Part zero: Introduction

3. Graphics

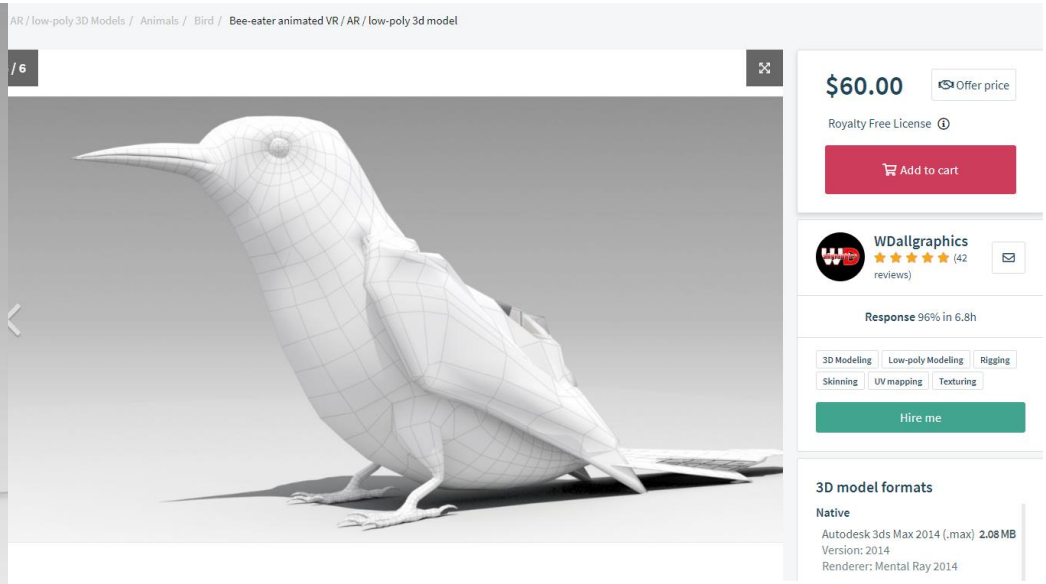
Outline

I. Graphics
II. Modeling
III. Rendering

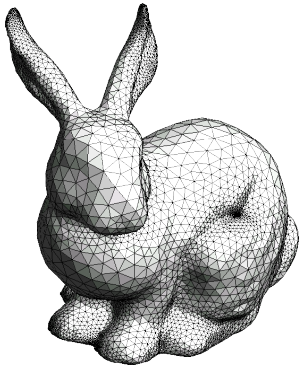
0. Real? or Fake?

사진? Graphic?

o. Real? or Fake?



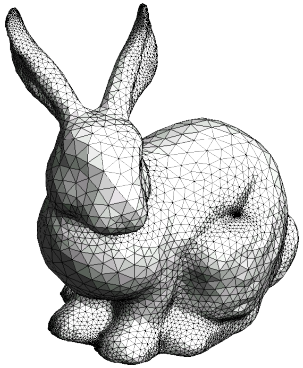
1. Graphics



Modeling

Rendering

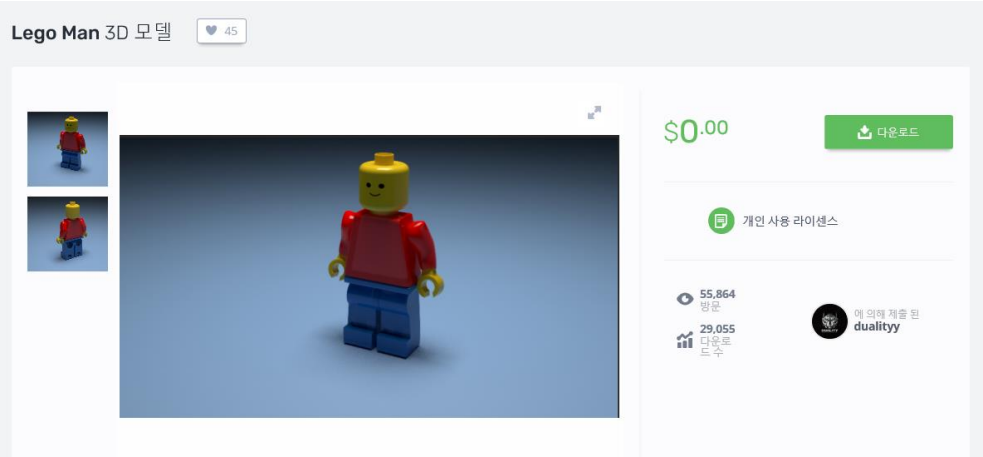
1. Graphics



Modeling

Rendering

1. Graphics



https://free3d.com/3d-model/lego-man-8986.html

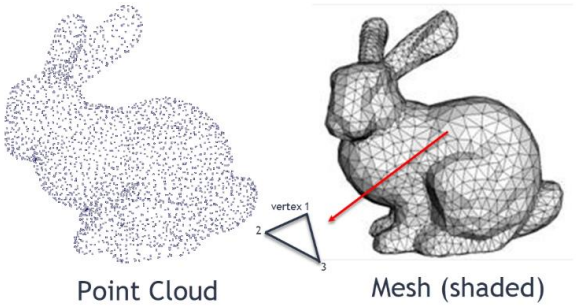
```
v  29.2550 63.0786 4.4300
v  31.8154 63.0786 4.4300
v  31.8104 63.0786 4.2768
v  31.7952 63.0786 4.1243
v  31.7700 63.0786 3.9729
v  31.7348 63.0786 3.8234
v  31.6899 63.0786 3.6763
v  31.6353 63.0786 3.5322
v  31.5712 63.0786 3.3917
v  31.4981 63.0786 3.2553
v  31.4160 63.0786 3.1236
v  31.3254 63.0786 2.9971
v  31.2266 63.0786 2.8764
v  31.1200 63.0786 2.7618
v  31.0061 63.0786 2.6540
v  30.8853 63.0786 2.5532
v  30.7580 63.0786 2.4598
v  30.6249 63.0786 2.3744
v  30.4864 63.0786 2.2970
v  30.3431 63.0786 2.2282
v  30.1956 63.0786 2.1680
v  30.0445 63.0786 2.1167
v  31.7348 64.3786 5.0366
v  31.7700 64.3786 4.8871
v  31.7952 64.3786 4.7357
v  31.8104 64.3786 4.5832
# 6302 vertices
```

