Nome: Lucas Miranda Mendonça Rezende
N. USP: 12542838

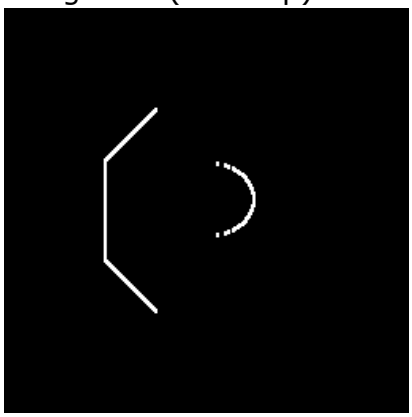
relatório.doc **Continuando filtros digitais**

Questão 1.1:

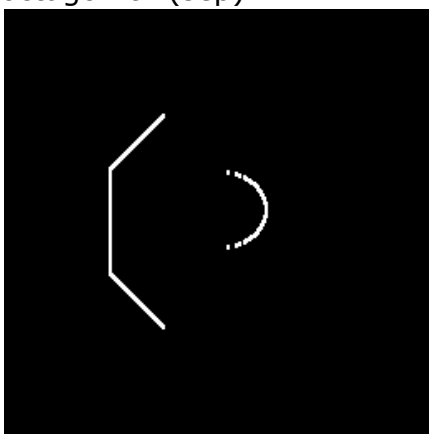
mit.tif (non-sep):

mit.tif (sep):

octagon.tif (non-sep):



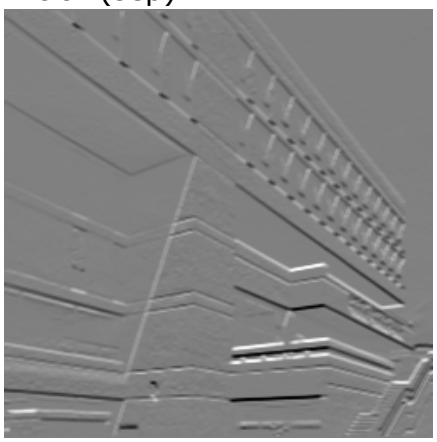
octagon.tif (sep):



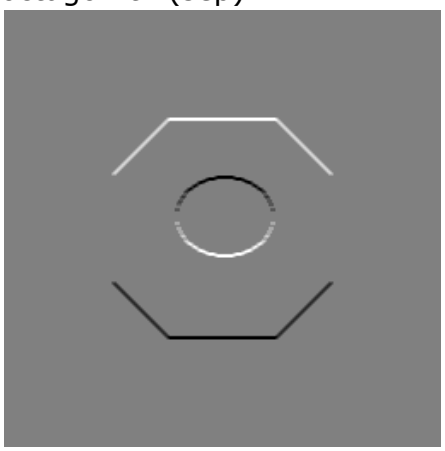
Questão 1.2:

```
static public ImageAccess detectEdgeHorizontal_Separable(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doAverage3(rowin, rowout);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doDifference3(colin, colout);
            out.putColumn(x, colout);
        }
        return out;
    }
```

mit.tif (sep):



octagon.tif (sep):



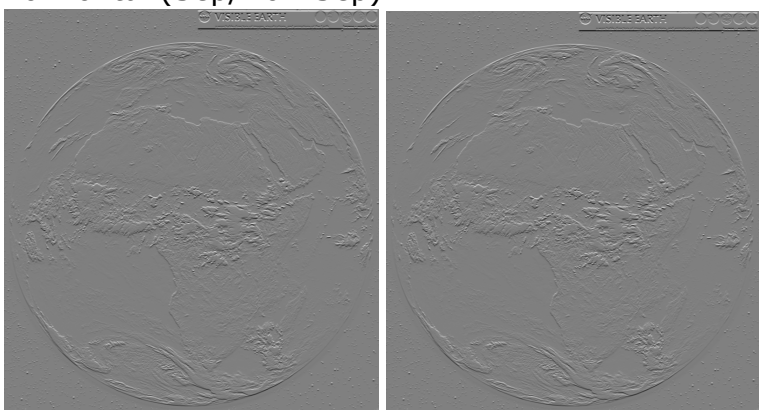
Questão 1.3:
Detector de Bordas Horizontal em africa.tif

	Tempo	Média	Minimo	Maximo
versão não-separável	47ms	0	-87.06	85.23
versão separável	33ms	0	-107.19	119.11

