**Lương Chung Hội – XLA – 62TH2**

**Bài tập tuần 5 (11/12/2023 – 16/12/2023)**

**Câu 1.** Thực hiện phát hiện biên bằng bộ lọc Sobel.

**Câu 2.** Thực hiện phát hiện biên bằng bộ lọc Prewitt

**Câu 3.** Thực hiện phát hiện biên bằng bộ lọc Kirsch

**Câu 4.** Thực hiện phát hiện biên bằng bộ lọc Laplacian:

|  |  |  |
| --- | --- | --- |
| 0 | -1 | 0 |
| -1 | 4 | -1 |
| 0 | -1 | 0 |

**Yêu cầu: Thay công thức và tính toán từng bước cụ thể. Không được làm tắt và ghi mỗi đáp số.**

Ma trận 30:

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

Ta có ma trận cửa sổ 3x3 tại các vị trí như sau:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| COL  ROW | 0 | 1 | 2 | 3 | 4 |
| 0 | 0 0 0  0 4 6  0 6 4 | 0 0 0  4 6 7  6 4 7 | 0 0 0  6 7 2  4 7 2 | 0 0 0  7 2 2  7 2 2 | 0 0 0  2 2 0  2 2 0 |
| 1 | 0 4 6  0 6 4  0 3 5 | 4 6 7  6 4 7  3 5 3 | 6 7 2  4 7 2  5 3 5 | 7 2 2  7 2 2  3 5 4 | 2 2 0  2 2 0  5 4 0 |
| 2 | 0 6 4  0 3 5  0 4 6 | 6 4 7  3 5 3  4 6 6 | 4 7 2  5 3 5  6 6 4 | 7 2 2  3 5 4  6 4 4 | 2 2 0  5 4 0  4 4 0 |
| 3 | 0 3 5  0 4 6  0 1 2 | 3 5 3  4 6 6  1 2 3 | 5 3 5  6 6 4  2 3 6 | 3 5 4  6 4 4  3 6 6 | 5 4 0  4 4 0  6 6 0 |
| 4 | 0 4 6  0 1 2  0 0 0 | 4 6 6  1 2 3  0 0 0 | 6 6 4  2 3 6  0 0 0 | 6 4 4  3 6 6  0 0 0 | 4 4 0  6 6 0  0 0 0 |

**Câu 1. Thực hiện phát hiện biên bằng bộ lọc Sobel.**

I =

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

K1 =

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

G(0, 0) = 0\*1 + 0\*0 + 0\*-1 + 0\*2 + 4\*0 + 6\*-2 + 0\*1 + 6\*0 + 4\*-1 = -16

G(0, 1) = 0\*1 + 0\*0 + 0\*-1 + 4\*2 + 6\*0 + 7\*-2 + 6\*1 + 4\*0 + 7\*-1 = -7

G(0, 2) = 0\*1 + 0\*0 + 0\*-1 + 6\*2 + 7\*0 + 2\*-2 + 4\*1 + 7\*0 + 2\*-1 = 10

G(0, 3) = 0\*1 + 0\*0 + 0\*-1 + 7\*2 + 2\*0 + 2\*-2 + 7\*1 + 2\*0 + 2\*-1 = 15

G(0, 4) = 0\*1 + 0\*0 + 0\*-1 + 2\*2 + 2\*0 + 0\*-2 + 2\*1 + 2\*0 + 0\*-1 = 6

G(1, 0) = 0\*1 + 4\*0 + 6\*-1 + 0\*2 + 6\*0 + 4\*-2 + 0\*1 + 3\*0 + 5\*-1 = -19

G(1, 1) = 4\*1 + 6\*0 + 7\*-1 + 6\*2 + 4\*0 + 7\*-2 + 3\*1 + 5\*0 + 3\*-1 = -5

G(1, 2) = 6\*1 + 7\*0 + 2\*-1 + 4\*2 + 7\*0 + 2\*-2 + 5\*1 + 3\*0 + 5\*-1 = 8

G(1, 3) = 7\*1 + 2\*0 + 2\*-1 + 7\*2 + 2\*0 + 2\*-2 + 3\*1 + 5\*0 + 4\*-1 = 14

G(1, 4) = 2\*1 + 2\*0 + 0\*-1 + 2\*2 + 2\*0 + 0\*-2 + 5\*1 + 4\*0 + 0\*-1 = 11

G(2, 0) = 0\*1 + 6\*0 + 4\*-1 + 0\*2 + 3\*0 + 5\*-2 + 0\*1 + 4\*0 + 6\*-1 = -20

G(2, 1) = 6\*1 + 4\*0 + 7\*-1 + 3\*2 + 5\*0 + 3\*-2 + 4\*1 + 6\*0 + 6\*-1 = -3

G(2, 2) = 4\*1 + 7\*0 + 2\*-1 + 5\*2 + 3\*0 + 5\*-2 + 6\*1 + 6\*0 + 4\*-1 = 4

G(2, 3) = 7\*1 + 2\*0 + 2\*-1 + 3\*2 + 5\*0 + 4\*-2 + 6\*1 + 4\*0 + 4\*-1 = 5

G(2, 4) = 2\*1 + 2\*0 + 0\*-1 + 5\*2 + 4\*0 + 0\*-2 + 4\*1 + 4\*0 + 0\*-1 = 16

G(3, 0) = 0\*1 + 3\*0 + 5\*-1 + 0\*2 + 4\*0 + 6\*-2 + 0\*1 + 1\*0 + 2\*-1 = -19

G(3, 1) = 3\*1 + 5\*0 + 3\*-1 + 4\*2 + 6\*0 + 6\*-2 + 1\*1 + 2\*0 + 3\*-1 = -6

G(3, 2) = 5\*1 + 3\*0 + 5\*-1 + 6\*2 + 6\*0 + 4\*-2 + 2\*1 + 3\*0 + 6\*-1 = 0

G(3, 3) = 3\*1 + 5\*0 + 4\*-1 + 6\*2 + 4\*0 + 4\*-2 + 3\*1 + 6\*0 + 6\*-1 = 0

G(3, 4) = 5\*1 + 4\*0 + 0\*-1 + 4\*2 + 4\*0 + 0\*-2 + 6\*1 + 6\*0 + 0\*-1 = 19

G(4, 0) = 0\*1 + 4\*0 + 6\*-1 + 0\*2 + 1\*0 + 2\*-2 + 0\*1 + 0\*0 + 0\*-1 = -10

G(4, 1) = 4\*1 + 6\*0 + 6\*-1 + 1\*2 + 2\*0 + 3\*-2 + 0\*1 + 0\*0 + 0\*-1 = -6

G(4, 2) = 6\*1 + 6\*0 + 4\*-1 + 2\*2 + 3\*0 + 6\*-2 + 0\*1 + 0\*0 + 0\*-1 = -6

G(4, 3) = 6\*1 + 4\*0 + 4\*-1 + 3\*2 + 6\*0 + 6\*-2 + 0\*1 + 0\*0 + 0\*-1 = -4

G(4, 4) = 4\*1 + 4\*0 + 0\*-1 + 6\*2 + 6\*0 + 0\*-2 + 0\*1 + 0\*0 + 0\*-1 = 16

Kết quả:

Gx =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -16 | -7 | 10 | 15 | 6 |
| -19 | -5 | 8 | 14 | 11 |
| -20 | -3 | 4 | 5 | 16 |
| -19 | -6 | 0 | 0 | 19 |
| -10 | -6 | -6 | -4 | 16 |

