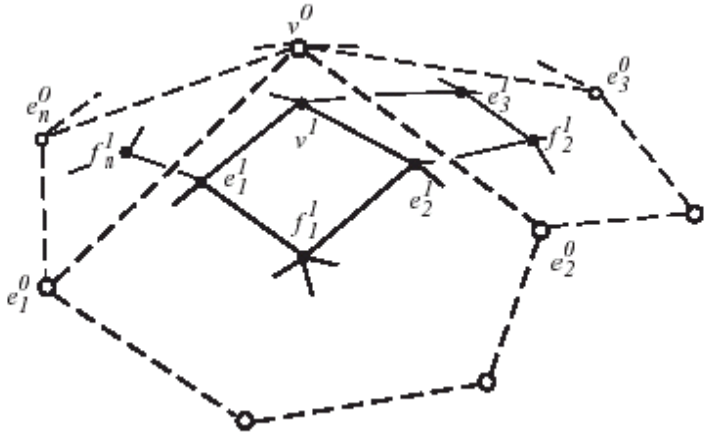
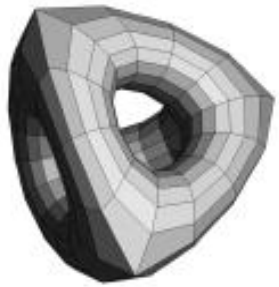
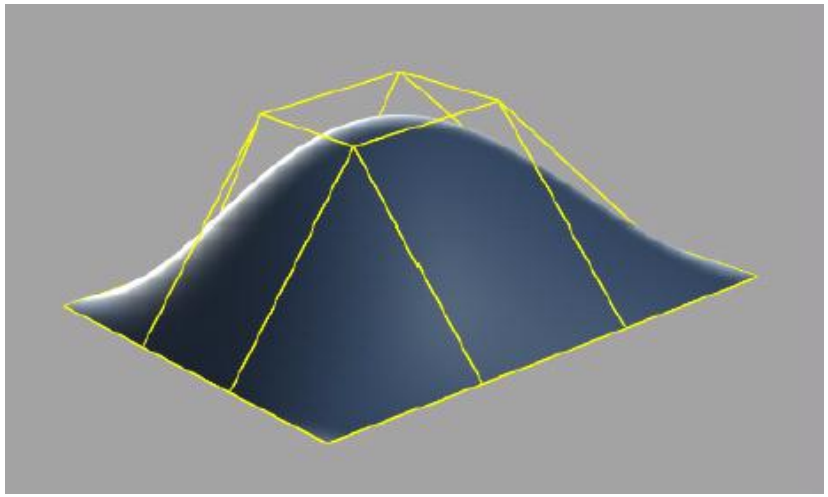
고급 그래픽스 기법들

서울대학교 컴퓨터공학부
김명수
http://cse.snu.ac.kr/mskim
http://3map.snu.ac.kr

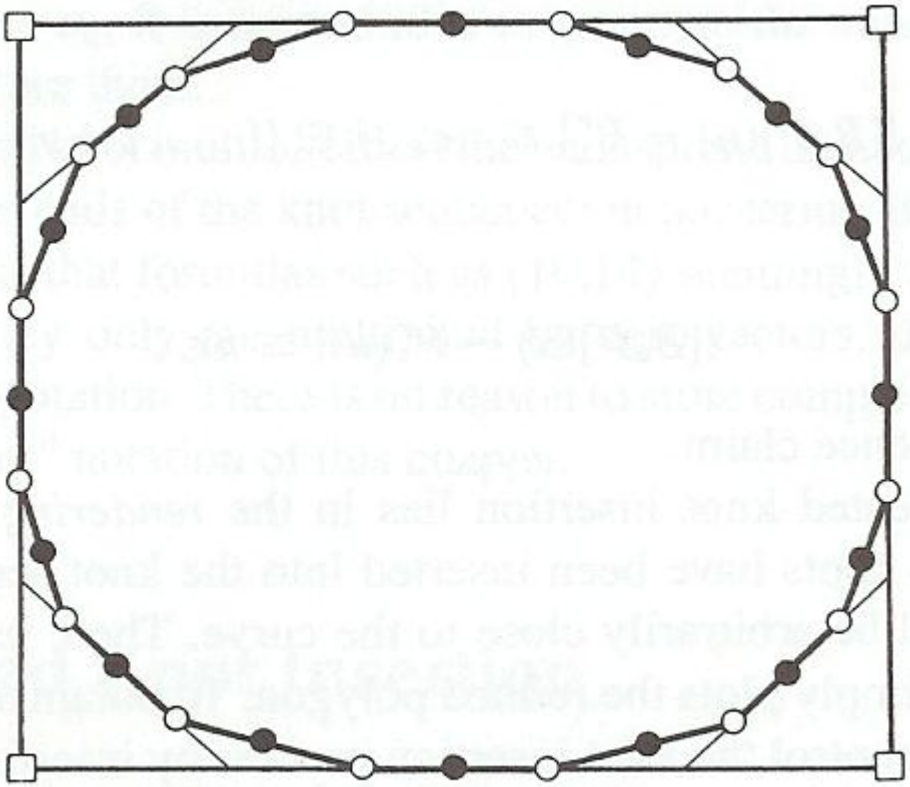
Subdivision 곡면



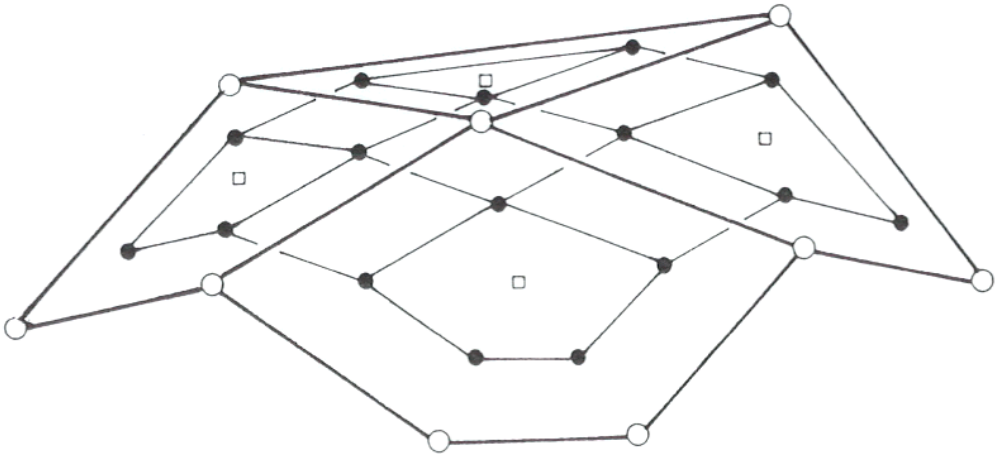


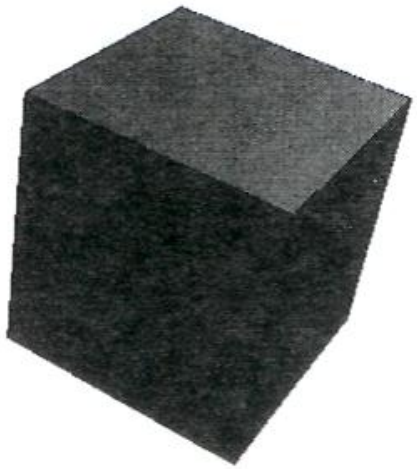


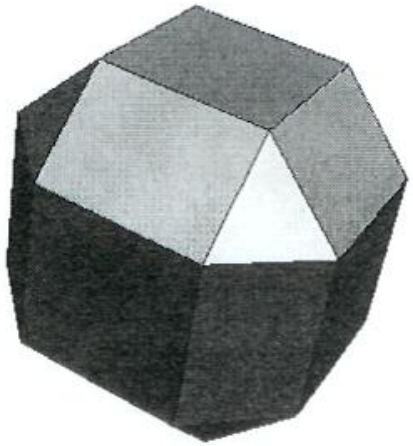
Chaikin의 알고리즘 (1974)

