This part is to calculate 24 culm traits as has been showed in the following table

No.	trait	No.	trait
1	Max_area_culm	13	Max_diameter_culm
2	Mean_area_culm	14	SD_diameter_culm
3	SD_area_culm	15	Major_axis_culm
4	Max_APR_culm	16	Minor_axis_culm
5	Mean_APR_culm	17	Wall_thickness_culm
6	SD_APR_culm	18	MENTA
7	CHA_culm	19	MAXTA
8	CHR_culm	20	SDTA
9	CCR_culm	21	Total_volume_culm
10	Total_area_culm	22	Total_SA_culm
11	TN	23	Culm_density_mean
12	Mean diameter_culm	24	Culm_density_total

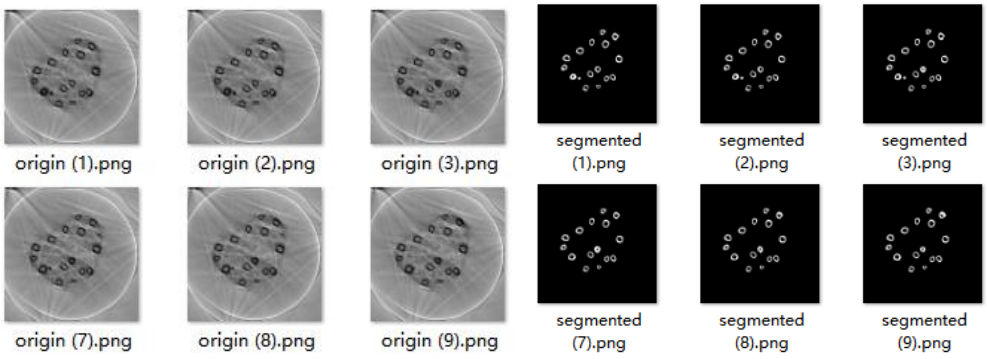
To employ the code for culm traits extraction, the file structure should be like the this:

/Sanple1/

origin/

segmented/

As has been provided in the demo, there are 80 original slices and 80 corresponding segmented slices of one single rice plant, original slices could been found in folder "/Sample1/original", and segmented slices in folder "/Sample1/segmented". Both origin slices and segmented slices were renamed regularly, for origin slices, there are "origin (1)", "origin (2)", "origin (3)", …, "origin (80)", and for segmented slices, there are "segmented (1)", "segmented (2)", "segmented (3)", …, " segmented (80)", make sure that "segmented (i)" is the binary segmented result of "origin (i)".



Make sure the variable value of "folder" in line 245 in "main.cpp" has been changed to the absolute path where you put the folder "Sample1".

```
336  void main() {
337      double resolution_XY = 0.07, resolution_Z = 0.7;
338      int sliceNumber = 80;
339      double culmVolume = 0;
340      double culm_density = 0;
341      double tillerNumber = 0;
342      bool output_cluster = true;
343      bool output_center = true;
344      bool output_regression = true;
345      string folder = "E:\\Sample1";      //change to the
346
```

Recommended environment to run the program

Visual studio 2015 (v140)