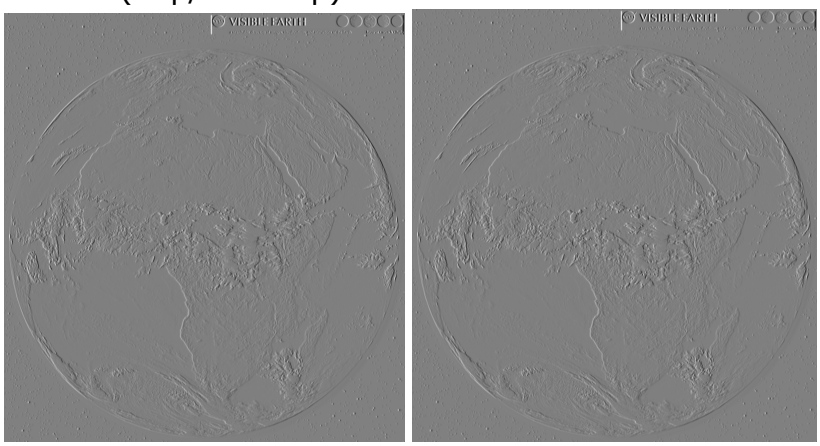
Comparação:

Embora semelhantes, a imagem da versão não separável parece que é mais clara, tem contraste maior. A versão não separável é a versão mais computacionalmente cara (+42%).

Horizontal (Sep/Non-Sep)



Vertical (Sep/Non-Sep)



Insira a parte do código escrito para vertical edge detector (mit.tif)

```
static public ImageAccess detectEdgeVertical_NonSeparable(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        double arr[][] = new double[3][3];
        double pixel;
        ImageAccess out = new ImageAccess(nx, ny);
        for (int x = 0; x < nx; x++) {
            for (int y = 0; y < ny; y++) {
                input.getNeighborhood(x, y, arr);
                pixel =
arr[2][0]+arr[2][1]+arr[2][2]-arr[0][0]-arr[0][1]-arr[0][2];
                pixel = pixel / 6.0;
                out.putPixel(x, y, pixel);
            }
        }
        return out;
    }
```

```
static public ImageAccess detectEdgeVertical_Separable(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doDifference3(rowin, rowout);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doAverage3(colin, colout);
            out.putColumn(x, colout);
        }
        return out;
    }
```

Insira a parte do código escrito para horizontal edge detector (mit.tif)

```
static public ImageAccess detectEdgeHorizontal_NonSeparable(ImageAccess input)
{
        int nx = input.getWidth();
        int ny = input.getHeight();
        double arr[][] = new double[3][3];
        double pixel;
        ImageAccess out = new ImageAccess(nx, ny);
        for (int x = 0; x < nx; x++) {
            for (int y = 0; y < ny; y++) {
                input.getNeighborhood(x, y, arr);
                pixel= arr[0][2]+arr[1][2]+arr[2][2]-arr[0][0]-arr[1][0]-arr[2][0];
                pixel = pixel / 6.0;
                out.putPixel(x, y, pixel);
            }
        }
        return out;
    }
```

```
    static public ImageAccess detectEdgeHorizontal_Separable(ImageAccess input)
{
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doAverage3(rowin, rowout);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doDifference3(colin, colout);
            out.putColumn(x, colout);
        }
        return out;
    }
```

Questão 2.1:

```
static public ImageAccess doMovingAverage5_NonSeparable(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        double arr[][] = new double[5][5];
        double pixel;
        ImageAccess out = new ImageAccess(nx, ny);

        for (int x = 0; x < nx; x++) {
            for (int y = 0; y < ny; y++) {
                input.getNeighborhood(x, y, arr);
                pixel = 0.0;
                for (int i = 0; i < 5; i++) {
                    for (int j = 0; j < 5; j++) {
                        pixel += arr[i][j];
                    }
                }
```

```
                pixel = pixel / 25.0;
                out.putPixel(x, y, pixel);
            }
        }
        return out;
    }
```

Questão 2.2:

```
static public ImageAccess doMovingAverage5_Separable(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doAverage5(rowin, rowout);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doAverage5(colin, colout);
            out.putColumn(x, colout);
        }

        return out;
    }

static private void doAverage5(double vin[], double vout[]) {
        int n = vin.length;
       vout[0] = (vin[0] + 2.0 * vin[1] + 2.0 * vin[2]) / 5.0;
       vout[1] = (vin[0] + vin[1] + vin[2] + vin[3]) / 5.0;
       for (int k = 2; k < n-2; k++) {
            vout[k] = (vin[k-2] + vin[k-1] + vin[k] + vin[k+1] + vin[k+2]) / 5.0;
        }
        vout[n-2] = (vin[n-4] + vin[n-3] + vin[n-2] + vin[n-1]) / 5.0;
        vout[n-1] = (vin[n-3] + 2.0 * vin[n-2] + vin[n-1]) / 5.0;
    }
```

