

MUX104

Synthèse d'image et réalité virtuelle

Morphogénèse

Pierre Cubaud
cubaud @ cnam.fr

mars 2020

le **cnam**

Plan du cours

- 1) Bruit de Worley**
- 2) Automates cellulaires**
- 3) Grammaires de formes (L-systèmes)**

1. Bruit de Worley

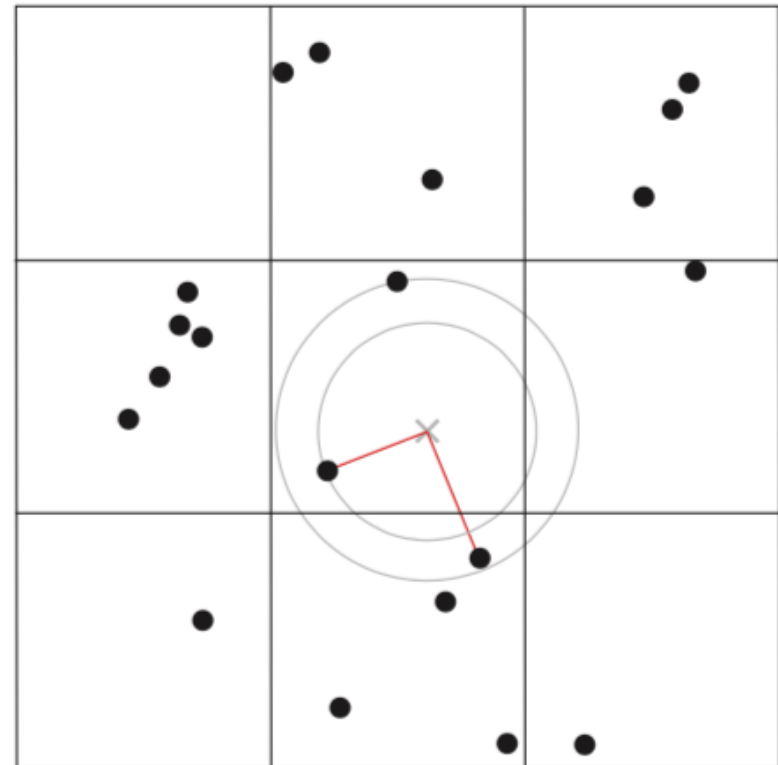
Steven Worley
A Cellular Texture Basis Function
ACM, 1996

**subdivision d'un volume (3D)
ou du plan (2D) en cellules égales**

**On pose des "feature points" FP
dans chaque cellule selon une loi
de Poisson**

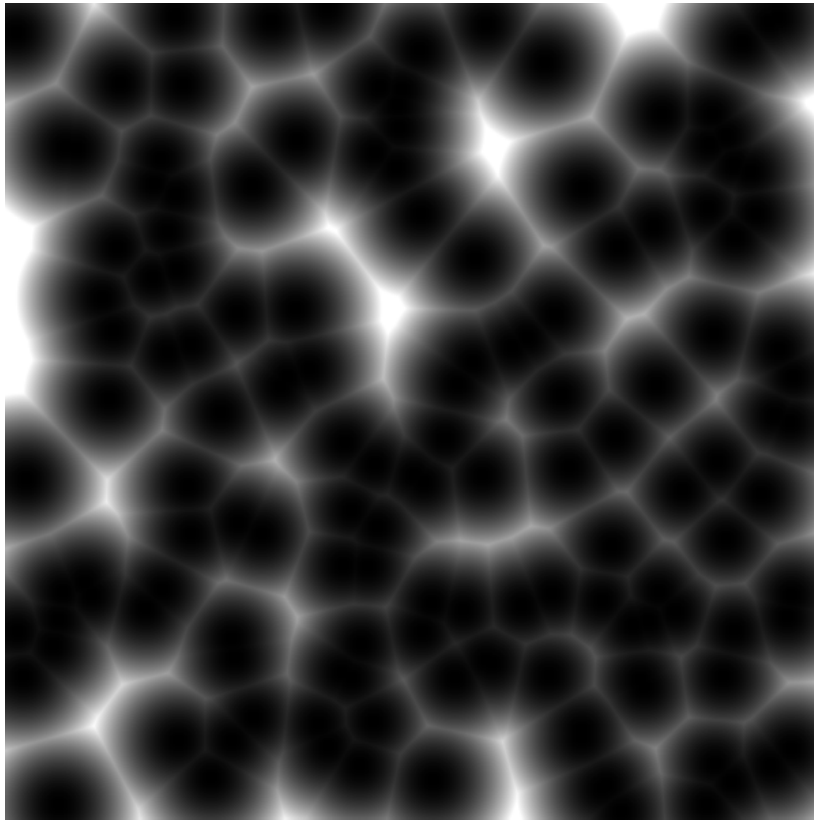
**Pour chaque point P, on définit le bruit
 $B(P,n)$ comme fonction de la distance
au n-ième plus proche des FP au point P**

