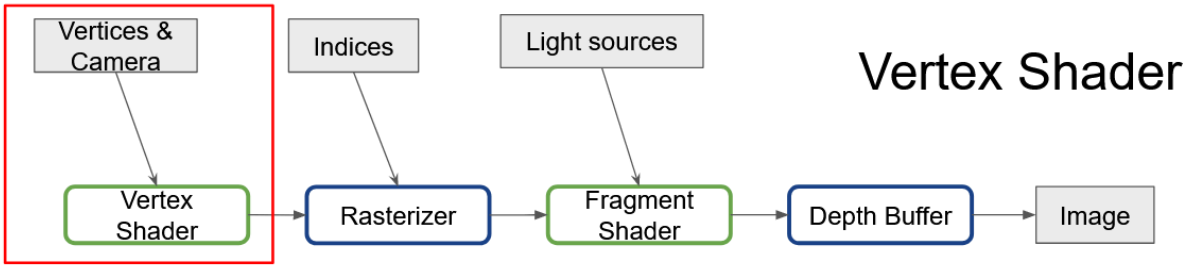
TP2 Graphic 3D

The vertex shader

The goal of this practical work is to implement a vertex shader. The vertex shader is the first stage of our rendering pipeline:



It takes vertices expressed in the scene space and camera information as inputs and output vertices re-expressed in the projected space.

First, let's define our scene, for that, we'll reuse the code to create a cube from the previous practical work:

```
vertices = np.array([
  [0.0,0.0,0.0], #0
  [1.0,0.0,0.0], #1
  [0.0,1.0,0.0], #2
  [1.0,1.0,0.0], #3
  [0.0,0.0,1.0], #4
  [1.0,0.0,1.0], #5
  [0.0,1.0,1.0], #6
  [1.0,1.0,1.0], #7
])

triangles = np.array([
  [1,0,2],
  [3,1,2],
  [4,5,6],
  [5,7,6],
  [0,1,4],
  [4,1,5],
  [2,6,3],
```

```
  [3,6,7],
  [0,6,2],
  [4,6,0],
  [1,3,7],
  [5,1,7]
], dtype=int)
```

Then we need to define a camera for that you'll need the camera.py and the projection.py files. The first one contain a class that will help us define a Camera in space :

```
import numpy as np

class Camera:
  def __init__(self, position, lookAt, up, right) :
    self.position = position
    self.lookAt = lookAt
    self.up = up
    self.right = right

  def getMatrix(self):
    #todo
    pass
```

The second one will help us define the part of the camera space seen by the camera (frustum):

```
import numpy as np

class Projection:
  def __init__(self, near,far,fov,aspectRatio) :
    self.nearPlane = near
    self.farPlane = far
    self.fov = fov
    self.aspectRatio = aspectRatio

  def getMatrix(self) :
    #todo
    pass
```

Let's create a camera with the following command:

```
position = np.array([5,5,5])
lookAt = normalize(np.array([-0.577,-0.577,-0.577]))
up = np.array([0.33333333,  0.33333333, -0.66666667])
right = np.array([-0.57735027,  0.57735027,  0.])

cam = Camera(position, lookAt, up, right)
```

And a projection :