K2 =

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

G(0, 0) = 0\*1 + 0\*2 + 0\*1 + 0\*0 + 4\*0 + 6\*0 + 0\*-1 + 6\*-2 + 4\*-1 = -16

G(0, 1) = 0\*1 + 0\*2 + 0\*1 + 4\*0 + 6\*0 + 7\*0 + 6\*-1 + 4\*-2 + 7\*-1 = -21

G(0, 2) = 0\*1 + 0\*2 + 0\*1 + 6\*0 + 7\*0 + 2\*0 + 4\*-1 + 7\*-2 + 2\*-1 = -20

G(0, 3) = 0\*1 + 0\*2 + 0\*1 + 7\*0 + 2\*0 + 2\*0 + 7\*-1 + 2\*-2 + 2\*-1 = -13

G(0, 4) = 0\*1 + 0\*2 + 0\*1 + 2\*0 + 2\*0 + 0\*0 + 2\*-1 + 2\*-2 + 0\*-1 = -6

G(1, 0) = 0\*1 + 4\*2 + 6\*1 + 0\*0 + 6\*0 + 4\*0 + 0\*-1 + 3\*-2 + 5\*-1 = 3

G(1, 1) = 4\*1 + 6\*2 + 7\*1 + 6\*0 + 4\*0 + 7\*0 + 3\*-1 + 5\*-2 + 3\*-1 = 7

G(1, 2) = 6\*1 + 7\*2 + 2\*1 + 4\*0 + 7\*0 + 2\*0 + 5\*-1 + 3\*-2 + 5\*-1 = 6

G(1, 3) = 7\*1 + 2\*2 + 2\*1 + 7\*0 + 2\*0 + 2\*0 + 3\*-1 + 5\*-2 + 4\*-1 = -4

G(1, 4) = 2\*1 + 2\*2 + 0\*1 + 2\*0 + 2\*0 + 0\*0 + 5\*-1 + 4\*-2 + 0\*-1 = -7

G(2, 0) = 0\*1 + 6\*2 + 4\*1 + 0\*0 + 3\*0 + 5\*0 + 0\*-1 + 4\*-2 + 6\*-1 = 2

G(2, 1) = 6\*1 + 4\*2 + 7\*1 + 3\*0 + 5\*0 + 3\*0 + 4\*-1 + 6\*-2 + 6\*-1 = -1

G(2, 2) = 4\*1 + 7\*2 + 2\*1 + 5\*0 + 3\*0 + 5\*0 + 6\*-1 + 6\*-2 + 4\*-1 = -2

G(2, 3) = 7\*1 + 2\*2 + 2\*1 + 3\*0 + 5\*0 + 4\*0 + 6\*-1 + 4\*-2 + 4\*-1 = -5

G(2, 4) = 2\*1 + 2\*2 + 0\*1 + 5\*0 + 4\*0 + 0\*0 + 4\*-1 + 4\*-2 + 0\*-1 = -6

G(3, 0) = 0\*1 + 3\*2 + 5\*1 + 0\*0 + 4\*0 + 6\*0 + 0\*-1 + 1\*-2 + 2\*-1 = 7

G(3, 1) = 3\*1 + 5\*2 + 3\*1 + 4\*0 + 6\*0 + 6\*0 + 1\*-1 + 2\*-2 + 3\*-1 = 8

G(3, 2) = 5\*1 + 3\*2 + 5\*1 + 6\*0 + 6\*0 + 4\*0 + 2\*-1 + 3\*-2 + 6\*-1 = 2

G(3, 3) = 3\*1 + 5\*2 + 4\*1 + 6\*0 + 4\*0 + 4\*0 + 3\*-1 + 6\*-2 + 6\*-1 = -4

G(3, 4) = 5\*1 + 4\*2 + 0\*1 + 4\*0 + 4\*0 + 0\*0 + 6\*-1 + 6\*-2 + 0\*-1 = -5

G(4, 0) = 0\*1 + 4\*2 + 6\*1 + 0\*0 + 1\*0 + 2\*0 + 0\*-1 + 0\*-2 + 0\*-1 = 14

G(4, 1) = 4\*1 + 6\*2 + 6\*1 + 1\*0 + 2\*0 + 3\*0 + 0\*-1 + 0\*-2 + 0\*-1 = 22

G(4, 2) = 6\*1 + 6\*2 + 4\*1 + 2\*0 + 3\*0 + 6\*0 + 0\*-1 + 0\*-2 + 0\*-1 = 22

G(4, 3) = 6\*1 + 4\*2 + 4\*1 + 3\*0 + 6\*0 + 6\*0 + 0\*-1 + 0\*-2 + 0\*-1 = 18

G(4, 4) = 4\*1 + 4\*2 + 0\*1 + 6\*0 + 6\*0 + 0\*0 + 0\*-1 + 0\*-2 + 0\*-1 = 12

Kết quả:

Gy =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -16 | -21 | -20 | -13 | -6 |
| 3 | 7 | 6 | -4 | -7 |
| 2 | -1 | -2 | -5 | -6 |
| 7 | 8 | 2 | -4 | -5 |
| 14 | 22 | 22 | 18 | 12 |

G = |Gx| + |Gy|

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 32 | 28 | 30 | 28 | 12 |
| 22 | 12 | 14 | 18 | 18 |
| 22 | 4 | 6 | 10 | 22 |
| 26 | 14 | 2 | 4 | 24 |
| 24 | 28 | 28 | 22 | 28 |

**Bài 2: Thực hiện phát hiện biên bằng bộ lọc Prewitt**

I =

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

K1 =

|  |  |  |
| --- | --- | --- |
| 1 | 0 | -1 |
| 1 | 0 | -1 |
| 1 | 0 | -1 |

G(0, 0) = 0\*1 + 0\*0 + 0\*-1 + 0\*1 + 4\*0 + 6\*-1 + 0\*1 + 6\*0 + 4\*-1 = -10

G(0, 1) = 0\*1 + 0\*0 + 0\*-1 + 4\*1 + 6\*0 + 7\*-1 + 6\*1 + 4\*0 + 7\*-1 = -4

G(0, 2) = 0\*1 + 0\*0 + 0\*-1 + 6\*1 + 7\*0 + 2\*-1 + 4\*1 + 7\*0 + 2\*-1 = 6

G(0, 3) = 0\*1 + 0\*0 + 0\*-1 + 7\*1 + 2\*0 + 2\*-1 + 7\*1 + 2\*0 + 2\*-1 = 10

G(0, 4) = 0\*1 + 0\*0 + 0\*-1 + 2\*1 + 2\*0 + 0\*-1 + 2\*1 + 2\*0 + 0\*-1 = 4

G(1, 0) = 0\*1 + 4\*0 + 6\*-1 + 0\*1 + 6\*0 + 4\*-1 + 0\*1 + 3\*0 + 5\*-1 = -15

G(1, 1) = 4\*1 + 6\*0 + 7\*-1 + 6\*1 + 4\*0 + 7\*-1 + 3\*1 + 5\*0 + 3\*-1 = -4

G(1, 2) = 6\*1 + 7\*0 + 2\*-1 + 4\*1 + 7\*0 + 2\*-1 + 5\*1 + 3\*0 + 5\*-1 = 6

G(1, 3) = 7\*1 + 2\*0 + 2\*-1 + 7\*1 + 2\*0 + 2\*-1 + 3\*1 + 5\*0 + 4\*-1 = 9

G(1, 4) = 2\*1 + 2\*0 + 0\*-1 + 2\*1 + 2\*0 + 0\*-1 + 5\*1 + 4\*0 + 0\*-1 = 9

G(2, 0) = 0\*1 + 6\*0 + 4\*-1 + 0\*1 + 3\*0 + 5\*-1 + 0\*1 + 4\*0 + 6\*-1 = -15

G(2, 1) = 6\*1 + 4\*0 + 7\*-1 + 3\*1 + 5\*0 + 3\*-1 + 4\*1 + 6\*0 + 6\*-1 = -3

G(2, 2) = 4\*1 + 7\*0 + 2\*-1 + 5\*1 + 3\*0 + 5\*-1 + 6\*1 + 6\*0 + 4\*-1 = 4

G(2, 3) = 7\*1 + 2\*0 + 2\*-1 + 3\*1 + 5\*0 + 4\*-1 + 6\*1 + 4\*0 + 4\*-1 = 6

G(2, 4) = 2\*1 + 2\*0 + 0\*-1 + 5\*1 + 4\*0 + 0\*-1 + 4\*1 + 4\*0 + 0\*-1 = 11

G(3, 0) = 0\*1 + 3\*0 + 5\*-1 + 0\*1 + 4\*0 + 6\*-1 + 0\*1 + 1\*0 + 2\*-1 = -13

G(3, 1) = 3\*1 + 5\*0 + 3\*-1 + 4\*1 + 6\*0 + 6\*-1 + 1\*1 + 2\*0 + 3\*-1 = -4

G(3, 2) = 5\*1 + 3\*0 + 5\*-1 + 6\*1 + 6\*0 + 4\*-1 + 2\*1 + 3\*0 + 6\*-1 = -2

G(3, 3) = 3\*1 + 5\*0 + 4\*-1 + 6\*1 + 4\*0 + 4\*-1 + 3\*1 + 6\*0 + 6\*-1 = -2

G(3, 4) = 5\*1 + 4\*0 + 0\*-1 + 4\*1 + 4\*0 + 0\*-1 + 6\*1 + 6\*0 + 0\*-1 = 15

G(4, 0) = 0\*1 + 4\*0 + 6\*-1 + 0\*1 + 1\*0 + 2\*-1 + 0\*1 + 0\*0 + 0\*-1 = -8

G(4, 1) = 4\*1 + 6\*0 + 6\*-1 + 1\*1 + 2\*0 + 3\*-1 + 0\*1 + 0\*0 + 0\*-1 = -4

G(4, 2) = 6\*1 + 6\*0 + 4\*-1 + 2\*1 + 3\*0 + 6\*-1 + 0\*1 + 0\*0 + 0\*-1 = -2

G(4, 3) = 6\*1 + 4\*0 + 4\*-1 + 3\*1 + 6\*0 + 6\*-1 + 0\*1 + 0\*0 + 0\*-1 = -1

G(4, 4) = 4\*1 + 4\*0 + 0\*-1 + 6\*1 + 6\*0 + 0\*-1 + 0\*1 + 0\*0 + 0\*-1 = 10

Kết quả:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -10 | -4 | 6 | 10 | 4 |
| -15 | -4 | 6 | 9 | 9 |
| -15 | -3 | 4 | 6 | 11 |
| -13 | -4 | -2 | -2 | 15 |
| -8 | -4 | -2 | -1 | 10 |