En pratique, on utilise $n=1$ et $n=2$

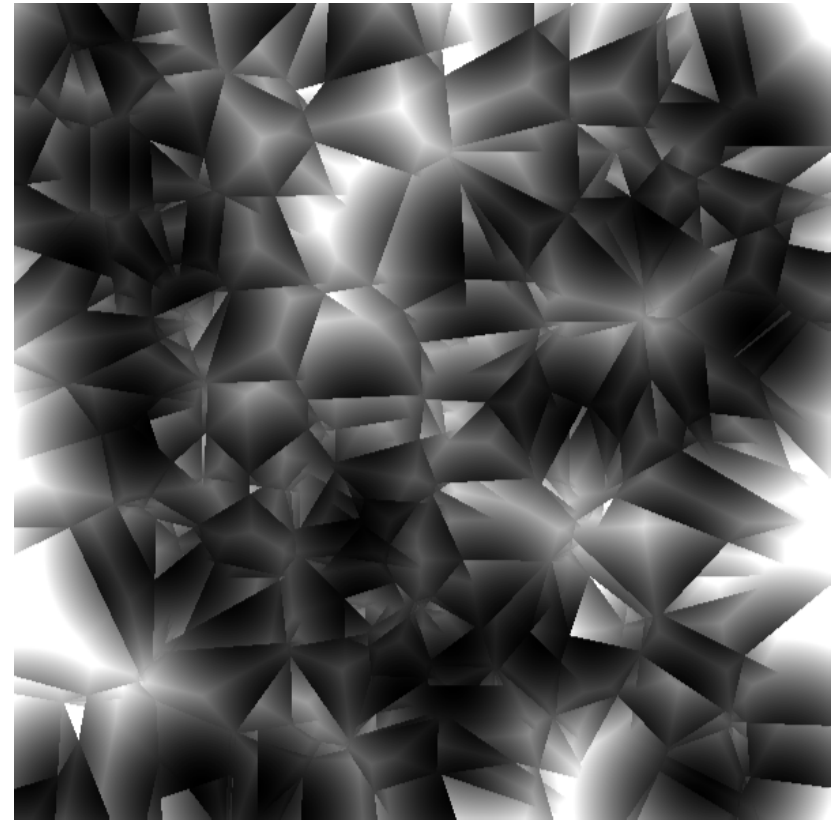


[http://www.carljohanrosen.com/share/
CellNoiseAndProcessing.pdf](http://www.carljohanrosen.com/share/CellNoiseAndProcessing.pdf)

modulation du gris selon distance

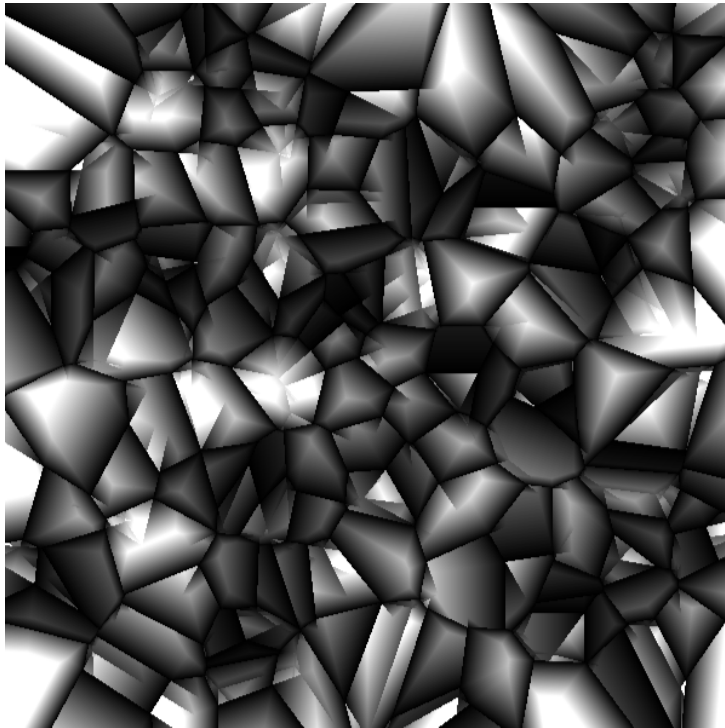


au 1^{er} FP plus près : d1
=> espaces de Voronoï

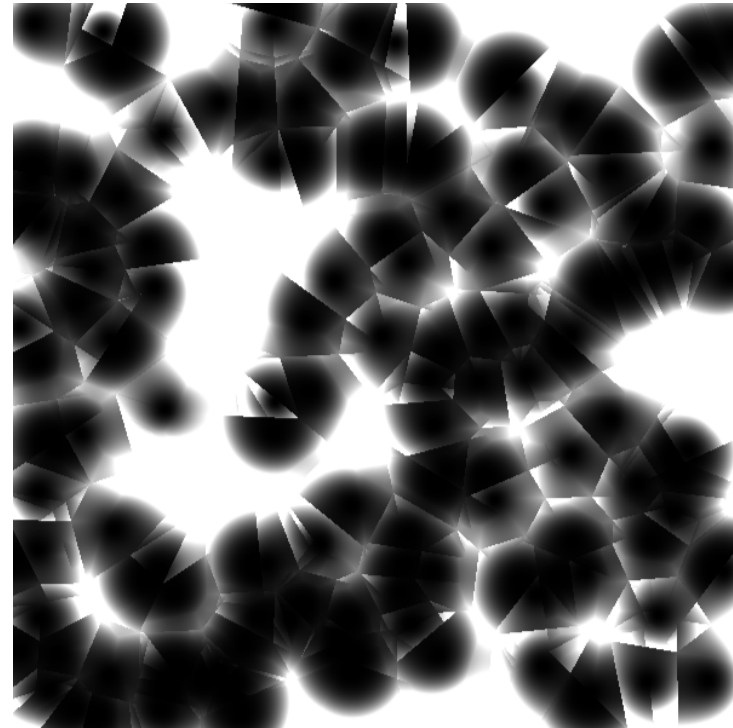


au 2^{ème} FP plus près : d2

d1 - d2



d1*d2



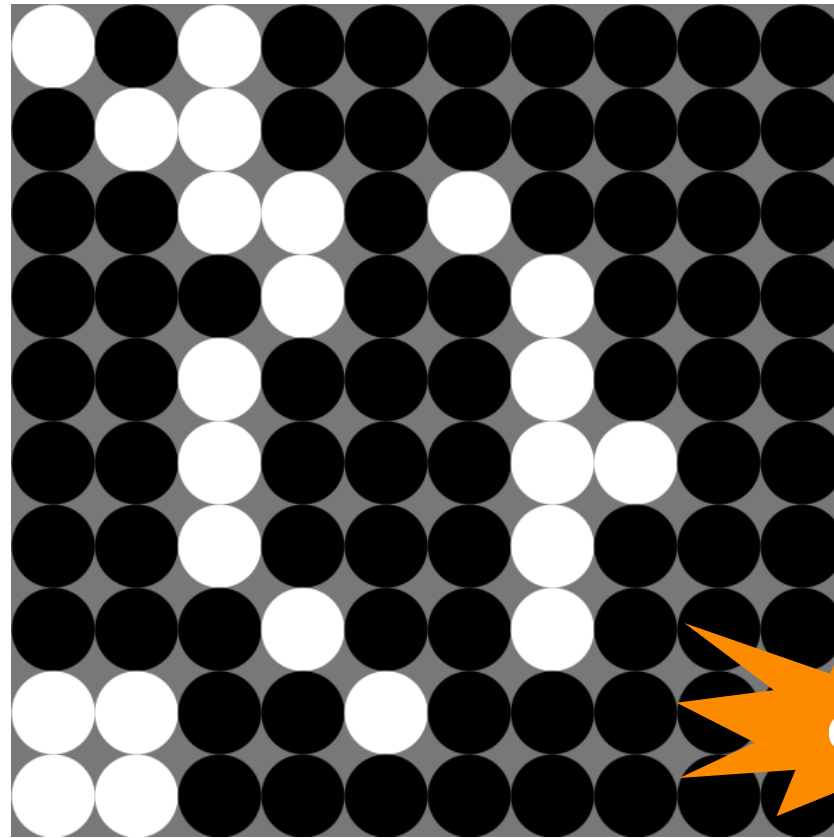
Nombreuses autres possibilités !

