
Les images binaires...

Chapitre 4

Pourquoi tant d'intérêt ?

Un pas de plus vers l'interprétation

- Après la segmentation
 - Fond = blanc / formes = noires
 - 1 objet → 1 région → 1 composante noire
 - Comptage, analyse, caractérisation des objets à partir de l'image binaire

Morphologie mathématique et géométrie discrète

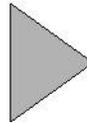
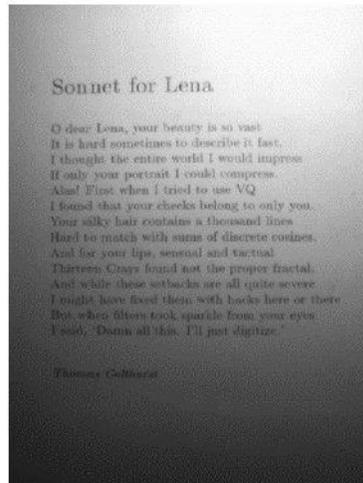
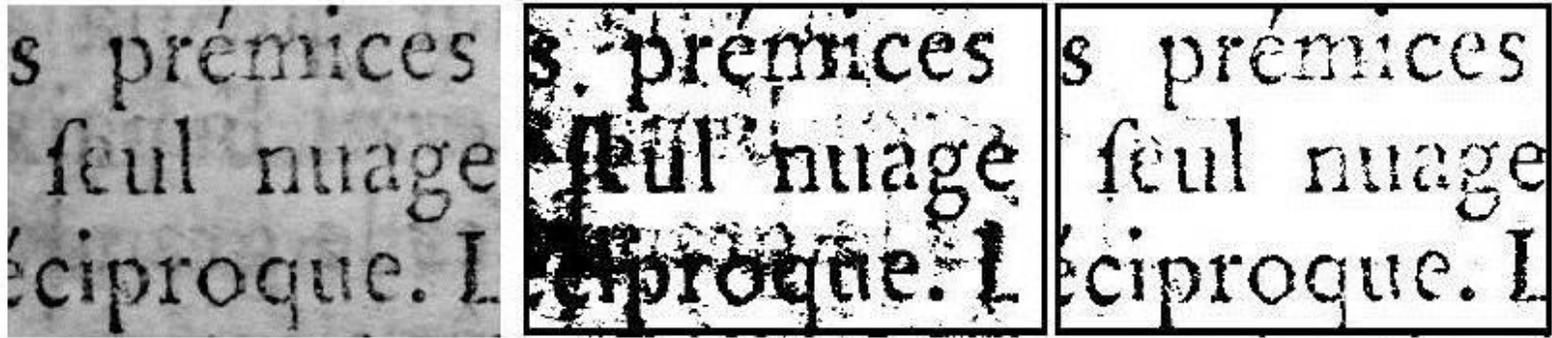
- Opérations sur les images binaires



Rappel sur la binarisation

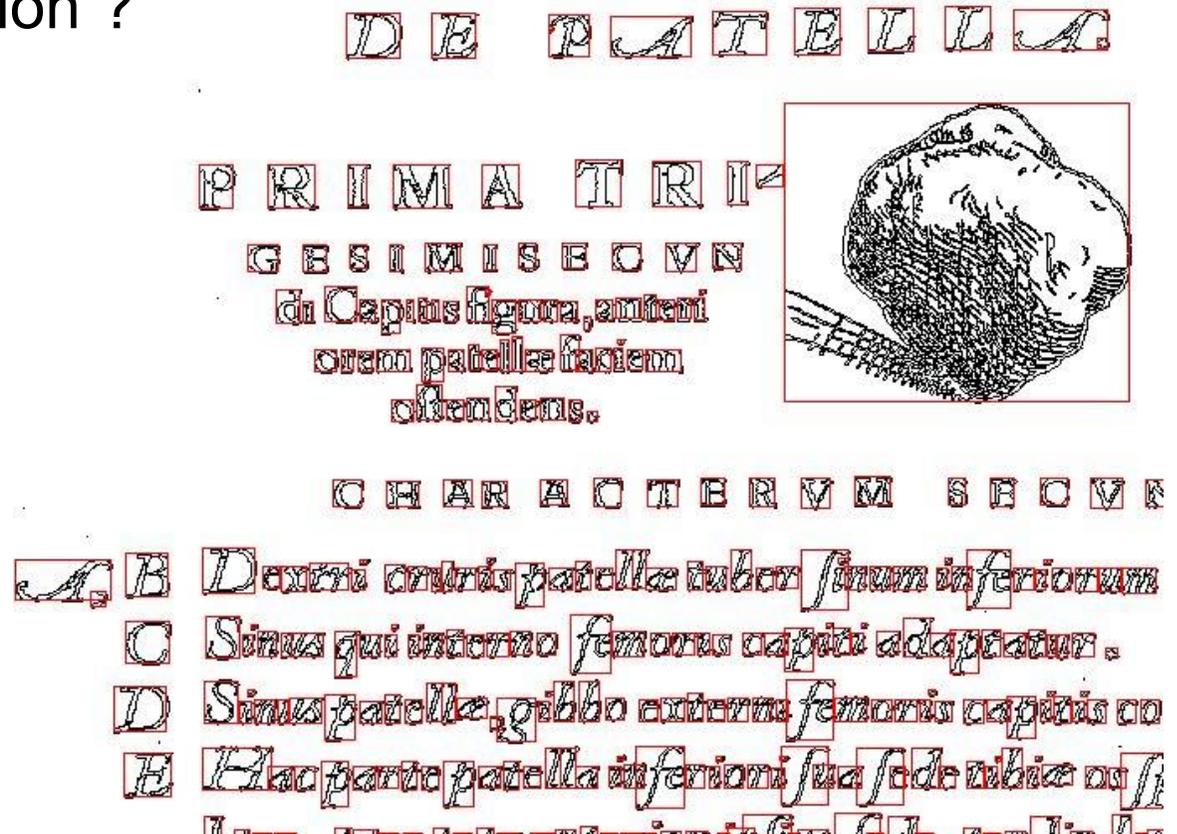
Transformer une image en niveau de gris en image binaire

- Comment choisir le bon seuil → une multitude de méthodes



Segmentation fond-formes

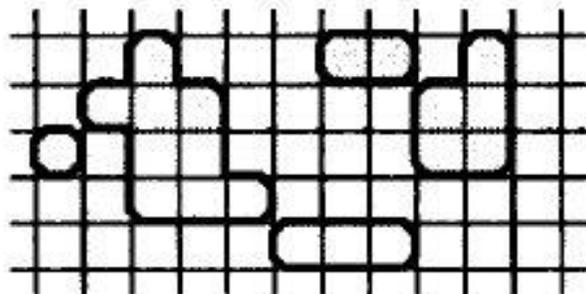
- Exploitation des **composantes connexes**
 - C'est quoi ?
 - Algorithme d'extraction ?



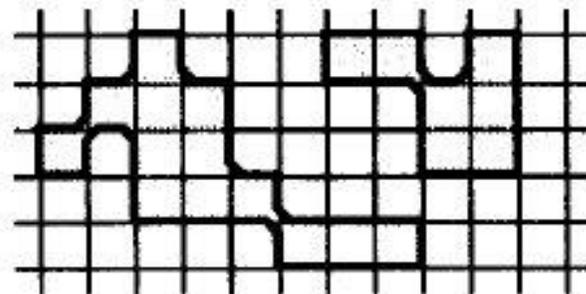
Extraction des composantes connexes

◆ Composante connexe

- Un ensemble S de pixels est une composante 4-connexe si et seulement si pour toute paire de pixels $P, Q \in S$, il existe un 4-chemin p_1, p_2, \dots, p_n tel que $p_1 = P$ et $p_n = Q$ et tous les $p_i \in S$.
- Un ensemble S de pixels est une composante 8-connexe si et seulement si pour toute paire de pixels $P, Q \in S$, il existe un 8-chemin p_1, p_2, \dots, p_n tel que $p_1 = P$ et $p_n = Q$ et tous les $p_i \in S$.



5 composantes 4-connexes



2 composantes 8-connexes

Extraction des composantes connexes

◆ Etiquetage de composantes connexes

```

. . . . .
. . . * * . . . * * * . . .
. . . * * . . . * * * . . .
. . * * * * . * * * * . . .
. . . * * * * * * * * . . .
. . . . . * * * * . . .
. . . . . * * * . . * . .
. . * * . . * * * . . * * .
. . * * . . . . . . . .
. . . . .

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(b) Original binary image.

```

. . . . .
. . . 1 1 . . . 2 2 2 . . .
. . . 1 1 . . . 2 2 2 . . .
. . 1 1 1 1 . 2 2 2 2 . . .
. . . 1 1 1 ? * * * * . . .
. . . . . * * * * . . .
. . . . . * * * . . * . .
. . . . . * * * . . * * .
. . * * . . * * * . . * * .
. . * * . . . . . . . .
. . . . .

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(c) Labeling in progress.

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. . . . .
. . . 1 1 . . . 2 2 2 . . .
. . . 1 1 . . . 2 2 2 . . .
. . 1 1 1 1 . 2 2 2 2 . . .
. . . 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 . . .
. . . . . 1 1 1 . . 3 . .
. . . . . 1 1 1 . . 3 3 . .
. . 4 4 . . 1 1 1 . . 3 3 . .
. . 4 4 . . . . . . . .
. . . . .

```

(d) Scanning completion.

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. . . . .
. . . 1 1 . . . 1 1 1 . . .
. . . 1 1 . . . 1 1 1 . . .
. . 1 1 1 1 . 1 1 1 1 . . .
. . . 1 1 1 1 1 1 1 1 . . .
. . . . . 1 1 1 1 . . .
. . . . . 1 1 1 . . 2 . .
. . . . . 1 1 1 . . 2 2 . .
. . 3 3 . . 1 1 1 . . 2 2 . .
. . 3 3 . . . . . . . .
. . . . .

```

(e) After label unification and reassignment.

Composantes connexes

• Analyse de documents textuels

- α, α 1, 5 *Secundum fibulae latus.*
- γ, γ 1, 3 *Prima tibiae ossis linea.*
- ε, ε 1, 2, 3, 4 *Tertia tibiae ossis linea.*
- η 1, 3 *Secundum tibiae ossis latus.*
- κ 2, 4 *Aspera tertij tibiae ossis lateris linea, cui musculus in*

dl.

Tibia.

Fibula.

Tibia os.

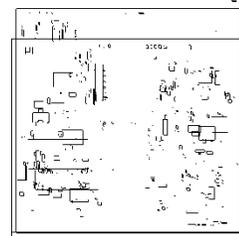


TIBIA similiter atque in crates perpetuò tibiae ossa appelle quod totius membri nomine *levh* exteriùs locatur, & interiori crassi *gòvq*, Latinis autem fura & fibula u dio crassius os, tibiae os appellab^r guens, quod his ossibus, musculi nia ambienti formatur. Gracilius autem os fibula opp ci, quia ueluti tibiae uenter est, *γαστρονομία* nuncupant^r supra infraq; appendix coalescit, ac superior quidē tibi est, anteriori tamen sede crassior, ac in anteriori tibiae r^e sum duci cernitur. Huic* duo oblongi insculpuntur i distincti, & lubrica cartilagine incrustati. His sinibus i

Tibiae ossis & fibulae appendices.

Sedes cui femur ad tibiam articuletur.

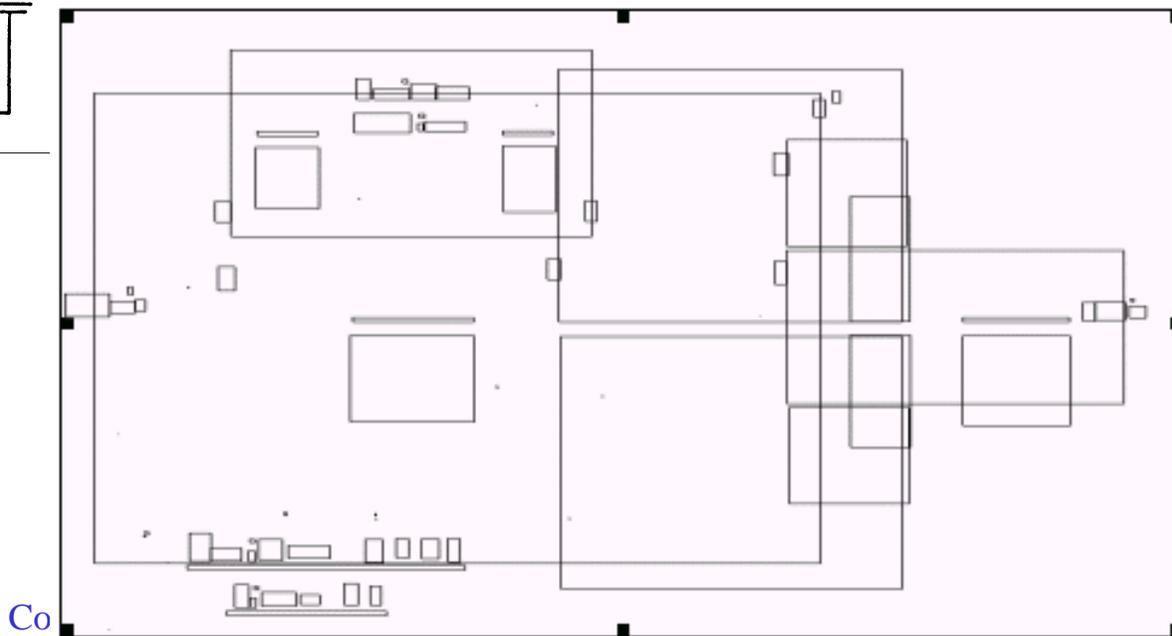
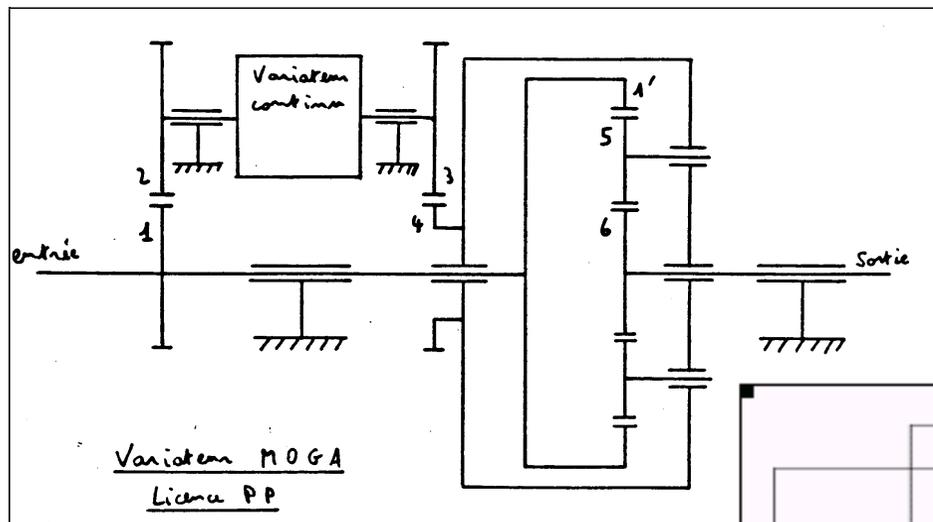
Handwritten text in a historical script, likely Hebrew or Aramaic, with some words underlined.



Handwritten text in a historical script, continuing the discussion or providing further details related to the anatomical diagram.

Séparation Texte – Graphique ?

- Découpage en couches superposées ?



