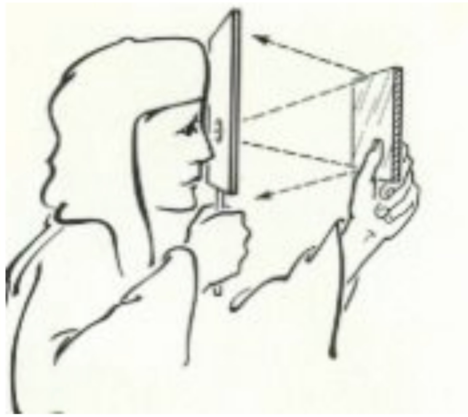
Département Informatique, CNAM
RSX206 - Conception d'applications Multimédia 2
2007

Images de synthèse avancée

P. Cubaud, A. Topol

6 séances :

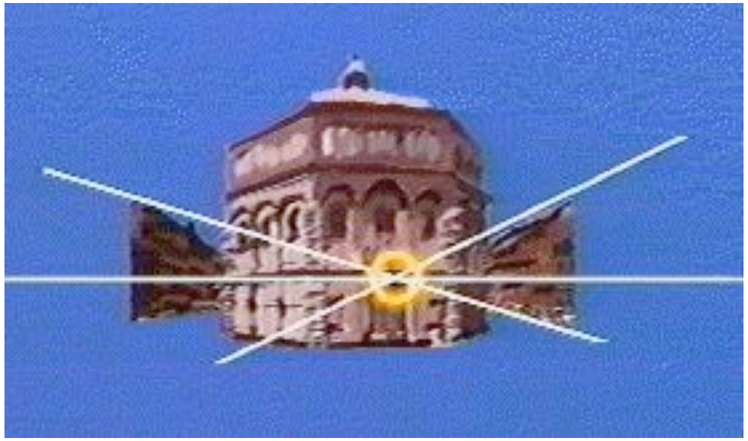
1. Généralités introductives
2. Animatique
3. Animatique encore
4. API 3D
5. API 3D encore
6. Humanoïdes

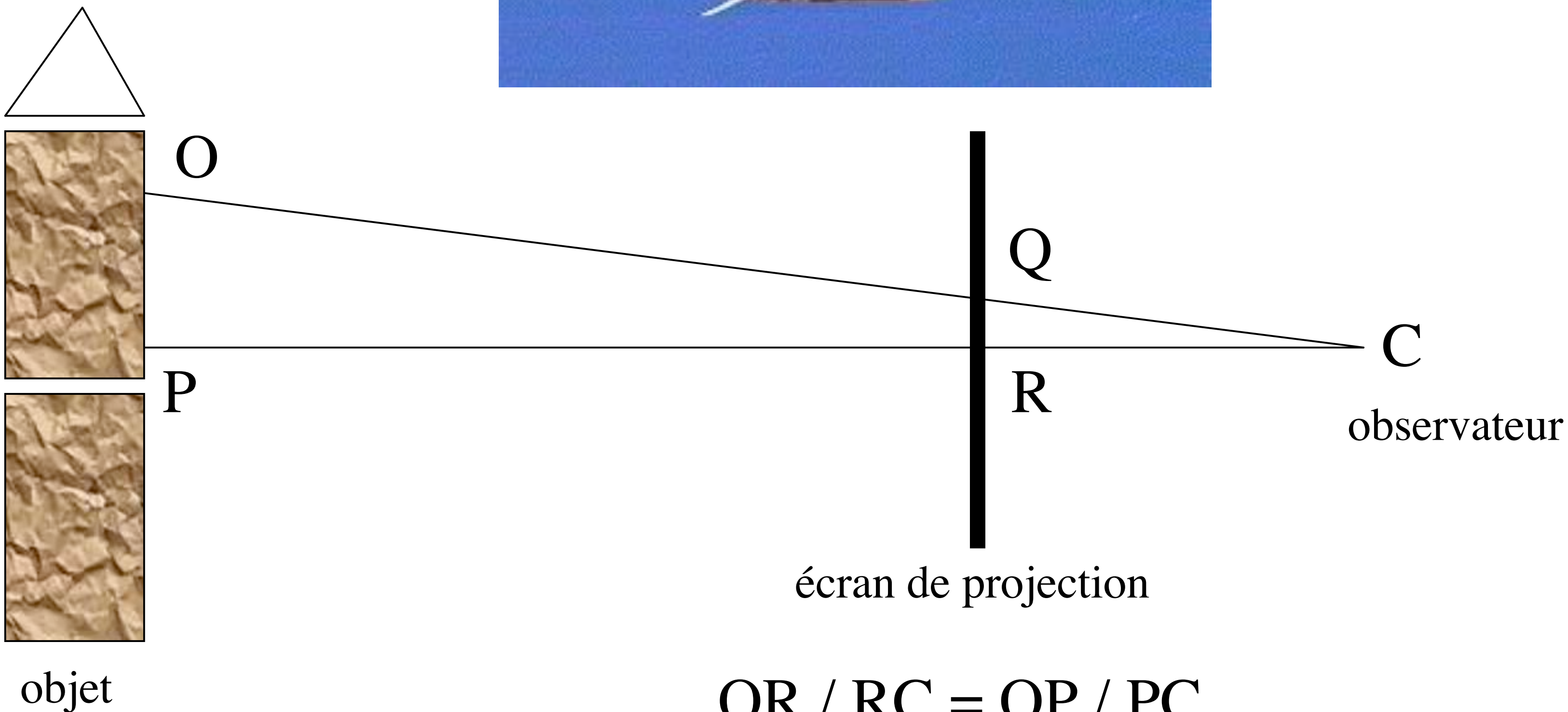


http://www.kap.pdx.edu/trow/winter01/perspective/

ca 1415 - Filippo BRUNELLESCHI - L’image calculée

Calcul de la position sur le dessin

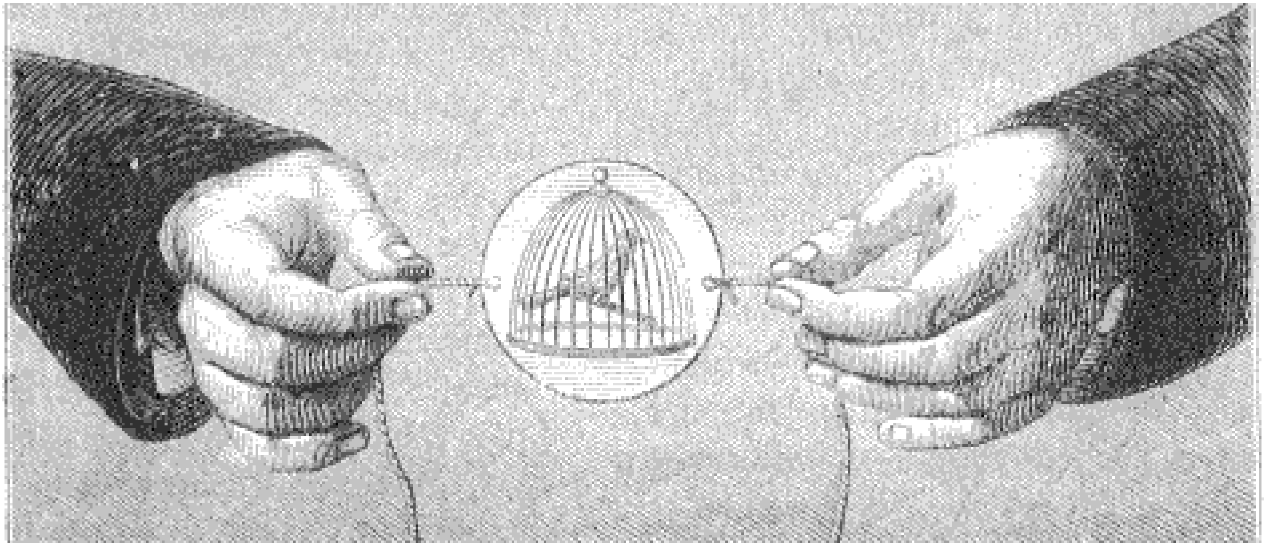




$$QR / RC = OP / PC$$

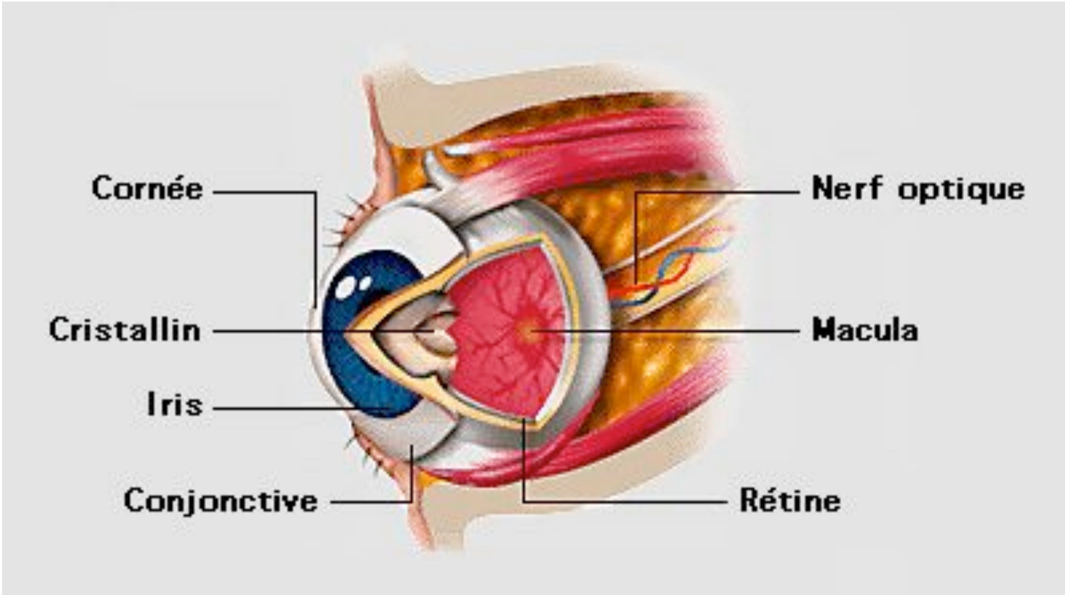
ca 1450 - Piero della Francesca - flagellation du Christ

Fig. 1. Disque du thaumatrope vu en dessus (*a*) et en dessous (*b*).

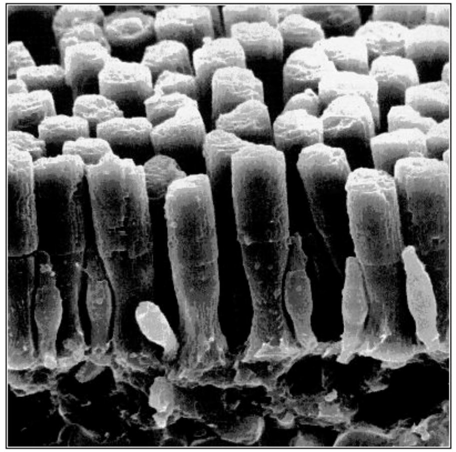


revue *La Nature* http://cnum.cnam.fr

1829 - Joseph PLATEAU (Belgique) - Thaumatrope



http://telesun.insa-lyon.fr/~telesun/Humain/L01/titre.html

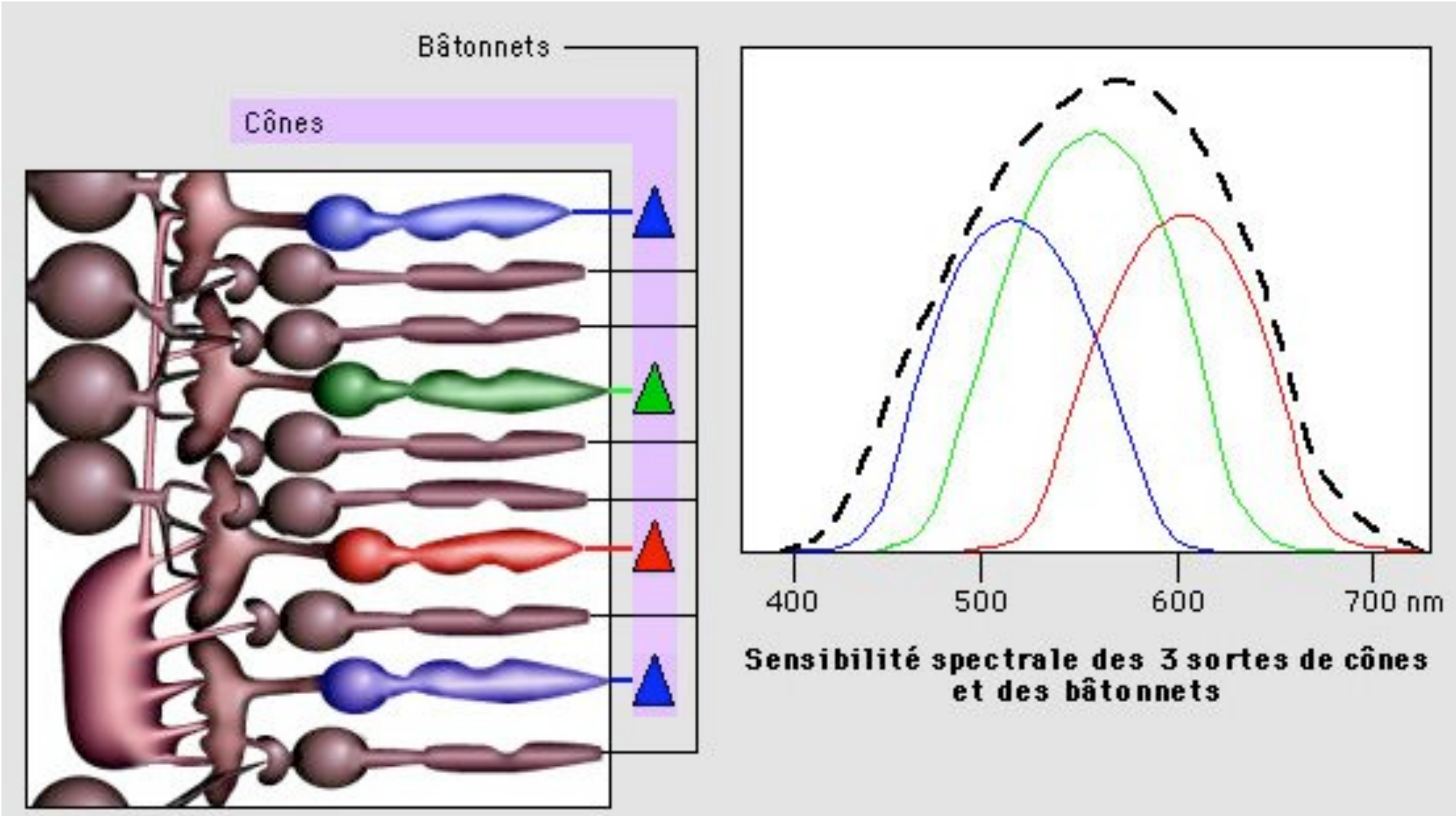


http://lajoie.uqam.ca/percept/bloc1/bloc1-2/microsc-con&bat.html

8 M cônes (jour + couleur) 100 M batonnets (nuit)

Acuité : 1’ = 1/60° minimum
Sur 180 ° : 180*60 = 10800 objets (très optimiste)
Rapport d’observation VR = distance / hauteur image
Nb max de pix visibles = 3440/VR

Perception des couleurs



http://telesun.insa-lyon.fr/~telesun/Humain/L01/titre.html

• Perception du mouvement :

dans les centres corticaux (mouvement phi)
2 images quasi identiques apparaissent en 2 points voisins
de la rétine à dt = 0.1s donnent l'impression d'un mouvement continu

• Persistence rétinienne :

Quand on fixe un objet très lumineux (soleil), on continue de
le « voir » pendant quelques minutes

