(4-2-1-2) Adaptive Filters: -These filters are based on the location statistics of the image and also on the mathematical model.

Adaptive filters are commonly used in image processing to enhance or restore data by removing noise without significantly blurring the structures in the image.

a- Lea and Kaun Filters.

b- Homomorphic filters. (**Powerful filters**)

a) Lea and Kaun Filters.

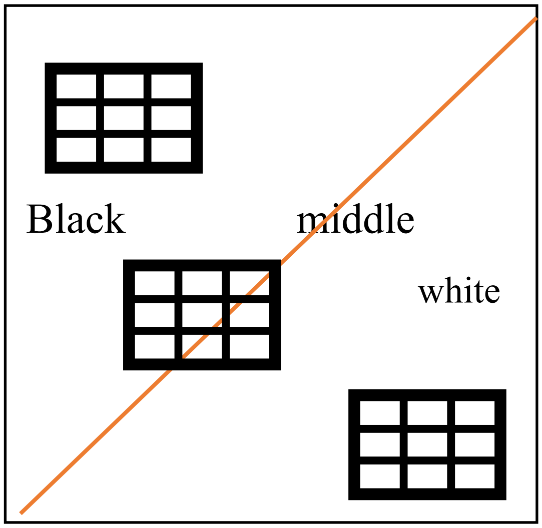
$$R(x,y) = \underbrace{W\,\bar{I}}_{\text{Smoothing}} - \underbrace{(1 - W)\,\bar{I}}_{\text{Edge}}$$

يعمل تنعيم كبير يحافظ على الحافات

$$0 \leq W \leq 1$$

- A window has been placed on different image areas (black, white, and middle) to interpret each region.

Black and white	Middle
No edge	Edge Presence Edge and blurring
μ , σ = very small **≈ 0** تباين قليل لذلك تعمل تنعيم	**μ , σ = very high** تباين عالي (منطقة الحافة مهمة بسبب احتواءها على اغلب المعلومات فيجب المحافظة عليها)
W = 1 عامل التنعيم **R=I**	**W= different values وجود موديلين** **من الضوضاء الجمعية والضربية**
التنعيم بنسبة 100% (فلتر المعدل)	W= 0 **حافات قوية دون تشويه**



b-Homomorphic filters

1- It is one of the most powerful filters, but alone it is not powerful

If we have additive noise related to $R.R^2$, we take either the square root or the cube root of R.

$$R\,R^2 = \mathbf{R}\sqrt{R^2}$$

2- If the noise is Multiplicative, then the situation is difficult here, take its logarithm

$$I = R.\,F$$

$$\mathrm{Log}(I) = \log(R) + \log(F)$$

تم تحويل الموديل من الضرب الى جمع

$$\bar{\mathbf{I}} = (\bar{\mathbf{R}} + \bar{\mathbf{n}})$$

الان نستطيع المعالجة بالأساليب التقليدية.

(4-2-1-3) Edge Detection Filters (derivative Operator)

It plays an important role in many image processing applications and is very important in the process of analyzing the image and extracting useful information and features from it through the edge. The presence of the edge depends on the value of the point and its similarity to the values of its neighboring points. If the grayscale value of a particular point is similar to the values of its neighbors, it is not considered an edge. If the difference is large, then it represents an edge.

Its uses

1- To improve the edges in the image by increasing the contrast, that is, the sharpness of the details in the image. This is the opposite of smoothing, which weakens the edge.

2- Improve contrast 3- Image analysis, that is, extracting edges that represent details of the image or a feature of the body, and extracting edges with features that are different from each other.

- **Edge: -** A discontinuity in grayscale values, that is, a sudden change in the values of a point with its neighbors, as well as a change in color and texture.
- **Thresholding:** - It is a process that takes place after distinguishing and showing the contrast and the effect of the points that are part of an edge, after which the points are connected to form the boundaries that distinguish the components and separate them from the background of the image, and they are chosen intuitively.

$$T = \frac{\sum F(i,j)}{W x h} \approx 0 \Rightarrow 1$$

- There are several derived filters, which are:

1- Robert's mask Filter: -

Gx=

-1	0
0	1

, Gy=

0	-1
1	0

كشف الحافات الافقية

كشف الحافات العمودية

2- Soble Mask: - Gx=¼

1	2	1
0	0	0
-1	-2	-1

Gy=¼

1	0	-1
2	0	-2
1	0	-1

كشف الحافات الافقية

3-Laplacian filter: - 1/4

1	2	1
0	0	0
-1	-2	-1

1/8

1	1	1
1	-8	1
1	1	1

يستخدم لتحسين التفاصيل في جميع الاتجاهات وتكون الحافات واضحة في هذا الفلتر.