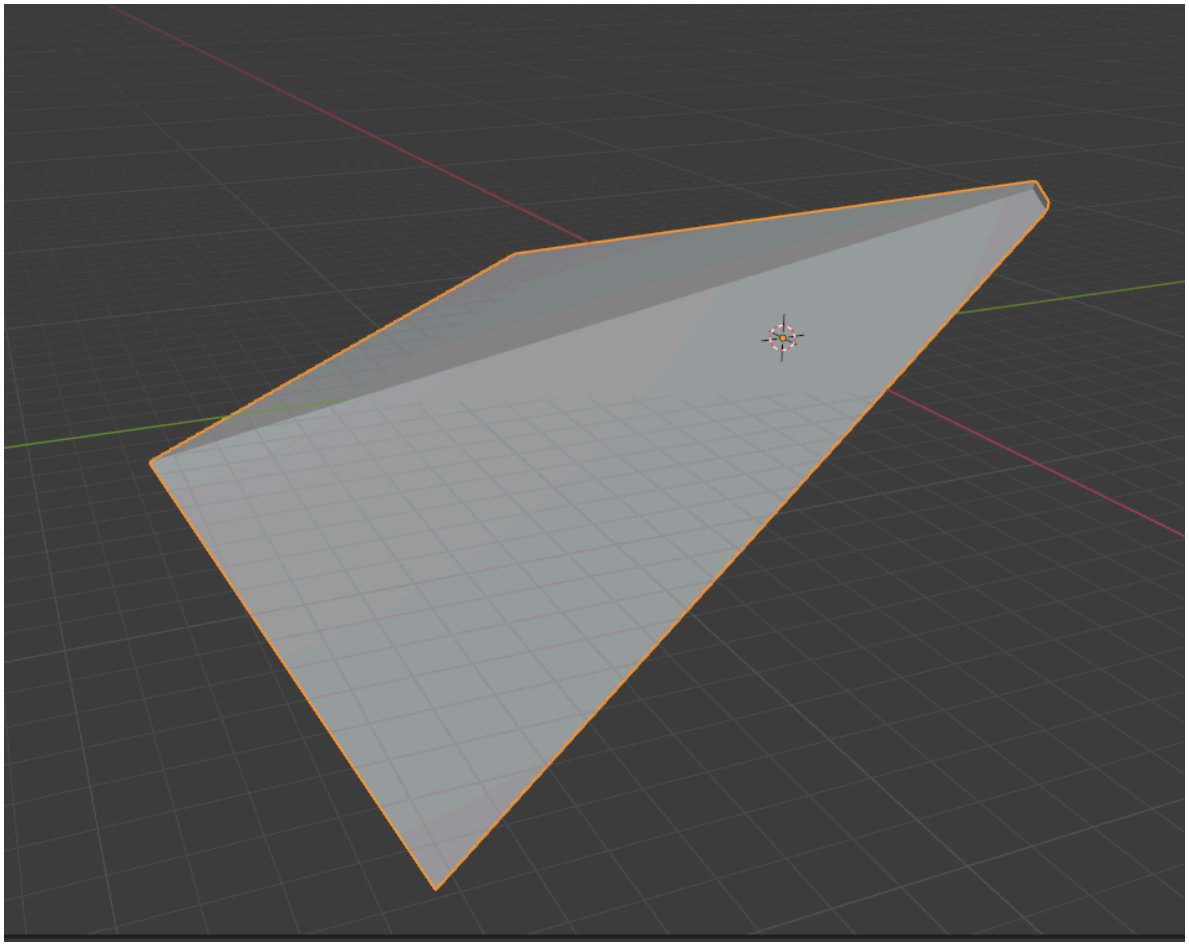
```
nearPlane = 1.0
farPlane = 20.0
fov = 1.22173
aspectRatio = 16/9

proj = Projection(nearPlane ,farPlane,fov, aspectRatio)
```

Now using the following lines we will export a representation of the Frustum:

```
from generateFrustum import generateFrustum
generateFrustum(cam, proj)
```