En luminosité normale : 1/16 s. environ
c'est la fréquence critique de fusion

1839 - DAGUERRE - Le Daguerréotype

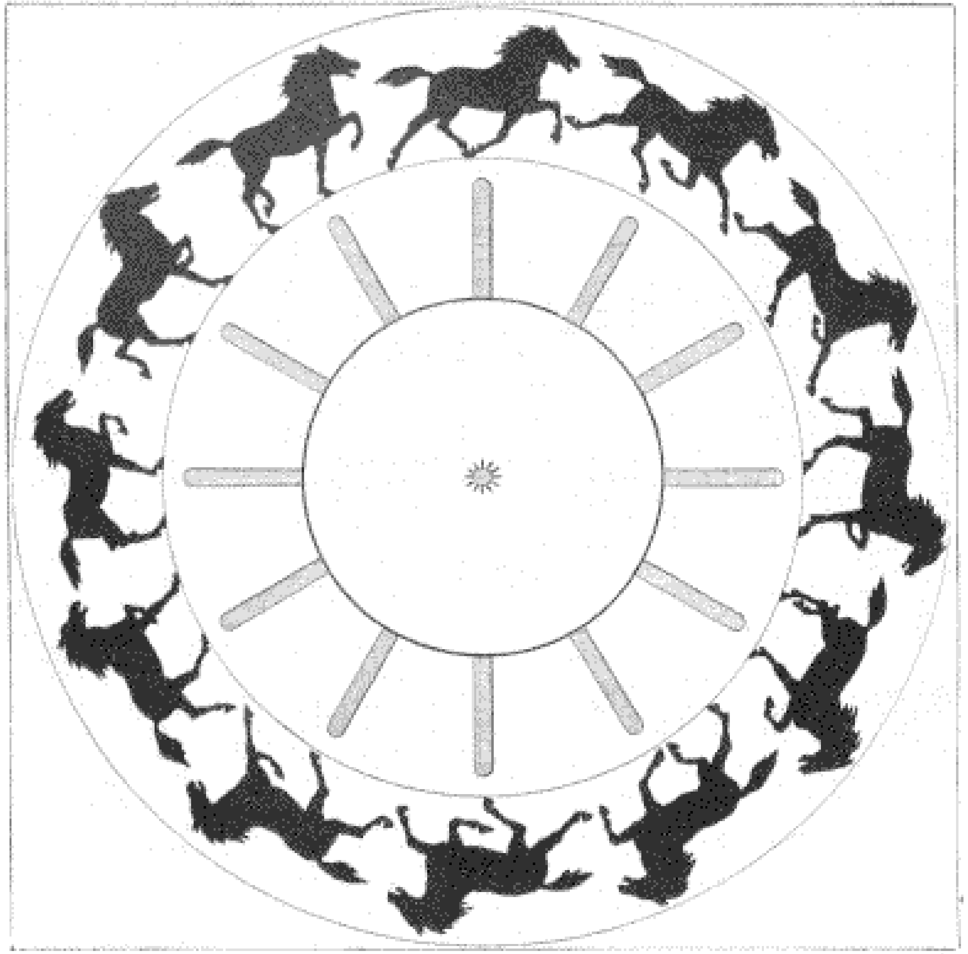


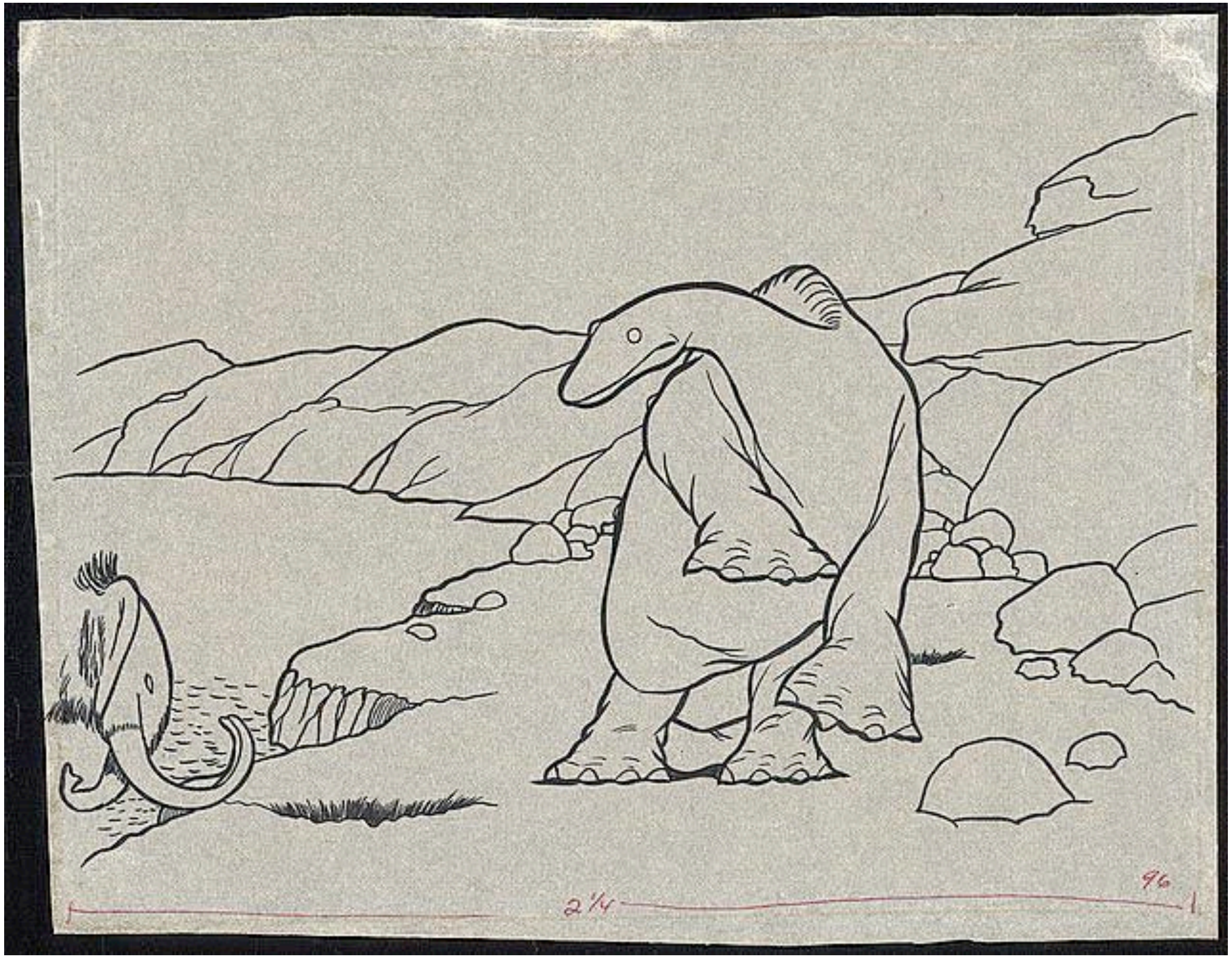
Fig. 1. Disque zootropique d'un cheval au trot. (D'après les photographies instantanées de M. Muybridge.)

revue *La Nature* http://cnum.cnam.fr

E. MUYBRIDGE - Zoopraxinoscope

1895 - Auguste et Louis LUMIERE (Lyon)- Le cinématographe

1902 - George MELIES (Montreuil) - Voyage dans la lune

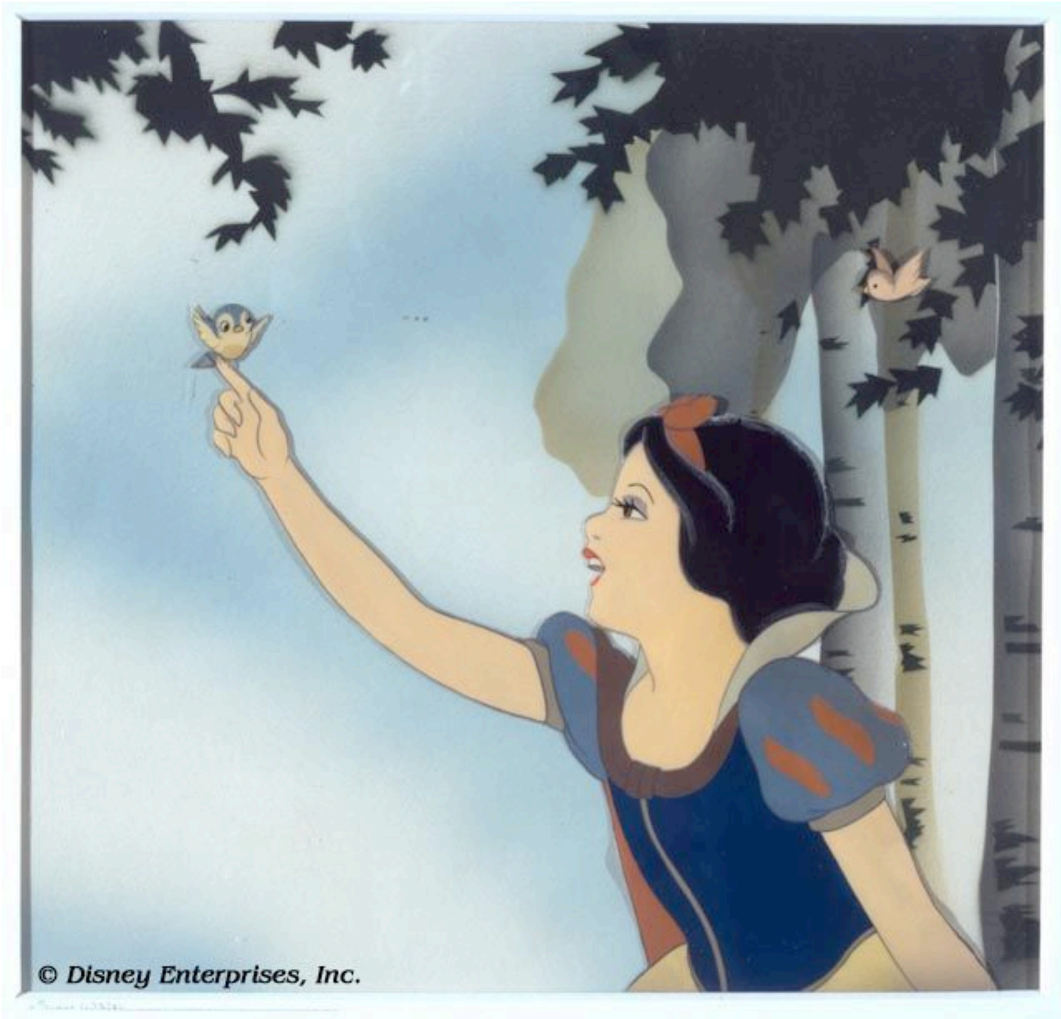


http://www.loc.gov/rr/print/swann/artwood/aw-animation.html

ca 1910 - Windsor McCAY - Gertie the dinosaur

http://frames.free.fr/cello.htm

1915 - Earl HURD - Les calques en celluloïde (« cellulos », « cel »)



1937 - Walt DISNEY - Snow White

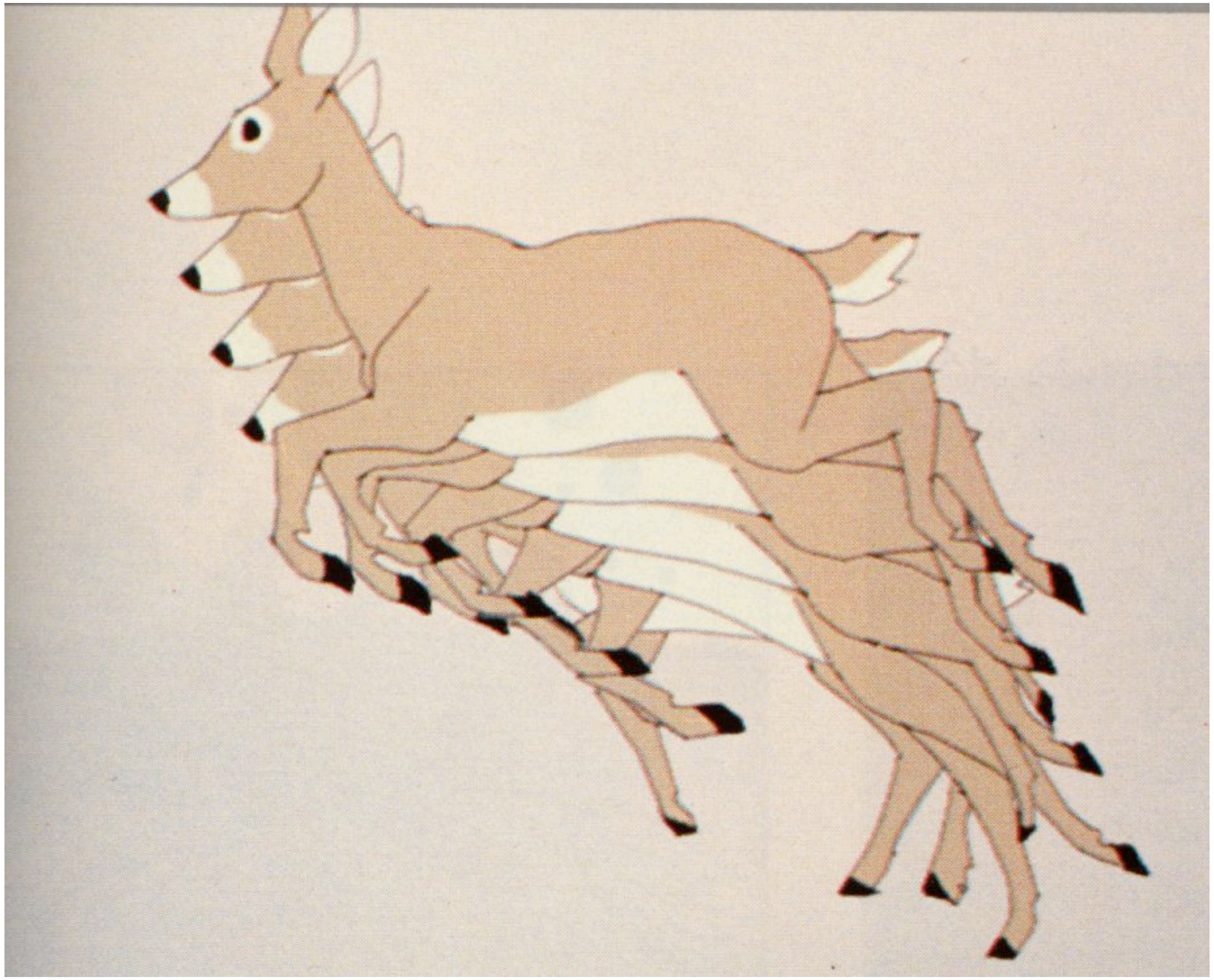
Multiplane camera

(musée du Walt Disney studio, Burbank)

Effets de caméra et transitions

Pan	A pan (contraction of panorama) is an effect in which the camera is moved horizontally from one point to another.
Tilt	A tilt is an effect in which the camera is moved vertically from one point to another.
Zoom	A zoom is an effect which makes a subject appear larger of smaller. In a two-dimensional cartoon, the effect can be obtained by moving the camera closer to or further away from the subject. This technique of moving the camera is quite impossible in three dimensions, because of the perspective effect; however, excellent zoom lenses can be used in the camera to get the three dimensional effect. A zoom can be continuous.
Spin	A spin is an effect produced by rotating the camera.
Fade-in	A fade-in is an effect used at the beginning of a scene: The scene gradually appears from black.
Fade-out	A fade-out is an effect used at the end of a scene: The scene gradually darkens to black.
Cross-dissolve	A cross-dissolve is an effect that is very often used for the transition between scenes. It corresponds to a fade-out of one scene and a fade-in of the next scene over the same length of film.

Wipe : one scene appears to slide over the preceding scene (different possible forms)



Les images-clé « keyframes »

Le découpage plan-séquence

PRODUCTION

SEQUENCE 1 SEQUENCE 2 SEQUENCE 3

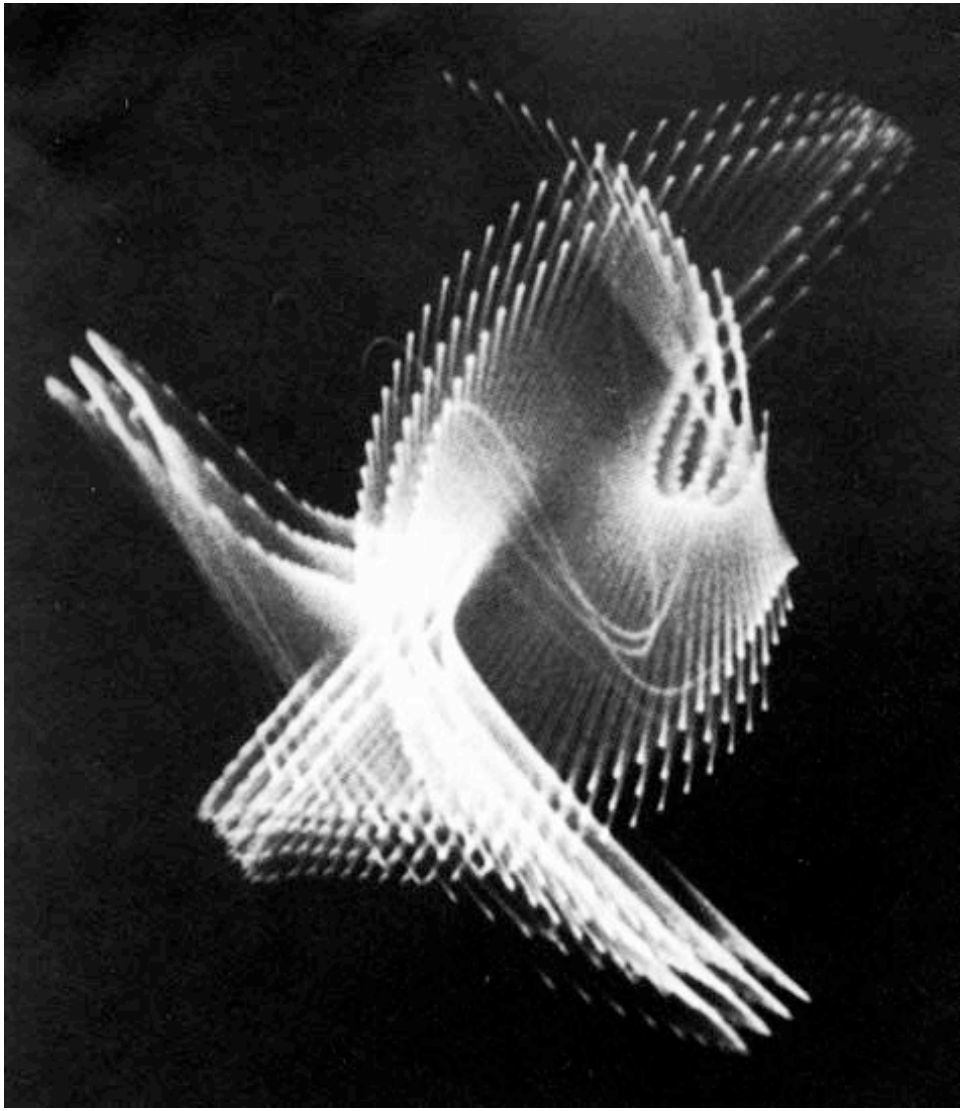
séquence = « scene » = un épisode, un décor

