Saving Face
Analysis of the Model Building Routine

The basic premise of the 3D Model

Expected Input (Transformed Depth Data such that the Head is placed in the correct orientation in model space)

Generis Algorithm for constructing the model
While[Frames < N]
Read in byte stream
Get Fixed Point, and Yaw Pitch and Roll From SDK
Calculate Transformation Matix Based On Yaw Pitch and Roll
Determine Relative Location Of Head SDK. (No need to process everything)
For[Vertices]
Apply Linear Transform to bring point relative to origin
Apply Rotational Transform To Align Head
//Error Checking Make Sure Point is In Model Space
Map Point to Model Byte[]
Increase that point by one
Save Model
End

To Transform a series of 3D vertices into hits on a 3 dimensional byte array

The X, Y and Z indices of the Array represent a fixed offset from a predetermined minimum
in x,y,z where the point <0,0,0> is $x_{min,}\ Y_{min,}\ Z_{min}$

The point <n,m,k> translates to $< X_{min} + \Delta_x * n,\ Y_{min} + \Delta_y * m,$
$Z_{min} + \Delta_y * k)$

Given Parameters (Temporary values) units are in meters

These are adjustable for tunable performance.

In[311]:=
```
xmin = -0.25;
ymin = -0.25;
zmin = -.1;
xmax = 0.25;
ymax = 0.25;
zmax = 0.4;
deltax = 0.0025;
deltay = 0.0025;
deltaz = 0.0025;
xind = (xmax - xmin)/deltax // N;
yind = (ymax - ymin)/deltay // N;
zind = (zmax - zmin)/deltaz // N;
model = Table[0, {i, 1, xind * yind * zind}];
lengthx = yind * zind;
lengthy = zind;

Length[model]

8 000 000 (*Huge... Probably Need to Dial Down The Deltas*)
```

Function to Transform Coords To Model Space

In[286]:=
```
CoordTransform[vertex_] := {Floor[(vertex[[1]] - xmin) / deltax],
  Floor[(vertex[[2]] - ymin) / deltay], Floor[(vertex[[3]] - zmin) / deltaz]}
```

Smoke Test Transform Function

```
CoordTransform[{xmin, ymin, zmin}]
```

```
{0, 0, 0}
```

```
CoordTransform[{xmax, ymax, zmax}]
```

```
{200, 200, 200}
```

```
CoordTransform[{0.123567, -0.23363424, -0.23657342}]
```

```
{149, 6, 85}
```

Model Point Increment Function Note(In *Mathematica* Array index starts at 1)

In[287]:=
```
ApplyCoord[index_] := Module[{},
   model[[(index[[1]] - 1) * lengthx + (index[[2]] - 1) * lengthy + index[[3]]]] =
     model[[(index[[1]] - 1) * lengthx + (index[[2]] - 1) * lengthy + index[[3]]]] + 1;
  ];
```

Test Should Increment each value in the array exactly once

```
Dynamic[{i, j, k}]
For[i = 1, i ≤ xind, i++,
  For[j = 1, j ≤ yind, j++,
    For[k = 1, k ≤ zind, k++,
      ApplyCoord[{i, j, k}]
     ];
   ];
 ];
```

```
{i, j, 15509}
```

Check

```
DeleteDuplicates[model[[1 ;; 100]]]
```

```
{1}
```

Transform Module

Move points To Origin

In[223]:=
```
MoveToOrigin[vertex_, referenceVertex_] := {vertex[[1]] - referenceVertex[[1]],
  vertex[[2]] - referenceVertex[[2]], vertex[[3]] - referenceVertex[[3]]}
```

Smoke Test

In[149]:=
```
refV = {100, 100, 100};
MoveToOrigin[refV, refV](*Should Return {0,0,0}*)
```

Out[150]=
```
{0, 0, 0}
```

Magnitude of the vector

In[289]:=
```
Magnitude[vertex_] := √(vertex[[1]]^2 + vertex[[2]]^2 + vertex[[3]]^2)  // N
```