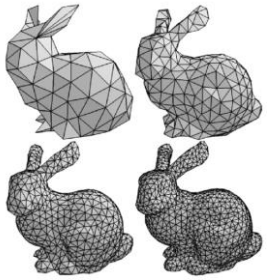
```
vn 0.0000 1.0000 -0.0000
vn -0.0072 1.0000 0.0005
vn -0.0472 0.9989 0.0031
vn -0.0474 0.9989 -0.0000
vn -0.0072 1.0000 -0.0000
vn -0.0071 1.0000 0.0009
vn -0.0469 0.9989 0.0061
vn -0.9864 0.0000 -0.1643
vn -0.9951 0.0000 -0.0989
vn -0.9995 0.0000 -0.0330
# 6205 vertex normals
```

```
vt 10.4836 7.5263 0.0000
vt 10.5039 7.5250 0.0000
vt 10.5241 7.5238 0.0000
# 3407 texture coords
```

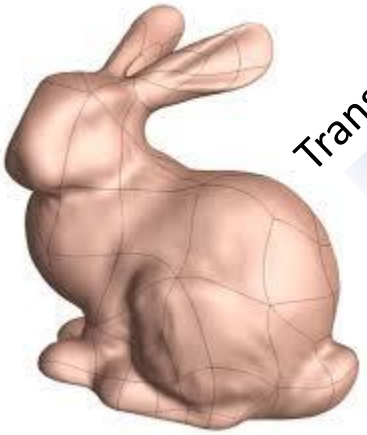
```
f 6289/88/6192 6290/89/6192 89/89/6192 88/88/6192
f 6290/89/6193 6291/90/6193 90/90/6193 89/89/6193
f 6291/90/6194 6292/91/6194 91/91/6194 90/90/6194
f 6292/91/6195 6293/92/6195 92/92/6195 91/91/6195
f 6293/92/6196 6294/93/6196 93/93/6196 92/92/6196
f 6294/93/6197 6295/94/6197 94/94/6197 93/93/6197
f 6295/94/6198 6296/95/6198 95/95/6198 94/94/6198
f 6296/95/6199 6297/96/6199 96/96/6199 95/95/6199
f 6297/96/6200 6298/97/6200 97/97/6200 96/96/6200
f 6298/97/6201 6299/98/6201 98/98/6201 97/97/6201
f 6299/98/6202 6300/99/6202 99/99/6202 98/98/6202
f 6300/99/6203 6301/100/6203 100/100/6203 99/99/6203
f 6301/100/6204 6302/101/6204 101/101/6204 100/100/6204
f 6302/101/6205 6204/2/6205 2/2/6205 101/101/6205
# 6200 polygons - 200 triangles
```

