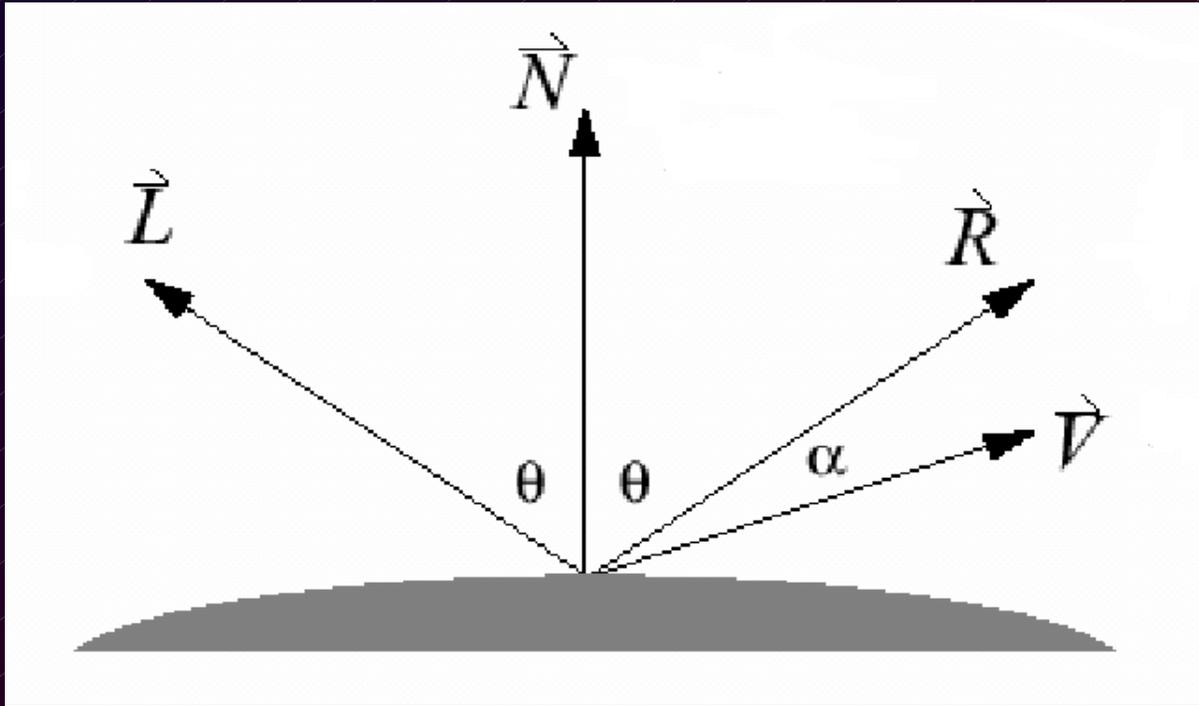
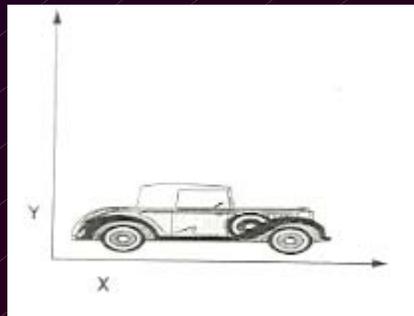
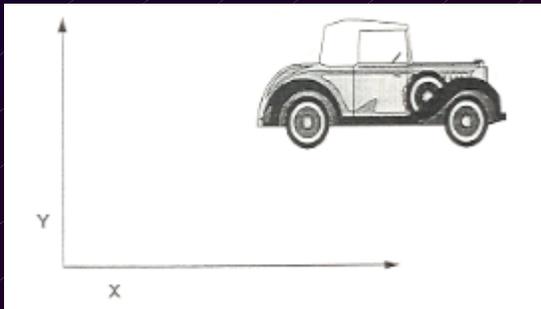
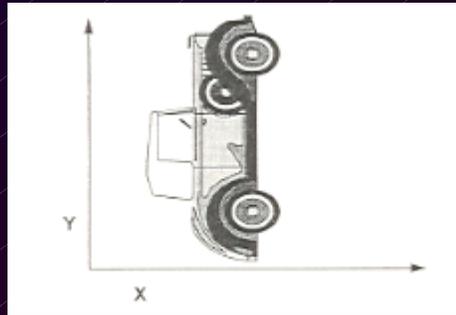
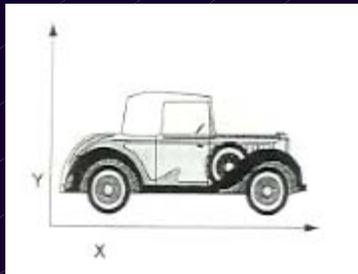


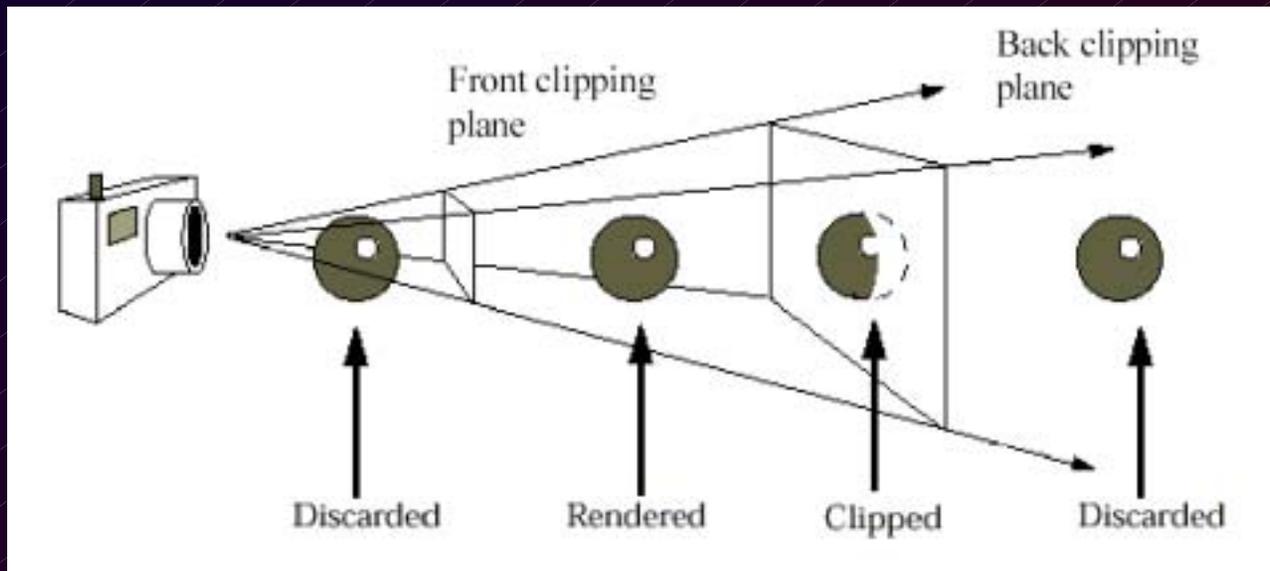
<http://cse.snu.ac.kr/mskim>

<http://3map.snu.ac.kr>









- 1950 MIT Whirlwind
- 1963 Ivan Sutherland
MIT SketchPad
- 1970 University of Utah
Evans-Sutherland
- 1979 Stanford University
James Clark 가 Geometry Engine

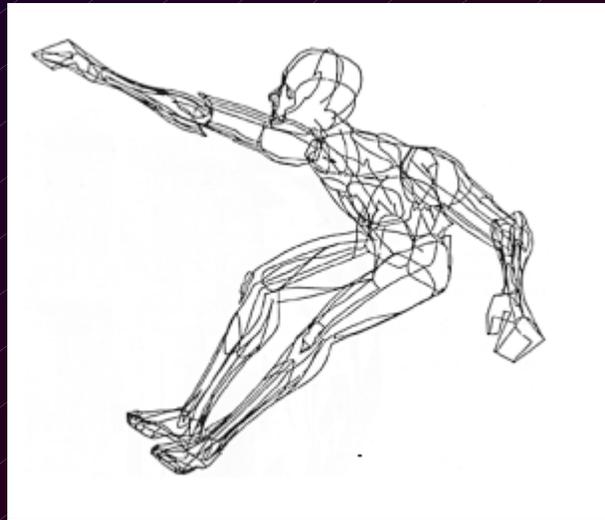
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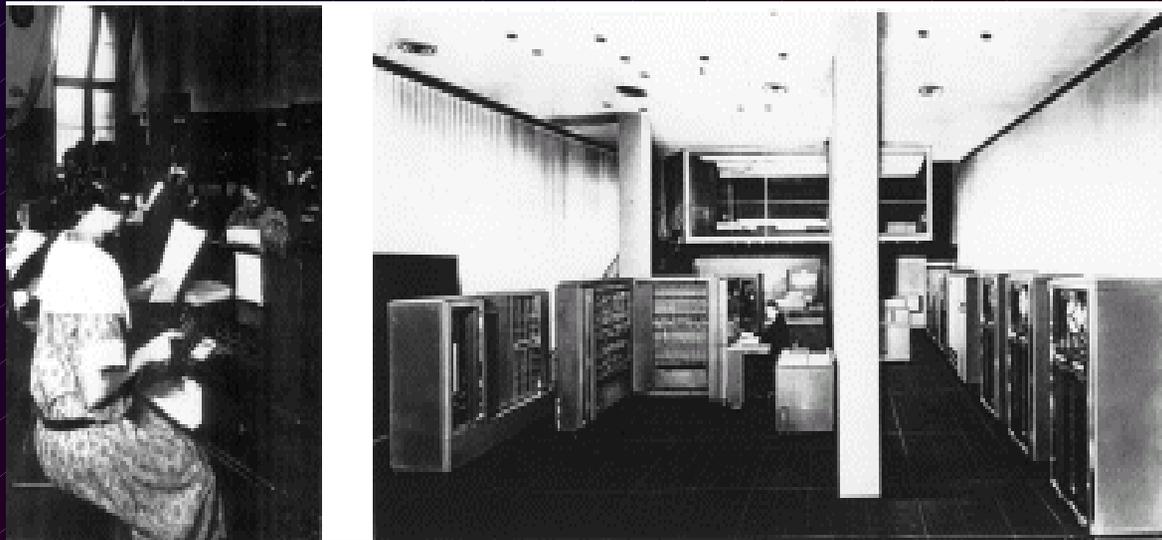
- 1960 Boeing William Fetter가

//

//



(IBM704)



- 1963 Ivan Sutherland MIT
"Sketchpad, a Man-Machine Graphical
Interface Systems"

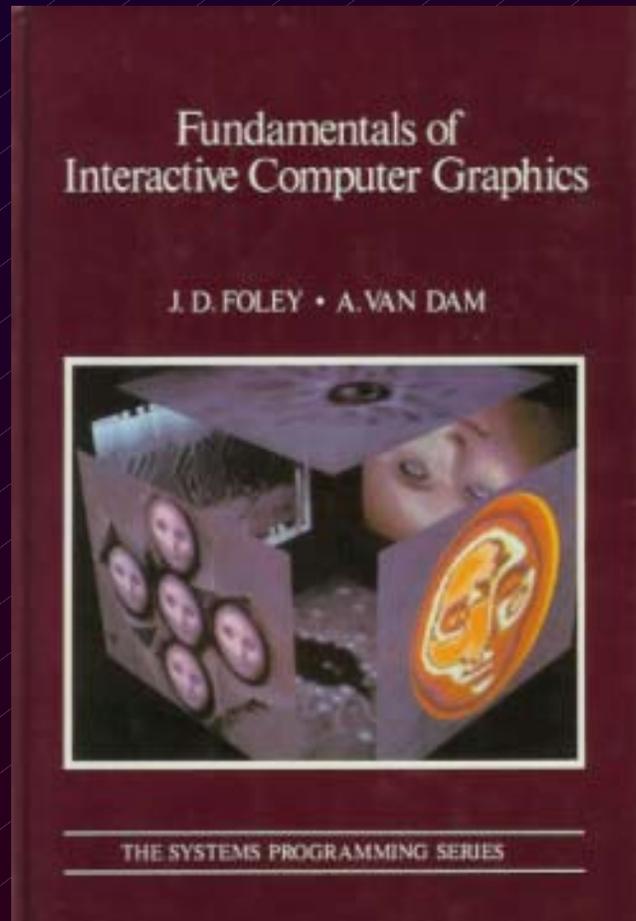


Geometry Engine

- 1979 Stanford University
James Clark
-
- 1982 James Clark Stanford
Silicon Graphics, Inc.
- *Jurassic Park, Terminator II, Batman Forever,
Casper, Toy Story*

Foley

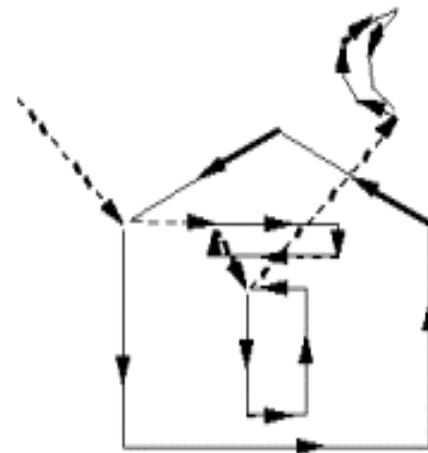
van Dam
(1982)



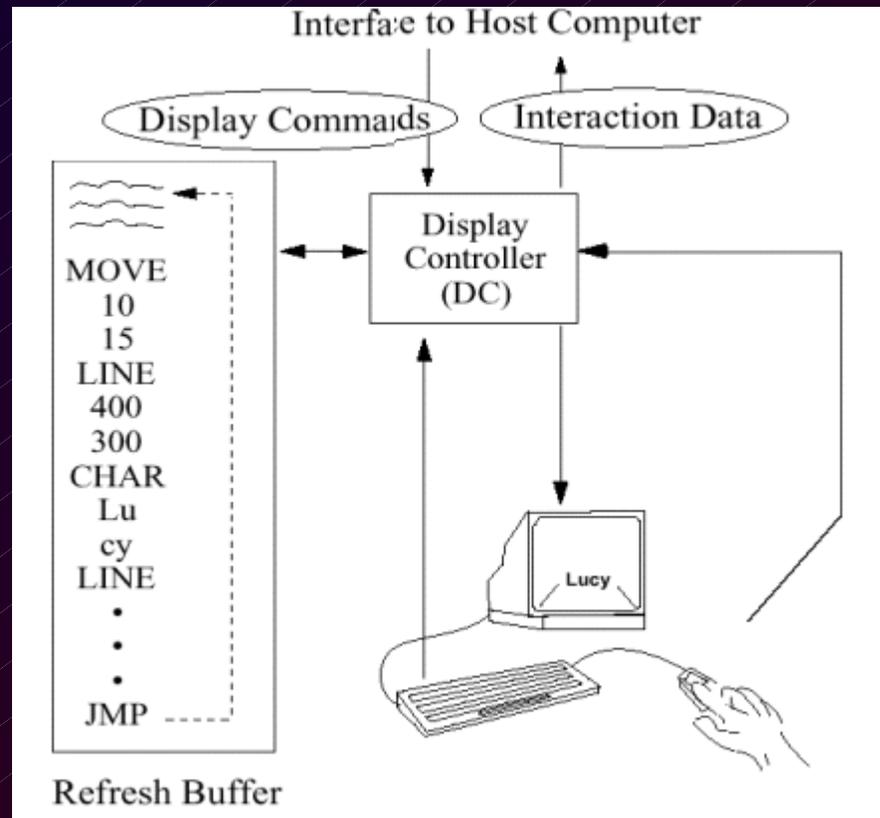




Ideal Drawing



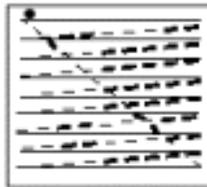
Vector Drawing







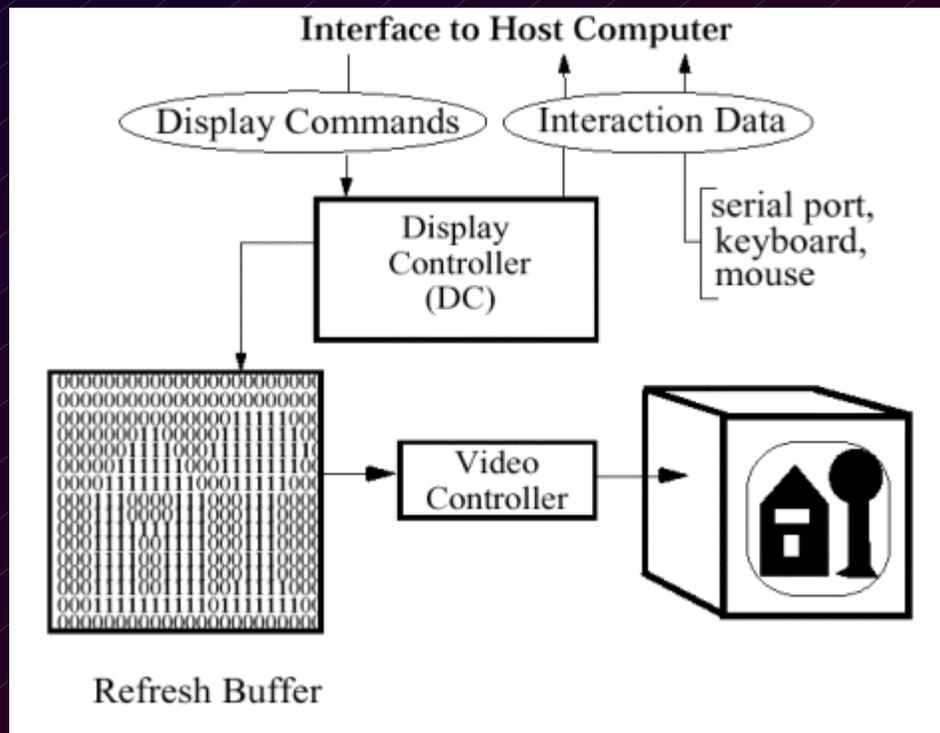
outline primitives



Raster



filled primitives



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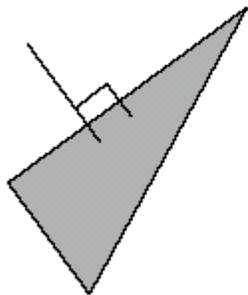
●

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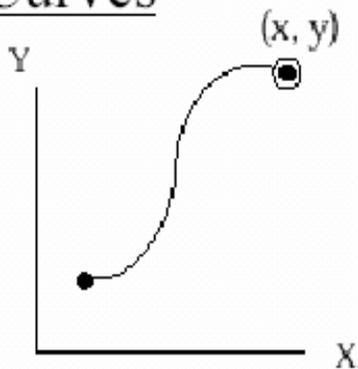
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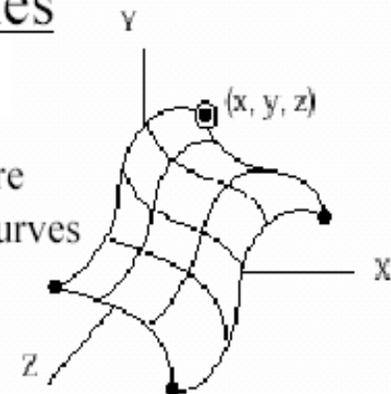


Curves



Patches

Boundaries are
Polynomial curves
In 3D







(GUI)

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Fig. 3 Generic supersonic transport aircraft; Modelling wing deformations for aeroelastic computations.

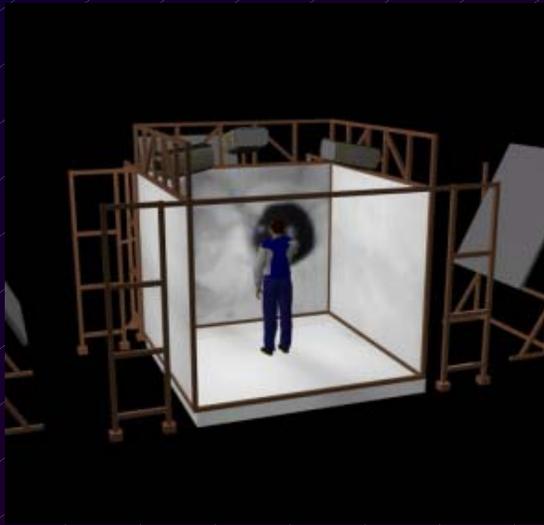


Fig. 4 Pressure field in a cross section generated by the wing-body configuration of a generic supersonic transport aircraft.

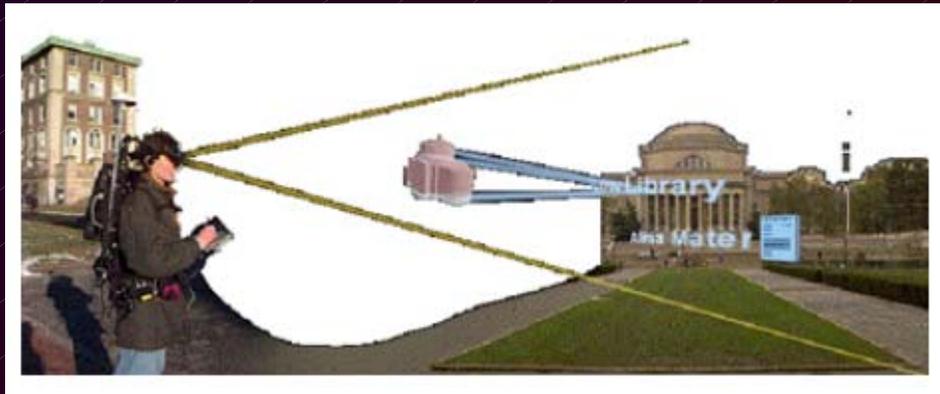


Fig. 6 Visualization of unsteady hypersonic flow; Ramjet unstart. Isofringes for the pressure field.

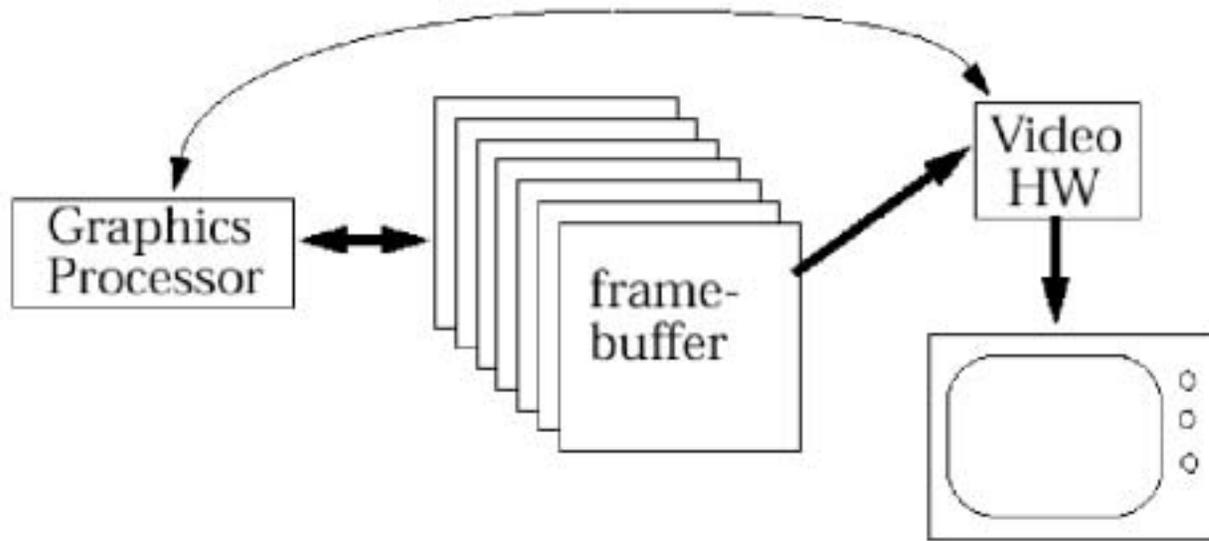
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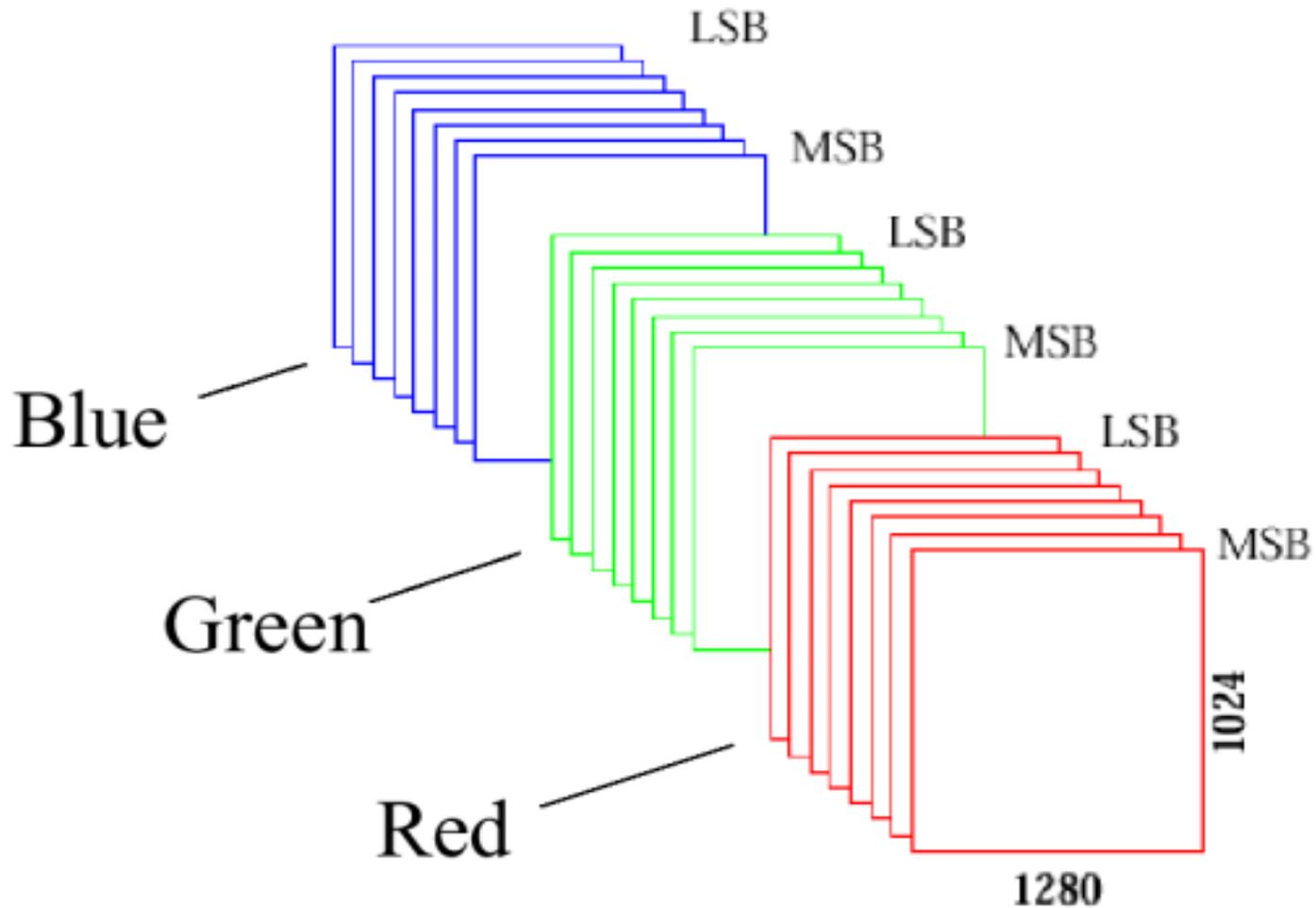
Cave Painting