Smoke Test

In[288]:=
```
Magnitude[{1, 1, 1}]
```

Out[288]=
```
Magnitude[{1, 1, 1}]
```

Rotate a point around the origin in x, y, z

Basic Equations

In[2]:=
```
RotateX[vertex_, θ_] :=
 vertex . {{1, 0, 0}, {0, Cos[θ], -Sin[θ]}, {0, Sin[θ], Cos[θ]}}
RotateY[vertex_, θ_] :=
 vertex . {{Cos[θ], 0, Sin[θ]}, {0, 1, 0}, {-Sin[θ], Sin[θ], Cos[θ]}}
RotateZ[vertex_, θ_] :=
 vertex . {{Cos[θ], -Sin[θ], 0}, {Sin[θ], Cos[θ], 0}, {0, 0, 1}}
```

This Method Calculates The Matrix Once and Reuses the calculations

In[5]:=
```
SetRotationMatrixX[θ_] :=
  Module[{}, Tx = {{1, 0, 0}, {0, Cos[θ], -Sin[θ]}, {0, Sin[θ], Cos[θ]}} // N];
(*Expensive Operation only do once perframe*)
SetRotationMatrixY[θ_] :=
  Module[{}, Ty = {{Cos[θ], 0, Sin[θ]}, {0, 1, 0}, {-Sin[θ], 0, Cos[θ]}} // N];
(*Expensive Operation only do once perframe*)
SetRotationMatrixZ[θ_] :=
  Module[{}, Tz =  {{Cos[θ], -Sin[θ], 0}, {Sin[θ], Cos[θ], 0}, {0, 0, 1}} // N];
(*Expensive Operation only do once perframe*)
SetCombinedMatrix[θ_, ϕ_, ρ_] := Module[{},
   SetRotationMatrixX[θ];
   SetRotationMatrixY[ϕ];
   SetRotationMatrixZ[ρ];
   Tm = Tx . Ty . Tz;
  ];
```

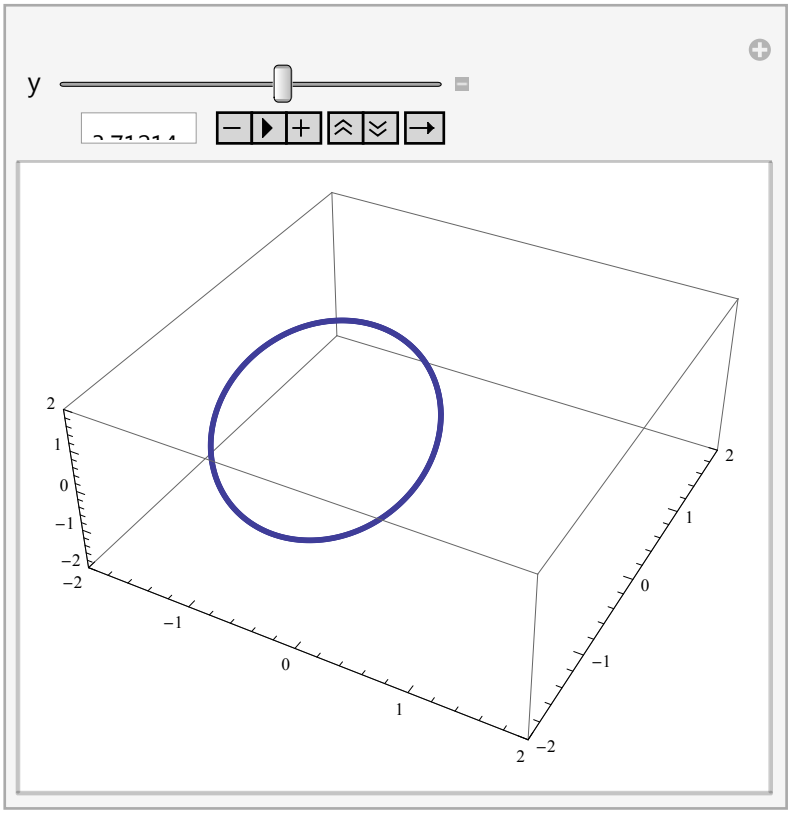
In[340]:=
```
ApplyTransform[v_] := v.Tm
```

Test Method

In[12]:=
```
TestPoint[v_, test_] := Module[{},
   SetCombinedMatrix[test[[1]], test[[2]], test[[3]]];
   Return[v . Tm]
  ];
```