plan 1 2 3 plan 1 2 plan 1 2 3 4

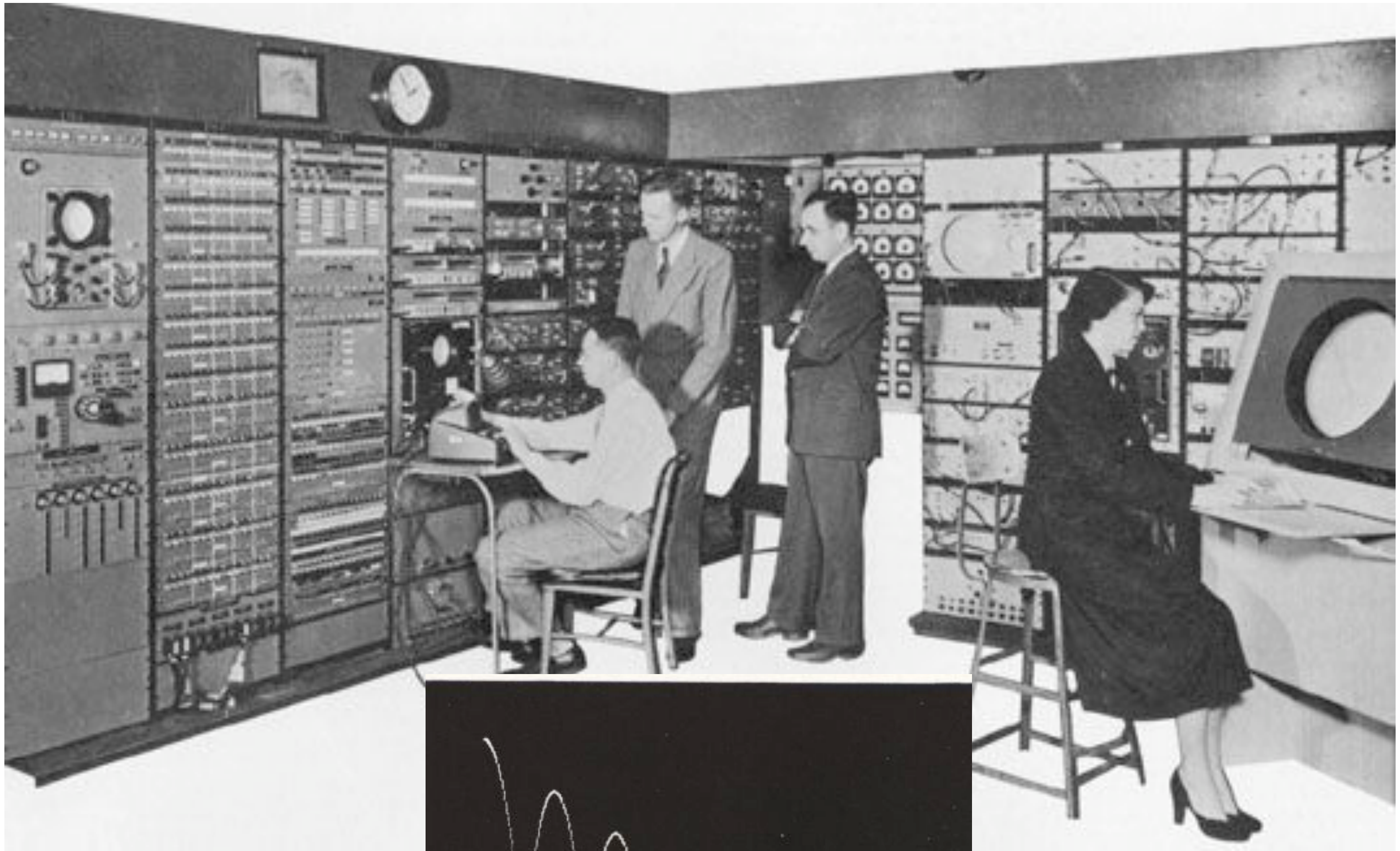
plan = « shot» = un enregistrement en continu

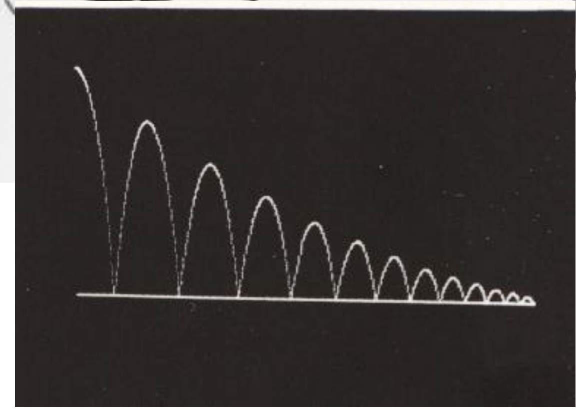
---------------------- N images ------------------------

1946 - RCA - Modèle 630TS (écran de 10 pouces)

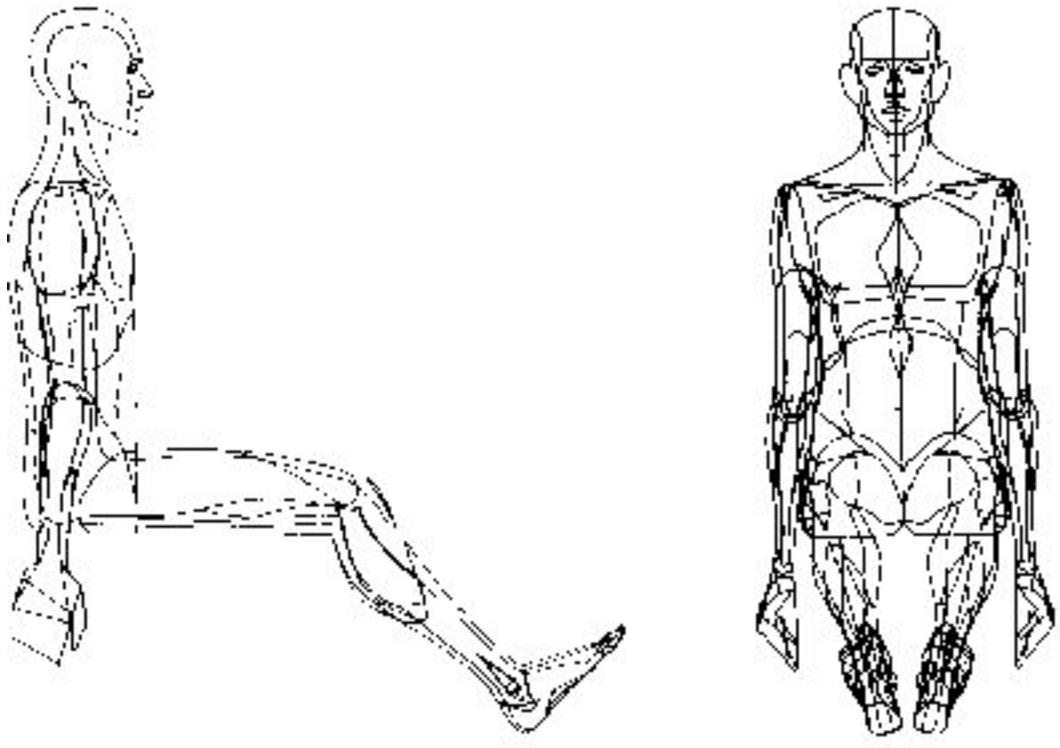


1950 - Ben Laposky

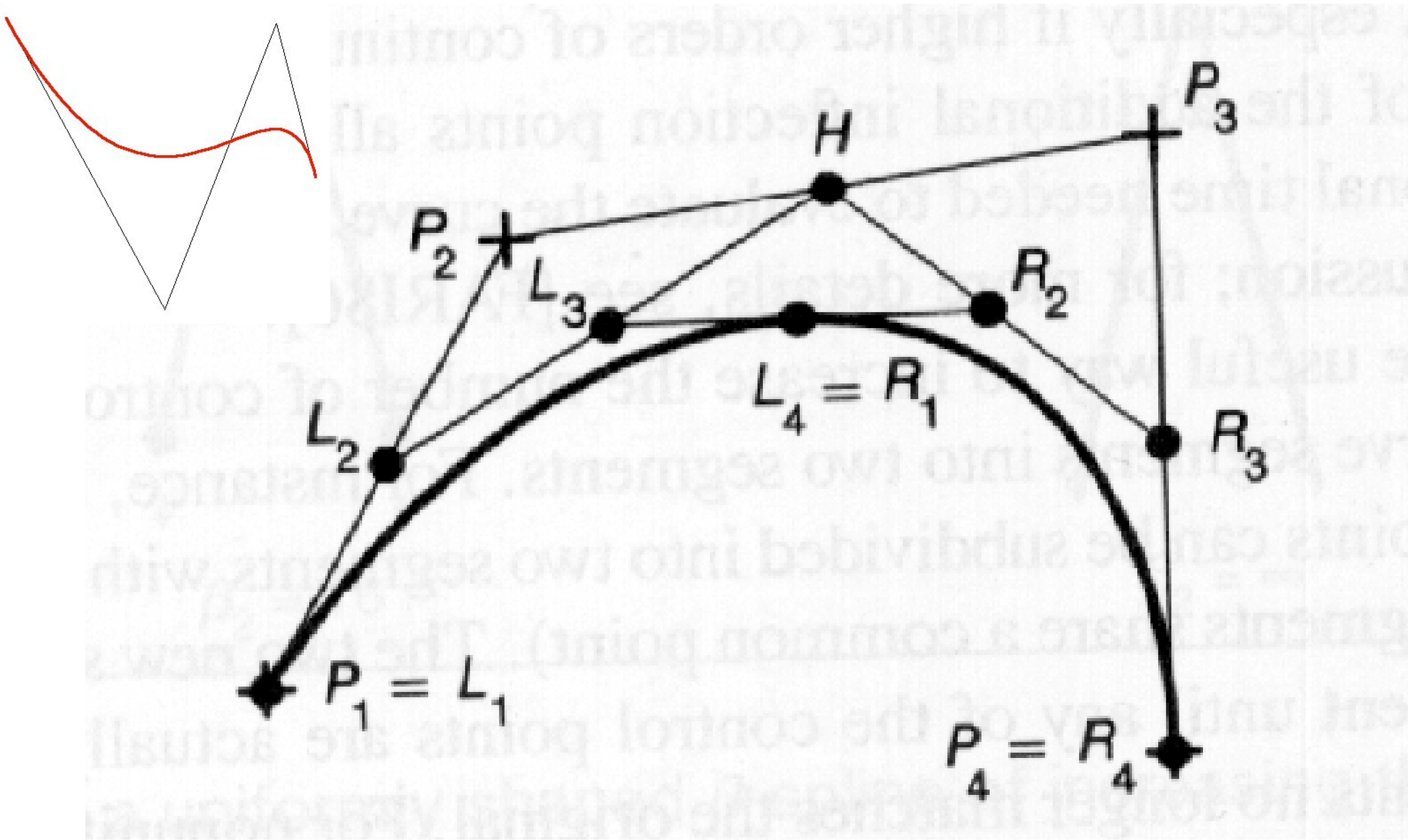




1949-51 - Projet WHIRLWIND

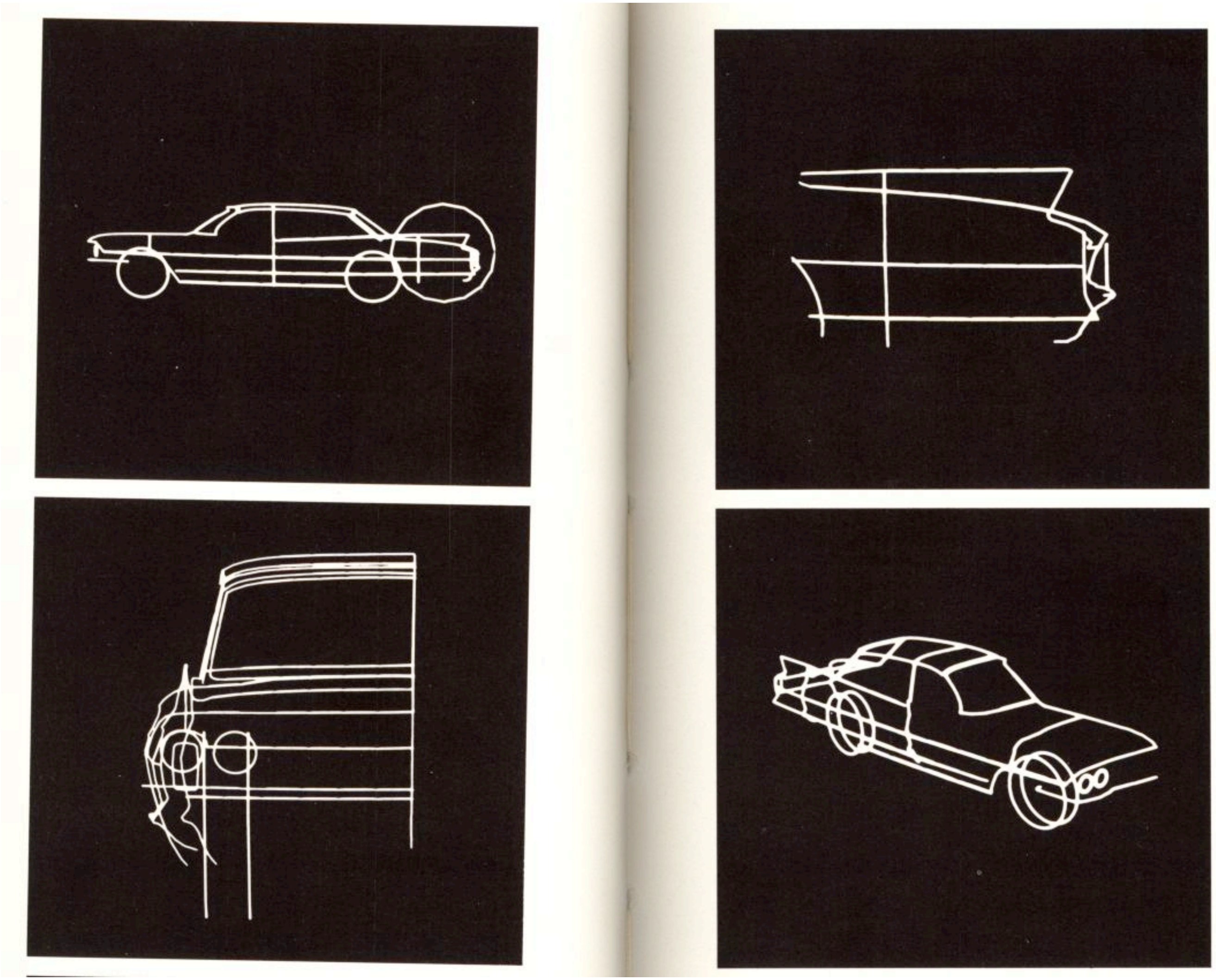


1960 - William FETTER (Boeing) : « computer graphics »



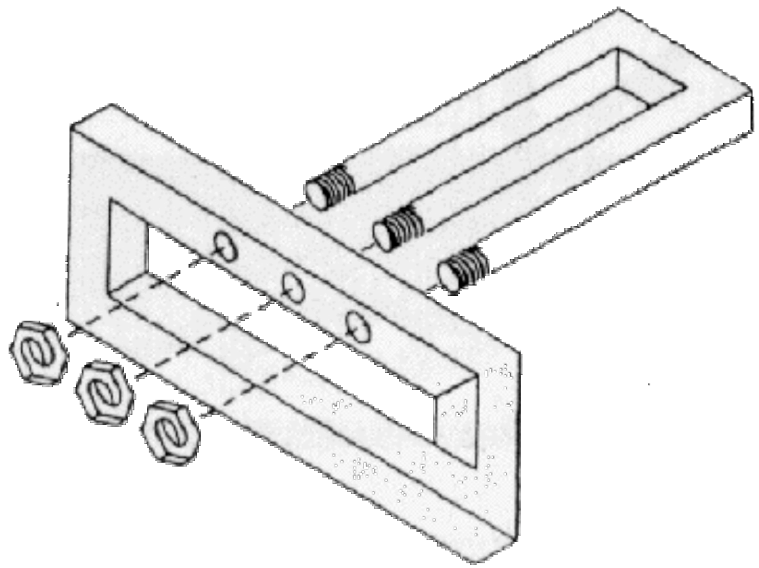
60’s - Courbes et surfaces paramétrées
de Casteljau - Bézier - Fergusson- Coons

1961 - Yvan SUTHERLAND (MIT) - Sketchpad sur TX2
en 1h, un pavage de 900 hexagones = 2j dessin prof.



