三维视觉与理解课程

实验一

环境配置

In [74]:
```
!pip install open3d
```

```
^C
```

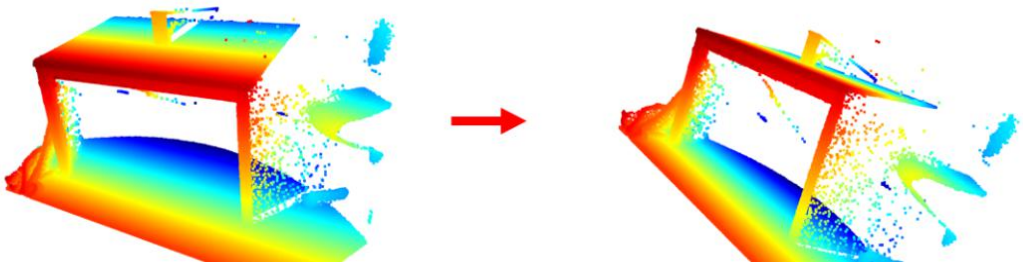
In [46]:
```
import open3d as o3d
import copy #点云拷贝库
import numpy as np
```

点云读写与可视化

In [71]:
```
#读点云：从文件路径处读取pcd格式的点云文件（table.pcd）
point_cloud = o3d.io.read_point_cloud("table.pcd")

#查看点云中，点的个数
print("原始点云：",point_cloud)
```

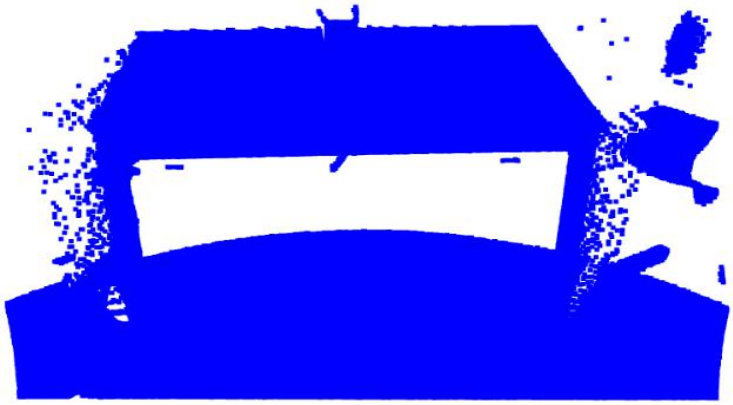
原始点云： PointCloud with 460400 points.

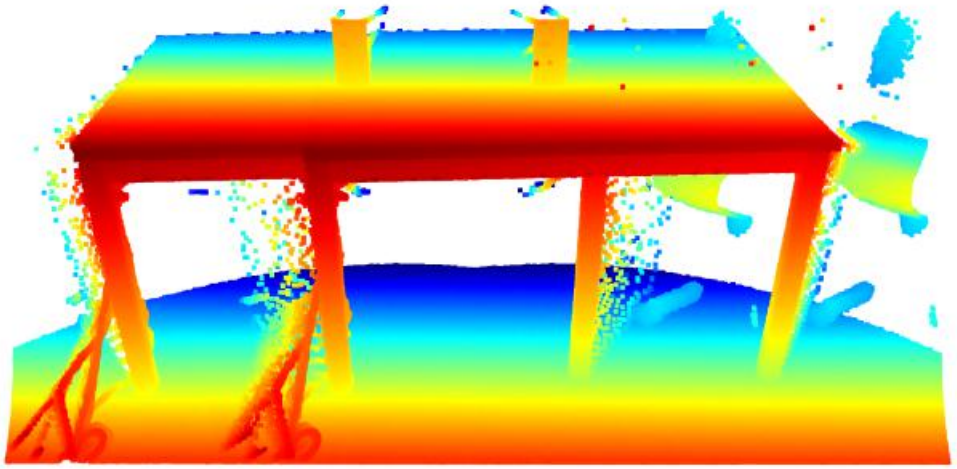
In [72]:
```
# 将点云复制，并将复制后的点云在x方向上平移若干个单位
o3d.visualization.draw_geometries([point_cloud],window_name="task1")
point_cloud_copy = copy.deepcopy(point_cloud).translate((50.0,0.0,0.0))
o3d.visualization.draw_geometries([point_cloud_copy],window_name="task2")
```