1. Modeling

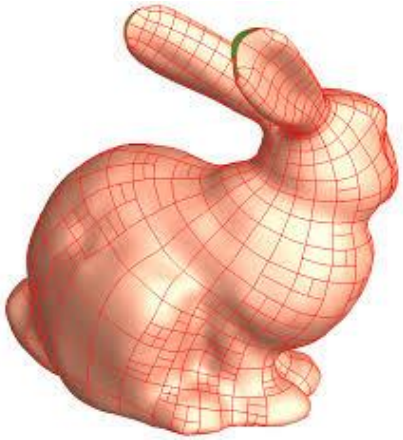




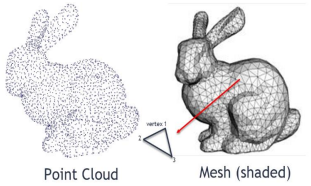
spline

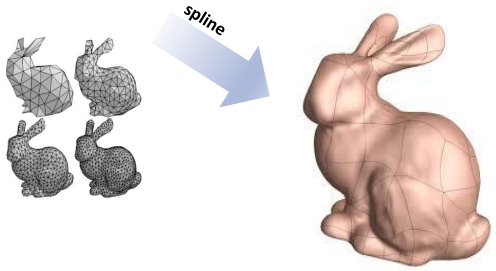


Transform

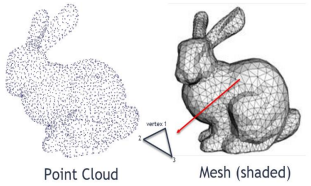


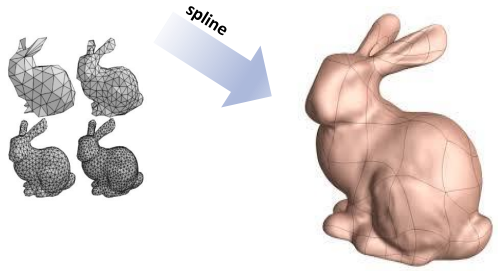
1. 1 Splines



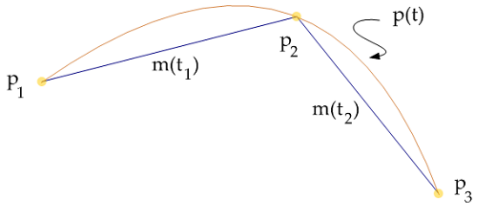


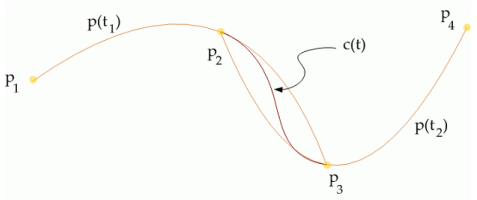
1. 1 Splines



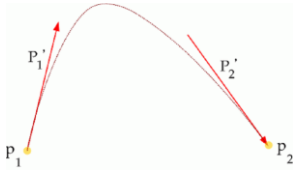


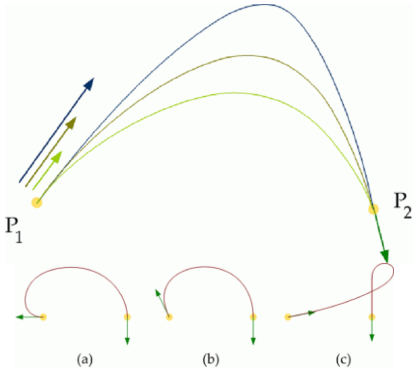
Cardinal Splines



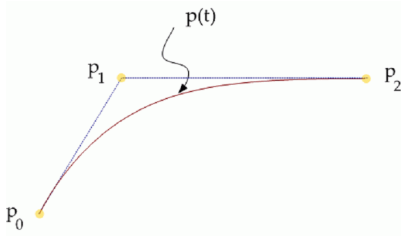


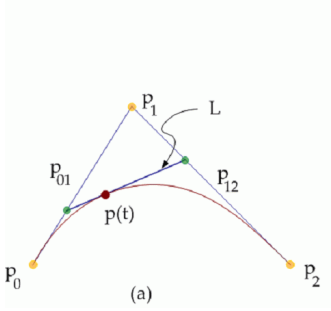
Hermite Splines

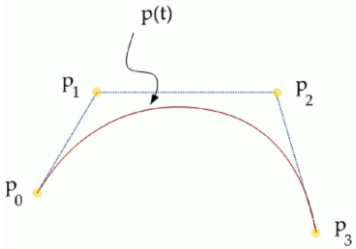




Bezier Splines

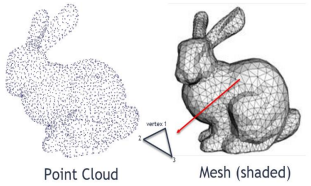


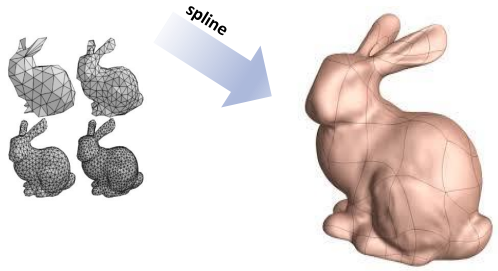


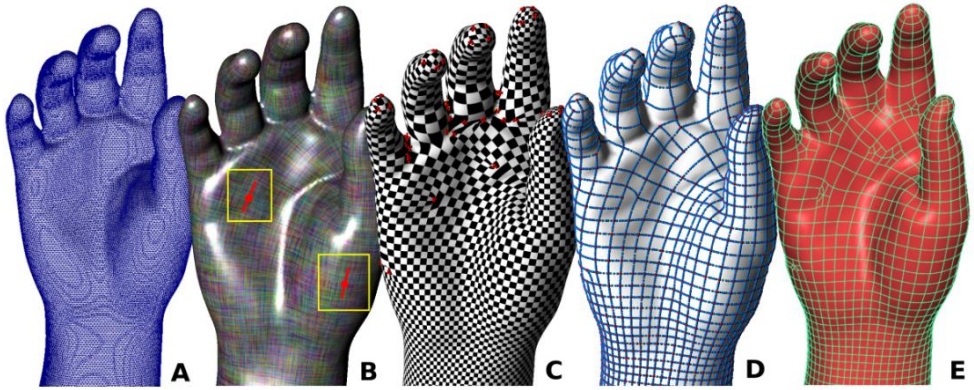


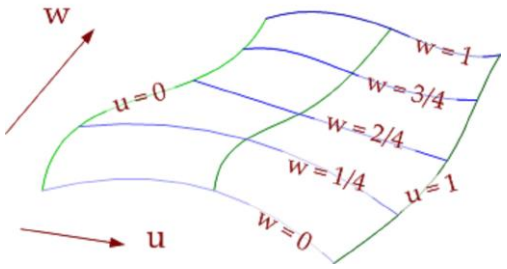
1. 2 Surfaces

Spline 곡면

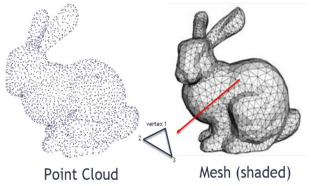


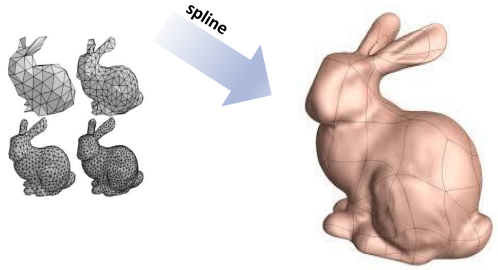




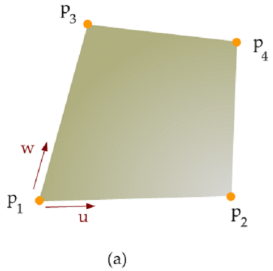


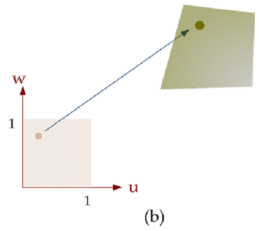
1. 2 Surfaces



