BioE 1330 - Review Chapter 3 1/26/2010

Instructions: On the Answer Sheet, enter your 2-digit ID number (with a leading 0 if needed) in the boxes of the ID section. *Fill in the corresponding numbered circles.* Answer each of the numbered questions by filling in the corresponding circles in the numbered question section. Print your name in the space at the bottom of the answer sheet. Sign here stating that you have neither given nor received help.

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your signature

1. The following is true of the Gaussian function, generally of the form $e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. Convolution with another Gaussian always yields a Gaussian whose standard deviation σ at least as large as the larger of the two constituent's σ.

B. When $\mu = 0$, the Gaussian is an even function.

C. It represents a cosine in the real domain and a sine in the imaginary domain.

D. It approaches an impulse function when σ approaches 0.

E. Multiplication with another Gaussian having the same mean μ yields a Gaussian with the same mean.

2. The following are true about the Modulation Function $m_f = \frac{f_{max}-f_{min}}{f_{max}+f_{min}}$ of $f(x, y)$, *except*

A. For a sinusoidal variation in intensity, it represents the amplitude of the sinusoid over its average value.

B. It is a measure of the contrast in an image.

C. It equals 1 only when$f_{min} = 0$.

D. It is always in the range $0 \leq m_f \leq 1$.

E. It equals $\frac{1}{2}$ when there is no contrast in the image.

3. In the continuous domain, the following are true about the probability *density* function.

I - It represents the derivative of the probability *distribution* function.
II - It has an area of 1.
III - It can never be negative.

A. None of them is true.

B. I and III.

C. II and III.

D. I and II.

E. I, II, and III.

4. The following are true about the Poisson distribution *except*

A. It is used to represent variation between samples of high-energy photons in an x-ray image.

B. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf)

C. It may represent continuous or discrete random variables.

D. Its mean and variance are equal.

E. It can model randomly occurring discrete events.

5. Please match following terms with their definitions

a - Contrast
b - Resolution
c - Noise
d - Artifacts
e - Distortion

1 - is any geometric inaccuracy in size or shape.
2 - is any random fluctuation in an image.
3 - is the ability of an imaging system to distinguish and depict two signals that differ in space, time, or energy as distict.
4 - refers to the difference in image intensity of an object or target and surrounding objects or background.
5 - are false signals in an image that do not represent any valid structural or functional signal in the patient.

A. a - 4, b - 3, c - 2, d - 1, e - 5

B. a - 3 , b - 4 , c - 2, d - 5, e - 1

C. a - 4, b - 3, c - 5, d - 2, e - 1

D. a - 2, b - 5, c - 1, d - 3, e - 4

E. a - 4, b - 3, c - 2, d - 5, e - 1

6. A physical examination was used to screen for breast cancer in 2,500 women with biopsy-proven adenocarcinoma of the breast and in 5,000 age- and race-matched control women. The results of the physical examination were positive in 1,800 cases and in 800 control women, all of whom showed no evidence of cancer at biopsy. Find the sensitivity of the physical examination

A. 36.0

B. 72.0

C. 28.0

D. 69.2

E. 84.0

7. A population of 1000 people is tested for a disease. 800 receive a negative result. The prevalence of the disease is known to be 15%. What is the minimum value for the sensitivity of the test required to make the diagnostic accuracy at least 90%?

A. 0.625

B. 0.833

C. 0.850

D. 0.912

E. 0.800

8. You are visiting the doctor for a checkup. You have a routine test performed, and the result of the test is negative. You ask the doctor what it means to have a negative result: "Given that I have a negative test result, what is the chance that I actually don't have the disease?" Which term describes the value that the doctor is about to give you?

A. Prevalence

B. Specificity

C. Diagnostic accuracy

D. Negative predictive value

E. Positive predictive value

9. Which of the following statements is false?

A. The modulation transfer function of an imaging system characterizes the contrast in the system.

B. The modulation transfer function of an imaging system is the Fourier transform of the point spread function of that system normalized to the Fourier transform at DC.

