Introduction to Machine Vision
(EECS 101)

Homework #2

Name: Stefan Cao
ID#: 79267250
Date: 27 January 2017

1.

a) Interline transfer uses opaque columns of pixels meaning that for every 'live' image column there is, there is a 'mask' column next to. This means that when a image is taken, all the live images will shift to the mask columns to block it from being exposed to light. Therefore, if a CCD were using interline transfer, one transfer would be exposed. Hence the image would look like there is a dot on the middle.

$$\frac{1 \text{ transfers*sec}}{7.5 \times 10^6 \text{ transfers}} = \boxed{0.00013 \text{ msec}}$$

which means the image contamination is very small.
In addition:

$$s = T \int b(\lambda)q(\lambda)d\lambda$$
$$= \frac{1 \text{ msec} * 10^9 \text{photons} * 1}{1 \text{ potential wells}}$$
$$\boxed{s = 10^6 \text{ electrons/potential well}}$$

b) Frame transfer uses a mask storage array that is the same size as the live storage array. Nevertheless, after taking an image, all the potential wells have to move up to that storage array which can be an issue as light is still being exposed affecting the potential wells. Hence, if there is a spot of light that is focused on a single potential well at the center of the array, there will be 251 exposed transfers. Hence the image would look like there is a line going from middle of the picture to the bottom of the picture.

$$\frac{251 \text{ transfers*sec}}{7.5 \times 10^6 \text{ transfers}} = \boxed{0.033 \text{ msec}}$$

which means it is an acceptable small image contamination.
In addition:

$$s = T \int b(\lambda)q(\lambda)d\lambda$$
$$= \frac{1 \text{ msec} * 10^9 \text{photons} * 1}{251 \text{ potential wells}}$$
$$\boxed{s = 3984.06 \text{ electrons/potential well}}$$

2.

$$C = (S + N_A + N_P)A$$

a)

$$VAR(C) = VAR((S + N_A + N_P)A)$$
$$= VAR(SA + N_AA + N_PA)$$

(assuming the sources are independent)

$$= A^2VAR(S) + A^2VAR(N_A) + A^2VAR(N_P)$$

(assuming S is constant $=>$ $VAR(S) = 0$; $VAR(N_A) = 1$; $VAR(N_P) = S$)

$$\boxed{VAR(C) = A^2(1 + S)}$$

b)

$$\text{signal-to-noise(C)} = \frac{E(C)}{\text{standard deviation(C)}}$$

Expected Value of C:

$$\begin{aligned} E(C) &= E((S + N_A + N_P)A) \\ &= E(SA + N_A A + N_P A) \\ &= E(SA) + E(N_A A) + E(N_P A) \\ &= AE(S) + AE(N_A) + AE(N_P) \end{aligned}$$

(assuming S is constant; $E(N_A) = 0$; $E(N_P) = 0$)

$$E(C) = AS$$

Standard Deviation of C:

$$\begin{aligned} \text{standard deviation(C)} &= \sqrt{VAR(C)} = \sqrt{A^2(1+S)} \\ \text{signal-to-noise(C)} &= \frac{AS}{\sqrt{A^2(1+S)}} \\ &= \frac{AS}{A\sqrt{(1+S)}} \end{aligned}$$

$$\boxed{\text{signal-to-noise(C)} = \frac{S}{\sqrt{(1+S)}}}$$

c)

$$\text{signal-to-noise(C)} = \frac{S}{\sqrt{(1+S)}}$$

If signal-to-noise(C)=100:

$$100 = \frac{S}{\sqrt{(1+S)}}$$

$$\boxed{S = 10000.99}$$

Hence, the minimum value that S can be for the signal-to-noise to not exceed 100 is being 10000.99 or less.

3.
$f = 4cm$
$z' = 6cm$
$d = 2cm$

a)

$$\frac{1}{z'} + \frac{1}{-z} = \frac{1}{f}$$

$$\frac{1}{6cm} + \frac{1}{-z} = \frac{1}{4cm}$$

$$\boxed{z = -12cm}$$

We have to place the image 12 cm away from the lens to get the image in focus.

b)
Image Blur Equation:

$$b = d\frac{(\bar{z}' - z')}{\bar{z}'}$$

$\frac{2cm}{500} = \frac{1}{250}cm$ Therefore:

$$\frac{1}{250}cm = 2cm\frac{(\bar{z}' - 6cm)}{\bar{z}'}$$

$$\bar{z}' = 6.012cm$$

$$\frac{1}{6.012cm} + \frac{1}{-\bar{z}} = \frac{1}{4cm}$$

$$\bar{z} = 11.95cm$$

$$\boxed{\text{max distance} = 12cm - 11.95cm = 0.05cm}$$

4.