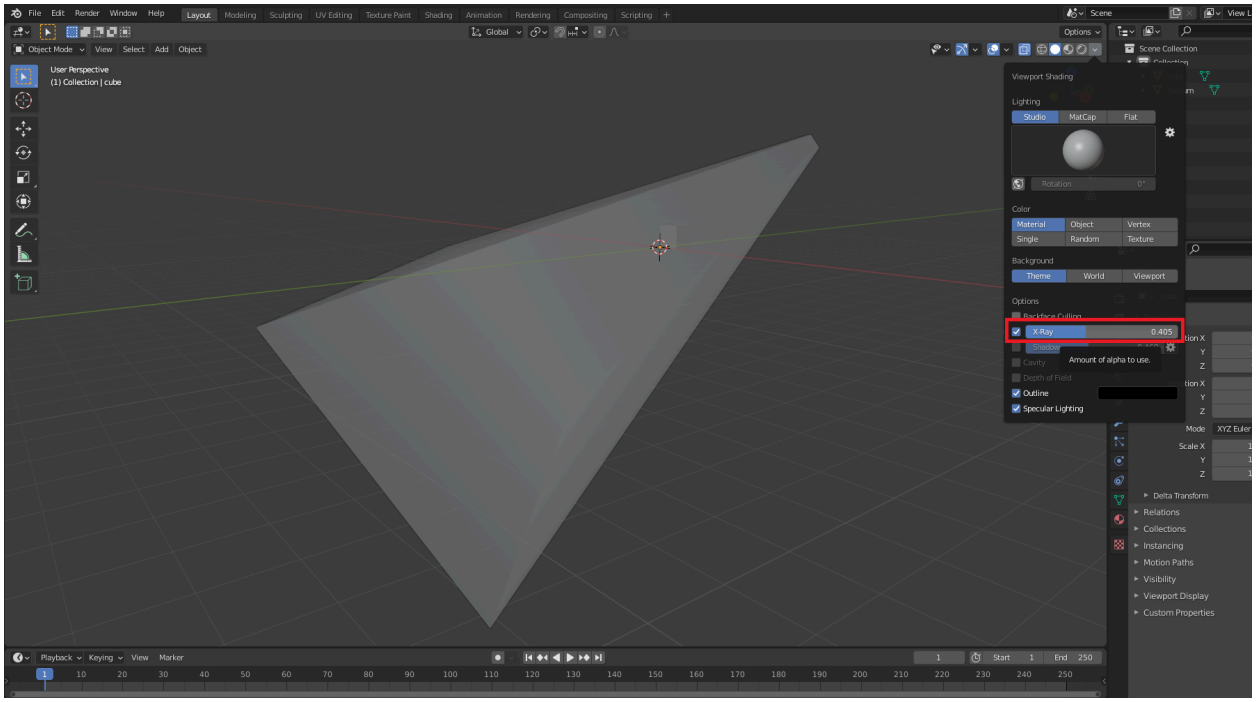
This should create a frustum.ply file that we can open in Blender, you should see the following:



Now we can export our cube as we did in the previous practical work using the following commands:

```
from exportToPly import write_ply_file
write_ply_file(vertices,triangles, 'cube.ply' )
```

Import it in Blender and activate the x-ray mode in blender you should see something like this:



As you can see our cube is inside the frustum so it is visible to the camera. Now try changing the parameters of the projection to see how they affect the frustum shape.

Question 1: Vertex shader and camera space

The job of the vertex shader is to re-express each vertex in the projected space frustum space We first need to project all vertices in the camera space to do that. For this operation, we need the view matrix as seen in the lectures.

1)Modify the getmatrix function in the Camera class such that it returns the view matrix.

2) Call this function on the camera we defined, and store the result in a dictionary as follows:

```
data = dict([
  ('viewMatrix',cam.getMatrix()),
])
```

3) open the VertexShader.py file and modify the vertex shader function such that it applies the camera matrix on every vertex:

```
import numpy as np

def VertexShader(vertices, data) :
  outputVertices = np.zeros_like(vertices)
  for i in range(vertices.shape[0]) :
    #todo
    pass
  return outputVertices
```