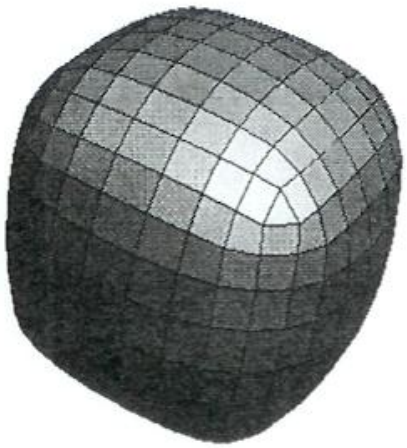


Doo-Sabin 알고리즘

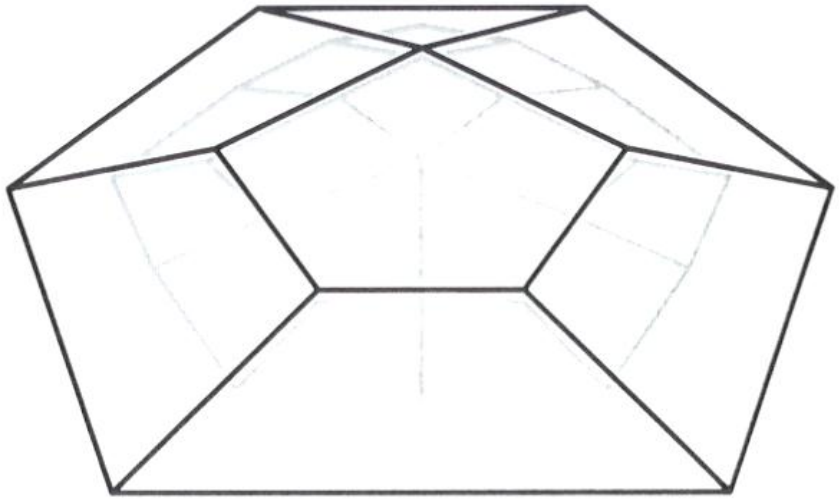


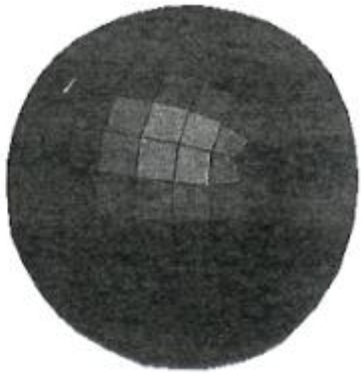




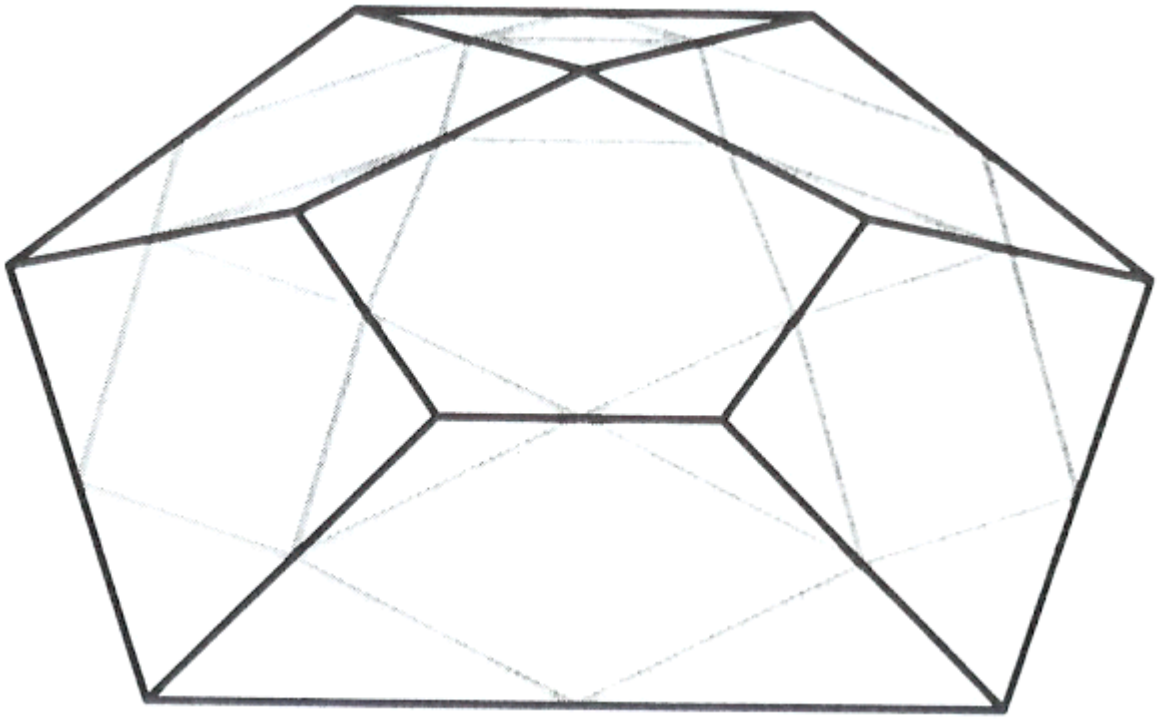


Catmull-Clark 알고리즘





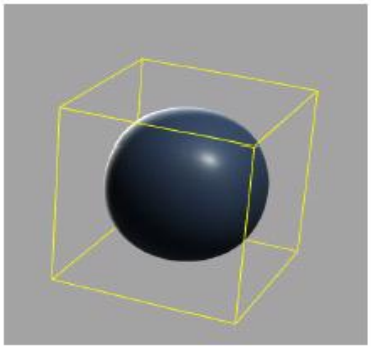
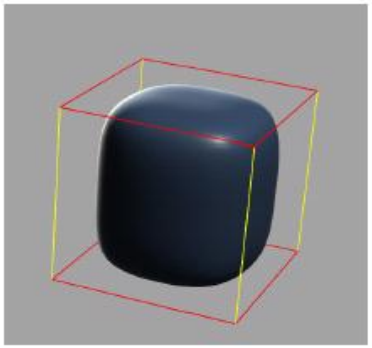
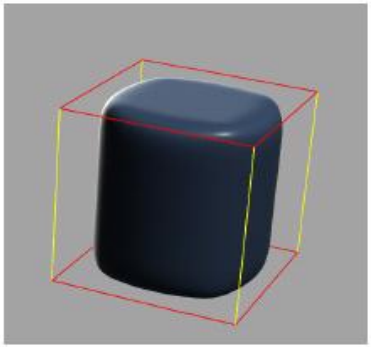
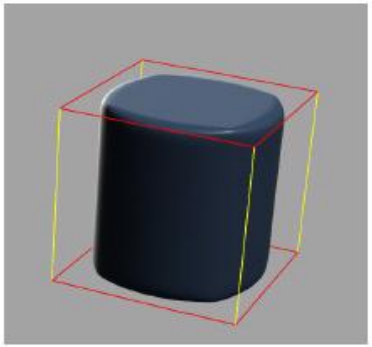
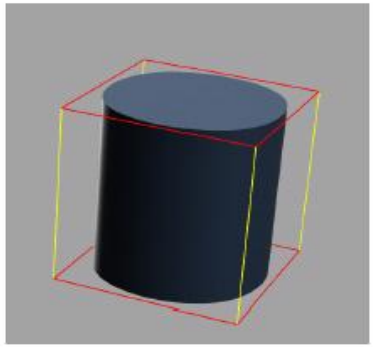
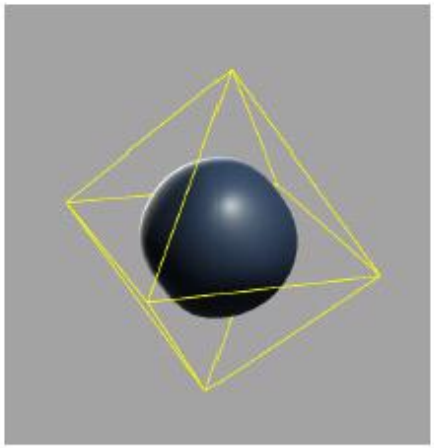
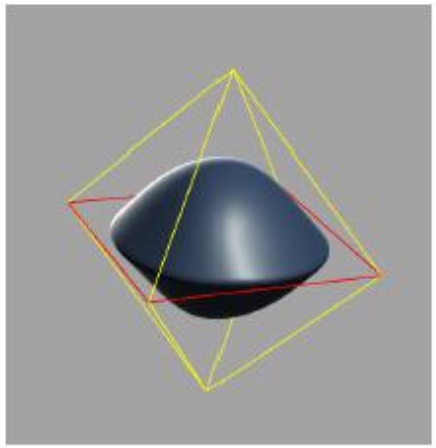
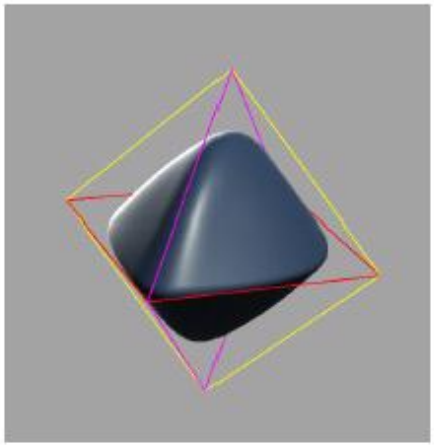
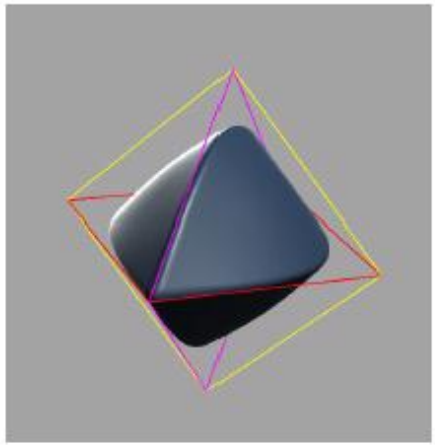
중간점 분할 알고리즘