---------------------------------------------

K2 =

|  |  |  |
| --- | --- | --- |
| 1 | 1 | 1 |
| 0 | 0 | 0 |
| -1 | -1 | -1 |

G(0, 0) = 0\*1 + 0\*1 + 0\*1 + 0\*0 + 4\*0 + 6\*0 + 0\*-1 + 6\*-1 + 4\*-1 = -10

G(0, 1) = 0\*1 + 0\*1 + 0\*1 + 4\*0 + 6\*0 + 7\*0 + 6\*-1 + 4\*-1 + 7\*-1 = -17

G(0, 2) = 0\*1 + 0\*1 + 0\*1 + 6\*0 + 7\*0 + 2\*0 + 4\*-1 + 7\*-1 + 2\*-1 = -13

G(0, 3) = 0\*1 + 0\*1 + 0\*1 + 7\*0 + 2\*0 + 2\*0 + 7\*-1 + 2\*-1 + 2\*-1 = -11

G(0, 4) = 0\*1 + 0\*1 + 0\*1 + 2\*0 + 2\*0 + 0\*0 + 2\*-1 + 2\*-1 + 0\*-1 = -4

G(1, 0) = 0\*1 + 4\*1 + 6\*1 + 0\*0 + 6\*0 + 4\*0 + 0\*-1 + 3\*-1 + 5\*-1 = 2

G(1, 1) = 4\*1 + 6\*1 + 7\*1 + 6\*0 + 4\*0 + 7\*0 + 3\*-1 + 5\*-1 + 3\*-1 = 6

G(1, 2) = 6\*1 + 7\*1 + 2\*1 + 4\*0 + 7\*0 + 2\*0 + 5\*-1 + 3\*-1 + 5\*-1 = 2

G(1, 3) = 7\*1 + 2\*1 + 2\*1 + 7\*0 + 2\*0 + 2\*0 + 3\*-1 + 5\*-1 + 4\*-1 = -1

G(1, 4) = 2\*1 + 2\*1 + 0\*1 + 2\*0 + 2\*0 + 0\*0 + 5\*-1 + 4\*-1 + 0\*-1 = -5

G(2, 0) = 0\*1 + 6\*1 + 4\*1 + 0\*0 + 3\*0 + 5\*0 + 0\*-1 + 4\*-1 + 6\*-1 = 0

G(2, 1) = 6\*1 + 4\*1 + 7\*1 + 3\*0 + 5\*0 + 3\*0 + 4\*-1 + 6\*-1 + 6\*-1 = 1

G(2, 2) = 4\*1 + 7\*1 + 2\*1 + 5\*0 + 3\*0 + 5\*0 + 6\*-1 + 6\*-1 + 4\*-1 = -3

G(2, 3) = 7\*1 + 2\*1 + 2\*1 + 3\*0 + 5\*0 + 4\*0 + 6\*-1 + 4\*-1 + 4\*-1 = -3

G(2, 4) = 2\*1 + 2\*1 + 0\*1 + 5\*0 + 4\*0 + 0\*0 + 4\*-1 + 4\*-1 + 0\*-1 = -4

G(3, 0) = 0\*1 + 3\*1 + 5\*1 + 0\*0 + 4\*0 + 6\*0 + 0\*-1 + 1\*-1 + 2\*-1 = 5

G(3, 1) = 3\*1 + 5\*1 + 3\*1 + 4\*0 + 6\*0 + 6\*0 + 1\*-1 + 2\*-1 + 3\*-1 = 5

G(3, 2) = 5\*1 + 3\*1 + 5\*1 + 6\*0 + 6\*0 + 4\*0 + 2\*-1 + 3\*-1 + 6\*-1 = 2

G(3, 3) = 3\*1 + 5\*1 + 4\*1 + 6\*0 + 4\*0 + 4\*0 + 3\*-1 + 6\*-1 + 6\*-1 = -3

G(3, 4) = 5\*1 + 4\*1 + 0\*1 + 4\*0 + 4\*0 + 0\*0 + 6\*-1 + 6\*-1 + 0\*-1 = -3

G(4, 0) = 0\*1 + 4\*1 + 6\*1 + 0\*0 + 1\*0 + 2\*0 + 0\*-1 + 0\*-1 + 0\*-1 = 10

G(4, 1) = 4\*1 + 6\*1 + 6\*1 + 1\*0 + 2\*0 + 3\*0 + 0\*-1 + 0\*-1 + 0\*-1 = 16

G(4, 2) = 6\*1 + 6\*1 + 4\*1 + 2\*0 + 3\*0 + 6\*0 + 0\*-1 + 0\*-1 + 0\*-1 = 16

G(4, 3) = 6\*1 + 4\*1 + 4\*1 + 3\*0 + 6\*0 + 6\*0 + 0\*-1 + 0\*-1 + 0\*-1 = 14

G(4, 4) = 4\*1 + 4\*1 + 0\*1 + 6\*0 + 6\*0 + 0\*0 + 0\*-1 + 0\*-1 + 0\*-1 = 8

Kết quả:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -10 | -17 | -13 | -11 | -4 |
| 2 | 6 | 2 | -1 | -5 |
| 0 | 1 | -3 | -3 | -4 |
| 5 | 5 | 2 | -3 | -3 |
| 10 | 16 | 16 | 14 | 8 |

G = |Gx| + |Gy|

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 20 | 21 | 19 | 21 | 8 |
| 17 | 10 | 8 | 10 | 14 |
| 15 | 4 | 7 | 9 | 15 |
| 18 | 9 | 4 | 5 | 18 |
| 18 | 20 | 18 | 15 | 18 |

**Câu 3. Thực hiện phát hiện biên bằng bộ lọc Kirsch**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| K1 = | -3 | -3 | 5 | K5 = | 5 | -3 | -3 |
| -3 | 0 | 5 | 5 | 0 | -3 |
| -3 | -3 | 5 | 5 | -3 | -3 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| K2 = | -3 | 5 | 5 | K6 = | -3 | -3 | -3 |
| -3 | 0 | 5 | 5 | 0 | -3 |
| -3 | -3 | -3 | 5 | 5 | -3 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| K3 = | 5 | 5 | 5 | K7 = | -3 | -3 | -3 |
| -3 | 0 | -3 | -3 | 0 | -3 |
| -3 | -3 | -3 | 5 | 5 | 5 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| K4 = | 5 | 5 | -3 | K8 = | -3 | -3 | -3 |
| 5 | 0 | -3 | -3 | 0 | 5 |
|  | -3 | -3 | -3 |  | -3 | 5 | 5 |

