Assignment 4:

In this assignment, you need to write a program to convert the input depth image into the file of control points of a Bezier patch (as what you can read-in for Assignment 3). Some example depth images have been given together with the assignment. Your can decide the degree of u-, v-parameters of Bezier patch by yourself. The expected output of this assignment will be able to read-in by the program of your assignment 3 to display the Bezier patch as the surface fitting results of points.

Hint: Least-square fitting needs to be used for generating the control points. The parameters of a data point can be determined by its x-, y-coordinates in the depth image. Note that, you can filter out the points that are considered as noises if their depth value are extremely large or extremely small.

Preliminary Knowledge: Depth map to point cloud

From camera model (fig.1) we know that,

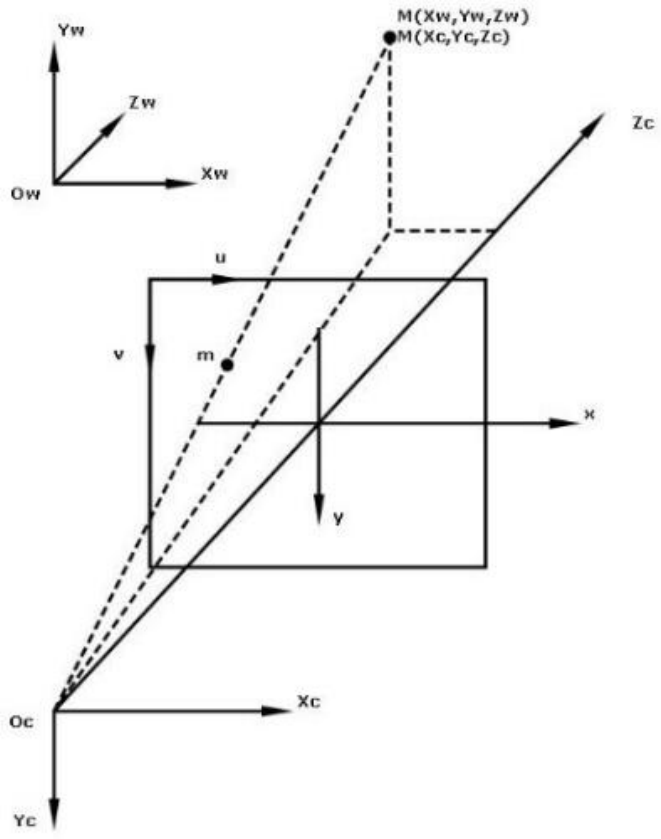

Fig. 1 Camera Model

$$z_c \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \begin{bmatrix} f/dx & 0 & u_0 \\ 0 & f/dy & v_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} R & T \end{bmatrix} \begin{bmatrix} x_w \\ y_w \\ z_w \\ 1 \end{bmatrix}$$

Where (u,v) is the coordinate point in the 2D depth map image. u_0, v_0 is the center coordinate point. x_w,y_w,z_w represent the 3D coordinate point in the world coordinate system. z_c is the depth value from object to camera. R, T are the rotation matrix and translation vector from camera extrinsic parameters.

We assume that original point of world coordinate system and camera coordinate system is the same. In this case, R is Identity matrix and all coefficients in T are zero. Also, we can know that z_c=z_w.

Now we can rewrite the first formulation as below,

$$z_c \begin{pmatrix} u \\ v \\ 1 \end{pmatrix} = \begin{bmatrix} f/dx & 0 & u_0 \\ 0 & f/dy & v_0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_w \\ y_w \\ z_c \\ 1 \end{bmatrix}$$

So the relationship between depth map and point cloud is,

$$\begin{cases} x_w = z_c \cdot (u - u_0) \cdot dx/f \\ y_w = z_c \cdot (v - v_0) \cdot dy/f \\ z_w = z_c \end{cases}$$

Assignment 4 format description

Given .txt files will provide you with the depth map of scanned scenarios. The depth map is stored in a matrix format. Each entity represents the height information of each pixel of the depth image.

Here is the file description,

==========
##rows of matrix ##cols of matrix

z_c in image(0,0) ..... z_c in image(0, cols-1)
.
.
.
.

.
.
z_c in image(rows-1,0) ..... z_c in image(rows-1,cols-1)

==========

Please notice that the unit of z_c is millimeter.

Here are the camera intrinsic parameters,

u_0 = 906.09

v_0 = 522.28

f/dx = 1097.53

f/dy = 1108.70

Example conversion for scan 3,