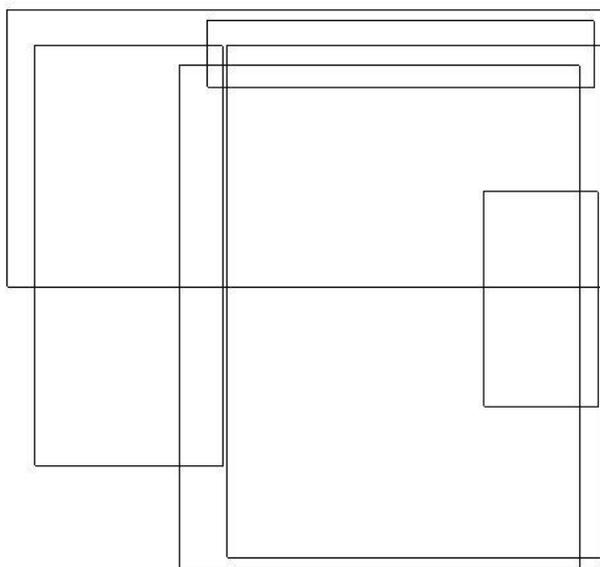
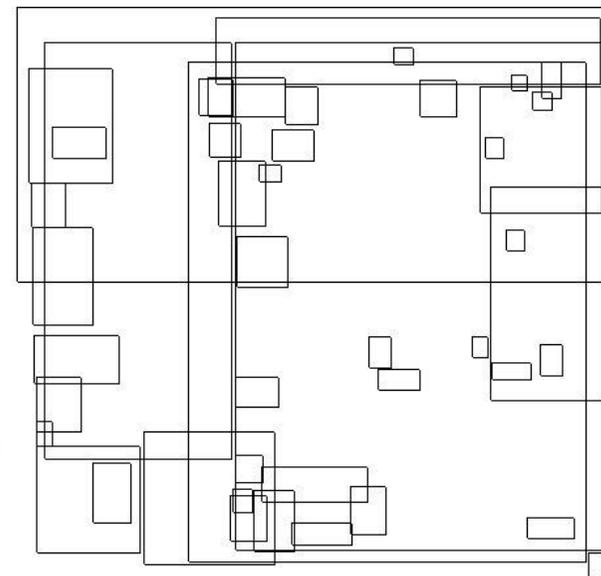
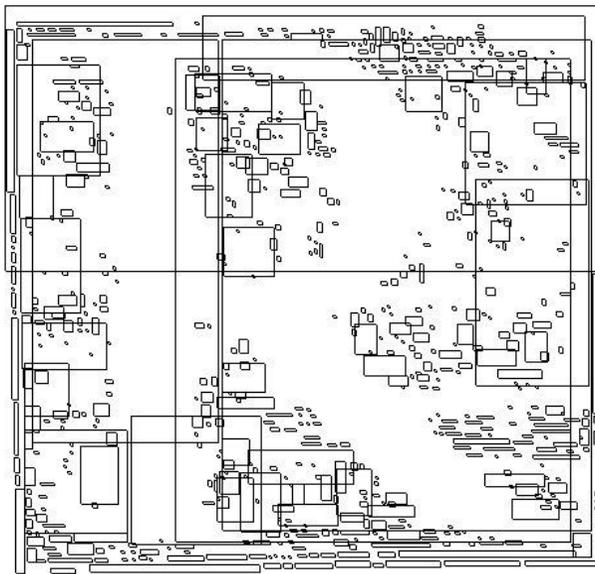
Application : Analyse de structure de page

■ Principe

- Analyse des composantes connexes
- Fusion des ccx en éléments de plus en plus importants
- Propriétés utilisées pour la fusion sont soit connues a priori ou déduites directement à partir de calculs statistiques sur les espacements de l'image.



Le problème : rupture de connexité

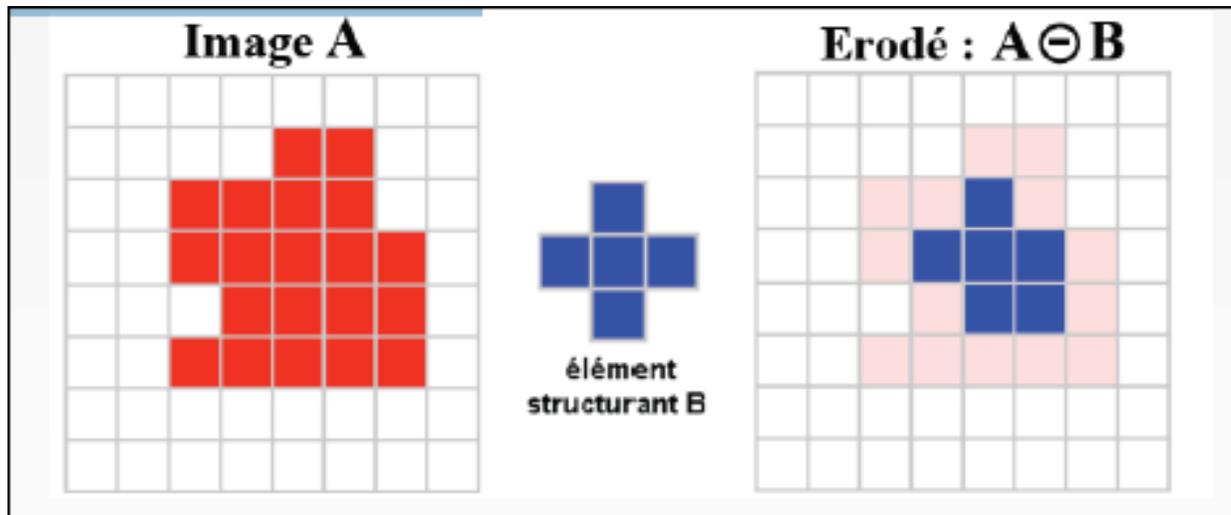


Opération d'Erosion

Soit B un élément structurant et Bx l'élément positionné sur le pixel x

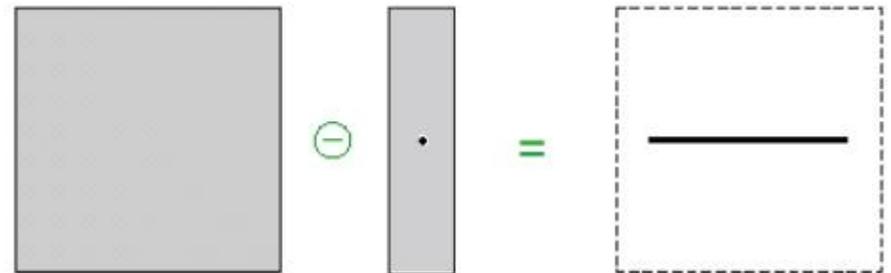
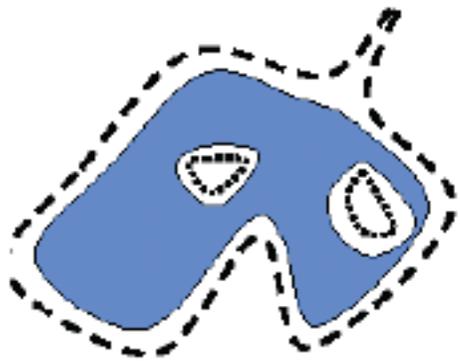
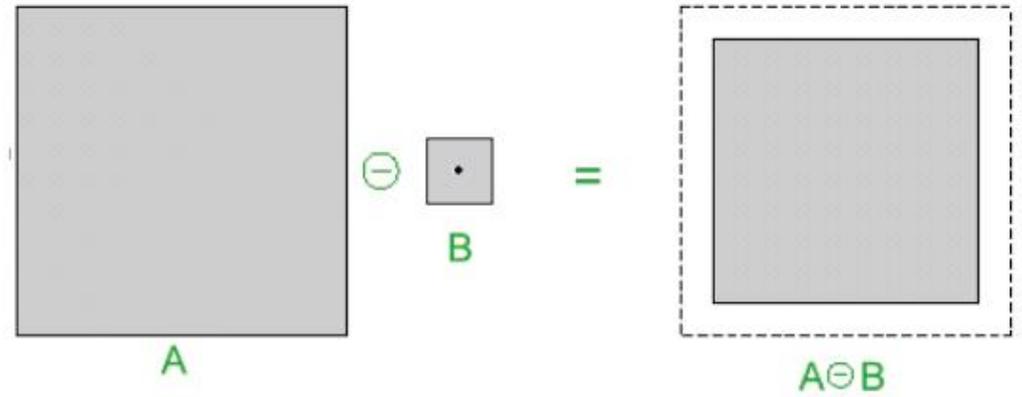
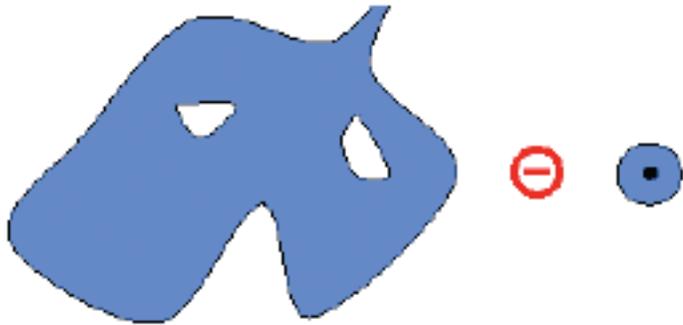
Algorithme :

- On positionne l'origine de B en chaque pixel x de l'objet A.
- Si tous les pixels de B font partie de l'objet A, alors l'origine de B appartient à l'érodé



Erosion

- Exemples

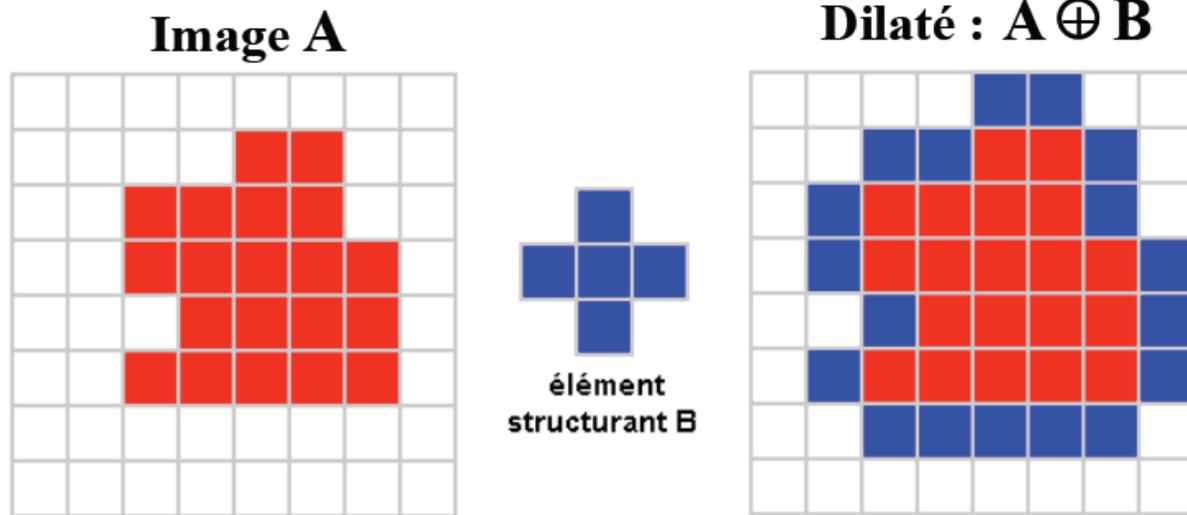


Opération de Dilatation

Soit B un élément structurant et Bx l'élément positionné sur le pixel x

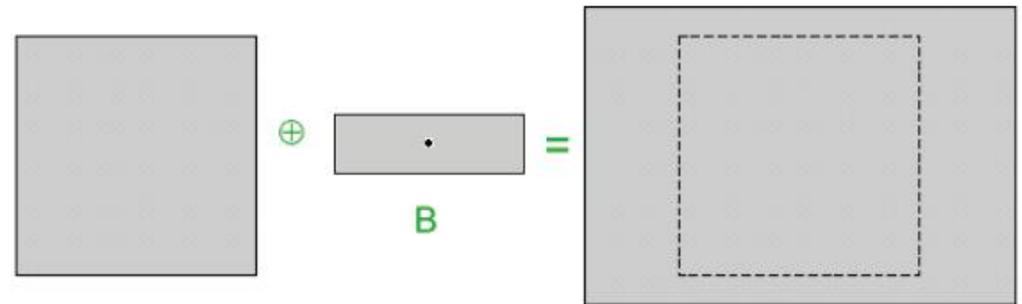
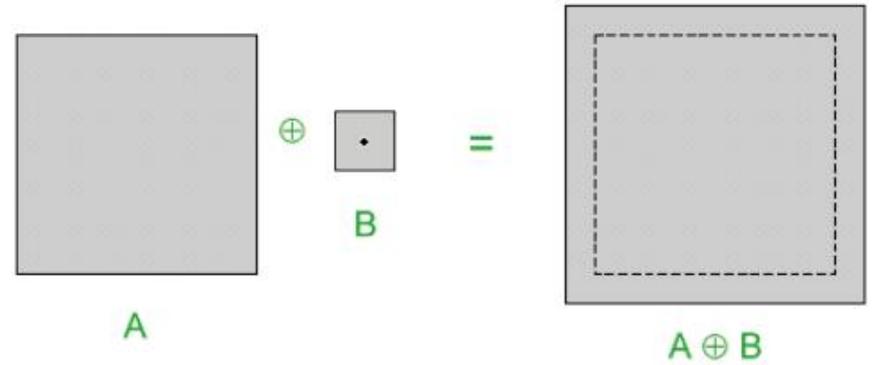
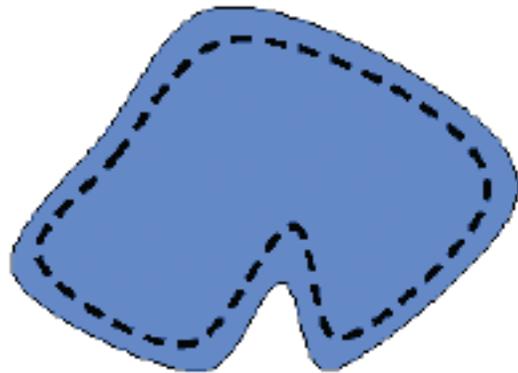
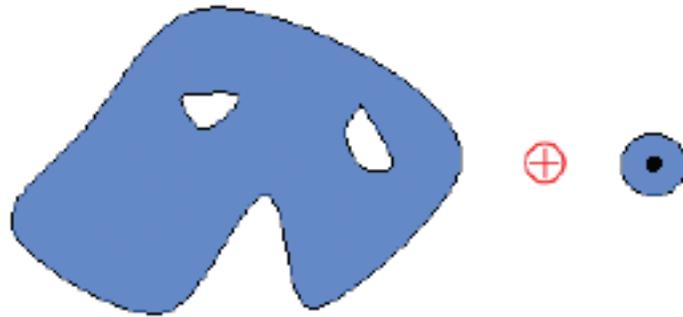
Algorithme :

- On positionne l'origine de B en chaque pixel x de l'objet A.
- Si l'intersection de B et de A est non vide, alors l'origine de B appartient à l'image dilatée