C. The modulation transfer function of an imaging system can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

D. The modulation transfer function of an imaging system is a model of the noise and artifacts present in the system.

E. The modulation transfer function of an imaging system can be used to quantify the resolution of that system.

10. Which of the following statements is false?

A. Artifacts degrade images in a repeatable or reproducible manner.

B. Noise can be modeled using probability and random variables, making it possible to reduce the effect of noise.

C. A smaller signal-to-noise ratio is one indication that the output of a medical imaging system is of high image quality.

D. Artifacts can occur as a result of poor image reconstruction techniques.

E. It is possible to remove some artifacts from images in an efficient and automated fashion.

11. Which of the following statements is false?

A. In a sample of 10,000 coin tosses, the probability of getting exactly 4,900 heads is zero.

B. The uniform distribution is a continuous random variable.

C. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

D. In a sample of 10,000 people, the probability of someone having a height of exactly 5' 11" is zero.

E. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

12. Which of the following statements about image resolution is false?

A. Resolution is related to the point spread function of an imaging system.

B. Resolution is unrelated to the signal-to-noise ratio of an imaging system.

C. Resolution is related to the modulation transfer function of an imaging system.

D. Resolution can be thought of as the ability of an imaging system to accurately depict two distinct events (in space, time, or frequency) as separate.

E. High resolution in an image is characterized by "low smearing."

13. The following are all true about contrast, resolution, and noise in an imaging system *except*

A. They can each effect the quality of an image and the accuracy of a diagnosis made from that image.

B. They can be related to each other using mathematics that involves the Fourier transform.

C. Increased noise tends to lead to increased contrast and increased resolution.

D. They can each be quantified for an imaging system, although the method of quantification for each can be defined in various ways.

E. Each can be described as a function of frequency.

14. Which of the following statements is *false* about discrete random variables?

A. A probability distribution function can describe the distribution of values.

B. They can only assume integer values.

C. A probability mass function can describe the distribution of values.

D. In physical system they are often described by a Poisson Distribution.

E. A probability density function can describe the distribution of values.

15. The contingency table relates the results of a test to the presence of a disease, permitting the calculation of various quantities involving diagnostic accuracy, including all of the following, *except*

A. resolution

B. prevalence

C. specificity

D. positive predictive value

E. sensitivity

16. $f(x)$ and $g(x)$ are band limited signals with Nyquist sampling frequencies of 250 Hz and 100 Hz respectively. Find the Nyquist sampling frequency for $f(x) + g(x)$.

A. 200 Hz

B. 250 Hz

C. 500 Hz

D. 350 Hz

E. 100 Hz

17. If $\mathcal{F}[PSF] = \sqrt{5\pi}e^{-5\pi^2u^2}$ find the MTF. (*hint*: the Modulation Transfer Function (MTF) is the magnitude of the Fourier transform of the Point Spread Function (PSF), normalized by Fourier transform at 0 Hz.)

A. $e^{-5\pi^2u^2}$

B. $e^{\frac{x^2}{5}}$

C. $\sqrt{5\pi}e^{-5\pi^2u^2}$

D. $e^{5\pi^2u^2}$

E. $\sqrt{5\pi}$

18. If $h(x) = e^{\frac{-x^2}{2}}$, find the FWHM (Full Width Half Maximum).

A. $\sqrt{2ln(\frac{1}{2})}$

B. $2\sqrt{2ln(2)}$

C. $4\sqrt{2ln(\frac{1}{2})}$

D. $2\sqrt{2ln(\frac{1}{2})}$

E. $\sqrt{2ln(2)}$

19. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Diagnostic Accuracy.

A. 0.95

B. .10

C. .12

D. 1.0

E. 0.67

20. In the discrete domain, the following is (are) true about the probability *mass* function.

I - It represents the derivative of the probability *distribution* function.
II - It is a histogram with an area of 1.
III - It can never be negative.

A. I and III.

B. I and II.

C. II and III.

D. None of them is true.

E. I, II, and III.

21. Which of the following statements is *false* about the modulation transfer function (MTF) of an imaging system?

A. It characterizes the contrast in the system.

B. It is always the same for any real imaging system.

C. It can be used to quantify the resolution of that system.

D. It can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

E. It is the Fourier transform of the point spread function (PSF) of that system normalized to the Fourier transform at DC.