voir article de Carl-Johan Rosén

<http://www.carljohanrosen.com/share/CellNoiseAndProcessing.pdf>

2. Automates cellulaires

Le jeu de la vie (Conway, années 50)




```

int DIM = 10;
float R;

int[][] C = new int[DIM][DIM];
int[][] D = new int[DIM][DIM];
int i,j;
float x,y;

void setup(){
  size(600,600);
  smooth();
  noStroke();
  R = width/DIM;
  frameRate(1);
  for (i=0;i<DIM;i++){
    for (j=0;j<DIM;j++){
      {if (random(1)<0.5) C[i][j]=0; else C[i][j]=1;}
    }
  }

  void draw(){
    background(120);
    // calcul nvelle etape
    for (i=0;i<DIM;i++){
      for (j=0;j<DIM;j++){
        int m=SommeMoore(i,j);
        if (C[i][j]==0)
          if (m==3) D[i][j]=1; else D[i][j]=0;
        else
          if ((m==2)||(m==3)) D[i][j]=1; else D[i][j]=0;
      }
    }

// affichage resultat
x = R/2; y = R/2;
for (i=0;i<DIM;i++){
  for (j=0;j<DIM;j++){
    if (D[i][j]==0) fill(0); else fill(255);
    ellipse(x,y,R,R);
    x += R;
  }
  y += R;x = R/2;
}

// recopie etat courant
for (i=0;i<DIM;i++) for (j=0;j<DIM;j++) C[i][j]=D[i][j];

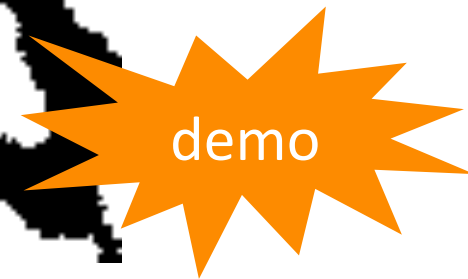
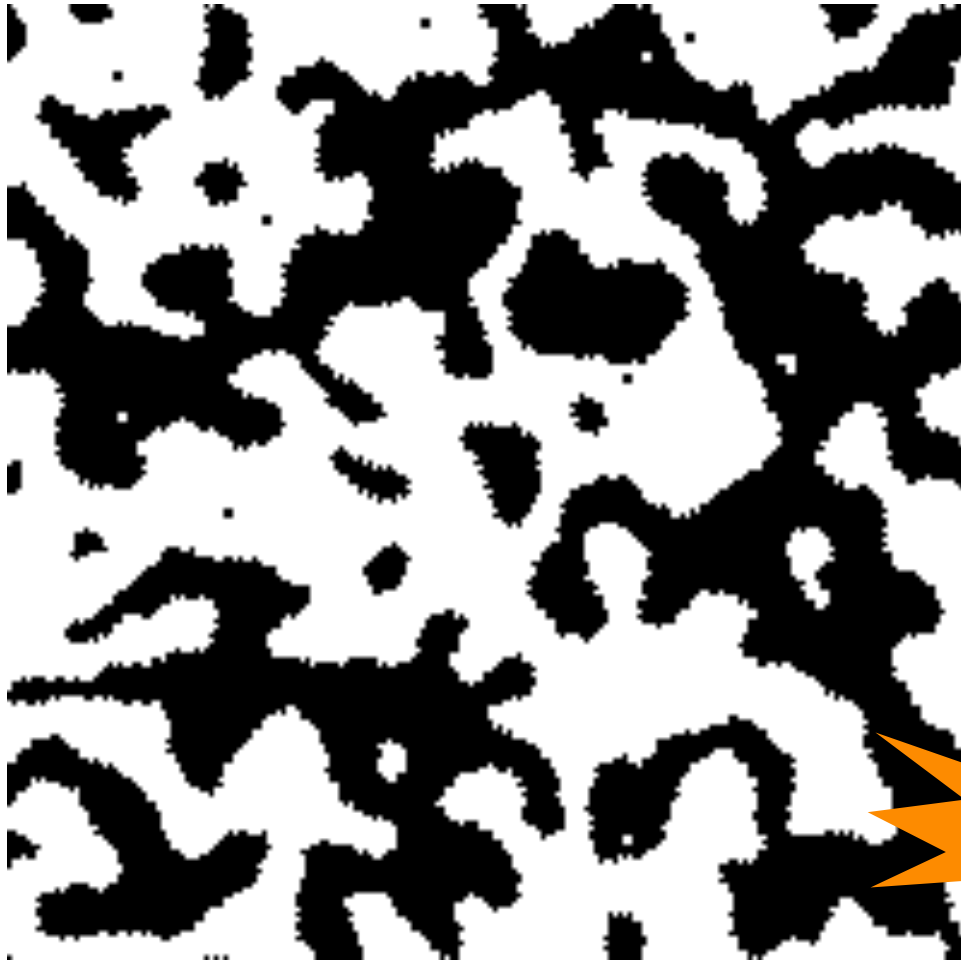
println(frameCount);
}

void keyPressed(){
  noLoop();
  save("jeu"+frameCount+".png");
}

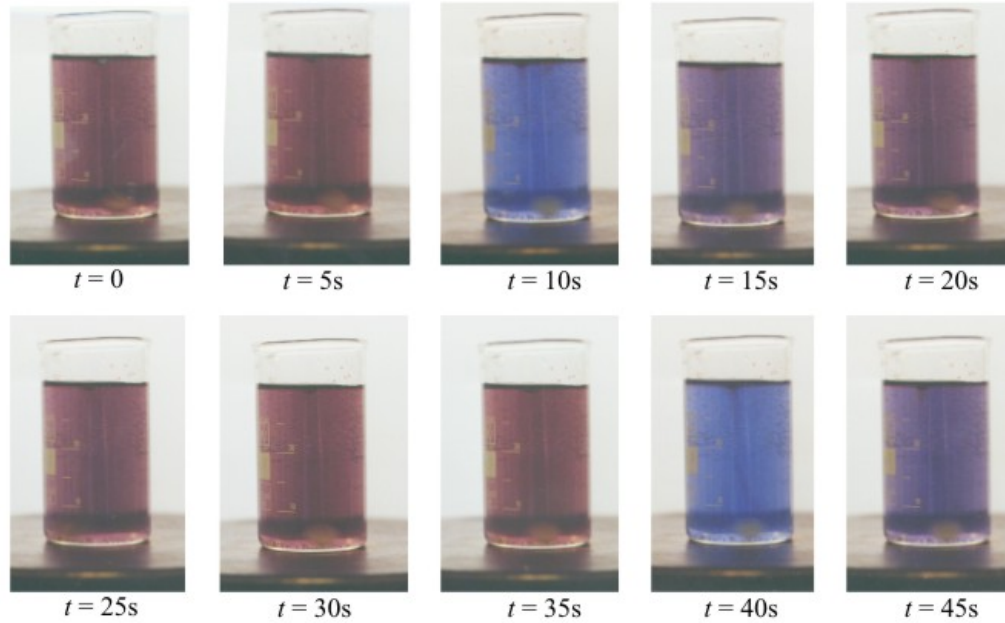
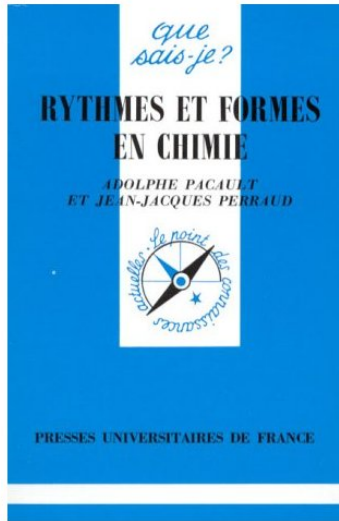
int SommeMoore(int i, int j) {
  int im1 = (i == 0)?DIM-1:i-1;
  int ip1 = (i == DIM-1)?0:i+1;
  int jm1 = (j == 0)?DIM-1:j-1;
  int jp1 = (j == DIM-1)?0:j+1;
  //int s= C[i][j];
  int s = 0;
  s+= C[im1][jm1];
  s+= C[im1][j];
  s+= C[im1][jp1];
  s+= C[i][jm1];
  s+= C[i][jp1];
  s+= C[ip1][jm1];
  s+= C[ip1][j];
  s+= C[ip1][jp1];
  return s;
}

