Assignment 3

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20 September 2018

1 Dilation

1.1 Set Difference

Let A={1 2 3 4 5 6} and B={4 5 6 7 8 9} $\implies$ C=A-B=[1 2 3]
Let A={1 2 3 4 5 6} and B={10} $\implies$ C=A-B=[1 2 3 4 5 6]
Let A={1 } and B={4 5 6 7 8 9} $\implies$ C=A-B=[1]

1.2 Set complement

Let U={1 2 3 4 5 6} and A={4 5 6 } $\implies$ C=A^c=[1 2 3]
Let U={}(When U is not specified) and A={1 2 3} $\implies$ C=A^c=[NaN] (Universal set not properly defined)
Let U={4 5 6} and B={4 5 6} $\implies$ C=A^c=[ ] (null set)

1.3 Set reflection

Let A={1 2 3 4 5 6} $\implies$ C=$\hat{A}$=[6 5 4 3 2 1]
Let A={4 5 6} $\implies$ C=$\hat{A}$=[6 5 4]
Let A={1 2 3} $\implies$ C=$\hat{A}$=[3 2 1]

1.4 Set A subset of Set B

Let A={1 2 3} and B={1 2 3 4 5 6} $\implies$ C=A $\subset$ B=1 (boolean logic)
Let A={1 2 3 4 5 6} and B={10} $\implies$ C=A $\subset$ B=0 (boolean logic)
Let A={1 } and B={4 5 6 7 8 9} $\implies$ C=A $\subset$ B=0 (boolean logic)

1.5 Set A intersection Set B

Let A={1 2 3 4 5 6} and B={4 5 6 7 8 9} $\implies$ C=A $\cap$ B=[4 5 6]
Let A={1 2 3} and B={8 9 0} $\implies$ C=A $\cap$ B=[ ] (null set)

Let A={1 } and B={1 4 5 6 7 8 9} $\implies$ C=A $\cap$ B=[1]

1.6 Set A union Set B

Let A={1 2 3} and B={4 5 6} $\implies$ C=A $\cup$ B=[1 2 3 4 5 6]
Let A={1 2 3} and B={8 9 0} $\implies$ C=A $\cup$ B=[1 2 3 8 9 0]
Let A={1 } and B={4 5 6 7 8 9} $\implies$ C=A $\cup$ B=[1 4 5 6 7 8 9]