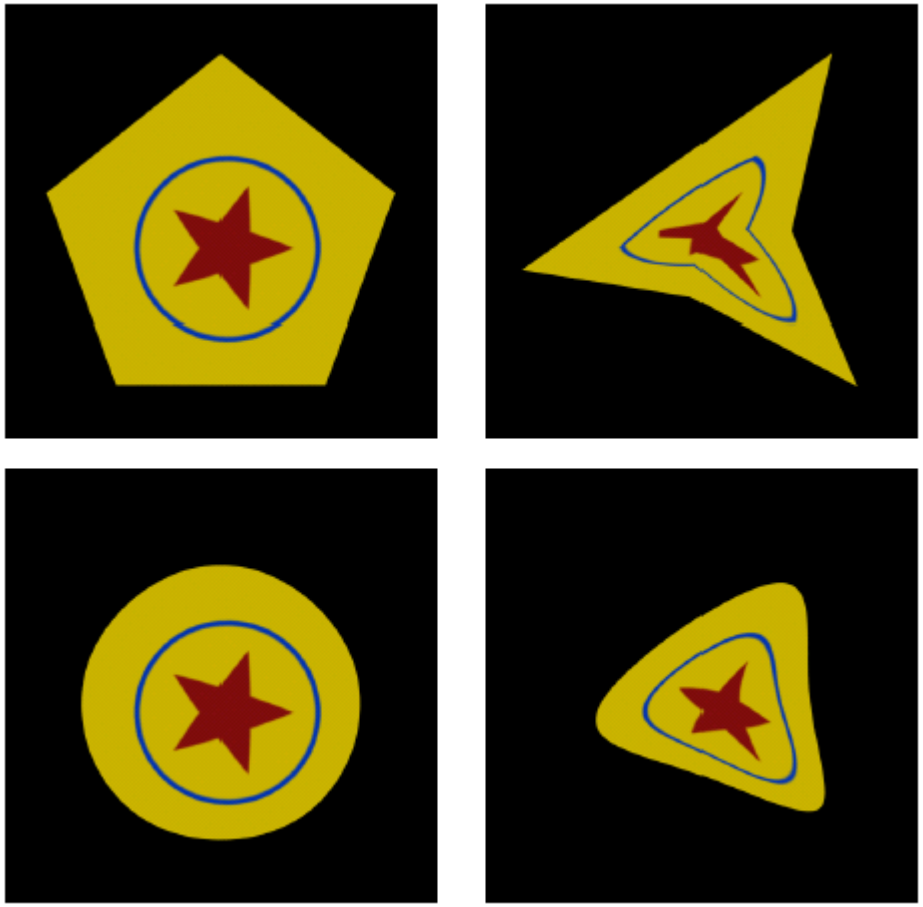
Geri's Game: Pixar Animation

Subdivision 곡면 모델링의 예

Sharpness 제어

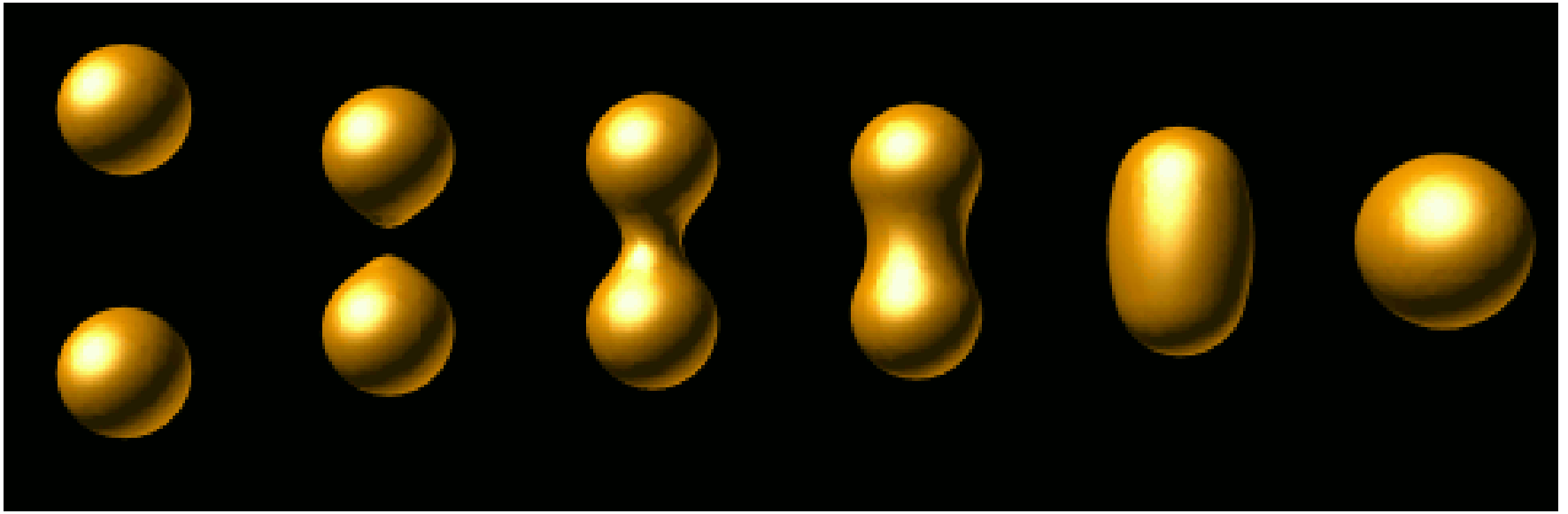
텍스처 매핑



5개의 삼각형으로
이루어진 다각형에
대한 텍스처 매핑

Subdivision
곡면으로 모델링된
경우의 텍스처 매핑

음함수 곡면

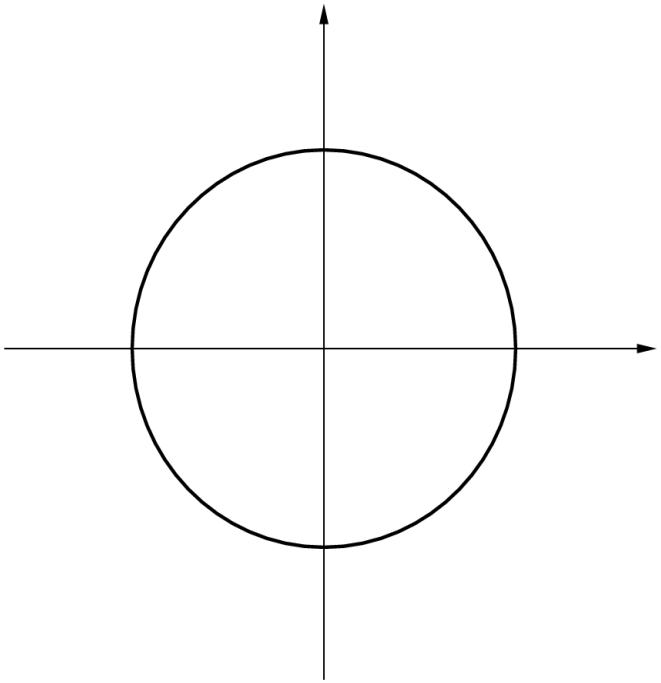


매개변수 표현과 음함수 표현

$$(\cos\theta, \sin\theta)$$

$$\left(\frac{1-t^2}{1+t^2}, \frac{2t}{1+t^2}\right)$$

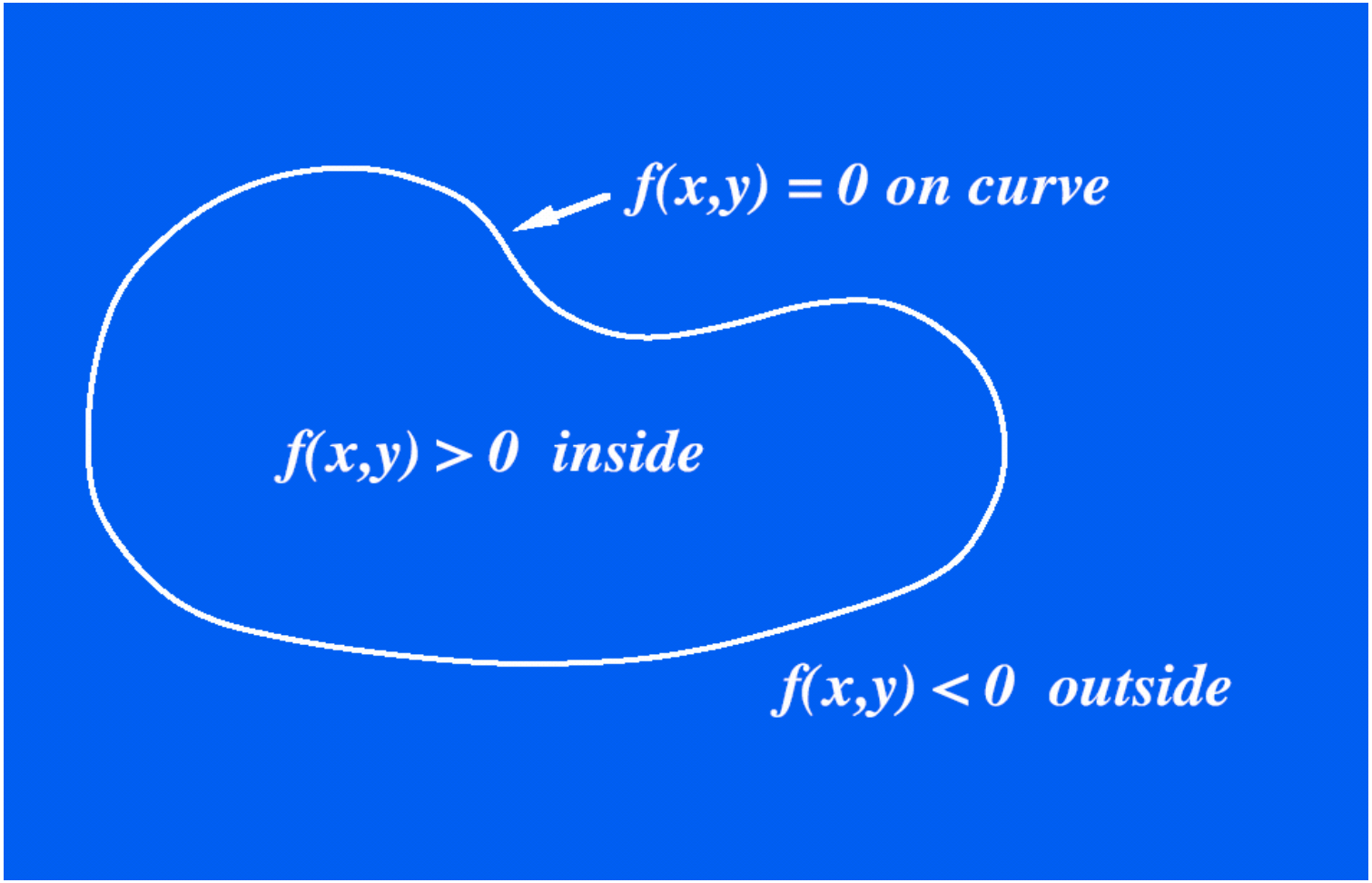
$$x^2 + y^2 = 1$$



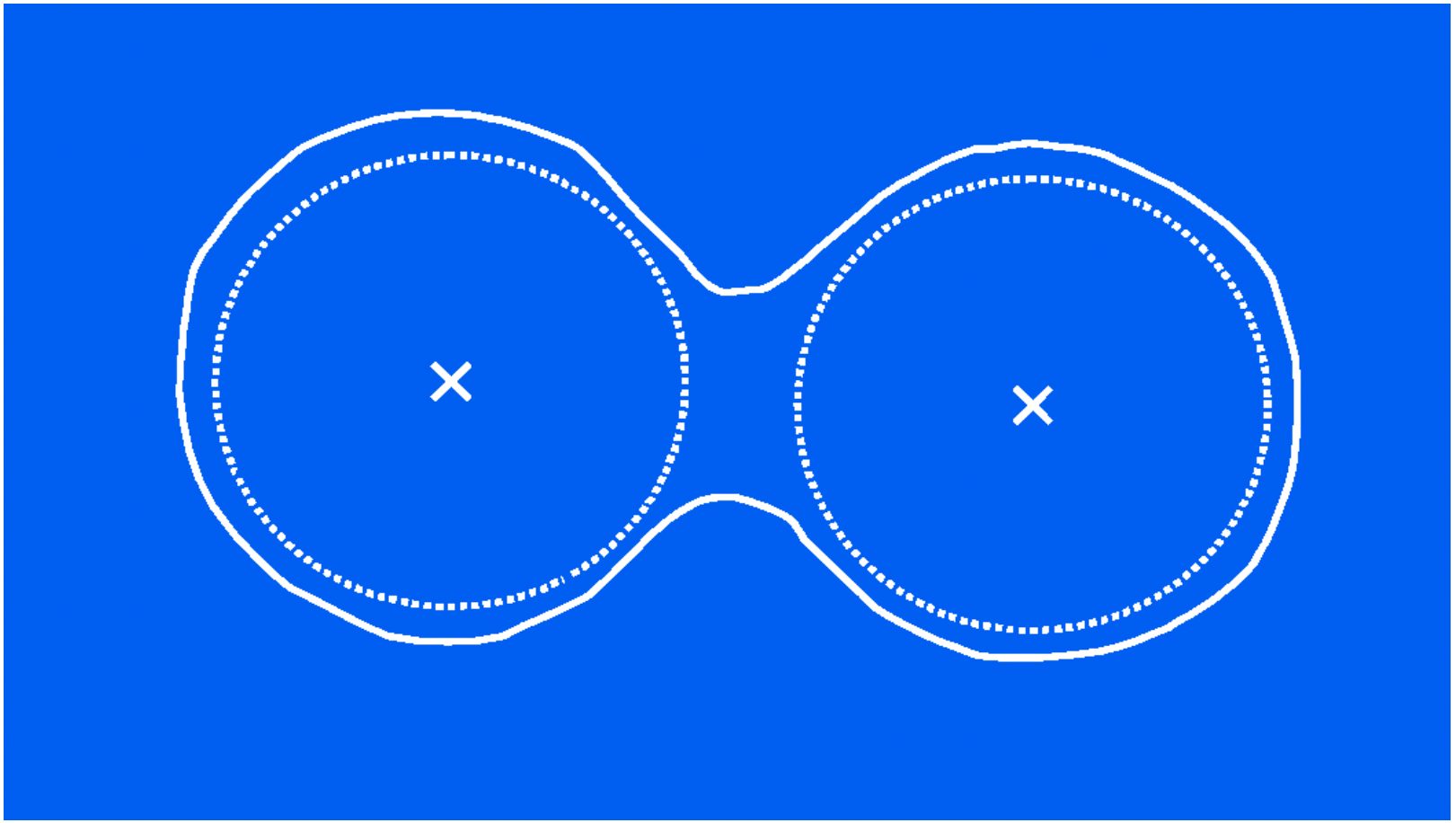
음함수 곡면 모델링

- Blobby 모델
- Meta Ball
- 음함수 곡면 (Implicit Surface)
- Soft Object

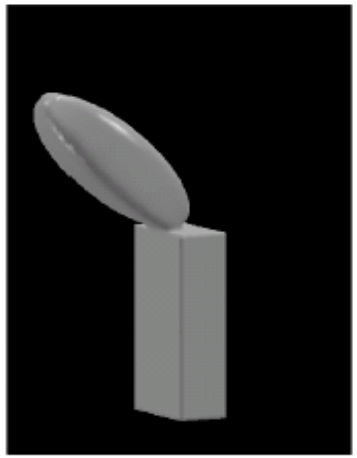
음함수 곡선 모델링



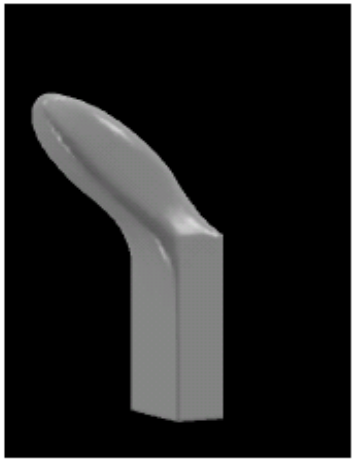
Blobby 공의 블렌딩



음함수 곡면을 이용한 블렌딩 효과

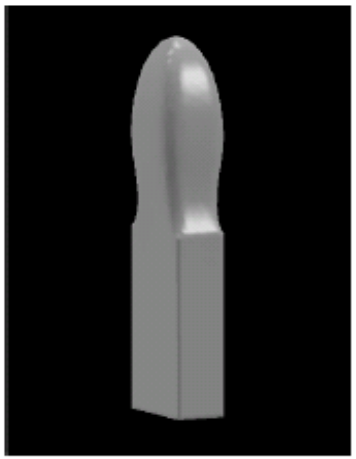


(a)



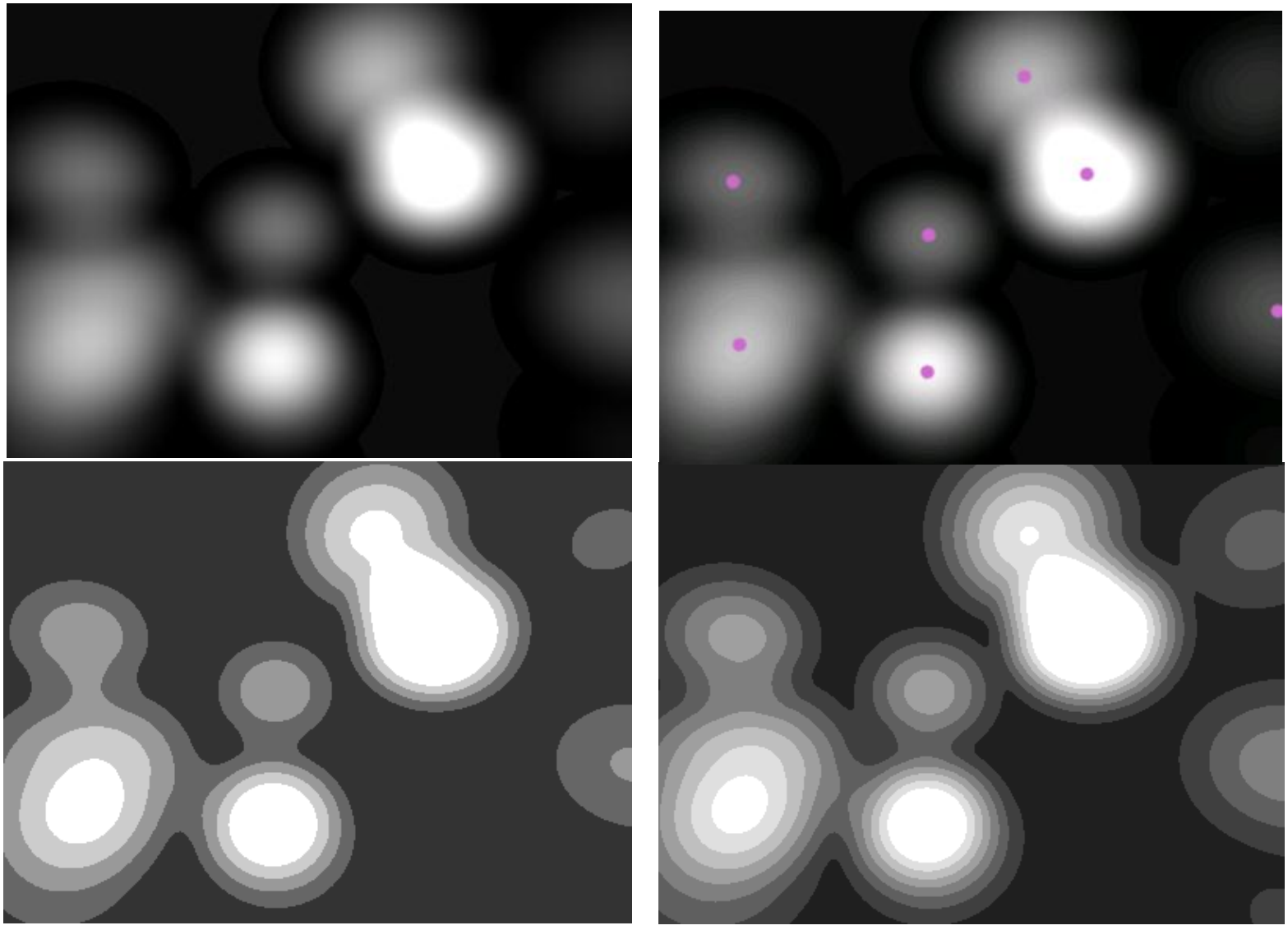
(b)

(c)

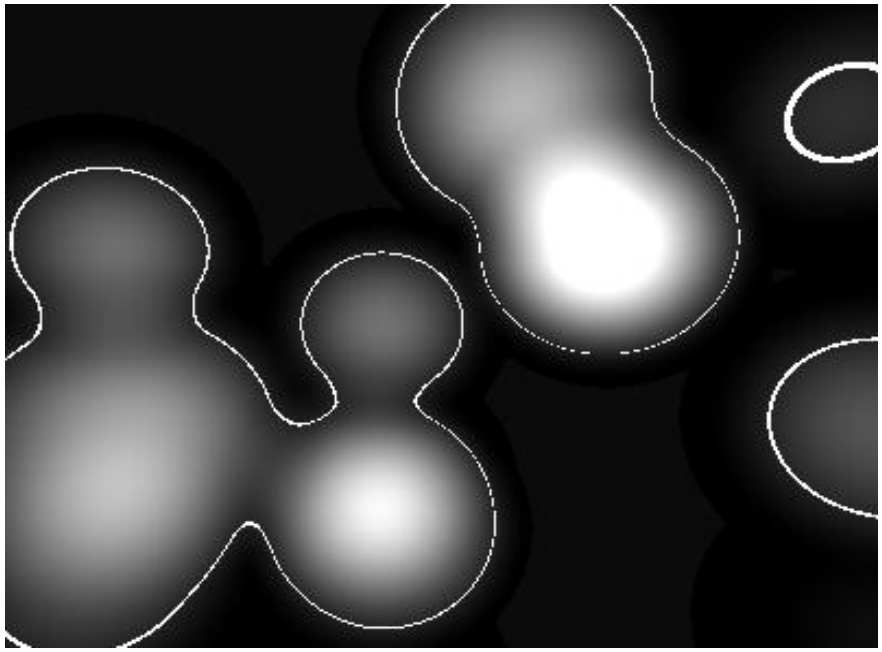


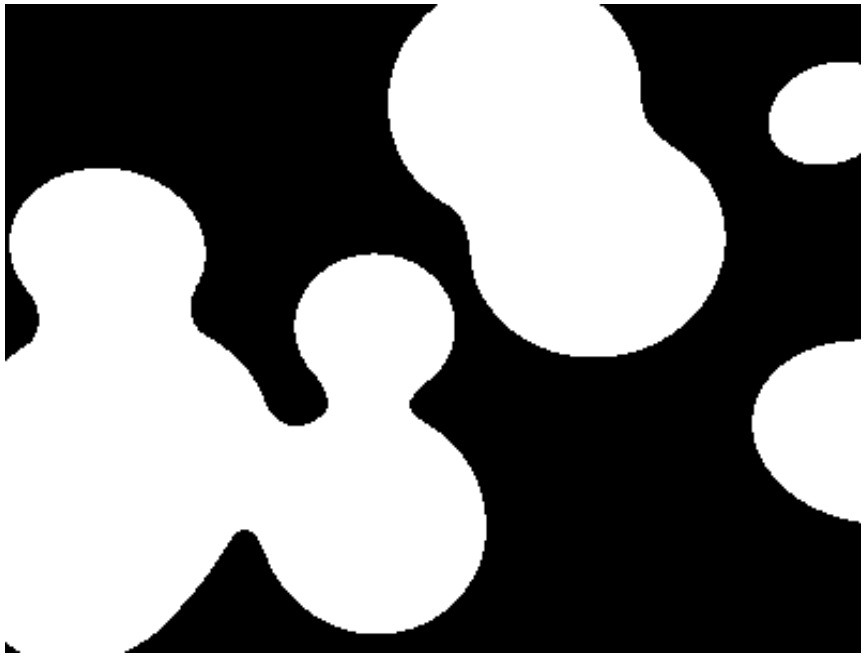
(d)