```

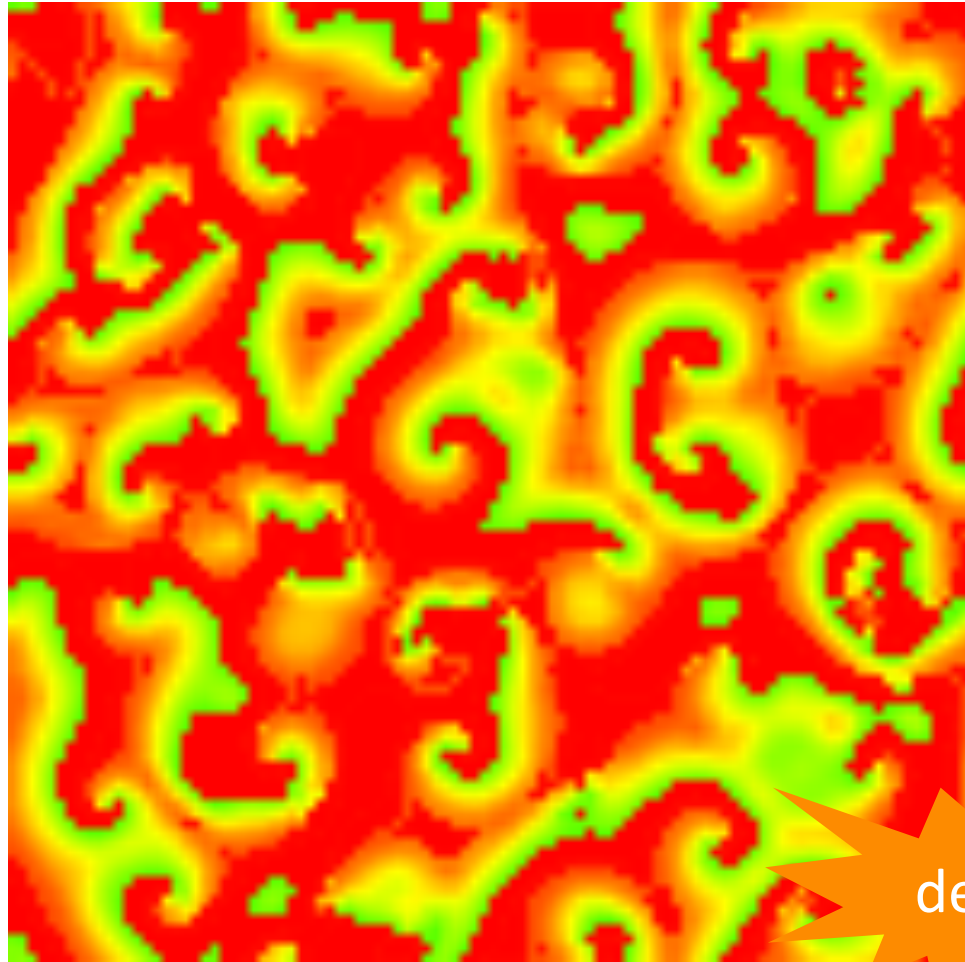
Voteurs (et voteurs perturbés) / Tofoli & Margolus



