Project : 3D Scanner

General Progress Report : 9

Group Number : 2

Submitted to : Yohan Fougerolle

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Centre Universitaire Condorcet - Master Computer Vision

1. OBJECTIVE

The goal of this report is to briefly explain the development,difficulties and future aspects of the project 3D scanner with a small summary of overall progress.

2. TASKS ASSIGNED LAST WEEK

- Zain - Filtering by depth and saving data.
- Sepideh and Utpal - Planar Removal.
- Yamid and Mohit - Streaming through GUI Qt with advancement.
- Julia and Marc - Optimizing and Combining Code.
- Leo and Wajahat - Applying Meshes and Finishin ICP.
- Thomas, Carmen and Omair - Solving 3D reconstruction issues.

Github link : https://github.com/WajahatAkhtar/Project-S.E.

2.1. Filtering by depth and saving data

We worked on the task of filtering point cloud data along the x, y, z axis and saved them in a vector so that it could be used for post processing.

Filtering was already accomplished but when trying to save all the data in a vector, the computer we used hanged after approximately 15 minutes of aquisition.We then decided to save only some images at a specified time interval lets say 2 seconds.

We used the library QElaspedTimer to instantiate a timer object which restarts every 2 two seconds. Simultaneously, an if condition montiors the state of the timer and as soon as it crosses two seoconds, a variable of type boolean is set to true and at the same time another if condition is monitoring the state of our boolean variable. If the variable is true, it is set back to false and our vector stores the pointcloud data at that time.

This task is sucsessfully done and the next step is to compile all this code(Kinect graber, viewer, filtering and saving) into a class.

2.2. Planar Removal

2.2.1. First Approch

We did the literature survey on the topic and studied one recent paper .Automated Removal of Planar Clutter from 3D Point Clouds for Improving Industrial Object"by T. Czerniawski, M. Nahangi, S. Walbridge, C. Haas published in 33rd International Symposium on Automation and Robotics in Construction (ISARC 2016).

This paper presents following steps and results shown is efficient:
Input Point Cloud = Down Sampling = Calculate Normal Vector = Point Cloud to Normal Vector Space = Density Based Clustering = Segmentation and Removal of of Large Planes.

But as the algorithm is computationally expensive and our environment is simple, we discussed together and decided to use some simple process. We proposed a simple process that we take the cluster of points with same y-coordinates and detect the plane having maximum points with same y-coordinates then remove all the points in the point cloud having y-coordinate less than or equal to that plane and our team member agree with the logic so our next week task is to implement this process for planar removal.

2.2.2. Second Approach

Removing background creates several artifacts which might affect rendering process. Essentially, discrimination between vertexes of target object and the background in the marginal region (so called background-object boundary) is very important and mistakenly classifying each points might remove detail from target object and cut the detail. For instance, if the bounding box as explained before is not correctly placed then part of table (scene/background) will be added to the 3D model of the object and the final rendering will not be as supposed to be. Several attempt is made using SVM classifier of the PCL library but the result is not very satisfactory and further attempt will be made during the next week with simpler methods such as defining marginal region using Euclidian distance and selecting a point by adding some neighboring weight. It seems using only binary weighting should work. For instance, all the points attached to the model will be given weight "l1 = 4" and background weight "l0 = -4". The weight of the point will be recalculated using 25-points neighboring method (just heuristic assumption) and above individual points.

No result to present so far.

2.3. Streaming through GUI Qt

In the previous week, we've continued working with the interfacing of the Kinect sensor within Qt. The goal now is to show the infrared sensor, the depth the RGB camera inside the program's environment, letting the user to know all the information about a scene and allowing him to take better scans of an object.

There will be two ways to display the sensor data:
The first consists of two or three new dockable frames that will appear only when the user clicks the Capture button. Like this, the user will be able to see the state of the current scene along with the live pointcloud acquisition. The second approach consist leaving one visualization window and giving the user the possibility to choose which information to display inside the widget.