에너지 장

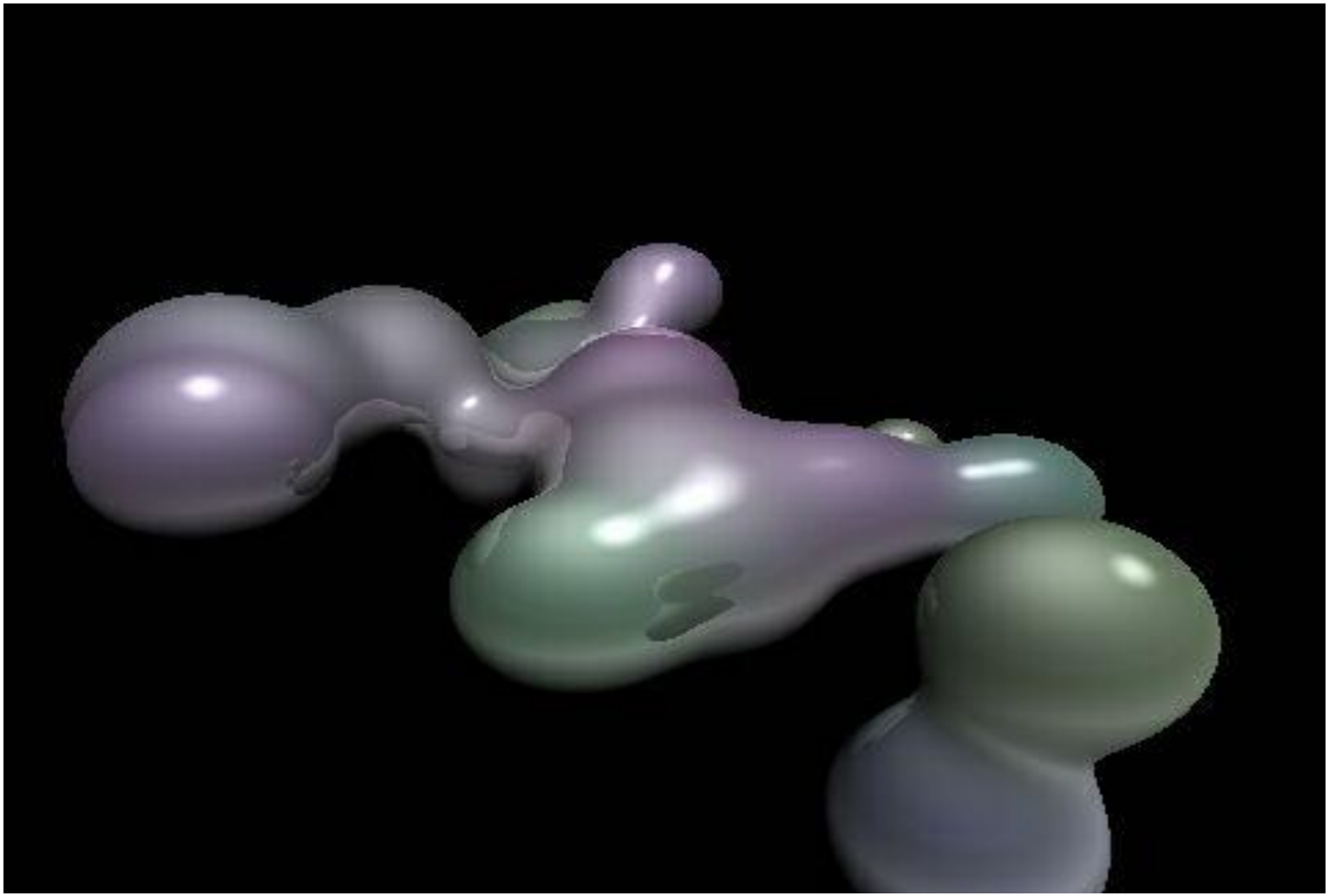


음함수 모델링





음함수 곡면 모델링의 예



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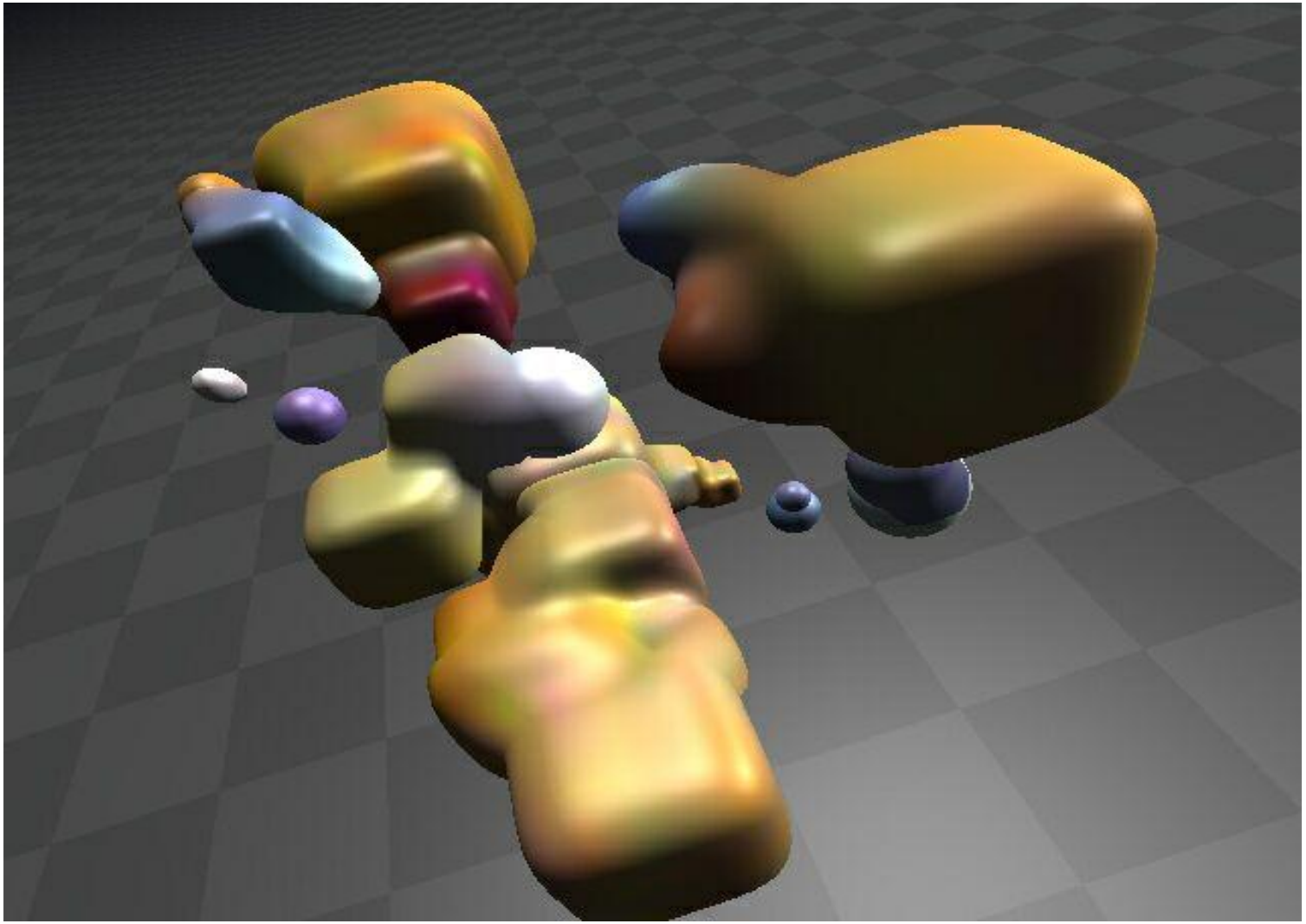
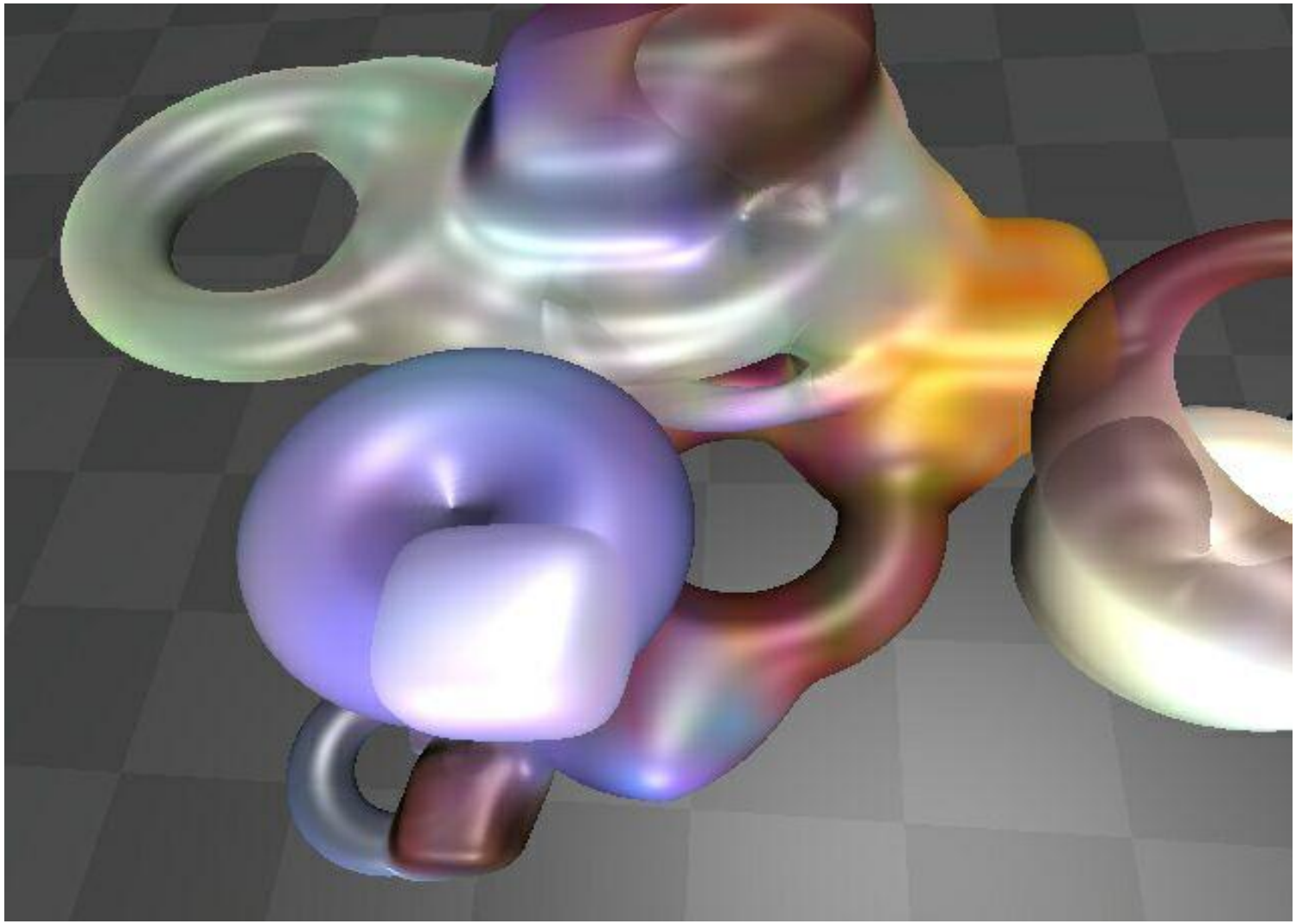