PCL-1.8

OpenCV 330

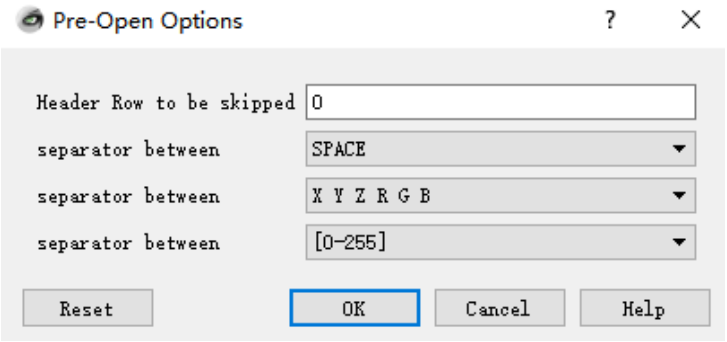
Results

Run the code and the console should output like this:

```
load images:  80/80
Not enough neighbors are considered: source of R=7639 is out of range! Co
Not enough neighbors are considered: ffn or sfn out of range! Consider in
!
Number of neighborhood size increase requests for fringe neighbors: 145
Number of neighborhood size increase requests for source: 118
Total_SA_culm = 17712
done
stem 0: ignored
stem 1: ignored
stem 2: number of counted layer: 80
stem 3: number of counted layer: 80
stem 4: ignored
stem 5: ignored
stem 6: number of counted layer: 80
stem 7: number of counted layer: 80
stem 8: number of counted layer: 75
stem 9: number of counted layer: 80
stem 10: number of counted layer: 80
stem 11: number of counted layer: 80
stem 12: number of counted layer: 80
stem 13: number of counted layer: 80
stem 14: number of counted layer: 75
11 stems were counted
Max_area_culm = 4930.11
Mean_area_culm = 3770.04
SD_area_culm = 919.276
Max_APR_culm = 23.7623
Mean_APR_culm = 19.6024
SD_APR_culm = 3.00245
MENTA = 78.9968
MAXTA = 84.1155
SDTA = 3.5206
Total_volume_culm (culm volume): 5.01818e+06
global_area_culm = 4181.82
Total _area_culm) ave_area_section = 62727.3
CHA_culm (ave_area_convexHull) = 865074
ave_area_circle = 1.19992e+06
CHR_culm (ave_ratio_section_to_convexHull) = 0.0757619
CCR_culm (ave_ratio_section_to_circle) = 0.054403
Culm_density_total (grayValue) = 1.187e+09
Culm density_mean (culm density) = 236.539
TN (tilletNumber) = 15
Mean_diameter_culm = 104.585
Max_diameter_culm = 107.003
SD_diameter_culm = 1.77271
Major_axis_culm = 111.183
Minor_axis_culm = 97.987
Wall_thickness_culm = 12.1478
```

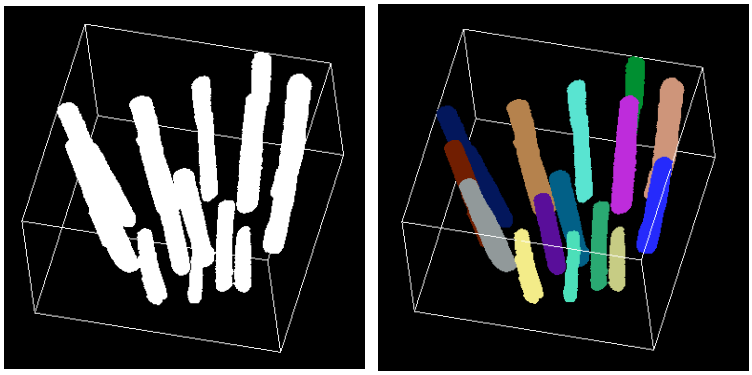
Now, there are several files, “center.txt”, “cluster.txt”, “regression.txt” and “surface.ply” in the folder “/Sample1”, these are generated automatically by the process and you can open these files

either with CloudCompare or Meshlab to find out how the code works and check the correctness of the process. If opened with Meshlab, pre-open options should be changed as follows:



Separated the culms

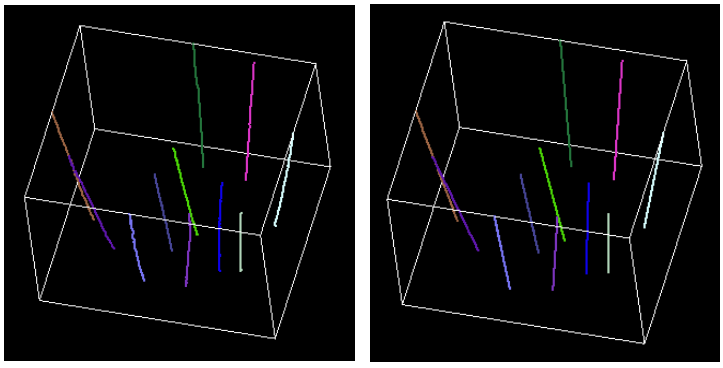
Together there are 80 slices for each rice plant, and they form the 3d image of the rice culm. The sections of culms form several connected components at different location in a segmented slice, the connected components of the sections of a specific culm changes gradually with height. According to graduality, it could be determined that which connected component at the next slice is corresponding to the current one. Thus the 3d image can be separated into several bunches, each bunch is the combination of sections of the same culm but locate at different height.