1.7 Set translation

Let

$$A = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

and

$$h = \begin{bmatrix} 1 & 1 \end{bmatrix}$$

$\implies$ C=A_h=

$$\begin{bmatrix} 2 & 3 \\ 4 & 5 \\ 6 & 7 \end{bmatrix}$$

1.8 Dilation definition1

Problem solved in the class
Let

$$A = \begin{bmatrix} 1 & 1 \end{bmatrix}$$

and

$$B = \begin{bmatrix} 0 & -1 \\ 0 & 2 \end{bmatrix}$$

$\implies$ C=A $\oplus$ B=

$$\begin{bmatrix} 1 & 0 \\ 1 & 3 \end{bmatrix}$$

1.9 Dilation definition2

Let

$$A = \begin{bmatrix} 1 & 1 \end{bmatrix}$$

and

$$B = \begin{bmatrix} 0 & -1 \\ 0 & 2 \end{bmatrix}$$

$\implies$ C=A $\oplus$ B=

$$\begin{bmatrix} 1 & 0 \\ 1 & 3 \end{bmatrix}$$

1.10 Dilation definition3

Let

$$A = \begin{bmatrix} 1 & 1 \end{bmatrix}$$

and

$$B = \begin{bmatrix} 0 & -1 \\ 0 & 2 \end{bmatrix}$$

$\implies$ C=A $\oplus$ B=

$$\begin{bmatrix} 1 & 0 \\ 1 & 3 \end{bmatrix}$$

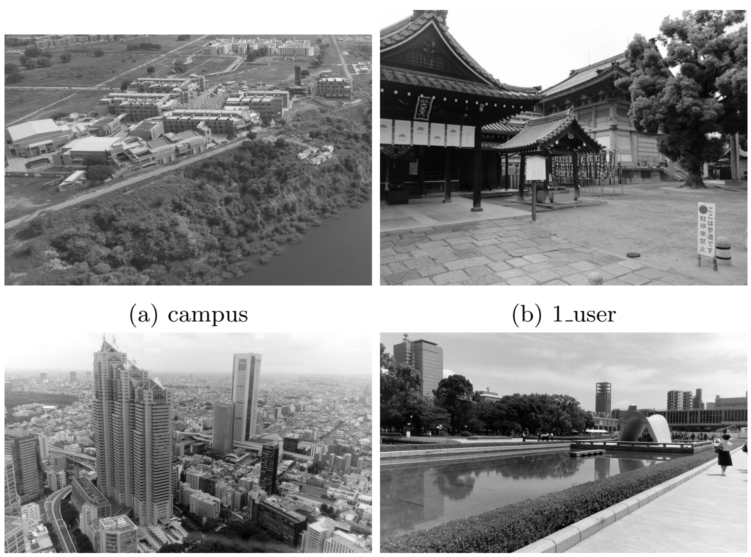
REMARK: Dilation calculated using all the three formulas is same.

2 Image Halftoning

Let

$$\alpha = \begin{bmatrix} \alpha 1 & \alpha 2 & \alpha 3 & \alpha 4 & \alpha 5 & \alpha 6 & \end{bmatrix}$$

and



(a) campus

(b) 1_user

(c) 2_user

(d) 3_user

Figure 1: Input Images to the code

2.1 Thresholding

1. Input Image $\longrightarrow$ campus

Figure 2: Image after thresholding

$$\alpha = \begin{bmatrix} 62.3617 & 62.9058 & 62.7899 & 68.3735 & 0.3529 & 0.00010357 & \end{bmatrix}$$

2. Input Image $\longrightarrow$ 1_user

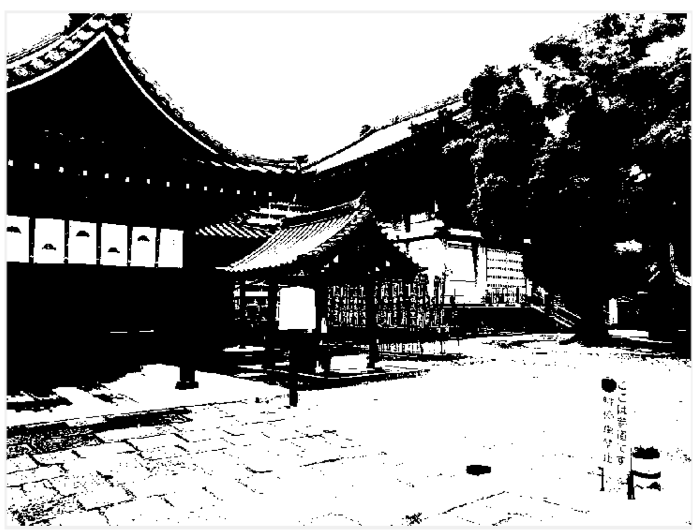


Figure 3: Image after thresholding

$$\alpha = \begin{bmatrix} -130.02183 & 130.4281 & 130.69 & 126.3663 & -254.4314 & 0.0006300905 \end{bmatrix}$$

3. Input Image $\longrightarrow$ 2_user

Figure 4: Image after thresholding

$$\alpha = \begin{bmatrix} -139.0461 & 139.3274 & 139.5907 & 135.1631 & -254.2863 & 0.0005157546 \end{bmatrix}$$