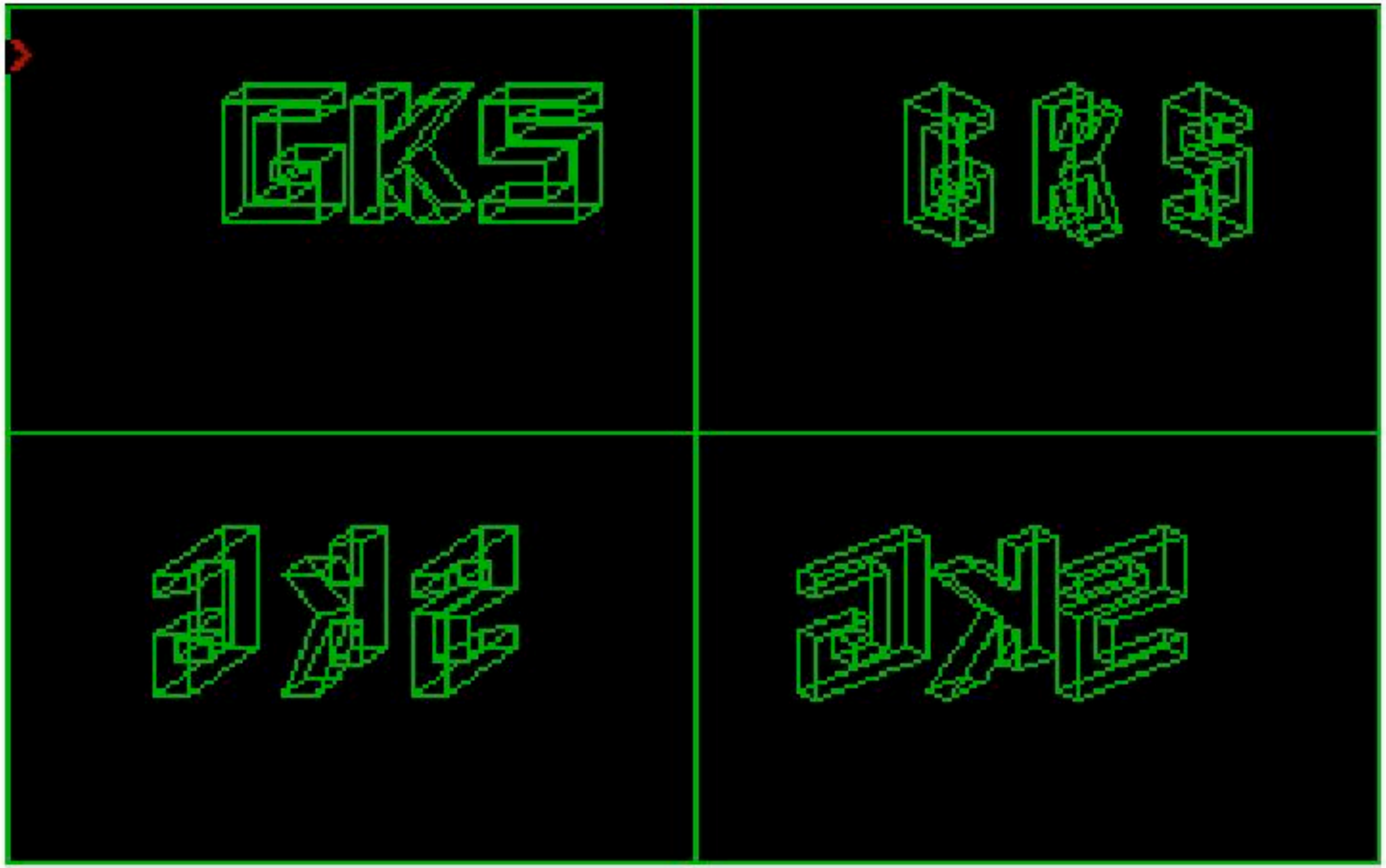
1964 - General Motors - DAC-1
design augmented by computer

Les objets sont décrits par les frontières de leurs faces (supposées définies…)



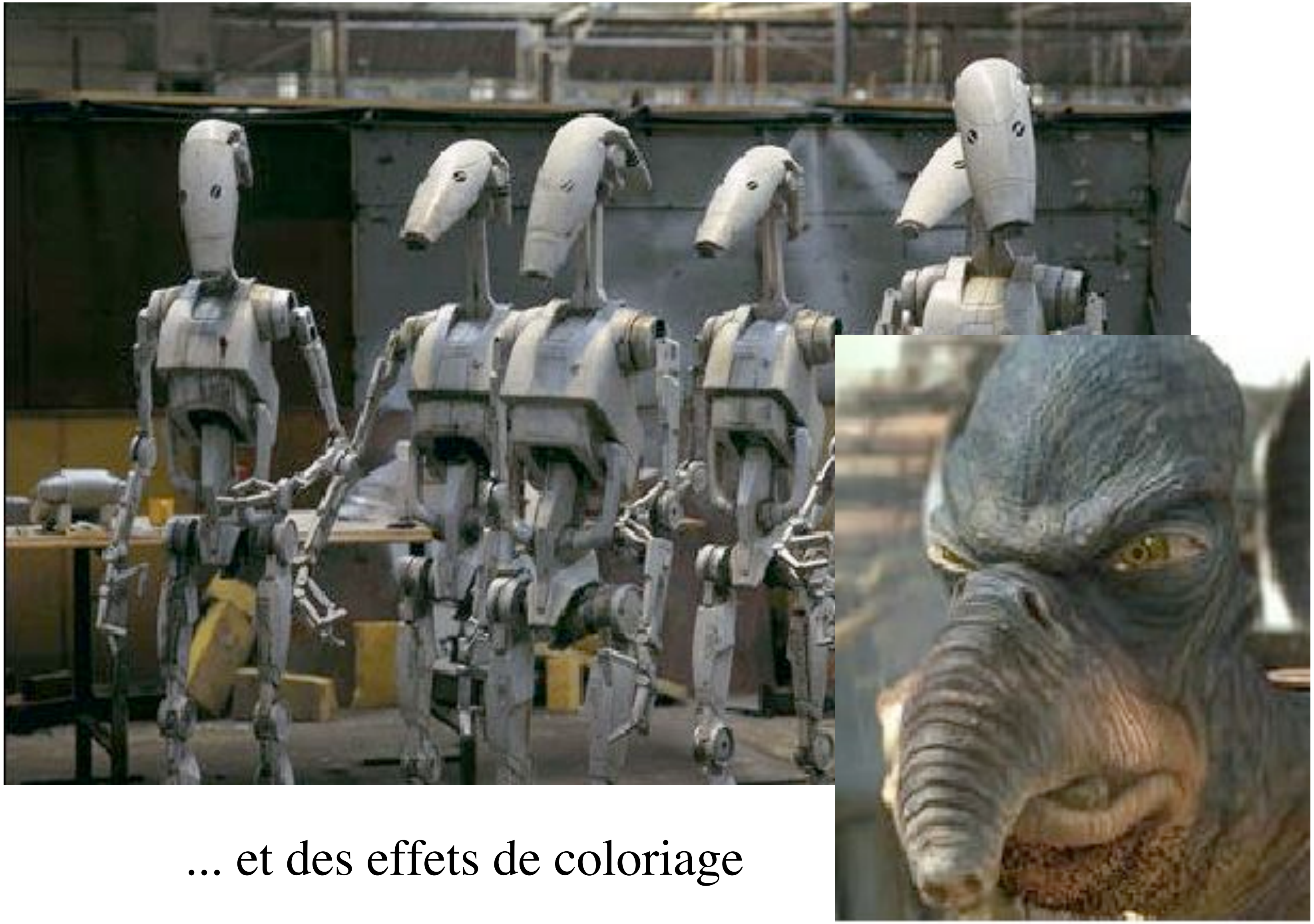
"Objet Impossible", in Skywriter 1966

très peu de polyèdres...



P. Cubaud, GrafPak, 1985 (IBM PC XT, carte graphique CGA)

Beaucoup de polyèdres...



... et des effets de coloriage

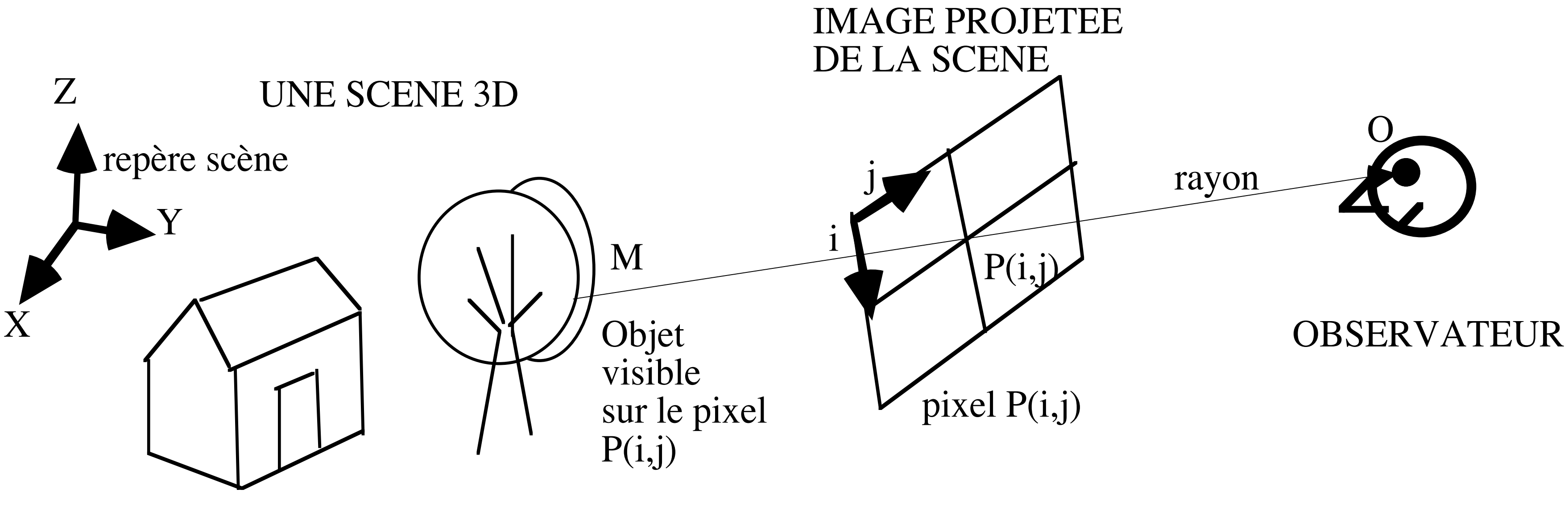
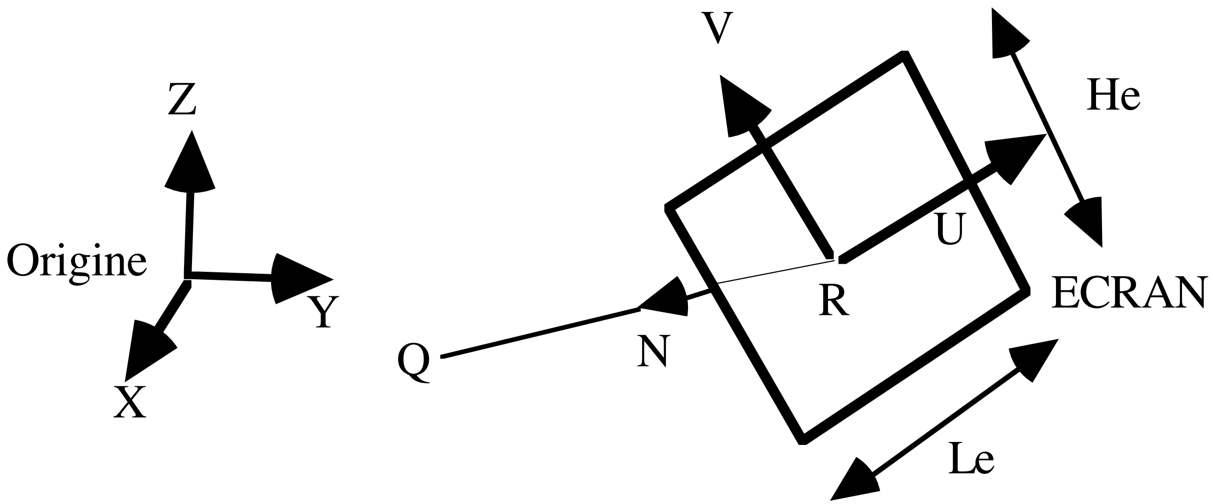


IMAGE PROJETEE
DE LA SCENE
Z
UNE SCENE 3D
repère scène
Y
X
M
Objet
visible
sur le pixel
P(i,j)
j
i
P(i,j)
pixel P(i,j)
rayon
O
OBSERVATEUR


V
He
Z
U
Origine
R
ECRAN
Y
Q
N
X
Le

Un petit programme de tracé :

```
#include <stdio.h>
#include <math.h>

/* structure pour decrire la scene */
#define MAXFACES 500
double OB[MAXFACES][3][3];
double O2[MAXFACES][3][2];
int NB;/* nombre reel de facettes  */


/* position de l'observateur et distance de l'ecran
*/
#define R 10
#define theta 45
#define phi 30
#define D 5

/* zone de dessin en coord. ecran */
#define xa 3
#define ya 7.35
#define xb 18
#define yb 22.25

/* variables diverses */
int i,j;
double
sthe,cthe,sphi,cphi,x,y,z,xx,yy,zz,minx,maxx,miny,max
y;
double px,py,pz,qx,qy,qz,nn,xo,yo,zo;

main()
{
 /*--- coord. cart. de l'observateur ---*/
 sthe=sin(theta*3.1416/180);
 cthe=cos(theta*3.1416/180);
 sphi=sin(phi*3.1416/180);
 cphi=cos(phi*3.1416/180);
 xo= R*cthe*cphi;
 yo= R*sthe*cphi;
 zo= R*sphi;

 /*--- lecture des coordonnees ---*/
 NB=0;i=0;
 while (scanf("%lg %lg %lg\n",
     &OB[NB][i][0],&OB[NB][i][1],&OB[NB][i][2])!=EOF)
 {
  i++;
  if (i==3) {i=0;NB++;}
 }


 /****** CODE A INSERER ICI POUR LA SUITE ********/

 /*--- proj. perspective (cf cours chap 6) ---*/
 for (i=0;i<NB;i++)
 {
  for (j=0;j<3;j++)
  {
   x=OB[i][j][0];y=OB[i][j][1];z=OB[i][j][2];
   xx= -x*sthe+y*cthe;
   yy= -x*cthe*sphi-y*sthe*sphi+z*cthe;
   zz= -x*cthe*cphi-y*sthe*cphi-z*sphi+R;
   O2[i][j][0]= D*xx/zz;
   O2[i][j][1]= D*yy/zz;
  }
 }

 /*--- pour eviter le clipping :
       calcul de la fenetre maximale ---*/
 minx=O2[0][0][0];maxx=minx;
```

```c
 miny=O2[0][0][1];maxy=miny;
 for (i=0;i<NB;i++)
 {
  for (j=0;j<3;j++)
  {
   if (O2[i][j][0]<minx) {minx=O2[i][j][0];}
   if (O2[i][j][0]>maxx) {maxx=O2[i][j][0];}
   if (O2[i][j][1]<miny) {miny=O2[i][j][1];}
   if (O2[i][j][1]>maxy) {maxy=O2[i][j][1];}
  }
 }

 /*--- calcul des coordonnees ecran */
 for (i=0;i<NB;i++)
 {
  for (j=0;j<3;j++)
  {
   O2[i][j][0]=xa + (xb-xa)*(O2[i][j][0]-minx)/(maxx-
minx);
   O2[i][j][1]=ya + (yb-ya)*(O2[i][j][1]-miny)/(maxy-
miny);
  }
 }

 /*--- generation des ordres de trace en Postcript */
 printf("newpath\n");
 for (i=0;i<NB;i++)
 {
  printf("%.5f %.5f moveto\n",
         O2[i][0][0],O2[i][0][1]);
  printf("%.5f %.5f lineto\n",
         O2[i][1][0],O2[i][1][1]);
  printf("%.5f %.5f lineto\n",
         O2[i][2][0],O2[i][2][1]);
  printf("%.5f %.5f lineto\n",
         O2[i][0][0],O2[i][0][1]);
 }
 printf("stroke\n");
}
```

