TP 3. Segmentation des images

1. Détection des contours

$I := READ\_IMAGE("hand2.jpg")$ Nombre de colonnes : $Nx := cols(I)$ $Nx = 340$ Nombre de lignes : $Ny := rows(I)$ $Ny = 318$

Q3.1. Ecrire la fonction NormeGradient4Diff(I). L'appliquer sur l'image hand2.jpg préalablement lissée (par un filtre moyenneur 3x3 ou par l'opérateur median3x3 ou par par l'opérateur de Nagao).

Interprétation des résultats en fonction du type de lissage utilisé.

Comparer les résultats de NormeGradient4Diff(I) avec ceux de la fonction Derivation(I,Mask3x3) basée sur la convolution 2D avec l'opérateur de dérivation 2D ∇_{2D}.

Rappel des fonctions déjà utilisées

```
Convol(I, Mask) ≡
  for y ∈ 1 .. rows(I) − 2
    for x ∈ 1 .. cols(I) − 2
      som ← 0
      for j ∈ 0 .. 2
        for i ∈ 0 .. 2
          som ← som + (I[y−j+1, x−i+1] · Mask[i, j])
      som ← 255 if som > 255
      som ← 0 if som < 0
      J[y, x] ← round(som)
  J
```

```
Binarisation(I, seuil) ≡
  Nx ← cols(I)
  Ny ← rows(I)
  for y ∈ 0 .. Ny − 1
    for x ∈ 0 .. Nx − 1
      J[y, x] ← 0 if I[y, x] < seuil
      J[y, x] ← 255 otherwise
  J
```

```
Moyenne(I) ≡
  M ← | 1/9 1/9 1/9 |
      | 1/9 1/9 1/9 |
      | 1/9 1/9 1/9 |
  J ← Convol(I, M)
  J
```

```
Nagao(I) ≡
  for y ∈ 2 .. rows(I) − 3
    for x ∈ 2 .. cols(I) − 3
      for j ∈ 0 .. 2
        for i ∈ 0 .. 2
          for m ∈ 0 .. 2
            for k ∈ 0 .. 2
              Tmp[m·3+k] ← I[y+j+m−2, x+i+k−2]
          Moy[3·j+i] ← mean(Tmp) if i·j ≠ 1
          Moy[3·j+i] ← 0 otherwise
          Var[3·j+i] ← max(Tmp) − min(Tmp) if i·j ≠ 1
          Var[3·j+i] ← 255 otherwise
      Mini ← min(Var)
      for i ∈ 0 .. 8
        W[y−2, x−2] ← Moy[i] if Var[i] = Mini
  W
```

```
Median(I) ≡
  for y ∈ 1 .. rows(I) − 2
    for x ∈ 1 .. cols(I) − 2
      for i ∈ 0 .. 2
        for j ∈ 0 .. 2
          v[3·i+j] ← I[y+i−1, x+j−1]
      vtri ← sort(v)
      J[y, x] ← vtri[4]
  J
```

```
Ampli(I, gain) ≡
    for y ∈ 0 .. rows(I) − 1
        for x ∈ 0 .. cols(I) − 1
            J[y,x] ← I[y,x] · gain
            J[y,x] ← 255  if J[y,x] > 255
            J[y,x] ← 0  if J[y,x] < 0
    J
```

```
RecadrageDyn(I) ≡
    mini ← min(I)
    maxi ← max(I)
    Δ ← 255 / (maxi − mini)
    for y ∈ 0 .. rows(I) − 1
        for x ∈ 0 .. cols(I) − 1
            J[y,x] ← round[(I[y,x] − mini) · Δ]
    J
```