$$D = (S + N_A + N_P)A + N_Q$$

Expected Value of D:

$$E(D) = E((S + N_A + N_P)A + N_Q)$$

$$= E(SA + N_A A + N_P A + N_Q)$$

$$= E(SA) + E(N_A A) + E(N_P A) + E(N_Q)$$

$E(N_A) = E(N_P) = E(N_Q) = 0$
Therefore:

$$E(D) = \boxed{\mu = SA}$$

Variance of D:

$$VAR(D) = VAR(SA + N_A A + N_P A + N_Q)$$

$$= VAR(SA) + VAR(N_A A) + VAR(N_P A) + VAR(N_Q)$$

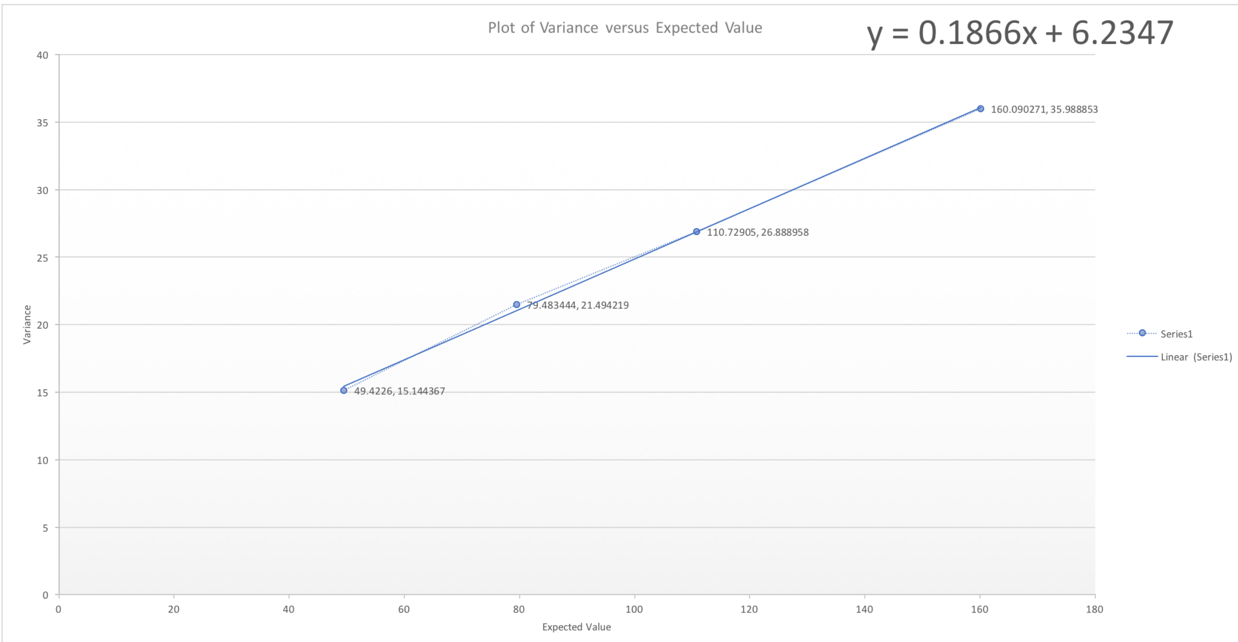
$S = constant, VAR(N_A) = \sigma_A^2, VAR(N_P) = S, VAR(N_Q) = \sigma_Q^2$
Therefore:

$$VAR(D) = 0 + A^2\sigma_A^2 + A^2 S + \sigma_Q^2$$

$\sigma_C^2 = A^2\sigma_A^2 + \sigma_Q^2$
Therefore:

$$VAR(D) = \boxed{\sigma_D^2 = A\mu + \sigma_C^2}$$

image	$\hat{\mu}$	$\hat{\sigma_D^2}$
image1.raw	49.422600	15.144367
image2.raw	79.483444	21.494219
image3.raw	110.729050	26.888958
image4.raw	160.090271	35.988853



$$\sigma_D^2 = A\mu + \sigma_C^2$$

$$\sigma_D^2 = 0.1866\mu + 6.2347$$

$$\boxed{A = 0.1866}$$

$$\boxed{\sigma_C^2 = 6.2347}$$