Queen's University
CISC/CMPE 457
Test 1

October 4, 2017
Duration: 50 minutes

Closed book

Initial of Family Name: ___

Student Number: Solutions
(Write this at the top of every page.)

There are 4 questions and 23 marks total.

Answer all questions.

This exam paper should have 5 pages,
including this cover page.

1 – Short Answers	/ 5
2 – Intensity Mapping	/ 6
3 – Image Operations	/ 6
4 – Convolutions	/ 6
Total	/ 23

The candidate is urged to submit with the answer paper a clear statement of any assumptions made if doubt exists as to the interpretations of any question that requires a written answer.

1 Short Answers — 5 points

Part A — 1 point What is the dynamic range of an image in which the intensity is represented with 10 bits per pixel?

1 : 1024 or 1 : 2^10

Part B — 1 point Why is RGB not a good colourspace?

Linear interpolation of colours in RGB doesn't produce the perception of linear interpolation.

Part C — 1 point What image problem does a median filter correct?

Salt and pepper noise. I.e. isolated pixels that are much brighter or much dimmer than the surrounding pixels.

Part D — 1 point What visual effect does histogram equalization have on an image?

Increases contrast at intensities where there are many pixels, and decreases contrast at intensities where there are few pixels.

Part E — 1 point What is the infinity norm and where is it used in image processing?

d(a,b) = max(|a_x - b_x|, |a_y - b_y|). That is, the maximum single-coordinate difference.

Used to define a square neighbourhood around a pixel.

... continued

2 Intensity Mapping — 6 points

Part A — 2 points Explain **why** and **how** gamma correction is used with a computer monitor.

A computer monitor will display intensity p as p^{gamma}, which is incorrect.

So gamma correction takes the intensity p in the image and replaces it with p^{1/gamma} before sending it to the monitor. This ensures that the correct intensity is shown.

Part B — 2 points What two image characteristics can a linear transform of intensity affect? Explain which characteristic is affected by which part of the linear transform.

x' = m x + b for original intensity x and new intensity x'

The contrast is varied by m.

The brightness is varied by b.

Part C — 2 points When is a histogram considered to be equalized? Why can a histogram have no pixels at some intensities and still be considered to be equalized?

It's equalized when all pixel intensities occur with the same frequency (i.e. when the histogram is flat).

The frequency can be considered over a larger number of intensity levels (i.e. making bigger bins in the histogram, such as bins containing four levels each). When gaps exist, this frequency over more levels will be approximately constant over the histogram.

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3 Image Operations — 6 points

Part A — 2 points What two properties of sensor noise are necessary for an average of many images taken with the sensor to be more accurate than a single image taken with the sensor? Explain.

The noise must be zero-mean so that, on average, it's zero.

The noise must be uncorrelated, so that there's no pattern.

Part B — 2 points Describe carefully how vignetting is removed from an image.

Find the multiplicative factor by which each pixel's intensity is exaggerated. Build an image of the recipricols of these factors (each pixel stores the recipricol of the factor at that pixel). Then multiply the captured image by the recipricol image.

Part C — 2 points Describe two types of geometric transformation in which forward projection does *not* result in gaps in the transformed image. Explain why gaps do not form.

Translation
Scaling by a factor less than 1

Each of these does not cause pixels to spread out.

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4 Convolutions — 6 points

Part A — 2 points Show the convolution of filter $\begin{bmatrix} 10 & 20 \end{bmatrix}$ with image $\begin{bmatrix} 0 & 1 \\ 2 & 3 \end{bmatrix}$. The origin of the filter is at the 20.

Don't forget to flip the filter.

```
[  0  10  20 ]
[ 20  70  60 ]
```

Part B — 2 points Show a 2D filter which, when **convolved** with an image, shifts the image one pixel right and two pixels up. Clearly mark the origin of your filter's coordinate system.

```
[  0  1 ]
[  0  0 ]
[  0  0 ]
```

The origin is the bottom-left 0.

Part C — 2 points Let F be the first finite difference filter $\begin{bmatrix} 1 & -1 \end{bmatrix}$ with its origin at the -1. Let $I' = I + 0.2\, I * F$ where $*$ is convolution and I and I' are images.

On what edges in the image is a pixel of I' **darker** than the corresponding pixel of I? Explain carefully. Recall that edges are light-to-dark or dark-to-light transitions in the image.

Vertical edges (since the filter detects such edges) that are light on the left and dark on the right (since the filter returns a negative value for those edges, as opposed to a positive value for dark-to-light edges).