Réaction de Bélousov-Zhabotinsky



(Wikipedia)



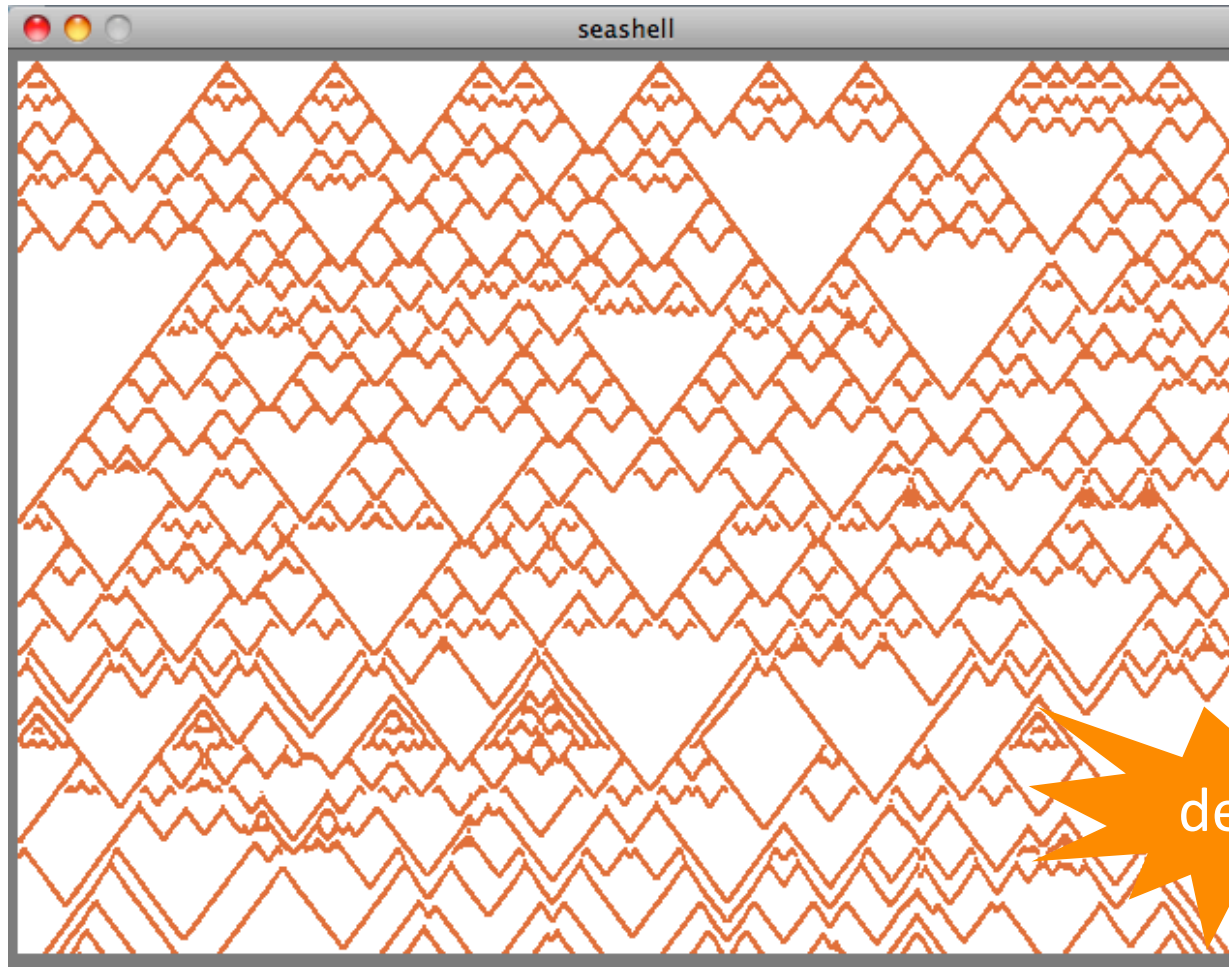
demo

Hans Meinhardt "Algo. beauty of sea shells", Springer, 1995

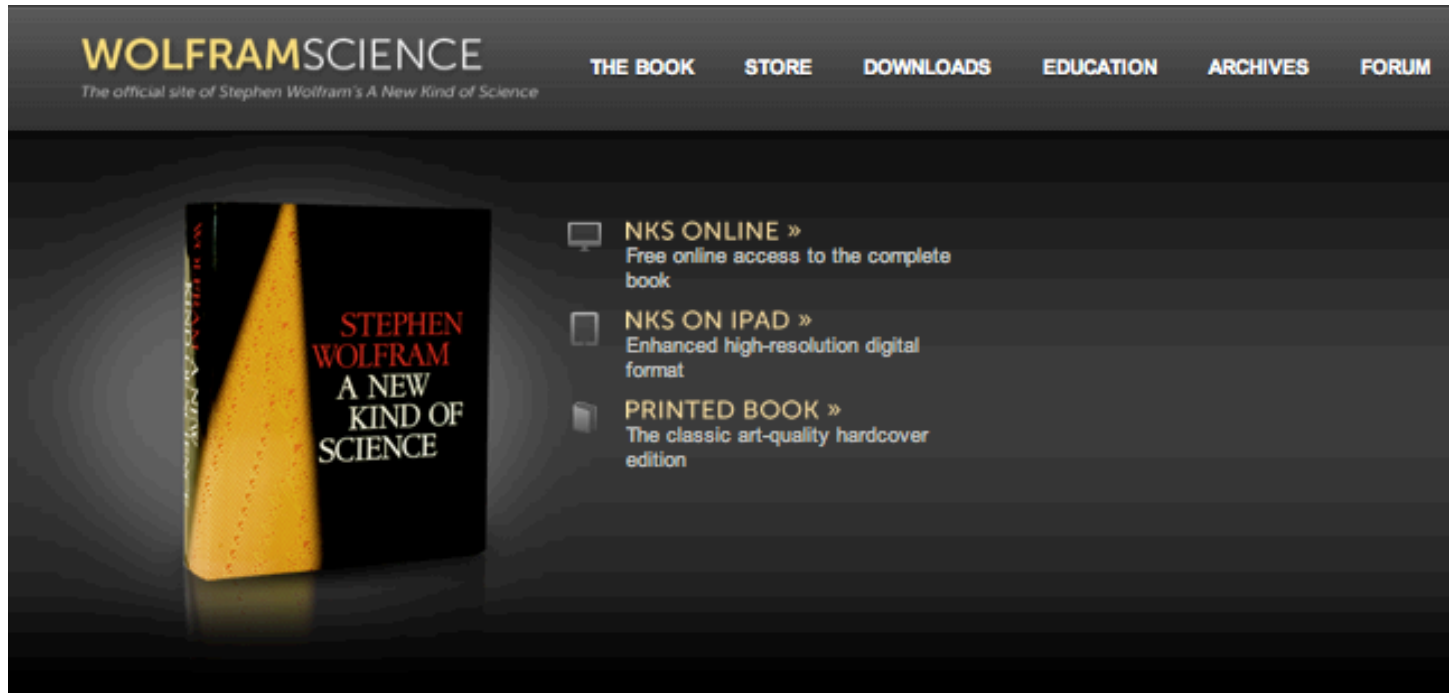


Portage en Processing du code Basic de Meinhardt :

<http://www.eb.tuebingen.mpg.de/research/emeriti/hans-meinhardt/shell-program.html>



Pour continuer sur le sujet : livre et site de S. Wolfram



The screenshot shows the top navigation bar of the Wolfram Science website. The main title "WOLFRAMSCIENCE" is in yellow and white, with the subtitle "The official site of Stephen Wolfram's A New Kind of Science" below it. The navigation menu includes "THE BOOK", "STORE", "DOWNLOADS", "EDUCATION", "ARCHIVES", and "FORUM". The main content area features a large image of the book "A New Kind of Science" by Stephen Wolfram, with a yellow and black cover. To the right of the book image are three links with icons: "NKS ONLINE" (free online access), "NKS ON IPAD" (enhanced high-resolution digital format), and "PRINTED BOOK" (classic art-quality hardcover edition).



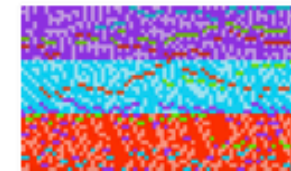
Summer School 2014
12th Annual Wolfram
Science Summer School »



Wolfram Demonstrations
Hundreds of interactive
Wolfram Science CDF
Demonstrations »



Wolfram|Alpha
Knowledge engine made
possible by Wolfram
Science ideas »



Wolfram Tones
An experiment in a new
kind of music »

3. L-systems



[ABOP]

1990

**pdf en ligne,
offert par les
auteurs**



Principe des grammaires de forme

- Exemple fondateur : le flocon de von Koch (1919)

On peut décrire ce type de courbe par une grammaire générative :

w : F-F-F-F

P : $F \Rightarrow F-F+F+FF-F-F+F$

F :avance

+ :à gauche

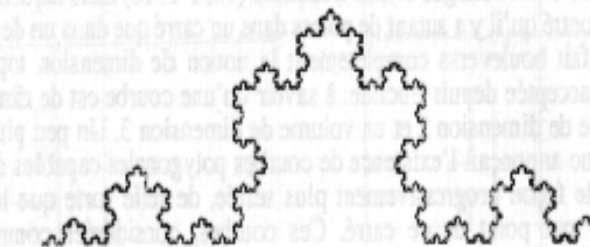
- :à droite



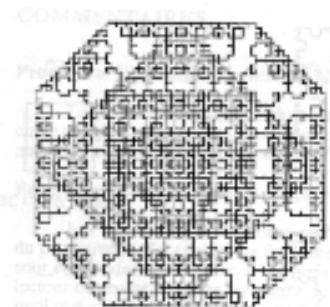
Niveau 2: on applique le même procédé à chacun des nouveaux segments ainsi déterminés.