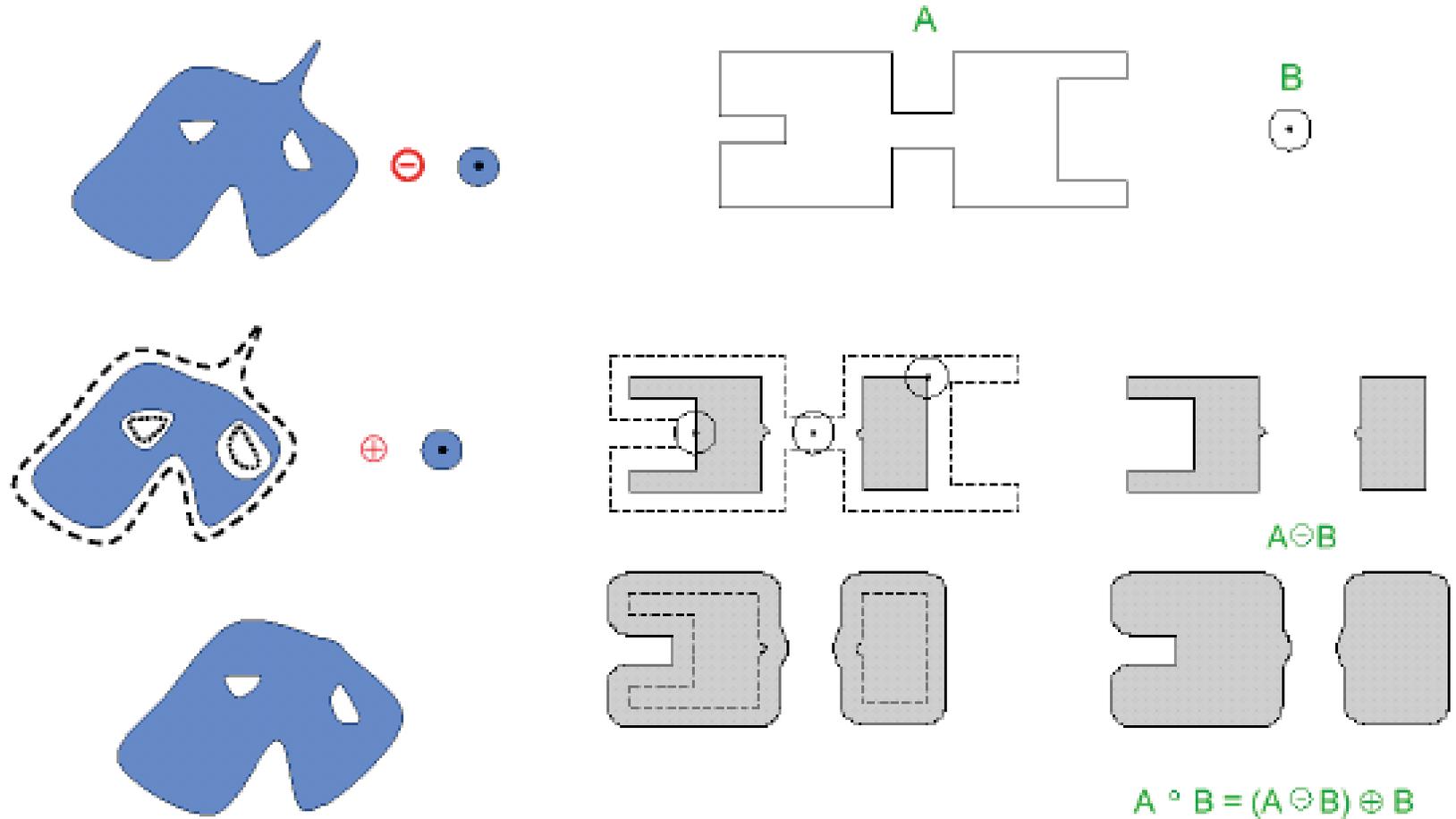
Dilatation

- Exemples



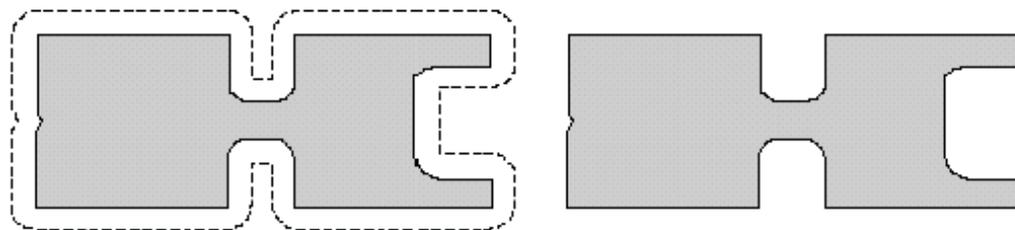
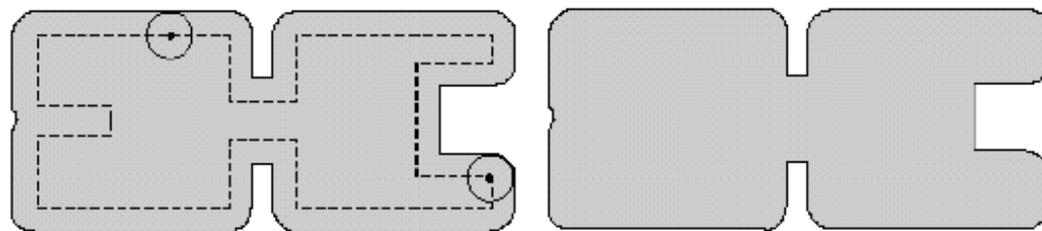
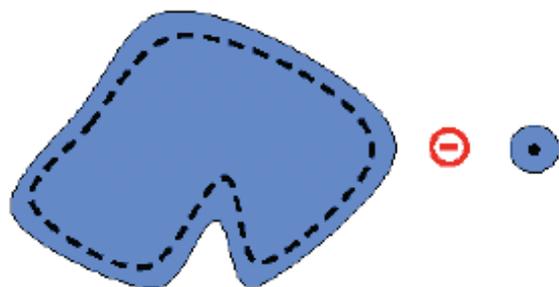
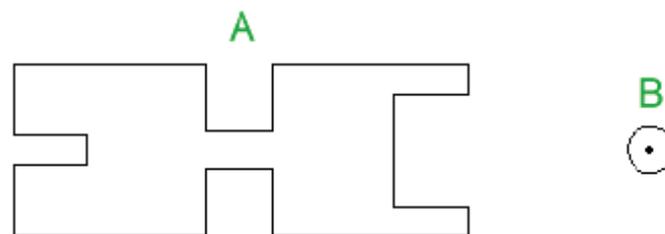
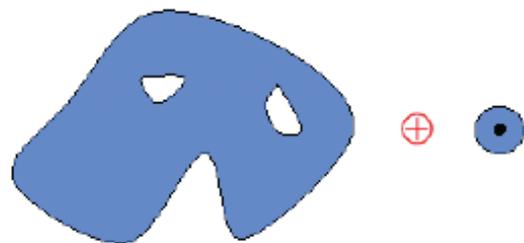
Opération d'Ouverture

- $A \vee B = (A - B) + B$



Opération de Fermeture

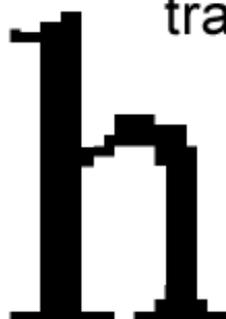
- $A \bullet B = (A \oplus B) \ominus B$



$$A \bullet B = (A \oplus B) \ominus B$$

Restauration d'images binaires

Application de masques binaires

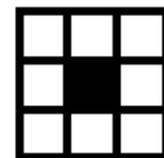


Pixels isolés

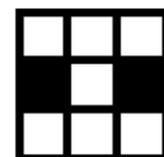
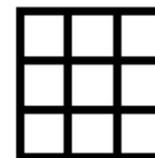
traits Verticaux

Réparation rupture

Si



alors



Ect...

Restauration d'images binaires

CHRI
BEAV-IE
BEAV-I
Vavaignac D



Restauration d'images binaires



Élément structurant

- Un choix important



Dilatations



Dilatations



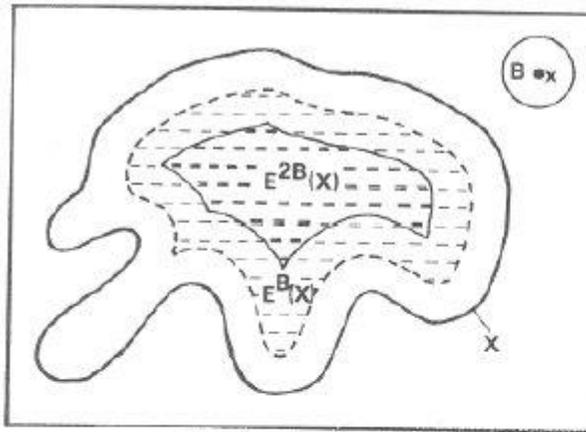
Erosions



Erosions

Squelettisation

Traitements itératifs (exemple : érosions itératives)

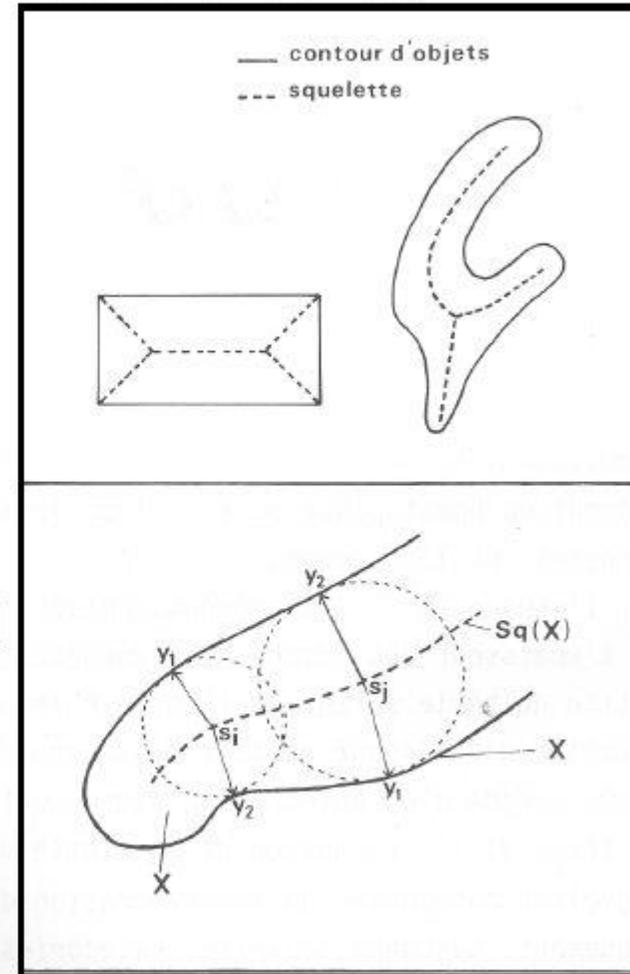


Squelettes

L'ensemble des points situés à équidistance de deux points du bord

L'ensemble des centres des boules maximales incluses dans la forme

Les squelettes sont calculées par érosion morphologique



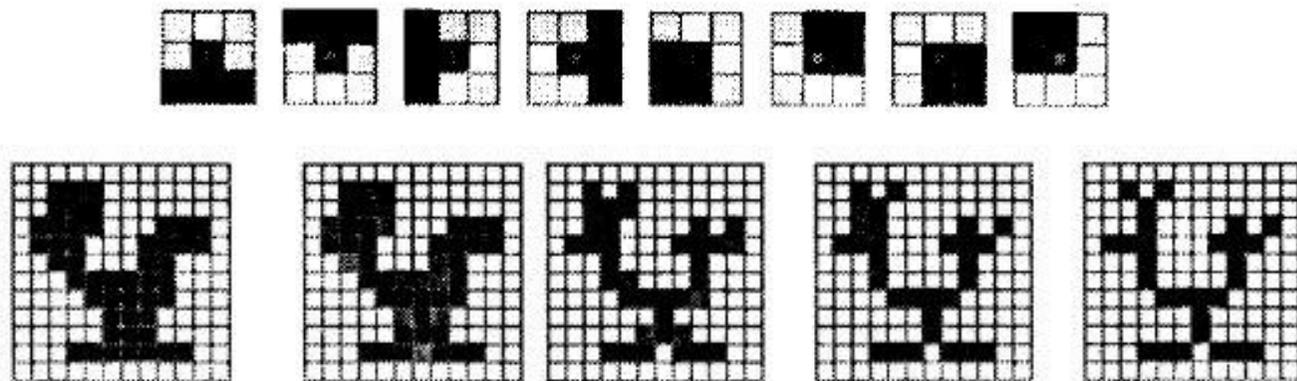


Illustration de la construction du squelette: composante initiale X , amincissement par les masques M_1 à M_4 , résultat des deux premières itérations et squelette obtenu $Sq(X)$

Élagage

La squelettisation produit souvent des formes bruitées caractérisées par des barbules se greffant sur le squelette proprement dit. L'élagage est une opération morphologique qui permet de supprimer les barbules.

Le procédé consiste à éliminer de manière itérative des pixels terminaux au moyen des masques.

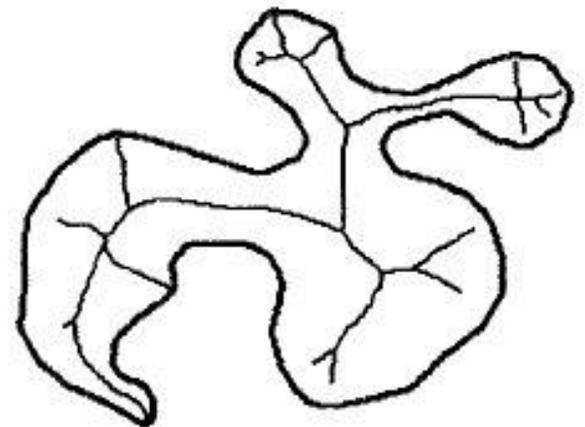
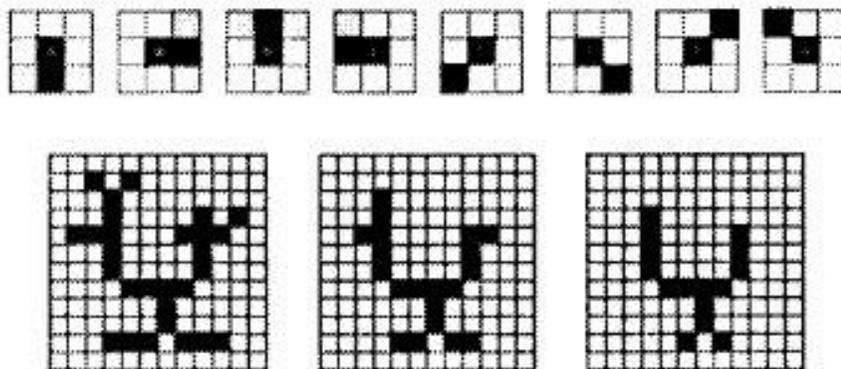
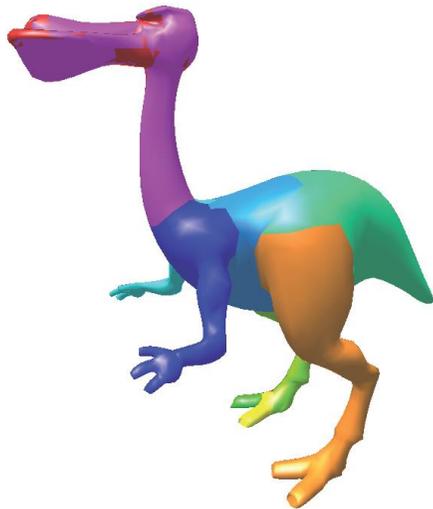
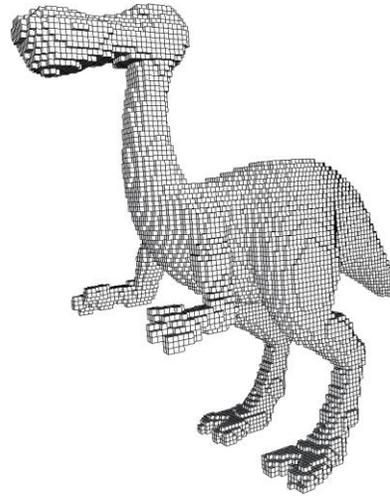
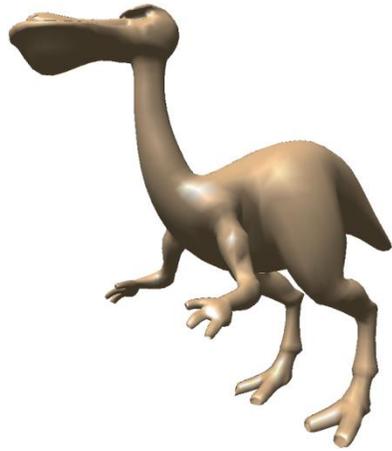