4. Input Image $\longrightarrow$ 3_user

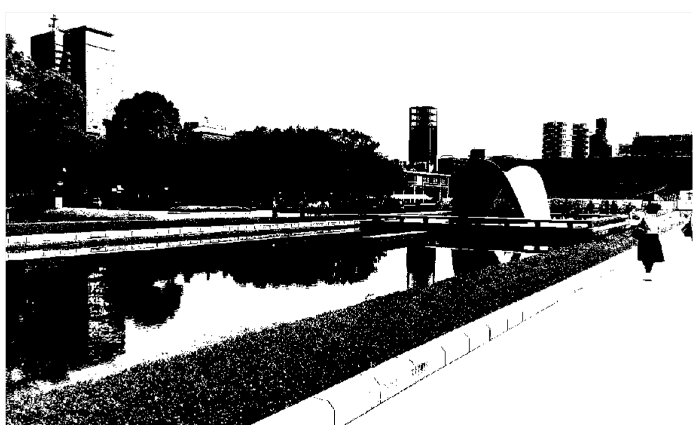


Figure 5: Image after thresholding

$$\alpha = \begin{bmatrix} -62.3617 & 62.9058 & 62.7899 & 68.3735 & 0.352941 & 0.00010357 \end{bmatrix}$$

2.2 Random noise Binarization

1. Input Image $\longrightarrow$ campus

Figure 6: Image after addition of random noise

Figure 7: Image after Binarization

$$\alpha = \begin{bmatrix} -62.3617 & 62.9058 & 62.7899 & 68.3735 & 0.352941 & 0.00010357 \end{bmatrix}$$

2. Input Image $\longrightarrow$ 1_user

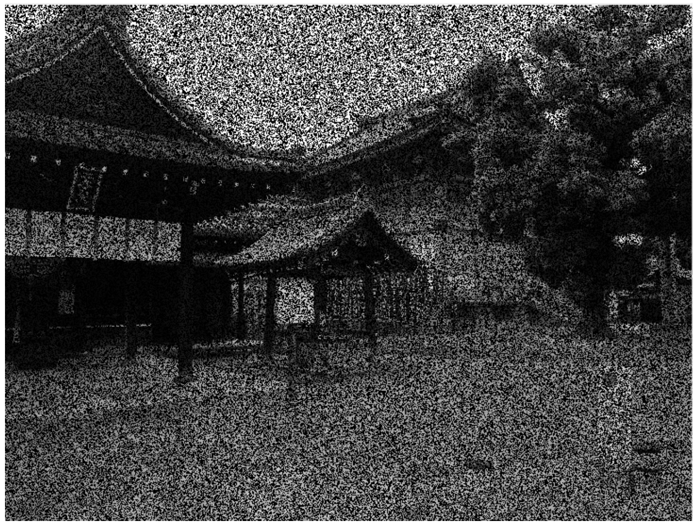


Figure 8: Image after addition of random noise

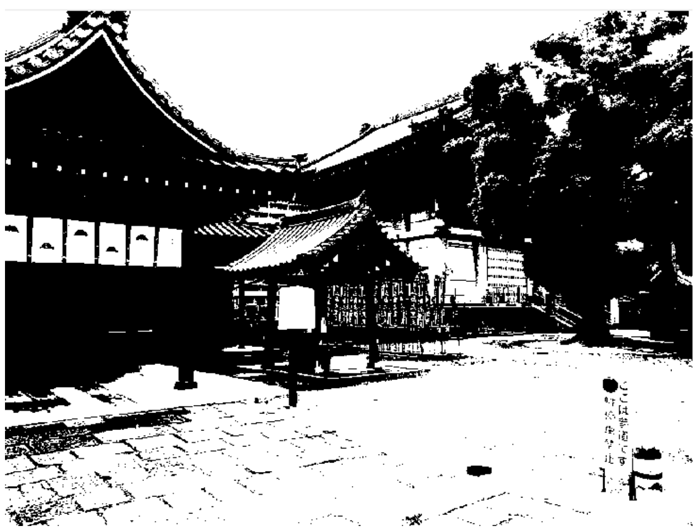


Figure 9: Image after Binarization

$$\alpha = \begin{bmatrix} -130.02183 & 130.4281 & 130.69 & 126.3663 & -254.4314 & 0.000063000905 \end{bmatrix}$$