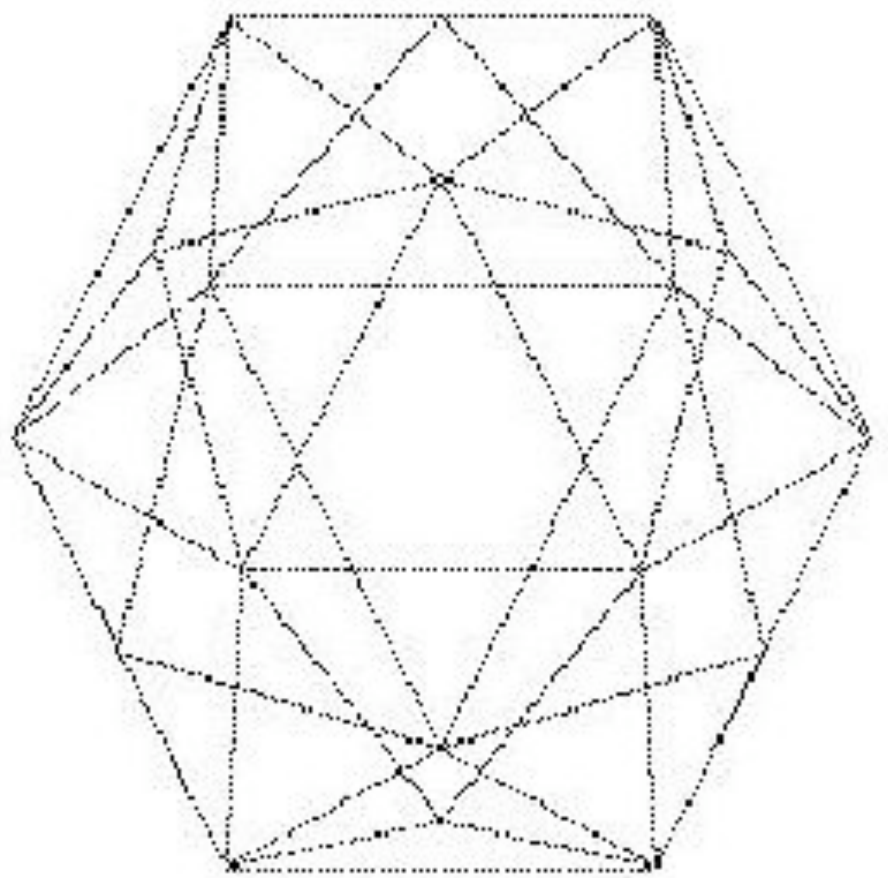
- Données transmises en entrée par sphere.c

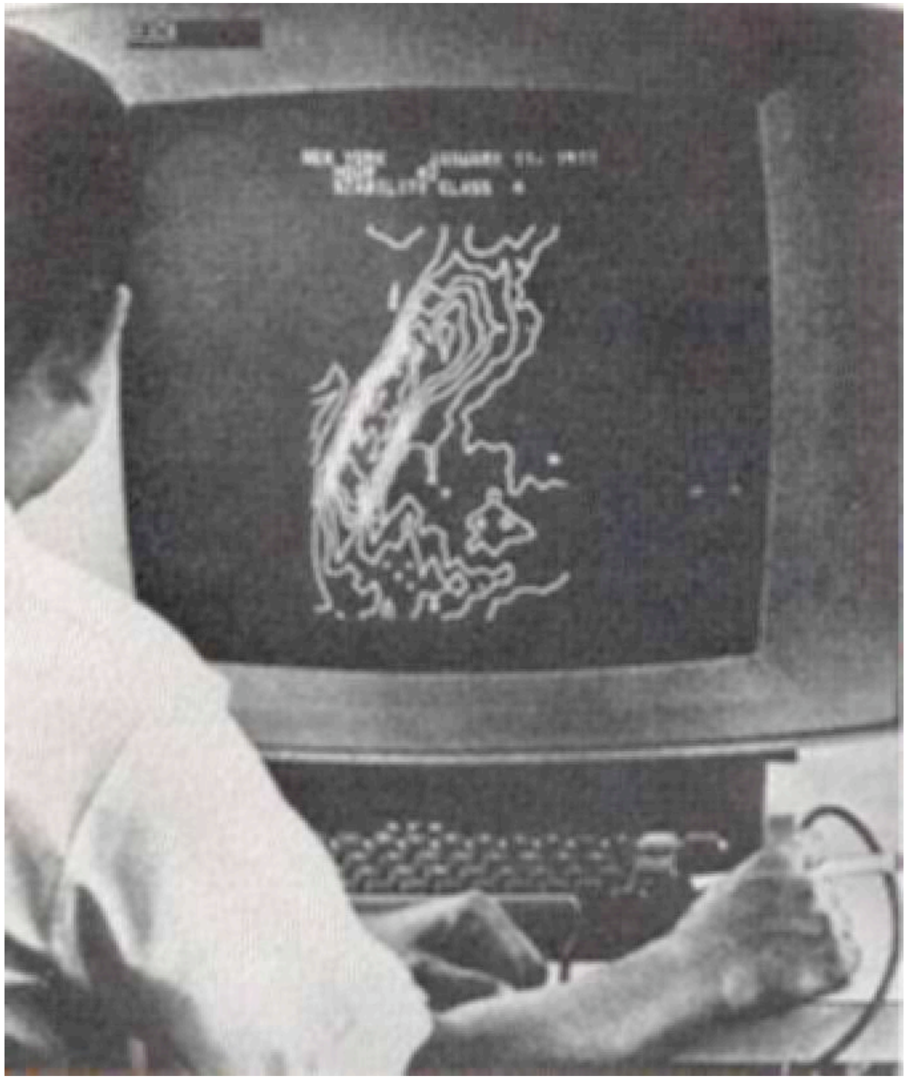
```
1.00000 0.00000 0.00000
0.00000 0.00000 1.00000
0.00000 1.00000 0.00000
0.00000 1.00000 0.00000
0.00000 0.00000 1.00000
-1.00000 0.00000 0.00000
-1.00000 0.00000 0.00000

.... etc ...
```

- Résultats du programme

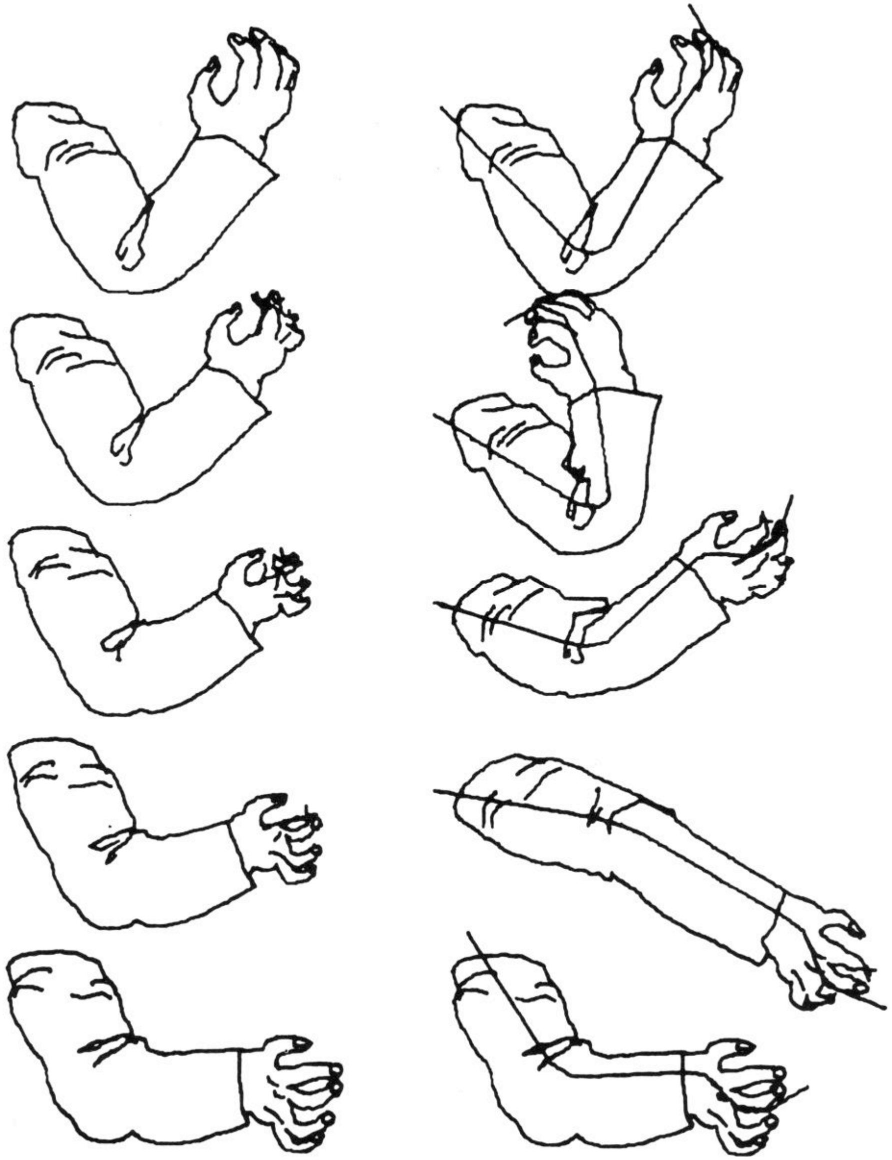
```
/centimetre {72 mul 2.54 div} def
1 centimetre 1 centimetre scale
0.014 setlinewidth
newpath
10.50000 14.80000 moveto
10.50000 22.25000 lineto
18.00000 14.80000 lineto
10.50000 14.80000 lineto
18.00000 14.80000 moveto
10.50000 22.25000 lineto
10.50000 14.80000 lineto
18.00000 14.80000 lineto
.... etc ...
10.50000 7.35000 lineto
10.50000 14.80000 lineto
3.00000 14.80000 moveto
10.50000 14.80000 lineto
10.50000 7.35000 lineto
3.00000 14.80000 lineto
stroke
```

Observateur en $R = 10$, $D = 5$, $\theta = 45°$, $\phi = 30°$





1965 - IBM - terminal 2250 1024x1024 pix 125 K$
en 1972 : terminal Tektronix : 4K$



1971 - BURTNYK & WEIN (Canada)

Années 70 - université d'UTAH

December 1969:
Ivan Sutherland(left) and Dave Evans(right) with LDS1.

http://www.cs.utah.edu/dept/history/

John WARNOCK (PhD 69) Adobe

Ed CATMULL (74) PIXAR ANIMATION STUDIOS

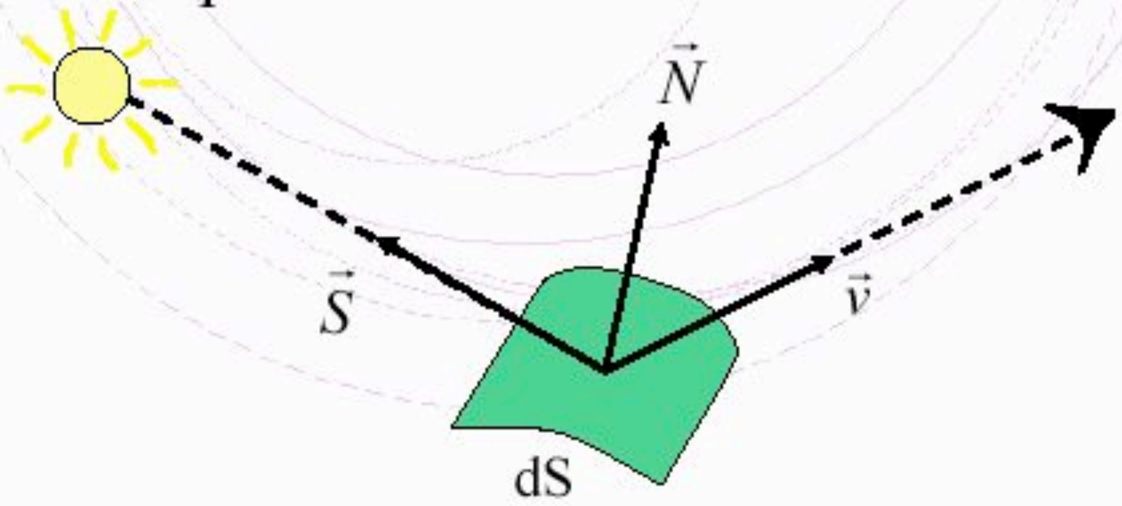
Jim CLARCK (74) SiliconGraphics

Gouraud, Henri. Continuous Shading of Curved Surfaces. IEEE Transactions on Computers C-20(6), June 1971, p. 623-29.

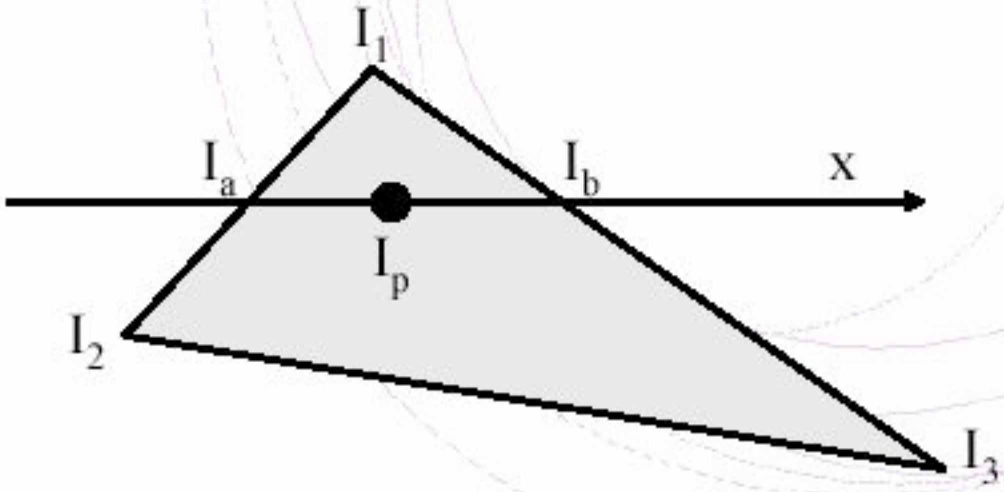
Henri GOURAUD (71) Bui TUONG-PHONG (74)

Deux types de réflexion :

- <u>Diffuse</u> : La surface de l'objet "réagit". La lumière est ré-émise dans toutes les directions. Sa couleur est affectée.
- <u>Spéculaire</u> : La surface de l'objet ne "réagit" pas. La lumière est ré-émise selon l'angle d'incidence. Sa couleur n'est pas affectée.



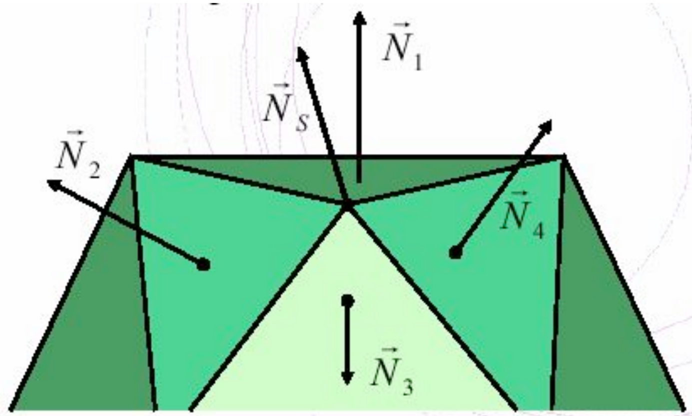
Loi de Lambert : $I_{diff} = I_P K_d(\vec{n}.\vec{s}) = I_P K_d \cos\theta$