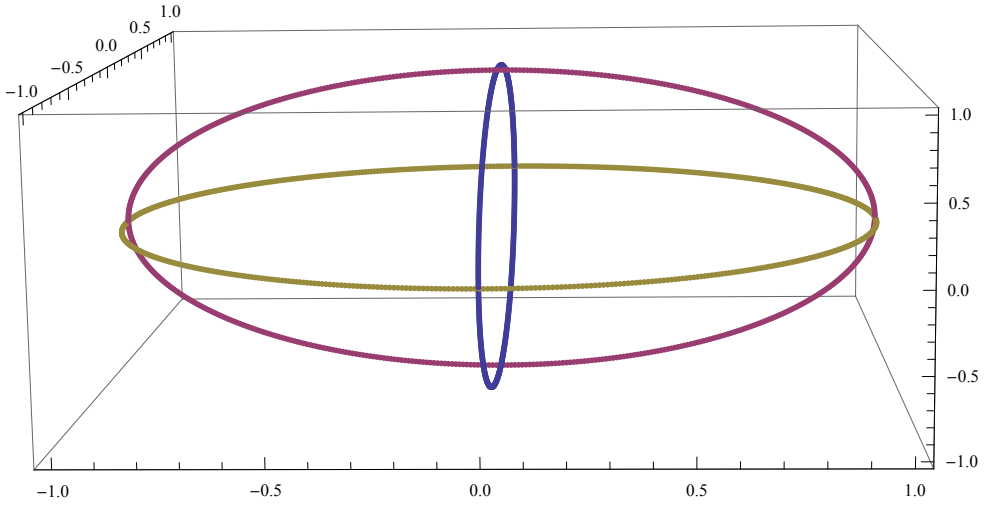
In[20]:=
```
Manipulate[ListPointPlot3D[Table[TestPoint[{1, 1, 1}, {x, y, 0}], {x, 0, 2 π, .01}],
  PlotRange → {{-2, 2}, {-2, 2}, {-2, 2}}], {y, 0, 2 π}]
```

Out[20]=



In[10]:=
```
ListPointPlot3D[{Table[RotateX[{0, 1, 0}, p], {p, 0, 2 π, .01}],
  Table[RotateY[{1, 0, 0}, p], {p, 0, 2 π, .01}],
  Table[RotateZ[{0, 1, 0}, p], {p, 0, 2 π, .01}]}]
```

Out[10]=



Test On Actual Data

To Validate the assumption that the Point of Origin and Yaw, Pitch and Roll have been gathered.
They will be manually Calculated for this Analysis.

In[21]:=
```
FileNameSetter[Dynamic[image1]]
```

Out[21]=

Browse...