3. Input Image $\longrightarrow$ 2_user

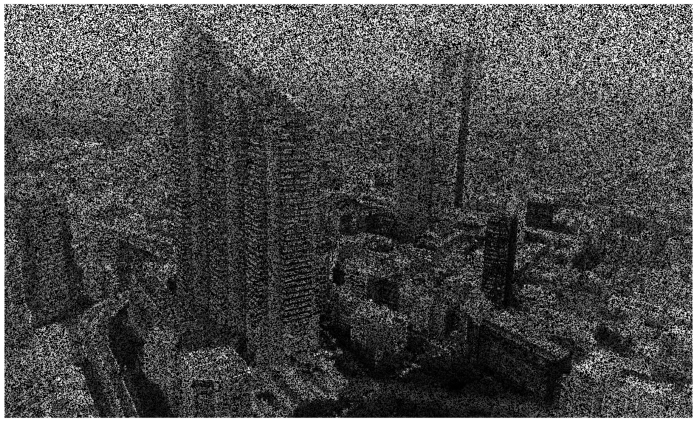


Figure 10: Image after addition of random noise

Figure 11: Image after Binarization

$$\alpha = \begin{bmatrix} -139.0461 & 139.3274 & 139.5907 & 135.1631 & -254.2863 & 0.0005157546 \end{bmatrix}$$

4. Input Image $\longrightarrow$ campus

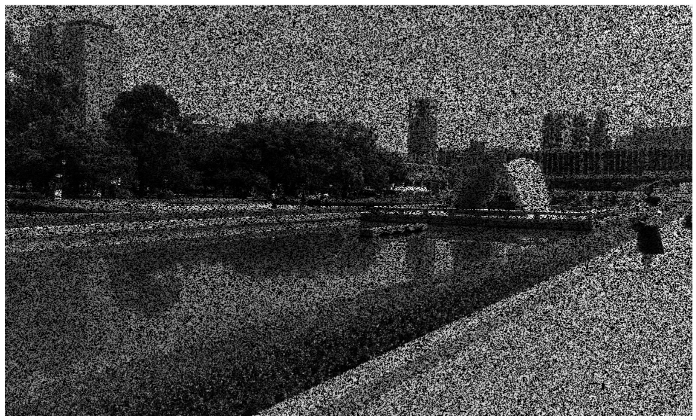


Figure 12: Image after addition of random noise

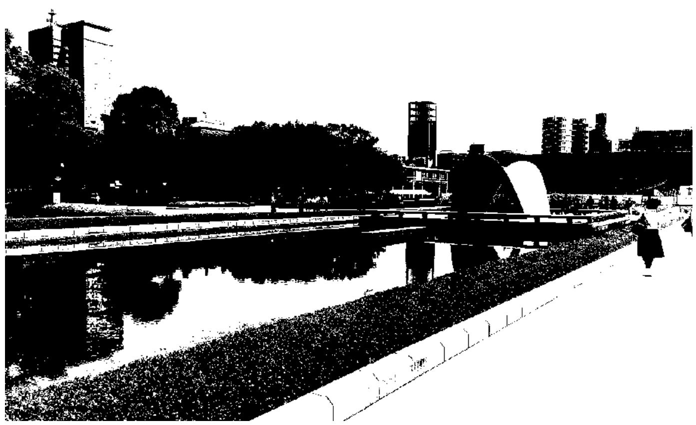


Figure 13: Image after Binarization

$$\alpha = \begin{bmatrix} -135.296 & 135.5374 & 135.8314 & 131.0317 & -254.0863 & 0.0005100184 & \end{bmatrix}$$