We are also in process of redesigning some of the icons for the post-processing dock, seeking to include the following techniques:

-Fusion through ICP
-3D Reconstruction through Greedy Projection
-3D Reconstruction through Poisson

For the 3D reconstruction techniques, we are designing a small popup window that will be displayed each time the user clicks on the respective button, and in which he can configure the different parameters for either algorithm. This will help the user to obtain better results according to the complexity of the scanned object.
The application is now able to generate .pcd files from a variable containing a pointcloud data set. As long as the acquisition process is complete (the live stream of pointcloud data from the kinect is stored in a variable), we will integrate it into the general application.

2.4. Class Development / Optimisation / Standards

First, this week, I worked on the editing of Standard of Codes.After some talks, we was saying that it was maybe a waste of time or just too muchtime consuming. But we adapter to our situation. Me without any computer to run PCL oranything, and able to develop classes and use my own standard that I just wrote, I'll spendmy time by making classes, embedding codes, adding generic classes and functions. And likethis the other will be able to develop more things. It will save us time and it will optimiseour time because I'm not able to work anymore really on the project without my new laptop(28 December delivery).Next to this, to improve our general level in coding, I proposed small lectures to helpeveryone with their weakness and to have a better general level in C++ but also in generalknowledge or coding, like analyzing the code. This will take place only if people needs it.

2.5. ICP

For the progress of ICP as it is the core of the project we are trying to study as much as we can and understand all the important things necessary to do it and been able to get a clear and smooth mesh, As in last week we showed our results with images and proposed different techniques in order to get rid of the problem we had , we are implementing those techniques and soon we gonna get some results we have also researched about ECLH (Explicit Loop Closing Heuristic) , and as it is important to enclose all the point clouds in a circle because the error between them keep increasing if we continue taking point cloud of the whole body of the person.So this the first thing we are implementing and then applying ICP.

Secondly we are trying to implement smoothing after aligning the Point Cloud locally ,but still the problem of points disappearing from the sides is specially on the shoulders of the person front and back of the person aligns properly , what might be causing problem is some zero values in the point cloud we have, and for that we tried different dataset of point cloud with maximum overlapping between the frames specially on the hand or shoulders and the results were little better as compared to what we had before but still problem of missing points occurs.We will updating soon about this task in the meeting and would like to discuss and to show better results as soon as possible to Finish our Project .

2.6. 3D Reconstruction

This week we have continue exploring both methods for reconstruction, Greedy Triangulation and Poisson, testing both in a Point Cloud, which previously was obtaining after applying ICP. We got this Point Cloud from another group, however the data does not have the best accuracy. The results we obtained were promising, although with some problems

At the same time we worked on restucturing the 3D Reconstruction code to build it in an appropiate and standard class, so as to follow the best practices of object oriented programming.

The descriptions and details of the tasks mentioned can be found below.

2.6.1. Applying Reconstruction Methods in Registered Point Clouds

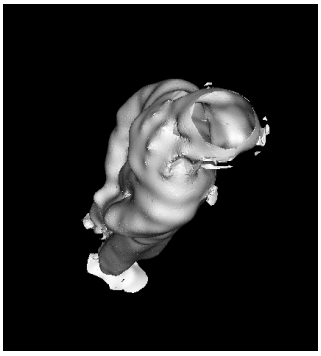
- **Greedy Triangulation.**

  On the following pictures it can be observed that we still have holes in the reconstruction after applying this method. There are two types of holes: a few very small holes, and three big holes: one on the head and two on the feet. In our opinion, the overall details of the model have been captured satisfactorily. For the holes, we will try to implement some hole filling algorithms.