Illustration de l'élagage d'un squelette obtenu en deux itérations successives

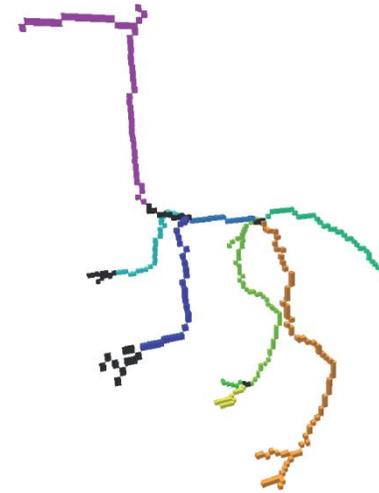
Squelette en 3D



C

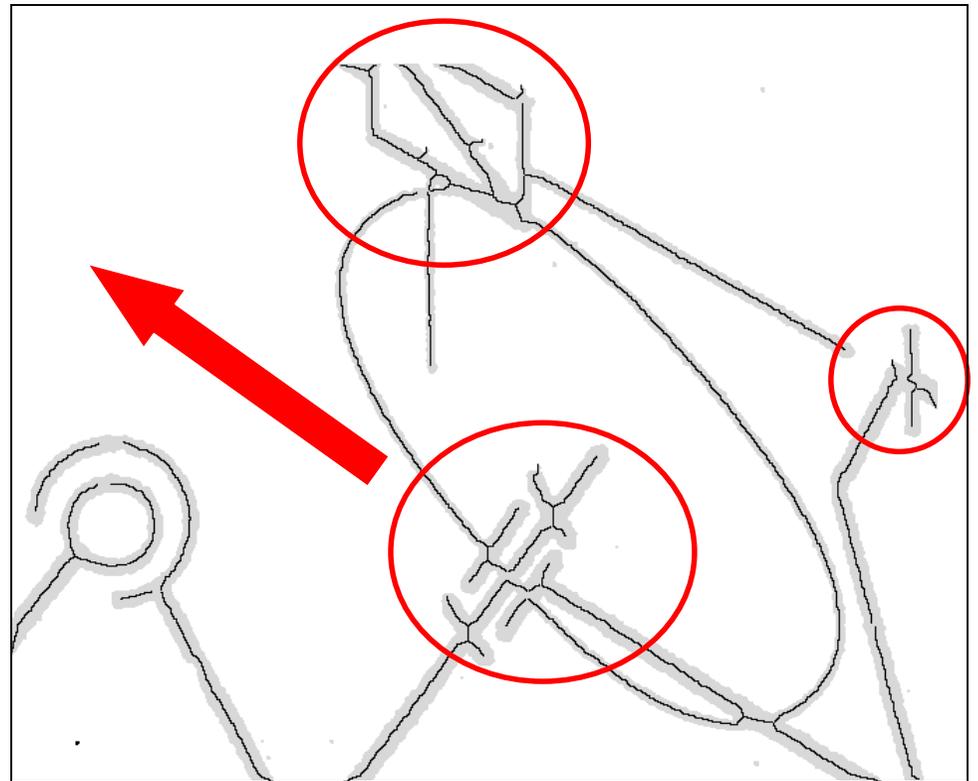
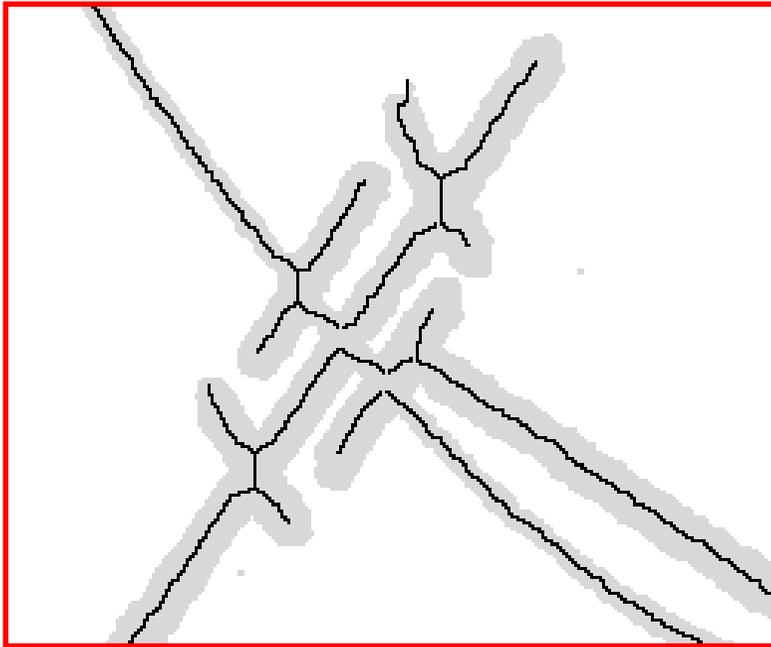


A



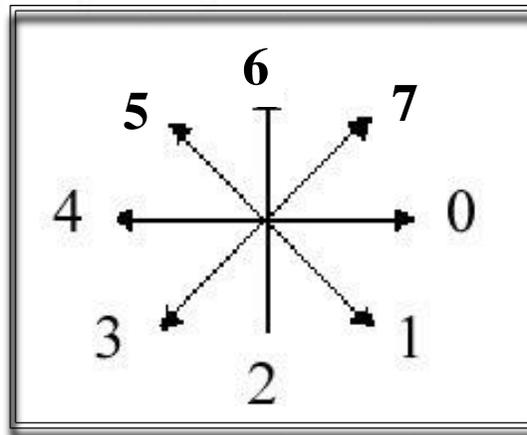
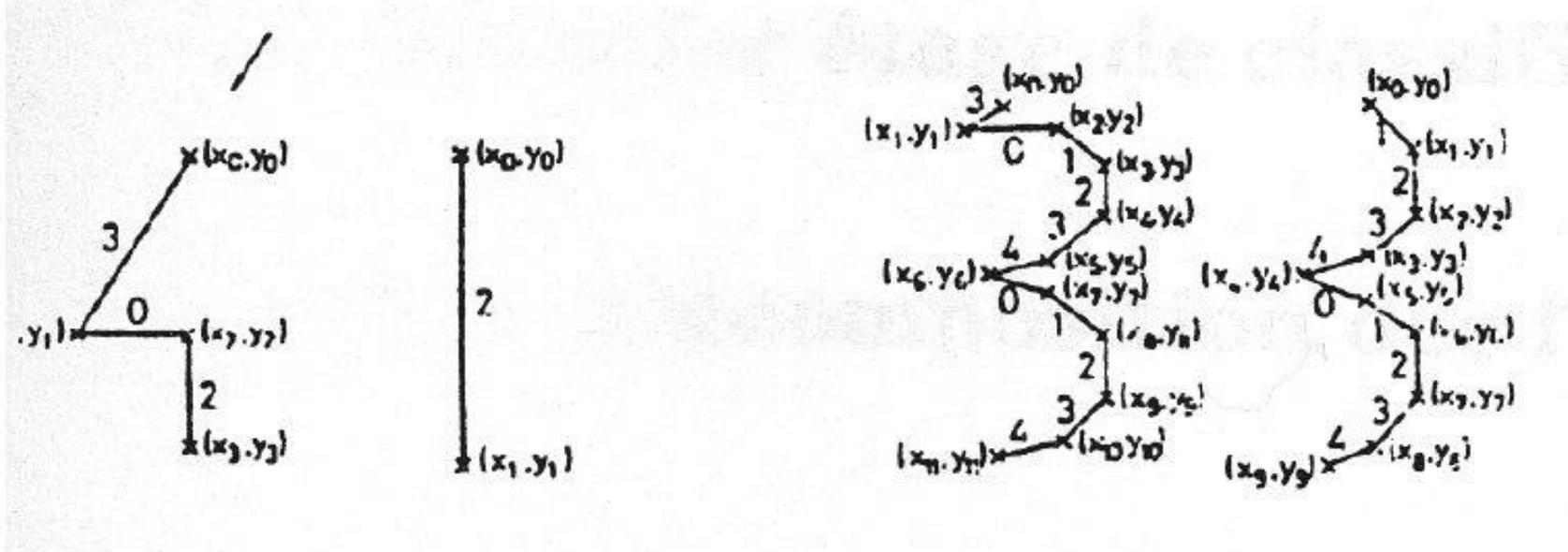
Problème du squelette . . .

Barbules, jonctions et croisements

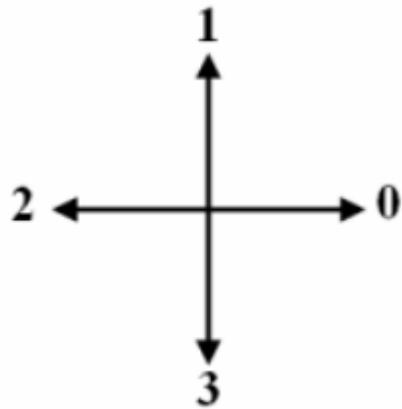


Squelette, vecteurs et après ?

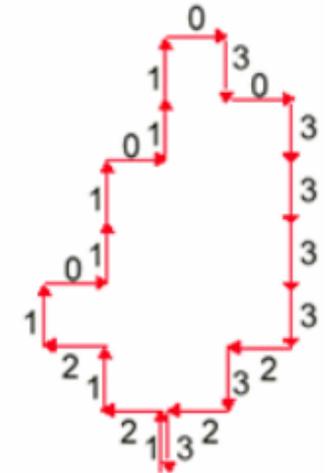
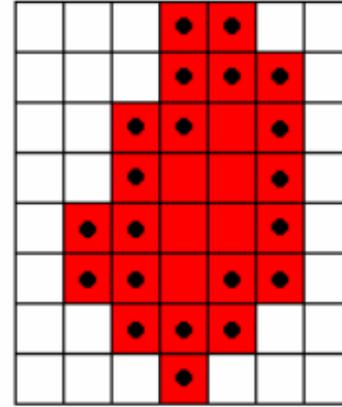
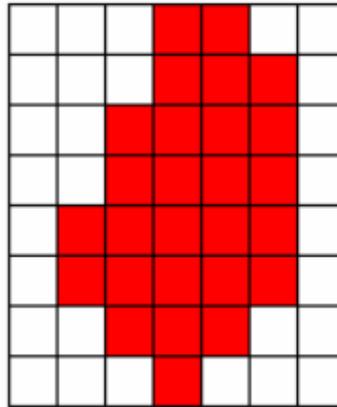
Chainage (suivi) du squelette \rightarrow directions de Freeman



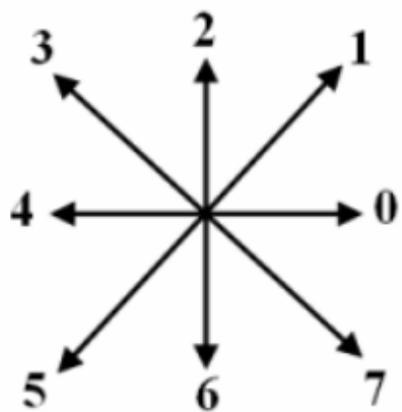
Codage de Freeman



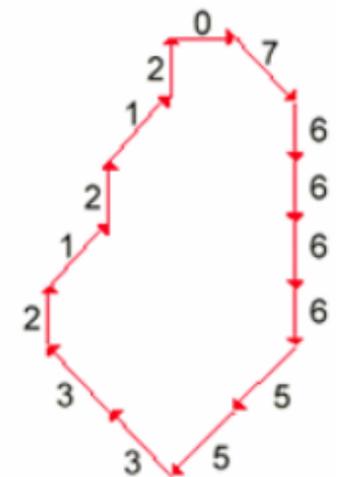
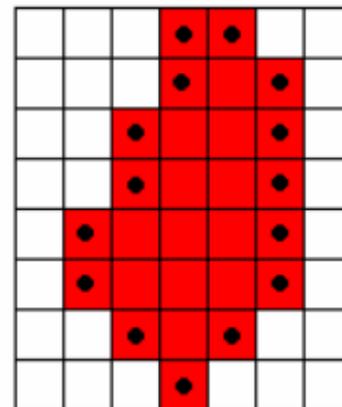
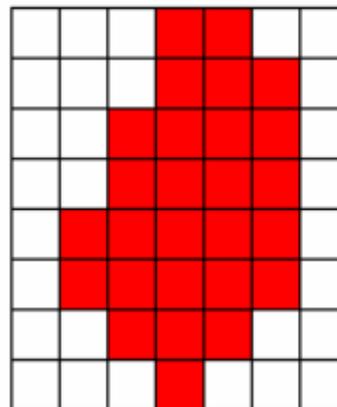
4-connexité



03033333232312121011



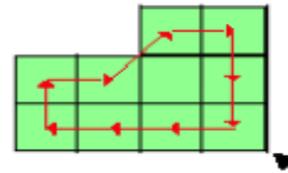
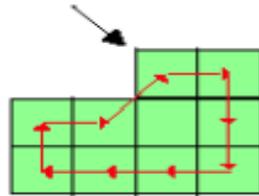
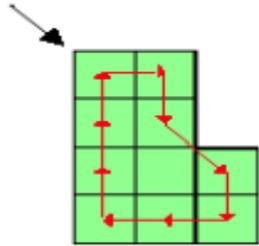
8-connexité