2.3 Ordered Dithering

For all the images processed, following where the index and threshold matrices.
Index Matrices

$$i2 = \begin{bmatrix} 1 & 2 \\ 3 & 0 \end{bmatrix}$$

$$i4 = \begin{bmatrix} 5 & 9 & 6 & 10 \\ 13 & 1 & 14 & 2 \\ 7 & 11 & 4 & 8 \\ 15 & 3 & 12 & 0 \end{bmatrix}$$

$$i8 = \begin{bmatrix} 21 & 37 & 25 & 41 & 22 & 38 & 26 & 42 \\ 53 & 5 & 57 & 9 & 54 & 6 & 58 & 10 \\ 29 & 45 & 17 & 33 & 30 & 46 & 18 & 34 \\ 61 & 13 & 49 & 1 & 62 & 14 & 50 & 2 \\ 23 & 39 & 27 & 43 & 20 & 36 & 24 & 40 \\ 55 & 7 & 59 & 11 & 52 & 4 & 56 & 8 \\ 31 & 47 & 19 & 35 & 28 & 44 & 16 & 32 \\ 63 & 15 & 51 & 3 & 60 & 12 & 48 & 0 \end{bmatrix}$$

Threshold Matrices

$$t2 = \begin{bmatrix} 95.625 & 159.375 \\ 223.125 & 31.875 \end{bmatrix}$$

$$t4 = \begin{bmatrix} 87.65625 & 151.40625 & 103.59375 & 167.34375 \\ 215.15625 & 23.90625 & 231.09375 & 39.84375 \\ 119.53125 & 183.28125 & 71.71875 & 135.46875 \\ 247.03125 & 55.78125 & 199.21875 & 7.96875 \end{bmatrix}$$

$$t8 = \begin{bmatrix} 85.66 & 149.41 & 101.60 & 165.35 & 89.64 & 153.39 & 105.58 & 169.33 \\ 213.16 & 21.91 & 229.10 & 37.85 & 217.14 & 25.89 & 233.08 & 41.83 \\ 117.53 & 181.28 & 69.72 & 133.47 & 121.52 & 185.27 & 73.71 & 137.46 \\ 245.03 & 53.78 & 197.22 & 5.97 & 249.02 & 57.77 & 201.21 & 9.96 \\ 93.63 & 157.38 & 109.57 & 173.32 & 81.67 & 145.42 & 97.61 & 161.36 \\ 221.13 & 29.88 & 237.07 & 45.82 & 209.17 & 17.92 & 225.11 & 33.86 \\ 125.50 & 189.25 & 77.69 & 141.44 & 113.55 & 177.30 & 65.74 & 129.49 \\ 253.00 & 61.75 & 205.19 & 13.94 & 241.05 & 49.80 & 193.24 & 1.99 \end{bmatrix}$$

1. Input Image $\longrightarrow$ campus
   For t2 matrix

   $$\alpha = \begin{bmatrix} 0.0110 & 113.6441 & 104.9981 & 125.9509 & 90 & 0.0003 \end{bmatrix}$$

   For t4 matrix

   $$\alpha = \begin{bmatrix} -0.0446 & 113.7263 & 104.9625 & 126.0115 & 90 & 0.0003 \end{bmatrix}$$

   For t8 matrix

   $$\alpha = \begin{bmatrix} -0.0711 & 113.7557 & 105.0047 & 126.0203 & 90 & 0.0003 \end{bmatrix}$$