I =

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

K1 =

|  |  |  |
| --- | --- | --- |
| -3 | -3 | 5 |
| -3 | 0 | 5 |
| -3 | -3 | 5 |

G1(0, 0) = 0\*-3 + 0\*-3 + 0\*5 + 0\*-3 + 4\*0 + 6\*5 + 0\*-3 + 6\*-3 + 4\*5 = 32

G1(0, 1) = 0\*-3 + 0\*-3 + 0\*5 + 4\*-3 + 6\*0 + 7\*5 + 6\*-3 + 4\*-3 + 7\*5 = 28

G1(0, 2) = 0\*-3 + 0\*-3 + 0\*5 + 6\*-3 + 7\*0 + 2\*5 + 4\*-3 + 7\*-3 + 2\*5 = -31

G1(0, 3) = 0\*-3 + 0\*-3 + 0\*5 + 7\*-3 + 2\*0 + 2\*5 + 7\*-3 + 2\*-3 + 2\*5 = -28

G1(0, 4) = 0\*-3 + 0\*-3 + 0\*5 + 2\*-3 + 2\*0 + 0\*5 + 2\*-3 + 2\*-3 + 0\*5 = -18

G1(1, 0) = 0\*-3 + 4\*-3 + 6\*5 + 0\*-3 + 6\*0 + 4\*5 + 0\*-3 + 3\*-3 + 5\*5 = 54

G1(1, 1) = 4\*-3 + 6\*-3 + 7\*5 + 6\*-3 + 4\*0 + 7\*5 + 3\*-3 + 5\*-3 + 3\*5 = 13

G1(1, 2) = 6\*-3 + 7\*-3 + 2\*5 + 4\*-3 + 7\*0 + 2\*5 + 5\*-3 + 3\*-3 + 5\*5 = -30

G1(1, 3) = 7\*-3 + 2\*-3 + 2\*5 + 7\*-3 + 2\*0 + 2\*5 + 3\*-3 + 5\*-3 + 4\*5 = -32

G1(1, 4) = 2\*-3 + 2\*-3 + 0\*5 + 2\*-3 + 2\*0 + 0\*5 + 5\*-3 + 4\*-3 + 0\*5 = -45

G1(2, 0) = 0\*-3 + 6\*-3 + 4\*5 + 0\*-3 + 3\*0 + 5\*5 + 0\*-3 + 4\*-3 + 6\*5 = 45

G1(2, 1) = 6\*-3 + 4\*-3 + 7\*5 + 3\*-3 + 5\*0 + 3\*5 + 4\*-3 + 6\*-3 + 6\*5 = 11

G1(2, 2) = 4\*-3 + 7\*-3 + 2\*5 + 5\*-3 + 3\*0 + 5\*5 + 6\*-3 + 6\*-3 + 4\*5 = -29

G1(2, 3) = 7\*-3 + 2\*-3 + 2\*5 + 3\*-3 + 5\*0 + 4\*5 + 6\*-3 + 4\*-3 + 4\*5 = -16

G1(2, 4) = 2\*-3 + 2\*-3 + 0\*5 + 5\*-3 + 4\*0 + 0\*5 + 4\*-3 + 4\*-3 + 0\*5 = -51

G1(3, 0) = 0\*-3 + 3\*-3 + 5\*5 + 0\*-3 + 4\*0 + 6\*5 + 0\*-3 + 1\*-3 + 2\*5 = 53

G1(3, 1) = 3\*-3 + 5\*-3 + 3\*5 + 4\*-3 + 6\*0 + 6\*5 + 1\*-3 + 2\*-3 + 3\*5 = 15

G1(3, 2) = 5\*-3 + 3\*-3 + 5\*5 + 6\*-3 + 6\*0 + 4\*5 + 2\*-3 + 3\*-3 + 6\*5 = 18

G1(3, 3) = 3\*-3 + 5\*-3 + 4\*5 + 6\*-3 + 4\*0 + 4\*5 + 3\*-3 + 6\*-3 + 6\*5 = 1

G1(3, 4) = 5\*-3 + 4\*-3 + 0\*5 + 4\*-3 + 4\*0 + 0\*5 + 6\*-3 + 6\*-3 + 0\*5 = -75

G1(4, 0) = 0\*-3 + 4\*-3 + 6\*5 + 0\*-3 + 1\*0 + 2\*5 + 0\*-3 + 0\*-3 + 0\*5 = 28

G1(4, 1) = 4\*-3 + 6\*-3 + 6\*5 + 1\*-3 + 2\*0 + 3\*5 + 0\*-3 + 0\*-3 + 0\*5 = 12

G1(4, 2) = 6\*-3 + 6\*-3 + 4\*5 + 2\*-3 + 3\*0 + 6\*5 + 0\*-3 + 0\*-3 + 0\*5 = 8

G1(4, 3) = 6\*-3 + 4\*-3 + 4\*5 + 3\*-3 + 6\*0 + 6\*5 + 0\*-3 + 0\*-3 + 0\*5 = 11

G1(4, 4) = 4\*-3 + 4\*-3 + 0\*5 + 6\*-3 + 6\*0 + 0\*5 + 0\*-3 + 0\*-3 + 0\*5 = -42

G1 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 32 | 28 | -31 | -28 | -18 |
| 54 | 13 | -30 | -32 | -45 |
| 45 | 11 | -29 | -16 | -51 |
| 53 | 15 | 18 | 1 | -75 |
| 28 | 12 | 8 | 11 | -42 |

|G1| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 32 | 28 | 31 | 28 | 18 |
| 54 | 13 | 30 | 32 | 45 |
| 45 | 11 | 29 | 16 | 51 |
| 53 | 15 | 18 | 1 | 75 |
| 28 | 12 | 8 | 11 | 42 |

-------------------------------------------------------------------------------------

K2 =

|  |  |  |
| --- | --- | --- |
| -3 | 5 | 5 |
| -3 | 0 | 5 |
| -3 | -3 | -3 |

G2(0, 0) = 0\*-3 + 0\*5 + 0\*5 + 0\*-3 + 4\*0 + 6\*5 + 0\*-3 + 6\*-3 + 4\*-3 = 0

G2(0, 1) = 0\*-3 + 0\*5 + 0\*5 + 4\*-3 + 6\*0 + 7\*5 + 6\*-3 + 4\*-3 + 7\*-3 = -28

G2(0, 2) = 0\*-3 + 0\*5 + 0\*5 + 6\*-3 + 7\*0 + 2\*5 + 4\*-3 + 7\*-3 + 2\*-3 = -47

G2(0, 3) = 0\*-3 + 0\*5 + 0\*5 + 7\*-3 + 2\*0 + 2\*5 + 7\*-3 + 2\*-3 + 2\*-3 = -44

G2(0, 4) = 0\*-3 + 0\*5 + 0\*5 + 2\*-3 + 2\*0 + 0\*5 + 2\*-3 + 2\*-3 + 0\*-3 = -18

G2(1, 0) = 0\*-3 + 4\*5 + 6\*5 + 0\*-3 + 6\*0 + 4\*5 + 0\*-3 + 3\*-3 + 5\*-3 = 46

G2(1, 1) = 4\*-3 + 6\*5 + 7\*5 + 6\*-3 + 4\*0 + 7\*5 + 3\*-3 + 5\*-3 + 3\*-3 = 37

G2(1, 2) = 6\*-3 + 7\*5 + 2\*5 + 4\*-3 + 7\*0 + 2\*5 + 5\*-3 + 3\*-3 + 5\*-3 = -14

G2(1, 3) = 7\*-3 + 2\*5 + 2\*5 + 7\*-3 + 2\*0 + 2\*5 + 3\*-3 + 5\*-3 + 4\*-3 = -48

G2(1, 4) = 2\*-3 + 2\*5 + 0\*5 + 2\*-3 + 2\*0 + 0\*5 + 5\*-3 + 4\*-3 + 0\*-3 = -29

G2(2, 0) = 0\*-3 + 6\*5 + 4\*5 + 0\*-3 + 3\*0 + 5\*5 + 0\*-3 + 4\*-3 + 6\*-3 = 45

G2(2, 1) = 6\*-3 + 4\*5 + 7\*5 + 3\*-3 + 5\*0 + 3\*5 + 4\*-3 + 6\*-3 + 6\*-3 = -5

G2(2, 2) = 4\*-3 + 7\*5 + 2\*5 + 5\*-3 + 3\*0 + 5\*5 + 6\*-3 + 6\*-3 + 4\*-3 = -5

G2(2, 3) = 7\*-3 + 2\*5 + 2\*5 + 3\*-3 + 5\*0 + 4\*5 + 6\*-3 + 4\*-3 + 4\*-3 = -32

G2(2, 4) = 2\*-3 + 2\*5 + 0\*5 + 5\*-3 + 4\*0 + 0\*5 + 4\*-3 + 4\*-3 + 0\*-3 = -35

G2(3, 0) = 0\*-3 + 3\*5 + 5\*5 + 0\*-3 + 4\*0 + 6\*5 + 0\*-3 + 1\*-3 + 2\*-3 = 61

G2(3, 1) = 3\*-3 + 5\*5 + 3\*5 + 4\*-3 + 6\*0 + 6\*5 + 1\*-3 + 2\*-3 + 3\*-3 = 31

G2(3, 2) = 5\*-3 + 3\*5 + 5\*5 + 6\*-3 + 6\*0 + 4\*5 + 2\*-3 + 3\*-3 + 6\*-3 = -6

G2(3, 3) = 3\*-3 + 5\*5 + 4\*5 + 6\*-3 + 4\*0 + 4\*5 + 3\*-3 + 6\*-3 + 6\*-3 = -7

G2(3, 4) = 5\*-3 + 4\*5 + 0\*5 + 4\*-3 + 4\*0 + 0\*5 + 6\*-3 + 6\*-3 + 0\*-3 = -43

G2(4, 0) = 0\*-3 + 4\*5 + 6\*5 + 0\*-3 + 1\*0 + 2\*5 + 0\*-3 + 0\*-3 + 0\*-3 = 60

G2(4, 1) = 4\*-3 + 6\*5 + 6\*5 + 1\*-3 + 2\*0 + 3\*5 + 0\*-3 + 0\*-3 + 0\*-3 = 60

G2(4, 2) = 6\*-3 + 6\*5 + 4\*5 + 2\*-3 + 3\*0 + 6\*5 + 0\*-3 + 0\*-3 + 0\*-3 = 56

G2(4, 3) = 6\*-3 + 4\*5 + 4\*5 + 3\*-3 + 6\*0 + 6\*5 + 0\*-3 + 0\*-3 + 0\*-3 = 43

G2(4, 4) = 4\*-3 + 4\*5 + 0\*5 + 6\*-3 + 6\*0 + 0\*5 + 0\*-3 + 0\*-3 + 0\*-3 = -10

G2 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0 | -28 | -47 | -44 | -18 |
| 46 | 37 | -14 | -48 | -29 |
| 45 | -5 | -5 | -32 | -35 |
| 61 | 31 | -6 | -7 | -43 |
| 60 | 60 | 56 | 43 | -10 |

|G2| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0 | 28 | 47 | 44 | 18 |
| 46 | 37 | 14 | 48 | 29 |
| 45 | 5 | 5 | 32 | 35 |
| 61 | 31 | 6 | 7 | 43 |
| 60 | 60 | 56 | 43 | 10 |

-------------------------------------------------------------------------------------