076666553321212

Codage de Freeman

- Indépendance de l'origine et de l'orientation



Code du contour

067644222

066444201

444201066

Courbure = différence

-6-11202002

-6020022-11

0022-11-602

Courbure normalisée = différence modulo 8

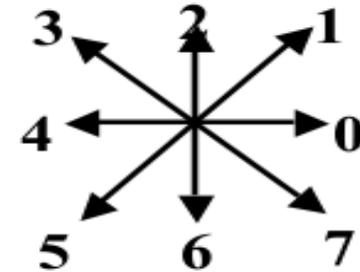
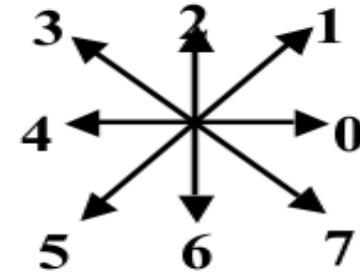
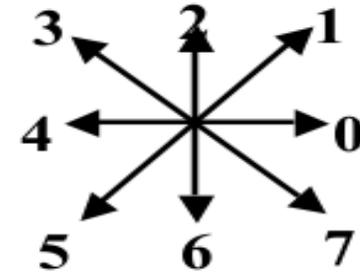
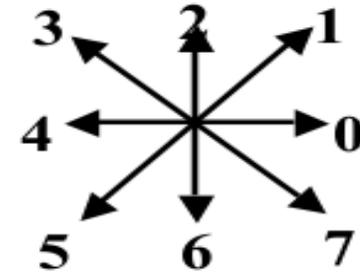
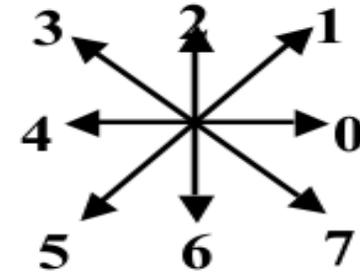
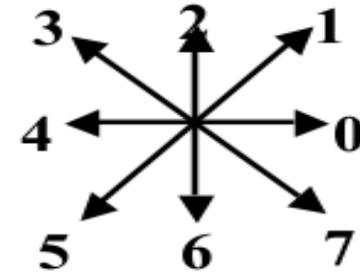
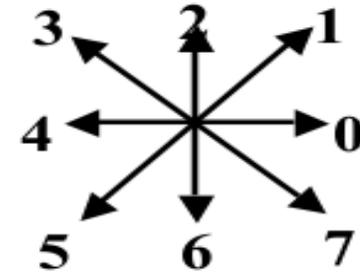
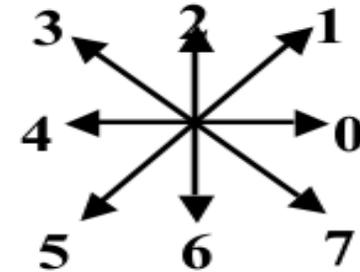
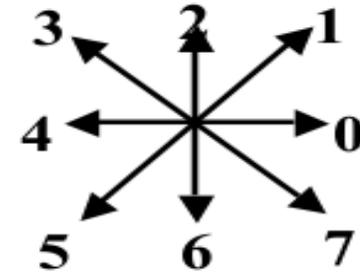
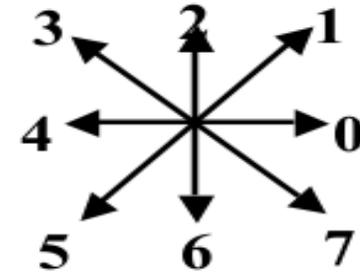
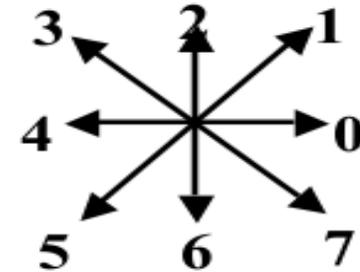
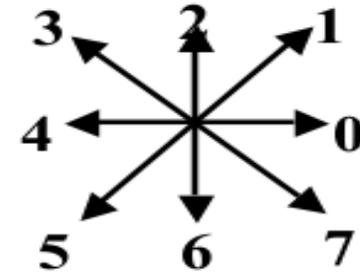
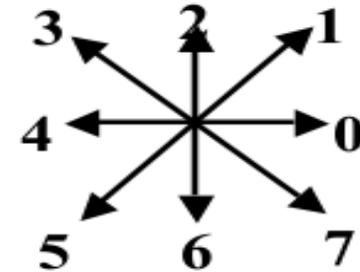
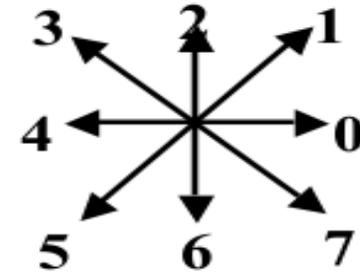
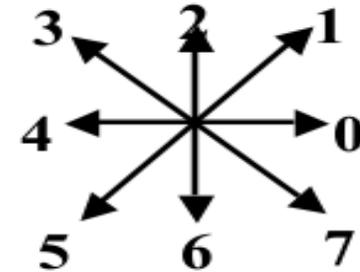
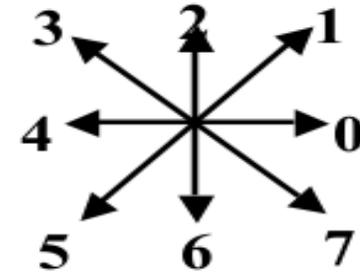
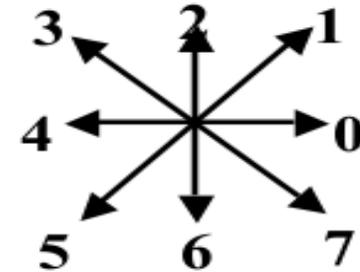
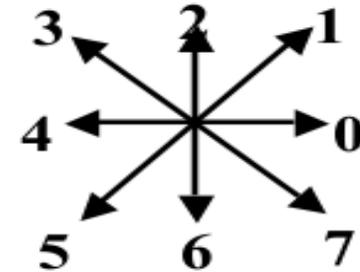
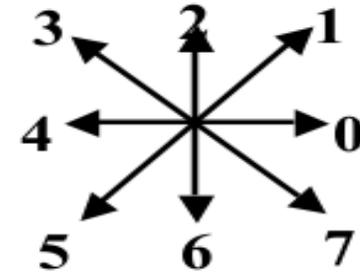
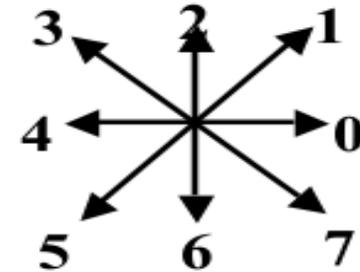
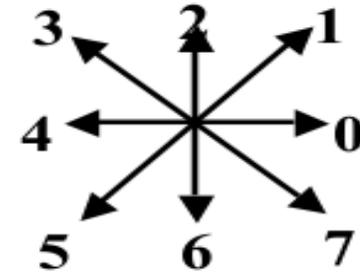
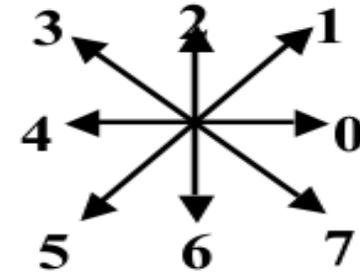
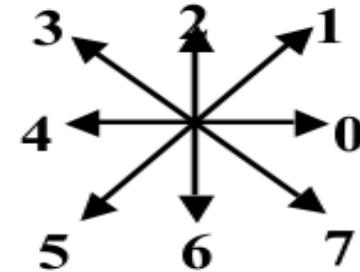
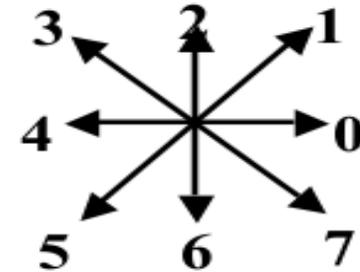
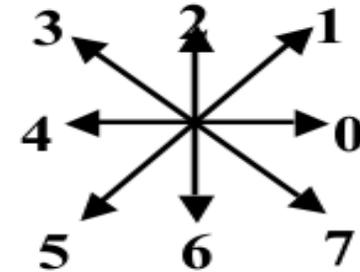
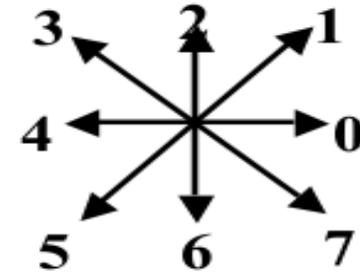
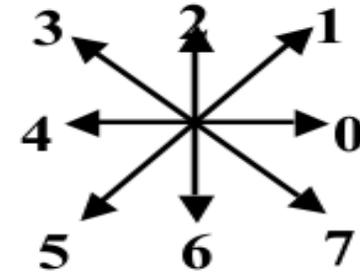
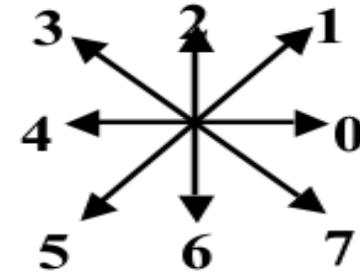
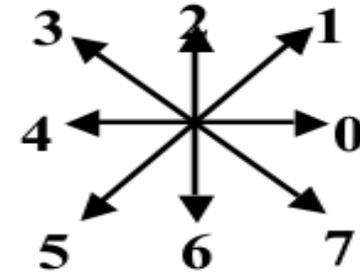
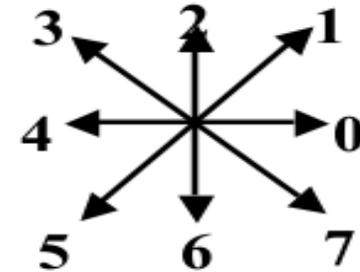
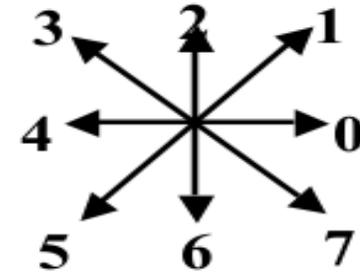
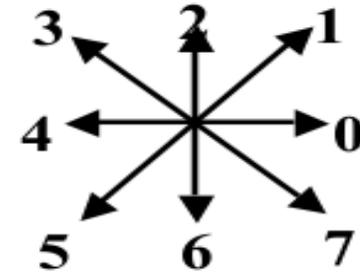
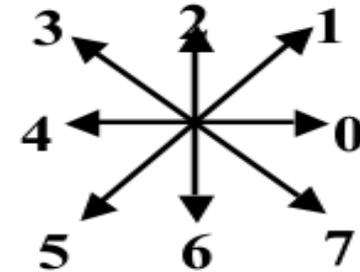
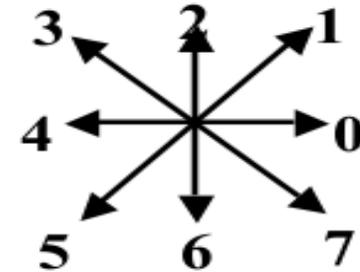
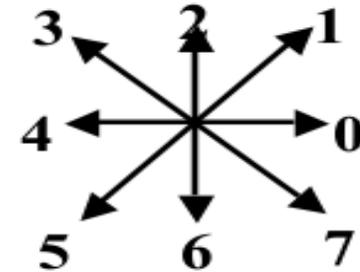
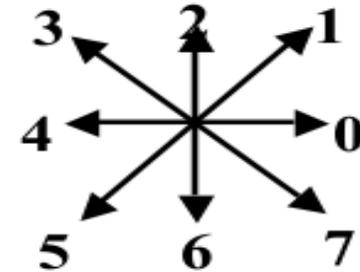
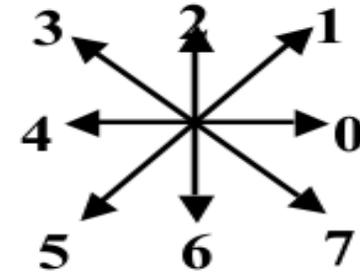
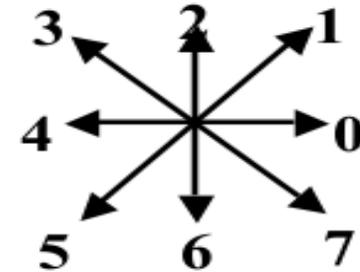
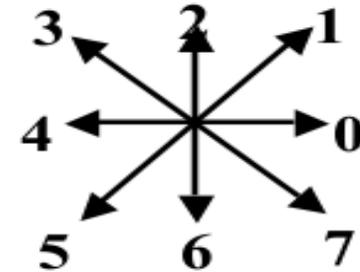
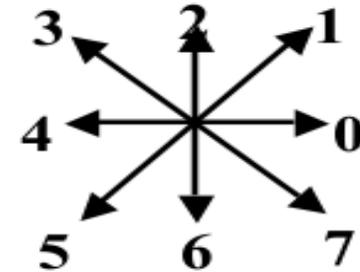
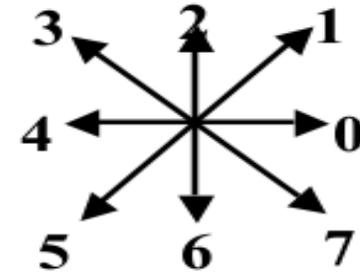
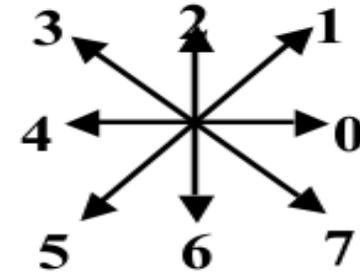
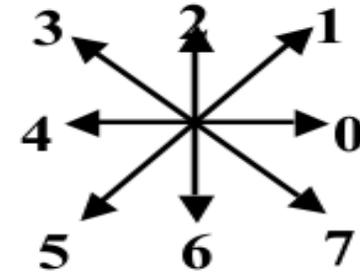
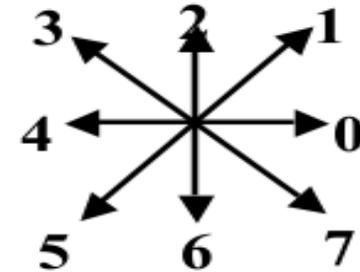
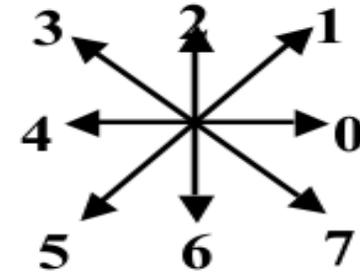
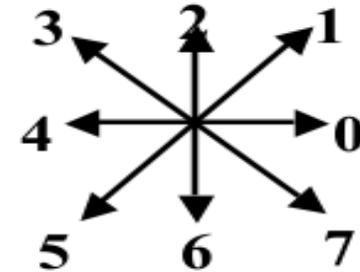
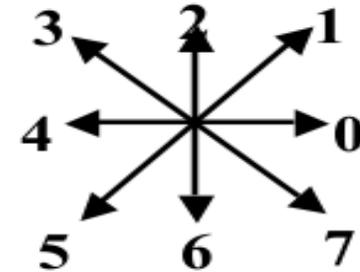
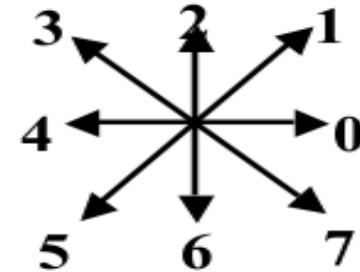
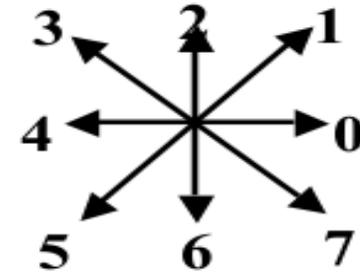
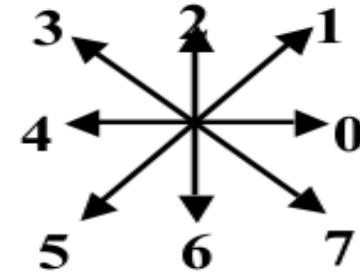