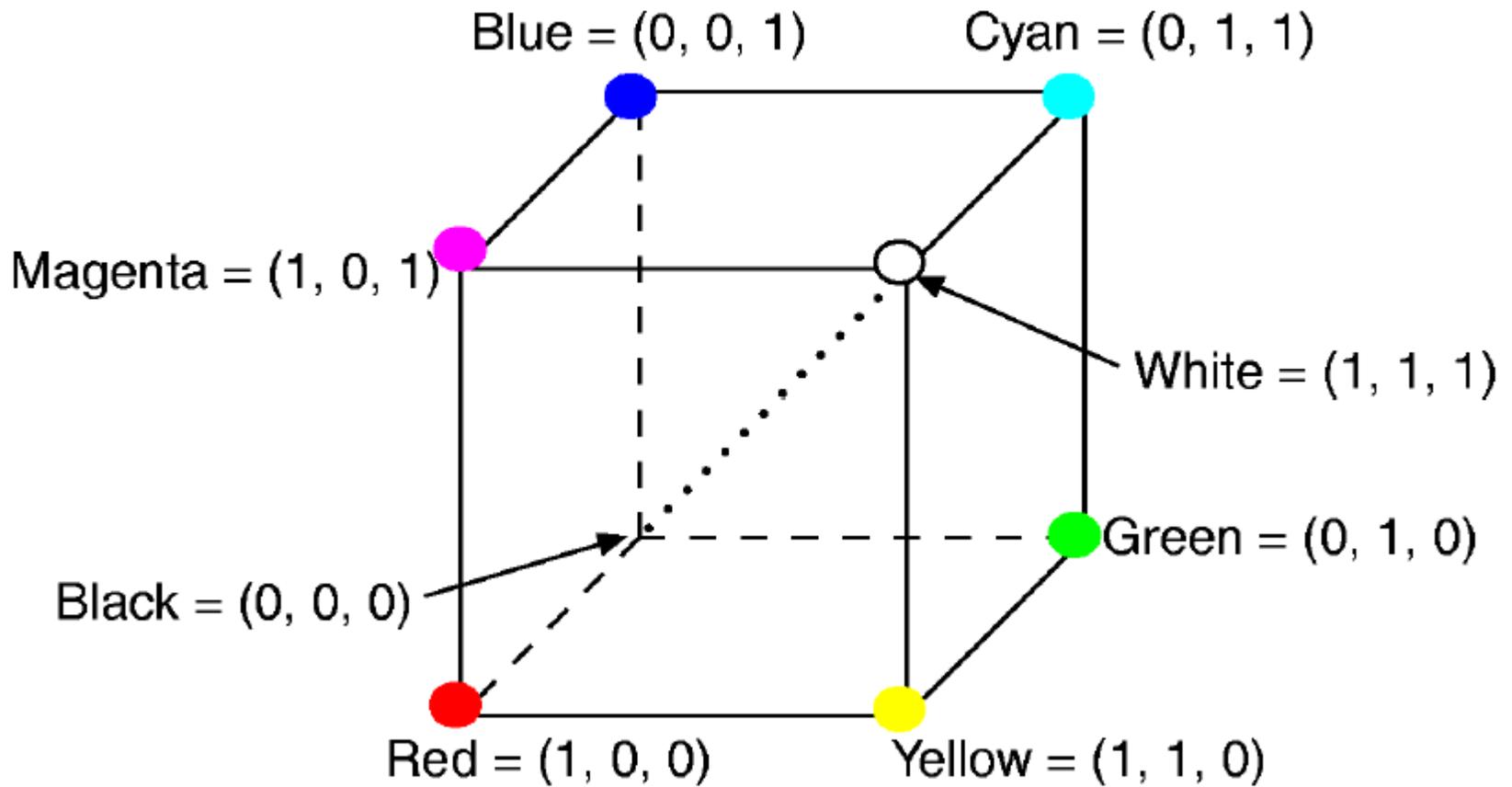




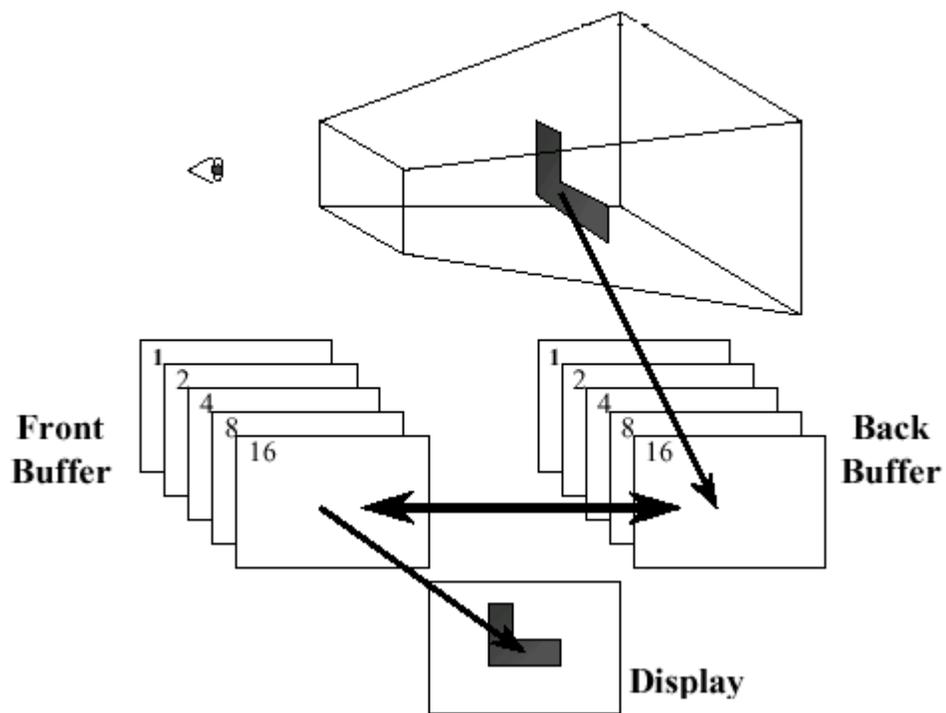
Frame



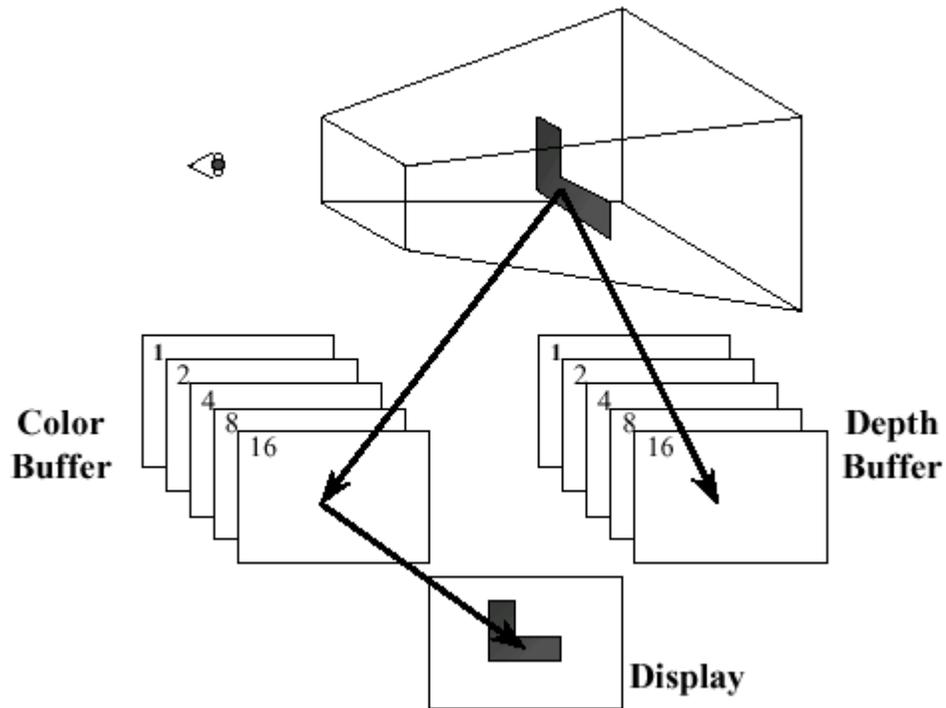
RGB



Double



Color Depth



3

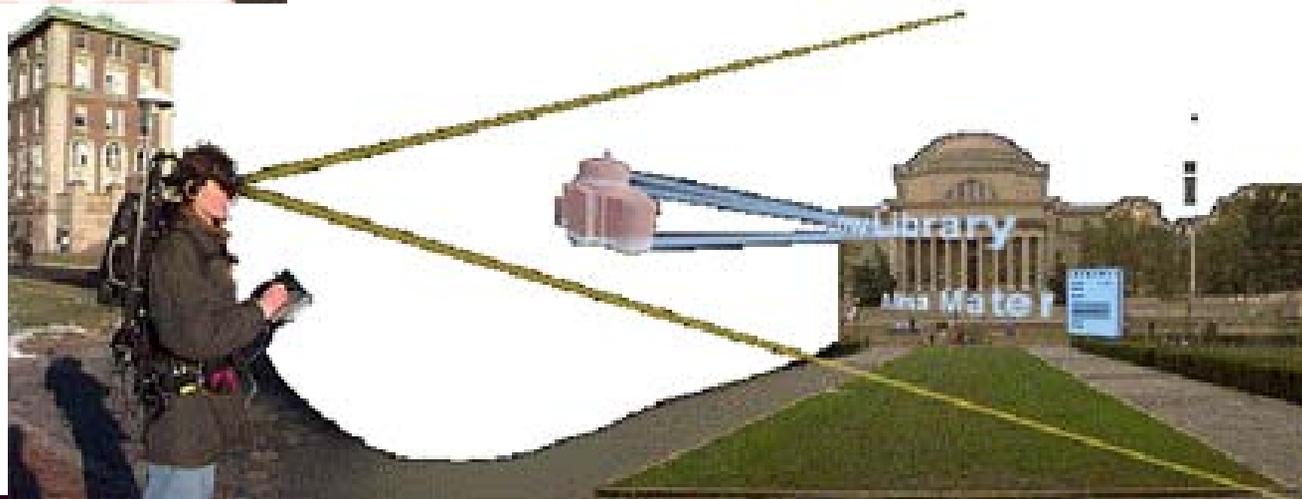




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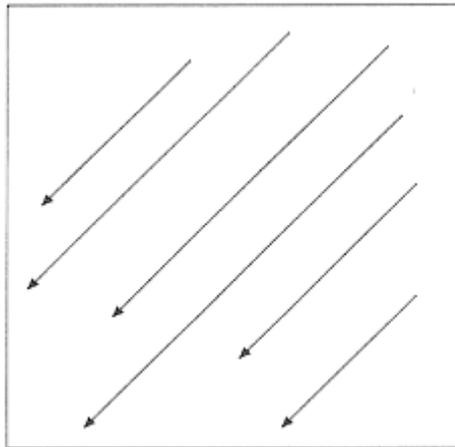
Augmented Reality



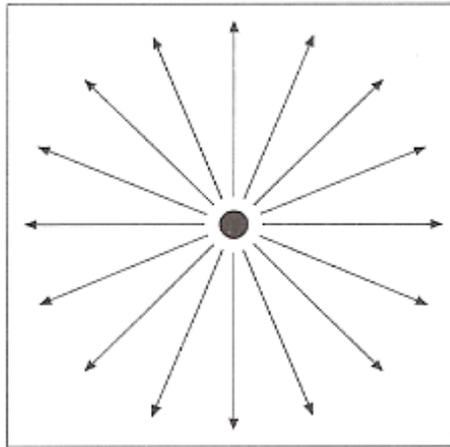


(I Illumination)

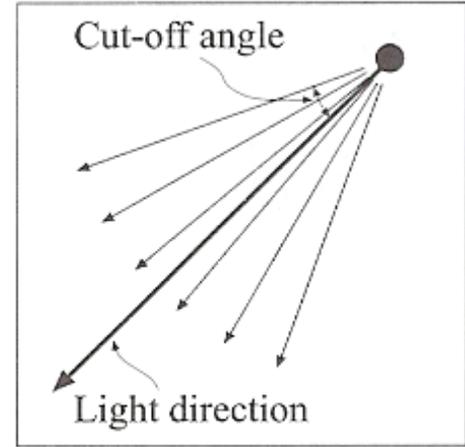
- (Ambient Light)
- 가
(Diffuse Reflection)
- 가
(Specular Reflection)
- 가
(Emission Light)



Directional Light



Point Light



Spot Light

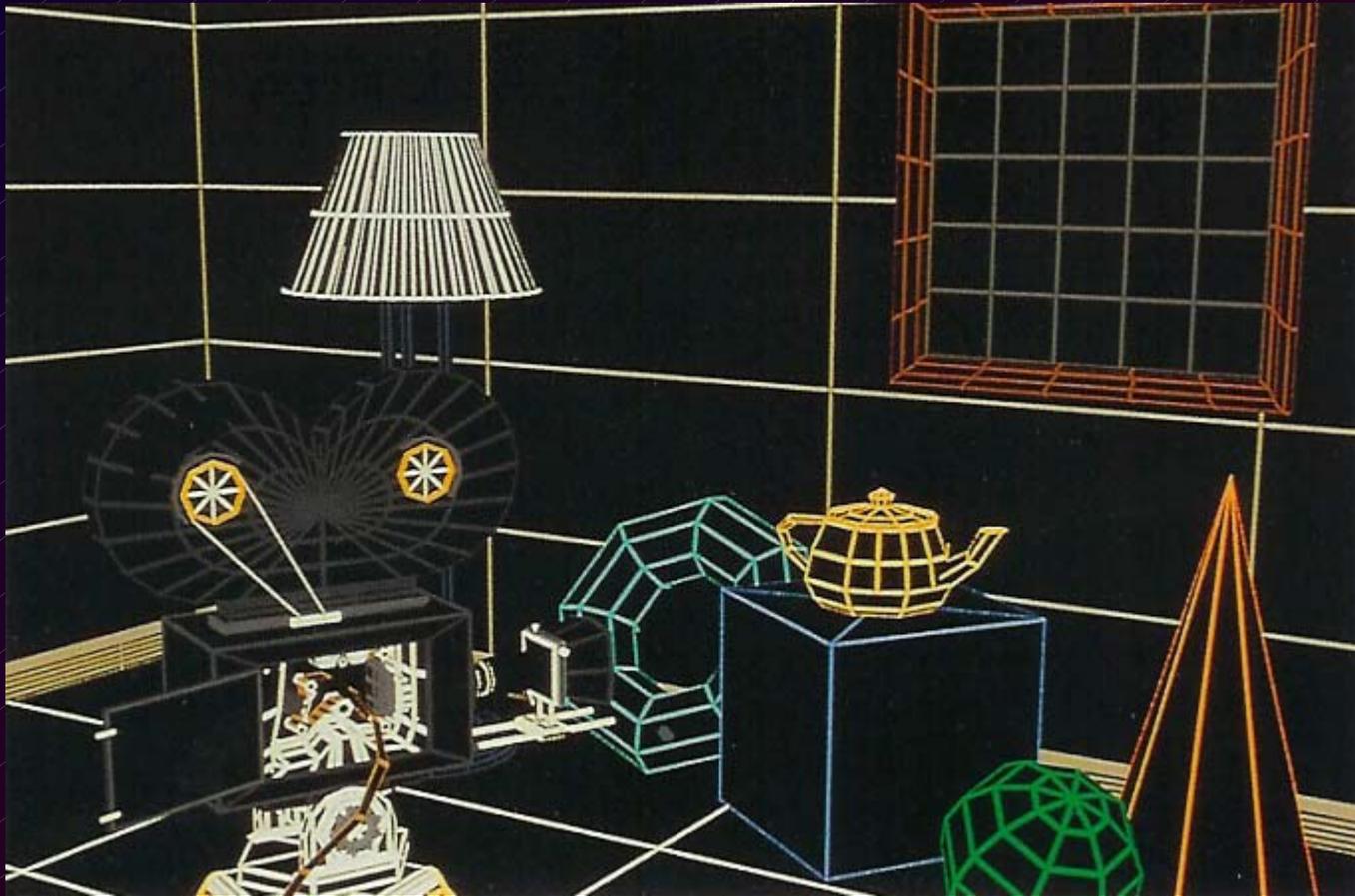
(Ambient Light)

$$I = I_a k_a$$

I_a : 주변 빛의 세기

k_a : 주변 빛의 반사계수

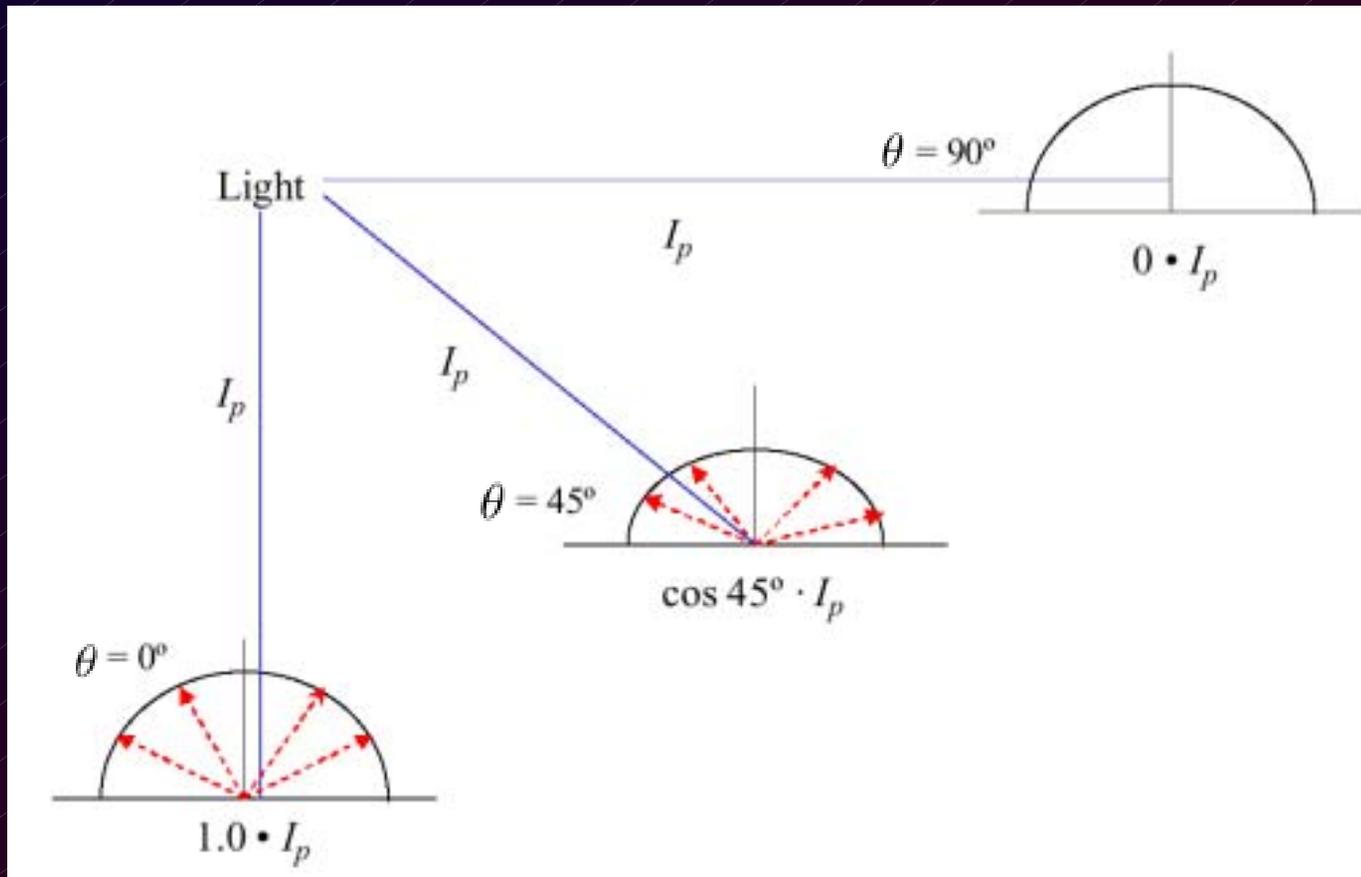
()



(Ambient Light)



(Diffuse Reflection)



(Diffuse Reflection)

$$I = I_p k_d \cos \theta = I_p k_d \langle N, L \rangle$$

I_p : 광원의 세기

k_d : 난반사계수

N : 면의 법선벡터 (단위벡터)

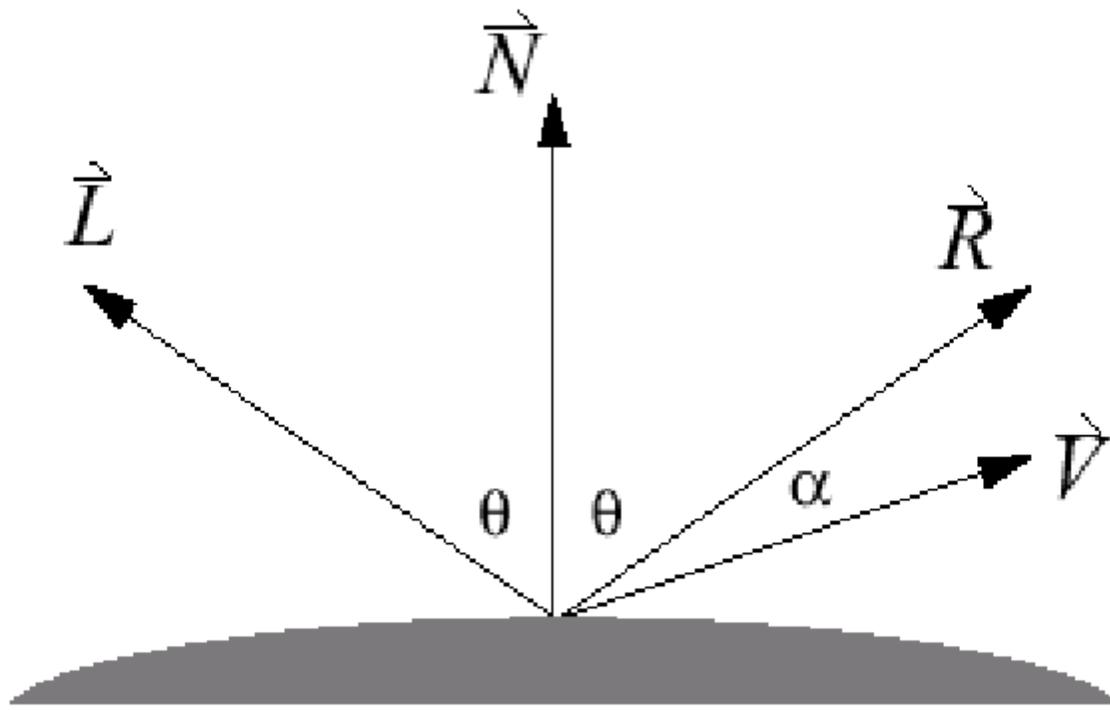
L : 광원으로부터의 방향벡터 (단위벡터)

θ : 두 벡터 N 과 L 사이의 각

(Diffuse Reflection+Flat Shading)



(Specular Reflection)



$$I = I_p k_s \cos^n \alpha = I_p k_s \langle R, V \rangle^n$$

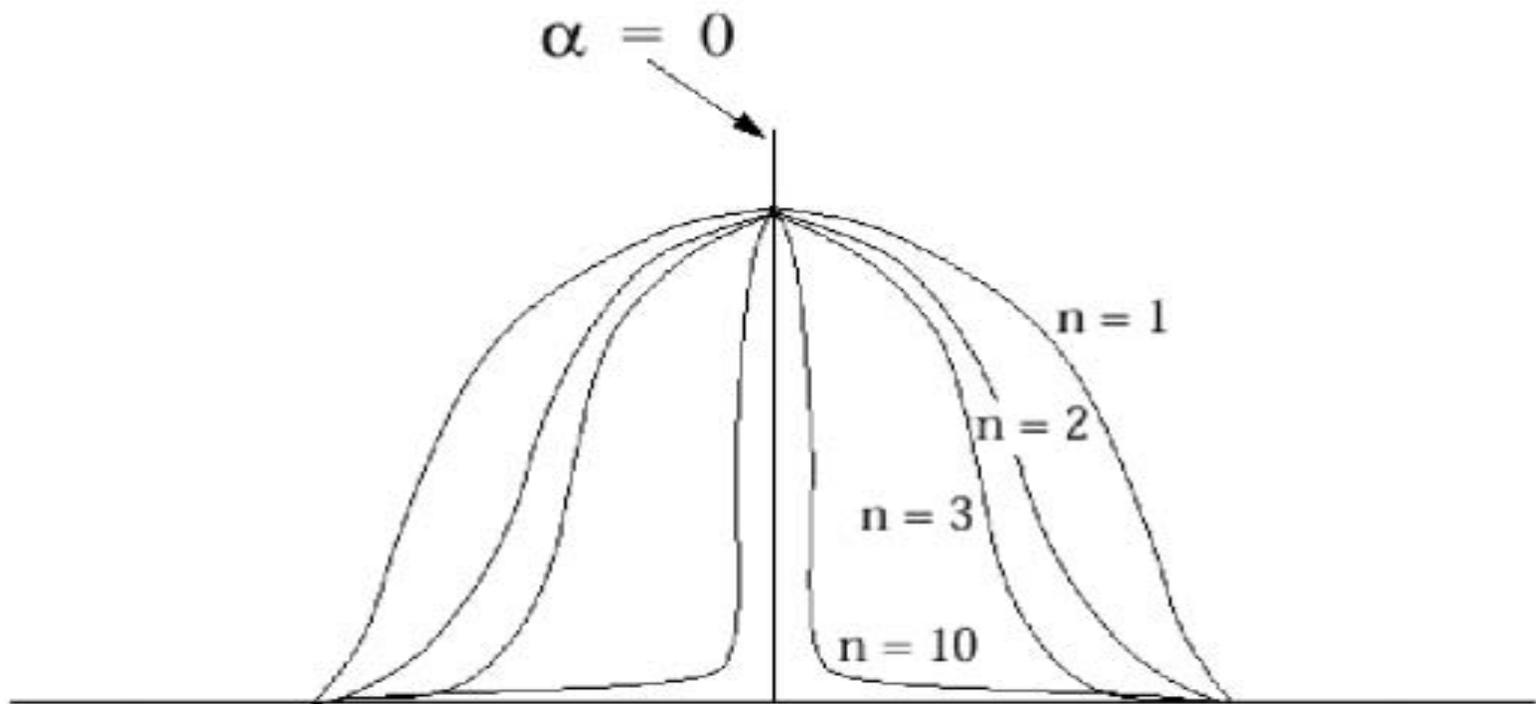
I_p : 광원의 세기

k_s : 정반사계수

R : 정반사되는 방향으로의 단위벡터

V : 눈이 있는 방향으로의 단위벡터

α : 두 벡터 R 과 V 사이의 각



n 은 완전 반사체 (거울)의 경우 ∞ 이고,
표면의 재질에 따라서 달라진다.