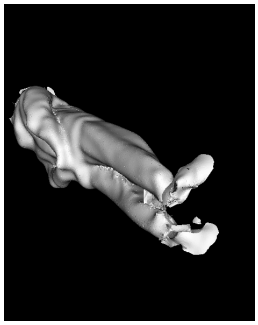
(a) Front View

(b) Side View

Figura 1: Greedy Triangulation



(a) Hole in the Head



(b) Hole in the Feet

Figura 2: Greedy Triangulation Defaults

- **Poisson.**

  We applied this method on the same registered point clouds to have a better comparasion between them. First at all, now that we understand better the functions and variables of this method we know the impact that they have when the value setted is not appropiate. For example, the variable for set the radius search, that determine the k-nearest neighbors for the Normal Estimal, in the pictures below it can be seen the effects when the value is accurate and when it is not.

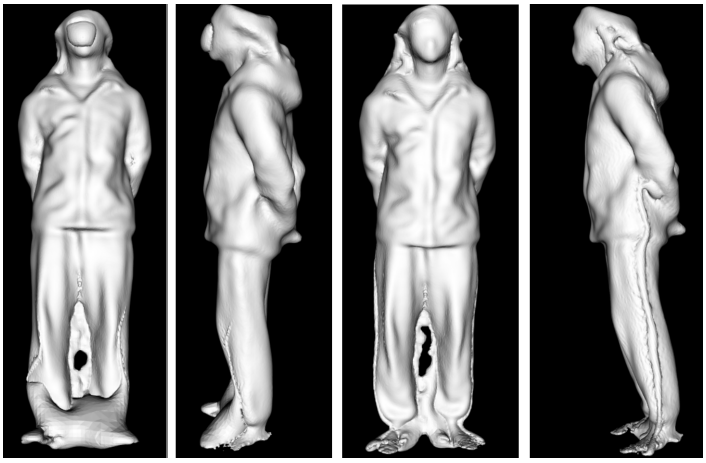


Figura 3: Reconstruction with Poisson algorithm. From left to right (ad). (a & b) Frontal and Lateral view of reconstrucction with the variable SetRadiusSearch = 0.2. (c & d) Frontal and Lateral view of reconstrucction with the variable SetRadiusSearch = 0.4

Therefore, analysing the results, we are still having overmesh when the object has a complex form (in this case the problem is between the legs and arms) and also we have a lack of details on the part of the face. The main reason of this problems is because the data that we receive is not so accurate, we want to apply some functions on the code to pre-process the data before applying the reconstruction in order to have better results. For now we will try to delete the points that do not form part of the object because they represent noise for the Poisson method.

2.6.2. Restructuring the Code

We had previously decided that our 3D Scanner software will have a big "DataÇlass containing the variables of results of each individual operations. Therefore, the classes of each big operation like ICP, 3D Reconstruction etc. will inherit this Data class in order to modify these variables.

To conform to this structure, we converted our raw code into a class, comprising of the required member functions and variables. We made individual functions for each sub-task in our class, after identifying the required argument and return types.

Not all the variables we use in the 3D Reconstruction code will be declared in the Data class and accessed by the mechanism of inheritance. As we have to save some crucial variables from being accessed/mutated by other classes (like ICP), we have defined them inside the 3D Reconstruction class. Moreover, we have implemented the required Accessors and Mutators for each of these variables.

The software will give user the option of choosing either the Greedy Reconstruction Method or Greedy Projection Triangulation Method. Furthermore, the user will have an additional option to modify the default input parameters of the reconstruction method (e.g octree depth etc. in case of Poisson method and Maximum Nearest Neighbours etc. in case of Greedy Triangulation method).

At this stage, we have setup our code for integration with the main code. Also, this code will help us optimize our work flow and help us in efficiently debugging our problems.

2.6.3. Future Tasks

We are unable to display the mesh with colours, as of yet. We plan to fix this by using the datatype appropriate to store the point clouds and use to perform different operations.

Work in the pre-processing of the point clouds before apply the reconstruction method.

3. NEXT WEEK OBJECTIVES

- Create a functional Class which contains the grabbing functions and the database class.
- Planar Removal.
- Continue the Work on the GUI (Add the processing functionalities).
- Optimizinga and Combining Code
- Finishin ICP.
- Colour 3D Reconstruction and "pre-processing treatement".

Github link : https://github.com/WajahatAkhtar/Project-S.E.