In [6]:
```
# 将复制后的点云统一染成任意颜色(与之前颜色不同)
point_cloud_copy.paint_uniform_color([0,0,1.0])
o3d.visualization.draw_geometries([point_cloud_copy],window_name="task1")

# 将染色后点云与原始点云合并为一个点云(相加)，并显示。
multi_point_cloud = point_cloud_copy + point_cloud
print("合并后的点云：",multi_point_cloud)
o3d.visualization.draw_geometries([multi_point_cloud],window_name="task1")
```

合并后的点云： PointCloud with 920800 points.





In [34]:
```
# 写点云：将合并后的点云保存在桌面位置，命名为t1.pcd
o3d.io.write_point_cloud('t1.pcd', multi_point_cloud)
```

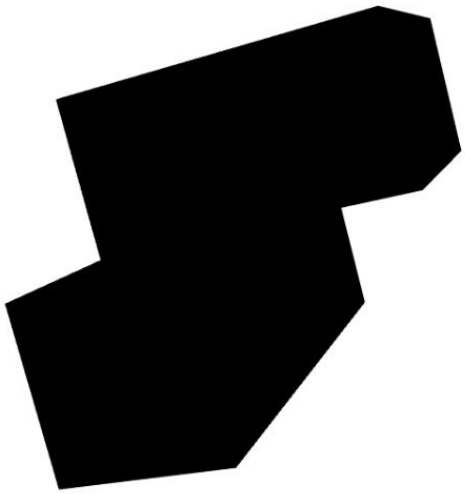
Out[34]: True

点云的体素化

In [61]:
```
#以斯坦福兔子点云（bunny.pcd）为基础，生成点云体素化之后的数据
bunny = o3d.io.read_point_cloud("bunny.pcd")
print("斯坦福兔子点云个数:",bunny)

bunny_3D = o3d.geometry.VoxelGrid.create_from_point_cloud(bunny,voxel_size=0.1)

print(bunny_3D)

o3d.visualization.draw_geometries([bunny_3D],window_name="task2")
```

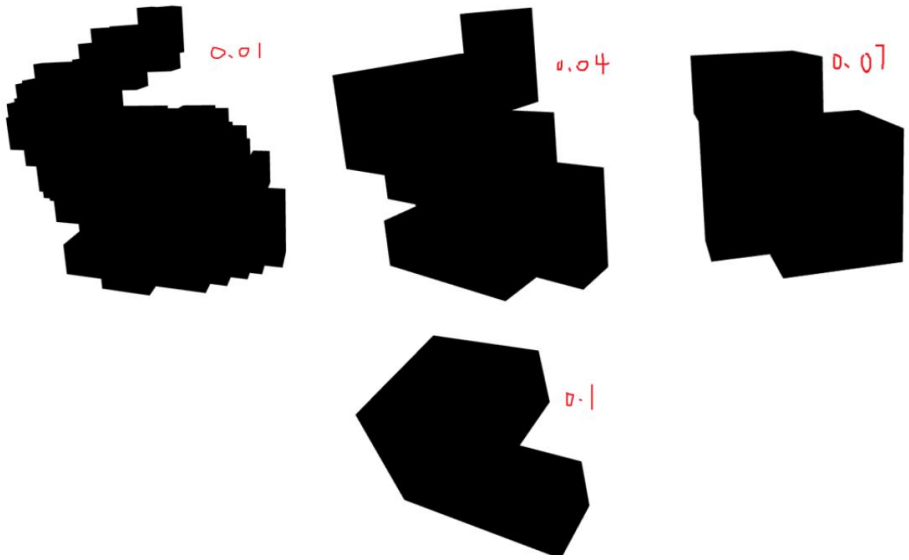
```
斯坦福兔子点云个数: PointCloud with 397 points.
VoxelGrid with 7 voxels.
```


```
斯坦福兔子点云个数: PointCloud with 397 points.
VoxelGrid with 7 voxels.
```