음함수 곡면 모델링의 예



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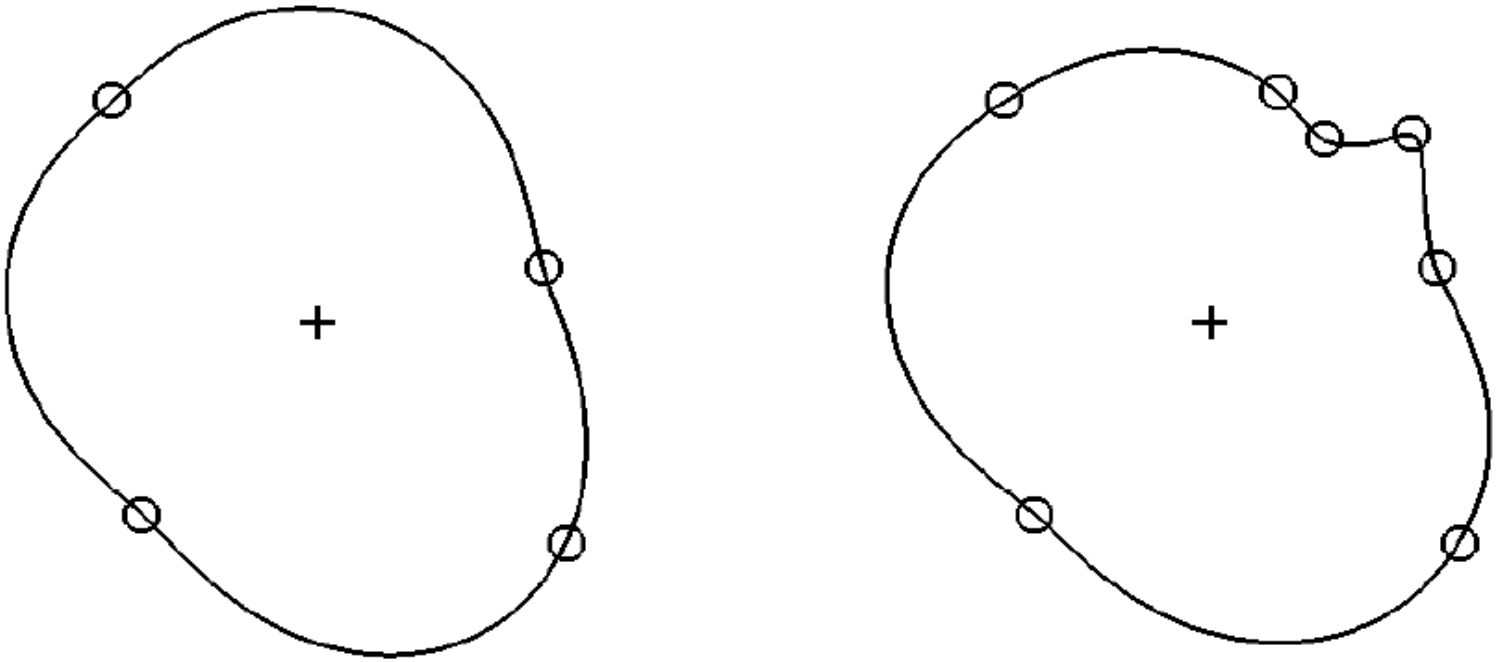
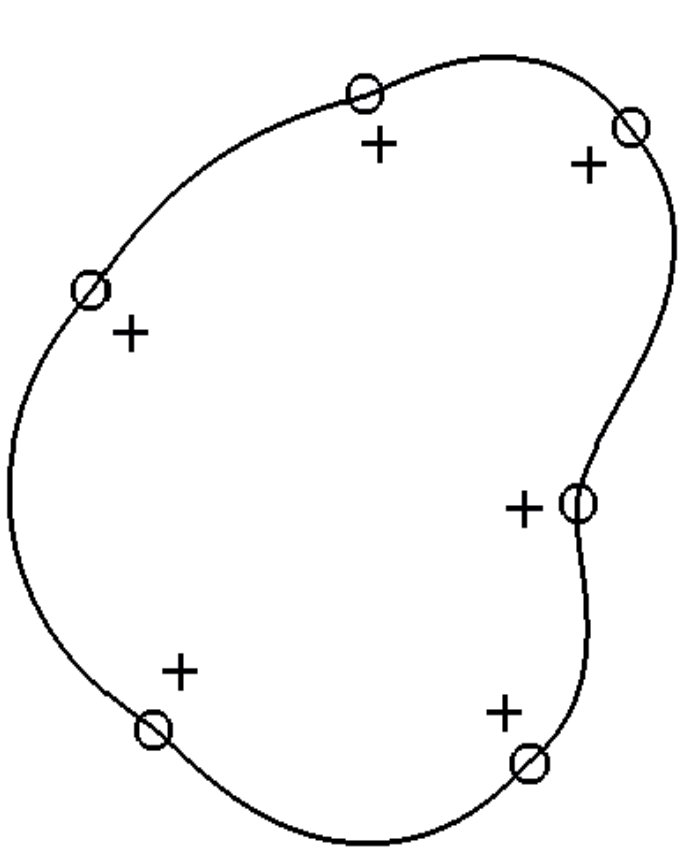
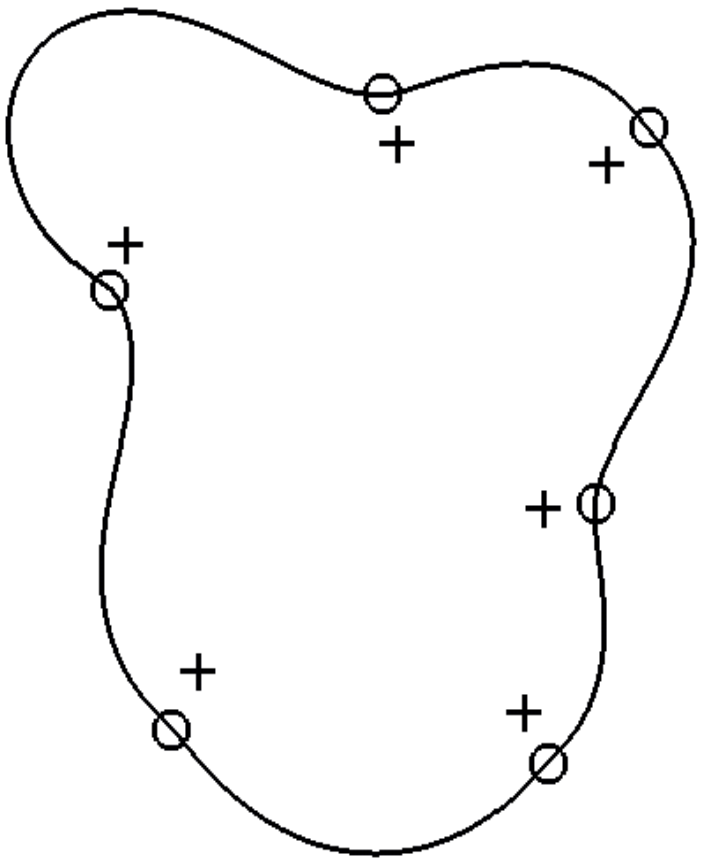
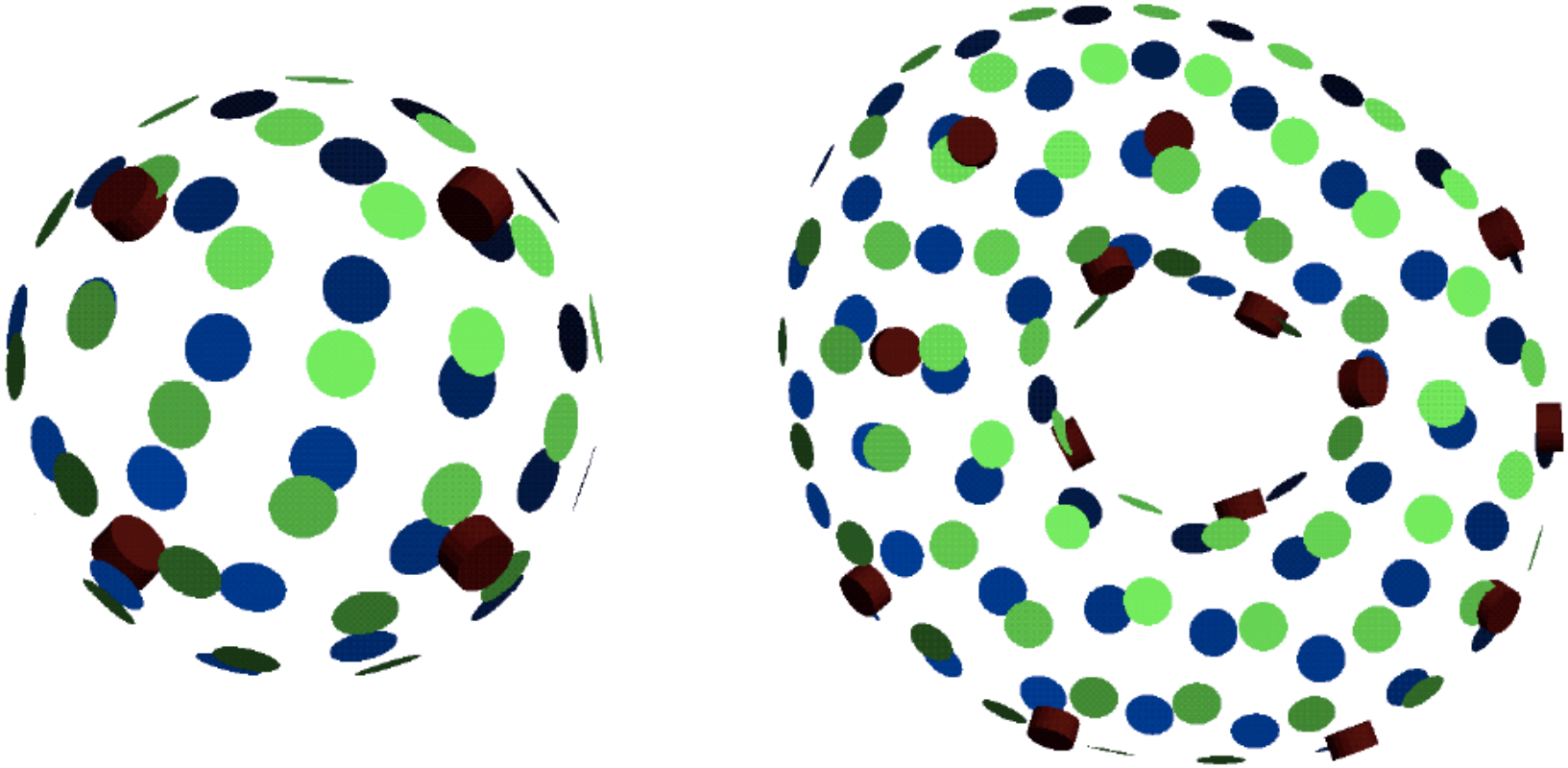


다양한 구속조건: 법선방향





대화형 모델링: 경계점 제어



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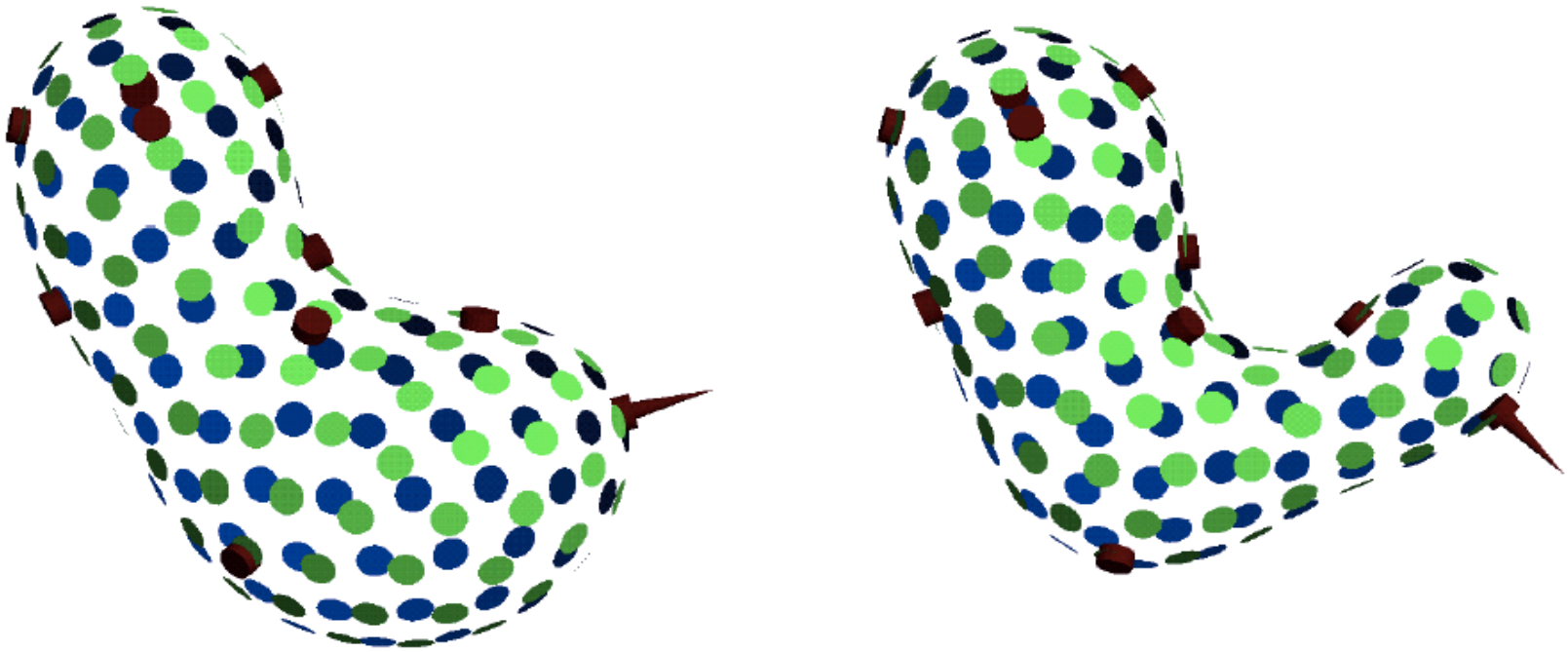


Particle Systems

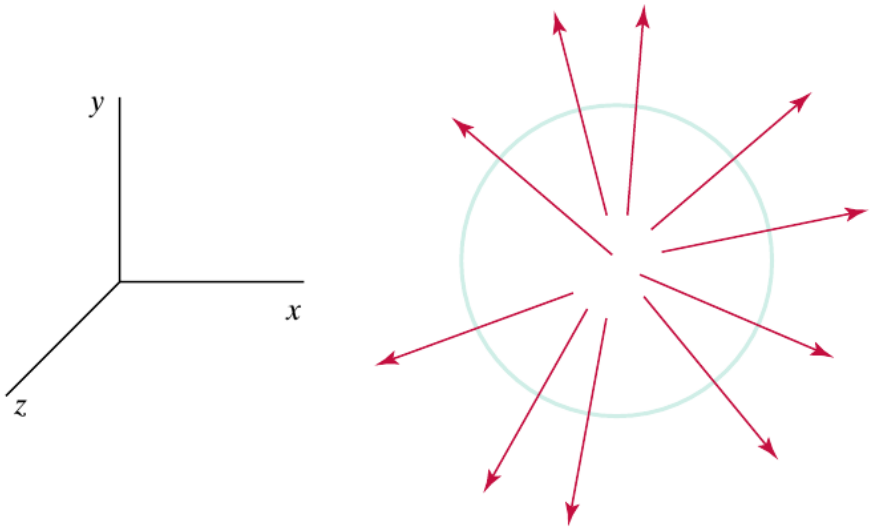


FIGURE 8-113 Modeling fireworks as a particle system with particles traveling radially outward from the center of a sphere.

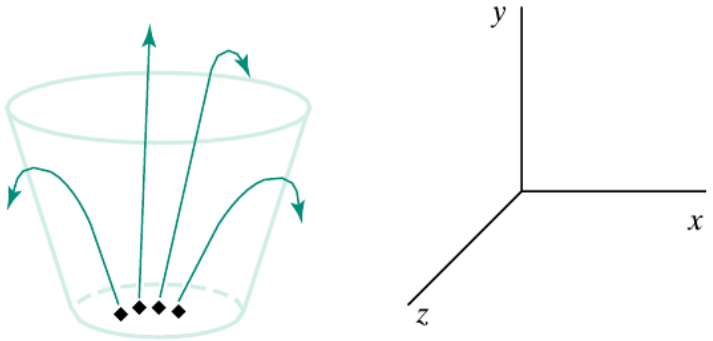


FIGURE 8-114 Modeling a clump of grass by firing particles upward within a tapered cylinder. The particle paths are parabolas due to the downward force of gravity.

