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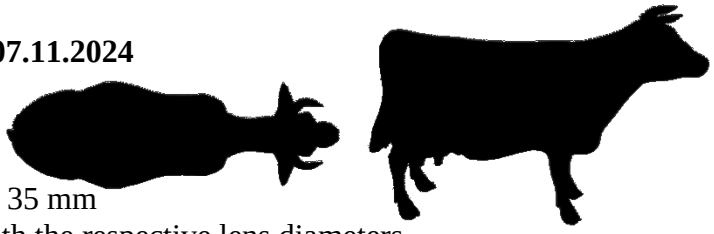
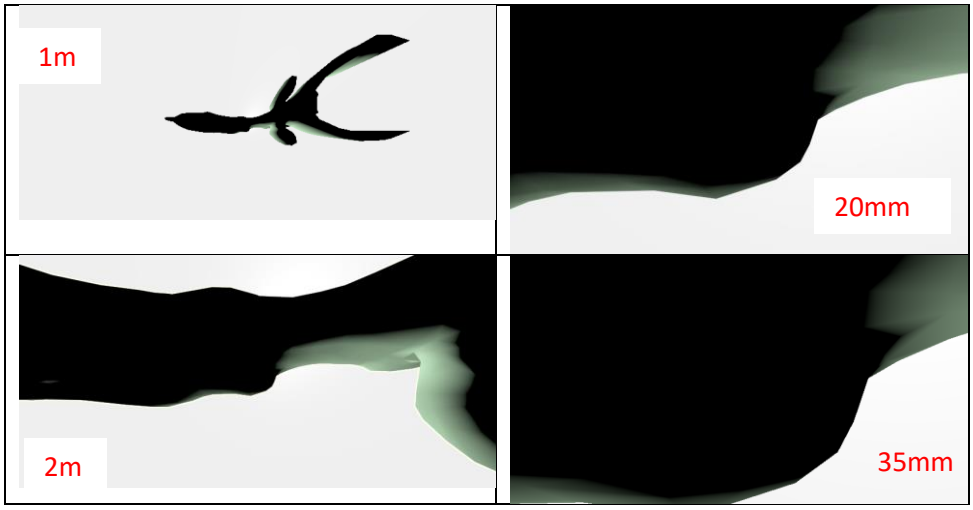
BLG453E – Midterm Exam 1 (CRN: 13633) – 07.11.2024

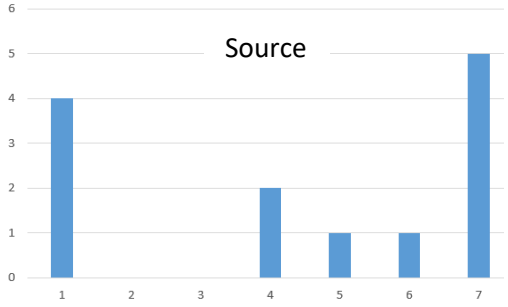


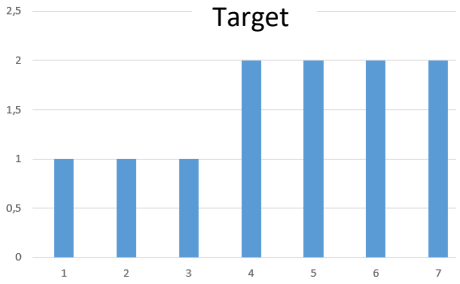
Q1) [10 pts] The synthetic cow shown on the right was captured from the top using a camera equipped with lenses of 1 mm, 2 mm, 20 mm, and 35 mm focal lengths. Match the outcomes given below with the respective lens diameters.



Since the printed visualusations are confusing, all answers are considered true.

Q2) [10 pts] For the given source and target histograms, design the LUT.





Source CDF: 0.307, 0.307, 0.307, 0.461, 0.538, 0.6153, 1
Target CDF: 0.090, 0.181, 0.272, 0.454, 0.636, 0.818, 1

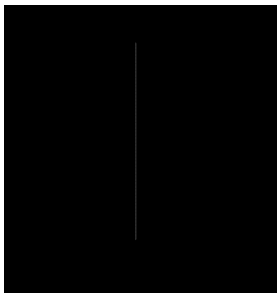
LUT: 3,3,3,4,4,5,7

Q3) [10 pts] The 8x8 filter given on the right is applied to an image containing a 1 pixel thick line on a black background. At least how many bits are required to quantize the resulting image?