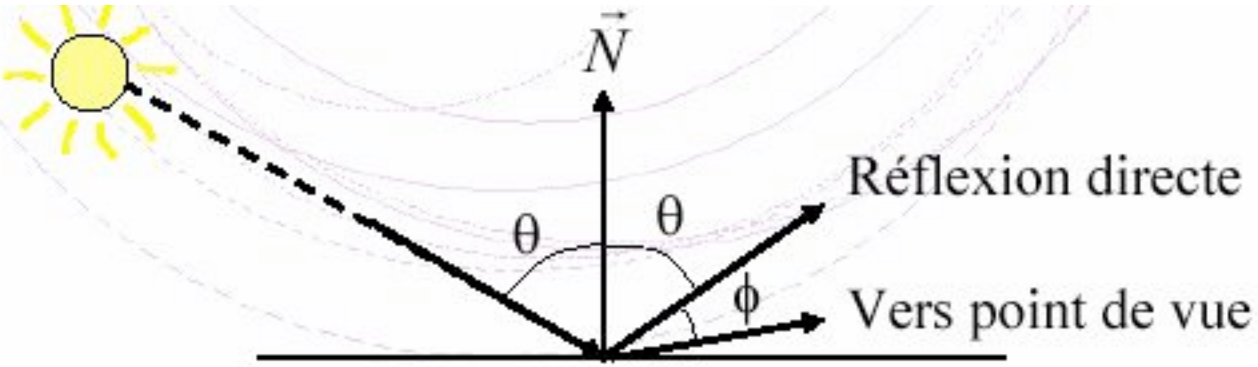


$$I_a = \frac{I_1(y_S - y_2) + I_2(y_S - y_1)}{y_1 - y_2}$$

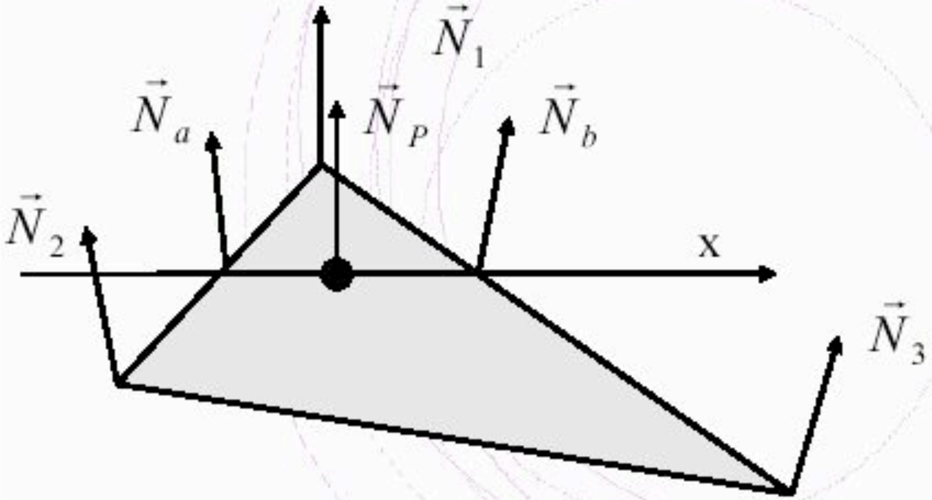
$$I_b = \frac{I_1(y_S - y_3) + I_3(y_1 - y_S)}{y_1 - y_3}$$

$$I_p = \frac{I_b(x_b - x_p) + I_a(x_p - x_a)}{x_b - x_a}$$





- Pour déterminer θ localement, on interpole les normales au lieu des intensités



$$\vec{N}_a = \frac{(y_1 - y_S)\vec{N}_1 + (y_S - y_2)\vec{N}_2}{y_1 - y_2}$$

$$\vec{N}_b = \frac{(y_1 - y_S)\vec{N}_1 + (y_S - y_3)\vec{N}_3}{y_1 - y_3}$$

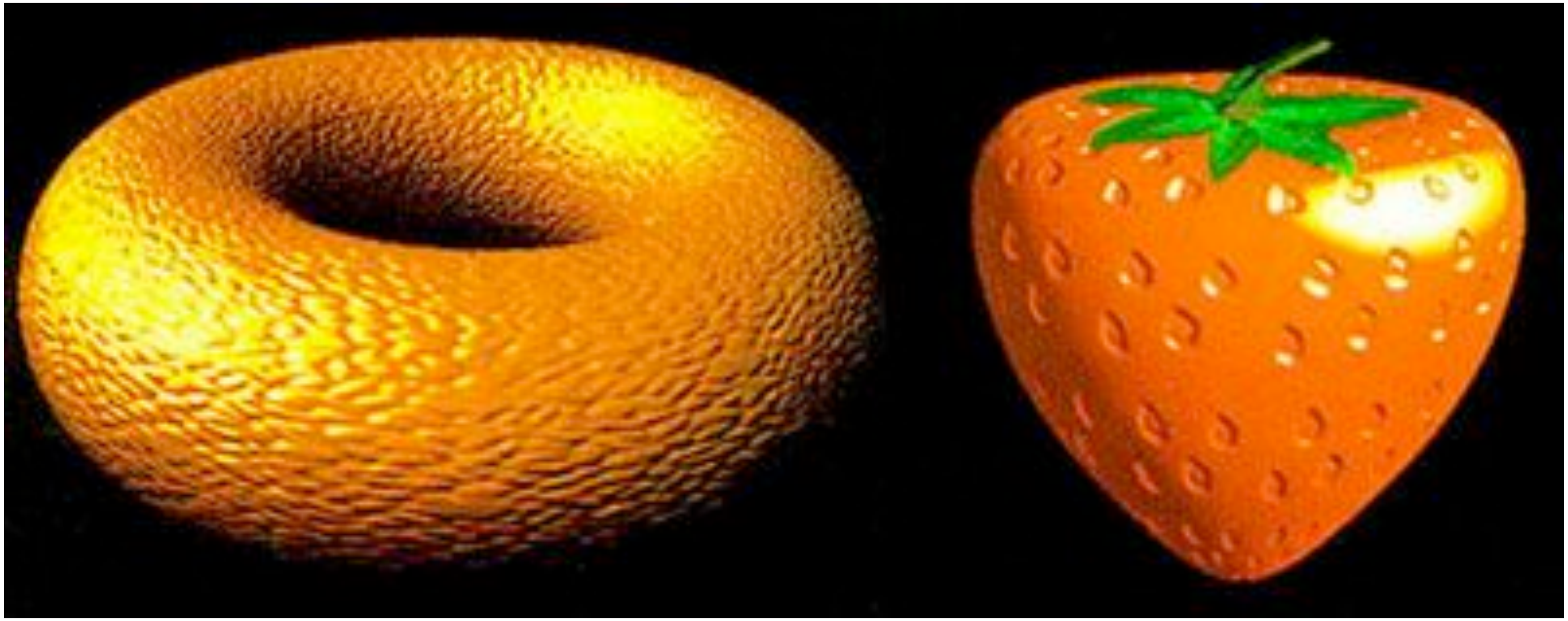
$$\vec{N}_P = \frac{(x_P - x_a)\vec{N}_a + (x_b - x_P)\vec{N}_b}{x_b - x_a}$$

- Modèle (empirique) retenu :

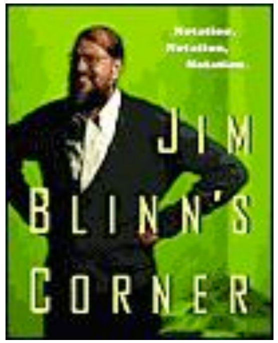
$$I_{spec} = I_P K_S \cos^n \phi \Rightarrow I_{total} = I_{diff} + I_{spec} = I_P(K_d \cos\theta + K_S \cos^n \phi)$$

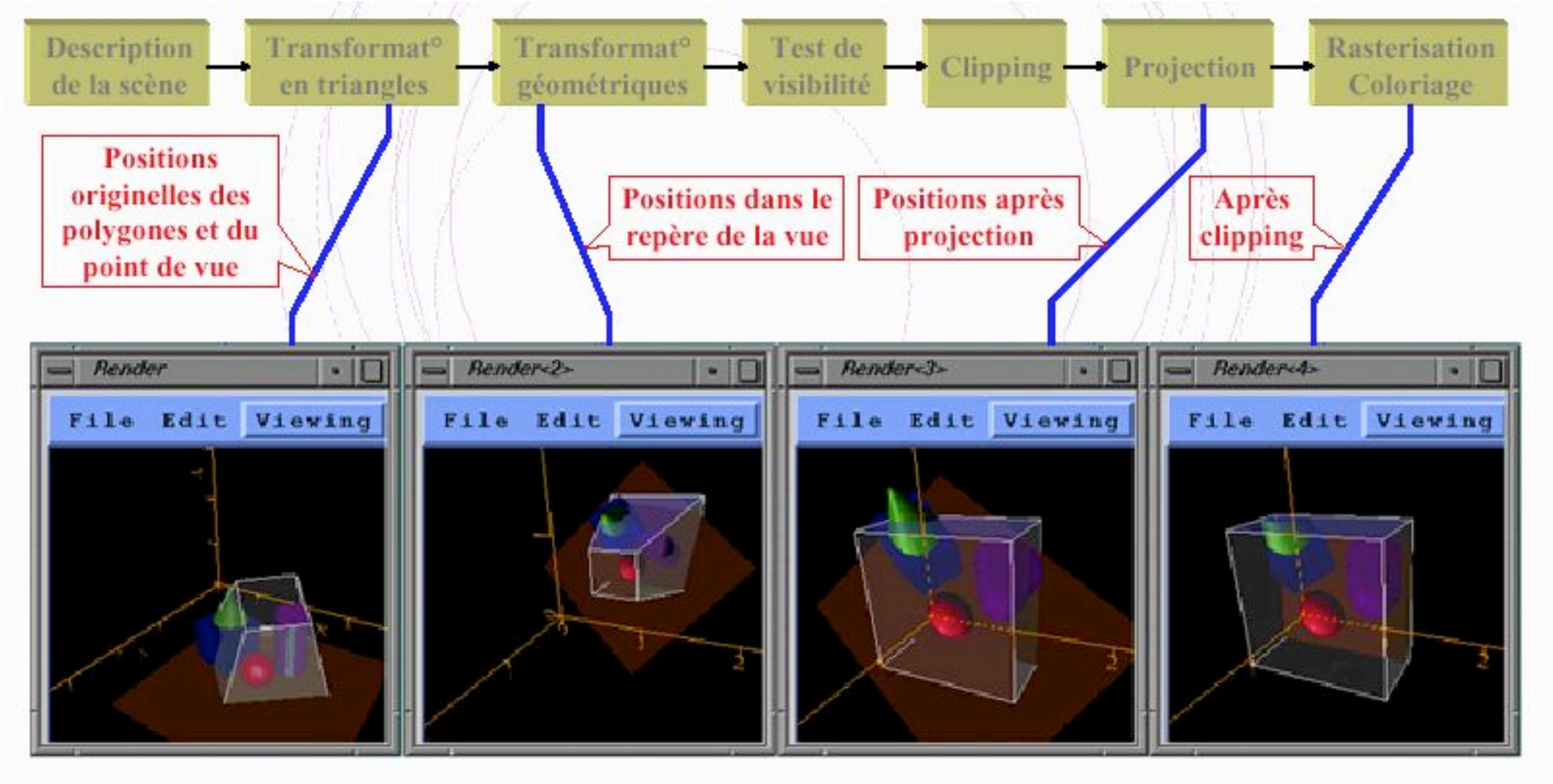
http://sjbaker.org/teapot/

Martin NEWELL (75) - Utah teapot



Jim BLINN (78) - Textures





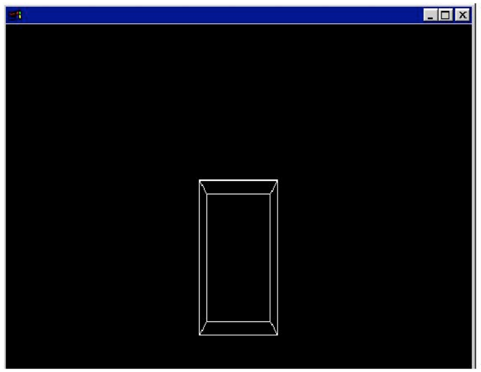
Le pipeline standard de rendu

●SGI 初のハードウエア「IRIS 1000」グラフィックスターミナル

1982 - Silicon Graphics

1992 - Kurt Akely - OpenGL

```
Extrait du "red book" d'OpenGL - fichier cube.c

#include <GL/glut.h>
#include <stdlib.h>

void init(void) {
   glClearColor (0.0, 0.0, 0.0, 0.0);
   glShadeModel (GL_FLAT);
}

void display(void) {
   glClear (GL_COLOR_BUFFER_BIT);
   glColor3f (1.0, 1.0, 1.0);
   glLoadIdentity ();/* clear the matrix */
   /* viewing transformation  */
   gluLookAt (0.0, 0.0, 5.0, 0.0,
              0.0, 0.0, 0.0, 1.0, 0.0);
   glScalef (1.0, 2.0, 1.0);
  /* modeling transformation */
   glutWireCube (1.0);
   glFlush ();
}
```



```
void reshape (int w, int h){
   glViewport (0, 0, (GLsizei) w, (GLsizei) h);
   glMatrixMode (GL_PROJECTION);
   glLoadIdentity ();
   glFrustum (-1.0, 1.0, -1.0, 1.0, 1.5, 20.0);
   glMatrixMode (GL_MODELVIEW);
}

void keyboard(unsigned char key, int x, int y){
   switch (key) { case 27: exit(0); break; }
}

int main(int argc, char** argv){
   glutInit(&argc, argv);
   glutInitDisplayMode (GLUT_SINGLE | GLUT_RGB);
   glutInitWindowSize (500, 500);
   glutInitWindowPosition (100, 100);
   glutCreateWindow (argv[0]);
   init ();
   glutDisplayFunc(display);
   glutReshapeFunc(reshape);
   glutKeyboardFunc(keyboard);
   glutMainLoop();
   return 0;
}
```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Démarrage
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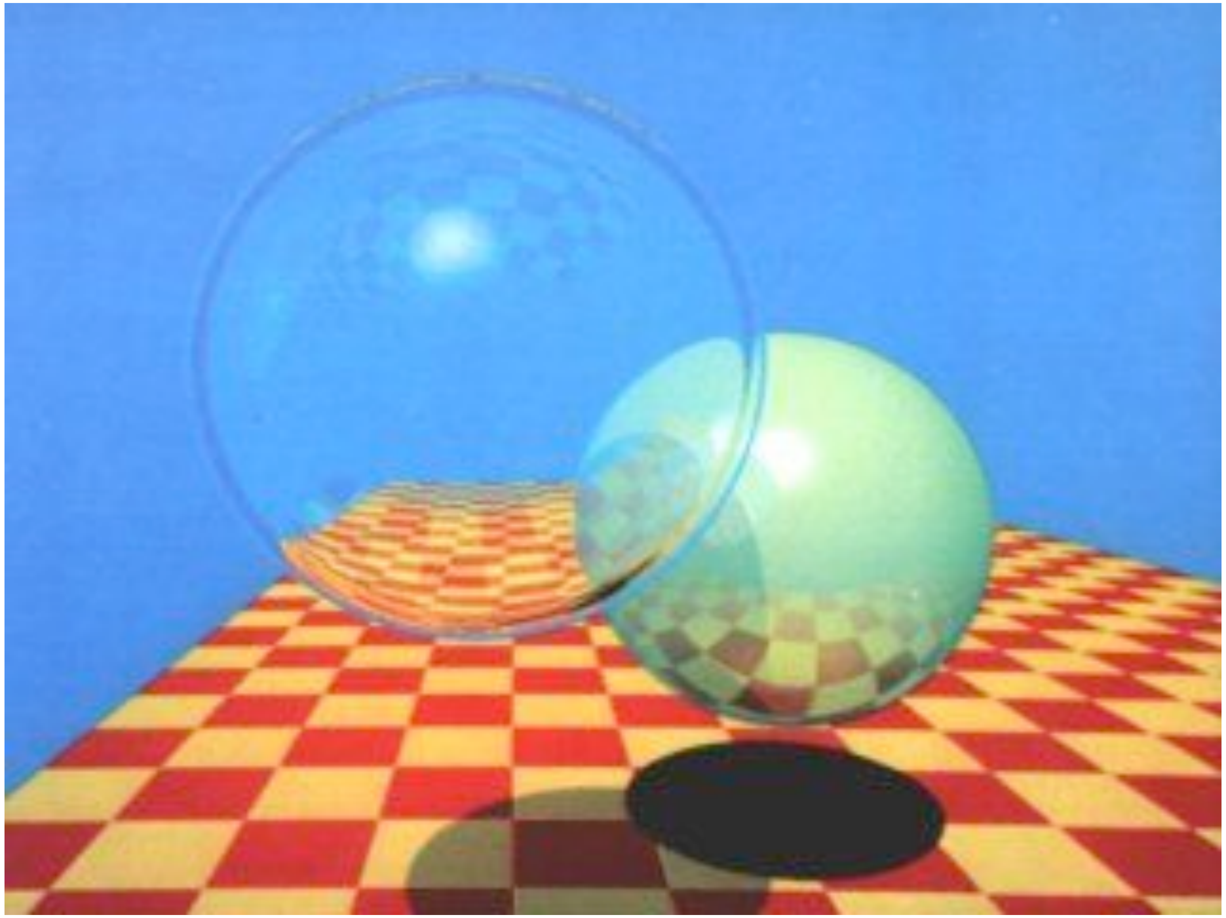
Introducing a new era in multimedia mobile phones
NVIDIA GoForce
TALK
END
1
2 ABC
3 DEF

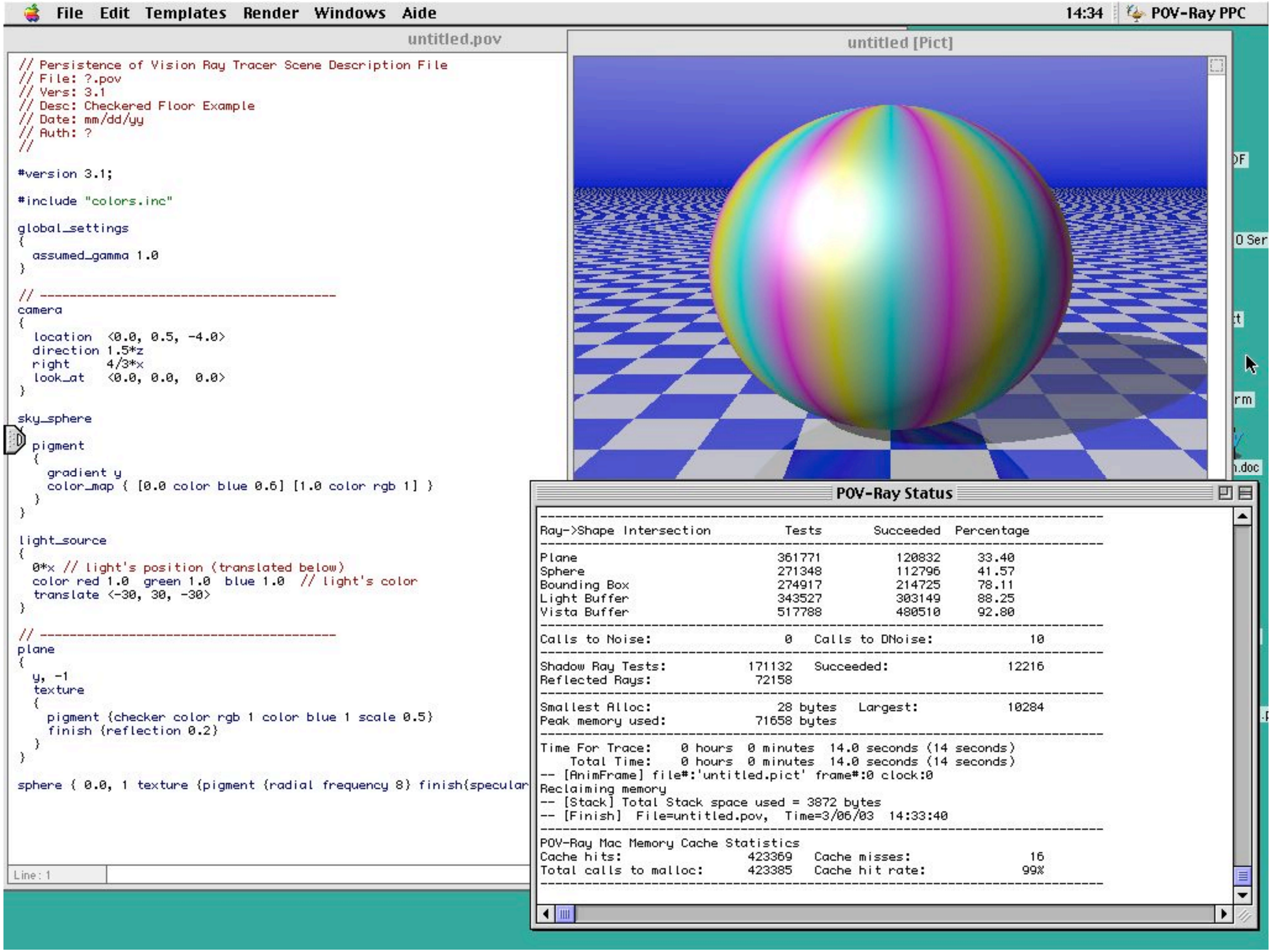
An Improved Illumination Model for Shaded Display