Particle Systems

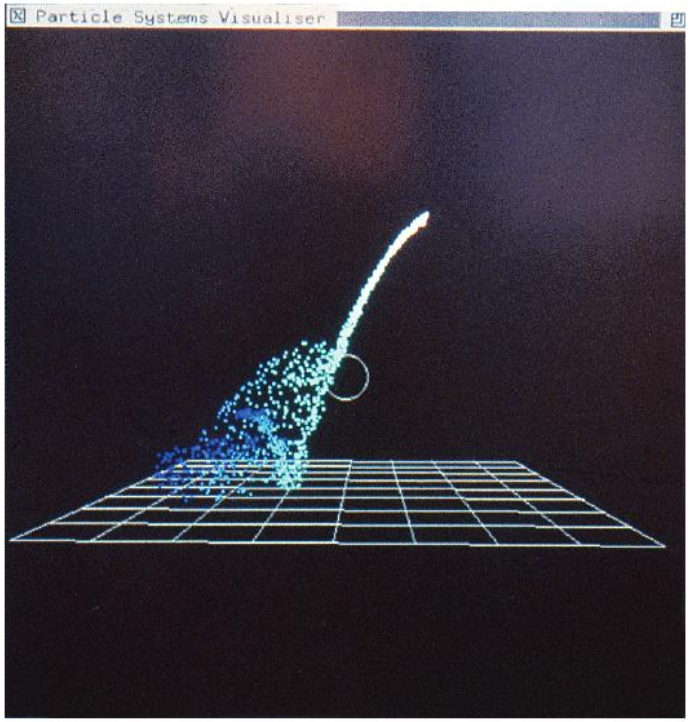


FIGURE 8-115 Simulation of the behavior of a waterfall hitting a stone (circle). The water particles are deflected by the stone and then splash up from the ground. (*Courtesy of M. Brooks and T. L. J. Howard, Department of Computer Science, University of Manchester.*)

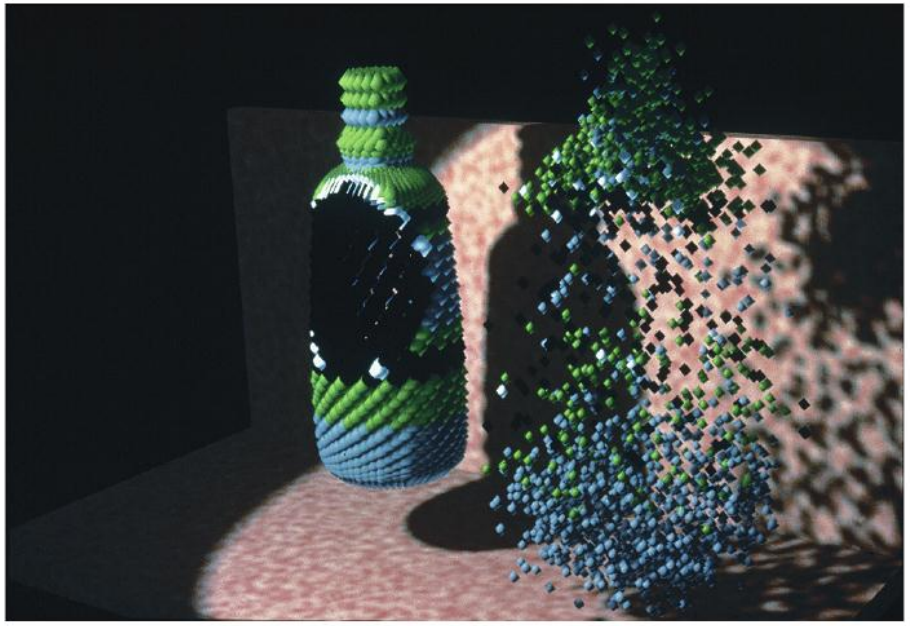


FIGURE 8-116 An object disintegrating into a cloud of particles. (*Courtesy of Autodesk, Inc.*)

Physically-Based Modeling

$$F_s = -F_x = -kx$$

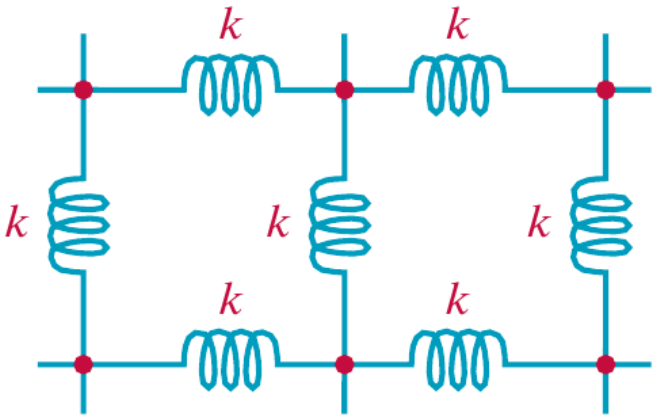


FIGURE 8–118 A two-dimensional spring network, constructed with identical spring constants k.

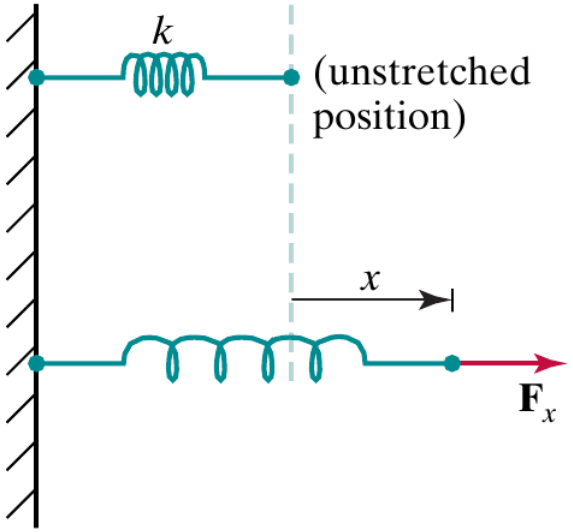


FIGURE 8–119 An external force F_x pulling on one end of a spring, with the other end rigidly fixed.

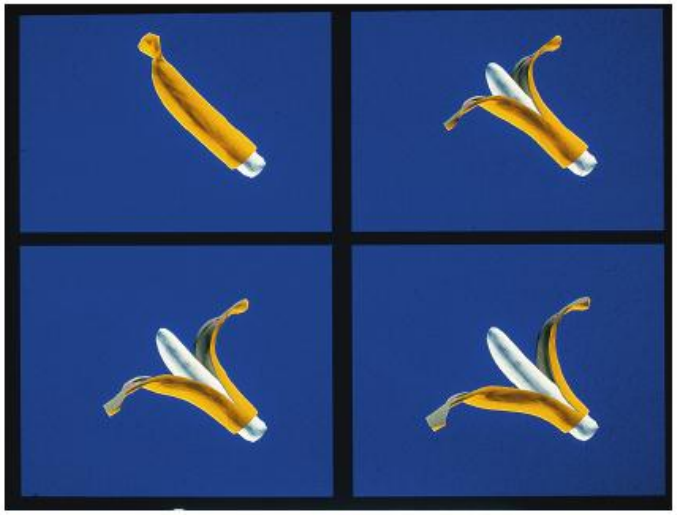


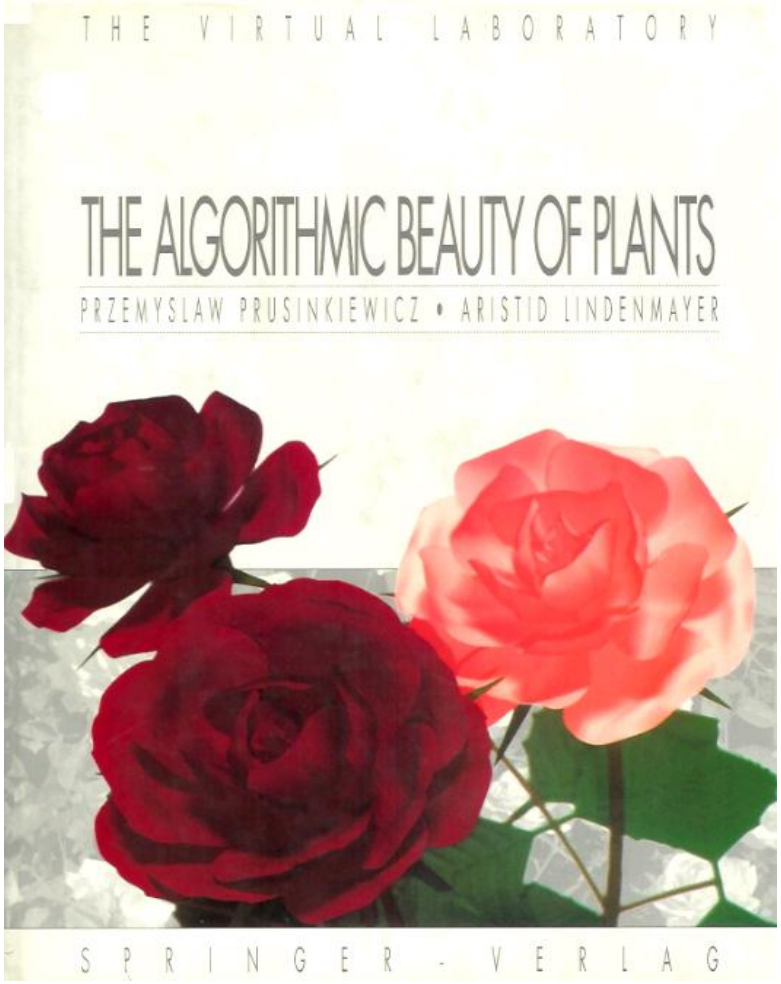
FIGURE 8-120 Modeling the flexible behavior of a banana peel with a spring network. (*Courtesy of David Laidlaw, John Snyder, Adam Woodbury, and Alan Barr, Computer Graphics Lab, California Institute of Technology.* © *1992.*)

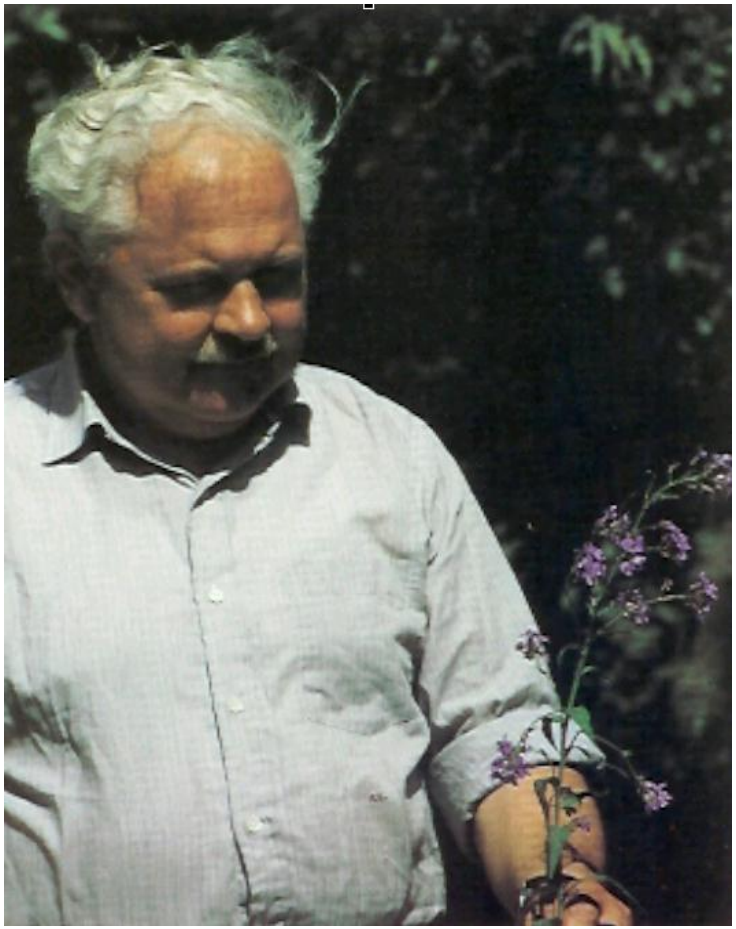
FIGURE 8-121 Modeling the flexible behavior of cloth draped over furniture using energy-function minimization. (*Courtesy of Gene Greger and David E. Breen, Design Research Center, Rensselaer Polytechnic Institute.* © *1992.*)

(a) (b) (c)

FIGURE 8-122 Modeling the characteristics of (a) cotton, (b) wool, and (c) polyester cotton using energy-function minimization. (*Courtesy of David E. Breen and Donald H. House, Design Research Center, Rensselaer Polytechnic Institute.* © *1992.*)

L-System

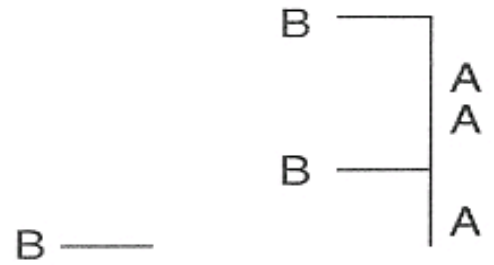




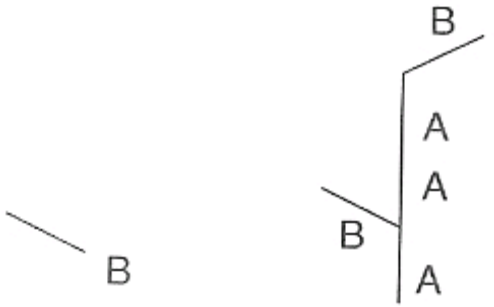
Aristid Lindenmayer (1925-1989)