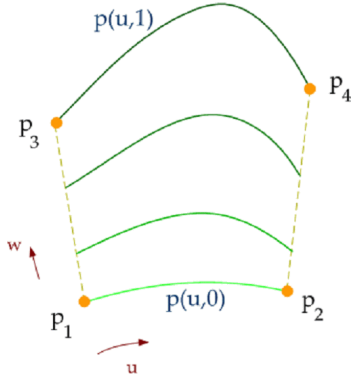


공간상 4점

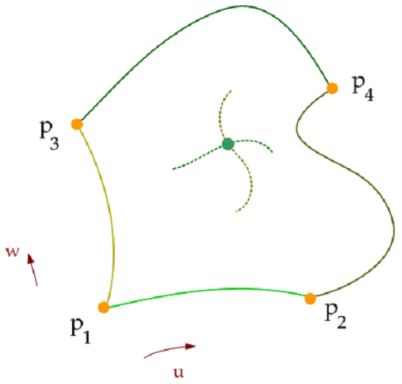




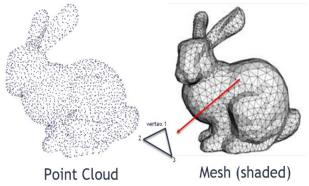
2개의 공간 곡선

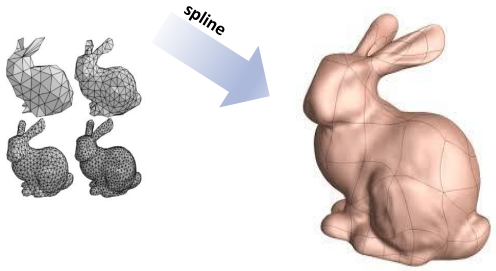


4개의 경계 곡선

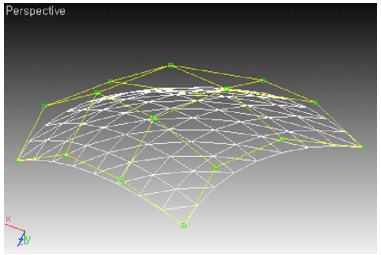


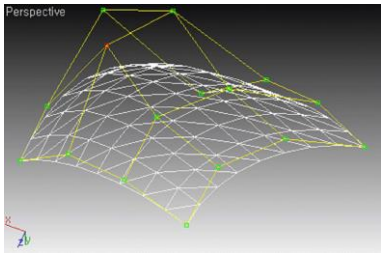
1. 2 Surfaces

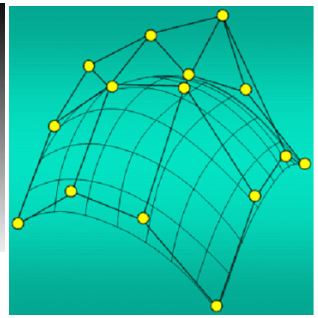




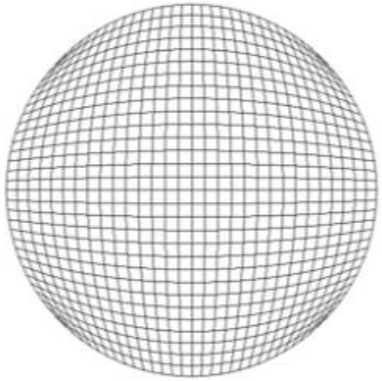
Bezier Surfaces



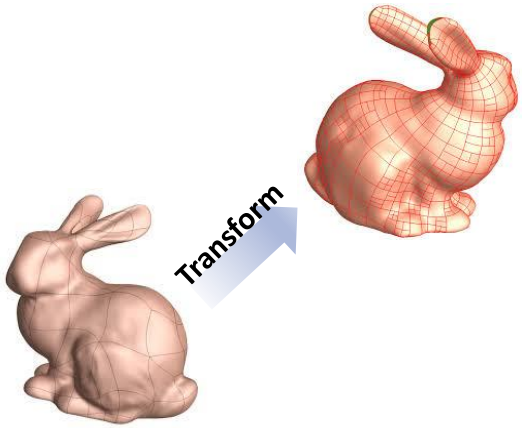




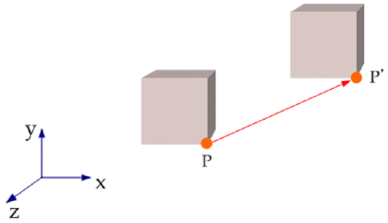
Quadric Surfaces



1. 3 Transform

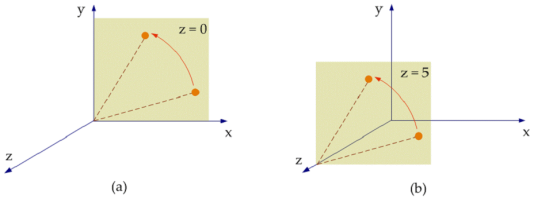


Translation



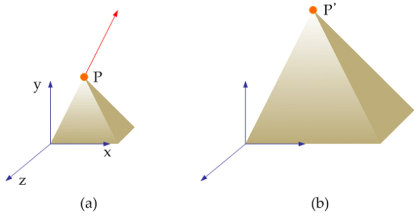
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & T_x \\ 0 & 1 & 0 & T_y \\ 0 & 0 & 1 & T_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Rotation



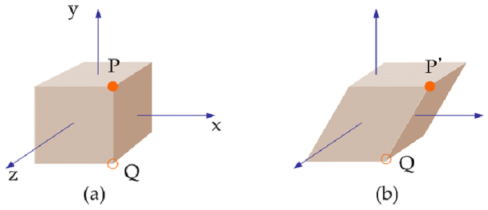
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Scaling



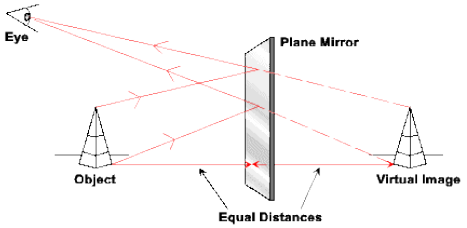
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Shearing