Nouvelles fonctions

```
NormeGradient4Diff(I) ≡
    for y ∈ 1 .. rows(I) − 2
        for x ∈ 1 .. cols(I) − 2
            d0 ← I[y,x] − I[y,x−1]
            d1 ← I[y−1,x] − I[y,x−1]
            d2 ← I[y−1,x] − I[y,x]
            d3 ← I[y−1,x−1] − I[y,x]
            for i ∈ 0 .. 3
                Di ← |di|
            NormeGradient[y,x] ← max(D)
    NormeGradient
```

```
IndiceMax(v) ≡
    N ← length(v)
    IndiceMax ← 0
    Max ← v0
    for i ∈ 1 .. N − 1
        if vi > Max
            Max ← vi
            IndiceMax ← i
    IndiceMax
```

```
DirGradient4Diff(I) ≡
    for y ∈ 1 .. rows(I) − 2
        for x ∈ 1 .. cols(I) − 2
            d0 ← I[y,x] − I[y,x−1]
            d1 ← I[y−1,x] − I[y,x−1]
            d2 ← I[y−1,x] − I[y,x]
            d3 ← I[y−1,x−1] − I[y,x]
            for i ∈ 0 .. 3
                Di ← |di|
            imax ← IndiceMax(D)
            DirGradient[y,x] ← imax  if dimax ≥ 0
            DirGradient[y,x] ← imax + 4  otherwise
    DirGradient
```

Lissage (moyenne, médian, Nagao ...) : $J := \text{Moyenne}(I)$ ou $J := \text{Median}(I)$ ou $J := \text{Nagao}(I)$

Gradient à 4 différences : $K := \text{NormeGradient4Diff}(J)$

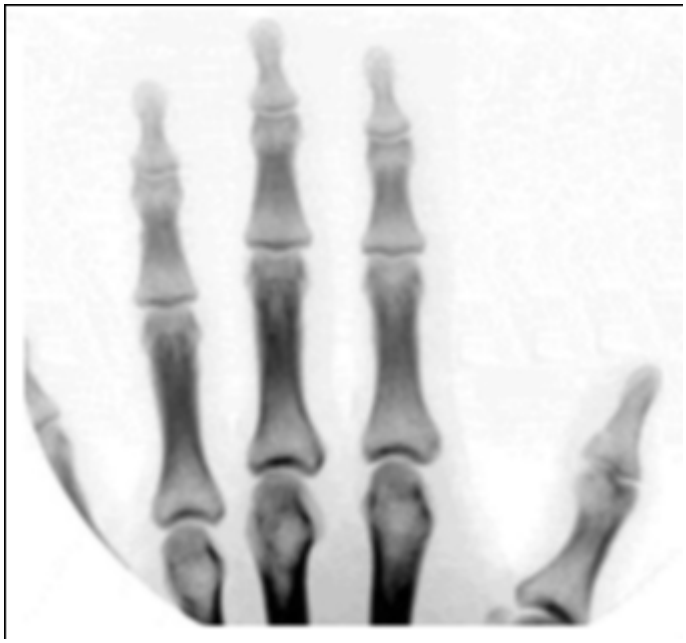
Recadrage Dynamique : $L := \text{Ampli}(K, 3)$ ou $L := \text{RecadrageDyn}(K)$

Seuillage : $M := \text{Binarisation}(K, 10)$

Originale

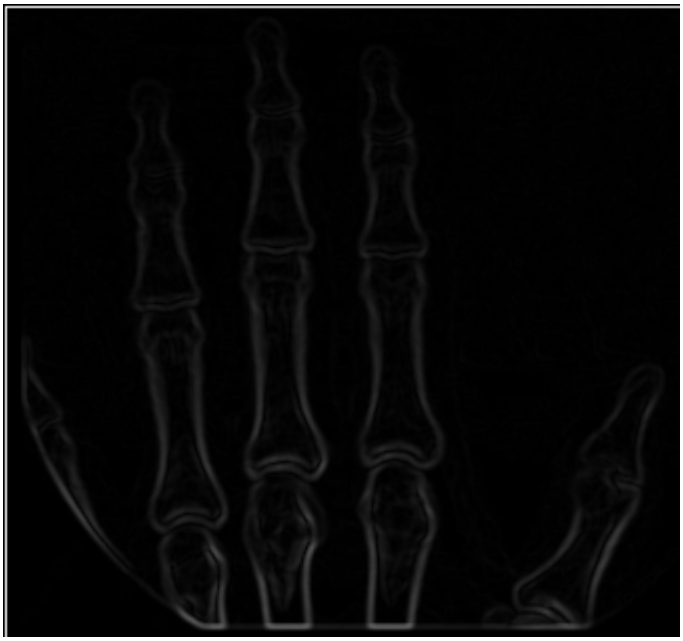
I

Lissée



J

Norme Gradient



K

Norme Gradient amplifiée

L

N := DirGradient4Diff(J)