식물체 성장모델링

- A -> AA
  B -> A[B]AA[B]



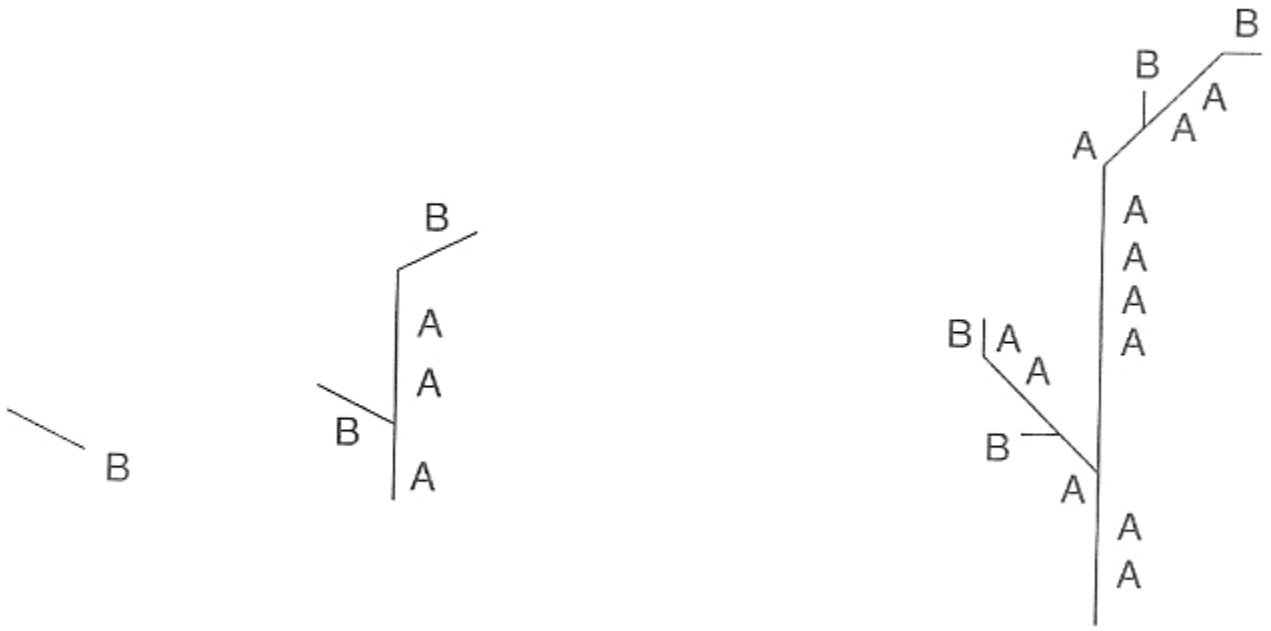
- A -> AA
  B -> A[B]AA(B)



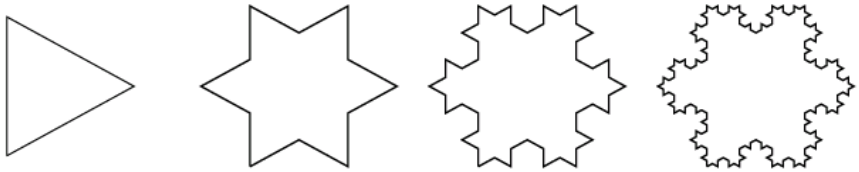
식물체 성장모델링

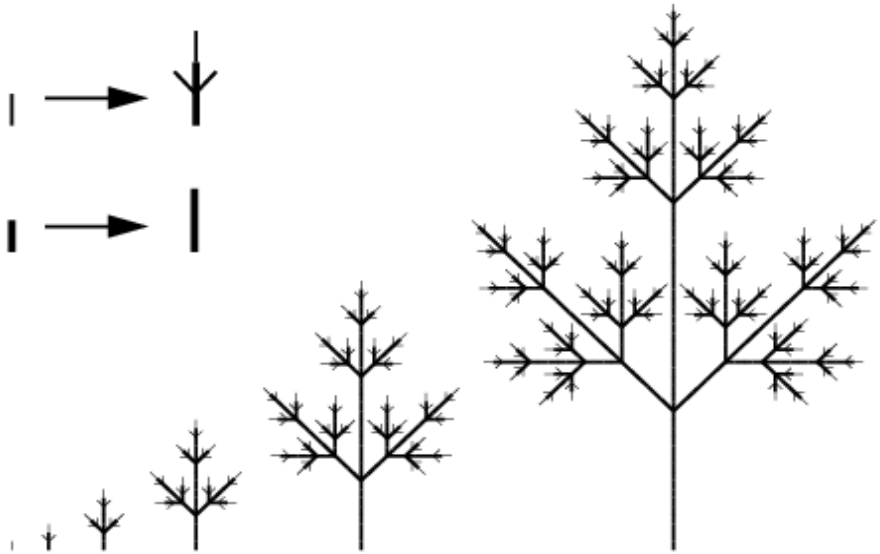
B => A[B]AA(B)

=> AA[A[B]AA(B)]AAAA(A[B]AA(B))

