3D Annotation Tool

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1 Introduction

3D Annotation Tool is an application designed to annotate objects in a point cloud scene. Initially, it was developed with the aim to annotate the objects of a table. The rest of the document is written with the intention of annotating objects in a table scenario without loss of generality. The format of the point cloud supported is .pcd[1]. The 3D Annotation Tool has been developed by Adrià Gallart del Burgo at KTH in 2013.

This software can perform:

Plane detection The program estimates the plane of the table or "*table plane*" automatically using RANSAC[2].

Plane definition If the plane detection estimates a wrong plane, it is possible to manually define the table plane by picking *any* three points located on the table plane.This situation arises only when the automatic plane detection algorithm in the tool detects a plane other than the table plane as the most dominant plane in the scene.

Plane segmentation Once the table plane is defined, a Plane segmentation is done by picking three *specific* points 3.2.5.

Object annotation An object is annotated by defining a cuboid containing all the points that make up the object. This cuboid is called the *bounding box*. To annotate each object, a bounding box and its pose is defined as it is shown in the image below:

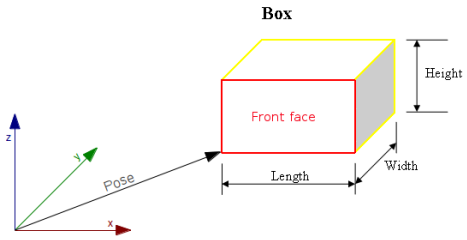

Figure 1: Bounding box and its pose

The orientation of the bounding box is defined by the roll, pitch and yaw angles.

Export object information The information of all annotated objects and the dimensions of the table is export into a .xml file.

Import object information The information of previously annotated objects can be imported from Import from a .xml file.

[1] http://pointclouds.org/
[2] http://en.wikipedia.org/wiki/RANSAC

1.1 Prerequisites for Installation

Two options are available to install the prerequisites for the 3D Annotation Tool. The first requires the previous installation of the *ROS Groovy*[3].

ROS Groovy If the ROS Groovy is installed in your machine:

1. Make sure that the pcl package is installed inside the ros. If it is not installed:

   ```
   sudo apt-get install ROS Groovy-pcl.
   ```

2. Install the vtk-qt library:

   ```
   sudo apt-get install libvtk5.8-qt4
   ```

Without ROS Groovy If the ROS Groovy is not installed, the pcl library has to be installed. The following is required:

1. **PCL library:**

   ```
   sudo add-apt-repository ppa:v-launchpad-jochen-sprickerhof-de/pcl

   sudo apt-get update

   sudo apt-get install libpcl-all-dev
   ```

2. **VTK-QT library:**

   ```
   sudo apt-get install libvtk5.8-qt
   ```

1.2 Installation of the 3D Annotation Tool

To install the 3D Annotation Tool execute the sequence of commands:

1. `cd` */your/path/3d_annotation_tool/*
2. `mkdir build`
3. `cd build`
4. `cmake ..`
5. `make`

The above commands build the 3D Annotation Tool. To run the application:

1. `cd` */your/path/3d_annotation_tool/bin*
2. `cd bin`
3. `./Annotation_tool`

[3]Available in: http://ros.org/wiki/groovy/Installation/Ubuntu

2 Interface

2.1 Main Window

Below is a screenshot of the 3D Annotation Tool GUI:

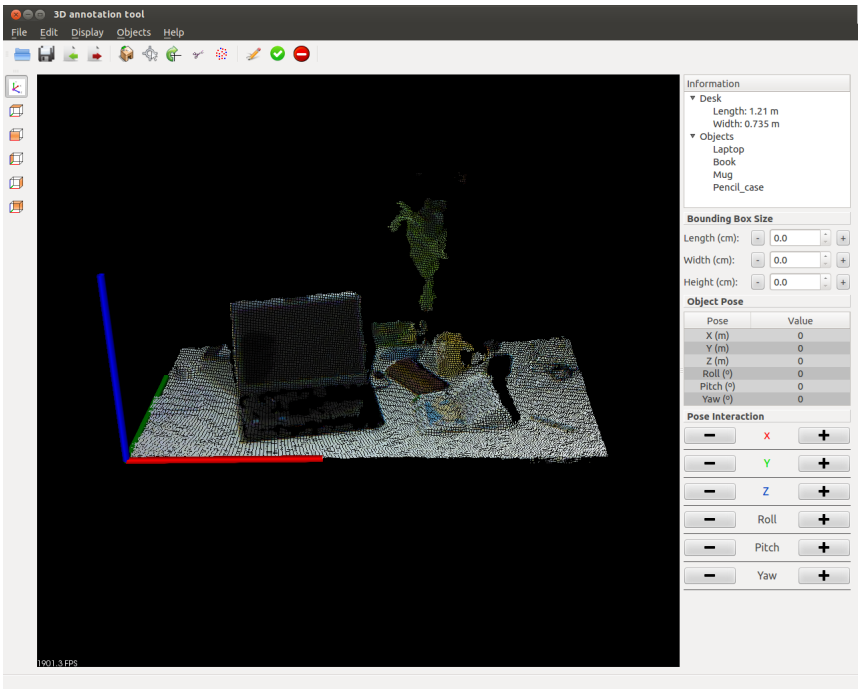

Figure 2: Main window

In the above figure we can see the following sections:

1. **Menu Bar:** It has access to the functions grouped in File, Edit, Objects and Help.
2. **Toolbar:** Two different toolbars are available giving quick access to some functions.
3. **Information:** This widget gives information about all the objects annotated and the dimensions of the table.
4. **Bounding Box Size:** This widget modifies the dimensions of the bounding box that contains the object of interest (OI).
5. **Object Pose:** This widget displays the pose of the bounding box containing the OI. This field also allows the user to manually modify all the pose parameters (x-y-z and roll-pitch-yaw). The absolute pose parameter values can be manually entered here.
6. **Pose Interaction:** This widget modifies the pose of the bounding box containing the OI. However, this modifies the pose parameters in predefined step sizes only (1 cm or 1 degree accordingly).

7. **3D visualizer:** This is a widget which provides a field to visualize the point cloud.

2.2 Information Widget - details

The Information widget contains details about the table size and all the objects annotated. When "Table" is selected or the triangle icon is clicked, it displays the dimensions of the table in the widget. When "Objects" is selected or the triangle icon is clicked, all annotated objects are displayed as a list in the widget. Also, when "Objects" is clicked, all the annotated objects are highlighted in different vivid pre-chosen colors.

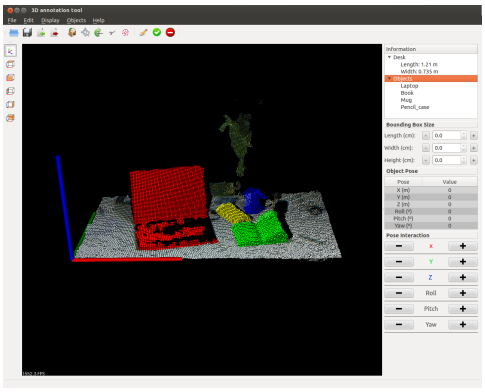

Figure 3: All objects highlighted in vivid pre-chosen colors

When a particular object in the "Objects" list is selected, only that object is highlighted in the scene and it's bounding box is displayed. Moreover, it is also possible to modify the bounding box's properties by changing the pose and the dimensions of the bounding box 3.4.1.

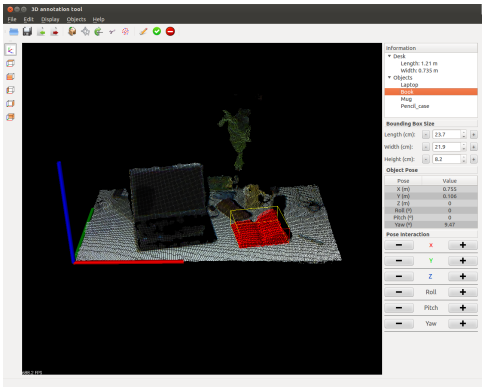

Figure 4: One object selected and it's bounding box

2.3 3D Visualizer Widget - details

In the 3D Visualizer the point cloud loaded by the user is displayed along with the reference spatial coordinate system.