22. Which of the following statements is false?

A. The random variable associated with the current temperature at the North Pole is a continuous random variable.

B. The Probability *Distribution* Function is only applicable to continuous variables.

C. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

D. In a sample of 100,000 people, the probability of someone having a height of exactly 5' 6" is zero.

E. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

23. The concept of Resolution can be used in which of the following domains?

I - Spatial
II - Temporal
III - Spectral (frequency)

A. None of them is true.

B. I, II, and III.

C. II and III.

D. I and II.

E. I and III.

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BioE 1330 - Review Chapter 3 1/26/2010
Answer Sheet - Correct answer is A for all questions

1. The following is true of the Gaussian function, generally of the form $e^{\frac{-(x-\mu)^2}{2\sigma^2}}$ *except*

A. It represents a cosine in the real domain and a sine in the imaginary domain.

B. Multiplication with another Gaussian having the same mean μ yields a Gaussian with the same mean.

C. Convolution with another Gaussian always yields a Gaussian whose standard deviation σ at least as large as the larger of the two constituent's σ.

D. When $\mu = 0$, the Gaussian is an even function.

E. It approaches an impulse function when σ approaches 0.

Explanation: The complex exponential, not the Gaussian, represents the cosine in the real domain and a sine in the imaginary domain
[*imaging0006.mcq*]

2. The following are true about the Modulation Function $m_f = \frac{f_{max}-f_{min}}{f_{max}+f_{min}}$ of $f(x, y)$, *except*

A. It equals $\frac{1}{2}$ when there is no contrast in the image.

B. It is always in the range $0 \leq m_f \leq 1$.

C. It is a measure of the contrast in an image.

D. For a sinusoidal variation in intensity, it represents the amplitude of the sinusoid over its average value.

E. It equals 1 only when$f_{min} = 0$.

Explanation: It equals 0 when there is no contrast in the image.
[*imaging0011.mcq*]

3. In the continuous domain, the following are true about the probability *density* function.

I - It represents the derivative of the probability *distribution* function.
II - It has an area of 1.
III - It can never be negative.

A. I, II, and III.

B. I and II.

C. II and III.

D. I and III.

E. None of them is true.

Explanation: All are true.
[*imaging0013.mcq*]

4. The following are true about the Poisson distribution *except*

A. It may represent continuous or discrete random variables.

B. It is used to represent variation between samples of high-energy photons in an x-ray image.

C. It may be represented by a probability mass function (PMF) but not by a probability density function (pdf)

D. It can model randomly occurring discrete events.

E. Its mean and variance are equal.

Explanation: The Poisson distribution can only represent discrete variables.
[*imaging0014.mcq*]

5. Please match following terms with their definitions

a - Contrast
b - Resolution
c - Noise
d - Artifacts
e - Distortion

1 - is any geometric inaccuracy in size or shape.
2 - is any random fluctuation in an image.
3 - is the ability of an imaging system to distinguish and depict two signals that differ in space, time, or energy as distict.
4 - refers to the difference in image intensity of an object or target and surrounding objects or background.
5 - are false signals in an image that do not represent any valid structural or functional signal in the patient.

A. a - 4, b - 3, c - 2, d - 5, e - 1

B. a - 2, b - 5, c - 1, d - 3, e - 4

C. a - 4, b - 3, c - 2, d - 1, e - 5

D. a - 3 , b - 4 , c - 2, d - 5, e - 1

E. a - 4, b - 3, c - 5, d - 2, e - 1

Explanation: See definitions in book.
[*imaging0020.mcq*]

6. A physical examination was used to screen for breast cancer in 2,500 women with biopsy-proven adenocarcinoma of the breast and in 5,000 age- and race-matched control women. The results of the physical examination were positive in 1,800 cases and in 800 control women, all of whom showed no evidence of cancer at biopsy. Find the sensitivity of the physical examination

A. 72.0

B. 84.0

C. 69.2

D. 28.0

E. 36.0

Explanation: $(1800/2500) * 100$
[*imaging0024.mcq*]

7. A population of 1000 people is tested for a disease. 800 receive a negative result. The prevalence of the disease is known to be 15%. What is the minimum value for the sensitivity of the test required to make the diagnostic accuracy at least 90%?