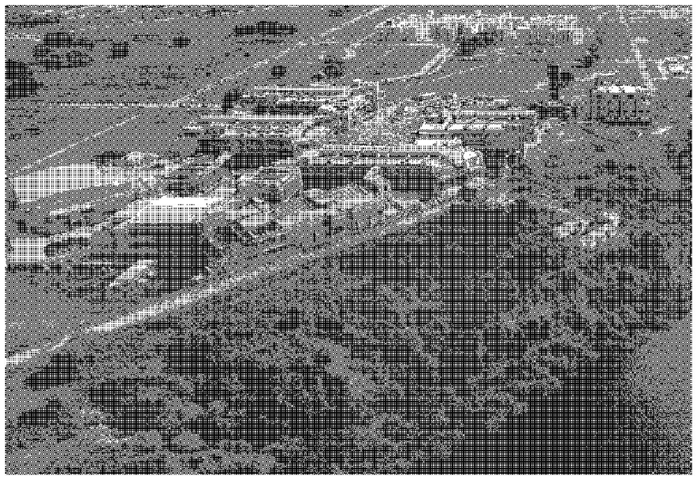


Figure 14: Image after Dithering with t2 matrix

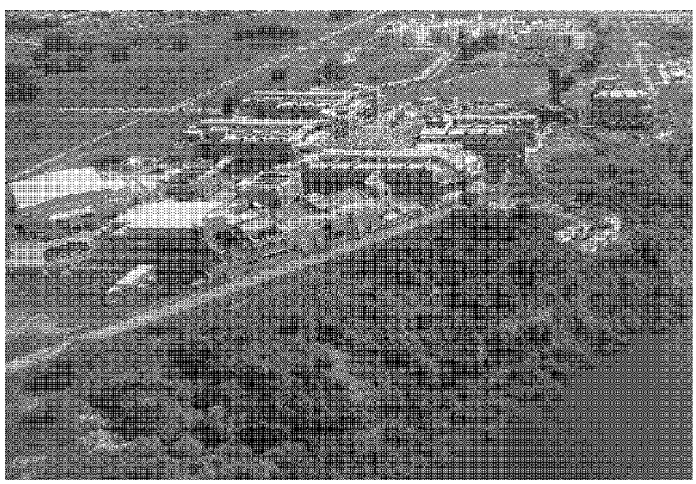


Figure 15: Image after Dithering with t4 matrix

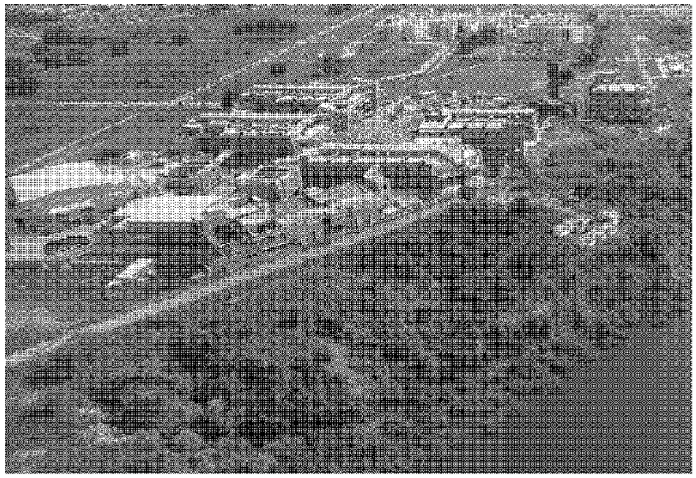


Figure 16: Image after Dithering with t8 matrix

2. Input Image $\longrightarrow$ 1_user
   For t2 matrix

$$\alpha = \begin{bmatrix} 0.7954 & 80.1650 & 78.5373 & 93.7523 & 145 & 0.0003 \end{bmatrix}$$

   For t4 matrix

$$\alpha = \begin{bmatrix} -0.3396 & 82.3677 & 80.5479 & 95.3697 & 145 & 0.0003 \end{bmatrix}$$

   For t8 matrix

$$\alpha = \begin{bmatrix} -0.1028 & 82.3852 & 80.5514 & 95.4292 & 145 & 0.0003 \end{bmatrix}$$

Figure 17: Image after Dithering with t2 matrix

Figure 18: Image after Dithering with t4 matrix

Figure 19: Image after Dithering with t8 matrix

3. Input Image $\longrightarrow$ 2_user
   For t2 matrix
   $$\alpha = \begin{bmatrix} -2.3736 & 90.9633 & 92.9450 & 96.7172 & 182 & 0.0003 \end{bmatrix}$$
   For t4 matrix
   $$\alpha = \begin{bmatrix} -0.0985 & 92.5632 & 93.8796 & 98.7433 & 182 & 0.0003 \end{bmatrix}$$
   For t8 matrix
   $$\alpha = \begin{bmatrix} 0.0114 & 92.6321 & 93.9389 & 98.8261 & 182 & 0.0003 \end{bmatrix}$$