In [62]:
```
# 调整voxel_size，分别令其取值为0.01、0.04、0.07与0.1，并将体素化的结果进行展示。

vixel_size = [0.01,0.04,0.07,0.1]

for v_size in vixel_size:
    b = o3d.geometry.VoxelGrid.create_from_point_cloud(bunny,voxel_size=v_size)
    print(f"当前VixelSize为:{v_size}, {b}")
    o3d.visualization.draw_geometries([b],window_name="task")
```

```
当前VixelSize为:0.01, VoxelGrid with 333 voxels.
当前VixelSize为:0.04, VoxelGrid with 34 voxels.
当前VixelSize为:0.07, VoxelGrid with 15 voxels.
当前VixelSize为:0.1, VoxelGrid with 7 voxels.
[Open3D WARNING] [ViewControl] SetViewPoint() failed because window height and width are not set.
```



请回答：结合可视化实验结结果，用自己的语言描述，点云体素化是什么意思?

体素是什么？体素即体积像素。二维图片最小单元是像素，对应到三位空间最小单元即体素。点云体素化，即把每个拥有三个坐标值的点云映射成单个体素。点云数据三维格网化通常用于基于体素的深度学习数据预处理、局部相对特征计算以及投影。

请回答：Voxel_size参数在点云体素化中起到了什么作用?

Voxel_size是体素网格的分辨率，分辨率越高(voxel_size数低)体素化后的图形越接近真实形状，分辨率越低(比如上图0.1)体素化后的形状越接近方块，越抽象。

代码解读练习

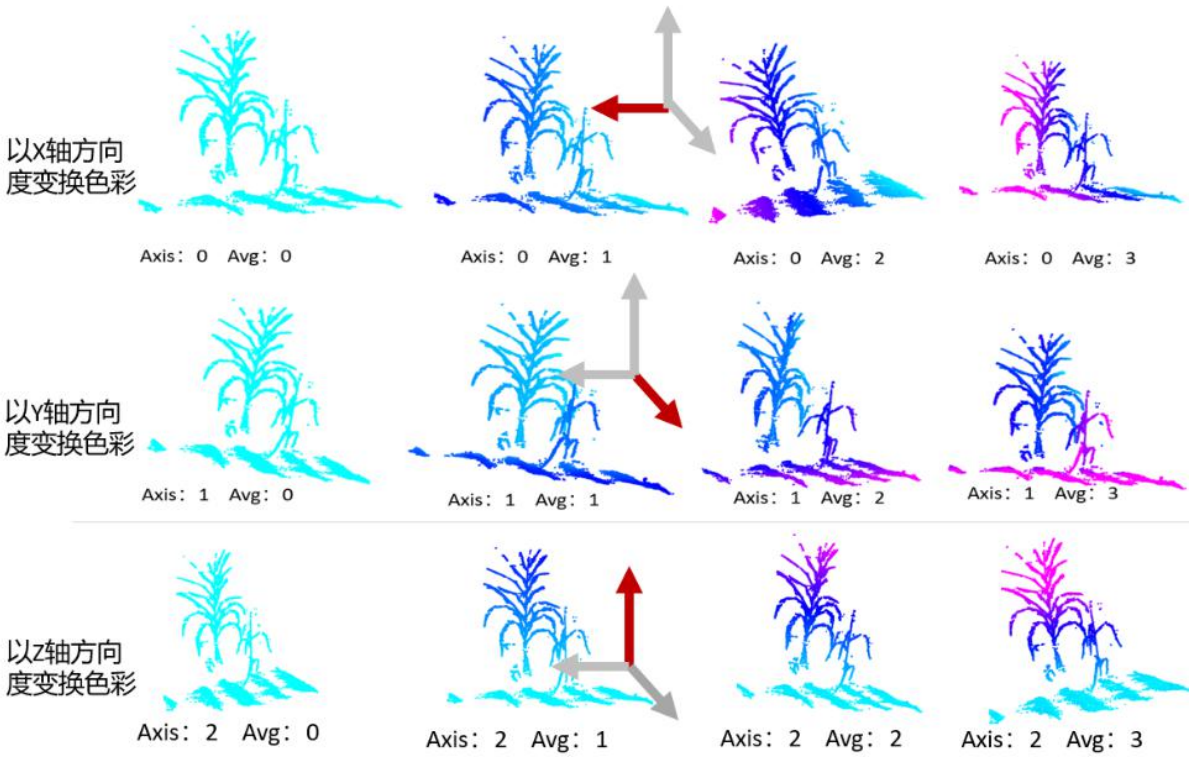
color.py代码中，实现了以点云（maize.pcd）坐标为依据，对点云进行渐变式赋色。请结合代码内容、可视化结果、控制台输出等