A. 0.833

B. 0.850

C. 0.912

D. 0.625

E. 0.800

Explanation: Setting up the contingency table with the given values, we have four equations with four unknowns.
$a + b + c + d = 1000$
$c + d = 800$
$a + c = 150$
$a + d = 900$

Solving, we get $a = 125$, $b = 75$, $c = 25$, and $d = 775$. We then calculate the sensitivity as $\frac{a}{a+c} = \frac{125}{150} = 0.833$.
[*imaging0028.mcq*]

8. You are visiting the doctor for a checkup. You have a routine test performed, and the result of the test is negative. You ask the doctor what it means to have a negative result: "Given that I have a negative test result, what is the chance that I actually don't have the disease?" Which term describes the value that the doctor is about to give you?

A. Negative predictive value

B. Positive predictive value

C. Specificity

D. Diagnostic accuracy

E. Prevalence

Explanation: Negative predictive value for a test describes the probability that a patient does not actually have the disease, given a negative test result.
[*imaging0029.mcq*]

9. Which of the following statements is false?

A. The modulation transfer function of an imaging system is a model of the noise and artifacts present in the system.

B. The modulation transfer function of an imaging system characterizes the contrast in the system.

C. The modulation transfer function of an imaging system is the Fourier transform of the point spread function of that system normalized to the Fourier transform at DC.

D. The modulation transfer function of an imaging system can be used to quantify the resolution of that system.

E. The modulation transfer function of an imaging system can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

Explanation: MTF does not model the degradations of an imaging system – rather, it tells us about the resolution and contrast in the system.
[*imaging0031.mcq*]

10. Which of the following statements is false?

A. A smaller signal-to-noise ratio is one indication that the output of a medical imaging system is of high image quality.

B. Noise can be modeled using probability and random variables, making it possible to reduce the effect of noise.

C. Artifacts can occur as a result of poor image reconstruction techniques.

D. Artifacts degrade images in a repeatable or reproducible manner.

E. It is possible to remove some artifacts from images in an efficient and automated fashion.

Explanation: SNR is typically computed by taking the ratio of signal amplitude or power to that of the noise. A higher SNR indicates a better imaging system is in place. The other statements are true.
[*imaging0032.mcq*]

11. Which of the following statements is false?

A. In a sample of 10,000 coin tosses, the probability of getting exactly 4,900 heads is zero.

B. The uniform distribution is a continuous random variable.

C. In a sample of 10,000 people, the probability of someone having a height of exactly 5' 11" is zero.

D. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

E. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

Explanation: Continuous distributions cannot have nonzero probabilities associated with particular values, which is why we use density functions to calculate ranges of probabilities. Discrete distributions, however, do have nonzero probabilities associated with each discrete value.
[*imaging0034.mcq*]

12. Which of the following statements about image resolution is false?

A. Resolution is unrelated to the signal-to-noise ratio of an imaging system.

B. Resolution can be thought of as the ability of an imaging system to accurately depict two distinct events (in space, time, or frequency) as separate.

C. Resolution is related to the point spread function of an imaging system.

D. High resolution in an image is characterized by "low smearing."

E. Resolution is related to the modulation transfer function of an imaging system.

Explanation: Resolution, MTF, and PSF are all inter-related, and the SNR of a system is also related to its MTF. Thus, resolution is related to SNR as well.
[*imaging0035.mcq*]

13. The following are all true about contrast, resolution, and noise in an imaging system *except*

A. Increased noise tends to lead to increased contrast and increased resolution.

B. They can be related to each other using mathematics that involves the Fourier transform.

C. They can each be quantified for an imaging system, although the method of quantification for each can be defined in various ways.

D. Each can be described as a function of frequency.

E. They can each effect the quality of an image and the accuracy of a diagnosis made from that image.

Explanation: Increased noise tends to lead to *decreased* contrast and *decreased* resolution.
[*imaging0069.mcq*]

14. Which of the following statements is *false* about discrete random variables?

A. A probability density function can describe the distribution of values.

B. A probability mass function can describe the distribution of values.

C. They can only assume integer values.

D. A probability distribution function can describe the distribution of values.

E. In physical system they are often described by a Poisson Distribution.

Explanation: Only a continuous random variables can have a probability density function.
[*imaging0070.mcq*]

15. The contingency table relates the results of a test to the presence of a disease, permitting the calculation of various quantities involving diagnostic accuracy, including all of the following, *except*

A. resolution

B. sensitivity

C. specificity

D. positive predictive value

E. prevalence

Explanation: Resolution is not a measure of accuracy, but rather a basic quality of the image itself.
[*imaging0071.mcq*]

16. $f(x)$ and $g(x)$ are band limited signals with Nyquist sampling frequencies of 250 Hz and 100 Hz respectively. Find the Nyquist sampling frequency for $f(x) + g(x)$.