Voici la courbe obtenue au niveau 6



- Autres exemples [DONY] p. 159



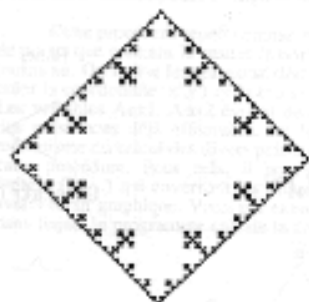
Base



Generatrice



Ordre 10



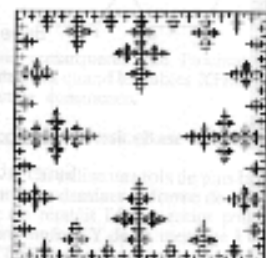
Base



Generatrice



Ordre 5



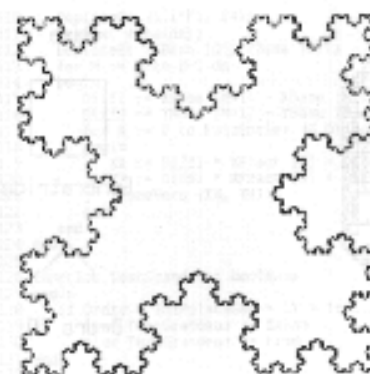
Base



Generatrice



Ordre 5



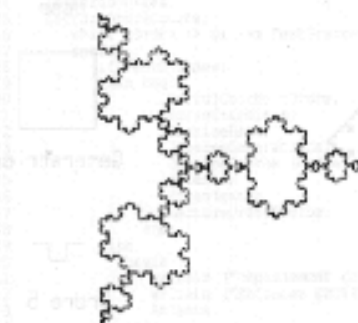
Base



Generatrice



Ordre 5



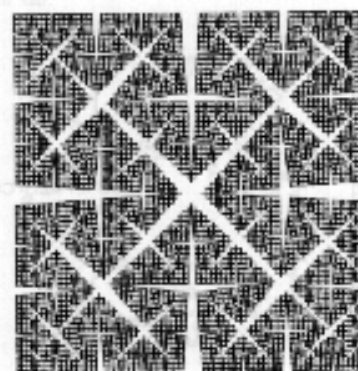
Base



Generatrice



Ordre 5



Base

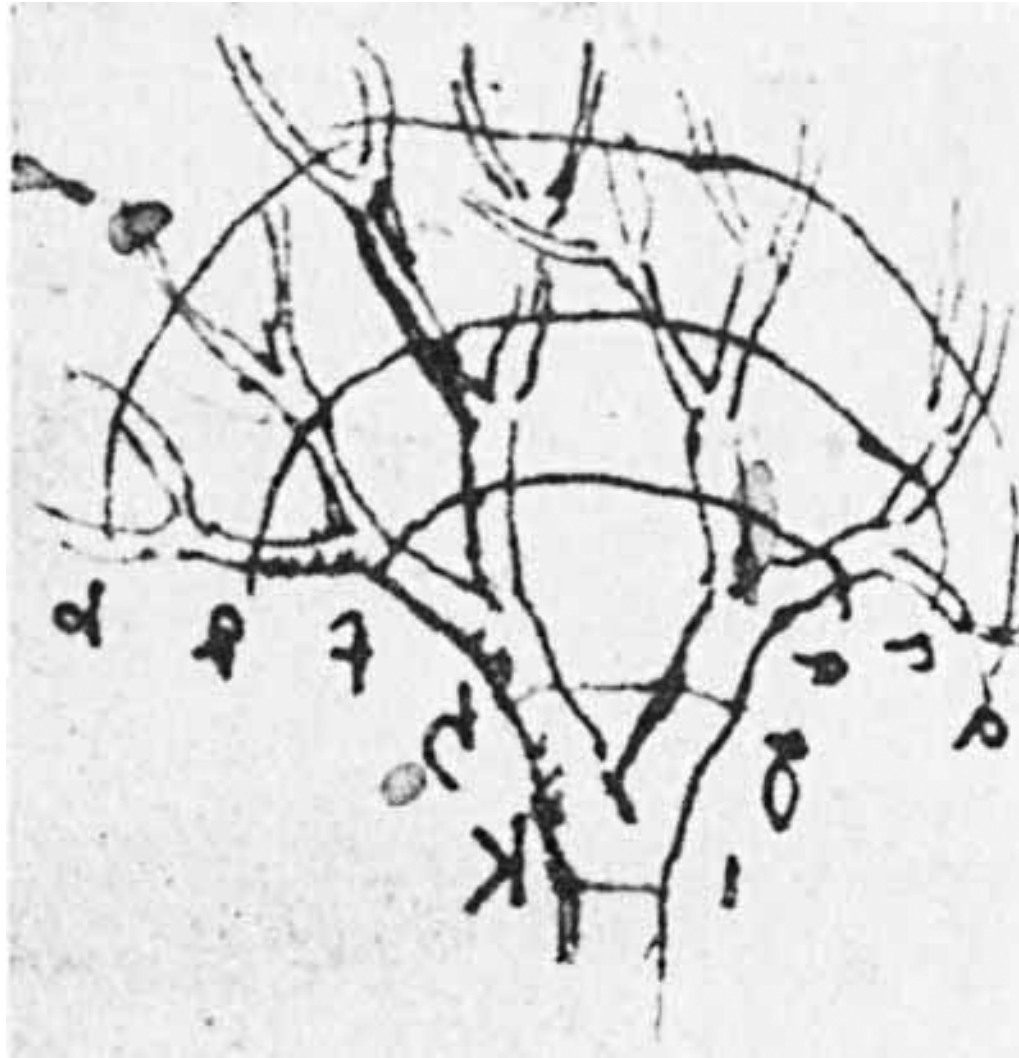


Generatrice



Ordre 6

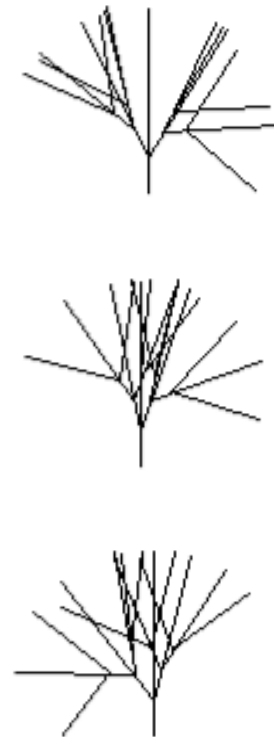
Croissance végétale



carnet de Léonard de Vinci

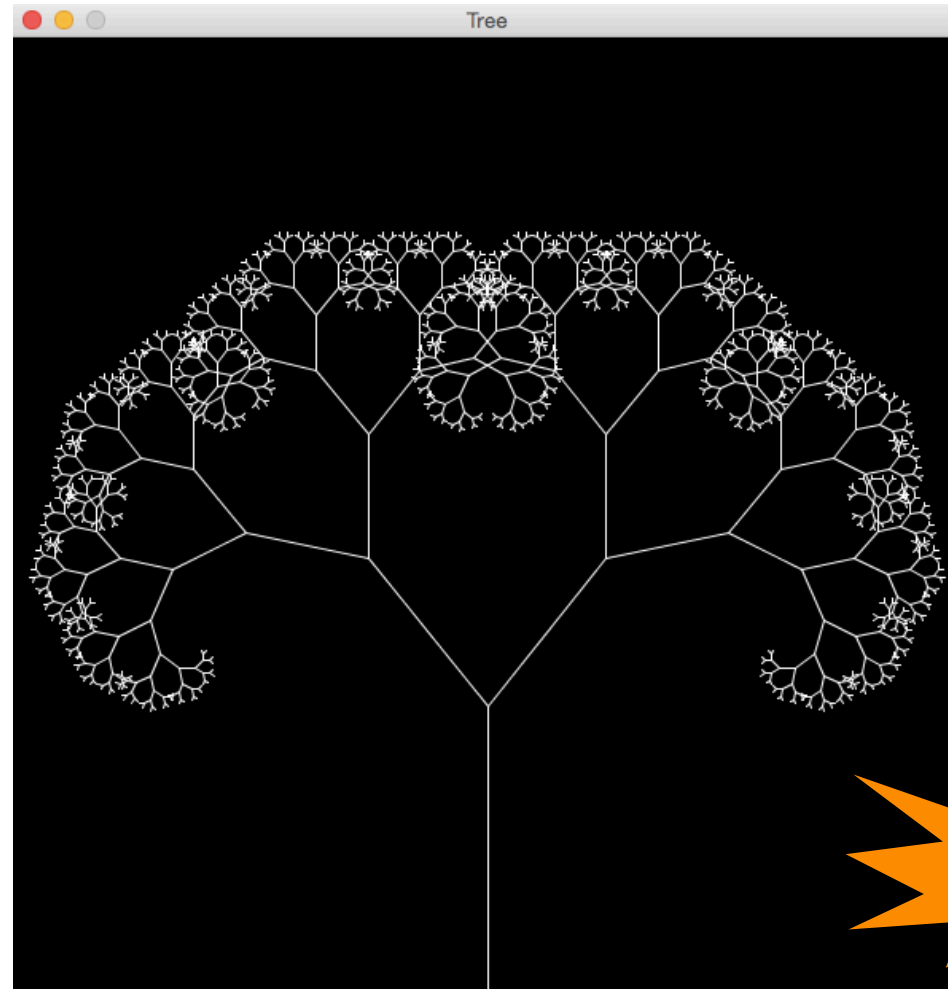
Algorithme récursif

```
void Fractale(Graphics g,int ax,int ay,int bx,int by,double
angle,int i) {
    g.drawLine(ax,ay,bx,by);
    if (i!=iter) {
        double ag=angle-Math.random()*ang;
        double ad=angle+Math.random()*ang;
        double dist=Math.sqrt((bx-ax)*(bx-ax)+(by-
ay)*(by-ay));
        int cx=(int) (pos*bx+(1-pos)*ax);
        int cy=(int) (pos*by+(1-pos)*ay);
        int dx=(int) (cx+rap*dist*Math.sin(ag));
        int dy=(int) (cy-rap*dist*Math.cos(ag));
        int ex=(int) (cx+rap*dist*Math.sin(ad));
        int ey=(int) (cy-rap*dist*Math.cos(ad));
        Fractale(g,cx,cy,dx,dy,ag,i+1);
        Fractale(g,cx,cy,ex,ey,ad,i+1);
    }
}
```



