BioE 1330 - Review Chapter 6 2/24/2010

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. Which of the following statements is true about filtered backprojection and convolution backprojection?

A. The filtering is needed to fill out high frequency portions of the Fourier transform of the image, because the transforms of the individual projections are only lines through the origin and are further apart as one moves further from the origin.

B. None of the other answers are correct.

C. Line integrals along the paths of the x-rays spread out as they reach the detector elements, and this loss or resolution needs to be compensated for.

D. Hounsfield units do not correct for the inherent loss of high frequency in the image.

E. The Radon transform does not work at low frequencies as well as at high frequencies.

2. The following are true about Helical (Spiral) CT scanners, *except*

A. They can produce scans of the entire torso in under 30 seconds, reducing motion artifact due to breathing by allowing the patient to hold his breath.

B. Filtered backprojection is still possible, by interpolating several spiral "cuts" into a flat slice.

C. Although they are more expensive than conventional CT scanners, they pay for themselves by permitting faster patient throughput.

D. Because they require slip-ring electrical connectors, which produce electrical noise and Bremsstrahlung, they are not suitable for clinical use.

E. They are inherently smoother than older scanners in that the patient moves continuously through the scanner without stopping and starting.

3. The following are true about CT numbers (Hounsfield units) *except*

A. They account for the fact that CT, compared to most other imaging modalities, is very quantitative in the physical meaning of pixel intensity.

B. They allow individual scanners to be calibrated, given that the effective energy of a given x-ray tube can vary.

C. They yield standard values for tissue types such as -1000 HU for air, 0 HU for water, 3000 for bone, etc., that vary by only about $\pm$ 2 HU between scans and across scanners.

D. They are based on measured values for the linear attenuation coefficient for water.

E. They allow filtered backprojection to compensate for motion artifact due to the patient breathing.

4. The following are true about the sinogram, *except*

A. It contains all the information gathered during an individual CT scan.

B. It exhibits sinusoidal 'traces' each representing the apparent motion of a point within the patient as the angle of projection rotates around the patient.

C. It consists of the individual 1D projections through the patient stacked into a 2D image.

D. It is the 2D Fourier transform of the desired cross-sectional image.

E. It contains intense spots where individual lines of projection encounter particularly high attenuation.

5. The following are true of Filtered Back Projection *except*

A. It constitutes a process for creating a tomographic image from a series of projections.

B. It is used to maximize resolution in Planar Radiography.

C. Filtering is used to boost high frequencies, in effect, to fill in under-sampled areas in the Fourier transform of the tomographic image.

D. It is based on the inverse Radon transform and the fact that the Fourier transform of a projection through a 2D image is a line through the origin of the Fourier transform of that image.

E. It can be accomplished either by multiplication in the frequency domain or convolution in the spatial domain.

6. Which of the following statements about the Projection Slice Theorem is *false*?

A. The Projection Slice Theorem depends on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

B. The Projection Slice Theorem requires the projection to be along one of the cardinal axes, i.e., the x-axis or the y-axis.

C. A set of lines is produced using the Projection Slice Theorem that must be filtered to "fill in" the high frequency regions between those lines.

D. The Projection Slice Theorem allows us to perform image reconstruction using filtered backprojection in the frequency domain.

E. It states that the 1-D Fourier transform of the projection through a 2-D image is a line through the origin of the 2-D Fourier transform of that image.

7. All of the following statements are true about the sinogram, *except*:

A. The sinogram of a uniformly gray 2-D image does not exist.

B. The sinogram results from applying the Radon transform to a 2-D image, and as such has an inverse transform to recreate the original image.

C. It represents a collection of 1-D projections through a 2-D image.

D. One axis of the sinogram represents the angle of projection.

E. Only angles between 0 and π need to be represented, since projection in one direction is the same as in the opposite direction.