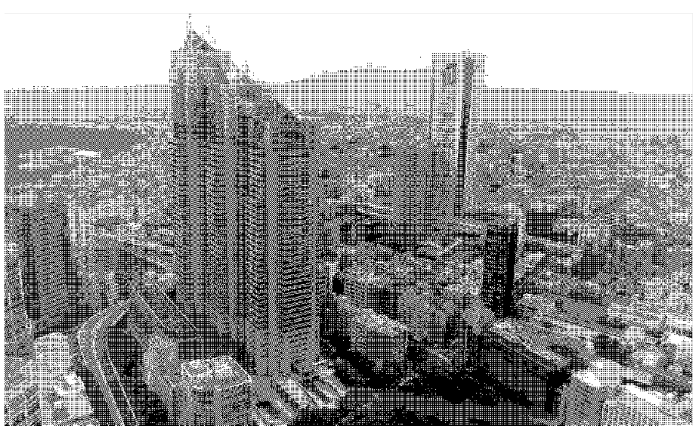


Figure 20: Image after Dithering with t2 matrix

Figure 21: Image after Dithering with t4 matrix

Figure 22: Image after Dithering with t8 matrix

4. Input Image $\longrightarrow$ 3_user
   For t2 matrix

$$\alpha = \begin{bmatrix} 3.2266 & 84.8967 & 87.2740 & 93.4432 & -220.0001 \end{bmatrix}$$

For t4 matrix

$$\alpha = \begin{bmatrix} 0.1539 & 84.2340 & 87.7616 & 91.9374 & -220.0001 \end{bmatrix}$$

For t8 matrix

$$\alpha = \begin{bmatrix} 0.1164 & 84.1998 & 87.7271 & 91.9079 & -22 & 0.0001 \end{bmatrix}$$