Codage pseudo-couleurs de Direction du Gradient : r := Rvb(N) v := rVb(N) b := rvB(N)

Direction 2 = N = Bleu

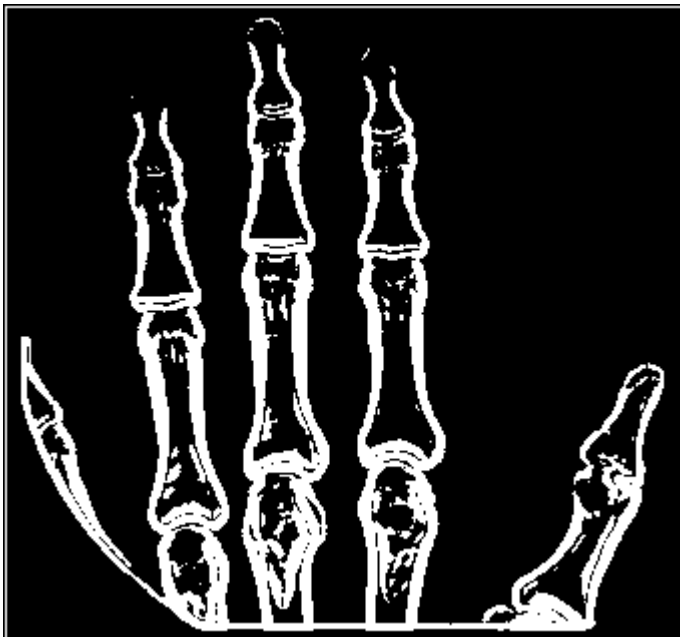
Direction 3 = NO = Orange Direction 1 = NE = Vert

Direction 4 = O = Magenta Direction 0 = E = Rouge

Direction 5 = SO = Kaki Direction 7 = SE = Jaune

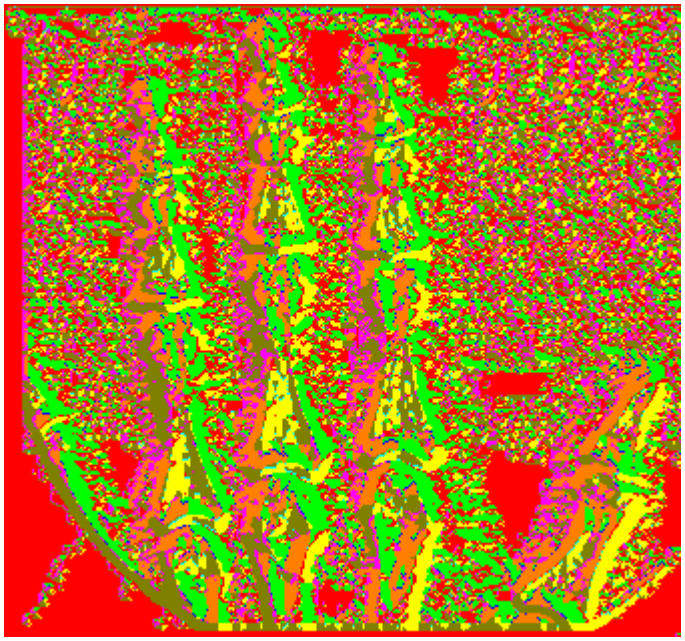
Direction 6 = S = Cyan

Norme Gradient seuillée (Contours)



M

Direction Gradient



r, v, b

Suppression des non maxima locaux du gradient (amincissement) :

$$\Delta x \equiv (1 \;\; 1 \;\; 0 \;\; -1 \;\; -1 \;\; -1 \;\; 0 \;\; 1)^T \qquad \Delta y \equiv (0 \;\; -1 \;\; -1 \;\; -1 \;\; 0 \;\; 1 \;\; 1 \;\; 1)^T$$