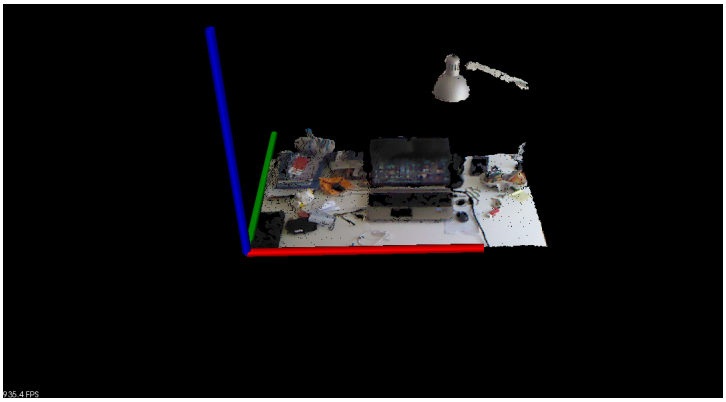

Figure 5: 3D visualizer

2.3.1 Interactivity

Using the mouse, it is possible to change the point of view. The next modifications can be done:

Rotation To rotate the current scene displayed in the 3D Visualizer widget follow these steps:

1. Assume there is a coordinate system with horizontal and vertical axes overlaid on the 3D Visualizer widget with the origin at the center of the widget.
2. Hold down the left mouse button at any point in the 3D Visualizer.
3. Moving the cursor parallel to the horizontal axis makes the scene rotate about the vertical axis.
4. Moving the cursor parallel to the vertical axis makes the scene rotate about the horizontal axis.
5. If all this is too hard for you - just hold down the left mouse button and shake the mouse randomly and vigorously until you get the desired rotation :D.
6. For further instructions to use the mouse please refer the documentation at `http://windows.microsoft.com/is-is/windows-vista/using-your-mouse` :D :D :D.

Zoom Zoom in/out is done by scrolling the mouse.

Translate Holding down the scroll of the mouse performs a translation of the scene in the widget.

It is also possible to interact with the visualizer using the keyboard and some of the interactions are listed below:

Take snapshot Pressing j or J it is possible to take a .PNG snapshot of the current window view.

Display scale grid A scale grid corresponding to the previously defined imaginary axes is available for toggle by pressing g or G.

Help If h is pressed all the possible keyboard interactions are shown in the terminal.

2.4 Toolbar - details

The buttons available in the toolbar are listed below along with their respective actions:

Button	Action	Description
	Open	Section 3.1.1
	Save	Section 3.1.2
	Import	Section 3.1.3
	Export	Section 3.1.4
	Plane detection	Section 3.2.2
	Plane definition	Section 3.2.3
	Rotation	Section 3.2.4
	Plane segmentation	Section 3.2.5
	Downsample	Section 3.2.6
	Coordinate system	Section 3.3.1
	Top view	Section 3.3.2
	Front view	Section 3.3.2
	Left view	Section 3.3.2
	Right view	Section 3.3.2
	Back view	Section 3.3.2
	Insert object	Section 3.4.1
	Confirm object	Section 3.4.2
	Delete object	Section 3.4.3

3 Functions

3.1 File Menu

3.1.1 Open PCD file

To load a .pcd file the following dialog box is opened to select the desired file:

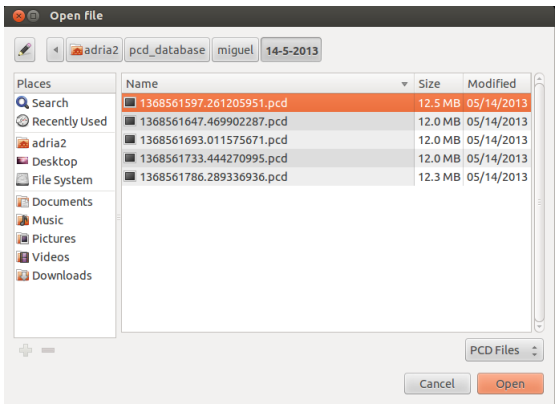

Figure 6: Load file

3.1.2 Save PCD file

If the point cloud has been modified it is possible to save it. This should usually be done at least after the Plane segmentation.