가

$$I = I_a k_a + I_p k_d \langle N, L \rangle + I_p k_s \langle R, V \rangle^n$$

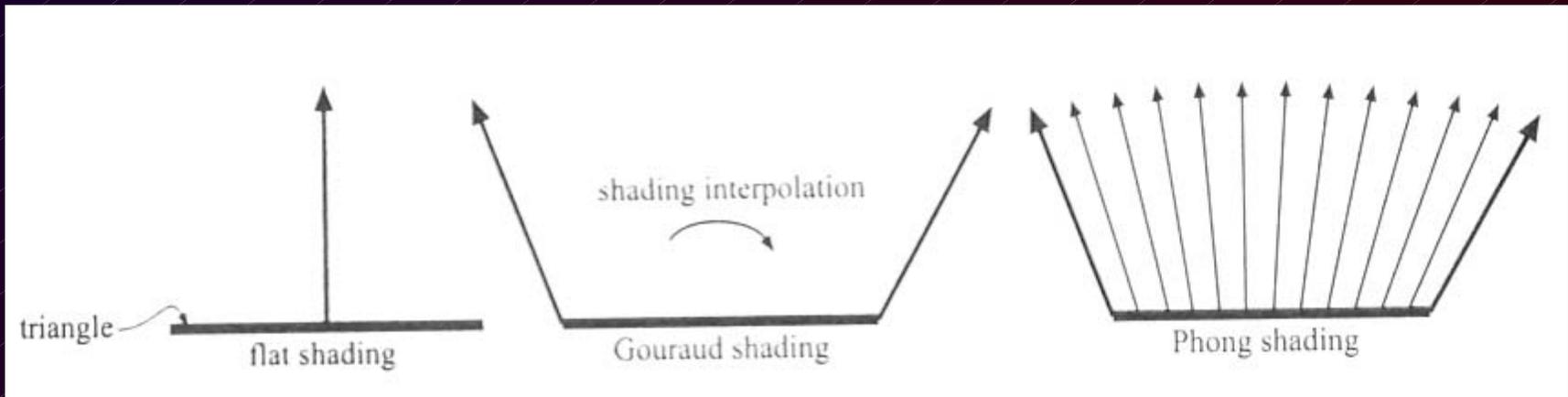
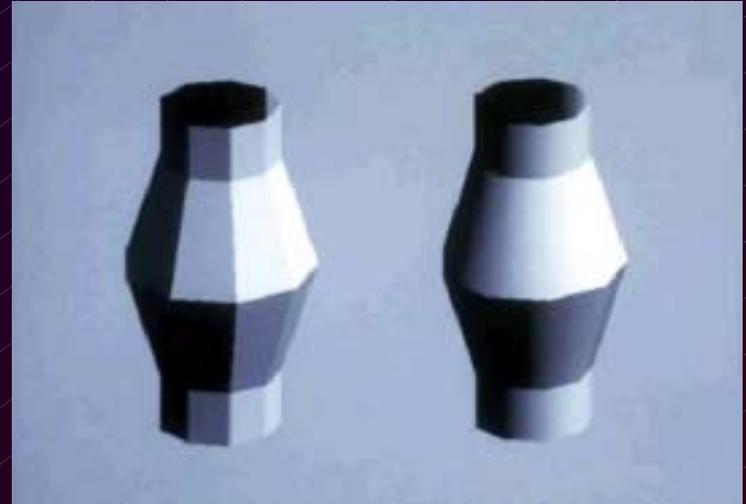
$$f_{att} = \frac{1}{c_1 + c_2 d + c_3 d^2}$$

$$I = I_a k_a + f_{att} (I_p k_d \langle N, L \rangle + I_p k_s \langle R, V \rangle^n)$$

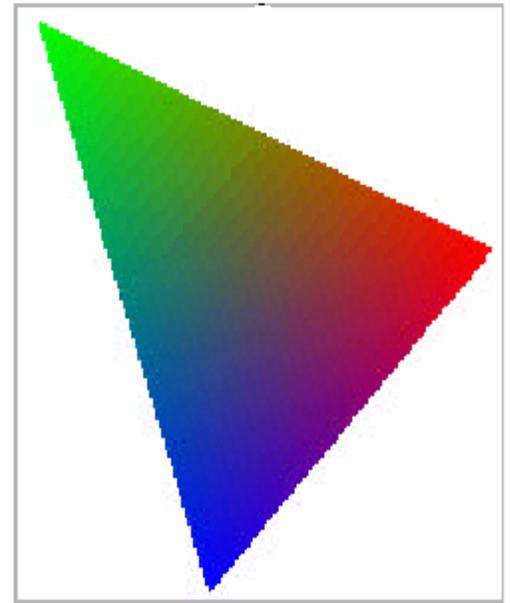
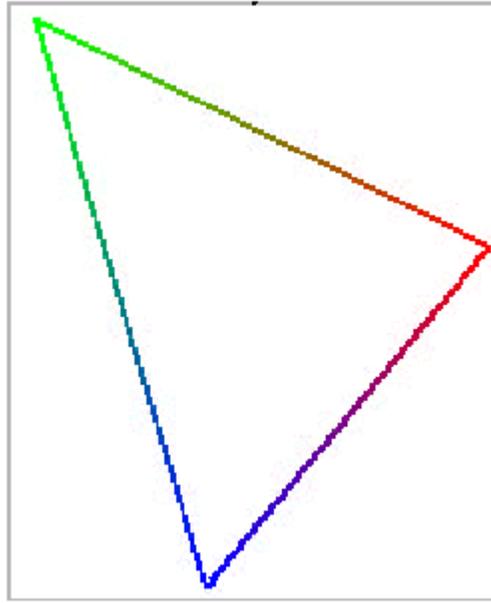
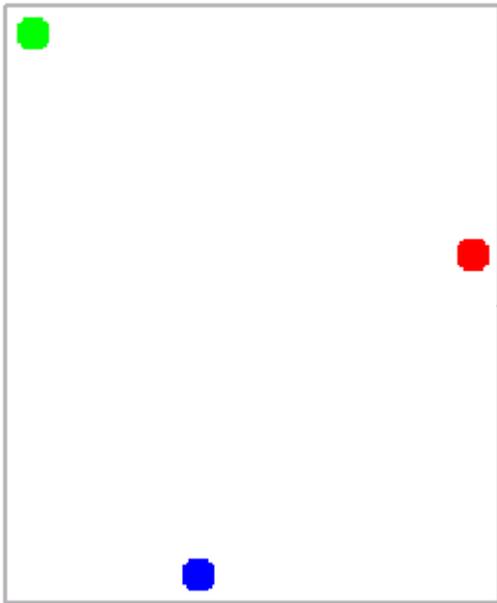
d : 광원으로 부터의 거리

Shading

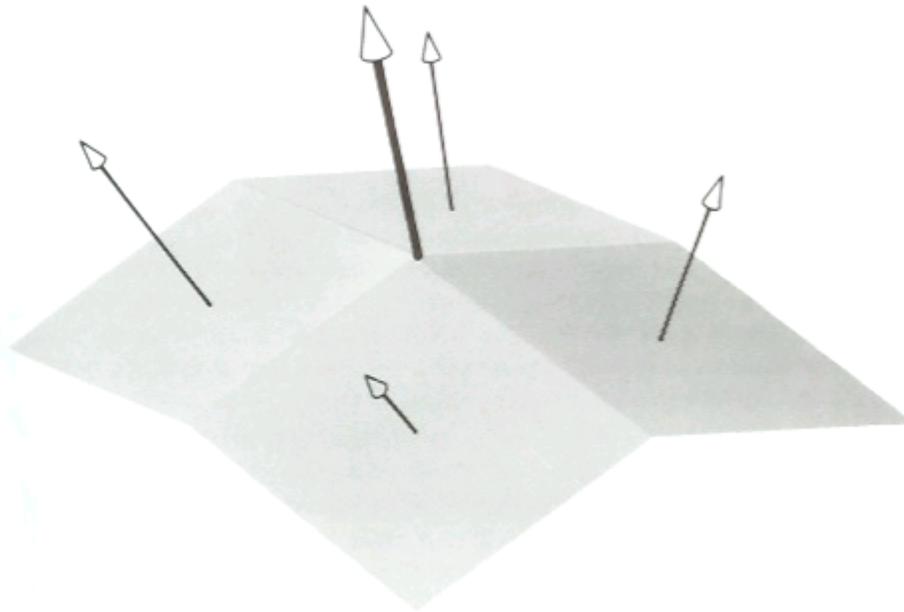
- Flat Shading
- Gouraud Shading
- Phong Shading



Gouraud Shading (Smooth Shading)



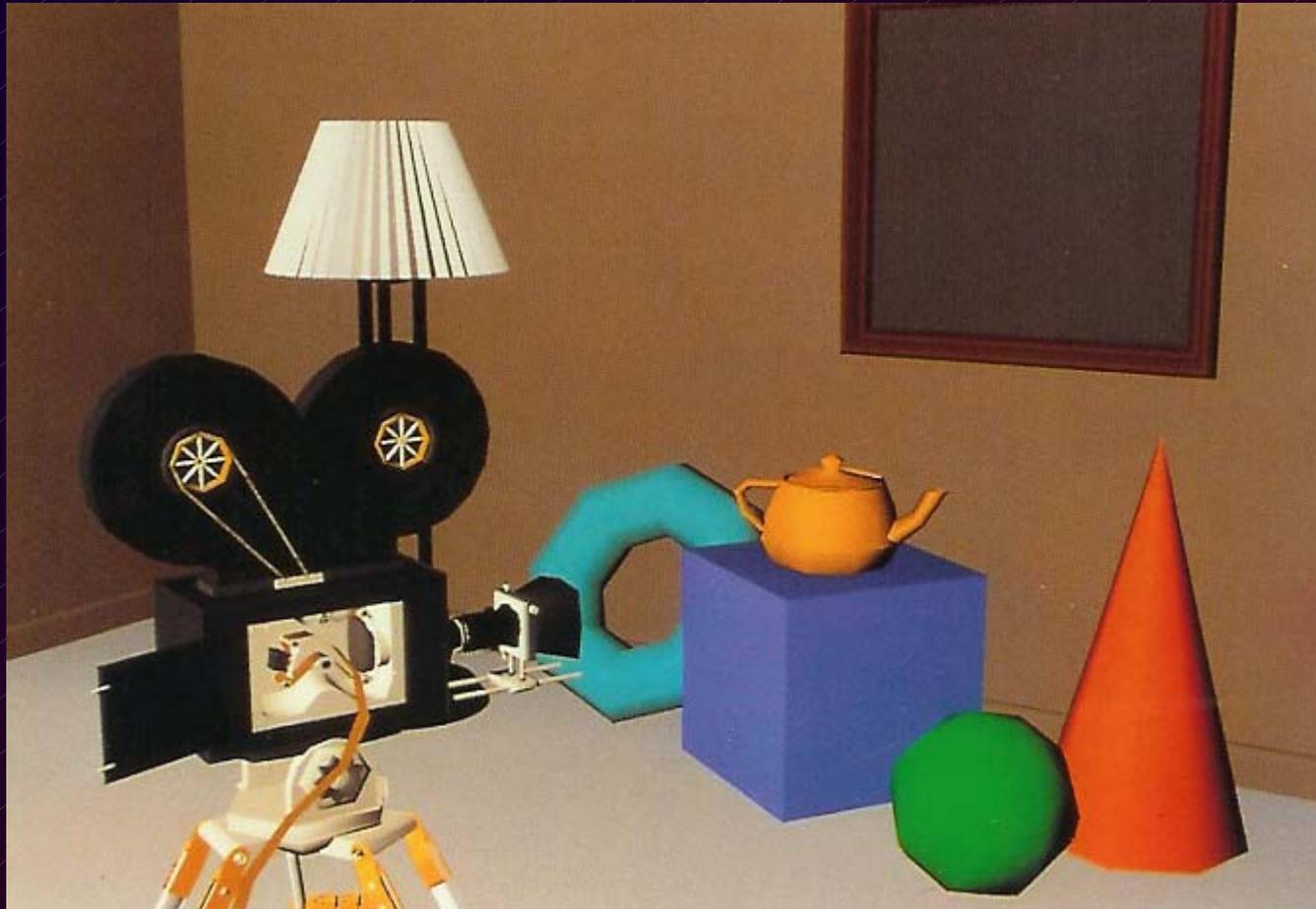
Vertex



Diffuse Reflection + Flat Shading



Diffuse Reflection + Gouraud (Smooth) Shading



Specular Reflection + Gouraud Shading

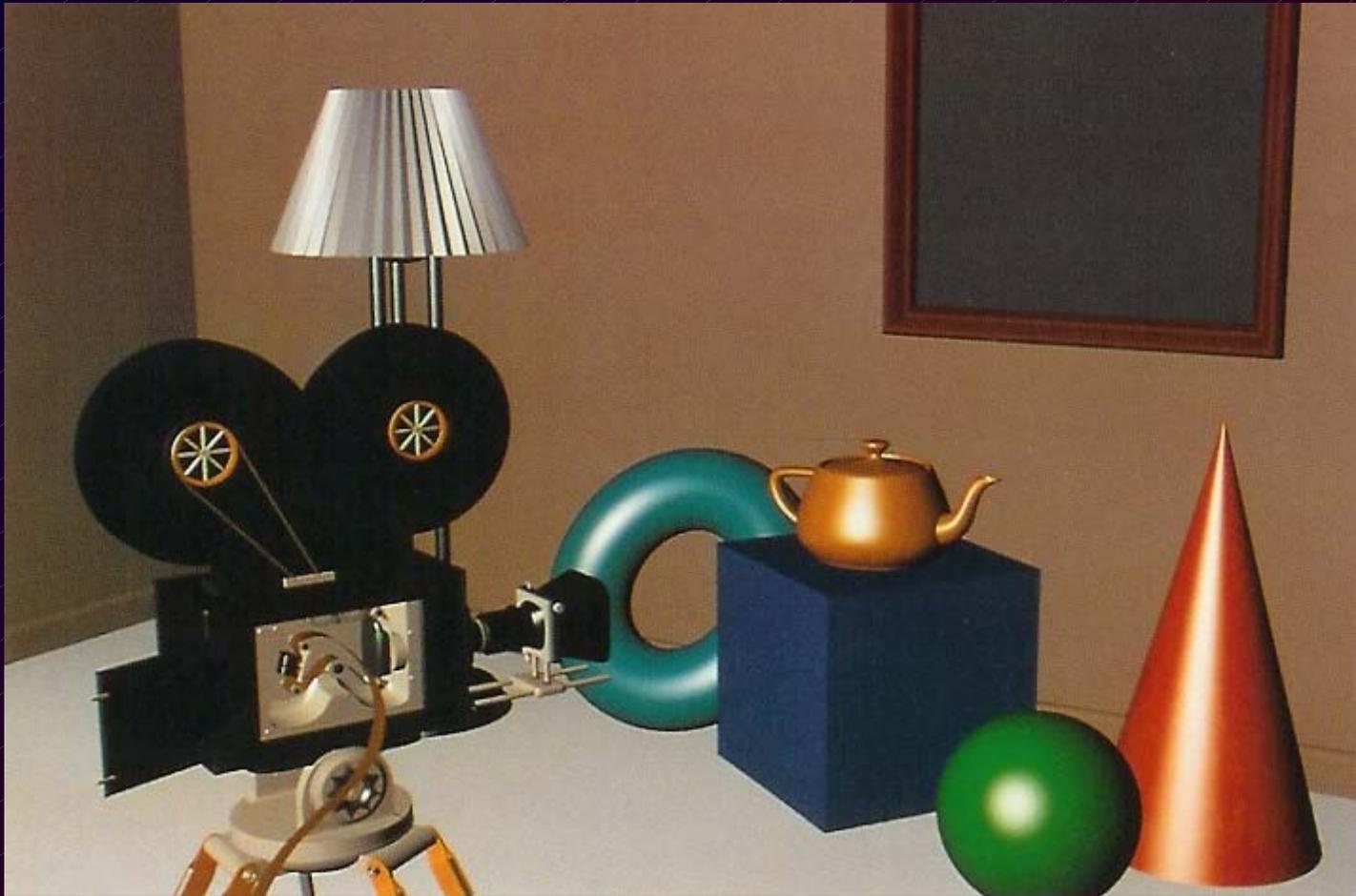


Specular Reflection + Phong Shading



Specular Reflection

+



-
- Environment
- Bump

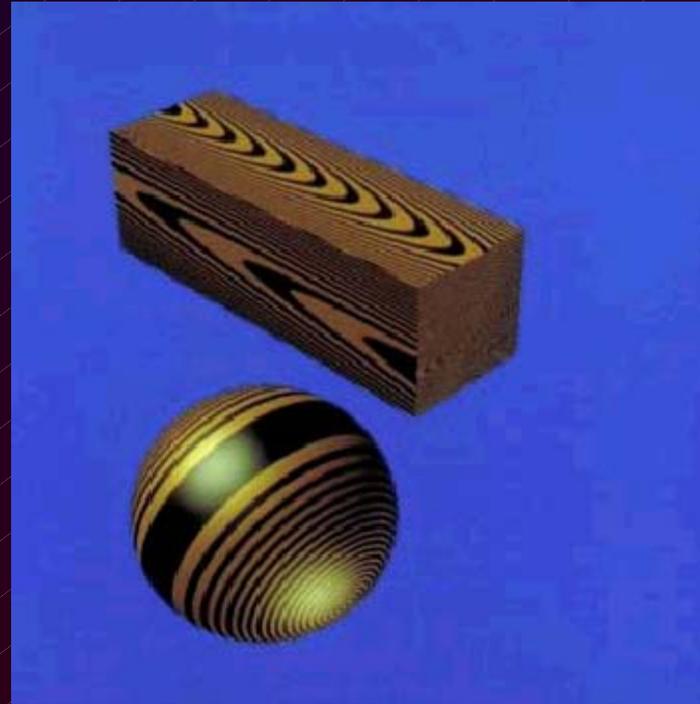
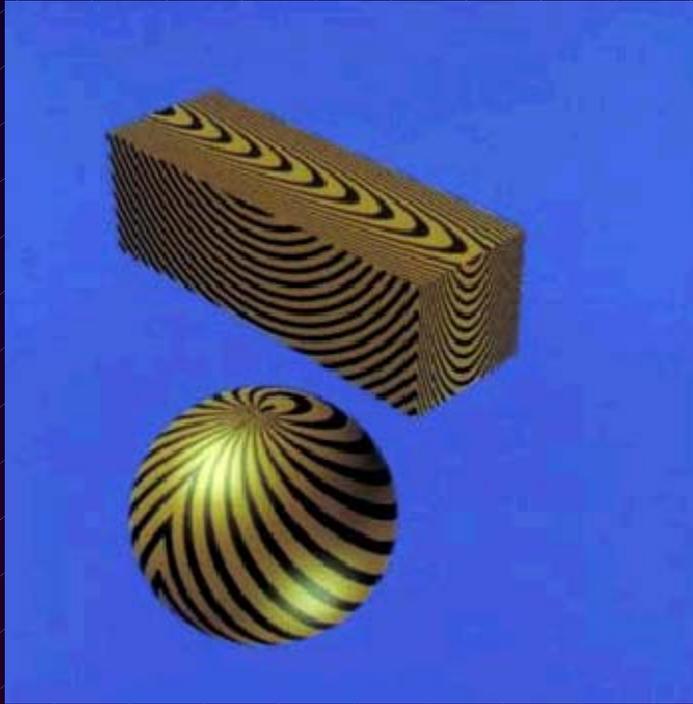




