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Lappeenranta University of Technology
LUT Mathematics and Physics

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BM40A1200 Digital Imaging and Image Preprocessing

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Exam 2015-03-24

Material allowed in the exam: a calculator.

Other instructions: i) justify your answers well and ii) if there are any appendices given with this exam paper, they must be returned with your answers.

1. Understanding of concepts (10 p): Explain briefly the following terms related to digital imaging and image processing. In the case of more than one term (... *vs.* ...), explain also the differences of the mentioned terms. The maximum length of the answer to the whole task, which will be taken into account, is **1 page**.

   (a) Bayer filter
   (b) Histogram equalisation
   (c) Rolling shutter *vs.* global shutter
   (d) Signal-to-noise ratio (SNR)
   (e) Wavefront

2. Light interaction with matter (10 p):

   (a) Draw a cross-section and explain the operating principle of a silicon photodiode.
   (b) Fig. 1 presents typical light response of a silicon photodiode. Explain why there is practically no response below 300 nm and above 1100 nm.

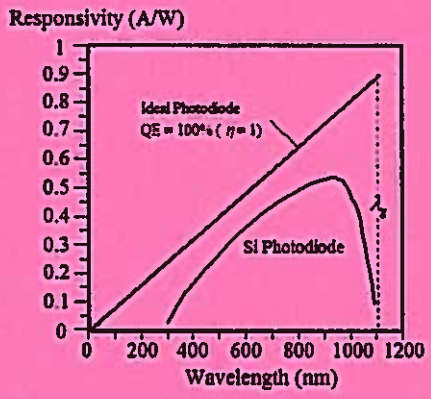

Figure 1: Typical light response of a silicon photodiode.

3. Imaging technology (10 p): Mention the three main charge-coupled device (CCD) image sensor types, and explain their operating principles. Note also the main differences and benefits/drawbacks of each design.

4. Optics (10 p):

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(a) Find the chromatic aberration A of a double convex lens of crown glass with $n_C = 1.51764$, $n_F = 1.52582$ and radii of 6.0 cm.

(b) Design a lens pair with $A = 0$ using the double convex lens and a flint glass lens with $n_C = 1.61218$ and $n_F = 1.62904$, that is, find the second radii of the convex lens that compensates the chromatic aberration.

Additional information: Eq. 1.

$$1/f = (n-1)(1/R_1 - 1/R_2)\,;\;\; 1/f = 1/f_1 + 1/f_2 \tag{1}$$

5. Image filtering (10 p): Digital images captured of natural scenes and real objects contain noise. Digital filtering can be used to process the image pixel values for different purposes.

(a) Describe the types of noise present in digital images and their sources, that is, where from does each type of noise originate.

(b) How each of the before-mentioned types of noise can be controlled by using digital filtering? What kind of digital filter should be effective for each type of noise?