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1. Consider a camera with a simple lens. Suppose there is a scene point P at a distance of 60 centimeters from the lens. The lens creates a focused image of P at a distance of 12 centimeters from the lens. What is the focal length of the lens?

2 / 2 points

- ○ 50 millimeters
- ◉ 100 millimeters
- ○ 200 millimeters
- ○ 400 millimeters

Correct
Use the Gaussian lens law: $o = 60$ centimeters, $i = 12$ centimeters.
Calculate $f = \frac{o \times i}{o+i}$.

2. Suppose a camera takes an image that is blurred due to defocus. The camera then takes another image with the aperture diameter halved. The blur circle diameter in the new image will

1 / 1 point

- ○ Be doubled as compared to the original image
- ◉ Be halved as compared to the original image
- ○ Be the same as compared to the original image
- ○ Depend on the scene distances, and cannot be determined from the provided information

Correct

Defocus blur circle diameter b is directly proportional to the lens diameter. Everything else remaining the same, halving the lens diameter will half the blur circle size.

3. Which of the following statements about the Point Spread Function is FALSE?

1 / 1 point

- ◯ The Point Spread Function and Impulse Response are equivalent terms.
- ◉ For a Pillbox-like PSF, if the blur-circle diameter increases, the light at each pixel increases to satisfy the Law of Conservation of Energy.
- ◯ For a Pillbox-like PSF, the light is uniformly distributed across the blur circle.
- ◯ For a Gaussian-like PSF, a good approximation is that the blur-circle diameter is about twice as large as the PSF's sigma.

Correct

The first, third, and last answer choices are all true. However, in the case of the second answer choice, in order to satisfy the Law of Conservation of Energy, as the blur-circle diameter increases, the light at each pixel must decrease. This is expressed by the Pillbox PSF:

$$h(x,y) = \begin{cases} 4/\pi b^2, & x^2+y^2 \le b^2/4 \\ 0, & otherwise \end{cases}$$

4. Which of the following statements best describes the behavior of defocus?

1 / 1 point

- ◯ Defocus attenuates lower frequencies and therefore serves as a good low-pass filter
- ◯ Defocus attenuates lower frequencies and therefore serves as a good high-pass filter
- ◉ Defocus attenuates higher frequencies and therefore serves as a good low-pass filter
- ◯ Defocus attenuates higher frequencies and therefore, serves as a good high-pass filter

Correct
See the explanation in the lecture on the Point Spread Function.

5. You have a depth-from-focus system for measuring depths. You capture a stack of 10 images by moving the sensor with respect to the lens. For a particular image patch, the best focused image was taken at sensor location s = 52 mm. The focal length of the camera lens that you used is 50 mm. What was the distance of the scene point imaged at this patch?

2 / 2 points

- ○ 1 meter
- ○ 1.1 meters
- ○ 1.2 meters
- ● 1.3 meters

Correct
Use Gaussian lens law.
$f = 50\ mm, s = 52\ mm \rightarrow o = \frac{sf}{s-f} = 1.3\ meters$

6. You are tasked with developing a depth from focus system for an embedded device. You are especially worried that your system might miss simultaneous rapid changes in the x and in the y direction. Furthermore, your system should be able to capture even subtle changes in scene depth and operate in real-time. Which of the following design choices seem to best address your problem?

0 / 1 point

- ○ Choose $\left|\frac{\partial^2 f}{\partial x^2}\right| + \left|\frac{\partial^2 f}{\partial y^2}\right|$ as a focus measure and use Gaussian interpolation
- ○ Choose $\left|\frac{\partial^2 f}{\partial x^2}\right| + \left|\frac{\partial^2 f}{\partial y^2}\right|$ as a focus measure and take images using many sensor locations
- ○ Choose $\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$ as a focus measure and use Gaussian interpolation
- ● Choose $\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}$ as a focus measure and take images using many sensor locations

Incorrect

7. Your Depth-From-Focus System has collected the following three *(sensor distance, focus measure)* tuples: $(1, e), (2, e^3), (3, e^2)$. Using Gaussian Interpolation, determine the interpolated peak sensor distance. **2 / 2 points**

- (selected) $\frac{13}{6}$
- $\frac{7}{3}$
- $\frac{16}{7}$
- $\frac{15}{8}$

Correct
The answer can be obtained by simply plugging the values into the Gaussian Interpolation formula as shown in the lecture:

$$\bar{s} = \frac{(lnM_{s_2} - lnM_{s_3})(s_2^2 - s_1^2) - (lnM_{s_2} - lnM_{s_1})(s_2^2 - s_3^2)}{2(s_3 - s_2)[(lnM_{s_2} - lnM_{s_1}) + (lnM_{s_2} - lnM_{s_3})]}$$

$$\bar{s} = \frac{(3-2)(4-1)-(3-1)(4-9)}{2(3-2)[(3-1)+(3-2)]}$$

$$\bar{s} = \frac{3+10}{2\times 3}$$

$$\bar{s} = \frac{13}{6}$$

8. Which of the following is a good approximation of the relation between Gaussian-like PSF's paramter σ and the blur circle diameter b? **1 / 1 point**

- (selected) $\sigma = \frac{b}{2}$
- $\sigma = \frac{b^2}{2}$
- $\sigma = \frac{b}{4}$
- $\sigma = \frac{b^2}{4}$

Correct
As seen in the lecture

9. What is the main disadvantage of the Naïve Depth From Defocus Algorithm? **1 / 1 point**

- It needs 3 or more distinctly focused images to recover the depth.

- ( ) It requires the knowledge of the imaging system.
- (•) It is susceptible to noise.
- ( ) During the computation, the content of the scene is disregarded.

Correct
As seen in the lecture, the Naïve Depth From Defocus Algorithm requires only 2 distinctly focused images to recover depth, so the first answer choice is false. The second answer choice is not a disadvantage of the Naïve Depth From Defocus Algorithm, as Reconstruction-based Depth From Defocus algorithm also requires the knowledge of the imaging system, so the second answer choice is not correct. The last answer choice is true yet not a disadvantage, therefore it is the wrong response. Since the Naïve Depth From Defocus Algorithm needs to focus on the changes in the high frequencies, which include grainy noise, the results become unstable. Therefore the third answer choice is correct.

10. A camera has a lens with focal length $f = 50mm$ and aperture diameter $D = 20mm$. The distance of the sensor from the lens is $s = 55mm$. The blur circle diameter b (e.g., using depth-from-defocus) for a scene point is $b = 0.02mm$. How far is the scene point? **2 / 2 points**

- ( ) $5.4cm$
- (•) $54cm$
- ( ) $545cm$
- ( ) $54m$

Correct
Use the expression for object distrance in terms of blur circle diameter $o = \frac{sf}{s-f+b(f/D)}$.

11. Which of the following options is a possible way to handle objects with little texture by Depth from Defocus systems? **1 / 1 point**

- ( ) Increasing the lens aperture

- ○ Moving the sensor with respect to the lens
- ○ Capturing the scene from multiple angles
- ◉ Projecting a pattern onto the scene

Correct
As seen in the lecture, professor Nayar used a light source to project a fine pattern onto the scene, which ”forced” texture even onto objects with little to no texture.