Part 1 of 26 - 0 — 0.25/ 0.25 Points

Question 1 of 28 — 0.25/ 0.25 Points

I certify that

- [x] A. I am talking this exam solely and entirely on my own, without any help from any other individual.
- [x] B. I am aware of the Georgia Tech Honor Code (link) and I affirm to here, as I take this exam.
- [x] C. I am the student who is enrolled in this class
- [x] D. I will NOT print or save any part of this exam, for any purpose whatsoever.

Feedback:

Feedback: Thanks.

Part 2 of 26 - 1 — 4.0/ 4.0 Points

Question 2 of 28 — 4.0/ 4.0 Points

[CP02a2] Consider an CMYK Image where each channel is 8 bits. The resolution of this image is height = 3456 and width = 5184. What is the exact memory requirement of this image?

- ( ) A. 52488 KiloBytes
- (•) B. 69984 Kilobytes
- ( ) C. 4299816960 bits
- ( ) D. 8192 Megabytes

Feedback: YES!

W x H x BitsPerPixelPerChannel x Number of Channels / 8192

8192 is the number of bits in a kilobyte.
8 Bits/Pixel
4 Number of Channels for CMYK

Part 3 of 26 - 2b: Image Histograms — 4.0/ 4.0 Points

Question 3 of 28 — 4.0/ 4.0 Points

[CP02b1] Select the true statements about Histogram Equalization from the list below.

- [x] A. Histogram equalization allows for areas of lower local contrast to gain a higher contrast by spreading out the most frequent intensity values.
- [ ] B. Histogram equalization should be applied to the entire image and the entire image only.
- [x] C. Histogram equalization can produce undesirable effects (like visible image gradient, sometimes with bands) when applied to images with low color depth.
- [x] D. Histogram equalization is like HDR; by changing the range of the image intensities, one can often produce unrealistic (not physically possible by normal sensors) effects in photographs.
- [x] E. Histogram equalization is used to provide better detail in photographs that are over or under-exposed, sometimes with other (undesirable) artifacts.
- [x] F. Histogram equalization is a method in image processing for contrast adjustment using the image's histogram.
- [ ] G. There is no known evidence that histogram equalization has any biological significance (for humans or otherwise).

Feedback: Some of these ideas were mentioned in Lecture "Digital Images" as well as Lecture 02-1 on Udacity , with the HDR statement in the HDR lectures (05-4 on Udacity). Additional details are on the web, including the Wikipedia Page (http://en.wikipedia.org/wiki/Histogram_equalization)

Part 4 of 26 - 02c: Image Overlay — 4.0/ 4.0 Points

Question 4 of 28 — 4.0/ 4.0 Points

[CP02c2] The attached image is the equation of the blend mode "Overlay". Which of the following statements are true about about this blend mode?

$$f_{blend}(a,b) = \begin{cases} 2ab, & \text{if } a < 0.5 \\ 1 - 2(1-a)(1-b), & \text{otherwise} \end{cases}$$

- [ ] A. The parts of the top layer where the base layer is light become darker, and the parts where the base layer is dark become lighter.
- [x] B. It combines the "Multiply" and the "Screen" blend modes depending on the pixel value of the top layer.
- [ ] C. It models the Dodge blend mode, well-known by dark room photographers.
- [ ] D. It is the reason we see the green effect in the lecture videos.

Feedback: Please review Lecture "Digital Images" or Lecture 02-3

Feedback: This question entirely based on Lecture "Digital Images" or Lecture 02-3 on Udacity

Part 5 of 26 - 02d: Point Processes — 4.0/ 4.0 Points

Question 5 of 28 — 4.0/ 4.0 Points

[CP02d1] Given the two attached images from the lectures, please explain the differences between them in terms of how they were generated from 3 different images.

Hint: Review the lectures where these images were used!

- A. DS-1 image is 3 images added without any correction, while DS-2 is DS-1 with histogram equalization.
- B. DS-1 image is an overexposed image, while DS-2 is NOT.
- C. DS-1 image is 3 images added without any correction, while DS-2 is the same 3 images added with .33 weight factor (ie., $0.33*I_1 + 0.33*I_2 + 0.34*I_3$).
- D. DS-1 image an image without any Bayer corrections, while DS-2 is after Bayer correction has been applied.