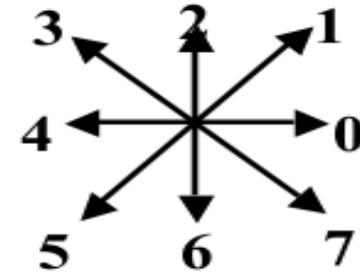
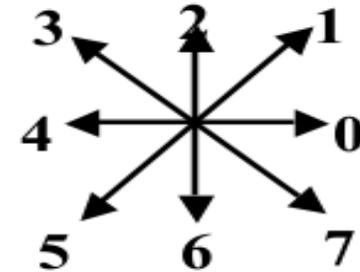
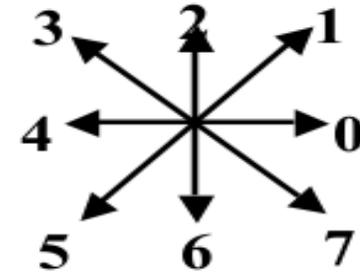
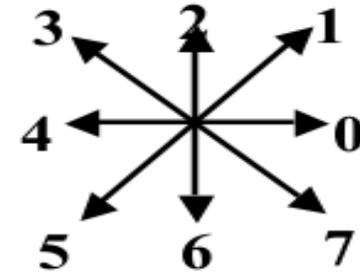
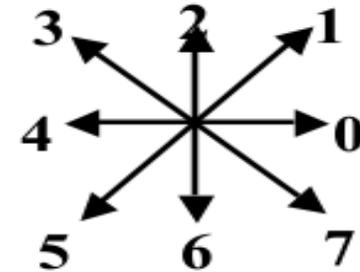
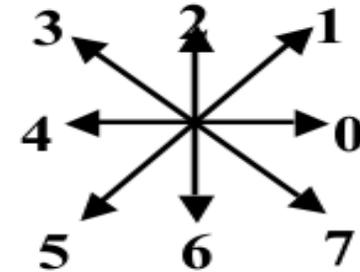
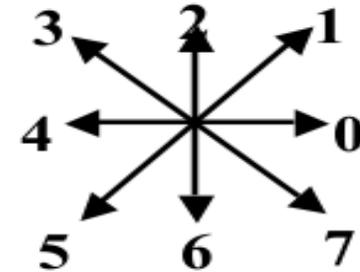
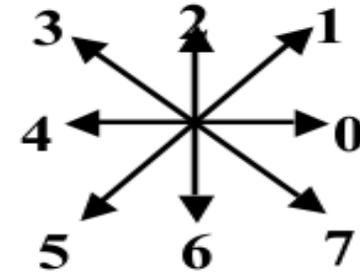
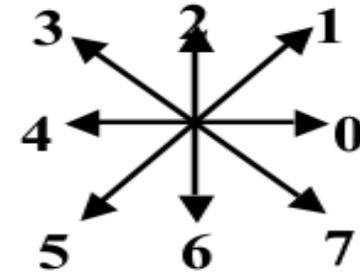
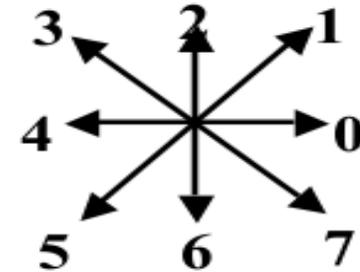
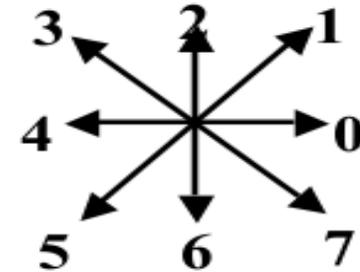
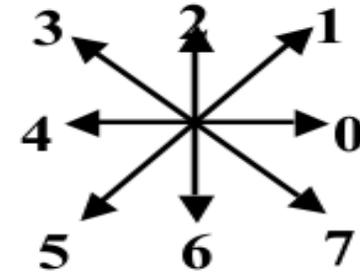
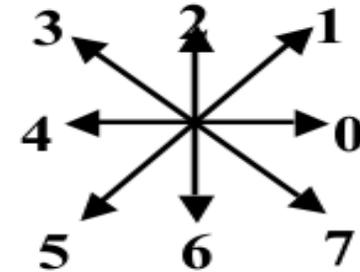
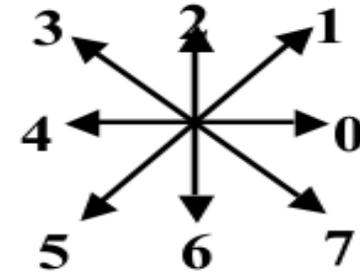
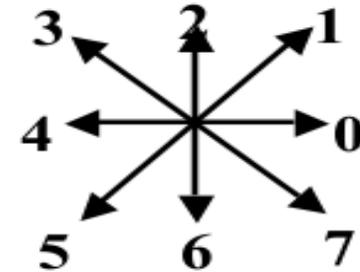
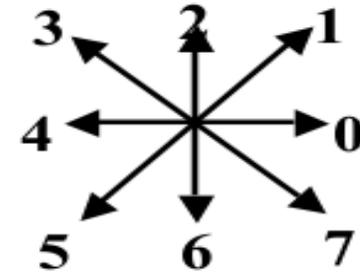
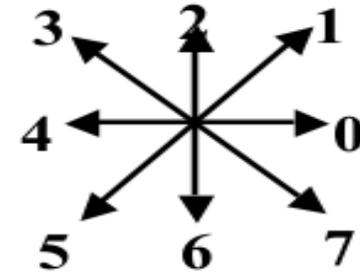
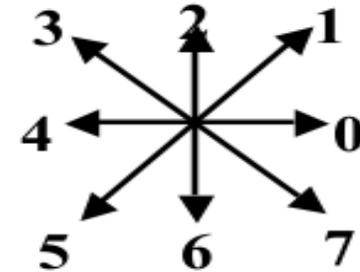
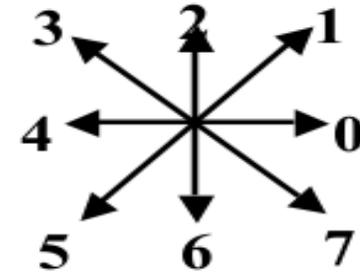
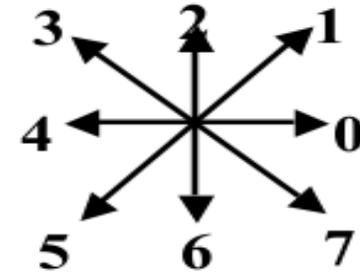
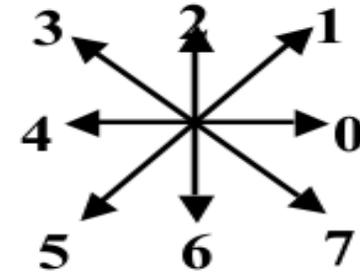
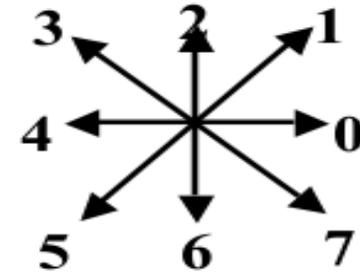
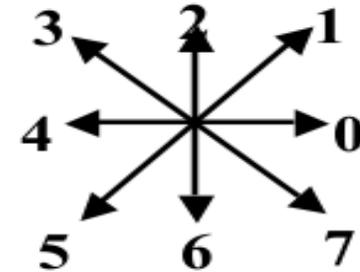
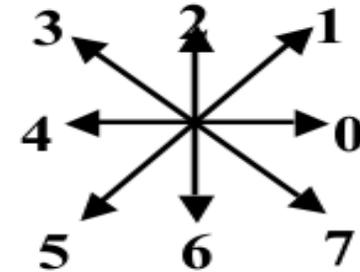
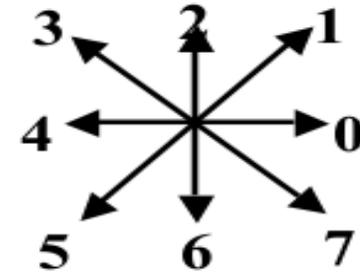
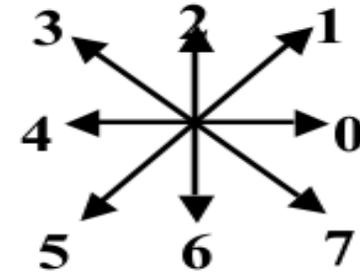
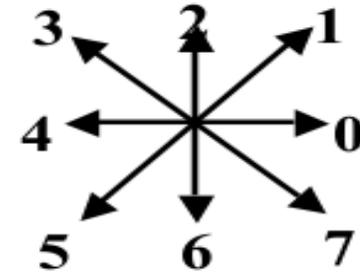
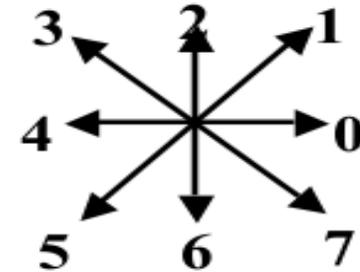
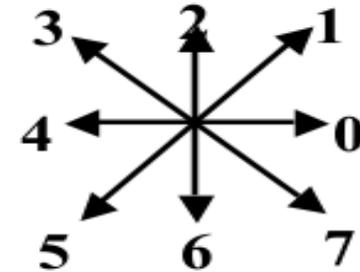
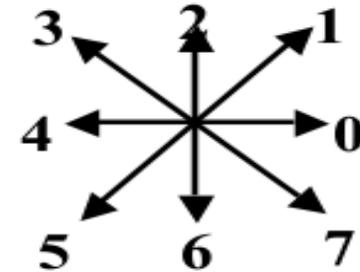
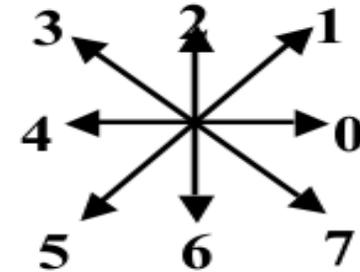
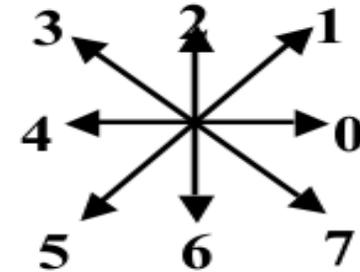
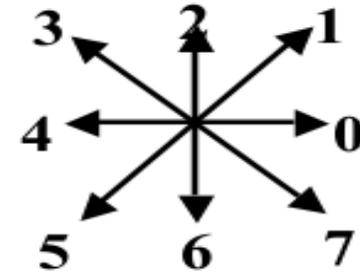
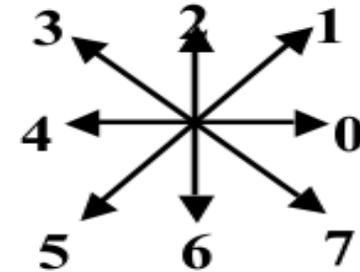
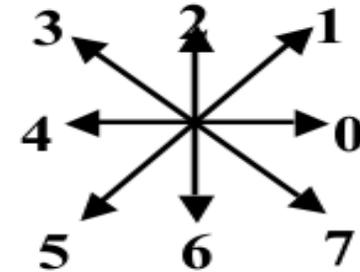
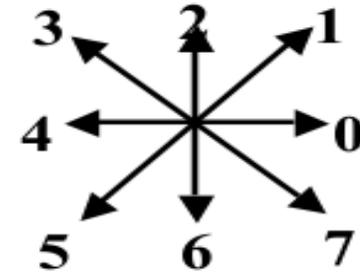
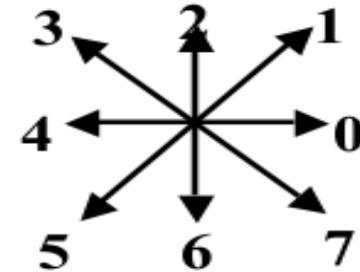
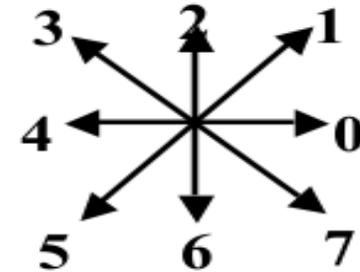
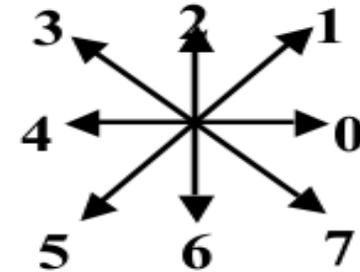
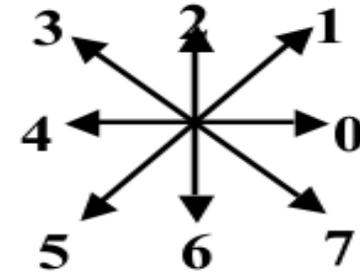
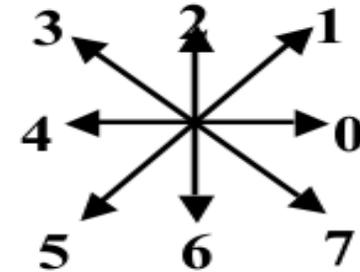
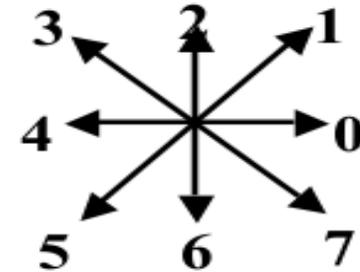
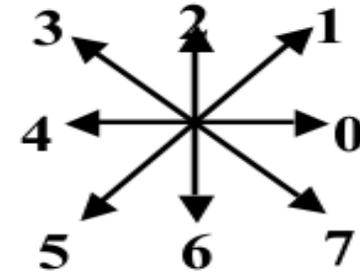
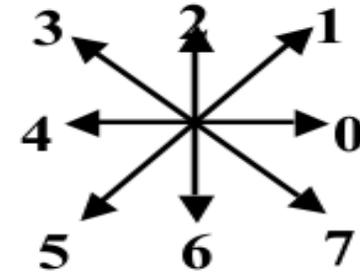
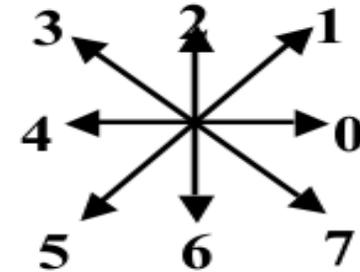
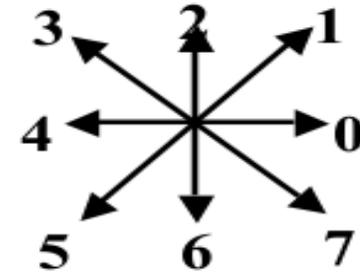
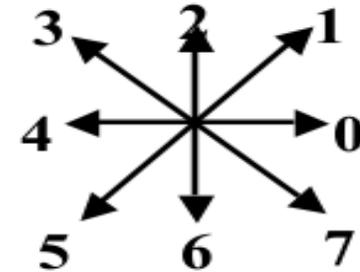
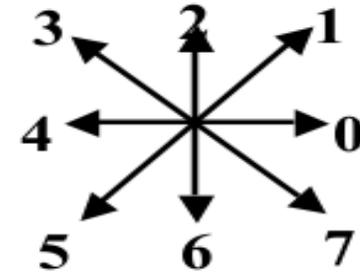
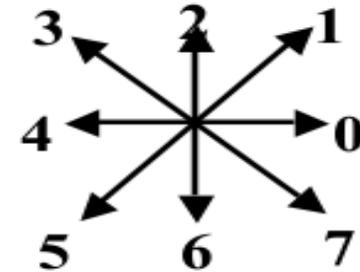
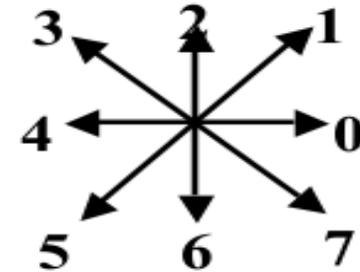
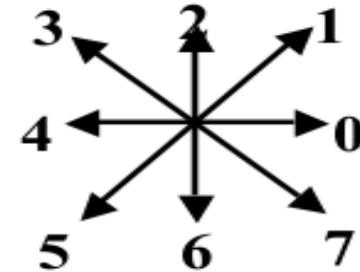
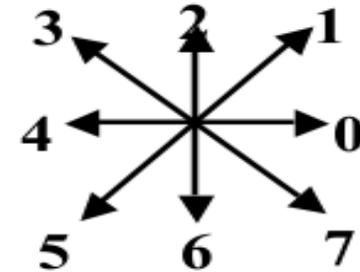
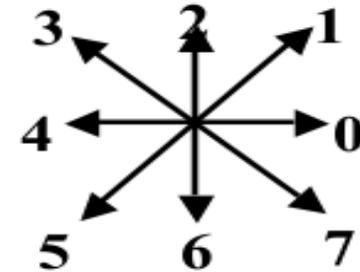
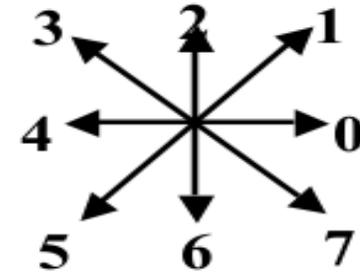
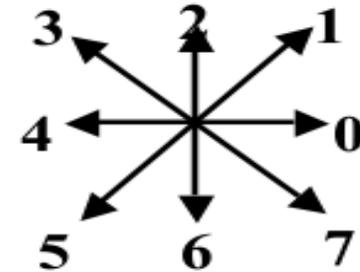
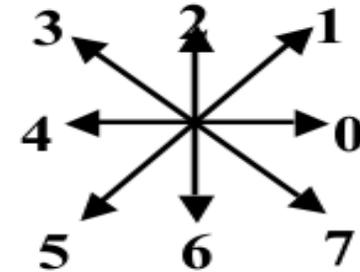
