1. Explain briefly: (1.5 p. / item)

    (a) histogram specification
    (b) median filtering
    (c) psycho-visual redundancy
    (d) 1D run-length encoding

2. Calculate the value of the following image at coordinates (1.6, 2.2) using:

    (a) nearest neighbour interpolation.   (2 p.)
    (b) bilinear interpolation.   (4 p.)

2	3	5	7
6	1	8	9
1	3	2	5
0	0	0	2

The coordinates (0, 0) correspond to the top-left corner of the image and the first coordinate represents the vertical direction.

3. Perform gradient based edge detection to the following image using Prewitt gradient operator and gradient magnitude approximation $G \approx |G_x| + |G_y|$. Use threshold $T = 10$ for edge detection. Non-maximum suppression **does not need** to be done. Process only such pixels that have all the needed neighbours.   (6 p.)

$$h_x = \begin{pmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{pmatrix}, h_y = \begin{pmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{pmatrix}$$

3	3	4	8
6	4	5	9
2	7	9	0
8	9	1	2

4. (a) Explain the image degradation model.   (3 p.)

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(b) Suppose image degradation due to atmospheric turbulence can be modeled with transfer function:

$$H(u, v) = e^{-k(u^2+v^2)^{5/6}}$$

Give the expression for the corresponding Wiener filter* (as defined below), assuming that the ratio of power spectra of the noise and undegraded signal is a constant. (3 p.)

* The Wiener filter is:

$$\hat{F}(u, v) = \left[\frac{1}{H(u, v)} \frac{|H(u, v)|^2}{|H(u, v)|^2 + S_\eta(u, v)/S_f(u, v)} \right] G(u, v),$$

5. (a) Determine $\mathbf{A} \ominus \mathbf{B}$, the morphological erosion of the image $\mathbf{A}$ with the structuring element $\mathbf{B}$. The origin of the structuring-element $\mathbf{B}$ is underlined.

$$\mathbf{A} = \begin{array}{|c|c|c|c|c|c|c|c|}
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\
\hline
0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\
\hline
0 & 0 & 1 & 1 & 1 & 0 & 1 & 0 \\
\hline
0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\hline
\end{array}
\qquad
\mathbf{B} = \begin{array}{|c|c|c|}
\hline
0 & 0 & 0 \\
\hline
1 & 1 & 1 \\
\hline
\end{array}$$

(3 p.)

(b) Morphological opening is erosion followed by dilation:

$$\mathbf{A} \circ \mathbf{B} = (\mathbf{A} \ominus \mathbf{B}) \oplus \mathbf{B}.$$

Perform the morphological opening of the image $\mathbf{A}$ with the structuring-element $\mathbf{B}$. (3 p.)