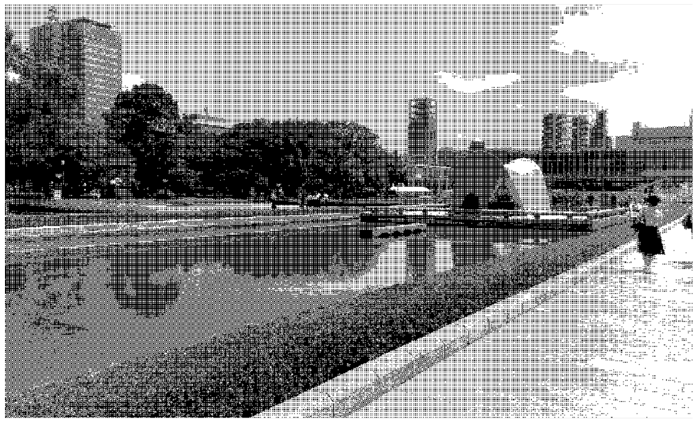


Figure 23: Image after Dithering with t2 matrix

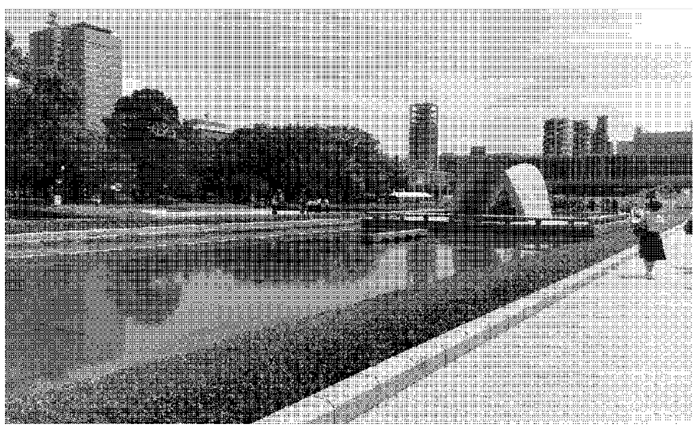


Figure 24: Image after Dithering with t4 matrix

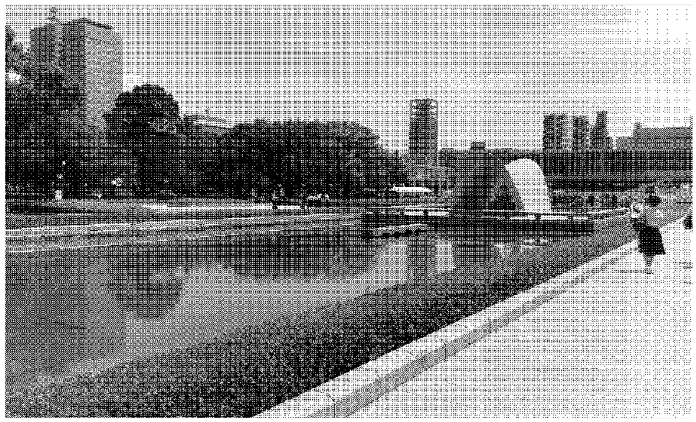


Figure 25: Image after Dithering with t8 matrix

2.4 Error Diffusion

1. Input Image $\longrightarrow$ campus

$$\alpha = \begin{bmatrix} 0.2627 & 115.5004 & 106.5642 & 127.3678 & -165 & 0.0004 \end{bmatrix}$$

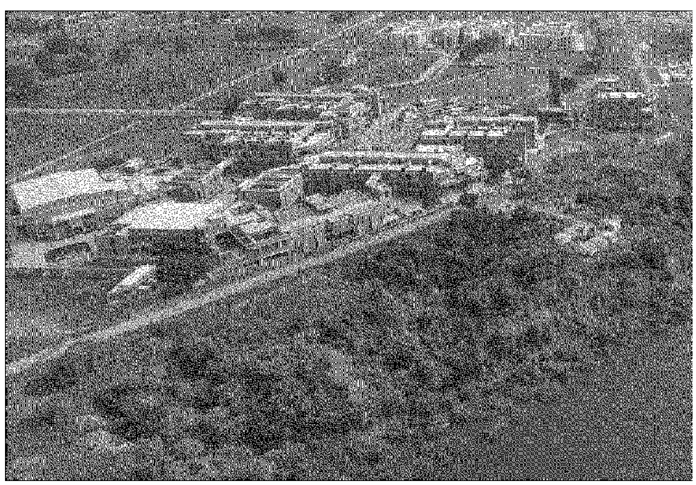


Figure 26: Image after Error diffusion

2. Input Image $\longrightarrow$ 1_user

$$\alpha = \begin{bmatrix} 0.3553 & 83.5323 & 81.5369 & 96.4339 & -110 & 0.0003 \end{bmatrix}$$

Figure 27: Image after Error diffusion

3. Input Image $\longrightarrow$ 2_user

$$\alpha = \begin{bmatrix} 0.2924 & 94.7623 & 95.9311 & 100.4578 & 182 & 0.0003 \end{bmatrix}$$

Figure 28: Image after Error diffusion

4. Input Image $\longrightarrow$ 3_user

$$\alpha = \begin{bmatrix} 0.3875 & 85.9201 & 89.0826 & 93.4100 & -22 & 0.0001 \end{bmatrix}$$

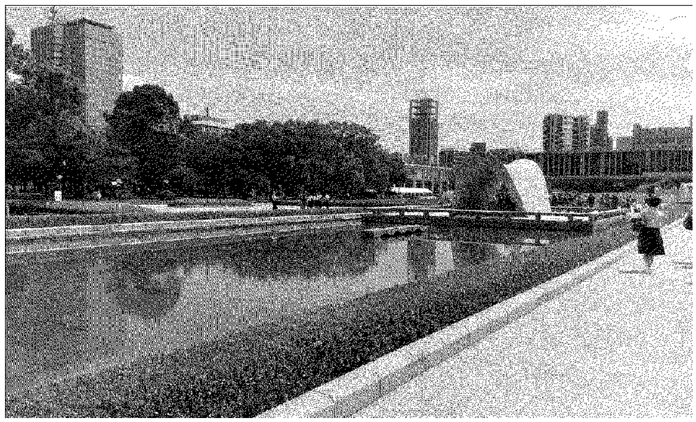


Figure 29: Image after Error diffusion