File Selected

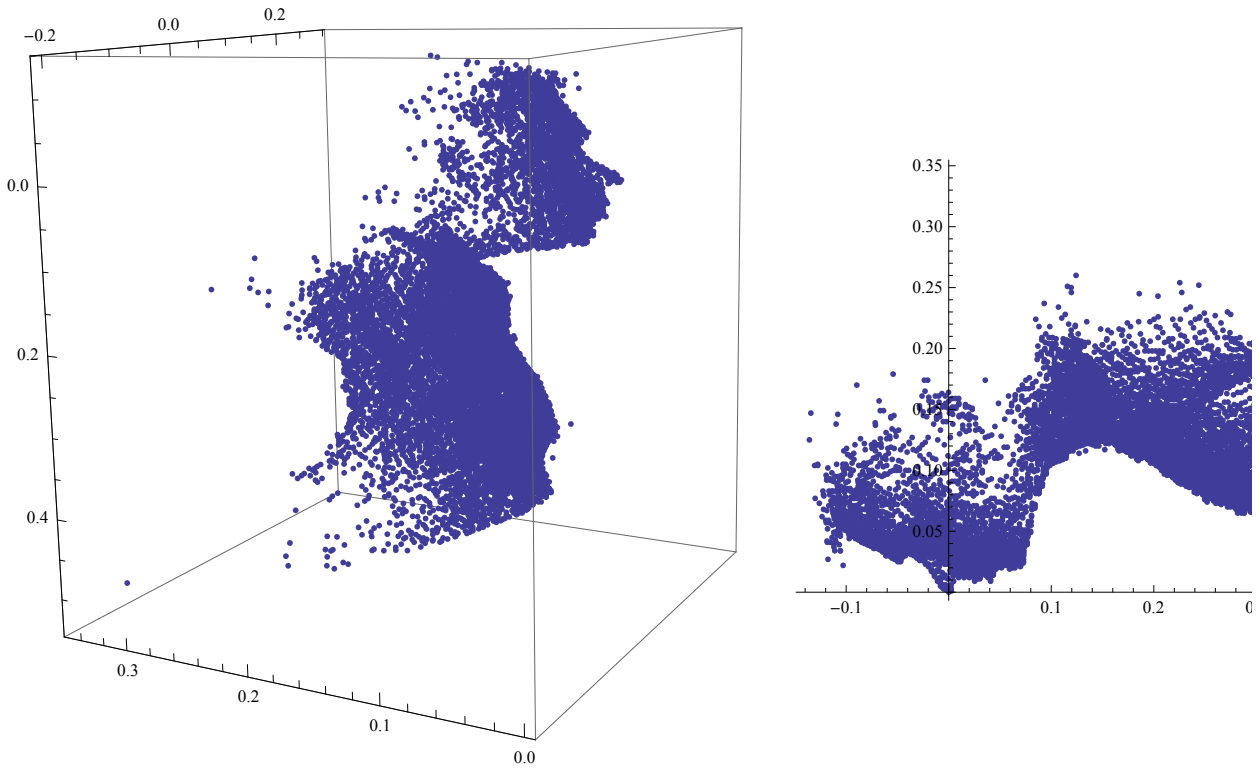
In[22]:=
```
image1
```

Out[22]=
```
G:\camera_uvmap\test\test_1_5.csv
```

In[326]:=
```
Image1 = Import[image1];
Image1 = Select[Image1, #[[1]] > -0.25 ⋀ #[[1]] < 0.25 &];
Image1 = Sort[Image1, #1[[3]] < #2[[3]] &];
Image1[[1 ;; 20]]
v1 = Image1[[1]];
For[k = 1, k ≤ Length[Image1], k++,
  Image1[[k]] = MoveToOrigin[Image1[[k]], v1];
 ];
{{ListPointPlot3D[Image1, AspectRatio → 1, BoxRatios → {1, 1, 1}],
   ListPlot[Image1[[1 ;;, 2 ;; 3]]]}} // TableForm
```

Out[329]=
```
{{-0.0444447, -0.03565, 0.586}, {-0.0445167, -0.0331572, 0.587},
 {-0.0471449, -0.035715, 0.587}, {-0.0523965, -0.0357241, 0.587},
 {-0.0472212, -0.0332176, 0.588}, {-0.0419684, -0.0357677, 0.588},
 {-0.0472295, -0.0383348, 0.588}, {-0.0420362, -0.0332665, 0.589},
 {-0.0499444, -0.0384047, 0.589}, {-0.0446807, -0.0409592, 0.589},
 {-0.052585, -0.0409744, 0.589}, {-0.0500246, -0.035902, 0.59},
 {-0.0447522, -0.0384607, 0.59}, {-0.0526691, -0.038475, 0.59},
 {-0.0473948, -0.0410336, 0.59}, {-0.0448371, -0.0436715, 0.591},
 {-0.0501898, -0.0334477, 0.592}, {-0.0528383, -0.0334521, 0.592},
 {-0.0422578, -0.0385868, 0.592}, {-0.0502037, -0.0411777, 0.592}}
```

Out[332]//TableForm=



Test Build Model (Zeroed But Not Oriented)

Can be safely Multi-threaded

In[297]:=
```
BuildModel[image_] := Module[{},
    For[k = 1, k <= Length[image], k++,
      If[image[[k, 1]] >= xmin ⋀ image[[k, 1]] ≤ xmax ⋀
          image[[k, 2]] >= ymin ⋀ image[[k, 2]] ≤ ymax ⋀
          image[[k, 3]] >= zmin ⋀ image[[k, 3]] ≤ zmax ,
        ApplyCoord[CoordTransform[image[[k]]]];
       ];
     ];
   ];
```

In[291]:=
```
Dynamic[k]
```

Out[291]= 15 509

In[333]:=
```
BuildModel[Image1]
```

In[334]:=
```
DeleteDuplicates[model]
```

Out[334]= {0, 1}

Test Reverse Engineers the model

In[371]:=
```
modelDat = {};
Dynamic[{x, y, z}]
For[x = 1, x <= xind, x++,
  For[y = 1, y <= yind, y++,
    For[z = 1, z <= zind, z++,
      If[model[[((x - 1) * lengthx) + ((y - 1) * lengthy) + z]] ≥ 1,
        modelDat = Append[modelDat, {x, y, z}];
       ];
     ];
   ];
 ];
```

