CS 548: Assignment 01

Programming Assignments (95%)

python/Assign01.py

This Python script will contain the following functions:

- **def load_pcd(filename)**
  - This will read in a file in version 0.7 of the PCD format and return it as a (legacy) Open3D PointCloud.
  - PCD File Format Documentation: https://pointclouds.org/documentation/tutorials/pcd_file_format.html
  - You may make the following simplifications/assumptions:
    - The file is assumed to be in the correct format (e.g., no error checking is necessary).
    - Header section
      - You SHOULD be able to skip over comment lines (first character "#") or blank lines in the header.
      - The following lines will need to be processed:
        - FIELDS
          - You can expect the following possible fields:
            - x
            - y
            - z
            - normal_x
            - normal_y
            - normal_z
            - rgb
          - rgb represents a SINGLE value.
          - You may assume all values are a 32-bit float.
          - The ORDERING of these fields may be arbitrary.
        - POINTS
          - You may use this to read in the number of points (thus you can ignore the WIDTH and HEIGHT fields).
        - DATA
          - You need only find this to determine where the data section starts.

        - Data section
            - You may assume that the data is in ascii format (as opposed to binary or binary_compressed).
            - You may assume there are no comment lines or blank lines in the data section.
            - Remember that rgb is stored as a float. You will want to do the following:
                - Store the value as a numpy array with dtype=np.float32
                - Use the view() function to interpret it as a 32-bit unsigned int:
                    - rgb_i = rgb_f.view(np.uint32)
                - The individual RGB values are stored in different bytes:
                    - blue → lowest order byte
                    - green
                    - red
                    - (padding) → highest order byte
                - Use bit-shifting and masking to extract the individual channels.
                - Each channel has value range [0,255]; convert to float and rescale to [0,1].
                - Store floating-point color values.
            - In terms of the storage within your point cloud, you can assume numpy arrays of shape (point count, 3) of dtype=np.float32.
                - These will need to be converted via open3d.utility.Vector3dVector() before storage in the PointCloud object.
    - You are free to implement this in any reasonable fashion, EXCEPT you CANNOT use any Open3D loading functions!
        - You can of course use the no-arg constructor for PointCloud and the open3d.utility.Vector3dVector() conversion function.
- **def main():**
    - If the number of command line arguments (len(sys.argv)) is less than 2, print an error and exit(1)
    - Read the input file path from sys.argv[1]
    - Load the PointCloud using your load_pcd function.
    - Visualize your PointCloud with this function:
        - **o3d.visualization.draw_geometries([pcd], point_show_normal=pcd.has_normals())**

In addition, have the customary main function call on the bottom of your program:

if __name__ == "__main__": main()

src/include/PCD.hpp

This will include the prototype for one function:

pcl::PointCloud<pcl::PointXYZRGBNormal>::Ptr loadPCD(string filename);

You should have the following includes as well:

```
#pragma once
#include <pcl/io/pcd_io.h>
#include <pcl/point_types.h>
#include <pcl/common/common.h>
#include <iostream>
#include <sstream>
#include <fstream>
#include <cmath>
#include <cstring>
#include <unordered_map>
using namespace std;
```

src/lib/PCD.cpp

Include "PCD.hpp" and define the following:

- **pcl::PointCloud<pcl::PointXYZRGBNormal>::Ptr loadPCD(string filename)**
  - Create a Ptr to a PointCloud<PointXYZRGBNormal>.
  - Open the file identified by filename for reading.
  - If the file fails to open, print an error message and return nullptr.
  - The logic and rules for reading this file are similar to the Python version with two notable exceptions:
    - You will have to set the width and height fields of the point cloud (width = number of points, height = 1)
    - The rgb values stored in the points will REMAIN unsigned integer-like values in the range [0,255]
  - Remember to close the file once you are done.
  - As will the Python version, you are largely free to make any reasonable implementation that passes the tests, EXCEPT that you cannot use PCL's file loading functionality!
  - Return the Ptr to the point cloud.

src/app/Assign01.cpp

In the main function:

- If argc is less than 2, print an error message and exit.
- Load the cloud from the file at string(argv[1]) using your loadPCD function.
- Create a PCLVisualizer with:
    - A gray background (0.7, 0.7, 0.7)
    - Your point cloud
    - Your point cloud's normals (every 10th point, length of 0.01, black)
- Run the visualizer.

Testing Screenshot (5%)

I have provided several files for testing:

- data/assign01
    - BunnyXYZ.pcd
    - BunnyXYZN.pcd
    - BunnyXYZNRGB.pcd
    - BunnyXYZRGB.pcd
- python/
    - Test_Assign01.py – the test program for the Python code
- src/
    - include/
        - doctest.h
    - tests/
        - Test_Assign01.cpp – the test program for the C++ code
- CMakeLists.txt – updates to include testing

Run the testing program through the testing section of Visual Code.

You MUST run the tests and send a screenshot of the test results! Even if your program(s) do not pass all the tests, you MUST send this screenshot!

None of the tests check the main functions; I will test this manually.

Python Tests

You may have to do "Command Palette" → "Python: Configure Tests" → pytest → python (directory)

You should then be able to run the Python tests in your testing window in Visual Code.

ALTERNATIVELY: open a terminal and enter: **pytest python/Test_Assign01.py**

…then take a screenshot of the terminal output.

