

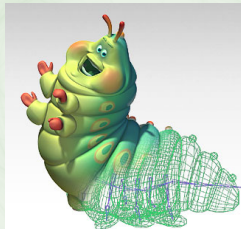
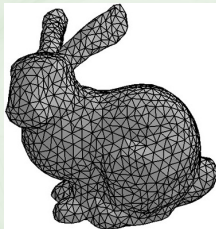
An Introduction to Computer Graphics

Rodolphe Vaillant

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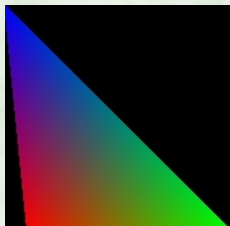
Surface representation



Triangles are very popular in : games, 3D movies, 3D modeling software. Most graphic hardware accelerate its rendering.

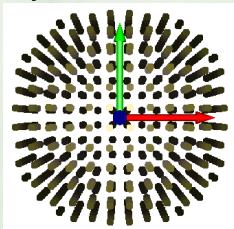
A simple program

```
glTranslate3f(0., 10, 0.)  
glBegin(GL_TRIANGLES);  
    glNormal(1., 0., 0.);  
  
    glColor3f(0.0, 0.0, 1.0); /* blue */  
    glVertex3f(0, 0, 100.);  
    glColor3f(0.0, 1.0, 0.0); /* green */  
    glVertex3f(200, 200, 100.);  
    glColor3f(1.0, 0.0, 0.0); /* red */  
    glVertex3f(20, 200, 100.);  
glEnd();
```

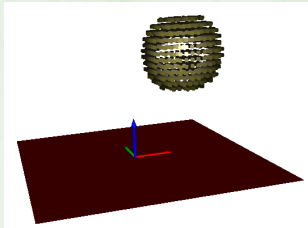


Transform and lighting

Object coordinate :

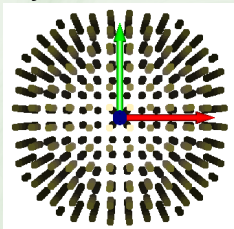


Into world coordinate :

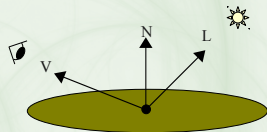
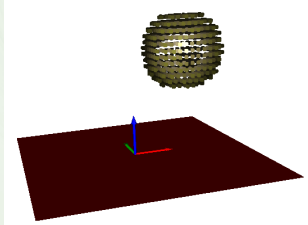


Transform and lighting

Object coordinate :



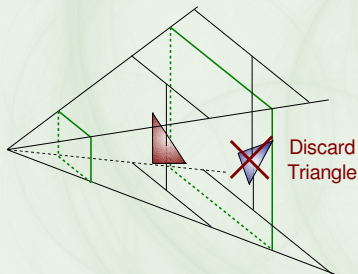
Into world coordinate :



- Light is computed with the Blinn-Phong model
- Brightness is calculated thanks to the angle between the normal, the light and the viewer

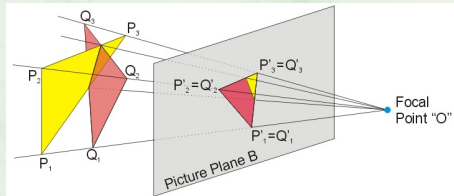
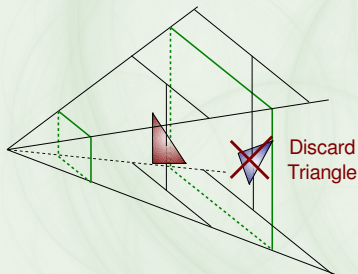
Projection and clipping

The frustum :

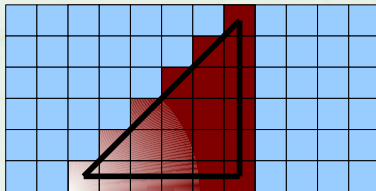


Projection and clipping

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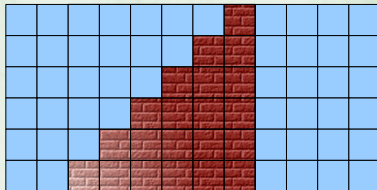
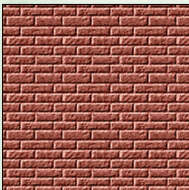


Rasterization



- Triangles are discretized into pixels
- Colour is linearly interpolated as the other vertices attributes
- Each element of the grid is called **fragment**
Fragments attributes are :
 - Colour
 - (X, Y) position
 - Depth
 - Normal etc.

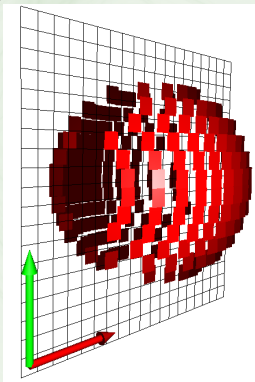
Texturing



At this stage fragments are blend with textures.