3.1.3 Import object information

If in a previous session the user has saved the scene's information in a .xml file, this information can be imported and loaded. Then it is possible to modify this file by adding/deleting some objects or change their pose and inclusion properties.

3.1.4 Export object information

Exports the annotation information into a .xml file with all the details about the scene and it's objects. This is the information saved:

1. Type of the scenario (desk or floor).
2. Point cloud file name for which the annotation was performed.
3. Dimensions of the table (length and width).
4. Number of objects annotated.
5. For each annotated object the following is saved:
   - Name of the object.

- Highlight color associated with that object (see figure 3).
- Absolute pose of the bounding box with respect to the fixed reference spatial coordinate system: x-y-z coordinates and the roll, pitch and yaw angles.
- Dimensions of the bounding box: length, width and height of the bounding box.
- Indices: all the indices of the points contained in the defined bounding box for this object.

Below is shown an example of the output file obtained:

```
<scenario>
    <type>desk</type>
    <annotatedFrom>/data/example_segmentated.pcd</annotatedFrom>
    <dimensions>
        <length>1.21264</length>
        <width>0.741531</width>
    </dimensions>
    <allObjects>
        <numberOfObjects>3</numberOfObjects>
        <object>
            <name>Laptop</name>
            <color>red</color>
            <pose>
                <x>0.293258</x>
                <y>0.0700548</y>
                <z>0</z>
                <roll>0</roll>
                <pitch>0</pitch>
                <yaw>0.211196</yaw>
            </pose>
            <dimensions>
                <length>0.38</length>
                <width>0.38</width>
                <height>0.27</height>
            </dimensions>
            <indices>3014 3015 3026 3027 3028 3029 3030 3031 3032
                3033 3034 3035 3036 3037 3038 3039 3040 3041 3042
                3043 3044 3055 3056 3057 3058 3059 652 48653 48654
                 48655 48656  </indices>
        </object>
        <object>
            <name>Mug</name>
            <color>blue</color>
            <pose>
                <x>0.787483</x>
                <y>0.460005</y>
                <z>0</z>
                <roll>0</roll>
                <pitch>0</pitch>
                <yaw>0.00677016</yaw>
            </pose>
            <dimensions>
                <length>0.12</length>
                <width>0.1</width>
                <height>0.11</height>
            </dimensions>
```

```
44          <indices>10122 10123 10124 10125 10313 10314 10315
                10316 10317 10318 10319 10506 10507 10508 10509
                10510 10511 10512  </indices>
45      </object>
46      <object>
47          <name>Pencil_case</name>
48          <color>yellow</color>
49          <pose>
50              <x>0.745578</x>
51              <y>0.325982</y>
52              <z>0</z>
53              <roll>0</roll>
54              <pitch>0</pitch>
55              <yaw>0.596957</yaw>
56          </pose>
57          <dimensions>
58              <length>0.11</length>
59              <width>0.21</width>
60              <height>0.05</height>
61          </dimensions>
62          <indices>18318 18319 18320 18321 18322 18323 18694
                18695 18696 18697 18698 18699 18700 18701 19062
                19063 19064 19065 19068 19069 19070 19071 19072
                19073 19074 19075 19076 19077 19078 19439 19440
                19441  </indices>
63      </object>
64    </allObjects>
65 </desk>
```

3.2 Edit Menu

The software provides some different tools to modify the loaded point cloud scene such as plane detection, rotation and segmentation. The goal of all the modifications is to change the point cloud to get the coordinate origin in the lower left corner of the table and align the x-axis to the table's front edge and the y-axis to the left edge of the table. Therefore, after doing this action we would like to have our point cloud as in the figure below.

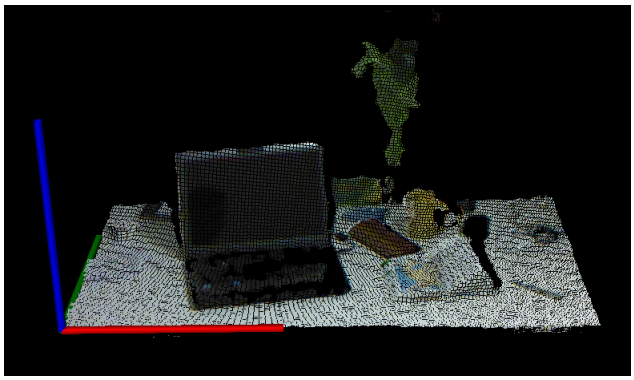

Figure 7: Desired location of the coordinate system

3.2.1 Undo

This provides the option to be able to undo the actions of Filter (Section 3.2.6) and Plane segmentation (Section 3.2.5).