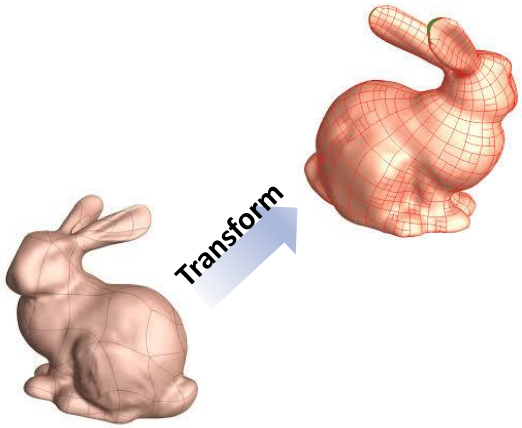
$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & Sh_y & 0 & 0 \\ Sh_x & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

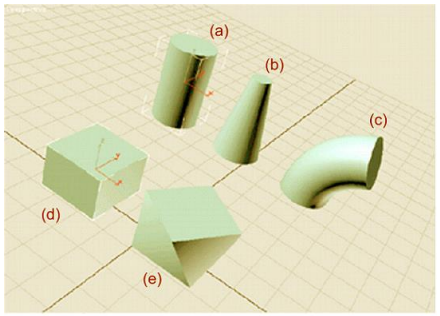
Reflection

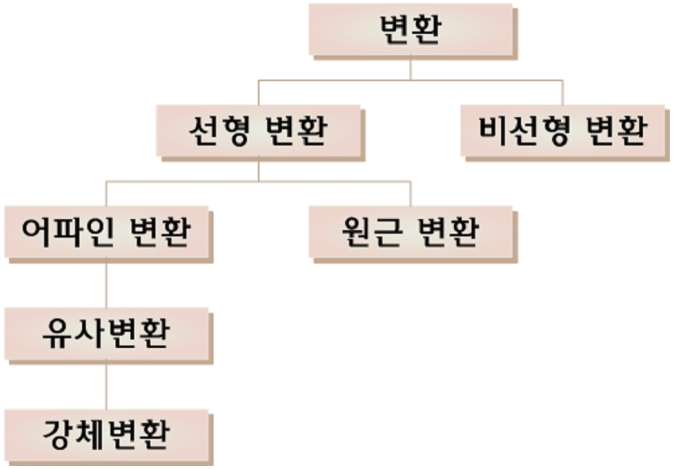


$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

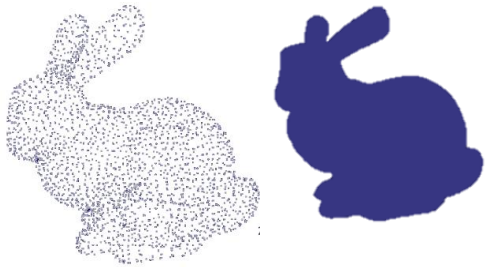
1. 3 Transform





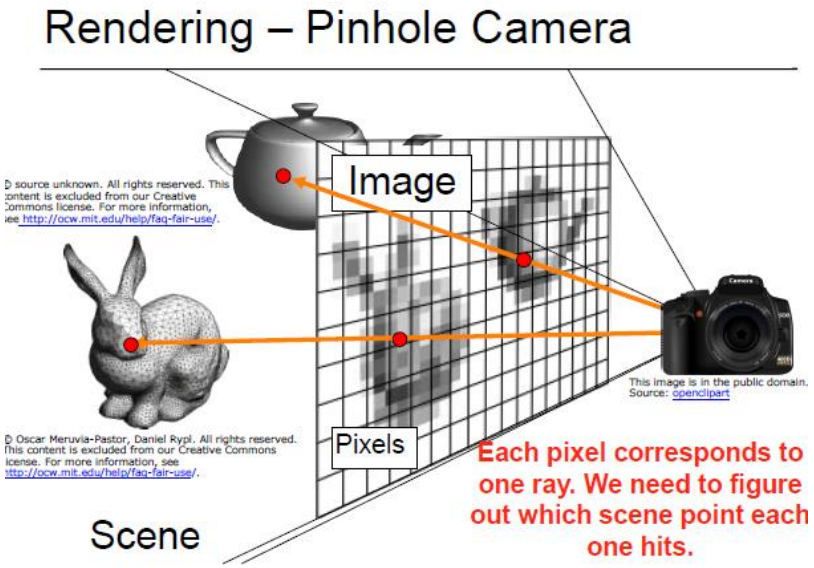


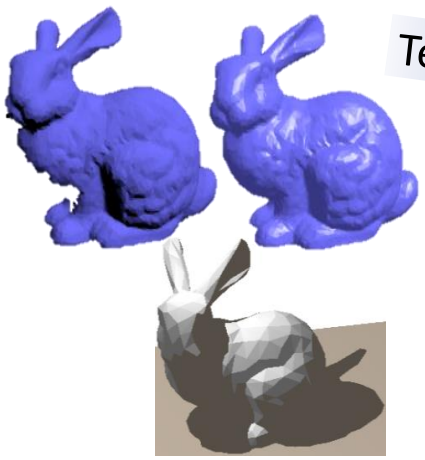
2. Rendering



Rendering

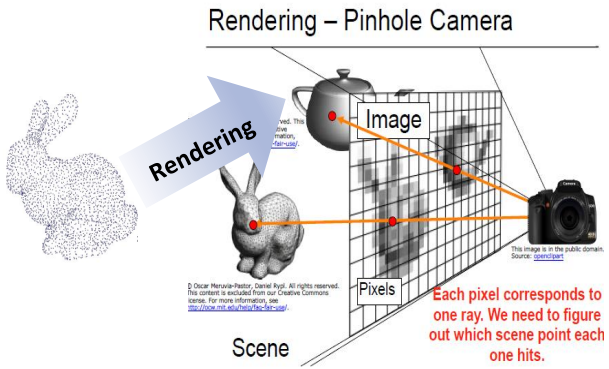
Shading



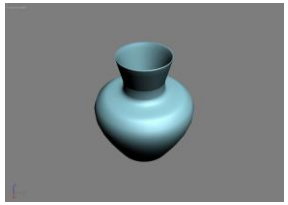


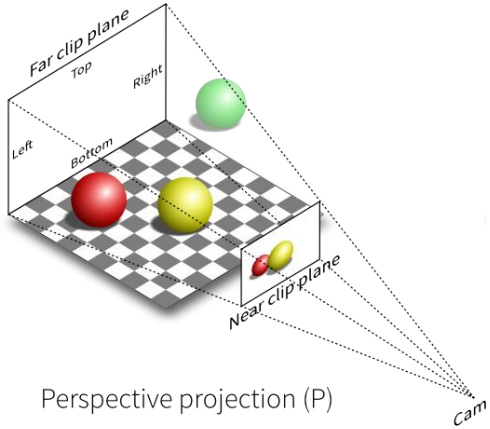
Texturing

2.1 Projection, 투상변환



Perspective Projection



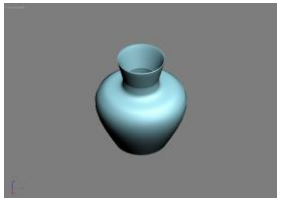


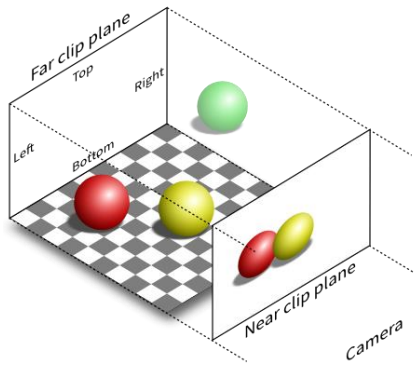
Perspective projection (P)

$$P' = \begin{pmatrix} x' \\ y' \\ -d \\ 1 \end{pmatrix} = \begin{pmatrix} x \\ y \\ -z \\ z/d \end{pmatrix}$$