K3 =

|  |  |  |
| --- | --- | --- |
| 5 | 5 | 5 |
| -3 | 0 | -3 |
| -3 | -3 | -3 |

G3(0, 0) = 0\*5 + 0\*5 + 0\*5 + 0\*-3 + 4\*0 + 6\*-3 + 0\*-3 + 6\*-3 + 4\*-3 = -48

G3(0, 1) = 0\*5 + 0\*5 + 0\*5 + 4\*-3 + 6\*0 + 7\*-3 + 6\*-3 + 4\*-3 + 7\*-3 = -84

G3(0, 2) = 0\*5 + 0\*5 + 0\*5 + 6\*-3 + 7\*0 + 2\*-3 + 4\*-3 + 7\*-3 + 2\*-3 = -63

G3(0, 3) = 0\*5 + 0\*5 + 0\*5 + 7\*-3 + 2\*0 + 2\*-3 + 7\*-3 + 2\*-3 + 2\*-3 = -60

G3(0, 4) = 0\*5 + 0\*5 + 0\*5 + 2\*-3 + 2\*0 + 0\*-3 + 2\*-3 + 2\*-3 + 0\*-3 = -18

G3(1, 0) = 0\*5 + 4\*5 + 6\*5 + 0\*-3 + 6\*0 + 4\*-3 + 0\*-3 + 3\*-3 + 5\*-3 = 14

G3(1, 1) = 4\*5 + 6\*5 + 7\*5 + 6\*-3 + 4\*0 + 7\*-3 + 3\*-3 + 5\*-3 + 3\*-3 = 13

G3(1, 2) = 6\*5 + 7\*5 + 2\*5 + 4\*-3 + 7\*0 + 2\*-3 + 5\*-3 + 3\*-3 + 5\*-3 = 18

G3(1, 3) = 7\*5 + 2\*5 + 2\*5 + 7\*-3 + 2\*0 + 2\*-3 + 3\*-3 + 5\*-3 + 4\*-3 = -8

G3(1, 4) = 2\*5 + 2\*5 + 0\*5 + 2\*-3 + 2\*0 + 0\*-3 + 5\*-3 + 4\*-3 + 0\*-3 = -13

G3(2, 0) = 0\*5 + 6\*5 + 4\*5 + 0\*-3 + 3\*0 + 5\*-3 + 0\*-3 + 4\*-3 + 6\*-3 = 5

G3(2, 1) = 6\*5 + 4\*5 + 7\*5 + 3\*-3 + 5\*0 + 3\*-3 + 4\*-3 + 6\*-3 + 6\*-3 = 19

G3(2, 2) = 4\*5 + 7\*5 + 2\*5 + 5\*-3 + 3\*0 + 5\*-3 + 6\*-3 + 6\*-3 + 4\*-3 = -13

G3(2, 3) = 7\*5 + 2\*5 + 2\*5 + 3\*-3 + 5\*0 + 4\*-3 + 6\*-3 + 4\*-3 + 4\*-3 = -8

G3(2, 4) = 2\*5 + 2\*5 + 0\*5 + 5\*-3 + 4\*0 + 0\*-3 + 4\*-3 + 4\*-3 + 0\*-3 = -19

G3(3, 0) = 0\*5 + 3\*5 + 5\*5 + 0\*-3 + 4\*0 + 6\*-3 + 0\*-3 + 1\*-3 + 2\*-3 = 13

G3(3, 1) = 3\*5 + 5\*5 + 3\*5 + 4\*-3 + 6\*0 + 6\*-3 + 1\*-3 + 2\*-3 + 3\*-3 = 7

G3(3, 2) = 5\*5 + 3\*5 + 5\*5 + 6\*-3 + 6\*0 + 4\*-3 + 2\*-3 + 3\*-3 + 6\*-3 = 2

G3(3, 3) = 3\*5 + 5\*5 + 4\*5 + 6\*-3 + 4\*0 + 4\*-3 + 3\*-3 + 6\*-3 + 6\*-3 = -15

G3(3, 4) = 5\*5 + 4\*5 + 0\*5 + 4\*-3 + 4\*0 + 0\*-3 + 6\*-3 + 6\*-3 + 0\*-3 = -3

G3(4, 0) = 0\*5 + 4\*5 + 6\*5 + 0\*-3 + 1\*0 + 2\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 44

G3(4, 1) = 4\*5 + 6\*5 + 6\*5 + 1\*-3 + 2\*0 + 3\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 68

G3(4, 2) = 6\*5 + 6\*5 + 4\*5 + 2\*-3 + 3\*0 + 6\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 56

G3(4, 3) = 6\*5 + 4\*5 + 4\*5 + 3\*-3 + 6\*0 + 6\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 43

G3(4, 4) = 4\*5 + 4\*5 + 0\*5 + 6\*-3 + 6\*0 + 0\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 22

G3 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -48 | -84 | -63 | -60 | -18 |
| 14 | 13 | 18 | -8 | -13 |
| 5 | 19 | -13 | -8 | -19 |
| 13 | 7 | 2 | -15 | -3 |
| 44 | 68 | 56 | 43 | 22 |

|G3| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 48 | 84 | 63 | 60 | 18 |
| 14 | 13 | 18 | 8 | 13 |
| 5 | 19 | 13 | 8 | 19 |
| 13 | 7 | 2 | 15 | 3 |
| 44 | 68 | 56 | 43 | 22 |

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K4 =

|  |  |  |
| --- | --- | --- |
| 5 | 5 | -3 |
| 5 | 0 | -3 |
| -3 | -3 | -3 |

G4(0, 0) = 0\*5 + 0\*5 + 0\*-3 + 0\*5 + 4\*0 + 6\*-3 + 0\*-3 + 6\*-3 + 4\*-3 = -48

G4(0, 1) = 0\*5 + 0\*5 + 0\*-3 + 4\*5 + 6\*0 + 7\*-3 + 6\*-3 + 4\*-3 + 7\*-3 = -52

G4(0, 2) = 0\*5 + 0\*5 + 0\*-3 + 6\*5 + 7\*0 + 2\*-3 + 4\*-3 + 7\*-3 + 2\*-3 = -15

G4(0, 3) = 0\*5 + 0\*5 + 0\*-3 + 7\*5 + 2\*0 + 2\*-3 + 7\*-3 + 2\*-3 + 2\*-3 = -4

G4(0, 4) = 0\*5 + 0\*5 + 0\*-3 + 2\*5 + 2\*0 + 0\*-3 + 2\*-3 + 2\*-3 + 0\*-3 = -2

G4(1, 0) = 0\*5 + 4\*5 + 6\*-3 + 0\*5 + 6\*0 + 4\*-3 + 0\*-3 + 3\*-3 + 5\*-3 = -34

G4(1, 1) = 4\*5 + 6\*5 + 7\*-3 + 6\*5 + 4\*0 + 7\*-3 + 3\*-3 + 5\*-3 + 3\*-3 = 5

G4(1, 2) = 6\*5 + 7\*5 + 2\*-3 + 4\*5 + 7\*0 + 2\*-3 + 5\*-3 + 3\*-3 + 5\*-3 = 34

G4(1, 3) = 7\*5 + 2\*5 + 2\*-3 + 7\*5 + 2\*0 + 2\*-3 + 3\*-3 + 5\*-3 + 4\*-3 = 32

G4(1, 4) = 2\*5 + 2\*5 + 0\*-3 + 2\*5 + 2\*0 + 0\*-3 + 5\*-3 + 4\*-3 + 0\*-3 = 3

G4(2, 0) = 0\*5 + 6\*5 + 4\*-3 + 0\*5 + 3\*0 + 5\*-3 + 0\*-3 + 4\*-3 + 6\*-3 = -27

G4(2, 1) = 6\*5 + 4\*5 + 7\*-3 + 3\*5 + 5\*0 + 3\*-3 + 4\*-3 + 6\*-3 + 6\*-3 = -13

G4(2, 2) = 4\*5 + 7\*5 + 2\*-3 + 5\*5 + 3\*0 + 5\*-3 + 6\*-3 + 6\*-3 + 4\*-3 = 11

G4(2, 3) = 7\*5 + 2\*5 + 2\*-3 + 3\*5 + 5\*0 + 4\*-3 + 6\*-3 + 4\*-3 + 4\*-3 = 0

G4(2, 4) = 2\*5 + 2\*5 + 0\*-3 + 5\*5 + 4\*0 + 0\*-3 + 4\*-3 + 4\*-3 + 0\*-3 = 21

G4(3, 0) = 0\*5 + 3\*5 + 5\*-3 + 0\*5 + 4\*0 + 6\*-3 + 0\*-3 + 1\*-3 + 2\*-3 = -27

G4(3, 1) = 3\*5 + 5\*5 + 3\*-3 + 4\*5 + 6\*0 + 6\*-3 + 1\*-3 + 2\*-3 + 3\*-3 = 15

G4(3, 2) = 5\*5 + 3\*5 + 5\*-3 + 6\*5 + 6\*0 + 4\*-3 + 2\*-3 + 3\*-3 + 6\*-3 = 10

G4(3, 3) = 3\*5 + 5\*5 + 4\*-3 + 6\*5 + 4\*0 + 4\*-3 + 3\*-3 + 6\*-3 + 6\*-3 = 1

G4(3, 4) = 5\*5 + 4\*5 + 0\*-3 + 4\*5 + 4\*0 + 0\*-3 + 6\*-3 + 6\*-3 + 0\*-3 = 29

G4(4, 0) = 0\*5 + 4\*5 + 6\*-3 + 0\*5 + 1\*0 + 2\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = -4

G4(4, 1) = 4\*5 + 6\*5 + 6\*-3 + 1\*5 + 2\*0 + 3\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 28

G4(4, 2) = 6\*5 + 6\*5 + 4\*-3 + 2\*5 + 3\*0 + 6\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 40

G4(4, 3) = 6\*5 + 4\*5 + 4\*-3 + 3\*5 + 6\*0 + 6\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 35

G4(4, 4) = 4\*5 + 4\*5 + 0\*-3 + 6\*5 + 6\*0 + 0\*-3 + 0\*-3 + 0\*-3 + 0\*-3 = 70

G4 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -48 | -52 | -15 | -4 | -2 |
| -34 | 5 | 34 | 32 | 3 |
| -27 | -13 | 11 | 0 | 21 |
| -27 | 15 | 10 | 1 | 29 |
| -4 | 28 | 40 | 35 | 70 |

|G4| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 48 | 52 | 15 | 4 | 2 |
| 34 | 5 | 34 | 32 | 3 |
| 27 | 13 | 11 | 0 | 21 |
| 27 | 15 | 10 | 1 | 29 |
| 4 | 28 | 40 | 35 | 70 |

-------------------------------------------------------------------------------------