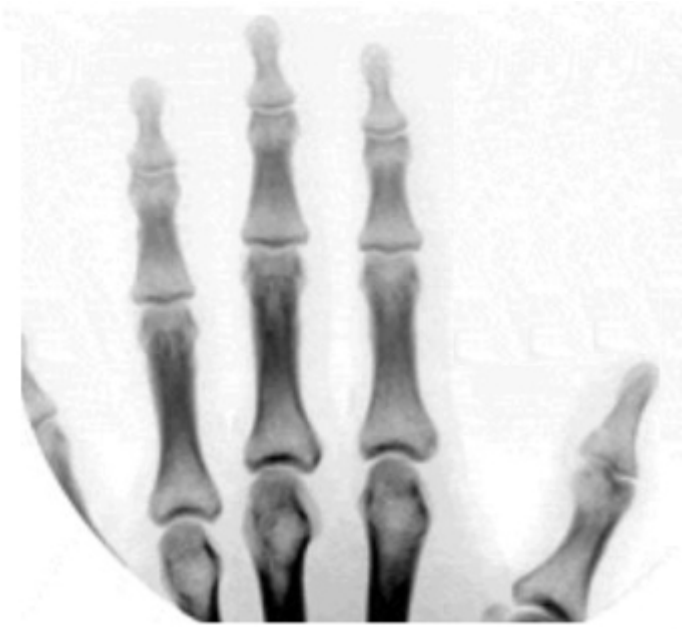
$$\text{SuppressionNonMaximaLocaux}(M, D) \equiv \left| \begin{array}{l} \text{for } y \in 1 .. \text{rows}(M) - 2 \\ \quad \text{for } x \in 1 .. \text{cols}(M) - 2 \\ \quad\quad \left| \begin{array}{l} i \leftarrow D_{y,x} \\ j \leftarrow \text{mod}(i + 4, 8) \\ M_{y,x} \leftarrow 0 \text{ if } M_{y,x} \le M_{y+\Delta y_i, x+\Delta x_i} \\ M_{y,x} \leftarrow 0 \text{ if } M_{y,x} \le M_{y+\Delta y_j, x+\Delta x_j} \end{array} \right. \\ M \end{array} \right.$$

Gradient 4 diff : $K2 := \text{SuppressionNonMaximaLocaux}(K, N)$

Recadrage Dynamique : $L2 := \text{Ampli}(K2, 8)$

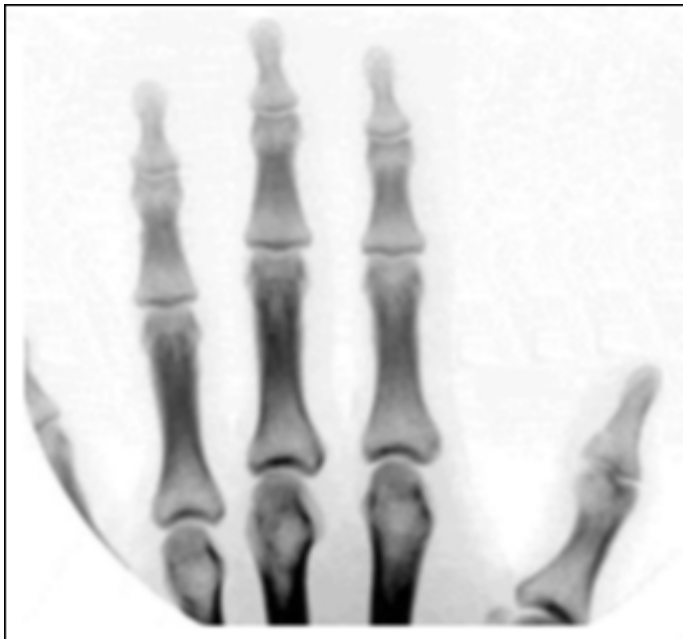
Seuillage : $M2 := \text{Binarisation}(K2, 13)$