Out[372]= {201, 201, 201}

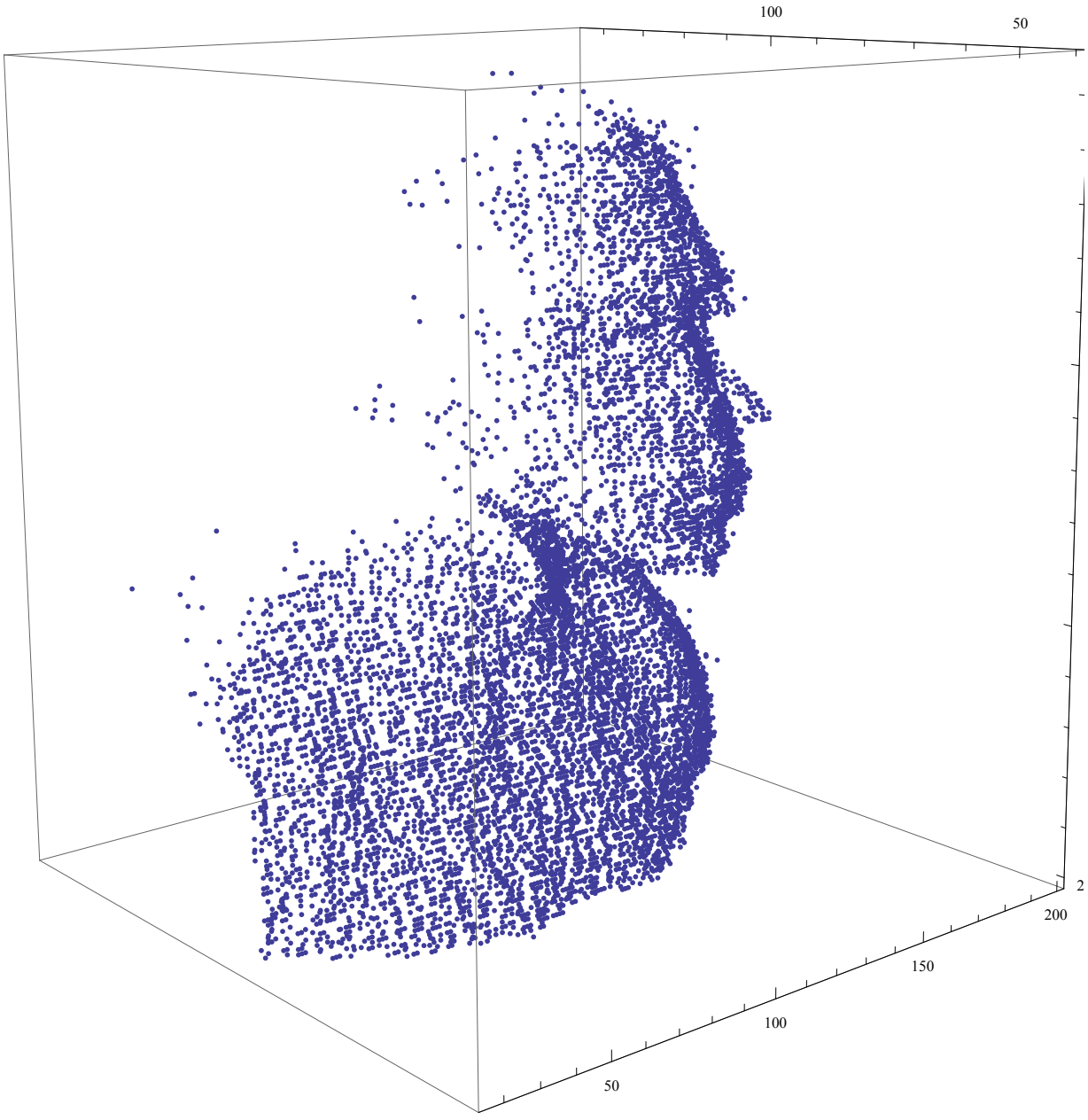
In[338]:=
```
Length[modelDat]
```

Out[338]= 9721

Static View Of Model

In[359]:=
```
ListPointPlot3D[modelDat, AspectRatio → 1, BoxRatios → {1, 1, 1}, PlotRange → All]
```