4-Laplacian + addition يستخدم لتحسين الحافات لا تساوي صفر

0	-1	0
-1	5	-1
0	-1	0

5-Convolution filter: - (مهم جدا) يعمل على التواء الصورة

Gx=

- 1	1

Gy=

1
-1

1- Sharping filter: -

من الفلاتر المهمة التي تعمل على أ- تقوية الحافات ب- زيادة التباين أي زيادة الحدة في التفاصيل ج- تنعيم الحافات.

عرفنا ان معدل فلاتر التنعيم = 1 معدل فلاتر الحافات = صفر

اما معدل فلاتر الحدة فلا يساوي صفر ولا واحد

1/8

1	1	1
1	-9	1
1	1	1

2- Uniform filter (average Mask)

1/9

1	1	1
1	1	1
1	1	1

8. Non-uniform filter

1/16

1	2	1
2	4	2
1	2	1

يفضل الفلتر غير المنتظم وذلك لأنه أكثر وزنا.

✓ الفلاتر السابقة تعتمد على المشتقة

بيضاء اسود

1D

x+1, y	x, y

$$\Delta x = 1 \qquad , \frac{\partial f}{\partial x} = f\ (x+1,y) - f(x,y)$$

x, y+1	x, y

$$\Delta y = 1 \qquad , \frac{\partial f}{\partial y} = f\ (x,y+1) - f(x,y)$$

المشتقة الثانية

$$\frac{\partial^2 f}{\partial x^2} = f\ (x+1,y) + f(x-1,y) - 2\,f\ (x,y) \ldots (4\text{-}1)$$

$$\frac{\partial^2 f}{\partial y^2} = f\ (x,y+1) + f(x,y-1) - 2\,f(x,y) \ldots\ldots (4\text{-}2)$$

The gradient

$$\nabla f = \frac{\partial f(x,y)}{\partial x} + \frac{\partial f(x,y)}{\partial y} = \frac{\partial f(x,y)}{\partial x\,\partial y}$$

➢Laplacian

$$\nabla^2 f = \frac{\partial^2 f(x,y)}{\partial x^2 \partial y^2} = \frac{\partial^2 f(x,y)}{\partial x^2} + \frac{\partial^2 f(x,y)}{\partial y^2}$$

بتعويض المعادلات (4-1)و(4-2) في المعادلة السابقة لنحصل على

$$\nabla^2 f = f\ (x+1,y) + f(x-1,y) + f\ (x,y+1) + f(x,y-1) - 4\, f(x,y) \quad \ldots\ldots\ldots\ldots (4\text{-}3)$$

هناك بعض المؤثرات تستعمل اكثر من دالة مثل لابلاس +الجمع وكالاتي :-

سالبة $g(x,y) = f(x,y) - \nabla^2 f(x,y)$

$g(x,y) =$

موجبة $g(x,y) = f(x,y) + \nabla^2 f(x,y)$

➢Laplacian + addition

$$g(x,y) = f(x,y) - [\ f\ (x+1,y) + f(x-1,y) + f\ (x,y+1) + f(x,y-1)\ ] + 4\, f(x,y)$$

$$= 5\, f(x,y) - [\ f\ (x+1,y) + f(x-1,y) + f\ (x,y+1) + f(x,y-1)\ ]$$

To calculate

C_1	C_2	C_3
C_4	C_5	C_6
C_7	C_8	C_9

$$\nabla^2 f = |\, Gx^2 + Gy^2 \,|$$

$$\nabla f = |\, Gx^2 + Gy^2 \,|^{\frac{1}{2}} \qquad \ldots\ldots..(4\text{-}4)$$

To calculate the Roberts mask

-1	**0**
0	**1**

0	-1
1	0

$Gx = |\, C_9 - C_5 \,|$

$Gy = |\, C_8 - C_6 \,|$

$$\nabla f = |\, Gx^2 + Gy^2 \,|^{\frac{1}{2}}$$

If g =max (Gx, Gy) $\geq$ threshold then edge point e (x, y) =255 else e (x, y) =0 (Smoothing)

To calculate the Soble Mask

$Gx = |\, C_7 + 2\, C_8 + C_9 \,| - |\, C_1 + 2\, C_2 + C_3 \,|$

$Gy = |\, C_3 + 2\, C_6 + C_9 \,| - |\, C_1 + 2\, C_4 + C_7 \,|$

$$\nabla f = |\, Gx^2 + Gy^2 \,|^{\frac{1}{2}}$$

If g =max (Gx, Gy) = $\frac{(Gx, Gy)}{2}$ $\geq$ threshold then edge point e (x, y) =255 else e(x, y) =0

Example: - Apply the Roberts mask on the image, where the threshold =25?

4	3	7	100	99
5	4	100	101	103
6	7	99	102	113
10	8	8	100	104

Solution: - Robert's mask

Gx= $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$, Gy= $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$

1- V(4)= ?

Gx= -4 +4 = 0

Gy= -3 + 5= 2 $\longrightarrow$ $\nabla f = |0| + |2| = 2$

2< th $\therefore v(4) = 0$

2- V (3) =?