8. Which of the following is (are) true about the 2D Radon Transform?

A. All of the other answers.

B. It is a linear operator.

C. Circularly symmetric functions produce a projections that are independent of the angle.

D. It has an inverse transform.

E. It describes projections measured in a CT scanner.

9. Hounsfield units are defined relative to the CT absorption coefficient of

A. Metal.

B. Iodine.

C. Water.

D. Barium.

E. Air.

10. The following are true about Beam Hardening *except*

A. It causes a breakdown in the simplifying assumption of a single "effective" energy in the absorption along a given projection path.

B. It is especially a problem around metal and dense bone.

C. It results in a net increase in the mean energy of x-ray photons.

D. It is more of a problem for planar radiography than for CT.

E. It constitutes energy-selective attenuation of x-rays.

11. Which of the following statements about the Projection Slice Theorem is FALSE?

A. The 2-D Fourier transform of the projection of an object equals a line passing through the origin of the 1-D Fourier transform of that object, at that angle corresponding to the projection.

B. The 1-D Fourier transform of a projection of an object is a slice of the 2-D Fourier transform of that object.

C. The projection-slice theorem allows us to mathematically demonstrate why filtered backprojection works as a method of image reconstruction.

D. The projection-slice theorem does explain the importance of angular sampling required for image reconstruction.

E. The projection-slice theorem is related to the radon transform.

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Answer Sheet - Correct answer is A for all questions

1. Which of the following statements is true about filtered backprojection and convolution backprojection?

A. The filtering is needed to fill out high frequency portions of the Fourier transform of the image, because the transforms of the individual projections are only lines through the origin and are further apart as one moves further from the origin.

B. The Radon transform does not work at low frequencies as well as at high frequencies.

C. Hounsfield units do not correct for the inherent loss of high frequency in the image.

D. Line integrals along the paths of the x-rays spread out as they reach the detector elements, and this loss or resolution needs to be compensated for.

E. None of the other answers are correct.

Explanation: The construction of the entire Fourier domain from individual projections needs to "splat" larger areas at high frequencies.
[*imaging0040.mcq*]

2. The following are true about Helical (Spiral) CT scanners, *except*

A. Because they require slip-ring electrical connectors, which produce electrical noise and Bremsstrahlung, they are not suitable for clinical use.

B. They are inherently smoother than older scanners in that the patient moves continuously through the scanner without stopping and starting.

C. They can produce scans of the entire torso in under 30 seconds, reducing motion artifact due to breathing by allowing the patient to hold his breath.

D. Filtered backprojection is still possible, by interpolating several spiral "cuts" into a flat slice.

E. Although they are more expensive than conventional CT scanners, they pay for themselves by permitting faster patient throughput.

Explanation: The Bremsstrahlung answer is completely bogus.
[*imaging0041.mcq*]

3. The following are true about CT numbers (Hounsfield units) *except*

A. They allow filtered backprojection to compensate for motion artifact due to the patient breathing.

B. They allow individual scanners to be calibrated, given that the effective energy of a given x-ray tube can vary.

C. They are based on measured values for the linear attenuation coefficient for water.

D. They yield standard values for tissue types such as -1000 HU for air, 0 HU for water, 3000 for bone, etc., that vary by only about $\pm$ 2 HU between scans and across scanners.

E. They account for the fact that CT, compared to most other imaging modalities, is very quantitative in the physical meaning of pixel intensity.

Explanation: Breathing artifact cannot be corrected by the use of HU.
[*imaging0042.mcq*]

4. The following are true about the sinogram, *except*

A. It is the 2D Fourier transform of the desired cross-sectional image.

B. It contains all the information gathered during an individual CT scan.

C. It exhibits sinusoidal 'traces' each representing the apparent motion of a point within the patient as the angle of projection rotates around the patient.

D. It consists of the individual 1D projections through the patient stacked into a 2D image.

E. It contains intense spots where individual lines of projection encounter particularly high attenuation.

Explanation: The sinogram is not the actual Fourier transform of the image.
[*imaging0043.mcq*]

5. The following are true of Filtered Back Projection *except*

A. It is used to maximize resolution in Planar Radiography.

B. It constitutes a process for creating a tomographic image from a series of projections.

C. It is based on the inverse Radon transform and the fact that the Fourier transform of a projection through a 2D image is a line through the origin of the Fourier transform of that image.