Feedback: Yes, as it was described in Lecture "Digital Images" and Lecture 02-2

Part 6 of 26 - 2e: Convolution / X-Correlation I — 4.0/ 4.0 Points

Question 6 of 28 — 4.0/ 4.0 Points

[CP02e2] Cross-Correlation is ... (select the correct statements)

- [ ] A. is an operation that calculates the area of overlap between two functions
- [x] B. a measure of similarity between two waveforms
- [x] C. is equivalent to convolution when the kernel is symmetric both in x and y.
- [x] D. a sliding dot product or sliding inner-product

Feedback: Lectures on "Groups of Pixels" lectures 02-5/6

Part 7 of 26 - 2f: Convolution / X-Correlation II — 4.0/ 4.0 Points

Question 7 of 28 — 4.0/ 4.0 Points

[CP02f2] See the attached equation. Select the choices below, which are correct about this equation.

$$G[i,j] = \sum_{u=-k}^{k} \sum_{v=-k}^{k} h[u,v]F[i-u, j-v]$$

- [x] A. This is the general form of an equation for convolution over a neighborhood of pixels, where *k* is the size of the neighborhood (above, below, left, right) — Feedback: See Lectures 02-4/5/6
- [x] B. This equation can be applied for Gaussian kernels, as weights are distributed across the neighborhood. — Feedback: See Lectures 02-4/5/6
- [ ] C. This is the equation is for cross-correlation with uniform weights over a neighborhood of pixels, where *k* is the size of the neighborhood (above, below, left, right)
- [ ] D. This is the equation for convolution with uniform weights over a neighborhood of pixels, where *k* is the size of the neighborhood (above, below, left, right)
- [ ] E. This equation only applies to square or average smoothing, as weights are equally distributed across the neighborhood.

Feedback: See Lectures 02-4/5/6

Part 8 of 26 - 2g: Image Gradients — 2.67/ 4.0 Points

Question 8 of 28 — 2.67/ 4.0 Points

[CP02g2] Image Gradients (select the correct statements)

- [x] A. The Gradient vector points in the direction of most rapid increase in the intensity in an image at any point on the image. — Feedback: See lecture "Groups of Pixels" and Lecture 02-6 on Udacity
- [x] B. Gradient Magnitude at any point on the image provides edge strength. — Feedback: See lecture "Groups of Pixels" and Lecture 02-6 on Udacity
- [ ] C. An edge in an image is usually aligned with the Gradient direction in an image.
- [ ] D. The Gradient vector points in the direction of least rapid increase in the intensity in an image at any point on the image.
- [ ] E. Image Gradients are a change in the discrete image function in *i* and *j*

Feedback: See lecture "Groups of Pixels" and Lecture 02-6 on Udacity

Part 9 of 26 - 03a: Pinhole Photography — 4.0/ 4.0 Points

Question 9 of 28 — 4.0/ 4.0 Points

[CP03a2] A pinhole photograph is/has .... (select correct statements!).

- [ ] A. Usually suffers from motion blur.
- [x] B. Ideally, has virtually no geometric distortion. Straight lines remain straight. Feedback: See Lecture "Cameras" or Lecture 03-1 on Udacity
- [x] C. Has infinite depth of field. Everything is in focus. Feedback: See Lecture "Cameras" or Lecture 03-1 on Udacity
- [x] D. Usually suffers from low light because of the size of the opening / aperture. Feedback: See Lecture "Cameras" or Lecture 03-1 on Udacity

Feedback: See Lecture "Cameras" or Lecture 03-1 on Udacity

Part 10 of 26 - 03b: Aperture **2.67/ 4.0 Points**

Question 10 of 28 2.67/ 4.0 Points

[CP3b2] Consider the following statements about aperture and select the correct ones. Attached is an equation relating the Area (A) of aperture opening to the focal length (f) and the aperture number (N).

$$Area = \pi \left(\frac{f}{2N}\right)^2$$

- [ ] A. The amount of light that falls on a sensor or film in a camera is proportional to the area of the aperture opening, and is referred to as RADIANCE.
- [ ] B. The aperture number, or the f-number (N) usually marked on all lenses, is designed to give irradiance irrespective of the lens in use.
- [x] C. The radius of the opening is simply f/2N (from the above equation of Area of the opening, which is a circle). Feedback: See lecture 03-3
- [x] D. Low f-number (N) on a lens usually means it has a BIG lens. This is especially noticeable for Telephoto lenses, which have larger focal lengths. [A 800mm lens of f-number 4, will have 200mm aperture diameter] Feedback: See lecture 03-3
- [ ] E. Doubling N reduces Area by 4 times, and therefore reduces light by 2 times.