Filter

$\frac{1}{26}x$

Input



By horizontally shifting the filter on a vertical line, 4 different value will occur. Also considering the black background, there will be 5 uniue values in total. 5 unique values could be represented by 3 bits since $2^2 < 5 < 2^3$

Q4) The image in Fig.2. (on the right) contains both Gaussian type noise and Salt-Pepper type noise.



(a) [15 pts.] Which spatial filtering operations would be preferably used to obtain a denoised image? Write the equations and a short pseudo-code for the filtering loop.

For Gaussian noise, mean filtering is an option. For Salt-Pepper noise we should use median filtering.

```
for i from 0 to height:
    for j from 0 to width:
        neighborhood = extract window from centered at (i + pad_size, j + pad_size)
        mean_value = mean(neighborhood)
        filtered_image[i, j] = mean_value
```

```
for i from 0 to height:
    for j from 0 to width:
        neighborhood = extract window from centered at (i + pad_size, j + pad_size)
        median_value = median(neighborhood)
        filtered_image[i, j] = mean_value
```

(b) [15 pts.] Can you write a filter mask for the above filtering operation? If not, explain why not? (at most 2 sentences)

We cannot write a filter mask for median filtering.

(c) [5 pts.] What is one advantage of linear filters versus nonlinear filters? *Hint:*You can relate to your answer from b).

Linear filters are comptutationally efficient.

(d) [5 pts.] When should we use a larger filter size as opposed to a smaller one when performing image smoothing?

If bluring the image is not a problem or if there are not many details in the image, we should use a larger filter.

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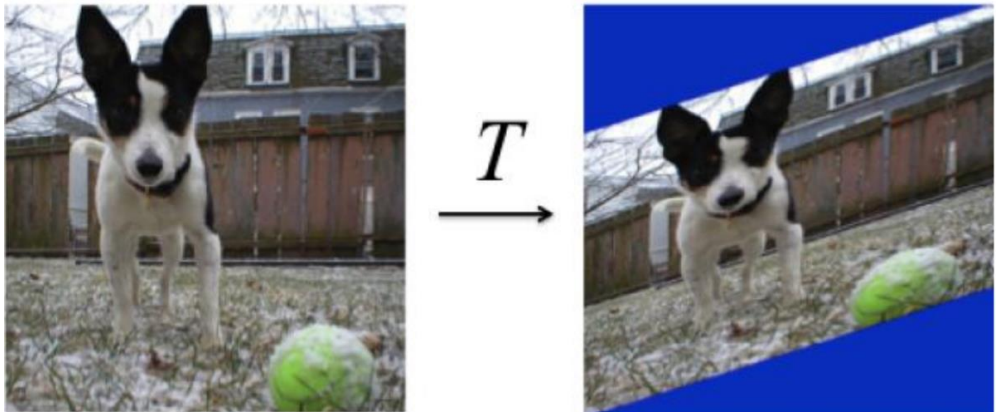
Q5) You want to estimate the geometric transformation between the two images given in the figure.



(a) [15 pts.] Based on the given images, write down the most appropriate parametric model you will use as the geometric transform between the two images. Then derive a linear least squares formulation to estimate the unknown parameters of the transform you selected.

A model for affine transform is needed.

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} = \begin{bmatrix} a_{11}x + a_{12}y + a_{13} \\ a_{21}x + a_{22}y + a_{23} \\ 1 \end{bmatrix}$$

$$\begin{bmatrix} x'_1 \\ y'_1 \\ x'_2 \\ y'_2 \\ x'_3 \\ y'_3 \end{bmatrix} = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_1 & y_1 & 1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_2 & y_2 & 1 \\ x_3 & y_3 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x_3 & y_3 & 1 \end{bmatrix} \begin{bmatrix} a_{11} \\ a_{12} \\ a_{13} \\ a_{21} \\ a_{22} \\ a_{23} \end{bmatrix}$$

$$A = (M^T M)^{-1} M^T X$$

(b) [15 pts] How many unknown parameters are there in the geometric transform in part 4 (a) ? Write down briefly the algorithm to estimate those unknown parameters using the formula you derived in (a). (*Hint:* You should also state the number of corresponding point pairs you have to select from the image etc.).

There are six unknowns in the system, thus we need 3 point pairs.

i. Select 3 corresponding points between I1 and I2.
ii. Calculate least squares solution
iii. If the error between the images is higher than a threshold, select another 3 points.