two different points:  0.029607793645051315
dist between two different points:  0.023478084956570392
dist between two different points:  0.0214876800987001
dist between two different points:  0.021727135615486712
dist between two different points:  0.03440224261315838
dist between two different points:  0.015916300065516576
dist between two different points:  0.019175046359976022
dist between two different points:  0.014474059253148364
dist between two different points:  0.014397087206785645
```

Fig 9. pcl 的 shot 实验结果

3．耗时方面。自己实现的 fpfh 和 pcl 的 fpfh 方法，feature radius 稍微搞大点，耗时就一下子上去了，shot 表现则非常稳定的快。

三、提问

1．feature radius 是不是确实对结果的影响会比较大？该如何调参

2. 我现在是在 m40 数据集上，如果换到激光得到的点云，点与点之间的尺度一下子就变大了，这些参数如何跟着改动？

3. 除了开多线程，有哪些方法可以加速 fpfh 的速度？