Feedback: See lecture 03-3

Part 11 of 26 - 03c: Lenses **4.0/ 4.0 Points**

Question 11 of 28 4.0/ 4.0 Points

[CP03c2] Select the following correct statements about Lenses.

- [ ] A. Field of view (FOV) of a lens only depends on the Focal Length, as the sensor is placed on the focal plane of the lens.
- [x] B. Focal length is a fixed parameter for each specific lens.
- [x] C. A focused image for a lens forms only on a screen placed focal length distance from the lens. Anywhere else, the image formed is unfocused and suffers from optical blur.
- [x] D. The Combined Focal length of a combination of lenses can vary and depends on the distance between the lenses and their individual focal lengths.

Part 12 of 26 - 4a1 - Optimal Window Size **4.0/ 4.0 Points**

Question 12 of 28 4.0/ 4.0 Points

[CP04a11] Factors to consider for optimal window size for image blending are ... (Choose the correct ones!)

- [x] A. Largest frequency ≤ 2 × size of smallest frequency Feedback: See Lecture "Image Processing" or Lecture 04-2 on Udacity.
- [x] B. To avoid ghosting: Window ≤ 2× size of smallest prominent “feature” Feedback: See Lecture "Image Processing" or Lecture 04-2 on Udacity.
- [ ] C. To avoid seams: Window = size of smallest prominent “feature”
- [x] D. Image frequency content should occupy one “octave” (power of 2) Feedback: See Lecture "Image Processing" or Lecture 04-2 on Udacity.

Feedback: See Lecture "Image Processing" or Lecture 04-2 on Udacity.

Part 13 of 26 - 4a2 - Pyramids **2.0/ 4.0 Points**

Question 13 of 28 2.0/ 4.0 Points

[CP04a22] Choose the statements that are CORRECT about a Laplacian Pyramid

- [x] A. Each Laplacian Image in the Pyramid is a difference between two levels of a Gaussian Pyramid Feedback: Please review Lecture 04-3
- [x] B. Each Laplacian is computed using $L_l = g_l - \text{REDUCE}(g_{l+1})$ Feedback: Please review Lecture 04-3. EXPAND, not REDUCE!
- [x] C. A Laplacia Pyramid is a series of “error” images, L_0, L_1, L_2, ... Feedback: Please review Lecture 04-3
- [ ] D. A Laplacian is simply computed using $L_k = \text{REDUCE}(g_{k-1})$

Feedback: Please review Lecture 04-3

Part 14 of 26 - 4a3 - Cuts vs Blends **2.0/ 4.0 Points**

Question 14 of 28 2.0/ 4.0 Points

[CP04a32] Which of the following statements are TRUE for using Cuts vs. Blending images?

- [ ] A. Cuts use dynamic programing to find the best window size in which to merge images.
- [x] B. Using Cuts is better when there is motion that causes ghosting, as the same object will have moved to another point in image during blending. Feedback: See Lecture 04-4
- [x] C. Seam carving works by find a cut between two images. Feedback: Seam carving is applied to only one image to remove a similar cut!
- [x] D. Cuts are a better approach when you want to have the exact pixel from original images replicated in the final output. Feedback: See Lecture 04-4

Feedback: See Lecture 04-4

Part 15 of 26 - 4b1 - Good Features

4.0/ 4.0 Points

Question 15 of 28

4.0/ 4.0 Points

[CP04b12] Please select the correct characteristics of Good Features

- A. Dominant -- Give a strong response to x-correlation
- B. Size -- Relatively size of the feature in the image;
- C. Saliency/Matchability -- Distinctive description — Feedback: Review Lecture "Corners and Features" or Lecture 04-5 on Udacity
- D. Repeatability/Precision -- Find the same feature despite geometric and photometric transformations — Feedback: Review Lecture "Corners and Features" or Lecture 04-5 on Udacity
- E. Frequency - How many similar features are there.
- F. Compactness and efficiency -- Many fewer features than image pixels — Feedback: Review Lecture "Corners and Features" or Lecture 04-5 on Udacity

Feedback: Review Lecture "Corners and Features" or Lecture 04-5 on Udacity

Part 16 of 26 - 4b2

2.67/ 4.0 Points

Questions related to Harris Detector

Question 16 of 28

2.67/ 4.0 Points

[CP04b22] Which of the following is CORRECT about the Harris Detector?