Displacement



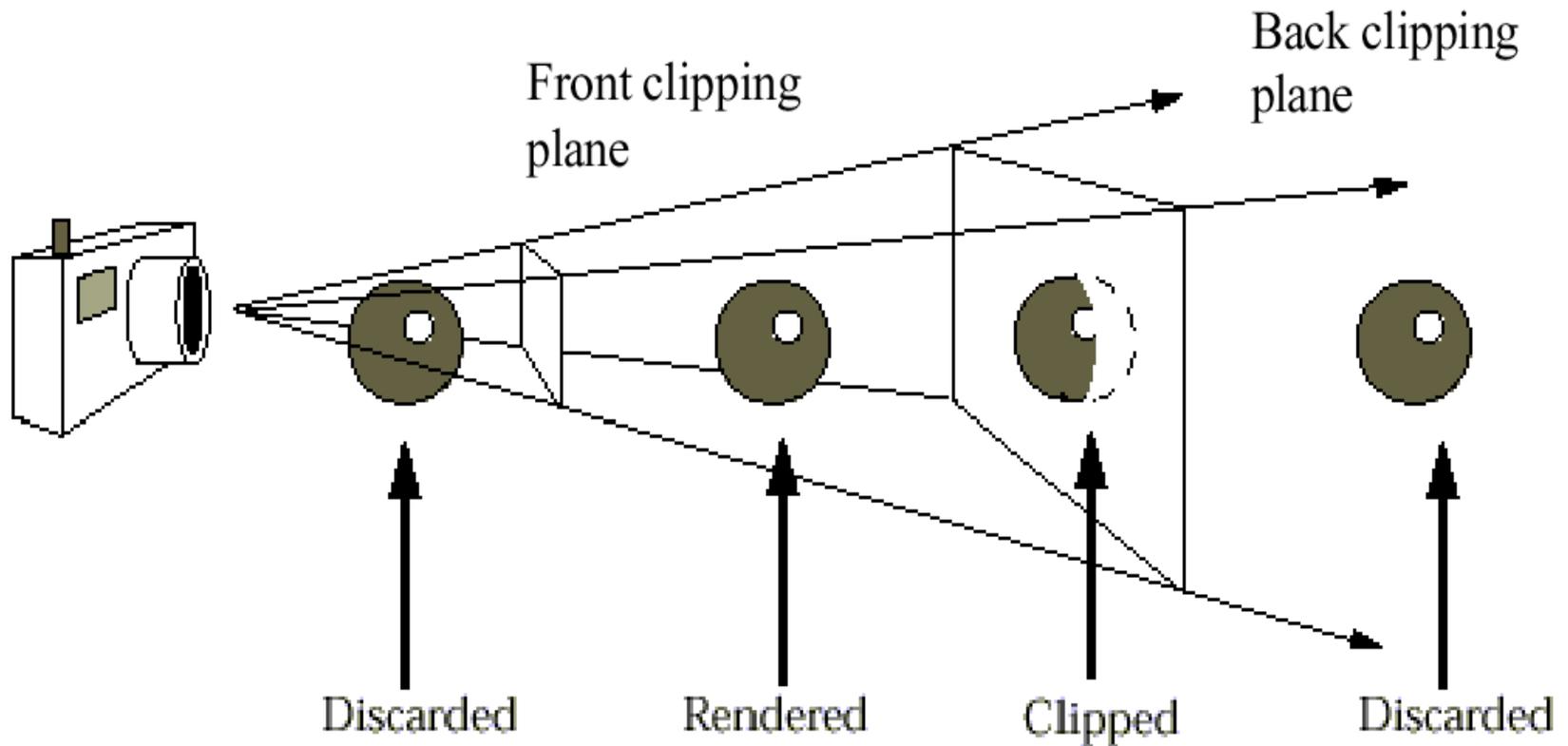
Solid



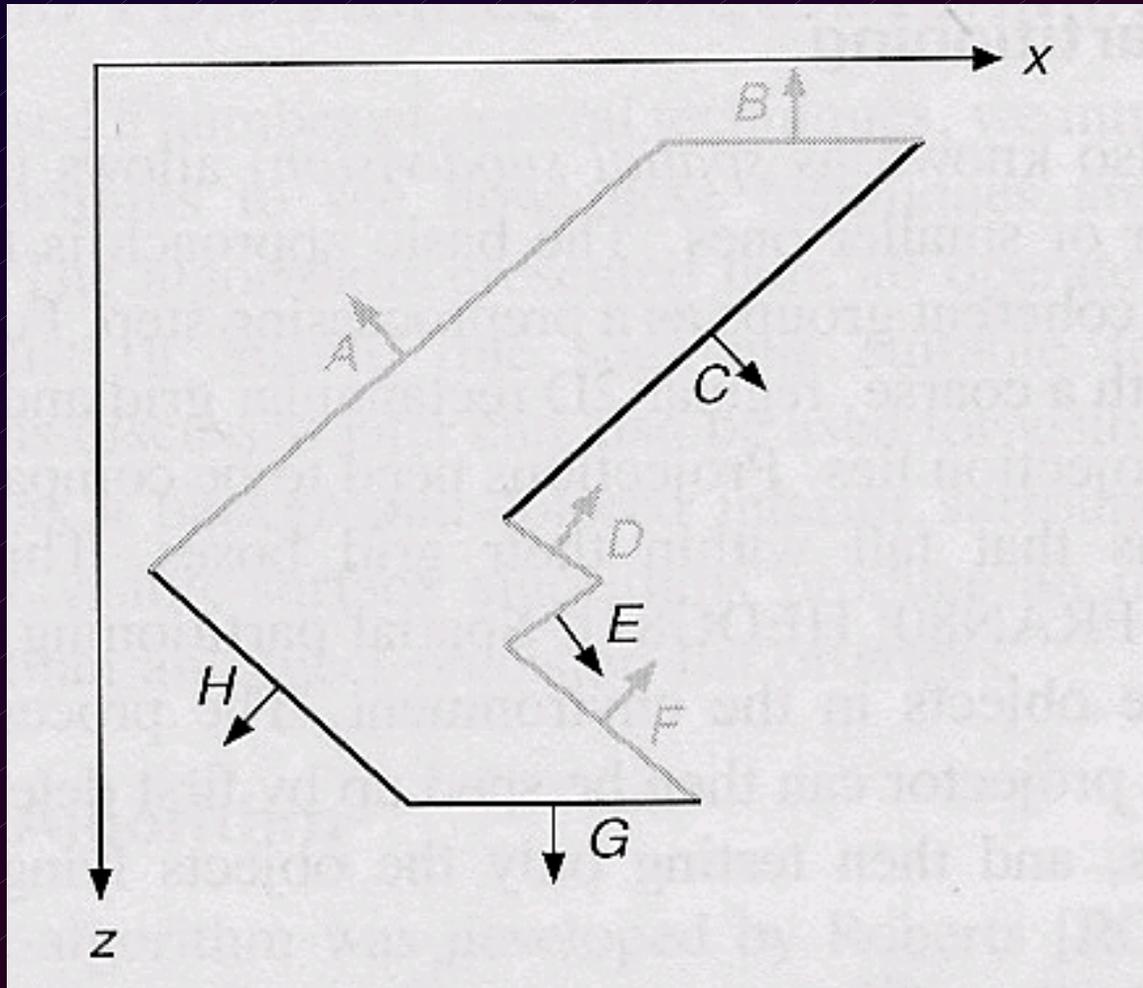


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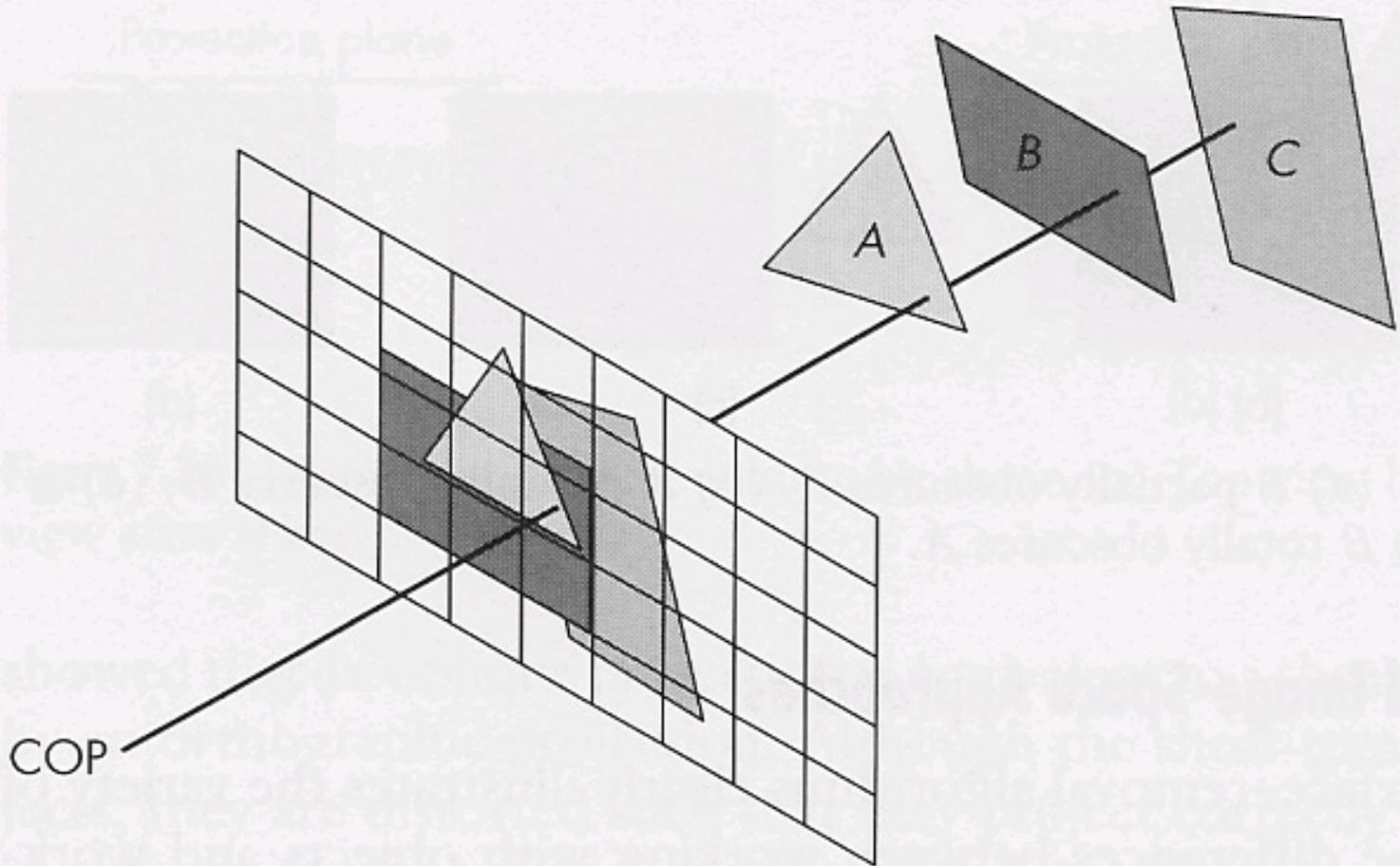
Culling and Clipping



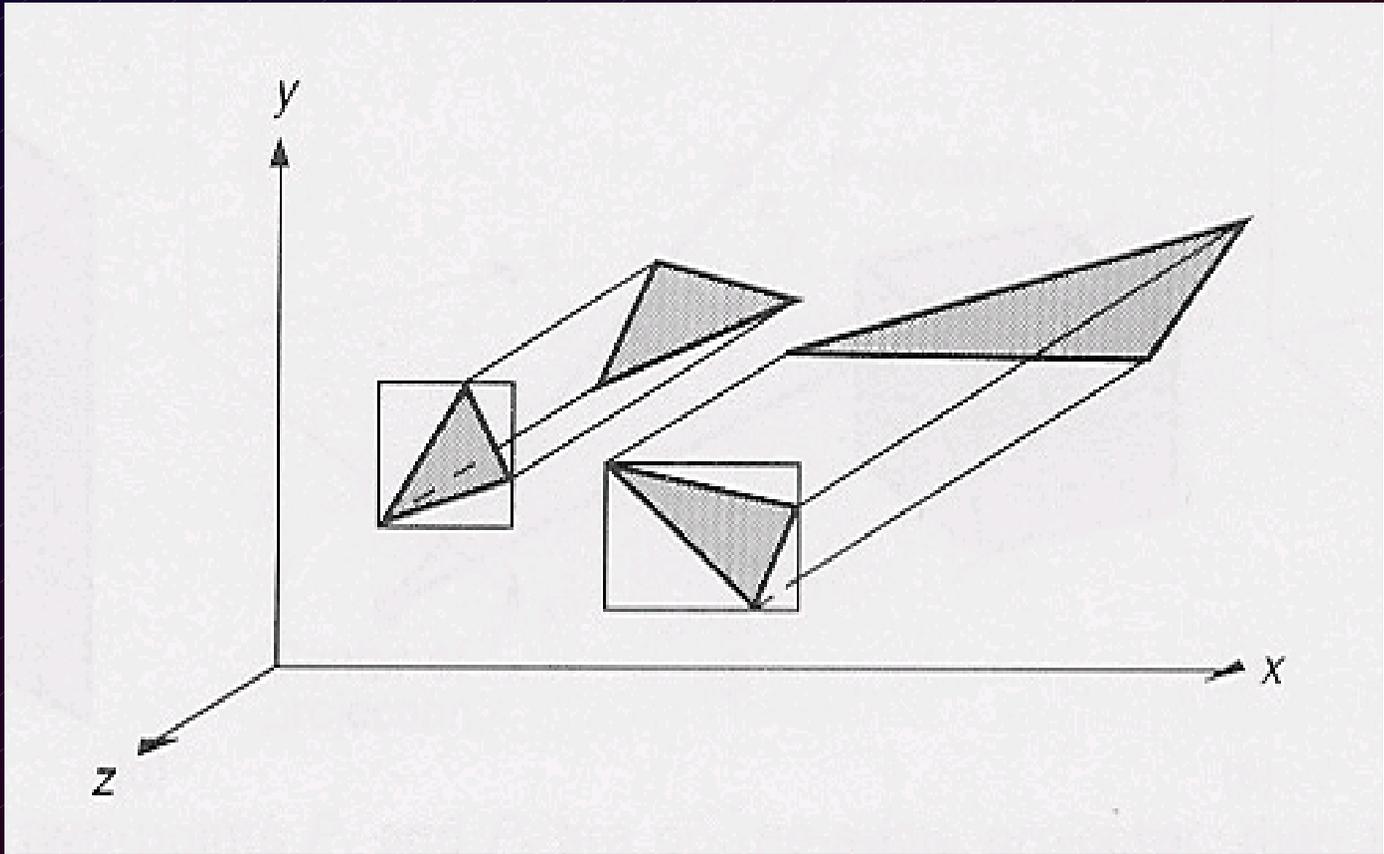
Back Face Culling



Projecting planes

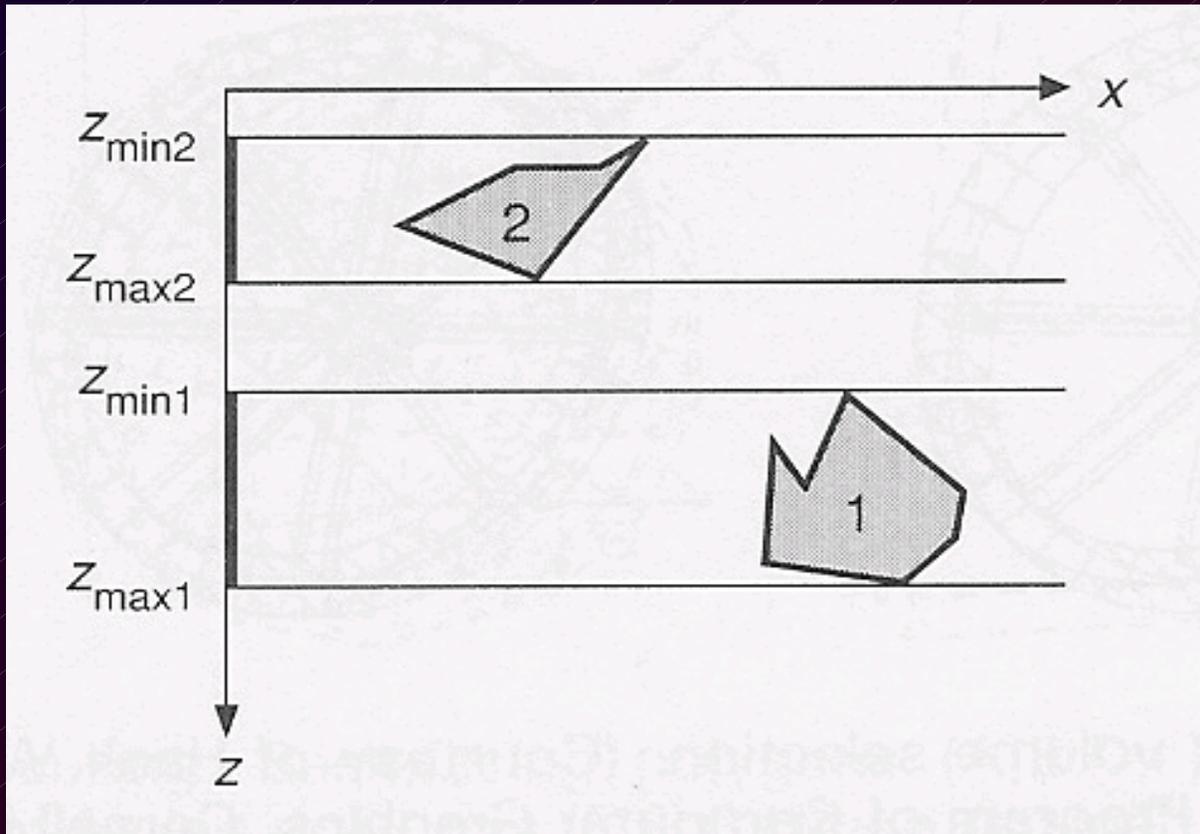


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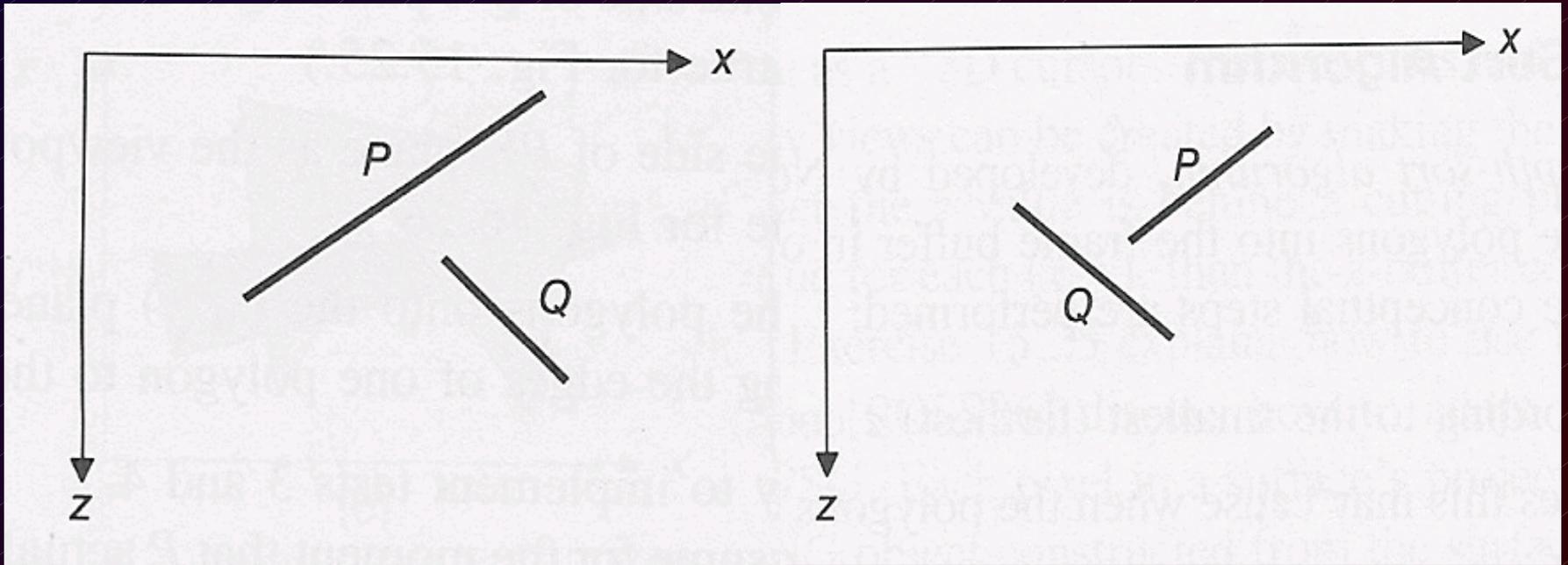
가

, 가



가

- P, Q



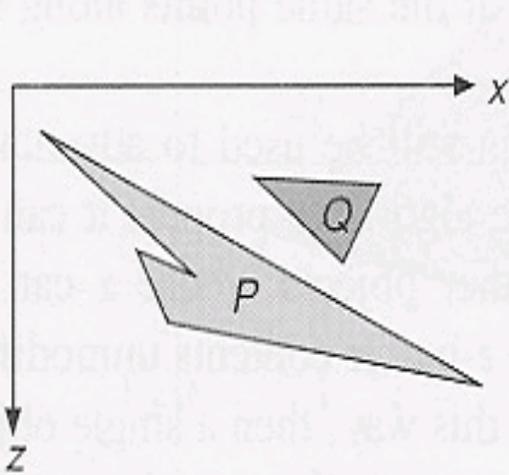
가

(a) Q

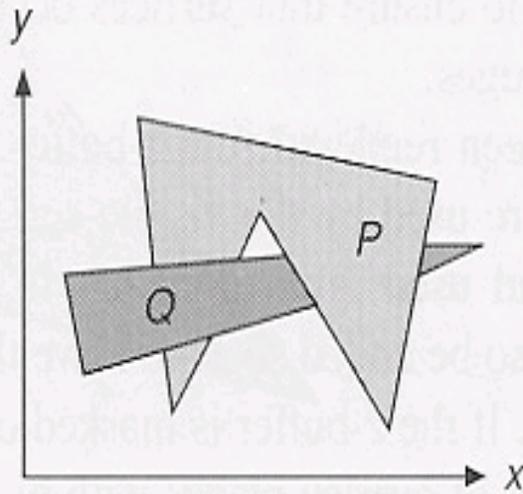
, P

(b) P

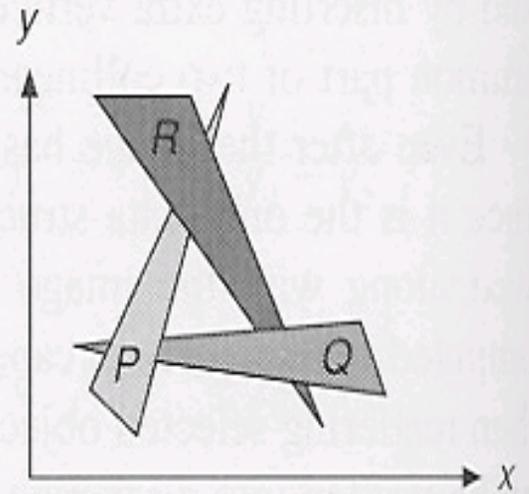
(c) R



(a)



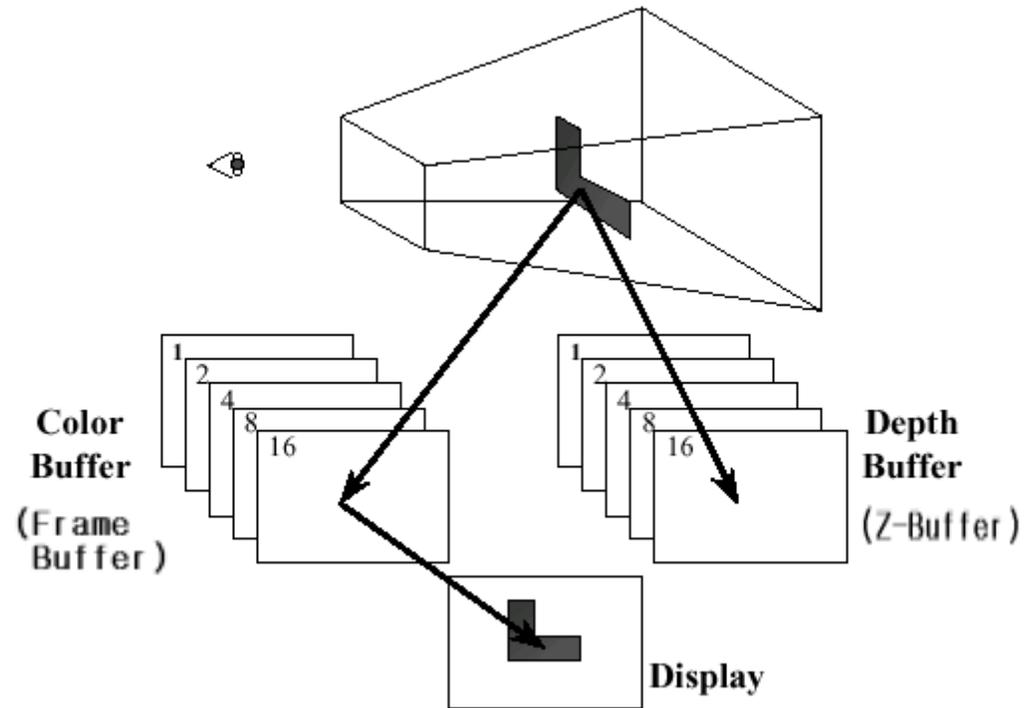
(b)



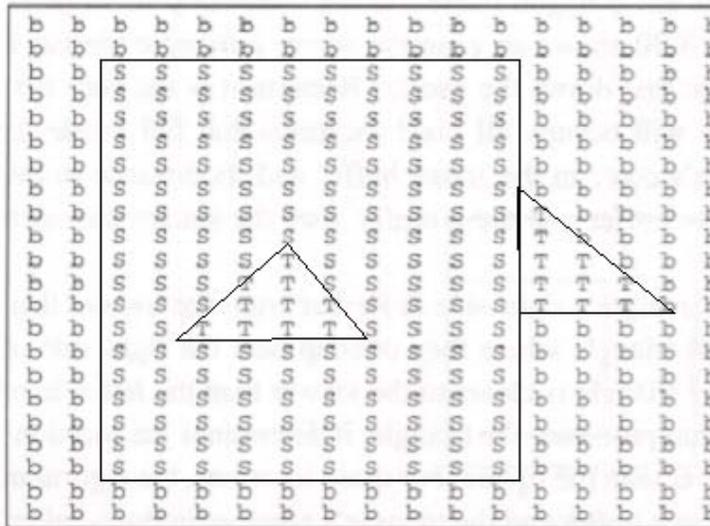
(c)

- Z-Buffer (Depth-Buffer)
 - Frame Buffer (Color Buffer)
 - Z-Buffer (Depth-Buffer)

Color Buffer and Depth Buffer

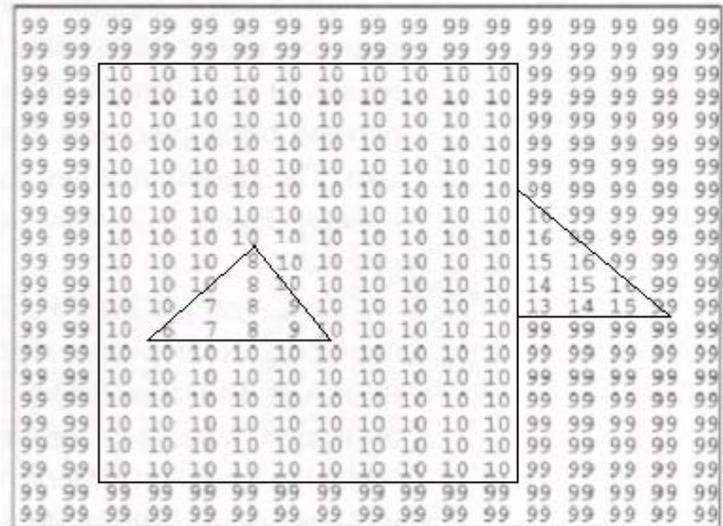


Z-Buffer



b: background color
 S: square's color
 T: triangle's color

frame buffer



z-buffer



- Animate:

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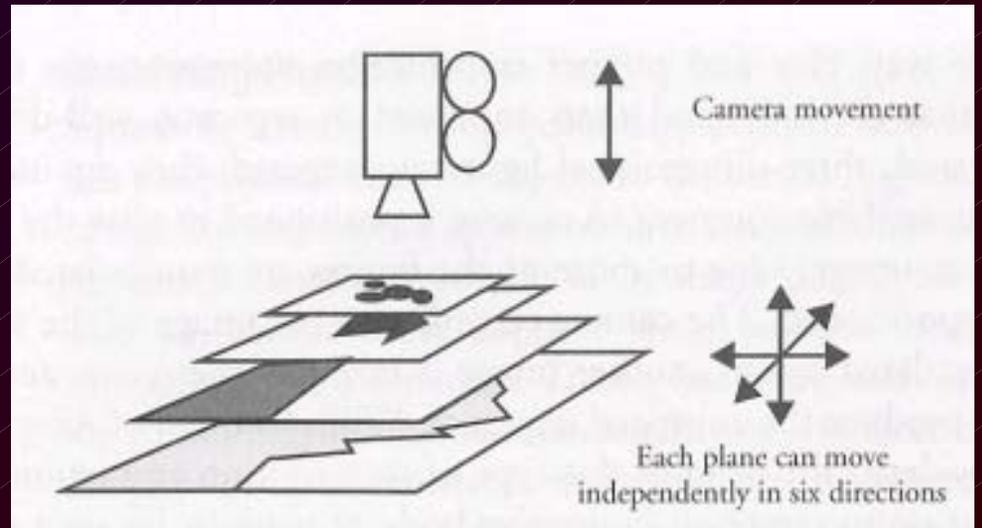
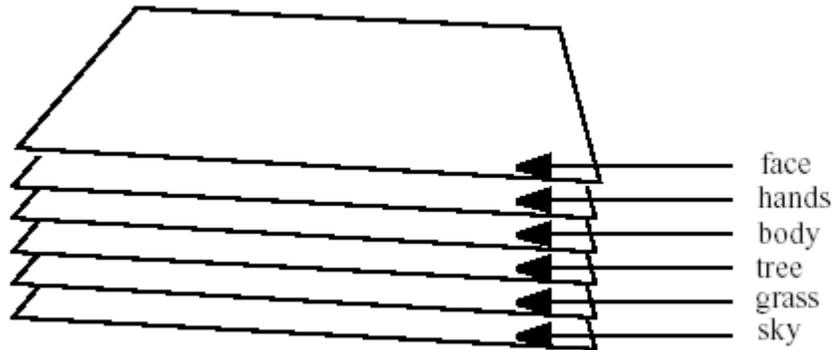
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Zeotrope:



2D



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(in-between)
(pencil test)
celluloid



(in-between)
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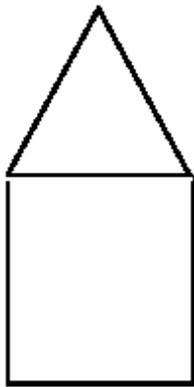
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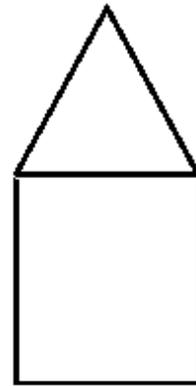
Stop

- Stop (Nightmare before Christmas)
- (Luxo Jr.)
- (Donkey Kong Country)