Out[359]=

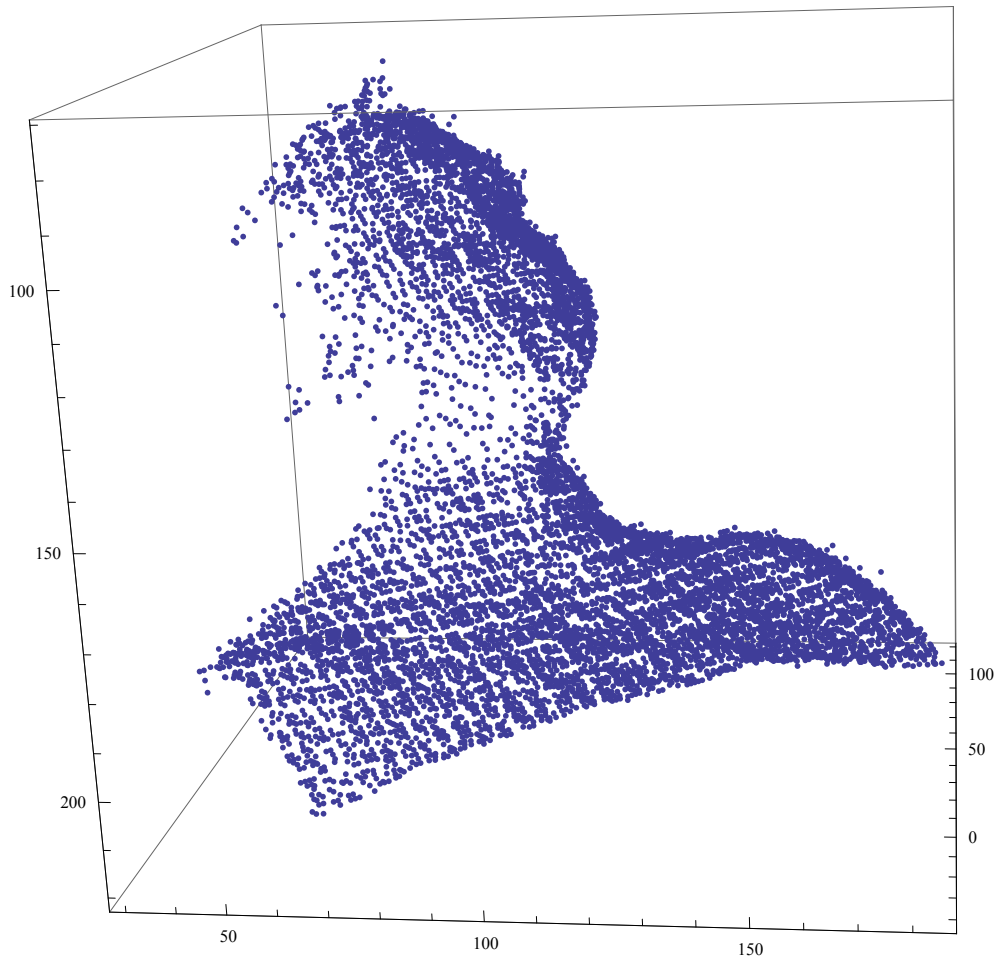


Model Rotated 45 Degrees about x and y

In[368]:=

```
SetCombinedMatrix[π / 4, π / 4, 0];
modelDat = Map[ApplyTransform, modelDat];
ListPointPlot3D[modelDat, AspectRatio → 1, BoxRatios → {1, 1, 1}, PlotRange → All]
```

Out[370]=



In[363]:=

```
TestRotate[x_, y_, z_] := Module[{},
    SetCombinedMatrix[x, y, z];
    Return[Map[ApplyTransform, modelDat]]
  ];
```

Model Rotated in any direction

In[376]:=
```
Manipulate[ListPointPlot3D[TestRotate[x, y, z], AspectRatio → 1,
  BoxRatios → {1, 1, 1}, PlotRange → All], {x, 0, 2 π}, {y, 0, 2 π}, {z, 0, 2 π}]
```

Out[376]=