Turner Whitted
Bell Laboratories
Holmdel, New Jersey



1980 - Le lancé de rayon récursif

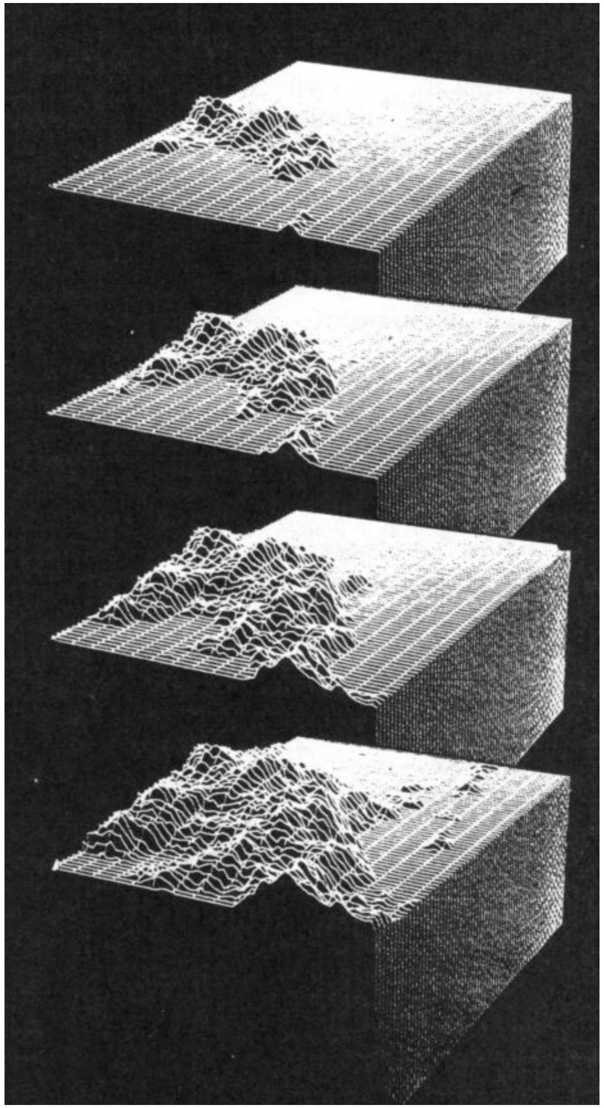
http://www.povray.org



Steve Anger "Philco 6Z4" 1993 avec POVray http://www.povray.org/

Radiance - http://radsite.lbl.gov/radiance/HOME.html

Les fractales (B. Mandelbrot, 1975)

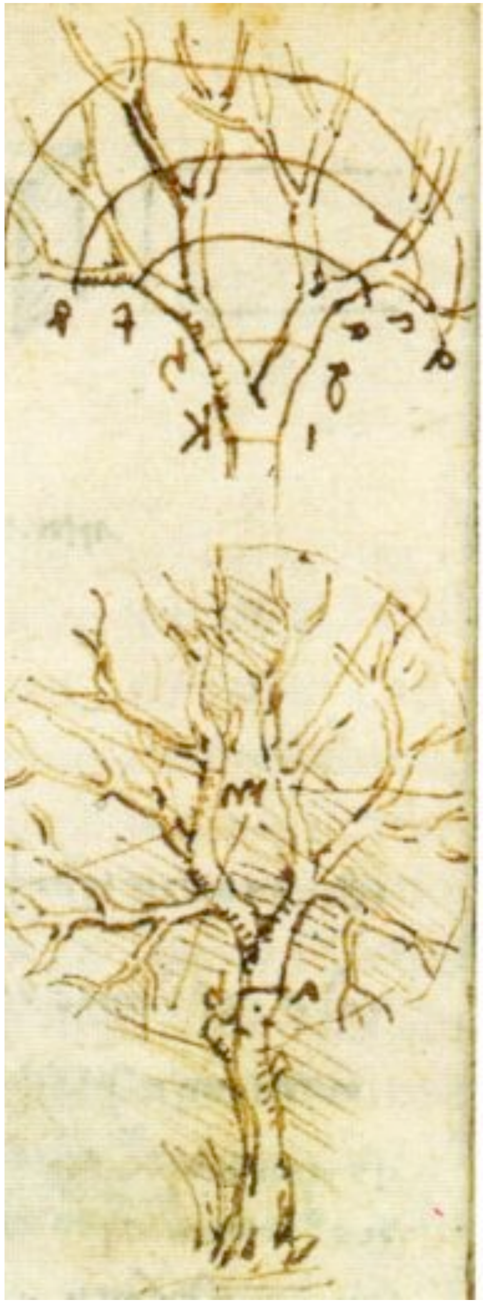


F.K. Musgrave "Other State"

http://www.solo.com/studio/algorists.html

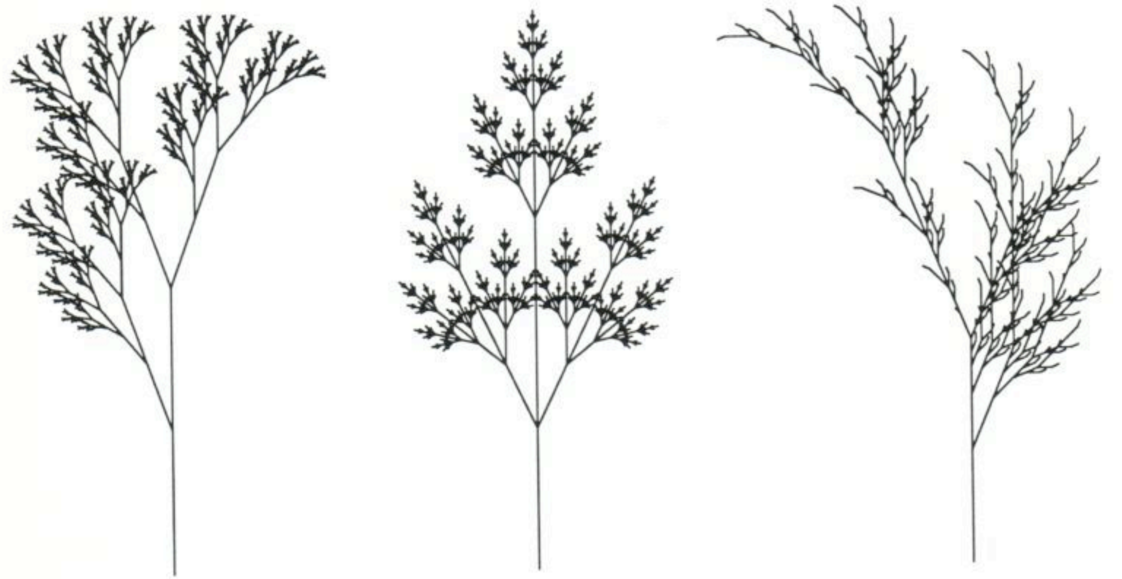
F.K. Musgrave "Alps" in [Ebert et al.]

D.S. EBERT in [Ebert et al.]



Les grammaires de forme

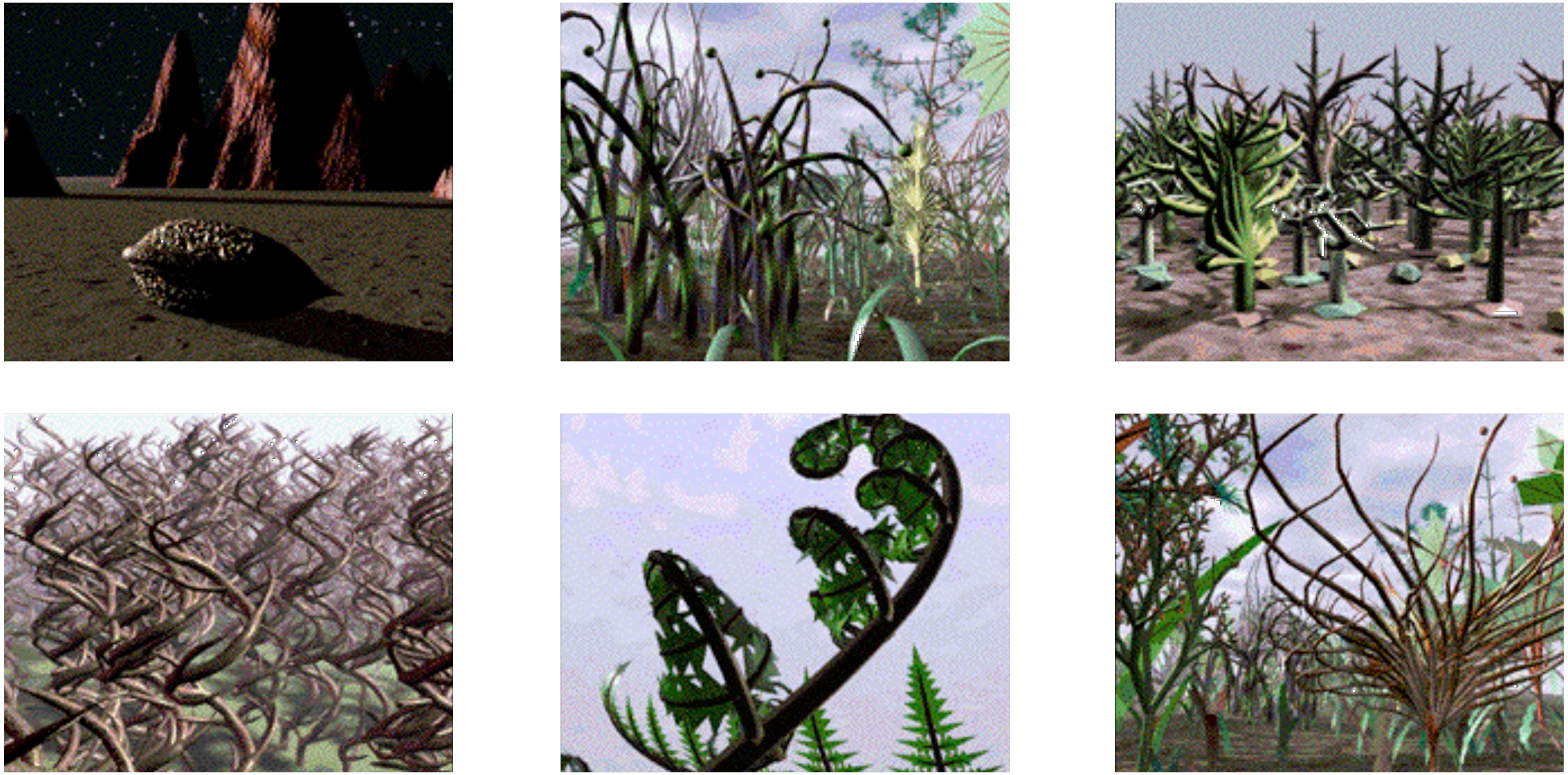
arbre ::= tronc + des branches
tronc ::= cylindre
branche ::= arbre (plus petit)