Questão 2.3:

```
static public ImageAccess doMovingAverage5_Recursive(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doAverage5_Recursive(rowin, rowout, 0);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doAverage5_Recursive(colin, colout, 0);
            out.putColumn(x, colout);
        }

        return out;
    }

    static public void doAverage5_Recursive(double vin[], double vout[], int k)
{
        int n = vin.length;
        if (k == 0) {
            vout[0] = (vin[0] + 2.0 * vin[1] + 2.0 * vin[2]) / 5.0;
            vout[1] = (vin[0] + vin[1] + vin[2] + vin[3]) / 5.0;
            doAverage5_Recursive(vin, vout, k + 2);
        } else if (k >= n-2) {
            vout[n-2] = (vin[n-4] + vin[n-3] + vin[n-2] + vin[n-1]) / 5.0;
            vout[n-1] = (vin[n-3] + 2.0 * vin[n-2] + vin[n-1]) / 5.0;
        } else {
            vout[k] = (vin[k-2] + vin[k-1] + vin[k] + vin[k+1] + vin[k+2]) /
5.0;
            doAverage5_Recursive(vin, vout, k + 1);
        }
    }
```

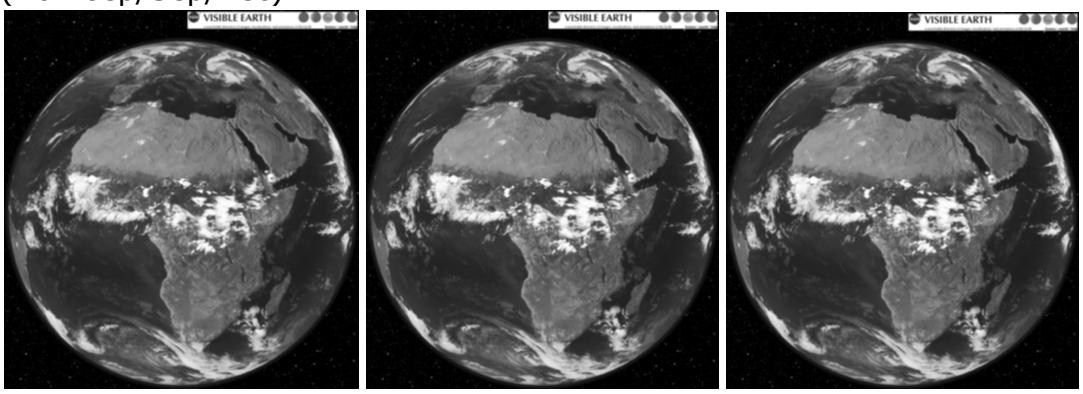
Média-móvel 5*5 em africa.tif

	Tempo	Média	Mínimo	Maximo
versão não-separável	74ms	71.44	0	255
versão separável	28ms	71.44	0	255
versão recursiva	31ms	71.44	0	255

Comparação:

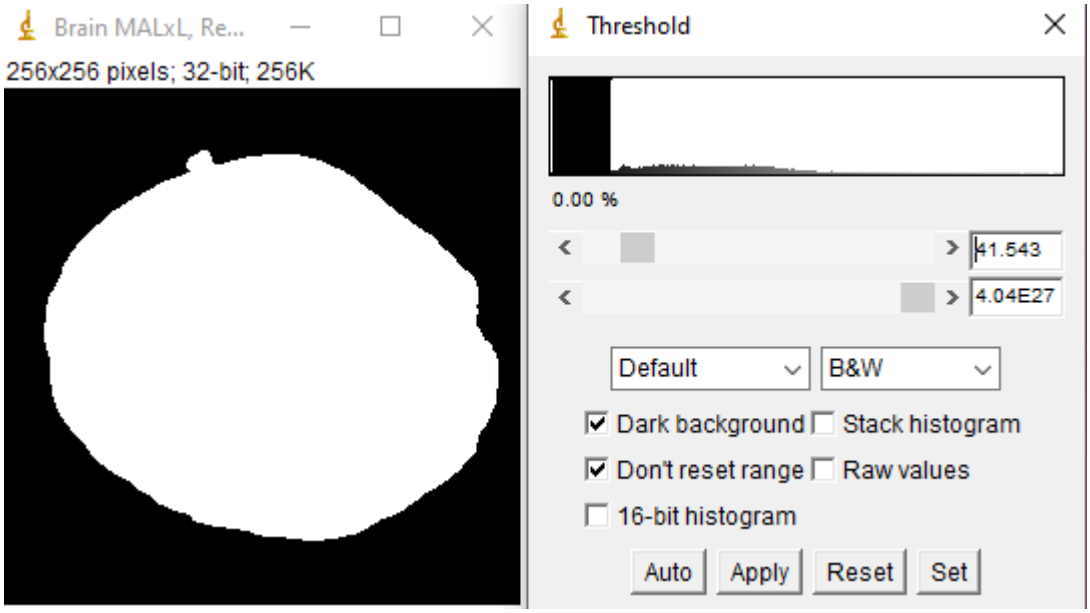
As imagens são muito semelhantes. A versão Não Separável parece levemente mais borrada. A versão Não Separável é consideravelmente mais cara computacionalmente, a versão Separável é a mais barata e a Recursiva é marginalmente mais cara que esta.