3.2.2 Automatic plane detection

When using the automatic plane detection the software performs a plane detection using the RANSAC method. Once the plane detection is completed, the point cloud is rotated and translated such that the detected dominant plane is parallel to the x-y plane of the reference spatial coordinate system.

3.2.3 Manual plane definition

Depending on the point cloud, sometimes the automatic plane detection cannot exactly detect the dominant plane as humans perceive it semantically. In such a case the dominant plane is chosen manually by selecting three points belonging to it and in doing so enforce the plane detection algorithm to consider this new chosen plane as the dominant plane in the scene.

3.2.4 Roll 180

Sometimes, after having detected the correct dominant plane in the scene, it might be required to rotate the z-axis of the point cloud by 180 degrees to obtain the correct position of the coordinate system. This is achieved using this functionality.

3.2.5 Plane segmentation

This option provides a means to segment the dominant plane in the scene. This also implicitly places the coordinate system to the lower left corner of the dominant plane. This action removes all the points outside and under the dominant plane. Also is asked to the user which is the scenario.

3.2.6 Downsample

Downsample option gives the user a means to reduce the number of points in the displayed point cloud scene. This is useful when the resolution is higher than required for that scene. If the point cloud resolution is unnecessarily high it causes slowing down of the interactivity of the system. The Downsample works using user inputs to create a lower resolution voxel grid which merges many points in a voxel into a single point.

3.2.7 Preferences

This option provides the possibility to switch off some redundant user information messages during repeated use.

3.3 Display Menu

3.3.1 Coordinate system

It is possible to show and hide the axes of the reference spatial coordinate system in the 3D Visualizer.

3.3.2 Perspective

The perspective can be chosen from amongst five different options: Top view, Front view, Left view, Right view and Back view.

3.4 Objects Menu

The annotation of the objects is the most important feature of this software. To object is defined by specifying the pose and dimensions of the bounding box that can efficiently encapsulate the points belonging to the object in the scene. The pose of the bounding box is defined using the lower left corner after specifying the "*front-face*" of the box (figure 1).

3.4.1 Insert new object

When the user wants to insert an object in the annotated list, an initial rough bounding box is insert by picking 4 particular points. The front side of the bounding box is drawn in red and the points inside the bounding box are highlighted. To fit all the points belonging to the object, the bounding box can be modified using the Bounding Box Size, Object Pose and Pose Interaction widgets (Section 2.1).

1. **Bounding Box Size:** The length, width and the height of the bounding box can be modified in two ways: with the + and - buttons or manually inserting a value.

2. **Object Pose:** The pose of the object can be modified to any resolution by manually editing the current value displayed.

3. **Pose Interaction:** The pose of the object can be modified by predefined step sizes by using the + and - buttons.

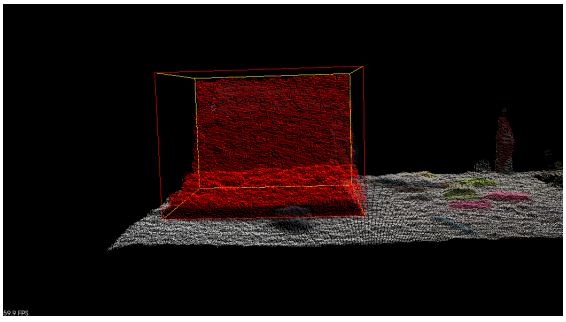

Figure 8: Inserting an object

3.4.2 Confirm position

Once the bounding box is constructed around the points of the OI this option confirms the position and saves all the pose and dimension information related to the object.

3.4.3 Delete object

If the user for some reason wants to delete a previously annotated object, it can be done by selecting the name of the object from the annotated list.