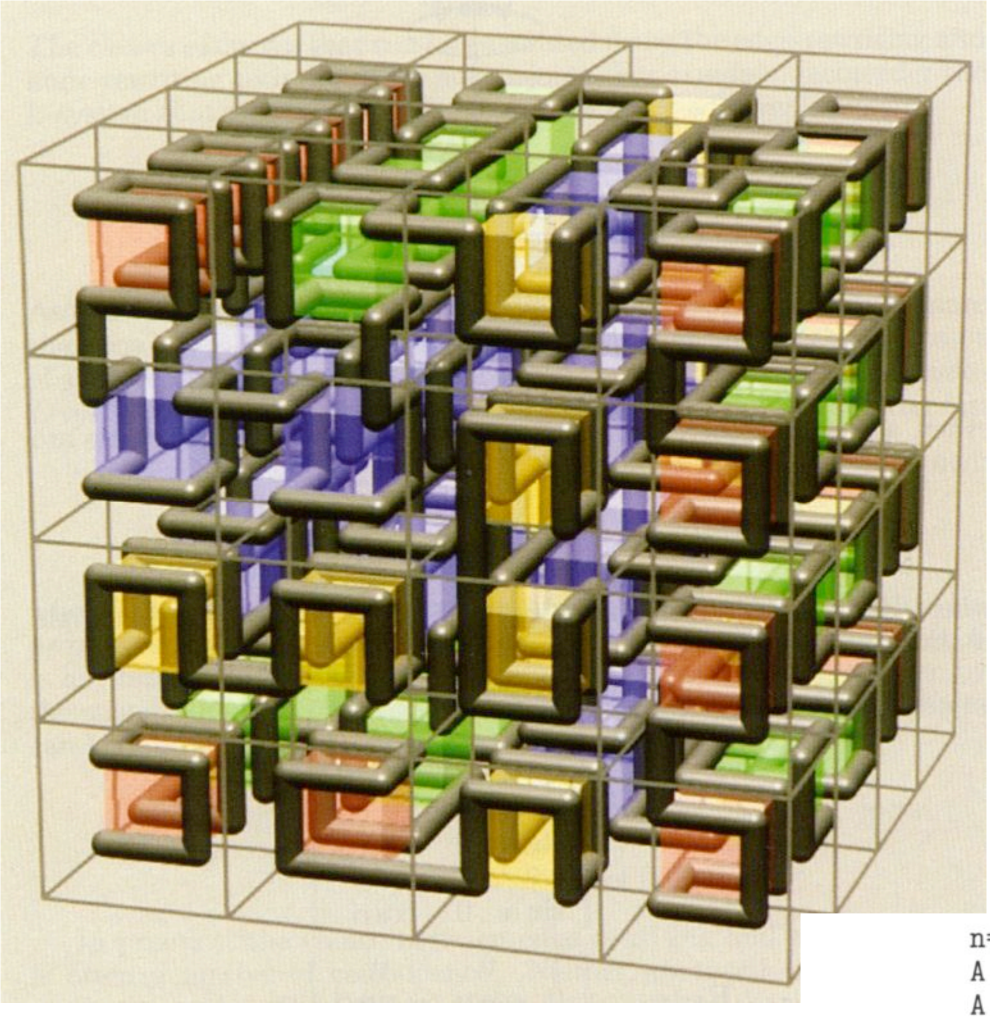
d
n=7, δ=20°
X
X → F[+X]F[-X]+X
F → FF

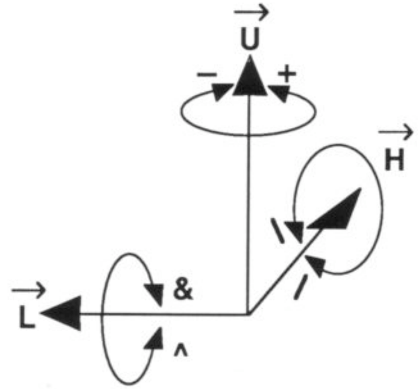
e
n=7, δ=25.7°
X
X → F[+X][-X]FX
F → FF

f
n=5, δ=22.5°
X
X → F-[[X]+X]+F[+FX]-X
F → FF



Karl Sims "Panspermia" in [POPPER] p. 101





n=2, δ=90°

A

A → B-F+CFC+F-D&F∧D-F+&&CFC+F+B//

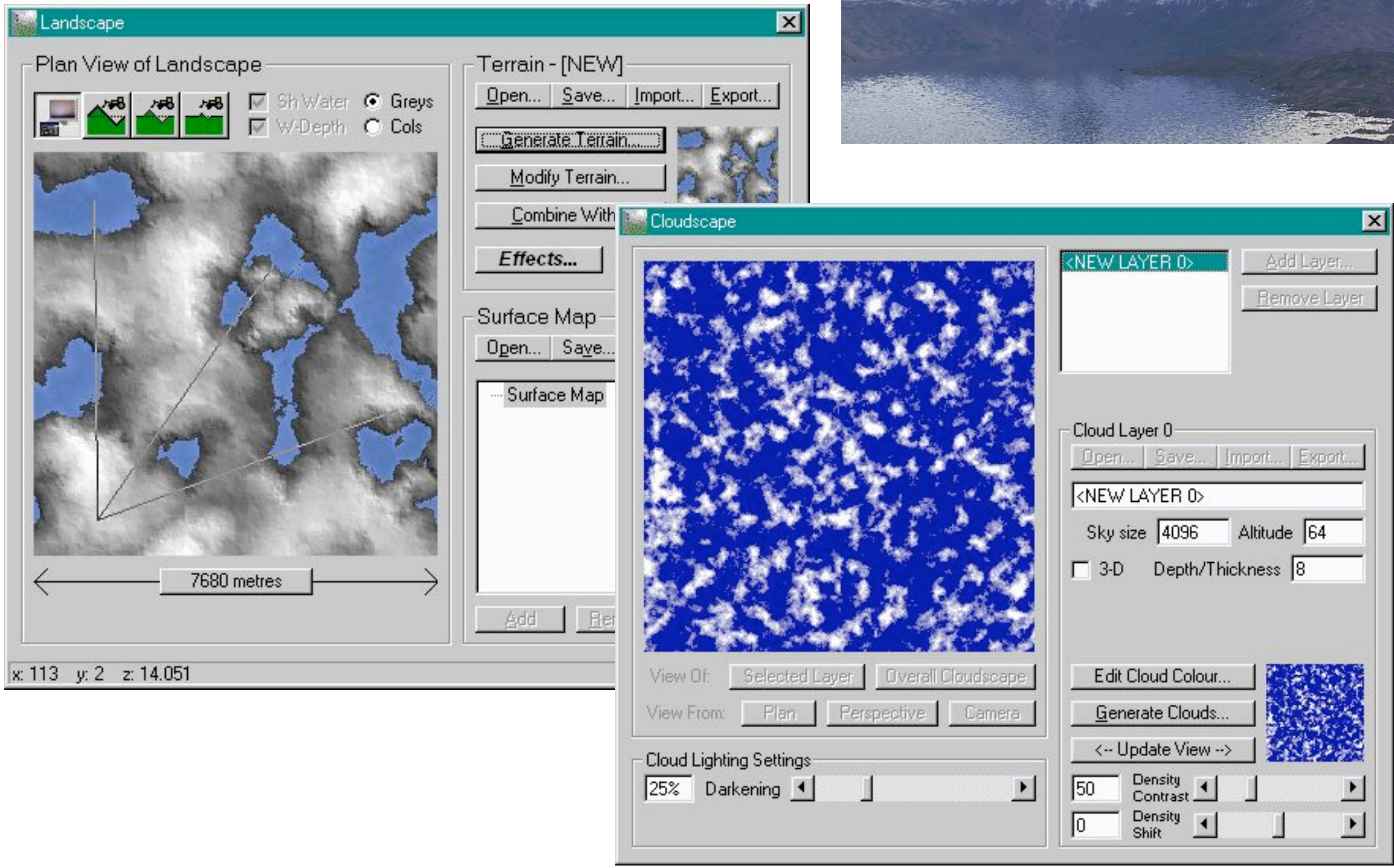
B → A&F∧CFB∧F∧D∧∧-F-D∧|F∧B|FC∧F∧A//

C → |D∧|F∧B-F+C∧F∧A&&FA&F∧C+F+B∧F∧D//

D → |CFB-F+B|FA&F∧A&&FB-F+B|FC//

Figure 1.19: A three-dimensional extension of the Hilbert curve [139]. Colors represent three-dimensional "frames" associated with symbols A (red), B (blue), C (green) and D (yellow).

terragen (PC) : http://www.planetside.co.uk/terragen/



SIGGRAPH Video Review

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1. TOPES - *Bell Laboratories*
2. Newshole - *University of Toronto*
3. VideoCel - *Computer Creations*
4. Sunstone - *Emshwiller*
5. Voyager 2 - *Blinn et al.*
6. Information International Demo Reel
7. DNA with Ethidium - *Max et al.*

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1. The Compleat Angler - *Whitted*
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4. Peak - *Snitly*
5. Doxorubicin/DNA - *Max et al.*
6. Digital Effects Demo Reel
7. MAGI Synthavision Demo Reel
8. Spatial Data Mgt. System - *Herot et al.*
9. Pantomation - *DeWitt et al.*
10. Artifacts - *The Vasulkas*

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3. Imagination - *Acme Cartoon Company*
4. Dubner Demo Tape
5. Vidsizer - *Franzblau*
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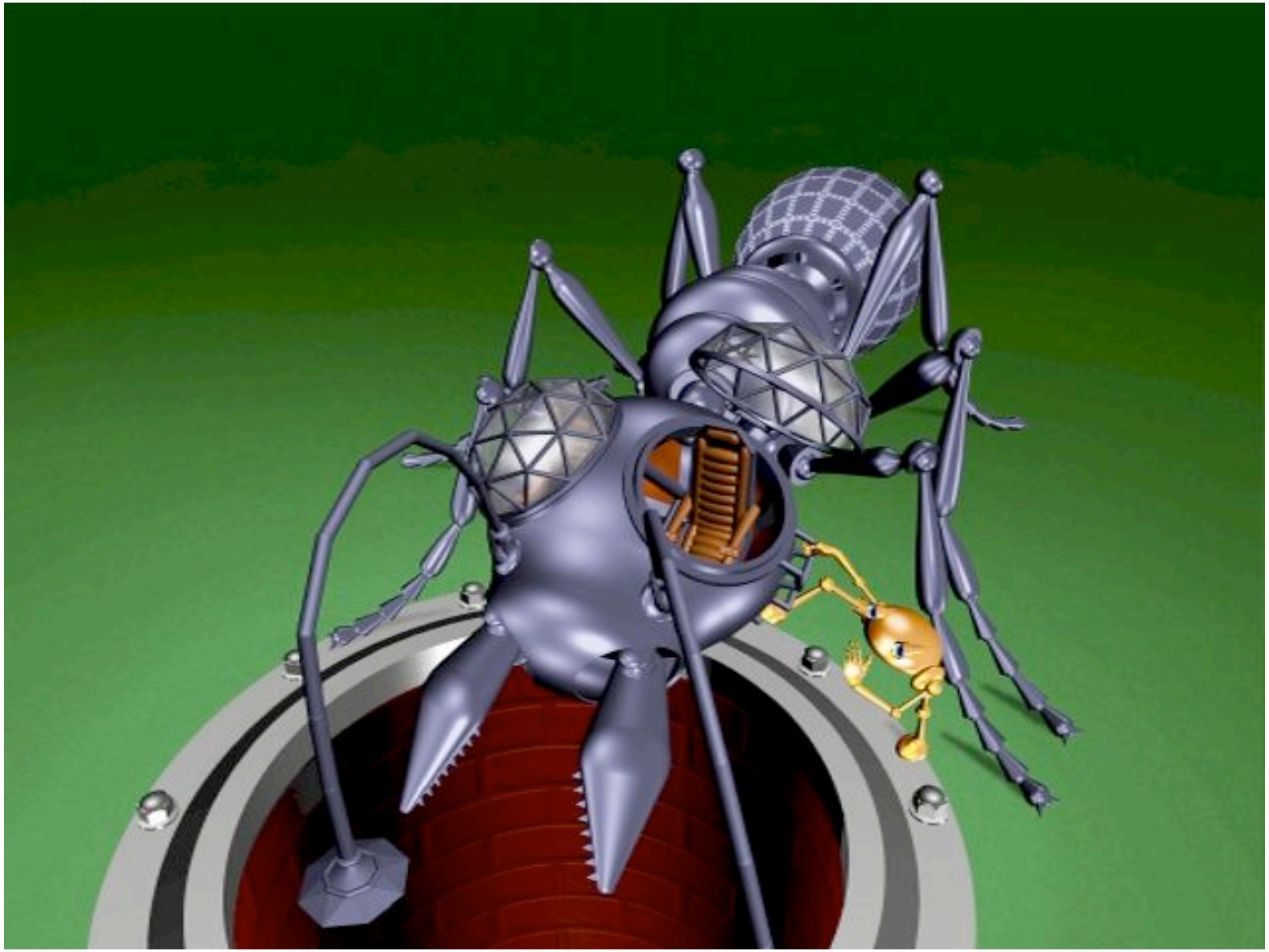
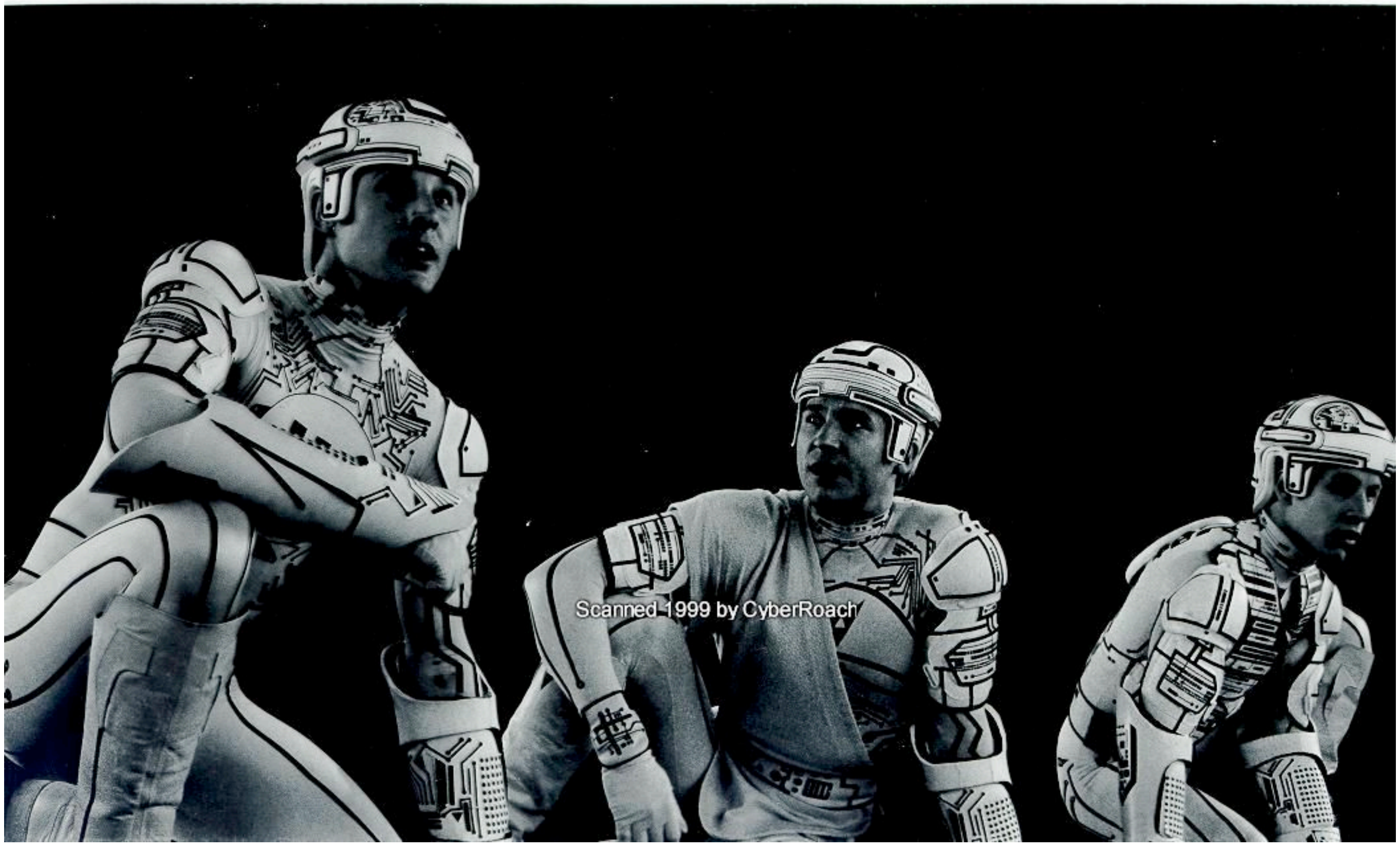
1. Abel Demo Reel - *Kovacs et al.*
2. Image West Demo Reel
3. OSU Computer Graphics Research Group Terrain Model - *Csuri et al.*
4. Computer-Assisted Dance Notation - *Calvert et al.*



1980 - NYIT - The works



1982 - MAGI, Digital effects, etc... - TRON

1986 - Pixar (Lasseter et al.) - Luxo junior

1986 - Young Sherlock Holmes - 1ere animation de synthèse dans un long métrage

1989 - Abyss

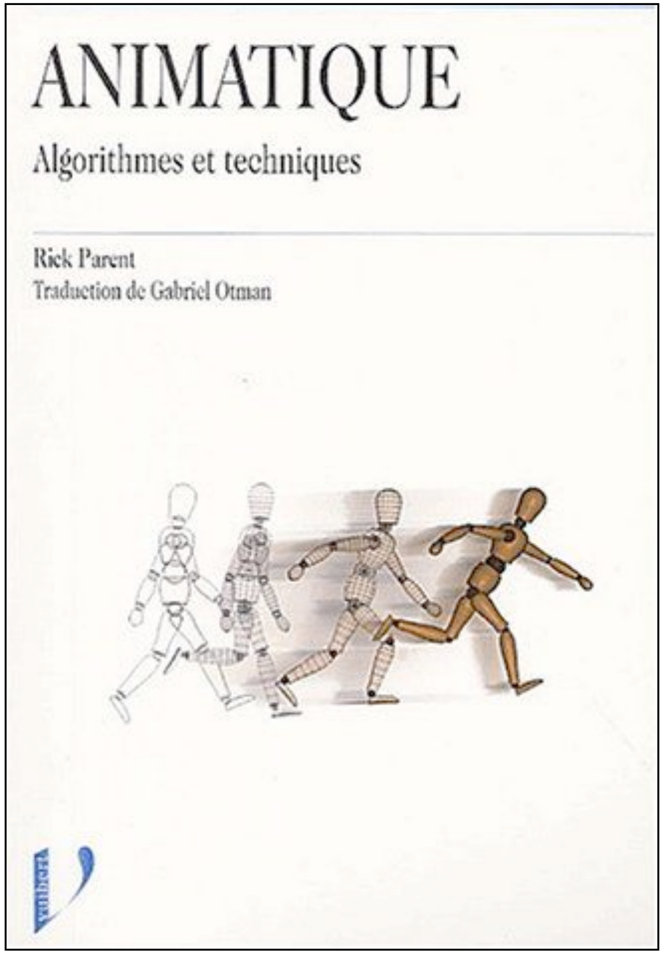
1993 - Jurassic parc - 1ers animaux de synthèse

1995 - Jumanji - idem avec animaux contemporains
1995 - Batman returns - 1ere doublure numérique
1995 - Casper
1995 - Toy story - 1er dessin animé LM en synthèse 3D

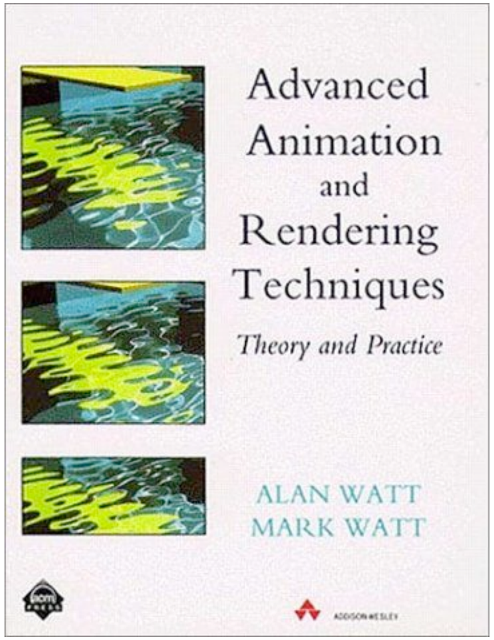
1996 - Mars attacks

1999 - Starwars 1 - 1er humanoïde de synthèse

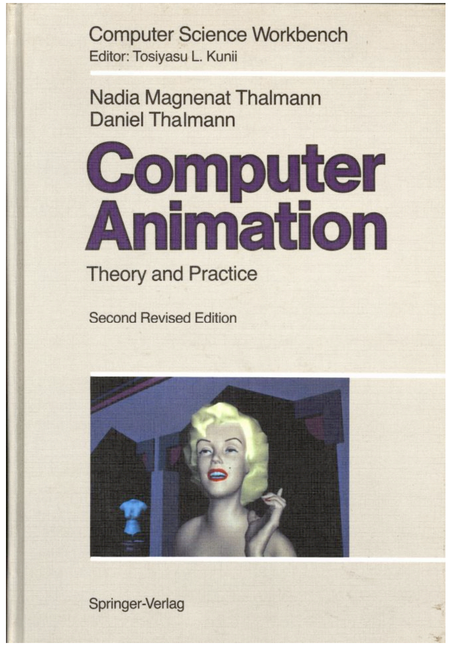
Bibliographie pour la prochaine fois



trad. en 2003, 45 euros env.



1992, non traduit
(partie IV seulement)



1985 et 90