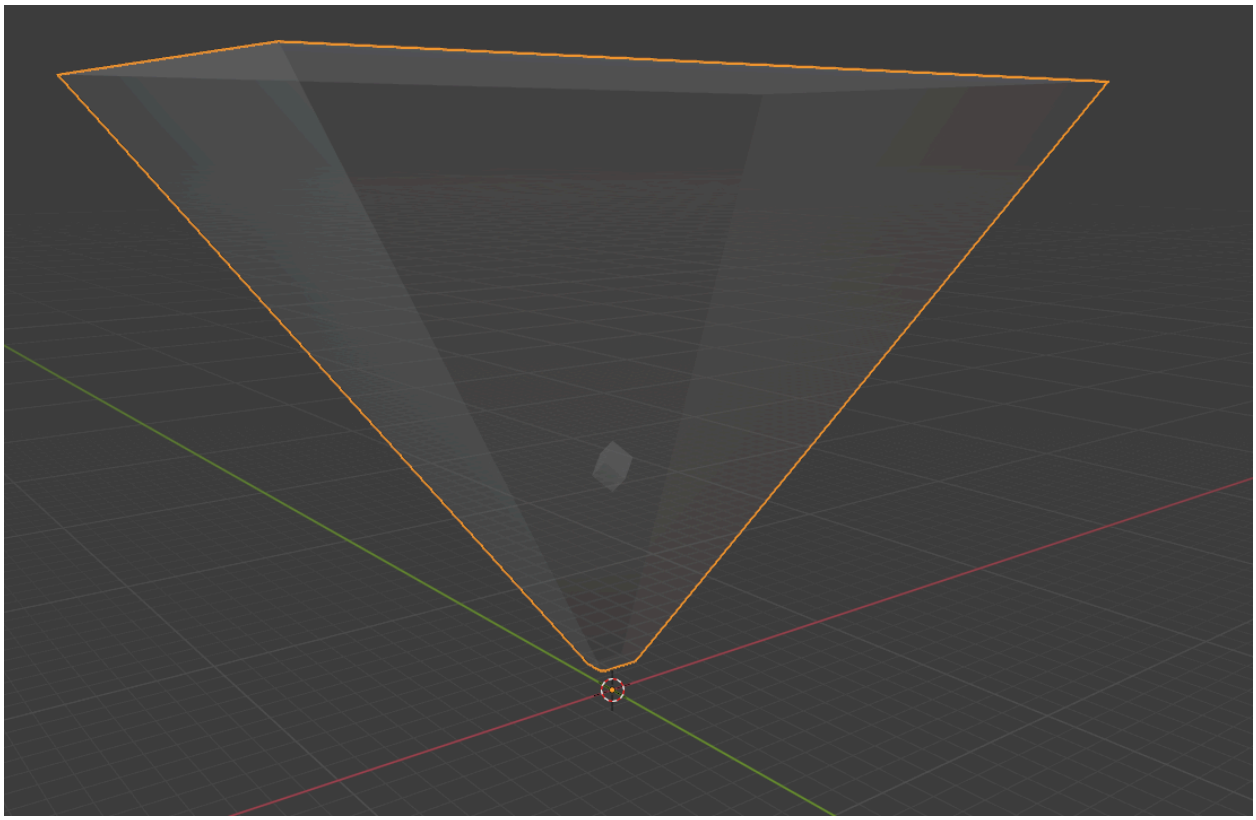
4) call your vertex shader using the following lines :

```
from vertexShader import VertexShader
vertices_cam = VertexShader(vertices, data)
```

5) export your scene in the camera space with the following lines:

```
from generateFrustum import generateFrustumCameraSpace
generateFrustumCameraSpace(proj)
write_ply_file(vertices,triangles, 'cubeCamera.ply' )
```

It should generate two ply files, one named frustumCameraSpace.ply and one named cubeCamera.ply, if you open them in Blender you should see the following :



As you can see now our frustum is aligned on the three main axes of the scene, and our cube is still a the same position inside the frustum.

Now we need to apply the projection to represent the visible part of the screen in a cube rather than in a frustum as it will simplify future operation

Question 2: Vertex shader and Project space

1) Modify the getmatrix function in the Projection Class to return the projection matrix.