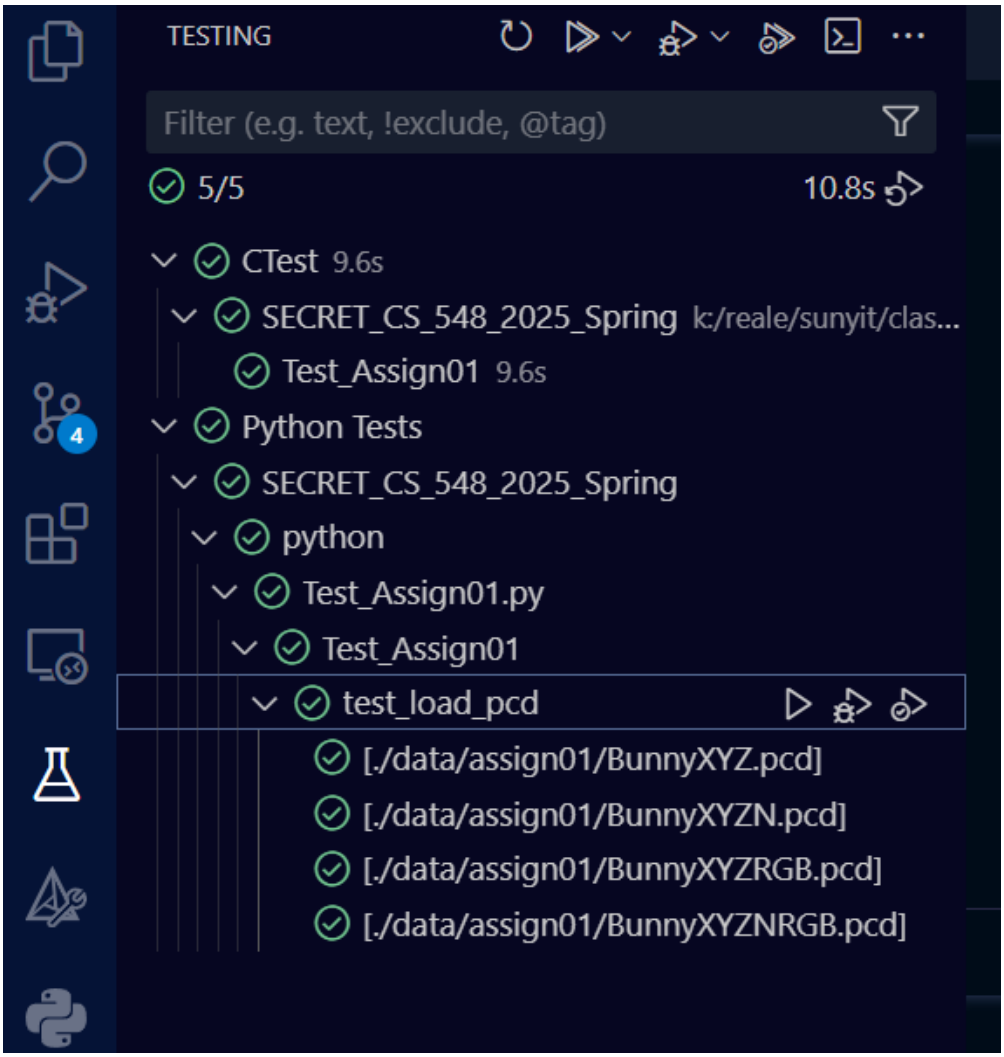
C++ Tests

In your CMake window, set the Debug test to Test_Assign01.

In the test window, run the tests in NON-debug mode!

Screenshot Example

This screenshot should show clearly the testing view in Visual Code:



Grading

Your OVERALL assignment grade is weighted as follows:

- 5% - Testing results screenshot
- 95% - Programming assignments

I reserve the right to take points off for not meeting the specifications in this assignment description. In general, these are things that will be penalized:

- **Code that is not syntactically correct (up to 60 points off!)**
- Sloppy or poor coding style
- Bad coding design principles
- Code that crashes, does not run, or takes a VERY long time to complete
- Using code from ANY source other than the course materials
- Collaboration on code of ANY kind; this is an INDIVIDUAL PROJECT
- Sharing code with other people in this class or using code from this or any other related class
- Output that is incorrect
- Algorithms/implementations that are incorrect
- Submitting improper files
- Failing to submit ALL required files

Hints

C++ Strings

Strings in C++ can be compared with ==

if(token == "DATA") { … }

C++ Bit Manipulation

You can shift things left and right in C++. For example, to shift two bytes to the right (puts it lower):

int new_val = (value >> 16);

You can also use a bit-wise AND to mask values; the following only keeps the lowest order byte:

int new_val = value & 0x000000FF;

Handling the Fields

To keep track of the fields and ordering, I recommend a **dictionary** in Python and an **unordered_map<string, int>** in C++. This will allow you to connect field to index.

You can check for the presence of a key in an unordered_map via count(): **if(myMap.count("x") > 0) {…}**

C++ Vectors

You can create a resizable list in C++ using a vector:

```
vector<string> myNames;
myNames.append("Bob");
int cnt = myNames.size();        // Returns 1
string n = myNames.at(0);
```

You can also allocate space ahead of time:

```
vector<string> myNames;
myNames.resize(10);              // myNames now has 10 items
myNames[2] = "Joe";
```

C++ File IO

Opening, checking, reading, and closing a file (as well as creating a string stream to parse a string):

```
ifstream file(filename);
// Is file open?
if(!file) {
    cerr << "ERROR: Could not open " << filename << "!" << endl;
    return nullptr;
}

string line;
while(getline(file, line)) {
    // Create string stream
    stringstream ss(line);
    // Read in token
    string token;
    ss >> token;
    // Read in float
    float f;
    ss >> f;
    // While it still has tokens, keep reading a new token
    while(ss >> token) {
       // Do stuff
    }
}

// Close file
file.close();
```