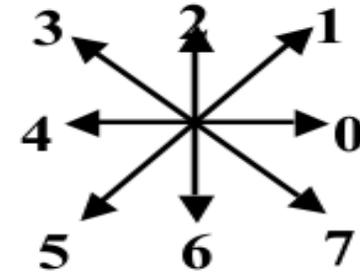
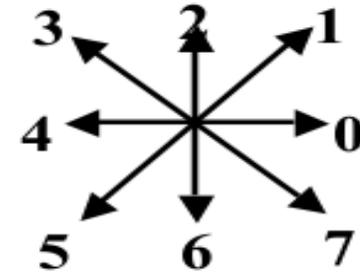
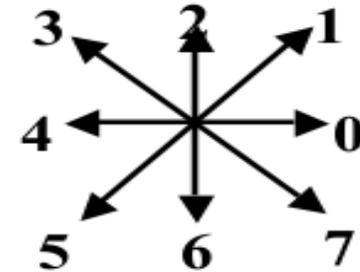
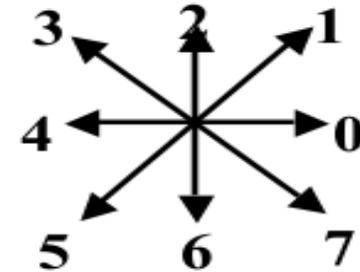
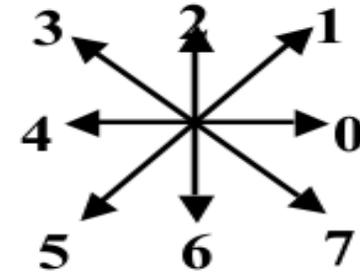
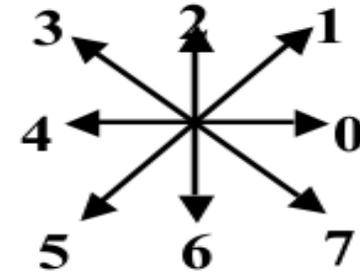
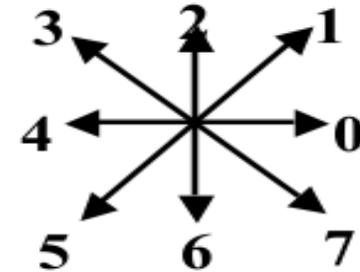
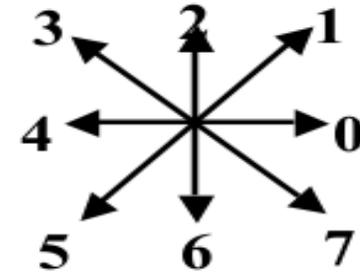
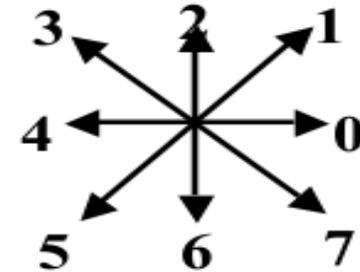
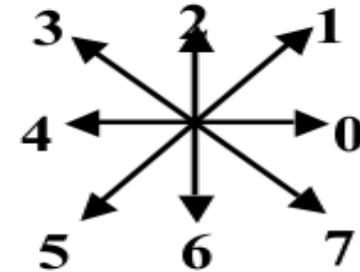
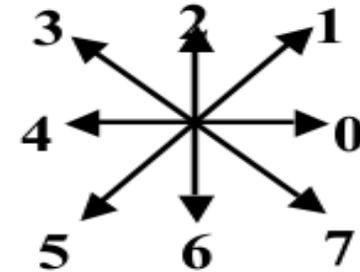
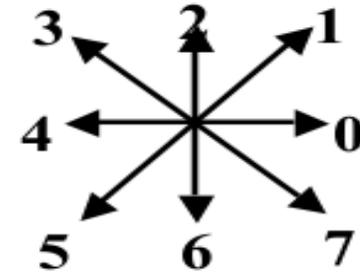
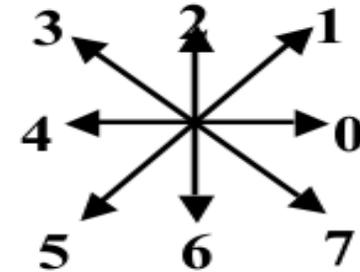
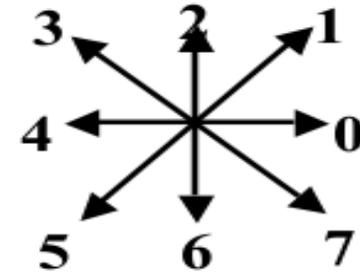
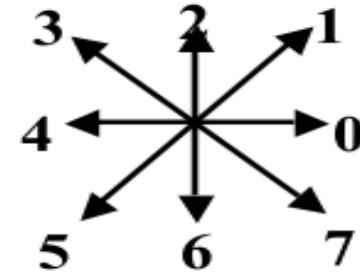
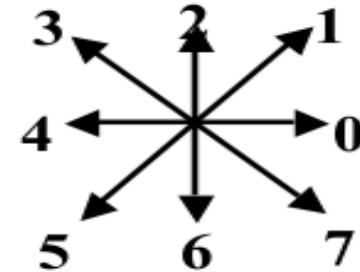
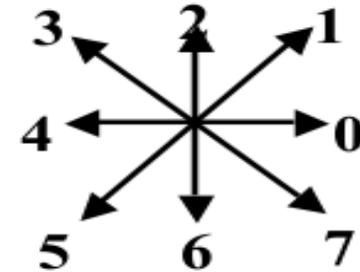
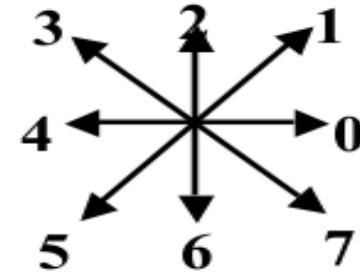
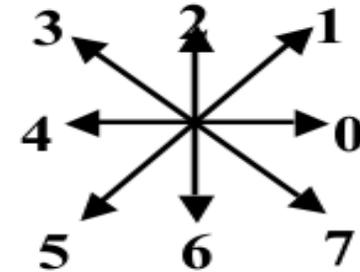
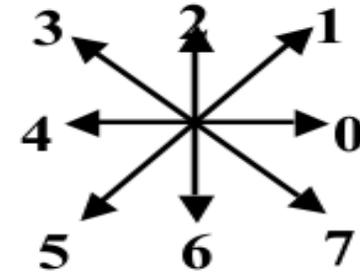
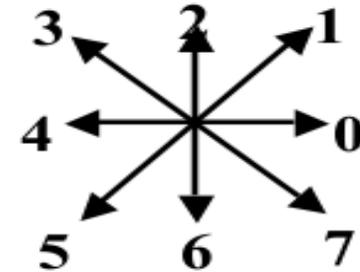
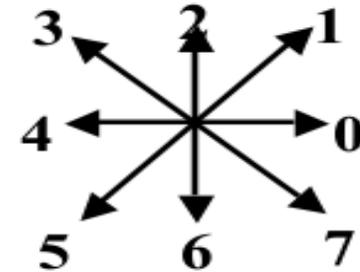
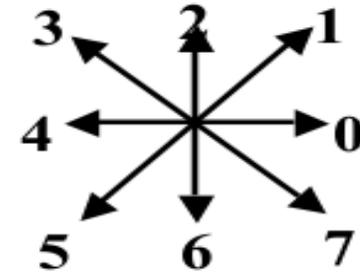
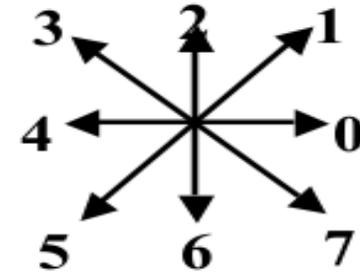
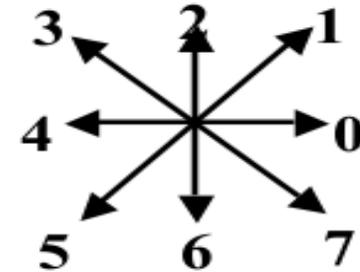
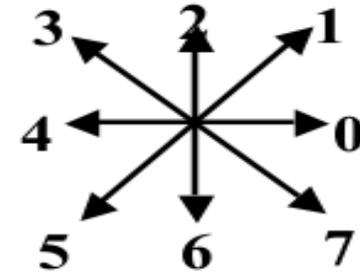
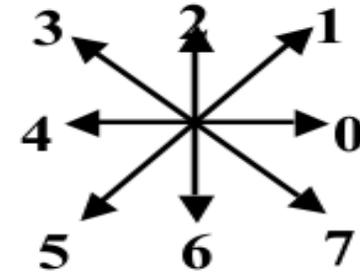
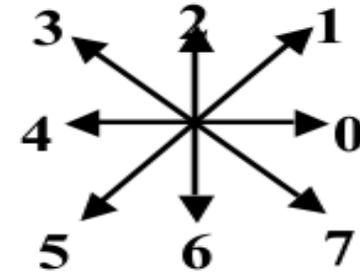
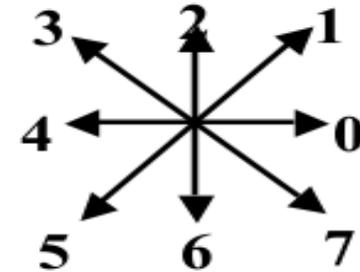
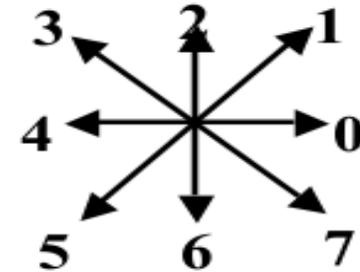
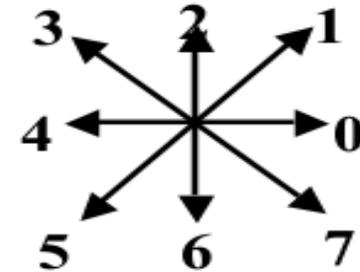
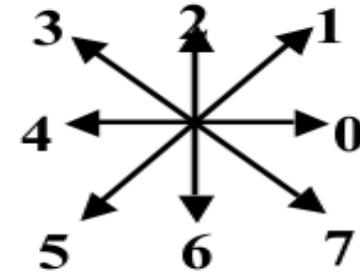
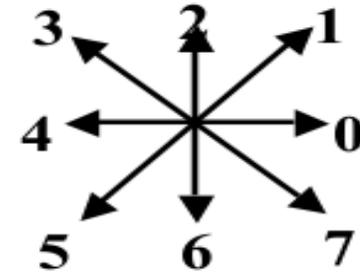
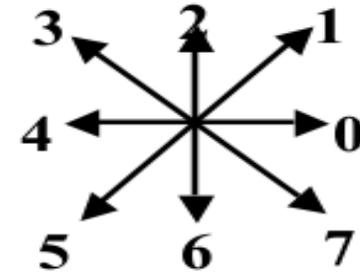
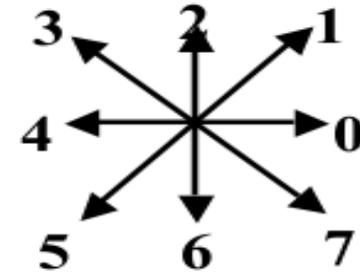
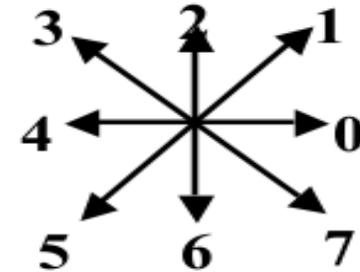
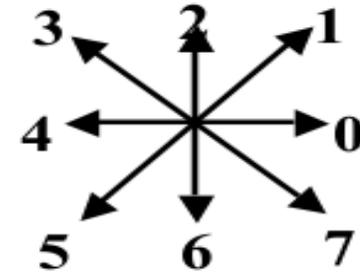
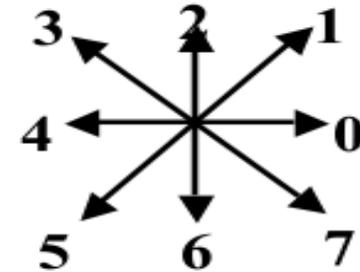
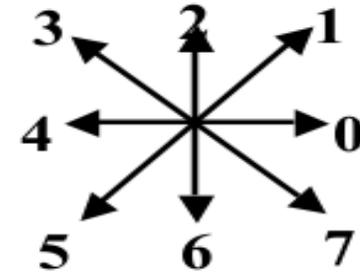
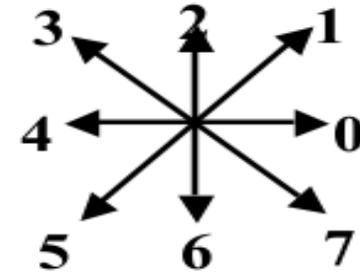
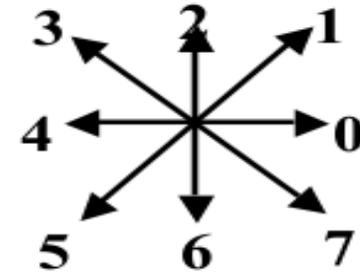
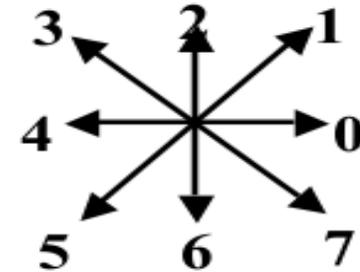
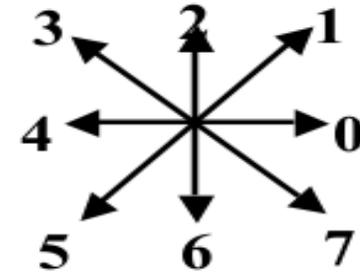
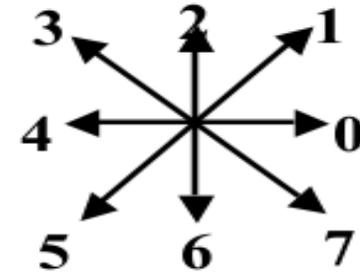
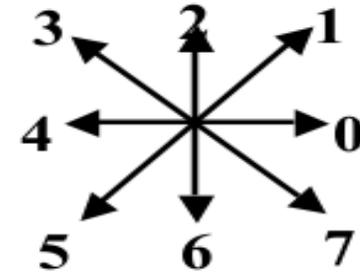
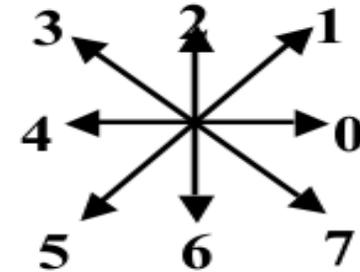
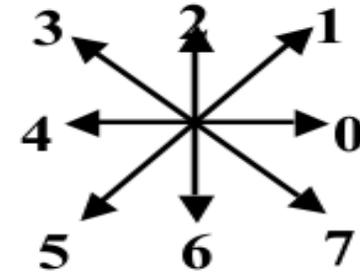
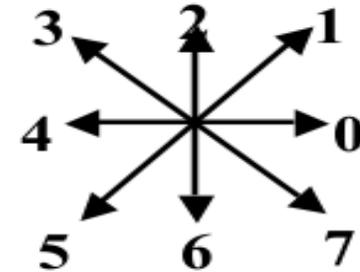
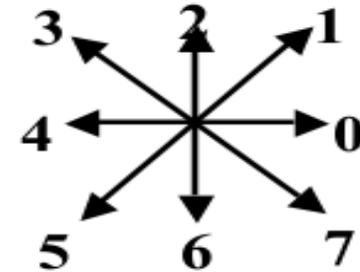
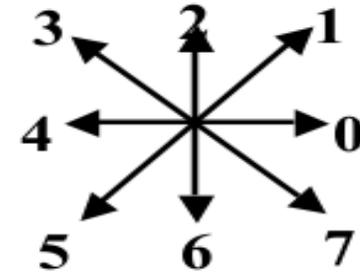
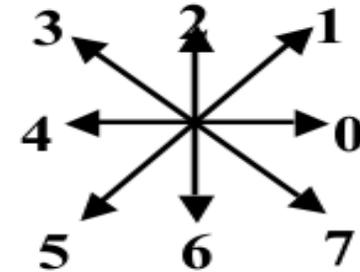
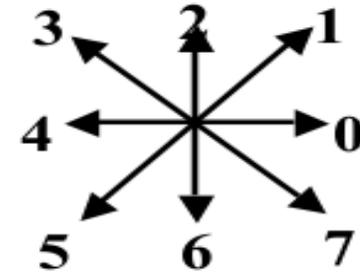
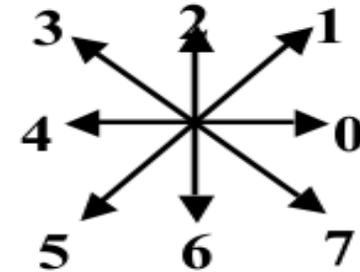
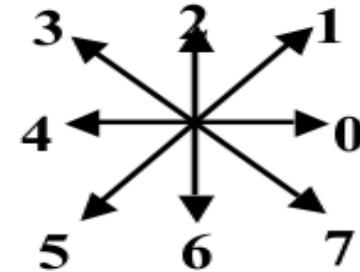
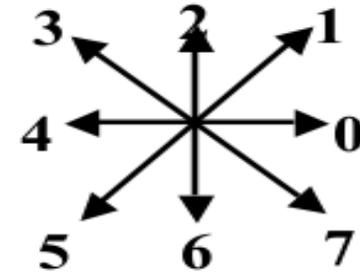
271202002