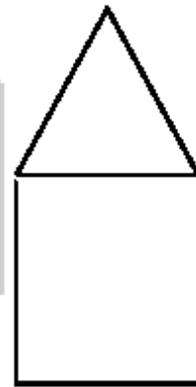




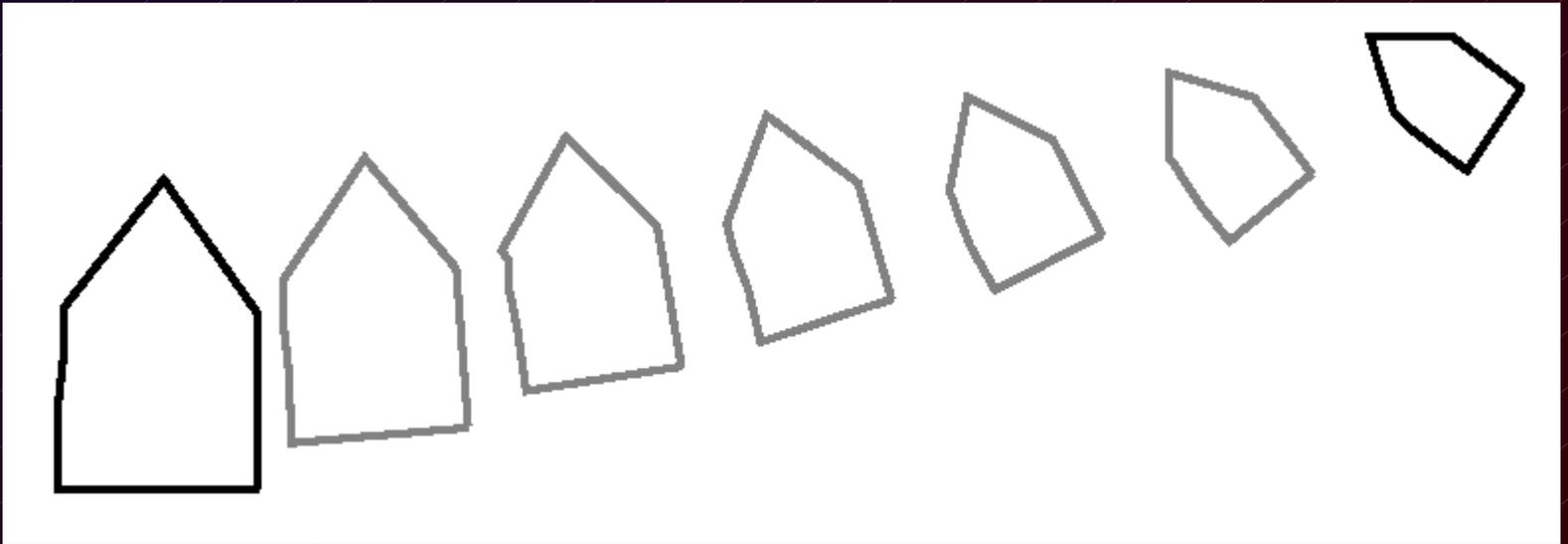
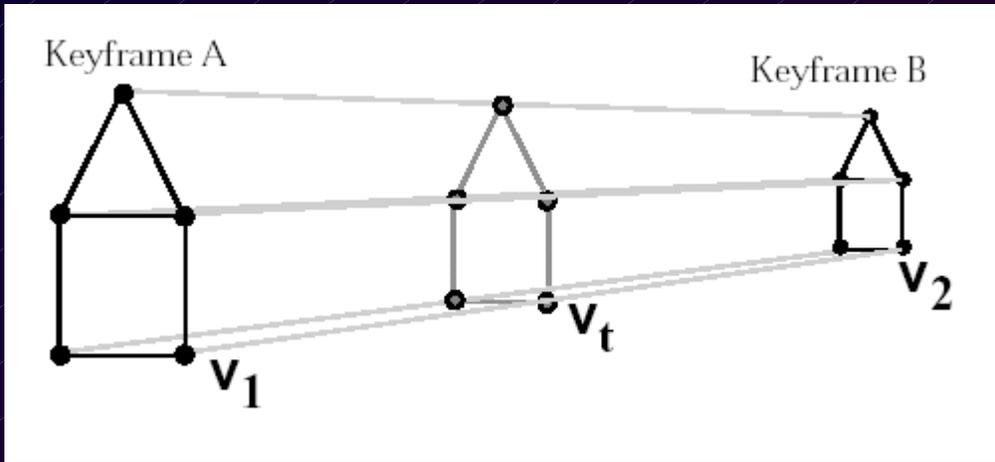
key frame #1



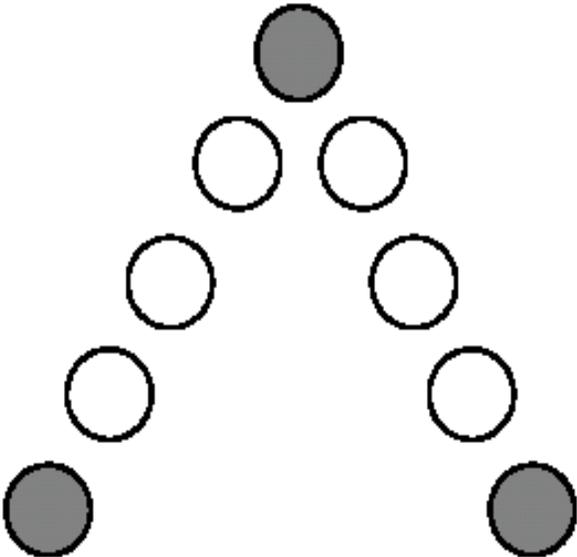
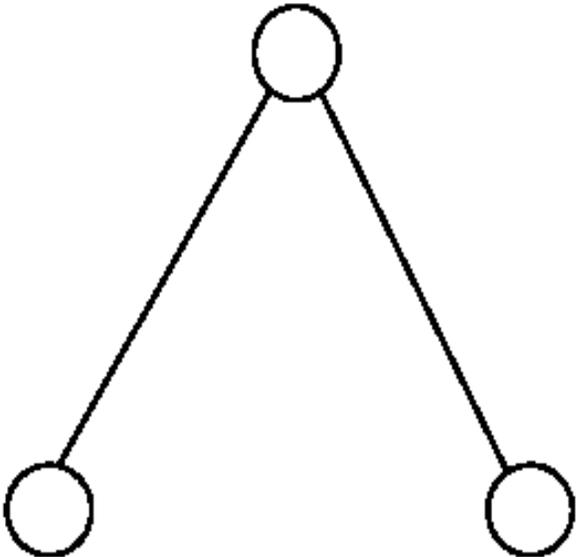
key frame #2

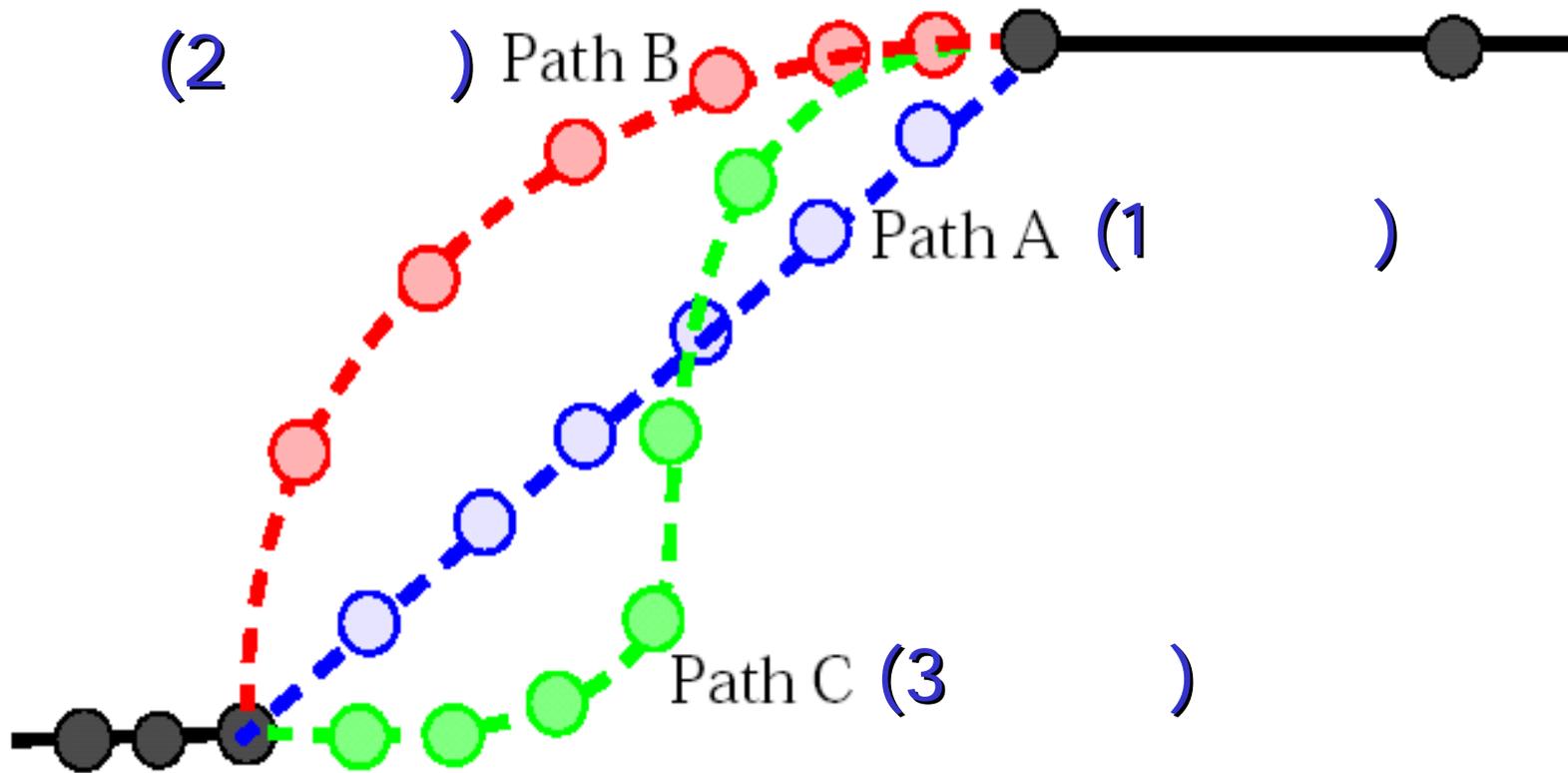


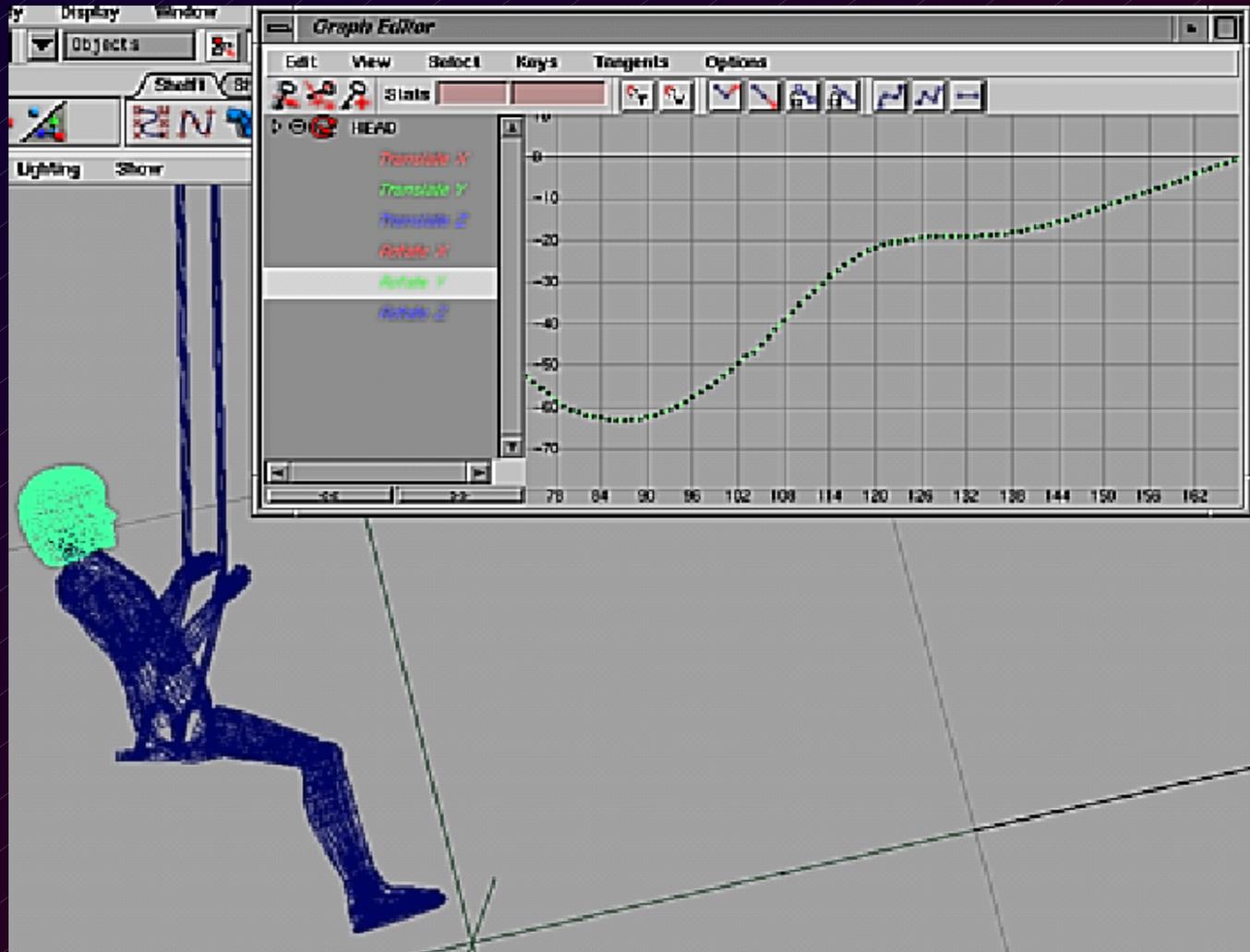
key frame #3



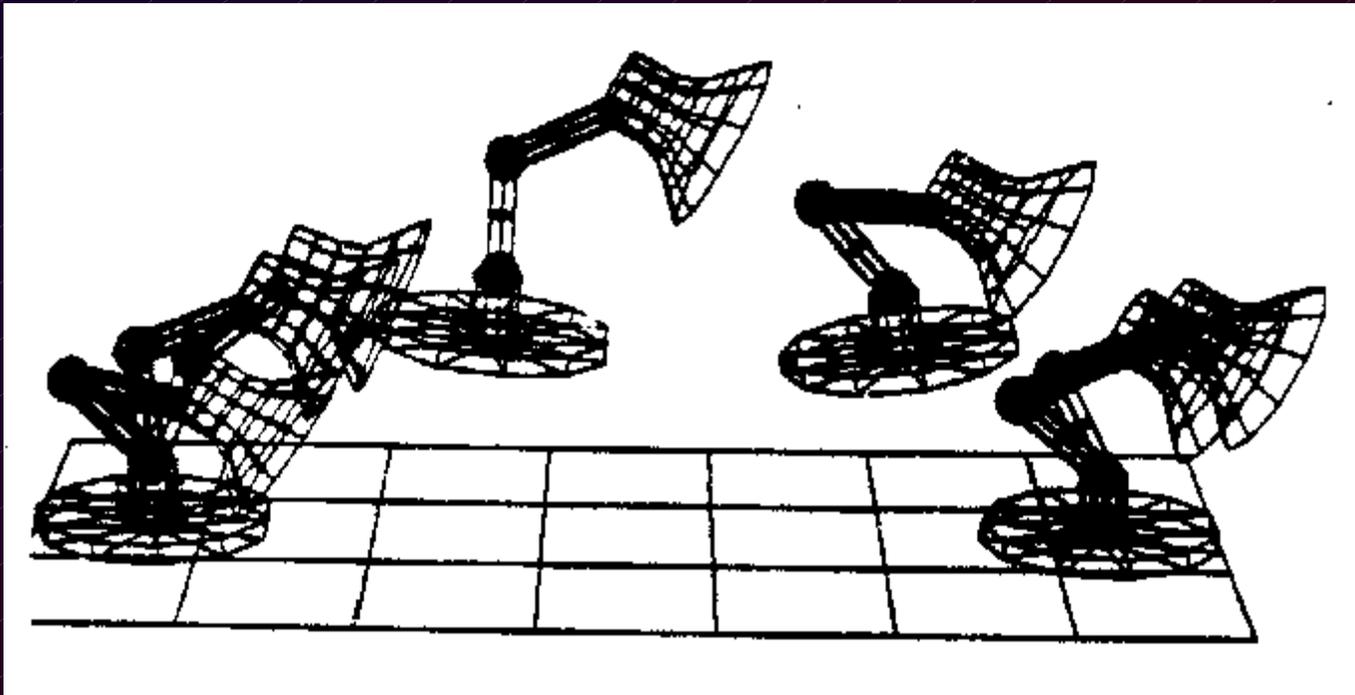
[Empty dark blue rectangular box]



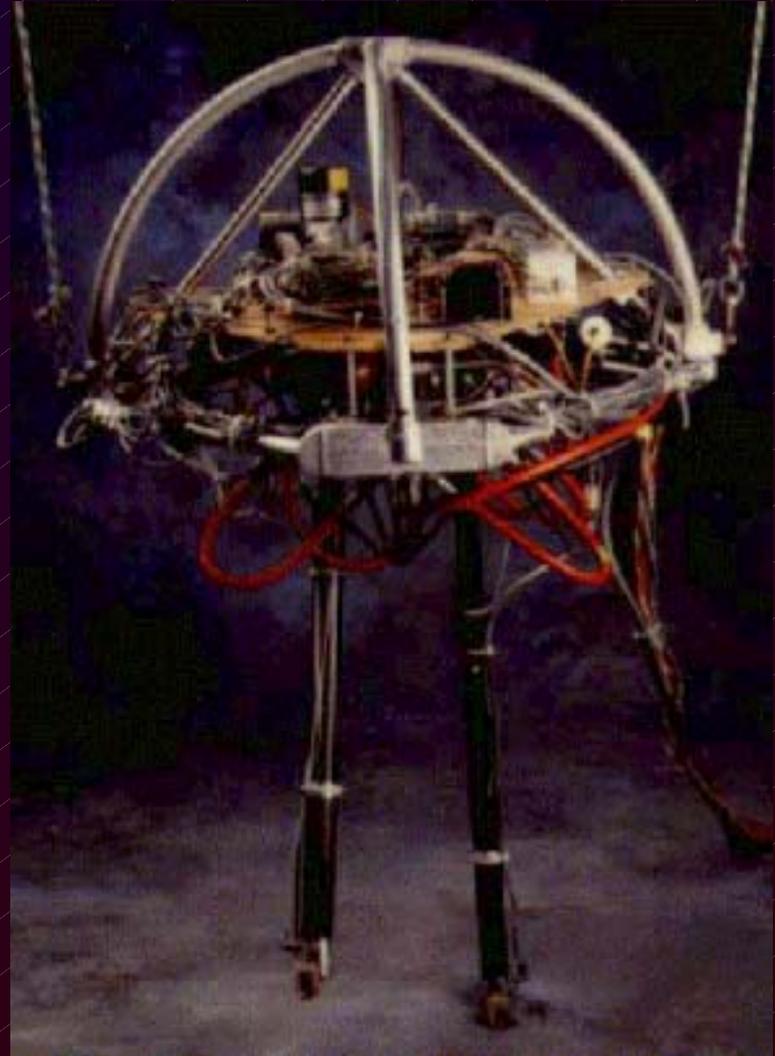




A. Witkin and M. Kass
"Space Time Constraint" SIGGRAPH 88



Hopping Robot
M. Raibert's
Leg Lab at MIT





cross-dissolve

**source
image**



**dest.
image**

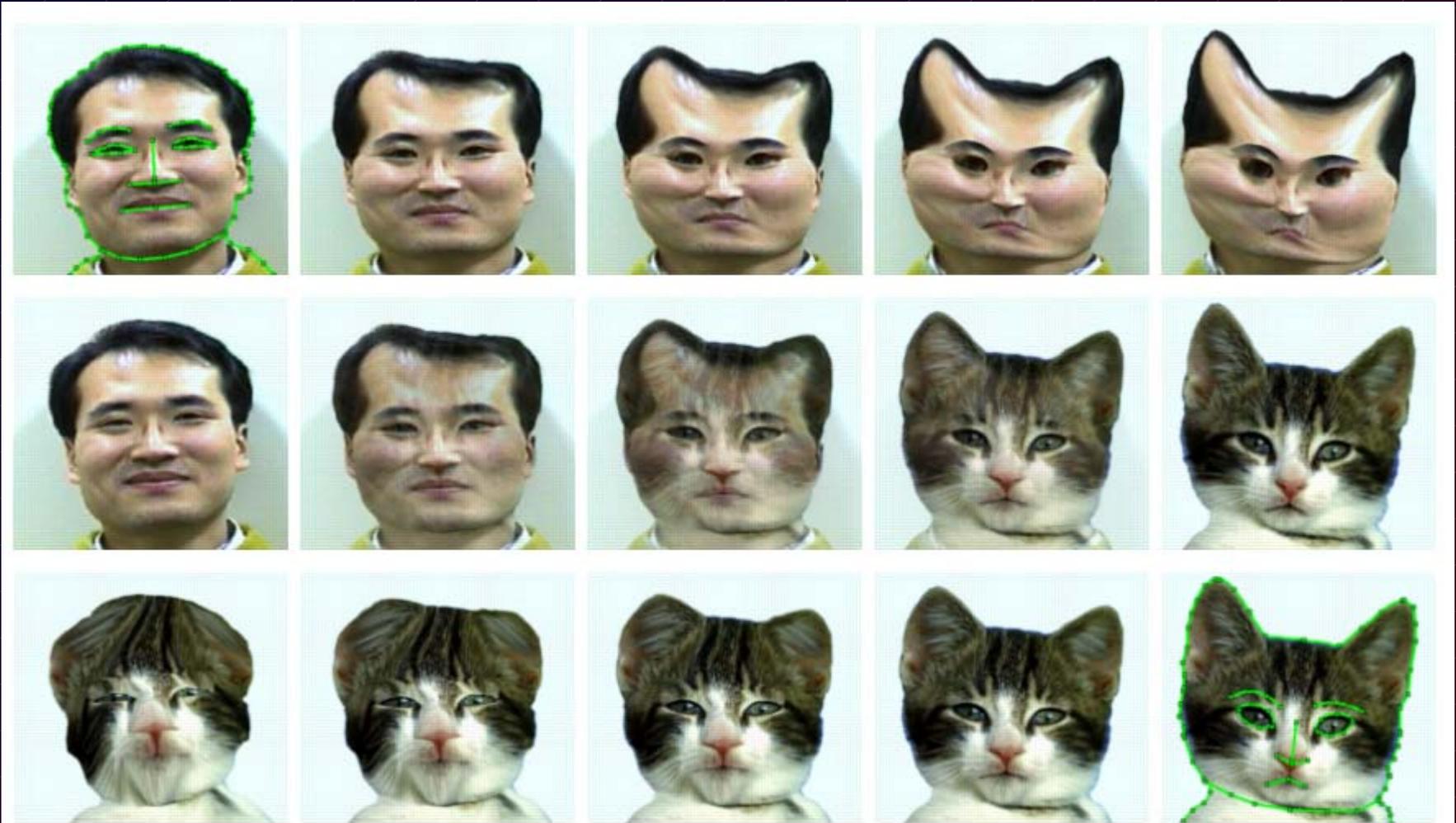
**warped
source
image**



**warped
dest.
image**

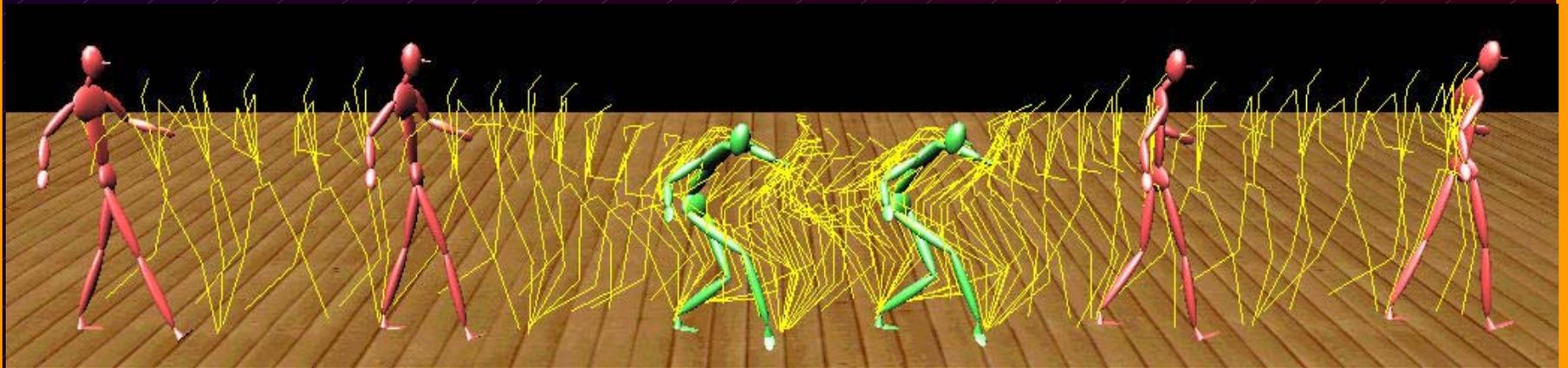
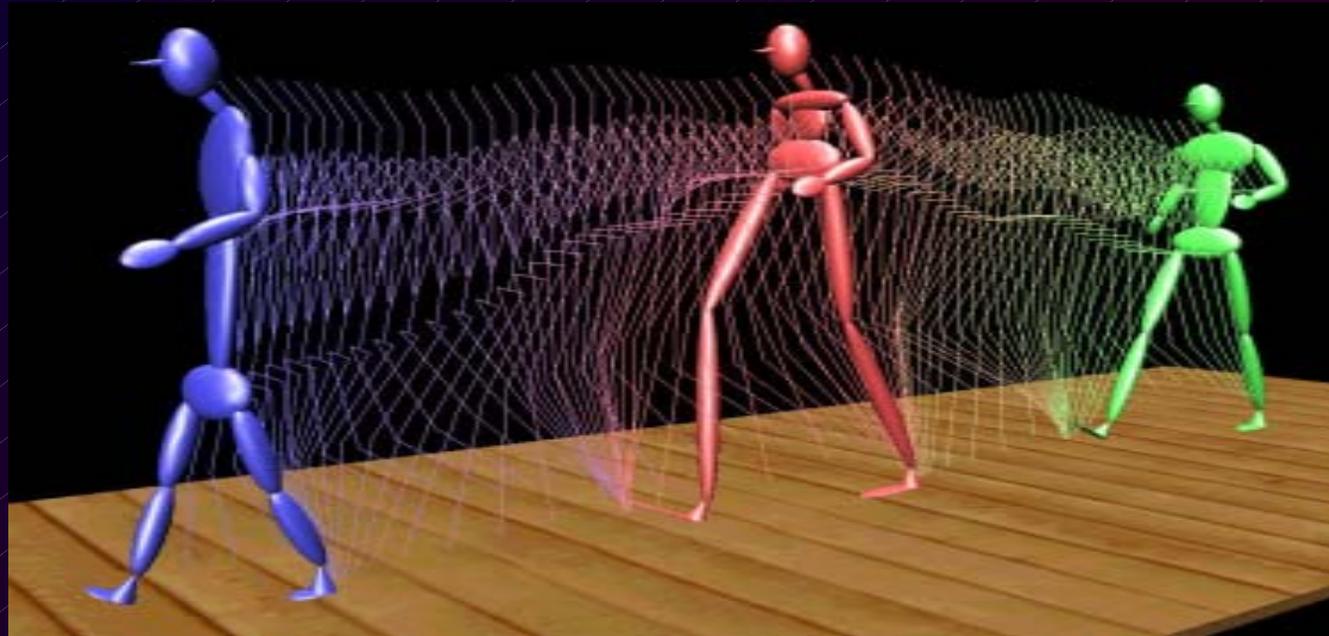
image morphing