D. Filtering is used to boost high frequencies, in effect, to fill in under-sampled areas in the Fourier transform of the tomographic image.

E. It can be accomplished either by multiplication in the frequency domain or convolution in the spatial domain.

Explanation: Planar Radiography does not rely on Filtered Back Projection.
[*imaging0096.mcq*]

6. Which of the following statements about the Projection Slice Theorem is *false*?

A. The Projection Slice Theorem requires the projection to be along one of the cardinal axes, i.e., the x-axis or the y-axis.

B. It states that the 1-D Fourier transform of the projection through a 2-D image is a line through the origin of the 2-D Fourier transform of that image.

C. A set of lines is produced using the Projection Slice Theorem that must be filtered to "fill in" the high frequency regions between those lines.

D. The Projection Slice Theorem depends on the fact that rotating a 2-D image corresponds to rotating its 2-D Fourier transform.

E. The Projection Slice Theorem allows us to perform image reconstruction using filtered backprojection in the frequency domain.

Explanation: Any angle of projection is allowed. The cardinal axes of the image are, after all, arbitrary. Rotating the 2-D image results in rotating the 2-D Fourier transform of that image.
[*imaging0106.mcq*]

7. All of the following statements are true about the sinogram, *except*:

A. The sinogram of a uniformly gray 2-D image does not exist.

B. It represents a collection of 1-D projections through a 2-D image.

C. The sinogram results from applying the Radon transform to a 2-D image, and as such has an inverse transform to recreate the original image.

D. One axis of the sinogram represents the angle of projection.

E. Only angles between 0 and π need to be represented, since projection in one direction is the same as in the opposite direction.

Explanation: Any 2-D image has a sinogram, since projections can always be computed.
[*imaging0107.mcq*]

8. Which of the following is (are) true about the 2D Radon Transform?

A. All of the other answers.

B. Circularly symmetric functions produce a projections that are independent of the angle.

C. It is a linear operator.

D. It has an inverse transform.

E. It describes projections measured in a CT scanner.

Explanation: All are true of the 2D Radon Transform.
[*imaging0114.mcq*]

9. Hounsfield units are defined relative to the CT absorption coefficient of

A. Water.

B. Air.

C. Metal.

D. Iodine.

E. Barium.

Explanation: Water is the standard: $h = 1000 \times \frac{\mu - \mu_{water}}{\mu_{water}}$.
[*imaging0115.mcq*]

10. The following are true about Beam Hardening *except*

A. It is more of a problem for planar radiography than for CT.

B. It constitutes energy-selective attenuation of x-rays.

C. It results in a net increase in the mean energy of x-ray photons.

D. It is especially a problem around metal and dense bone.

E. It causes a breakdown in the simplifying assumption of a single "effective" energy in the absorption along a given projection path.

Explanation: Beam Hardening is a problem primarily in CT, where filtered backprojection relies on the simplifying assumption of a single "effective" energy in the absorption along a given projection path. In projection radiography no such assumption is required to produce an image, because each projection path contributes to the image independently.
[*imaging0116.mcq*]

11. Which of the following statements about the Projection Slice Theorem is FALSE?

A. The 2-D Fourier transform of the projection of an object equals a line passing through the origin of the 1-D Fourier transform of that object, at that angle corresponding to the projection.

B. The 1-D Fourier transform of a projection of an object is a slice of the 2-D Fourier transform of that object.

C. The projection-slice theorem does explain the importance of angular sampling required for image reconstruction.

D. The projection-slice theorem is related to the radon transform.

E. The projection-slice theorem allows us to mathematically demonstrate why filtered backprojection works as a method of image reconstruction.

Explanation: See section 6.3 in Prince.

Errata: There are several poorly worded answers in this question and it should not be used.
[*imaging0172.mcq*]