In [47]:
```
#读文件
cloud = o3d.io.read_point_cloud("maize.pcd")

#调颜色：绿色
cloud.paint_uniform_color([0,1,0])

#可视化
o3d.visualization.draw_geometries([cloud])

# 点云转换为数组
pts = np.asarray(cloud.points)
print("点云矩阵")
print(pts)
```

```
点云矩阵
[[ 7.0967999  -4.8207002   0.4303    ]
 [ 7.0918002  -4.8204002   0.43009999]
 [ 7.0840001  -4.8213      0.4298    ]
 ...
 [ 6.2782998  -3.3692999  -1.6933    ]
 [ 6.2722001  -3.3685999  -1.692     ]
 [ 6.2512002  -3.3620999  -1.6869    ]]
```

In [58]:
```python
# 改变轴
Axis = [0,1,2]  #### 按照Axis轴填颜色####

# 平分程度
Avg = [0,1,2,3]  ####调整颜色的多样性####

def fun(axis,avg):
    # 根据高度生成色彩
    colors = np.zeros([pts.shape[0], 3])  # 生成一个空的与点云相同大小的ndarray

    height_max = np.max(pts[:, axis])  # z轴最大

    height_min = np.min(pts[:, axis])  # z轴最小

    delta_c = abs(height_max - height_min) / (255 * avg)

    for j in range(pts.shape[0]):
        color_n = (pts[j, axis] - height_min) / delta_c
        if color_n <= 255:
            colors[j, :] = [0, 1 - color_n / 255, 1]
        else:
            colors[j, :] = [(color_n - 255) / 255, 0, 1]
    print(f"当前axis:{axis},avg:{avg}")
    print("颜色矩阵")
    print(colors)
    print("点云矩阵+颜色矩阵")
    print(np.concatenate((pts,colors),axis=1))
    cloud.colors = o3d.utility.Vector3dVector(colors)  # 给点云逐点赋色
    o3d.visualization.draw_geometries([cloud])  # 可视化

for axis in Axis:
    for avg in Avg:
        fun(axis,avg)
```

```
当前axis:0,avg:0
颜色矩阵
[[0. 1. 1.]
 [0. 1. 1.]
 [0. 1. 1.]
 ...
 [0. 1. 1.]
 [0. 1. 1.]
 [0. 1. 1.]]
点云矩阵+颜色矩阵
[[ 7.0967999  -4.8207002   0.4303      0.          1.          1.        ]
 [ 7.0918002  -4.8204002   0.43009999  0.          1.          1.        ]
 [ 7.0840001  -4.8213      0.4298      0.          1.          1.        ]
 ...
 [ 6.2782998  -3.3692999  -1.6933      0.          1.          1.        ]
 [ 6.2722001  -3.3685999  -1.692       0.          1.          1.        ]
```



(1)用自己的语言说明，从矩阵的角度看，点云中的每个点怎样被赋予不同颜色的?