Originale



I

Lissée

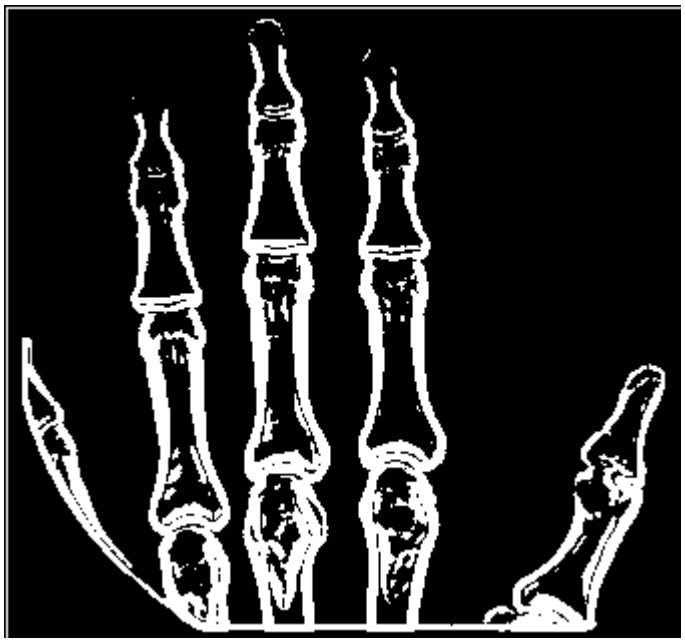


J

Norme Gradient amplifiée

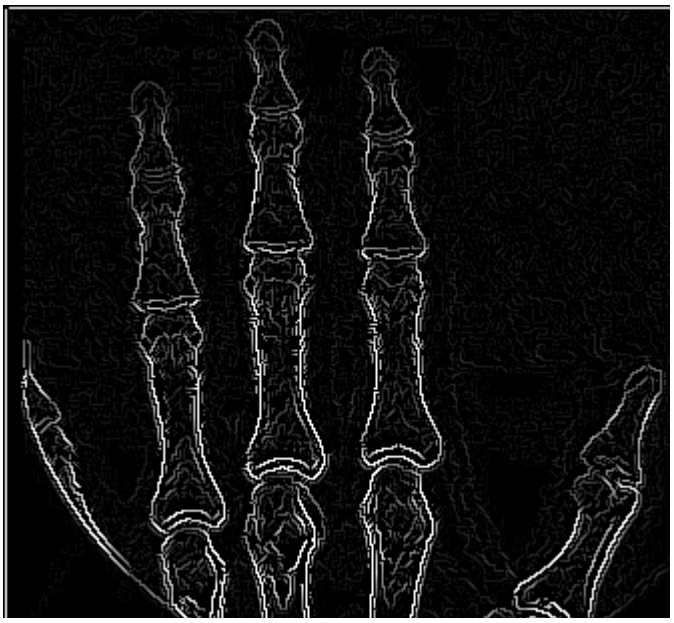
L

Norme Gradient seuillée (Contours)



