York University
EECS 4422/5323 Fall 2018 – Practice Problems
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1. **2D Geometric Transformations.** For an image stitching application, you need to align Image A with Image B. This alignment involves the following sequence of transformations to Image A:

   (a) Clockwise rotation by 34 deg.

   (b) Scaling by a factor of 0.9.

   (c) Translation by +7 pixels horizontally and -4 pixels vertically.

   Represent this alignment with a single transformation matrix that maps from augmented to inhomogeneous (Euclidean) coordinates.

2. **Resolution.** Of all the planets in our solar system, Venus is our nearest neighbour, roughly 3.8×10^{10} m away at its closest approach. It is bigger than Earth, at 1.2×10^7 m in diameter.

   (a) What is the angular subtense of Venus, in seconds of arc?

   (b) In the human fovea, the spacing between hexagonally-packed cones is roughly 30 seconds of arc. Suppose that you look directly at Venus, at its closest approach, and one of your cones is centred on the optic axis. How many cones in total will receive light directly from Venus, neglecting atmospheric effects, eye movements, diffraction, focal blur, optical aberrations etc?

3. **Phong Shading.** The Phong shading model is given by

$$L_r\left(\hat{\boldsymbol{v}}_r;\lambda\right) = k_a(\lambda)L_a(\lambda) + k_d(\lambda)\sum_i L_i(\lambda)\left[\hat{\boldsymbol{v}}_i \cdot \hat{\boldsymbol{n}}\right]^+ + k_s(\lambda)\sum_i L_i(\lambda)\left(\hat{\boldsymbol{v}}_i \cdot \hat{\boldsymbol{s}}_i\right]^{k_e} \quad (1)$$

   Explain the role of each term and each factor of each term.

4. **Gamma.** Explain the relationship between the nonlinear mapping of intensity in a camera and a typical display.

5. **Digital Camera.** In 1-2 sentences, describe the function of each of the following stages of a typical digital camera.

   (a) Optics

   (b) Aperture

   (c) Shutter

   (d) Sensor

(e) Gain (ISO)

(f) A/D

(g) Demosaic

(h) White balance

(i) Gamma

6. **Linear Shift Invariant Systems.**

   (a) What properties must an operator $h()$ satisfy in order to be called linear?

   (b) What property must an operator $h()$ satisfy in order to be called shift invariant?

7. **Bilateral Filters** What is a bilateral filter? Name one advantage of a bilateral filter over a standard spatial filter.

8. **Wiener Filters** What is a Wiener filter? What mathematical problem does it solve? Given an expression for the transfer function of a Wiener filter in terms of the power spectral density of the noise-free signal process and the noise process.

9. **Fourier Transforms.** What is Parseval's theorem?