- A. Harris detectors are NOT Invariant to Image Intensity Variations. — Feedback: See Lecture "Corners and Features" or Lecture 04-6 on Udacity
- B. Harris detectors are NOT Invariant to Image Scale changes. One needs to use Fourier transforms to convert the image into the Frequency domain and model the variations.
- C. Harris detectors are Invariant to Rotation. — Feedback: See Lecture "Corners and Features" or Lecture 04-6 on Udacity
- D. Harris detectors are NOT Invariant to Image Scale changes. One needs to use a scale-space representation using Pyramids to detect features at different scales. — Feedback: See Lecture "Corners and Features" or Lecture 04-6 on Udacity
- E. Harris detectors are Invariant to Image Scale changes
- F. Harris detectors are Invariant to Translation. — Feedback: See Lecture "Corners and Features" or Lecture 04-6 on Udacity

Feedback: See Lecture "Corners and Features" or Lecture 04-6 on Udacity

Part 17 of 26 - 5a1: Image Transformations

4.0/ 4.0 Points

Image Transformations

Question 17 of 28

4.0/ 4.0 Points

[CP05a12] Which of the following statements are true about Projective Transformation?

- A. 6 Degrees of Freedom
- B. 8 Degrees of Freedom — Feedback: See Lecture "Image Transformations and Warping" or Lecture 05-1 on Udacity
- C. The leftmost two columns of the transformation matrix need to be computed to model this transformation. — Feedback: See Lecture "Image Transformations and Warping" or Lecture 05-1 on Udacity
- D. 4 Point Correspondences Needed for computation
- E. 3 Point Correspondences Needed for computation
- F. All 8 values except the bottom right element (which should be 1) need to be computed — Feedback: See Lecture "Image Transformations and Warping" or Lecture 05-1 on Udacity

Feedback: See Lecture "Image Transformations and Warping" or Lecture 05-1 on Udacity

Part 18 of 26 - 5b1: Camera Calibration

3.2/ 4.0 Points

Question 18 of 28

3.2/ 4.0 Points

[CP05b12] Camera Calibration: Select the statements that are correct about Camera Calibration from the following

- A. Homography calculation in support of Camera Calibration can work well with only taking enough pictures to allow for solving a linear system of 8 equations. If we have more than 8 images, then we can use least squares to solve an overdetermined linear system. — Feedback: 8 are the number of unknowns in the linear system. More data will support an overdetermined system and will result in better estimates.
- B. To forgo accurate modeling of geometric camera calibration, we can get relative estimates of camera calibration by taking many pictures of a known geometry from different viewpoints, find correspondences, and solve for an overdetermined linear system. — See Lectures "Panoramas" and "Image Transformations and Warping" OR Lecture 05-3 and 05-1 on Udacity
- C. In Radiometric/Photometric Camera Calibration, the goal is to extract how irradiance on the sensor, relates to the actual radiance amounts of the scene captured in photographs. — Feedback: See Lecture "Panoramas" or Lecture 05-3 on Udacity
- D. In Geometric Camera Calibration, we only need to extract the location, orientation, and the focal length of the camera from a series of images and then we can compute relative measurements of known objects in the scene.
- E. In Radiometric/Photometric Camera Calibration, the goal is to extract how sensor irradiance can be captured by a Camera Raw Image File on the sensor, for later post-processing.
- F. In lieu of accurate radiometric camera calibration, we can get good estimates of how pixels match to scene radiance by taking many pictures of a scene at different settings of the camera, and using Least Squares Fitting to estimate the response curve of a camera for a scene. — Feedback: See Lecture "HDR" or Lecture 05-4 on Udacity
- G. In Geometric Camera Calibration, the goal is to extract extrinsic (focal length) and intrinsic (location, orientation, etc.) of the camera, so as to the know the real geometry of the scene captured in photographs.