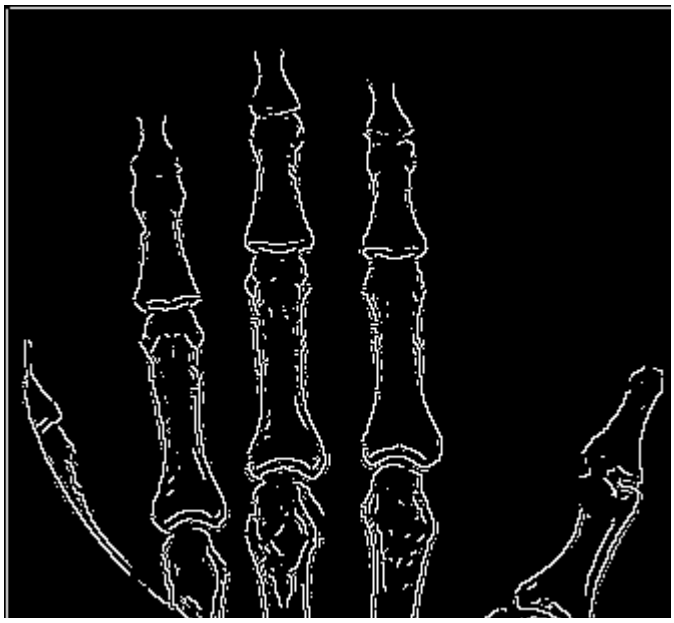
M

Norme Gradient amplifiée *(Suppression non maxima)*



L2

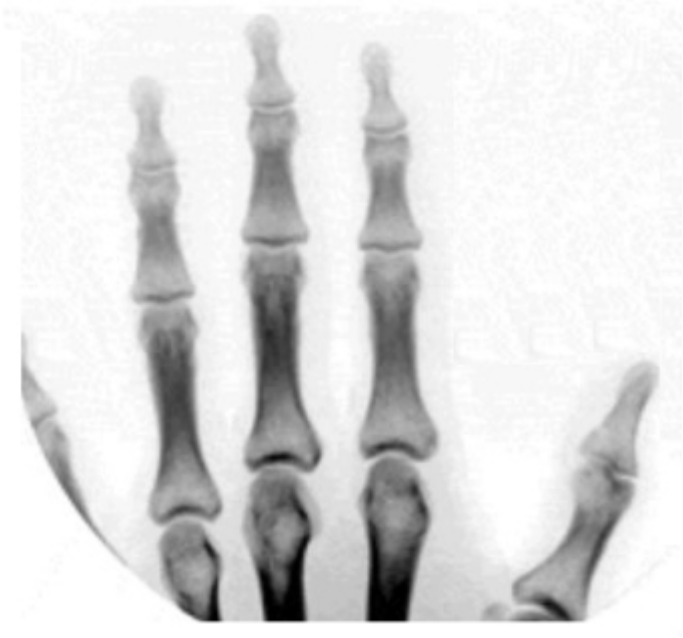
Norme Gradient seuillée (Contours) *(Suppression non maxima)*



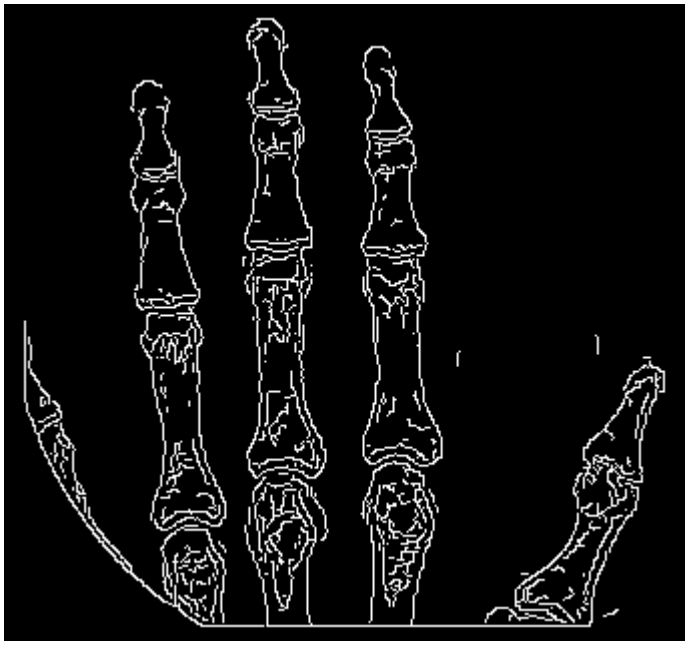
M2

Q3.2. Facultatif : Comparer les résultats de NormeGradient4Diff(I) avec ceux de l'opérateur de Canny (disponible dans la librairie OpenCV)

Opérateur de Canny $\sigma := 0.2$ $low := 1.1$ $high := 1.9$ $P := 255 \cdot canny(I, \sigma, low, high)$ low < high $0 < \sigma < 2$



I



P

Fonctions Bibliothèque :

```
Histo(I) ≡
  for n ∈ 0..255
    H_n ← 0
  for y ∈ 0..rows(I) − 1
    for x ∈ 0..cols(I) − 1
      n ← I_{y,x}
      H_n ← H_n + 1
  H
```

```
Derivation(I, Mask3x3) ≡
  for y ∈ 1..rows(I) − 2
    for x ∈ 1..cols(I) − 2
      som ← 0
      for i ∈ 0..2
        for j ∈ 0..2
          som ← som + I_{y+i−1, x+j−1} · Mask3x3_{i,j}
      som ← |som|
      som ← 255 if som > 255
      som ← 0 if som < 0
      J_{y,x} ← som
  J
```