A. 250 Hz

B. 100 Hz

C. 350 Hz

D. 200 Hz

E. 500 Hz

Explanation: The Nyquist sampling frequency is the minimum sampling frequency you required to avoide aliasing. In the combined signal, the Nyquist sampling frequency will be the higher of that for the two constituent signals.
[*imaging0076.mcq*]

17. If $\mathcal{F}[PSF] = \sqrt{5\pi}e^{-5\pi^2u^2}$ find the MTF. (*hint*: the Modulation Transfer Function (MTF) is the magnitude of the Fourier transform of the Point Spread Function (PSF), normalized by Fourier transform at 0 Hz.)

A. $e^{-5\pi^2u^2}$

B. $\sqrt{5\pi}$

C. $\sqrt{5\pi}e^{-5\pi^2u^2}$

D. $e^{\frac{x^2}{5}}$

E. $e^{5\pi^2u^2}$

Explanation: The Fourier transform at $u = 0$ Hz is $\sqrt{5\pi}$.
[*imaging0077.mcq*]

18. If $h(x) = e^{\frac{-x^2}{2}}$, find the FWHM (Full Width Half Maximum).

A. $2\sqrt{2ln(2)}$

B. $\sqrt{2ln(2)}$

C. $4\sqrt{2ln(\frac{1}{2})}$

D. $\sqrt{2ln(\frac{1}{2})}$

E. $2\sqrt{2ln(\frac{1}{2})}$

Explanation: This is a Gaussian, symmetrical around $x = 0$. It is even, and monotonic in both the positive and negative directions. Find x when $h(x) = \frac{1}{2}$.
[*imaging0078.mcq*]

19. Given the following Contingency Table,

		disease	
		+	-
test	+	10	0
	-	5	85

find the Diagnostic Accuracy.

A. 0.95

B. 0.67

C. 1.0

D. .10

E. .12

Explanation: Given

		disease	
		+	-
test	+	a	b
	-	c	d

Diagnostic Accuracy is $\frac{a+d}{a+b+c+d}$.
[*imaging0079.mcq*]

20. In the discrete domain, the following is (are) true about the probability *mass* function.

I - It represents the derivative of the probability *distribution* function.
II - It is a histogram with an area of 1.
III - It can never be negative.

A. I, II, and III.

B. I and II.

C. II and III.

D. I and III.

E. None of them is true.

Explanation: All are true.
[*imaging0082.mcq*]

21. Which of the following statements is *false* about the modulation transfer function (MTF) of an imaging system?

A. It is always the same for any real imaging system.

B. It characterizes the contrast in the system.

C. It is the Fourier transform of the point spread function (PSF) of that system normalized to the Fourier transform at DC.

D. It can be used to quantify the resolution of that system.

E. It can be utilized to determine the signal-to-noise ratio of that system, assuming the noise spectrum is known.

Explanation: It MTF does not model the degradations of an imaging system – rather, it tells us about the resolution and contrast in the system.
[*imaging0084.mcq*]

22. Which of the following statements is false?

A. The Probability *Distribution* Function is only applicable to continuous variables.

B. The random variable associated with the current temperature at the North Pole is a continuous random variable.

C. In a sample of 100,000 people, the probability of someone having a height of exactly 5' 6" is zero.

D. The random variable associated with flipping a coin and counting the number of heads that appear is a discrete random variable.

E. The Poisson distribution, a common model describing the number of photons that strike an x-ray detector in a given amount of time, is associated with discrete random variables.

Explanation: The Probability *Distribution* Function is used for both continuous and discrete variables.
[*imaging0085.mcq*]

23. The concept of Resolution can be used in which of the following domains?

I - Spatial
II - Temporal
III - Spectral (frequency)

A. I, II, and III.

B. I and II.

C. II and III.

D. I and III.

E. None of them is true.

Explanation: All are true.
[*imaging0091.mcq*]