K5 =

|  |  |  |
| --- | --- | --- |
| 5 | -3 | -3 |
| 5 | 0 | -3 |
| 5 | -3 | -3 |

G5(0, 0) = 0\*5 + 0\*-3 + 0\*-3 + 0\*5 + 4\*0 + 6\*-3 + 0\*5 + 6\*-3 + 4\*-3 = -48

G5(0, 1) = 0\*5 + 0\*-3 + 0\*-3 + 4\*5 + 6\*0 + 7\*-3 + 6\*5 + 4\*-3 + 7\*-3 = -4

G5(0, 2) = 0\*5 + 0\*-3 + 0\*-3 + 6\*5 + 7\*0 + 2\*-3 + 4\*5 + 7\*-3 + 2\*-3 = 17

G5(0, 3) = 0\*5 + 0\*-3 + 0\*-3 + 7\*5 + 2\*0 + 2\*-3 + 7\*5 + 2\*-3 + 2\*-3 = 52

G5(0, 4) = 0\*5 + 0\*-3 + 0\*-3 + 2\*5 + 2\*0 + 0\*-3 + 2\*5 + 2\*-3 + 0\*-3 = 14

G5(1, 0) = 0\*5 + 4\*-3 + 6\*-3 + 0\*5 + 6\*0 + 4\*-3 + 0\*5 + 3\*-3 + 5\*-3 = -66

G5(1, 1) = 4\*5 + 6\*-3 + 7\*-3 + 6\*5 + 4\*0 + 7\*-3 + 3\*5 + 5\*-3 + 3\*-3 = -19

G5(1, 2) = 6\*5 + 7\*-3 + 2\*-3 + 4\*5 + 7\*0 + 2\*-3 + 5\*5 + 3\*-3 + 5\*-3 = 18

G5(1, 3) = 7\*5 + 2\*-3 + 2\*-3 + 7\*5 + 2\*0 + 2\*-3 + 3\*5 + 5\*-3 + 4\*-3 = 40

G5(1, 4) = 2\*5 + 2\*-3 + 0\*-3 + 2\*5 + 2\*0 + 0\*-3 + 5\*5 + 4\*-3 + 0\*-3 = 27

G5(2, 0) = 0\*5 + 6\*-3 + 4\*-3 + 0\*5 + 3\*0 + 5\*-3 + 0\*5 + 4\*-3 + 6\*-3 = -75

G5(2, 1) = 6\*5 + 4\*-3 + 7\*-3 + 3\*5 + 5\*0 + 3\*-3 + 4\*5 + 6\*-3 + 6\*-3 = -13

G5(2, 2) = 4\*5 + 7\*-3 + 2\*-3 + 5\*5 + 3\*0 + 5\*-3 + 6\*5 + 6\*-3 + 4\*-3 = 3

G5(2, 3) = 7\*5 + 2\*-3 + 2\*-3 + 3\*5 + 5\*0 + 4\*-3 + 6\*5 + 4\*-3 + 4\*-3 = 32

G5(2, 4) = 2\*5 + 2\*-3 + 0\*-3 + 5\*5 + 4\*0 + 0\*-3 + 4\*5 + 4\*-3 + 0\*-3 = 37

G5(3, 0) = 0\*5 + 3\*-3 + 5\*-3 + 0\*5 + 4\*0 + 6\*-3 + 0\*5 + 1\*-3 + 2\*-3 = -51

G5(3, 1) = 3\*5 + 5\*-3 + 3\*-3 + 4\*5 + 6\*0 + 6\*-3 + 1\*5 + 2\*-3 + 3\*-3 = -17

G5(3, 2) = 5\*5 + 3\*-3 + 5\*-3 + 6\*5 + 6\*0 + 4\*-3 + 2\*5 + 3\*-3 + 6\*-3 = 2

G5(3, 3) = 3\*5 + 5\*-3 + 4\*-3 + 6\*5 + 4\*0 + 4\*-3 + 3\*5 + 6\*-3 + 6\*-3 = -15

G5(3, 4) = 5\*5 + 4\*-3 + 0\*-3 + 4\*5 + 4\*0 + 0\*-3 + 6\*5 + 6\*-3 + 0\*-3 = 45

G5(4, 0) = 0\*5 + 4\*-3 + 6\*-3 + 0\*5 + 1\*0 + 2\*-3 + 0\*5 + 0\*-3 + 0\*-3 = -36

G5(4, 1) = 4\*5 + 6\*-3 + 6\*-3 + 1\*5 + 2\*0 + 3\*-3 + 0\*5 + 0\*-3 + 0\*-3 = -20

G5(4, 2) = 6\*5 + 6\*-3 + 4\*-3 + 2\*5 + 3\*0 + 6\*-3 + 0\*5 + 0\*-3 + 0\*-3 = -8

G5(4, 3) = 6\*5 + 4\*-3 + 4\*-3 + 3\*5 + 6\*0 + 6\*-3 + 0\*5 + 0\*-3 + 0\*-3 = 3

G5(4, 4) = 4\*5 + 4\*-3 + 0\*-3 + 6\*5 + 6\*0 + 0\*-3 + 0\*5 + 0\*-3 + 0\*-3 = 38

G5 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| -48 | -4 | 17 | 52 | 14 |
| -66 | -19 | 18 | 40 | 27 |
| -75 | -13 | 3 | 32 | 37 |
| -51 | -17 | 2 | -15 | 45 |
| -36 | -20 | -8 | 3 | 38 |

|G5| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 48 | 4 | 17 | 52 | 14 |
| 66 | 19 | 18 | 40 | 27 |
| 75 | 13 | 3 | 32 | 37 |
| 51 | 17 | 2 | 15 | 45 |
| 36 | 20 | 8 | 3 | 38 |

-------------------------------------------------------------------------------------

K6 =

|  |  |  |
| --- | --- | --- |
| -3 | -3 | -3 |
| 5 | 0 | -3 |
| 5 | 5 | -3 |

G6(0, 0) = 0\*-3 + 0\*-3 + 0\*-3 + 0\*5 + 4\*0 + 6\*-3 + 0\*5 + 6\*5 + 4\*-3 = 0

G6(0, 1) = 0\*-3 + 0\*-3 + 0\*-3 + 4\*5 + 6\*0 + 7\*-3 + 6\*5 + 4\*5 + 7\*-3 = 28

G6(0, 2) = 0\*-3 + 0\*-3 + 0\*-3 + 6\*5 + 7\*0 + 2\*-3 + 4\*5 + 7\*5 + 2\*-3 = 73

G6(0, 3) = 0\*-3 + 0\*-3 + 0\*-3 + 7\*5 + 2\*0 + 2\*-3 + 7\*5 + 2\*5 + 2\*-3 = 68

G6(0, 4) = 0\*-3 + 0\*-3 + 0\*-3 + 2\*5 + 2\*0 + 0\*-3 + 2\*5 + 2\*5 + 0\*-3 = 30

G6(1, 0) = 0\*-3 + 4\*-3 + 6\*-3 + 0\*5 + 6\*0 + 4\*-3 + 0\*5 + 3\*5 + 5\*-3 = -42

G6(1, 1) = 4\*-3 + 6\*-3 + 7\*-3 + 6\*5 + 4\*0 + 7\*-3 + 3\*5 + 5\*5 + 3\*-3 = -11

G6(1, 2) = 6\*-3 + 7\*-3 + 2\*-3 + 4\*5 + 7\*0 + 2\*-3 + 5\*5 + 3\*5 + 5\*-3 = -6

G6(1, 3) = 7\*-3 + 2\*-3 + 2\*-3 + 7\*5 + 2\*0 + 2\*-3 + 3\*5 + 5\*5 + 4\*-3 = 24

G6(1, 4) = 2\*-3 + 2\*-3 + 0\*-3 + 2\*5 + 2\*0 + 0\*-3 + 5\*5 + 4\*5 + 0\*-3 = 43

G6(2, 0) = 0\*-3 + 6\*-3 + 4\*-3 + 0\*5 + 3\*0 + 5\*-3 + 0\*5 + 4\*5 + 6\*-3 = -43

G6(2, 1) = 6\*-3 + 4\*-3 + 7\*-3 + 3\*5 + 5\*0 + 3\*-3 + 4\*5 + 6\*5 + 6\*-3 = -13

G6(2, 2) = 4\*-3 + 7\*-3 + 2\*-3 + 5\*5 + 3\*0 + 5\*-3 + 6\*5 + 6\*5 + 4\*-3 = 19

G6(2, 3) = 7\*-3 + 2\*-3 + 2\*-3 + 3\*5 + 5\*0 + 4\*-3 + 6\*5 + 4\*5 + 4\*-3 = 8

G6(2, 4) = 2\*-3 + 2\*-3 + 0\*-3 + 5\*5 + 4\*0 + 0\*-3 + 4\*5 + 4\*5 + 0\*-3 = 53

G6(3, 0) = 0\*-3 + 3\*-3 + 5\*-3 + 0\*5 + 4\*0 + 6\*-3 + 0\*5 + 1\*5 + 2\*-3 = -43

G6(3, 1) = 3\*-3 + 5\*-3 + 3\*-3 + 4\*5 + 6\*0 + 6\*-3 + 1\*5 + 2\*5 + 3\*-3 = -25

G6(3, 2) = 5\*-3 + 3\*-3 + 5\*-3 + 6\*5 + 6\*0 + 4\*-3 + 2\*5 + 3\*5 + 6\*-3 = -14

G6(3, 3) = 3\*-3 + 5\*-3 + 4\*-3 + 6\*5 + 4\*0 + 4\*-3 + 3\*5 + 6\*5 + 6\*-3 = 9

G6(3, 4) = 5\*-3 + 4\*-3 + 0\*-3 + 4\*5 + 4\*0 + 0\*-3 + 6\*5 + 6\*5 + 0\*-3 = 53

G6(4, 0) = 0\*-3 + 4\*-3 + 6\*-3 + 0\*5 + 1\*0 + 2\*-3 + 0\*5 + 0\*5 + 0\*-3 = -36

G6(4, 1) = 4\*-3 + 6\*-3 + 6\*-3 + 1\*5 + 2\*0 + 3\*-3 + 0\*5 + 0\*5 + 0\*-3 = -52

G6(4, 2) = 6\*-3 + 6\*-3 + 4\*-3 + 2\*5 + 3\*0 + 6\*-3 + 0\*5 + 0\*5 + 0\*-3 = -56

G6(4, 3) = 6\*-3 + 4\*-3 + 4\*-3 + 3\*5 + 6\*0 + 6\*-3 + 0\*5 + 0\*5 + 0\*-3 = -45

G6(4, 4) = 4\*-3 + 4\*-3 + 0\*-3 + 6\*5 + 6\*0 + 0\*-3 + 0\*5 + 0\*5 + 0\*-3 = 6

G6 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0 | 28 | 73 | 68 | 30 |
| -42 | -11 | -6 | 24 | 43 |
| -43 | -13 | 19 | 8 | 53 |
| -43 | -25 | -14 | 9 | 53 |
| -36 | -52 | -56 | -45 | 6 |

|G6| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 0 | 28 | 73 | 68 | 30 |
| 42 | 11 | 6 | 24 | 43 |
| 43 | 13 | 19 | 8 | 53 |
| 43 | 25 | 14 | 9 | 53 |
| 36 | 52 | 56 | 45 | 6 |