Feedback: See Lectures "Panoramas" and "Image Transformations and Warping" OR Lecture 05-3 and 05-1 on Udacity

Part 19 of 26 - 5b2: Stereo

4.0/ 4.0 Points

Question 19 of 28

4.0/ 4.0 Points

[CP05b22] Determine which of the following statements are CORRECT about a Stereo method to compute Depth or Disparity in a scene

- A. The disparity computed for a stereo pair is usually smaller for closer surfaces than farther ones. This is due to parallax in the scene.
- B. The epipolar constraint for computing disparity simplifies how corresponding pixels are detected in a stereo pair. — Feedback: See Lecture "Stereo Vision" or Lecture 05-5 on Udacity.
- C. A simple stereo system used to compute 3D scene geometry assumes that there are two cameras of the same focal length translated by a small distance. — Feedback: See Lecture "Stereo Vision" or Lecture 05-5 on Udacity.
- D. Epipolar constraint is also used in the case of a Kinect RGBD sensor, as the 2nd camera is replaced by a IR light source. — Feedback: See Lecture "Stereo Vision" or Lecture 05-5 on Udacity. The layout of the camera and the infrared light source, pretty much mimic the stereo camera set up.

Feedback: See Lecture "Stereo Vision" or Lecture 05-5 on Udacity.

Part 20 of 26 - 6a: Video

4.0/ 4.0 Points

Question 20 of 28

4.0/ 4.0 Points

[CP6a2] Which of the following describes Beta Movement?

- [x] A. It is an optical illusion in which a series of static images appears like a smooth motion.
- [ ] B. It is an optical illusion in which a series of luminous impulses (lights going on and off) create apparent motion.
- [x] C. It requires a frame rate greater than 12 fps.
- [ ] D. It requires the video to be saved in a file with a specific codec.

Feedback: See Lecture "Digital Video" or Lecture 6-1 on Udacity

Feedback: See Lecture "Digital Video" or Lecture 6-1 on Udacity

Part 21 of 26 - 6b: Video Textures

4.0/ 4.0 Points

Question 21 of 28

4.0/ 4.0 Points

[CP6b2] Select the statements from the following which are correct for the concept of Video Textures.

- [ ] A. Crossfading and blending create too much blur and should never be used for video textures.
- [x] B. Though L1 and L2 similarity metrics are discussed for generating video textures, other similarity metrics can also be used to compare frames.
- [x] C. Video Textures can be applied to sub-regions of images, like video sprites.
- [x] D. The primary concept that supports Video Texture analysis is that frames repeat in videos.
- [ ] E. Video Textures only work when there is an image texture in a video.

Feedback: See lecture 06-02

Feedback: See lecture 06-02

Feedback: See lecture 06-02

Feedback: See lecture 06-02

Feedback: See lecture 06-02

Part 22 of 26 - 6c: Video Stablization

4.0/ 4.0 Points

Question 22 of 28

4.0/ 4.0 Points

[CP06c12] Which of the following statements is true about the Video Stabilization system discussed in lecture 06-3?

- [ ] A. Rolling shutter adds unwanted rigid motions to the video due to delay in readout from photosites.
- [x] B. It is a 2D camera path stabilization method, where only estimates of 2D motion are used, then constrained using standard notions of camera movements and L1 optimization.
- [ ] C. It is a 4D camera path stabilization method, where first the 3D path is computed and then a smoothing process is applied. The additional dimension is scaling, which deals with zoom.
- [ ] D. It is a 2D camera path stabilization method, where only estimates of 2D motion are used and then constrained using built-in accelerometer data.
- [x] E. Cropping is used to crop the view, which avoids dealing with hole filling. When the whole frame is aligned, we may see regions with no pixels from the original video as the camera shakes.
- [x] F. The approach for video stabilization is independent of the camera being used and is applied as a post-process.
- [ ] G. Cropping is used to zoom into the view and is fixed.

Feedback: See Lecture 06-3

Feedback: See Lecture 06-3

Feedback: See Lecture 06-3

Feedback: See Lecture 06-3

Feedback: See Lecture 06-3

Part 23 of 26 - 07a: Lightfields

4.0/ 4.0 Points

Question 23 of 28

4.0/ 4.0 Points

[CP7b22] Which of the following statements are CORRECT about a Light field Camera?

