TO..... FROM..... DATE..... 80

EE4211 Homework 1

① (a)

| | | |
|---|---|---|
| 2 | 7 | 4 |
| 6 | 5 | 1 |
| 5 | 1 | 4 |

3×3 at (3,3)

$$\text{Output} = \frac{1}{9}[2+7+4+6+5+1+5+1+4]$$
$$= \frac{1}{9}[35] = 3.889 \approx 4$$

(b)

| | | |
|---|---|---|
| 5 | 2 | 7 |
| 1 | 6 | 5 |
| 7 | 5 | 1 |

3×3 at (2,3)

Output of median filter :

1, 1, 2, 5, (5), 5, 6, 7, 7

= 5

(c)

| | | |
|---|---|---|
| 4 | 5 | 2 |
| 3 | 1 | 6 |
| 2 | 7 | 5 |

3×3 at (1,3)

*

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | -8 | 1 |
| 1 | 1 | 1 |

Laplacian filter

Output = (4×1) + (5×1) + (2×1) + (3×1) + (1×-8) + (6×1) + (2×1) + (7×1) + (5×1)

= 4 + 5 + 2 + 3 + (-8) + 6 + 2 + 7 + 5

= 26

(d)

| i | $\hat{h}_i$ |
|---|---|
| 0 | 2/25 |
| 1 | 4/25 |
| 2 | 5/25 |
| 3 | 2/25 |
| 4 | 3/25 |
| 5 | 3/25 |
| 6 | 3/25 |
| 7 | 3/25 |

TO..... FROM..... DATE..... NO.....

(e)

| i | $\hat{h}_i$ | $\hat{C}_i$ | $7\hat{C}_i$ |
|---|---|---|---|
| 0 | 2/25 | 2/25 | 1 |
| 1 | 4/25 | 6/25 | 2 |
| 2 | 5/25 | 11/25 | 3 |
| 3 | 2/25 | 13/25 | 4 |
| 4 | 3/25 | 16/25 | 4 |
| 5 | 3/25 | 19/25 | 5 |
| 6 | 3/25 | 22/25 | 6 |
| 7 | 3/25 | 25/25 | 7 |

$\Rightarrow$

Equalized image

| y \ x | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 0 | 4 | 7 | 6 | 3 | 1 |
| 1 | 3 | 3 | 6 | 1 | 2 |
| 2 | 4 | 5 | 3 | 7 | 4 |
| 3 | 4 | 2 | 6 | 5 | 2 |
| 4 | 3 | 7 | 5 | 2 | 4 |

$\Downarrow$

New histogram of result

| i | $\hat{h}_i$ |
|---|---|
| 0 | 0/25 |
| 1 | 2/25 |
| 2 | 4/25 |
| 3 | 5/25 |
| 4 | 5/25 |
| 5 | 3/25 |
| 6 | 3/25 |
| 7 | 3/25 |

TO ..... FROM ..... DATE ..... NO .....

③ (a). Spatial average is:

$$g(x,y) = \frac{1}{4}\left[f(x,y+1) + f(x+1,y) + f(x-1,y) + f(x,y-1)\right]$$

• Using the property:

$$f(x-x_0, y-y_0) \Leftrightarrow F(u,v)\, e^{-j2\pi(ux_0/M + vy_0/N)}$$

$$G(u,v) = \frac{1}{4}\left[e^{j2\pi v/N} + e^{j2\pi u/M} + e^{-j2\pi u/M} + e^{-j2\pi v/N}\right] F(u,v)$$

$$= H(u,v)\, F(u,v)$$

where the $H(u,v)$ is the filter function. The transfer function is:

$$H(u,v) = \frac{1}{2}\left[\cos(2\pi u/M) + \cos(2\pi v/N)\right]$$

• The $H(u,v)$ Filter function can be centered by:

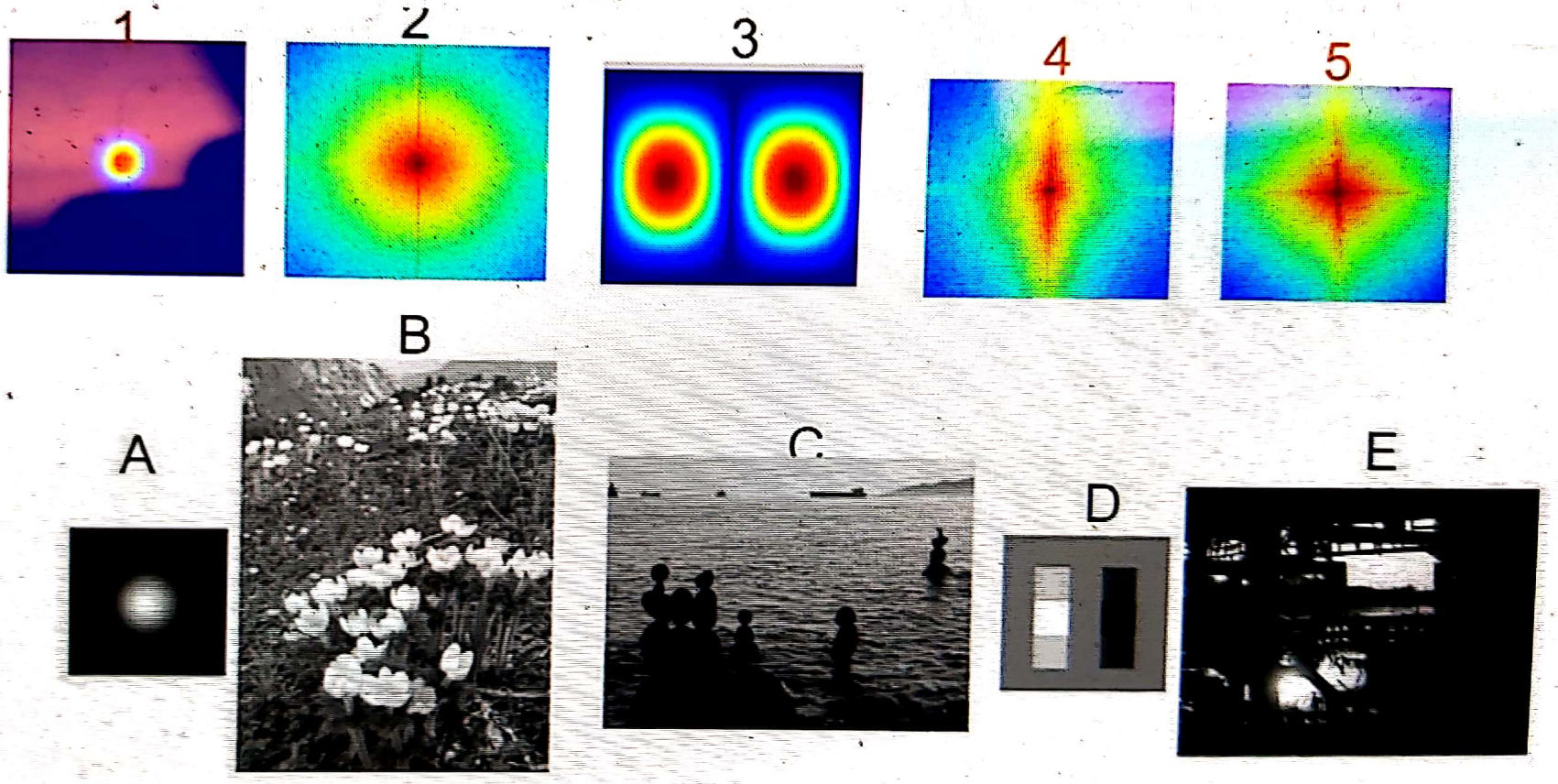
$$H(u,v) = \frac{1}{2}\left[\cos(2\pi[u - M/2]/M) + \cos(2\pi[v - N/2]/N)\right]$$

(b) Consider one variable for convenience. As u ranges from 0 to M, the value of $\cos(2\pi[u-M/2]/M)$ starts at -1, peaks at 1 when $u = M/2$ (the center of the filter) and then decreases to -1 again when $u = M$. Hence, the amplitude of the filter decreases as a function of distance from the origin of the centered filter, which is the characteristic of a lowpass filter.

A similar argument can also be easily carried out when considering both variables simultaneously.

**Question 2 (15 marks)**

Please match following images A-E with the corresponding Fourier spectrum 1-5? Explain the reasons.




1-A,2-B,3-D,4-C,5-E