2) Modify the data dictionary to add the projection matrix:

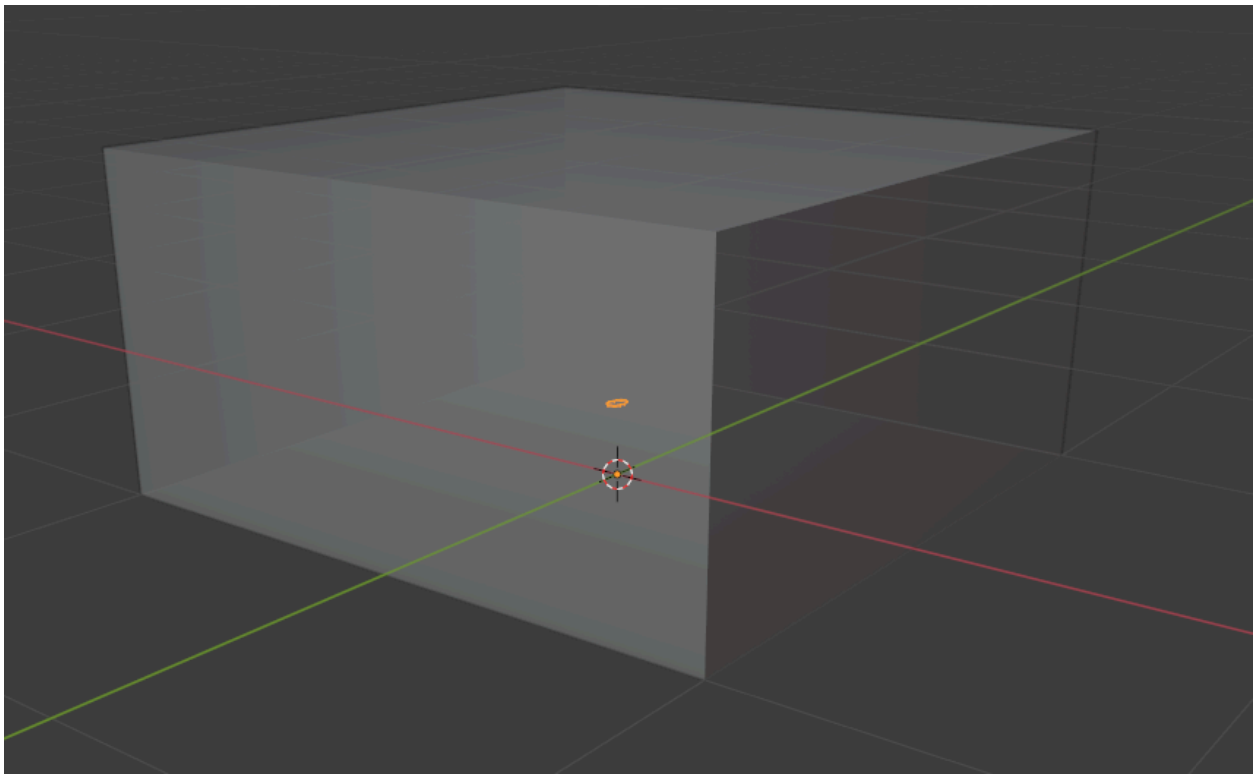
```
data = dict([
  ('viewMatrix', cam.getMatrix()),
  ('projMatrix', proj.getMatrix())
])
```

3) Modify the Vertex Shader to project all vertex in the projected space.
(do not forget to divide you x,y, and z coordinates by w to correctly apply the projection).

Export the projected mesh and the projected frustum with the following lines:

```
write_ply_file(vertices_cam,triangles, 'cubeProjected.ply' )
from generateFrustum import generateProjectedFrustum
generateProjectedFrustum()
```

In Blender you should see the following:



As you can see the cube is now very small and its shape changed. It is normal, as the projected space is a lot smaller than the shape of the space went from a pyramid to a Rectangular cuboid.