Uniform



Non-Uniform





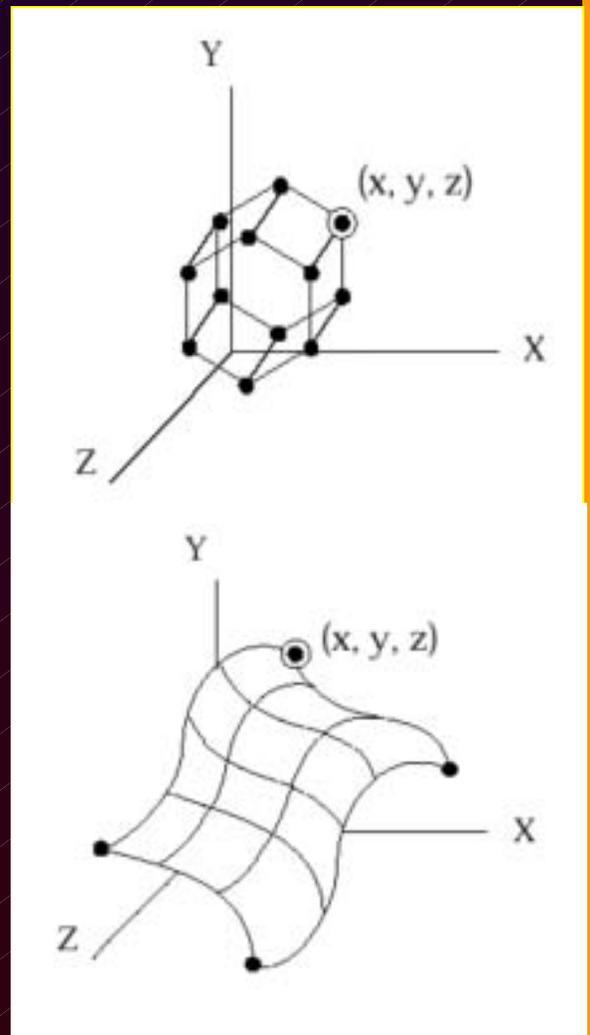
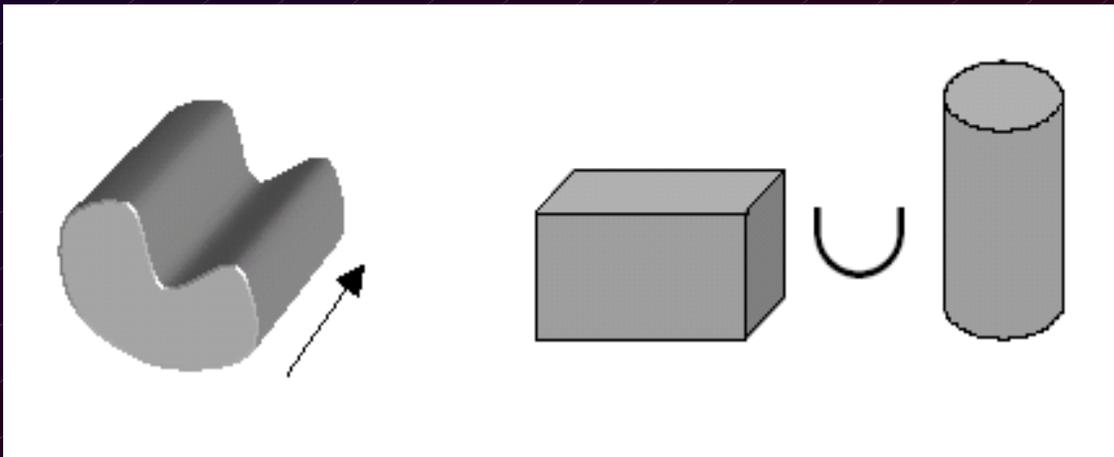


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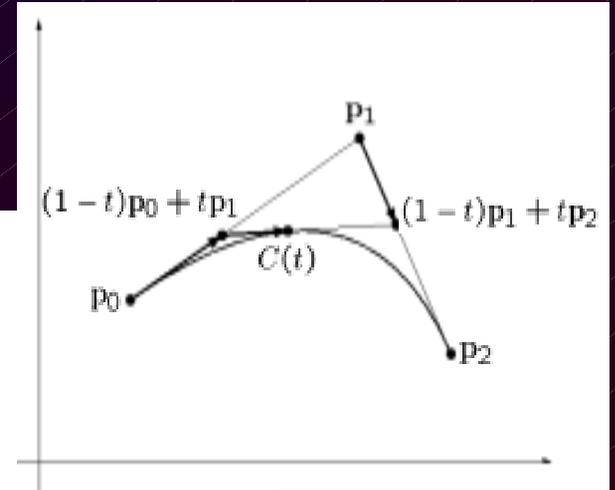
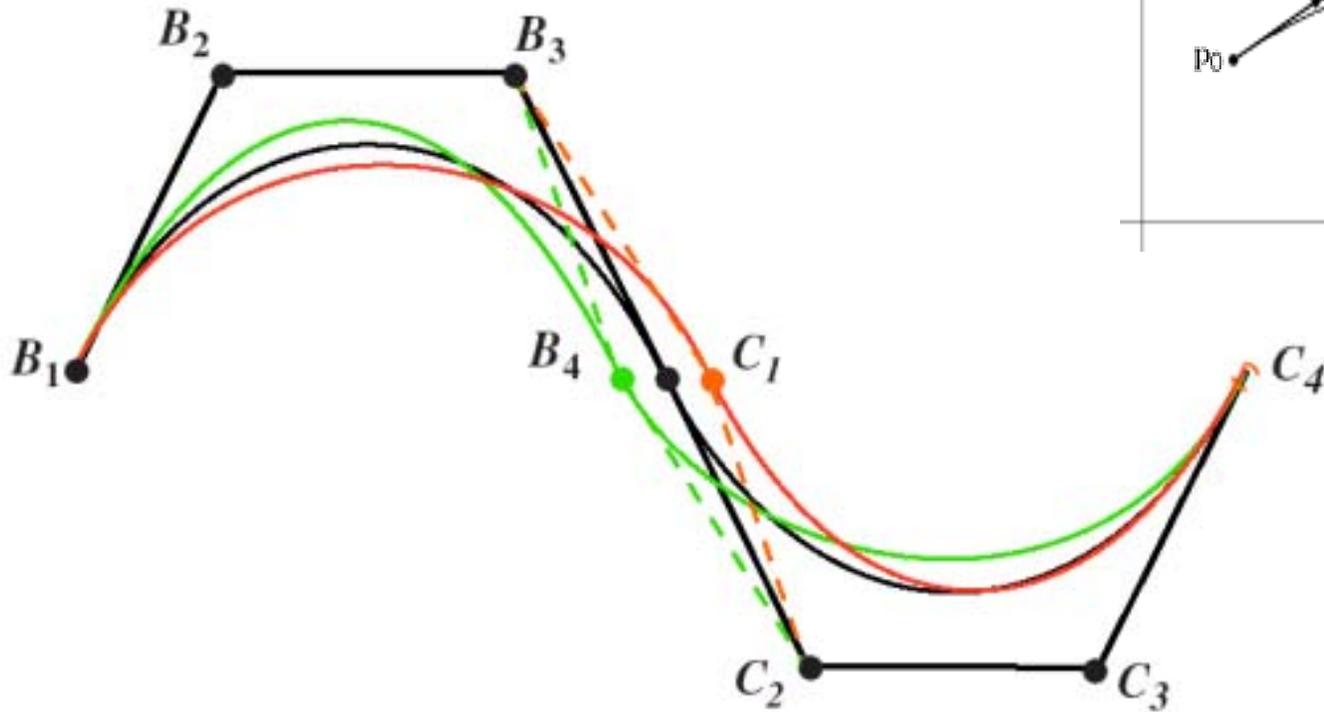
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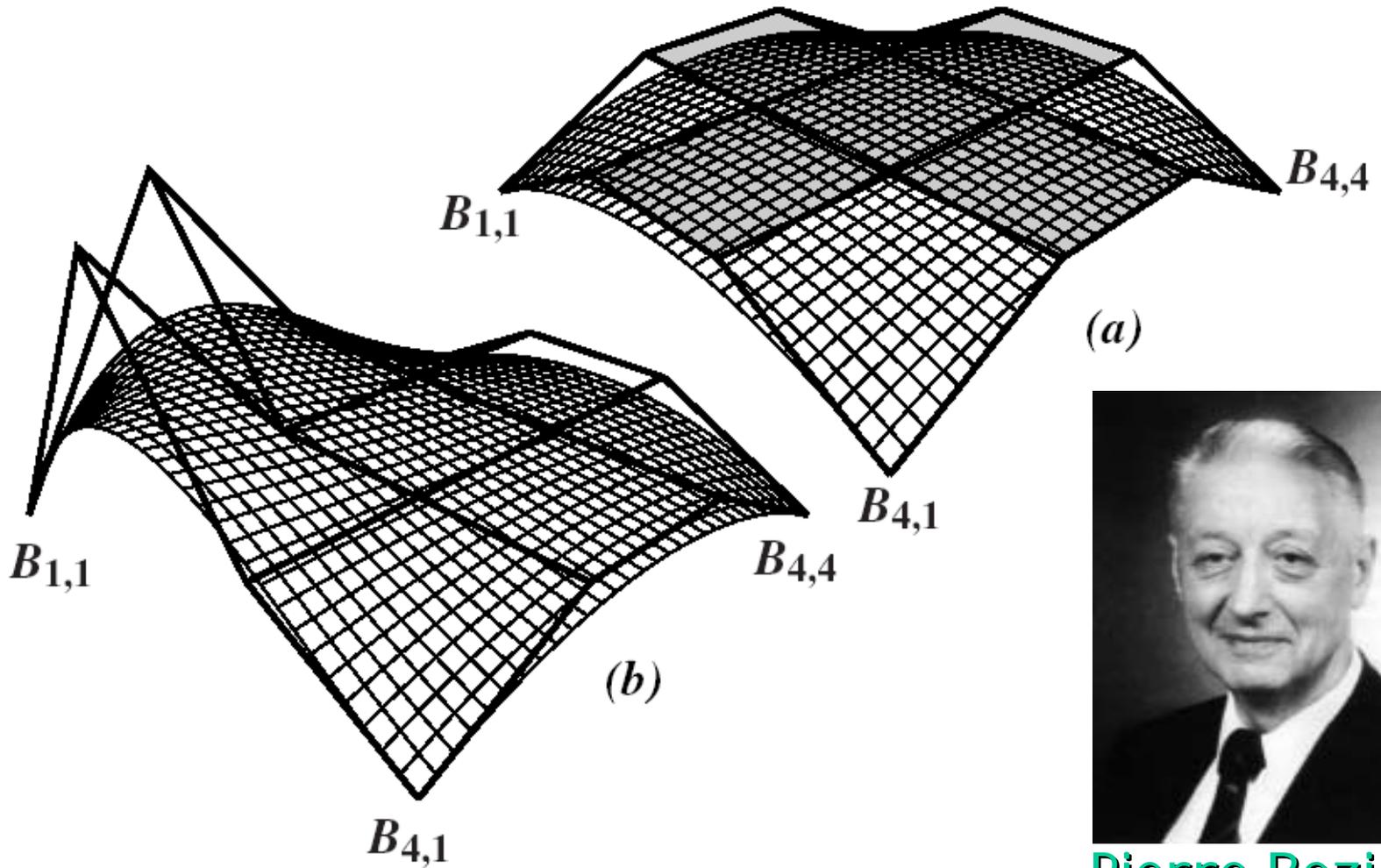
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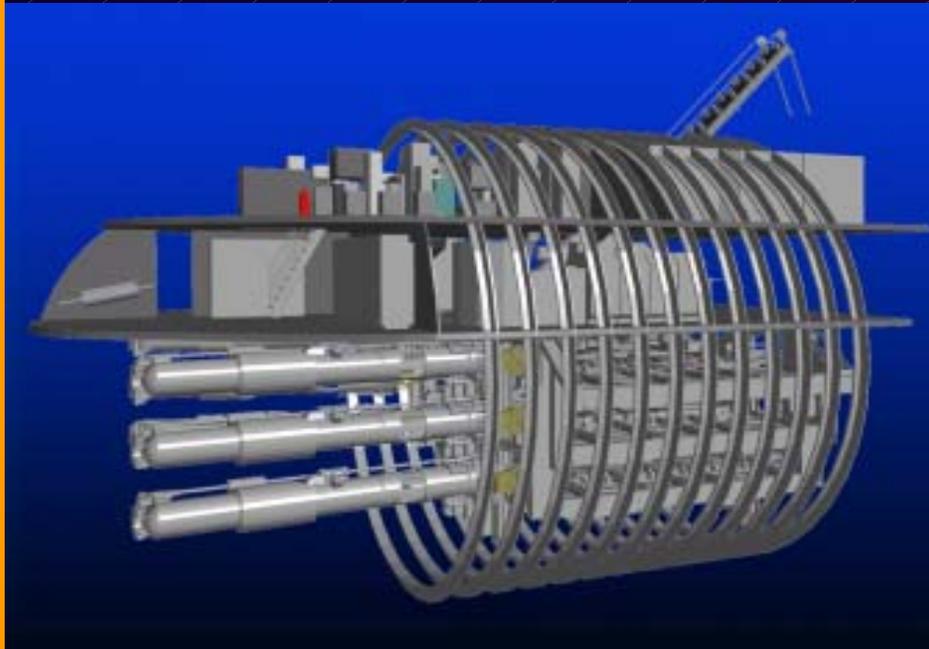
Bezier



Bezier



Pierre Bezier

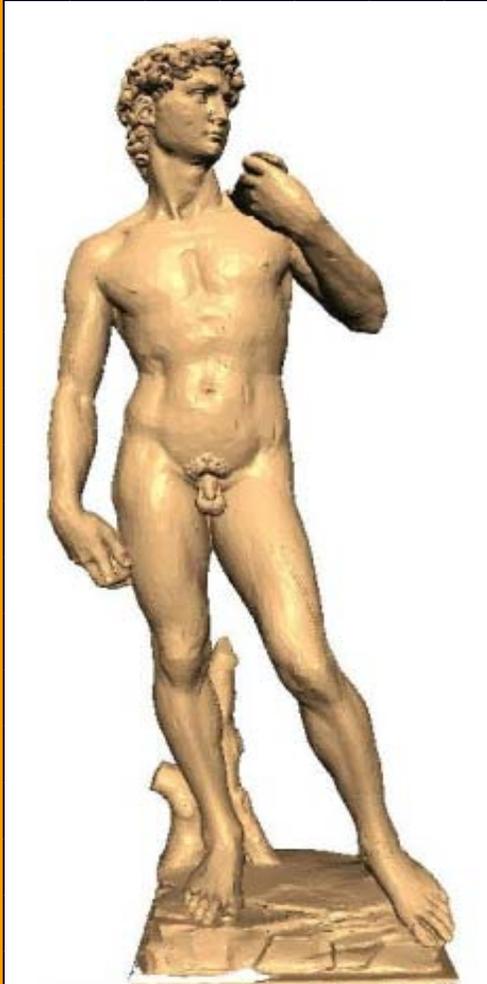


70

1300



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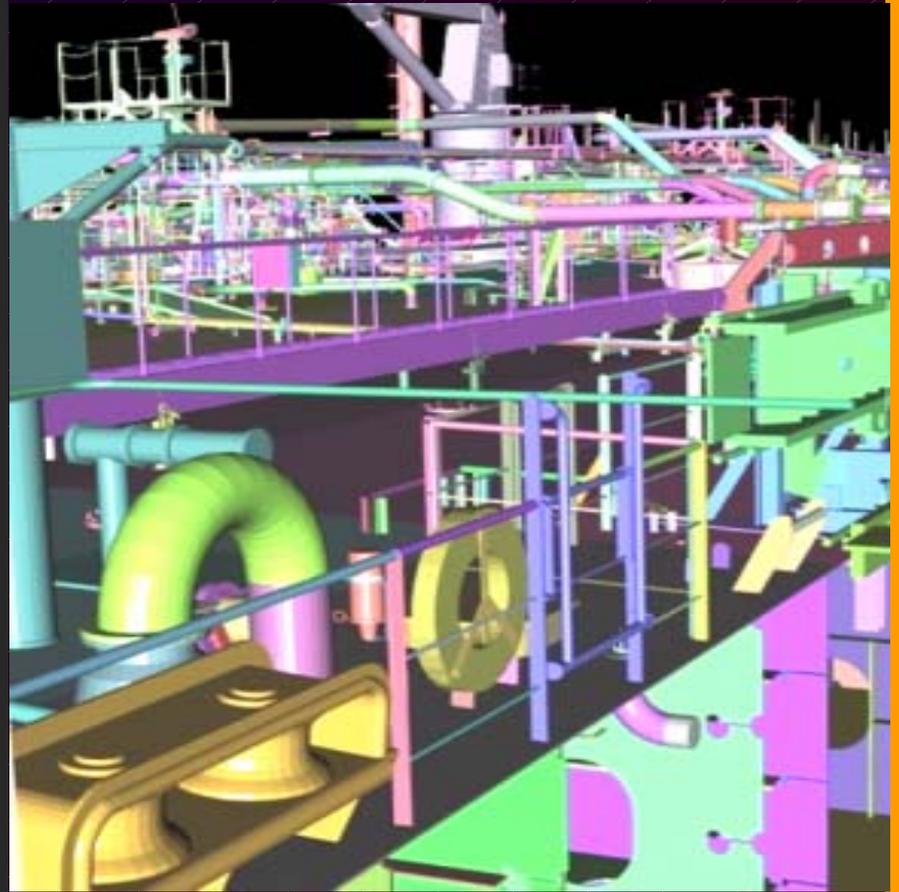
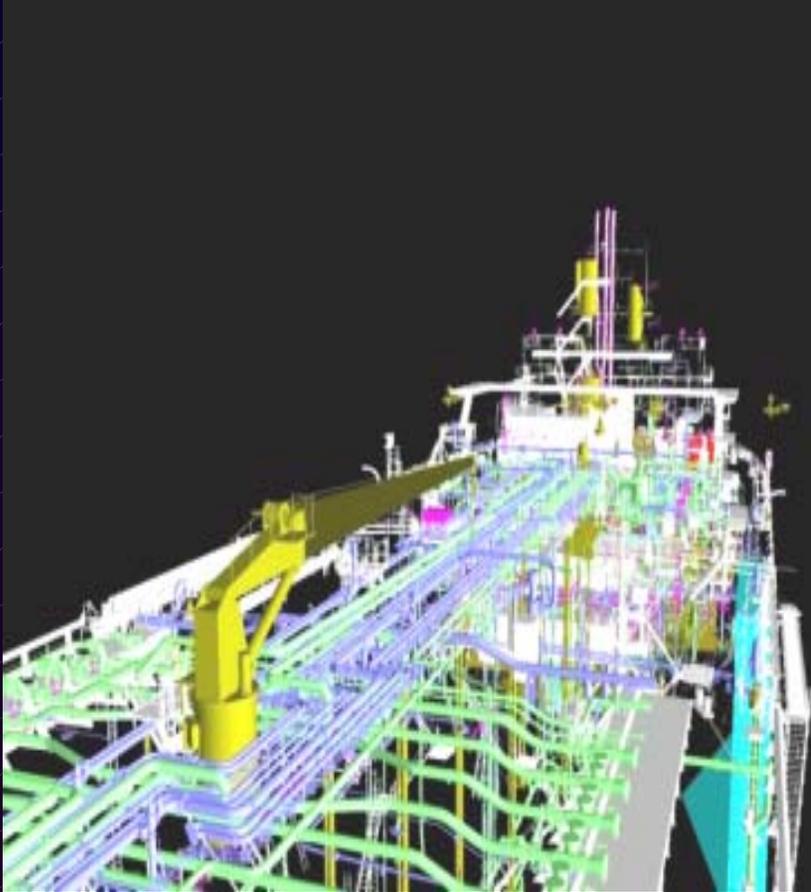


5600 polygon

1700 polygon



3



8200 polygon

Level of Detail (LOD)

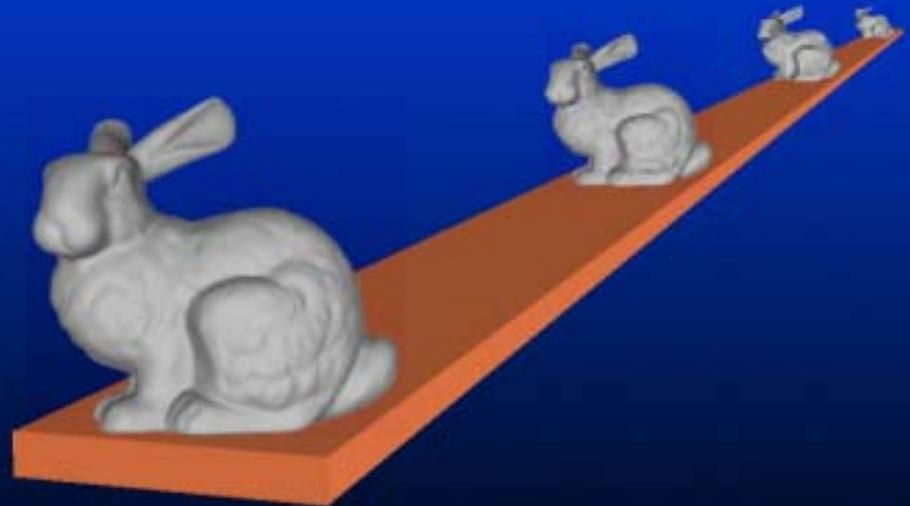


69,451 polys

2,502 polys

251 polys

76 polys



Level of Detail (LOD)

7,809 tris



3,905 tris



1,951 tris



975 tris



488 tris



Level of Detail (LOD)



Triangles:

41,855

27,970

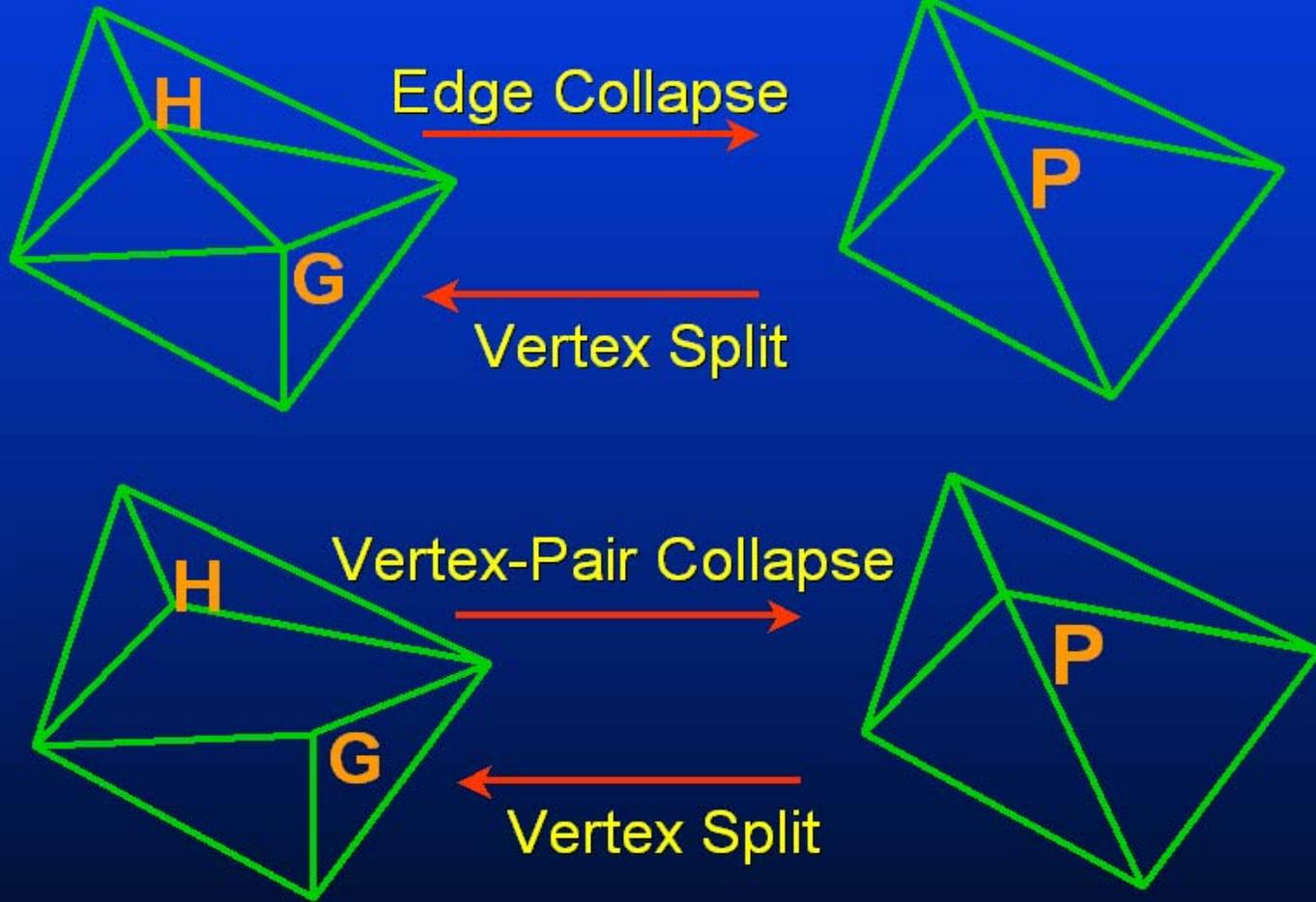
20,922

12,939

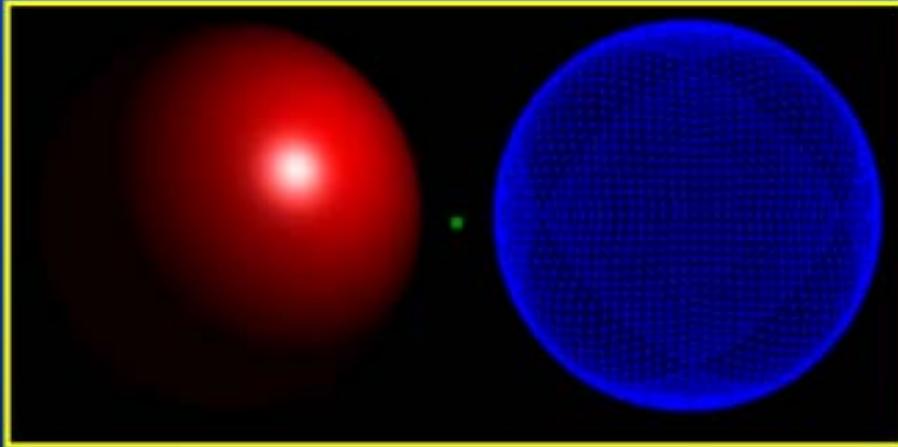
8,385

4,766

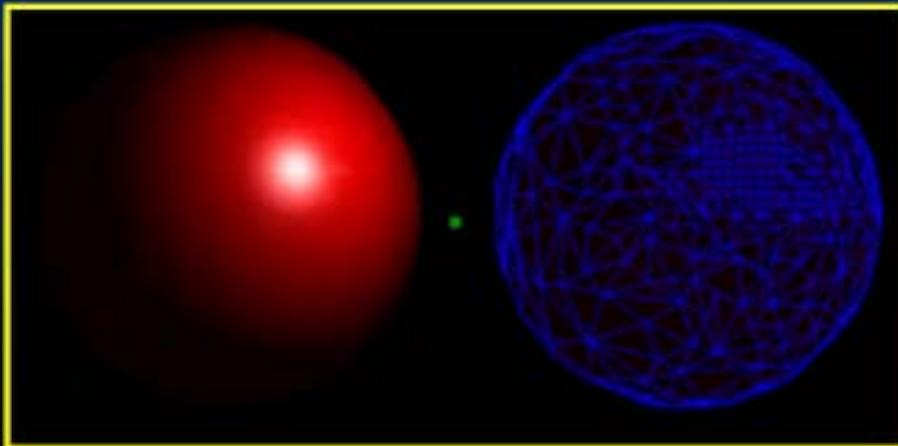
LOD



LOD

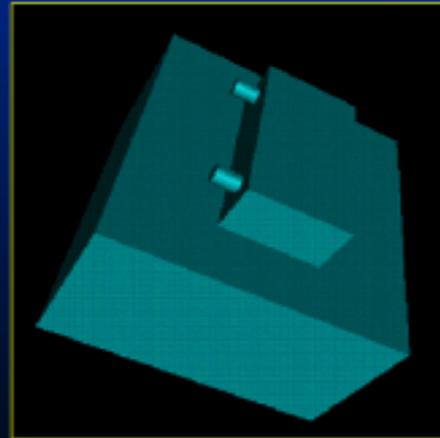
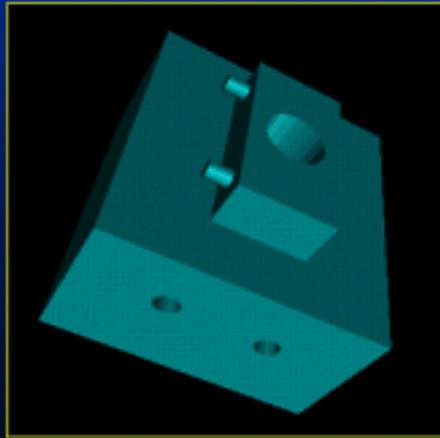
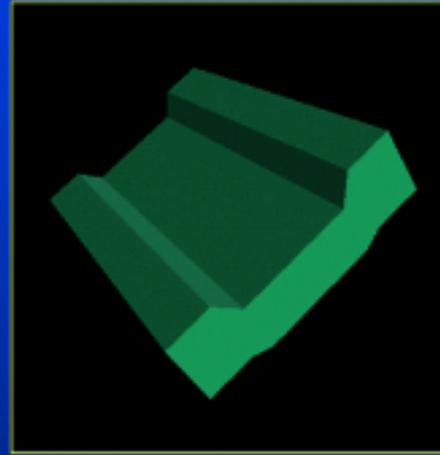
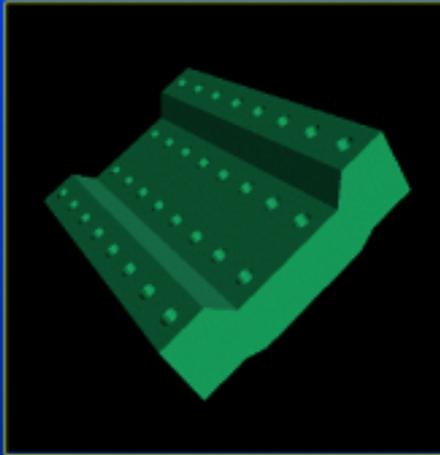