$$= \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 1/d & 0 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$

Orthographic Projection

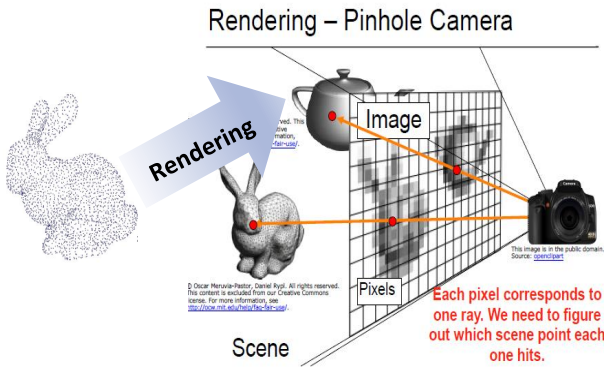




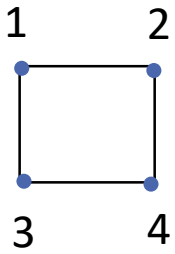
$$P' = M_{parallel} \cdot P$$

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & -d \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix} = \begin{pmatrix} x \\ y \\ -d \\ 1 \end{pmatrix}$$

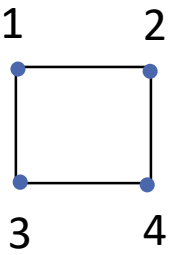
2.2 가시성 변환



표면과 이면

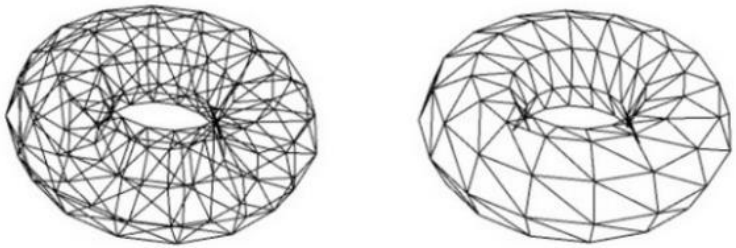


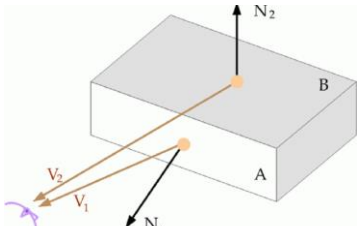
Polygon: 1, 2, 4, 3



Polygon: 1, 3, 4, 2

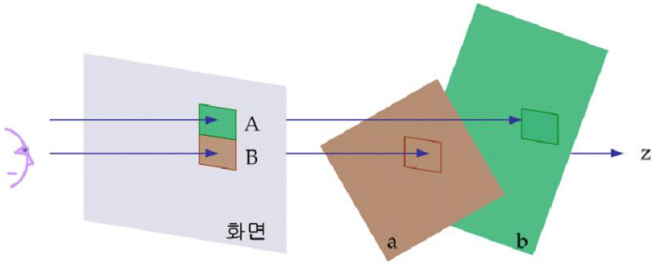
후면 제거

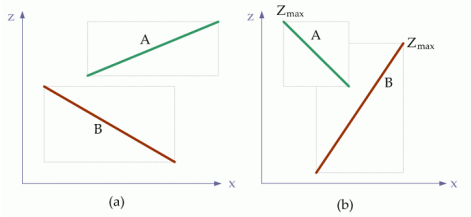




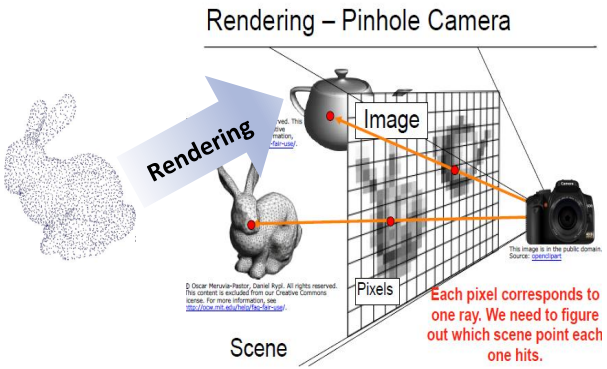
$$Backface = (N \cdot V < 0) = (|N||V|\cos\theta < 0)$$