Gx= -3+100 =97

Gy= -7+ 4 = -3 $\longrightarrow \nabla f = |97| + |-3| = 97+3=100$

100 > th $\therefore v(3) = 255$

3- V(7) =?

Gx= -7+101= 94

Gy = 100-100=0 ⟹ ∇f= |94| +| 0| =94+0=94

94 > th ∴ V(7) = 255

4- V(100) = ?

Gx = -100 + 103 = 3 , Gy = -99 + 101 = 2

∇f =|3| +| 2| =5 5 < th ∴ V(100) = 0

5- V(5) = ?

Gx= -5 +7 = 2 , Gy= -4+6= 2

∇f = |2| +| 2| =4 4 < th ∴ V(100) = 0

4	3	7	100	99
5	4	100	101	103
6	7	99	102	113
10	8	8	100	104

⟹

0	255	255	0	0
0	255	0	0	0
0	255	255	0	0
0	0	0	0	0

Example: - Apply the Soble mask on the same image, where the threshold = 25?

Solution: -

Gx=1/4

1	2	1
0	0	0
-1	-2	-1

Gy =1/4

1	0	-1
2	0	-2
1	0	-1

1-V(4)= ?

Gx= ¼ | 4+6+7-6-14-99| =1/4 |-102|=1/4 *102 =102/4 = 25.5

Gy= ¼ | 4+10+6 -7-200-99 | = ¼ |-286|= 1/4 * 286 =286/4 = 71.5

g =(Gx+Gy) /2 = 48.5

g = max (Gx, Gy) > th. then e (x, y) = 255

2-V(100)= ?

Gx= ¼ | 3+14+100-7-198-102| = 1/4 |-190|

Gx = ¼ * 190 = 190/4 =47.5

Gy = ¼ | 3+8+7 -100-202-102|= ¼|-386|= 96.5

g =(Gx+Gy) /2 = 72

g = max (Gx, Gy) > th. then e (x, y) = 255

3-V(101)=?

$Gx = \frac{1}{4} | 7+200+99-33-204-113 | = \frac{1}{4} |-110|$

$= 110/4 = 27.5$

$Gy = \frac{1}{4} | 7+200+99-99-206-113 | = \frac{1}{4} |-112|$

$= 112/4 = 28$

$g = (Gx+Gy)/2 = 55.5/2 = 27.75$

$g = \max(Gx, Gy) > th.$ then $e(x, y) = 255$

وهكذا بقية البكسلات لتنتج الصورة الاتية

4	3	7	100	99
5	4	100	101	103
6	7	99	102	113
10	8	8	100	104

0	0	0	0	0
0	255	255	255	0
0	255	255	255	0
0	0	0	0	0

Example: - Apply the mask average (1) for the following matrix?

1/9

1	1	1
1	1	1
1	1	1

0	1	10	100	102	103
5	4	11	102	108	100
4	7	100	103	105	103
5	8	9	10	100	102
10	50	50	57	60	61
10	51	52	55	61	52

Sol.

Row 2

2-R (4) = 1/9 (0+1+10+5+4+11+4+7+100) = 142/9 =16

2-R (11) =1/9(1+10+100+4+11+102+7+100+103) =438/9=49

2-R(102)=1/9(10+100+102+11+102+108+100+103+105)=741/9= 82.3 =82

2-R(108)= 1/9(100+102+103+102+108+100+103+105+103)=926/9=102.8=103

Row 3

3-R (7) = 1/9(5+4+11+4+7+100+5+8+9)=153/9 = 17

3-R (100) = 1/9(4+11+102+7+100+103+8+9+10) = 354/9=39.3=39

3-R(103)= 1/9(11+102+108+100+103+105+9+10+100)=648/9=72

3-R(105)= 1/9(102+108+100+103+105+103+10+100+102)=833/9=
92.5=93

Row 4

4-R(8)= 1/9(4+7+100+5+8+9+10+50+50)=243/9 =27

4-R(9)= 1/9(7+100+103+8+9+10+50+50+57)= 394/9=43.7=44

4-R(10)=1/9(100+103+105+9+10+100+50+57+60)=594/9=66

4-R(100)=1/9(103+105+103+10+100+102+57+60+61)=701/9=77.8 =78

و هكذا للصف الخامس نقوم بنفس العمل

اما الصف الأول والسادس والعمود الاول والسادس فيتم تصفيرهم فتصبح المصفوفة كالاتي:-

0	**1**	**10**	**100**	**102**	**103**
5	4	11	102	108	100
4	7	100	103	105	103
5	8	9	10	100	102
10	50	50	57	60	61
10	51	52	55	61	52

→

0	**0**	**0**	**0**	**0**	**0**
0	16	49	82	103	0
0	17	39	72	93	0
0	27	44	66	78	0
0	27	38	50	62	0
0	0	0	0	0	0

H.W: - Apply the mask average (2) for the same matrix?