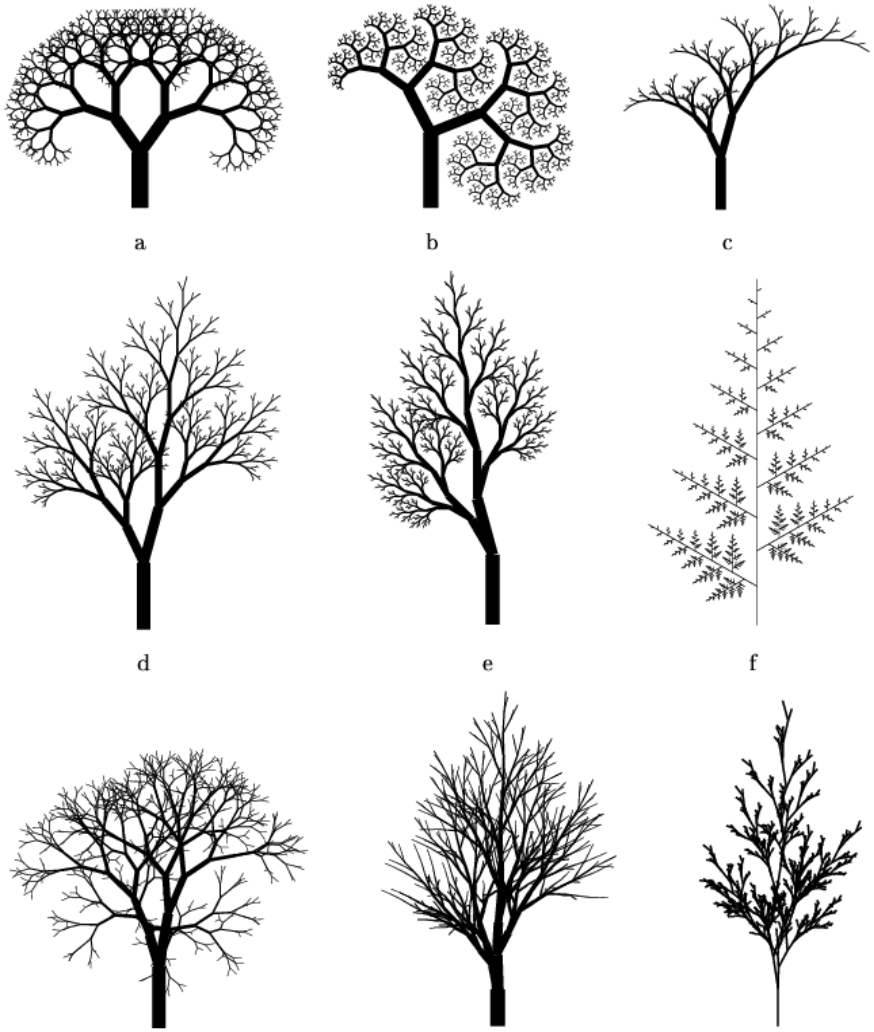


문법기반 모델링

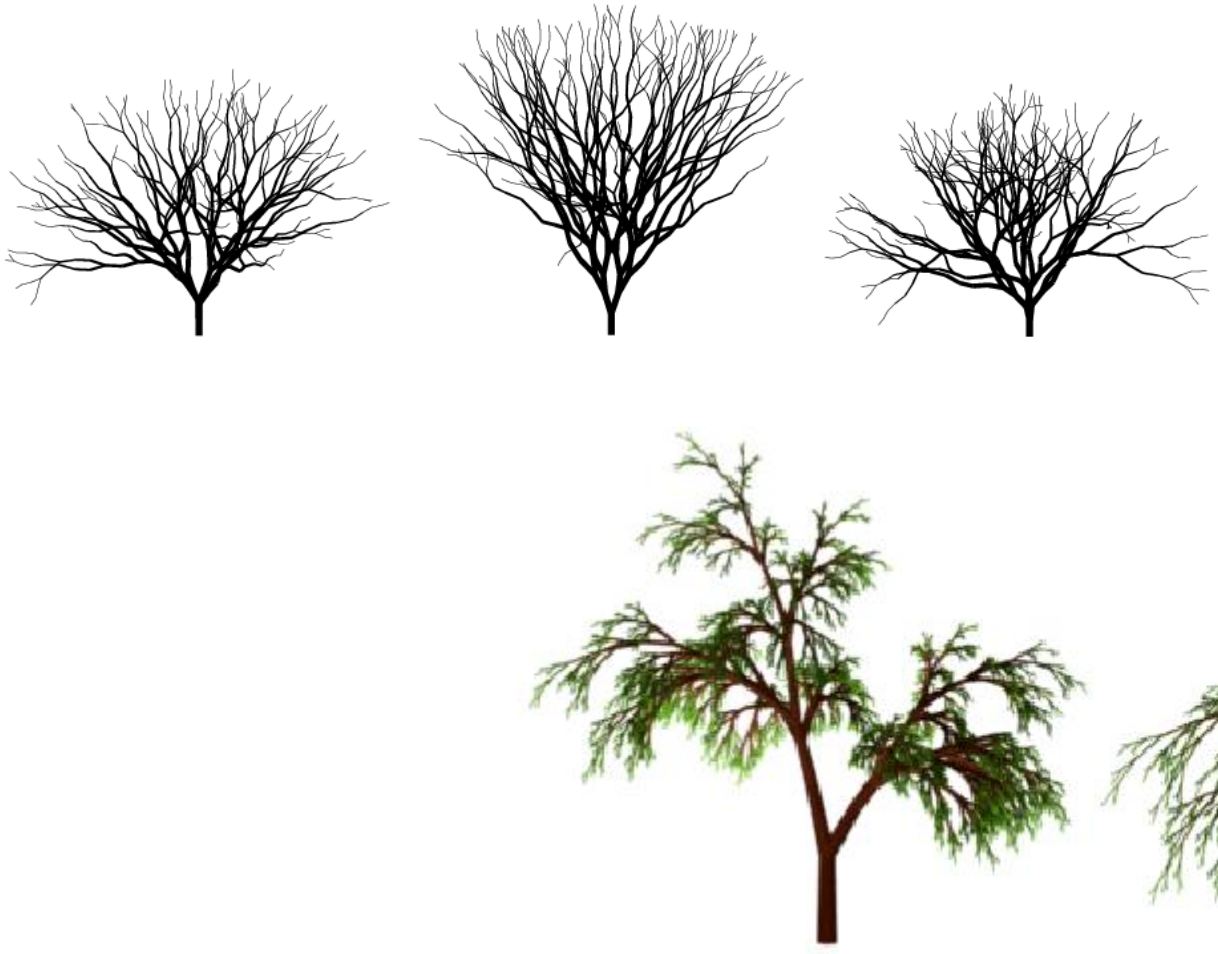




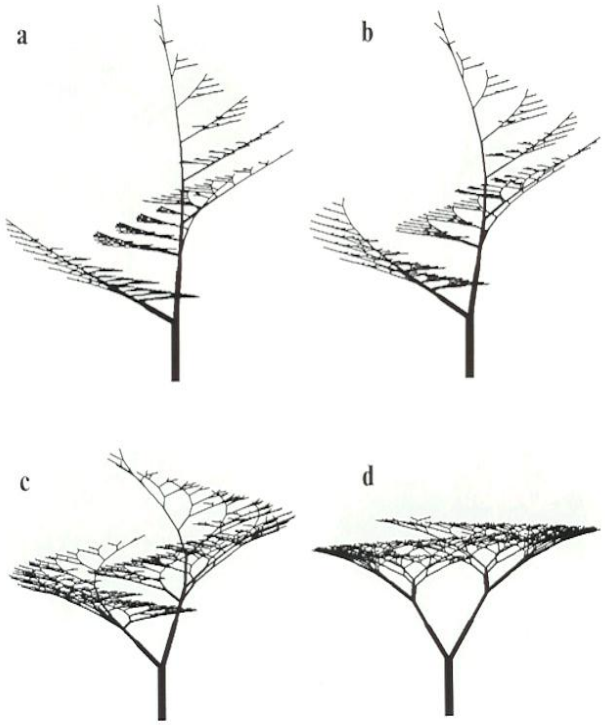
다양한 형태의 나무 모델링



다양한 형태의 나무 모델링



나무 모델링 프로그램

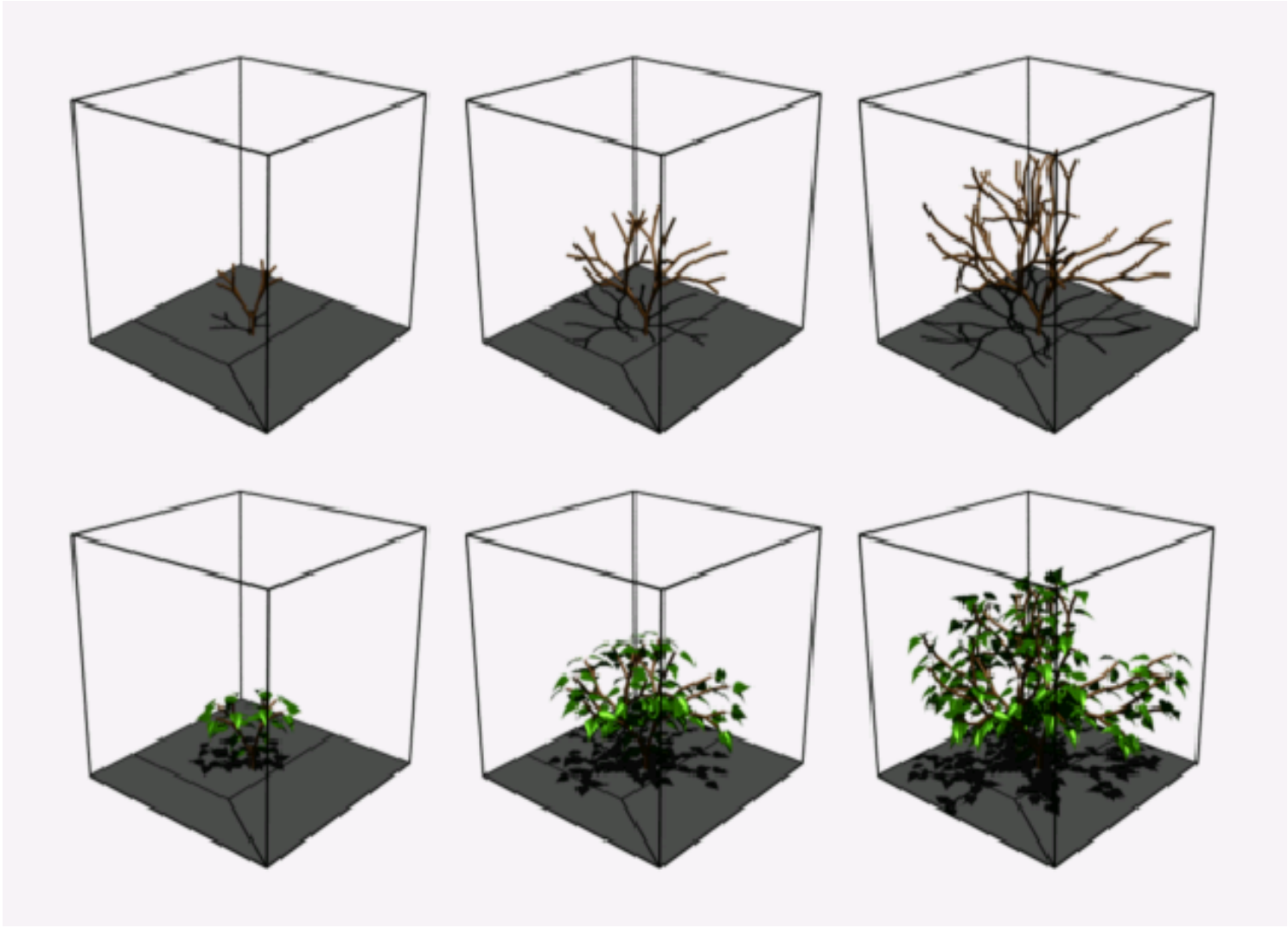



```
n = 10
#define r1 0.9     /* contraction ratio 1 */
#define r2 0.7     /* contraction ratio 2 */
#define a1 10      /* branching angle 1 */
#define a2 60      /* branching angle 2 */
#define wr 0.707   /* width decrease rate */

ω  :  A(1,10)
p1 :  A(l,w) : * → !(w)F(l)[&(a1)B(l*r1,w*wr)]
                  /(180)[&(a2)B(l*r2,w*wr)]
p2 :  B(l,w) : * → !(w)F(l)[+(a1)$B(l*r1,w*wr)]
                  [-(a2)$B(l*r2,w*wr)]
```

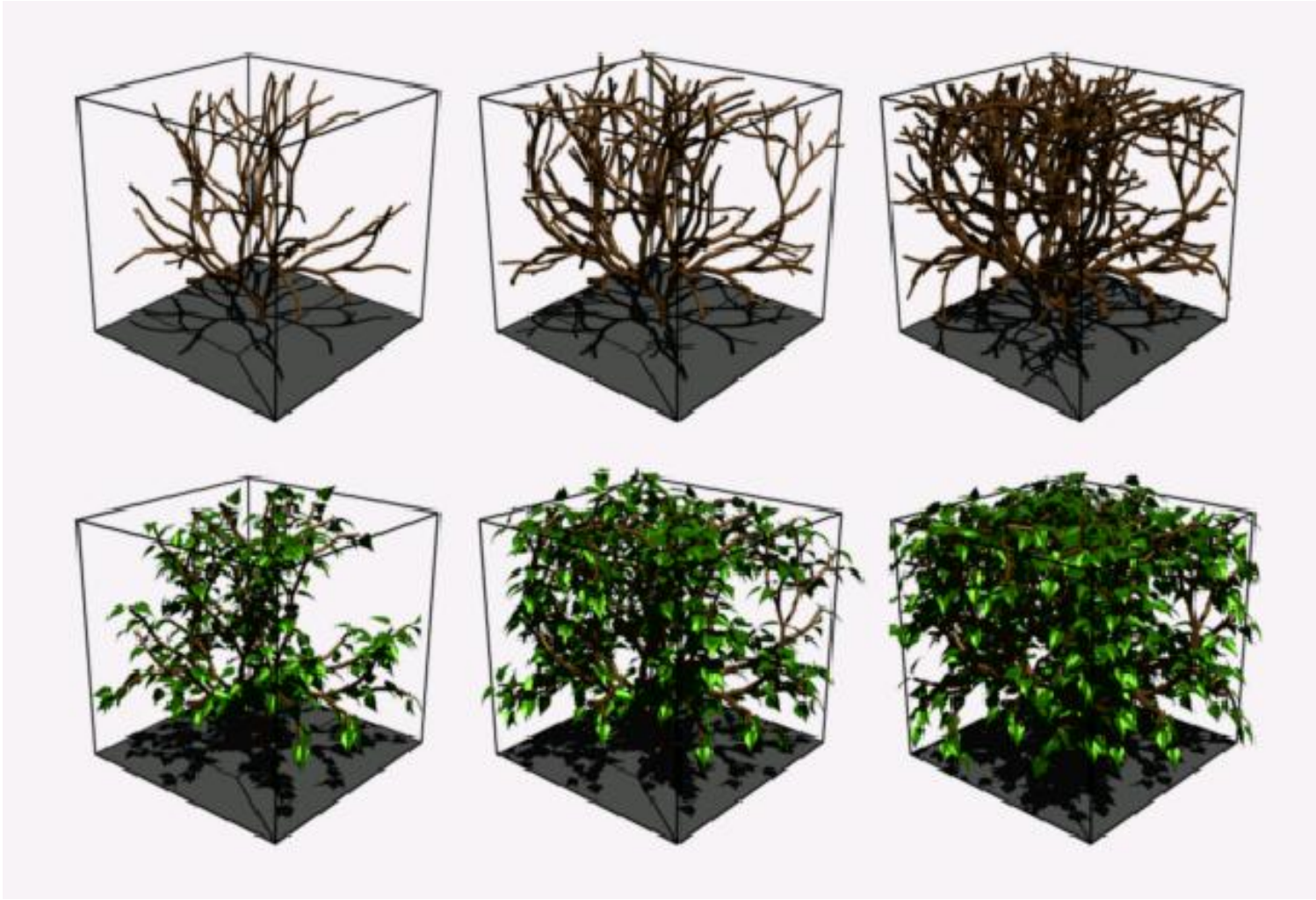
식물 모델링 프로그램

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

ω  :  A(0)
p1 :  A(n) :  * → +(137.5)[f(n^0.5)C(n)]A(n+1)
p2 :  C(n) :  n <= 440                  → ~S
p3 :  C(n) :  440 < n & n <= 565        → ~R
p4 :  C(n) :  565 < n & n <= 580        → ~M
p5 :  C(n) :  580 < n & n <= 595        → ~N
p6 :  C(n) :  595 < n & n <= 610        → ~O
p7 :  C(n) :  610 < n                   → ~P
```

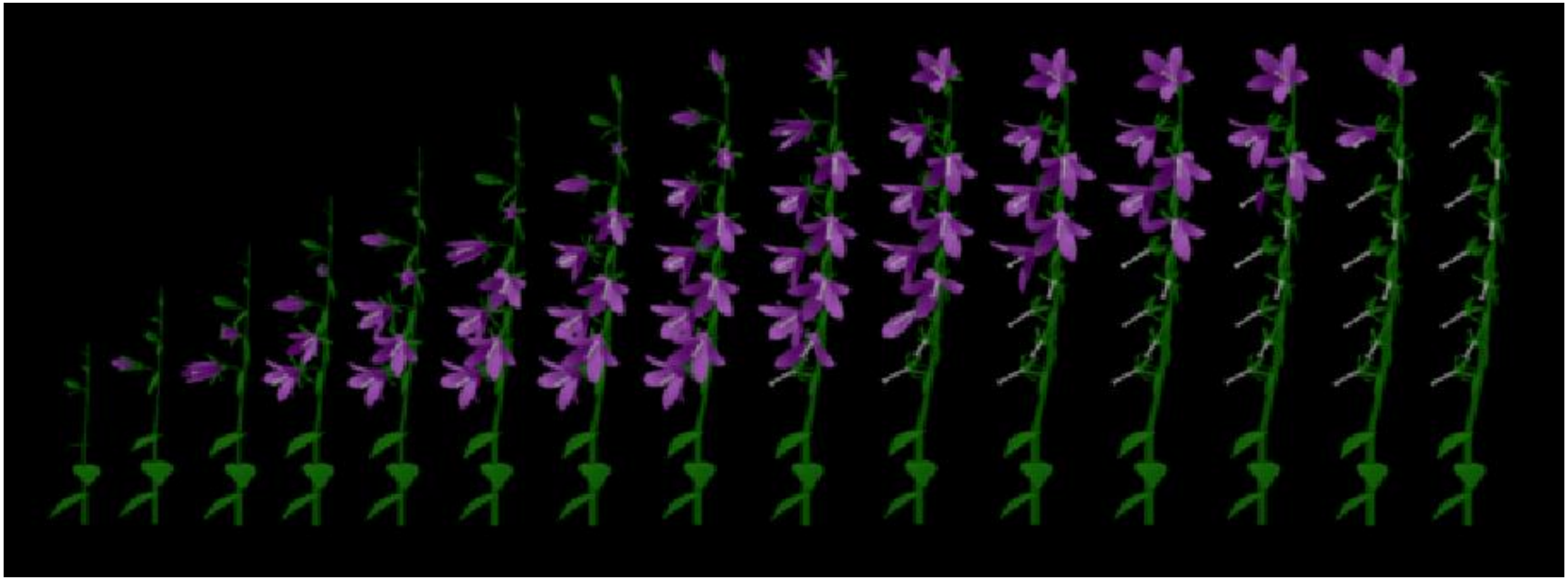
식물성장 모델링



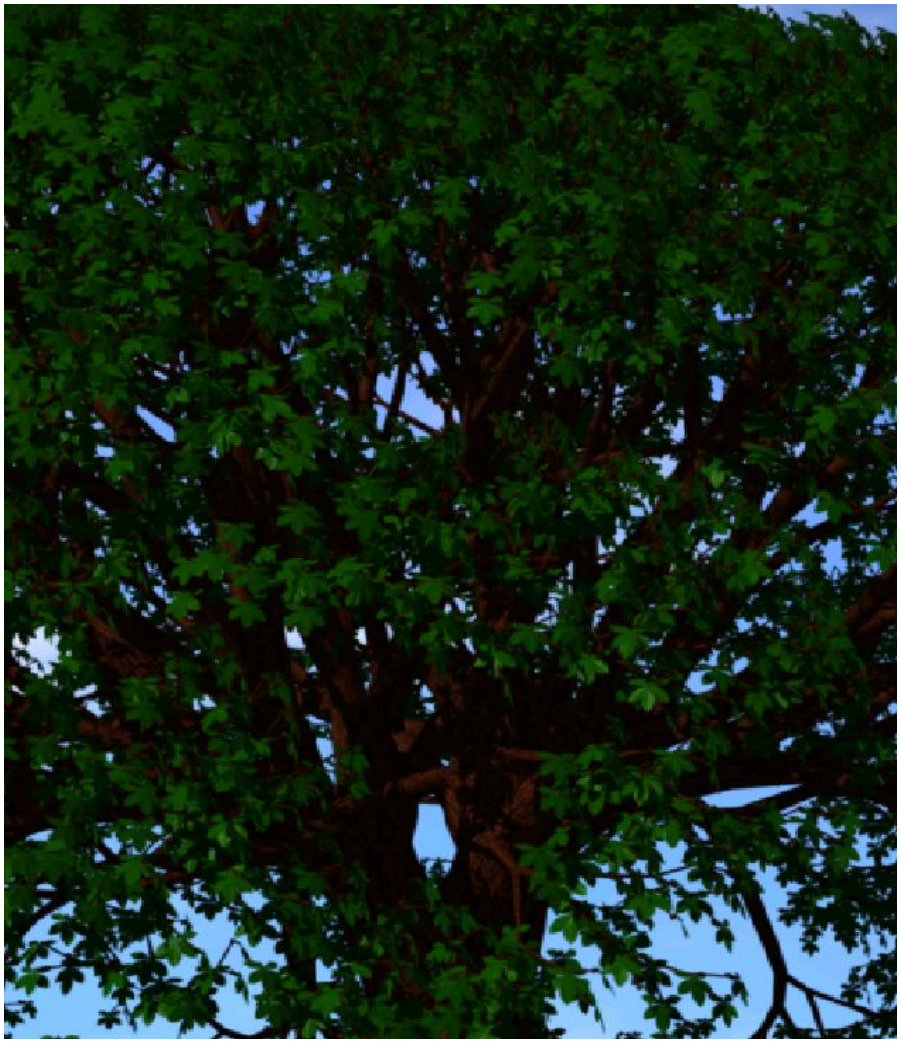
식물성장 모델링



식물성장 모델링



나무 모델링 및 렌더링



식물체 모델링 및 렌더링