1^{er} prog. Java de P. Cubaud (1995)

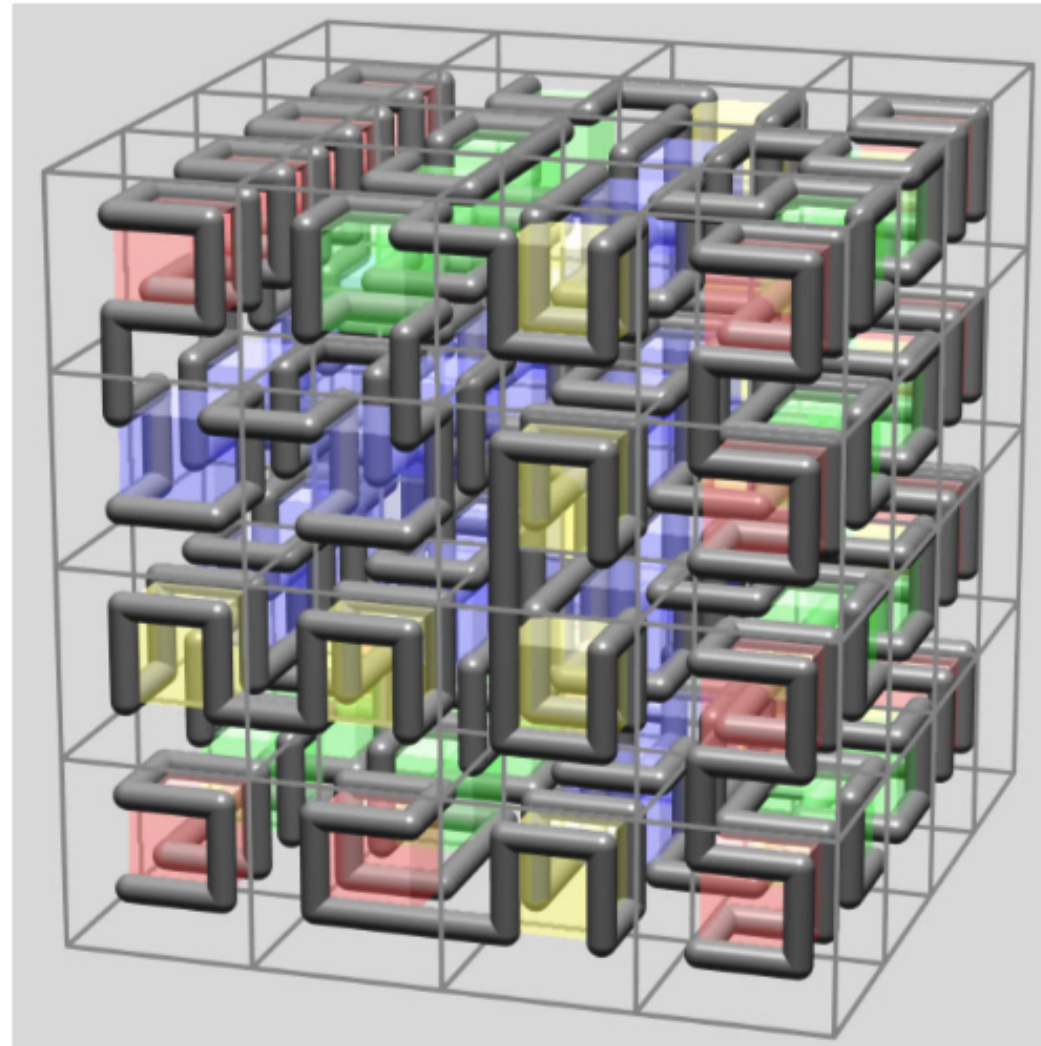
Code « Tree » dans Examples->Topics->Fractals and L-Systems





En 3D aussi !

[ABOP] p.20



$n=2, \delta=90^\circ$

A

A \rightarrow B-F+CFC+F-D&F^AD-F+&&CFC+F+B//

B \rightarrow A&F^ACFB^AF^AD^A^A-F-D^A|F^AB|FC^AF^A//

C \rightarrow |D^A|F^AB-F+C^AF^A&&FA&F^AC+F+B^AF^AD//

D \rightarrow |CFB-F+B|FA&F^A&&FB-F+B|FC//

Une technologie à maturité : exemple de FORESTER



<https://www.3dquakers.com/>