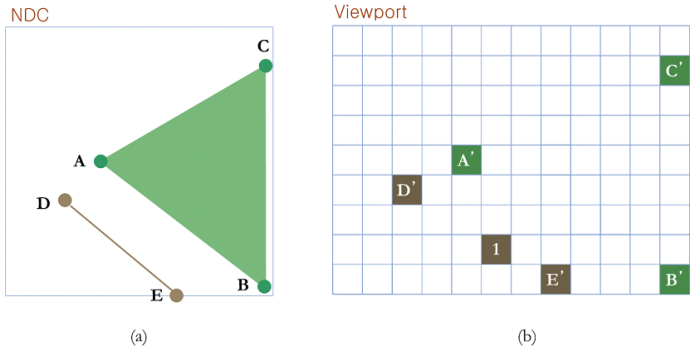
은면 제거

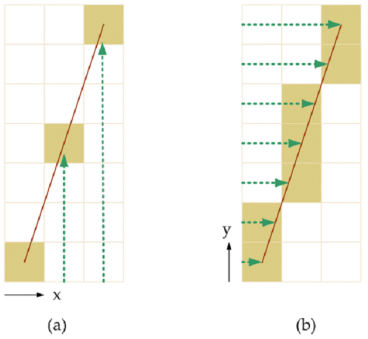


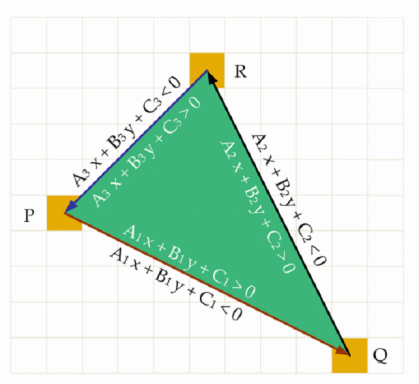


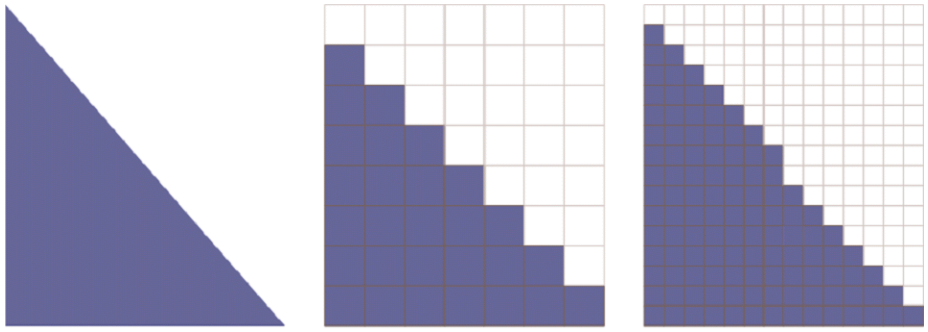
2.3 래스터 변환


Rendering – Pinhole Camera
Rendering
Image
Pixels
Scene
Each pixel corresponds to one ray. We need to figure out which scene point each one hits.


NDC
C
A
D
E
B
Viewport
C'
A'
D'
1
E'
B'
(a)
(b)

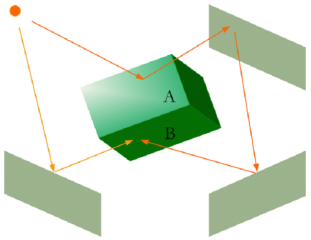

x
y
(a)
(b)


R
P
Q
$A_3x + B_3y + C_3 < 0$
$A_3x + B_3y + C_3 > 0$
$A_2x + B_2y + C_2 < 0$
$A_2x + B_2y + C_2 > 0$
$A_1x + B_1y + C_1 > 0$
$A_1x + B_1y + C_1 < 0$

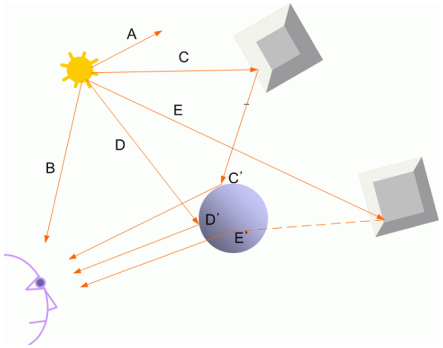

(a)
(b)
(c)