8192 triangles

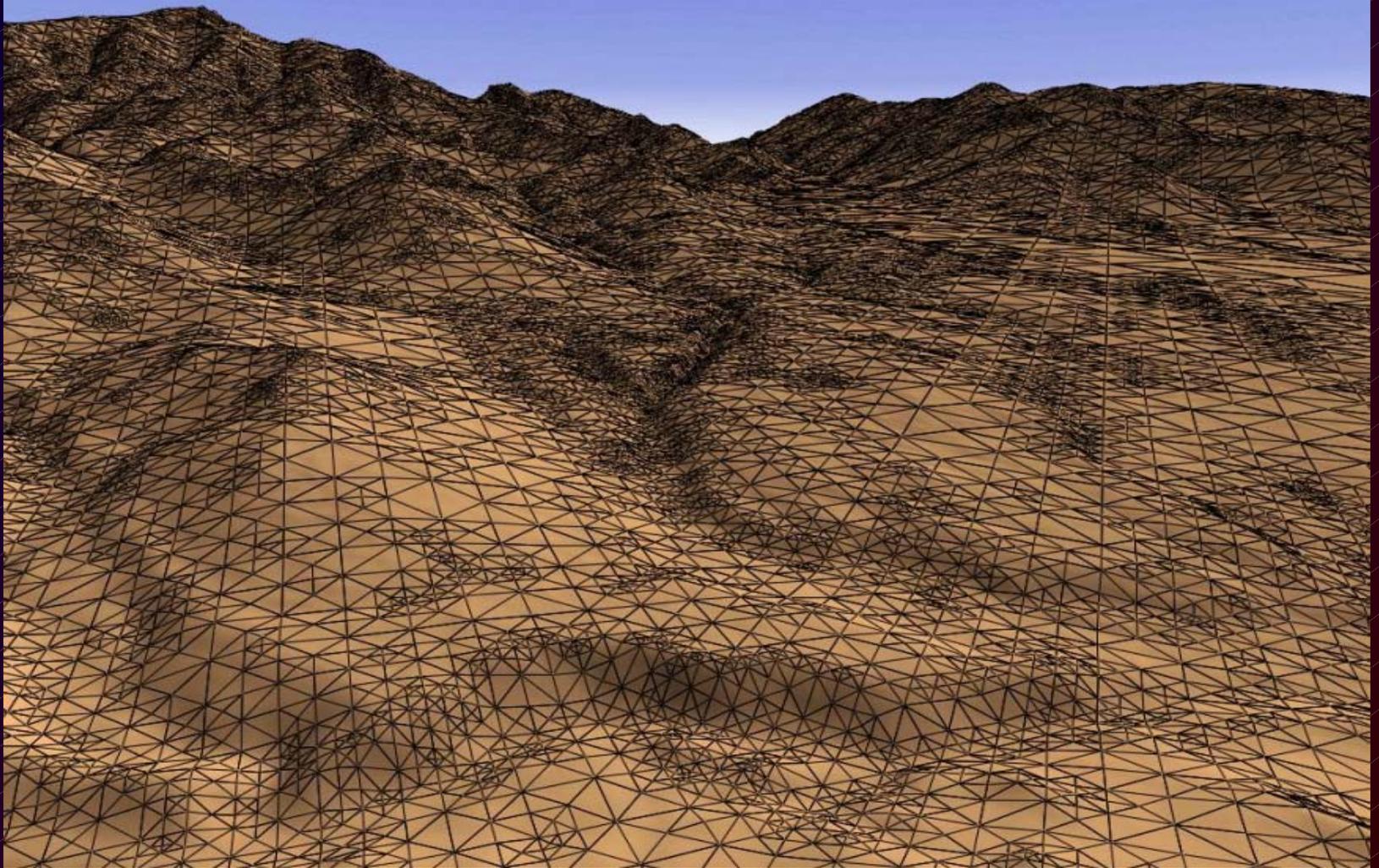


537 triangles

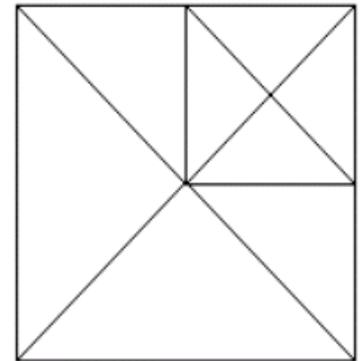
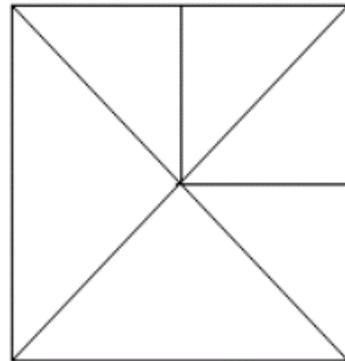
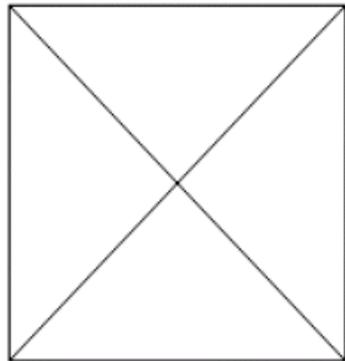
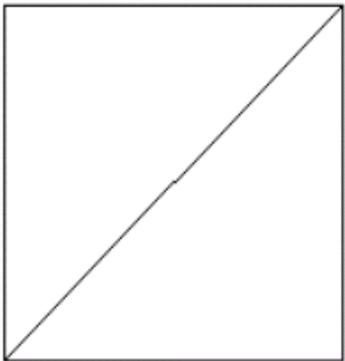
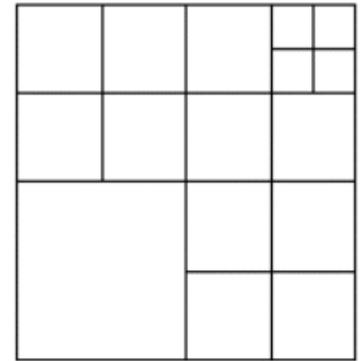
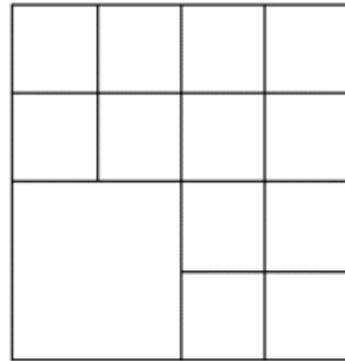
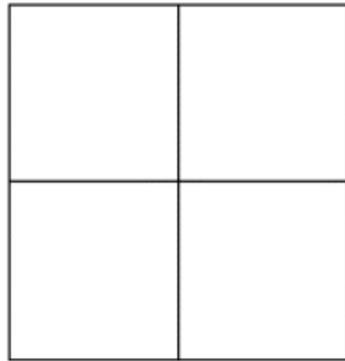
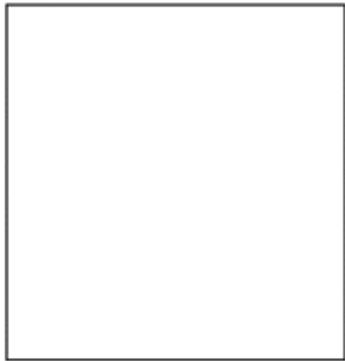
LOD



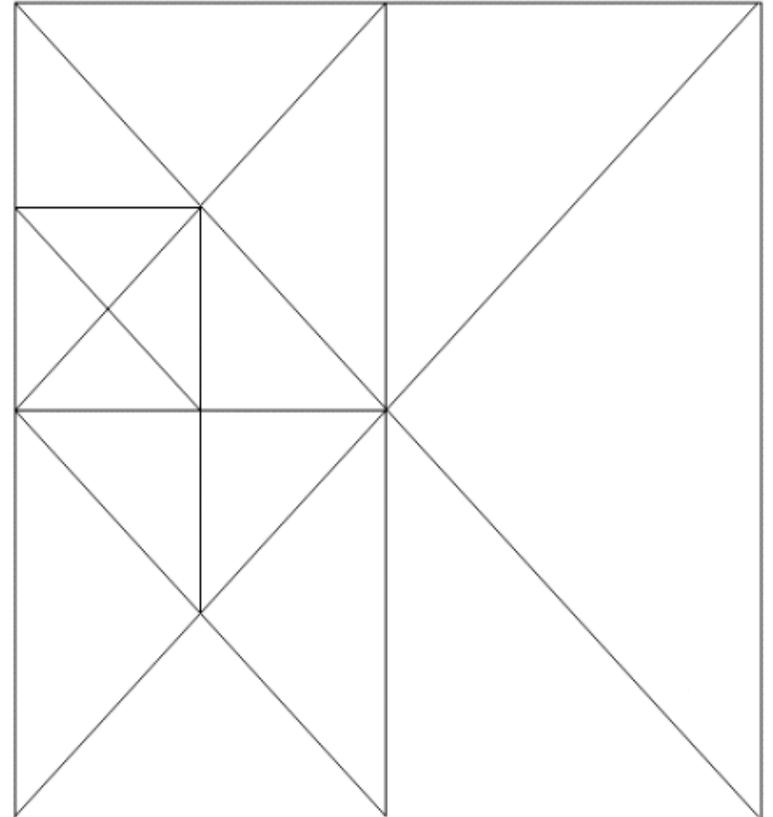
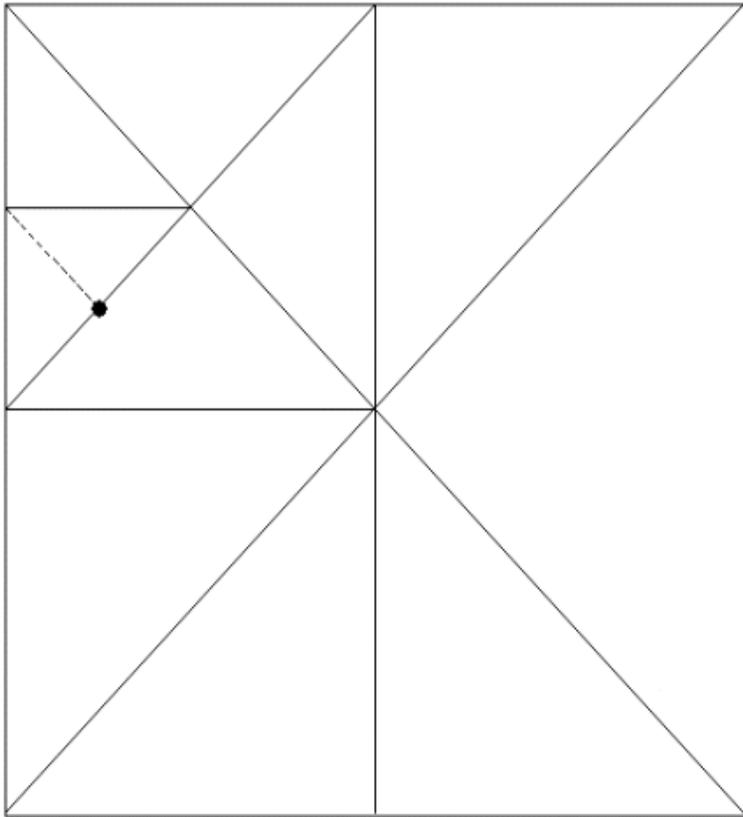
LOD



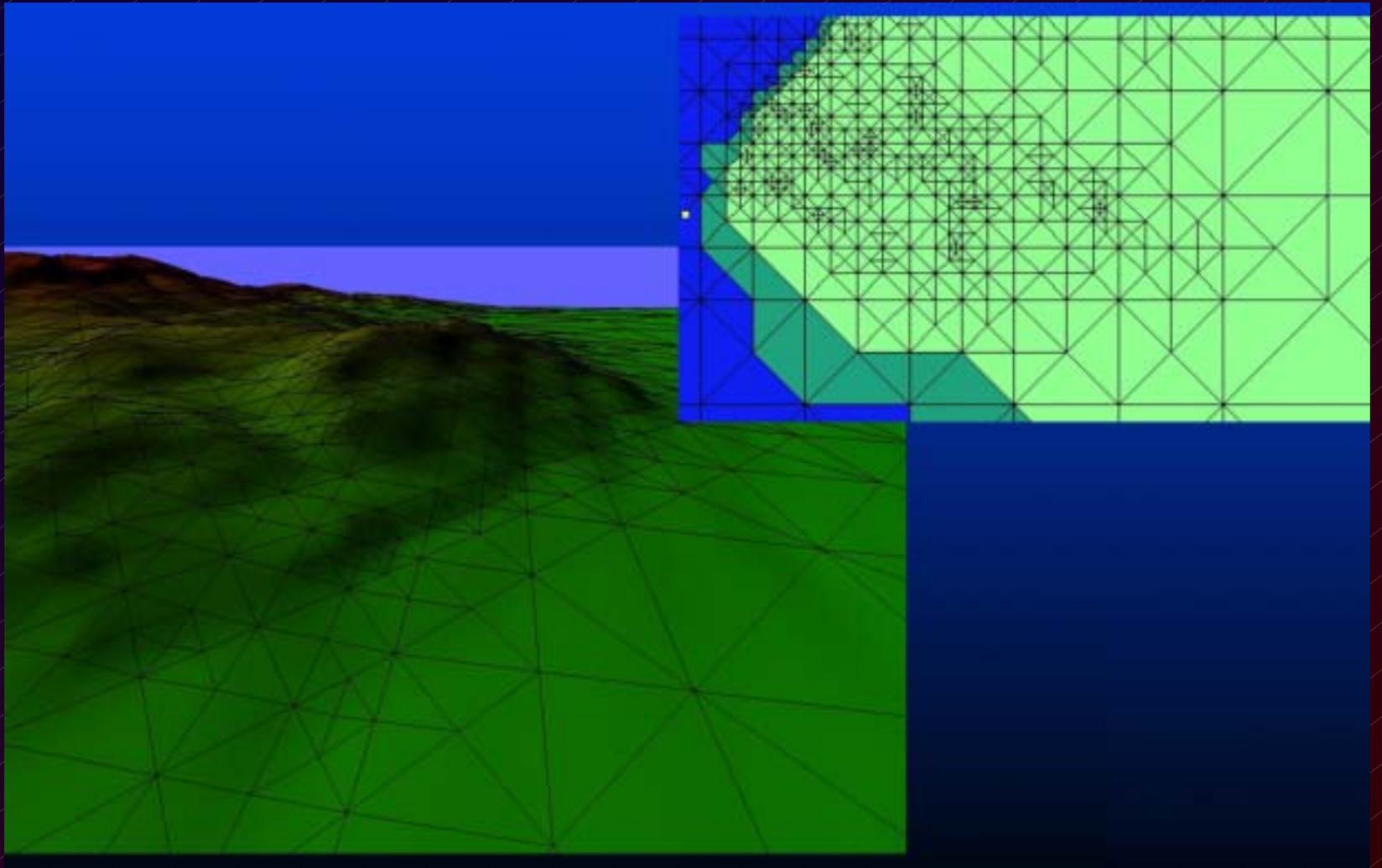
Quadtree and Bintree



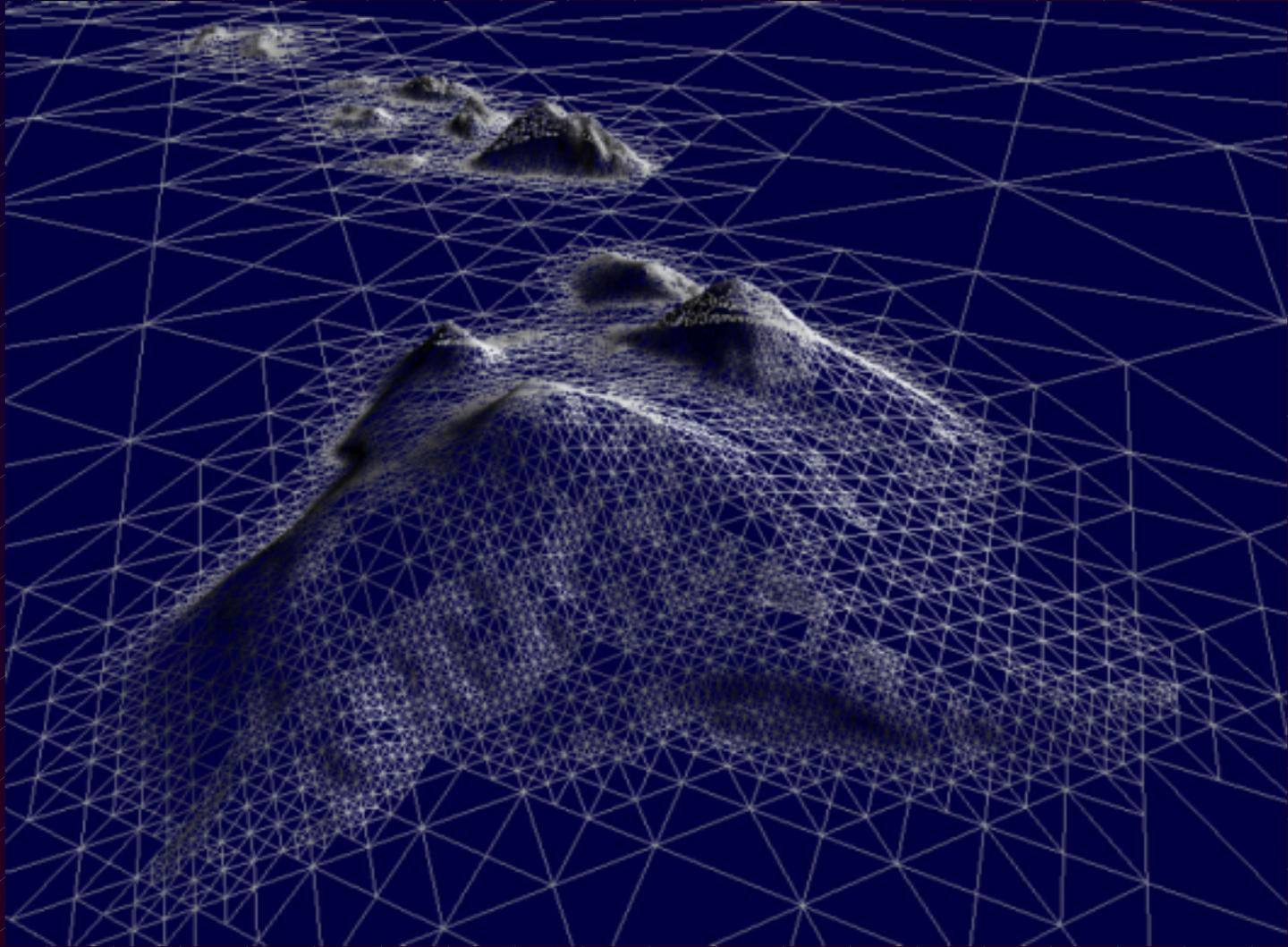
T-Junction



LOD

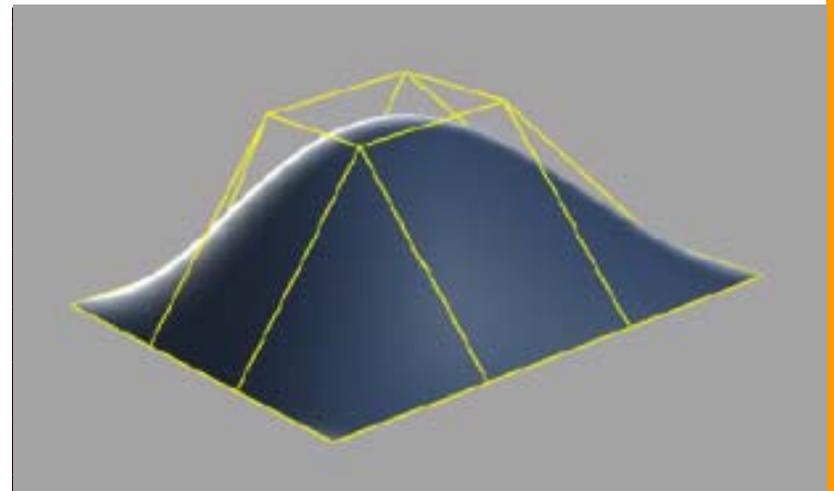
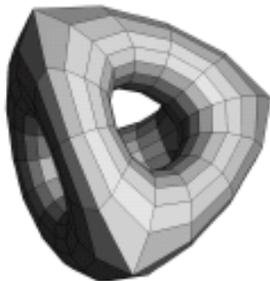
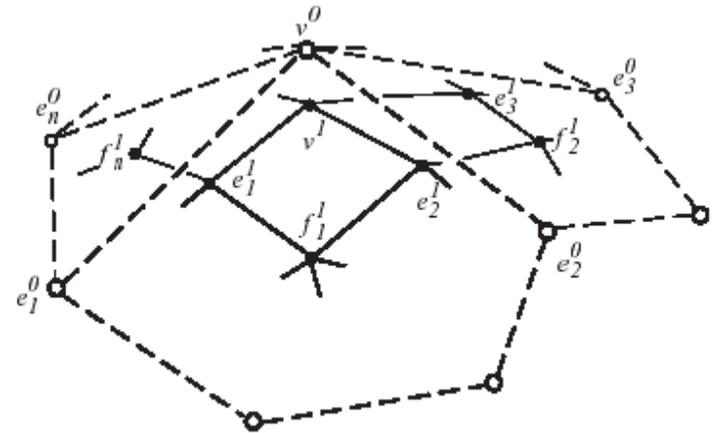
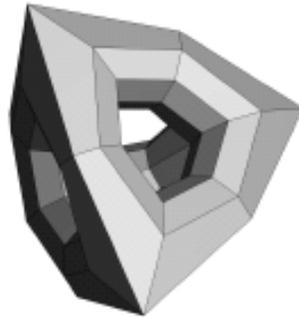
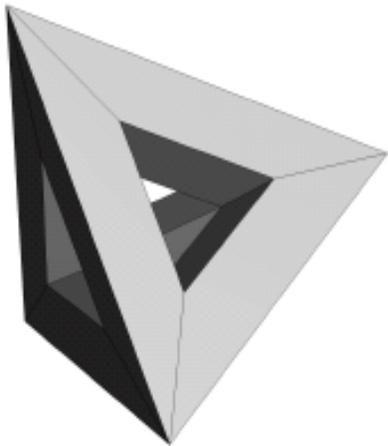