$$D_1 \equiv \begin{pmatrix} 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad D_2 \equiv \begin{pmatrix} 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad D_3 \equiv \begin{pmatrix} 1 & 1 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix} \quad D_4 \equiv \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$D_5 \equiv \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{pmatrix} \quad D_6 \equiv \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 \end{pmatrix} \quad D_7 \equiv \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 \end{pmatrix} \quad D_8 \equiv \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

```
Chanda(I) ≡ for y ∈ 2 .. rows(I) − 3
              for x ∈ 2 .. cols(I) − 3
                SDG ← 0
                SG ← 0
                for k ∈ 1 .. 8
                  S ← 0
                  for j ∈ 0 .. 4
                    for i ∈ 0 .. 4
                      S ← S + [ I_{y+j−2, x+i−2} · (D_k)_{j, i} ]
                  S ← S / 6
                  S2 ← 0
                  for j ∈ 0 .. 4
                    for i ∈ 0 .. 4
                      S2 ← S2 + [ I_{y+j−2, x+i−2} · (D_k)_{j, i} ]^2
                  S2 ← S2 / 6
                  D ← S − I_{y, x}
                  G ← ( |S2 − S^2| )^(1/2)
                  SDG ← SDG + D·G
                  SG ← SG + G
                J_{y, x} ← I_{y, x} − SDG / SG
                J_{y, x} ← 0   if J_{y, x} < 0
                J_{y, x} ← 255   if J_{y, x} > 255
              J
```

Codage RVB de la Direction du Gradient :

Noir (RVB=0,0,0)
Rouge (RVB=255,0,0)
Vert (RVB=0,255,0)
Bleu (RVB=0,0,255)
Jaune (RVB=255,255,0)
Blanc (RVB=255,255,255)
Magenta (RVB=255,0,255)
Kaki (RVB=127,127,0)
Cyan (RVB=0,255,255)
Orange (RVB=255,127,0)
Gris (RVB=127,127,127)
Marron(127,0,0)
Violet (RVB=127,0,127)

Direction 2 = N = Bleu
Direction 3 = NO = Orange
Direction 1 = NE = Vert
Direction 4 = O = Magenta
Direction 0 = E = Rouge
Direction 5 = SO = Kaki
Direction 7 = SE = Jaune
Direction 6 = S = Cyan

$$
\begin{array}{l}
Rvb(I) \equiv \\
\quad \text{for } y \in 0..rows(I)-1 \\
\quad\quad \text{for } x \in 0..cols(I)-1 \\
\quad\quad\quad R_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 0 \\
\quad\quad\quad R_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 1 \\
\quad\quad\quad R_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 2 \\
\quad\quad\quad R_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 3 \\
\quad\quad\quad R_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 4 \\
\quad\quad\quad R_{y,x} \leftarrow 127 \text{ if } I_{y,x} = 5 \\
\quad\quad\quad R_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 6 \\
\quad\quad\quad R_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 7 \\
\quad R
\end{array}
\qquad
\begin{array}{l}
rVb(I) \equiv \\
\quad \text{for } y \in 0..rows(I)-1 \\
\quad\quad \text{for } x \in 0..cols(I)-1 \\
\quad\quad\quad V_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 0 \\
\quad\quad\quad V_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 1 \\
\quad\quad\quad V_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 2 \\
\quad\quad\quad V_{y,x} \leftarrow 127 \text{ if } I_{y,x} = 3 \\
\quad\quad\quad V_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 4 \\
\quad\quad\quad V_{y,x} \leftarrow 127 \text{ if } I_{y,x} = 5 \\
\quad\quad\quad V_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 6 \\
\quad\quad\quad V_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 7 \\
\quad V
\end{array}
\qquad
\begin{array}{l}
rvB(I) \equiv \\
\quad \text{for } y \in 0..rows(I)-1 \\
\quad\quad \text{for } x \in 0..cols(I)-1 \\
\quad\quad\quad B_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 0 \\
\quad\quad\quad B_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 1 \\
\quad\quad\quad B_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 2 \\
\quad\quad\quad B_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 3 \\
\quad\quad\quad B_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 4 \\
\quad\quad\quad B_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 5 \\
\quad\quad\quad B_{y,x} \leftarrow 255 \text{ if } I_{y,x} = 6 \\
\quad\quad\quad B_{y,x} \leftarrow 0 \text{ if } I_{y,x} = 7 \\
\quad B
\end{array}
$$