2. 4 Lighting

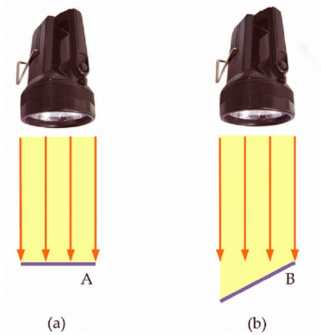
Ambient Reflection



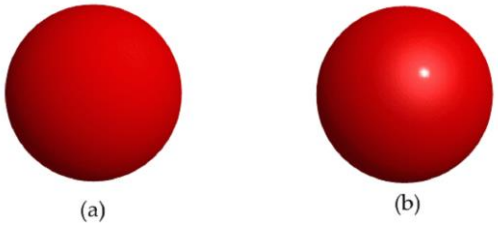
Shading



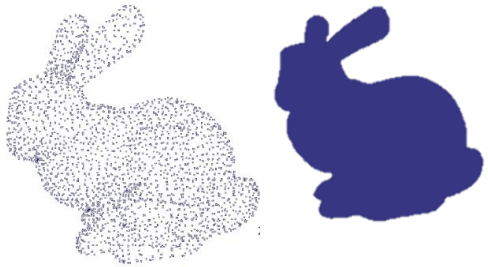
Diffusive Reflection



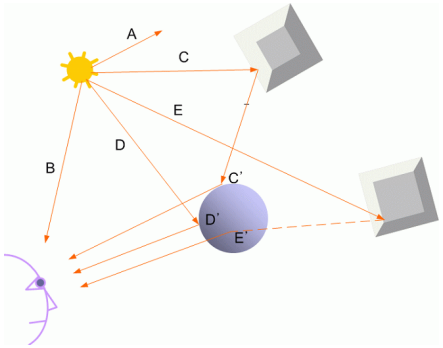
Specular Reflection



2. 5 Shading (음영), Shade (그림자)



Shading



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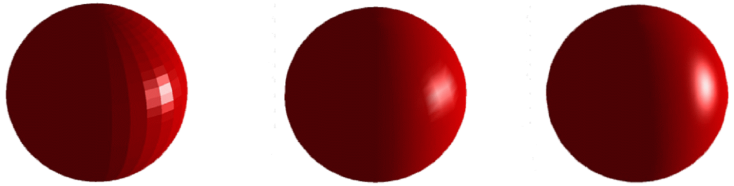
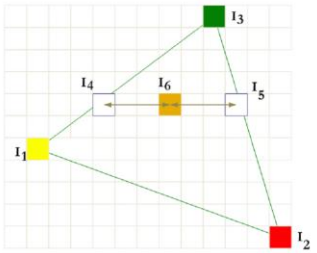
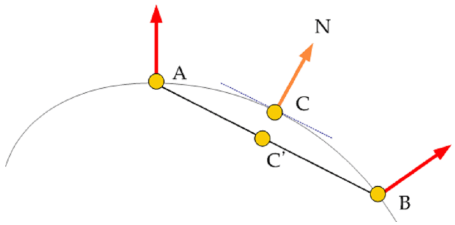
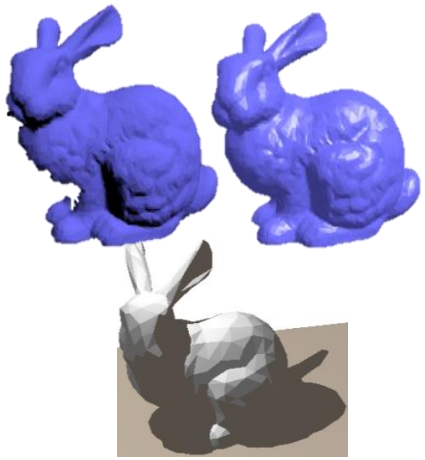
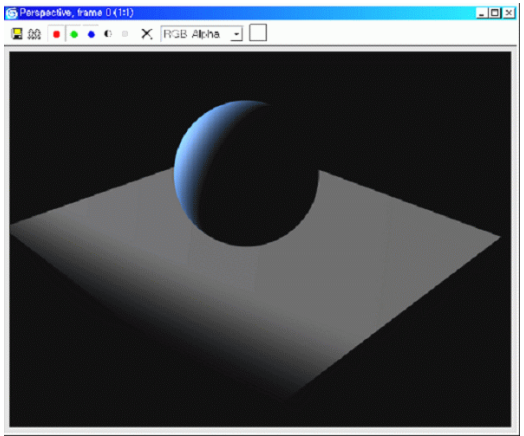


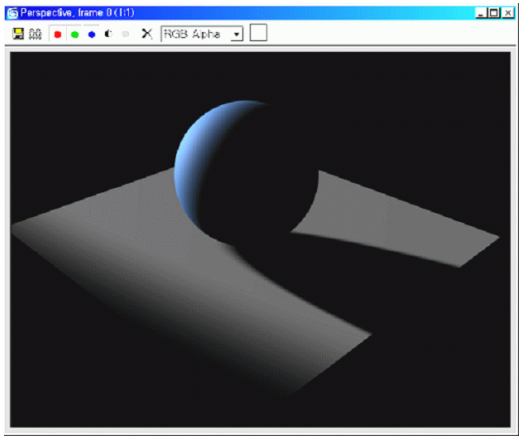




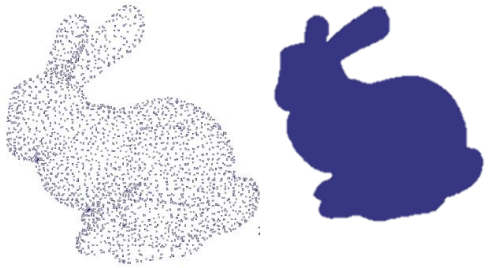
그림자



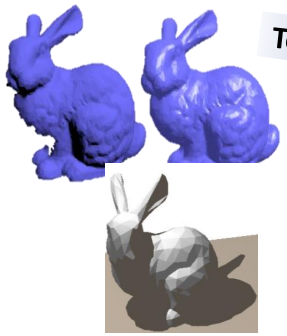




2.6 Texture Mapping



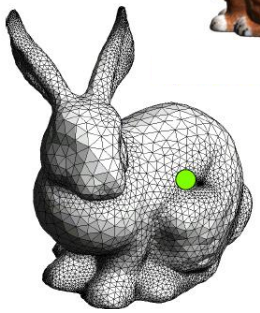
Shading



Texturing

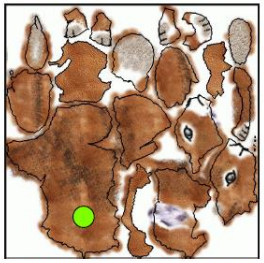
UV Texture

Texture mapped model



?

Texture map (2D image)



다각형 곡면