染色点云矩阵 = 点云矩阵 X 颜色矩阵

(2)通过查阅代码，结合改变变量的实验结果，尝试阐明代码中的axis与avg变量的作用。

Axis：按照Axis轴填颜色
Avg：调整颜色的多样性

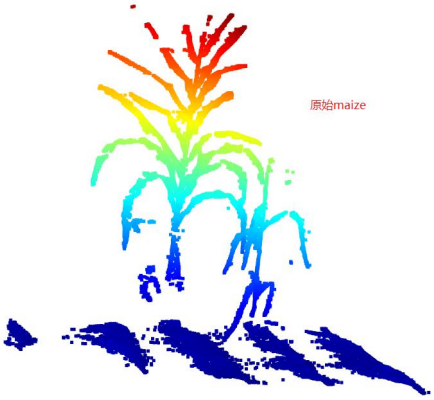
进阶任务

参照color.py代码，编写程序针对maize.pcd点云实现如下操作：x坐标≤7的点染为红色、x坐标＞7但≤7.4的点染为绿色、x坐标＞7.4的点染为蓝色，并将染色后的结果进行实时显示。

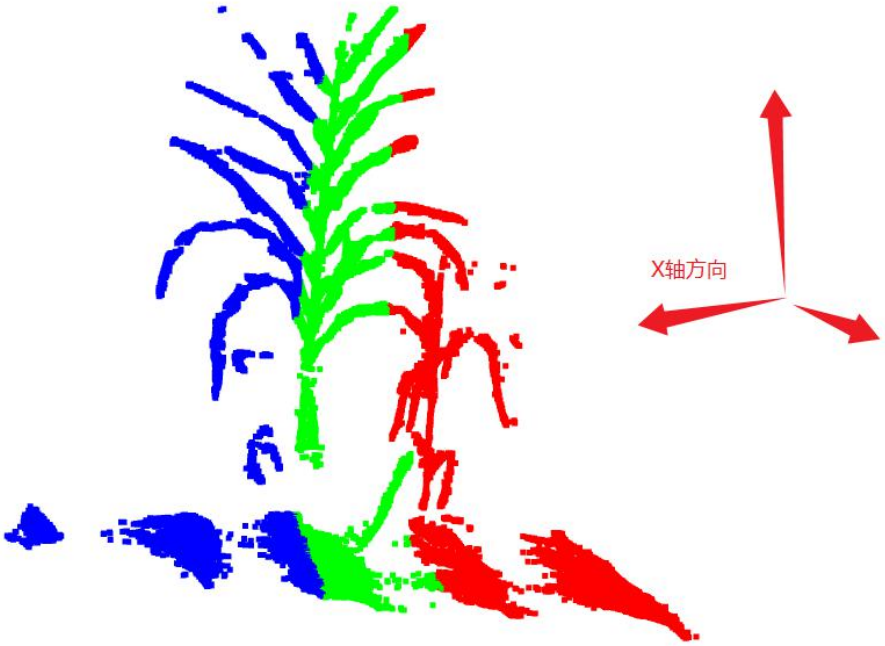
9]:
```
maize = o3d.io.read_point_cloud("maize.pcd")

print("点云个数：",maize)
```

```
点云个数： PointCloud with 39432 points.
```

0]:
```
o3d.visualization.draw_geometries([maize])  # 可视化
```



In [68]:
```
# x坐标≤7的点染为红色、x坐标＞7但≤7.4的点染为绿色、x坐标＞7.4的点染为蓝色

#初始化颜色矩阵
colors = np.zeros([len(cloud.points), 3])

#修改逻辑
for i, point in enumerate(cloud.points):
    x_coord = point[0]
    if x_coord <= 7:
        colors[i] = [1, 0, 0]  #red
    elif x_coord <= 7.4:
        colors[i] = [0, 1, 0]  #green
    else:
        colors[i] = [0, 0, 1]  #blue


cloud.colors = o3d.utility.Vector3dVector(colors)


o3d.visualization.draw_geometries([cloud])
```



实验总结

用自己的语言描述，点云和传统的2D图像有什么区别？从数据结构、数据特征、处理方法等角度，至少说出两点。

数据结构方向：点云包含点的三个维度，是空间点集，基本数据单元是体素，而传统2D图形是二维的，图片是二维像素点集，基本单元是像素。
数据特征方面：点云3D点的集和，2D图形是2D像素点的集和。
处理方法方面：点云可以对三个维度方向进行操作，有空间旋转、三维平移、翻转，而图像是两个维度操作，即普通的平移变换，对称变换。