- [x] A. One can build a light field camera, capable of depth, focus, and illumination estimation by combining a lens and micro-lens array system.
- [x] B. A plenoptic or a light field camera attempts to capture a light field rather than pixels. The captured light field can be rendered as a traditional image in pixels as a post-capture step.
- [x] C. A hologram is represented as a 7-D Light Field.
- [ ] D. Panoramas can't be represented using the plenoptic function.

Feedback: See Lecture "Light Fields" or Lecture 07-1 on Udacity

Feedback: See Lecture "Light Fields" or Lecture 07-1 on Udacity

Feedback: See Lecture "Light Fields" or Lecture 07-1 on Udacity

Feedback: See Lecture "Light Fields" or Lecture 07-1 on Udacity

Part 24 of 26 - 07c: Coded Photography

3.2/ 4.0 Points

Question 24 of 28

3.2/ 4.0 Points

[CP7b12] Which of the following statements are correct about Epsilon or Coded Photography?

- [ ] A. Low light and image resolution are the primary limitation of adding codings to cameras as shown in lecture 07-3
- [x] B. Coded photography uses a "code" to encode variations in an image (or video) in neighboring pixels. Epsilon photography just captures all variations and tends to deal with it in a post-processing.
- [x] C. Coded Photography takes standard pictures, except with an encoding that adds additional functionality.
- [x] D. Coded Photography and Epsilon Photography have similar goals; encoding variation in an image to capture more detail.
- [x] E. A coded shutter essentially changes the shutter opening to provide variations in captured image, which can then be computationally adapted.
- [ ] F. Epsilon Photography has very limited data compression needs, as it stores only the necessary parts of the images.

Feedback: See lecture 07-3

Feedback: See lecture 07-3

Feedback: See lecture 07-3

Feedback: See lecture 07-3

Part 25 of 26 - 8: Additional Readings

7.5/ 7.5 Points

Question 25 of 28

2.5/ 2.5 Points

[81] Select the statements that are correct for the "Interactive Photomontage" approach presented in 08-1

- [x] A. It works on a stack of images, along the lines of Epsilon Photography
- [x] B. Gradient-domain image fusion in the color space is used to align the colors amongst the stack of images.
- [ ] C. Alignment of images if NOT required for the processing of images.
- [x] D. Cuts are used to merge and generate a new image

Feedback: See module 08-1

Feedback: See module 08-1

Feedback: See module 08-1

E. Images are blended to generate a new image

Feedback: See module 08-1

Question 26 of 28 — 2.5/ 2.5 Points

[83] Which of the follow applies to the concept of "Eulerian Video Magnification" Concept from 08-3?

A. They note that decomposing a video sequence into spatial frequency bands reveals small motions that can be selectively magnified. — Feedback: See Module 8-3

B. They use Laplacian Pyramids to capture the variations at different scales. — Feedback: See Module 8-3

C. Lagrangian methods are used to track motions.

Feedback: See Module 8-3

Question 27 of 28 — 2.5/ 2.5 Points

[86] "PatchMatch" is a method widely used for image editing. Which of the following statements is true for this method? (see Module 08-6)

A. The core of the PatchMatch system is an algorithm for computing patch correspondences efficiently using an approximate Nearest Neighbor approach. — Feedback: see Module 08-6

B. PatchMatch is an algorithm for image completion, which lets a user simply erase an unwanted portion of an image, which the computer automatically synthesizes a fill region that plausibly matches the remainder of the image

C. PatchMatch is an interactive structural image-editing framework, which makes it possible to grab portions of an image and move them around — Feedback: see Module 08-6

Feedback: see Module 08-6

Part 26 of 26 - Closing — **0.25/ 0.25 Points**

Question 28 of 28 — 0.25/ 0.25 Points

[Closing] Reminder and recertification on closing:

I certify that

A. I took this exam solely and entirely on my own, without any help from any other individual.

B. I am aware of the Georgia Tech Honor Code (link) and I affirm it here as I take this exam.

C. I am the student who is enrolled in this class.

D. I will not copy or print this exam for any reason!

Feedback: Thanks.