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K7 =

|  |  |  |
| --- | --- | --- |
| -3 | -3 | -3 |
| -3 | 0 | -3 |
| 5 | 5 | 5 |

G7(0, 0) = 0\*-3 + 0\*-3 + 0\*-3 + 0\*-3 + 4\*0 + 6\*-3 + 0\*5 + 6\*5 + 4\*5 = 32

G7(0, 1) = 0\*-3 + 0\*-3 + 0\*-3 + 4\*-3 + 6\*0 + 7\*-3 + 6\*5 + 4\*5 + 7\*5 = 52

G7(0, 2) = 0\*-3 + 0\*-3 + 0\*-3 + 6\*-3 + 7\*0 + 2\*-3 + 4\*5 + 7\*5 + 2\*5 = 41

G7(0, 3) = 0\*-3 + 0\*-3 + 0\*-3 + 7\*-3 + 2\*0 + 2\*-3 + 7\*5 + 2\*5 + 2\*5 = 28

G7(0, 4) = 0\*-3 + 0\*-3 + 0\*-3 + 2\*-3 + 2\*0 + 0\*-3 + 2\*5 + 2\*5 + 0\*5 = 14

G7(1, 0) = 0\*-3 + 4\*-3 + 6\*-3 + 0\*-3 + 6\*0 + 4\*-3 + 0\*5 + 3\*5 + 5\*5 = -2

G7(1, 1) = 4\*-3 + 6\*-3 + 7\*-3 + 6\*-3 + 4\*0 + 7\*-3 + 3\*5 + 5\*5 + 3\*5 = -35

G7(1, 2) = 6\*-3 + 7\*-3 + 2\*-3 + 4\*-3 + 7\*0 + 2\*-3 + 5\*5 + 3\*5 + 5\*5 = 2

G7(1, 3) = 7\*-3 + 2\*-3 + 2\*-3 + 7\*-3 + 2\*0 + 2\*-3 + 3\*5 + 5\*5 + 4\*5 = 0

G7(1, 4) = 2\*-3 + 2\*-3 + 0\*-3 + 2\*-3 + 2\*0 + 0\*-3 + 5\*5 + 4\*5 + 0\*5 = 27

G7(2, 0) = 0\*-3 + 6\*-3 + 4\*-3 + 0\*-3 + 3\*0 + 5\*-3 + 0\*5 + 4\*5 + 6\*5 = 5

G7(2, 1) = 6\*-3 + 4\*-3 + 7\*-3 + 3\*-3 + 5\*0 + 3\*-3 + 4\*5 + 6\*5 + 6\*5 = 11

G7(2, 2) = 4\*-3 + 7\*-3 + 2\*-3 + 5\*-3 + 3\*0 + 5\*-3 + 6\*5 + 6\*5 + 4\*5 = 11

G7(2, 3) = 7\*-3 + 2\*-3 + 2\*-3 + 3\*-3 + 5\*0 + 4\*-3 + 6\*5 + 4\*5 + 4\*5 = 16

G7(2, 4) = 2\*-3 + 2\*-3 + 0\*-3 + 5\*-3 + 4\*0 + 0\*-3 + 4\*5 + 4\*5 + 0\*5 = 13

G7(3, 0) = 0\*-3 + 3\*-3 + 5\*-3 + 0\*-3 + 4\*0 + 6\*-3 + 0\*5 + 1\*5 + 2\*5 = -27

G7(3, 1) = 3\*-3 + 5\*-3 + 3\*-3 + 4\*-3 + 6\*0 + 6\*-3 + 1\*5 + 2\*5 + 3\*5 = -33

G7(3, 2) = 5\*-3 + 3\*-3 + 5\*-3 + 6\*-3 + 6\*0 + 4\*-3 + 2\*5 + 3\*5 + 6\*5 = -14

G7(3, 3) = 3\*-3 + 5\*-3 + 4\*-3 + 6\*-3 + 4\*0 + 4\*-3 + 3\*5 + 6\*5 + 6\*5 = 9

G7(3, 4) = 5\*-3 + 4\*-3 + 0\*-3 + 4\*-3 + 4\*0 + 0\*-3 + 6\*5 + 6\*5 + 0\*5 = 21

G7(4, 0) = 0\*-3 + 4\*-3 + 6\*-3 + 0\*-3 + 1\*0 + 2\*-3 + 0\*5 + 0\*5 + 0\*5 = -36

G7(4, 1) = 4\*-3 + 6\*-3 + 6\*-3 + 1\*-3 + 2\*0 + 3\*-3 + 0\*5 + 0\*5 + 0\*5 = -60

G7(4, 2) = 6\*-3 + 6\*-3 + 4\*-3 + 2\*-3 + 3\*0 + 6\*-3 + 0\*5 + 0\*5 + 0\*5 = -72

G7(4, 3) = 6\*-3 + 4\*-3 + 4\*-3 + 3\*-3 + 6\*0 + 6\*-3 + 0\*5 + 0\*5 + 0\*5 = -69

G7(4, 4) = 4\*-3 + 4\*-3 + 0\*-3 + 6\*-3 + 6\*0 + 0\*-3 + 0\*5 + 0\*5 + 0\*5 = -42

G7 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 32 | 52 | 41 | 28 | 14 |
| -2 | -35 | 2 | 0 | 27 |
| 5 | 11 | 11 | 16 | 13 |
| -27 | -33 | -14 | 9 | 21 |
| -36 | -60 | -72 | -69 | -42 |

|G7| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 32 | 52 | 41 | 28 | 14 |
| 2 | 35 | 2 | 0 | 27 |
| 5 | 11 | 11 | 16 | 13 |
| 27 | 33 | 14 | 9 | 21 |
| 36 | 60 | 72 | 69 | 42 |