202002271

002271202

Plus petit entier (permutation cyclique) \Rightarrow unicité

002271202



Contours et composantes connexes

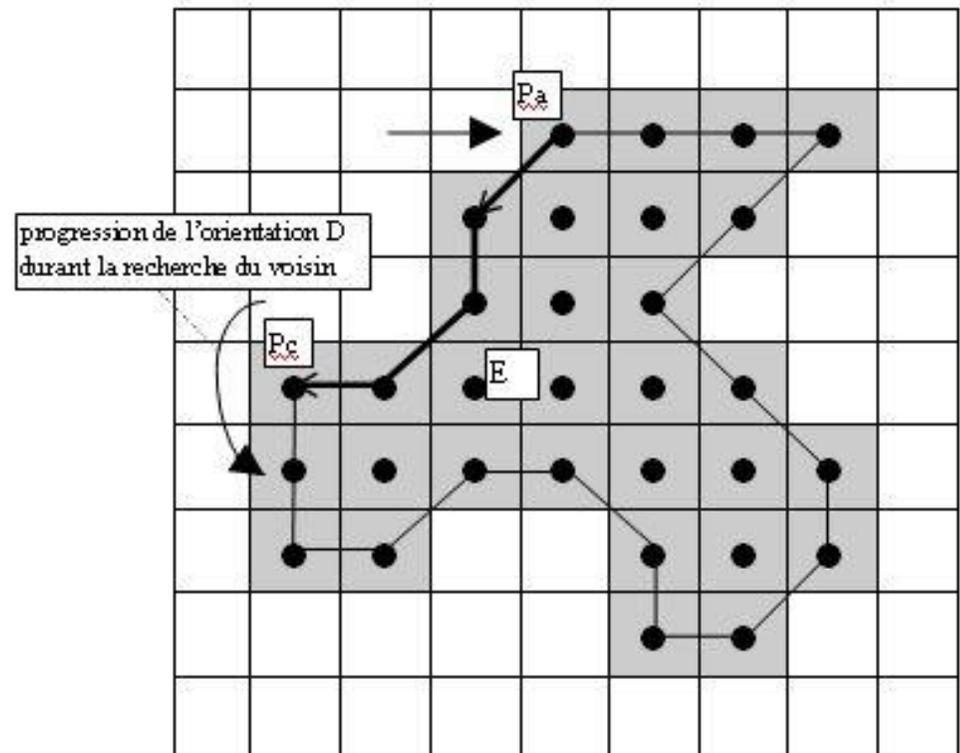
- Suivi de contour →

3	2	1
4	P_c	0
5	6	7

Image naturelle (NdG) !!!



Image binaire



Codage de Freeman et composantes connexes

$$Dd = D1 - D2$$

Si $(D1 - D2) > 4$ **alors** $Dd = Dd - 8$

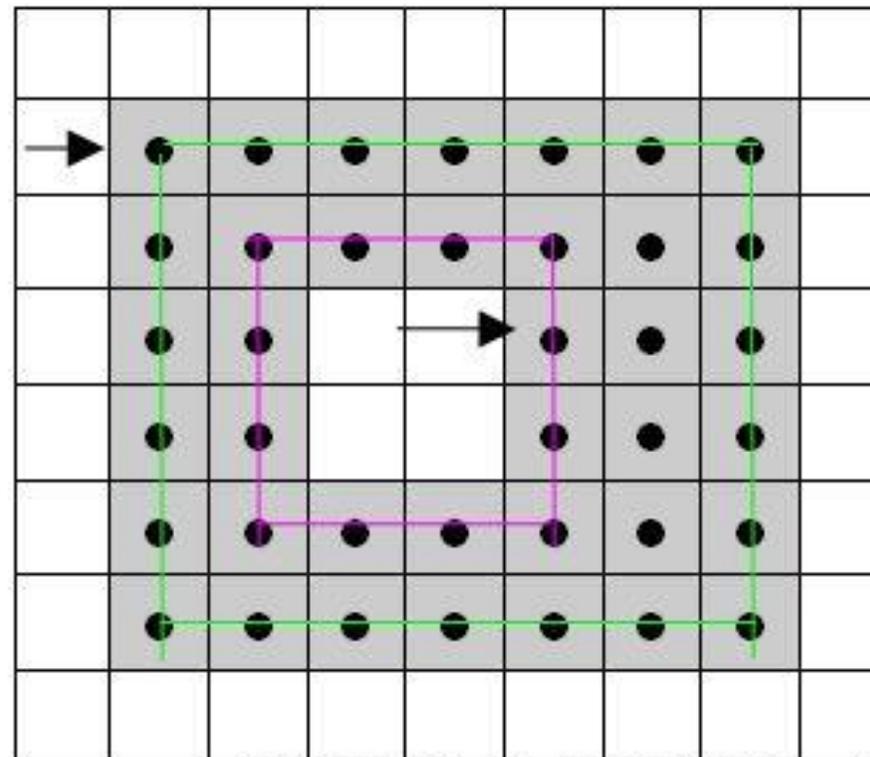
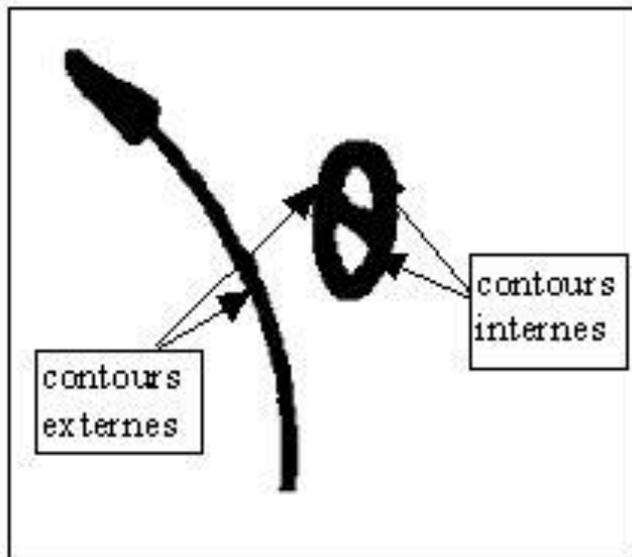
Si $(D1 - D2) < -3$ **alors** $Dd = Dd + 8$

Le retour-arrière ne se produisant jamais, $(D1 - D2) = -4$ ne se réalise jamais.

Avantages et inconvénients

Point de départ

Changement d'échelle

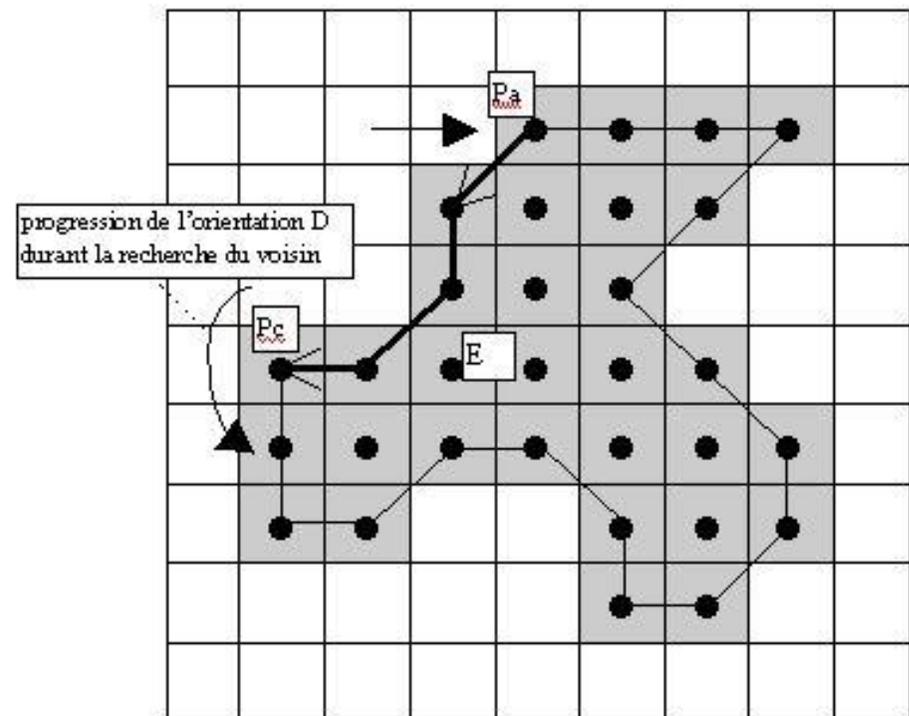
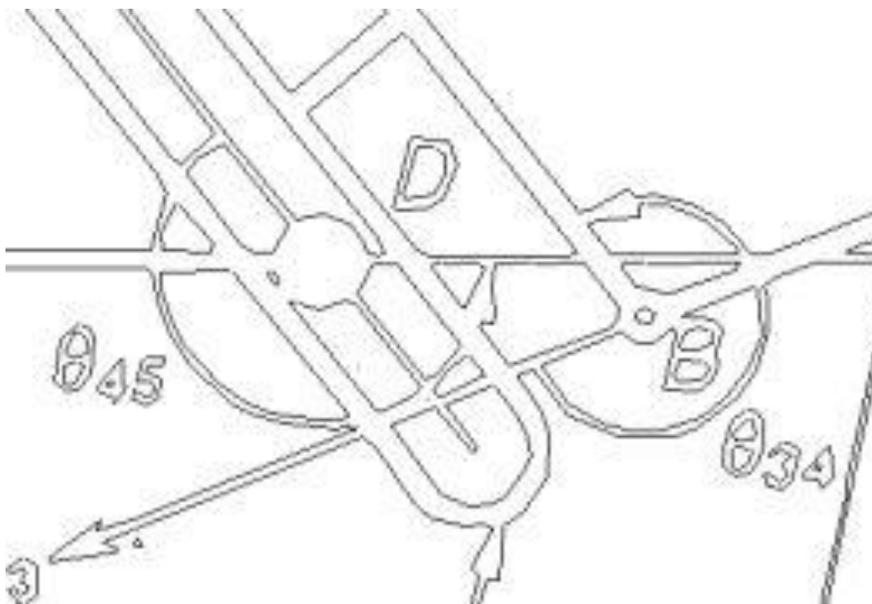


Contour interne : 664442220006 => 0-200-200-200-20 => $S_d = -8$

Contour externe : 6666600000022222444444 => 000020000200002000002 => $S_d = 8$

Approximation polygonale \rightarrow Vectorisation

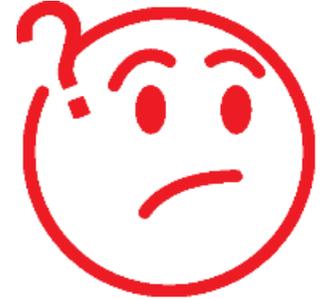
- Des contours/squelettes aux vecteurs



TP : Pourquoi tant d'intérêt ?

Un pas de plus vers l'interprétation...

- Après la segmentation
 - Fond = blanc / formes = noires
 - 1 objet → 1 région → 1 composante noire



A utiliser lors des TP

→ Comptage, analyse, caractérisation des objets à partir de l'image binaire