(Non-sep/Sep/Rec)



Questão 3.1:

Segmentando com o Operador Smoothing
L = 13
T = 41



Insira a parte do código escrito.

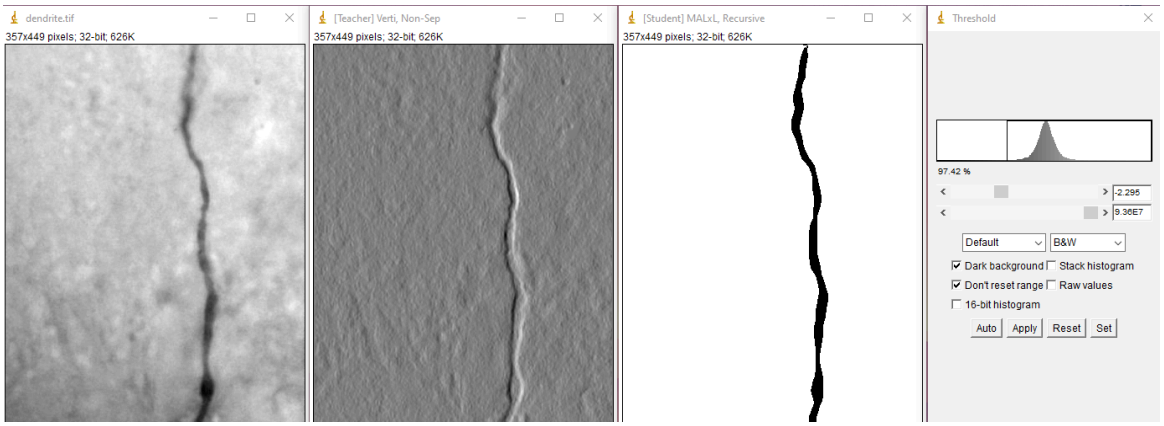
```
static public ImageAccess doMovingAverageL_Recursive(ImageAccess input, int length) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doAverageL_Recursive(rowin, rowout, 0, length);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doAverageL_Recursive(colin, colout, 0, length);
            out.putColumn(x, colout);
        }

        return out;
    }

    static public void doAverageL_Recursive(double vin[], double vout[], int k, int length) {
        int n = vin.length;
        if (k >= n) {
            return;
        }
        if (k == 0) {
            double sum = 0.0;
            for (int i = 0; i < length; i++) {
                int index = Math.min(Math.max(i, 0), n - 1);
                sum += vin[index];
            }
            vout[0] = sum / (double) length;
        } else if (k >= n - length / 2) {
            double sum = 0.0;
            for (int i = n - length; i < n; i++) {
                int index = Math.min(Math.max(i, 0), n - 1);
```

```
                sum += vin[index];
            }
            vout[k] = sum / (double) length;
        } else {
            double sum = 0.0;
            for (int i = k - length / 2; i <= k + length / 2; i++) {
                int index = Math.min(Math.max(i, 0), n - 1);
                sum += vin[index];
            }
            vout[k] = sum / (double) length;
        }
        doAverageL_Recursive(vin, vout, k + 1, length);
    }
```

Questão 3.2:

Descreva o procedimento

1. Vertical Edge Non-Separable
2. Moving Average 13x13
3. Threshold



Insira a parte do código escrito

Código reutilizado: Questão 1.1 e Questão 3.1

Questão 4:

Operador Sobel

Journal

File Edit Font

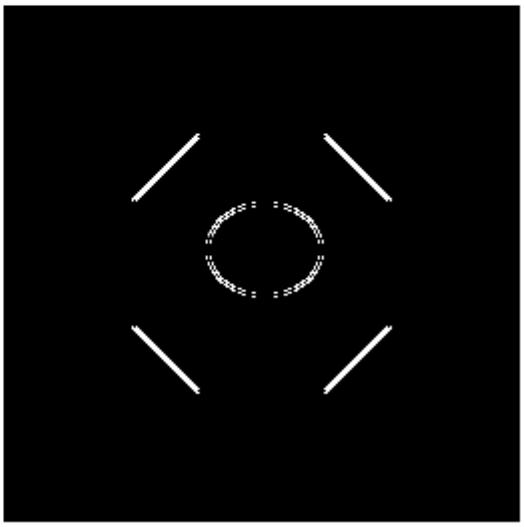
Input Image	Filter	Impl.	Time [ms]	Output Image	Mean(out)	Min(out)	Max(out)
mit.tif	Sobel		60.00	[Student] Sobel	20.75	0.00	469.52
octagon.tif	Sobel		24.00	[Student] Sobel	4.14	0.00	360.62

[Student] Sobel

256x256 pixels; 32-bit; 256K

[Student] Sobel

256x256 pixels; 32-bit; 256K



Insira a parte do código escrito para este exercício

```
static public ImageAccess doSobel(ImageAccess input) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        double gx, gy;

        // Apply horizontal Sobel kernel to rows
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doSobelHorizontal(rowin, rowout);
            out.putRow(y, rowout);
```

```java
        }

        // Apply vertical Sobel kernel to columns
        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doSobelVertical(colin, colout);
            out.putColumn(x, colout);
        }

        // Combine the results
        for (int x = 0; x < nx; x++) {
            for (int y = 0; y < ny; y++) {
                gx = out.getPixel(x, y);
                gy = out.getPixel(x, y);
                double pixel = Math.sqrt(gx * gx + gy * gy);
                out.putPixel(x, y, pixel);
            }
        }

        return out;
    }

    static private void doSobelHorizontal(double vin[], double vout[]) {
        int n = vin.length;
        vout[0] = vin[0] - vin[2];
        for (int k = 1; k < n - 1; k++) {
            vout[k] = vin[k - 1] - vin[k + 1];
        }
        vout[n - 1] = vin[n - 2] - vin[n - 1];
    }

    static private void doSobelVertical(double vin[], double vout[]) {
        int n = vin.length;
        vout[0] = vin[0] - vin[2];
        for (int k = 1; k < n - 1; k++) {
            vout[k] = vin[k - 1] - vin[k + 1];
        }
        vout[n - 1] = vin[n - 2] - vin[n - 1];
    }
```

Questão 5:

(Mesmo código da questão 3.1)

```
static public ImageAccess doMovingAverageL_Recursive(ImageAccess input, int length) {
        int nx = input.getWidth();
        int ny = input.getHeight();
        ImageAccess out = new ImageAccess(nx, ny);
        double rowin[]  = new double[nx];
        double rowout[] = new double[nx];
        for (int y = 0; y < ny; y++) {
            input.getRow(y, rowin);
            doAverageL_Recursive(rowin, rowout, 0, length);
            out.putRow(y, rowout);
        }

        double colin[]  = new double[ny];
        double colout[] = new double[ny];
        for (int x = 0; x < nx; x++) {
            out.getColumn(x, colin);
            doAverageL_Recursive(colin, colout, 0, length);
            out.putColumn(x, colout);
        }

        return out;
    }

    static public void doAverageL_Recursive(double vin[], double vout[], int k,
int length) {
        int n = vin.length;
        if (k >= n) {
            return;
        }
        if (k == 0) {
            double sum = 0.0;
            for (int i = 0; i < length; i++) {
                int index = Math.min(Math.max(i, 0), n - 1);
                sum += vin[index];
            }
            vout[0] = sum / (double) length;
        } else if (k >= n - length / 2) {
            double sum = 0.0;
            for (int i = n - length; i < n; i++) {
```

```
                int index = Math.min(Math.max(i, 0), n - 1);
                sum += vin[index];
            }
            vout[k] = sum / (double) length;
        } else {
            double sum = 0.0;
            for (int i = k - length / 2; i <= k + length / 2; i++) {
                int index = Math.min(Math.max(i, 0), n - 1);
                sum += vin[index];
            }
            vout[k] = sum / (double) length;
        }
        doAverageL_Recursive(vin, vout, k + 1, length);
    }
```