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K8 =

|  |  |  |
| --- | --- | --- |
| -3 | -3 | -3 |
| -3 | 0 | 5 |
| -3 | 5 | 5 |

G8(0, 0) = 0\*-3 + 0\*-3 + 0\*-3 + 0\*-3 + 4\*0 + 6\*5 + 0\*-3 + 6\*5 + 4\*5 = 80

G8(0, 1) = 0\*-3 + 0\*-3 + 0\*-3 + 4\*-3 + 6\*0 + 7\*5 + 6\*-3 + 4\*5 + 7\*5 = 60

G8(0, 2) = 0\*-3 + 0\*-3 + 0\*-3 + 6\*-3 + 7\*0 + 2\*5 + 4\*-3 + 7\*5 + 2\*5 = 25

G8(0, 3) = 0\*-3 + 0\*-3 + 0\*-3 + 7\*-3 + 2\*0 + 2\*5 + 7\*-3 + 2\*5 + 2\*5 = -12

G8(0, 4) = 0\*-3 + 0\*-3 + 0\*-3 + 2\*-3 + 2\*0 + 0\*5 + 2\*-3 + 2\*5 + 0\*5 = -2

G8(1, 0) = 0\*-3 + 4\*-3 + 6\*-3 + 0\*-3 + 6\*0 + 4\*5 + 0\*-3 + 3\*5 + 5\*5 = 30

G8(1, 1) = 4\*-3 + 6\*-3 + 7\*-3 + 6\*-3 + 4\*0 + 7\*5 + 3\*-3 + 5\*5 + 3\*5 = -3

G8(1, 2) = 6\*-3 + 7\*-3 + 2\*-3 + 4\*-3 + 7\*0 + 2\*5 + 5\*-3 + 3\*5 + 5\*5 = -22

G8(1, 3) = 7\*-3 + 2\*-3 + 2\*-3 + 7\*-3 + 2\*0 + 2\*5 + 3\*-3 + 5\*5 + 4\*5 = -8

G8(1, 4) = 2\*-3 + 2\*-3 + 0\*-3 + 2\*-3 + 2\*0 + 0\*5 + 5\*-3 + 4\*5 + 0\*5 = -13

G8(2, 0) = 0\*-3 + 6\*-3 + 4\*-3 + 0\*-3 + 3\*0 + 5\*5 + 0\*-3 + 4\*5 + 6\*5 = 45

G8(2, 1) = 6\*-3 + 4\*-3 + 7\*-3 + 3\*-3 + 5\*0 + 3\*5 + 4\*-3 + 6\*5 + 6\*5 = 3

G8(2, 2) = 4\*-3 + 7\*-3 + 2\*-3 + 5\*-3 + 3\*0 + 5\*5 + 6\*-3 + 6\*5 + 4\*5 = 3

G8(2, 3) = 7\*-3 + 2\*-3 + 2\*-3 + 3\*-3 + 5\*0 + 4\*5 + 6\*-3 + 4\*5 + 4\*5 = 0

G8(2, 4) = 2\*-3 + 2\*-3 + 0\*-3 + 5\*-3 + 4\*0 + 0\*5 + 4\*-3 + 4\*5 + 0\*5 = -19

G8(3, 0) = 0\*-3 + 3\*-3 + 5\*-3 + 0\*-3 + 4\*0 + 6\*5 + 0\*-3 + 1\*5 + 2\*5 = 21

G8(3, 1) = 3\*-3 + 5\*-3 + 3\*-3 + 4\*-3 + 6\*0 + 6\*5 + 1\*-3 + 2\*5 + 3\*5 = 7

G8(3, 2) = 5\*-3 + 3\*-3 + 5\*-3 + 6\*-3 + 6\*0 + 4\*5 + 2\*-3 + 3\*5 + 6\*5 = 2

G8(3, 3) = 3\*-3 + 5\*-3 + 4\*-3 + 6\*-3 + 4\*0 + 4\*5 + 3\*-3 + 6\*5 + 6\*5 = 17

G8(3, 4) = 5\*-3 + 4\*-3 + 0\*-3 + 4\*-3 + 4\*0 + 0\*5 + 6\*-3 + 6\*5 + 0\*5 = -27

G8(4, 0) = 0\*-3 + 4\*-3 + 6\*-3 + 0\*-3 + 1\*0 + 2\*5 + 0\*-3 + 0\*5 + 0\*5 = -20

G8(4, 1) = 4\*-3 + 6\*-3 + 6\*-3 + 1\*-3 + 2\*0 + 3\*5 + 0\*-3 + 0\*5 + 0\*5 = -36

G8(4, 2) = 6\*-3 + 6\*-3 + 4\*-3 + 2\*-3 + 3\*0 + 6\*5 + 0\*-3 + 0\*5 + 0\*5 = -24

G8(4, 3) = 6\*-3 + 4\*-3 + 4\*-3 + 3\*-3 + 6\*0 + 6\*5 + 0\*-3 + 0\*5 + 0\*5 = -21

G8(4, 4) = 4\*-3 + 4\*-3 + 0\*-3 + 6\*-3 + 6\*0 + 0\*5 + 0\*-3 + 0\*5 + 0\*5 = -42

G8 =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 80 | 60 | 25 | -12 | -2 |
| 30 | -3 | -22 | -8 | -13 |
| 45 | 3 | 3 | 0 | -19 |
| 21 | 7 | 2 | 17 | -27 |
| -20 | -36 | -24 | -21 | -42 |

|G8| =

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 80 | 60 | 25 | 12 | 2 |
| 30 | 3 | 22 | 8 | 13 |
| 45 | 3 | 3 | 0 | 19 |
| 21 | 7 | 2 | 17 | 27 |
| 20 | 36 | 24 | 21 | 42 |

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G = max{ |G1|, |G2|, |G3|, |G4|, |G5|, |G6|, |G7|, |G8| }:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 80 | 84 | 73 | 68 | 30 |
| 66 | 37 | 34 | 48 | 45 |
| 75 | 19 | 29 | 32 | 53 |
| 61 | 33 | 18 | 17 | 75 |
| 60 | 68 | 72 | 69 | 70 |

**Câu 4. Thực hiện phát hiện biên bằng bộ lọc Laplacian:**

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

Thực hiện dò biên theo phương pháp Laplacian. Sử dụng mặt nạ:

|  |  |  |
| --- | --- | --- |
| -1 | -1 | -1 |
| -1 | 4 | -1 |
| -1 | -1 | -1 |

G(0, 0) = 0\*-1 + 0\*-1 + 0\*-1 + 0\*-1 + 4\*4 + 6\*-1 + 0\*-1 + 6\*-1 + 4\*-1 = 0

G(0, 1) = 0\*-1 + 0\*-1 + 0\*-1 + 4\*-1 + 6\*4 + 7\*-1 + 6\*-1 + 4\*-1 + 7\*-1 = -4

G(0, 2) = 0\*-1 + 0\*-1 + 0\*-1 + 6\*-1 + 7\*4 + 2\*-1 + 4\*-1 + 7\*-1 + 2\*-1 = 7

G(0, 3) = 0\*-1 + 0\*-1 + 0\*-1 + 7\*-1 + 2\*4 + 2\*-1 + 7\*-1 + 2\*-1 + 2\*-1 = -12

G(0, 4) = 0\*-1 + 0\*-1 + 0\*-1 + 2\*-1 + 2\*4 + 0\*-1 + 2\*-1 + 2\*-1 + 0\*-1 = 2

G(1, 0) = 0\*-1 + 4\*-1 + 6\*-1 + 0\*-1 + 6\*4 + 4\*-1 + 0\*-1 + 3\*-1 + 5\*-1 = 2

G(1, 1) = 4\*-1 + 6\*-1 + 7\*-1 + 6\*-1 + 4\*4 + 7\*-1 + 3\*-1 + 5\*-1 + 3\*-1 = -25

G(1, 2) = 6\*-1 + 7\*-1 + 2\*-1 + 4\*-1 + 7\*4 + 2\*-1 + 5\*-1 + 3\*-1 + 5\*-1 = -6

G(1, 3) = 7\*-1 + 2\*-1 + 2\*-1 + 7\*-1 + 2\*4 + 2\*-1 + 3\*-1 + 5\*-1 + 4\*-1 = -24

G(1, 4) = 2\*-1 + 2\*-1 + 0\*-1 + 2\*-1 + 2\*4 + 0\*-1 + 5\*-1 + 4\*-1 + 0\*-1 = -7

G(2, 0) = 0\*-1 + 6\*-1 + 4\*-1 + 0\*-1 + 3\*4 + 5\*-1 + 0\*-1 + 4\*-1 + 6\*-1 = -13

G(2, 1) = 6\*-1 + 4\*-1 + 7\*-1 + 3\*-1 + 5\*4 + 3\*-1 + 4\*-1 + 6\*-1 + 6\*-1 = -19

G(2, 2) = 4\*-1 + 7\*-1 + 2\*-1 + 5\*-1 + 3\*4 + 5\*-1 + 6\*-1 + 6\*-1 + 4\*-1 = -27

G(2, 3) = 7\*-1 + 2\*-1 + 2\*-1 + 3\*-1 + 5\*4 + 4\*-1 + 6\*-1 + 4\*-1 + 4\*-1 = -12

G(2, 4) = 2\*-1 + 2\*-1 + 0\*-1 + 5\*-1 + 4\*4 + 0\*-1 + 4\*-1 + 4\*-1 + 0\*-1 = -1

G(3, 0) = 0\*-1 + 3\*-1 + 5\*-1 + 0\*-1 + 4\*4 + 6\*-1 + 0\*-1 + 1\*-1 + 2\*-1 = -1

G(3, 1) = 3\*-1 + 5\*-1 + 3\*-1 + 4\*-1 + 6\*4 + 6\*-1 + 1\*-1 + 2\*-1 + 3\*-1 = -3

G(3, 2) = 5\*-1 + 3\*-1 + 5\*-1 + 6\*-1 + 6\*4 + 4\*-1 + 2\*-1 + 3\*-1 + 6\*-1 = -10

G(3, 3) = 3\*-1 + 5\*-1 + 4\*-1 + 6\*-1 + 4\*4 + 4\*-1 + 3\*-1 + 6\*-1 + 6\*-1 = -21

G(3, 4) = 5\*-1 + 4\*-1 + 0\*-1 + 4\*-1 + 4\*4 + 0\*-1 + 6\*-1 + 6\*-1 + 0\*-1 = -9

G(4, 0) = 0\*-1 + 4\*-1 + 6\*-1 + 0\*-1 + 1\*4 + 2\*-1 + 0\*-1 + 0\*-1 + 0\*-1 = -8

G(4, 1) = 4\*-1 + 6\*-1 + 6\*-1 + 1\*-1 + 2\*4 + 3\*-1 + 0\*-1 + 0\*-1 + 0\*-1 = -12

G(4, 2) = 6\*-1 + 6\*-1 + 4\*-1 + 2\*-1 + 3\*4 + 6\*-1 + 0\*-1 + 0\*-1 + 0\*-1 = -12

G(4, 3) = 6\*-1 + 4\*-1 + 4\*-1 + 3\*-1 + 6\*4 + 6\*-1 + 0\*-1 + 0\*-1 + 0\*-1 = 1

G(4, 4) = 4\*-1 + 4\*-1 + 0\*-1 + 6\*-1 + 6\*4 + 0\*-1 + 0\*-1 + 0\*-1 + 0\*-1 = 10

Kết quả:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| G = |I ⊕ H| = | |  |  |  |  |  | | --- | --- | --- | --- | --- | | 0 | -4 | 7 | -12 | 2 | | 2 | -25 | -6 | -24 | -7 | | -13 | -19 | -27 | -12 | -1 | | -1 | -3 | -10 | -21 | -9 | | -8 | -12 | -12 | 1 | 10 | |