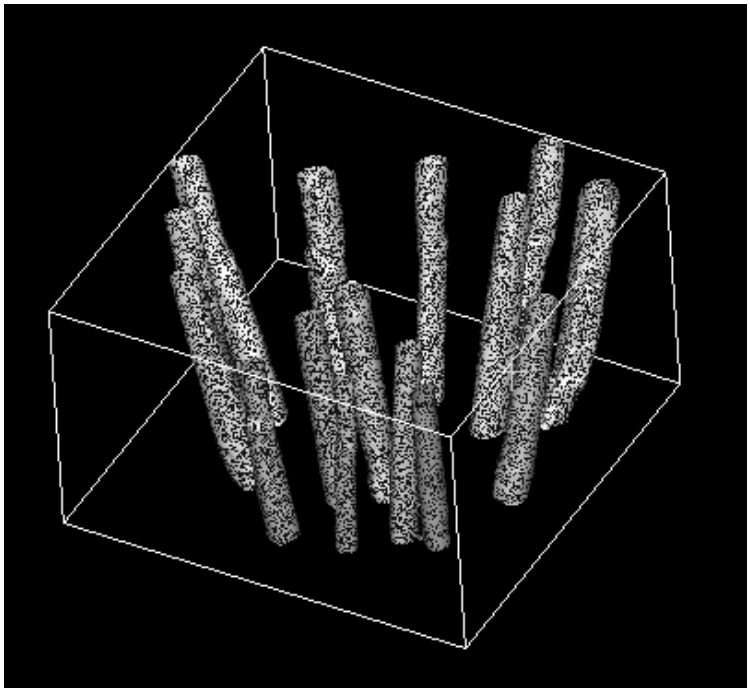
Cloud points of stems before (left image) and after (right image) clustering,
"/Sample1/cluster.txt" opened with CloudCompare

Compute tiller angles

After all the stems have been separated, for each stem, calculate the gravity center of each layer, determine the tiller angle of the stem according to the regression line of these gravity centers.



Gravity center points of each layer for each stem (left image) and regression line of each stem (right image)
"/Sample/center.txt" and "/Sample/regression.txt" opened with CloudCompare



Delaunay triangulation of external surface of stems
“/Sample/surface.ply” opened with CloudCompare

Look into “/Sample1/detail_param.txt” for more detail traits of each stem.

stemNum majorAxis minorAxis diameter wallThickness tillerAngle areaCulm areaCulmFilled perimeter ratio_area_perimeter
stem 0 96.3004 72.6362 84.4683 11.05 81.9798 3518.18 5353.16 288.545 18.5323
stem 1 114.555 99.4517 107.003 12.7352 81.0611 4930.11 8588.39 360.943 23.7623
stem 2 108.044 97.562 102.803 10.9819 77.8923 4584.21 7824.56 349.609 22.3698
stem 3 99.6605 79.2469 89.4538 12.1478 81.1561 4050.89 5698.95 305.068 18.6713
stem 4 107.864 96.4685 102.166 12.7231 84.1155 4656.83 7717.64 347.902 22.1528
stem 5 110.951 96.9472 103.949 12.7264 79.3468 4914.16 7991.42 361.762 22.0057
stem 6 88.9362 75.2006 82.0684 9.38894 81.3053 2932.38 4878.73 273.265 17.856
stem 7 99.3494 89.5362 94.4428 10.5316 79.2892 3591.48 6785.34 314.292 21.5875
stem 8 97.186 75.657 86.4215 9.61908 70.8486 3276.56 5516.16 293.477 18.7764
stem 9 64.9108 52.1475 58.5291 8.51455 75.269 1842.28 2554.57 199.059 12.8282
stem 10 89.1778 72.4307 80.8043 9.47944 76.7008 3173.36 4834.37 280.981 17.084