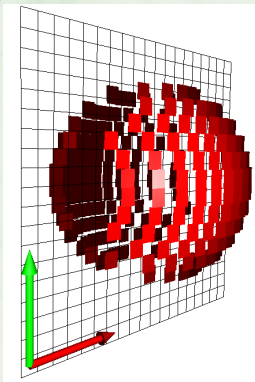
Z-Test and others

The Z-test discard fragments behind others :

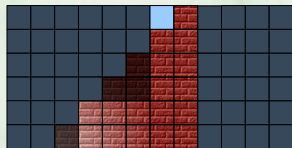


Z-Test and others

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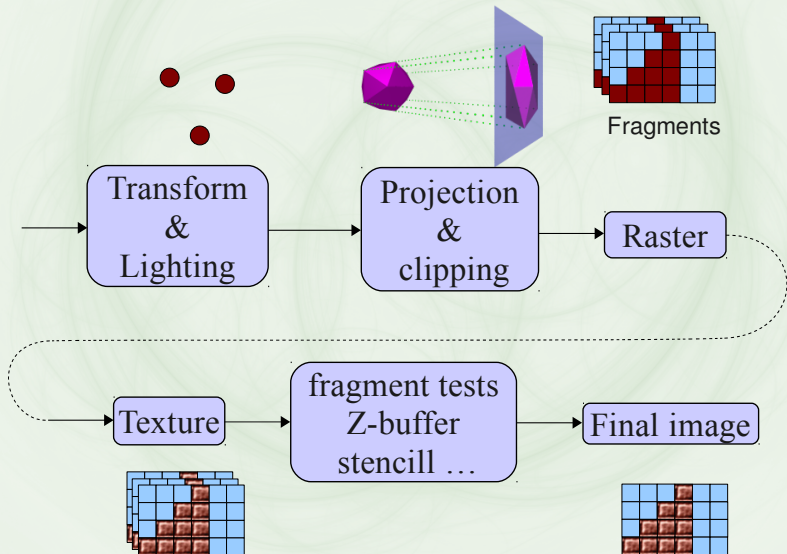


The stencil tests defined the area to draw with a mask :



Other tests exists ...

Fixed Pipeline Summary



The fixed pipeline is limited

Problems

- Shadows are not computed
- Limited number of lights
- One model of light and no other
- ...
- Thousands of effects not supported or hard to achieve

The fixed pipeline is limited

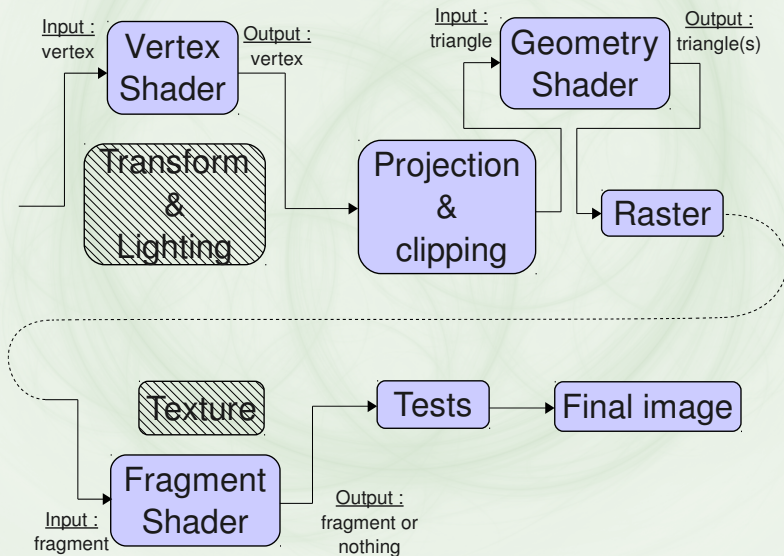
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Solution

A programmable pipeline.

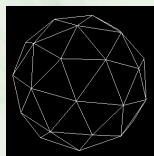
Programmable pipeline with shaders



Example of a shader program



Per vertex



Wireframe view

Lighting with the fixed pipeline

- Light is computed for each vertex
- Colour is then linearly interpolated



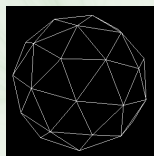
Example of a shader program



Per vertex



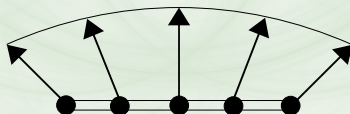
Per fragment



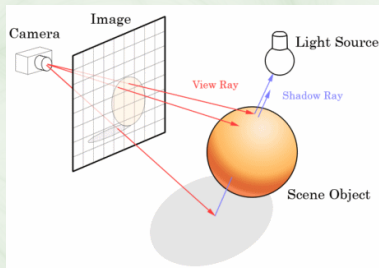
Wireframe view

Lighting with shaders

- Normal is interpolated between two fragments
- Light can be computed for each fragment (pixel)



Alternative



Ray tracing

- Too slow for real time applications like games
- Used in 3D movies
- Automatic reflection / refraction / shadows
- Needs a computer farm too be efficient !

Questions ?