LOD



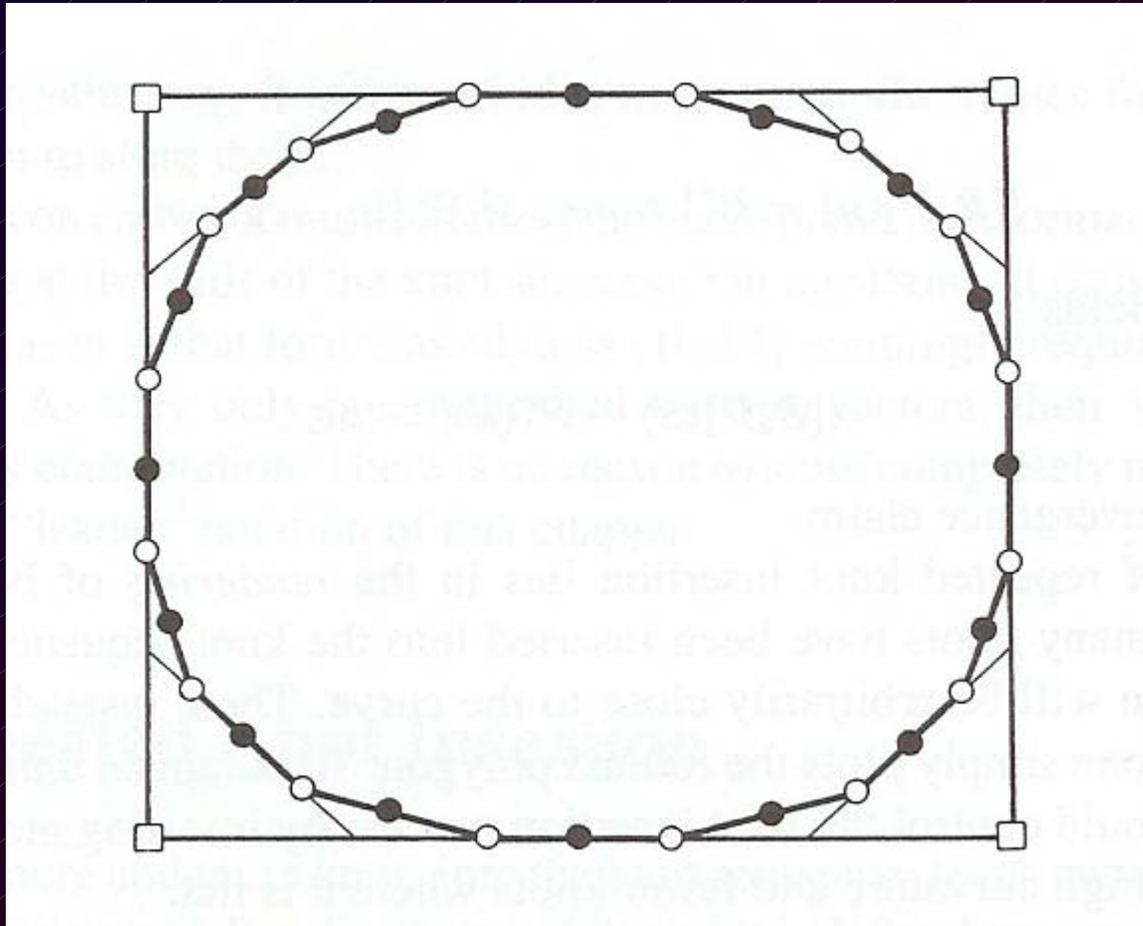


Subdivision

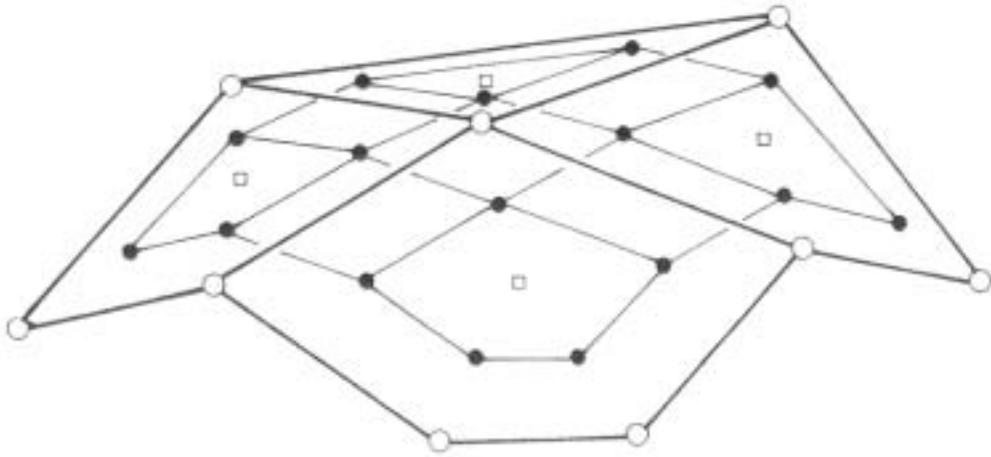


Chaikin

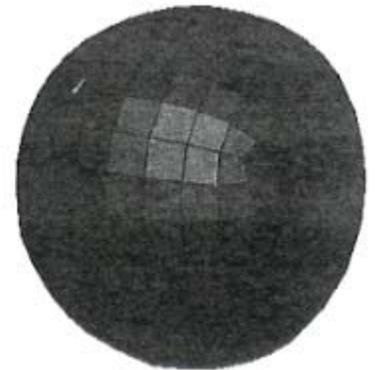
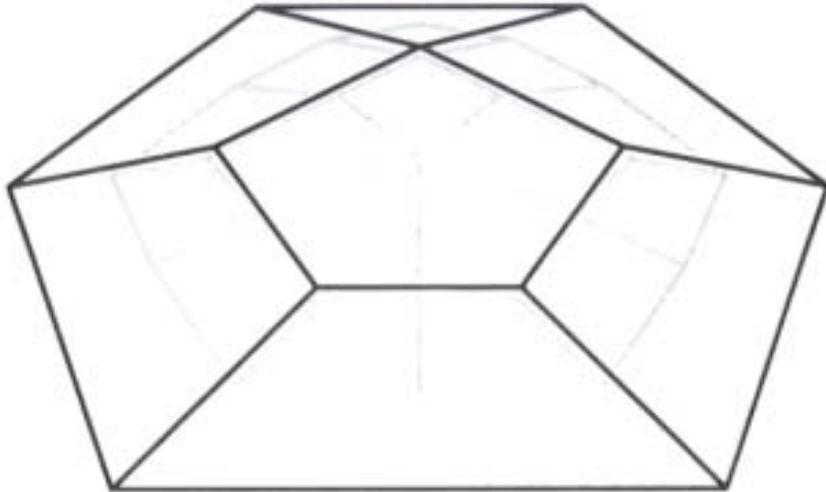
(1974)

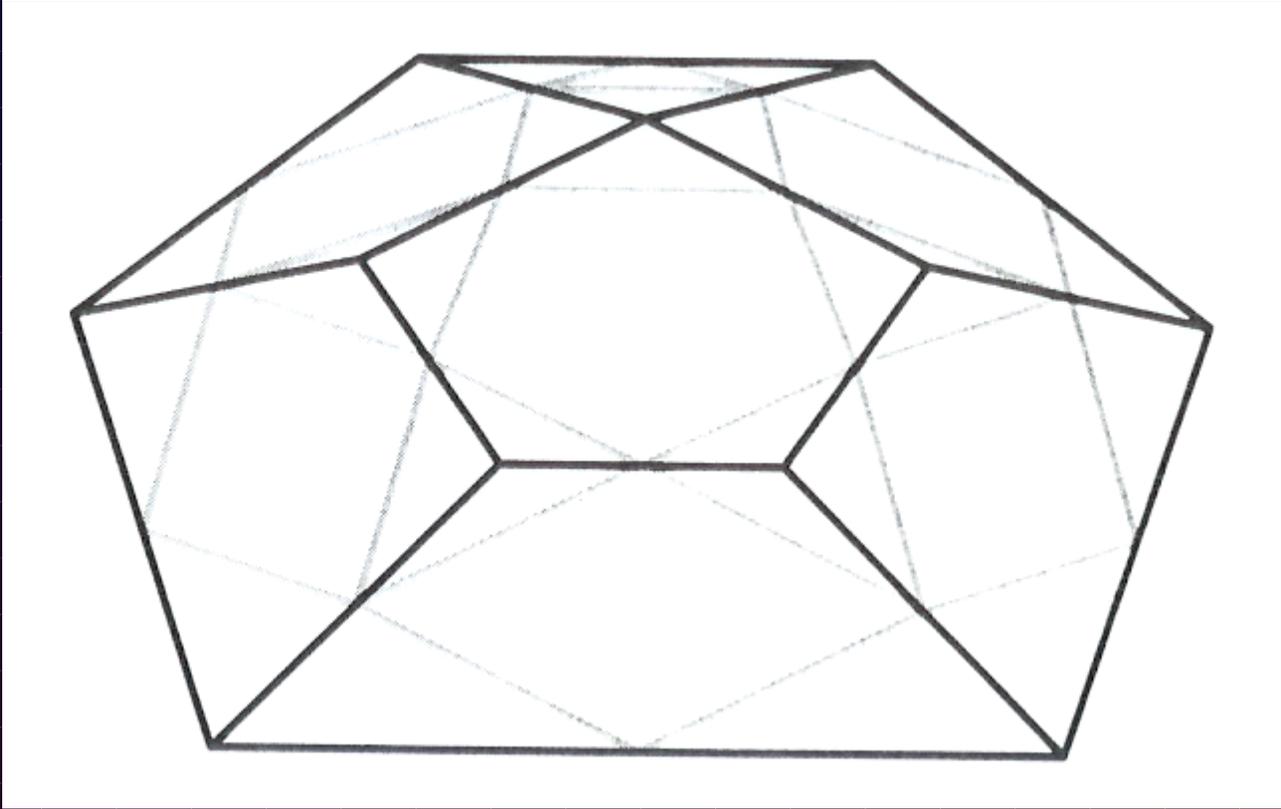


Doo-Sabin



Catmull-Clark





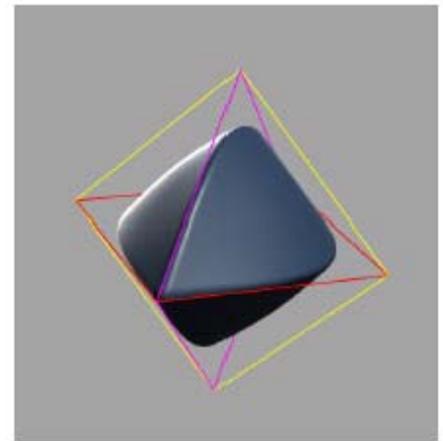
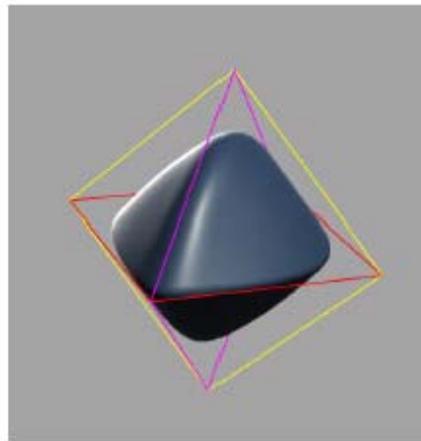
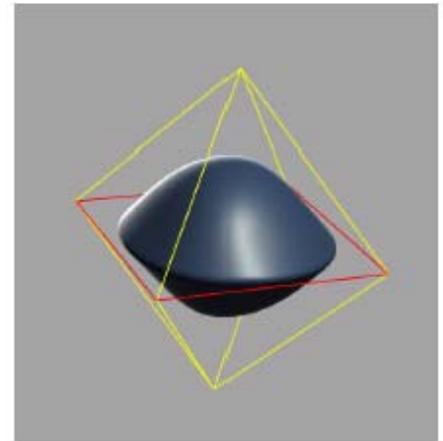
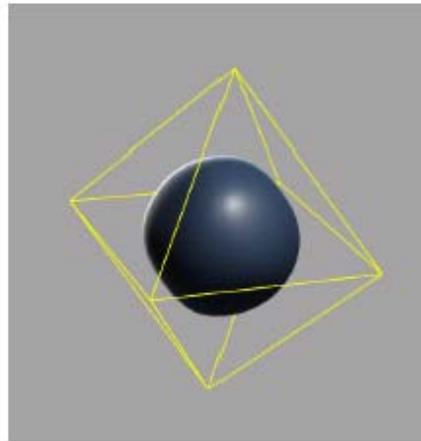
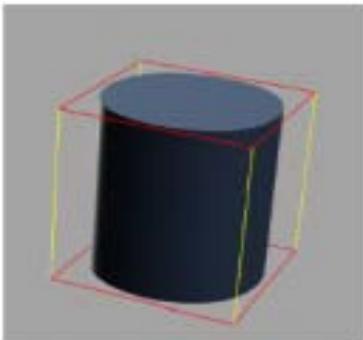
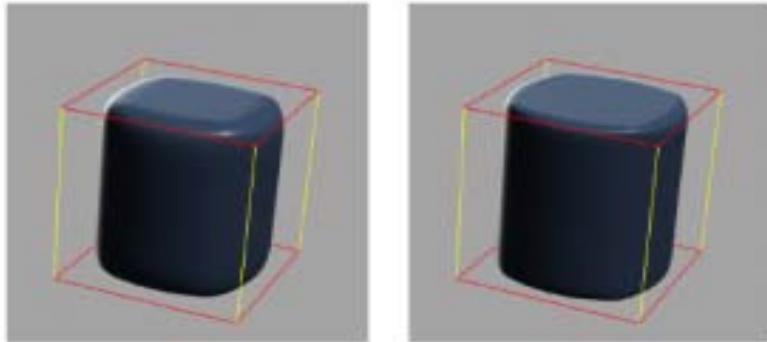
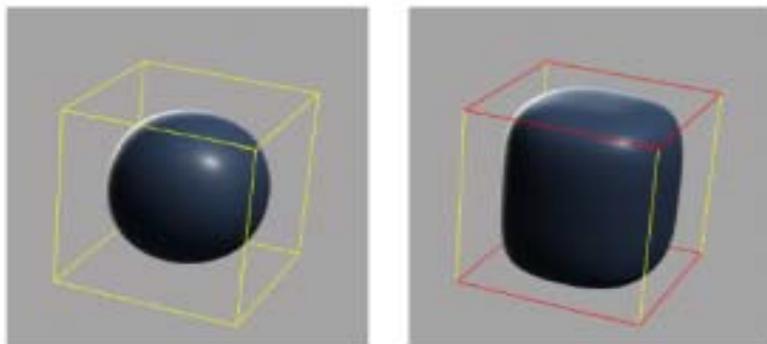
Geri's Game: Pixar Animation

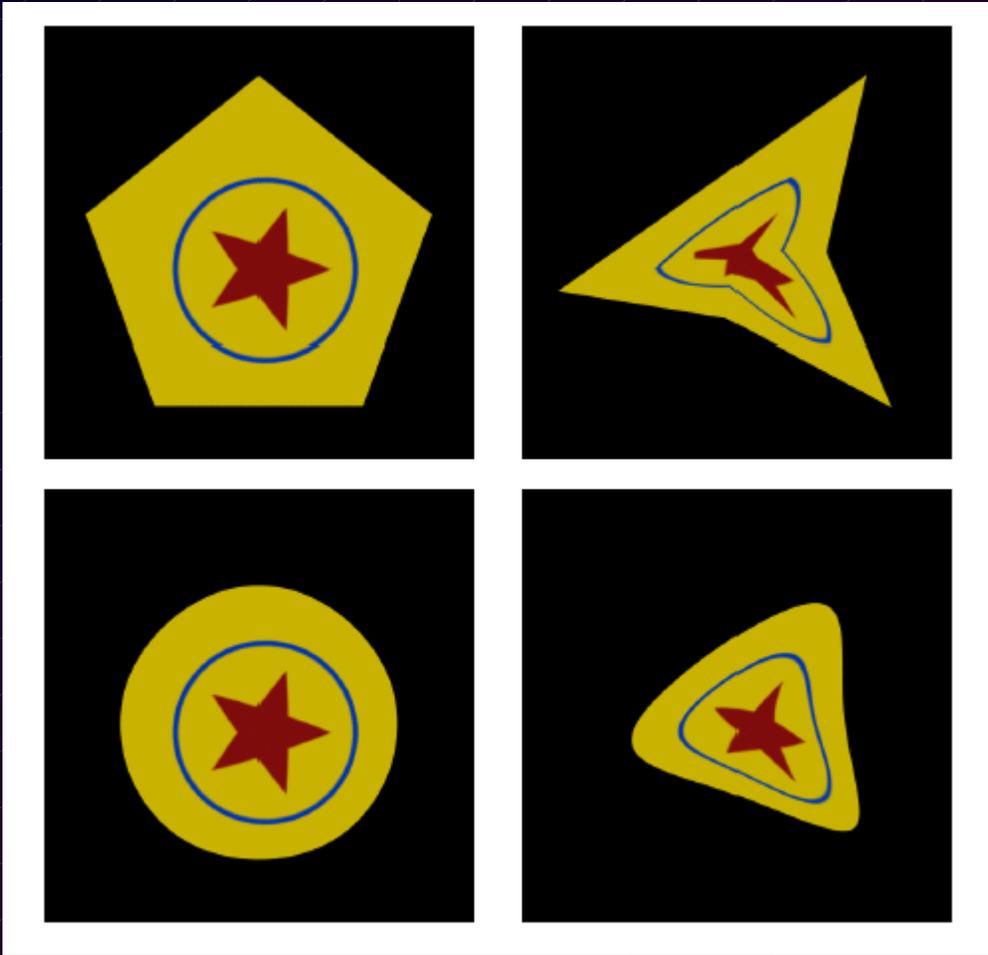


Subdivision



Sharpness

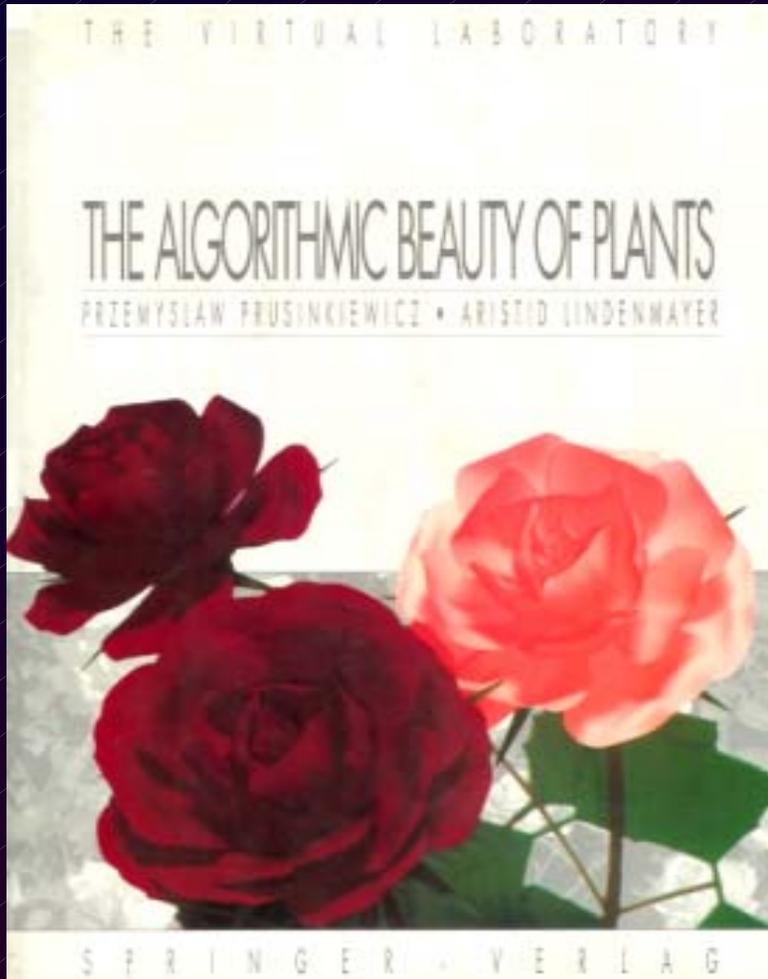




5

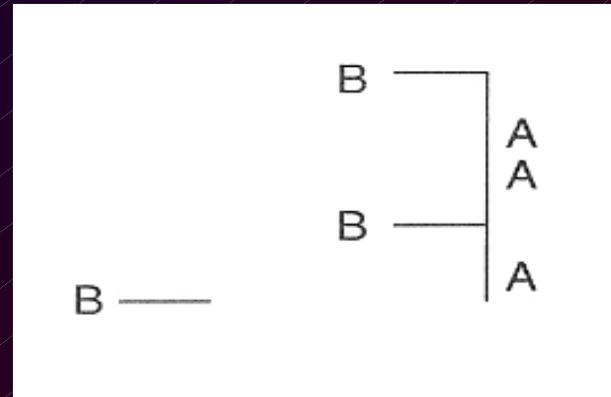
Subdivision

L-System

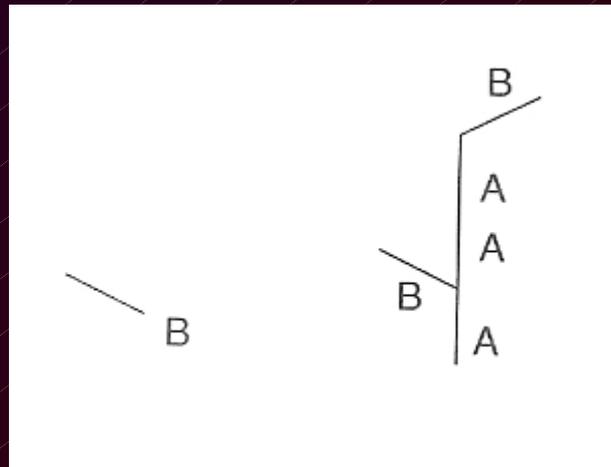


Aristid Lindenmayer (1925-1989)

- $A \rightarrow AA$
 $B \rightarrow A[B]AA[B]$

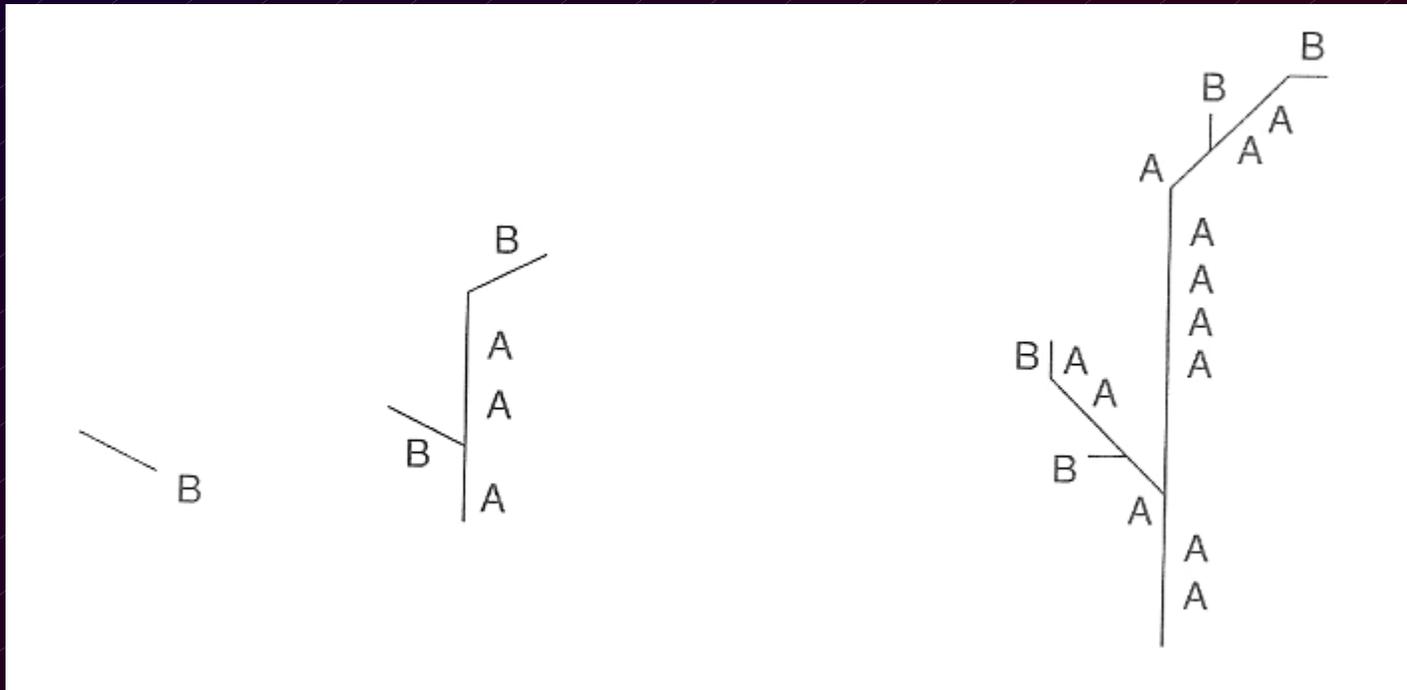


- $A \rightarrow AA$
 $B \rightarrow A[B]AA(B)$



$B \Rightarrow A[B]AA(B)$

$\Rightarrow AA[A[B]AA(B)]AAAA(A[B]AA(B))$





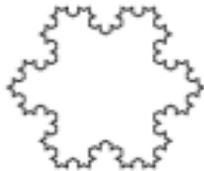
$n = 0$



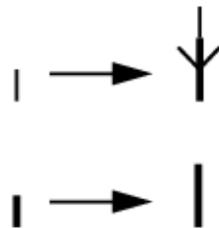
$n = 1$



$n = 2$



$n = 3$





a



b



c



d



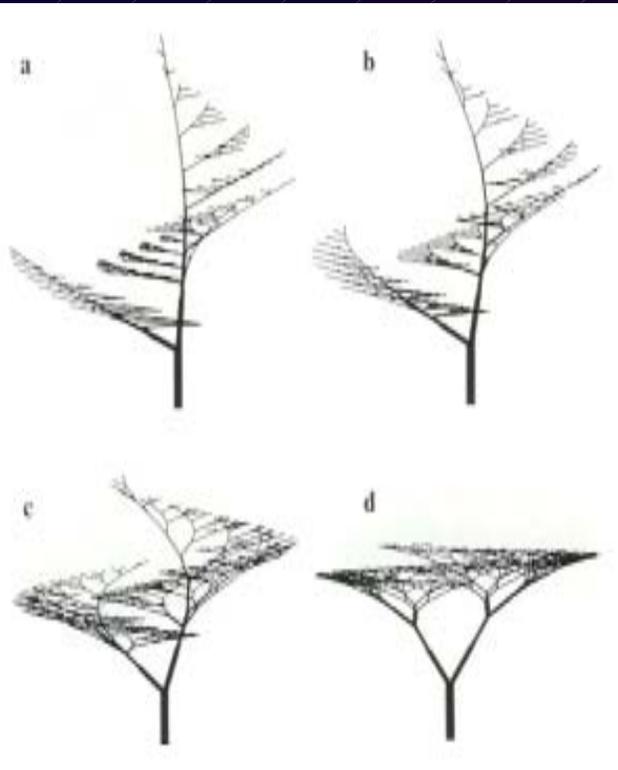
e



f







```

n = 10
#define r1 0.9 /* contraction ratio 1 */
#define r2 0.7 /* contraction ratio 2 */
#define a1 10 /* branching angle 1 */
#define a2 60 /* branching angle 2 */
#define w_r 0.707 /* width decrease rate */

omega : A(1,10)
p1 : A(1,w) : * -> !(w)F(1) [&(a1)B(l*r1,w*w_r)]
      /(180) [&(a2)B(l*r2,w*w_r)]
p2 : B(1,w) : * -> !(w)F(1) [+ (a1)$B(l*r1,w*w_r)]
      [- (a2)$B(l*r2,w*w_r)]

```



```
#define S          /* seed shape */  
#define R          /* ray floret shape */  
#include M N O P  /* petal shapes */
```

```
 $\omega$  : A(0)  
p1 : A(n) : *  $\rightarrow$  +(137.5) [f(n0.5)C(n)]A(n+1)  
p2 : C(n) : n  $\leq$  440  $\rightarrow$   $\sim$ S  
p3 : C(n) : 440 < n & n  $\leq$  565  $\rightarrow$   $\sim$ R  
p4 : C(n) : 565 < n & n  $\leq$  580  $\rightarrow$   $\sim$ M  
p5 : C(n) : 580 < n & n  $\leq$  595  $\rightarrow$   $\sim$ N  
p6 : C(n) : 595 < n & n  $\leq$  610  $\rightarrow$   $\sim$ O  
p7 : C(n) : 610 < n  $\rightarrow$   $\sim$ P
```

